

# Coastal Zone Management Plan for the Tweed Coast Estuaries





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June 2013

*Cover Photos: Clockwise from left: Cudgen Creek (DLWC, 2000) Source: <http://www.environment.nsw.gov.au/estuaries/stats/CudgenCreek.htm>; Cudgera Creek (DECCW, 1999) Source: [http://www.ozcoasts.gov.au/search\\_data/detail\\_result.jsp](http://www.ozcoasts.gov.au/search_data/detail_result.jsp); Cudgera Creek looking east (DECCW, 1999) Source: [http://www.ozcoasts.gov.au/search\\_data/detail\\_result.jsp](http://www.ozcoasts.gov.au/search_data/detail_result.jsp); Mooball Creek (DECCW, 1999) Source: [http://www.ozcoasts.gov.au/search\\_data/detail\\_result.jsp](http://www.ozcoasts.gov.au/search_data/detail_result.jsp).*

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**PROJECT 11-008 – COASTAL ZONE MANAGEMENT PLAN FOR TWEED COAST ESTUARIES**

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A	Draft for internal review	K Pratt	M Howland	M Howland	26 Oct 2012
0	Draft for Council review	K Pratt	M Howland	M Howland	7 Nov 2012
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2	Final Draft CZMP	K Pratt	M Howland	M Howland	18 June 2013

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## EXECUTIVE SUMMARY

### Introduction

The Tweed Coast Estuaries comprising the Cudgen Creek and Cudgen Lake, Cudgera Creek and Mooball Creek systems are highly valued by the community and are focal points for recreation, tourism and local commerce. The estuaries, with the associated catchments, wetlands and waterways, support a rich biodiversity and a range of important environmental functions. Despite these recognised values, the systems are under pressure from past and existing development, catchment disturbance, hydrological modification, land use management, large-scale vegetation changes and community use. The upper reaches of the estuaries have been extensively modified, primarily through clearing and draining of the floodplain, to allow for sugar cane farming and grazing. Looking forward, the estuaries face continued pressure from future development and population growth within the catchments. Some of the natural characteristics of the catchments and floodplains, such as presence of acid sulfate soils, interact with and exacerbate human pressures and contribute to the degradation of the waterways. To improve the health and resilience of the estuaries, a total catchment management approach is recommended.

The aim of this Coastal Zone Management Plan (CZMP) is to document Tweed Shire Council's ten year strategy for management of the Tweed Coast Estuaries and their catchments consistent with NSW state policy. The CZMP will address identified pressures on estuary health through the implementation of integrated, balanced, responsible strategies to restore and maintain the ecological sustainability of the estuaries and catchments as well as the associated recreational and commercial activities.

The long-term vision for the Tweed Coast Estuaries is:

***“The Tweed Coast Estuaries and their catchments will exhibit increased ecological health and resilience, support viable native fauna and flora habitats and populations, and provide a range of recreational opportunities and other ecosystems services that are valued by the community.”***

The Plan is supported by the scientific knowledge gathered during the *Baseline Ecosystem Health Assessment, Bank Erosion Study and Catchment Modelling Report*. These data collection exercises have been undertaken during the development of the plan and provide valuable information on the status of the health of these systems and the key factors within the creeks and their catchments that are affecting the ecological health and recreational values of the systems. The Plan also draws on information from a range of existing background information including the preceding *Tweed Coast Estuaries Management Plan 2004-2008* and other local studies.

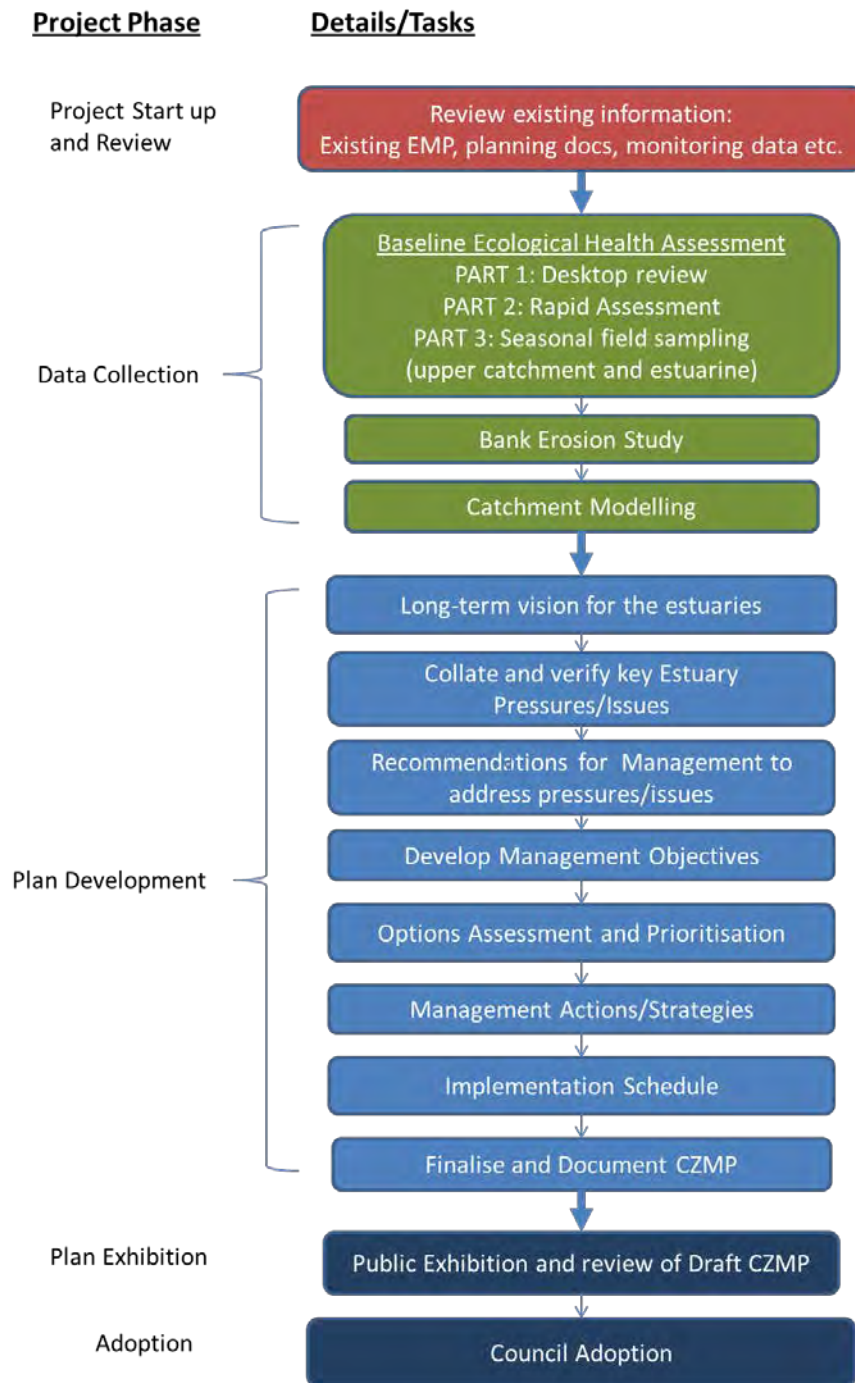
### Management Framework

The CZMP supports the goals and objectives of the *NSW Coastal Policy 1997* and the *NSW Sea Level Rise Policy Statement, 2009* and will assist in implementing integrated coastal zone management for the Tweed Coast Estuaries. The CZMP was prepared in accordance with Part 4A of the *Coastal Protection Act, 1979* and NSW Government's *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010a). The CZMP will be formally adopted by Tweed Shire Council (TSC). Following adoption, formal approval will be sought from the NSW Government in accordance with the *Coastal Protection Act, 1979* section 55H.

During the completion of this CZMP the NSW Government announced changes to its approach to coastal management including the retraction of its policy to specify sea level rise benchmarks for NSW. In the absence of any additional information, TSC has adopted the projected sea level rise benchmarks from the *NSW Sea Level Rise Policy Statement* (DECCW, 2009) for the purposes of this CZMP. Further changes to NSW coastal management policies are unknown at this stage; however they are not expected to affect the completion of this CZMP.

### CZMP Development Process

The CZMP was prepared through a series of project phases. Each phase was an essential step in the development of the CZMP. The preparation process and key phases are illustrated in Figure 1 below.



**Figure 1: CZMP preparation process for the Tweed Coast Estuaries**

Estuary health pressures and management issues to be addressed by this CZMP were collated from the review of background information and technical investigations undertaken including:

- *Tweed Coast Estuaries: Bank Erosion Study* (attached as Appendix 3)
- *Tweed Coast Estuaries and Catchments: Baseline Ecosystem Health Assessment* (attached as Appendix 4); and
- *Tweed Coast Estuaries: Catchment Modelling Report* (attached as Appendix 5).

## COASTAL ZONE MANAGEMENT PLAN FOR THE TWEED COAST ESTUARIES

Management objectives were developed based on the values of the estuaries and the identified pressures impacting on these values. The objectives are consistent with the nine goals of the *NSW Coastal Policy 1997*, *TSC Community Strategic Plan*, and previous objectives set for the local estuaries and coastal zone. They are targets for future management to ensure a balance between long-term utilisation and conservation of the Tweed Coast Estuaries.

The management objectives proposed for the Tweed Coast Estuaries CZMP are:

Primary Management Objective	Local Objectives for the Tweed Coast Estuaries
O1 - To protect, rehabilitate and improve the natural environment	<ul style="list-style-type: none"> <li>• Reduce pollution impacting the estuary</li> <li>• Maintain, rehabilitate and/or improve the riparian zone</li> <li>• Minimise adverse impacts on the estuaries</li> <li>• Enhance habitat values of the estuary</li> </ul>
O2 - To recognise and accommodate natural processes and climate change.	<ul style="list-style-type: none"> <li>• Set appropriate setbacks for infrastructure, access points and buildings from river bank escarpments</li> </ul>
O3 - To protect and enhance the aesthetic qualities of the coastal zone	<ul style="list-style-type: none"> <li>• Preserve the natural beauty and unique character of the Tweed Coast Estuaries</li> <li>• Protect and improve estuarine water quality</li> <li>• Protect flora and fauna species and habitat values to enhance nature watching activities around the estuary and coastline.</li> </ul>
O4 - To protect and conserve cultural heritage	<ul style="list-style-type: none"> <li>• To identify significant cultural heritage sites</li> <li>• To assess impacts on sites</li> <li>• To minimise impacts on sites</li> </ul>
O5 - To promote ecologically sustainable development and use of resources	<ul style="list-style-type: none"> <li>• Enhance recreational amenity</li> <li>• Preserve community uses (fishing, swimming, surfing, beach, estuary and foreshore use, etc.)</li> <li>• Enhance social benefits (employment, sense of place, community)</li> <li>• Promote economic benefits for the community (tourism dollars, land value, etc.)</li> </ul>
O6 - To provide for ecologically sustainable human settlement.	<ul style="list-style-type: none"> <li>• To minimise the impacts of present and planned urban settlements.</li> </ul>
O7 - To provide for appropriate public access and use.	<ul style="list-style-type: none"> <li>• Ensure suitable access to foreshore and beaches is retained</li> <li>• Maintain/repair or relocate access that is impacted by coastal hazards</li> <li>• Implement management strategies to avoid or address risks to community assets</li> <li>• Allow for ongoing use of community assets</li> <li>• To minimise risk to public health and safety</li> </ul>
O8 - To provide information to enable effective management	<ul style="list-style-type: none"> <li>• Undertake community education about issues, the need for management and the options assessment process</li> <li>• Enhance public awareness and support of adopted management strategies</li> <li>• Include community in decision making</li> </ul>

Primary Management Objective	Local Objectives for the Tweed Coast Estuaries
O9 - To provide for integrated planning and management.	<ul style="list-style-type: none"> <li>• To provide a consistent management framework that logically facilitates efficient and effective management</li> <li>• To ensure consistency with other strategic planning instruments and programs without duplicating management actions. The CZMP will support and refer to other programs where appropriate</li> <li>• Conduct monitoring of management strategies to measure success and improve practice</li> <li>• Identify equitable funding sources for implementation of management</li> </ul>
O10 - To minimise overall cost while achieving the goals of the CZMP	<ul style="list-style-type: none"> <li>• Minimise costs where possible while achieving aims of management (get the best 'bang for buck')</li> <li>• Ensure true costs are reflected in assessment of options (quick fix may be cheap but costs may be more in the long run)</li> </ul>

Management actions were recommended to address identified coastal hazard risk, estuary health, and community use pressures. Recommended actions were developed with consideration of the nature and causes of the problem(s), the location and frequency of occurrence and by considering what work has already been undertaken. Where information was lacking on the source of pressures, management recommendations were focussed on investigation to better define the issues and recommend appropriate management actions. In cases where the source of pressures could not be directly addressed by management, actions aim to ameliorate key risks to acceptable levels.

In order to prioritise actions, they were assessed in terms of:

- their effectiveness in addressing the management objectives;
- the expected level of community support and acceptance;
- cost of implementation; and
- the likely environmental benefits and/or impacts of the action (both positive and negative).

The prioritised actions were grouped into fifteen management strategies for on-ground implementation and it is these strategies that form the basis of this CZMP. The priorities assigned to the strategies are reflected in the scheduled timing and recommended level of resources allowed for implementation.

## **Summary of Identified Estuary Pressures and Recommended Management Strategies**

Table 1 lists the identified estuary pressures and the management strategies and actions developed to address them and provides links to the description of tasks. A summary of the strategies and actions follows the table.

Table 1: Management strategies to address key estuary pressures

No.	Estuary Pressure	Recommended Management Strategy
P1	Decline in seagrass area in all estuaries between 2006 and latest assessments conducted in 2011.	Strategy 2: Estuary Habitat
P2	Dramatic decline in seagrass area and health in Mooball Creek.	Strategy 1: Monitoring, Evaluation and Review
P3	Estuarine habitats (seagrass, mangroves and saltmarsh areas) remain vulnerable to a number of threats affecting their overall health and continued protection.	Strategy 15: Education and Consultation
P4	Alteration of habitat is a major pressure for aquatic fauna and a primary cause of decreasing native fish populations. Channelisation of natural waterways, altered flow regimes, poor condition riparian zones and poor water quality are main contributors to habitat alteration.	Strategy 2: Estuary Habitat Strategy 3: Aquatic Fauna Strategy 5: Riparian Vegetation Strategy 7: Acid Sulfate Soils Strategy 8: Agricultural Land
P5	Partial barriers to fish passage may prevent the migration of native fish species during some flow conditions.	Strategy 3: Aquatic Fauna
P6	Introduced fauna species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. The introduced Mosquito Fish ( <i>Gambusia holbrooki</i> ) and an aquarium fish, Swordtail ( <i>Xiphophorus helleri</i> .) are species of concern for the freshwater reaches of Tweed Coast Estuaries.	Strategy 15: Education and Consultation
P7	Threats to shorebirds include introduced pests such as foxes, weed invasion, coastal processes, entanglement and ingestion of fishing line, tackle and pollutants, natural predation and disturbance from beach users and domestic dogs.	Strategy 4: Shorebirds and Coastal Raptors Strategy 15: Education and Consultation
P8	Specific concern has been raised in the community that dogs are negatively impacting on shorebirds in foreshore areas of lower Cudgera Creek.	
P9	Concerns have been raised by local bird enthusiasts that shorebird use of Cudgen and Mooball Creeks is not well understood and may well be important.	
P10	Threats to coastal raptors include habitat loss and degradation, human disturbance to breeding, entanglement and ingestion of fishing line, tackle and pollutants, reduced water clarity, reduced fish health and availability and collision with power line and vehicles.	
P11	Historical clearing of riparian vegetation has created poor condition riparian areas in many areas and particularly on the highly modified floodplain.	Strategy 5: Riparian Vegetation
P12	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary.	Strategy 8: Agricultural Land Strategy 9: Urban Development and Stormwater
P13	Lack or poor condition of riparian vegetation compromises habitat connectivity and habitat value (both in-stream and terrestrial habitat).	Strategy 5: Riparian Vegetation Strategy 2: Estuary Habitat
P14	Lack of suitable buffer zones between land use and waterways limits riparian zones.	Strategy 5: Riparian Vegetation Strategy 8: Agricultural Land Strategy 9: Urban Development and Stormwater
P15	Disturbance associated with infrastructure including waterfront structures and roads in close proximity to waterways.	Strategy 5: Riparian Vegetation Strategy 6: Bank Erosion
P16	Weed invasion reduces habitat and amenity values of vegetation communities.	Strategy 5: Riparian Vegetation Strategy 15: Education and Consultation
P17	Bank erosion can destabilise riparian vegetation.	Strategy 6: Bank Erosion Strategy 5: Riparian Vegetation



No.	Estuary Pressure	Recommended Management Strategy
P18	Clearing and/or mowing of riparian vegetation for improved water views and access.	Strategy 5: Riparian Vegetation Strategy 15: Education and Consultation
P19	Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.	Strategy 6: Bank Erosion
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.	
P21	Acid sulfate runoff negatively impacts overall estuarine ecosystem health. Impacts include fish kills and major aquatic habitat changes, reduced plant growth (acid scalds), and corrosion of concrete, iron and steel structures.	Strategy 7: Acid Sulfate Soils Strategy 8: Agricultural Land
P22	Historical drainage of former backswamp wetlands are the main cause of ASS problems as they facilitate the exposure of ASS to oxygen, which produces acid runoff.	Strategy 1: Monitoring, Evaluation and Review
P23	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.	
P24	Unrestricted stock access causes vegetation damage and bank erosion.	Strategy 8: Agricultural Land Strategy 5: Riparian Vegetation Strategy 6: Bank Erosion
P25	Large areas of the Tweed Coast Estuaries study area are planned to be developed into urban areas.	Strategy 9: Urban Development and Stormwater
P26	Stormwater runoff from urban areas can increase contaminants, litter, nutrients and sediment loads to the estuary.	Strategy 1: Monitoring, Evaluation and Review Strategy 15: Education and Consultation
P27	The Tweed Coast Estuaries are already under existing pressure from agriculture and urban land use and without adequate mitigation, further urban development may add to these pressures.	
P28	Urbanisation can affect hydrologic characteristics through increases in impervious surfaces and by increasing the rate of delivery of catchment runoff to downstream waterways.	
P29	The construction phase of urban development poses the highest risk to water quality of receiving environments.	
P30	High levels of faecal indicator bacteria were identified at sites downstream of Mooball and Burringbar villages indicating either failing OSSM or pollution from surface runoff.	Strategy 1: Monitoring, Evaluation and Review Strategy 10: Wastewater Management
P31	Litter and dumped waste decreases the visual amenity of the estuaries and foreshore areas and poses a risk to wildlife.	Strategy 15: Education and Consultation
P32	There is a risk that natural upslope migration of estuarine habitats due to sea level rise will be curtailed by anthropogenic constraints (roads, agriculture, urban development etc.).	Strategy 11: Climate Change Adaptation
P33	Sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure and bank erosion.	
P34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues.	
P35	Bank erosion has potential to impact public access points to estuary foreshore areas by undermining and destabilising structures such as stairs and walkways.	Strategy 12: Public Access Strategy 6: Bank Erosion
P36	Potential estuarine inundation during extreme weather events such as king tides, severe storms or catchment flooding threatens the viability of some public access points and this may be increased with sea level rise.	Strategy 11: Climate Change Adaptation
P37	There is anecdotal evidence of mangroves being illegally removed from Crown Land foreshore areas.	Strategy 2: Estuary Habitat Strategy 15: Education and Consultation
P38	Private landholder use and occupation of Crown Land foreshore areas is restricting public access.	Strategy 12: Public Access
P39	Community concern that a minority of boat users break the rules concerning boat speed and operation.	Strategy 13: Recreational Use

No.	Estuary Pressure	Recommended Management Strategy
P40	Boat wash can increase rates of bank erosion and disturb sensitive vegetation in the estuary.	Strategy 6: Bank Erosion
P41	Areas of sensitive estuarine vegetation such as seagrass beds may be affected by boating due to propeller and anchor damage.	Strategy 2: Estuary Habitat
P42	Boating navigation in the lower estuaries through to the ocean is hampered by natural processes and can present a safety risk.	Strategy 4: Shorebirds and Coastal Raptors Strategy 15: Education and Consultation
P43	The passage of canoes and other paddle craft through the upper reaches of Cudgen Creek is obstructed by fallen dead, and low-hanging live trees.	Strategy 13: Recreational Use
P44	Community concern that a fish stocks have declined over recent decades.	Strategy 3: Aquatic Fauna
P45	Overfishing can impact fish stocks.	Strategy 13: Recreational Use
P46	Power boating poses a safety risk to people swimming in estuaries.	Strategy 1: Monitoring, Evaluation and Review
P47	Poor water quality impacts the amenity of waterways and may present health concerns for swimmers.	Strategy 15: Education and Consultation
P48	Water quality sampling has identified a potential risk to human health (faecal contamination) at one site in Cudgera Creek.	
P49	Concern about conflict of use between passive recreation activities and active recreation activities (e.g. nature appreciation such as bird watching and use of powered watercraft which can disturb birds) and the potential for increasing conflict into the future.	
P50	Currently there is no overriding plan within the study area to guide the management of Aboriginal cultural heritage.	Strategy 14: Cultural Heritage

## Fundamental Strategies

### Strategy 1: Monitoring, Evaluation and Review

- Action 1a: Ecosystem Health monitoring program - Implementation of a coordinated catchment-wide monitoring program to monitor estuary health, measure the success of management actions and inform decision making in accordance with the NSW Natural Resources Monitoring, Evaluation and Reporting (MER) Strategy.
- Action 1b: Review of CZMP progress and monitoring of KPIs - Ensure continuous improvement towards the CZMP objectives across the full range of identified pressures.
- Action 1c: 10 year review of CZMP - The CZMP will be reviewed to assess whether the desired outcomes are being achieved, and updated to incorporate any new scientific knowledge or changes in community attitudes, government policy, strategic planning and estuary management issues.

### Strategy 11: Climate Change Adaptation

- Action 11a: Assessment and mapping of tidal inundation extent including potential sea level rise – Provide clear definition of potential risks due to tidal inundation for the Tweed Coast Estuaries is used to facilitate adaptation to climate change.
- Action 11b: Planning for sea level rise and climate change impacts - Catchment and estuary specific information regarding climate change is used to facilitate adaptation to climate change.

## High Priority Strategies

### Strategy 6: Bank Erosion

- Action 6a: Bank erosion works planning for high risk sites- Plan for effective resolution of bank erosion at high risk sites identified by the *Bank Erosion Study*.
- Action 6b: Bank erosion remediation works - Effective remediation of bank erosion at high risk sites.

### Strategy 7: Acid Sulfate Soils

- Action 7a: Identify and prioritise key sites for remediation – Prioritisation of ASS hot spots for on-ground remediation works to provide the greatest benefits for the effort expended.
- Action 7b: Acid Sulfate Soil remediation works - Reduce the environmental impacts of ASS hotspots on the estuaries and promote communication of findings to community and decision makers.

### Strategy 5: Riparian Vegetation

- Action 5a: Identify priority riparian areas for rehabilitation - Prioritisation of riparian areas for protection and rehabilitation to provide the greatest benefits for the effort expended.
- Action 5b: Riparian rehabilitation works – Carry out works to improve cover and condition of riparian areas with positive flow on effects increasing the health and resilience of waterways.

### Strategy 8: Agricultural Land

- Action 8a: Support and promote sustainable agricultural initiatives - Support current initiatives encouraging best practice management of agriculture in the catchments, and promote sustainable management practices to community and decision makers.
- Action 8b: Cost Benefit Analysis (CBA) of alternative options for agricultural land- Compare environmental, social and economic costs and benefits of agricultural land management practices and land uses to identify viable farming options with improved outcomes for estuary health.

### Strategy 4: Shorebirds and Coastal Raptors

- Action 4a: On-going protection of shorebirds and their habitat in the study area - Support existing programs to reduce impacts on shorebirds and carry out further work to identify vulnerable habitats and protect them from disturbance.

- Action 4b: Management of dogs within vicinity of shorebird habitat at Cudgera Creek mouth - Extension of dog exclusion areas to cover important nesting, foraging and roosting habitat and clear signage, regulation and community education.
- Action 4c: On-going protection of coastal raptors and their habitat in the study area - Reduce impacts on coastal raptors to ensure these iconic species continue to exist in the Tweed Coast Estuaries.

### **Strategy 15: Education and Consultation**

- Action 15a: Community education and consultation program - to improve understanding of the pressures affecting estuary values and bring about positive changes in behaviour.
- Action 15b: Signage - Raise awareness of the location of sensitive habitats to reduce damage caused by physical disturbance.

## **Medium Priority Strategies**

### **Strategy 2: Estuary Habitat**

- Action 2a: Investigation of seagrass decline - Determine the sources of decline in seagrass extent in the Tweed Coast Estuaries and recommend remedial action where possible to address root causes.
- Action 2b: On-going protection of estuary habitat (seagrass, saltmarsh and mangroves) within the Tweed Coast Estuaries.

### **Strategy 9: Urban Development and Stormwater**

- Action 9a: Stormwater planning controls and regulation – Ensure on-going improvements in stormwater management resulting in reduction of contaminants transported to the estuary.

### **Strategy 10: Wastewater Management**

- Action 10a: Wastewater management – Ensure optimum performance of wastewater management systems resulting in no adverse impacts to estuary health, function and recreational use.

### **Strategy 13: Recreational Use**

- Action 13a: Support and promote safe and ecologically sustainable recreational use – Ensure continued recreational use of the Tweed Coast Estuaries with no adverse impacts on the environment, cultural values or public health and safety.
- Action 13b: Investigation of sources of faecal contamination in Cudgera Creek - Identify the source of faecal contamination in Cudgera Creek and direct management action to address the issue so that recreational water quality objectives are achieved.

### **Strategy 3: Aquatic Fauna**

- Action 3a: Aquatic habitat restoration and protection - Identify opportunities and undertake aquatic habitat restoration and protection works
- Action 3b: Christies Creek fish surveys - Undertake surveys on Christies Creek to determine the extent of Swordtail infestation and determine the feasibility of removal of this species at this location.

### **Strategy 14: Cultural Heritage**

- Action 14a: Cultural heritage - Provide for effective protection and management of cultural heritage and where appropriate provide access and signage to cultural sites to promote the cultural values of the estuary.

### **Strategy 12: Public Access**

- Action 12a: Public access - Public access to estuaries and foreshores is maintained and key future risks are identified for future planning.

### Monitoring, Evaluation and Review of the CZMP

The ability to achieve the management objectives will be determined through the success of the management actions. Evaluation will require coordinated monitoring across the estuary as well as on-going review of performance against defined targets.

The success of the defined management actions should be measured through achievement of the key performance indicators (KPIs) so that any required amendments can be identified. An adaptive management approach should be implemented through:

- Review and reporting of KPIs for each action as part of the council State of the Environment (SoE) Reporting (Action 1b: Review of CZMP progress and monitoring of KPIs);
- A ten year review of the CZMP considering results of the SoE reviews, any barriers identified to the effective implementation of actions or overall success of actions, data provided by the estuary monitoring program, any new or updated scientific knowledge, prevailing community attitudes, estuary management issues, objectives and government policy (Action 1c: 10 year review of CZMP); and
- Adoption and gazettal of the amended CZMP as required.

### Implementation Program

Table 18, in Section 9 provides an overview of the recommended strategies, listing the key actions, responsibilities and indicative timing and costs estimated over the ten year implementation period. The total cost of the CZMP implementation is estimated to be approximately \$2.8 million over ten years. This funding is additional to the concurrent strategies and programs already adopted for the local area.

The CZMP strategies are expected to be funded through Council and State and Federal Government contributions, grants and in-kind contributions. Potential grant funding sources have been identified for each action and successful grant application is a critical component to ensure work is adequately funded.

On-going community involvement and liaison with industry bodies, private landholders and community groups will be required to ensure successful implementation of the CZMP.

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APPENDIX 4 –TWEED COAST ESTUARIES AND CATCHMENTS: BASELINE ECOSYSTEM HEALTH ASSESSMENT

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## 1. INTRODUCTION

### 1.1 Purpose of this Coastal Zone Management Plan

The aim of the CZMP is to document Tweed Shire Council's ten year strategy for management of the Tweed Coast estuaries and catchment tributaries consistent with NSW state policy. The CZMP will address identified pressures on estuary health through the implementation of integrated, balanced, responsible strategies to restore and maintain the ecological sustainability of the estuaries as well as the associated recreational and commercial activities.

The CZMP incorporates a review of the *Tweed Coast Estuaries Management Plan 2004-2008* and provides:

- updated ecosystem assessment;
- identification of current estuary pressures and the status of existing management;
- identification of risks from coastal hazards; and
- recommended management strategies to address current key issues affecting the health and amenity of the Tweed Coast Estuaries.

The long-term vision for the Tweed Coast Estuaries is:

***“The Tweed Coast Estuaries and their catchments will exhibit increased ecological health and resilience, support viable native fauna and flora habitats and populations, and provide a range of recreational opportunities and other ecosystems services that are valued by the community”.***



**Figure 2: Lower Cudgera Creek at Hastings Point is highly valued for its natural amenity and is a popular location for recreation.**

## 1.2 The Study Area: Key Features and Values

The area included in this CZMP is within the Tweed Shire Council LGA in northern NSW, and comprises three estuaries their catchments: Cudgen Creek (estuary mouth at Kingscliff), Cudgera Creek (estuary mouth at Hastings Point) and Mooball Creek (estuary mouth at Pottsville). Figure 3 provides an overview of the study area. A description of each estuary and key features and values of waterways and catchments is provided in the following sections.

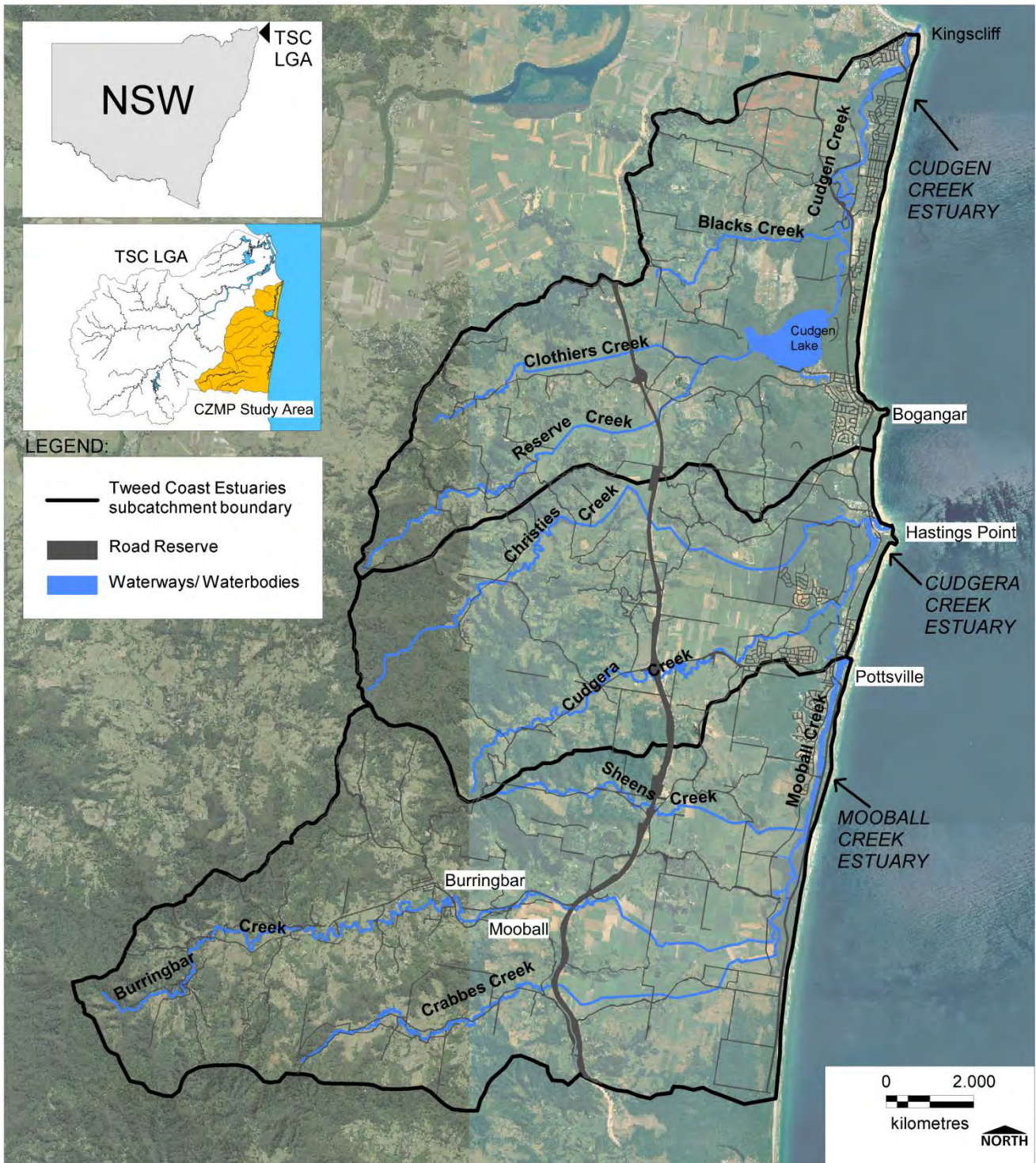


Figure 3 - The Tweed Coast Estuaries Study Area

### 1.2.1 Cudgen Creek Estuary

The Cudgen Creek estuary is a drowned river valley, which also includes Cudgen Lake. The Cudgen Creek entrance, located at Kingscliff was modified by the construction of training walls in 1967 to maintain a constantly open system. The Cudgen Creek Catchment and main waterways are shown in Figure 4.

The estuary water body is estimated to cover approximately 2.1 km<sup>2</sup> (OEH, 2012). Cudgen Lake is a shallow (1-2 m deep) perched tidal lagoon covering an area of approximately 1.65 km<sup>2</sup>. Cudgen Lake drains into Cudgen Creek which follows a generally northerly, meandering 9.4 km course to its ocean entrance at Kingscliff. The lake is contained within the Cudgen Nature Reserve gazetted in 1995, and is under the care and control of NSW National Parks and Wildlife Service (NPWS). Cudgen Lake has been the subject of extensive study in recent years and management guidance has been set out in the *Cudgen Nature Reserve Plan of Management* (NPWS, 1998) and more recently the *Cudgen Lake Sustainability Assessment and Management Strategy* (DECCW, 2009). This CZMP does not seek to replicate management of Cudgen Lake, but key findings and overall management strategies relevant to improved management of Cudgen Lake are included. Two main creeks, Reserve and Clothiers Creeks drain the upstream catchment and feed into the lake. The tidal limit of the estuary is located on Clothiers Creek tributary approximately 13.4 km from the ocean mouth and on Reserve Creek tributary approximately 13.8 km from the ocean mouth (NSW Office of Water, 2010). Blacks Creek is a highly modified tributary that drains the catchment area north of Cudgen Lake and joins Cudgen Creek estuary about halfway along its course (Figure 4).

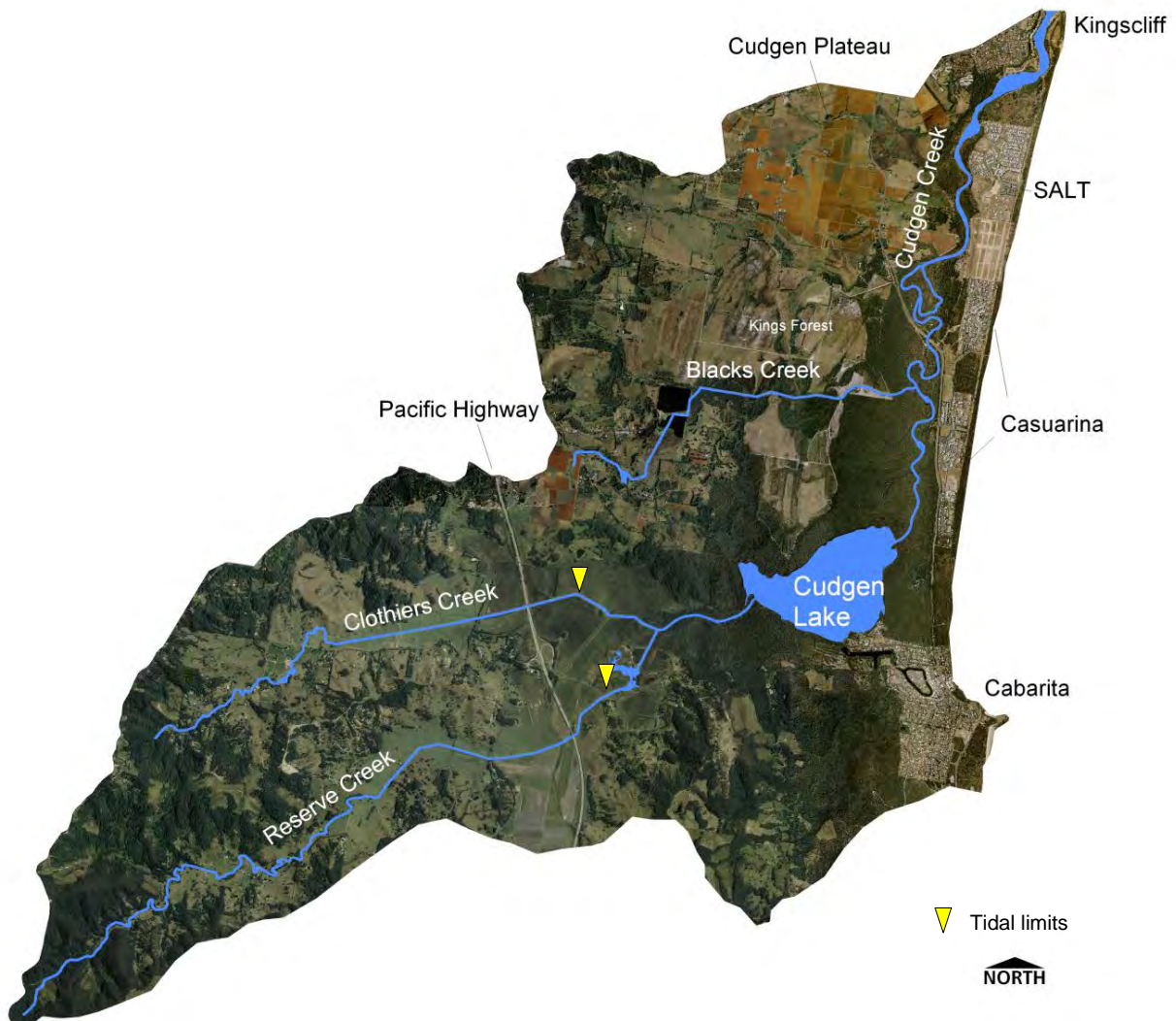


Figure 4: Cudgen Creek Catchment (2009 Aerial photography supplied by TSC; Tidal limit markers extracted from NSW Office of Water, 2010).

There are significant reaches of estuarine wetlands along much of the length of the estuary including areas of mangroves, saltmarsh and seagrass. The lateral limits of the estuary are defined by the extent of saltmarsh, mangroves or swamp forest that are regularly or infrequently subject to tidal inundation. The estuary water body is estimated to cover approximately 2.1 km<sup>2</sup> (DECCW, 2010d). Adjacent foreshores, wetlands, floodplains and lands are also included within the study area. Consideration is also given to the wider catchment areas in so far as they may affect the estuary and estuarine processes.

The Cudgen Creek catchment area covers approximately 67 km<sup>2</sup>. Historical development of the area was primarily for grazing, timber harvesting and sand mining before its development for coastal villages, and other forms of agriculture such as sugarcane and cropping. Today, the dominant land uses in the estuary catchment are agriculture 64% (including grazing), wetlands/forest/scrub 23%, urban 6%, and conservation 6%. The Cudgen Plateau in the north of the catchment contains large areas of intensive agriculture (e.g. vegetable growing). A large proportion of the lower floodplain lands are classified as containing potential acid sulfate soils (ASS).

Mineral sand mining operations commenced at Bogangar in the early 1950s. Many areas of the lower and mid Cudgen Creek estuary were severely disturbed during past sand mining activities. The remains of an old quarry from the past mineral sand mining activities occurs in the south-eastern section of the Cudgen Nature Reserve (NPWS, 1998).

Kingscliff is a growing urban centre and a popular holiday destination, and there are major urban and tourist developments recently constructed and continuing to the south of Kingscliff with close proximity to Cudgen Creek, such as Casuarina Beach and SALT. Kings Forest is one of the largest proposed urban developments in the catchment comprising approximately 880 ha (8.8 km<sup>2</sup>). Kings Forest is situated 5 km north of Bogangar (Cabarita Beach) and 4 km south of Kingscliff and is bounded by rural land to the north, west and south west and by Cudgen Lake and Cudgen Creek to the south and east. The small coastal town of Bogangar (Cabarita Beach) lies in the south of the catchment with some urban areas within the catchment of Cudgen Lake (Figure 4).

Major pressures acting upon the estuary include:

- Acid runoff from disturbed ASS in the catchment above Cudgen Lake;
- Entrance shoaling inhibits navigation for recreational boating;
- Major urban and tourist developments at Casuarina Beach and SALT at South Kingscliff and their effects on estuarine health;
- Potential future impacts and cumulative impacts of planned urban development in the catchment, including major development at Kings Forest;
- Bank erosion; and
- Soil erosion from intensive vegetable growing area of Cudgen plateau.

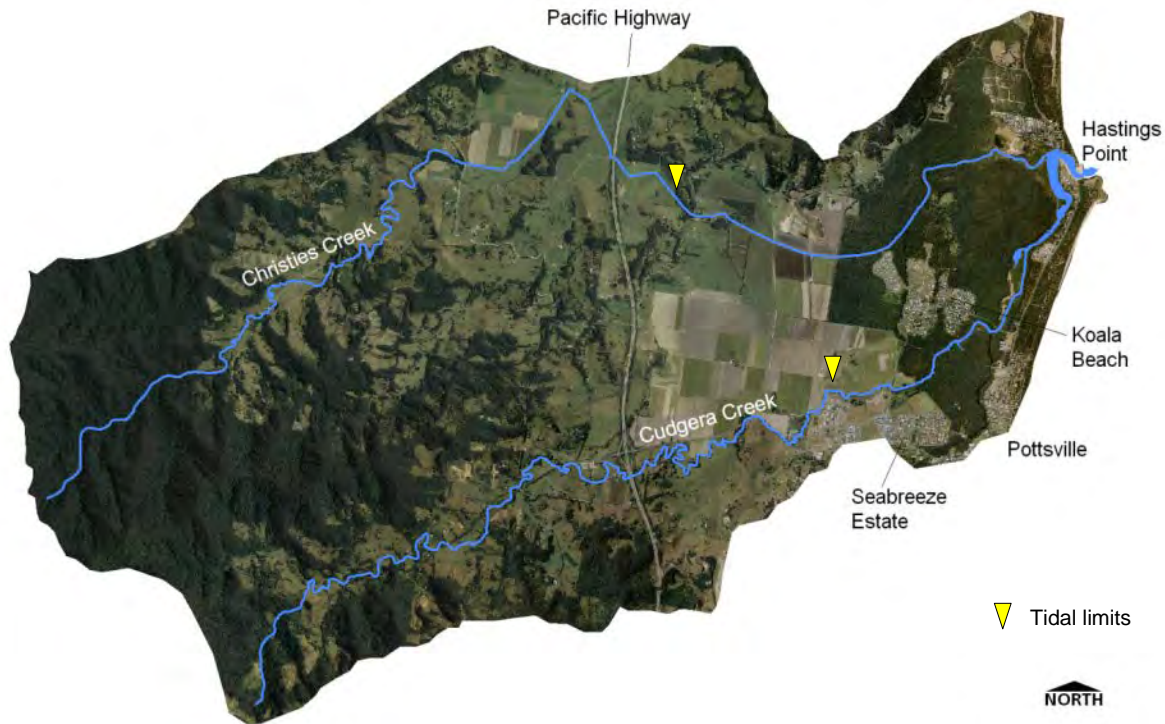
These issues are likely to be exacerbated into the future as a result of population increase, climate change impacts and projected rises in mean sea level.

### 1.2.2 Cudgera Creek Estuary

The Cudgera Creek estuary is a shallow inlet with an approximate length of 3.5 km. A bedrock headland, on the south side of the entrance, naturally trains the tidal flow and contributes to entrance stability (DNR, 2006a). There has been no training wall construction at the mouth and the entrance has been known to close with sand accumulation from time to time and has been artificially opened in the past to allow for tidal flushing and improvement of poor water quality conditions.

The estuary water body is estimated to cover approximately 0.5 km<sup>2</sup> (OEH, 2012). Adjacent foreshores,

wetlands, floodplains and lands are also included within the study area. Two main creeks, Christies Creek and Cudgera Creek drain the upper catchment areas and feed into the estuary. The tidal limit of the estuary is located on Cudgera Creek approximately 5.4 km from the ocean mouth, and on Christies Creek tributary approximately 5.9 km from the ocean mouth (NSW Office of Water, 2010). The Cudgera Creek catchment area covers approximately 58 km<sup>2</sup>. The extent of the Cudgera Creek Catchment and main waterways are shown in Figure 5.



**Figure 5: Cudgera Creek Catchment (2009 Aerial photography supplied by TSC; Tidal limit markers extracted from NSW Office of Water, 2010)**

Historical development of the area was primarily for grazing, timber harvesting and sand mining before its development for coastal villages, and other forms of agriculture such as sugarcane and cropping. Today, dominant land uses in the catchment are agriculture 54%, wetlands/forest/scrub 23%, urban 5%, and conservation 18%. Many areas of the lower floodplain lands are classified as containing potential ASS.

The small town of Hastings Point is located at the Cudgera Creek mouth and it is a popular holiday destination year-round. Recent urban developments include the Koala Beach and Seabreeze Estates to the north and west of Pottsville respectively. There are significant reaches of estuarine wetlands along much of the length of the estuary including areas of mangroves, saltmarsh and seagrass. On the Coast Road at Pottsville Beach between two arms of Cudgera Creek, the Tweed Bicentennial Environmental Park contains fresh and saltwater (mangrove) wetland, coastal eucalypt forest and remnants of heath and rainforest. The Park is managed by Tweed Shire Council and contains a number of recreation facilities including walking trails, picnic areas and amenities block.

Major pressures acting upon the estuary include:

- Acid runoff from disturbed ASS in the catchment of Cudgera Creek;
- Entrance shoaling - during times of high longshore sand transport and low creek flows, the entrance can become heavily shoaled and sometimes closes. This can create flooding and water quality concerns. On occasions the creek entrance has been artificially opened;
- Water quality monitoring indicates there is a human health risk for primary and secondary contact recreation in the estuary at times.

- Bank erosion, particularly near the mouth downstream of the bridge crossing.

These issues are likely to be exacerbated into the future as a result of population increase, climate change impacts and projected rises in mean sea level.

**1.2.3 Mooball Creek Estuary**

Mooball Creek estuary extends 9 km parallel to the coastal dunes, draining from south to north. The entrance, located at Pottsville was modified by the construction of training walls in the 1960’s to maintain a constantly open system.

The estuary area estimated to cover approximately 0.5 km<sup>2</sup> (OEH, 2012). There are significant reaches of estuarine wetlands along much of the length of the estuary including areas of mangroves, saltmarsh and some small patches of seagrass. Three main creeks, Burringbar Creek, Crabbes Creek, and Sheens Creek drain the upper catchment areas and feed into the estuary. Burringbar Creek is the longest of the upper catchment creeks in the Tweed Coastal Creeks study area stretching approximately 25 km from headwaters to the estuary. The tidal limit of the estuary is located on Burringbar Creek approximately 11.2 km from the ocean mouth and on Crabbes Creek tributary approximately 11 km from the ocean mouth (NSW Office of Water, 2010). The Mooball Creek catchment area covers approximately 108 km<sup>2</sup>. The extent of the Mooball Creek Catchment and main waterways are shown in Figure 6.

Historical development of the area was primarily for grazing, timber harvesting and sand mining before its development for coastal villages, and other forms of agriculture such as sugarcane and cropping. Today, dominant land uses in the catchment are agriculture 61%, wetlands/forest/scrub 30%, urban 3%, and conservation 4%. Many areas of the lower floodplain lands are classified as containing potential ASS.

Pottsville has a relatively large urban area with further development occurring at Black Rocks Estate, south of Pottsville town centre. The rural towns of Mooball and Burringbar lie in the upper catchment along Burringbar Creek. Wooyung Nature Reserve is located along the coastal strip between Pottsville and Wooyung. The reserve is bounded by Mooball Creek to the west and the Pacific Ocean to the east and is managed by NPWS.



**Figure 6: Mooball Creek Catchment (2009 Aerial photography supplied by TSC; Tidal limit markers extracted from NSW Office of Water, 2010)**



Major pressures acting upon the Mooball Creek estuary include:

- Acid flows from ASS disturbance
- Cumulative impacts of on-site sewage management systems in Burringbar and Mooball villages affecting water quality;
- Urban development expansion and the impact of stormwater and increased recreational use of the creek; and
- Bank erosion especially from uncontrolled foreshore access.

These issues are likely to be exacerbated into the future as a result of population increase, climate change impacts and projected rises in mean sea level.

### 1.2.4 Ecological Values

The Tweed Coast Estuaries and wetland areas provide a diversity of habitats for a range of terrestrial and aquatic species. This includes those protected under state and Commonwealth legislation, species of fisheries value and migratory birds protected under international agreements. Important protected species known to occur within the study area include: Beach Stone-curlew (critically endangered in NSW); Pied Oystercatcher (endangered in NSW); Eastern Osprey (vulnerable in NSW); Green Turtle (vulnerable in Australia); and Loggerhead Turtle (endangered in Australia).

The study area also supports a number of rare and threatened communities. Examples are SEPP 14 wetlands, Endangered Ecological Communities (EECs) including Coastal Saltmarsh and Littoral Rainforest. Estuarine habitats including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function. The role of these coastal wetland habitats includes bed/bank stabilisation, cycling of nutrients and habitat for fisheries nursery and breeding grounds.

The riparian zone, extending from the estuary foreshores to the upper catchment fresh water tributaries provides a number of important ecological functions. It provides wildlife corridors that create connectivity in a largely cleared and fragmented landscape. It also provides a buffer for waterways to reduce and filter overland runoff of nutrients and contaminants. Riparian vegetation cover provides shade which reduces water temperature, increases dissolved oxygen levels and reduces aquatic weed, thus enhancing aquatic habitat value.

Good water quality is highly valued and considered a general indicator of estuary and catchment health by the community. The general perception within the community is that if water quality is good, then ecological, economic and social values will be preserved or enhanced.



**Figure 7: Left: Good condition riparian zone along Cudgera Creek providing valuable freshwater aquatic and terrestrial habitats. Right: A pair of Endangered Pied Oystercatchers.**

### 1.2.5 Social and Cultural Values

The Tweed Coast Estuaries, foreshore areas and freshwater creeks are highly valued by the community and visitors for recreational activities. Activities include fishing, boating, kayaking, canoeing, stand up paddle boarding, swimming, walking, nature appreciation and bird watching. It is important to the local community to have permanent public access to the estuaries and foreshore areas. Tourism is a key contributor to the local economy and this relies heavily on the environmental, social and cultural values of the area. The natural appeal of the estuaries should be preserved.

Scenic amenity is valued highly by the local community and visitors. Specific characteristics identified include clean foreshore areas, presence of native flora and fauna (including threatened species), good water quality and appreciation of landscape and estuarine features.

The Tweed Coast Estuaries and catchments have high cultural and spiritual significance to local Aboriginal communities. There are many sites of Aboriginal heritage significance in the study area and their recognition and protection is of high importance to the community. Fishing along the estuary and freshwater lakes and creeks is an important part of Aboriginal culture.



**Figure 8: Left: Stand up paddle boarding on Cudgen Creek. Right: Canoes near Cudgera Creek mouth.**

### 1.2.6 Economic Values

The Tweed Coast Estuaries and catchments, particularly the lower estuaries are considered to be major attractions for tourists and recreational users to the area, with associated economic benefits. Tourism activities include recreational fishing, boating, swimming, holidaying, day trips, ecotourism, bird watching and nature appreciation. Tourism has been identified as a priority industry for the North Coast Region and was estimated to have a value of \$646 million for the region (ABER, 2007).

Fishing contributes to the local and regional economy. Recreational fishing is a popular lifestyle choice for residents and visitors to the estuary with flow-on economic implications for local commerce including boat supplies, bait/tackle shops and tourism.

The study area supports a wide range of land uses which are important contributors to the local and regional economy. Real-estate values and the associated rate base are recognised as a major driver of the local economy and are related to estuary health, coastal lifestyle, the recreational opportunities and scenic amenity. Agricultural practices occupy a large percentage of the study area. Sugar cane and cattle grazing are the predominant agricultural activities.

### 1.3 The Tweed Coast Estuaries Coastal Zone Management Program

The aim of the CZMP is to document TSC's ten year strategy for management of the Tweed Coast Estuaries consistent with NSW state policy. Coastal councils are required to prepare a CZMP in accordance with the Minister's guidelines adopted in 2010 under section 55D of the *Coastal Protection Act, 1979* (DECCW 2010). The CZMP was prepared in accordance with Part 4A of the *Coastal Protection Act, 1979* and CZMP Guidelines (DECCW, 2010a).

This CZMP supports the goals and objectives of the *NSW Coastal Policy 1997* and the *NSW Sea Level Rise Policy Statement, 2009* and assists in implementing integrated coastal zone management for the Tweed Coast Estuaries. Detailed information on the planning processes that apply to the management of the Tweed Coast Estuaries is provided as Appendix 1.

During the completion of this CZMP the NSW Government announced changes to its approach to coastal management including the retraction of its policy to specify sea level rise benchmarks for NSW. In the absence of any additional information, TSC has adopted the projected sea level rise benchmarks from the 2009 NSW Sea Level Rise Policy Statement (DECCW, 2009) for the purposes of this CZMP. Further changes to NSW coastal management policies are unknown at this stage; however they are not expected to affect the completion of this CZMP. Future revisions of the CZMP will need to consider any further coastal management reforms (see Appendix 1 for further details).

To be consistent with NSW State policy, this CZMP needs to:

- Link Council's coastal zone management planning with other planning processes in the coastal zone to facilitate integrated coastal zone management;
- Involve the community in the preparation of the CZMP including making information relating to the plan publicly available;
- Recognise and accommodate natural coastal processes and hazards. The CZMP will include strategies to deal with threats to existing development and to ensure that new development is not exposed to such threats;
- Maintain the condition of high value coastal ecosystems and rehabilitate priority degraded coastal ecosystems;
- Address the current and potential risks to estuary health;
- Protect amenity, maintain and improve public access arrangements to foreshores, support recreational uses and protect the cultural and heritage environment; and
- Base decisions for managing risks to public safety and built assets and pressures on coastal ecosystems and community uses of the Tweed Coast Estuaries on the best available information and reasonable practice, including adopting an adaptive management approach.

The effects of climate change, including sea level rise, on ecosystem health and community uses of the estuary are an integral component of the management actions.

The CZMP has adopted a risk management approach to managing risks to public safety and assets and pressures on coastal ecosystems, including avoiding risks where feasible and mitigation where risks cannot be reasonably avoided. Interim actions are adopted to manage high risks while long-term options are implemented. Management actions in the CZMP have been prioritised based on public benefit including cost-effectively achieving the best practical long-term outcomes.

The CZMP Guidelines specify the minimum requirements that are to be met when preparing a CZMP, in addition to the requirements in the Act. Appendix 2 summarise the minimum requirements and how they have been met by the CZMP and other related planning processes.

The minimum requirements for the preparation of a CZMP (DECCW, 2010a) call for consideration of the following coastal hazards affecting estuaries:

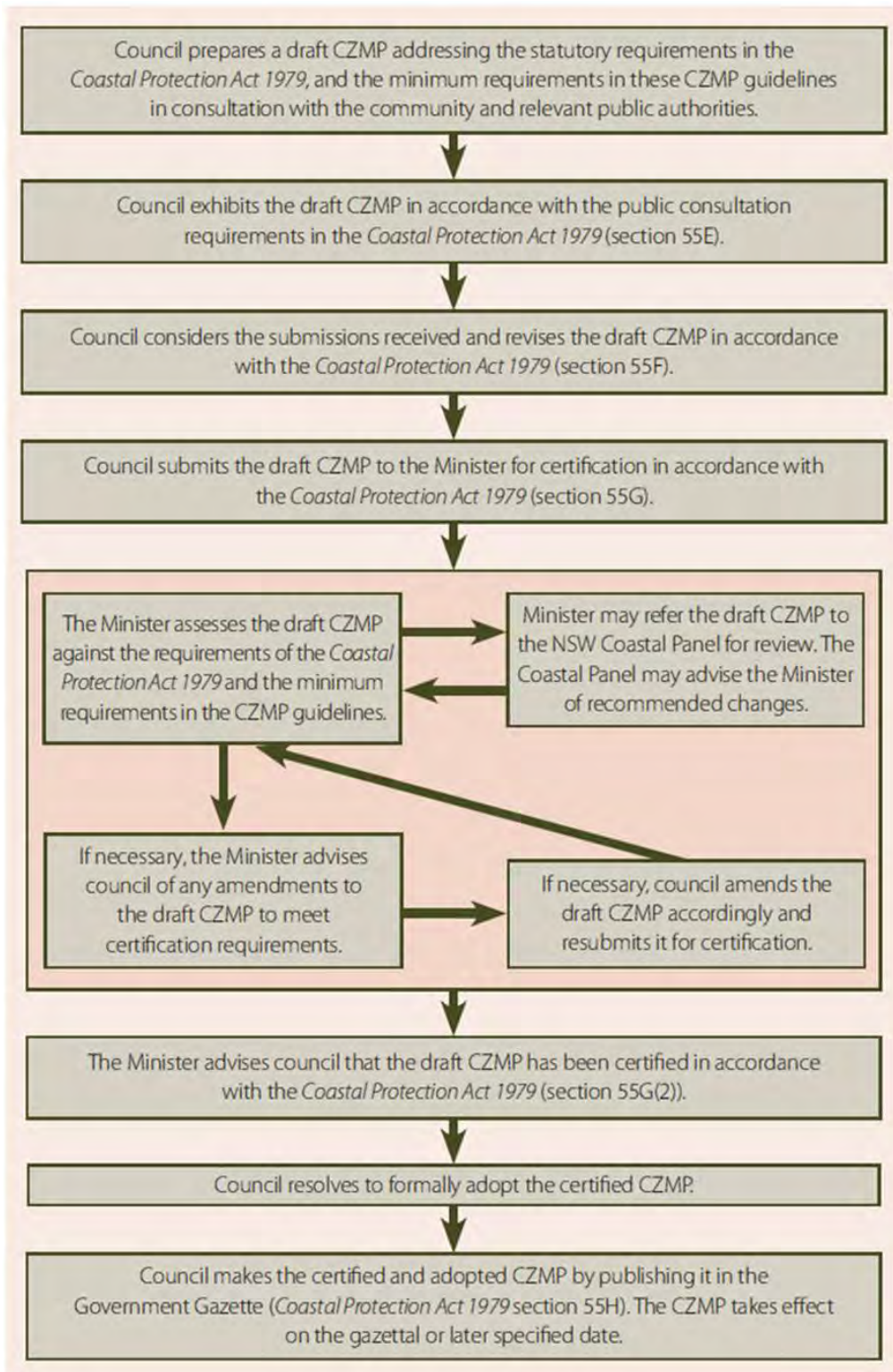
- Bank erosion;
- Entrance instability;
- Tidal inundation; and
- Coastal (oceanic) inundation.

Refer to Section 1.4 for further discussion of how this CZMP has addressed coastal hazards.

To achieve the aims outlined above, the CZMP was prepared through a series of project phases. Each phase was an essential step in the development of the CZMP (refer to Figure 1, Executive Summary for a flow chart showing the overall process). The key phases were as follows:

- Project Start up and review - collection and consolidation of existing background information from a range of sources including existing documentation, Council staff, external stakeholders and the monitoring data;
- Data Collection – to supplement and update the existing information a number of data collection exercises were undertaken including:
  - *Tweed Coast Estuaries: Bank Erosion Study* (Appendix 3);
  - *Tweed Coast Estuaries and Catchments: Baseline Ecosystem Health Assessment* (Appendix 4); and
  - *Tweed Coast Estuaries: Catchment Modelling Report* (Appendix 5).
- Plan Development including:
  - Long-term vision for the estuaries;
  - Collation and verification of key estuary pressures and issues;
  - Recommendations for management actions to address the identified pressures/issues;
  - Develop management objectives consistent with the goals of the *NSW Coastal Policy* and encompassing relevant local objectives for the Tweed Coast Estuaries.
  - Prioritise management actions, by assessing effectiveness in addressing the management objectives, the expected level of community support and acceptance, cost of implementation, and the likely environmental impacts (both positive and negative).
  - Development of a strategic plan to address the estuary pressures and management issues including an implementation framework with clearly defined and prioritised outcomes, actions, timeframes, funding, responsibilities and monitoring requirements;
  - Development of an Implementation Schedule with prioritised actions, costs, funding, timing and monitoring requirements.
- Plan Exhibition - Consultation with stakeholders and the community to obtain feedback on the proposed strategy; and
- Adoption of the CZMP by Council.

This CZMP will be adopted by TSC. Following local government adoption, the plan will be referred to the NSW Government for formal approval. The management strategies contained in this CZMP will direct Council’s future strategic planning, as well as other government agencies with responsibility for management of the Tweed Coast Estuaries. The CZMP certification process is shown in Figure 9.



**Figure 9 - CZMP preparation and certification process for the Tweed Coast Estuaries**

Source: DECCW, 2010a

\*Note that this certification process is currently under review as part of the NSW Government Coastal Management Reforms. In the interim, Council is to formally adopt the CZMP and refer to the NSW Government for approval.

### 1.4 Coastal Hazards

This CZMP has addressed coastal hazards affecting the estuaries through a combination of field investigation and assessment (in the case of bank erosion), and reference to investigation and assessment undertaken in an additional and concurrent Tweed Shire Council project, the *Tweed Shire Coastal Hazards Assessment* (BMT WBM, 2012), (in the case of entrance instability, coastal inundation and tidal inundation).

Documentation of coastal hazards in the Tweed Coast Estuaries CZMP has been for the purpose of highlighting any significant risk to life or property arising from these hazards, and to highlight the existence of the more relevant hazard study.

A summary of findings related to coastal hazards is included in section 2.2.5 Bank Erosion, and section 2.3, Coastal Hazards and Climate Change Impacts.

### 1.5 Concurrent/Parallel Programs

The study area includes large areas of National Parks Estate (Nature Reserves), Crown Reserves (either managed by DPI-Crown Lands or Reserve Trusts such as TSC), and private land. Local Council, government agencies and statutory bodies are implementing management programs in parallel with the preparation of this CZMP. Many of these initiatives are related to the management of the Tweed Coast Estuaries. This CZMP will complement existing plans of management. The roles and responsibilities of the various land managers are summarised in Appendix 6.

Council programs include:

- *Tweed Coast Estuaries Management Plan 2004-2008* (Australian Wetlands 2003) – to be replaced by this CZMP;
- Tweed Shire Council Coastal Creeks water quality monitoring program (from 1998 and on-going);
- *Tweed Urban Stormwater Quality Management Plan* (USQMP, TSC, 2000);
- *Tweed Urban Stormwater Quality Management Plan Draft* (Australian Wetlands, 2012);
- *Tweed Shire Integrated Water Cycle Management Plan* (Hydrosphere Consulting, 2013);
- *Tweed-Byron Coastal Creeks Flood Study* (WBM, 2009);
- *Tweed Shire Council Sustainable Agriculture Strategy* (being developed by TSC);
- Australian Research Council Linkage Projects – Acid Sulfate Soil Research in Tweed Coastal Creek Catchments. Projects undertaken by University of NSW in association with Tweed Shire Council, New South Wales Cane Growers' Association Inc., New South Wales Sugar Milling Cooperative (Collins *et al.*, 2012);
- *Cudgen Creek Recreation and Public Access Plan* (GeoLINK, 2008);
- *On-Site Sewage and Wastewater Management Strategy* (TSC, 2002);
- *Water Supply and Wastewater Asset Management Plans* (TSC, 2011b and 2011c);
- *Tweed Shire Coastline Hazard Definition Study* (WBM, 2007);
- *Tweed Shire Coastline Management Study* (Umwelt, 2005);
- *Tweed Shire Coastline Management Plan* (Umwelt, 2005);
- *Tweed Vegetation Management Strategy* (Kingston *et al.*, 2004);
- *Water Supply Catchment Stream Bank Protection Policy (2007)*. This policy is currently only applicable to the Tweed drinking water catchments and does not include the Tweed Coast Estuaries

study area, although has been identified as an important potential funding source for estuary remediation works. Successful funding applications will require a change in the current policy to allow works outside the drinking water catchments;

- *Community Strategic Plan 2011/2021* (TSC, 2011a);
- *Tweed Local Environmental Plan* (TSC, 2000).

Agency programs in the study area include:

- *Tweed Coast Regional Crown Reserve Plan of Management* (Land and Property Management Authority, 2005);
- *Cudgen Nature Reserve Plan of Management* (NPWS, 1998);
- *Cudgen Lake Sustainability Assessment and Management Strategy* (DECCW, 2009);
- *Wooyung Nature Reserve Plan of Management* (NPWS, 2007);
- *NSW Water Quality and River Flow Objectives – Tweed River* (OEH, 2006);
- *ANZECC (2000). Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council, Canberra; and
- NSW Government's Minor Ports and River Entrance Programs.

Agency programs in the broader, Northern Rivers area with relevance to the study area include:

- *Northern Rivers CMA Catchment Action Plan* (NRCMA, 2006);
- Northern Rivers CMA programs including community capacity building;
- *NSW Diffuse Source Water Pollution Strategy* (DECC, 2009);
- *Far North Coast Regional Strategy* (NSW Department of Planning, 2006);
- DPI - Fisheries assessment of waterfront structures;
- DPI – Agriculture landholder education programs;
- *Northern Rivers Regional Biodiversity Management Plan* (DECCW, 2010b);
- *Northern Rivers Region Pest Management Strategy 2008-2011* (DECC, 2007); and
- *Threatened Species (Pied Oystercatcher) Management Strategy* (Department of Lands, 2007).

A discussion of the relevant legislation and application in estuary management is included in Appendix 1 (Planning Context).

## 2. HEALTH OF ESTUARIES AND FRESHWATER TRIBUTARIES

This section provides an assessment of the health of the Tweed Coast Estuaries including:

- A description of the status of the health of the Tweed Coast Estuaries and freshwater tributaries;
- A description of the pressures affecting the health of the Tweed Coast Estuaries and freshwater tributaries; and
- A description of the projected climate change impacts on ecosystem health.

As part of the development of the CZMP, a number of technical studies were undertaken to provide information on the current health status of key components of the estuaries and their catchments. The studies were:

- *Tweed Coast Estuaries: Bank Erosion Study* (attached as Appendix 3)
- *Tweed Coast Estuaries and Catchments: Baseline Ecosystem Health Assessment* (attached as Appendix 4); and
- *Tweed Coast Estuaries: Catchment Modelling Report* (attached as Appendix 5)

The main findings and conclusion of the studies have been summarised in the following sections. For further information, refer to the relevant appendices.

### 2.1 Estuary Health Status

The *Tweed Coast Estuaries and Catchments: Baseline Ecosystem Health Assessment* (Hydrosphere Consulting 2012) provided a snap-shot of the health of the Tweed Coast Estuaries and their freshwater tributaries, through rapid assessment of key environmental health indicators at representative sites. The indicators provide information on water quality, geomorphology, status of key habitats, ecological indicators and presence of contaminants in waterway sediment. This information provides a baseline assessment that can be replicated over time in order to ascertain changes in the ecological health of these waterways. Figure 11, Figure 12, and Figure 13 show the sample sites for the various ecosystem components assessed in Cudgen, Cudgera and Mooball Creeks. A copy of the monitoring report is provided as Appendix 4.



**Figure 10: Ecosystem Health Assessment sampling. Clockwise from top left: freshwater fish species; Christies Creek site; soldier crab; seagrass; floodplain site; electrofishing in Burringbar Creek.**



LEGEND

- Minor waterways
- Main waterways
- ◆ Seagrass & benthic macroinvertebrate sites
- Freshwater fish & macroinvertebrate sites
- ▼ TSC water quality monitoring sites
- Rapid assessment sites
- Sediment contamination screening sites

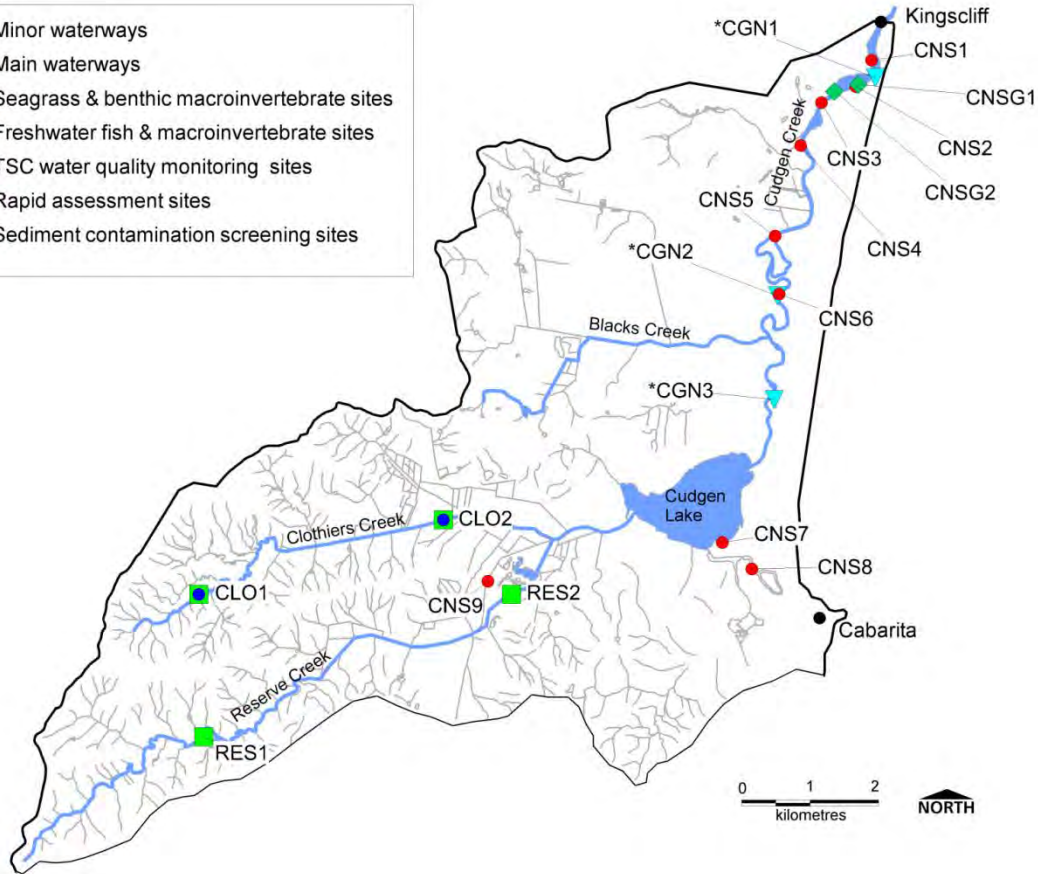


Figure 11: Cudgen Creek Catchment Ecological Health Assessment sample sites.

LEGEND

- Minor waterways
- Main waterways
- ◆ Seagrass & benthic macroinvertebrate sites
- Freshwater fish & macroinvertebrate sites
- ▼ TSC water quality monitoring sites
- Rapid assessment sites
- Sediment contamination screening sites

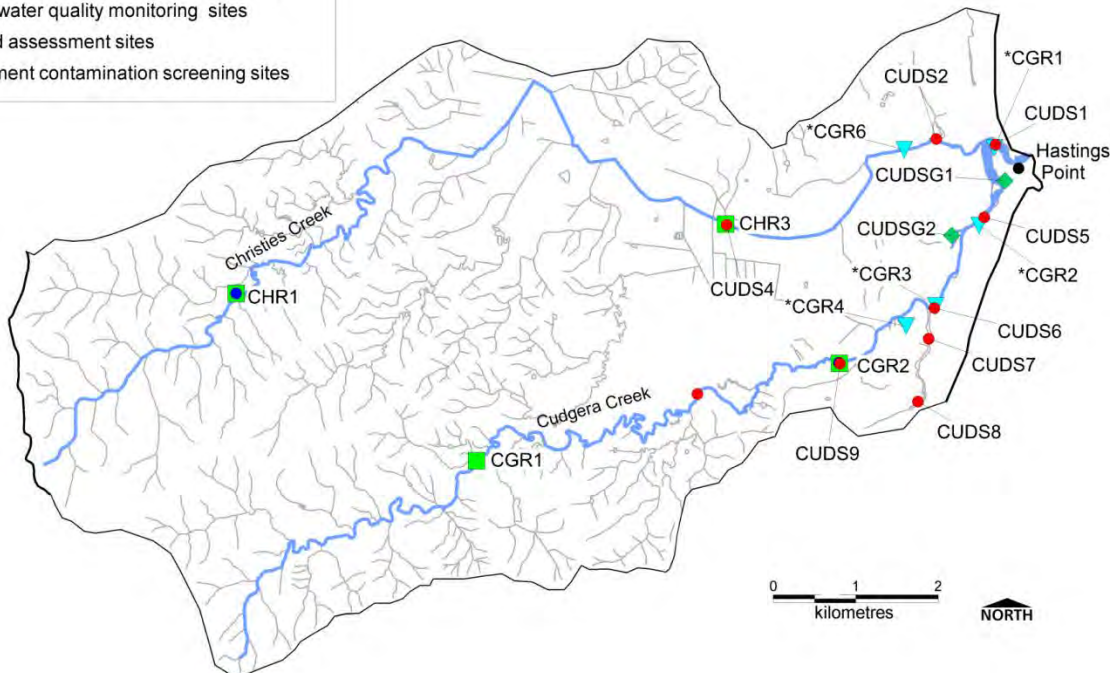


Figure 12: Cudgera Creek Catchment Ecological Health Assessment sample sites.

LEGEND

- Minor waterways
- Main waterways
- ◆ Seagrass & benthic macroinvertebrate sites
- Freshwater fish & macroinvertebrate sites
- ▼ TSC water quality monitoring sites
- Rapid assessment sites
- Sediment contamination screening sites

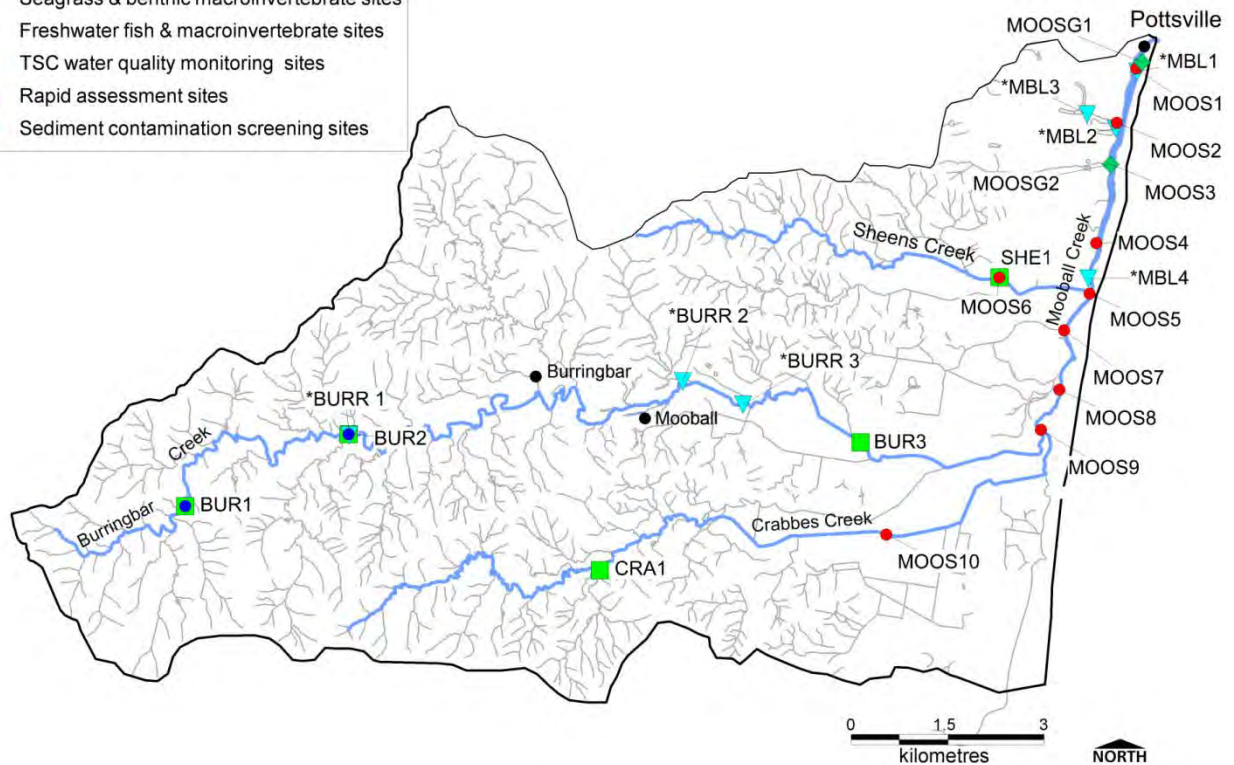


Figure 13: Mooball Creek Catchment Ecological Health Assessment sample sites.

### 2.1.1 Freshwater Stream Health Scores

The *Baseline Ecosystem Health Assessment* identified a general gradient of decreasing health observed from the largely unmodified upper catchment waterways to the highly modified floodplain. Upper catchment sites generally had stable banks and stream bed, diverse and abundant in-stream habitat, riparian zones were often continuous with widths greater than 10 m and native vegetation was generally dominant. Water quality was excellent and fish and macroinvertebrate species present indicated healthy functioning ecosystems. The stream health scores of mid-catchment waterways were decreased for many indicators at most sites due to catchment modifications (clearing, roads etc.). Most of the floodplain waterways were in poor condition due to highly modified hydrology, widespread vegetation clearing for cropping and grazing, riparian zones in poor condition, acid runoff and low dissolved oxygen affecting water quality. Figure 14 below maps the combined stream health scores for each freshwater site in the Tweed Coastal Catchments. Refer to Appendix 4 for further details of freshwater stream health scores and site photos.



### 2.1.2 Tweed Coast Estuaries Ecosystem Health Assessment

#### Water Quality

Tweed Shire Council has been undertaking long-term water quality monitoring at a number of sites within the estuaries since 1999. Previous studies have examined and analysed water quality up to 2008. The *Baseline Ecosystem Health Assessment* included a review of TSC water quality data from 2008-2011, which has been collected on a bi-monthly basis (sample sites shown in Figure 11, Figure 12, and Figure 13). Discussion of the results of the water quality review is provided in Appendix 4. Further water quality sampling was conducted in 2012 as part of the catchment modelling exercise. This involved dedicated water quality sampling along the salinity profile of each estuary in April and June 2012. The analysis of measured water quality data combined with the long term water quality dataset for the creeks and local knowledge of the systems. Discussion of the results of the water quality review is provided in Appendix 5.

A summary of the main findings in relation to water quality in the Tweed Coast Estuaries is provided below.

#### Cudgen Creek:

- Dissolved oxygen, turbidity, Chlorophyll *a* and faecal coliform indicators were all within levels acceptable for aquatic ecosystem health and recreation targets.
- The mid and upper estuary of Cudgen Creek is periodically affected by low pH, particularly following rainfall events. There are known issues associated with ASS in the catchment and this result is attributable to acid runoff from these areas. Drainage of the floodplain to allow for agricultural use has facilitated the exposure of ASS and subsequent acid runoff in many areas.
- Total Nitrogen was elevated in the mid and upper estuary. Diffuse nutrient sources related to agricultural and urban land use are likely to contribute to the TN load in the estuary. Results are similar to those assessed from 1999-2003.

#### Cudgera Creek:

- Dissolved oxygen results for sites in the mid and upper estuary sites (CGR3, 4 and 6) were below what is considered the level of a healthy functioning ecosystem. Low dissolved oxygen had been observed at sites directly upstream of the estuary (cane drains) and this is likely to be contributing to low DO downstream. The creeks traversing the floodplain have been highly modified by past drainage activities, are subject to runoff from agricultural land and have little or no riparian cover. These factors contribute to poor water quality at these sites, which appear to be directly affecting the downstream estuaries. Turbidity was also elevated at site CGR6 on Christies Creek.
- Total Nitrogen was also elevated in the mid and upper estuary sites, and this indicates potential for nuisance plant growth and/or algal blooms. This result is likely to be linked to the poor dissolved oxygen result at these sites. The lower estuary nutrient results (site CGR1) were within suitable levels for ecosystem health and tidal flushing is likely to be a large factor in maintenance of good water quality at these sites.
- Chlorophyll *a* was elevated slightly at CGR4 and this indicates excess algal growth at this site. All other sites (even those with elevated nitrogen) did not show high Chl *a* levels which indicates that there must be factors at work that limit algal growth (e.g. channel shading, tidal flushing etc.)
- Thermo-tolerant Coliforms were also persistently elevated at site CGR4. This site is located approximately 150m upstream of the Koala Beach housing estate, and it is possible that primary and secondary contact recreation occurs in the vicinity. This raises concerns for human health and warrants further investigation. Other estuary sites were within levels considered appropriate for primary contact recreation (ANZECC, 2000).

Mooball Creek (estuary) and Burringbar Creek:

- All Mooball Creek sites (estuarine sites) were assessed as being within guideline levels for ecosystem health except for site MBL4 in the upper estuary where TN was slightly elevated. Chlorophyll a was within reasonable levels at MBL4, indicating that algal growth is not an issue at this site at present. Factors such as in-stream processing, channel shading and tidal flushing are likely to be limiting algal growth.
- All of the Burringbar Creek sites (BURR1, 2 and 3) showed high levels of thermo tolerant coliforms and there was a clear trend identified where spikes in faecal indicators followed rainfall events. Levels did not exceed the ANZECC criteria but are clearly elevated and warrant further investigation. The two likely sources of faecal contamination are surface runoff transporting animal faeces (livestock, pets and native animals), and potentially failing (or surcharging) on-site sewage management systems (OSSM) in this area. The villages of Burringbar and Mooball are in the process of becoming sewered, and this is likely to reduce water quality risk in years following these improvements.
- Site BURR2, located downstream of the town of Mooball and Burringbar showed slightly lowered dissolved oxygen levels, pH was slightly acidic (pH 5.6) and TN was slightly elevated. These results indicate a risk to aquatic ecosystem health at this site.

General characteristics indicated by water quality measured in the Tweed Coast Estuaries (ABER, 2012):

- All three estuaries are characterised by the presence of tannin-rich groundwater indicated by high colour readings. Visually, this can be seen as tannin-stained waters (brown in colour) flowing from the freshwater reaches to mix with ocean water in the tidal sections of the lower estuary. This can be observed in the lower estuaries from time to time, particularly following substantial rainfall.
- Nitrogen in the three estuaries was dominated by dissolved organic forms which appear to be largely coming from groundwater inputs along the upper estuary and via floodplain drains. There was a relatively high contribution of bio-available nitrate and ammonium along the creeks which may be coming from a variety of agricultural and urban inputs.
- The salinity profile sampling conducted in April and June 2012 captured a large algal bloom event, which was the largest ever recorded by the TSC monitoring program. This suggests changes may be required to the regular monitoring regime to detect true variation in algal biomass.
- The data suggest that phytoplankton blooms can be limited by short water residence times and high turbidity despite high nutrient availability. Conversely, when conditions for algal growth are optimal (residence times long enough to become established, clear skies, high temperature etc.) large blooms can develop when nutrient concentrations are relatively low (from approximately 0.3 mg/L).
- A relationship between Chlorophyll a and TN concentrations was estimated for the Tweed Coast estuaries for the June 2012 sample. The relationship demonstrates there is generally an increasing risk of phytoplankton blooms with increased TN, although as discussed above, there are a number of other factors at play (residence times, turbidity, light availability, etc.) that affect the formation of phytoplankton blooms.
- A good relationship between TN and bio-available nitrogen was identified. This result suggests that TN can be used as one indicator of the risk of phytoplankton blooms as a long-term average indicator, providing other limiting factors such as nutrient cycling, residence time, light and temperature factors, etc. are considered in any interpretation of TN values;
- On average, the data shows that there is an increased risk of algal blooms with TN concentrations above approximately 0.25-0.3mg/L. This is consistent with the ANZECC/OEH default water quality guideline of 0.3mg/L TN for estuaries, indicating that this trigger level is appropriate for assessing the risk to ecosystem health.

- The estuaries have a high TN: TP ratio suggesting that phosphorus has the potential to be limiting in Cudgen, Cudgera and Mooball Creek estuaries. Even though nitrogen is generally considered to be the key parameter of concern, this finding indicates that management strategies need to consider both nitrogen and phosphorus.
- Dissolved oxygen (DO) saturation demonstrated a close relationship with water colour (i.e. tannin content), indicating the input of deoxygenated groundwater as a primary cause. There was also indication that fine particulates were implicated in low DO saturation in Mooball and Cudgera Creeks.

### Seagrass

- Review of historical seagrass mapping has shown a high degree of temporal variability in the extent of seagrass beds.
- A steadily increasing trend in seagrass area was apparent from the 1980's to 2006 in Cudgen and Cudgera Creeks. Recent ground-truthing carried out in 2011, shows a decline in the seagrass area across all Creeks from 2006 DPI mapping, although limitations of comparing data from different sources may account for some of the variability. Mooball Creek showed the most dramatic decline in area over this time with a total area of only 0.03 ha (300 m<sup>2</sup>) observed during ground-truthing exercises in 2011, which comprised two small seagrass beds in the lower estuary.
- Epiphytic growth was high at sites in Mooball Creek and Cudgera Creek. Water quality data from the TSC sampling program showed elevated TN at nearby water quality sampling sites, and this is likely to be a factor in epiphyte colonisation.
- There was a marked reduction in seagrass health indicators assessed between spring and summer. This is likely to be linked to seasonal fluctuations in growth, and a particularly wet summer season for most sites, but large declines at some sites may signal a general decline in seagrass health (specifically Mooball Creek sites).
- The causes of seagrass decline recorded by the *Baseline Ecosystem Health Assessment* are not known at this time. Causative factors require further investigation, but preliminary work indicates that possible causes of decline may include, and are likely to be a combination of:
  - sedimentation and smothering of seagrass beds, either through catchment derived runoff or sand movement within estuaries;
  - tidal and flood scouring of the estuary bed including shifting channel locations;
  - physical disturbance by boat propellers or other human activity;
  - high levels of epiphytic (algae) growth which can cover seagrass blades and prevent photosynthesis. Excessive epiphytes can be stimulated by high nutrient levels in the water column; and
  - poor water quality including high suspended solids, nutrients and contaminants. Because the estuaries are typically less than 1m in depth, light limitation is not considered to be a major factor in decline of seagrass, although there may be short periods of poor water quality following major flood events that may restrict light penetration to seagrass beds.
- Extensive areas of seagrass have been observed by TSC staff in a large man-made canal estate which is connected to Mooball Creek estuary via stormwater pipes creating a tidal system. While neither the historical mapping nor the current study assessed seagrass communities in the Mooball Creek Canal, TSC observations indicate that this location may represent an important habitat area, considering the decline in seagrass area in the estuary itself. TSC staff have reported that due to poor tidal flow through the stormwater pipes and a large inflow of fresh water from the upstream wetland, the water body has developed into an overly fresh environment, oysters have died off, seagrass appears to have suffered and fish life is reportedly much reduced. TSC have recently completed works to clear the pipes and restore tidal flushing with the aim of re-establishing the pre-existing salinity and tidal range.

### Benthic Macroinvertebrates

- Benthic macroinvertebrates associated with seagrass beds in the Tweed Coast estuaries were variable in distribution and abundance but showed broad results in line with other data indicating that these seagrass habitats are under pressure.
- The most striking result was the difference in abundance between seasons, with the wet season surveys recovering only 27% of total number of animals sampled. The reasons for this remain unclear, but appear to mirror observations of the overall decline in the health extent of the seagrass beds.

### Sediment Contamination Screening

- There were no organochloride, organophosphate or PCB pesticides detected in any of the sediment samples for the three coastal creeks.
- Generally, heavy metal concentrations were within ecological and human health guideline levels or were assessed to be low risk with no further action necessary. Exceptions were elevated arsenic at site MOOS6 on Sheens Creek and elevated mercury at site MOOS3 on Mooball Creek. The results indicate there may be some level of contamination at these sites and the ANZECC guidelines recommend further investigation if considered to pose risk to aquatic health.

## 2.2 Estuary Health Pressures

Existing and potential pressures affecting estuary health have been identified for the Tweed Coast Estuaries. Information has been collated from past study and combined with information gathered from investigations carried out as part of this CZMP (Appendices 3, 4 and 5).

For each topic, the nature of the pressure is described from what is currently known and how this is affecting the value of the estuarine ecosystem. Potential management options that could be employed to alleviate estuary health pressures are discussed. The status of current management occurring in the study area is outlined and recommendations for improvement to management or additional actions are outlined with the view to improving ecosystem health.

The following headings have been used to structure the discussion:

- Description of Estuary Health Pressures- documentation of the key pressures or issues to be addressed through management actions and strategies;
- Potential Management Options - discussion of potential management options that could be employed to address issues and alleviate pressures;
- Status of Existing Management in the Tweed Coast Estuaries - the current status of management occurring in the catchments (what is already being done); and
- Recommendations for Management – based on the nature of the problem, its location and considering what work has already been undertaken, recommend further actions where necessary to address issues. In many cases existing actions may be deemed to be sufficient and the Plan may recommend these actions are supported and continued.

### 2.2.1 Estuary Habitat

Saltmarsh, mangrove and seagrass are classified as marine vegetation and are protected under the Fisheries Management Act 1994. These habitats play a vital role in the coastal ecosystems of Australia and are particularly important in the sustainability of commercial and recreational fisheries because of their roles in maintaining sediment stability and water quality, and in providing shelter and food critical to the survival of a wide variety of aquatic biota. These habitats are essential nursery areas for many species of commercially and recreationally important fish (Hannan & Williams 1998) and crustaceans and the food they eat, contributing large amounts of organic material to the ecosystem. Depending on their type and location, this

vegetation can reduce the effects of erosion due to waves or currents and help trap sediments. On a local level, saltmarsh and mangroves also act as a buffer from acidic floodplain areas and function as a filtration system for sediment and nutrients entering the waterway from the terrestrial environment (Russel, 2005).

### Description of Estuary Health Pressures

Cudgen, Cudgera and Mooball estuaries have undergone significant changes in macrophyte area between the 1940s and 2000 (Russel (2005). Cudgen, Cudgera and Mooball Creeks underwent the greatest losses of mangrove and saltmarsh habitats by proportion out of all the Northern Rivers estuaries assessed by Russel (2005). These systems lost more than half of their 1940s area of saltmarsh, Mooball Creek exhibiting the greatest loss (91%). In most cases though, some off-set to the total macrophyte area has occurred in the form of proportionally large increases in the areas of mangroves.

### Seagrass

A wide variety of activities may affect seagrasses detrimentally, either directly or indirectly. Activities that are identified by Fisheries NSW (1997) as 'of concern' include:

- Collection or "trimming" of live seagrass;
- Collection of dead seagrass from oceanic or estuarine beaches;
- Dredging and reclamation;
- Construction of groynes and breakwaters;
- Construction of jetties, wharves, bridges, ramps, moorings and pontoons;
- Boating and anchoring;
- Fishing, bait digging and collecting ;
- Construction and operation of aquaculture facilities; and
- Point source pollution.

The *Baseline Ecosystem Health Assessment* carried out as part of development of this CZMP assessed seagrass communities in the Tweed Coast Estuaries. The study detected a decline in seagrass area across all Tweed Coast Estuaries between 2006 and 2011. The most dramatic declines were experienced in Mooball Creek and this was considered to be outside expected seasonal differences and indicative of a general decline in health and extent of seagrass in Mooball Creek estuary. Management action is required which aims to prevent seagrass from disappearing completely from Mooball Creek in the near future. As noted in Section 2.1.2, large areas of seagrass have been observed by TSC staff in a large man-made canal estate which is connected to Mooball Creek. This area is likely to represent an important habitat site, given the poor condition and extent of seagrass in the estuary itself.

The *Baseline Ecosystem Health Assessment* concluded that seagrass extent was highly variable through time which is in agreement with the conclusions of the general literature. Russel (2005) also concluded that saltmarsh, mangrove and seagrass habitats are temporally and spatially dynamic on the North Coast of NSW. This finding has key implications for estuary management and emphasises the need for significant buffers to development to accommodate natural and anthropogenic change.

### Coastal Saltmarsh

Coastal saltmarsh is recognised as an Endangered Ecological Community (EEC) listed as facing a very high risk of extinction in NSW under the *Threatened Species Conservation Act 1995*. Threatening processes to coastal saltmarsh identified by the NSW Scientific Committee (2004) include:

- Infilling – historically saltmarsh areas have been undervalued and considered by many to be boggy swamps and wastelands of little practical use. As a result substantial areas have been in-filled for



roads, residential development, recreational areas, waste disposal, and for industrial and agricultural purposes.

- Modified tidal flow - patterns of tidal flow have been restricted by artificial structures in many NSW saltmarshes, while discharge of stormwater alters salinity regimes, increases nutrient levels and facilitates the spread of weeds.
- Mangrove invasion - in recent decades there has been widespread invasion of saltmarsh in southeast Australia by mangroves. The factors driving mangrove invasion are still unclear. Mangrove colonisation of saltmarsh has been observed at several locations in the Tweed Coast Estuaries (pers. comm. T. Alletson, 2013) and it is likely to continue with sea level rise (refer Section 2.3.5 for discussion of climate change impacts).
- Weed invasion - a large number of weed species occur in saltmarshes and degrade these habitats through changes to the community structure and function. The likely sources of weeds are through dispersal of seed via wind, water or wildlife; dumping of garden waste or 'escape' from adjacent urban gardens;
- Damage by domestic and feral animals - grazing and trampling by domestic stock and feral herbivores can cause adverse impacts. Stock grazing has been shown to substantially change the vegetation composition and structure, while on muddy substrates trampling can cause loss of plant cover and modify drainage patterns.
- Human disturbance - damage to saltmarshes by recreational vehicles, including four wheel drives, is widespread, and deep wheel ruts persist for many years even after exclusion of vehicles.
- Climate change - increased relative sea level is likely to pose an increasing threat to the survival of many areas of Coastal Saltmarsh, particularly in areas where saltmarsh is restricted from natural upslope migration due to the presence of other habitat types (e.g. Mangroves) or anthropogenic barriers such as roads or urban areas (refer Section 2.3.5 for further discussion of climate change impacts).

### **Mangroves**

The total area of mangroves in Cudgera and Mooball Creeks increased from 1940-2000, while in Cudgen Creek, loss of large areas of mangroves is attributed to historical sandmining and clearing for agricultural and urban development (Russel, 2005). The key to mangrove habitats in NSW are identified by Fisheries NSW (2008) as:

- Tidal barriers, drainage and flood mitigation works. Changes to the natural hydrology and tidal regimes can impede normal drainage and lead to death of mangrove plants. Foreshore structures such as floodgates, levees and culverts often physically block the dispersal of mangrove seeds, limit the natural landward migration of mangrove and render upstream water quality unsuitable for healthy mangrove growth;
- Uncontrolled stock access. Livestock feed on mangrove leaves and stems, killing young seedlings and stunting the growth of trees and shrubs. Stock trampling can destroy root systems and compact the soil, severely impacting on the habitat value of mangrove areas;
- Increasing demands for foreshore developments. Water frontages are considered to be prime real estate and are often gained by in-filling or clearing mangrove wetlands. Mangroves are also often illegally cut down, poisoned or trimmed by owners of waterfront properties to obtain water views and private access to waterways;
- Use of off-road vehicles. Trail bikes and other off road vehicles can cause damage to seedlings and trees, destroy the roots and compact the soil;

- Dumping of rubbish/waste, oil spills and toxic chemicals;
- Trampling by humans. Humans walking through mangrove forests can trample and cause destruction to mangrove root systems, leading to the death of the tree over time. Seedlings can also be destroyed; and
- Climate change and sea level rise. Mangroves found along the NSW coast are at risk from climate change and rising sea levels. Urban and industrial development along the NSW coast has limited the locations where mangroves can exist. As sea levels rise, mangroves may be left with nowhere to migrate to, resulting in their loss from some urban coastal sites (refer Section 2.3.5 for further discussion of climate change impacts).

No.	Estuary Habitat Pressures
P1	Decline in seagrass area in all estuaries between 2006 and latest assessments conducted in 2011.
P2	Dramatic decline in seagrass area and health in Mooball Creek.
P3	Estuarine habitats (seagrass, mangroves and saltmarsh areas) remain vulnerable to a number of threats affecting their overall health and continued protection.
Related pressures discussed in other sections:	
P32	There is a risk that natural upslope migration of estuarine habitats due to sea level rise will be curtailed by anthropogenic constraints (roads, agriculture, urban development etc.).
P40	Boat wash can increase rates of bank erosion and disturb sensitive vegetation in the estuary.
P41	Areas of sensitive estuarine vegetation such as seagrass beds may be affected by boating due to propeller and anchor damage.

### Potential Management Options

Examples of measures to protect estuarine habitat from disturbance include:

- Designation of land for protection of environmental values will afford protection for estuarine habitats within these areas. Protected areas such as National Parks Estate, mapped as SEPP 14 Coastal Wetlands, SEPP 26 Littoral Rainforest or areas zoned for environmental protection in the Local Environmental Plan are preserved and protected for environmental, social and economic reasons. Any works likely to affect these areas may only be carried out with the consent of the land managers (Local Council, NPWS, Crown Lands, etc.) and the agreement of the Director General of the Department and Planning. Such development may also require an environmental impact statement to be lodged with a development application.
- Measures to improve water quality and particularly turbidity and nutrient levels will be beneficial to the health of estuarine habitats. Land management practices in the catchment are key to achieving improved water quality.
- Maintaining tidal flows.
- Protect saltmarsh from physical disturbance by fencing or erecting of bollards where it is vulnerable.
- Ensure all cases of harm to marine vegetation, particularly mangrove clearing, are reported to DPI Fisheries for investigation.
- Education about the value of estuarine habitats and their role in ecosystem function is important in the ongoing conservation and protection of these areas. Specific examples include:

- Signage of seagrass beds can be used to raise awareness of communities and their susceptibility to damage from physical damage (e.g. boat propellers).
- Where saltmarsh or mangrove areas border private land, educational programs highlighting the significance of the community and impacts of threatening processes will raise awareness of the issues and seek to change damaging behaviours.
- Implement public education programs for residents to limit damaging substances going into stormwater.

Restoration of degraded habitats is much more difficult than protecting existing communities. Management should focus on the protection of existing areas as a priority, however, in some cases restoration works may be necessary where environmental conditions have been altered by human actions. Due to their naturally dynamic environment, estuarine vegetation is able to migrate and recolonise areas successfully. The general principles for restoration works in estuarine environments therefore is to aim for restoration of natural conditions (e.g. tidal flushing, hydrology, water quality, etc.) and allow for natural re-colonisation to take place. Seeding or transplanting of seedlings from healthy donor sites is a technique that has been used at other locations to restore estuarine habitats. However, transplanting is very labour intensive, and results are variable. Fisheries NSW has recently completed major trials of seagrass transplanting and has formed a policy position that it does not support transplanting of seagrass to off-set impacts of development or reverse seagrass declines within an estuary (pers. comm. M. Riches, 2013). For these reasons, seagrass transplanting has not been proposed by this CZMP as an effective technique in seagrass restoration.

Examples of measures likely to restore degraded estuarine habitats include:

- Restoration of natural tidal regimes by removing barriers;
- Modifications to stormwater structures and outlets to approximate a more natural hydrology. Increasing Infiltration in urban areas will allow for slower release of freshwater through groundwater pathways opposed to high volume 'flashy' runoff associated with typical impervious urban areas; and
- Broader management of catchment impacts (e.g. drainage and waterway modifications and barriers, agricultural runoff, wastewater management, road runoff, etc.) to improve water quality and restore a more natural hydrology in the estuaries.

### Status of Existing Management in the Tweed Coast Estuaries

Most of the areas identified as estuary habitat within the Tweed Coast Estuary study area are currently protected within National Parks estate or SEPP 14 areas. Land preserved as National Parks Estate or mapped under the SEPP 14 *Coastal Wetlands Policy* are preserved and protected for environmental, social and economic reasons. Any works likely to affect these areas may only be carried out with the consent of the land managers (local council, NPWS, Crown Lands, etc.) and the agreement of Fisheries NSW and the Director General of the Department and Planning. Such development also requires an environmental impact statement to be lodged with a development application.

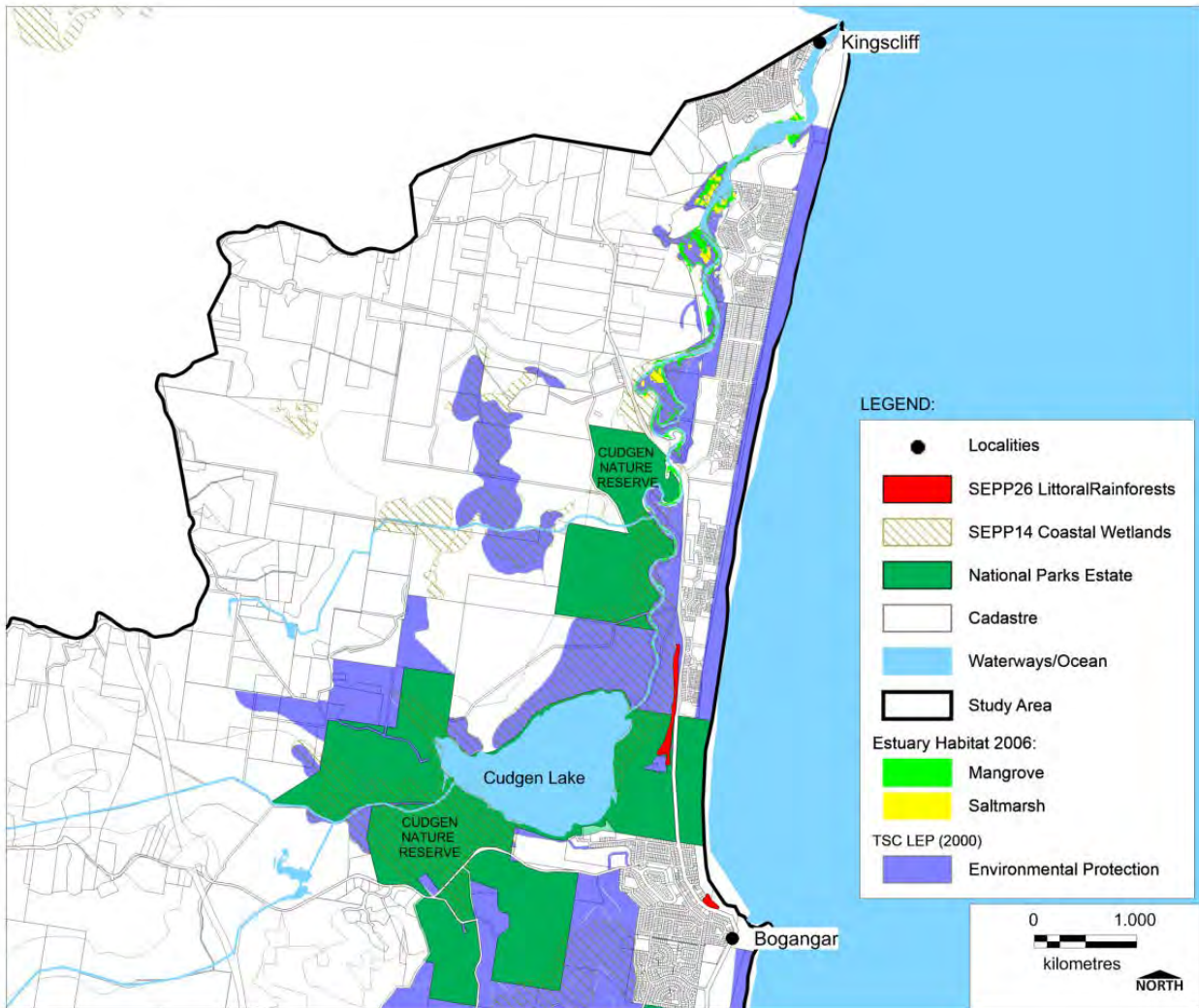
The Tweed Shire Development Control Plan: Section A5 – Subdivision Manual, Section A5.4.5 stipulates that "*Land containing SEPP14 wetlands are to be preserved and no works should be proposed in these areas unless there are no other alternatives available*". A 50 m buffer is also required around any wetland by the DCP (TSC, 2008). Many of the provisions of the DCP related to protection of riparian buffers (discussed in Section 2.2.4) apply to estuarine habitat, especially mangrove and saltmarsh vegetation communities.

Figure 15, Figure 16, and Figure 17 map the existing network of nature reserves and SEPP 14 and SEPP 26 protected areas in relation to mangrove and saltmarsh habitat areas mapped by TSC (TSC, 2006).

Environmental Protection Zonings under the TSC LEP (2000) are also shown in the following maps. Note that the LEP (2000) and associated land zoning is currently under review and these zones may change with the new LEP once adopted. Also note that seagrass mapping has been omitted from maps, as recent

surveys as part of the *Baseline Ecosystem Health Assessment* indicates the location of seagrass beds vary significantly from the 2006 mapping.

Despite most of the estuarine habitat areas in the Tweed Coast Estuaries being included in protected areas, reserve status, however, does not confer protection from weed invasion, mangrove invasion of saltmarsh, human physical disturbance, recreational vehicles, pollution, or sea level rise without active management.



**Figure 15: Cudgen Creek environmental protection mapping and areas of estuarine habitat**

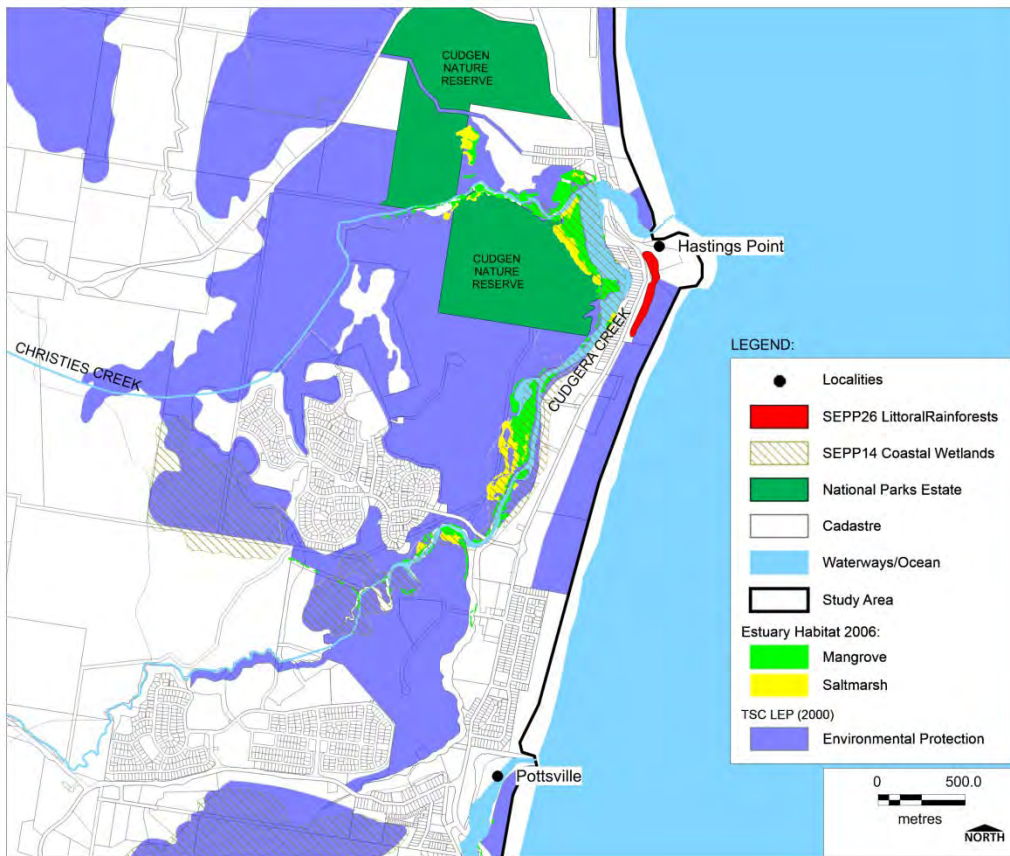


Figure 16: Cudgera Creek environmental protection mapping and areas of estuarine habitat

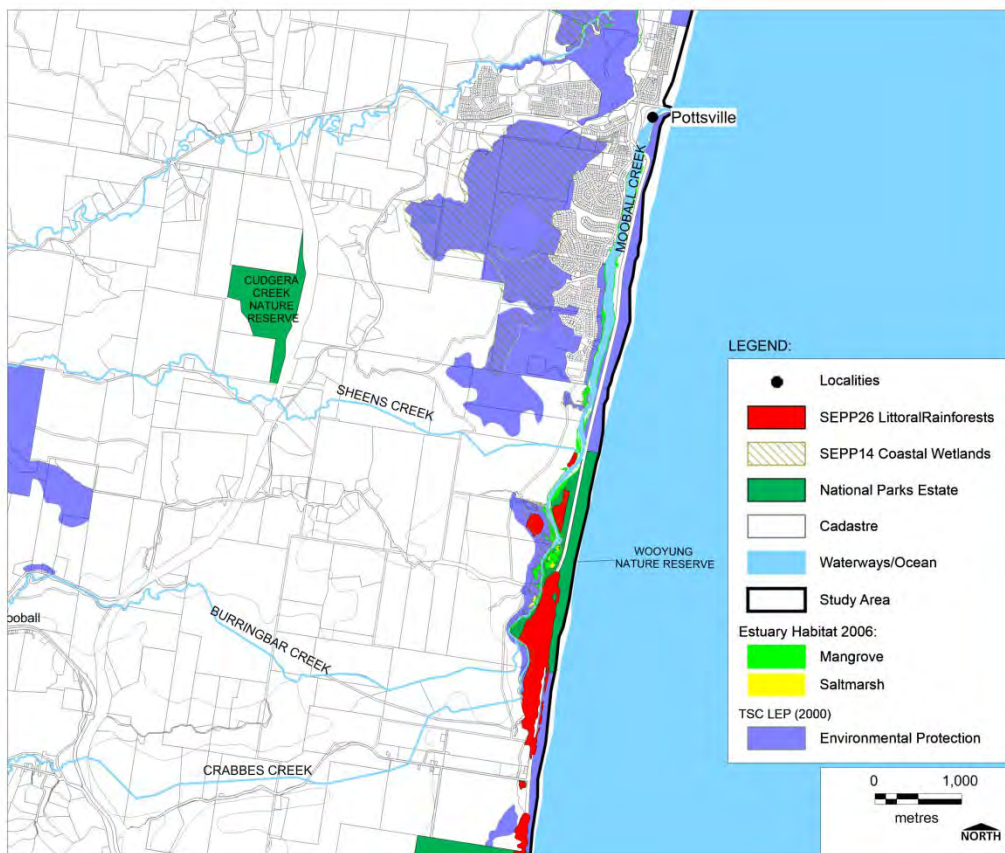


Figure 17: Mooball Creek environmental protection mapping and areas of estuarine habitat

Fisheries NSW is responsible for the management of marine vegetation including mangroves, saltmarsh and seagrass, under the *Fisheries Management Act 1994*. Any development or activity that may harm marine vegetation must be referred to Fisheries NSW for approval. Removal of marine vegetation without a permit issued by Fisheries NSW is an offence under the Act.

Roads and Maritime Services (RMS) have set boating speed limits in the estuaries' to minimise boat wash and reduce bank erosion and damage to estuary habitat areas. The speed limits are currently set at 4 knots for the lower estuaries up to the first bridge and then 8 knots upstream of the bridge in all estuaries. Mooball Creek is a 'No wash zone' for its entire length. The NSW Maritime Boating Maps for the estuaries mark the speed limit areas and 'no wash zones'. Speed limit signs are readily observable in the lower estuary. In terms of seagrass damage, direct contact with boats and propellers is likely to be one of the key causative factors, with the speed of boats (limited to the current speed limits) a possible secondary issue. Boat speeds that generate wake and wave action may contribute to bank erosion and subsequent sedimentation and turbidity issues, which in turn may affect seagrass health. At this stage, the current boat speed limits are considered appropriate, however the issue of boats exceeding the speed limits has been raised in the past as a concern by the community (Australian Wetlands, 2003). Education and enforcement of speed limits may help to reduce adverse impacts on seagrass habitat.

### Recommendations for Management

Despite being protected under several pieces of legislation, estuarine habitats remain vulnerable to a number of threats due to their close proximity to urban centres and popular recreational areas. Management options to address impacts on estuary habitat include actions to reduce nutrient loads to the estuary, controls on urban development (stormwater control and buffer zones, etc.) as well as ongoing community education to reduce physical disturbance of habitats caused by recreational activities. Recommendations for management are:

- Broad land management practices (both urban and agricultural) should aim to reduce nutrient and sediment loads to the estuary.
- It is important that any new development areas fully comply with Council's stormwater regulations and requirements in terms of achieving water quality and flow standards.
- Stormwater outlets to be located away from sensitive estuarine habitats in accordance with Fisheries NSW policy and guidelines.
- Riparian buffers between development areas and waterways provide a range of important ecological functions (see Section 2.2.4). With regard to estuarine habitats, buffers allow space for estuarine vegetation communities to migrate in response to changing conditions. This will be particularly important when considering future sea level rise scenarios (refer Section 2.3).
- Education will be important to protect estuary habitat areas from potential harm caused by physical disturbance. Specific measures include:
  - Signage of particularly sensitive sites may be necessary for protection against physical disturbance (e.g. site MOOSG1 in lower Mooball Creek);
  - Wherever practical and a clear need has been identified, use fencing or bollards along the intertidal zone to prevent stock and vehicular access to habitat areas;
  - Avoid walking, riding or driving through habitat areas at low tide;
  - Dispose of rubbish, oils and chemicals in the correct manner; and
  - Report activities harming marine vegetation, particularly mangrove clearing to Fisheries NSW for investigation.
- Determine the sources of decline in seagrass extent in the Tweed Coast Estuaries and recommend remedial action where possible to address root causes.

- Monitoring and evaluation of estuarine habitats will be important to monitor trends in extent and health of these communities, measure the success of management actions and inform decision making. Specific recommendations for monitoring are:
  - Continue seasonal seagrass monitoring carried out during the *Baseline Ecosystem Health Assessment* to assess the on-going state of seagrass and whether the beds are continuing to decline or whether they are showing signs of recovery.
  - Mooball Creek seagrass has been identified as being particularly stressed and in a state of rapid decline. These sites should be prioritised for further survey of seagrass extent and health to allow for assessment of trends over time and potential recovery.
  - Future ecosystem health investigations should aim to assess seagrass communities existing in the man-made Mooball Creek canal near Pottsville. Monitoring the response of these seagrass communities to the recently completed works to restore the tidal regime would be beneficial in providing guidance for future management of the system and other similar systems.
  - Further studies, including saltmarsh, seagrass and mangrove extent mapping and health monitoring are recommended in order to fully determine the drivers for degradation of these communities and the ecological implications of this for the Tweed Coast estuaries. There are opportunities to coordinate with Fisheries NSW in their estuarine habitat mapping exercises, and the OEH's MER Program which should be explored and utilised wherever possible in gathering this information.

### 2.2.2 Aquatic Fauna

Aquatic fauna have intrinsic value and are integral components of estuaries and their connected freshwater waterways. Fish, macroinvertebrate communities and other aquatic fauna such as platypus are familiar components of freshwater environments and reflect a range of natural and human-induced disturbances through changes in abundance and species composition. The platypus is known to occur in the freshwater reaches of the Tweed Coast Estuaries and is an iconic species with a high level of community interest.

#### Description of Estuary Health Pressures

Significant pressures on aquatic fauna identified for the Tweed Coast Estuaries include:

- Alteration of habitat. This is a major pressure for aquatic fauna and a primary cause of decreasing native fish populations. Removal of snags reduces available habitat for fish and other aquatic and terrestrial organisms, increases erosion and decreases variation in channel shape.
- Barriers to fish passage prevent the migration of native fish species and can have severe implications for these populations. In extreme cases, barriers can result in localised extinctions (Fisheries NSW, 2012).
- The loss or degradation of riparian vegetation. Riparian vegetation provides habitat and shading and also buffers freshwater ecosystems from disturbances in the catchment and promotes recovery afterwards, helping to maintain biodiversity.
- Altered flow regimes have also changed the physical habitat in river systems, and patterns of habitat connectivity essential to the population viability of many freshwater species. This has also facilitated the invasion of some exotic species.
- Inputs of sediment, nutrients, and a broad range of contaminants such as pesticides and herbicides;
- Introduced fauna species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. Noted exotic species in the local area include

the introduced Mosquito Fish (*Gambusia holbrooki*) and an aquarium fish, the Swordtail (*Xiphophorus helleri*.)

The *Baseline Ecosystem Health Assessment* assessed fish and macroinvertebrate communities within freshwater reaches of the Tweed Coast Catchments and benthic macroinvertebrate communities associated with seagrass beds in the estuaries. The following is a summary of conclusions from the study:

- The freshwater fish communities in the catchments of the Tweed coast estuaries are in generally good health with moderate to high diversity of native species. The upper catchment sites had higher fish health indices reflecting the reduced level of habitat impact and generally better water quality.
- Although there are numerous partial barriers to fish movement in all the catchments, no critical barriers were identified and the longitudinal zonation of fish species within the catchments was similar to those observed in other northern NSW waterways.
- The lowest Fish Health Index was recorded for a site within the channelised section of Clothiers Creek. Although there is severe habitat disturbance due to channelisation, the greatest threat to fish in this zone is poor water quality. Further downstream of the site, dissolved oxygen levels of zero had been recorded during one field inspection and there is evidence of severe acid sulfate issues at other nearby sites.
- There were two exotic species recorded during the surveys, but not at all sites. Mosquito Fish *Gambusia holbrooki* were most prevalent and were far more abundant during the summer samples, this seasonal pattern has also been observed at other locations in northern NSW, however, the reasons for this are not fully understood. Although recorded in lesser numbers and at only two sites, the presence of Swordtails *Xiphophorus helleri* is of concern as this indicates that this second exotic species may be becoming established.
- The freshwater macroinvertebrate results have provided an excellent snapshot of the health of six indicator sites within the catchment and in combination with the fish surveys demonstrate that both water quality and habitat availability are contributing to degradation of the aquatic environments in the freshwater middle reaches of the Tweed Coast estuary catchments.
- Sites in the upper catchments were all found to contain relatively healthy macroinvertebrate communities; however some sites on the floodplain were found to be degraded and reflected both the intuitive assessment of these sites as well as the results obtained from a suite of other data collected during the study.
- Benthic macroinvertebrates associated with seagrass beds in the Tweed Coast estuaries were variable in distribution and abundance but showed broad results in line with other data indicating that these seagrass habitats are under pressure.
- The most striking result was the difference in abundance between seasons, with the wet season surveys recovering only 27% of total number of animals sampled. The reasons for this remain unclear, but appear to mirror observations of the overall decline in the health extent of the seagrass beds.

While not directly assessed as part of the *Baseline Ecosystem Health Assessment*, Platypus are known to inhabit the Tweed Coast Estuaries study area at many of the upper catchment sites (TSC, 2013). Currently there is little information available on distribution, population sizes and trends within the Tweed Shire. The platypus is an important part of freshwater environments in Australia and a good indicator of the productivity of aquatic ecosystems. Suitable habitat conditions for the platypus, a generalised top predator, will also favour many other freshwater species. Actions that enhance platypus habitat also promote biodiversity conservation in general.



The platypus, alongside many other native species, is vulnerable to many threats and pressures including:

- General modification of natural waterways including construction of waterway barriers, river bank erosion, riparian degradation and water quality decline;
- Loss of habitat makes isolated populations more vulnerable to decreased genetic diversity;
- Platypus are vulnerable to being caught in fish nets and traps as well as occasionally on fishing lines baited with worms;
- Foxes and cats;
- Climate change causing drought and loss of habitat.

No.	Aquatic Fauna Pressures
P4	Alteration of habitat is a major pressure for aquatic fauna and a primary cause of decreasing native fish populations. Channelisation of natural waterways, altered flow regimes, poor condition riparian zones and poor water quality are main contributors to habitat alteration.
P5	Partial barriers to fish passage may prevent the migration of native fish species during some flow conditions.
P6	Introduced fauna species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. The introduced Mosquito Fish ( <i>Gambusia holbrooki</i> ) and an aquarium fish, Swordtail ( <i>Xiphophorus helleri</i> .) are species of concern for the freshwater reaches of Tweed Coast Estuaries.
Related pressures discussed in other sections:	
P44	Community concern that a fish stocks have declined over recent decades.
P45	Overfishing can impact fish stocks.

### Potential Management Options

Aquatic fauna are biological indicators of the health of ecosystems. To improve the health and resilience of aquatic fauna communities, the source of pressures on aquatic habitats need to be addressed. This involves a total catchment management approach to reduce pollutant loads and contaminants entering waterways, maintenance of natural flow regimes, and healthy riparian buffers. Management options to reduce many of these pressures are outlined in relevant sections related to Riparian Vegetation (Section 2.2.4); Acid Sulfate Soils (Section 2.2.6); Agriculture (Section 2.2.7), Urban Development and Stormwater (Section 2.2.8); and Wastewater Management (Section 2.2.9),

In addition to catchment management, specific management options related to aquatic fauna include:

- Minimise fish passage barriers wherever possible to allow adequate fish passage.
- Education about release of exotic aquarium species into the wild may reduce this identified source of disturbance. A key message to be conveyed to the community is not to 'dump' fish.

### Status of Existing Management in the Tweed Coast Estuaries

Tweed Shire Council planning controls contain requirements for the protection of aquatic fauna and their habitats. The Tweed Shire Development Control Plan: Section A5 – Subdivision Manual (TSC, 2008), Section A5.4.7 requires that “*Subdivision layouts and works are to be designed to avoid adverse impacts on fish and aquatic habitat and are to comply with the NSW Fisheries (1999) Policy and Guidelines Aquatic Habitat Management and Fish Conservation and the Fisheries Management Act 1994 and Fisheries Management (General) Regulation 1995.*” This includes ensuring preservation of fish an aquatic habitat, development does not result in pollution to waterways, conservation of native vegetation by retention of

riparian buffers, and requirements that no works create barriers to fish passage (TSC, 2008).

No critical barriers to fish passage were identified for the Tweed Coast Estuaries waterways assessed during the *Baseline Ecosystem Health Assessment*. Partial barriers do exist at many locations and may restrict fish passage particularly during dry times when water levels are low.

The *Baseline Ecosystem Health Assessment* conducted as part of this CZMP is the first known catchment-wide assessment of fish and macroinvertebrate populations conducted in the study area.

TSC has recently initiated a Platypus Project for the Tweed Shire with the aim of protecting platypus habitat and reducing threats to Tweed platypus populations (TSC, 2013). The project involves community education and consultation, collection of location data through community surveys and community participation in a 'spotting' campaign.

### Recommendations for Management

- Identify opportunities for aquatic habitat restoration, either as additional complimentary works associated with identified riparian rehabilitation or acid sulfate soil remediation sites, or sites identified by landholders, community members, Council or Fisheries NSW staff.
- Funding should be set aside as part of the CZMP to assist in implementing aquatic habitat restoration projects.
- Support and coordinate with the Tweed Platypus Project.
- Follow-up monitoring of fish populations as part of an Ecosystem Health monitoring program and at work sites to determine the efficacy of habitat restoration and exotic fish removal measures as appropriate.
- Support education of the public about the negative effects of releasing aquarium fish into the wild. Undertake additional surveys on Christies Creek to determine the extent of Swordtail infestation and determine the feasibility of removal of this species at this location.
- The macroinvertebrate survey methodology provides readily obtainable, repeatable and quantitative data that allows for on-going condition assessment of these waterways. It is suggested that repeat surveys over time using this methodology would provide cost-effective on-going assessment of catchment health and is recommended to be conducted on an annual basis following the protocols adopted in this study.

### 2.2.3 Shorebirds and Coastal Raptors

Shorebirds and coastal raptors are important components of coastal ecosystems, representing higher order consumers. They are often the most visible proportion of vertebrate fauna within estuarine environments adding to natural amenity and recreational enjoyment of estuary foreshores. Shorebirds and coastal raptors are discussed separately in the following sections.

#### Shorebirds

Shorebirds are small to medium size waders characterised by slender, probing bills and long legs that inhabit estuaries, beaches and wetlands. They include the sandpipers, oystercatchers, plovers, curlews, tattlers and terns. Shorebirds can be divided into two groups, migrants, which breed elsewhere (mainly in the northern hemisphere) and spend the non-breeding season in Australia, and residents, which reside permanently in Australia. Resident shorebirds also undertake regular movements between coastal and inland wetlands and along the coast (Sandpiper Ecological Surveys, 2005).

Many species of shorebird are of high conservation value due to their migratory habits, small population sizes, susceptibility to threatening processes and/or declining population size. All migratory species are listed on the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. Numerous species are also

listed as Endangered or Vulnerable on Schedules 1 and 2 of the EPBC Act and the NSW *Threatened Species Conservation (TSC) Act 1995*. Migratory shorebirds are also protected by international treaties such as the *Japan-Australia Migratory Bird Agreement (JAMBA)* and the *China-Australia Migratory Bird Agreement (CAMBA)*.

Shorebirds have three basic habitat requirements:

1. Feeding areas – where they can forage in a manner that enables them to satisfy their daily energy requirements;
2. Roosts – where they can rest at high tide when foraging habitats are unavailable; and
3. Nesting areas – where they can nest and raise chicks.

**Description of Estuary Health Pressures**

Habitats relied upon by shorebirds are also often used intensively for recreation and can occur within estuarine systems that are affected by industry, urban development and agriculture. Shorebirds are therefore vulnerable to many threatening processes, as a result of the competing uses in vicinity of their habitat.

The Tweed Coast Estuaries contain important habitat for resident and migratory shorebirds. Australian Wetlands (2003) reported a number of shorebirds observed by local bird watchers in the Cudgera Creek area. More recent observations recorded in 2012 and 2013 include additional protected species in all three estuaries. Table 2 lists the species recorded in 2003 and 2012.

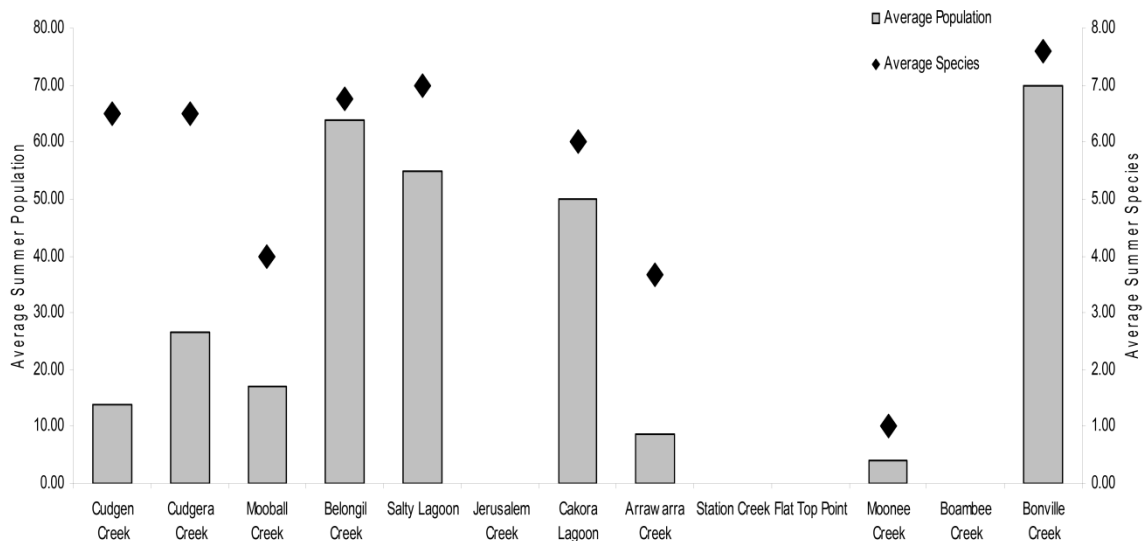
**Table 2: Protected shorebird species recorded at Cudgera Creek mouth**

Date recorded	Estuary	Common Name	Scientific Name	Protection status	Data Sources*
2003	Cudgera Creek	Pied Oystercatcher	<i>Haematopus longirostris</i>	Endangered, NSW TSC Act	1
	Cudgera Creek	Sooty Oystercatcher	<i>Haematopus fuliginosus</i>	Vulnerable, NSW TSC Act	1
	Cudgera Creek	Curlew Sandpiper	<i>Calidris ferrugenea</i>	Migratory, EPBC Act	1
2012 and 2013	All	Pied Oystercatcher	<i>Haematopus longirostris</i>	Endangered, NSW TSC Act	2,3,5
	All	Sooty Oystercatcher	<i>Haematopus fuliginosus</i>	Vulnerable, NSW TSC Act	2,5
	Cudgera and Cudgera Creek	Little Tern	<i>Sterna albifrons</i>	Endangered, NSW TSC Act	2
	Cudgera and Mooball Creek	Beach Stone-curlew	<i>Esacus neglectus</i>	Critically Endangered, NSW TSC Act	2,3,5
	Cudgera Creek	Wandering Tattler	<i>Tringa incana</i>	Migratory, Bonn, CAMBA, JAMBA, EPBC	4
	Mooball Creek	Grey-tailed Tattler	<i>T. brevipes</i>	Migratory, Bonn, CAMBA, JAMBA, ROKAMBA, EPBC	2
	Cudgera Creek	Whimbrel	<i>Numenius phaeopus</i>	Migratory, Bonn, CAMBA, JAMBA, ROKAMBA, EPBC	2
	Cudgera Creek	Eastern Curlew	<i>N.madagascariensis</i>	Migratory, Bonn, CAMBA, JAMBA, ROKAMBA, EPBC	2,3
	Cudgera Creek	Bar-tailed Godwit	<i>Limosa lapponica</i>	Migratory, Bonn, CAMBA, JAMBA, ROKAMBA, EPBC	2,3
Cudgera and Mooball Creek	Pacific Golden Plover	<i>Pluvialis fulva</i>	Migratory, Bonn, CAMBA, JAMBA, ROKAMBA, EPBC	2,3	

\*Data Sources:

- |  |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. Australian Wetlands (2003)</li> <li>2. Tweed Bird Observers Survey Team</li> <li>3. D. Banks – pictures supplied to TSC</li> </ol> | <ol style="list-style-type: none"> <li>4. T. Alletson pers. comm., 2012</li> <li>5. From TSC GIS layer – Natural Resource Management Unit</li> </ol> |
|--|--|

The recent study: *Shorebirds of Northern New South Wales* (DECCW, 2010c) collated existing shorebird data across major and minor estuaries across Northern NSW. Cudgen, Cudgera and Mooball Creeks were included in the study area. Figure 18 shows the average summer diversity and population estimates at minor estuaries in northern NSW including Cudgen, Cudgera and Mooball Creeks (DECCW, 2010c). The Tweed Coast Estuaries had much lower abundance of shorebirds compared to some of the other minor estuaries in northern NSW. However, average species diversity at Cudgen and Cudgera Creek were similar to sites with larger total shorebird populations. Cudgera Creek had the highest species diversity and population numbers of the Tweed Coast Estuaries.



**Figure 18: Average 'summer' diversity and population estimates for shorebirds at minor estuaries and ICOLs in northern NSW (DECCW, 2010c)**

Threats to shorebirds include introduced pests such as foxes, weed invasion, coastal processes, entanglement and ingestion of fishing line, tackle and pollutants, natural predation and disturbance from beach users and domestic dogs. These threats may result in the destruction of nests, eggs and chicks, disturbance to foraging, nesting and resting birds and loss of habitat. Indirect impacts can occur when the activities of beach users unknowingly disturb birds from their nests which expose eggs and chicks to predation and weather extremes (Department of Lands, 2007).

There have been specific concerns raised in the community that dogs are negatively impacting on shorebirds in foreshore areas of lower Cudgera Creek, Hastings Point. The lower Cudgera Creek Estuary, near the entrance, is a popular recreational use area with picnic areas and public facilities provided in the adjacent park.

No.	Shorebird Pressures
P7	Threats to shorebirds include introduced pests such as foxes, weed invasion, coastal processes, entanglement and ingestion of fishing line, tackle and pollutants, natural predation and disturbance from beach users and domestic dogs.
P8	Specific concern has been raised in the community that dogs are negatively impacting on shorebirds in foreshore areas of lower Cudgera Creek.
P9	Concerns have been raised by local bird enthusiasts that shorebird use of Cudgen and Mooball Creeks is not well understood and may well be important.

### Potential Management Options

There are existing local and state-wide management guideline documents for the management of shorebirds. The *Best Practice Guideline for Managing threatened beach-nesting shorebirds* (DECC, 2008) provides potential management options and strategies to reduce threats to shorebirds. Sandpiper Ecological Surveys, 2003 cited in *Australian Wetlands*, 2010) recommended a five tiered approach to managing estuarine birds in the Tweed River Estuary, including:

1. Protection of important sites.
2. Restoration of important sites that have been degraded by threatening processes.
3. Creation of new habitat in areas where habitat has declined in suitability.
4. Monitoring and research.
5. Ongoing management of estuarine bird habitat.

The *Threatened Species (Pied Oystercatcher) Management Strategy* (Department of Lands, 2007) is a local strategy which addresses issues pertaining to shorebird habitat and sources of disturbance. The strategy was developed to provide guidance for land managers within the Richmond River area, however many of the broad actions could be used to address issues in the Tweed Coast Estuaries. In general, the strategies for protecting Pied Oystercatchers also benefit other species of shorebirds. Management actions that could be implemented to protect nesting birds include:

- Community education and awareness;
- Limits to 'on-leash' dog exercising areas and implementation of exclusion zones;
- Controls for introduced animals and specifically fox control methods;
- On-going rationalisation of beach access tracks;
- Weed management; and
- Monitoring and evaluation.

The recent *Coastal Zone Management Plan for Cobaki Broadwater and Terranora Broadwater* (Australian Wetlands, 2010) provided a detailed analysis of shorebird communities, their health status and key threats. Following on from targeted shorebird surveys, management recommendations were targeted at improvement or creation of habitat at specific sites. Further investigation of human recreation impacts on shorebirds and development of a policy on the management of dynamic estuarine areas for which there are often conflicting uses (e.g. recreation versus shorebird habitat) was also recommended.

### Status of Existing Management in the Tweed Coast Estuaries

- Development and implementation of guidelines for the management of beach-nesting birds on Tweed Coast public lands (joint project TBO and TSC funded by BirdLife Australia);
- Bitou Bush control programs have significantly reduced the extent of Bitou Bush along much of the Tweed Coastline;
- TSC works to increase awareness of regulation of and commitment to reducing the impact of domestic pets on wildlife through ongoing work of TSC rangers and educational material;
- Most of the estuary foreshore area downstream of the bridge is a designated 'dog exclusion area', however the following issues have been identified:
  - Only some of the area has signage to notify the public of this requirement. This is shown as the green area in Figure 19, where signage is located in the park/car park area along the foreshore;
  - The spit on the north side of Cudgera Creek mouth (shown as yellow area in Figure 19) is a designated dog exclusion area, but there is currently no signage at this location; and

- o The area to the south of the creek mouth extending to the rocky shore (shown in red in Figure 19) is not officially designated as a dog exclusion zone.



**Figure 19: Current status of Cudgera Creek mouth dog exclusion areas (approximate locations for foreshore areas shown and extended to the centreline of the creek)**

**Recommendations for Management**

- Continue implementation of protocol to manage and protect beach-nesting birds on TSC public lands (joint project TBO and TSC funded by BirdLife Australia);
- Continue Bitou Bush and other weed control programs in coastal areas;
- Consider implementation of fox control programs;
- Continue community education and awareness programs about impacts on shorebirds through TSC public information provision including TweedLink articles and Council Webpage updates;
- Detailed maps of dog use areas on the Tweed Coast should be developed and made available in brochures and on the TSC web page.
- Due to the frequency and numbers of birds roosting in the vicinity of Cudgera Creek mouth, this whole area should be designated as a dog exclusion area. This includes all the areas in Figure 19 from the Peninsula Street beach access track in the north to the rock platform on the south side of the creek mouth. Clear signage and regulation of the areas is required to ensure effective management. Other forms of public notification could also be considered at the time of signage installation including: Council notices in local paper, TweedLink article, Council Webpage, etc.;

- Enforcement of rules through extra TSC Ranger patrols of the area following signage deployment to reinforce the requirement and issue warnings and/or fines as appropriate. Patrols can also be used as a means of providing information about shorebird values and the need for restrictions. Enforcement is a critical component of management and as population increases, the demand for extra patrols and enforcement personnel will also increase. It is vital that TSC allocates sufficient resources to ensure exclusion zones are observed.
- It should be determined whether other sites in the estuary and at Cudgen and Mooball estuaries would benefit from signage. Dog exclusion zones may be suitable for other areas where shorebirds are identified as under threat. Further investigation is required to determine whether there is a need for exclusion zones and the nature, timing and requirements of zones.

### Coastal Raptors

Coastal raptors are birds of prey inhabiting coastal environments such as beaches, estuaries and wetlands. They include species such as ospreys, sea-eagles and kites. They require extensive areas of open fresh, brackish or saline water for foraging (Marchant & Higgins 1993). They generally search for prey by soaring, quartering or circling above a body of water and scanning below for fish. Their talons and beaks tend to be relatively large, powerful and adapted for tearing flesh. Coastal raptors frequent a variety of wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes. They typically exhibit a preference for elevated nesting sites which can be natural (e.g. partly dead trees) or artificial (e.g. platforms, power poles etc.) but are known to nest on the ground in some locations (Department of Sustainability, Environment, Water, Population and Communities, 2013).

Two iconic species of coastal raptor known to inhabit the Tweed Coast Estuaries and are known to be vulnerable to human pressures are the Eastern Osprey *Pandion cristatus*, and the White-bellied Sea-Eagle *Haliaeetus leucogaster*.

The Eastern Osprey is listed as Vulnerable under the *TSC Act 1995*, and Migratory under the *EPBC Act*. All known Osprey nests in the Tweed LGA are listed as heritage items in the *Tweed Shire Community Based Heritage Study and Community Plan* (TSC, 2011d). The White-bellied Sea-Eagle is a listed migratory and marine species under the *EPBC Act* and is a listed migratory species by CAMBA. The species is not currently listed as threatened in NSW, although there is evidence that this species is more sensitive and demanding in terms of breeding-habitat requirements than the Eastern Osprey and a listing as Vulnerable has been recommended for this species (Debus, 2008).

### Description of Estuary Health Pressures

Threats to the Eastern Osprey and White-bellied Sea-Eagle in the Tweed Coast Estuaries have been identified through monitoring, research and observations of the Tweed Bird Observers (pers. comm. L. Brannian, 2013). Key threats are:

- Loss, degradation or alteration of habitat for agricultural, urban or tourism development;
- Disturbance during nesting;
- Entanglement and ingestion of discarded or lost fishing line and tackle, and irresponsible recreational fishing behaviour;
- Ingestion of prey items containing pollutants such as pesticides or heavy metals;
- Reduced water quality and turbidity at foraging grounds caused by discharge of effluent or runoff;
- Fish health and availability; and
- Collision with power lines and vehicles.

It was noted that White-bellied Sea-Eagle are particularly susceptible to loss of habitat due to land development and disturbance of nesting pairs by human activity (Dennis, McIntosh, & Shaughnessy 2011).

No.	Coastal Raptor Pressures
P10	Threats to coastal raptors include habitat loss and degradation, human disturbance to breeding, entanglement and ingestion of fishing line, tackle and pollutants, reduced water clarity, reduced fish health and availability and collision with power line and vehicles.

### Potential Management Options

There are existing state-wide management guideline documents for the management of the Eastern Osprey. *The Biology and Management of the Osprey (Pandion halaetus cristatus) in NSW* (Clancy, 1991) provides potential management options and strategies to reduce threats applicable to most coastal raptors. The Department of Sustainability, Environment, Water, Population and Communities (2013) lists the following actions which could be implemented to aid the conservation of the Eastern Osprey that are directly applicable to most coastal raptor species:

- Protect breeding habitat by establishing buffer zones around nest sites;
- Identify and protect foraging habitat (including feeding perches) and sites from which nest material is collected;
- Liaise with authorities to ensure consideration of the species and its habitat requirements in planning processes;
- Work with landholders to manage or translocate nests in hazardous or undesirable locations;
- Introduce mitigation measures to protect estuarine and foreshore habitats from pollution;
- Trial predator-proof artificial nest platforms and determine the effect of these on breeding productivity;
- Determine current levels of organochlorines and other contaminants likely to impact on the species;
- Increase community awareness of the species and its requirements through initiatives such as media releases, brochures and signage; and
- Determine the success of implemented recovery actions.

### Status of Existing Management in the Tweed Coast Estuaries

- All known Osprey nests in the Tweed LGA are listed as heritage items in the Tweed Shire Community Based Heritage Study and Community Plan (TSC, 2011d). Their presence in the vicinity of a proposed development would trigger the need for an environmental impact assessment (see next point).
- Proposed development that is likely to impact threatened species such as the Eastern Osprey, triggers the need to complete an assessment of significance under the *TSC Act*. If a significant impact on threatened species is likely, a Species Impact Statement must be prepared that assesses the full nature and extent of impacts and prescribes necessary mitigation and/or suitable offset measures (where possible) to reduce the impact of the proposal to suitable levels. In the case of Osprey, these measures may include suitable buffer distances to nesting sites, provision of artificial nesting sites in other locations, and habitat restoration measures.
- Council is in the process of producing a Habitat DCP which has the scope to incorporate further investigation and definition of suitable buffer distances to sensitive ecological sites such as nests.



### Recommendations for Management

Measures which address the specific pressures identified for the Tweed Coast Estuaries and to ensure protection of coastal raptors would include:

- Public education on responsible behaviour and the impacts of personal behaviour. This includes:
  - correct use and disposal of litter, fishing line and tackle to avoid ingestion or entanglement of wildlife;
  - fishing line should be recovered wherever possible and disposed of correctly;
  - increased visibility of Fisheries NSW Officers to enforce penalties for non-compliance;
  - Council support for biodegradable bait bags and fishing gear. However, in order to be successful, this program needs to have a broader reach, such as a regional, state or national program.
- Establishment of sites off-limits to recreational fishing such as bridges where there is a demonstrated problem of fishing line entanglement affecting wildlife.
- The TSC Habitat DCP which is currently in preparation should consider the investigation and definition of suitable buffer distances of developments to coastal raptor nests.

### 2.2.4 Riparian Vegetation

Riparian zone functions include fisheries habitat, terrestrial habitat, fauna corridors, bank stability and maintenance of soil structural integrity, land use buffering, water quality filtering, lowering water temperature and reducing aquatic weeds as well as providing scenic amenity. Riparian zones can also offer resilience to climate change by creating a buffer for development and providing space for migration of vegetation communities with changes in water level. Achieving intact, vegetated functioning riparian zones is a key step towards the protection and enhancement of waterway health in Tweed Coast Estuaries.

#### Description of Estuary Health Pressures

Major disturbance factors for riparian vegetation are:

- Clearing of the bank and riparian vegetation. In many areas of the Tweed Coast Estuaries catchments, historical clearing is still prevalent today;
- Ongoing disturbances associated with unrestricted stock access to banks;
- Lack of suitable buffer zones between land use and waterways, which is particularly significant in areas of high soil disturbance such as cropping areas on steep slopes;
- Disturbance associated with infrastructure including waterfront structures and roads in close proximity to waterways; and
- Weed invasion.

Investigations as part of the *Baseline Ecosystem Health Assessment* found that riparian vegetation condition and extent varied throughout the Tweed Coastal Creeks study area. A general trend in overall riparian condition could be seen from better condition observed in the upper freshwater reaches, to poor condition on the highly modified floodplain (refer Appendix 4 for further details). Riparian vegetation along the estuarine reaches also varies considerably, although riparian zones are generally in better condition than the floodplain areas immediately upstream. This is largely due to the presence of SEPP 14 Coastal Wetland areas, National Parks estate, Nature reserves and Crown Land bordering the estuaries affording protection to these areas (refer to Figure 15, Figure 16 and Figure 17 for maps of protected areas).

No.	Riparian Vegetation Pressures
P12	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary.
P13	Lack or poor condition of riparian vegetation compromises habitat connectivity and habitat value (both in-stream and terrestrial habitat).
P14	Lack of suitable buffer zones between land use and waterways limits riparian zones.
P15	Disturbance associated with infrastructure including waterfront structures and roads in close proximity to waterways.
P16	Weed invasion reduces habitat and amenity values of vegetation communities.
P17	Bank erosion can destabilise riparian vegetation.
P18	Clearing and/or mowing of riparian vegetation for improved water views and access.
Related pressures discussed in other sections:	
P19	Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.
P23	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.
P24	Unrestricted stock access causes vegetation damage and bank erosion.

### Potential Management Options

A strategic approach to riparian restoration to improve existing riparian zones combined with land use planning controls to ensure ongoing protection of these areas is required.

A catchment-wide plan for prioritising riparian rehabilitation presents an advantageous approach to management. Benefits include strategic planning of works to achieve the best outcomes in locations that would benefit the most and continued support for funding based on an overriding plan. By identifying and prioritising riparian areas for rehabilitation, managers can assess the areas that will provide the greatest benefits for the effort expended or 'best bang for buck'.

Restoration works may be restricted, or more difficult to execute effectively on private land. While options for rehabilitation on private land should be encouraged and supported, existing Crown land parcels and Council reserves along foreshore areas should be a priority for management. Education of farmers, landowners and the community is required to demonstrate the value of riparian zones

### Status of Existing Management in the Tweed Coast Estuaries

The importance of riparian buffers to waterways is reflected in the Tweed Shire planning scheme as follows:

- Tweed Shire Development Control Plan: Section A5 – Subdivision Manual:
  - Section A5.4.7 Stormwater Runoff, Drainage, Waterways and Flooding states:
 

*“Development in or adjacent to waterways, water bodies, wetlands or within their catchments must provide a riparian buffer of 50m along major streams (Tweed River, Rous River, Oxley River, Cudgen Creek, Cudgera Creek, Mooball Creek and major tributaries) and a width along other streams in accordance with Table A5-5.”*

- Section A5.4.5 Environmental Constraints states: “*Development sites must be assessed to determine if there are areas of significant vegetation*”. The definition of significant vegetation includes riparian vegetation, which must be preserved.
- The *Tweed Coast Estuaries Management Plan 2004-2008* recommends a minimum 50m buffer zone around estuary banks.
- The *Tweed Urban Stormwater Quality Management Plan Draft* (Australian Wetlands, 2012) Section 7.2 recommends: “...*a minimum riparian buffer of 50m is adopted for all major waterways (rivers and creeks) and wetlands in which development is excluded. In addition, buffers to minor waterways (25m) and ephemeral drainage lines (10m) should be adopted. However, this would not negate the recommendation of a wider buffer prescribed within a specific locality or Coastal Zone Management Plan.*” Australian Wetlands (2012) also recommend prioritising waterway categories for riparian restoration works.

The *Tweed Vegetation Management Strategy* (Kingston *et al.*, 2004) provides a coordinated approach to the management of vegetation in the Tweed Shire. Development of the strategy included a number of tasks including:

- Ecological Assessment – including detailed vegetation mapping of the Tweed Shire, assessment of ecological status, sensitivity and threatened species;
- Assessment of soil and water resources - comprised a review of major issues affecting land degradation and water quality in Tweed Shire. It was determined that management of native vegetation through clearing controls and rehabilitation has an important role in protecting and enhancing soil and water resources. In particular vegetation on steep and unstable lands, riparian zones, coastal dunes and ASS should be considered a priority (Kingston *et al.*, 2004).
- Socio-economic evaluation- found that Tweed Shire is a rapidly urbanising centre with Tourism the biggest industry, with declines in primary and secondary sector industries. It was also suggested that given the low income base for the majority of rural land owners and the likely decreases in agricultural viability all levels of government should canvass positive incentives to assist rural and rural residential landowners to protect and manage remnant vegetation and riparian areas.
- Overview of Aboriginal values - indicated that despite major cultural disruption to the local Aboriginal community since European settlement, the region has a rich and continuing Aboriginal heritage.
- The Planning Assessment evaluated the level of protection provided by the current planning arrangements to remnant vegetation areas of differing ecological status
- Management and Rehabilitation Framework - provides some strategic direction and priorities in this area. Strategic approaches were outlined to identify ecological priorities for: 1) the recovery existing bushland areas; 2) restoration of previously cleared areas; 3) Threatened species recovery, 4) management of threatening processes and 5) education, monitoring, planning and research. A series of GIS databases were also produced for inclusion into the Council's GIS system; and
- Strategic Directions and Implementation Framework - involved the synthesis of the technical investigations, the development of goals and objectives, and review of the available tools and mechanisms for implementation.

The *Tweed Vegetation Management Strategy* provides an overriding approach to vegetation management and detailed background and vegetation mapping across the shire. Further work is required at a local level within the Tweed Coast Estuaries to build on this existing information so sites can be prioritised for management actions.

On-ground works to improve riparian zones in the study area have been undertaken by a number of different stakeholders including government agencies, property developers, Landcare Groups, and private

landholders. Most of the work is carried out on a case by case basis where landholders or groups are willing and funding is available. Other works have been undertaken by developers as part of the development approvals process. Examples of recent projects include:

- Cudgen Plateau Farmland Erosion Control Works – a demonstration project conducted by Richmond Landcare Inc. in conjunction with the NRCMA, DPI and landholders;
- Creek Bank Stabilisation Cudgen Creek - following on from recommendations of the Tweed Coast Estuaries Management Plan 2004-2008, TSC prepared a Creek Bank Stabilisation Plan for the northern bank of Cudgen Creek at Jack Julius Park which included riparian restoration;
- Cudgen Creek Recreation and Public Access Plan - Council commissioned this study following concerns for the sustainability of Cudgen Creek, which is under increasing pressure for greater use and access from a range of recreational activities. Strategies include revegetation of riparian areas to assist in stabilising banks.
- Cudgen Creek riparian zone restoration and management – works completed for riparian zone adjacent to the Salt Development subdivision south of Kingscliff.

These projects have been successful in improving riparian cover and condition and minimising erosion at the project sites.

### **Recommendations for Management**

Given the degraded nature of many of the riparian zones assessed as part of the *Baseline Ecosystem Health Assessment*, restoration works are needed if an improvement in riparian condition and function is to be achieved. A strategic approach to riparian rehabilitation across the Tweed Coast Estuaries and Catchments in accordance with the *Tweed Vegetation Management Strategy* is recommended.

Based on the findings of water quality, geomorphic and vegetation investigations undertaken during the preparation of this plan, a suite of minimum riparian buffer distances has been developed for the Tweed Coastal Creeks and catchments and their tributaries. To be consistent with the *Coastal Zone Management Plan for Cobaki Broadwater and Terranora Broadwater* it is recommended that:

- the minimum buffer distance to any waterway or wetland vegetation in the catchment is 10m. This will provide for filtering of runoff, increased bank stability and improved water quality;
- On agricultural land, increasing riparian buffers to a width of 30m will provide for effective filtering of runoff and accommodate bed and bank morphological change, as well as provide value as a wildlife habitat and corridors. It is recognised that buffers of this width will not be achievable in all cases, and that buffers will generally not be a uniform width along a stream reach. Wherever practically achievable, livestock should be prevented from entering natural waterways;
- In areas where development is proposed anywhere adjacent to estuary foreshores, a minimum 50m buffer is recommended; and
- The recommended buffer distance to rural land use in non-tidal sections of the creeks is 30m.

Generally, buffers should be fully vegetated with appropriate local native riparian species.

### 2.2.5 Bank Erosion

#### Description of Estuary Health Pressures

Bank erosion can lead to a range of environmental, social and economic problems such as the loss of riverfront property and infrastructure, damage and loss of cultural heritage sites, water quality degradation, destruction of natural and artificial levees, loss or destabilisation of native trees and the destruction of habitat and aquatic plants and animals. Water quality issues associated with erosion include high turbidity and the mobilisation and transportation of nutrients and contaminants associated with sediment from land to waterways.

The *Tweed Coast Estuaries Bank Erosion Study* (Appendix 3) assessed bank erosion and the level of current risk to built and natural assets. The underlying causes of erosion are natural processes which are exacerbated by human impacts in some areas (i.e. boat wash, uncontrolled access to foreshores, stormwater outlets and other structures). Eight sections of bank were identified as being 'high risk' bank erosion sites where significant assets were under threat. These sites have been prioritised for management. Figure 20, Figure 21 and Figure 22 show the location of the bank erosion risk assessment for Cudgen, Cudgera and Mooball Creeks respectively.



Figure 20: Cudgen Creek Bank Erosion Risk (refer Appendix 3 for further details)



Figure 21: Cudgera Creek Bank Erosion Risk (refer Appendix 3 for further details)



Figure 22: Mooball Creek Bank Erosion Risk (refer Appendix 3 for further details)



No.	Bank Erosion Pressures
P19	Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.
Related pressures discussed in other sections:	
P17	Bank erosion can destabilise riparian vegetation.
P24	Unrestricted stock access causes vegetation damage and bank erosion.
P35	Bank erosion has potential to impact public access points to estuary foreshore areas by undermining and destabilising structures such as stairs and walkways.

### Potential Management Options

The selection of management options to address bank erosion is highly dependent on the nature of erosion, the location of the site and the values to be protected. Where erosion presents a significant risk to built assets that cannot be easily relocated, structural engineering options for erosion control such as rock revetment works and groynes may be considered. Where possible, the relocation of assets such as stairs and structures that are deemed at immediate risk may be the most practical alternative. Where significant natural assets are threatened, consideration of remediation works will need to consider the impact of intervention works on natural site values against the threat of allowing natural processes to proceed. Restoration of vegetation and providing formalised access points to the estuary are management options to increase the resilience and strength of banks to prevent or minimise erosion. In some cases monitoring of sites to better assess the rate of recession and level of risk may be the most appropriate action prior to any major commitment to capital expenditure by Council or other land managers.

### Status of Existing Management in the Tweed Coast Estuaries

The *Tweed Coast Estuaries Bank Erosion Study* categorised the condition of banks in each estuary including the length of banks in each estuary that had some type of bank erosion controls in place. The majority of erosion controls were located in the lower reaches, in the form of rock revetment along estuary banks. Formalised access to foreshore areas was provided at many locations, particularly within public parks and reserves. Specific sites have been targeted for bank stabilisation works and provision of formalised access points in recent years including the northern bank of Cudgen Creek at Jack Julius Park and works associated with the Casuarina, Salt and Seaside developments.

In terms of planning controls related to bank erosion, many of the provisions of the Tweed Shire DCP regarding the protection of riparian buffers (discussed in Section 2.2.4) will also assist in reducing the risk of bank erosion, both on natural and built assets. The requirement for a 50m buffer on all major waterways will allow for natural channel meandering without risk to new development areas and will increase the resilience of vegetation communities to respond to changes. While planning controls offer a means to avoid future risks due to bank erosion, they will not change the current level of risk posed by existing bank erosion to assets located in close proximity to eroding estuary banks. Management action is required at identified high risk sites as described in Appendix 3.

### Recommendations for Management

- The high risk bank erosion sites have been identified by the *Bank Erosion Study* (Appendix 3). Due to the potentially high costs involved with protection works, the next logical step in addressing bank erosion involves some strategic planning to confirm risks, determine priorities between the high risk sites, and investigate cost effective methods for works. The bank erosion planning should consider and expand upon the management recommendations detailed in the *Bank Erosion Study*.

### 2.2.6 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are acidic and sulfur rich soils found within the floodplain of coastal areas generally below RL 5m AHD. Potential Acid Sulfate Soils (PASS) is the common name given to soil and sediment containing iron sulfide (usually pyrite). They can become Actual Acid Sulfate Soils (AASS) and produce sulfuric acid if they become exposed to air through excavation or lowering of the water table. The majority of ASS problems in NSW are caused by historical drainage of former backswamp wetlands, and most backswamps are now artificially drained for agriculture (Tulau, 2002).

#### Description of Estuary Health Pressures

ASS runoff impacts on the estuarine environment include low pH, high concentrations of dissolved iron, aluminium and other metals (ABER, 2008). Exposure to ASS runoff can impair gill function and increase susceptibility to disease in fish. Additionally, initial flushes of floodwaters in ASS environments can mobilise large amounts of monosulfidic black ooze (MBO) from drain sediments which can cause local hypoxia events. Major negative implications of ASS impacts include fish kills and major aquatic habitat changes, reduced plant growth (acid scalds), and corrosion of concrete, iron and steel structures.

ASS have been classified and mapped as part of the TSC Local Environment Plan (LEP) (2000). Figure 23 shows that there are large areas of Class 1, 2 and 3 ASS occupying the majority of the floodplain within Cudgen, Cudgera and Mooball Creek catchments. Most of these areas have been extensively modified by drainage systems to allow for agricultural use, particularly sugarcane cropping.

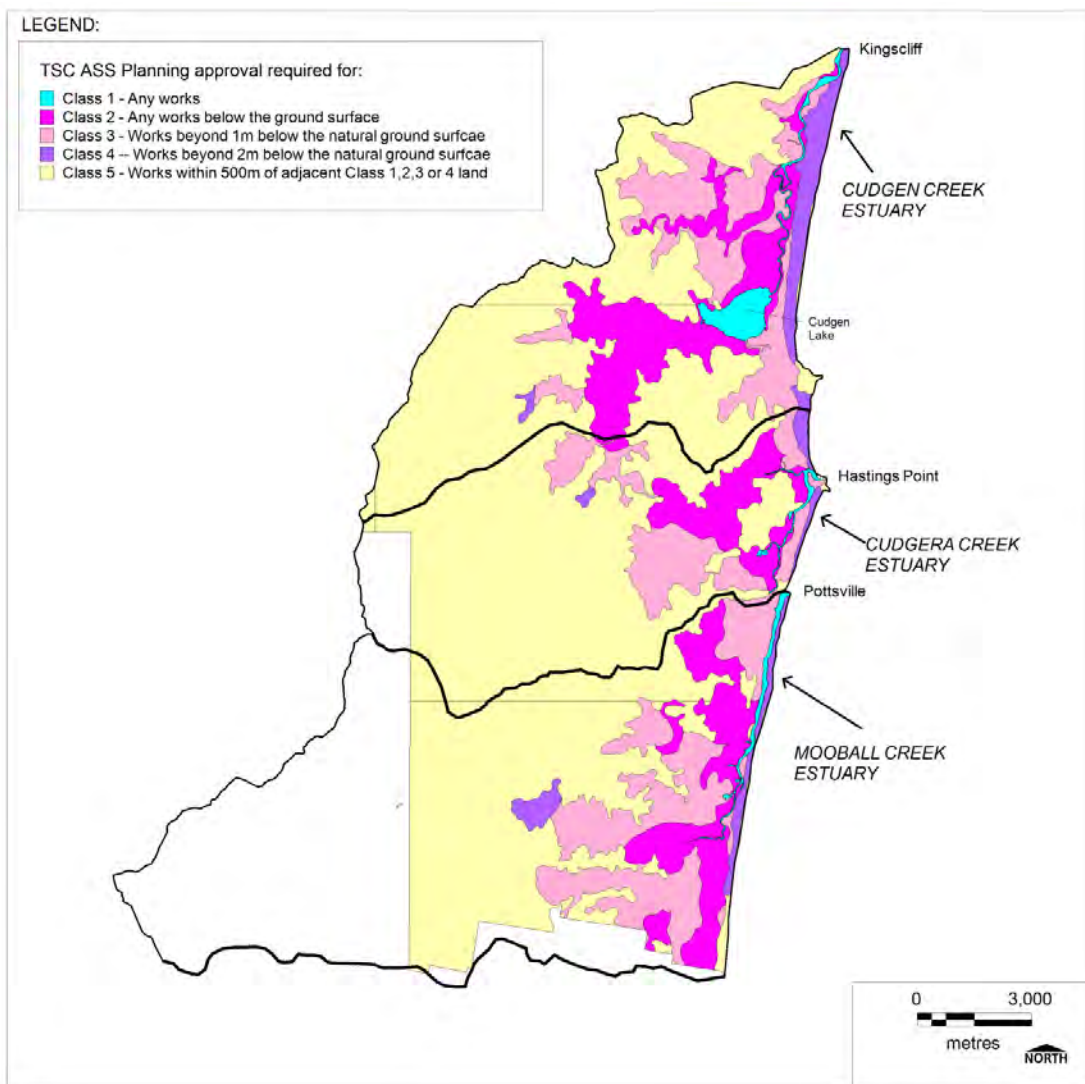


Figure 23: TSC Acid Sulfate Soil mapping for the Tweed Coast Estuaries' catchments

In a previous state-wide study of ASS (Tulau, 1999), three priority areas for the management of ASS in the Lower Tweed Floodplains were identified. Cudgen Lake and its tributaries Clothiers Creek and Reserve Creek was the high priority area identified by Tulau (1999) within the Tweed Coast Estuaries catchments. Water quality data reviewed as part of the *Baseline Ecosystem Health Assessment* (Appendix 4) found that the mid and upper estuary of Cudgen Creek is periodically affected by low pH, particularly following rainfall events and this is likely to be a result of ASS issues in this area.

More recently, the Christies Creek floodplain (a tributary of Cudgera Creek) was identified as an acid sulfate area requiring management (Kinsela *et al.* 2009). Christies Creek has experienced fish kills, heavy iron flocs and arsenic concentrations exceeding ANZECC (2000) water quality guidelines which have all been linked to ASS (Kinsela *et al.* 2009). The source of the arsenic and indeed other contaminants identified in the catchment (iron and aluminium) is the underlying ASS (Collins *et al.*, 2012). Further investigation revealed that the arsenic was not bio-available and therefore not a risk to people or the environment (Kinsela *et al.* 2009).

Although large areas of the Mooball Creek floodplain are mapped as high risk ASS, and past studies have noted previous disturbance of ASS resulting in acidic waters entering Mooball Creek (WBM, 1997), no specific areas have been identified for management to date.

Cudgen Lake (Clothiers and Reserve Creeks) has experienced large fish kills which are believed to be linked to rain-induced discharges from oxidising ASS in the catchment (MacDonald *et al.*, 2004).

A significant management issue for agencies and landowners and currently affecting the Cudgen catchment is a large accumulation of fallen trees and debris that have formed a log jam in a channelized reach of Clothiers Creek, just upstream of Cudgen Lake. This debris is reported to have significantly restricted flows of receding floodwaters into the lake, leading to prolonged inundation of crops and pasture. Landowners and the Clothiers Creek Drainage Union are working with Council and State Government agencies to resolve this issue. Land tenure, planning and environmental regulations, difficult access, prolonged wet weather and the potential cost of works make this issue very complex, and this CZMP does not seek to recommend a management 'solution' to this specific problem. It is however essential that the environmental implications of this drainage restriction and its relationship with ASS management be acknowledged.

The impact of the drainage restriction (confirmed by TSC water level monitoring) is that flood waters are remaining on low lying pasture and crop land for longer periods than has recently and typically occurred in this catchment. Recent investigations by the University of NSW (Collins *et al.*, 2012) have shown that this is leading to an increase in the potential for creation black water events. Blackwater events occur when bacterial decomposition of pasture (killed by inundation during floods) strips dissolved oxygen from overlying waters. When this water flows into drains and creeks it displaces existing water containing dissolved oxygen, and fish kills can occur.

On this basis, there is an environmental justification for supporting removal of the drainage restriction. However, it has also been established that prolonged inundation of drains and ASS further upstream in the catchment (in paddocks south west of the Clothiers Creek Road/highway roundabout) reduces the potential for further oxidation of ASS in these areas, and therefore restricts the potential discharge of more toxic levels of dissolved iron and aluminium to Clothiers Creek and Cudgen Lake. Physical works involved in removal of the drainage restriction could also mobilise significant quantities of monosulfidic black ooze (MBO), which also has the potential to severely deplete dissolved oxygen levels and cause fish kills.

Removal of the drainage restriction upstream of Cudgen Lake should not be considered in isolation from broader catchment hydrology and impacts on ASS management. Ideally, drains in the upper part of the Clothiers and Reserve Creek catchments should be rehabilitated before the drainage restriction is removed. Care will be required if works to remove the drainage restriction are undertaken so any that MBO's are not mobilised.

No.	Acid Sulfate Soil Pressures
P21	Acid sulfate runoff negatively impacts overall estuarine ecosystem health. Impacts include fish kills and major aquatic habitat changes, reduced plant growth (acid scalds), and corrosion of concrete, iron and steel structures.
P22	Historical drainage of former backswamp wetlands are the main cause of ASS problems as they facilitate the exposure of ASS to oxygen, which produces acid runoff.
Related pressures discussed in other sections:	
P23	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.

### Potential Management Options

There are existing local planning controls and state-wide management guidelines and for the management of ASS:

- Local Environmental Plans. The land use controls in LEPs are a key regulatory mechanism to ensure the sustainable management of acid sulfate soils in the coastal zone. The zoning and development control provisions in LEPs provide local councils with the opportunity to ensure that land uses are carried out in an appropriate manner and that any intensification of land use does not pose unacceptable risks to the environment. The DLWC has prepared ASS Risk Maps which have been converted into Acid Sulfate Soil Planning Maps for use with LEPs (refer Figure 23 above).
- The NSW *Acid Sulfate Soils Planning Guidelines* (Stone and Hopkins, 1998) provide advice on preparation of ASS provisions in LEPs and provides links to other guideline documents.
- The *Acid Sulfate Soils Manual* (Stone *et al.*, 1998) provide information on the formation of acid sulfate soil, the likely effects if it is to be disturbed and best practice in the assessment and management of works undertaken in acid sulfate areas.
- *Restoring the balance - guidelines for managing floodgates and drainage systems on coastal floodplains* (Johnston *et al.*, 2003)

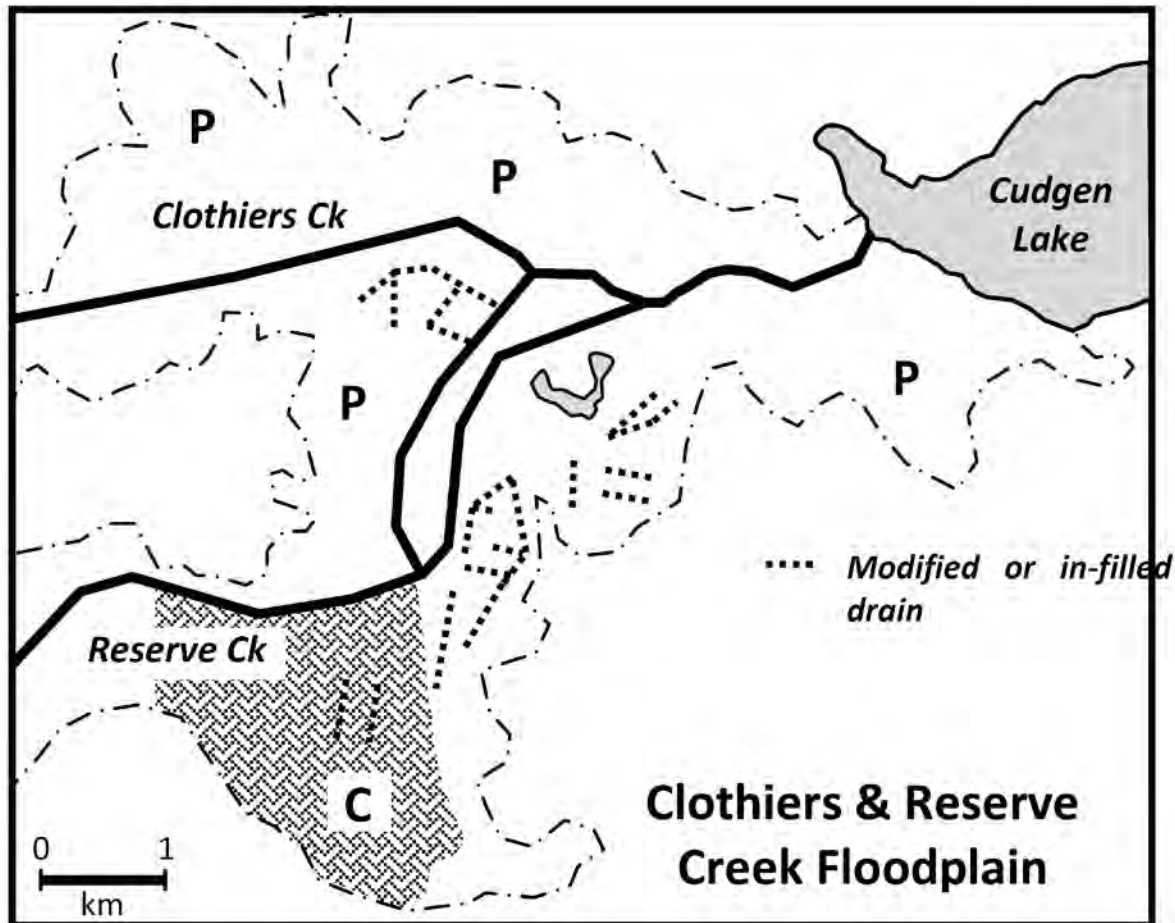
Understanding of acid sulfate soil chemistry and its effects has increased rapidly in recent years, but there is still much to be learnt about management and rehabilitation of these soils. Management actions generally seek to manage ASS by reducing the exposure of pyrite within the soil profile to air. The NSW DPI (2004) summarise management solutions into the following categories:

- Avoidance: The best technique for managing acid sulfate soils is to avoid disturbing or draining the iron sulfide layer in the first place. Iron sulfides are harmless while covered by water.
- Recognition: It is useful to know what the iron sulfide layer looks like so that if it is uncovered accidentally it can be re-covered with water immediately.
- Liming: Sulfuric acid can be neutralised with agricultural lime, but this is too costly for large areas of badly affected land. One technique that has had good results to date is liming of drains so that the sulfuric acid produced in the drain walls is neutralised by the lime as it is washed out. Acid water can also be neutralised by lime.
- Water cover: Covering land with water to prevent further oxidation may be one solution for badly affected areas where the land is scalded. The water cover encourages the growth of acid-tolerant grasses such as water couch and provides drought pasture for stock. However, it is important that the water remains on the affected area; if it evaporates the soil will oxidise again.

- Shallow drainage: Wide, shallow drains like the one shown below allow surface water to drain quickly from the surface of low-lying land without exposing the iron sulfide layer beneath the soil. Deep, narrow drains are more likely to expose the iron sulfide layer and leak sulfuric acid into waterways.

**Status of Existing Management in the Tweed Coast Estuaries**

- Under Clause 35 of the Tweed Shire LEP, a person is required to obtain development consent to undertake works on land shown as being Class 1,2,3,4, or 5 on the Acid Sulfate Soil Planning Map (Figure 23). Satisfactory neutralisation of the disturbed ASS by application of agricultural lime is generally required for development consent to be issued.
- Clothiers and Reserve Creek Floodplain (Cudgen Lake) has been the subject of previous research and remediation studies including the NSW Environmental Trust ASS Hot Spot Remediation Program (2000- 2004). Remediation works included modification and in-filling of approximately 6 km of drains in the upstream floodplain and almost 11,000 m<sup>2</sup> of severely degraded ‘acid scald’ being remediated (refer Figure 24). Despite significant remediation works water quality problems and fish kills continue to occur within Cudgen Lake (Collins, *et al.*, 2012).



**Figure 24: Previous remedial work undertaken in Clothiers Creek/ Reserve Creek. Catchment boundaries are denoted by the dot-dash lines. (Source: Collins *et al.*, 2012)**

Tweed Shire Council in partnership with NSW Cane Growers Association, NSW Sugar Milling Co-operative, private landholders and researchers at University of NSW have undertaken remedial works and field research within the Tweed Coastal Creeks Catchments in recent years. The work has been conducted under the Australian Research Council (ARC) Linkage project LP110100480 ‘Exploiting Natural Processes to Effectively Remediate Acidified Coastal Environments’ which commenced in 2011 and is continuing.

Christies Creek has been targeted for remedial works. Remedial work has been undertaken at a site within the Christies Creek catchment with a view to minimising aluminium discharge in drain waters. Remedial works undertaken in August/September 2011 included limited drain shallowing in one of the major drains, improvements to the drain batters and a liming trial at 1 and 2 tonne(s)/acre (to increase soil pH). Results of monitoring of the site to assess any changes are expected in early 2013 (Collins *et al.*, 2012).

### Recommendations for Management

- The existing planning provisions for ASS management contained in the Tweed Shire LEP and related policies are considered to be suitable for managing potential impacts resulting from future development work in known ASS areas.
- There are a number of sites within the Tweed Coast Estuaries study area with known ASS issues and remediation works are required to mitigate adverse impacts. The current remediation trials underway in Christies Creek Catchment aim to provide information on the viability of various options to address ASS issues in the Tweed Coastal Creeks. Future management should build on the results of these trials and look to wider implementation of successful remediation techniques for remaining hot spot areas in the Tweed Coastal Creek Catchments.
- Council investigate all available incentive and regulatory options to expedite remediation of the high priority ASS hotspots in the upper part of Cudgen catchment, and that these works be undertaken prior to removal of the existing drainage restriction, upstream of Cudgen Lake.
- In order to direct management effort in areas where it will produce the best results for overall estuary health, it will be necessary to identify and prioritise key sites for remedial works. An initial prioritisation study is required with on-ground monitoring to confirm high acid export areas.

### 2.2.7 Agriculture

Agriculture is an important contributor to the local economy and is a key component in the social fabric of the region. Approximately 60% of the Tweed Coast Estuaries study area is used for various forms of agricultural use, with grazing and sugarcane cropping comprising the largest land area (refer Appendix 5). Management of these lands has a large bearing on future outcomes for estuarine values.

#### Description of Estuary Health Pressures

Agricultural land use and some management practices are identified as one of the major causes of poor water quality in the catchment and contribute to a broad range of issues in the estuary. Addressing the impacts of agricultural land use on downstream waterways, while continuing to enhance the local economy and protecting rural lifestyles, is one of the biggest challenges facing long-term management of the estuaries.

Key issues relating to agricultural land management are discussed below. Details on related issues are discussed in Section 2.2.6 (Acid Sulfate Soils), and Section 2.2.4 (Riparian Vegetation) where farm related practices have a large influence.

- Sediment and nutrient runoff. Water quality data from the estuaries indicate that nutrient levels can be high and algal blooms occur periodically (refer Section 2.1.2). The observed high contribution of bio-available nitrate and ammonium along the creeks may be coming from a variety of agricultural and urban inputs (ABER, 2012). Excessive fertiliser use, poor timing of fertiliser application, high stock loading rates and poor riparian zone management are all agricultural practices which can increase the nutrient run-off rates from rural areas (TSC, 2007). The *Tweed Coast Estuaries Management Plan 2004-2008* identified the Cudgen Plateau vegetable growing area as a key source of sediment and nutrient to the Cudgen Creek Estuary.
- Chemical runoff. The use of agricultural chemicals in the catchment and subsequent runoff is a potential issue, although ever-increasing regulation of the industry has greatly reduced the risk of

widespread contamination, community concern about the potential for contamination remains. Sediment contamination testing throughout the estuaries did not detect significant contamination issues, however two sites in Mooball Creek were identified for further investigation through minor exceedences of sediment guidelines.

- Stock access to waterways. Allowing stock to access waterways is a common farming practice which alleviates the need to provide off-stream watering and allows stock access to fresh feed and shade within the riparian margin. Stock usually gain access to waterways through unfenced creek boundaries, often in areas where riparian vegetation has been cleared to the water's edge. Sediment loads into the estuary are likely to have increased in response to grazing pressures in the catchment. Bank instability and high grazing pressure prevents re-establishment of native riparian vegetation in cattle impacted areas and results in increased weed infestation of riparian zones. Cattle urinate and defecate directly in the water, hence creating direct sources of nutrients and faecal contamination which is borne downstream to the estuary.

No.	Agriculture Pressures
P23	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.
P24	Unrestricted stock access causes vegetation damage and bank erosion.
Related pressures discussed in other sections:	
P19	Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.
P22	Historical drainage of former backswamp wetlands are the main cause of ASS problems as they facilitate the exposure of ASS to oxygen, which produces acid runoff.
P12	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary.
P13	Lack or poor condition of riparian vegetation compromises habitat connectivity and habitat value (both in-stream and terrestrial habitat).
P14	Lack of suitable buffer zones between land use and waterways limits riparian zones.

### Potential Management Options

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

There is a great variety of existing guideline documents for sustainable agricultural land management. NSW DPI Agriculture provides a range of accessible resources on best practice farming including advice on farm environmental management systems, conservation farming and farm chemical management. Industries bodies such as Canegrowers Australia provide a number of best management practice guidelines to promote sustainable sugarcane production (Schroeder *et al.*, 2008).

LEP land zonings for rural land have certain provisions about the type of activities permitted within zones, but day to day management practices are managed by landowners. Provision of educational resources, research trials of remediation methods and providing incentives to change unsustainable practices may result in reduced impacts, but implementation is ultimately up to the individual landholders.

Investigation of alternative land use options for agricultural land offers a strategic approach to management on a catchment wide basis. At some locations a cost benefit analysis of existing agricultural land use against potential alternatives such as lower impact crops, alternate uses and buy back of land parcels for environmental services would allow the social, environmental and economic costs to be weighed up and compared. Such investigations may identify areas where alternative land use presents better outcomes for the health of catchments and estuaries, and acceptable incentives for private land holders to make the change. An example may be areas of known ASS, where farming practices are limited and environmental impacts from management practices (e.g. existing drainage systems) can be severe on sensitive receiving environments and downstream areas valued for recreation. Alternative options for this land may be to restore a natural floodplain hydrology by filling in drains and reinstating natural vegetation adapted to floodplain conditions. It is expected that these actions would remove many of the pressures on estuary ecosystem health such as ASS runoff, and nutrient and sediment export and improve the condition and function of the downstream estuaries. The value of environmental and social returns may outweigh the current benefit derived from limited agricultural use. Incentives could include buy back and/or long term stewardship payments or other compensation programs. Properties bought back would require ongoing management by a Government department, agency, community group or Non-Government Organisation (NGO). Another option is voluntary purchase and resale with a conservation covenant attached, such as the NSW Nature Conservation Trust covenant program.

### **Status of Existing Management in the Tweed Coast Estuaries**

The *Tweed Shire Community Strategic Plan 2011- 2021* identifies a need to foster a viable farming community and improve the environmental capacity of Tweed farmland. Tweed Shire Council is committed to meeting these objectives through its Sustainable Agriculture Program, with support from the Tweed River Committee, Tweed Coastal Committee and state agencies. A Sustainable Agriculture Strategy is currently being prepared that will identify actions and delivery pathways that support, now and for the future, a healthy natural resource base, a strong farming community and a resilient agricultural economy (Mongard, 2011). One of the long-term strategy outcomes is to *“Enhance environmental quality and the natural resource base which underpins the agricultural economy”*.

On-ground agricultural activities and day to day management practices in the Tweed Coast Estuary catchments are managed by private landholders. Tweed Shire Council has been involved with private landholders, research partners and government agencies in projects aimed at investigating and improving land management practices for better environmental outcomes within the Tweed Coast Estuaries study area. Examples include:

- Cudgen Plateau Farmland Erosion Control Works – a demonstration project conducted by Richmond Landcare Inc. in conjunction with the NRCMA, DPI and landholders; and
- ASS research and management trials in Clothiers and Reserve Creek Floodplain (Cudgen Lake), and Christies Creek (discussed in Section 2.2.6).

### **Recommendations for Management**

- Preparation of the Sustainable Agriculture Strategy should include actions for the Tweed Coast Estuary Catchments to improve water quality and ecosystem health of waterways and particularly downstream estuarine reaches. The aims of the Strategy are consistent with this CZMP.
- Recommended management for ASS described in Section 2.2.6.



- A cost benefit analysis of alternative land use options for some areas of agricultural land use is recommended as a strategic approach to long-term land management in the catchments. Benefits are likely to be most pronounced in areas where agriculture is marginal, environmental impacts are evident and simple hydrological modifications and/or land use change could facilitate significant environmental benefit.

### 2.2.8 Urban Development and Stormwater

#### Description of Estuary Health Pressures

Urbanisation can affect estuarine processes through:

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

Stormwater runoff can significantly affect water quality by transporting and discharging contaminants, particularly nutrients and suspended sediments, but also pathogens, oxygen-demanding substances, hydrocarbons (oils and surfactants), toxicants including pesticides, herbicides and heavy metals, litter and vegetative debris. Algal blooms created by excessive nutrient concentrations in waterways can be harmful to aquatic organisms due to the consumption of dissolved oxygen as a bloom decomposes; or due to toxins produced by some algal species. Urban runoff can impact receiving waterways through water quality decline and modified hydrology leading to declines in habitat values such as seagrass health and cover, aquatic ecosystem health, visual amenity of waterways and the suitability of water for recreational activities involving human contact. Water quality monitoring has detected that diffuse nutrient sources related to agricultural and urban land use are likely to contribute to the high load of bio-available nitrate and ammonium along the estuaries (ABER, 2012).

The *Tweed Coast Estuaries: Catchment Modelling Report* (Hydrosphere Consulting, 2012 – Appendix 5) has shown that future urban development within the Tweed Coast Estuary catchments has the potential to increase nutrient and sediment loads to these waterways. Without appropriate mitigation, most of the urban development planned within the study area is likely to increase contaminant loads. This is particularly true during the construction phase for such projects, where estimated contaminant loads could be significantly greater. The outcomes of this study indicate that significant algal blooms are presently occurring and the risk of more frequent, more widespread or more severe blooms is likely to increase with urban development without suitable stormwater control measures in place. However, if developers were able to meet the pollutant reduction targets set out in the Tweed Urban Stormwater Quality Management Plan (Australian Wetlands, 2012); and maintain the treatment efficiency of stormwater devices in the long-term, the modelling indicates that pollutant loads delivered to the estuaries would not increase from the existing modelled situation.

While the modelling indicates that stormwater mitigation is achievable, it is important to note that these results are for a fully developed urban case, with stormwater improvement devices operating at optimum efficiency. In real life situations, achieving and maintaining the load reduction targets relies on a number of factors. It is recognised that it may take some time for subdivisions and stormwater improvement devices to reach optimum efficiency. The long-term success of stormwater control devices is also dependant on adequate maintenance of stormwater improvement devices. The asset manager (usually Council) will need to allocate sufficient on-going resources to implement an adequate maintenance schedule for the long-term achievement of stormwater quality objectives.

The catchment model identified the construction phase of developments as the highest risk for nutrient and sediment export. Minimising the total area of land in a construction phase at any one time and implementing adequate erosion and sediment controls will be critical in reducing the risk to water quality in downstream waterways.

No.	Urban Development and Stormwater Pressures
P25	Large areas of the Tweed Coast Estuaries study area are planned to be developed into urban areas.
P26	Stormwater runoff from urban areas can increase contaminants, litter, nutrients and sediment loads to the estuary.
P27	The Tweed Coast Estuaries are already under existing pressure from agriculture and urban land use and without adequate mitigation, further urban development may add to these pressures.
P28	Urbanisation can affect hydrologic characteristics through increases in impervious surfaces and by increasing the rate of delivery of catchment runoff to downstream waterways.
P29	The construction phase of urban development poses the highest risk to water quality of receiving environments.
Related pressures discussed in other sections:	
P14	Lack of suitable buffer zones between land use and waterways limits riparian zones.
P47	Poor water quality impacts the amenity of waterways and may present health concerns for swimmers.
P30	High levels of faecal indicator bacteria were identified at sites downstream of Mooball and Burringbar villages indicating either failing OSSM or pollution from surface runoff.
P32	There is a risk that natural upslope migration of estuarine habitats due to sea level rise will be curtailed by anthropogenic constraints (roads, agriculture, urban development etc.).
P33	Sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure and bank erosion.

### Potential Management Options

Urban stormwater management is required to both reduce impacts caused by existing urban developments and to provide long-term management strategies that will satisfy the needs of an expanding population while ensuring environmental sustainability.

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

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

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

### Status of Existing Management in the Tweed Coast Estuaries

Council is actively involved in the management of urban stormwater through a variety of projects, programs and policies including Council's Urban Stormwater Management Plan and Tweed Shire Development Control Plan.

The Tweed Urban Stormwater Quality Management Plan (Tweed USQMP) was adopted by Council in 2000 in response to the Notice issued to all NSW local councils by the Environment Protection Authority (now OEH) under Section 12 of the *Protection of the Environment Administration Act, 1991*. A review of the 2000 plan was undertaken in 2011/12 and the revised Tweed USQMP is currently in Draft format (Australian Wetlands, 2012). The revised plan aims to:

- Confirm Council's stormwater management objectives,
- Provide ambient and stormwater quality objectives,
- Insist on the use of best practice design guidance available to the industry, and
- Provide specific and measurable guidance for monitoring and maintenance of stormwater quality improvement devices (SQIDs).

Tweed Shire Council Development Design Specification D7 – Stormwater Quality is the policy specification that prescribes stormwater quality measures to be adopted for development requiring consent under the *Environmental Planning and Assessment Act 1979*. This specification details the information relating to stormwater quality required to accompany development applications and construction certificate applications. This specification complements the Tweed USQMP by detailing stormwater objectives/standards and prescribed stormwater management measures that comply with the Tweed USQMP and contemporary best practice. The stormwater objectives provided in this specification apply to new development in the Tweed Region unless there is a catchment specific stormwater objective provided in the Tweed USQMP.

In relation to the design and management of Stormwater Quality Improvement Devices (SQIDs), the updated Tweed USQMP aims to ensure the following (Australian Wetlands, 2011):

- Stormwater design and maintenance is always consistent with current best practices; and
- All stages of SQID implementation, including the planning, design, construction, performance monitoring and asset handover phases, are conducted with consultation between the applicant and Council.

The USQMP recommends the implementation of a SQID design and management process consistent with the Water by Design program of the South East Queensland Healthy Waterways Partnership.

Recent on-ground works within the Tweed Coast Estuaries include installation of SQIDs on stormwater outfalls discharging into Cudgen Creek at Kingscliff. Works were completed with financial assistance from Environment Australia.

Catchment Modelling was undertaken for the Tweed Coast Estuaries catchments as part of this CZMP (refer Appendix 5).

### Recommendations for Management

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

The following recommendations were derived from the *Catchment Modelling Report*:

- Management of future urban development in the Tweed Coast estuary catchments should aim to ensure water quality standards are achieved and importantly, that construction phase impacts are

mitigated through application of best practice erosion and sediment controls. Council has indicated that erosion and sediment controls during construction is an aspect of urban development that does not currently attract a level of compliance monitoring sufficient to guarantee optimum performance. This is a key area for improvement.

- TSC should consider the incremental risk of concurrent multiple developments or large scale development on the risk to estuary health and assess cumulative impacts on a case-by-case basis. It may be appropriate to alter the phasing of projects or to introduce additional water quality and hydrological controls to large scale or concurrent developments;
- Ensure that TN, TP and TSS are equally considered in catchment management strategies as these factors all contribute to estuarine degradation;
- A review of the long term TSC water quality monitoring program is recommended to ensure adequate assessment of system health; and
- Providing OEH can satisfactorily rectify the hydrology issues identified in the CERAT Estuary Response Module for the Tweed Coast Estuaries, the estuary model could be used to provide more detailed results on how the ecological response components respond to the retained TN exports

### 2.2.9 Wastewater Management

The majority of urban areas within the Tweed Coast Estuaries study area are connected to Council's centralised wastewater management system. The villages of Mooball and Burringbar are the only exception, however the Mooball- Burringbar wastewater treatment plant (WWTP) is currently under construction and will provide centralised wastewater treatment for the villages. All other dwellings in the catchments are in rural and rural residential areas which rely on on-site wastewater management systems such as septic systems, composting toilets, aerated wastewater systems, pump-out systems and grey water treatment systems.

#### Description of Estuary Health Pressures

There are no WWTP discharges to any of the Tweed Coast Estuaries at present. The Hastings Point WWTP is located within the Cudgera Creek catchment, but its discharge location is a dune injection system behind the beach north of Hastings point (outside the estuary catchment). Australian Wetlands (2003) reported two instances of the WWTP effluent overflowing to Christies Creek during extreme weather events in 2001. Subsequent upgrades of the plant and increased storage capacity have improved operation and no overflows have been recorded since 2001.

On-site wastewater management systems are an acceptable wastewater solution provided the wastewater is contained and disposed of effectively on-site. If wastewater seeps from the property it can pollute surrounding soils, waterways or groundwater, exposing the community to environmental, public health and amenity risks. The analysis of water quality monitoring data for the Tweed Coast Estuaries showed high levels of thermo tolerant coliforms (faecal indicator bacteria) at Burringbar Creek sites downstream of Burringbar and Mooball Villages. There was a clear trend identified where spikes in faecal indicators followed rainfall events (refer Appendix 4). The two likely sources of faecal contamination were identified as surface runoff transporting animal faeces (livestock, pets and native animals), and potentially failing (or surcharging) wastewater management systems in this area.

No.	Wastewater Management Pressures
P30	High levels of faecal indicator bacteria were identified at sites downstream of Mooball and Burringbar villages indicating either failing OSSM or pollution from surface runoff.
Related pressures discussed in other sections:	
P47	Poor water quality impacts the amenity of waterways and may present health concerns for swimmers.
P33	Sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure and bank erosion.

### Potential Management Options

Centralised wastewater management for urban areas is best practice for management of wastewater and to minimise risk of contamination of the environment. Residential areas should be connected to reticulated wastewater systems wherever possible.

Environment protection licences are the central means to control the localised, cumulative and acute impacts of pollution in NSW although they are only applicable to point sources. Responsibility for management of WWTP discharges remains with Council, regulated by the Environmental Protection Agency (EPA) under the *Protection of the Environment Operations Act, 1997*. This includes options for reuse of treated wastewater.

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

### Status of Existing Management in the Tweed Coast Estuaries

Sewerage systems (including WWTPs and overflow structures) are managed by TSC and regulated by the EPA through Environment Protection Licences (under the *Protection of the Environment Operations Act, 1997*) held by Council.

The *On-site Sewage and Wastewater Management Strategy* (TSC, 2002) details Council's approach to the supervision of wastewater management systems in the Tweed Shire. The *Local Government Act* requires landowners to obtain Council approval to operate their on-site wastewater management systems and to maintain and operate their systems to standards protecting public health, the environment and community living. The Act gives local councils the responsibility to issue approvals to operate and to monitor all systems to ensure they meet the standards.

The objectives of *Council's On-Site Sewage and Wastewater Management Strategy* are:

- Prevention of public health risk;
- Protection of environmental health; and
- Conservation and reuse of resources.

The Strategy describes the risk assessment and inspection program and performance standards for on-site systems. Inspections are undertaken for the purposes of Section 68 approvals to operate, install or upgrade, pre-purchase inspections and follow-up repairs/complaints/investigations. The frequency of inspections depends on the risk category:

- Low Risk - Inspection every 6 years;
- Medium Risk - Inspection every 4 years; and
- High Risk - Inspection every 2 years.

The risk assessment is based on flood potential, exposure/aspect, slope, distance to waterways, property area, soil type, type of effluent disposal and health, environmental and community amenity hazards

(determined from a desktop audit and site audit). Quarterly reports are provided to Council summarising the inspections undertaken and the number of failing systems.

**Recommendations for Management**

- Reduction of point source pollution such as nutrients and faecal coliforms from wastewater management systems is consistent with the aims of the CZMP. As these activities are managed and regulated by existing administrative processes, it is proposed that these activities continue outside but complimentary to the CZMP process, while ensuring consistency with the CZMP.
- A direct recommendation coming out of the *Baseline Ecosystem Health Assessment* is to continue to monitor water quality downstream of Burringbar and Mooball villages to assess whether the centralised sewage system has been effective in improving water quality in the waterways. If an improvement in health is not apparent, further investigation into the causes of water quality decline should be investigated.

**2.2.10 Litter**

**Description of Estuary Health Pressures**

There are general community concerns regarding the impact of litter on fauna and the continued safe use and enjoyment of the estuaries. Types of litter that has been identified as of concern includes:

- Discarded fishing materials (e.g. hooks, fishing line and bait bags);
- Marine debris washed into estuaries (e.g. plastics and bottles);
- General litter dumped in and around the estuary foreshores;
- Dumping of household rubbish along the coast road and vehicle tracks adjacent to the estuaries (e.g. fridges and TVs); and
- Garden waste, dumped from adjacent residential areas which can facilitate the spread of weeds into estuarine habitats.

Not only does litter and dumped waste decreases the visual amenity of the estuaries and foreshore areas, but these have been a number of instances where wildlife such as birds, have been injured or killed due to entanglement or ingestion of litter such as fishing line and hooks.

Undertake an education program targeting the impacts of discarded fishing materials (e.g. hooks and fishing line) and general litter including plastics on sea birds and marine life generally.

No.	Litter Pressures
P31	Litter and dumped waste decreases the visual amenity of the estuaries and foreshore areas and poses a risk to wildlife.
Related pressures discussed in other sections:	
P10	Threats to coastal raptors include habitat loss and degradation, human disturbance to breeding, entanglement and ingestion of fishing line, tackle and pollutants, reduced water clarity, reduced fish health and availability and collision with power line and vehicles.
P26	Stormwater runoff from urban areas can increase contaminants, litter, nutrients and sediment loads to the estuary.

### Potential Management Options

Any program designed to minimise littering in the community must include a mix of approaches. An integrated approach to litter prevention is likely to be the most effective method of tackling the litter problem in our communities. Integrated approaches include education, regulatory and enforcement strategies, and adequate provision of highly visible and accessible means of disposal.

### Status of Existing Management in the Tweed Coast Estuaries

Littering is illegal under the *Protection of the Environment Operations Act, 1997* (POEO Act) and a range of fines are enforceable under the Act. The Australian Government has conducted a number of public education programs to raise awareness about the environmental impacts of littering and the notion of personal responsibility. Examples of recent and on-going campaigns are:

- ‘Don’t be a Tosser’ focussing on littering from vehicles. All local Councils received ‘Don’t be a Tosser’ campaign resource kits to support local anti-littering programs;
- The ‘Clean Up Australia’ campaign which provided funding for two community-based litter prevention projects, one focusing on beach litter prevention and the other on school litter prevention;

TSC continues to implement a number of waste management initiatives, through the promotion of waste avoidance, reuse and recycling. Council provides public garbage bins at many estuary foreshore sites.

### Recommendations for Management

Measures which address the specific pressures identified for the Tweed Coast Estuaries would include:

- Public education on responsible behaviour and the impacts of personal behaviour. This includes:
  - public education campaign around the damage caused to wildlife due to litter using local examples to illustrate these impacts;
  - correct use and disposal of litter, fishing line and tackle to avoid ingestion or entanglement of wildlife;
  - the flow-on effects of dumping household and garden waste in natural areas and alternative disposal and reuse methods such as composting;
  - Signage displayed at garbage bins locations highlighting impacts of littering and encouraging correct disposal.
- Review the current provision of garbage bins at key locations along the estuaries and supplement as needed.

## 2.3 Coastal Hazards and Climate Change Impacts

### 2.3.1 Bank Erosion

Refer to Section 2.2.5 and 8.6 for findings of a detailed investigation and assessment of bank erosion. The *Tweed Coast Estuaries Bank Erosion Study* is provided as Appendix 3.

### 2.3.2 Entrance instability

The *Tweed Shire Coastal Hazards Assessment 2012* (BMT WMB, 2012) has assessed the behaviour of coastal entrances based on review of aerial photography and historical knowledge.

Cudgen and Mooball Creek entrances are stable within the boundaries of their training walls. Training walls will be maintained by the NSW Government in order to keep the location of entrances stable and open.

The effect of training walls on longshore sand transport has been investigated for Cudgen Creek, with full detail provided in The *Tweed Shire Coastal Hazards Assessment 2012* (BMT WMB, 2012). Stabilisation of Cudgen Creek in 1967 has had a significant impact on the local shoreline behaviour.

Significant shoaling does occur within the trained entrances of Mooball and Cudgen creeks. They are both very shallow and make navigation very difficult and dangerous.

Mooball Creek entrance has exhibited a complete closure at low tide on occasions due to shoaling. The creek has not remained closed during a high tide, and severe shoaling has not generally persisted for more than a week. The *Tweed Coastline Hazard Definition Study* (WMB, 2007) identifies a possible risk of breakthrough of the spit to the south of Mooball Creek entrance in the long term (100 years) planning horizon. This could be realised in a shorter time period if significant erosion of the eastern bank of the creek also occurs.

While the Cudgera Creek mouth is not trained, natural rock outcrops provide stability against any significant effects of migration of the creek to the south. The channel can, and has migrated along the beach to the north creating an increased erosion hazard zone in the immediate vicinity of the entrance. There may be some short term exchanges of beach sand with deposits in the lower estuary; however these are small in the context of the movements of sand in the beach system (BMT WMB, 2012).

However, the sand spit to the north of the creek mouth has relatively low dune crest levels (3.5-4m AHD) and is vulnerable to overtopping and potential breakthrough during major storm events. This entire spit area is considered to be within the erosion hazard both in the immediate near term and with future sea level rise (BMT WMB, 2012).

Council has negotiated with Fisheries NSW to develop an opening protocol for Cudgera Creek. Drivers for entrance opening include inundation of low lying agricultural land and concerns regarding water quality, specifically the risk of elevated bacteriological counts impacting on primary contact recreation. Large storms leading to erosion and sand transport in the nearshore coastal zone have a major influence on the dynamics of the Cudgera Creek entrance, including the entrance shoal and north bank spit. It is considered that there is a low risk of major issues arising with the potential to threaten life or property due to coastal entrance instability over the ten year planning horizon for which this CZMP is prepared.

### 2.3.3 Tidal Inundation

The *Tweed-Byron Coastal Creeks Flood Study* (WBM, 2009) has modelled flood behaviour across the catchments of the Tweed Coast estuaries and resulted in preparation of flood maps which predict inundation depth and flow velocity for events ranging from 5 year ARI to probable maximum flood.

Downstream ocean levels used in the study were based on *Floodplain Management Guidelines No.5* (DIPNR, 2004) and consultation with DECCW and TSC. Peak storm surge levels accounted for a tide surge interaction with the storm surge and wave setup superimposed upon normal variations in water level estimates.

Tweed Shire Council's Tweed Coastal Creeks Flood Management Plan will assess risks to human safety, environment, development and infrastructure within the estuaries.

The *Tweed Shire Coastal Hazards Assessment 2012* (BMT WMB, 2012) includes analysis of coastal inundation incorporating assessment of:

- Elevated ocean levels;
- Design wave conditions;
- Wave run-up and overtopping; and
- Creek estuary inundation levels.



Lower estuary inundation levels have been determined for each estuary, based on the following parameters:

- The present design storm tide of +1.44m (AHD), including the 0.66m rise in sea level since 1990;
- A flood flow gradient provision of 0.4m;
- A wave setup component of 0.68m, based on 10% of the local design wave height at the creek mouth of approximately 6.75m; and
- Future sea level rise (as per TSC's adopted policy, consistent with the previous NSW Governments withdrawn Sea level rise Policy Statement, that is, an increase on 1990 levels of 0.4m by 2050 and 0.9 by 2100).

Immediate, 2050 and 2100 hazard lines have been identified for areas immediately landward of each lower estuary. For access to comprehensive and detailed information relating to this coastal hazard, please refer to the *Tweed Shire Coastal Hazards Assessment 2012* (BMT WMB, 2012).

It is considered that there is a low risk of major issues arising with the potential to threaten life or property due to tidal inundation (independent of flood and storm surge) over the ten year planning horizon for which this CZMP is prepared.

### **2.3.4 Coastal (oceanic) Inundation**

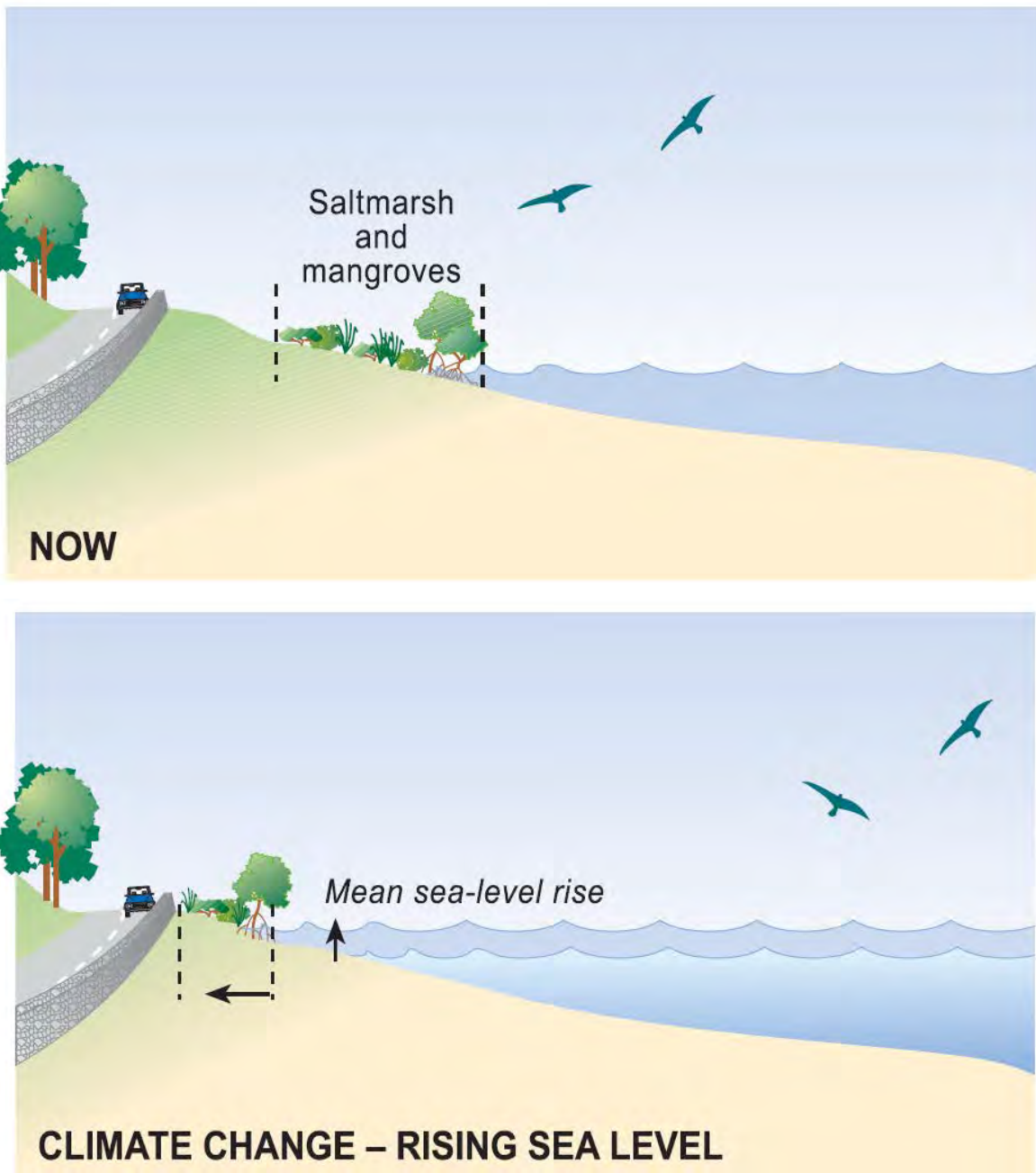
Coastal inundation has been considered in detail in the *Tweed Shire Coastal Hazards Assessment 2012* (BMT WMB, 2012). Please refer to this document for further information on this issue. Actions to address risks from coastal inundation will be included in a revised CZMP for Tweed Coastline Management.

### **2.3.5 Climate Change and Estuary Health Impacts**

#### **Description of Estuary Health Pressures**

Sea level rise is expected to increase the average depth in the estuary and extend tidal propagation up the estuary with potential changes in salinity regime. It is anticipated that sea level rise will naturally result in the landward recession of fringing estuarine wetland systems. The location of estuarine habitats such as mangrove forests and salt marsh are controlled principally by tidal range and salinity influence and will gradually respond to changes in increases in average water levels and salinity. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, levees, agriculture and urban development on the landward side (Department of Climate Change, 2009). This impact has been named "Coastal Squeeze" by the Department of Climate Change (2009). Under these conditions the landward side of these important habitats will be fixed but the lower margin will gradually be pared away, leading to a loss of habitat area (refer Figure 25 below). Increased estuary levels may also affect riparian and other low-lying vegetation in the freshwater reaches of the estuary in a similar way. Water-logging will gradually kill off the lower vegetation, whereas the upper boundary may be restricted.

While the location of estuarine vegetation communities in the Tweed Coast Estuaries has been mapped by Fisheries NSW, it is not currently known to what extent barriers to upslope migration will affect the wetlands and vegetation communities. Due the existing high level of vegetation cover along the majority of the Tweed Coast Estuaries, and the planning protection afforded by environmental zoning along most of the estuaries, it is likely that upslope migration of estuarine communities will proceed naturally for most of the estuarine extent. Exceptions may exist in the lower estuary where urban development could curtail migration of communities such as mangroves and small pockets of communities may be lost.



**Figure 25: ‘Coastal squeeze’ under sea-level rise: impact of development (Source: Department of Climate Change, 2009).**

The potential changes in salinity regime and implications for estuarine ecosystems and adjoining land uses has not been fully explored. There may be increasing pressure to reduce saline intrusion into low-lying farm lands and long-term floodgate management policies will need to consider the implications of sea level rise and potential salinity increases. Similarly, more frequent flooding of low-lying urban areas creates risks for the estuary in terms of managing urban drainage impacts, potential effects on sewerage infrastructure and overflows.

The issue of potential increased storminess is even less well understood. It is generally anticipated that rainfall events will become more intense in response to climate change (CSIRO, 2007). This may result in effects such as more floods as well as greater erosion of unconsolidated sediments within the catchment. It is not known whether key issues for the estuary such as poor water quality episodes and fish kills will be exacerbated by climate change factors, however increased temperatures are expected to have implications for water quality.

No.	Climate Change Pressures
P32	There is a risk that natural upslope migration of estuarine habitats due to sea level rise will be curtailed by anthropogenic constraints (roads, agriculture, urban development etc.).
P33	Sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure and bank erosion.
P34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues.
P36	Potential estuarine inundation during extreme weather events such as king tides, severe storms or catchment flooding threatens the viability of some public access points and this may be increased with sea level rise.
Related pressures discussed in other sections:	
P1	Decline in seagrass area in all estuaries between 2006 and latest assessments conducted in 2011.
P14	Lack of suitable buffer zones between land use and waterways limits riparian zones.

### Potential Management Options

Climate change is an important consideration for strategic planning, particularly in coastal areas where the combined effects of sea level rise and potentially increased storminess are considered key threats. Sea level rise may result in impacts associated with tidal inundation, bank erosion, shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems and landward migration of ecological communities. The increase in frequency and intensity of storm events and altered flooding patterns will also potentially exacerbate erosion, bank stability and water quality issues. An overall goal for the management is to ensure that the estuary is as healthy and resilient as possible, so that it can respond naturally to the impacts of climate change.

### Status of Existing Management in the Tweed Coast Estuaries

The Tweed-Byron Coastal Creeks Flood Study (WBM, 2009) has modelled flood behaviour across the catchments of the Tweed Coast estuaries and resulted in preparation of flood maps which predict inundation depth and flow velocity for events ranging from 5 year ARI to probable maximum flood. Downstream ocean levels used in the study were based on *Floodplain Management Guidelines No.5* (DIPNR, 2004) and consultation with DECCW and TSC. Peak storm surge levels accounted for a tide surge interaction with the storm surge and wave setup superimposed upon normal variations in water level estimates. In its current state, the flood study mapping within estuaries does not satisfy the minimum requirements stipulated by the *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010a). TSC has indicated that the Tweed Coastal Creeks Flood Management Plan, to be developed in the near future, will undertake the tidal inundation mapping required by DECCW (2010a) and assess risks to human safety, environment, development and infrastructure within the estuaries.

### Recommendations for Management

- It will be necessary to consider the impacts of climate change as part of each management option and strategy.
- Complete the tidal inundation mapping in accordance with the minimum requirements of DECCW (2010a).
- The bank erosion study completed as part of this CZMP should be reviewed in light of the tidal inundation mapping (recommended above) to identify risks due to sea level rise.
- Map predicted future estuarine wetland habitat distribution in response to changes in sea level, tide propagation and salinity regime within the estuary, building on existing research/models where

appropriate. This mapping should identify barriers to upslope transgression (e.g. current development, road embankments, etc.) and highlight key areas of importance for maintaining the balance of future habitats within the estuary. This information should be compiled as a set of GIS layers which are available for land use planning and development controls;

- A strategic plan for long-term estuarine habitat management should be prepared to ensure that upslope migration of key habitats can be accommodated within the long-term land use adjoining the estuary. This should include provision for buffer zones and offsets as appropriate to achieve no net loss of mangrove, saltmarsh habitats and priority riparian habitats within the study area; and
- All catchment/estuary specific information regarding climate change and potential risks for the estuary should be made available to decision makers in the catchment. This should include provision of a resource base (e.g. projected tidal inundation maps, habitat management strategies, etc.) to be utilised in LEP reviews, development assessment, education campaigns and strategic planning.

### 3. COMMUNITY USES OF THE COASTAL ZONE

TSC recognises the importance of community uses of the coastal zone. In the preparation of this CZMP, public access refers to the ability of the general public to gain appropriate access to public lands in the estuary including access to coastal environments such as estuarine waterways.

#### 3.1 Public Access

Public access to estuarine foreshore areas is highly valued by the community. One of the aims of the *NSW Coastal Policy* is to ensure the provision of public access to foreshores where feasible and environmentally sustainable. Whilst providing and maintaining access to public lands in coastal environments is important, access and use must be balanced by protection of the environment and the maintenance of public safety. TSC recognises that:

- Access to and sympathetic use of publicly owned coastal lands is desirable where it does not conflict with environmental management objectives;
- Uncontrolled public access has the potential to irreparably damage fragile coastal environments; and
- Human safety is a prime consideration when planning access.

##### 3.1.1 Current access arrangements

The *Tweed Coast Estuaries: Bank Erosion Study* (Appendix 3) documents the current status of public access points to estuary foreshores. Access points are described for each section of bank in the Bank Condition Assessment Database including:

- Location (mapping of each section provided);
- Type of access (e.g. uncontrolled access or formalised access such as walkways, stairs, boat ramps, jetties, etc.);
- Ownership where known (e.g. public or private access);
- Land tenure;
- LEP Zoning;
- Erosion category (Minor, Moderate, Severe);
- Erosion Risk Rating (High, Medium, Low); and
- Erosion controls and adequacy of controls.

##### **Description of Community Uses Pressures (Potential impacts on access arrangements)**

Bank erosion has potential to impact public access points to estuary foreshore areas by undermining and destabilising structures such as stairs and walkways. Uncontrolled access to the foreshores via estuary banks can in turn exacerbate bank erosion and damage riparian vegetation. All of the high risk bank erosion sites identified by the *Tweed Coast Estuaries: Bank Erosion Study* (Appendix 3) contained public access points that were considered to be under threat either now or in the near future by the observed erosion (refer Table 3).

**Table 3: Public access points at risk of bank erosion**

Site ID	Location	Public access point at risk from current or future bank erosion (within 20m of current erosion scarp)
CN01	Lower Cudgen Creek, right bank near entrance	Stairs to estuary foreshore beach, access road, car park
CN6	Lower Cudgen Creek, right bank downstream of bridge	Access road, car park and uncontrolled pedestrian access from adjacent park to foreshore
CN14	Mid Cudgen Creek, right bank adjacent to Salt housing development	Concrete footpath along the waterway. Some evidence of uncontrolled pedestrian access to the estuary.
CN17	Mid Cudgen Creek, right bank adjacent to Casuarina housing development	Concrete footpath along the top of bank. Some evidence of uncontrolled pedestrian access to the estuary.
CUD1	Lower Cudgera Creek, left bank downstream of bridge	Access stairs to the estuary foreshore beach. Evidence of uncontrolled pedestrian access exacerbating bank erosion at this site.
MOO9	Lower Mooball Creek, left bank upstream of bridge	A public road is located within 5m of the existing erosion scarp and is likely to be affected by erosion is left unchecked. Uncontrolled pedestrian access exacerbating bank erosion at this site
MOO55, MOO57, MOO59	Mid Mooball Creek, right bank	A public road (Coast Road) is located within 10m of the existing erosion scarp and is likely to be affected by erosion is left unchecked. Uncontrolled pedestrian access exacerbating bank erosion at this site
MOO60	Mid Mooball Creek, right bank	A public road (Coast Road) is located within 20m of the existing erosion scarp and is likely to be affected by erosion is left unchecked. Uncontrolled pedestrian access exacerbating bank erosion at this site

Potential estuarine inundation during extreme weather events such as king tides, severe storms or catchment flooding threatens the viability of some public access points to the Tweed Coast Estuaries and foreshores. At present, these restrictions are expected to be experienced for a short time only. Water levels will recede as water levels abate and public access will be restored. Because it is unlikely the community would want to access the estuary or foreshores during severe storms and floods, this is considered to be an issue of minor consequence at present. However, if estuarine flooding and tidal inundation increases as is predicted with sea level rise, there may be a point in the future where public access points are affected more severely and management action will be required to modify current access arrangements or provide alternatives.

Concerns have been raised in the community regarding estuary foreshore areas (Crown Land) being used by adjacent private landholders in a way that restricts public access. Structures such as jetties and platforms are evident along much of the Tweed Coastal Creeks and many are constructed on Crown Land and impede public access to foreshores. There is also anecdotal evidence of mangroves being removed, which is illegal without a permit to remove marine vegetation under the *Fisheries Management Act* and carries penalties for individuals and organisations.

No.	Public Access Pressures
P35	Bank erosion has potential to impact public access points to estuary foreshore areas by undermining and destabilising structures such as stairs and walkways.
P36	Potential estuarine inundation during extreme weather events such as king tides, severe storms or catchment flooding threatens the viability of some public access points and this may be increased with sea level rise.
P38	Private landholder use and occupation of Crown Land foreshore areas is restricting public access.
Related pressures discussed in other sections:	
P19	Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.
P33	Sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure and bank erosion.
P34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues.

### Potential Management Options

Management of bank erosion issues will involve creating and maintaining adequate public access points. Refer to Section 2.2.5 for discussion of bank erosion management controls.

Modifications or relocation of access points may be required if tidal inundation mapping identifies significant risk to current access arrangements.

### Status of Existing Management in the Tweed Coast Estuaries

Providing appropriate public access to estuary foreshores is a key objective of the *NSW Coastal Policy*. Estuary foreshores are generally located within Crown Land and access arrangements are the responsibility of DPI-Crown Lands or Reserve Trusts such as TSC as appointed by the Minister of Lands.

The *Tweed Coast Regional Crown Reserve Plan of Management* (Land and Property Management Authority, 2005) has an agreed vision of “Publicly accessible Crown Land with enhanced and sustainable environmental, social and cultural and economic values for the benefit of the community”. It sets out a management framework which includes objectives of providing for safe public access to foreshore areas.

The *Creek Bank Stabilisation Cudgen Creek* (GeoLINK, 2004) at Jack Julius Park was prepared following on from recommendations of the 2003 Estuary Management Plan. The Plan provided designs to stabilise erosion at the study site, access management strategies to reduce the impact of pedestrians on creek banks and existing vegetation, and strategies for vegetation management including recommendations for weed management and supplementary planting.

The *Cudgen Creek Recreation and Public Access Plan* (GeoLINK, 2008), was prepared for TSC to provide guidance in managing recreational use and public access around Cudgen Creek. The plan was developed in response to increased recreational pressures created by new residential developments in the area.

### Recommendations for Management

- Implement management recommendations for the high risk bank erosion sites detailed in Appendix 3.
- Complete the recommended actions outlined in Section 2.3:

- Tidal inundation mapping in accordance with the minimum requirements of DECCW (2010a);
  - The bank erosion study completed as part of this CZMP should be reviewed in light of the tidal inundation mapping (recommended above) to identify risks due to sea level rise; and
  - Review access points as part of the bank erosion study review to highlight any changes in risk rating for access points affected by projected sea level rise impacts.
- Support implementation of the *Tweed Coast Regional Crown Reserve Plan of Management* as it applies to provision of public access within the reserve.

### 3.2 Recreational Use of the Coastal Zone

The waterways and foreshores of the Tweed Coast estuaries are of great importance for both passive and active uses. 'Active uses' are those with the greatest potential for impacts on the environment and on other pursuits. They include recreational activities such as boating, swimming, and recreational fishing. In contrast are 'passive uses' that have less potential for impacts. Examples of passive uses include nature conservation, habitat protection, walking tracks and nature appreciation.

The nature of activities that should be permitted within a given area varies according to natural constraints, community objectives, accessibility issues, legislation, land tenure, government policies and seasonal variations.

#### 3.2.1 Boating and other Watercraft

Recreational boating in all kinds of craft is a popular pastime on the Tweed Coast Estuaries. Public boat ramps are located in the lower reaches of the estuaries, providing access to the water. Canoeing, kayaking and more recently, stand up paddle boarding, are very popular recreational activities within all of the Tweed Coast Estuaries. Canoe hire operators are licensed by Council to work within both Cudgen and Cudgera Creek. The shallow, sheltered waters and wetland habitats provide ideal opportunities for observing aquatic, avian and terrestrial wildlife. Support of this passive recreational use is a recommendation of this management plan.

#### Description of Community Use Pressures

Australian Wetlands (2003) reported that most powered boats are fairly small, with a low impact on the physical and ecological values of the waterways. However, concerns were expressed at some community meetings during development of the *Estuary Management Plan 2004-2008* that a minority of boat users tended to break the accepted rules concerning boat speed and operation. Similar concerns were raised during public exhibition of this CZMP in 2013. Boat wash is increased at greater speeds and this can impact bank erosion and disturb sensitive vegetation in the estuary. Areas of sensitive estuarine vegetation such as seagrass beds may also be affected by boating due to propeller and anchor damage.

As discussed in Section 2.3.2, boating navigation can be difficult in the estuaries due to shallow depths and shoaling within the entrances, particularly the trained entrances of Mooball and Cudgen creeks. The shallow entrances make crossing to the ocean particularly difficult and dangerous. There are occasional calls from the community for dredging of Cudgen Creek mouth to improve navigability. The potential options to undertake dredging and the associated costs and benefits have been assessed on a number of occasions. A detailed investigation into dredging Cudgen Creek was undertaken in 2003, which determined that due to high sand infill rate, an almost continuous dredging campaign would be required incurring high cost to the community (DIPNR, 2003). The investigation also highlighted the potential for adverse environmental impacts in the lower estuary and adjacent coastline areas and the need for an environmental impact assessment to fully assess this risk (DIPNR, 2003). Based on the results of previous investigations,



dredging has not been pursued by TSC due to the high cost, limited benefit and potential for adverse environmental impacts due to dredging. Management to date has focussed on public education about the navigation risks and warnings regarding dangerous conditions.

In relation to passive watercraft use in the estuaries (e.g. canoeing and stand up paddle boarding), an issue raised during community consultation is the highly restricted ability for canoes to traverse the upper reaches of Cudgen Creek, between the Tweed Coast Road bridge, and the downstream connection with Cudgen Lake. Canoe passage through this reach of Cudgen Creek is obstructed by fallen dead, and low-hanging live trees, requiring canoes to be manhandled past logs, in some cases overland for short distances. This is difficult but possible for able bodied paddlers, but makes passage virtually impossible for the elderly or less strong.

No.	Boating Pressures
P39	Community concern that a minority of boat users break the rules concerning boat speed and operation.
P40	Boat wash can increase rates of bank erosion and disturb sensitive vegetation in the estuary.
P41	Areas of sensitive estuarine vegetation such as seagrass beds may be affected by boating due to propeller and anchor damage.
P42	Boating navigation in the lower estuaries through to the ocean is hampered by natural processes and can present a safety risk.
P43	The passage of canoes and other paddle craft through the upper reaches of Cudgen Creek is obstructed by fallen dead, and low-hanging live trees.
Related pressures discussed in other sections:	
P1	Decline in seagrass area in all estuaries between 2006 and latest assessments conducted in 2011.
P19	Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.

### Potential Management Options

- Rules regarding boating including speed limits and no wash zones advertised by estuary signage on maritime boating maps and enforced by NSW Maritime.
- Signage and exclusion zones for sensitive sites such as seagrass beds to minimise physical disturbance.
- Education regarding boating impacts on bank erosion and sensitive vegetation
- Warnings for boating regarding the estuary conditions and navigability published on NSW Maritime Boating Maps and signage at boat ramps and key points around the estuary.
- Dredging is a potential option to improve navigability in the short term, however this has been assessed as having high costs and limited benefits for the estuaries.
- It would be possible to undertake selective, minor trimming and lopping of branches to improve the navigability of the upper Cudgen Creek reaches, without compromising the ecological values of the waterway. Passage should be restricted to no more than 1.5 metres, where significant impediments to passage are found.

### Status of Existing Management in the Tweed Coast Estuaries

Boating speed limits have been set for the Tweed Coast Estuaries. Limits are advertised by estuary signage on maritime boating maps and are enforced by NSW Maritime.

Following recommendations of the *Estuary Management Plan 2004-2008* TSC established the Canoe Trail project which provides a series of educational signage throughout estuaries.

The NSW Maritime boating maps for the estuaries have warnings for boat users regarding entrance conditions, shallow depths and provide approximate navigable extents of the estuaries as follows:

- Cudgen Creek: The entrance is extremely dangerous and should only be attempted by those possessing expert local knowledge. The creek is generally navigable to Cudgen Lake for small water craft at high water only (no powered vessels allowed on Cudgen Lake);
- Cudgera Creek: The entrance is dangerous and is not considered navigable. The creek is generally navigable for 2 km upstream of the road bridge for small craft at high water only; and
- Mooball Creek: The entrance is dangerous and is not considered navigable.

As discussed above the feasibility of dredging Cudgen Creek has been assessed (DIPNR, 2003) and TSC has not pursued this option due to high cost and limited benefit to be gained through dredging.

### Recommendations for Management

- Continue speed limits, signage and enforcement of boating rules.
- Provide educational material about impacts of boating.
- Signage and exclusion zones for sensitive sites such as seagrass beds to minimise physical disturbance. This may be particularly important for seagrass beds identified as under extreme pressure in Mooball Creek.
- Continue to provide warnings for boating regarding navigability of estuaries and entrances.
- Carry out the Cudgera Creek mouth stability and risk assessment as part of the review of the Tweed Coastline Hazard Study.
- Proposal for dredging creeks to improve navigability should not be supported due to the limited benefit provided.
- Council discuss the issue of restricted paddle craft passage in upper Cudgen Creek with relevant State government Agencies, with a view to undertaking necessary environmental assessments and trimming works, to support paddle craft passage between Kingscliff and Cudgen Lake.
- Prepare investigation and assessments necessary to undertake selective, minor vegetation trimming as required to allow improved paddle craft passage through significant obstructions in Cudgen Creek.

### 3.2.2 Recreational Fishing

Recreational fishing is widespread and highly valued by local residents and visitors to the Tweed Coast Estuaries. Like water quality, there is general community perception that the state of the estuary's fish health and productivity is a key indicator of overall estuary health.

#### Description of Community Use Pressures

Australian Wetlands (2003) reported that many people at community meetings expressed their concerns and wishes for the estuaries in terms of recreational fishing values. There was a view that fish stocks had seriously declined over recent decades. This perceived decline in fish stocks since the 'good old days' is a common sentiment on the NSW coastline. Whether or not fish stocks are continuing to decline in the Tweed

Coast Estuaries is difficult to determine. The factors implicated in the decline of fish stocks are reasonably well understood at a general level, however the key causes and the relative degree to which they influence fishing in the Tweed Coast Estuaries is not known. Given the migratory nature of many fish between estuaries, impacts in other estuaries as well as fishing effort along the coastline also have an impact on the Tweed Coast Estuaries fishery.

Within the Tweed Coast Estuaries key considerations are:

- Habitat availability is a key factor in controlling fish populations in the estuary. The nursery value of estuaries for many species is well known and the degradation or complete removal of important habitats is as a major factor in fisheries management as loss of habitat can lead to fewer fish to share amongst all stakeholders;
- The presence of instream barriers such as weirs, floodgates and culverts in the catchment interrupt fish migration and dispersal within the catchment. These migrations are often essential for fish to complete their life cycle and the productivity of the catchment as a whole is reduced when effective fish passage is not available between downstream and upstream habitats;
- Poor water quality has a range of effects on fish populations. More chronic effects of water quality degradation include fish kills and effects on fish stocks through restricting fish movement or habitat use in unfavourable areas, reduction on productivity and influences on the food chain and productivity; and
- The impact of overfishing can be dramatic as evidenced by the collapse of many fisheries throughout the world.

No.	Recreational Fishing Pressures
P44	Community concern that a fish stocks have declined over recent decades.
P45	Overfishing can impact fish stocks.
Related pressures discussed in other sections:	
P1	Decline in seagrass area in all estuaries between 2006 and latest assessments conducted in 2011.
P2	Dramatic decline in seagrass area and health in Mooball Creek.
P3	Estuarine habitats (seagrass, mangroves and saltmarsh areas) remain vulnerable to a number of threats affecting their overall health and continued protection.
P4	Alteration of habitat is a major pressure for aquatic fauna and a primary cause of decreasing native fish populations. Channelisation of natural waterways, altered flow regimes, poor condition riparian zones and poor water quality are main contributors to habitat alteration.
P5	Partial barriers to fish passage may prevent the migration of native fish species during some flow conditions.
P6	Introduced fauna species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. The introduced Mosquito Fish ( <i>Gambusia holbrooki</i> ) and an aquarium fish, Swordtail ( <i>Xiphophorus helleri</i> .) are species of concern for the freshwater reaches of Tweed Coast Estuaries.
P21	Acid sulfate runoff negatively impacts overall estuarine ecosystem health. Impacts include fish kills and major aquatic habitat changes, reduced plant growth (acid scalds), and corrosion of concrete, iron and steel structures.
P23	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.

### Potential Management Options

Management of habitat availability, fish passage barriers and catchment management affecting water quality are discussed in Section 2.2.2.

Setting of bag and size limits for recreational anglers. This information is provided at a number of boat ramps within the Tweed Coast Estuaries, as well as at bait and tackle stores and with information provided when obtaining recreational fishing licences in NSW.

### Status of Existing Management in the Tweed Coast Estuaries

- Setting of bag and size limits for recreational anglers. This information is provided at a number of boat ramps within the Tweed Coast Estuaries, as well as at bait and tackle stores and with information provided when obtaining recreational fishing licences in NSW;
- The impact of changes in fisheries regulation for NSW estuaries was assessed under the General Fisheries EIS produced in 2003. The associated strategy provides measures to address a range of goals including conservation of biological diversity, sustainable harvesting, conservation of threatened species and ecological communities, resourcing sharing and conflict minimisation, on-going commercial viability, management efficiency, knowledge improvement as well as monitoring and review. Many of these measures are consistent with the aims of the CZMP process and are supported

### Recommendations for Management

- Implement actions associated with management of habitat availability, fish passage barriers and catchment management affecting water quality are discussed in Section 2.2.2.
- Continue to enforce bag and size limits for recreational anglers

### 3.2.3 Swimming

Swimming is a widespread and popular activity in all three estuaries. Most swimming is done near the entrances, where often-clear ocean water provides an inviting place to swim. Large numbers of people swim in holiday periods, particularly at Christmas, but regular swimmers use the estuaries all year round. Australian Wetlands (2003) reported that at community meetings regarding the EMP, swimmers stated a strong interest in the maintenance and enhancement of the estuaries as safe and healthy recreational resources.

#### Description of Community Use Pressures

The main perceived threats to these values were power boating and water quality issues. Community members in Kingscliff have raised specific safety concerns regarding the conflict between swimmers and boats at the boat ramp in the lower Cudgen Creek estuary.

Water quality data reported as part of the *Baseline Ecosystem Health Assessment* identified one site in Cudgera Creek where faecal contamination indicators were persistently elevated. The site is located approximately 150m upstream of the Koala Beach housing estate, and it is possible that primary and secondary contact recreation occurs in the vicinity. This raises concerns for human health and warrants further investigation. Other estuary sites were within levels considered appropriate for primary contact recreation.

No.	Swimming Pressures
P46	Power boating poses a safety risk to people swimming in estuaries.
P47	Poor water quality impacts the amenity of waterways and may present health concerns for swimmers.
P48	Water quality sampling has identified a potential risk to human health (faecal contamination) at one site in Cudgera Creek.
Related pressures discussed in other sections:	
P12	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary.
P20	Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.
P22	Historical drainage of former backswamp wetlands are the main cause of ASS problems as they facilitate the exposure of ASS to oxygen, which produces acid runoff.
P23	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.
P30	High levels of faecal indicator bacteria were identified at sites downstream of Mooball and Burringbar villages indicating either failing OSSM or pollution from surface runoff.

### Potential Management Options

- Management of catchment sources of water quality degradation are discussed in Acid Sulfate Soils (Section 2.2.6); Agriculture (Section 2.2.7), Urban Development and Stormwater (Section 2.2.8); and Wastewater Management (Section 2.2.9),
- Support and promote on-going safe and ecologically sustainable recreational use. At some locations this may include signage to highlight hazards and to clarify roles and responsibilities of different estuary users with regard to public safety.
- Further investigation of sources of faecal contamination in Cudgera Creek to determine the best course of action to address pollution.
- Monitoring recreational water quality should be undertaken according to the current best practice and recommendations of NHRMC (2008).

### Status of Existing Management in the Tweed Coast Estuaries

- Tweed Shire Council water quality monitoring program assesses selected water quality parameters including some recreational water quality parameters. Review of the program identified areas for improvement with regard to recreational water quality.

### Recommendations for Management

- Further investigation of sources of faecal contamination in Cudgera Creek to determine the best course of action to address pollution.
- TSC should review the indicators used and sampling frequency of their water quality program to be amended to come up to speed with current best practice and recommendations of NHRMC (2008).
- An alternative option is to omit recreational triggers from the estuary monitoring and assess as part of dedicated recreational program such as the OEH "Beachwatch" program.

- TSC to investigate installation of signage that highlights safety hazard associated with swimmers and boats at the Cudgen Creek public boat ramp and clarifies the role and responsibilities of both swimmers and vessel/vehicle operators in regard to avoiding accidents.

### 3.2.4 Nature Appreciation and Bird Watching

Nature appreciation activities such as bird watching, wildlife spotting and sightseeing are popular recreational activities in and around the estuaries and foreshores of the Tweed Coast Estuaries. These activities can occur throughout the study area, but are mostly concentrated in the lower reaches of the estuaries and are often synonymous with recreational watercraft use such as canoes and stand up paddle boards.

Tweed Bird Observers is a community group comprising local people concerned with the protection of native birds and their habitat. The group undertakes regular bird observations, carries out surveys and has occasionally conducted counts of waders and other shorebirds in the Tweed Coast Estuaries.

#### Description of Community Use Pressures

Many of the factors affecting nature appreciation activities are related to general impacts affecting the health and aesthetics of the estuarine environment. The following issues have been identified through the development of the CZMP including input from the community:

- Litter not only decreases the general aesthetic value of the estuaries and foreshore areas, but can pose a risk to wildlife (refer to Section 2.2.10 for further discussion of litter pressures). Ingestion or entanglement in discarded fishing line and tackle was raised as a significant problem observed in the Tweed Coast Estuaries resulting in injury and sometimes death of birdlife.
- Threats to shorebirds and coastal raptors discussed in Section 2.2.3, affecting bird health and occurrence in the estuaries.
- Poor water quality, particularly aesthetic water quality such as turbid or discoloured water and gross pollutants detracts from nature appreciation activities. As discussed in Section 3.2.3, water quality suitable for safe swimming is also desirable for nature appreciation activities which involve direct contact with the water.
- Conflict of use between passive and non-passive activities has been raised as a concern in some locations. A prime example is conflict between bird watching activities and the use of powered watercraft such as jet skis producing noise and wake waves that disturb wildlife. Powered watercraft that exacerbates bank erosion issues are also in conflict with nature appreciation activities by contributing to water quality issues and general decreased amenity.

No.	Nature Appreciation and Bird Watching Pressures
P49	Concern about conflict of use between passive recreation activities and active recreation activities (e.g. nature appreciation such as bird watching and use of powered watercraft which can disturb birds) and the potential for increasing conflict into the future.
Related pressures discussed in other sections:	
P7	Threats to shorebirds include introduced pests such as foxes, weed invasion, coastal processes, entanglement and ingestion of fishing line, tackle and pollutants, natural predation and disturbance from beach users and domestic dogs.
P8	Specific concern has been raised in the community that dogs are negatively impacting on shorebirds in foreshore areas of lower Cudgera Creek.
P9	Concerns have been raised by local bird enthusiasts that shorebird use of Cudgen and Mooball Creeks is not well understood and may well be important.
P10	Threats to coastal raptors include habitat loss and degradation, human disturbance to breeding, entanglement and ingestion of fishing line, tackle and pollutants, reduced water clarity, reduced fish health and availability and collision with power line and vehicles.
P31	Litter and dumped waste decreases the visual amenity of the estuaries and foreshore areas and poses a risk to wildlife.
P39	Community concern that a minority of boat users break the rules concerning boat speed and operation.
P40	Boat wash can increase rates of bank erosion and disturb sensitive vegetation in the estuary.
P46	Power boating poses a safety risk to people swimming in estuaries.
P47	Poor water quality impacts the amenity of waterways and may present health concerns for swimmers.

### Potential Management Options

Many of the pressures recognised as affecting nature appreciation activities are addressed through management options identified in other sections. Examples of management options used to address issues of conflicting recreational uses are as follows:

- Further investigation of usage conflicts, including information on safety risks, locations of conflicts, any incidents such as collisions or injuries to better direct management action. As the population of the Tweed Coast and nearby increases;
- Education to raise awareness of the issues and promote responsible practices;
- Passive and 'low impact' recreational use should be supported and promoted;
- A more involved management option is the creation of special use zones to separate conflicting uses. This could involve restriction of certain watercraft in particularly sensitive areas, such as shorebird nesting sites or popular areas for passive recreation. An example of this management approach has been implemented at large dam sites in South East QLD, where the waterways draw large numbers of recreational users and require a high level of active management. It is unlikely that the current level of recreational use in the Tweed Coast Estuaries would justify the level of resources needed to create and manage special use zones. However, this could be a consideration for the future as the population continues to increase and with further diversification of recreational use.

### Status of Existing Management in the Tweed Coast Estuaries

NSW Maritime currently controls waterway usage for the purposes of boating. The NSW Maritime boating maps provide details of navigational controls, speed restrictions and other warnings for the Tweed Coast

Estuaries. NSW Maritime also has a policing role on the waterway and responds to various complaints about nuisance activities on the water and conflicts between different uses. While the control mechanisms in place by NSW Maritime are currently addressing issues as required, a growing population and expanding recreational use of the estuaries may create a need for increased management in the future. While usage conflicts are considered to be very minor occurrences at present, there is concern among the community about potential for future problems.

### Recommendations for Management

- Investigate the nature and location of usage conflicts over time to keep track of changing trends in use and any emerging issues. This information should be used to better direct management action and the need for greater intervention.
- Carry out public communication to raise awareness of the issues and promote responsible practices. Passive and 'low impact' recreational use should be supported and promoted in the Tweed Coast Estuaries.

### 3.3 Cultural and Heritage Environment

The Tweed Coast Estuaries and their catchments have a rich cultural history. Most significantly, it is part of the traditional lands of the Bundjalung people, who occupied the Tweed Valley for over 60,000 years (Land and Property Management Authority, 2005). There were two tribal groups, the Nganduwal/Ngarakwal and Minyanbal. The Nganduwal tribal boundary is bounded by McPherson, Tweed and Burringbar Ranges and the Minyanbal tribal boundary is south of Burringbar Range and Cudgera Creek (Tweed Heads Taskforce, 2004). Aboriginal cultural occupation is evidenced by significant Aboriginal sites, items and landscapes. Within the coastal zone there are significant Aboriginal sites at Hastings Point and Wooyung (Umwelt, 2005). Hastings Point has significant cultural heritage values. The rock platform, headland and look-out point provides potential education and interpretation opportunities (Land and Property Management Authority, 2005). Aboriginal middens are located at Wooyung. A basic search of the OEH Aboriginal Heritage Information Management System (AHIMS) revealed a large number of recorded Aboriginal Sites in the search area which attests to the Aboriginal cultural significance of the study area.

The Tweed Coast Estuaries and their catchments also have historical and cultural significance to Europeans due to early agricultural settlers, sandmining and associated infrastructure. In 1770 Captain Cook almost ran aground at Point Danger (at Durambah north of the study area) whilst he was mapping the north coast of NSW.

A search of the NSW Heritage register revealed a number of listed heritage items within the study area. Places with relevance to waterways included railway creek crossings at Burringbar and Mooball, osprey nests mapped by NPWS, and a "Natural Area North of Brunswick Heads" along the coast road at Wooyung.

#### Description of Community Use Pressures

Aboriginal cultural heritage issues are complex and care should be taken at every level of the planning decision making process to ensure that all the issues regarding impact are identified and considered. There are many issues such as the appropriate use of sensitive cultural information. Some Aboriginal sites, areas, and landscapes in the Tweed/Byron region are inherently sensitive, and in some cases, our community may wish to keep information about these sites from the public for risk of vandalism or harm (Tweed Byron LALC, 2012). Currently there is no overriding plan within the study area to guide the management of Aboriginal cultural heritage.



No.	Cultural Heritage Pressures
P50	Currently there is no overriding plan within the study area to guide the management of Aboriginal cultural heritage.

### Potential Management Options

The OEH is currently developing a range of tools for Aboriginal heritage regional assessment in NSW. Such assessments will assist in the recording of local knowledge and protection of remaining sites from inappropriate development or vandalism.

The management of the Aboriginal cultural site requires liaison with the Tweed-Byron Local Aboriginal Land Council and is subject to further recommendations for management from the Land Council.

### Status of Existing Management in the Tweed Coast Estuaries

All levels of Government maintain registers of important sites, which are then afforded varying levels of protection under current legislation. The principle laws, which deal with cultural heritage, are (also refer Appendix 1):

- *National Parks and Wildlife Act 1974* – This Act provides statutory protection for all Aboriginal objects and places in NSW. Areas are gazetted as Aboriginal places if the Minister is satisfied that there is enough evidence to show the area is, or was, of special significance to Aboriginal culture;
- *Heritage Act 1977* – This Act protects the State's natural and cultural heritage. Aboriginal and non-aboriginal places or objects that are recognised as having high cultural value are listed on the State Heritage Register;
- *Historic Shipwrecks Act 1976* - protects sites of historic shipwrecks in and around coasts and estuaries.
- *Environmental Planning and Assessment Act 1979* – This Act provides protection by considering impacts on cultural heritage in land use and planning decisions. The three main areas are:
  - Planning instruments allow particular uses for land and specify constraints. Cultural heritage is a value which should be assessed when determining land use;
  - Section 79C of the Act lists matters which must be considered before development approval is granted. Cultural heritage is one of the issues considered under the terms of Section 79C; and
  - State government agencies act as the determining authority on the environmental impacts of proposed activities and must consider a variety of community and cultural factors, including cultural heritage, in their decisions.

The Tweed DCP provides guidelines and requirements in relation to assessing impacts of development on “Heritage or cultural items of Aboriginal or European origin” (Tweed Shire Council (2008). The DCP states:

- *“Development sites must be assessed by suitably qualified persons to determine the presence of any heritage or cultural items of Aboriginal or European origin.*
- *Items of heritage or cultural significance are to be preserved.*
- *A site plan showing the location, settings and characteristics of any identified items must be submitted with a development application for subdivision.*
- *For items identified, a report must accompany the development application demonstrating how the subdivision design accounts for these items and protects the heritage and cultural values of the site and how these items are to be preserved, given the future proposed land uses in the area.”*

Tweed Shire Council has recently commissioned a new Aboriginal Cultural Heritage Management Plan (CHMP) for the Tweed Shire which is due for completion in 2013 (Everick Heritage Consultants, 2012)

The CHMP preparation will be undertaken in 5 stages:

- Consulting with the Aboriginal community and developing a memorandum of understanding between Council, the consultants, and in the first instance, the Aboriginal Advisory Committee (AAC), which represents many of the Tweed's Aboriginal community groups and will provide further advice as necessary.
- Documentary research and culturally appropriate mapping of known sites and places, including destroyed and damaged sites.
- A thematic history of Aboriginal culture in the Tweed. A thematic history is not developed chronologically; rather, it is based on historic themes. The themes are still to be determined in consultation with the Aboriginal community.
- Landform and predictive modelling for Aboriginal sites and places, using predictive mapping based on sound methodology such as assessment of landscapes and Aboriginal community input.
- Recommendations for land use planning and Aboriginal cultural heritage management

### **Recommendations for Management**

The Tweed Coast Estuaries have spiritual and cultural significance for local communities. Both European and Aboriginal heritage sites and items exist in and around the estuaries and their recognition and protection are important to the local community.

While the protection of cultural heritage is provided for under several pieces of State Government legislation, there is recognition that further work is required to identify, assess and manage cultural heritage of the Tweed Coast Estuaries. The recently commissioned CHMP for the Tweed Shire will provide a holistic assessment of cultural heritage for the Tweed Shire and will include the Tweed Coast Estuaries study area. Development of the CHMP is supported by this CZMP.

#### 4. COMMUNITY AND STAKEHOLDER CONSULTATION

Community and stakeholder consultation has been undertaken throughout previous work relevant to this CZMP and during the development of this CZMP including:

- The *Tweed Coast Estuaries Management Plan 2004-2008* (EMP) obtained information on community values, issues and concerns with regard to the Tweed Coast Estuaries;
- Consultation undertaken for the 2005 Tweed Coastline Management Plan included local and state government, Tweed Coastal Committee and Community input. Consultation activities collected information on the values and uses of the coastline, issues and potential management options;
- Consultation undertaken for the present study included Tweed Link articles, community liaison including market stalls and information stands, targeted stakeholder consultation with the Tweed Coastal Committee, public exhibition of the CZMP and community 'drop-in' sessions during public exhibition stage. Community feedback and written submissions received during the public exhibition stage were considered in the final revision of the CZMP.

## 5. MANAGEMENT OBJECTIVES

Management objectives were developed based on the values of the estuaries and the identified pressures impacting on these values. The objectives are consistent with the nine goals of the *NSW Coastal Policy 1997*, *TSC Community Strategic Plan*, and previous objectives set for the local estuaries and coastal zone. They are targets for future management to ensure a balance between long-term utilisation and conservation of the Tweed Coast Estuaries.

The nine goals of the *NSW Coastal Policy 1997* are proposed as the primary objectives for the Tweed Coast Estuaries CZMP. An additional primary objective has been added (Objective 10) to reflect Council's financial responsibilities and objectives of the *TSC Community Strategic Plan* related to delivering best value services and consideration of the community's capacity to pay.

A set of local objectives have been developed for each of the primary objectives based on previous community and stakeholder consultation and existing plans of management for the study area:

- *Tweed Coast Estuaries Management Plan 2004-2008* (Australian Wetlands 2003) – “Overall Desirable Outcomes” derived through community consultation;
- *Tweed Shire Coastline Management Plan* (Umwelt, 2005) – management objectives; and
- *Community Strategic Plan 2011/2021* (TSC, 2011a).

Appendix 7 shows the relationship between the primary management objectives, local objectives and preceding management

Table 4: Tweed Coast Estuaries CZMP management objectives

Primary Management Objective	Local Objectives for the Tweed Coast Estuaries
O1 - To protect, rehabilitate and improve the natural environment	<ul style="list-style-type: none"> <li>• Reduce pollution impacting the estuary</li> <li>• Maintain, rehabilitate and/or improve the riparian zone</li> <li>• Minimise adverse impacts on the estuaries</li> <li>• Enhance habitat values of the estuary</li> </ul>
O2 - To recognise and accommodate natural processes and climate change.	<ul style="list-style-type: none"> <li>• Set appropriate setbacks for infrastructure, access points and buildings from river bank escarpments</li> </ul>
O3 - To protect and enhance the aesthetic qualities of the coastal zone	<ul style="list-style-type: none"> <li>• Preserve the natural beauty and unique character of the Tweed Coast Estuaries</li> <li>• Protect and improve estuarine water quality</li> <li>• Protect flora and fauna species and habitat values to enhance nature watching activities around the estuary and coastline.</li> </ul>
O4 - To protect and conserve cultural heritage	<ul style="list-style-type: none"> <li>• To identify significant cultural heritage sites</li> <li>• To assess impacts on sites</li> <li>• To minimise impacts on sites</li> </ul>

Primary Management Objective	Local Objectives for the Tweed Coast Estuaries
O5 - To promote ecologically sustainable development and use of resources	<ul style="list-style-type: none"> <li>• Enhance recreational amenity</li> <li>• Preserve community uses (fishing, swimming, surfing, beach, estuary and foreshore use, etc.)</li> <li>• Enhance social benefits (employment, sense of place, community)</li> <li>• Promote economic benefits for the community (tourism dollars, land value, etc.)</li> </ul>
O6 - To provide for ecologically sustainable human settlement.	<ul style="list-style-type: none"> <li>• To minimise the impacts of present and planned urban settlements.</li> </ul>
O7 - To provide for appropriate public access and use.	<ul style="list-style-type: none"> <li>• Ensure suitable access to foreshore and beaches is retained</li> <li>• Maintain/repair or relocate access that is impacted by coastal hazards</li> <li>• Implement management strategies to avoid or address risks to community assets</li> <li>• Allow for ongoing use of community assets</li> <li>• To minimise risk to public health and safety</li> </ul>
O8 - To provide information to enable effective management	<ul style="list-style-type: none"> <li>• Undertake community education about issues, the need for management and the options assessment process</li> <li>• Enhance public awareness and support of adopted management strategies</li> <li>• Include community in decision making</li> </ul>
O9 - To provide for integrated planning and management.	<ul style="list-style-type: none"> <li>• To provide a consistent management framework that logically facilitates efficient and effective management</li> <li>• To ensure consistency with other strategic planning instruments and programs without duplicating management actions. The CZMP will support and refer to other programs where appropriate</li> <li>• Conduct monitoring of management strategies to measure success and improve practice</li> <li>• Identify equitable funding sources for implementation of management</li> </ul>
O10 - To minimise overall cost while achieving the goals of the CZMP	<ul style="list-style-type: none"> <li>• Minimise costs where possible while achieving aims of management (get the best 'bang for buck')</li> <li>• Ensure true costs are reflected in assessment of options (quick fix may be cheap but costs may be more in the long run)</li> </ul>

## **6. ASSESSMENT OF MANAGEMENT ACTIONS AND STRATEGIES**

### **6.1 Development of Management Actions and Strategies**

A broad range of management actions were recommended to address estuary health pressures identified in Section 2 and community use pressures identified in Section 3 of this CZMP. The recommended actions to address these issues are based on the nature of the problem, its location and consideration of what work has already been undertaken.

### **6.2 Evaluation of Management Actions and Strategies**

The list of management actions were evaluated and prioritised by considering a number of factors including:

- Cost of implementation;
- Effectiveness of each action in addressing the management objectives;
- Expected level of community support and acceptance of the action; and
- Environmental impacts (both positive and negative).

Management strategies were created by combining management actions into practical units for implementation. Priorities for the strategies were then assigned based on the average scores of actions making up that strategy.

Details of the assessment process are presented in Appendix 7. The outcome of the assessment is a comparative score and priority ranking for each management action and strategy. Two strategies were considered to be essential to the implementation of the CZMP because of their over-arching influence on estuary values and the fact that most of the other strategies rely on their implementation. They were categorised as “Fundamental” Strategies and were not assessed in the same way as the other actions and strategies. They were:

- Strategy 1: Monitoring, Evaluation and Review; and
- Strategy 11: Climate Change Adaptation.

### 6.3 Preferred Management Strategies

Table 5 presents the Management Strategies ranked in order of comparative scores. The higher comparative scores the greater the benefit to the Tweed Coast Estuaries. See Appendix 7 for a breakdown of all management action scores.

**Table 5: Combined strategy scores and priorities ranked by score**

Strategy	Score	Priority
Strategy 1: Monitoring, Evaluation and Review	n/a	Fundamental
Strategy 11: Climate Change	n/a	Fundamental
Strategy 6: Bank Erosion	15	High
Strategy 7: Acid Sulfate Soils	14	High
Strategy 5: Riparian Vegetation	14	High
Strategy 8: Agriculture	14	High
Strategy 4: Shorebirds and Coastal Raptors	14	High
Strategy 15: Education and Consultation	13	High
Strategy 2: Estuary Habitat	12	Medium
Strategy 9: Urban Development and Stormwater	12	Medium
Strategy 10: Wastewater Management	11	Medium
Strategy 13: Recreational Use	11	Medium
Strategy 3: Aquatic Fauna	10	Medium
Strategy 14: Cultural Heritage	9	Medium
Strategy 12: Public Access	9	Medium

**Table 6: Priority Scoring**

Priority rank	lower limit	higher limit
High	13	20
Medium	6	12
Low	0	< 6
Fundamental	Required for effective management	

## **7. IMPLEMENTATION REQUIREMENTS**

### **7.1 Management Actions**

The management strategies (Section 8) include a list of actions or steps which have been developed to address priority estuary pressures and progress towards the achievement of the management objectives.

Actions consist of a combination of studies, investigations and on-ground works. Generally, all strategies require some research or assessment prior to implementation of on-ground works. This is to ensure the appropriate effort, funding and geographical focus of on-ground works is undertaken.

Management strategies and actions have been developed for a ten year period. The CZMP and the progress of the management actions should be reviewed to ensure the actions remain relevant and the implementation of the plan is being achieved.

### **7.2 Responsibilities**

Responsibilities for implementation of the management strategies have been assigned to Government Agencies or entities responsible for management of that land parcel. In addition, support from various other local government and non-government organisations and groups, including industry bodies, private landholders and community groups, will be essential in the implementation of the plan.

In most cases Council has been assigned as the Lead Organisation assigned to the management action. The Tweed Coastal Committee (TCC) has also been added as a Lead Organisation for most strategies as they hold an overall coordination role for the CZMP. The actions also identify Support Organisations which may be required and/or requested to assist in implementation of the action, either through their regulatory role or land management function or as a potential funding or information source.

### **7.3 Timeframe**

Based on the priorities developed in this CZMP, timeframes for management actions have been developed. Management strategies in Section 8 have been scheduled according to the following timeframes:

- Immediate (year 1);
- On-going: starting year 1 and implemented over the 10 year life of the CZMP with possible extension beyond that period;
- Short Term: year 1 – 3;
- Medium term: year 4 – 6; and
- Long term: year 7 – 10.

High priority actions have been programmed to start either immediately or within the short term. The beginning of the implementation period for the CZMP is estimated to be the start of the 2014/2015 financial year (from 1<sup>st</sup> July 2014). This start time allows for Council adoption of the CZMP and government gazettal in 2013, and inclusion of actions within TSC budget for the 2014/15 financial year. Further details of recommended timeframes is provided within each specific action in Section 8, and tabled in the implementation program (Section 9).

### **7.4 Concurrent/Parallel Programs**

Local Council, government agencies and statutory bodies are implementing management programs in parallel with the preparation of this CZMP. Many of these initiatives are related to the management strategies presented here and have been considered in the development of the various management actions. For example, the management actions build on and support concurrent initiatives where they are directly relevant



to achievement of the CZMP objectives, where these are matched to available funding and where support from landholders and other agencies is expected to be achieved. A list of concurrent/parallel programs is provided in Section 1.4 of this CZMP.

### 7.5 Funding

The CZMP strategies are expected to be funded through Council and State Government contributions, grants and in-kind contributions. Identification of grants and successful application is an important component of this CZMP. Collaboration with universities may also provide opportunities for research projects. The responsible agency/ies have been identified for each strategy, together with potential funding sources. It is important to note that many grants and funding sources are only available up to a limited budget and as such, the available grants are changing from year to year. It will be necessary to keep abreast of current funding availability throughout the implementation of the CZMP.

Where actions are implemented through a concurrent program, additional expenditure and funding have not been included. Similarly, where a study/review is required to determine the appropriate level of expenditure, the cost of the future works has been broadly estimated, but should be confirmed or updated by the results of the review. Cost estimates provided in the action descriptions are preliminary only and based on the best available information.

A summary of potentially relevant and available grant schemes is given in Appendix 4. In most cases it is expected that in-kind contributions will be provided from TSC or agencies and this has been identified for each action.

The *Water Supply Catchment Stream Bank Protection Policy (2007)* is currently only applicable to the Tweed drinking water catchments and therefore does not include the Tweed Coast Estuaries study area. Council adopted the policy in 2007 to support rural land owners in the drinking water supply catchment to manage their stream banks in a manner which protects and enhances the integrity of Tweed Shires raw water supply. Through adoption of the policy, Council has implemented a River Health Grants program to improve and protect water quality. The scheme supplies funding to rural land holders to target the typical problems found on river banks including erosion and weed infestation. To improve the hygiene of water supplies, a priority activity is to supply off-stream stock watering points throughout the catchment. The River Health Grants Program is funded through the Catchment Water Quality Budget. While many projects have been undertaken within the catchment, uptake of the program to date has not utilised all of the funding currently available. If the policy was amended to allow funding of works outside the drinking water catchments, it may be a valuable source of funding for the CZMP to improve catchment waterways. The CZMP offers a strategic approach to allocation of funding for prioritised projects.

### 7.6 Community Involvement

On-going community involvement will be required to ensure successful implementation of the CZMP. This will include:

- Ongoing consultation with interested and committed community groups;
- A high degree of engagement and collaboration with landholders;
- On-ground participation in management actions, particularly local community groups such as Landcare and fishing groups;
- Consultation and collaboration with local Aboriginal representatives and groups; and
- Education programs.

Achievement of the management plan objectives is reliant on community understanding and effective involvement in the management process.

## 7.7 Measures of success of the CZMP

Most of the management objectives listed in Section 5 are aspirational in that they are high level goals that may not be achievable within the life of this plan. However they remain as long-term desires held by the Tweed Coast Estuaries stakeholders. Continuous improvement towards these objectives across the full range of issues should be seen as the first measure of success.

Success of the CZMP will be indicated by the implementation of substantial measures to address the root cause of issues facing the estuary, as well as conclusive documentation of the effectiveness of such measures. Success of the CZMP will be gauged by:

- Stakeholder acceptance;
- Adoption of the plan by TSC;
- Incorporation of the plan recommendations into business planning for the responsible agencies;
- Securing sufficient funds to implement these actions;
- Implementation of actions in an efficient and timely manner;
- Uptake of actions by stakeholders and others;
- Positive stakeholder feedback on improvements; and
- Measured improvements in estuary health such as improved water quality and reduction of frequency and severity of adverse environmental events such as fish kills.

Key Performance Indicators (KPIs) have been identified where appropriate for each management action to provide a target for achievement of the major steps in each action.

## 8. MANAGEMENT STRATEGIES

The following tables summarise the components of the CZMP management strategies. Each strategy contains:

- Priority assigned to the strategy during options assessment process;
- A brief introduction which provides an overview of the strategy;
- A table for each action making up the strategy. Where there is more than one action, a summary table is provided of the key details after the strategy introduction. Each action table includes:
  - Objectives – list of management objectives relevant to the strategy;
  - Estuary Pressures targeted – list of identified ‘pressures’ that are to be addressed through the strategy;
  - Desired Outcome - the specific goal to be achieved by implementation of each action;
  - Lead Organisation – the body or bodies responsible for implementation of the action;
  - Support Organisation – provide assistance in the implementation and contribution of staff, resources and/or funding;
  - Cost Estimate – broad estimate of costs for implementation over the 10 year life of the plan. In some cases actions are implemented only in the first few years, and others are on-going actions, to be implemented continuously over the 10 years. Refer to Section 9 - Implementation Program for a breakdown of action costs for each financial year. Note that all costs are current (2013 financial year) dollars and make no allowance for inflation in subsequent years;
  - Potential Funding – identified possible sources of funding from currently available grants and contributions although it is acknowledged that resources will change over the course of the plan and new sources of funding will need to be sought on a regular basis;
  - Timing – indicative timeframe for implementation ;
  - Description of Tasks – an outline of the scope of works required;
  - KPIs (Key Performance Indicators) – target(s) for each action which can be used to measure the level of success; and
  - Complimentary strategies.

Management strategies are not presented in priority order in this section but follow the order in which they were discussed in Sections 2 and 3. The Implementation Program provided in Section 9 ranks the strategies in priority order.

## 8.1 Strategy 1: Monitoring, Evaluation and Review

### Priority: Fundamental

There are two key aspects of monitoring, evaluation and review that are regarded as essential components of the CZMP:

- Ecosystem Health Monitoring - an effective environmental monitoring and reporting system is regarded as a key component of a CZMP in order to measure the overall health of the estuaries, identify relative sources of contamination, and to assess the success of management efforts implemented as part of the CZMP; and
- Review of CZMP implementation progress and success of actions - The ability to achieve the management objectives will be determined through the success of the management actions. This will require coordinated monitoring across the estuary as well as on-going review of performance against defined targets. Ongoing reporting of progress of the CZMP will be undertaken as part of the Council State of the Environment (SoE) Reporting. A major review of this CZMP will also be required towards the end of the 10-year lifespan of this plan or as dictated by changing circumstances.

Monitoring of estuary status and obtaining feedback on the success of management initiatives is a critical aspect of effective management of the Tweed Coast Estuaries. Performance indicators need to incorporate evaluation of the status of estuary health, as well as documenting trends in underlying ecological processes. Monitoring of environmental condition and processes, estuary stressors and community opinions should all be undertaken to provide a solid information base for future decision making.

All monitoring should seek to capitalise as much as possible on existing information in order to provide a baseline from which the success of management actions can be measured and effort can be targeted to appropriate actions. The monitoring program should provide robust scientific data while considering the limited human and financial resources available. Council and agency staff should be involved in the development of the program. The existing Council monitoring programs (e.g. as required by Environment Protection Licences) should continue, however the estuary monitoring program should capitalise on all available information and consider these information sources in the overall monitoring program design.

The design of a monitoring program will need to be consistent with the NSW Natural Resources Monitoring, Evaluation and Reporting (MER) Strategy which guides the monitoring, evaluation and reporting of natural resources in NSW. The MER Strategy focuses on developing a seamless link between local, regional, state and national data on natural resource management (NRM) that will inform the community on how it cares for the natural resources of NSW. Of particular relevance are the recently released OEH protocols entitled *Assessing estuary ecosystem health: Sampling, data analysis and reporting protocols NSW Natural Resources Monitoring, Evaluation and Reporting Program* (OEH, 2013). Integration with the strategy will assist in keeping the monitoring program in line with current protocols, allow for data sharing and maximise cost effectiveness.

**Table 7: Summary of Monitoring and Evaluation actions**

<p><b>Objectives:</b></p> <p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O4. To protect and conserve cultural heritage;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O7. To provide for appropriate public access and use;</p> <p>O8. To provide information to enable effective management;</p> <p>O9. To provide for integrated planning and management; and</p> <p>O10. To minimise overall cost while achieving the goals of the CZMP</p>				
<p><b>Estuary Pressures targeted:</b></p> <p>All</p>				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
1a) Ecosystem Health monitoring program	\$320,000	On-going (years 1-10)	Study Area	TSC
1b) Review of CZMP progress and monitoring of KPIs	Not Estimated	Ongoing (every four years)	Study Area	TSC
1c) 10 year review of CZMP	\$100,000	Long term (year 10)	Study Area	TSC
<p><b>Complimentary Strategies:</b></p> <ul style="list-style-type: none"> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 6: Bank Erosion</li> <li>• Strategy 15: Education and Consultation</li> </ul>				

**Action 1a: Ecosystem Health monitoring program**

<b>Desired Outcome</b>	Implementation of a coordinated catchment-wide monitoring program to monitor estuary health, measure the success of management actions and inform decision making in accordance with the NSW Natural Resources MER Strategy.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, DPI-Crown Lands, Fisheries NSW
<b>Cost Estimate (10 year)</b>	\$320,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions)
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Whole study area, including key sites in both estuarine and freshwater reaches
<b>DESCRIPTION OF TASKS:</b>	
<p>Tasks to be completed include:</p> <ul style="list-style-type: none"> <li>• Monitoring program design – the design should be specific to management issues identified in this CZMP and the <i>Baseline Ecosystem Health Assessment</i>, community concerns identified through consultation phases and actions implemented as part of the CZMP to address issues. Additionally: <ul style="list-style-type: none"> <li>○ The program will need to be consistent with the NSW Natural Resources MER Strategy and utilise the protocols: <i>Assessing estuary ecosystem health: Sampling, data analysis and reporting protocols NSW Natural Resources Monitoring, Evaluation and Reporting Program</i> (OEH, 2013);</li> <li>○ It will be important to complete a review of the <i>Baseline Ecosystem Health Assessment</i> as part of monitoring design. Evaluating the effectiveness of sampling methodologies and improving on techniques will ensure a robust program for repeat sampling. The <i>Baseline Ecosystem Health Assessment Report</i> (Appendix 4) contains review of certain monitoring components and recommendations for management such as changes to the current TSC water quality sampling regime to better assess recreational health indicators and to revise limits of recording for some parameters;</li> <li>○ Include saltmarsh, seagrass and mangrove extent mapping and health monitoring to fully determine the drivers for degradation of these communities and the ecological implications of this for the Tweed Coast estuaries. There are opportunities to coordinate with Fisheries NSW in their estuarine habitat mapping exercises, and the OEH's MER Program which should be explored and utilised wherever possible in gathering this information;</li> <li>○ Incorporate surveys to determine the efficacy of management actions as appropriate. This would include looking for improvements in general trends in ecosystem health (e.g. water quality, aquatic and riparian habitat, fish and macroinvertebrate communities) and more specific sites where restoration works have been undertaken.</li> <li>○ Expand the spatial coverage of TSC's existing ambient water quality monitoring program to include more sites in the mid to upper reaches of each catchment;</li> <li>○ In the absence of locally derived water quality objectives the OEH (2006) water quality guidelines for the Tweed River are recommended to assess water quality risk;</li> <li>○ Measuring trends in water quality in areas influenced by management efforts will be required to determine the success of actions and confirm issues or identify further management requirements. The catchment-wide approach of the Ecosystem Health monitoring program also offers a means to compare the effect of localised management on the health of the estuary and therefore assist in future management direction;</li> <li>○ Assessment of known contaminant point sources such as stormwater outlets, drains from intensive agricultural areas (e.g. Cudgen Plateau farmland) and the future Mooball Burringbar WWTP will be important to compare impacts from these sources in comparison to diffuse pollution sources. A direct recommendation coming out of the <i>Baseline Ecosystem Health Assessment</i> is to continue to monitor water quality downstream of Burringbar and Mooball villages to assess whether the centralised sewage system has been effective in improving water quality in the waterways. If an improvement in health is not apparent, further investigation into the causes of water quality decline should be investigated. Sample sites should be established in Cudgen Lake and at key sites upstream of the Lake to assess potential blackwater events identified by Colins <i>et al.</i> (2012) (refer Section 2.2.6); and</li> </ul> </li> </ul>	

DESCRIPTION OF TASKS cont.:	
<ul style="list-style-type: none"> <li>○ The sampling regime should allow for assessment of average conditions and also capture high risk events for the estuaries such as summer floods.</li> <li>● Catchment-wide reporting will allow for an assessment of relative contributions of pollutants to the estuary and help to direct management actions.</li> </ul>	<p>Communication of the findings of the program to the wider community is a key requirement. It will be important to produce simple, easily understandable reports to inform the community about the health and specific needs of the estuary related to their local catchments and management efforts. Well-designed report cards offer a means to convey results in simple, visual terms and are easily distributed as single page leaflets or web downloads.</p> <p>Communication will be carried out a part of Action 15a: Community education and consultation program.</p> <ul style="list-style-type: none"> <li>● A review should be undertaken annually to analyse trends as well as optimise and update the program.</li> </ul> <p>Implementation costs have been estimated based on the following:</p> <ul style="list-style-type: none"> <li>● \$20,000 has been allowed for the initial design of the monitoring program including scheduling, timing and confirmation of cost estimations.</li> <li>● Continuation of TSC water quality monitoring, amended as per the design of the Ecosystem Health monitoring program. At this stage the CZMP assumes that the existing level of funding will be adequate to cover water quality monitoring costs and no additional funds are sought for this component.</li> </ul> <p>A repeat of similar sampling to what was carried out for the <i>Baseline Ecosystem Health Assessment</i> once every 4 years. \$100,000 has been allowed for each sample event including desktop assessment, field sampling, lab analysis, statistical analysis and reporting. The nature and timing of the repeat surveys will be confirmed by the design of the monitoring program. Note that more frequent seagrass monitoring is recommended as part of Action 2a: Investigation of seagrass decline.</p> <p>Over the ten year life of the CZMP this equates to a total of \$320,000.</p>
<b>KPIs</b>	<ul style="list-style-type: none"> <li>● Design of the Tweed Coast Estuaries Ecosystem Health monitoring program by March 2014.</li> <li>● Program commenced by June 2014.</li> <li>● Annual reports and community report cards prepared for each year of the program.</li> </ul>

**Action 1b: Review of CZMP progress and monitoring of KPIs**

<b>Desired Outcome</b>	Continuous improvement towards the CZMP objectives across the full range of identified pressures
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW, DPI-Crown Lands
<b>Cost Estimate (10 year)</b>	Included in SoE reporting
<b>Potential Funding</b>	n/a
<b>Timing</b>	2016, 2020, 2024
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>Success of the CZMP will be indicated by the implementation of substantial measures to address the root cause of issues facing the estuary. Key tasks are:</p> <ul style="list-style-type: none"> <li>• Reporting against KPIs for each management action to assess the achievement of the major steps in each action.</li> <li>• Annual review and reporting of progress towards the KPIs. Conclusive documentation of the effectiveness of these measures will be required and should be reported.</li> <li>• Collation of annual reviews as part of the Council State of the Environment (SoE) Reports (every 4 years).</li> <li>• Community education regarding progress of the CZMP and achievement of KPIs should be carried out as part of Action 15a: Community education and consultation program.</li> </ul>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Review and reporting undertaken as part of SoE reporting – 2016, 2020 and 2024</li> </ul>

**Action 1c: 10 year review of CZMP**

<b>Desired Outcome</b>	Management strategies remain appropriate for the long term
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW, DPI-Crown Lands, NRCMA
<b>Cost Estimate (10 year)</b>	\$100,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions)
<b>Timing</b>	Long term (year 10)
<b>Management Zones</b>	Whole study area
<b>DESCRIPTION OF TASKS:</b>	
<p>A ten year review (or earlier if warranted by legislative or management changes or improved scientific understanding) of the CZMP is required to consider:</p> <ul style="list-style-type: none"> <li>• Results of the four-yearly KPI reviews (Action 1b);</li> <li>• Any barriers identified to the effective implementation of actions or overall success of actions;</li> <li>• Any new or updated scientific knowledge;</li> <li>• Data provided by the estuary monitoring program (Action 1a); and</li> <li>• Prevailing community attitudes, government policy, strategic planning and estuary management issues.</li> </ul> <p>A budget amount of \$100,000 has been allowed based on similar reviews.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Review and reporting undertaken by year 10.</li> <li>• Adoption and gazettal of the amended CZMP as required.</li> </ul>



## 8.2 Strategy 2: Estuary Habitat

Priority: Medium

**Table 8: Summary of Estuary Habitat actions**

<p><b>Objectives:</b></p> <p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O7. To provide for appropriate public access and use;</p> <p>O8. To provide information to enable effective management</p>				
<p><b>Estuary Pressures targeted:</b></p> <p>P1. Decline in seagrass area in all estuaries between 2006 and latest assessments conducted in 2011.</p> <p>P2. Dramatic decline in seagrass area and health in Mooball Creek.</p> <p>P3. Estuarine habitats (seagrass, mangroves and saltmarsh areas) remain vulnerable to a number of threats affecting their overall health and continued protection.</p>				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
2a: Investigation of seagrass decline	\$40,000	Work to commence ASAP (by June 2013), continues in the short-term (year 1-2)	Study Area	TSC
2b: On-going protection of estuary habitat	Not Estimated	On-going (years 1-10)	Study Area	TSC
<p><b>Complimentary Strategies:</b></p> <ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 15: Education and Consultation</li> </ul>				

**Action 2a: Investigation of seagrass decline**

<b>Desired Outcome</b>	Determine the sources of decline in seagrass extent in the Tweed Coast Estuaries and recommend remedial action where possible to address root causes.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW
<b>Cost Estimate (10 year)</b>	\$40,000
<b>Potential Funding</b>	Fisheries NSW Habitat Action Grants, NSW Estuary Management Program, TSC
<b>Timing</b>	Work to commence ASAP (by July 2013), continues in the short-term (Year 1-2)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>Investigation of the causes of seagrass decline in the Tweed Coast Estuaries detected by the baseline assessment will involve the following tasks:</p> <ul style="list-style-type: none"> <li>• Review of background information including general seagrass literature and local studies to determine likely causes of seagrass decline.</li> <li>• Review historical mapping of estuarine habitats conducted by Fisheries NSW. This has been done in the baseline assessment for information available up to 2011. Additional mapping should be reviewed as available.</li> <li>• If seagrass mapping is not available from Fisheries NSW, it is recommended that this mapping be undertaken across the estuaries using the same methods of aerial photography interpretation confirmed by field inspection. Note that costs for seagrass mapping have not been included in the cost estimate for this action.</li> <li>• A review of the methodologies used to assess seagrass extent in previous assessments should be undertaken to attempt to identify changes attributable to differences in method rather than actual changes in seagrass extent.</li> <li>• Continuation of the seasonal seagrass monitoring carried out during the baseline assessment to assess the ongoing state of seagrass and whether the beds are continuing to decline or whether they are showing signs of recovery. A review of the monitoring methodology should be undertaken to optimise the sampling regime. Monitoring should aim to capture any signs of disturbance, noting accretion or sedimentation of beds. Two years of seasonal monitoring (2 times per year) is recommended as a minimum to assess trends over time and between years. The need for further monitoring should be assessed at the end of the two years.</li> <li>• Due to the poor state of seagrass in Mooball Creek, it is recommended that this location is given a high priority for monitoring.</li> <li>• Review water quality monitoring data for the estuaries to detect potential causes of seagrass decline.</li> <li>• Based on the findings of the investigation, recommend management action where possible to address the root cause of seagrass decline with the aim of improving seagrass habitat across the estuaries.</li> </ul> <p>Community education regarding estuary habitat values communicating the results of the study should be carried out as part of Action 15a: Community education and consultation program.</p> <p>Costs of this task have been estimated based on the methods carried out as part of the baseline assessment and allowing additional time for background information review and reporting. It does not include costs for ongoing water quality monitoring carried out by TSC and it is assumed this will be available for the study.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Commence investigation by July 2013 to allow for Spring sampling to commence in Sep/Oct 2013;</li> <li>• Report of findings of 2 year monitoring by April 2015.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 3: Aquatic Fauna</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 6: Bank Erosion</li> <li>• Strategy 15: Education and Consultation</li> </ul>

**Action 2b: On-going protection of estuary habitat**

<b>Desired Outcome</b>	On-going protection of seagrass, saltmarsh and mangrove habitats within the Tweed Coast Estuaries.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW
<b>Cost Estimate (10 year)</b>	Not Estimated – costs incorporated into complimentary strategies
<b>Potential Funding</b>	Fisheries NSW Habitat Action Grants, NSW Estuary Management Program, TSC
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<ul style="list-style-type: none"> <li>• Education will be important to protect estuary habitat areas from potential harm caused by physical disturbance. Specific measures include: <ul style="list-style-type: none"> <li>○ Signage of particularly sensitive sites may be necessary for protection against physical disturbance (e.g. site MOOSG1 in lower Mooball Creek);</li> <li>○ Wherever practical and a clear need has been identified, use fencing or bollards along the intertidal zone to prevent stock and vehicular access to habitat areas,</li> <li>○ Avoid walking, riding or driving through habitat areas at low tide;</li> <li>○ Dispose of rubbish, oils and chemicals in the correct manner; and</li> <li>○ Report activities harming marine vegetation, particularly mangrove clearing to Fisheries NSW for investigation.</li> </ul> </li> <li>• Riparian buffers between development areas and waterways provide a range of important ecological functions. With regard to estuarine habitats, buffers allow space for estuarine vegetation communities to migrate in response to changing conditions. This will be particularly important when considering future sea level rise scenarios (refer Strategy 5: Riparian Vegetation).</li> <li>• Broad land management practices (both urban and agricultural) should aim to reduce nutrient and sediment loads to the estuary (refer Strategy 8: Agricultural Land, Strategy 7: Acid Sulfate Soils, Strategy 9: Urban Development and Stormwater, and Strategy 10: Wastewater Management).</li> <li>• It is important that any new development areas fully comply with Council's stormwater regulations and requirements in terms of achieving water quality and flow standards.</li> <li>• Stormwater outlets to be located away from sensitive estuarine habitats in accordance with Fisheries NSW policy and guidelines.</li> <li>• Further studies, including saltmarsh, seagrass and mangrove extent mapping and health monitoring to fully determine the drivers for degradation of these communities and the ecological implications of this for the Tweed Coast estuaries. There are opportunities to coordinate with Fisheries NSW in their estuarine habitat mapping exercises, and the OEH's MER Program which should be explored and utilised wherever possible in gathering this information. This task should be incorporated into Action 1a: Ecosystem Health monitoring program.</li> </ul> <p>Community education regarding estuary habitat values, key threats and communicating the results of monitoring etc. should be carried out as part of Action 15a: Community education and consultation program.</p> <p>As the majority of tasks under this strategy are best carried out within complementary strategies identified, no additional costs have been assigned to this action.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• KPIs relevant to complementary strategies achieved.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 6: Bank Erosion</li> <li>• Strategy 9: Urban Development and Stormwater</li> <li>• Strategy 15: Education and Consultation</li> </ul>

### 8.3 Strategy 3: Aquatic Fauna

**Priority: Medium**

This strategy is aimed at the conservation and management of aquatic fauna and habitat within the freshwater reaches of the Tweed Coast Estuaries study area. Many of the overriding pressures on aquatic fauna are related to catchment management and particularly management affecting water quality and the condition of riparian zones which are addressed by complimentary strategies contained in this plan and listed at the bottom of Table 9. Action 3a aims to address identified aquatic habitat pressures. Action 3b focusses on addressing the exotic fish problem identified by the *Baseline Ecosystem Health Assessment*.

**Table 9: Summary of Aquatic Fauna Actions**

<b>Objectives:</b>				
O1. To protect, rehabilitate and improve the natural environment;				
O8. To provide information to enable effective management; and				
O9. To provide for integrated planning and management.				
<b>Estuary Pressures targeted:</b>				
P4. Alteration of habitat is a major pressure for aquatic fauna and a primary cause of decreasing native fish populations. Channelisation of natural waterways, altered flow regimes, poor condition riparian zones and poor water quality are main contributors to habitat alteration.				
P5. Partial barriers to fish passage may prevent the migration of native fish species during some flow conditions.				
P6. Introduced fauna species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. The introduced Mosquito Fish ( <i>Gambusia holbrooki</i> ) and an aquarium fish, Swordtail ( <i>Xiphophorus helleri</i> ) are species of concern for the freshwater reaches of Tweed Coast Estuaries.				
P44. Community concern that a fish stocks have declined over recent decades.				
P45. Overfishing can impact fish stocks.				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
3a) Aquatic habitat restoration and protection	\$100,000	On-going (years 1-10)	Study Area	TSC
3b) Christies Creek fish surveys	\$15,000	Short-term (year 2)	Study Area	TSC
<b>Complimentary Strategies:</b>				
<ul style="list-style-type: none"> <li>• Strategy 15: Education and Consultation</li> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 6: Bank Erosion</li> </ul>				

**Action 3a: Aquatic habitat restoration and protection**

<b>Desired Outcome</b>	Restoration and protection of aquatic habitats within the Tweed Coast Estuaries study area.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	Fisheries NSW
<b>Cost Estimate (10 year)</b>	\$100,000 (\$10,000 set aside each year for works as opportunities and funding grants arise)
<b>Potential Funding</b>	Fisheries NSW Habitat Action Grants, TSC
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<ul style="list-style-type: none"> <li>• Identify opportunities for aquatic habitat restoration, either as additional complimentary works associated with identified riparian rehabilitation or acid sulfate soil remediation sites, or sites identified by landholders, community members, Council or Fisheries NSW staff. Landholder willingness will be one of the key factors in determining suitable sites and the success of restoration works.</li> <li>• Plan and implement habitat restoration works which may include:             <ul style="list-style-type: none"> <li>○ Restoring in-stream woody habitat (“re-snagging”);</li> <li>○ Restoring riparian areas by removing , replanting with native plants and fencing;</li> <li>○ Bank stabilisation works;</li> <li>○ Reinstatement of natural flow regimes;</li> <li>○ Improving fish passage by installing fishways, making road crossings more fish friendly, removing weirs and actively managing floodgates;</li> <li>○ Platypus habitat protection works (in cooperation with TSC’s Platypus Project).</li> </ul> </li> <li>• Follow up surveys should be conducted as part of the Ecosystem Health monitoring program to determine the efficacy of habitat restoration measures as appropriate.</li> <li>• On-going communication with Fisheries NSW to allow for the two-way sharing of information including any monitoring undertaken, remediation of sites and notification of any specific issues such as fish passage barriers, exotic fish infestations etc.</li> </ul> <p>Community education communicating the works planned or undertaken should be carried out as part of Action 15a: Community education and consultation program</p> <p>Funding of \$10,000 per year has been set aside for aquatic habitat restoration works for the ten year life of the plan. The Fisheries NSW Habitat Action Grants can provide additional funding (up to \$40,000) for one year projects.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• By 2017, at least 70% of the funding set aside has been used in aquatic habitat restoration projects.</li> <li>• By completion of the ten year implementation period at least 70% of the funding set aside has been used in aquatic habitat restoration projects.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 6: Bank Erosion</li> <li>• Strategy 7: Acid Sulfate Soils</li> <li>• Strategy 8: Agricultural Land</li> <li>• Strategy 9: Urban Development and Stormwater</li> <li>• Strategy 15: Education and Consultation</li> </ul>

**Action 3b: Christies Creek fish surveys**

<b>Desired Outcome</b>	Undertake surveys on Christies Creek to determine the extent of Swordtail infestation and determine the feasibility of removal of this species at this location.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	Fisheries NSW, OEH
<b>Cost Estimate (10 year)</b>	\$15,000
<b>Potential Funding</b>	Fisheries NSW Habitat Action Grants, NSW Estuary Management Program, TSC
<b>Timing</b>	Short-term (year 2)
<b>Location</b>	Christies Creek (upper catchment)
<b>Objectives:</b>	<p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O7. To provide for appropriate public access and use; and</p> <p>O8. To provide information to enable effective management.</p>
<b>Estuary Health Pressures targeted:</b>	P5. Introduced fauna species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. The introduced Mosquito Fish ( <i>Gambusia holbrooki</i> ) and an aquarium fish, Swordtail ( <i>Xiphophorus helleri</i> ) are species of concern for the freshwater reaches of Tweed Coast Estuaries.
<b>DESCRIPTION OF TASKS:</b>	
<ul style="list-style-type: none"> <li>• Desktop assessment to determine extent of study area and survey sites to be sampled. Preliminary work completed as part of the <i>Baseline Ecosystem Health Assessment</i> will provide suitable background information for the survey. In selecting sites it will be important to identify potential aquarium fish release points for investigation. Evaluation of the potential for any in-stream barriers to upstream migration is also required as this may influence the fish community composition.</li> <li>• Initial site inspection to confirm survey sites and methodologies.</li> <li>• The selection of sampling methodology will be somewhat dependent on the sample sites to be incorporated. The sampling methodology design should aim to: <ul style="list-style-type: none"> <li>○ Provide an assessment of the extent of the Swordtail infestation in at least two different seasons (i.e. spring and summer) to account for seasonal differences. This may involve sampling a sequence of sites starting from the site where the infestation was first detected and moving upstream and downstream until no further individuals are detected;</li> <li>○ Provide an representative sample of the whole fish communities at the selected locations to determine the impact of Swordtail presence on the overall fish community;</li> <li>○ Include field assessment of water quality at each site. Key parameters are DO, pH, EC, Salinity and Temperature, which should be measured in-situ using a hand-held multi probe;</li> <li>○ Include a rapid assessment of in-stream habitat features;</li> <li>○ Provide a robust assessment that is repeatable and comparable over time;</li> <li>○ Evaluate likely numbers of Swordtail; and</li> <li>○ Creates minimal environmental impact and will not influence the results of subsequent sampling.</li> </ul> </li> <li>• Where sites are adjacent to private land it will be necessary to notify private landholders of activities and gain permission for access where necessary.</li> <li>• Surveys to be undertaken by suitably qualified and experienced aquatic ecologist. A valid Scientific Collection Permit and Animal Ethics approval will be required from Fisheries NSW prior to carrying out the work.</li> <li>• Any exotic species captured during surveys must be euthanased following an approved method by Fisheries NSW.</li> </ul>	

<b>DESCRIPTION OF TASKS (continued):</b>	
<ul style="list-style-type: none"> <li>• Reporting of fish capture statistics will include at a minimum:                             <ul style="list-style-type: none"> <li>○ Fish species presence/absence and relative abundance (i.e. standardised catch per unit effort);</li> <li>○ Observed versus expected native species; and</li> <li>○ Ratio of exotic to native species.</li> </ul> </li> <li>• Based on the results of surveys, provide an assessment of the feasibility of removal of exotic species at this location.</li> <li>• Methods of removal should be discussed and recommendation made for the most appropriate options.</li> </ul> <p>Follow up surveys should be conducted as part of the Ecosystem Health monitoring program to determine the efficacy of habitat restoration and exotic fish removal measures as appropriate.</p> <p>Community education communicating the results of the study should be carried out as part of Action 15a: Community education and consultation program</p> <p>Costs have been estimated based on previous fish sampling work in the catchment.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Seasonal surveys completed by end of summer 2016.</li> <li>• Report to Council submitted by April 2016.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 15: Education and Consultation</li> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 6: Bank Erosion</li> </ul>

## 8.4 Strategy 4: Shorebirds and Coastal Raptors

Priority: High

**Table 10: Summary of shorebird and coastal raptor management actions**

<b>Objectives:</b>				
O1. To protect, rehabilitate and improve the natural environment;				
O2. To recognise and accommodate natural processes and climate change;				
O3. To protect and enhance the aesthetic qualities of the coastal zone;				
O5. To promote ecologically sustainable development and use of resources;				
O6. To provide for ecologically sustainable human settlement;				
O7. To provide for appropriate public access and use;				
O8. To provide information to enable effective management;				
<b>Estuary Pressures targeted:</b>				
P7. Threats to shorebirds include introduced pests such as foxes, weed invasion, coastal processes, natural predation and disturbance from beach users and domestic dogs.				
P8. Specific concern has been raised in the community that dogs are negatively impacting on shorebirds in foreshore areas of lower Cudgera Creek.				
P9. Concerns have been raised by local bird enthusiasts that shorebird use of Cudgen and Mooball Creeks is not well understood and may well be important.				
P10. Threats to coastal raptors include habitat loss and degradation, human disturbance to breeding, entanglement and ingestion of fishing line, tackle and pollutants, reduced water clarity, reduced fish health and availability and collision with power line and vehicles.				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
Action 4a: On-going protection of shorebirds and their habitat in the study area	\$20,000	On-going (years 1-10)	Shorebird habitat areas within the Study Area	TSC
Action 4b: Management of dogs within vicinity of shorebird habitat at Cudgera Creek mouth	Not Estimated – included in Action 15b: Signage	Immediate (year 1)	Cudgera Creek mouth	TSC
Action 4c: On-going protection of coastal raptors and their habitat in the study area	\$5,000	On-going (years 1-10)	All estuaries	TSC
<b>Complimentary Strategies:</b>				
<ul style="list-style-type: none"> <li>• Strategy 15: Education and Consultation</li> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 5: Riparian Vegetation</li> </ul>				



**Action 4a: On-going protection of shorebirds and their habitat in the study area**

<b>Desired Outcome</b>	Continue and support existing programs to reduce impacts on shorebirds and carry out further work to identify vulnerable habitats and protect them from disturbance.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, NPWS
<b>Cost Estimate (10 year)</b>	\$20,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC, Tweed Bird Observers, BirdLife Australia
<b>Timing</b>	On-going (year 1-10), with habitat prioritisation study in year 2
<b>Location</b>	Shorebird habitat areas within the Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>There are a number of existing programs in operation in the local area that assist in improving shorebird habitat and minimising the key risks. This shorebird management strategy supports the on-going implementation of these programs including:</p> <ul style="list-style-type: none"> <li>• Development and implementation of guidelines for the management of beach-nesting birds on Tweed Coast public lands (joint project TBO and TSC funded by BirdLife Australia);</li> <li>• Bitou Bush and other weed control programs undertaken by Council, DPI-Crown lands and other organisations such as community Land care and Coast care groups in coastal areas. Weed invasion can result in loss of habitat for shorebirds and restoring natural vegetation to coastal and estuary foreshore areas is encouraged;</li> <li>• Follow up monitoring of shorebirds as recommended by the recent study: <i>Shorebirds of Northern New South Wales</i> (DECCW, 2010c). The initial study compiled background information to form a baseline of shorebird populations. Future surveys will assist in tracking the health of communities and help to assess the success of management effort.</li> </ul> <p>In addition to continuation of existing programs, the following tasks are recommended:</p> <ul style="list-style-type: none"> <li>• Community education and awareness programs about shorebird values and status, their breeding ecology, vulnerability to disturbance and ways for individuals to assist in mitigating impacts in their local areas. Shorebird education should be carried out as part of Action 15a: Community education and consultation program.</li> <li>• Detailed maps of dog use areas on the Tweed Coast be developed and made available in brochures and on the TSC web page;</li> <li>• Consideration of fox control baiting programs as part of shorebird management strategies;</li> <li>• Shorebird habitat prioritisation to identify important habitat features and sites that require protection. Shorebird habitat prioritisation such as has been previously undertaken for the Tweed River estuary (Sandpiper Ecological Surveys, 2003) would identify high risk sites for protection and allow for recommendation about the most appropriate management strategies. The recent publication <i>Shorebirds of Northern New South Wales</i> (DECCW, 2010c) will provide good preliminary information on habitat areas. Consultation with the local community, National Parks personnel and local shorebird experts should also be undertaken to identify sites.</li> <li>• It should be determined whether key habitat sites in the estuaries would benefit from signage as part of the prioritisation study.</li> </ul> <p>This action assumes that the existing programs are continued and no budget for continuation of existing work has been factored into this CZMP. Additional tasks recommended by this action and costed in the CZMP are:</p> <ul style="list-style-type: none"> <li>• Costs of the shorebird habitat prioritisation task are estimated to be approximately \$20,000, relying on background information, local expert knowledge and limited field surveys.</li> </ul> <p>Education and signage has been included in cost estimation for Strategy 15: Education and Consultation</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Existing programs continue;</li> <li>• Shorebird habitat prioritisation completed by end of 2016 financial year.</li> </ul>

**Action 4b: Management of dogs within vicinity of shorebird habitat at Cudgera Creek mouth**

<b>Desired Outcome</b>	Protect shorebirds from disturbance by dogs in habitat areas located at Cudgera Creek mouth
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, NPWS, Tweed Bird Observers
<b>Cost Estimate (10 year)</b>	Not Estimated – included in Action 15b: Signage
<b>Potential Funding</b>	NSW Estuary Management Program, TSC
<b>Timing</b>	On-going (year 1-10), with habitat prioritisation study in year 2
<b>Location</b>	Cudgera Creek mouth
<b>DESCRIPTION OF TASKS:</b>	
<p>The Cudgera Creek Entrance foreshore area has been identified as a key site for a designated dog exclusion area to protect shorebird habitat. Most of the area is already designated in this way, but extension of the existing areas to cover the area south of the creek mouth and clear signage and regulation is required. Tasks include:</p> <ul style="list-style-type: none"> <li>• Designation of a dog exclusion zone for the entire foreshore areas adjacent to the Cudgera Creek mouth, and extending from the ocean to the bridge. This includes all the areas in Figure 12 (Section 2.2.3) from the Peninsula Street beach access track in the north to the rock platform on the south side of the creek mouth.</li> <li>• Designation should be formalised and advertised to the public via signage at the site, Council notices in local paper, TweedLink article, Council Webpage, etc.</li> <li>• Clear signage and regulation of the areas is required to ensure effective management. The type and location of signage will need to be carefully selected to ensure effectiveness.</li> <li>• Enforcement of rules through extra TSC Ranger patrols of the area following signage deployment to reinforce the requirement and issue warnings and/or fines as appropriate. Patrols can also be used as a means of providing information about shorebird values and the need for restrictions;</li> </ul> <p>Costs of signage in this area has been included in Action 15b: Signage.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Designation of dog exclusion areas at Cudgera Creek mouth asap (by June 2013);</li> <li>• Signage erected at the site by August 2013.</li> </ul>

**Action 4c: On-going protection of coastal raptors and their habitat in the study area**

<b>Desired Outcome</b>	Reduce impacts on coastal raptors to ensure these iconic species continue to exist in the Tweed Coast Estuaries.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, NPWS, Tweed Bird Observers
<b>Cost Estimate (10 year)</b>	\$5,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC, BirdLife Australia
<b>Timing</b>	On-going (year 1-10)
<b>Location</b>	All estuaries
<b>DESCRIPTION OF TASKS:</b>	
<p>Measures which address the specific pressures identified for the Tweed Coast Estuaries and to ensure protection of coastal raptors would include:</p> <ul style="list-style-type: none"> <li>• Public education on responsible behaviour and the impacts of personal behaviour. This includes: <ul style="list-style-type: none"> <li>○ awareness programs focussing on coastal raptor values and status, their breeding ecology, vulnerability to disturbance and ways for individuals to assist in mitigating impacts in their local areas;</li> <li>○ correct use and disposal of litter, fishing line and tackle to avoid ingestion of entanglement of wildlife. For example fishing line should be recovered and disposed of correctly;</li> <li>○ increased visibility of Fisheries Officers to enforce penalties for non-compliance;</li> <li>○ Council support for biodegradable bait bags and fishing gear. However, in order to be successful, this program needs to have a broader reach, such as a regional, state or national program.</li> </ul> </li> <li>• Coastal raptor education programs should be carried Enforcement of rules through extra TSC Ranger patrols of the area following signage deployment to reinforce the requirement and issue warnings and/or fines as appropriate. Patrols can also be used as a means of providing information about shorebird values and the need for restrictions.</li> <li>• Establishment of sites off-limits to recreational fishing such as bridges where there is a demonstrated problem of fishing line entanglement affecting wildlife. It will be necessary to investigate sites in consultation with NPWS, local community organisations such as Australian Seabird Rescue and Tweed Bird Observers to determine applicable sites and plan necessary measures. Signage and public education will be necessary to notify the community of changes and the reasons for the changes Enforcement of closures through extra TSC Ranger patrols of the area following closures to reinforce the requirement and issue warnings and/or fines as appropriate. Patrols can also be used as a means of providing information about coastal raptor values and the need for restrictions.</li> <li>• The TSC Habitat DCP which is currently in preparation should consider the investigation and definition of suitable buffer distances of developments to coastal raptor nests.</li> </ul> <p>This action assumes that the public education and signage components are carried out within the budget for Strategy 15: Education and Consultation. Additional tasks recommended by this action and costed in the CZMP are: Costs of the investigation and establishment of sites off-limits to recreational fishing such as bridges. The budget allocated to these tasks is \$5,000, relying on background information, liaison with NPWS and Fisheries NSW, accessing local expert knowledge and limited field surveys.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Establishment of sites off-limits to recreational fishing in areas completed by end of 2016 financial year.</li> </ul>

## 8.5 Strategy 5: Riparian Vegetation

### Priority: High

This strategy supports the on-going implementation of TSC planning policies with regard to riparian vegetation. Based on the findings of water quality, geomorphic and vegetation investigations undertaken during the preparation of this plan, a suite of minimum riparian buffer distances has been developed for the Tweed Coastal Creeks and catchments and their tributaries:

- The minimum buffer distance to any waterway or wetland vegetation in the catchment is 10m. This will provide for filtering of runoff, increased bank stability and improved water quality;
- On agricultural land, increasing riparian buffers to a width of 30m will provide for effective filtering of runoff and accommodate bed and bank morphological change, as well as provide value as a wildlife habitat and corridors. It is recognised that buffers of this width will not be achievable in all cases, and that buffers will generally not be a uniform width along a stream reach. Wherever practically achievable, livestock should be prevented from entering natural waterways;
- In areas where development is proposed anywhere adjacent to estuary foreshores, a minimum 50m buffer is recommended; and
- The recommended buffer distance to rural land use in non-tidal sections of the creeks is 30m.

Generally, buffers should be fully vegetated with appropriate local native riparian species.

The requirement for a 50m buffer to new development on all major waterways will retain existing valuable riparian vegetation and increase the resilience of vegetation communities to respond naturally to changes such as sea level rise and channel meandering. While planning controls offer a means to avoid future risks, they will not change the current level of riparian degradation and associated impacts on ecosystem health.

This strategy focuses on two primary actions. The first is to undertake a prioritisation study of riparian areas to identify priority sites for protection and rehabilitation in accordance with the *Tweed Vegetation Management Strategy*. The study will take a strategic approach to riparian zone management in the study area and presents many advantages including targeted works to maximise benefits, promotion of works at visible sites and continued support for funding based on an overriding plan. The second action involves the implementation of riparian restoration works at the priority sites.

**Table 11: Summary of Riparian Vegetation Actions**

<p><b>Objectives:</b></p> <p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O4. To protect and conserve cultural heritage;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O7. To provide for appropriate public access and use;</p> <p>O8. To provide information to enable effective management;</p> <p>O9. To provide for integrated planning and management; and</p> <p>O10. To minimise overall cost while achieving the goals of the CZMP</p>				
<p><b>Estuary Pressures targeted:</b></p> <p>P12 Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary.</p> <p>P13 Lack or poor condition of riparian vegetation compromises habitat connectivity and habitat value (both in-stream and terrestrial habitat).</p> <p>P14 Lack of suitable buffer zones between land use and waterways limits riparian zones.</p> <p>P15 Disturbance associated with infrastructure including waterfront structures and roads in close proximity to waterways.</p> <p>P16 Weed invasion reduces habitat and amenity values of vegetation communities.</p> <p>P17 Bank erosion can destabilise riparian vegetation.</p> <p>P18 Clearing and/or mowing of riparian vegetation for improved water views and access.</p> <p>P24. Unrestricted stock access causes vegetation damage and bank erosion</p>				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
5a) Identify priority riparian areas for protection and rehabilitation and annual review	\$75,000	Immediate (year 1) and on-going (years 1-10)	Study Area	TSC
5b) Riparian Rehabilitation works	\$1,000,000	On-going (years 1-10)	Study Area	TSC
<p><b>Complimentary Strategies:</b></p> <ul style="list-style-type: none"> <li>• Strategy 15: Education and Consultation</li> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 6: Bank Erosion</li> </ul>				

**Action 5a: Identify priority riparian areas for rehabilitation**

<b>Desired Outcome</b>	Prioritisation of riparian areas for protection and rehabilitation to provide the greatest benefits for the effort expended.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, DPI-Crown Lands, NRCMA, FNCW, landholders, relevant agricultural industry bodies, community groups
<b>Cost Estimate (10 year)</b>	\$75,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions), Caring for Our Country, Habitat Action Grants, Urban Sustainability Program, Maintaining Australia's Biodiversity Hotspots Program, NRCMA
<b>Timing</b>	Immediate prioritisation study (year 1) and on-going annual review (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>The action requires the identification and prioritisation of riparian areas for protection and rehabilitation. Managers can then assess the areas that will provide the greatest benefits for the effort expended or 'best bang for buck'. There are several examples of preliminary work and mapping tasks that have been carried out to date including:</p> <ul style="list-style-type: none"> <li>• Tweed Vegetation Management Strategy (Kingston et al., 2004);</li> <li>• NRCMA Biodiversity Program (DECCW, 2010b); and</li> <li>• The <i>Baseline Ecosystem Health Assessment</i> (Appendix 4).</li> </ul> <p>The prioritisation study would aim to draw together and build upon the existing information for use in the prioritisation study.</p> <p>Prioritisation should consider a number of factors including:</p> <ul style="list-style-type: none"> <li>• Identification of high quality riparian zones (mapped as HCV Tweed Vegetation Management Strategy) for on-going protection and where necessary, restoration of any degraded sections.</li> <li>• Identification of high impact land use, where vegetated buffers will provide benefits in soil retention/interception and improvement of overland runoff, thus improving water quality;</li> <li>• Identification and prioritisation of bank erosion areas that would benefit from riparian planting (Strategy 6: Bank Erosion);</li> <li>• The location of key habitats and fauna movement corridors and enhancement of these areas through greater connectivity created by riparian restoration (refer Strategy 2: Estuary Habitat, Strategy 4: Shorebirds)</li> <li>• Targeted programs to address riparian weeds;</li> <li>• The location of sites in terms of public visibility to promote activities and act as demonstration sites and to enhance aesthetic qualities of the estuary;</li> <li>• Coastal hazards contributing to erosion risk such as tidal inundation, the interaction of tidal waters with catchment flows and increased storminess (refer Strategy 6: Bank Erosion );</li> <li>• Land ownership and landowner willingness – Crown Land or Council owned land may be more successful candidates than privately owned land as demonstration sites;</li> <li>• Identification and prioritisation of rehabilitation areas based on factors discussed above; and</li> <li>• Develop a 10-year work schedule, reviewed annually, for the rehabilitation of prioritised riparian areas.</li> </ul> <p>Community education regarding riparian vegetation value and function and communicating the results of the prioritisation study should be carried out as part of Action 15a: Community education and consultation program.</p> <p>\$30,000 has been allowed for initial prioritisation study based on similar work in the local area. \$5,000 per year has been allowed for annual review of prioritisation and works schedule. Over ten years the total cost of this action is estimated to be \$75,000.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Prioritisation study and work schedule completed by end of 2015.</li> </ul>

**Action 5b: Riparian rehabilitation works**

<b>Desired Outcome</b>	Improved cover and condition of riparian areas in the Tweed Coast Estuaries and catchments with positive flow on effects increasing the health and resilience of waterways.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, DPI-Crown Lands, NRCMA, FNCW, landholders, relevant agricultural industry bodies, community groups
<b>Cost Estimate (10 year)</b>	\$1,000,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions), Habitat Action Grants, Urban Sustainability Program, Maintaining Australia's Biodiversity Hotspots Program, NRCMA
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>The action follows directly from Action 5a: Identify priority riparian areas for rehabilitation and involves on-ground restoration works at priority sites according to the work schedule.</p> <p>Tasks include:</p> <ul style="list-style-type: none"> <li>• Site planning – all rehabilitation works will require some level of site specific planning according to the site characteristics and level of disturbance. Factors to be considered include soil types, slope, endemic vegetation, weed encroachment, surrounding land use, stock access, etc. These factors will determine the nature of rehabilitation to be undertaken and allow for more detailed cost estimation. At some sites where a good base of native vegetation exists, bush regeneration methods may appropriate to reduce disturbance and allow natural regeneration. At cleared sites, more intensive rehabilitation effort may be required.</li> <li>• Initial rehabilitation works including site preparation, stock fencing, provision of off-stream stock watering facilities, weed removal and planting.</li> <li>• Follow up maintenance of sites until vegetation communities become established including weed removal and supplementary planting where necessary.</li> </ul> <p>Follow up monitoring and annual review should be conducted to determine the effectiveness of works, accuracy of cost estimation and to recommend on-going work. Any future management should consider the information available through the Ecosystem Health monitoring program (as per Action 1a: Ecosystem Health monitoring program).</p> <p>Community education providing updates on rehabilitation works progress should be carried out as part of Action 15a: Community education and consultation program.</p> <p>For the purposes of this plan, costs for this action were estimated using a number of assumptions from available data. In reality the actual implementation costs will be dependent on the results of the initial prioritisation study and contractor costs at the time of tendering for on-ground works. Assumption were as follows:</p> <ul style="list-style-type: none"> <li>• \$50,000 per ha has been estimated as a nominal allowance for rehabilitation. This estimate is based on costs of similar works undertaken recently. Depending on the extent of works (fencing, replanting or weed maintenance) and results of the review and prioritisation study the cost could vary significantly between sites. This estimate does not include long-term follow up weed maintenance (after year 3). There may also be a need for survey of property boundaries.</li> <li>• A total annual allowance of \$100,000 has been estimated to allow for rehabilitation of 2 ha per year. Assuming a minimum width of 10m of rehabilitation along waterways, 2ha is equivalent to 2km of bank. Therefore the yearly allowance equates to riparian rehabilitation for both banks along 1km of waterway. Note that the riparian buffer width to be revegetated at any particular site will be assessed on a case by case basis.</li> </ul>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Commence initial works within 6 months of completion of the prioritisation study;</li> <li>• Target rehabilitation of 2 ha per year;</li> <li>• Annual review of work schedule and project costing;</li> <li>• Ecosystem Health monitoring detects improvements in ecological indicators in following monitoring.</li> </ul>

## 8.6 Strategy 6: Bank Erosion

Priority: High

**Table 12: Summary of Bank Erosion Actions**

<p><b>Objectives:</b></p> <p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O4. To protect and conserve cultural heritage;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O7. To provide for appropriate public access and use;</p> <p>O8. To provide information to enable effective management;</p> <p>O9. To provide for integrated planning and management; and</p> <p>O10. To minimise overall cost while achieving the goals of the CZMP</p>				
<p><b>Estuary Pressures targeted:</b></p> <p>P19 Bank erosion is occurring in all three estuaries with varying levels of severity. Some areas of bank erosion pose high risk to built and natural assets.</p> <p>P20 Bank erosion can contribute to water quality issues such as high turbidity and mobilisation and transportation of nutrients and contaminants.</p> <p>P17 Bank erosion can destabilise riparian vegetation.</p> <p>P35 Bank erosion has potential to impact public access points to estuary foreshore areas by undermining and destabilising structures such as stairs and walkways.</p>				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
6a) Bank erosion works planning for high risk sites	\$40,000	Immediate (year 1)	Study Area	TSC
6b) Bank erosion remediation works	Not Estimated	Short – Medium term (years 2-6)	Study Area	TSC
<p><b>Complimentary Strategies:</b></p> <ul style="list-style-type: none"> <li>• Strategy 15: Education and Consultation</li> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 6: Bank Erosion</li> </ul>				



**Action 6a: Bank erosion works planning for high risk sites**

<b>Desired Outcome</b>	Plan for effective resolution of bank erosion at high risk sites identified by the <i>Bank Erosion Study</i> .
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, DPI Crown Lands
<b>Cost Estimate (10 year)</b>	\$40,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC, others to identified as part of action
<b>Timing</b>	Immediate (year 1)
<b>Location</b>	Sites identified in Cudgen, Cudgera and Mooball Estuaries
<b>DESCRIPTION OF TASKS:</b>	
<p>Most of the high priority sites identified by the <i>Bank Erosion Study</i> (Appendix 3) are likely to require hard engineering options such as rock revetment to protect assets and property. The cost of such works can be extensive, especially for long sections of erosion and further detailed planning is required for the sites to determine the most cost-effective solution at these sites.</p> <p>This action sets out the requirements for planning stages of the work to further prioritise works and select appropriate and cost effective protection methods. Tasks include:</p> <ul style="list-style-type: none"> <li>• Ranking of high risk sites. Of the eight high risk sites identified by the <i>Bank Erosion Study</i>, a further prioritisation task is recommended to confirm risks and rank sites for remedial action. The assessment carried out for the <i>Bank Erosion Study</i> was a longitudinal assessment across the three estuaries to identify high risk areas. Refinement of the risk assessment method and addition of other criteria that may influence priorities for on-ground works including:             <ul style="list-style-type: none"> <li>○ Refining the 20m buffer width used in the <i>Bank Erosion Study</i>. Breaking down the buffer zone into 5m increments will allow for greater resolution of the assets at immediate risk. Assets within 5m of the erosion scarp would be ranked higher than assets 15-20m from the immediate erosion zone.</li> <li>○ Incorporate tidal inundation mapping to assess the likely future risks due to sea level rise (refer Action 11a: Assessment and mapping of tidal inundation extent including potential sea level rise).</li> </ul> </li> <li>• Also review public access points to the estuary affected by bank erosion (itemised in Section 2.2.5) to highlight any changes in risk rating for access points affected by projected sea level rise impacts.             <ul style="list-style-type: none"> <li>○ Identify works already planned by Council or other authorities either to address bank erosion or for infrastructure provision or upgrade in the vicinity of bank erosion sites. It may be possible to incorporate bank erosion considerations into existing works such as road or bridge upgrades and minimise costs.</li> <li>○ Determine responsibility for works based on land ownership and management;</li> <li>○ Document the prioritised sites. This should identify those sites prioritised for works and those considered low priority, giving reasons for each.</li> </ul> </li> <li>• Organisations responsible for the works will then need to develop appropriate remediation strategy for prioritised sites considering the preliminary management recommendations provided in the <i>Bank Erosion Study</i>. This will include the following tasks:             <ul style="list-style-type: none"> <li>○ Determine appropriate protection methods (e.g. rock revetment, groynes, revegetation, formalised access provision, etc.), considering the assets to be protected, the longevity of works and any environmental or social impacts associated with the works;</li> <li>○ Design of works as required based on the nature and scale of erosion;</li> <li>○ Cost estimation for works;</li> <li>○ Identify funding sources;</li> <li>○ Assess environmental impacts and gain approvals; and</li> <li>○ Estimate timeframes for implementation of works.</li> <li>○ Details of follow up inspections to determine success of remediation work.</li> <li>○ Preparation of scope of works for construction to be used in the tender process.</li> </ul> </li> </ul>	

<b>DESCRIPTION OF TASKS (continued):</b>	
Community education about bank erosion issues and communicating the results of the remediation works should be carried out as part of Action 15a: Community education and consultation program.	
The cost estimation for this action includes the planning tasks only, of which \$40,000 has been allowed. Costs of on-ground works will be determined through this action.	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Prioritisation study complete by June 2015</li> </ul>

**Action 6b: Bank erosion remediation works**

<b>Desired Outcome</b>	Effective remediation of bank erosion at high risk with positive flow on effects increasing the health and resilience of waterways (e.g. improved water quality, riparian stability etc.).
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, DPI-Crown Lands
<b>Cost Estimate (10 year)</b>	Not Estimated – Costs will depend on outcomes of Action 6a
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions)
<b>Timing</b>	Short – Medium term (years 2-6)
<b>Location</b>	Sites identified in Cudgen, Cudgera and Mooball Estuaries
<b>DESCRIPTION OF TASKS:</b>	
<p>The action follows directly from Action 6a: Bank erosion works planning for high risk sites and involves on-ground implementation of bank stabilisation works at priority sites according to the work schedule.</p> <p>Follow up monitoring and annual review should be conducted to determine the effectiveness of works, accuracy of cost estimation and to recommend any further works required.</p> <p>Community education providing updates on bank stabilisation works progress should be carried out as part of Action 15a: Community education and consultation program.</p> <p>Costs for this action will be estimated as part of Action 6a: Bank erosion works planning for high risk sites.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Complete bank stabilisation works at two sites per year following completion of Action 6a.</li> </ul>

## 8.7 Strategy 7: Acid Sulfate Soils

Priority: High

**Table 13: Summary of Acid Sulfate Soil actions**

<p><b>Objectives:</b></p> <p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O8. To provide information to enable effective management;</p> <p>O9. To provide for integrated planning and management; and</p> <p>O10. To minimise overall cost while achieving the goals of the CZMP</p>				
<p><b>Estuary Pressures targeted:</b></p> <p>P21 Acid sulfate runoff negatively impacts overall estuarine ecosystem health. Impacts include fish kills and major aquatic habitat changes, reduced plant growth (acid scalds), and corrosion of concrete, iron and steel structures.</p> <p>P22 Historical drainage of former backswamp wetlands are the main cause of ASS problems as they facilitate the exposure of ASS to oxygen, which produces acid runoff.</p>				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
7a) Identify and prioritise key sites for remediation	\$100,000	Short-term (years 1-3)	Study Area	TSC
7a) Acid Sulfate Soil remediation works	\$600,000	On-going (years 1-10)	Study Area	TSC
<p><b>Complimentary Strategies:</b></p> <ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 15: Education and Consultation</li> </ul>				

**Action 7a: Identify and prioritise key sites for remediation**

<b>Desired Outcome</b>	Prioritisation of ASS hot spots for on-ground remediation works to provide the greatest benefits for the effort expended.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	UNSW Researchers, OEH, Fisheries NSW, NRCMA, DPI-Crown Lands, OEH, landholders, relevant agricultural industry bodies.
<b>Cost Estimate (10 year)</b>	\$100,000
<b>Potential Funding</b>	Australian Research Council (ARC) Linkage project, NSW Estuary Management Program, TSC
<b>Timing</b>	Short-term (years 1-3)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>This action involves the identification, evaluation and prioritisation of sites (e.g. drains and levees) for on-ground works to optimise the structures to minimise impacts of acid sulfate soils and restore more natural flows.</p> <p>The prioritisation study which consists of the following steps:</p> <ul style="list-style-type: none"> <li>• Compile inventory of existing drains and levees;</li> <li>• Document condition of drains and levees;</li> <li>• Document past and current management (include description of floodgate management, past infilling or reshaping works);</li> <li>• Compile available monitoring data (e.g. water quality, sediment, ecosystem data) to identify hotspot areas.</li> <li>• Spatial analysis including mapping of drainage assets and overlay with topographic, social and environmental data e.g. DEM and ASS priority areas, land tenure/ownership. The recently completed Coastal Creeks Flood Model should be utilised during this analysis;</li> <li>• Consideration of potential climate change effects;</li> <li>• Document approval requirements for proposed works;</li> <li>• Investigate all available incentive and regulatory options to expedite remediation of the high priority ASS hotspots in the upper part of Cudgen catchment, and that these works be undertaken prior to removal of the existing drainage restriction, upstream of Cudgen Lake.</li> <li>• Prioritise drains and levees for action. Prioritisation should consider at a minimum the following criteria:             <ul style="list-style-type: none"> <li>○ Current status of the drain or levee (whether or not it is still required for drainage and/or flood mitigation, or is it redundant and can be filled-in);</li> <li>○ Potential benefit of modifications (e.g. degree at which works will address the issues and achieve positive outcomes for estuary health);</li> <li>○ Groundwater extraction licences in the area and potential effects of extraction allowances on ASS;</li> <li>○ The expected costs of the on-ground works specific to the site;</li> <li>○ Other consequences of the works (e.g. inundation of private lands);</li> <li>○ Complementary works, where other management actions are being implemented in the location and the combination of the two actions together may improve the benefit of each over the two being conducted in isolation;</li> <li>○ Land tenure and ownership;</li> <li>○ Potential funding sources; and</li> <li>○ Landholder support (consent to undertake works affecting their properties).</li> </ul> </li> <li>• Based on the initial desktop study, identify priority sites for monitoring to confirm assumptions and prioritisation.</li> <li>• Design and implement monitoring program at key sites to confirm prioritisation study. Specific details of the monitoring will need to be worked out on a site specific basis (e.g. data logger deployment and locations, discrete sampling, and downstream monitoring etc.).</li> </ul>	

**DESCRIPTION OF TASKS (continued):**

- Based on results of the prioritisation study and follow up monitoring, produce a 5-year work plan (reviewed annually) for the on-ground optimisation works detailing timing, locations, responsibilities and costing for on-ground works.

Costs for this action have been estimated as follows:

- \$20,000 has been allowed for the initial desktop prioritisation study and work plan (drains and levees);
- \$70,000 has been allowed for monitoring and confirmation of priority sites. The actual costs of monitoring will depend on the outcomes of the desktop prioritisation study, final monitoring design, number of sites and equipment required.
- \$10,000 has been allowed for development of a 5 year work plan for on-ground remediation works at key sites

This equates to an estimated total of \$100,000 for this action.

**KPIs**

- Action 1a: Ecosystem Health monitoring program shows improvement in ecosystem health indicators following management trials

**Action 7b: Acid Sulfate Soil remediation works**

<b>Desired Outcome</b>	Reduce the environmental impacts of ASS hotspots on the estuaries and promote communication of findings to community and decision makers.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	UNSW Researchers, OEH, Fisheries NSW, NRCMA, DPI-Crown Lands, OEH, landholders, relevant agricultural industry bodies.
<b>Cost Estimate (10 year)</b>	\$600,000
<b>Potential Funding</b>	Australian Research Council (ARC) Linkage project, NSW Estuary Management Program, TSC
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Priority ASS Sites identified in Cudgen, Cudgera and Mooball Estuaries
<b>DESCRIPTION OF TASKS:</b>	
<p>This action supports current initiatives underway in the catchments and provides for the on-ground implementation of ASS remediation works at key sites identified in Action 7a: Identify and prioritise key sites for remediation.</p> <p>In the case of drains, optimisation works will involve either shallowing of channels, construction of sills or weirs to partially infill the drain or infilling if drains are no longer needed. The type of works will be dependent on a number of factors including the operational status and condition of the drain. Levees may be optimised by redesign and/or remodelling to improve flows while still retaining flood control facilities where needed. Any modification of drains and levees will require the consent of affected landowners.</p> <p>The specific tasks are:</p> <ul style="list-style-type: none"> <li>• Implement remediation techniques at priority sites according to the 5-year work plan produced as part of Action 7b above.</li> <li>• Follow up monitoring and annual review should be conducted to determine the effectiveness of works, accuracy of cost estimation and to recommend on-going work. Any future management should consider the information available through the monitoring program.</li> <li>• The monitoring program should report on any improvements in water quality following works (refer Action 1a: Ecosystem Health monitoring program).</li> <li>• Community education about acid sulfate soil issues and communicating the results of the remediation works should be carried out as part of Action 15a: Community education and consultation program.</li> </ul> <p>For the purposes of this plan, costs for this action were estimated using a number of assumptions from available data and taking into consideration the high priority of this strategy in estuary management. The actual implementation costs will be highly dependent on the results of the initial prioritisation study, and contractor costs at the time of tendering on-ground works. Assumption were as follows:</p> <ul style="list-style-type: none"> <li>• \$30,000 has been estimated as a nominal allowance for infilling and reshaping works for each drain or levee. Depending on the length and requirements (partial, infilling etc.) and results of the review and prioritisation study the cost could vary significantly between sites; and</li> <li>• A total annual allowance of \$600,000 for optimisation works has been estimated. This equates to allowing for optimisation of 2 sites (drains or levees) per annum. Follow up maintenance and re-shaping is also likely to be required over time which should be achievable within this budget.</li> </ul>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Action 1a: Ecosystem Health monitoring program shows improvement in ecosystem health indicators following management trials</li> </ul>

## 8.8 Strategy 8: Agricultural Land

Priority: High

Table 14: Summary of Agricultural Land actions

<p><b>Objectives:</b></p> <p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement;</p> <p>O8. To provide information to enable effective management;</p> <p>O9. To provide for integrated planning and management; and</p> <p>O10. To minimise overall cost while achieving the goals of the CZMP</p>				
<p><b>Estuary Pressures targeted:</b></p> <p>P23 Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary.</p> <p>P24 Unrestricted stock access causes vegetation damage and bank erosion.</p>				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
8a) Support and promote sustainable agricultural initiatives	Not Estimated	On-going (years 1-10)	Study Area	TSC
8b) Cost Benefit Analysis of alternative land use options	\$70,000	Short-term (year 2)	Study Area	TSC
<p><b>Complimentary Strategies:</b></p> <ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 7: Acid Sulfate Soils</li> <li>• Strategy 15: Education</li> </ul>				

**Action 8a: Support and promote sustainable agricultural initiatives**

<b>Desired Outcome</b>	Support current initiatives encouraging best practice management of agriculture in the catchments, and promote sustainable management practices to community and decision makers.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW, NRCMA, DPI-Crown Lands, OEH, landholders, relevant agricultural industry bodies.
<b>Cost Estimate (10 year)</b>	Not estimated – considered to be within TSC current activities
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions), Caring for Our Country, Habitat Action Grants, Maintaining Australia's Biodiversity Hotspots Program, NRCMA
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>This action acknowledges that there are a range of programs and initiatives from various government agencies (e.g. NSW DPI Agriculture), industry groups (e.g. Canegrowers Australia) and Council (e.g. Sustainable Agriculture Strategy) to promote sustainable agricultural land management. The aim is to support the existing initiatives and provide linkages between agricultural land management and flow on effects to downstream environments and values. The specific tasks are:</p> <ul style="list-style-type: none"> <li>• Coordinate with development of the Tweed Shire Sustainable Agriculture Strategy to ensure the strategy acknowledges and is consistent with this CZMP;</li> <li>• Support research initiatives which are consistent with this CZMP;</li> <li>• Where suitable, it may be possible to seek funding as part of this CZMP for agricultural initiatives that can be shown to have a positive impact on estuary health. Coordination with the Sustainable Agriculture Strategy will strengthen these links;</li> <li>• The Ecosystem Health monitoring program should report on identified sources of agricultural impacts and particularly any improvements in water quality following works. This will provide feedback on management practices and provide support for ongoing implementation (refer Action 1a: Ecosystem Health monitoring program).</li> <li>• Acknowledgement of the number of other strategies with linkages to agricultural management in this CZMP, in particular Action 7b: Acid Sulfate Soil remediation works and Action 5b: Riparian rehabilitation works. The riparian rehabilitation works incorporates stock fencing and provision of off-stream stock watering facilities as part of which is directly relevant to agricultural land management.</li> </ul> <p>Communication and education of the general public as well as landholders and decision makers should be carried out as part of Action 15a: Community education and consultation program. Increasing the understanding of the issues and the need for sustainable agriculture initiatives will be a factor in support of existing programs and ensuring increasing uptake of initiatives by landholders into the future. Links with the Action 1a: Ecosystem Health monitoring program will be important particularly in communicating identified linkages of management actions and ecosystem improvements.</p> <p>No additional budget has been allowed for this action, apart from the costs incorporated in Ecosystem Health monitoring and Community Education actions.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Tweed Shire Sustainable Agriculture Strategy acknowledgment of this CZMP;</li> <li>• Action 1a: Ecosystem Health monitoring program shows improvement in ecosystem health indicators following management trials</li> </ul>



**Action 8b: Cost Benefit Analysis (CBA) of alternative options for agricultural land**

<b>Desired Outcome</b>	Identify and assess cost and benefits of options for agricultural land use that reduce impacts of farming on waterway health.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, NRCMA, DPI-Agriculture
<b>Cost Estimate (10 year)</b>	\$70,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions), Caring for Our Country, NRCMA
<b>Timing</b>	Short-term (year 2)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>Agricultural land use is one of the key pressures contributing to the degradation of waterway condition in the Tweed Coast Estuaries and catchment waterways. Whilst changes in land use practice or restoration of farm land is desirable from a catchment management point of view, the economic and social contribution of agricultural production is an important community value of the region that needs to be considered.</p> <p>The objective of this action is to determine if there are opportunities for alternative land use or land management practices that will have tangible positive outcomes for the affected waterways and will also be acceptable for agricultural landholders. Demonstrating financial viability of alternative land uses/practices is important in order to provide incentive for private land holders to move to more waterway friendly alternatives. In the case where no financially viable alternatives exist, but the potential benefit of change is compelling, compensation or purchase of the land in the public interest may be appropriate.</p> <p>Cost Benefit Analysis (CBA) is a process for calculating and comparing benefits and costs of management actions and is recommended in order to evaluate options for potential land use change. The technique allows managers to compare total expected costs and benefits of different options to see whether the benefits outweigh the costs. The Cost Benefit Analysis methodology should be scoped in detail and agreed with Council to ensure methods will provide a robust assessment. A similar study is currently underway in the Richmond River catchment which could help to scope the work required for the Tweed Coast Estuaries. A broad outline of tasks includes:</p> <ul style="list-style-type: none"> <li>• Identification and characterisation of the agricultural land identified as likely to have a high impact on adjoining waterways and the downstream estuary. Characterisation should include physical and environmental factors such as land elevation, slope, soil type and proximity to waterways as well as land use factors (e.g. crop type, chemical use etc.);</li> <li>• Technical and environmental evaluation of potential alternative land uses for the land categories. This should include an assessment of land use capability, identification of option screening/ranking criteria in relation to anticipated environmental benefits and a multi-criteria assessment as to the general attractiveness of the potential options;</li> <li>• Undertake the CBA for screened options. This analysis should evaluate the current (base) case utilising information on the likely economic return for existing land uses compared to alternative scenarios during transitional and mature stages of implementation. This CBA should be undertaken initially at the broad scale, but may utilise farm scale examples to demonstrate the potential implications in terms of overall financial outlay, cash flow and cost-benefit ratio. The study should ensure that the cost-benefit implications of any particular option are clearly identified for both the private land holder and the community in general.</li> <li>• Recommendation of potentially viable strategies for changed land use or practices, identification of potential trial properties, estimation of implementation costs and summary of accrued benefits.</li> </ul> <p>Communication of findings of the CBA to the community should be carried out as part of Action 15a: Community education and consultation program.</p> <p>\$70,000 has been allowed for the CBA based on similar projects undertaken in other nearby catchments.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Cost Benefit Analysis completed end of 2016</li> </ul>

## 8.9 Strategy 9: Urban Development and Stormwater

### Priority: Medium

Stormwater from urban areas can often discharge significant amounts of pollutants to receiving water bodies. The potential impact of urban stormwater on estuarine water quality is a significant issue for Council. The importance of managing urban stormwater will also become increasingly important as the extent of urban development increases to accommodate the increase in population within the study area.

Stormwater management is a core responsibility of the TSC and the reduction of urban pollution such as nutrients, sediments and faecal coliforms is consistent with the aims of the CZMP.

### Action 9a: Stormwater planning controls and regulation

<b>Desired Outcome</b>	On-going improvements in stormwater management resulting in reduction of contaminants transported to the estuary
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH
<b>Cost Estimate (10 year)</b>	Not estimated – considered to be within TSC current activities
<b>Potential Funding</b>	Stormwater management levy, Council rebate programs, developer contributions, property owner contributions, Urban Sustainability Program
<b>Timing</b>	On-going (year 1-10)
<b>Location</b>	Study Area
<b>Objectives:</b>	<p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O5. To promote ecologically sustainable development and use of resources;</p> <p>O6. To provide for ecologically sustainable human settlement; and</p> <p>O8. To provide information to enable effective management.</p>
<b>Estuary Health Pressures targeted:</b>	<p>P25 Large areas of the Tweed Coast Estuaries study area are planned to be developed into urban areas.</p> <p>P26 Stormwater runoff from urban areas can increase contaminants, litter, nutrients and sediment loads to the estuary.</p> <p>P27 The Tweed Coast Estuaries are already under existing pressure from agriculture and urban land use and without adequate mitigation, further urban development may add to these pressures.</p> <p>P28 Urbanisation can affect hydrologic characteristics through increases in impervious surfaces and by increasing the rate of delivery of catchment runoff to downstream waterways.</p> <p>P29 The construction phase of urban development poses the highest risk to water quality of receiving environments.</p>
<b>DESCRIPTION OF TASKS:</b>	
<p>The management of stormwater should continue to occur outside the coastal zone management process as a core responsibility of TSC. This includes:</p> <ul style="list-style-type: none"> <li>• On-going review and update of Stormwater management plans;</li> <li>• On-going review and update of Development Control Plans and development guidelines;</li> <li>• Regular inspection and maintenance of existing stormwater treatment quality devices to ensure that they are operating optimally and protecting the environment effectively;</li> </ul>	

<b>DESCRIPTION OF TASKS (continued):</b>	
<ul style="list-style-type: none"> <li>• Community education (refer Action 15a: Community education and consultation program);</li> <li>• Incorporating water sensitive urban design in new developments;</li> <li>• Retrofitting stormwater/water quality controls to existing urban developments; and</li> <li>• The State Government BASIX program.</li> </ul> <p>A number of specific management recommendations and areas for improvement were identified during the development of this CZMP. TSC stormwater planning and regulation should consider:</p> <ul style="list-style-type: none"> <li>• Management of future urban development in the Tweed Coast estuary catchments should take a precautionary approach to stormwater management and consider each subdivision on a case by case basis. All cases should aim to ensure stormwater quality standards set out in the Tweed Urban Stormwater Quality Management Plan (TUSQMP) (Australian Wetlands, 2012) are achieved, that maintenance requirements are allowed for in Council budgets and importantly, that construction phase impacts are mitigated through application of best practice erosion and sediment controls;</li> <li>• The incremental risk of concurrent multiple developments occurring at any one time should be acknowledged and assessed by Council when considering development applications. It may be appropriate to require phasing of large projects or to introduce additional water quality and hydrological controls to large scale or concurrent developments;</li> <li>• Ensure that TN, TP and TSS are equally considered in stormwater management strategies as these factors all contribute to estuarine degradation;</li> <li>• As discussed in the TUSQMP, it is appropriate to consider compensatory offsets to mitigate residual loads where stormwater objectives cannot be technically achieved. This is contingent on the proponent being able to demonstrate:                             <ul style="list-style-type: none"> <li>○ That receiving environments will not be negatively impacted by the residual load; and</li> <li>○ Offsets will provide ecosystem benefits within the same catchment as the residual load.</li> </ul> </li> <li>• Undertake inspection, maintenance and rehabilitation of all existing stormwater quality treatment devices in urban development areas within the estuary catchments;</li> <li>• The construction phase of developments is considered to present the greatest risk to aquatic ecosystem health in the short-term due to high export of TN, TP and TSS in surface runoff. The regulation of construction site erosion and sediments controls should therefore be given a high priority. Minimising the total area of land in a construction phase at any one time and implementing adequate erosion and sediment controls is required to reduce the risk to water quality in downstream waterways. Council should allocate sufficient resources to construction site environmental auditing to ensure erosion and sediment controls are designed and constructed to ensure optimal performance. This will be particularly important for any large construction sites. Management should incorporate:                             <ul style="list-style-type: none"> <li>○ Education aimed at site managers and on-ground workers incorporated into guidelines for developers;</li> <li>○ Current best-practice erosion and sediment controls are in place that are suitable for the site considering physical characteristics (e.g. soil type, slope, climate, etc.);</li> <li>○ Site inspections of controls including during and immediately following major rainfall events;</li> <li>○ Water quality monitoring at receiving environments to assess the adequacy of controls in meeting required discharge limits.</li> </ul> </li> <li>• Ecosystem Health monitoring should report on changes to estuarine systems associated with urban developments and assist in identifying major sources of degradation as well as successful stormwater control projects (i.e. minimal or no impacts detected downstream of development sites)</li> </ul> <p>Education on the impacts of urban runoff and potential improvements should be incorporated into Action 15a: Community education and consultation program.</p> <p>No additional budget has been allowed for planning controls and regulation as this is believed to be within TSC existing activities. Related costs are incorporated in Ecosystem Health monitoring and Community Education actions.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Review of TSC planning controls (stormwater planning, DCP) consistent with objectives of this CZMP and considers specific recommendations of this action.</li> <li>• Action 1a: Ecosystem Health monitoring program reports on impacts of urban development.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 15: Education and Consultation</li> </ul>

## 8.10 Strategy 10: Wastewater Management

Priority: Medium

### Action 10a: Wastewater management

<b>Desired Outcome</b>	Optimum performance of wastewater management systems resulting in no adverse impacts to estuary health, function and recreational use.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, EPA
<b>Cost Estimate (10 year)</b>	Not estimated – considered to be within TSC current activities
<b>Potential Funding</b>	Council funding, Country Towns Water Supply and Sewerage Program
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>Objectives:</b>	<p>O1. To protect, rehabilitate and improve the natural environment;</p> <p>O5. To promote ecologically sustainable development and use of resources; and</p> <p>O6. To provide for ecologically sustainable human settlement.</p>
<b>Estuary Health Pressures targeted:</b>	P30 High levels of faecal indicator bacteria were identified at sites downstream of Mooball and Burringbar villages indicating either failing OSSM or pollution from surface runoff.
<b>DESCRIPTION OF TASKS:</b>	
<p>The management and regulation of wastewater systems should continue outside of the CZMP process as part of the EPA regulatory process and Council's internal regulation processes. To ensure consistency with this CZMP, the impact of wastewater system discharges on estuary health should be considered as part of the regulatory process. This includes:</p> <ul style="list-style-type: none"> <li>Continued implementation of the TSC <i>On-Site Sewage and Wastewater Management Strategy</i> including specification of design requirements and audit and inspection of on-site systems. Adequate funding should be allocated to these programs as part of the Council environmental health service budgets;</li> <li>Continued Council monitoring of performance of wastewater systems and the level of impact on downstream receiving environments regulated by the EPA through Environment Protection Licences (under the <i>Protection of the Environment Operations Act, 1997</i>); and</li> <li>Ongoing wastewater system improvements, including upgrades and new WWTPs where need is identified (e.g. Mooball Burringbar WWTP).</li> </ul> <p>The proposed Ecosystem Health monitoring program (Action 1a) will measure trends in water quality across the catchment and also assess known point sources (e.g. WWTPs) in comparison to diffuse pollution sources. A direct recommendation coming out of the <i>Baseline Ecosystem Health Assessment</i> (Appendix 4) is to continue to monitor water quality downstream of Burringbar and Mooball villages to assess whether the centralised sewage system has been effective in improving water quality in the waterways. This has been included in Action 1a: Ecosystem Health monitoring program.</p> <p>Community education about wastewater management and the positive ecosystem changes as a result of management (e.g. WWTP upgrades) should be carried out as part of Action 15a: Community education and consultation program.</p> <p>No additional budget has been allowed for wastewater management as part of this CZMP, apart from the costs incorporated in Ecosystem Health monitoring and Community Education actions.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>Action 1a: Ecosystem Health monitoring program shows improvement in ecosystem health indicators following management.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>Strategy 1: Monitoring, Evaluation and Review</li> <li>Strategy 15: Education and Consultation</li> </ul>

## 8.11 Strategy 11: Climate Change Adaptation

Priority: Fundamental

**Table 15: Summary of Climate Change Adaptation actions**

<b>Objectives:</b>				
O1.	To protect, rehabilitate and improve the natural environment;			
O2.	To recognise and accommodate natural processes and climate change;			
O3.	To protect and enhance the aesthetic qualities of the coastal zone;			
O5.	To promote ecologically sustainable development and use of resources;			
O6.	To provide for ecologically sustainable human settlement;			
O7.	To provide for appropriate public access and use;			
O8.	To provide information to enable effective management;			
O9.	To provide for integrated planning and management; and			
O10.	To minimise overall cost while achieving the goals of the CZMP.			
<b>Estuary Pressures targeted:</b>				
P32	There is a risk that natural upslope migration of estuarine habitats due to sea level rise will be curtailed by anthropogenic constraints (roads, agriculture, urban development etc.).			
P33	Sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure and bank erosion.			
P34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues.			
P36	Potential estuarine inundation during extreme weather events such as king tides, severe storms or catchment flooding threatens the viability of some public access points and this may be increased with sea level rise.			
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
11a) Assessment and mapping of tidal inundation extent including potential sea level rise	Not Estimated	Short-term (years 1-3)	Study Area	TSC
11b) Planning for sea level rise and climate change impacts	\$85,000	On-going from year 3 – 10	Study Area	TSC
<b>Complimentary Strategies:</b>				
<ul style="list-style-type: none"> <li>• Strategy 1: Monitoring, Evaluation and Review</li> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 5: Riparian Vegetation</li> <li>• Strategy 6: Bank Erosion</li> <li>• Strategy 15: Education and Consultation</li> </ul>				

**Action 11a: Assessment and mapping of tidal inundation extent including potential sea level rise**

<b>Desired Outcome</b>	Clear definition of potential risks due to tidal inundation for the Tweed Coast Estuaries is used to facilitate adaptation to climate change
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH
<b>Cost Estimate (10 year)</b>	Not estimated – part of flood management planning
<b>Potential Funding</b>	NSW Floodplain Management Program, NSW Estuary Management Program, TSC
<b>Timing</b>	Short-term (years 1-3)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>TSC’s adopted sea-level rise benchmarks should be used to identify risks from tidal inundation currently and into the future due to sea level rise.</p> <p>The flood model developed for the Tweed-Byron Coastal Creeks Flood Study should be used to identify areas that are potentially impacted for current day and sea-level rise scenarios in order to define the geographical area in which planning for sea level rise is a priority. This should include assessment and mapping of the tidal inundation extent for the estuary incorporating the TSC adopted sea level rise benchmarks for the 1, 50 and 100 year (average recurrence interval (ARI) events for the present day, 2050 and 2100 planning periods. Given their proximity to the coast and concentration of urban areas in the reaches of the estuaries, these are the priority for this study. This work will be undertaken as part of the Tweed Coastal Creeks Flood Management Plan.</p> <p>The assessment of tidal inundation risk should identify property risk and response categories for all properties located in the coastal hazard areas.</p> <p>Education on the predicted climate change implications should be incorporated into Action 15a: Community education and consultation program.</p> <p>No additional budget has been allowed for this action as it will be undertaken as part of Council’s flood management planning. Consultation costs to communicate findings are incorporated the Community Education action.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>Sea-level rise tidal inundation maps produced and available by end of 2017</li> </ul>

**Action 11b: Planning for sea level rise and climate change impacts**

<b>Desired Outcome</b>	Catchment and estuary specific information regarding climate change is used to facilitate adaptation to climate change
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW, NRCMA, DPI-Crown Lands
<b>Cost Estimate (10 year)</b>	\$85,000
<b>Potential Funding</b>	NSW Estuary Management Program and Coastal Management Program, Habitat Action Grants, Natural Disaster Resilience Grants Scheme, Caring for Our Country, Caring for Our Coast, TSC (through Council contributions)
<b>Timing</b>	On-going from year 3-10
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>Climate change implications need to be considered in all long-term management decisions affecting the estuary. Action 11a will identify areas susceptible to risks from sea level rise and tidal inundation. Changes in rainfall patterns and anticipated increases in 'storminess' are less defined however all planning decisions influenced by these factors should evaluate the implications of these changes for long-term estuary condition.</p> <p>The following specific tasks have been identified:</p> <ul style="list-style-type: none"> <li>• Map predicted future estuarine wetland habitat distribution in response to changes in sea level, tide propagation and salinity regime within the estuary, building on existing research/models where appropriate (for example the SLAMM modelling; Akumu <i>et al.</i>, 2010). This mapping should identify barriers to upslope transgression (e.g. current development, road embankments, etc.) and highlight key areas of importance for maintaining the balance of future habitats within the estuary. This information should be compiled as a set of GIS layers which are made available to council staff for land use planning and development controls.</li> <li>• A strategic plan for long-term estuarine habitat management should be prepared to ensure that upslope migration of key habitats can be accommodated within the long-term land use adjoining the estuary. This should include provision for buffer zones and offsets as appropriate to achieve no net loss of mangrove, saltmarsh habitats and priority riparian habitats within the study area (refer Strategy 2: Estuary Habitat and Strategy 5: Riparian Vegetation).</li> <li>• Estimate the extent of erosion risk within the estuary from projected tidal inundation levels (Action 11a) as well as the interaction of tidal waters with catchment flows. Areas susceptible to erosion risk (including risks to persons, development and infrastructure) and the requirement for mitigation measures such as buffer zones, riparian vegetation management or other erosion mitigation measures can then be determined (refer Action 6a: Bank erosion works planning for high risk sites).</li> <li>• Assess the risk of projected tidal inundation on the viability of public access points to estuaries and foreshore areas.</li> </ul> <p>All catchment/estuary specific information regarding climate change and potential risks for the estuary should be made available to decision makers in the catchment. This should include provision of a resource base (e.g. sea level rise maps, habitat management strategies, etc.) to be utilised in LEP reviews, development assessment, education campaigns (refer Action 15a: Community education and consultation program) and strategic planning.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Estuarine habitat transgression in response to Sea Level Rise (SLR) identified and strategic plan to cater for habitat migration developed by end of 2017;</li> <li>• Tidal inundation incorporated into bank erosion risk planning;</li> <li>• Tweed Coast Estuaries climate change resource base developed and made available to decision makers within the catchment by June 2018.</li> <li>• Review and update of resource base on an annual basis.</li> </ul>

## 8.12 Strategy 12: Public Access

Priority: Medium

### Action 12a: Public access

<b>Desired Outcome</b>	Public access to estuaries and foreshores is maintained and key future risks are identified for future planning.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, EPA, DPI-Crown Lands
<b>Cost Estimate (10 year)</b>	\$10,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC
<b>Timing</b>	Medium-term (year 4)
<b>Location</b>	Study Area
<b>Objectives:</b>	<p>O2. To recognise and accommodate natural processes and climate change;</p> <p>O3. To protect and enhance the aesthetic qualities of the coastal zone;</p> <p>O7. To provide for appropriate public access and use;</p> <p>O8. To provide information to enable effective management;</p> <p>O9. To provide for integrated planning and management; and</p> <p>O10. To minimise overall cost while achieving the goals of the CZMP</p>
<b>Estuary Health Pressures targeted:</b>	<p>P35 Bank erosion has potential to impact public access points to estuary foreshore areas by undermining and destabilising structures such as stairs and walkways.</p> <p>P36 Potential estuarine inundation during extreme weather events such as king tides, severe storms or catchment flooding threatens the viability of some public access points and this may be increased with sea level rise.</p> <p>P38 Private landholder use and occupation of Crown Land foreshore areas is restricting public access.</p>
<b>DESCRIPTION OF TASKS:</b>	
<p>Current public access arrangements to the Tweed Coast Estuaries and foreshore areas have been documented in the <i>Bank Erosion Study</i> (Appendix 3). Access points that are located in the high risk bank erosion sites are listed in Section 2.2.5 of this CZMP. Management of these access points will be included in Action 6a: Bank erosion works planning for high risk sites.</p> <p>The projected tidal inundation mapping will be utilised to assess the future viability of public access points and plan for alternative access arrangements (refer Strategy 11: Climate Change Adaptation).</p> <p>Concurrent implementation of the <i>Tweed Coast Regional Crown Reserve Plan of Management</i> may involve changes to public access arrangements at some locations. Any public access arrangements should be consistent with the objectives of this CZMP.</p> <p>A key action that will assist in the over-riding management of public access to the estuary and foreshores is to identify critical access points that are to be maintained. Examples include: public boat ramps, walkways, jetties and viewing platforms; public access tracks from Council managed parks and facilities and emergency access points. The key tasks are:</p> <ul style="list-style-type: none"> <li>Identify and map critical access points to estuaries and foreshores. Access points should be classified by type, and include a description of assets (boat ramp, jetty, stairs etc.) and ownership status (e.g. Crown Land, Council, NPWS owned);</li> </ul>	



<b>DESCRIPTION OF TASKS (continued):</b>	
<ul style="list-style-type: none"> <li>• Assess risks to access points. This will incorporate the bank erosion assessment work completed by this CZMP and risk to access points identified by tidal inundation mapping (refer Strategy 11: Climate Change Adaptation) and asset management planning (age of structures, renewals program etc.);</li> <li>• Document to status of existing or planned management (i.e. works planned as part of Action 6a: Bank erosion works planning for high risk sites or as part of the Tweed Coast Regional Crown Reserve Plan of Management); and</li> <li>• Recommend management actions or works to mitigate remaining risks to public access points. This might include opening up new access points, protecting existing ones, etc.</li> </ul> <p>Other recommendations to address identified public access issues:</p> <ul style="list-style-type: none"> <li>• Council to request DPI-Crown Lands to investigate private occupation and erection of structures in Crown Land, restricting public access to estuary foreshores; and</li> <li>• Council to request Fisheries NSW to investigate any reported incidents of harm to marine vegetation or excavation or retaining wall construction without approval.</li> </ul> <p>Timing of this action follows the completion of Action 6a: Bank erosion works planning for high risk sites and initial tasks as part of the Strategy 11: Climate Change Adaptation. Costs are based on having access to this information to be able to carry out comprehensive desktop assessment of critical access points with limited site visits to confirm access points and key risks.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Management of access points affected by bank erosion incorporated into Action 6a: Bank erosion works planning for high risk sites.</li> <li>• Management of access points affected by tidal inundation incorporated into Action 11b: Planning for sea level rise and climate change impacts.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 6: Bank Erosion</li> <li>• Strategy 11: Climate Change Adaptation</li> <li>• Strategy 15: Education and Consultation</li> </ul>

### 8.13 Strategy 13: Recreational Use

Priority: Medium

**Table 16: Summary of Recreational Use actions**

<b>Objectives:</b>				
O1. To protect, rehabilitate and improve the natural environment;				
O2. To recognise and accommodate natural processes and climate change;				
O3. To protect and enhance the aesthetic qualities of the coastal zone;				
O7. To provide for appropriate public access and use;				
O8. To provide information to enable effective management;				
O9. To provide for integrated planning and management; and				
O10. To minimise overall cost while achieving the goals of the CZMP.				
<b>Estuary Pressures targeted:</b>				
P39 Community concern that a minority of boat users break the rules concerning boat speed and operation.				
P40 Boat wash can increase rates of bank erosion and disturb sensitive vegetation in the estuary.				
P41 Areas of sensitive estuarine vegetation such as seagrass beds may be affected by boating due to propeller and anchor damage.				
P42 Boating navigation in the lower estuaries through to the ocean is hampered by natural processes and can present a safety risk.				
P43 The passage of canoes and other paddle craft through the upper reaches of Cudgen Creek is obstructed by fallen dead, and low-hanging live trees.				
P44 Community concern that a fish stocks have declined over recent decades.				
P45 Overfishing can impact fish stocks.				
P46 Power boating poses a safety risk to people swimming in estuaries.				
P47 Poor water quality impacts the amenity of waterways and may present health concerns for swimmers.				
P48 Water quality sampling has identified a potential risk to human health (faecal contamination) at one site in Cudgera Creek.				
P49. Concern about conflict of use between passive recreation activities and active recreation activities (e.g. nature appreciation such as bird watching and use of powered watercraft which can disturb birds) and the potential for increasing conflict into the future.				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
13a) Support and promote safe and ecologically sustainable recreational use	Not Estimated	On-going (years 1-10)	Study Area	TSC
13b) Investigation of sources of faecal contamination in Cudgera Creek	\$10,000	Immediate (year 1)	Study Area	TSC
<b>Complimentary Strategies:</b>				
<ul style="list-style-type: none"> <li>• Strategy 2: Estuary Habitat</li> <li>• Strategy 15: Education and Consultation</li> </ul>				

**Action 13a: Support and promote safe and ecologically sustainable recreational use**

<b>Desired Outcome</b>	Continued recreational use of the Tweed Coast Estuaries with no adverse impacts on the environment, cultural values or public health and safety.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW, DPI-Crown Lands, Roads and Maritime Services (RMS)
<b>Cost Estimate (10 year)</b>	Not estimated – considered part of concurrent programs
<b>Potential Funding</b>	NSW Maritime Partnerships Program, NSW Estuary Management Program, TSC
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>This action acknowledges that there are a range of programs and initiatives from various agencies (e.g. Roads and Maritime Services, Fisheries NSW) to manage recreational use of estuaries and promote sustainable and safe practices. The aim of this task is to support and promote the existing initiatives and provide linkages between actions in this plan and existing programs. The specific tasks are:</p> <ul style="list-style-type: none"> <li>• Continue speed limits, signage and enforcement of boating rules conducted by RMS.</li> <li>• Continue to provide warnings for boating regarding navigability of estuaries and entrances (RMS).</li> <li>• Provide educational material about impacts of boating as part of Action 15a: Community education and consultation program.</li> <li>• Investigate the nature and location of usage conflicts over time to keep track of changing trends in use and any emerging issues. This information should be used to better direct management action and the need for greater intervention.</li> <li>• Carry out public communication to raise awareness of the issues surrounding potential conflicts between recreational users of the waterways and promote responsible and safe practices.</li> <li>• Support and promote passive recreational use such as canoeing and stand up paddle boarding.</li> <li>• Signage for sensitive sites such as seagrass beds to minimise physical disturbance as part of Action 15b: Signage. This may be particularly important for seagrass beds identified as under extreme pressure in Mooball Creek.</li> <li>• Carry out the Cudgera Creek mouth stability and risk assessment as part of the review of the Tweed Coastline Hazard Study.</li> <li>• Implement actions associated with management of habitat (Strategy 2: Estuary Habitat) exotic fish (Strategy 3: Aquatic Fauna) and catchment management affecting water quality (Strategy 5: Riparian Vegetation; Strategy 8: Agricultural Land; and Strategy 9: Urban Development and Stormwater)</li> <li>• Fisheries NSW to continue to review, update and enforce bag and size limits and fishing licences for recreational anglers.</li> <li>• TSC to review their recreational water quality indicators used in their water quality program to come up to speed with current best practice and recommendations of NHRMC (2008) as part of Strategy 1: Monitoring, Evaluation and Review. An alternative option is to omit recreational triggers from the estuary monitoring and assess as part of dedicated recreational program such as the OEH “Beachwatch” program.</li> <li>• Council discuss the issue of restricted paddle craft passage in upper Cudgen Creek with relevant State government Agencies, with a view to undertaking necessary environmental assessments and trimming works, to support paddle craft passage between Kingscliff and Cudgen Lake.</li> <li>• Prepare investigation and assessments necessary to undertake selective, minor vegetation trimming as required to allow improved paddle craft passage through significant obstructions in upper Cudgen Creek.</li> </ul>	

**DESCRIPTION OF TASKS (continued):**

Action 15a: Community education and consultation program should be utilised to promote recreational use issues and linkages and reinforce existing management. A specific task of the community education program related to this action is monitoring estuary user satisfaction through a periodic community survey (once every 3 years). This aims to assess on-going status of issues related to estuary use and highlight any specific concerns regarding user conflicts, recreational amenity and emerging issues.

No additional budget has been allowed for this action, apart from the costs incorporated in Ecosystem Health monitoring and Community Education actions.

**KPIs**

- Recreational values of the estuaries are enhanced as demonstrated by Estuary User Satisfaction surveys conducted as part of Action 15a: Community education and consultation program.

**Action 13b: Investigation of sources of faecal contamination in Cudgera Creek**

<b>Desired Outcome</b>	Identify the source of faecal contamination in Cudgera Creek and direct management action to address the issue so that recreational water quality objectives are achieved.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH
<b>Cost Estimate (10 year)</b>	\$10,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC
<b>Timing</b>	Immediate (year 1)
<b>Location</b>	Cudgera Creek mid-upper estuary
<b>DESCRIPTION OF TASKS:</b>	
<p>Action 1a: Ecosystem Health monitoring program sets out the design and implementation of an on-going monitoring program incorporating water quality and recreation health assessment across all estuaries. In addition to this on-going program the following is recommended to address the specific risk to recreational water quality in Cudgera Creek:</p> <ul style="list-style-type: none"> <li>• Design and implement a targeted water quality sampling program during high risk periods in order to track down sources of faecal contamination. This should consider: <ul style="list-style-type: none"> <li>○ Select sites to isolate and assess potential sources;</li> <li>○ Sample design high risk events such as rainfall/runoff events;</li> <li>○ Water quality assessment should include faecal indicator bacteria (principally Intestinal Enterococci) in line with NHRMC (2008) and standard physico-chemical parameters;</li> <li>○ Where practical, water quality investigations should be coordinated or integrated with study area-wide Ecosystem Health monitoring (Action 1a: Ecosystem Health monitoring program) for efficiency.</li> </ul> </li> <li>• Develop management actions to address sources of contamination. Actions to manage sources of contamination may include both animal (e.g. cattle, birds, urban pets) and human (e.g. failed septic systems) sources. Management of these sources should be prioritised on proximity and level of influence on recreational areas and likely management effectiveness.</li> </ul> <p>The budget assigned to this task is based and indicative program (3 repeat samples taken at 6 sampling sites, and time allowed for research, data analysis and reporting. Actual costs of monitoring will be refined following confirmation of sampling methodology.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Monitoring investigation report completed by end 2015</li> </ul>

## 8.14 Strategy 14: Cultural Heritage

Priority: Medium

### Action 14a: Cultural heritage

<b>Desired Outcome</b>	To provide for effective protection and management of cultural sites and where appropriate provide access and signage to promote the cultural values of the estuary
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Local Aboriginal representatives/ groups
<b>Cost Estimate (10 year)</b>	Not estimated – considered to be within TSC current activities
<b>Potential Funding</b>	Aboriginal Heritage Projects, Working on Country, Indigenous Heritage Program
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>Objectives:</b>	O4. To protect and conserve cultural heritage;
<b>Estuary Health Pressures targeted:</b>	P50. Currently there is no overriding plan within the study area to guide the management of Aboriginal cultural heritage.
<b>DESCRIPTION OF TASKS:</b>	
<ul style="list-style-type: none"> <li>• All management actions as part of this CZMP to consider aboriginal cultural significance and assessment of impacts according to Council's DCP and under relevant legislation.</li> <li>• The Tweed Shire Aboriginal Cultural Heritage Management Plan (CHMP) is currently being developed. The CHMP will provide a holistic assessment of cultural heritage for the Tweed Shire and will include the Tweed Coast Estuaries study area. The CHMP is considered to be the suitable guiding document for cultural heritage. Providing:             <ul style="list-style-type: none"> <li>○ The objectives of this CZMP are considered in the CHMP.</li> <li>○ Review of the CZMP should consider any key outcomes of the CHMP in the study area.</li> </ul> </li> </ul> <p>Community education of significant aboriginal cultural heritage places or management actions identified by the CHMP within the Tweed Coast Estuaries could be carried out as part of Action 15a: Community education and consultation program.</p> <p>No additional budget has been allowed for this action as it is covered by existing Council activities. Consultation to be carried out as part of this CZMP has been costed as part of the Community Education actions.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Tweed Shire Aboriginal Cultural Heritage Management Plan (CHMP) completed by end 2014.</li> </ul>
<b>Complimentary Strategies:</b>	<ul style="list-style-type: none"> <li>• Strategy 15: Education and Consultation</li> </ul>

## 8.15 Strategy 15: Education and Consultation

### Priority: High

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

It will be important to raise public awareness of the values and sustainable use of the Tweed Coast Estuaries through targeted community education programs. Key considerations are:

- Opinions and perceptions are sometimes based on old or inaccurate information;
- Social acceptability of management actions will increase as community understanding of the pressure increases;
- Conflict between users can be alleviated with the provision of objective information; and
- Community satisfaction with estuary management is sometimes based on perception rather than fact (e.g. perception of the need for dredging).

This strategy is made up of an overriding community education and consultation program related to pressures identified during development of the plan and signage. Education and consultation actions are considered to be important in the overall acceptance of the CZMP and willingness to pay for the recommended actions and in some instances education actions seek to address the root cause of estuary health pressures.

**Table 17: Summary of education consultation actions**

<b>Objectives:</b>				
O1.	To protect, rehabilitate and improve the natural environment;			
O2.	To recognise and accommodate natural processes and climate change;			
O3.	To protect and enhance the aesthetic qualities of the coastal zone;			
O4.	To protect and conserve cultural heritage;			
O5.	To promote ecologically sustainable development and use of resources;			
O6.	To provide for ecologically sustainable human settlement;			
O7.	To provide for appropriate public access and use;			
O8.	To provide information to enable effective management;			
O9.	To provide for integrated planning and management; and			
O10.	To minimise overall cost while achieving the goals of the CZMP			
<b>Estuary Pressures targeted:</b> All				
Action (short name)	Ten Year Cost Estimate (\$)	Timing	Location	Lead Responsibility
15a) Community education and consultation program	\$200,000	On-going (years 1-10)	Study Area	TSC
15b) Signage	\$6,000	Immediate (year 1)	Various sites in estuaries	TSC
<b>Complimentary Strategies:</b> All				

**Action 15a: Community education and consultation program**

<b>Desired Outcomes</b>	To improve current understanding of the pressures affecting estuary health in the community and among decision makers;  To support CZMP initiatives and encourage positive changes in management practices and human behaviour; and  Provide community updates on the progress of the CZMP.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, DPI-Crown Lands, NRCMA, FNCW, Fisheries NSW, relevant agricultural industry bodies
<b>Cost Estimate (10 year)</b>	\$200,000
<b>Potential Funding</b>	NSW Estuary Management Program, TSC (through Council contributions), Fisheries NSW Habitat Action Grants, Caring for Our Coast, Caring for Our Country, Environmental Education Grants, Working on Country Program, Urban Sustainability Program
<b>Timing</b>	On-going (years 1-10)
<b>Location</b>	Study Area
<b>DESCRIPTION OF TASKS:</b>	
<p>Education and consultation is considered to be integral to the success of the CZMP implementation. Future education programs should build on the existing programs within Council and in the wider community, and particularly focus on:</p> <ul style="list-style-type: none"> <li>• Local ecological processes;</li> <li>• Education of decision makers regarding priority issues for the estuaries and required allocation of effort and funding;</li> <li>• The importance of human behaviours and their impacts on the estuaries;</li> <li>• Improving community understanding of what an estuary is and its value as an asset;</li> <li>• Significant flora and fauna issues (such as seagrass habitats and migratory shorebirds); and</li> <li>• Local issues that help to connect the local community with the health of the estuary and its subsequent impact on the local lifestyle.</li> </ul> <p>During development of the CZMP the need for specific messages to be communicated to the community were realised. Communicating these messages are important tasks within the strategies outlined in this CZMP and have been collated in this strategy for coordinated implementation as part of the overriding community education and consultation program. These include:</p> <ul style="list-style-type: none"> <li>• Ecosystem Health Monitoring – communication of the findings of the program to the wider community is a key requirement to inform the public about the ongoing health of the estuary related to their local catchments and success of management efforts. Simple, easily understandable reports and well-designed report cards will be produced as part of the outputs of Action 1a: Ecosystem Health monitoring program which can be distributed as single page leaflets or web downloads.</li> <li>• CZMP Progress Reporting – the progress of the CZMP and achievement of KPIs will be reported as part of Action 1b: Review of CZMP progress and monitoring of KPIs. A summary of progress should be made available to the community following each report.</li> <li>• Estuary Habitat – education about the value of estuarine habitat areas and key pressures. Management actions to protect sensitive habitat protection should be promoted including signage at key sites.</li> <li>• Aquatic Fauna – raise awareness of the negative effects of releasing aquarium fish into the wild in an effort to reduce infestations in the Tweed Coast Estuaries and catchment waterways. Promote Action 2b: On-going protection of estuary habitat to raise awareness and call for expressions of interest from landholders with suitable sites for restoration works;</li> </ul>	



**DESCRIPTION OF TASKS (continued):**

- Shorebirds and coastal raptors – raise awareness of the negative impacts due to disturbance of shorebirds by dogs (particularly at Cudgera Creek entrance) and the restricted 'no dog' areas and general requirement for dogs to be restrained on a lead in all other estuary foreshore areas of the Tweed Shire. Raise awareness about the coastal raptor values and status, their breeding ecology, vulnerability to disturbance and ways for individuals to assist in mitigating impacts in their local areas including correct use and disposal of fishing line and tackle and of correct disposal of litter to avoid ingestion or entanglement of wildlife;
- Riparian Protection and Restoration – education regarding riparian vegetation value and function and communicating the results of the prioritisation study and on-going rehabilitation works progress. Promoting of the remediation works can also call for expressions of interest from landholders with sites for future projects;
- Bank Erosion – raise awareness about bank erosion issues, causes and ways the broader community can assist to minimise pressures. Updates should also be provided on the remediation works undertaken and improvements realised for estuary values.
- Acid Sulfate Soils – community education about acid sulfate soil issues and communicating the results of the remediation works undertaken in the catchments and any improvements in water quality detected by the Ecosystem Health monitoring program.
- Agricultural land management – increasing the understanding of issues and the need for sustainable agriculture initiatives will be a factor in support of existing programs and ensuring increasing uptake of initiatives by landholders into the future.
- Urban Development and Stormwater – raise awareness of issues and in particular the role that residents play in minimising stormwater pollution.
- Wastewater Management - community education about wastewater management, key pressures and linkages to waterway health, landholder responsibilities (e.g. on-site sewage system management) and the positive ecosystem changes as a result of management actions (e.g. WWTP upgrades, replacing failing septic systems etc.)
- Climate Change – raise awareness of the potential implications of predicted climate change impacts and the work underway as part of this CZMP to assess impacts and plan for management to mitigate impacts.
- Public Access – education regarding the status of Crown Land foreshore areas which are to provide public access to estuaries. Highlight the issue of illegal private structures on Crown Land that restrict public access to foreshores. Education that highlights that it is illegal to harm, destroy or remove any marine vegetation (including mangroves) and the penalties incurred under the *Fisheries Management Act* for such activities.
- Recreational Use – conduct estuary user satisfaction surveys to assess on-going enjoyment of recreational use and highlight key issues. It is recommended that a brief survey be designed and undertaken periodically (i.e. once every 3 years) to assess on-going status of issues related to estuary use, success of management actions implemented as part of the CZMP and highlight any specific concerns regarding user conflicts, recreational amenity and emerging issues. Results should be made publicly available and used in Action 1b: Review of CZMP progress and monitoring of KPIs.
- Litter - education on responsible behaviour and the impacts of personal behaviour including:
  - public education campaign around the damage caused to wildlife due to litter using local examples to illustrate these impacts;
  - correct use and disposal of litter, fishing line and tackle to avoid ingestion or entanglement of wildlife;
  - the flow-on effects of dumping household and garden waste in natural areas and alternative disposal and reuse methods such as composting;
  - Signage displayed at garbage bins locations highlighting impacts of littering and encouraging correct disposal.
  - Review the current provision of garbage bins at key locations along the estuaries and supplement as needed.
- Promotion of Signage – the new signage (Action 15b: Signage) and their purpose should be undertaken prior to and following the deployment of signage to raise awareness and improve the effectiveness of the initiative;

Education tools include activity days, fact sheets, brochures and school education programs. Information and resources should be available through a central location such as libraries or Council website. Data provided by monitoring programs and investigations (refer Action 1a: Ecosystem Health monitoring program,) should also be made available for key issues or important geographical locations. To enable dissemination of key information to the community, TSC need to be aware of current initiatives and outcomes.

**DESCRIPTION OF TASKS (continued):**

Capacity-building will be a key component of the education program as empowerment and training of individuals and groups will improve the success of the outcomes and promote a greater understanding of the issues. Existing community groups such as Landcare and Coastcare should be supported. Coordination of efforts with other organisations such as the NPWS and local schools would also assist with resourcing and facilities. The participation of indigenous groups in future management actions should also be encouraged through education and training programs.

The key steps are:

- Design a targeted education program considering key estuary pressures, knowledge gaps, available funding and administrative responsibilities;
- Obtain funding;
- Implement the education program;
- Review the success of the program through follow-up community surveys; and
- Amend the program as necessary.

An estimated \$20,000 per year has been allowed for this action for the duration of the CZMP implementation period, giving a total cost of \$200,000 for the ten year plan.

**KPIs**                      • Improved community understanding of issues demonstrated through follow-up survey results.

**Action 15b: Signage**

<b>Desired Outcomes</b>	Raise awareness of the location of sensitive habitats to reduce damage caused by physical disturbance.
<b>Lead Organisation</b>	TSC, TCC
<b>Support Organisation</b>	OEH, Fisheries NSW, DPI-Crown Lands, NPWS
<b>Cost Estimate (10 yr)</b>	\$6,000
<b>Potential Funding</b>	Fisheries NSW Habitat Action Grants, NSW Estuary Management Program, TSC
<b>Timing</b>	Short term (year 1)
<b>Location</b>	Various sites in estuaries
<b>DESCRIPTION OF TASKS:</b>	
<p>In key locations where people are having a direct impact on estuary health, signage may help to inform the public about these impacts and assist in changing behaviours. This action acknowledges that overuse of signage can decrease the visual amenity of an area and reduce the effectiveness of the message. The aim is to provide a minimum amount of high value signage at key locations to convey important messages while not detracting from the values of an area.</p> <p>A number of areas were identified within the estuaries where signage would assist in reducing key risks. These were:</p> <ul style="list-style-type: none"> <li>• Seagrass beds: Education is important to protect seagrasses from potential harm caused by physical disturbance. Signage of particularly sensitive sites may be necessary for protection against physical disturbance such as boat propellers and anchors. Tasks include: <ul style="list-style-type: none"> <li>○ Consultation with Fisheries NSW to determine requirements and/or restrictions and discuss potential for funding under the Fisheries NSW Habitat Action Grants;</li> <li>○ Initial inspection of seagrass to select sites at most risk from damage and to scope signage requirements (size, pole height, materials, etc.) and to confirm costs. Factors such as visual impact of signage on the amenity of the area, safety considerations for waterway users, vulnerability to vandalism, and stability of the estuary bed sediments etc. will need to be assessed when selecting locations. It will be necessary to consult with Fisheries NSW and NSW Maritime to assess impacts on estuarine habitat and safety.</li> <li>○ Design of signage in consultation with Fisheries NSW and previous successful signage in local area.</li> <li>○ Advertising of the signs to be undertaken as part of Action 15a: Community education and consultation program to raise awareness about habitat disturbance.</li> <li>○ Signs should be inspected annually to determine maintenance or replacement requirements.</li> <li>○ The Ecosystem Health monitoring program should aim to monitor changes in the seagrass beds with signage to assess changes in extent and health.</li> </ul> </li> <li>• Designated dog exclusion areas in vicinity of shorebird habitat: A particular area of concern has been identified by the community in lower Cudgera Creek, near the entrance. Tasks include: <ul style="list-style-type: none"> <li>○ Deploy signage at key sites around Cudgera Creek mouth advising it is a dog exclusion area;</li> <li>○ Advertising of the signage to be undertaken as part of Action 15a: Community education and consultation program to raise awareness about the issues;</li> <li>○ Organise for the TSC Ranger to conduct extra patrols of the area following signage deployment to reinforce the requirement and issue warnings and/or fines as appropriate;</li> <li>○ Investigate shorebird habitat throughout the study area, to determine the need for similar signage (see Action 4a: On-going protection of shorebirds and their habitat in the study area).</li> </ul> </li> </ul> <p>The cost of signage will be confirmed after the initial site visit and when design requirements are finalised, but assuming 2 signs are deployed in each estuary (6 in total) \$6K has been allowed for sign construction and deployment. This was based on the cost of educational signage and advertising implemented in the Evans River estuary in recent years.</p>	
<b>KPIs</b>	<ul style="list-style-type: none"> <li>• Ecosystem Health monitoring annual reports show an improvement in seagrass after year 2.</li> <li>• Follow up monitoring recommended in Shorebirds of Northern New South Wales (DECCW, 2010c) show an improvement in shorebird populations.</li> <li>• Improved community understanding of issues demonstrated through follow-up survey results (see Action 15a: Community education and consultation program).</li> </ul>

## 9. IMPLEMENTATION PROGRAM

The management strategies have been compiled into a ten year implementation program as shown in Table 18.

Implementation costs for some strategies are not yet determined and have not been included here.

Table 18: CZMP Implementation Program (\$'000)

Priority	Action	Lead Organisation	Support Organisations	Ten Year Cost (\$k)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Fundamental	<b>Strategy 1: Monitoring, Evaluation and Review</b>														
	1a	Ecosystem Health monitoring program	TSC, TCC	OEH, DPI-Crown Lands, Fisheries NSW	320	120				100				100	
	1b	Review of CZMP progress and monitoring of KPIs (SoE Reporting)	TSC, TCC	OEH, Fisheries NSW, DPI-Crown Lands	NE										
	1c	10 year review of CZMP	TSC, TCC	OEH, Fisheries NSW, DPI-Crown Lands, NRCMA	100										100
	<b>Strategy 11: Climate Change</b>														
	11a	Assessment and mapping of tidal inundation extent including potential sea level rise	TSC, TCC	OEH	NE										
	11b	Planning for sea level rise and climate change impacts	TSC, TCC	OEH, Fisheries NSW, NRCMA, DPI-Crown Lands	85			50	5	5	5	5	5	5	5
High	<b>Strategy 6: Bank Erosion</b>														
	6a	Bank erosion works planning for high risk sites	TSC, TCC	OEH, DPI Crown Lands	40	40									
	6b	Bank erosion remediation works	TSC, TCC	OEH, DPI Crown Lands	NE										
	<b>Strategy 5: Riparian Vegetation</b>														
	5a	Identify priority riparian areas for protection and rehabilitation	TSC, TCC	OEH, DPI-Crown Lands, NRCMA, FNCW, landholders, relevant agricultural industry bodies, community groups	75	30	5	5	5	5	5	5	5	5	5
	5b	Riparian Rehabilitation works	TSC, TCC	OEH, DPI-Crown Lands, NRCMA, FNCW, landholders, relevant agricultural industry bodies, community groups	1000	100	100	100	100	100	100	100	100	100	100
	<b>Strategy 8: Agriculture</b>														
	8a	Support and promote sustainable agricultural initiatives	TSC, TCC	OEH, Fisheries NSW, NRCMA, DPI-Crown Lands, OEH, landholders, relevant agricultural industry bodies.	NE										
	8b	Cost Benefit Analysis of alternative land use options	TSC, TCC	OEH, NRCMA, DPI-Agriculture	70		70								
	<b>Strategy 7: Acid Sulfate Soils</b>														
	7a	Identify and prioritise key sites for remediation	TSC, TCC	UNSW Researchers, OEH, Fisheries NSW, NRCMA, DPI-Crown Lands, OEH, landholders, relevant agricultural industry bodies	100	20	70	10							
	7b	Acid Sulfate Soil remediation works	TSC, TCC	UNSW Researchers, OEH, Fisheries NSW, NRCMA, DPI-Crown Lands, OEH, landholders, relevant agricultural industry	600	60	60	60	60	60	60	60	60	60	60
	<b>Strategy 15: Education and Consultation</b>														
	15a	Community education and consultation program	TSC, TCC	OEH, DPI-Crown Lands, NRCMA, FNCW, Fisheries NSW, relevant agricultural industry bodies	200	20	20	20	20	20	20	20	20	20	20
	15b	Signage	TSC, TCC	OEH, Fisheries NSW, DPI-Crown Lands NPWS	6	6									
	<b>Strategy 4: Shorebirds and Coastal Raptors</b>														
	4a	Action 4a: On-going protection of shorebirds and their habitat in the study area	TSC, TCC	OEH, NPWS	20		20								
4b	Action 4b: Management of dogs within vicinity of shorebird habitat at Cudgera Creek mouth	TSC, TCC	OEH, NPWS	NE											
4c	On-going protection of coastal raptors and their habitat in the study area	TSC, TCC	OEH, NPWS, Tweed Bird Observers	5	5										

COASTAL ZONE MANAGEMENT PLAN FOR THE TWEED COAST ESTUARIES

Priority	Action	Lead Organisation	Support Organisations	Ten Year Cost (\$k)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Medium	<b>Strategy 9: Urban Development and Stormwater</b>														
	9a	Stormwater planning controls and regulation	TSC, TCC	OEH	NE										
	<b>Strategy 10: Wastewater Management</b>														
	10a	Wastewater Management	TSC, TCC	OEH, EPA	NE										
	<b>Strategy 13: Recreational Use</b>														
	13a	Support and promote safe and ecologically sustainable recreational use	TSC, TCC	OEH, Fisheries NSW, DPI-Crown Lands, Roads and Maritime Services (RMS)	NE										
	13b	Investigation of sources of faecal contamination in Cudgera Creek	TSC, TCC	OEH	10	10									
	<b>Strategy 2: Estuary Habitat</b>														
	2a	Investigation of seagrass decline in Mooball Creek	TSC, TCC	OEH, Fisheries NSW	40	20	20								
	2b	On-going protection of estuary habitat	TSC, TCC	OEH, Fisheries NSW	NE										
	<b>Strategy 14: Cultural Heritage</b>														
	14a	Cultural Heritage	TSC, TCC	OEH, Local Aboriginal representatives/ groups	NE										
	<b>Strategy 12: Public Access</b>														
	12a	Public access	Various	OEH, EPA, DPI-Crown Lands	NE				10						
	<b>Strategy 3: Aquatic Fauna</b>														
	3a	Aquatic habitat restoration and protection	TSC, TCC	OEH, Fisheries NSW	100	10	10	10	10	10	10	10	10	10	10
3b	Christies Creek fish surveys	TSC, TCC	OEH, Fisheries NSW	15		15									
<b>Totals</b>				<b>2,786</b>	<b>441</b>	<b>390</b>	<b>255</b>	<b>210</b>	<b>300</b>	<b>200</b>	<b>200</b>	<b>200</b>	<b>300</b>	<b>300</b>	

Notes:

Years correspond to end of financial year i.e. 2015 is year 1 (start 1st July 2014, end 30th June 2015), etc.

All costs are current (2013) dollars and make no allowance for inflation in subsequent years.

NE = Not Estimated – costs are already accounted for in current activities or costs need to be estimated as part of further work.

Shaded cells = Denotes the estimated timing of actions

\*Action to be implemented for Mooball Creek ASAP (i.e. by July 2013 to allow for spring sample in Sep/Oct)

## **GLOSSARY AND ABBREVIATIONS**

Acid sulfate soils (ASS)	Holocene soils occurring in low lying floodplain areas with high concentrations of iron pyrite, formed as the by-product of sulfate reduction. ASS formed approximately 7,000-3,000 years before present when post-glacial sea levels reached their current level creating vast intertidal mangrove swamps.
Algal bloom	The rapid growth of phytoplankton resulting in a high biomass in the water column.
Anoxic	An oxygen-free environment.
Antecedent	Preceding the present.
Anthropogenic	Any phenomenon caused by human activities.
Backswamp	A marshy area where floodwater may be confined between the river levees and higher ground, creating intermittent wetland areas following substantial rainfall. Backswamp areas accumulate fine silts and clays which settle after a flood.
BASIX	Building Sustainability Index
Benthic microalgae (BMA)	Microscopic algae living in the surface sediments
Benthic	Belonging to the bottom, or sediments, of the estuary.
Bio-available	Nutrient forms (usually inorganic) available for plant growth.
Biological oxygen demand (BOD)	A measure of the amount of oxygen that will be consumed by biological processes over a given time period (usually 5 days).
Biomass	The living weight of plant or animal material (organic matter).
Blackwater	A collective term used to describe low oxygen floodwaters emanating from backswamp areas and floodplains.
BONN	The Bonn Convention, also known as the Convention on the Conservation of Migratory Species of Wild Animals, aims to conserve terrestrial, marine and avian migratory species throughout their range
CAMBA	China-Australia Migratory Bird Agreement
CAP	Catchment Action Plan
Chemical oxygen demand (COD)	A measure of the amount of oxygen that will be consumed by chemical processes over a given time period (usually 5 days).
Chlorophyll-a	The green pigment in plants used to capture and use energy from sunlight to form organic matter (see photosynthesis). Concentrations of chlorophyll-a are used as an indicator for phytoplankton and benthic algae biomass.
CMA	Catchment Management Authority
CZMP	Coastal Zone Management Plan.
DECCW	Department of Environment, Climate Change and Water
Desired Outcome	A clear description of the intended outcomes of a specific action. A statement of the scope of the action.
Diffuse Source Pollution	Non-point source pollution such as sediment or nutrients from catchment runoff or groundwater inputs.
DPI	NSW Department of Primary Industries
Ecosystem	Refers to all the biological and physical parts of a biological unit (e.g. an estuary, forest, or planet) and their interconnections.
EPRG	Environment Protection and Regulation Group (OEH)
Eutrophication	The process of nutrient enrichment of a water body resulting in the increase in plant biomass (algal blooms) and bacterial decay (heterotrophic activity). Often results in a reduction in species diversity, visual amenity, and the prevalence of toxic algal species.
Foodchain	The predator / prey interactions of an ecosystem component.
Foodweb	Foodchain interactions of the whole ecosystem.
Freshwater flushing time	The time (in days) that freshwater stays within an estuary before being transported to the sea by advection and tidal mixing.
Grazing	The eating of plants (e.g. phytoplankton) by animals (e.g. zooplankton).

Hypoxic	Critically low concentrations of dissolved oxygen (see anoxic).
JAMBA	Japan-Australia Migratory Bird Agreement
KPIs	Key Performance Indicators - targets to allow the monitoring of Management Action implementation and where appropriate the degree of success in achieving the management objectives.
LEP	Local Environmental Plan
Light attenuation	The absorbance of sunlight by dissolved and particulate matter in a water body.
Long-term vision	An ultimate aspirational goal for the health and function of the estuaries
Management objectives	Targets for future management to ensure a balance between long-term utilisation and conservation of the Tweed Coast Estuaries
Management Actions	A specific set of actions to be undertaken that describes how the management objectives are to be achieved.
Management Strategies	Actions are grouped into strategies for implementation.
Macroinvertebrates	Animals without backbones that live in the water and are large enough to be seen by the naked eye (e.g. beetles, bugs, shrimp, snails).
Monosulfidic Black Ooze (MBO)	An iron sulfide compound formed as a by-product of sulfate reduction. MBOs commonly form in acid environments with high organic matter supply and have a high chemical oxygen demand.
NOW	NSW Office of Water
NPWS	National Parks and Wildlife Service
NRCMA	Northern Rivers Catchment Management Authority
NRM	Natural Resource Management
Nutrient budget	A simple model quantifying nutrient loadings (by weight) to a waterway from different sources over a given time period (e.g. one year).
Nutrient limitation	The restriction of phytoplankton growth by the low concentration (availability) of a nutrient.
OEH	NSW Office of Environment and Heritage
Physico-chemical	Basic water quality parameters e.g. temperature, pH, conductivity, turbidity.
Phytoplankton	Microscopic single-cell plants growing in the water column.
Point Source Pollution	A single point of pollutant discharge. For example, effluent from a sewage treatment plant.
Primary production	The formation of organic matter by autotrophs (e.g. phytoplankton).
Pristine	Undisturbed by human activities such as urban and agricultural development, pollution, erosion, weed infestations, etc.
Reticulated Sewage System	Sewage piped to a centralised sewage treatment plant for treatment and disposal.
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SEPP	State Environmental Planning Policy
Sulfate reduction	The bacterial breakdown of organic matter in anoxic sediments using sulfate instead of oxygen. Produces hydrogen sulfide, the 'rotten egg gas' smell common in muddy sediments.
STP	Sewage Treatment Plant. Raw sewage is collected from homes and businesses and transported via a network of pipes and pump stations to the sewage treatment plant, a centralised system for treatment and disposal.
Tasks	An outline of the steps required for implementation of a recommended Management Action.
TCC	Tweed Coastal Committee
TSC	Tweed Shire Council
Turbidity	A measure of the amount of light-attenuating particles in a water body.
Well-mixed	Where there is a little difference in salinity (or dissolved oxygen) between the surface and bottom water in the water column of an estuary.



### REFERENCES

- ABER (2012). Water quality processes in Cudgen, Cudgera and Mooball Creeks. Report prepared for Hydrosphere Consulting as part of the Tweed Coast Estuaries Baseline Ecological Health Assessment.
- Akumu, C.E., Pathirana, S., Baban, S. and Bucher, D. (2010). Examining the potential impacts of sea level rise on coastal wetlands in north-eastern NSW, Australia. *Journal of Coastal Conservation* (2011) 15:15 -12
- Australian Wetlands (2003). Tweed Coast Estuaries Management Plan 2004-2008. Report Prepared for Tweed Shire Council.
- Australian Wetlands(2010). Coastal Zone Management Plan for Cobaki Broadwater and Terranora Broadwater
- Australian Wetlands (2012). Draft Tweed Urban Stormwater Quality Management Plan. Report prepared for Tweed Shire Council. Report Prepared for Tweed Shire Council.
- BMT WBM (2012). Tweed Shire Coastal Hazards Assessment 2012. Prepared for Tweed Shire Council
- Collins, R., Yvanes-Giuliani, Y., Stroud, J. (2012). Exploiting Natural Processes to Effectively Remediate Acidified Coastal Environments. ARC Linkage Project LP110100480. Annual Progress Report for 2011.
- CSIRO (2007). Climate Change in the Northern Rivers Catchment. Prepared for the NSW Government by the CSIRO.
- Debus S.J. (2008). Biology and Diet of the White-bellied Sea-Eagle *Haliaeetus leucogaster* Breeding in Northern Inland New South Wales. *Australian Field Ornithology* 25, 165-193.
- DECC (2008). Aboriginal People, the Environment and Conservation – Principles to incorporate the rights and interests of Aboriginal people into the work of DECC.DECCW (2009). NSW Government Sea Level Rise Policy Statement.
- DECC (2009). NSW Diffuse Source Water Pollution Strategy.
- DECC (2010). Draft NSW Threat Abatement Plan for Predation by the Red Fox (*Vulpes vulpes*). NSW Department of Environment, Climate Change and Water, Hurstville.
- DECCW (2010a). Guidelines for Preparing Coastal Zone Management Plans. Published by Department of Environment, Climate Change and Water NSW, Sydney.
- DECCW (2010b). Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers Region, Department of Environment, Climate Change and Water NSW, Sydney.
- DECCW (2010c). Shorebirds of Northern New South Wales, based on a report prepared by D. Rohweder and funded by the Northern Rivers Catchment Management Authority, Department of Environment, Climate Change and Water NSW, Sydney.
- DECC (2007). Northern Rivers Region Pest Management Strategy 2008-2011. DECC, Sydney, NSW
- Dennis, T.E., McIntosh, R.R., Shaughnessy, P.D. (2011) Effects of human disturbance on productivity of White-bellied Sea-Eagles (*Haliaeetus leucogaster*). *Emu*, III, (2), 179-185.
- Department of Climate Change (2009). Climate Change Risks to Australia's Coast. A First Pass National Assessment. Australian Government.
- Department of Infrastructure, Planning and Natural Resources (DIPNR) (2003). Cudgen Creek Dredging Proposal: Information Paper. Prepared for Tweed Shire Council.
- Department of Lands (2007). Threatened Species (Pied Oystercatcher) Management Strategy. Funded by the Commonwealth natural Heritage Trust through the Northern Rivers Catchment Management Authority.

Department of Sustainability, Environment, Water, Population and Communities (2013). *Pandion cristatus* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Wed, 15 May 2013.

Fisheries NSW (1997). Fish Habitat Protection Plan 2: Seagrasses. Available at: [http://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0019/202744/Fish-habitat-protection-plan-2---Seagrass.pdf](http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0019/202744/Fish-habitat-protection-plan-2---Seagrass.pdf) - accessed Nov 2012.

Fisheries NSW (2008). Primefact 746: Mangroves. Available at: [http://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0020/236234/mangroves.pdf](http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0020/236234/mangroves.pdf) – accessed Oct 2012.

Fisheries NSW (2012). Barriers to Fish Passage. Available at: <http://www.dpi.nsw.gov.au/fisheries/habitat/threats/barriers> – accessed Oct 2012.

Everick Heritage Consultants (2012). 'New Aboriginal CHMP for the Tweed Shire'. Available at: <http://www.everick.com.au/new-aboriginal-chmp-for-the-tweed-shire.aspx> - accessed 10th Oct 2012.

GeoLINK (2008). Cudgen Creek Recreation and Public Access Plan. Report prepared for Tweed Shire Council.

Hannan, J. C. and Williams, R. J. (1998); Recruitment of juvenile marine fishes to seagrass habitat in a temperate Australian estuary. *Estuaries* 21, 1, 29-51.

HRC (2002). Health Rivers Commission Independent Public Inquiry into Coastal Lakes.

Johnston S, Kroon F, Slavich P, Cibilic A and Bruce A (2003). Restoring the balance: Guidelines for managing floodgates and drainage systems on coastal floodplains. (NSW Agriculture: Wollongbar, Australia). Available at [www.agric.nsw.gov.au/reader/floodgate-guidelines](http://www.agric.nsw.gov.au/reader/floodgate-guidelines) - accessed Sep 2012

Kingston, M.B., Turnbull, J.W. and Hall, P.W. (2004). Tweed Vegetation Management Strategy. Prepared for Tweed Shire Council.

Kinsela A, R Collins and TD Waite (2009). Sources, concentrations and bioavailability of arsenic in sediments: Christies Creek, north east NSW. UNSW Water Research Centre publication 2009/15, The University of New South Wales, Sydney, NSW 2052, Australia. p.27.

Land and Property Management Authority (2005). Tweed Coast Regional Crown Reserve Plan of Management.

Macdonald, B.C.T., Smith, J., Keene, A.F., Tunks, M., Kinsela, A and White, I. (2004). Impacts of runoff from sulfuric soils on sediment chemistry in an estuarine lake. *Science of the Total Environment* 329:115-130.

Marchant, S. and P.J. Higgins, eds. (1993). Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

Mongard, J. (2011). Tweed Sustainable Agriculture Strategy Discussion Paper. Prepared for Tweed Shire Council.

NPWS (1995). Vegetation Survey and Mapping of Upper North East New South Wales, report prepared for the Natural Resources Audit Council, NPWS, Coffs Harbour, NSW.

NPWS (1998). Cudgen Nature Reserve Plan of Management. National Parks and Wildlife Service.

NPWS (1999). Forest Ecosystem Classification and Mapping for the Upper and Lower North East CRA Regions, Project Undertaken for the Joint Commonwealth NSW Regional Forest Agreement Steering Committee. Available at: [http://www.daffa.gov.au/\\_data/assets/word\\_doc/0020/50717/nsw\\_ne\\_na35eh.doc](http://www.daffa.gov.au/_data/assets/word_doc/0020/50717/nsw_ne_na35eh.doc) - accessed June 2012.

NPWS (2002). Key habitats and corridors mapping. NSW National Parks and Wildlife Service, Northern Directorate.

NPWS (2007). Wooyung Nature Reserve Plan of Management. National Parks and Wildlife Service.

NSW Chief Scientist and Engineer (2012). Assessment of the science behind the NSW Government's sea level rise planning benchmarks. Report prepared for the Coastal Ministerial Taskforce.

NSW Office of Water, 2010. Water Sharing Plan for the Tweed River Area Unregulated and Alluvial Water Sources – Background document.

NSW DPI (2004). A Introduction to Acid Sulfate Soils. Available at: <http://www.dpi.nsw.gov.au/agriculture/resources/soils/ass/general/introduction>. – accessed July 2012.

NSW Scientific Committee (2004). Final Determination: Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions - endangered ecological community listing

OEH (2006). NSW Water Quality and River Flow Objectives – Tweed River. Available at: [http://www.environment.nsw.gov.au/ieo/tweed/report-03.htm#P307\\_25850](http://www.environment.nsw.gov.au/ieo/tweed/report-03.htm#P307_25850) – accessed August 2011.

OEH (2012). Estuaries of NSW: Physical characteristics, tidal surveys and hydrographic surveys Available at: <http://www.environment.nsw.gov.au/estuaries/list.htm>. - accessed June 2012.

OEH (2013). Assessing estuary ecosystem health: Sampling, data analysis and reporting protocols NSW Natural Resources Monitoring, Evaluation and Reporting Program.

Russell, K. (2005). NSW Northern Rivers Estuary Habitat Mapping - Final Analysis Report. NSW Department of Primary Industries, Port Stephens.

Sandpiper Ecological Surveys, 2005. Shorebird habitat improvement in the Tweed River Estuary: concept plan for an artificial shorebird roost. Report prepared for Tweed Shire Council.

Schroeder B., Calcino D., Hurney A., Smith R., Panitz J., Cairns R., Wrigley T., Allsopp P. (2008). SmartCane Principles of Best Management Practice. Prepared for Canegrowers with assistance from the Queensland Government and the EPA.

Stone, Y, Ahern C R, and Blunden B (1998). Acid Sulfate Soils Manual 1998. Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

Stone, Y., and Hopkins G., (1998). Acid Sulfate Soils Planning Guidelines. Published by the Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

Tulau M.J. (2002). Agricultural Drainage in Acid Sulfate Soil Backswamps in New South Wales, Australia – Technical, Regulatory and Policy Responses. Department of Land and Water Conservation, Sydney.

Tulau M.J. (1999). Acid Sulfate Soil Management Priority Areas in the Lower Tweed Floodplains. Report. Department of Land and Water Conservation, Sydney

Tweed Byron LALC (2012). Tweed Byron Local Aboriginal Land Council submission to Planning Review Panel: A New Planning System for NSW – Green Paper August 2012. Available at: [http://www.planning.nsw.gov.au/Portals/0/PolicyAndLegislation/GreenPaperSubmissions/Tweed\\_Byron\\_LALC.pdf](http://www.planning.nsw.gov.au/Portals/0/PolicyAndLegislation/GreenPaperSubmissions/Tweed_Byron_LALC.pdf) - accessed 18th October 2012.

Tweed Shire Council (2000). Tweed Local Environmental Plan.

Tweed Shire Council (2002). On-Site Sewage and Wastewater Management Strategy.

Tweed Shire Council (2007). State of the Environment Report 2007. Tweed Shire Council.

Tweed Shire Council (2008). Tweed Shire Development Control Plan.

Tweed Shire Council (2011a) Community Strategic Plan 2011/2021

Tweed Shire Council (2011b) Wastewater Asset Management Plan

Tweed Shire Council (2011c) Water Supply Asset Management Plan

Tweed Shire Council (2011d). Tweed Shire Community Based Heritage Study and Community Plan 2011.

Tweed Shire Council (2012). Responsible Dog and Cat Ownership Information Sheet. Available at: <http://www.tweed.nsw.gov.au/Community/AnimalRegsOffLeash.aspx> accessed Oct 2012.

Tweed Shire Council (2013). Platypus Project Communication Plan (Draft).

Tweed Shire Council (under development). Tweed Shire Council Sustainable Agriculture Strategy.

Umwelt (2005). Tweed Shire Coastline Management Plan. Report prepared for Tweed Shire Council.

Umwelt (2005). Tweed Shire Coastline Management Study. Report prepared for Tweed Shire Council.

WBM (1997). Estuary Management Plan. Cudgen, Cudgera and Mooball Creeks. Report prepared for Tweed Shire Council.

WBM (2007). Ecosystem Health Monitoring Program and Report Card Scoping Study.

WBM (2007). Tweed Shire Coastline Hazard Definition Study. Report prepared for Tweed Shire Council.

WBM, (2009). Tweed-Byron Coastal Creeks Flood Study. Prepared for Tweed Shire Council and Byron Shire Council.