Cardno
Shaping the Future

Brisbane Water Estuary Management Study

Prepared for Gosford City Council*

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Executive Summary

This study has been prepared by Cardno in association with the University of Newcastle for Gosford City Council (GCC).

The study area comprises the tidal waterway, foreshore and adjacent land of Brisbane Water, including the entrance area and tidal tributaries covering the whole region of Brisbane Water from the channel connecting the estuary to Broken Bay at the eastern end of Ocean Beach in the south to Gosford in the north, and associated tributaries and catchments. A locality map of the study area is shown in **Figure 1.1**. For the purposes of the Estuary Management Study and the following Estuary Management Plan, the estuary was broken down into a total of six management zones (**Figure 2.1**).

Study Context

One of the NSW Coastal Policy's strategic directions is the preparation and implementation by local Councils of detailed management plans for estuaries in accordance with the NSW Estuary Management Policy. The Estuary Management Policy is defined in the *Estuary Management Manual* (NSW Government, 1992). The policy outlines a structured management process (through various stages as outlined in **Section 1.2**) leading to the implementation of an Estuary Management Plan. In developing the plan all values and uses of the estuary are considered. The plan aims to be a balanced long-term management framework for the ecologically sustainable use of the estuary and its catchment.

The Estuary Processes Study, which is the third stage of the Estuary Management Process, was completed by Cardno on behalf of Council and DECCW in 2007. A summary of the key findings of that study are presented in **Section 4**.

This document represents the fourth stage of the Estuary Management planning process for Brisbane Water, the Estuary Management Study. This Study has sought to establish a management context for and provide guidance on the development of the Estuary Management Plan, which forms the next stage of the Estuary Management Process.

Stakeholder and Community Consultation

In accordance with the Estuary Management Manual (NSW Government, 1992), extensive community consultation was undertaken in order to ensure the community had opportunity to provide input on key aspects of the Study, including:

- The values and significance of the estuary (**Section 5**);
- Management issues they have observed (**Section 6**); and
- Options for addressing these issues (**Section 8**).

As well as seeking to involve the community in the development of the Management Study and Plan, a secondary objective of the community consultation program has been to provide opportunity for the community to gain a greater appreciation of the management context and an enhanced understanding of estuarine processes.

Further detail on the consultation program is provided in **Section 2**.

The development of the Brisbane Water Estuary Management Study (and the following Plan) has been overseen by Council's *Coastal and Estuary Management Committee* (CEMC). The Committee is chaired by Council and has a membership that includes a range of State government agencies, non-government organisations, special interest groups and community representatives. The Committee provided technical direction and feedback at key stages of the project. Additional agency stakeholder consultation was also undertaken outside of the formal Committee framework to ensure all relevant stakeholders were involved.

Council's technical personnel from a range of departments had involvement in the development of this Study, primarily through review of outputs from various stages of the study. Key contributions included the identification of additional management issues, developing new options, and identifying opportunities for efficiencies in the full options list. Council also assisted in outlining key concerns and challenges relating to the potential impacts of climate change on the Brisbane Water Estuary (**Section 5.10**). This Study has sought to provide Council with some additional tools to assist in managing and adapting to these impacts.

Management Objectives and Goals

A series of overarching management objectives and more specific management goals were developed in consultation with the Committee and the community to guide the future management of the Brisbane Water estuary (**Section 7**). The management goals and objectives constitute the framework of the Management Plan and any options considered in this study or activities proposed as part of the Plan should address these goals and objectives.

Management Options

A total of 185 management options were developed during the course of the Estuary Management Study (**Appendix F**). In the first instance, an initial list of management options was developed by a team of environmental specialists from Cardno. This list was then presented to Council and the Committee for review (**Section 2.1**). The next step in the options development phase was to hold a series of workshops with the community to obtain their suggestions for management options (described in **Section 2.3.4**).

In many cases, management options were developed to address a specific management issue observed by the study team, Council or the community (presented in **Table 5.2**). In other cases, management options may have been developed to assist in the future implementation of the Brisbane Water Estuary Management Plan, or to address remaining gaps in the dataset for the estuary. The consultation involved in developing the initial list of management options, and subsequent revision of the list following the public exhibition period, is outlined in **Section 2**. The options aim to fulfil the management goals and objectives (**Section 7**) identified for the Brisbane Water estuary.

Management options range from specific works to more overarching and long-term options. Management options have been categorised according to the following five management categories, which correlate generally with Council's organisational structure and are consistent with other estuary management plans to which Council is a stakeholder:

- Planning,
- Compliance,
- Works,
- Education, and
- Research/Monitoring.

The full list of management options was then subjected to an assessment in order to identify a list of 70 'high priority' options for implementation in the Plan. The options assessment framework adopted in this Study has been developed in order to make sound comparisons between each option and to rank options in a transparent and unbiased manner so as to identify those having the greatest overall benefit for the management of the estuary.

Recommendations & Conclusions

It is recommended that the *Brisbane Water Estuary Management Plan* (the next stage in the Estuary Management Process) adopt for consideration the full list of management options identified in **Appendices J and K**.

Once adopted in the Plan, the management 'options' will become management 'actions' to be considered on a priority basis for implementation. Implementation of the Plan will involve considerable expenditure (an estimated $20 million in capital costs alone) and therefore implementation must have regard to resource availability and the priorities of Council and other agencies identified as being responsible for implementing identified tasks. Additionally, it is noted that all options identified in this Study may be subject to further detailed investigation prior to implementation and may therefore become subject to modification or further consideration.

In recognition of the fact that resources are limited, and that some options are dependent upon the implementation of other options, it is recommended that in the first instance the management strategy examine the highest ranking management options as identified in **Sections 8.3.1 and 8.3.2**. However, in developing the management strategy, it is recommended that the Management Plan should retain sufficient flexibility such that Council may implement any of the management options at any time (e.g. upon receipt of funding).

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Glossary and Abbreviations

Ambient	Refers to the immediate surrounds. In the case of water quality, this refers to chronic or 'push' conditions.
Amenity	Those features of an area that foster its use for various purposes.
Animal	Any animal, whether vertebrate or invertebrate, and at whatever stage of development.
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soil(s)
Beach Nourishment	The supply of sediment by mechanical means to supplement sand on an existing beach or to build up an eroded beach.
Biota	Living organisms.
Bird	Any bird that is native to, or is of a species that periodically or occasionally migrates to Australia, and includes the eggs and the young thereof and the skin, feathers or any other part.
BoM	Bureau of Meteorology
CAP	Catchment Action Plan
CAMBA	China Australia Migratory Bird Agreement
Catchment	The area draining to a site. This always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
CBD	Central Business District
CEMC	Coastal and Estuary Management Committee
CLAM	Coastal Lake Assessment and Management Tool
CMA	Catchment Management Authority
COSS	Coastal Open Space System
CP Act	NSW *Coastal Protection Act, 1979*
DADHC	Department of Aging, Disability and Home Care
DCP	Development Control Plan
DECC	Formerly the Department of Environment and Climate Change; now known as the Department of Environment, Climate Change and Water.
DECCW	Department of Environment, Climate Change and Water
Depuration	The process by which shellfish metabolise and/or flush chemicals from their organs.
DoL	Formerly Department of Lands; now Land and Property Management Authority
DoP	Department of Planning
DPI	Formerly Department of Primary Industries; now Industry and Investment NSW.
Drogue	An instrument that can be deployed from a boat that is used to track currents.
DWE	Department of Water and Energy
Ecosystem	A community of living organisms, together with the environment in which they live and with which they interact.
EEC	Endangered Ecological Community as identified under the TSC Act or the EPBC Act.
Endangered Fauna	Protected fauna of a species under Schedule 1 or 2 of the *Threatened Species Conservation Act*, 1995.
EP&A Act	NSW *Environmental Planning and Assessment Act, 1979*

EPBC Act	Commonwealth *Environmental Protection and Biodiversity Conservation Act, 1999*.
Epiphytic	A plant that grows on another plant, but does not derive any nourishment from it.
ESD	Ecologically Sustainable Development
Eutrophication	The over-enrichment of a water body with nutrients, leading to the excessive growth of plants and plankton and the depletion of oxygen.
Fauna	Any mammal, bird, reptile, amphibian or fish.
Fish	All or any of the varieties of marine, estuarine or freshwater fishes (whether indigenous or not) and their young, fry and spawn and unless contrary intention be expressly stated, or the context otherwise requires, includes crustacea, oysters and all marine, estuarine and freshwater animal life.
FM Act	*Fisheries Management Act 1994*
GCC	Gosford City Council
GPSO	Gosford Planning Scheme Ordinance
GPT	Gross Pollutant Trap
Habitat	The places in which an organism or community lives.
HCRCMA	Hunter-Central Rivers Catchment Management Authority
I&I NSW	Industry and Investment NSW; formerly Department of Primary Industries
Invertebrate	Animal without a backbone or notochord.
IPCC	Intergovernmental Panel on Climate Change
JAMBA	Japan Australia Migratory Bird Agreement
LALC	Local Aboriginal Land Council
LEP	Local Environment Plan
LG Act	*Local Government Act, 1993*
LGA	Local Government Area
LPMA	Land and Property Management Authority; formerly Department of Lands
MHL	Manly Hydraulics Laboratory
MHWS	Mean High Water Springs
MHWN	Mean High Water Neaps
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MSL	Mean Sea Level
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NPWS	National Parks and Wildlife Services; part of DECCW
NSW	New South Wales
PASS	Potential Acid Sulfate Soils
PoEO Act	NSW *Protection of Environment Operations Act, 1997*
QX	A disease affecting the Sydney Rock Oyster, caused by the protozoan (i.e. single-celled) parasite *Marteilia sydneyi*.
Riparian Vegetation	Vegetation growing along banks of rivers.
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
RTA	NSW Roads and Traffic Authority
Runoff	That proportion of rainfall that drains off the lands surface.
Seawall	Wall built parallel to the shoreline to limit shoreline recession.
Sea Waves	Sea waves are generated locally and move in the same direction as the surface wind.

Sedimentation	The act or process of depositing sediment, especially by mechanical means of matter suspended in a liquid.
Semi-diurnal tides	Tides with a period, or time interval between two successive high or low waters, of about 12.5 hours.
SEPP	State Environmental Planning Policy
SES	State Emergency Service
Sewage	Refuse liquids or waste matter carried off by sewers.
Shoaling	The influence of the seabed on wave behaviour. Such effects only become significant in water depths of 60m or less. Manifested as a reduction in wave speed, a shortening in wavelength and an increase in wave height.
Shoreline Recession	A net long-term landward movement of the shoreline caused by a net loss in the sediment volume.
SLSA	Surf Life Saving Association
SREP	State Regional Environment Plan
Storm Surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components: the increase in water level caused by the reduction in barometric pressure (barometric setup) and the increase in water level caused by the action of wind blowing over the sea surface (wind setup).
Swell Waves	Waves that have travelled into the observation area having been generated by previous winds in other areas.
Tides	The regular rise and fall of the sea level in response to the gravitational attraction between the sun, moon and Earth.
TN	Total Nitrogen
TP	Total Phosphorous
TSC Act	*NSW Threatened Species Conservation Act, 1995*
TSS	Total Suspended Solids
Vertebrate	Animal with a backbone or notochord.
WSUD	Water Sensitive Urban Design

1 Introduction

This study has been prepared by Cardno in association with the University of Newcastle for Gosford City Council (GCC).

The study has been informed primarily by the *Brisbane Water Estuary Processes Study* (Cardno, 2008a), and also by the *Brisbane Water Data Compilation Study* (SMEC Australia and Umwelt (Australia), 2002).

1.1 Study Area

The study area comprises the tidal waterway, foreshore and adjacent land of Brisbane Water, including the entrance area and tidal tributaries covering the whole region of Brisbane Water from the channel connecting the estuary to Broken Bay at the eastern end of Ocean Beach in the south to Gosford in the north, and associated tributaries and catchments.

A locality map of the study area is shown in **Figure 1.1**.

For the purposes of the Estuary Management Study and Plan, the estuary was broken down into a total of six management zones. These management zones are functional units that have been derived from data on biological connectivity and ecological function within the estuary. The zones are as follows:

- ***Zone 1*** – Fagan's Bay;
- ***Zone 2*** – The Broadwater, enclosing Noonan's Point, Koolewong, Green Point, Rocky Point, Caroline Bay and Point Frederick;
- ***Zone 3*** – The Woy Woy Reach, enclosing Woy Woy Bay, Phegans Bay, Horsfield Bay and Correa Bay;
- ***Zone 4*** – The Central Reach, enclosing Woy Woy Channel, Pelican Island, Blackwall Point, St Huberts Island, Rileys Island, Lintern Channel and Paddys Channel;
- ***Zone 5*** – Kincumber/Cockle Bay, enclosing Cockle Channel, Cockle Bay and Kincumber Broadwater; and
- ***Zone 6*** – The Entrance Reach, including Booker Bay, Ettalong Beach, Lobster Beach, Wagstaff Point, Half Tide Rocks, Pretty Beach, Hardy's Bay and Rileys Bay.

The six management zones are mapped in **Figure 1.2**. The zones depicted in **Figure 1.2** effectively enclose those portions of the waterbody and foreshore falling within that zone.

Major tributary creeks of the system include the following as shown in **Figure 1.3**:

- Ettalong Creek;
- Woy Woy Creek;
- Coorumbine Creek;
- Upper and Lower Narara Creek;
- Upper and Lower Erina Creek; and
- Kincumber Creek.

Many other small creeks drain into the estuary, some of which are un-named.

As an overview, numeric values of key characteristics of the estuary are listed in **Table 1.1**. The information presented in **Table 1.1** has been drawn from the Estuary Processes Study (Cardno, 2008a) and the Data Compilation Study (SMEC Australia and Umwelt (Australia), 2002)and other later information (MHL, 2004).

Table 1.1 Key Parameters for Brisbane Water Estuary

Estuarine Characteristics	
Classification	Wave dominated estuary
Condition	Extensively modified but with some unmodified areas
Estuary length	17.72 km
Estuary width	3.74 km
Entrance width at narrowest point	0.16 km
Catchment and Tributaries	
Catchment area	165 km^2
Catchment land use proportions	• Forest: 49.9% • Residential: 27.2% • Rural: 17.3% • Industrial: 2.7% • Commercial: 1.3% • Road: 0.5% • Other: 1.3%.
Catchment soils	Predominantly Erina and Watagan, but ranging to Somersby and Norah Head. Soils are generally affected by erosion and water logging
Number of identified sewer overflow points in catchment	121 (based on the location of sewer pumping stations)
Number of major tributaries (not including stormwater inflows)	6 (Ettalong, Woy Woy, Coorumbine, Narara, Erina and Kincumber Creeks)
Waterbody and Riparian Zone	
Water surface area	27.2 km^2
Length of foreshore	89.43 km
Approximate minimum bed level	-38mAHD
Approximate average bed level	-5mAHD (but in many places as shallow as -3m AHD)
Approximate mean low water spring ocean tide level	-0.4m AHD
Approximate mean high water spring ocean tide level	+0.4m AHD
Maximum ocean tidal level (MHHW)	+0.7m AHD
Water Quality	
Key pollutant constituents and typical timing of delivery	TN and TP – 3-6 hours from onset of rainfall in the catchment
Average Salinity range in main water body	20 to 33ppt, depending upon runoff history
Flora and Fauna	
Fisheries value	High
Number of recorded bird species	110
Number of threatened and/or protected species, populations and ecological communities.	- 60 Vulnerable and 14 Endangered animal species, and 16 Vulnerable and 8 Endangered plant species (TSC Act, 1995). Most of these are terrestrial species or marine mammals that may visit the area. - SEPP 14 Wetlands

Site inspections of the study area have been undertaken by boat (30 June 2008) and by land (14-15 June 2009). A photolog of the study area is provided in **Appendix A**, with photographs archived generally on the basis of management zones.

1.2 Estuary Management Process

The NSW *Coastal Policy* (1997) has as its central focus the ecologically sustainable development (ESD) of the coastal zone. ESD refers to development that uses, conserves and enhances the community's resources so that the ecological processes on which life depends are maintained and the total quality of life now and in the future can be improved. The four principles of ESD are:

- Conservation of biological diversity and ecological integrity
- Inter-generational equity
- Improved valuation, pricing and incentive mechanisms
- The precautionary principle.

One of the Coastal Policy's strategic directions is the preparation and implementation by local Councils of detailed management plans for estuaries in accordance with the Estuary Management Policy. The Estuary Management Policy is defined in the *Estuary Management Manual* (NSW Government, 1992). The policy outlines a structured management process leading to the implementation of an Estuary Management Plan. In developing the plan all values and uses of the estuary are considered. The plan aims to be a balanced long-term management framework for the ecologically sustainable use of the estuary and its catchment.

The Estuary Management Manual recommends an eight step process in order to implement an Estuary Management Plan, as follows:

1. Form an Estuary Management Committee;
2. Assemble existing data (data compilation study);
3. Undertake an Estuary Processes Study;
4. **Undertake an Estuary Management Study;**
5. Prepare a draft Estuary Management Plan;
6. Review Estuary Management Plan;
7. Adopt and implement the Estuary Management Plan; and
8. Monitor and review the management process as necessary.

In compliance with steps 1 to 3, GCC has formed an Estuary Management Committee through their Coastal and Estuary Management Committee (CEMC) and the data compilation and estuary processes studies have been undertaken (SMEC Australia and Umwelt (Australia), 2002 and Cardno, 2008a; respectively). It should be noted that these studies are comprehensive volumes and should be read in conjunction with this report.

This document represents the fourth stage of the Estuary Management planning process for Brisbane Water, the Estuary Management Study.

The development of the Brisbane Water Estuary Management Study and Plan has been overseen by Council's CEMC. The Committee is chaired by Council and has a membership that includes a range of State government agencies, non-government organisations, special interest groups and community representatives. The Terms of Reference for the CEMC include:

- Provide advice and recommendations as to an integrated, balanced, responsible and ecological sustainable use of the City's estuaries, coastal and aquatic environments, including foreshore areas.
- Promote cooperation between the State Government, Local Government and estuary users in the development and implementation of Estuary and Coastal Zone Management Plans.
- Advise and recommend on how to improve the management of the City's estuaries, coastal and aquatic environments through environmental planning frameworks.
- Advise and recommend on how to implement Estuary, Coastal and Aquatic Environment Management Plan actions.

1.3 Management Principle Aim

The overarching aims for the management of Brisbane Water are to:

- Protect, rehabilitate and improve the natural estuarine environment;
- Manage the estuarine environment in the public interest to ensure its health and vitality;
- Improve the recreational amenity of estuarine waters and foreshores;
- Recognise and accommodate natural processes and climate change; and
- Ensure ecologically sustainable development and use of resources.

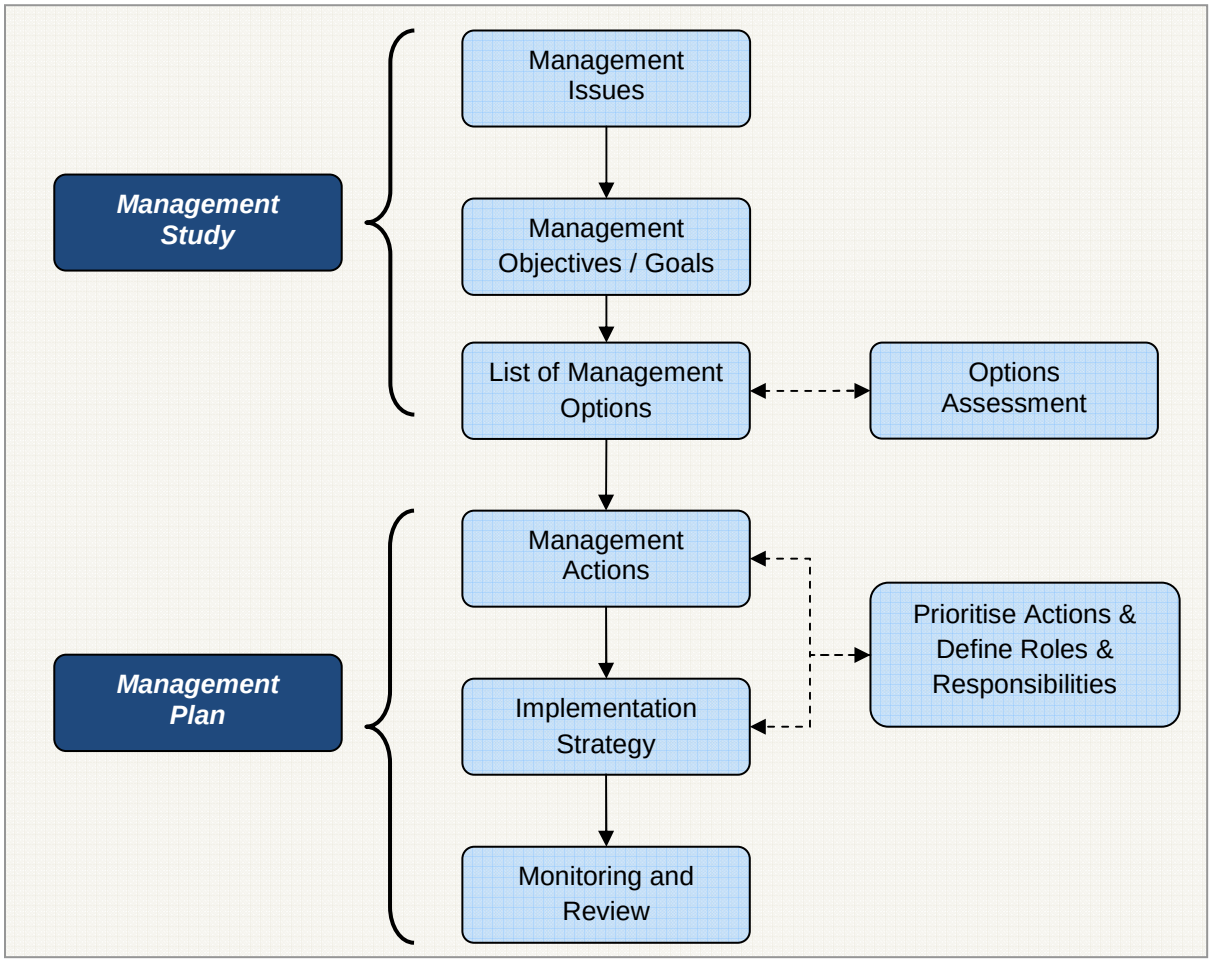
In order to address these overarching aims, the management issues affecting the study area must be considered. These form the core of the entire Management Study. Based on these issues a series of management objectives will be defined, for which a range of management options will be developed. All of these options must be assessed in order to identify the most appropriate course of action.

The outcome of this assessment is a series of prioritised management options. These management options represent the tasks that will be recommended to be incorporated in the Estuary Management Plan. The Study recommends prioritised actions for implementation, the allocation of roles and responsibilities and provides an indicative cost.

Monitoring and review will be an important component of the Management Plan. By monitoring a range of performance indicators, Council and other stakeholders can determine the success of the Management Plan in achieving the principle management aims listed above.

Consultation has been undertaken with Council, Department of Environment, Climate Change and Water (DECCW), the Committee, relevant government and industry stakeholders, local organisations and the community in the undertaking of this Management Study.

The flow chart below provides a diagrammatic representation of the process undertaken during the preparation of the Management Study and includes details of the next stage, the Estuary Management Plan.



1.4 Outline

The structure of this document is as follows:

- **Section 2** provides details of the consultation process undertaken;
- **Section 3** describes the regulatory and management context under which the Plan will operate;
- **Section 4** provides an overview of the outcomes of the Estuary Processes Study;
- **Section 5** outlines the uses, values and significance of the estuary;
- **Section 6** outlines the management issues relevant to the Brisbane Water Estuary;
- **Section 7** outlines a series of objectives and goals to address these issues;
- **Section 8** details the range of management options that may be considered. Also included is the outcome of the options assessment and the final list of recommended options; and
- **Section 9** contains conclusions and recommendations for the Plan.

Qualifications and references relating to this document can be found in **Sections 10 and 11** respectively.

2 Consultation

Consultation is critical in the undertaking of an Estuary Management Study. The program of consultation undertaken as part of this study not only canvassed the community and stakeholders for information and opinions, it also sought to improve awareness and understanding of the estuarine system by the local community, and to initiate commitments from the relevant stakeholders with respect to the subsequent stages of the process, being the implementation of the Plan.

The program of consultation described below consisted of actions throughout the duration of the study. A variety of methods were used in order to maximise the potential for consultation and participation in developing the Management Study.

2.1 Consultation with the Committee

Consultation with the CEMC included the following components:

- Project Initiation Meeting – 22 May 2008,
- Workshop – Management Goals and Options Development – 28 April 2009,
- Workshop – CLAM Development – 4 August 2009, and
- Presentation of the Draft Estuary Management Study – 27 October 2009.

At the project initiation meeting, the scope of the project and proposed consultation schedule were confirmed with the Committee. A list of preliminary management issues was presented and the Committee's input sought on any additional issues.

An options development workshop was held with the CEMC on 28 April 2009. The management issues and objectives identified by the study team during the early stages of the stakeholder and community consultation (see **Sections 2.2** and **2.3** below) were presented to the Committee. In addition, a more targeted series of management goals were tabled and discussed in detail. Development and refinement of the management goals was seen as crucial in establishing the direction of the Management Study and Plan, and in visioning the future of the Brisbane Water Estuary.

The Committee members were also invited to provide their input on options for implementation.

The outcome of this workshop was a series of targeted management goals and a draft list of management options for presentation at the community workshops (**Section 2.3**).

A second workshop was held with the CEMC on 4 August 2009 to provide an overview of the CLAM decision support tool development and function. Details of CLAM tool are provided in **Section 8.2.4** and **Appendix G**.

In addition, the Committee was given the opportunity to comment on the Draft Management Study (on 27 October 2009).

2.2 Agency Stakeholder Consultation

Agency stakeholder consultation (Government and primarily non-community based groups) included the following components:

- Initial stakeholder consultation – June 2008,
- Targeted consultation with the Department of Lands (DoL) (now LPMA) – 20 May 2009, and
- Key Stakeholder Workshop (Council and DECCW) – Preferred Options – 30 June 2009.

At the outset of the study, a letter was distributed to the organisations listed below, seeking their input to the Management Study and Plan, particularly with respect to identification of management issues:

- Boating Industry Association,
- Central Coast Community Environment Network,
- Darkinjung Local Aboriginal Land Council (LALC),
- DECC (now DECCW),
- Hunter-Central Rivers Catchment Management Authority (CMA),
- NSW National Parks and Wildlife Service (NPWS; DECCW),
- NSW Climate Change and Environment Protection Group (DECCW),
- NSW Fisheries (formerly Department of Primary Industries, now Industry and Investment NSW or I&I NSW),
- NSW Department of Lands (formerly DoL; now Land and Property Management Authority),
- NSW Department of Water and Energy (DWE) (now DECCW),
- NSW Department of Planning (DoP),
- NSW Maritime,
- Royal Volunteer Coastal Patrol, and
- Surfrider Foundation.

A copy of the form letter distributed to these stakeholders and responses received are provided in **Appendix B1**.

The stakeholder responses received are summarised in **Table 2.1**.

Table 2.1: Summary of Stakeholder Responses

Organisation	Response
NPWS	The NPWS manages a number of parks which are located within the study area, including Brisbane Water and Bouddi National Parks, and Cockle Bay, Rileys Island, Pelican Island and Saratoga Nature Reserves. The Draft Plan of Management for the Cockle Bay, Rileys Island, Pelican Island and Saratoga Nature Reserves identifies several activities developed to address particular issues, including: • Survey of the landward mangrove encroachment of saltmarsh communities;

Organisation	Response
	• Examination of feasibility and methods to manage mangrove encroachment; • Rehabilitation of saltmarsh EECs; and • Inclusion of the surrounding intertidal zones within the Nature Reserve boundaries.
DECCW Climate Change and Environment Protection Group	Sewer overflows used to be an issue in Brisbane Water estuary, particularly in relation to food safety and the oyster aquaculture industry. However, there have been significant improvements in recent years due the incorporation of additional capacity in the sewerage system.
DoL Crown Lands Division (Now LPMA)	The following points were outlined in the DoL response: • The bed of the estuary is Crown land and therefore any proposed uses or activities in this area requires the consideration and/or authorisation of DoL; • The consolidation and streamlining of the many planning instruments/documents relating to the waterway is recommended; • The development of a comprehensive DCP relating to foreshore structures is recommended, with due consideration of the findings of the Estuary Processes Study, to include specifications as to what constitutes compliant and non-compliant foreshore structures; • The importance of commercial activities and occupancies on the waterway was noted; • The DoL has authority to issue leases and licences for the use of Crown land and therefore can have a significant influence on estuary processes; • Requirements for small craft storage and deep-draught vessel mooring and management needs to be considered and facilitated; • The planning process for Gosford City and foreshores will have significant implications for this study; • The foreshore reserves representing Crown land and their associated infrastructure would be under the care and control of Council; • There should be consideration of reclamation of foreshore lands based on restrictions and needs, with due consideration of social, economic and environmental impacts; and • Catchment-based water quality controls and treatment devices are required.
NSW Maritime	NSW Maritime is aware of a number of issues in and around the estuary, including: • The need for dredging of waterways for improved navigability; • The occurrence of acid sulfate soils around the estuary; • Increased patronage of the Kincumber boat ramp due to the new housing development at this location; • Resident's request for maintenance dredging of the canals at St Huberts Island; • The estuary has some of the largest and healthiest seagrass beds in the region that are currently unprotected, and there is a need for community education; • There is a need for a strategy to manage the likely future

Organisation	Response
	intensification of use of the waterway by vessels; • There is a need for tighter controls on the development of small marinas, which are often proposed for sites coincident with shallow seagrass beds; • There is also a need for a strategy for larger marinas with sewage pump-outs and fuel storage facilities; • Need to review mooring arrangements so that larger vessels that require deeper water and more swing room can be accommodated with the existing moorings footprint; • Review of dinghy storage areas near popular mooring sites required; • There is a need for review of development applications for jetties/structures where the water is shallow; • There are a large number of derelict vessels around the waterway; and • Need to manage shoreline pollution within the major creeks.
DoP Hunter and Central Coast Region	The following matters should be considered: • Sustainable growth of oyster aquaculture development; • Expansion of marina/boating facilities and increased boating/fishing activities on Brisbane Water; • Stormwater impacts associated with increased development, particularly in those locations identified in the Central Coast Regional Strategy; • Preservation and protection of coastal wetlands; and • Impacts associated with climate change/sea level rise.
DoP Heritage Branch	The need to identify items listed under the GCC LEP, State Heritage Register and Register of the National Estate was stated. Furthermore, where any actions are proposed that may impact on a heritage item, a statement of significant and impact assessment should be undertaken.
Royal Volunteer Coastal Patrol	The following issues were identified: • There is a need to dredge Half Tide Rocks, particularly in the Lobster Beach area. It is difficult to bring a boat in under tow through this region; • There is also a need to dredge near the Coastal Patrol premises as there insufficient depth to deploy at low tide; and • Their busiest periods are over summer and during the school holidays.

As a major landowner, direct consultation was also undertaken with the Land and Property Management Authority (LPMA), attended by representatives from both Council and the Cardno study team on 20 May 2009. Key matters discussed at this meeting were as follows:

- There has been an historic proliferation of non-complying foreshore structures along the Brisbane Water estuary foreshore. Moving forward, LPMA would like to see a move toward more integrated foreshore planning (e.g. jetty sharing agreements). A comprehensive inventory of foreshore structures would prove useful in future foreshore planning; and
- LPMA would like to use leasing and licensing arrangements to provide better environmental outcomes and achieve more integrated foreshore planning. Through

utilisation of the leasing and licensing system, LPMA could, for example, help retain an element of control over larger foreshore developments. LPMA could also establish partnerships with leaseholders and implement capital works programs to be undertaken by leaseholders to benefit the community. These works could then be offset against the cost of the lease.

In addition, a key stakeholder workshop, attended by representatives of the study team, GCC and DECCW, was held on 30 June 2009. This workshop was attended by the key agencies responsible for the implementation of the Plan and sought their input on the preferred options for implementation. The titles of invited representatives are listed below (those unable to attend are identified in *italics*):

- From DECCW:
  - Senior Natural Resource Officer.
- From Gosford City Council:
  - Manager Integrated Planning,
  - Advisor Environment and Planning,
  - *Director Environment and Planning,*
  - Coordinator Natural Open Space,
  - Coastal and Estuary Officer,
  - Coordinator Parks, Playgrounds and Foreshores,
  - *Manager Regulatory Services (W&S),*
  - Regulatory Services Officer,
  - Acting Manager Maintenance Operations,
  - Manager Open Space and Leisure Services,
  - Advisor Flooding and Drainage Planning,
  - Senior Flooding and Drainage Engineer,
  - Manager Engineering Services,
  - Coordinator Engineering Investigations,
  - Advisor Land Use Planning,
  - *Director City Centre Development,*
  - Director City Services, and
  - Project Coordinator City Centre Development.

Prior to the meeting, a list of the top 20 estuary management options was produced through a cost-benefit analysis of the whole complement of options. This list was presented at the meeting and attendees were provided with an opportunity to rank the top 20 options according to their policies and ideas. However, the full list of management options was provided for review. Further feedback was provided to Cardno from the meeting attendees with regard to the system of ranking and the options themselves.

A commitment was also sought on allocation of roles and responsibilities with respect to the implementation strategy.

Several key stakeholders are members of the CEMC and were also able to provide significant input into the Study through that avenue.

2.3 Community Consultation

Consultation with the community included the following components:

- Newsletter and press release (project initiation) – 25 March 2009,
- Brisbane Water Estuary Processes Study Information Evening – 18 May 2009,
- Issues and Objectives Workshop – 4 April 2009,
- Options Development Workshops – 19-21 May 2009 at Wagstaffe, Gosford and Woy Woy (respectively),
- Newsletter and press release – Workshop outcomes – July 2009, and
- Public exhibition of the Draft Estuary Management Study – 18 January 2010 to 12 March 2010.

Copies of all community consultation materials can be found in **Appendix B**.

This section of the report provides details the distribution of consultation materials (where available) and the number of attendees at the different workshops and other events. Over the course of the study, a database of contact details for approximately 170 individuals was compiled on a voluntary basis. However, the names of the individuals in attendance at any events or held on the database have not been provided for privacy reasons.

2.3.1 Commencement of the Study and Plan – Public Notification

A press release was issued by Gosford City Council to announce the commencement of the Study and Plan. At the same time, a newsletter was distributed to the community to provide additional information about the purpose of the Study and Plan, and forthcoming consultation activities. The newsletter was distributed to approximately 6,500 local residences surrounding the estuary, and was also made available at Council Chambers and via a dedicated website for the project.

The press release, newsletter and website advertised the date of the subsequent 'Issues and Objectives' Workshop.

The Brisbane Water Estuary Study and Plan web page (http://www.gosford.nsw.gov.au/news_events/interest/2009-items-of-interest/public-workshops-for-brisbane-water-estuary-management-study) was established and maintained by Council for the duration of the project to provide a central information point for the community, to advise of upcoming consultation activities and pass on the outcome of the workshops.

A copy of the press release and community newsletter are provided in **Appendix B2**.

2.3.2 Brisbane Water Estuary Processes Study Information Evening

An information evening was held at the Erina Centre on 18 May 2009 to present the findings of the *Brisbane Water Estuary Processes Study* (Cardno, 2008a). Notification of the information evening was provided via Council's website and the community contacts database compiled for this project.

The evening consisted of presentations by a number of speakers, including the Cardno study team and representatives from Gosford City Council, Newcastle University and the University of New South Wales. Presentations were designed to provide attendees with information on the various processes occurring within the estuary, including catchment, hydraulic, ecological, recreational and cultural processes. Approximately 40 people were in attendance.

The information presented at the information evening can be found in the *Estuary Processes Study* (Cardno, 2008a).

2.3.3 Issues and Objectives Workshop

A half-day workshop was held at the Erina Centre on 4 April 2009 in order to gain community input on the management issues affecting the Brisbane Water Estuary. The issues and objectives workshop was advertised on Council's website and in the initial project newsletter (**Section 2.3.1**; distribution 6,500 residents).

The Mayor of Gosford opened the workshop and the Cardno study team provided a presentation of the following:

- A brief overview of the management issues identified as part of the Estuary Processes Study (Cardno, 2008a).
- General information as to the purpose and structure of the Estuary Management Study and Plan.
- The management objectives.
- The aim and structure of the workshop.

After the opening presentation, the workshop broke into four tables covering the different management zones (**Section 1.1** and **Figure 1.2**). Zones 1 and 2 had a combined work station, as did Zones 3 and 4, whereas Zones 5 and 6 each had a discrete work station. Each work station was manned by a member of the Cardno study team or a Council representative. The community was invited to visit the work station(s) for which they had a particular interest.

Each work station had an A1 sized colour map of the zone of interest overlaid on aerial photography with estuarine bathymetry representing the waterbody. Respondents were invited to identify location specific management issues, with the team member marking the location for which the issue is associated with a numbered sticker. Respondents were also invited to identify more general issues that were not location specific.

In addition to the work stations, all attendees at the workshop were provided with a feedback form for completion. The feedback form had two sections: Section One aimed to capture information as to what features or attributes of the estuary the community valued most highly and Section Two provided space for respondents to detail management issues they have observed.

A copy of the agenda, presentation and feedback form provided at the workshop is provided in **Appendix B3**. The feedback form and presentation were also made available via the dedicated web page on Council's website.

A total of 117 people attended the workshop. A total of 177 completed feedback forms were received, including five non-standard responses. The results were analysed and are presented in **Section 5.6**.

2.3.4 Options Development Workshops

A series of three workshops were held in order to obtain community input on management options for consideration as part of the Management Study and Plan:

- Wagstaffe Hall, 1pm to 4pm, Tuesday 19 May 2009,
- Gosford City Council Chambers, 6:30pm to 9:30 pm, Wednesday 20 May 2009, and
- South Woy Woy Progress Hall, 10am to 1pm, Thursday 21 May 2009.

The options development workshops were advertised at the issues and objectives workshop held in April (**Section 2.3.3**), the information evening (**Section 2.3.2**), via Council's website and via email for those contacts held on the contact database for the project.

An effort was made to attract a range of community members by hosting the workshops at different locations around the estuary and at different times of day. In addition, a series of notifications advertising the workshops were provided indirectly via Council's website and directly via email to interested community members.

Each workshop had the same format. The Cardno team presented a plain-English PowerPoint presentation outlining the objectives of the workshop. Information was provided in the presentation on the draft Management Goals and guidance as to the general types of management options that may be considered with a view to stimulating discussion. Feedback from the community was obtained via informal discussion and also via the preparation of a feedback form for attendees to complete. A total of approximately 40 people were in attendance at the three workshops.

Copies of the consultation materials presented at the Options Development Workshops are provided in **Appendix B4**.

A key outcome of this consultation process, which involved the study team, the community and other stakeholders, was an initial list of 248 management options which were presented in the Draft Estuary Management Study during the public exhibition period (**Section 2.3.5**).

At this stage, a second community newsletter and press release was prepared advising of the outcome of the three workshops. Copies of the media release and second community newsletter are provided in **Appendix B5**. The second community newsletter was distributed to the project contact database and made available on Council's website.

2.3.5 Public Exhibition of the Draft Estuary Management Study

The Draft Brisbane Water Estuary Management Study was publicly exhibited by Gosford City Council from 18 January to 12 March 2010. Copies of the Study were made available

on Council's website, at Council's offices, and at the three public libraries (in Erina, Kincumber and Woy Woy).

A total of nine written submissions were provided, covering the spectrum of members of the community, and representatives of the CEMC and State Government agencies. A range of Council technical personnel also provided comment on the draft Study.

In response to these submissions, the full list of 248 management options was collapsed into a final list of 185 management options. This was achieved primarily through the deletion of duplicate options or options that are considered inconsistent with existing Government policies or strategies. In addition, efficiencies were also achieved by combining two or more options into a single option, where appropriate.

2.3.6 Community Forum – Draft Plan of Management for Brisbane Water Estuary

The final component of the community consultation program will be a Community Forum undertaken during the public exhibition of the Draft Management Plan (the next stage). This forum will aim to advise the community as to how the Plan was developed and provide the community with an opportunity to ask any questions of the Cardno study team or Council.

3 Regulatory and Management Context

3.1 Overview

The objective of this chapter is to establish the management context for the Estuary Management Plan (the next phase in the Estuary Management Process) in terms of legislative requirements, policy directions and related management plans and actions. **Figure 3.1** outlines the context in diagrammatic form.

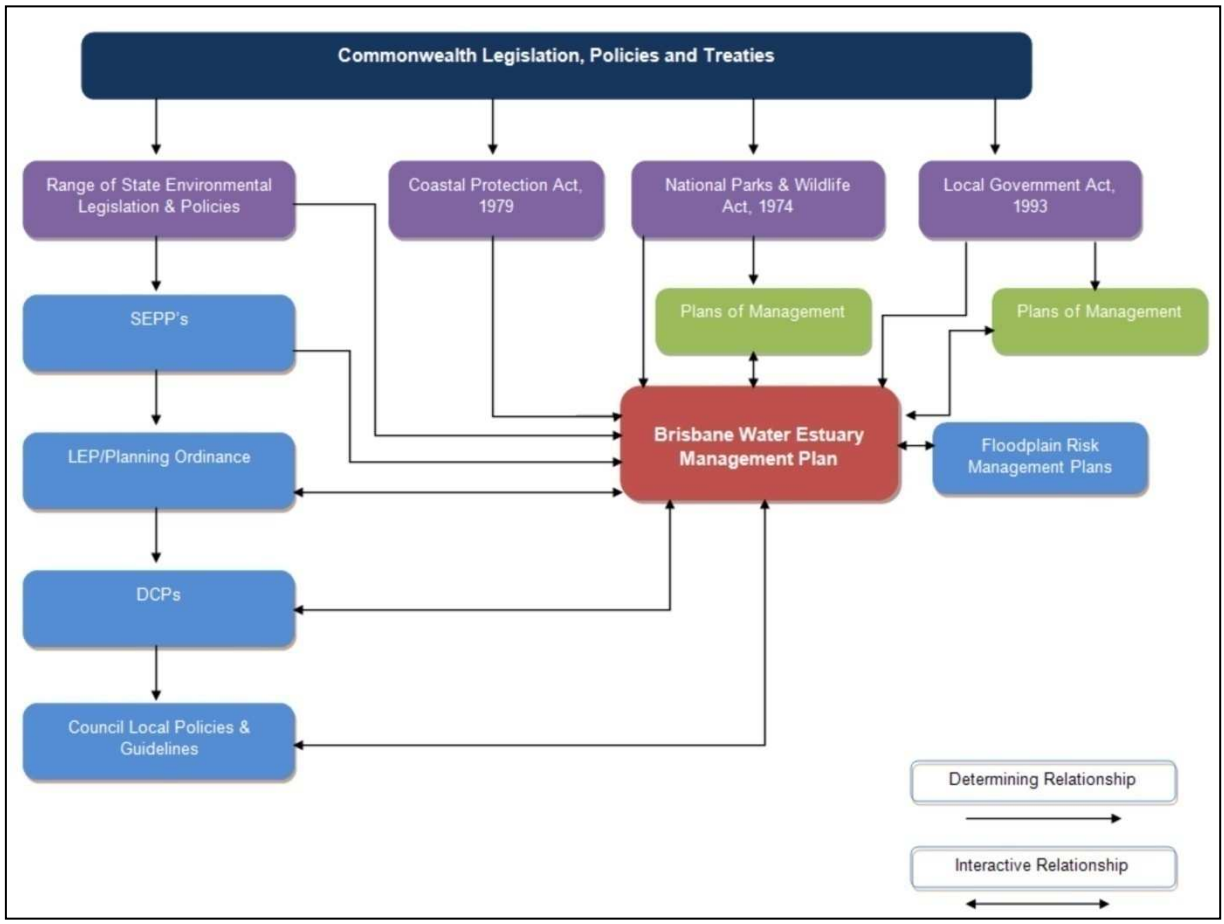


Figure 3.1: Regulatory and Management Context

3.1.1 Institutional Stakeholders

As is indicated in **Figure 3.1**, there are a number of institutional stakeholders with an interest in the management of the Brisbane Water estuary who administer various pieces of legislation. Implementation of the recommendations contained in the Study and Plan will rely heavily on an integrated approach to management by the relevant key stakeholder agencies in consultation with the community. These key stakeholders have been engaged during the development of the Study and will continue to play a role in the development and implementation of the Plan.

Table 3.1 provides an overview of the roles and responsibilities of the key stakeholders involved in estuary management.

Table 3.1: Overview of Roles and Responsibilities for Key Stakeholders

Agency/Organisation	Roles and Responsibilities Relating to Estuary Management
Gosford City Council (GCC)	Generally, GCC is responsible for the planning and management of estuaries within the Gosford LGA and this includes the Brisbane Water estuary. In this way, Council plays a key role in the Estuary Management Process. Council is the primary agency responsible for implementing the Estuary Management Plan. Council's roles and responsibilities include: › Establish and Chair the Estuary Management Committee, which is commonly formed of representatives of those agencies listed below, as well as community representatives; › Primary responsibility for the implementation of Estuary Management Plans; › Direct responsibility for implementation of many of the projects identified in the Estuary Management Plan; › Acting as an interface between the community and the various State authorities involved in estuary management; and › Development control, planning and determination for the LGA.
NSW Department of Environment, Climate Change and Water (DECCW)	DECCW is the State authority on a number of aspects of estuary management and performs a number of functions in this regard, including: › Administration of a number of Acts relating to estuary management, including the *Coastal Protection Act 1979* and the *Water Management Act 2000* (**Section 3.2.6**); › Administration of the *National Parks and Wildlife Act 1974*, which covers Indigenous heritage matters and national parks and reserves; › Development of relevant policies and guidelines such as the Sea Level Rise Policy Statement (**Section 3.2.7**); › Provides technical advice and undertakes research on estuarine processes; › Collects data on estuarine processes (e.g. water levels); › Assists and advises Council's in the preparation of Estuary Management Plans and implementation of projects; › Advises Council in the assessment of significant development proposals affecting estuaries; and › Administers and manages the State government's Estuary Management Program. DECCW includes the Environment Protection Authority and the NPWS.
NSW Land and Property Management Authority (LPMA)	The LPMA (formerly the Department of Lands) also plays an important role in estuary management: › As the land owner of all (Crown) lands below the mean high water mark (i.e. the estuary bed); › As the land owner of many estuary foreshore reserves and wetlands (Crown land); › Administration of the *Crown Lands Act 1989*; › Issue and management of leases, licences and permissible occupancies for Crown lands; and

Agency/Organisation	Roles and Responsibilities Relating to Estuary Management
	› Management of Crown reserves through reserve Trusts and/or with Council.
Industry and Investment NSW (I&I NSW)	I&I NSW (formerly the Department of Primary Industry) incorporates a range of functions in relation to forestry, minerals and petroleum, agriculture and fisheries and aquaculture. The primary body within I&I NSW that has an interest in estuary management is NSW Fisheries. Key roles and responsibilities relevant to estuary management include: › Protection of all aquatic animal and plant life in NSW, including the protection of key habitat; › Administration of a number of Acts including the *Fisheries Management Act 1994* (**Section 3.2.6**), under which permits may be issued for dredging works, works that obstruct fish passage and damage to marine vegetation (including mangroves and saltmarshes); › Management and licensing or all fisheries activities, both recreational and commercial, and aquaculture; › Provision of various grants for activities the enhance and protect aquatic habitats and fisheries; and › Assisting in the determination of development proposals relevant to creeks, streams, estuaries and the coastal zone.
NSW Maritime	NSW Maritime is responsible for all matters relating to marine safety, the regulation of commercial and recreational boating activities and ports operations. This includes: › Issuing of boat licences; › Management of navigational issues in estuaries; › Provision of various grants for activities that serve boating; and › May have a concurrence role in determining development proposals where the activity could have an effect on navigation or where Maritime is the landowner (the latter point does not apply to Brisbane Water).
NSW Department of Planning (DoP)	The DoP is the State government's authority on planning and development assessment. Roles and responsibilities include: › Development of environmental planning policies and guidelines relevant to the coastal zone, such as SEPP14 and the *Draft NSW Coastal Planning Guideline* (**Section 3.2.7**); › Administration of the *Environmental Planning and Assessment Act 1979*, with DoP playing a key role in determining development applications for major projects; › Administration of the *Heritage Act 1977*, which relates to items and sites of non-Indigenous heritage significance; › Assists and guides Council's in the preparation of Local Environment Plans; and › Development of strategies identifying future growth centres.
Hunter-Central Rivers Catchment Management Authority (HCRCMA)	The Brisbane Water estuary catchment lies within the larger Hunter-Central Rivers catchment, for which overarching management is undertaken by the HCRCMA. The CMA works with landholders, Councils, Landcare groups and other government agencies to plan, fund and carry out environmental projects in the catchment.

Agency/Organisation	Roles and Responsibilities Relating to Estuary Management
Darkinjung Local Aboriginal Land Council (LALC)	Brisbane Water falls within the extent of the traditional lands of the Darkinjung tribe. The LALC: › Represents the interests of the Darkinjung people; › Conserves and promotes Aboriginal culture; and › May make claims on Crown land.
NSW State Emergency Service (SES)	The SES is largely a volunteer organisation. Volunteers are provided with training and are mobilised during emergency situations such as floods or storms to assist in rescue and evacuation efforts. The SES functions under the *State Emergency Service Act 1989*.

Specific roles and responsibilities with respect to implementation of the *Brisbane Water Estuary Management Plan* have been identified (**Section 8.2**). While some options may identify other agencies as being responsible for implementation, GCC will be responsible for encouraging and facilitating the Plan's implementation.

3.2 Relevant Environmental and Planning Legislation

It is important to note the following legislation would need to be considered with respect to any future development proposed as a management action or otherwise.

3.2.1 Local Planning Legislation

The land use context of the catchment is provided in **Figure 4.1**.

Gosford Planning Scheme Ordinance (GCC, 2008)

The *Gosford Planning Scheme Ordinance* (GPSO; as at 1 February 2008) is the principal planning instrument for Gosford. The GPSO (GCC, 2008) guides what development is permitted in different parts of the Gosford LGA through land use tables, which corresponds to the zoning of each parcel of land. The GPSO also discusses standards for the creation of dual occupancies/subdivisions, floor space ratios, foreshore building lines and development on the bed of natural waterways. Heritage conservation is also considered and Schedule 8 of the GPSO lists items/sites of heritage significance. The GPSO has been amended over 460 times since gazettal in 1968.

The DoP has issued a Standard Instrument (LEP template) as part of planning reforms aimed at standardising planning throughout the state. The Gosford City Centre Local Environment Plan (LEP) and Draft Gosford LEP (2009) have been prepared in accordance with this Standard Instrument. The Draft Gosford LEP (2009) will replace the GPSO once gazetted.

Gosford City Centre Local Environment Plan (GCC, 2007a)

The *Gosford City Centre Local Environment Plan* (GCC, 2007a) applies to the Gosford City Centre and includes the Brisbane Water foreshore between Duke Street and Carawah Reserve. As with the GPSO, the City Centre LEP is the statutory planning framework that establishes zoning, heights, floor space ratios and establishes guidelines for development

within the City Centre. It is based on the *Standard Instrument (Local Environmental Plans)* Order 2006 that now applies to all councils in NSW.

One of the zones incorporated into the City Centre LEP is W2 *Recreational Waterways*. The objectives of land/waterways zoned W2 are:

- To protect the ecological, scenic and recreation values of recreational waterways.
- To allow for water-based recreation and related uses.
- To provide for sustainable fishing industries and recreational fishing.

Those inclusions having relevance to the management of Brisbane Water include:

- Development within the coastal zone;
- Development below the mean high water mark;
- Sun access planes and view corridors; and
- Heritage conservation.

Schedule 2 (Exempt Development of the City Centre) of the LEP provides guidelines relating to moorings and navigational aids. Schedule 5 (Environmental Heritage) provides details of heritage listed sites and items.

Gosford Local Environment Plan (2009) – DRAFT

The Gosford LEP (GCC, 2009a) is currently in draft format, however, once gazetted, will replace the GPSO. The Gosford LEP will provide guidance as to land use zoning within the LGA and the types of development that are permitted within each zone. Under this Draft LEP, zones *W1 Natural Waterways* and *W2 Recreational Waterways* are applied to parts of the LGA. The estuary is proposed predominantly for a zoning of W2, although some portions of the waterway around Pelican Island and in Cockle Bay are being proposed for a zoning of W1.

The objectives of waterways zoned W2 have been discussed above. The objectives of land zoned W1 are:

- To protect the ecological and scenic values of natural waterways;
- To prevent development that would have an adverse effect on the natural values of waterways in the zone;
- To provide for sustainable fishing industries and recreational fishing; and
- To make provision for the aquaculture activities.

Those inclusions in the Draft LEP having relevance to the management of Brisbane Water include:

- Development of lands affected by acid sulfate soils (ASS);
- Foreshore building lines;
- Development within the coastal zone (under the NSW Coastal Protection Act 1979 the “coastal zone” covers the whole of the Brisbane Water estuary and foreshores);
- Development below the mean high water mark; and
- Heritage conservation.

3.2.2 Local Policies and Guidelines

Gosford Vision 2025 (GCC, 2006a)

Vision 2025 (GCC, 2006a) provides an overview of the Council's strategic direction for the Gosford LGA. A number of key focus areas are defined, for which a series of objectives have been defined. It is understood that the maintenance of open space foreshore areas is particularly important, in terms of both public access and amenity, but working within the context of environmental management. Monitoring and maintenance of ecosystem functioning is considered important for both environmental protection purposes and public health and safety. It is noted that there is a particular emphasis on water resources and catchment management.

Central Coast Regional Strategy (DoP, 2008)

The Central Coast Regional Strategy covers the Gosford City and Wyong Shire LGAs and has been developed by the NSW Government as a long-term land use plan for the region. The regional strategy contains policies and actions designed to cater for the region's projected housing and employment growth over the period to 2031 and outlines how and where future development should occur to appropriately accommodate growth and to provide sufficient capacity to cater for more than 45,000 new jobs, reducing the need for local residents to commute outside of the region for work (DoP, 2008). Areas targeted for intensification of existing urban development to accommodate new residential dwellings include Gosford and Woy Woy. This issue is discussed further in relation to climate change considerations in **Section 4.10**.

The strategy contains provisions for the protection of the coastal environment, improvement of recreational facilities where appropriate, the minimisation of development pressure of tourist activities and the protection of cultural heritage values (DoP, 2008).

The Gosford Challenge (GCC and DoL, 2009)

As a collaborative effort of the LPMA, Gosford City Council and strategic design partner Cox Architects, the primary purpose of the Gosford Challenge is to create a better place for the people of the Central Coast of New South Wales through urban renewal of the Gosford City Centre.

Revitalising Gosford: City Centre Plan (DoP and GCC, 2006)

A collaboration between the Department of Planning's Cities Taskforce and Gosford City Council, the Gosford City Centre Plan is a plan for the revitalisation of the Gosford City Centre. The Plan sets a strategic framework for the city centre to grow into a vibrant and attractive city and comprises of a suite of four planning documents (DoP and GCC, 2006):

- Vision – this document describes a vision for the city centre, provides information on the history and development context, and includes future actions to facilitate the city centre's growth. It sets a strategic framework for the city centre to grow into a more prosperous, vibrant and attractive city;
- Local Environmental Plan (LEP) – The Gosford City Centre LEP (which has been previously discussed);

- Development Control Plan (DCP) – this document outlines the more detailed planning provisions for the built form, pedestrian amenity, access and environmental management for future development in the city centre. It establishes controls for building setbacks, awnings, and separations between buildings in order to take advantage of the winter sun within the city centre;
- Civic Improvement Plan (CIP) – this document establishes the importance of the public domain in terms of design principles for paving, parks, signage, lighting and the improvement of key public places. The document also lists the projects that Council would like to undertake based on funds levied from individual developments. This will include the traditional Section 94A levies as well as a new provision to levy for local infrastructure.

D2.11 Climate Change Policy (GCC, 2010)

This policy contains guiding principles for the management of climate change risks to natural and human systems in the Gosford LGA. It includes the following policy objectives:

- To provide a strategic framework, that is consistent with a whole of government, and whole of Council approach, that will assist Council prepare for**,** and assist the community and environment to become more resilient and adaptable to, the impacts of Climate Change.
- To undertake adaptation and mitigation actions as a sustainable response to climate change. These actions would support the known environmental, economic, social and cultural values of the local community.
- To review climate change risks and impacts (for example, sea level rise, carbon footprint, temperature increase, embodied carbon, precipitation change, and storm, bushfire, drought and flood events) as further reliable information becomes available.
- To provide Council and the public with objective information that will assist in understanding the problem, alternatives, opportunities and/or solutions.
- To continue to undertake research and to participate in opportunities that will improve climate change management capacity.
- To comply with applicable legal requirements and implement any relevant state government policies, guidelines and/or directives.
- To recognise Gosford's proportionate contribution to Australia's historic emissions and associated moral obligations.

R3.06 Dog Exercise Areas (GCC, 2003)

The Council policy relating to dog exercise areas provides details of designated off/on leash dog walking areas and defines owners' responsibilities in relation to the *Companion Animals Act (1998)*, which prohibits dogs from within 10m of children's playgrounds.

R0.18 Biodiversity Management Policy (GCC, 2001)

The objectives of this policy are "to conserve the diversity and abundance of locally occurring native plants and animals and microorganisms in Gosford City at the genetic, species and ecosystem level." A framework is provided as to how this is to be achieved.

R0.17 Wetlands Management Policy (GCC, undated)

This policy includes a defined management framework for the protection, restoration and enhancement of wetlands within the LGA. Guidelines on the management of wetland flora and fauna, activities prohibited in wetlands, wetland education programs, rate relief, drainage management strategies, and barrier and buffer mechanisms are provided. It was developed in accordance with the *NSW Wetlands Management Policy* (1996).

R0.15 Acquisition of Wetlands (GCC, undated)

The objective of this policy is the preservation of significant wetland areas and it states that Council will consider provision of funding for the acquisition of high priority wetlands where appropriate.

Reference should be made to the *Intertidal Zone Discussion Paper* (**Appendix D**) in relation to this policy.

3.2.3 Development Control Plans

Gosford DCP (2009) – DRAFT

The Gosford DCP (GCC, 2009c) is currently in draft format, however, once adopted, will replace the GPSO. The Gosford DCP provides detailed guidance for additional controls for general development and provides requirements for particular types of development or procedures Council must follow when considering applications for development.

Council currently has a number of DCPs, but under the planning reform currently being overseen by the State Government, all the existing DCPs will be brought together under the one instrument that applies to any land and is consistent with the Draft Gosford LEP.

DCP No. 89 Scenic Quality (GCC, undated)

This DCP applies to all land within the LGA. It aims to provide more detail with regard to the interpretation of management of the scenic quality of the Gosford area. The LGA is broken down into discreet Landscape Units, for which the absorptive capacity (ability to absorb development without compromising the landscape character), detracting elements and visual sensitivity are characterised.

DCP No. 119 Wharves and Jetties (GCC, undated)

The stated purpose of this DCP is to provide detailed guidelines for the "*development, management, conservation and economic use of Brisbane Water, including its tributaries and foreshores, in respect to privately owned or constructed wharves and jetties*." The objectives of the DCP emphasise:

- Maintenance of foreshores for public access;
- Retaining the natural and visual character of both foreshores and waterways;
- Ensuring that they do not encroach on navigation channels;
- Promoting equitable access to the waterway for all users;
- Encouraging innovative design and the use of shared structures;

- Minimising fragmentation of shallow inshore areas, particularly those that adjoin public reserves, those which afford public access or are important estuarine habitats;
- Ensuring the development does not adversely impact on estuarine flora, fauna habitats or fishing grounds;
- Ensure structures do not adversely affect circulation, cause rubbish accumulation in a manner likely to impact on water quality, cause weed accumulation or exacerbate sediment erosion or accretion; and
- Encourage retention and preservation of heritage items and conservation areas.

Guidelines and standards for the construction of wharves and jetties are provided.

DCP No. 145 Boating Facilities in St Huberts Island Canals (GCC, 2006b)

The purpose of this Development Control Plan (DCP) is to provide more detailed guidelines on the development of land for boating facilities, mooring and berthing within the canals of St Huberts Island. It focuses primarily on visual amenity. Potential impacts on the environment (e.g. natural sediment transport processes) are not considered.

It is noted that the DCP outlines the need to pay licence fees for boating facilities. It is understood that these monies are held by Council and may only be used for any works or investigations that seek to improve the canal system, as per a recommendation made in the St Huberts Island Drainage Reserves Task Group Report (SHIDRTG, 1997).

3.2.4 Key Plans of Management

This section provides details of key Plans of Management that are currently in place for part or all of the study area. An effort has been made to identify any plans that will be superseded or will require modification in light of the *Brisbane Water Estuary Management Study and Plan*.

Brisbane Water Plan of Management (GCC, 1995)

In response to increasing development pressure in the early 1990's, Council prepared a Plan of Management for Brisbane Water. A committee was established for the development and implementation of the Plan, with assistance provided by relevant technical specialists and organisations. The Plan covers:

- The context in which the Plan operates;
- Estuarine Habitat Management;
- Water Quality;
- Heritage Within Brisbane Water;
- Water Use and Occupations within Brisbane Water;
- Water Depth and Sedimentation;
- Channel and Foreshore Protection;
- Residential Structures within Brisbane Water;
- Tourism and Transportation;
- Public Water Access Facilities;
- Commercial and Club Waterfront Development;
- Planning Provisions for Brisbane Water; and

- Implementation and Future Actions.

Since the *Brisbane Water Plan of Management* (GCC, 1995) was developed, a considerable amount of additional information about the estuary processes and function of Brisbane Water estuary has become available, primarily through the *Estuary Processes Study* (Cardno, 2008a). This information has been critical in informing the Management Study and Plan (this document). In addition, some changes in the nature, magnitude and/or extent of the management issues affecting the estuary have occurred since this time and it is intended that this Study will represent a more up to date picture of the current status of the estuary.

The *Brisbane Water Plan of Management* (GCC, 1995) will be superseded by the Brisbane Water Estuary Management Plan (the next stage in the estuary management process).

Brisbane Water Foreshore Floodplain Risk Management Study and Plan (Cardno, in preparation)

The *Brisbane Water Foreshore Floodplain Risk Management Study and Plan* is currently being prepared by Cardno on behalf of Council. That Study and Plan will seek to derive an appropriate mix of management measures and strategies to effectively manage the full range of flood risks affecting the estuary foreshores in accordance with the Floodplain Development Manual (NSW Government, 2005).

The estuary foreshores are affected by a combination of catchment flooding and foreshore inundation (e.g. when estuary water levels are elevated) and the synergistic effects of these two types of flooding can result in significant risk to life and property. The study considers foreshore inundation for both current conditions and under climate change conditions.

The *Foreshore Floodplain Risk Management Study and Plan* is currently in the initial consultation phase and will be forthcoming at a later date. The Brisbane Water Foreshore Floodplain Risk Management Study and Plan will need to consider the potential for any flood mitigation/management measures proposed to impact on estuarine processes (physical, ecological and human usage). Similarly, this Brisbane Water Estuary Management Study and the subsequent Plan need to consider the potential for any options proposed to impact on foreshore inundation.

Further discussion on the climate change aspects of the *Floodplain Risk Management Study and Plan* are provided in **Section 4.10**.

Hunter-Central Rivers Catchment Action Plan (Hunter-Central Rivers CMA, 2007)

The Catchment Action Plan (CAP) defines the spatial extent of the catchment, which includes the study area, explains what the CAP plans to achieve and outlines how this fits in with past and current natural resources management. Management targets are provided in relation to a number of catchment characteristics. Those relating primarily to estuary management include: the protection and enhancement of wetlands, erosion, stormwater management, acid sulfate soils, riparian vegetation, foreshore stabilisation, protection of marine habitats and estuarine foreshore vegetation. Funding avenues for natural resource management are also identified.

Any actions identified for implementation in the CAP that affect the Brisbane Water Estuary should be implemented in a fashion that is consistent with the Management Study and Plan. In some cases, the objectives and actions identified in the CAP and the Brisbane Water Estuary Management Study and Plan may align and/or overlap with each other.

Central Coast Catchment Blueprint (DLWC, 2003)

The catchment blueprint was developed through consultation between the community and the government. It sets overarching natural resource management priorities for rural, coastal and urban catchments in the Central Coast region.

Management targets were established set for Aquatic Ecosystem Health in relation to both estuaries (including Brisbane Water) and river and creek systems. Targets were also set for Land Capability, Terrestrial Biodiversity and Native Vegetation. An Action Plan table lists priorities, actions, timeframe for implementation, responsible agencies/organisations and the desired investment level. Further details can be found therein.

As discussed above with reference to the CAP, any actions identified for implementation in the Blueprint that affect the Brisbane Water Estuary should be implemented in a fashion that is consistent with the Management Study and Plan.

Gosford City Council Plans of Management

Various Gosford City Council Plans of Management that are relevant to this Estuary Management Study and Plan include:

- Coastal Open Space System (COSS) Action Strategy (August 1992)
- Caroline Bay Plan of Management (February 1998)
- Plan of Management – Community Parks (June 1996)
- Ettalong Beach Reserve Plan of Management (2003) which also includes:
  - Ettalong Beach Dune Management Plan – Ettalong Foreshore (June 2007), and
  - Ettalong Beach Masterplan;
- Plan of Management – Foreshore Parks (1996);
- Plan of Management – Gosford Foreshore (2004);
- Natural Areas – Bushland Plan of Management (2002);
- Saratoga Recreation Area and Wetland – Final Plan of Management (2004); and
- Yattalunga Foreshore Reserve – Draft Plan of Management (2001).

A review of the ecological impact of these Plans of Management is provided in **Section 6.1.5** and **Appendix C**.

These Plans of Management have been prepared for lands that are under the care and control of Council. In some cases the existing Plans of Management may require review to ensure that the objectives of those Plans and the methods of implementation are consistent with the objectives of the Brisbane Water Estuary Management Study and Plan.

National Park Plans of Management

Plans of Management exist for the National Parks that exist in the Brisbane Water Estuary area, namely:

- *Bouddi National Park Draft Plan of Management* (NPWS, 1999), and
- *Brisbane Water National Park Plan of Management* (NPWS, 1992).

These two Plans of Management have been prepared for National Parks lands under the care and control of the NPWS. While these existing Plans are unlikely to require revision in relation to the *Brisbane Water Estuary Management Study and Plan*, it is recommended that NPWS and Council should endeavour to ensure that these respective plans and any associated activities are consistent with each other.

There are also several Natures Reserves in the study area including:

- Cockle Bay Nature Reserve,
- Riley's Island Nature Reserve,
- Saratoga Island Nature Reserve, and
- Pelican Island Nature Reserve.

Plans of Management have not been prepared for any of these Nature Reserves.

The location of National Parks lands within the study area is shown in **Figure 4.1**.

3.2.5 Regional Environmental Planning Policies

New planning reforms by the NSW State Government mean that from 1 July, 2009 regional environmental plans are no longer part of the hierarchy of environmental planning instruments in NSW.

Sydney Regional Environmental Plan (SREP) 6 - Gosford Coastal Areas

This SREP has been repealed by the *State Environmental Planning Policy (Repeal of REP Provisions)* 2009.

Sydney Regional Environmental Plan (SREP) 20 – Hawkesbury-Nepean River (No 2 – 1997)

The aim of this plan is to protect the environment of the Hawkesbury-Nepean River system by ensuring that the impacts of future land uses are considered in a regional context. The plan covers water quality and quantity, environmentally sensitive areas, scenic quality, agriculture, and urban and rural residential development and places development controls on activities that have the potential to impact on the river environment.

This environmental planning instrument has been deemed a SEPP under Division 2, Part 3 of the *Environmental Planning and Assessment Act*, 1979, however the title remains unchanged.

3.2.6 State Legislation

A summary of state legislation is presented in **Table 3.2**.

Table 3.2: Relevant State Legislation

Act/Regulation	Details
Environmental Planning and Assessment Act 1979 ***(DoP)***	The NSW environmental planning system operates under *the Environmental Planning and Assessment Act, 1979* (*EP&A Act*). It aims to encourage proper management, development and conservation of natural and artificial resources to ultimately promote the environment and the economic and social welfare of the community, and also seeks to promote the sharing of responsibility between state and local government and facilitate public involvement in the planning and assessment process. The *EP&A Act* is the primary legislation controlling development activity in the State of NSW and is administered by the DoP, Council and other consent or determining authorities. Under the Act, appropriate authorities must assess environmental impacts of new developments before development commences.
Protection of the Environment Operations Act 1997 ***(DECCW)***	The *Protection of the Environment Operations Act 1997* ultimately aims to protect, enhance and restore the quality of the environment in New South Wales, to reduce risk to human health and promote mechanisms that minimise environmental degradation through a strong set of provisions and offences. A licence is required from DECCW if any of the activities associated with the proposed works are determined to be a "scheduled activity" under Schedule 1 of the Act.
Threatened Species Conservation Act 1995 ***(DECCW)***	The provisions of this Act must be complied with for any future development proposals in or around the estuary likely to affect or have the potential to affect threatened species. DECCW administers this Act.
National Parks and Wildlife Act 1974 ***(DECCW)***	The Act aims to conserve the natural heritage of the State, including biological diversity, significant landforms or landscape features (including wilderness areas), objects or sites of significance to Aboriginal people and places of historical, architectural or scientific significance. A number of different permits and licences may be issued under the Act for various activities, including the undertaking of scientific studies (e.g. animal trapping) and archaeological investigations.
Noxious Weeds Management Act 1993 ***(I&I NSW)***	Any proposed vegetation rehabilitation for the estuary and foreshores must be in accordance with the *Noxious Weeds Management Act 1993*.
Water Management Act, 2000 ***(DECCW)***	The *Water Management Act 2000* controls the extraction of water, the use of water, the construction of works such as dams and weirs and the carrying out of activities in or near water sources in NSW. The Act creates mechanisms for protecting and restoring water sources and their dependent ecosystems, improved access rights to water, and partnership arrangements between the community and the government for water management.
Disabilities Services Act 1993 ***(DADHC)***	For any proposed development such as improvements to walkways or the like, compliance with the provisions of this Act is required.
Fisheries Management Act 1994 ***(I&I NSW)***	The *Fisheries Management Act 1994* aims to conserve, develop and share the fisheries resources of NSW for the benefit of present and future generations. To protect key fish habitats and conserve threatened aquatic species, this Act requires approval to be obtained from Industry and

Act/Regulation	Details
	Investment NSW (Fisheries) for any works that involve obstruction of fish passage, removal or damage to aquatic vegetation, dredging or reclamation, and using explosive or electrical devices in a waterway. *Posidonia* seagrass beds in Brisbane Water have recently been listed as an endangered population under Schedule 4 of the Act. Any future development proposals in or around the Brisbane Water estuary must comply with the provisions of this Act.
Fisheries Management (General) Regulation 2002 ***(I&I NSW)***	This regulation relates to a range of specifications for both recreational and commercial fishing practices, including prohibited fish size and bag limits, lawful fishing nets, protected fish species, etc.
Fisheries Management (Aquaculture) Regulation 2007 ***(I&I NSW)***	This regulation relates to aquaculture and includes provisions for the granting and renewal of aquaculture leases, the distribution of permits, marking of leased areas. Obligations to notify a fisheries officer of diseased fish and marine vegetation are also described.
Native Vegetation Act 2003 ***(DECCW)***	This Act aims to provide for, encourage and promote the management of native vegetation on a regional basis in keeping with the social, economic and environmental interests of NSW. Any future works which may affect native vegetation must be in accordance with the provisions of this Act. Exemptions of the Act include land that is critical habitat (under the *TSC Act* or *FM Act*), national parks, and land within a zone designated 'residential' (but not rural residential), 'village', 'township', 'industrial' or 'business' under the relevant environmental planning instrument.
Native Vegetation Regulation 2005 ***(DECCW)***	The *Native Vegetation Regulation 2005* provides regulations for the protection of Native Vegetation, including the use of Property Vegetation Plans (PVPs). This regulation relates mainly to rural agricultural land, and so given the nature of the land use zoning surrounding the subject waterways the regulation is unlikely to apply.
Coastal Protection Act 1979 ***(DECCW)***	This Act aims to provide for the protection of the coastal environment of the State for the benefit of both present and future generations. The Brisbane Water Estuary is located in the declared NSW Coastal Zone to which this Act applies.
Heritage Act 1977 ***(DoP)***	The *Heritage Act 1977* provides protection for natural and cultural heritage by providing for the listing of heritage items or places on the State Heritage Register and providing for the making of interim heritage orders for the protection of heritage items or places. Under the Heritage Act 1977, it is an offence to harm relics protected by Interim Heritage Orders, the State Heritage Register or environmental planning instruments.
Marine Safety Act 1998 ***(NSW Maritime)***	This Act aims to ensure the safe operation of vessels in ports and other waterways and to promote responsible operation of vessels so as to protect the safety and amenity of other users and the amenity of occupiers of adjoining land.

3.2.7 State Policies and Guidelines

A summary of state policies and guidelines is presented in **Table 3.3**.

Table 3.3: Relevant State Policies

Policy	Details
NSW Coastal Policy	The *NSW Coastal Policy* provides a framework for the balanced and coordinated management of the coastal zone in accordance with the principals of ecologically sustainable development. This policy applies to the Brisbane Water estuary and foreshores due to its proximity to the coast.
Estuary Management Manual and *Estuary Management Policy*	The Estuary Management Policy is defined in the Estuary Management Manual (NSW Government, 1992). The policy outlines a structured management process leading to the implementation of an Estuary Management Plan. This document provides the overarching framework for this Estuary Management Study and Plan.
NSW Sea Level Rise Policy Statement	The NSW Government have released a *Sea Level Rise Policy* (DECCW, 2009) outlining their objectives and commitments to communities affected by SLR. The primary objective of the Policy statement is to minimise the cost of climate change by: › Promoting an adaptive, risk-based approach to managing SLR impacts, › Providing guidance to local Councils to support their SLR adaptation planning, › Encouraging appropriate development on land projected to be at risk from SLR, › Continuing to provide emergency management support to coastal communities during times of floods and storms, › Continuing to provide updated information to the public about SLR and its impacts.
NSW Coastal Planning Guideline: Adapting to Sea Level Rise	The State Government have released a Guideline (DoP, 2010) that outlines a proposed approach to assist Councils, State agencies, planners and development proponents in incorporating sea level rise in land use planning and development assessment. The Guideline adopts the sea level rise values outlined in DECCW (2009). It contains six coastal planning principles for sea level rise adaptation: › Assess and evaluate coastal risks taking into account the NSW sea level rise planning benchmarks, › Advise the public of coastal risks to ensure that informed land use planning and decision-making can occur, › Avoid intensifying land use in coastal risk areas through strategic and land use planning, › Consider options to reduce land use intensity in coastal risk areas where feasible, › Minimise the exposure to coastal risks from proposed development in coastal areas, › Implement appropriate management responses and adaptation strategies with consideration for the environmental, social and economic impacts of each option.

Policy	Details
State Environmental Planning Policy (SEPP) No 14 – Coastal Wetlands	SEPP 14 aims to ensure that coastal wetlands are preserved and protected for environmental and economic reasons. SEPP 14 wetlands exist at a number of locations including Pelican Island, Rileys Island Cockle Bay and Saratoga Island Nature Reserves.
State Environmental Planning Policy (SEPP) No 62 – Sustainable Aquaculture	SEPP 62 aims to encourage sustainable aquaculture and aquaculture development to conserve and enhance the community's resources for now and in the future. This policy applies (in relation to natural water-based aquaculture in the form of oyster aquaculture) to all of NSW.
State Environmental Planning Policy (SEPP) No 71 – Coastal Protection	SEPP 71 aims to protect and manage the natural, cultural, recreational and economic attributes of the NSW coastal zone. The policy applies to land within the 'coastal zone' as defined in section 4A of the *Coastal Protection Act 1979* (CP Act). The Brisbane Water estuary and foreshores lie within this defined coastal zone.
State Environmental Planning Policy (SEPP) 50 – Canal Estate Development	This SEPP aims to prohibit canal estate development as described in this Policy in order to ensure that the environment is not adversely affected by the creation of new developments of this kind.
Flood Prone Land Policy	The policy promotes the use of a merit approach, which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable.
Coastal Design Guidelines for NSW 2003	The *Coastal Design Guidelines for NSW* have been prepared with reference to the NSW Government's Coastal Policy 1997 and complement the Government's Coastal Protection Package released in June 2001 and SEPP 71, which came into effect in November 2002. The coastal design guidelines are based on the principles of ecologically sustainable development.
Biodiversity Planning Guide for NSW Local Government 2001	This Guide aims to assist Local Councils in carrying out biodiversity conservation as part of their day-to-day functions, especially relating to planning and development. A "good practice guide" for biodiversity planning is provided for Council's use.
NSW Oyster Industry Sustainable Growth Strategy 2006	The NSW Oyster Industry Sustainable Aquaculture Strategy identifies those areas within NSW estuaries where oyster aquaculture is a suitable and priority outcome. It documents best practice for oyster farming in NSW to ensure ecologically sustainable development. Priority oyster aquaculture areas within Brisbane Water estuary are identified in accompanying mapping, as are current leases to be phased out (**Figure 4.10**).
Policy and Guidelines for Aquatic Habitat Management and Fish Conservation 1999	This document has been prepared by NSW Fisheries in order to improve the conservation and management of aquatic habitats in NSW. It is targeted at local and state government authorities, proponents of developments and their advisors, and individuals or organisations concerned with the planning and management of our aquatic resources, including conservation organisations.
Policy and Guidelines for Fish Friendly Waterway Crossings 2004	This document provides a summary of the specific legislation and policy requirements that must be observed by those intending to plan design and construct waterway crossings in NSW.

Policy	Details
NSW Water Quality and River Flow Objectives	This document outlines the Water Quality and River Flow Objectives for different catchments, however there are no specific objectives for the Brisbane Water estuary. Nearby water bodies that do have Water Quality and River Flow Objectives include Lake Macquarie and Tuggerah Lakes, and the Gosford and Northern Beaches Lagoons.
Managing Urban Stormwater: Soils and Construction 2004	This manual provides guidelines to minimise land degradation and water pollution at urban development sites in New South Wales. Any future works around the Brisbane Water estuary and foreshores would require necessary precautions in accordance to this manual.

3.2.8 Commonwealth Legislation

The Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC) provides for the protection and conservation of aspects of the environment that are matters of national environmental significance.

3.2.9 Commonwealth Policies and Strategies

A summary of Commonwealth policies and strategies is presented in **Table 3.4**.

Table 3.4: Relevant Commonwealth Policies and Strategies

Policy/Institution	Details
Caring for Our Country	Caring for our Country is the Australian Government's natural resource management initiative that integrates delivery of the Australian Government's previous natural resource management programs, including the Natural Heritage Trust, the National Landcare Program, the Environmental Stewardship Program and the Working on Country Indigenous land and sea ranger program.
Australia's Oceans Policy	Australia's Oceans Policy, released in 1998, sets in place the framework for integrated and ecosystem-based planning and management for all of Australia's marine jurisdictions.
National Strategy for Ecologically Sustainable Development	Adopted in 1992, this document sets out the broad strategic and policy framework under which governments will cooperatively make decisions and take actions to pursue ESD in Australia.
National Strategy for the Conservation of Australia's Biological Diversity	This strategy sets out a number of principles which have been adopted as a basis for the strategy's objectives and actions in conserving Australia's biological diversity.
National Water Quality Management Strategy	The main policy objective of the NWQMS is "to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000	This document outlines the important principles, objectives and philosophical basis underpinning the development and application of the guidelines. It outlines the management framework recommended for applying the water quality guidelines to the natural and semi-natural and freshwater resources in Australia and New Zealand.
The Wetlands Policy of the Commonwealth Government of Australia	The Wetlands Policy of the Commonwealth Government of Australia (Environment Australia 1997) provides strategies to ensure that the activities of the Commonwealth Government promote the conservation, ecologically sustainable use and enhancement, where possible, of wetlands functions.

Policy/Institution	Details
The Department of the Environment, Water, Heritage and the Arts Compliance and Enforcement Policy	This document sets out the policy framework the Department of the Environment, Water, Heritage and the Arts (DEWHA) will use when dealing with possible contraventions of Australian Government environment and heritage legislation. The legislation includes a number of different statutory regimes containing a range of criminal, civil and administrative penalty provisions. The purpose of this policy is to inform the public of the factors that will be taken into account in determining appropriate responses to contraventions, including whether legal proceedings will be pursued.
Japan-Australia Migratory Bird Agreement (JAMBA) 1974	This bilateral migratory bird agreement provides a formal framework for cooperation between Japan and Australia for the protection of terrestrial, water and shorebird species that migrate between the respective countries.
China-Australia Migratory Bird Agreement (CAMBA) 1986	This bilateral migratory bird agreement provides a formal framework for cooperation between China and Australia for the protection of terrestrial, water and shorebird species that migrate between the respective countries.
Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) 2002	This bilateral migratory bird agreement provides a formal framework for cooperation between the Republic of Korea and Australia for the protection of terrestrial, water and shorebird species that migrate between the respective countries.

4 Summary of Processes

4.1 Overview

This overview of the estuary processes operating within the Brisbane Water Estuary relates to current estuarine conditions and presents the key findings of the *Brisbane Water Estuary Processes Study* (Cardno, 2008a). A number of targeted investigations were undertaken as part of that study, the full details of which can found in Cardno (2008a).

Further brief discussion on climate change considerations is provided in **Section 4.10**, including additional information and discussion beyond that undertaken in the *Estuary Processes Study* (Cardno, 2008a).

4.2 Catchment Processes

The *Estuary Processes Study* characterised catchment processes by considering land use (historic, current and future), potential pollutant sources (licensed premises and sewer overflows), vegetation, geology, soils and climate. In addition, modelling of catchment runoff quality was undertaken (Cardno, 2007a), forming a critical input to the water quality modelling discussed in **Section 4.5**.

To give an overview of catchment inputs, **Figure 4.1** shows the land use characteristics of the catchment, in accordance with Gosford City Council zoning.

A number of key processes occurring in the estuary catchment were identified:

- **Catchment Planning:** The population of Gosford has grown significantly in recent years and this trend is expected to continue in the future. Planning will become increasingly important as the pressure on catchment processes increases, with associated impacts for the Brisbane Water Estuary.
- **Catchment Pollutant Loads:** Catchment-derived runoff and associated pollutants in excess of loads under pre-developed conditions are currently having a negative impact on some portions of the Estuary, leading to siltation and declining water and sediment quality. Siltation is currently affecting access and amenity in some portions of the Estuary. Catchment soils are predominately erosional in character and there is a substantial risk for exposed surfaces to contribute to sediment loads. Nutrient inputs can affect ecological processes and may result in eutrophication, leading to responses such as algal blooms, which can alter community dynamics in the short or long term. **Figure 4.2** shows major tributaries within the catchment and associated pollutant loads.
- **Sub-Catchment Prioritisation:** Narara and Erina Creeks are the greatest sources of catchment-derived sediments and nutrients, followed by Kincumber Creek. Any catchment based source controls should target these sub-catchments as a priority.
- **Catchment Controls:** Catchment based controls for both point and non-point pollution sources should form an important part of planning and development control. Catchment-based pollution control measures can play an important role in the

maintenance of the ecological health of the Estuary, and in providing a safe, high amenity resource for both commercial and recreational use. **Figure 4.3** shows the location of licensed premises and contaminated lands in the catchment that may potentially act as point sources of pollution. **Figure 4.3** has been prepared based on spatial data provided by Council and may not include all current licensed premises and contaminated lands in the catchment.

- **Sewer Overflows:** Sewer overflows may also affect water quality in Brisbane Water Estuary during high intensity rainfall events when their flow pumping and storage capacity is exceeded. **Figure 4.3** shows the location of sewer pumping stations located around the estuary.
- **Estuary Sediment Quality:** Sediment quality is also affected by catchment-derived pollutant inputs. Similarly, contaminants such as heavy metals are also associated primarily with Narara and Erina Creeks and have been significantly enriched since European settlement. Contaminants associated with sediments can have impacts on the ecology of the estuary.
- **Climate Change:** Climate change is likely to have a significant impact on rainfall patterns (and therefore catchment inputs) to Brisbane Water, resulting in expected lower average annual rainfall with consequent effects on environmental flows. Conversely, the intensity of flood-producing rainfall events is expected to increase resulting in a potential increased risk of creek flooding. Inundation of the Brisbane Water shoreline associated with estuary flooding is discussed in **Section 4.3**.

A comprehensive overview of processes occurring in the estuary catchment can be found in Section 3 of the *Brisbane Water Estuary Processes Study* (Cardno, 2008a).

4.3 Hydraulic Processes

Three dimensional modelling of the hydrodynamics of Brisbane Water was undertaken by Cardno Lawson Treloar using the Delft3D computer modelling software (Cardno, 2007b). This process, along with a review of existing data, facilitated the characterisation of hydraulic processes in terms of tidal behaviour, flushing times, wave processes, water levels and foreshore inundation (Cardno, 2008a). The key findings were:

- **Tidal Character:** Tides contribute significantly to estuarine flushing and day to day water levels. However, attenuation of the oceanic tide range occurs up-estuary, with 15% of the ocean tidal range attenuated at Ettalong. The Rip is another control on tidal range, with flushing times generally being longer for areas upstream of The Rip. **Figure 4.4** shows a tidal vector plot for The Rip area.
- **Tidal Character and Ecology:** The attenuation of tidal flows influences the ecology of the Brisbane Water Estuary. This relates not only to the salinity range within the Estuary, but also processes such as the dispersion of larvae. Modelling suggests that advection and dispersion is sufficient to transport larvae throughout the estuary, although some areas may have more limited connectivity than others. This has important implications for ecological management and conservation. Other studies undertaken as part of the *Estuary Processes Study* (Ford, Fowler and Suthers, 2006) suggest that larval dispersal may occur in a staged process, whereby a series of locations are important for connectivity between the ocean and the upper estuary.

- **Hydraulic Processes and Navigation:** Ocean swell, tidal currents, eddy formation and mobile sand shoals represent a significant hazard to boating activities and navigation in the region of The Rip and Ettalong. The estuary bathymetry is shown in **Figure 4.5**, where several hazardous shallow areas can been seen. Ocean waves can cause dangerous conditions at Half Tide Rocks and Ettalong, particularly over the Entrance and Ettalong Shoals.
- **Flushing:** Flushing of the estuary is generally complex, being of a relatively short duration at locations strongly influenced by tides (such as 2 to 3 days for The Rip and Ettalong), and longer in areas further upstream and in embayments (for example, the Gosford Broadwater has a flushing time of up to 30 days). Flushing is the primary control of water quality through the dispersion and dilution of pollutants and promotion of mixing. Narara Creek, which is a tributary of the Broadwater, is a major source of nutrients and suspended solids. Therefore, water quality may be compromised in this location and in similar areas in other parts of the estuary due to the coincidence of elevated catchment loads and relatively long flushing times. Water quality is discussed further in **Section 4.5**.
- **Wave Character:** At the Entrance and Ettalong there is little difference in wave heights in the estuary from ocean swell waves between the 5-years ARI and 100-years ARI storm events due to limited water depths over the Ettalong Shoals. Further up the Estuary from The Rip, ocean swell is attenuated and local sea (or locally generated wind waves) is the dominant wave force. This is evident in the larger expanses of open water, such as the Gosford Broadwater. Similarly, a comparison of 5-years and 100-years ARI wave conditions shows that there is not a large increase in local sea wave heights, although in this case this is due to limited fetch. **Figures 4.6 and 4.7** indicate 5 year and 100 year ARI wave conditions for the estuary.
- **Wave Character and Ecology:** Wave events can influence ecological processes. In terms of the estuarine ecology, more frequently occurring wave events will have a more significant influence on the community structure and biodiversity of the estuary. Due to limits on wave heights during extreme events, storm disturbance is likely to be relatively infrequent resulting in a generally stable community structure. For this reason, human-induced ecological disturbance has the potential to play an important role in the community structure and biodiversity of the estuarine ecology.
- **Wave Character and Shoreline Processes:** Wave events also play an important part in the process of shoreline recession. In general, the smaller wave heights in the upper estuary lead to lower levels of erosion of the foreshore from storm 'bite'. However, recovery from storm bite is inhibited by the lack of swell, which can result in permanent shoreline recession. This process may be exacerbated by uncontrolled shoreline development and where hard structures (e.g. seawalls) occur along the foreshore. Shoreline recession, particularly under climate change scenarios, should form an important consideration in future planning for foreshore areas for the Brisbane Water Estuary.
- **Wave Character and Bed Shear:** Bed-shear forces associated with waves passing over the bed can lead to the re-suspension of bed sediments. **Figure 4.8** indicates bed shear characteristics of the northern portion of the estuary for relatively regular events such as the 1 year ARI wave conditions and the 5 year ARI wave conditions.

Under certain conditions this process can result in the re-suspension of sediments over large areas of The Broadwater and Cockle Channel. In more sheltered areas such as Woy Woy Bay, only small areas of the bed are prone to re-suspension forces. In the vicinity of St Huberts Island, the high levels of sediment re-suspension in intertidal areas and around oyster leases has implications for the management of aquaculture operations, including the potential for increased vulnerability to disease. Sediment re-suspension may result in either positive or negative impacts on oyster growth. Where this process leads to increased nutrient levels in the water column, algal blooms may occur. These algal blooms have the potential to impact on the safety of oysters for human consumption. However, it is understood that shellfish poisoning has not been an issue for the Brisbane Water Estuary.

Further details on the hydrodynamics of the Brisbane Water Estuary can be found in Section 4 of Cardno (2008a) and in Cardno (2008b).

4.4 Morphological Processes

The morphological characteristics and siltation processes typifying the Brisbane Water Estuary were considered in terms of bed sediment characteristics, sediment quality, acid sulfate soils and bank erosion and shoreline dynamics. In addition, morphological modelling was conducted to identify the processes governing sediment transport (Cardno, 2007c).

The key findings of the *Estuary Processes Study* were:

- **Sediment Transport:** Estuarine geomorphology is influenced by catchment inputs and coastal/estuarine processes. Bed sediments may be sourced from catchment inflows (fluvial) or marine inputs. Where land use changes occur in the catchment, the annual volume of fluvial inputs will be affected. Similarly, the prevailing wave climate and/or tidal currents will affect sediment transport and deposition or erosion. Fine fluvial sediments are generally deposited in more tranquil (low energy) environments that form sediment sinks.
- **Geomorphology and Hydraulics:** Modelling indicates that the processes affecting the morphology of the Estuary are variable across specific locations and include depth, exposure, catchment runoff (e.g. Hardy's Bay), wave climate (e.g. Ettalong, Green Point) and tidal currents (e.g. The Rip). The processes create a dynamic, spatially variable estuarine morphology which affects navigation, amenity and ecological processes.
- **Catchment-Derived Sediments:** Human activities can have a significant impact on estuarine sedimentation. The present rate at which sediments are delivered to the catchment was determined to be approximately 5.7 million kg/year. The contribution of various tributaries varies. Some areas are thought to be subject to accelerated siltation (e.g. Correa Bay and Hardy's Bay). Siltation at certain locations, and with respect to the estuary as a whole, may be investigated through sediment cores.
- **Catchment Land Use:** Catchment land use is shown in **Figure 4.1** and pollutant loadings from the different parts of the catchments are shown in **Figure 4.2**. Human activities also impact on the quality of sediments via the introduction of a range of pollutants, including heavy metals. Lead, copper and zinc are present in the highest

concentrations in the estuarine sediments, primarily in the vicinity of foreshore areas. These metals are thought to be associated with roads and some industrial activities. Based on available data, the most significant source of heavy metal contaminants is Narara Creek, followed by Erina Creek. The results are consistent with land use, high runoff volumes, high concentrations of contaminants and the larger size of the respective sub-catchments. However, the entire estuary has been enriched with heavy metal contaminants since European settlement. This began in the northern reaches of Brisbane Water Estuary and these areas continue to be the most significantly affected today.

- **Ecological Impacts:** An assessment of the effects of heavy metal contaminants on the estuarine ecology has determined that low range negative impacts on the biota can be expected. This is an important consideration given the conservation value of the estuarine ecology and the commercial value of some species - oysters in particular (these filter feeders generally bio-accumulate such pollutants).
- **Acid Sulfate Soils:** Acid sulfate soils (ASS) are sediments and soils containing iron sulfides (mostly pyrite) that naturally occur in estuarine floodplains and coastal lowlands. When exposed to the air by drainage of overlying water or excavation, the iron sulfides oxidise and form sulfuric acid. Impacts of ASS oxidisation include damage to infrastructure such as bridges and levees, the release of heavy metals from contaminated soils, vegetation kills, weed invasion by acid tolerant plants, fish kills, outbreaks of fish disease and decreased productivity of agricultural land. Exposure of PASS can result in significant impacts on recreational fishing, commercial fishing, oyster farming and agricultural activities.
- **Regulation of Foreshore Development:** Human activities are also affecting estuarine morphology and coastal processes (e.g. the construction of foreshore structures, such as jetties, seawalls and boat ramps, a significant number of which have been unregulated). Foreshore structures can directly impact on patterns of sediment transport by forming a physical barrier, but also indirectly by altering coastal processes (e.g. waves, currents) which govern sediment transport. This can lead to accretion in some areas and erosion in others.
- **Foreshore Recession:** Modelling indicates that the natural shorelines of the estuary are subject to a general trend of recession, with storm bite expected to result in around 1-2m of horizontal recession in a very severe storm. In general, there is a high potential for shoreline recession within some sections of the Brisbane Water Estuary because post-storm beach recovery is limited.

Further details on sedimentary processes occurring in the estuary can be found in Section 5 of the *Estuary Processes Study* (Cardno, 2008a).

4.5 Water Quality Processes

The water quality of the estuary was assessed in terms of both ambient and transient conditions. Ambient conditions reflect the normal, day-to-day water quality, whereas transient conditions describe the impact of rainfall events on the water quality of the Brisbane Water Estuary.

Ambient water quality was assessed based on water quality data collected as part of regular monitoring undertaken by Council. The water quality data collected to date provides a 'snap-shot' in time and it is understood that there is limited consistency with respect to location and tidal phase of sampling sites. Therefore, it is difficult to identify trends in water quality for Brisbane Water estuary for either ambient or transient conditions. Transient water quality was assessed based on modelling of the estuary using estimates of catchment loads of nutrients discharged into the Brisbane Water estuary and a range of wet weather events (under wet, dry and average annual rainfall conditions) (Cardno, 2007d). Modelling investigated the transport of those nutrients from a large number of source locations (tributaries) for average annual catchment freshwater flow conditions.

The key findings of the *Estuary Processes Study* were:

- **Water Quality Dynamics:** The extent of oceanic influence in the estuary to some extent governs water quality processes within Brisbane Water estuary, whereby flushing times are much longer in the upper-estuary due to the attenuation of tidal flow and distance from Broken Bay. This is evident in the salinity data presented in the *Estuary Processes Study* (Cardno, 2008a), with salinity generally lower and showing a higher variability for stations located adjacent to creek mouths. In addition, those locations for which flushing occurs over a longer time period are also generally coincident with the major population and commercial/industrial centres. For these reasons, the upper-estuary, particularly The Broadwater, is subject to generally poorer water quality and longer recovery times after a rainfall event. Nonetheless, it appears that there may have been a general trend towards water quality improvement in more recent years, although whether this is due to the implementation of catchment-based controls or changes in rainfall patterns (i.e. drought periods) is unclear.
- **Ecological and Recreational Impacts:** Based on the water quality data used to assess ambient water quality, as well as modelling of transient conditions, it is apparent that water quality is an issue in some portions of the Brisbane Water estuary, particularly with respect to nutrient and sediment inputs. This has the potential to lead to a range of environmental impacts, such as eutrophication, algal blooms and a decline in seagrasses, and may alter the community dynamics in a range of estuarine habitats. Similarly, water quality also impacts on recreational usage of the waterway. Whilst available data suggests that water quality is currently of a standard generally suitable for recreational purposes, it is important that monitoring continues to ensure public health and safety and that human waste be prevented from entering the estuary.
- **Climate Change Scenarios:** A comparison between wet and dry years suggests that predicted changes in rainfall patterns (i.e. more intense rainfall events) may lead to a decline in water quality after rainfall events compared to current observations. Should this occur, this process will be exacerbated by the projected population increase for the Gosford region and future planning should carefully consider patterns of land use and catchment based controls on water quality.

Further details on the water quality of the Brisbane Water Estuary can be found in Section 6 of the *Estuary Processes Study* (Cardno, 2008a).

4.6 Ecological Processes

The estuary represents the interface between a range of different environments: marine and freshwater, terrestrial and aquatic. The characteristics of flora and fauna found in the estuary are discussed below with reference to the impacts of human activities and future conservation priorities.

The key findings of the *Estuary Processes Study* were:

- **Conservation Planning:** **Figure 4.9** shows aquatic vegetation mapping for the whole of the estuary (2004). Mangroves, seagrasses and saltmarshes are known to perform a range of important ecological functions. These habitats were also associated with high rates of diversity and abundance of fish and invertebrate fauna. One important aspect of all three habitat types is the structural complexity that they provide, which is associated with higher biodiversities. Therefore, maintenance of the physical/vegetation structure is a very important component of biodiversity conservation.
- **Aquatic Weeds:** *Caulerpa taxifolia* is a fast-growing marine seaweed that, although normally found in warm tropical waters, has become established in several areas that do not form part of its normal range of distribution (DPI, 2007a). *C. taxifolia* can alter marine habitats and affect biodiversity (e.g. by out-competing native flora). *C. taxifolia* has been detected in the Brisbane Water Estuary, however the origin of the NSW population is not known (DPI, 2007a). There is a management plan in place for the control of *C. taxifolia* (NSW I&I, 2009), however, the permanent eradication of *C. taxifolia* from Brisbane Water is currently not considered feasible due to the estuary's dynamic nature, the presence of natural and artificial vectors and the logistics of control work.
- **Avifauna:** The Brisbane Water estuary is habitat to a variety of shorebirds, waterbirds and forest birds, as it provides a diverse array of habitats suitable for birds. The Estuary is on the route of the East Asian-Australasian Flyway which is used by shorebirds to move between Australia / New Zealand, East Asia and the Arctic region of the northern hemisphere. An avifauna assessment by Robinson (2006) indicated that there are at least 110 species (including 4 exotic species) from 23 Orders, 34 Families (including 1 exotic family) and 79 Genera (including 3 exotic Genera) documented from the estuary. Eight species of resident shorebirds observed represent 44% of all Australian resident shorebird species. These results provide an indication of the importance of Brisbane Water Estuary for both regional and national avifauna conservation.
- **Estuary Biodiversity:** A comprehensive sampling program was undertaken throughout the Brisbane Water estuary, focusing on the biodiversity of macroinvertebrates (Gladstone, 2007). Five habitats were sampled throughout the estuary (*Z. capricorni* seagrass meadows, subtidal unvegetated sediment, intertidal mud flats, intertidal hard substrates (natural and anthropogenic) and mangroves) and a total of 324 species (72,524 individuals) were recorded, representing 16 phyla:
  - Foraminifera (1 species),
  - Porifera (2 species),
  - Ectoprocta (2 species),

- Chordata (3 species),
- Cnidaria (3 species),
- Platyhelminthes (1 species),
- Nematoda (2 species),
- Nemertea (1 species),
- Annelida (74 species),
- Sipuncula (2 species),
- Arthropoda (66 species),
- Echinodermata (7 species),
- Mollusca (141 species),
- Chlorophyta (5 species),
- Phaeophyta (5 species), and
- Rhodophyta (9 species).

- **Biological Connectivity:** Biological connectivity between habitats in different parts of the estuary is generally high, although some locations may have more limited connectivity than others, as indicated by larval studies described in Cardno (2008a).
- **Commercial Fisheries and Aquaculture:** Conservation of biodiversity and maintenance of ecological function are also important in commercial terms when considering the fishing, aquaculture and tourism industries. Oyster aquaculture is undertaken in Brisbane Water Estuary in accordance with the *NSW Oyster Industry Sustainable Aquaculture Strategy* (DPI, 2006). The location of oyster leases identified under the strategy is shown in **Figure 4.10**. Oysters are bivalve molluscs which feed by filtering phytoplankton, bacteria and nutrients from the surrounding water. Oyster leases can function to provide valuable habitat for a range of species, including fish (particularly juvenile fish) which shelter amongst the leases. In addition, oysters and the habitats associated with oyster leases may be important resources for other species, such as birds.
- **Foreshore Development and Planning:** An assessment of the foreshore identified that over 50% of the estuary foreshore was adjacent to substantially developed catchments and was considered disturbed to highly disturbed. The main cause of loss of intertidal habitats is the construction of seawalls, jetties and piers. While these structures enhance amenity for an individual residential property, they often have the effect of precluding public access to the foreshore, have poor habitat value and also impact on sediment dynamics. Loss and degradation of foreshore vegetated habitats results in loss of the ecological function that saltmarsh and mangroves provide, for example, shoreline protection, nutrient cycling, buffering water quality and sediment trapping.
- **Impacts of Human Activities:** The main causes of disturbance associated with human activities are related to catchment processes and recreational activities. Recreational activities that occur in the area with a high potential to impact on estuarine ecology include dog walking, boating activities, the introduction of weeds, predation by introduced species and disturbance related to the presence of people (e.g. noise, light, vehicles, etc.) In addition to simple loss of habitat, disturbance was found to result in the following impacts: declining water quality, declining vegetation cover, increased availability of mosquito breeding habitat, declining productivity and alterations to the assemblage structure for flora and fauna communities. These

types of impacts are thought to be leading to high rates of habitat loss for mangroves, seagrasses and saltmarsh. Climate change associated impacts, including sea level rise and changes to weather patterns, are also issues for biodiversity conservation.

Further discussion of ecological processes occurring in the Brisbane Water Estuary can be found in Section 7 of the *Estuary Processes Study* (Cardno, 2008a).

4.7 Cultural Heritage

Cultural heritage includes consideration of both Indigenous and non-Indigenous (European) heritage (HLA-Envirosciences, 2005). **Figure 4.11** shows the locations of non-Indigenous heritage sites and areas located on or near the estuary foreshores. Aboriginal sites are not shown for cultural reasons. Key findings with relation to cultural heritage were as follows:

- **Indigenous Heritage:** The natural resources found in the estuary and catchment made the Brisbane Water Estuary an attractive place for Aboriginal groups to camp and there are a large number of places and artefacts associated with the area. The areas of Pretty Beach and Daleys Point have the highest concentration of known sites, and Kariong, Woy Woy and Cockle Broadwater also have high numbers of sites.
- **Indigenous Heritage – Unidentified Sites:** With respect to the Indigenous heritage of Brisbane Water estuary, there are concerns over as yet unidentified sites, for which there is significant potential given the history of known Aboriginal occupation of the area. The high number and variability of sites recorded within the catchment indicates that there is high potential for more sites to be discovered.
- **Non-Indigenous Heritage:** There are 11 items of European heritage significance located on the estuary foreshores. These sites are particularly sensitive, including the general character, aesthetics and views.
- **Maritime Heritage:** There are a number of shipwrecks in the Estuary; however, the exact location of these wrecks is unknown. At least half of these wrecks are thought to be located on the bar near the entrance. This represents a particularly sensitive area.
- **Climate Change:** Global climate change and associated sea level rise have implications for the ongoing management and conservation of historic sites and artefacts, both Aboriginal and European. Direct threats to heritage sites resulting from climate change include, for example, sea level rise.

Further information on the cultural heritage values of the estuary is provided in Section 8 of the *Estuary Processes Study* (Cardno, 2008a).

4.8 Recreational Processes

The recreational and aesthetic environment of the Brisbane Water estuary is highly valued. Human use of the estuary has resulted in conflicts between users in relation to land use and the recreational use and enjoyment of the foreshore and waterways, as well as, degradation of the natural environment. High population growth and tourism has further exacerbated these conflicts. **Table 4.1** shows a summary of key current human uses of the estuary.

Table 4.1: Major Foreshore and Water-Based Recreational and Commercial Activities (After KBR, 2005)

Recreational Activities	Commercial Activities
1. Foreshore-Based	
Passive use of reserves and open space	Boat hire
Shore-based recreational fishing	Boat repairs
Picnicking	Boat storage
Bushwalking	Marina operations
Sightseeing	Equipment sales
Bird watching	Food outlets
Walking and jogging	Oyster depuration plants
Cycling	Light industrial activities (manufacturing,
Dog exercising	general storage)
Horse training	Other commercial and light industrial activities
Organised/team sports (e.g. football, cricket, etc)	Boat hire
Other recreational activities (e.g. yoga, tai chi, etc)	Boat repairs
2. Water-Based	
Power boating (e.g. personal water craft and jet skiing)	Oyster farming
Sailing	Boat tours
Paddling (e.g. canoeing/kayaking, rowing)	Boat charters
Swimming (e.g. wading, bathing)	Ferry operations
Windsurfing	Commercial fishing
Kite surfing	
Diving (e.g. scuba diving and surface snorkelling)	
Boat-based recreational fishing	
Shoreline fishing	

An evaluation of foreshore land ownership, uses and activities, waterway uses and activities, and human use and environmental conflicts was conducted as part of the *Estuary Processes Study* (KBR, 2005). An assessment of potential areas for increased tourism was also provided.

The key findings were:

- **Public Safety:** The range and variety of both land-based and waterway activities engaged in by recreational users of Brisbane Water estuary indicates that there is a high potential for conflict between different user groups. Public safety is also a significant concern, particularly with respect to boating activities. Pedestrian and driver safety may be compromised due to traffic congestion and illegal or improper parking, which can reduce driver vision, pedestrian visibility and, on occasion, force pedestrians off footpaths. Hazards to navigation include mobile sand shoals, erosion and sedimentation and strong tidal currents. The diverse range and size of watercraft and the intensity of boating activity also indicates the potential for safety hazards and conflict between recreational users.
- **Environmental Impacts:** It is understood that recreational fishing and boating activities are in general well regulated by NSW Fisheries and NSW Maritime (respectively) through the imposition of a range of rules and zonings (e.g. no wash zones). However, both of these activities have the potential to have environmental impacts and future monitoring should be directed at addressing these concerns.

Similarly, foreshore activities have the potential to impact on the environment. These environmental impacts include habitat loss and degradation (both terrestrial and aquatic), declining water and sediment quality, shoreline erosion, sedimentation and siltation and detrimental impacts on the aquaculture industry.

- **Planning and Management:** In order to manage the risk of conflict between users, as well as negative environmental impacts, the Estuary Processes Study recommended consideration of partitioning of activities. This may include the explicit use of zoning of different parts of the estuary for different user groups and should incorporate consideration of some form of protection for environmentally sensitive areas. It is understood that this method is already being employed by NSW Maritime and NSW Fisheries (discussed above), but may also be applied to foreshore areas. Where sensitive ecological communities or habitats are identified these areas could be assessed for exclusion of some activities, or for the implementation of methods by which the intensity of recreational usage is reduced. For example, the provision of facilities and pathways will encourage certain types of recreational activities. This is particularly important given projections of increased intensity of recreational usage of the estuary. Public education is likely to form an important component of any such activities.
- **Foreshore Development & Public Access:** At present 35% of the foreshore of Brisbane Water estuary is held in public reserves, National Parks and Nature Reserves. The remaining 65% is privately owned / managed. Historically, many un-regulated developments have occurred and it is understood that regulation of foreshore development represents a substantial planning challenge. Non-conforming foreshore development has associated impacts on ecological processes (e.g. fragmentation of natural foreshore habitat) and recreational activities (through prohibition of foreshore access in many locations).
- **Climate Change:** Any interactions between projected climate change impacts and recreational usage also need to be considered. For example, the impacts of various recreational activities and the limited potential for beach recovery after storm attack are likely to have a synergistic effect. The potential for shoreline recession in Brisbane Water estuary will need to be incorporated in future planning to ensure that open space and associated recreational infrastructure are retained. This may involve the introduction of mitigation measures or the reservation of additional open space (where possible, commensurate with conservation objectives).

4.9 Interactions Between Processes

A key finding of the evaluation of the interaction between estuarine processes is the importance of the maintenance of physical processes in maintaining the diversity, distribution and abundance of flora and fauna within the Brisbane Water Estuary (Cardno, 2008a).

The assessment of interactions between physical and ecological processes in Brisbane Water estuary identified the following key points:

- **Environmental Interactions:** It is apparent that interactions between estuarine processes are highly complex and vary over a range of spatio-temporal scales. In reality hydrodynamic, geomorphologic and water quality processes act synergistically

to shape patterns of species diversity, distribution and abundance. The key drivers of ecological variation in the Brisbane Water estuary are the astronomical tides, wave climate, bathymetry, net sediment flux and freshwater inflows.

- **Ecological Health:** The ecological health of the estuary is currently being negatively impacted by the effects of human intervention, namely the alteration of the foreshore (including reclamation in some locations), urbanisation of the catchment (with associated sediments and contaminants) and recreational users displacing or disturbing aquatic species.
- **Climate Change:** Projected climate change, in conjunction with the high potential for shoreline recession in the Brisbane Water estuary, is likely to affect foreshore facilities, foreshore development, foreshore recreational infrastructure and Aboriginal and non-Aboriginal heritage sites and artefacts. The key ecological concern with relation to climate change is whether species will have sufficient time to adapt to changes in these physical processes and, if not, if they can maintain essential biological functions (e.g. reproductive cycle) under higher rates of environmental change. However, their ability to do so will be further impacted by ongoing human impacts (e.g. disturbance, water quality impacts). Further discussion on potential impacts of climate change is provided in **Section 4.10**.

4.10 Climate Change Considerations

According to NSW Government, CSIRO and Bureau of Meteorology projections, the NSW community needs to prepare for higher temperatures, rising sea levels, less rainfall, more frequent and more severe droughts and more extreme storms. These changes are likely to have significant impacts on agriculture, water supply, settlements and infrastructure, natural resources, biodiversity and human health. A report prepared by HCCREMS and the University of Newcastle (Blackmore *et al.,* 2009) outlines some of the projected changes for the Gosford LGA.

Both Gosford Council and the NSW Government (DECCW) have a responsibility to address the issue of climate change through mitigation strategies (e.g. reduction in greenhouse gas emissions) and adaptation strategies (e.g. habitat management and development controls).

Climate change has been considered in this Estuary Management Study with the purpose of understanding how climate change may impact upon the ongoing management of the estuary. It should be noted that a comprehensive assessment of climate change processes and impacts is outside the scope of this Study. However, data collected as part of the *Estuary Processes Study* and best available information on climate change predictions have been utilised to discuss the possible impacts of climate change on the estuary, identify key issues and prioritise issues for further detailed consideration. Specifically, this study has included consideration of the following:

- Observed increases in estuarine water levels over time (**Section 4.10.1**);
- The potential shift in the intertidal zone and implications for management of intertidal vegetation (**Section 4.10.2**); and
- Planning initiatives relating to the potential impacts of climate change (**Section 4.10.3**).

4.10.1 Analysis of Historic Water Level Data

Cardno have undertaken a preliminary analysis of available water level data to investigate historic changes in mean estuarine water levels within Brisbane Water.

Methodology

Data from a total of six water level gauges operated by Manly Hydraulics Laboratory (MHL) for DECCW was obtained for analysis. The locations of these water level gauges are shown in **Figure 4.12**.

Water levels at each of these locations were recorded at 15 minute intervals for the duration of the monitoring period shown in **Table 4.2**. For some gauges, the water level records contain invalid data representing a period over which the gauge was out of operation or malfunctioning. The periods of invalid data vary in length from several hours to several months at some locations. Where a period of invalid data occurred in a data set, it was excluded from the analysis. The periods of invalid data (visible as a gap in the graph) can been seen in **Figures 4.13 - 4.19**.

The data were subjected to a process of 'data filtering' to remove the influence of tidal character on water levels at each site, thereby providing a more accurate representation of net changes in water levels over long periods of time. The analysis then took a 30 day moving average of the data in accordance with the methodology adopted for the Australian baseline sea level monitoring project established by the Australian Government and the BoM. Using this 30 day moving average, a water level trend (rate of rise in mm/yr) could be established for each gauge.

Results

The results are presented in **Table 4.2** and **Figures 4.13 - 4.19**.

Table 4.2: Sea Level Rise Analysis for Brisbane Water Estuary

Gauge Location	Rate of Sea Level Rise (mm/yr)*	Date Records Commenced	Most Recent Record	Length of Record
Ettalong	4.1	1 July 1985	30 June 2007	20 years
Koolewong	2.2	1 July 1985	30 June 2009	22 years
Manns Road, Narara Creek	2.1	7 March 1996	20 June 2009	13 years, 4 months
New Bridge, Erina Creek	#	4 June 2007	30 June 2009	2 years, 1 month
Punt Bridge	2.1	1 July 1995	30 June 2009	14 years
Wharf Street	0.6	1 July 1986	9 May 1995	8 years, 10 months

** The rate reported represents the rate calculated for the available data period, which varies as shown.*
 # The rate of sea level rise (mm/yr) has not been calculated for the New Bridge, Erina Creek, gauge due to the short period over which the gauge has been operational.

The results in **Table 4.2** show a general trend towards an increase in mean estuarine water level over the last 20 years, with rates of rise varying between 0.6-4.1 mm/yr, averaging a rate of rise of 2.2 mm/yr overall. The greatest increase was observed near the entrance at Ettalong (4.1 mm/yr). When considering data records of periods greater than 13 years only, average estuarine water level increases of 2.6 mm/yr were observed.

It is recommended, however, that these results be treated with caution due to the relatively short period over which the data was collected. As additional data is collated, the analysis may be updated. The analysis is further limited by the small number of gauges used to calculate the average rate of rise (i.e. the small sample size).

It is important to note that the data collected from those sites located in upstream areas of estuarine tributaries (i.e. the Manns Road and New Bridge gauges) are also influenced by catchment inflows and are therefore less representative of estuarine water levels than those gauges that are located directly on the estuarine foreshore. Rainfall events and past changes in land use in the catchment will all have an impact on creek water levels (due to changes in catchment inflows) and this may have led to some bias in the water level data collected at the two sites located in estuarine tributaries.

Discussion

An average rate of rise in estuarine water levels of 2.2 mm/yr over the past 20 years has been determined based on actual water level data collected for the Brisbane Water estuary. Whilst limitations associated with the analysis are recognised it is considered that the preliminary analysis presented here is sufficiently accurate to gain an appreciation of the rate of change in average estuarine water levels observed over the last 20 years. It is noted that ongoing water level monitoring will be vital in gaining a more comprehensive understanding of the impacts of sea level rise on estuarine water levels.

The results presented herein generally concur with the findings of a water level analysis conducted on tide gauge water level data collected over a 122 year period at Fort Denison, Sydney Harbour (You *et al.*, 2009). An analysis of the full data set from 1886 to 2007 identified a rate of rise in water levels in Sydney Harbour of 0.63(±1.4) mm/yr. However, where the analysis was limited to the more reliable data collected from 1950 to 2007, the rate of rise was determined as 0.58(±0.38) mm/yr (You *et al*., 2009).

Other studies have considered the global rate of rise in sea levels. The IPCC has recorded a global rise in average sea levels over the period 1961-2003 of 1.8 mm/yr (the range being 1.3-2.3 mm/yr), with more accelerated sea level rise occurring over the period 1993-2003, for which the average global rate of rise was 3.1 mm/yr (2.4-3.8 mm/yr) (Bindoff and Willebrand, 2007). In comparison, the forward prediction for the period from 2010 to 2100, presuming 0.9m in sea level rise (DECCW, 2009) occurs over this 90 year period, is an average of 10 mm/yr.

These other studies would suggest that the results from the data analysis undertaken for Brisbane Water Estuary water levels are within the range of recorded sea level rise.

4.10.2 Sea Level Rise and the Estuarine Intertidal Zone

A preliminary analysis of the extent of the future intertidal zone has been undertaken to investigate the potential for migration of intertidal estuarine vegetation under climate change conditions. A Discussion Paper presenting the results of the analysis has been provided in **Appendix D** and a brief overview of the key findings is provided below.

Introduction

The 'intertidal' zone is generally defined as the foreshore area between the low tide and high tide levels. It is also importantly situated at the convergence of aquatic and terrestrial habitats; biota living in this zone have adapted to living in a highly variable environment. Intertidal vegetation, including mangroves and saltmarshes, plays an integral role in the ecology of the whole estuary, particularly with regards to primary production and providing habitat for fish, birds, mammals and invertebrate fauna.

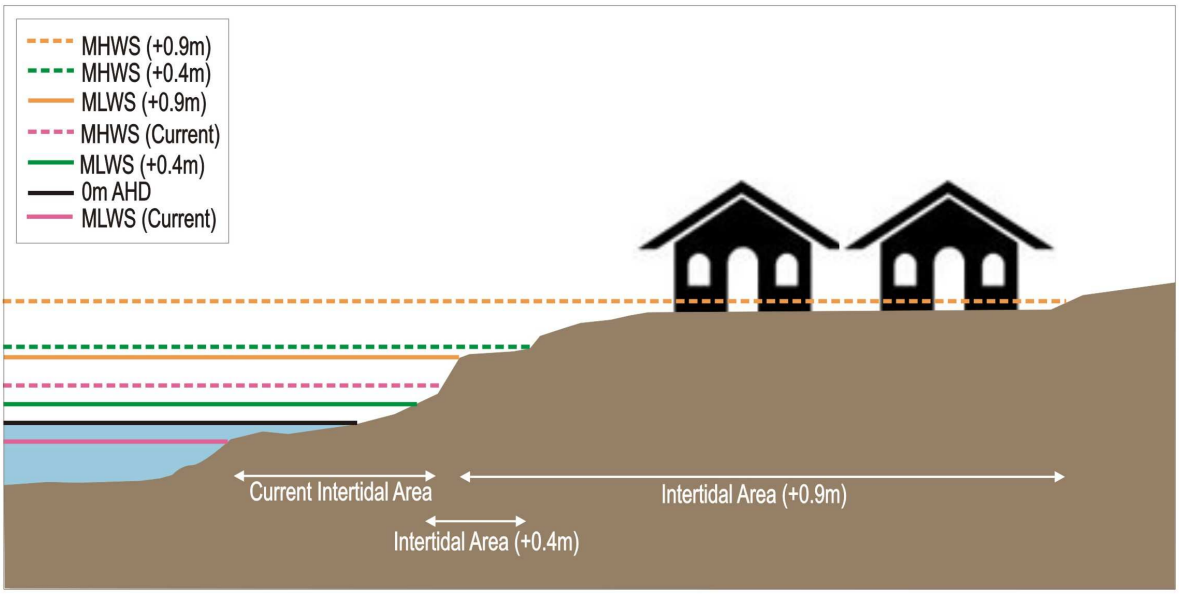
Climate-change induced sea level rise presents a future risk to intertidal ecosystems due to the potential for permanent inundation of existing intertidal areas and shoreline recession. Whilst migration of these intertidal ecosystems can occur (Saintilan *et al.*, 2009), migration may not be possible in all locations due to the presence of human constructs such as sea walls. In addition, the ongoing pressure from existing threatening processes is likely to further compromise the ability of these ecosystems to adapt to change, with subsequent implications for the ecology of the estuary as a whole.

To assist in providing a basis for further, more detailed studies on the potential impacts of sea level rise on estuarine ecology, a spatial analysis was undertaken of the intertidal zone for the present day and for 0.4m and 0.9m sea level rise scenarios.

It should be noted that the spatial analysis assumes that the ground levels and foreshore structures remain the same into the future (i.e. no large scale filling is undertaken and no new levees or other structures are built which inhibit the tidal extent).

Results and Discussion

The predicted future intertidal zones are mapped in Figures 1-4 of **Appendix D**. In terms of trends in the data, **Table 4.3** shows that intertidal areas tend to decrease between 2010 and the 0.4m sea level rise scenario, and then increase again to the 0.9m sea level rise scenario. This is due to the topography of the foreshore and adjacent areas. The results indicate that the foreshore is fairly steep up to the mean high water spring (high tide) with 0.4m of sea level rise and then flattens out beyond this level. This results in a constriction in the distance between the low and high tide when 0.4m of sea level rise is applied but then an expansion of this distance when 0.9m of sea level rise is applied. This is showed conceptually in the diagram below. As mentioned above, this assumes that existing foreshore structure (e.g. seawalls) and ground levels remain the same.



Based on the analysis, the critical point for estuarine vegetation is for moderate sea level rise increases of around 0.4m. Based on current predictions of sea level rise, management interventions would likely be required in the next 40 years to ensure saltmarsh and mangroves are not lost from Brisbane Water Estuary. Management interventions may involve increased protection of existing habitat in the short term through fencing, signposting and weed management and creation of future habitat areas for migration and replanting. Future habitat areas are likely to include existing open space areas and as such may come at the expense of some recreational uses. The creation of future habitat areas would likely consist of a combination of engineering works (e.g. modification of seawalls, regrading of future intertidal areas), development controls (e.g. prohibiting filling in future habitat areas), facilitated migration (e.g. replanting or fencing priority areas off) and establishment of a seed bank. Similar techniques have been successfully applied as part of wetland rehabilitation works at the Sydney Olympic Park site. Over the medium to long term, land acquisitions would become increasingly important.

Table 4.3: Current and Future Intertidal Zone Areas for the Brisbane Water Estuary

Zone	Total Intertidal Zone Area (ha)			2050 Intertidal Zone Area (0.4m SLR)		2100 Intertidal Zone Area (0.9m SLR)	
	2010	2050	2100	% Open Space	% Developed	% Open Space	% Developed
Zone 1	16.71	4.44	53.17	94	6	96	4
Zone 2	43.49	14.93	147.07	92	8	83	17
Zone 3	18.85	6.63	16.05	90	10	65	35
Zone 4	39.95	21.32	142.25	92	8	75	25
Zone 5	33.48	15.28	200.96	97	3	66	34
Zone 6	34.46	13.46	20.81	99	1	36	64
TOTAL	**186.94**	**76.06**	**580.31**				

The future intertidal zones mapped represent areas that may become available for the landward migration of intertidal vegetation. Patterns of change in the intertidal zone are, however, not easily predicted over long time scales due to a range of uncertainties (amount of sea level rise, land use change and human activities, and abiotic and biotic features) affecting the size and location of the intertidal zone, and therefore the analysis provided in **Appendix D** is preliminary in nature. However, the information in **Appendix D** can be used to assist Council in identifying key areas for future saltmarsh and mangrove habitat.

Management of intertidal vegetation under sea level rise conditions presents a significant challenge. Possible management options for the intertidal zone in the context of sea level rise are to:

- Allow natural migration of the intertidal zone into available open space areas;
- Facilitate migration of intertidal vegetation (via methods such as planting) to create an engineered intertidal zone that attempts to initiate the establishment of a relatively natural intertidal ecosystem habitat;
- Acquire privately owned land for incorporation into foreshore open space, thereby providing additional scope for migration (facilitated or otherwise); and/or
- Do nothing.

It is likely that a combination of the first three management options may be applicable dependent on the site specific constraints. Hence, management strategies would need to be considered on a location-by-location basis. Key to this process is the ongoing monitoring of key parameters (e.g. estuarine water levels and intertidal vegetation extents) and the development of trigger levels based on observed changes in these parameters at which to initiate a suitable and appropriate adaptive management response. Further discussion is provided in **Appendix D**.

4.10.3 Local Planning for Sea Level Rise

Sections 4.10.1 and 4.10.2 presented the findings of some technical investigations into the potential impacts of sea level rise on the Brisbane Water Estuary. Moving forward for Council, there is a need for strategic planning to manage and adapt to these impacts. Council has adopted a proactive approach in this regard, having adopted a Sea Level Rise Planning Level (see below) and conducted extensive community education in relation to this issue. However, there remain a number of challenges for strategic planning and some of these issues are described below.

Sea Level Rise Planning Level for Gosford LGA

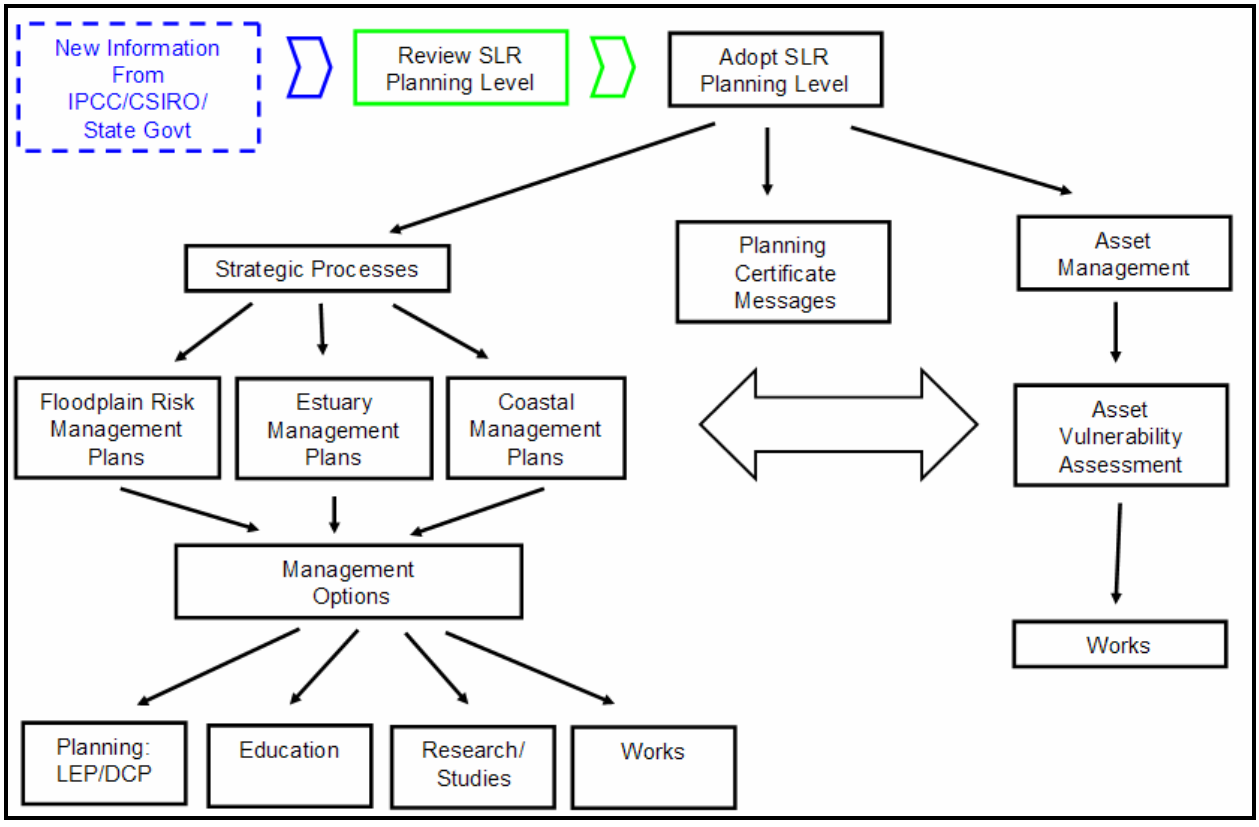
In recognition of the fact that Council has a duty of care to consider projected sea level rises and associated impacts in undertaking its strategic and regulatory planning activities, and (at that time) lacking guidance from the State and Federal Governments, in January 2009 Gosford City Council took the initiative of putting forward for adoption a Sea Level Rise Planning Level. The planning level adopted by Council on 10 December 2009 (minute No. 2009/823) is consistent with the level adopted by the NSW Government (i.e. 0.9 m sea level rise for the year 2100 with an assumed linear increase from 1990 levels.

The *Sea Level Rise Planning Level* was placed on public exhibition between 12 August 2009 and 18 September 2009 for public information purposes. Public exhibition materials included mapping showing the extent of areas vulnerable to inundation under:

- An average tide (adopting 0.7m AHD),
- King tide (very high tides that occur approx. twice a year; adopted water level not specified), and
- The 100 year ARI estuarine water levels (adopted water level not specified).

The mapping showed both the present day inundation extents, and also the inundation extents for three sea level rise scenarios (0.2m, 0.55m and 0.9m of sea level rise). Shortly after the public exhibition period in October 2009, the State Government released a *Sea Level Rise Policy Statement* (DECCW, 2009) that adopted sea level rise planning benchmarks of 0.4m by 2050 and 0.9m by 2100 (**Section 3.2.7)**.

The Sea Level Rise Planning Level policy document was adopted by Council in December 2009. Council has adopted a holistic approach to implementation of the Level as outlined in the flow chart provided below.



In accordance with this framework, Council has encoded all properties identified as being potentially affected by sea level rise up to 0.9m under Section 149(5) of the *Environmental Planning & Assessment Act 1979*. Council has a duty of care under Section 149(5) of the Act to encode properties with a message that will assist in warning existing and potential property owners of hazards, such as sea level rise, that may affect the property.

In 2010 Council also adopted a Climate Change Policy (**Section 3.2.2**) that advocates mitigation of and adaption to the impacts of climate change. In acknowledgement of the fact that some of the impacts of climate change are likely to be unavoidable, adaptive management has been identified as the key issue. It is important to emphasise that the adaptive management must be underpinned by the ongoing collation of data on the observed impacts of climate change, and an effort has been made to include priority monitoring activities suitable for this purpose as options in this Estuary Management Study (**Section 8**). There will be an increasing need to develop suitable and appropriate adaptive management mechanisms that consider the principles of Ecologically Sustainable Development (ESD), having regard for both short and long term environmental, social and economic impacts.

Strategic Planning Processes

As identified in Council's flow chart (see above), one of the key mechanisms for addressing sea level rise issues is via the State Government funded natural resource management planning programs. Sea level rise in estuarine areas is addressed through two key State Government programs:

- The Estuary Management Program, which provides for the development of estuary management studies and plans in accordance with the NSW *Rivers and Estuaries Policy* (**Section 1.2**); and
- The Floodplain Management Program, which provides for management of risk from flooding in accordance with the NSW *Flood Prone Land Policy*.

The focus of the Estuary Management Program is the protection and maintenance of ecosystem processes and their associated values. In accordance with the *Rivers and Estuaries Policy*, the program seeks to provide for the ongoing use and enjoyment of estuarine areas by the public, but within the context of the environmental values of those systems. Given the recent introduction of the *NSW Sea Level Rise Policy Statement* (DECCW, 2009), the extent to which climate change and sea level rise issues need to be addressed through the implementation of this program is not clear at present. It is understood that, unless the *Rivers and Estuaries Policy* is updated and additional funding is provided through this program to support local Councils, the focus of the Estuary Management Program remains largely on the impact of climate change on physical and ecological estuarine processes. This Program provides Council with an opportunity to obtain assistance from the State Government in relation to, for example, data collation activities that can inform adaptive management (such as monitoring estuarine water levels). However, the Program does not at this time address risk to assets and infrastructure associated with regularly occurring (i.e. day to day) tidal inundation.

The Floodplain Management Program provides for the assessment and management of risk to human life, assets and infrastructure from flooding, which in estuarine areas may involve foreshore inundation due to extreme (irregularly occurring) water levels. The key point of difference to the Estuary Management Program is that the focus is on managing risk to life and property resulting from flood events, which includes consideration of the impacts of climate change on flood levels in accordance with the *NSW Coastal Planning Guideline*

(DoP, 2010). As identified in **Section 3.2.4,** Council is currently working through the Flood Management Process for Brisbane Water with the development of a *Foreshore Floodplain Risk Management Study and Plan* (FRMS&P; Cardno, in prep.) that seeks to address the risk of flooding, primarily as a result of ocean storms. The flood levels and extents presented in this study incorporate 0.9m of sea level rise (as adopted in Council's Sea Level Rise Level). The FRMS&P presents a range of options to manage both existing and future flood risk (i.e. including 0.9m sea level rise). The FRMS&P does not identify planning or other mechanisms for managing the inundation risk associated with increased tidal level as a result of sea level rise (i.e. regular inundation). However, baseline assessments of tidal conditions and behaviour under sea level rise will be undertaken to identify key risk areas with regards to regular inundation under sea level rise conditions. This information will assist Council in developing management strategies to address this risk.

It can therefore be seen that the Estuary Management Study & Plan and the Floodplain Risk Management Study & Plan will provide Council with the framework required to move forward with planning for some of the impacts associated with sea level rise, primarily intertidal habitat and property impacts.

Asset Management

As identified in Council's flow chart above, asset management is also a challenge with regards to climate change. There will likely be a significant demand to upgrade and/or retrofit infrastructure to provide for climate change impacts, in addition to which there are challenges associated with the ongoing provision of services or infrastructure in locations identified as being highly vulnerable to climate change impacts.

A number of assets are owned and operated by Council and there is a need to consider in the first instance, whether existing assets should be upgraded, relocated or abandoned as resources become available. As previously identified by Council, this will likely require a more detailed assessment as to where and how assets are likely to be impacted by climate change, which will permit the development of an asset management strategy. In addition, it is anticipated that of such a strategy would be at considerable expense to Council and there may be need for support from the State and Federal Governments. Furthermore, it is understood that there is at present a lack of direction from other organisations that provide asset services in the study area as to how they intend to manage the impacts of climate change on their assets.

This Estuary Management Study does not directly address the issue of asset management; rather, it provides Council with some tools that may used as a starting point to consider the general vulnerability of assets to sea level rise.

Regional and Local Environmental Planning

To some extent, sea level rise is also addressed through the local and regional environmental planning process.

The NSW DoP has provided some guidance to Councils, State agencies and proponents as to how sea level rise should be addressed in the land use planning and development assessment processes through the *NSW Coastal Planning Guideline* (DoP, 2010). The guideline adopts six principles for sea level rise adaptation:

1. Asses and evaluate coastal risks taking into account the NSW sea level rise planning benchmarks.
2. Advise the public of coastal risks to ensure that informed land use planning and development decision-making can occur.
3. Avoid intensifying land use in coastal risk areas through appropriate strategic and land use planning.
4. Consider option to reduce land use intensity in coastal risk areas where feasible.
5. Minimise the exposure the coastal risks from proposed development in coastal areas.
6. Implement appropriate responses and adaptation strategies, with consideration for the environmental, social and economic impacts of each option.

As outlined above, Council has initiated as early as 2009 the first two of these steps in relation to their Sea Level Rise Planning Level. In addition, further work to assess risk from sea level rise is currently being addressed for Brisbane Water through the development of the FRMS&P. The FRMS&P is developing recommendations related to the management of flood risk associated with ocean storms under climate change scenarios. Some of these recommendations will also have benefits with regards to reducing the risk associated with increased tidal levels. However, it should be noted that recommendations relating to reducing risk in flood affected areas often relates to reduced development density. These recommendations and the principles adopted in the *NSW Coastal Planning Guideline* (DoP, 2010) may conflict with other State Government planning strategies. For example, the *Central Coast Regional Strategy* (DoP2008; **Section 3.2.2**), which identifies Woy Woy as being a Town Centre and a location for intensification of development in order to provide additional residential dwellings. Targeting of Woy Woy for land use intensification could be considered inconsistent with the principles of floodplain risk management and the principles adopted in the guideline (see above; DoP, 2010).

Furthermore, it is noted that the focus of many of the planning guidelines is on strategic land use planning and there is a current lack of both direction and funding from both the State and Federal Governments as to how to deal with existing development that will be affected by sea level rise.

There are difficulties in applying the sea level rise planning benchmarks when assessing development applications in areas known to be affected by hazard from climate change (i.e. “investigation areas” as per DoP, 2010), particularly in relation to the proposed life of the development and whether it will be affected by sea level rise during that period of time. Most developments are intended to have a design life of approximately 50 years, although it is not uncommon that the subject development would be in use for a number of years beyond this time frame, and determining authorities may be limited in their ability to refuse a development on this basis. At the same time, there is some concern in relation to Council’s potential exposure to future liability in the event that a development application approved by Council becomes affected by sea level rise in the future. The extent to which climate change

considerations can be applied in the determination of development proposals has recently been tested in the NSW Land and Environment Court. There is a need for the development of innovative development controls and planning mechanisms to manage the development of land vulnerable to climate change impacts, such as voluntary / compulsory foreshore land ownership transfer to public land, rolling easements and limited duration development consents may need to be considered by Council.

Some planning aspects relating to sea level rise are currently being addressed for the Gosford LGA through the preparation of the Draft DCP (**Section 3.2.3**). Additional or modifications to planning controls may also be proposed for incorporation into the DCP by the FRMS&P. Some modifications to the local environmental planning instruments have also been proposed as options in this Estuary Management Study (**Section 8**), although these typically relate to the preservation or conservation of ecological attributes or public open space areas.

5 Estuary Values and Significance

5.1 Overview

The following sections discuss the values and significance of the Brisbane Water estuary in the context of:

- Cultural values and significance;
- Recreational values and significance;
- Commercial values and significance; and
- Ecological values and significance.

Aesthetic, recreational, commercial, ecological and heritage-based attributes of the Brisbane Water Estuary are of significance and are valued at a local, regional or national level. Historically, the following elements were identified to contribute to the amenity of Brisbane Water (GCC, 1995):

- The attractiveness of both built and natural landscapes, both from on-shore and off-shore viewpoints;
- Varied opportunities for recreation including boating, fishing, nature walking and sightseeing;
- Access to the waterway and surrounding shorelines;
- Opportunities for general recreation and education activities; and
- The natural ecosystem of the estuary.

A community survey was carried out to establish the current view on which attributes of Brisbane Water are most valued (**Section 2.3.4**). The results have been collated and are presented in **Section 5.6**.

5.2 Cultural Values and Significance

The Brisbane Water Estuary and foreshores are utilised by a number of human user-groups for a wide and varied range of activities (**Table 4.2**).

5.2.1 Aboriginal Cultural Values

The greater Gosford area has traditionally been inhabited by the Kuringai (Gurringa) and Darkinjung tribes, and relevant Aboriginal groups today include the Gurringa people and the Darkinjung Local Aboriginal Land Council.

A number of Aboriginal heritage sites and places of significance are located within the Brisbane Water estuary and foreshore areas. The areas of Pretty Beach and Daleys Point have the highest concentration of known sites, and Kariong, Woy Woy and Cockle Broadwater also have high numbers of sites. Cardno (2008a) reported that 274 known Aboriginal heritage sites exist within Brisbane Water and the surrounding catchments and mostly consist of rock engravings, middens or shelters with middens.

Two places of significance to Aboriginal people are listed on the Register of the National Estate:

- Daleys Point Area; and
- Staples Lookout.

All Aboriginal sites are protected under the *National Parks and Wildlife* Act 1974 and therefore any proposed impacts on Aboriginal sites must be incorporated into the management of the estuary. Known Aboriginal sites should be left undisturbed where possible. If destruction of an Aboriginal heritage item is proposed, "due diligence" with regard to Aboriginal heritage in the area must be shown in conjunction with approval from DECCW (in the form of a Section 90 Consent to Destroy permit and possibly a precursory Section 87 Preliminary Research permit). In addition to existing heritage sites, the possibility of uncovering any as yet undiscovered Aboriginal heritage items must be incorporated into the management of the estuary.

5.2.2 Non-Aboriginal Cultural Values

Early explorations by European settlers occurred in the Brisbane Water area after 1788 and by 1840, the shores were being intensively settled by Europeans.

A total of some 170 non-Aboriginal heritage sites are listed in the Gosford LEP with 83 in the immediate vicinity of Brisbane Water and its surrounding suburbs. These are summarised in HLA Envirosciences (2005) and include 11 terrestrial heritage items located on the estuary foreshores, five terrestrial heritage places, 10 marine heritage items and two heritage items listed on the Register of the National Estate.

The Brisbane Water estuary and foreshores have particularly high scenic value and include areas of pristine vegetation and extensive views of the water from a number of locations. Beaches, inlets and bays can be distinguished in the foreground with inherent juxtaposition of bushland-covered hills in the distance. Access to existing key vantage points allows for the public to experience the landscape character of the Brisbane Water estuary and its surrounds.

The Brisbane Water and Bouddi National Parks provide opportunities for education and research by organisations such as schools and universities. Opportunities for research by qualified specialists are more limited, particularly on Pelican and Rileys Island Nature Reserves.

5.3 Recreational Values and Significance

Recreational users of the Brisbane Water foreshore can be categorised as either active users (those who require a vehicle, equipment or watercraft for their activity) or passive users (those users not requiring a watercraft, vessel or specialised equipment). A survey carried out by Integrated Open Space Services and detailed in KBR (2005) found that the majority of activities conducted in parks are passive.

People living in close proximity to the estuary are able to access the estuary and foreshores on a regular basis. The areas in which the public can best gain access to the foreshore occur between Ettalong Beach and Woy Woy, within Woy Woy Bay, between Koolewong and Tascott, between Point Clare and West Gosford, and at Yattalunga, Saratoga and Killcare (Cardno, 2008a).

The estuary and foreshores are important for local recreation clubs such as Gosford, Saratoga and Woy Woy Sailing Clubs, Gosford Water Ski Club and Woy Woy Sea Scouts which hold activities on a regular basis, particularly on weekends and during the summer.

There are two National Parks that exist within close proximity to the Brisbane Water Estuary, namely Brisbane Water National Park, which covers an area of 11,473 hectares between Gosford City and the Hawkesbury River, and Bouddi National Park which stretches from Macmasters Beach to Box Head and Wagstaffe Point. These nationally recognised areas have significant recreation value and include facilities for bushwalking, picnicking, camping, fishing and swimming.

5.4 Commercial Values and Significance

Commercial activities operating in the area are important for local people requiring goods and services such as food, fishing bait, boat maintenance or local water-based transport.

The oyster industry is an important part of the local economy. In terms of Sydney Rock Oyster production, in 2007/2008 a total of ~250,000 dozens of oysters were produced in the Brisbane Water estuary, with a total value of $1.3 million representing approximately 3.6% of the NSW industry total for 2007/2008 (Wiseman, 2009). In comparison, in 2004/2005, the production was more than double at ~520,000 dozens and the current production is a result of the system recovering after a QX outbreak.

Commercial fishing is an activity that can occur within Brisbane Water. As part of the Estuary General Fishery, commercial fishers within Brisbane Water can use hand lining, hand gathering, a dip net (for prawns only), and a landing net when used ancillary to handline fishing. No other forms of commercial fishing can occur within Brisbane Water.

The Brisbane Water estuary and foreshore areas provide an attractive destination for tourists. The relative proximity of the estuary to Sydney contributes to this, as Sydney residents wishing to travel only an hour or two north for a short break can access the estuary with relative ease and enjoy a range of activities. Examples of tourist activity include fishing charter, ferry trips, private vessel trips and kayak tours. The average annual value of tourism to the whole Gosford LGA is ~$456 million/year and supports approximately 3750 businesses (Tourism Research Australia, 2007). Major events such as fishing tournaments (e.g. the Bream Classic) and sailing/boat racing events also periodically occur. The Brisbane Water Oyster Festival, held in November each year, showcases produce from local oyster leases and attracts people from other areas in NSW and beyond.

5.5 Ecological Values and Significance

The Brisbane Water estuary represents the interface between a range of different environments, namely marine and freshwater, and terrestrial and aquatic. The natural environment is representative of the coastal morphology and biodiversity of the area, including the nearby national parks which are significant on a national level. Varied natural habitats range from terrestrial habitats (bushland), to intertidal habitats (wetlands / saltmarsh, Casuarina forest, mangroves, mudflats and rock platforms) and aquatic habitats (seagrass beds, submerged rock platforms and sandy or muddy estuarine beds). Although large portions of Brisbane Water have been largely modified by urban encroachment, it remains an area of considerable biodiversity.

5.5.1 Ecological Communities

Mangrove, seagrass and saltmarsh communities are particularly complex habitats and are of significance to local estuary processes and fauna species. **Table 5.1** summarises the key ecological significance of these estuarine communities.

Table 5.1: The Ecological Significance of Mangrove, Saltmarsh and Seagrass Habitats (After Cardno, 2008a)

Mangroves	Saltmarsh	Seagrass
Assist sediment accretion / trapping	Trap and bind sediments in the process of land progradation.	Stabilise sediments
Major source of primary productivity in coastal environments	Generate primary productivity and are a support resource for estuarine food webs, particularly for juvenile fish and crustaceans.	Generate high levels of primary productivity
Provide shoreline protection from storms and waves	Provide coastal protection from storm erosion and extreme tides.	Influence the immediate physical environment
Assist nutrient cycling	Mediate a balance of nutrients and organic matter between saltmarsh and other interacting estuarine ecosystems.	Assist nutrient cycling
Act as a buffer for water quality		Provide food and shelter for aquatic organisms
Provide important nursery habitat for many marine species, including fish and prawn species		Act as a nursery ground for numerous estuarine and marine species
Act as an indicator for monitoring change in coastal environments		Often act as a suitable indicator of ecological health
Act as a sink for atmospheric carbon (and help to mitigate climate change)		

Coastal Saltmarsh is listed as an endangered Ecological Community under the NSW *Threatened Species Conservation* Act 1995.

5.5.2 Flora and Fauna

The Brisbane Water Estuary and foreshores comprises a wide range of native flora and fauna, including a number of threatened species that are important on a state and national level.

Within the Brisbane Water estuary area, two species of bird are listed as endangered under the NSW *Threatened Species Conservation* Act 1995 (the Bush Stone-curlew (*Burhinus grallarius*) and the Little Tern (*Sterna albifrons*)), whilst nine species of bird are listed as vulnerable (Robinson, 2006).

On a national scale, there are 43 flora and fauna species listed under the Commonwealth EPBC Act (for a 100 km^2 area including the Brisbane Water Estuary), which includes 13 bird species, nine mammal species and eight plant species.

At an international level, the Brisbane Water estuary provides habitat for a range of migratory birds which come under bilateral and multilateral agreements such as JAMBA, CAMBA, ROKAMBA and the East Asian-Australasian Flyway Partnership. The estuary provides habitat for 26 JAMBA and 24 CAMBA listed species (Robinson, 2006).

5.5.3 National Parks and Nature Reserves

In the vicinity of the Brisbane Water estuary are two national parks (**Section 5.3**), the Bouddi and Brisbane Water National Parks, and the Pelican Island, Rileys Island, Saratoga Island and Cockle Bay Nature Reserves. Two of these four nature reserves are listed on the Register of the National Estate (Pelican Island and Rileys Island). These nature reserves are in a predominately natural condition and are considered to have high conservation value (DECC, 2008).

The primary purposes of nature reserves are the conservation of wildlife, natural and cultural environments, and environmental education, including scientific research. All of the reserves contain habitats which are sensitive to disturbance from inappropriate use, and so recreational opportunities on these reserves are very limited (NPWS, 2009). Cockle Bay and the Island Nature Reserves (as they are collectively known) play a significant role in the preservation of endangered ecological communities, seagrass beds, intertidal mudflats and extensive feeding and roosting habitats for large number of wading birds, several of which are protected under international agreements (NPWS, 2009). These Nature Reserves also comprise wetlands listed under SEPP 14 (Coastal Wetlands).

5.6 Community Values Survey

As part of the consultation process for the Brisbane Water Management Study, a community survey was undertaken as part of the Issues and Objectives Workshop (**Section 2.3.3**).

5.6.1 Survey Methodology

Five groupings of key attributes of the Brisbane Water estuary were identified:

- Recreation, access and amenity,
- Private and public property (relating to both assets and foreshore protection as well as public access),
- The natural environment (including heritage),
- Transport, and
- Commercial uses of the estuary.

Within each of these five key attributes, a number of different qualities or features of the attribute were identified and respondents were asked whether they considered each quality or feature as having high importance, medium importance or low importance. Each of the five estuary attributes is shown in **Tables 5.2 - 5.5** with their corresponding qualities or features.

The left-hand column of **Tables 5.2 - 5.5** show the question number from the feedback form, while the right-hand column details the attribute for which respondents were asked to provide a rank of high, medium or low importance depending upon how they valued that quality/feature.

Data from returned Brisbane Water community consultation feedback forms were collated and used to produce graphs (**Figures 5.1 to 5.5**) to show how the community values different features of the estuary.

The full community feedback form is provided in **Appendix B3**.

5.6.2 Results and Discussion

A total of 80 (out of a total 85) survey respondents provided ratings for each of these estuary attributes. The respondents were residents living around the estuary and represented a wide range of locations including Davistown, Empire Bay, Hardys Bay, Horsfield Bay, Koolewong, Point Clare, Saratoga, St Huberts Island and Woy Woy.

Recreation, Access and Amenity

Table 5.2: Community Survey Questions – Recreation, Access and Amenity

Attribute	Details
1. Recreation, access and amenity	
1.01	Foreshore public facilities (e.g. public toilets, pathways, picnic/BBQ areas, etc.)
1.02	Public access (to parks, walking tracks etc.)
1.03	Water quality suitable for recreational purposes, such as fishing, swimming or boating.
1.04	Passive recreational use opportunities within open spaces near the water (e.g. walking or picnicking).
1.05	Active recreational use opportunities for open spaces near the water (e.g. cycling or fishing).
1.06	Safe use of the waterways by residents and visitors (e.g. observing boating speed limits and through maintenance of navigation channels).
1.07	Harmony between recreational users, commercial users and conservation of ecological values.

Out of the different qualities/features relating to recreation, access and amenity (**Table 5.2**), the strongest and most consistent response was in relation to water quality (suitable for recreational purposes), which was ranked as having high importance by 88% of respondents (**Figure 5.1**). Safe usage of the waterways and harmonious use of the estuary by different user groups (and for ecological purposes) were also a high priority for respondents, with roughly 76% and 67% respectively of respondents ranking these features as being of high importance (**Figure 5.1**). More moderate, mixed responses were received for the other questions relating to recreation, access and amenity.

From these results, it seems likely that the respondents to this survey engage in recreational activities in the estuary and foreshores on a fairly regular basis and have high regard for the recreational value of the area. Water quality for recreational purposes also encompasses water quality for human health and for aesthetic reasons. Recreational usage of waterways is likely to be lower in areas of poor water quality due to the health implications that can arise from the utilisation of water which is not of a suitable recreational quality. Similarly, recreational usage of waterways is likely to be lower in areas with lower aesthetic value – a waterway that is pristine is more likely to receive patronage than one that is polluted and unsightly.

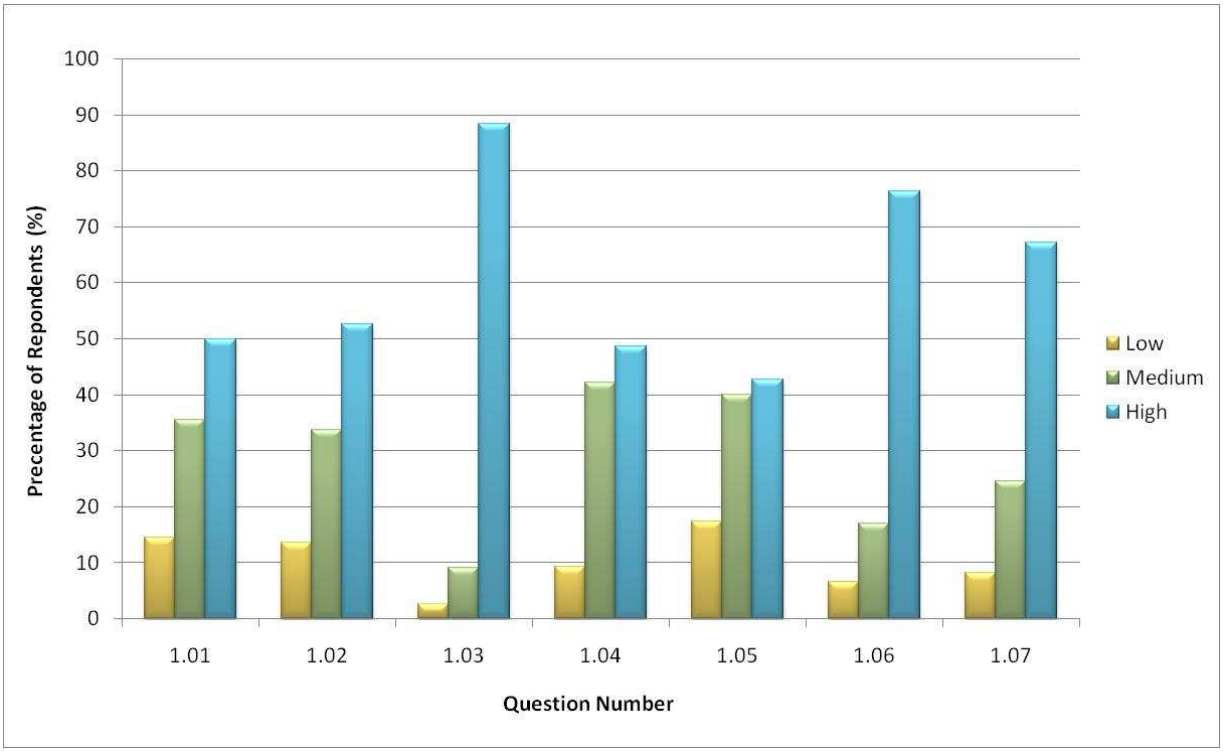


Figure 5.1: Community Values - Recreation, Access and Amenity

Cardno (2008a) suggests that water quality of the estuary is an issue at times, particularly with respect to nutrient and sediment inputs. While water quality is currently considered of a suitable standard suitable for recreational purposes, water quality monitoring and management should continue so that public health and safely can be maintained into the future (Cardno, 2008a).

Safe use of the estuary also relates to potential conflict between different user groups and how this conflict can be managed. Cardno (2008a) mentions that, due to the differing sizes and speeds of vessels using the estuary at any one point in time, conflicts and safety issues have the potential to arise.

Public and Private Property

Four different features/qualities were identified with respect to the attribute relating to public and private property (**Table 5.3**). Several of these features/qualities also relate to recreational amenity and access, while question 2.04 relates to protection of foreshore assets. The results for the series of questions relating to public and private property are shown in **Figure 5.2**.

Table 5.3: Community Survey Questions – Public and Private Property

Attribute	Details
2. Private and public property	
2.01	Boating facilities such as boat ramps, moorings and dinghy storage areas.
2.02	Pleasant views of Brisbane Water and foreshores.
2.03	Protecting public and private property in relation to wave inundation, flooding, erosion and/or sea level rise (e.g. via seawalls or flood control works).
2.04	Access to the foreshores and waterways from your property.

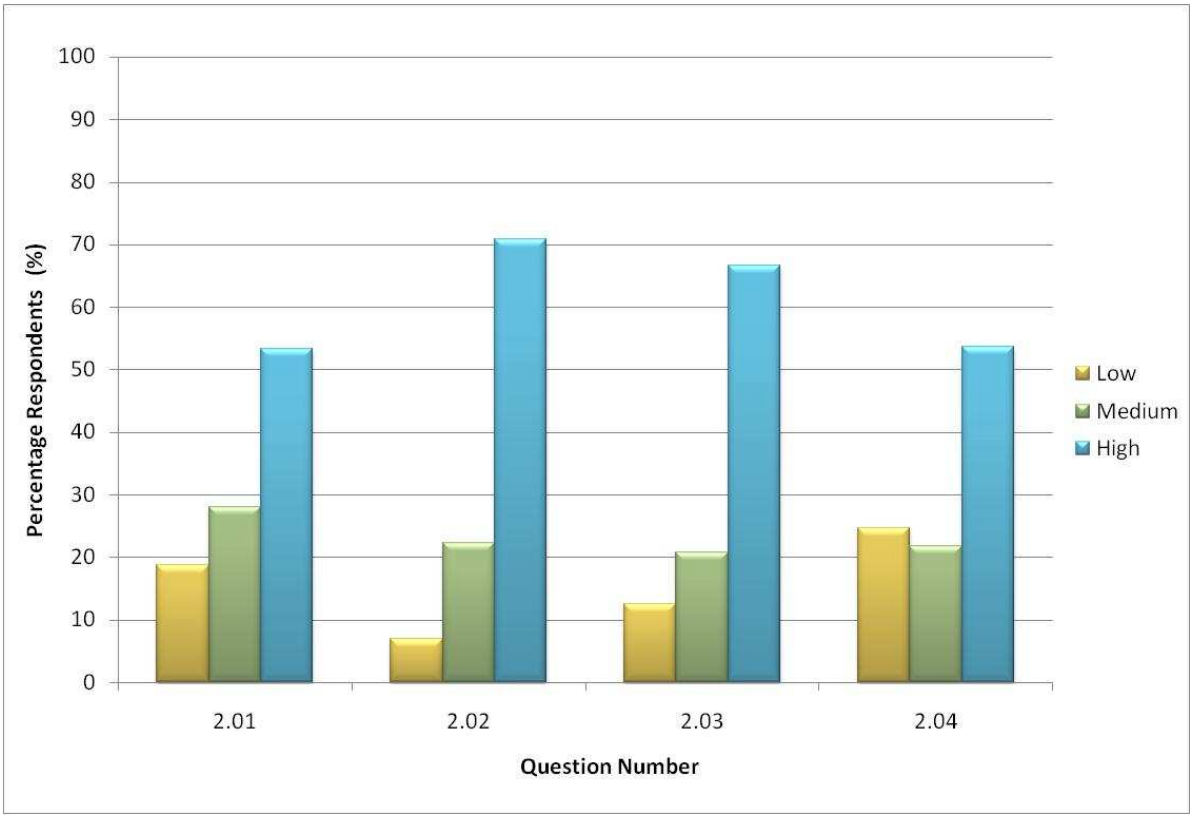


Figure 5.2: Community Values - Private and Public Property

The feature or quality scoring the highest percentage of high importance related to views of Brisbane Water and its foreshores (question 2.02), with 71% of respondents rating this feature as having high importance (**Figure 5.2**). It is noted that visual amenity has

increasingly become an issue throughout NSW as it relates to the impact of foreshore or waterway developments, and it is likely that the maintenance of the visual character of the Brisbane Water estuary and its foreshores will become increasingly important if the estuary is subjected to increasing development pressures.

The second highest rating feature was protection of foreshore infrastructure from coastal processes (question 2.03), with 67% rating this feature or requirement as being of high importance (**Figure 5.2**). With regard to the protection of public and private property, Cardno (2008a) outlines key "hot spots" where shoreline dynamics are affecting property through erosion and sedimentation, namely St Huberts Island, Hardys Bay, Ettalong foreshore and Correa Bay.

The Natural Environment

Four different features/qualities were identified with respect to the ecological aspects of the natural environment, with the final question relating to heritage (**Table 5.4**). Two of the questions related to water quality (3.01 and 3.04) and two questions related to flora and fauna (3.02 and 3.03). The results for the series of questions relating to the natural environment are shown in **Figure 5.3**.

Table 5.4: Community Survey Questions – The Natural Environment

Attribute	Details
3. The natural environment	
3.01	Water quality suitable for environmental conservation and aquatic health.
3.02	Native animals (e.g. birds, fish etc.)
3.03	Natural vegetation (e.g. saltmarshes) as habitat for animals.
3.04	Managing pollution and sedimentation associated with creeks and stormwater outlets.
3.05	European and Aboriginal heritage sites near or in the waterways.

Water quality was found to be a high priority for respondents, with 89% of respondents rating concerns relating to stormwater quality as having high importance, and 85% of respondents rating water quality for aquatic ecosystem health as having high importance (**Figure 5.3**). Furthermore, only 4% of respondents ranked stormwater quality as being low importance and no respondents ranked water quality for ecosystem health as having low importance. Taken in conjunction with the response to question 1.03 (**Figure 5.1**), it is apparent that water quality is of a primary importance for many local residents.

Responses relating to estuarine fauna and flora (questions 3.02 and 3.03) were more moderate, with 75% and 61% of respondents ranking these features/qualities as having high importance respectively (**Figure 5.3**).

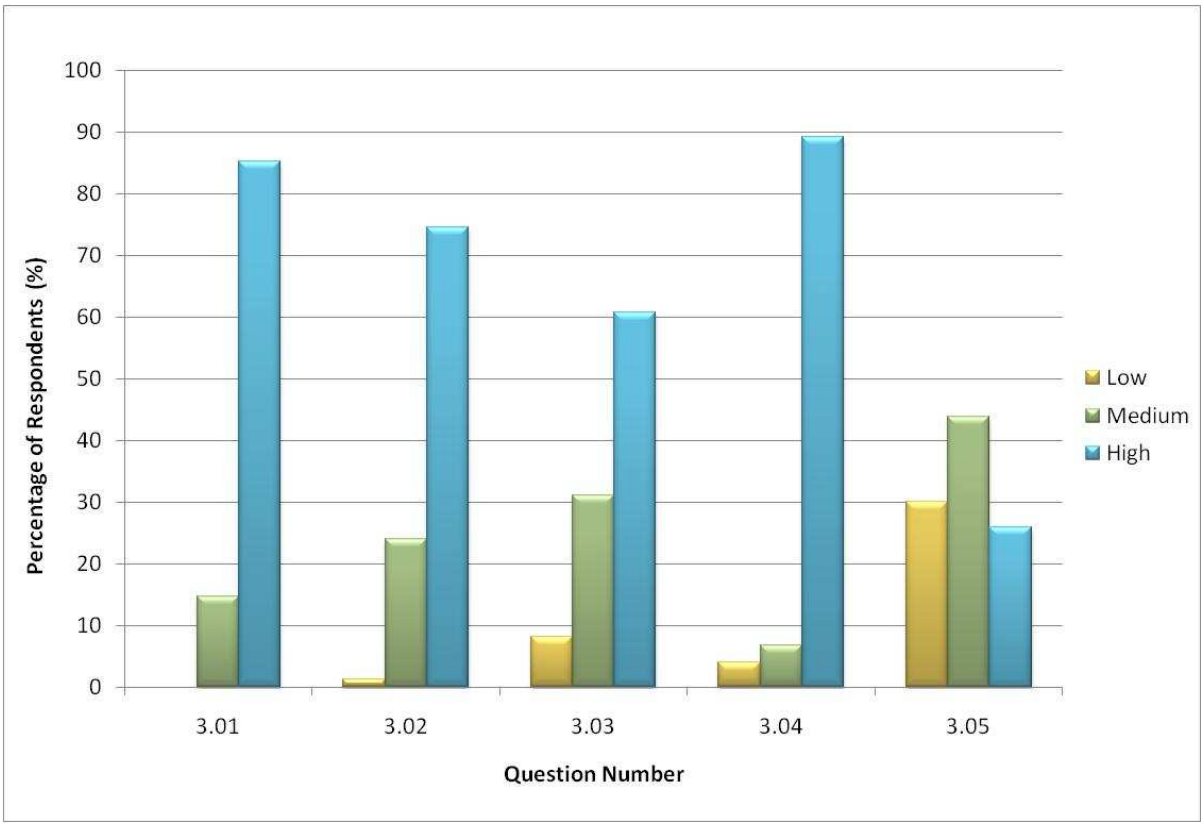


Figure 5.3: Community Values - The Natural Environment

Interestingly, the responses to the question relating to Indigenous and non-Indigenous heritage (question 3.05) were very moderate, with 26% rating this feature as having high importance, 43% rating it as having medium importance and 30% rating it as having low importance (**Figure 5.3**). This may be due to a lack of awareness within the community of the existence of such heritage items and sites in the Brisbane Water Estuary and along its foreshores and suggests that there is opportunity to promote the heritage values of estuary.

Transport, Commercial Activities and Tourism

One different feature/quality was identified with respect to transport and four different features/qualities were identified with respect to commercial activities and tourism (**Table 5.5**). Responses to those questions relating to both transport (question 4.01) and commercial activities and tourism (questions 5.01 to 5.04) have been presented together in **Figure 5.4**.

Table 5.5: Community Survey Questions – Transport / Commercial Activities and Tourism

Attribute	Details
4. Transport	
4.01	Using the waterways as a regular transport link.
5. Commercial activities and tourism	
5.01	Oyster leases as a local commercial activity.
5.02	Tour operators and vessels promoting tourism.
5.03	Transport operators and vessels providing public transport.
5.04	Foreshore businesses (e.g. marinas, restaurants, cafes, watercraft hire, slipway services, etc.)

Use of the waterways as a transport link (question 4.01) was important to some local residents, with 56% of respondents rating this feature as having high importance (**Figure 5.4**). It is noted that this is likely to be more important to some residents than others, with those areas located on the eastern margins of the estuary being generally more isolated that those on the western margins and to the north. Several residents noted that they were dependent upon local ferries for transport to and from work or school.

Generally speaking, there were quite mixed responses to those questions relating to commercial usage of the estuary. As identified above in relation to question 4.01, 60% of respondents ranked the provision of public transport by commercial operators as being of high importance (**Figure 5.4**). This suggests that the potential for further development of public transport on the waterway would be generally well received. Otherwise, the responses relating to other commercial activities including oyster aquaculture (question 5.01); tourism (question 5.02) and foreshore-based activities (question 5.4) were more mixed. In general, development of the estuary is a somewhat contentious issue.

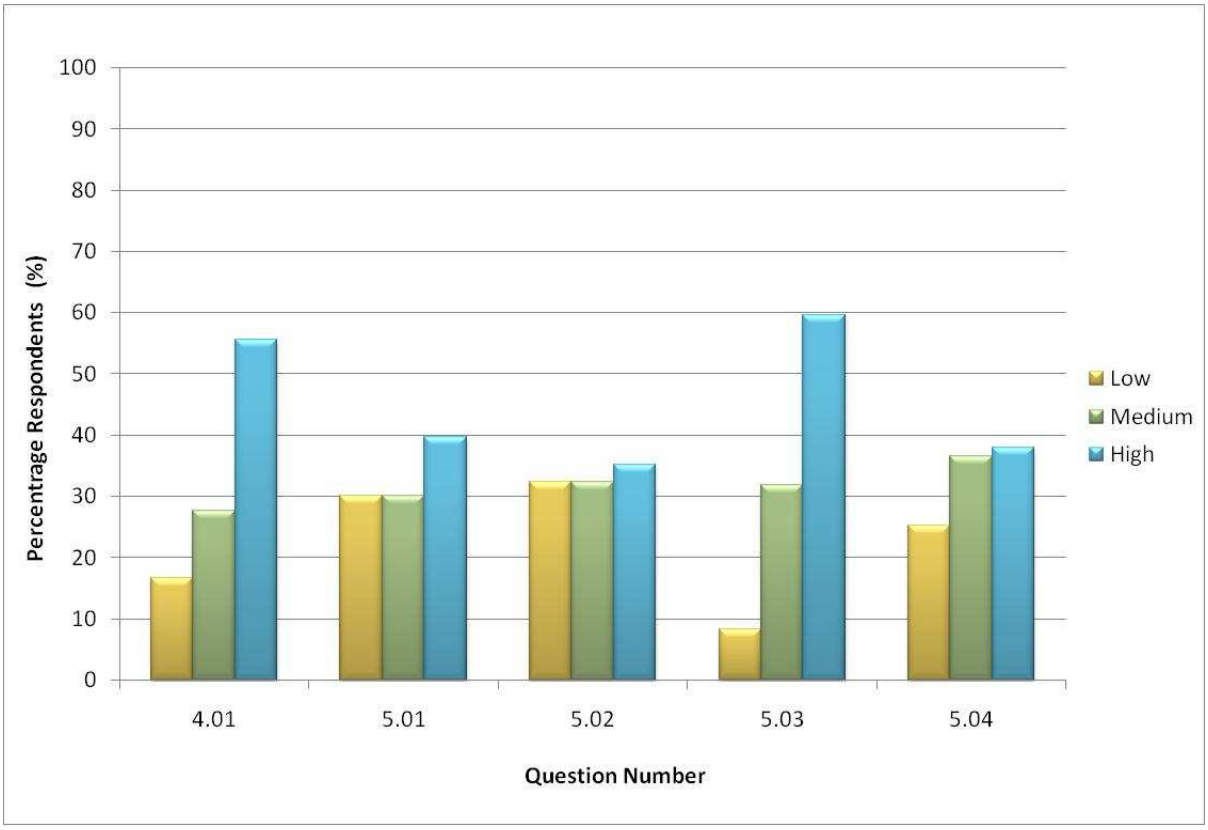


Figure 5.4: Community Values - Transport, Commercial Activities and Tourism

5.6.3 Summary

In order to directly compare the range of different features/qualities identified in the survey, a figure has been prepared showing the percentage of respondents who ranked each quality/feature as having high importance (**Figure 5.5**). The percentage responses ranked medium and low importance have been omitted for ease of interpretation.

Overall, the top three estuary features in terms of high importance ratings were:

- Water quality for recreational purposes (question 1.03),
- Managing pollution and sedimentation associated with creeks and stormwater outlets (question 3.04), and
- Water quality suitable for environmental conservation and aquatic health (question 3.01).

This suggests that the most valued estuary features relate to recreation and to the natural environment. Heritage items and commercial activities (e.g. tourism, oyster leases and foreshore businesses) were generally given lower ratings overall.

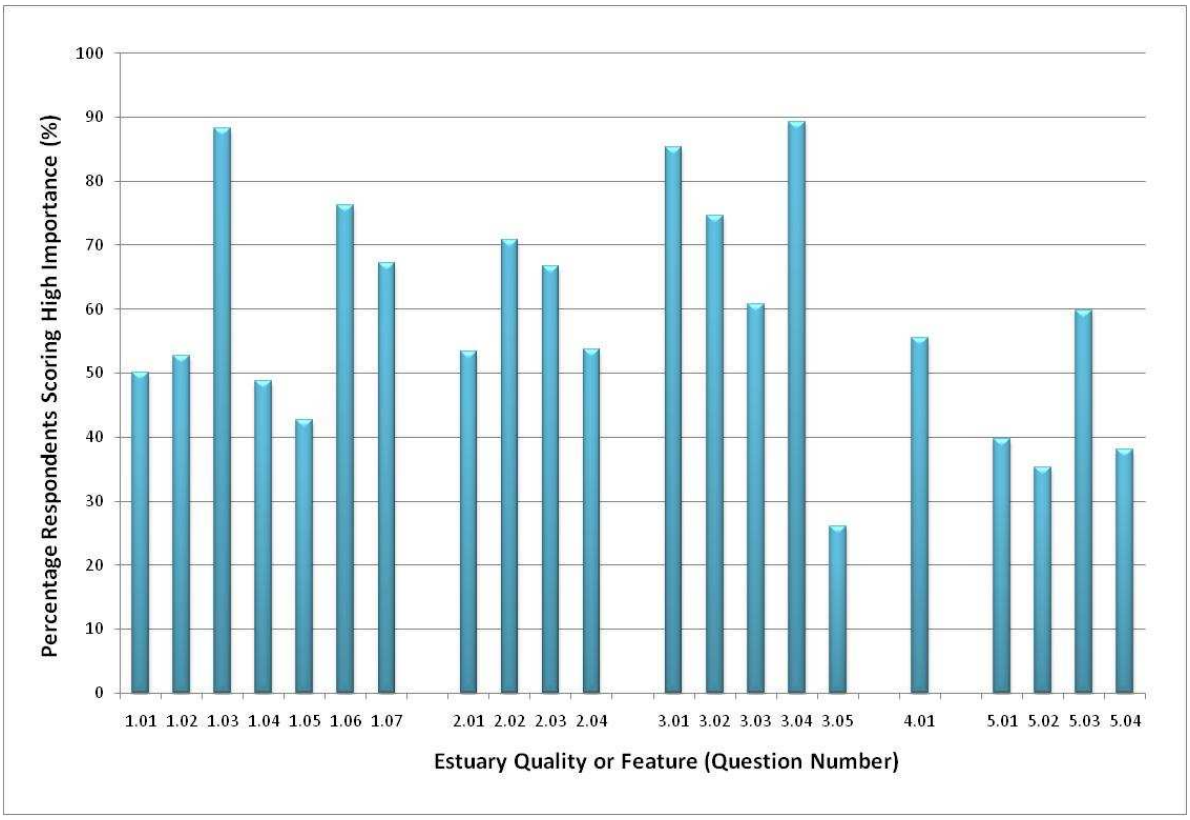


Figure 5.5: Comparison of High Importance Ratings for all Questions

It is important to note that this survey only gives an indication of the community's rankings of estuary features based on a limited sample size. It is likely that those individuals most interested in the management of Brisbane Water estuary and foreshores were more likely to respond than those individuals who were not interested. However, it is considered that the survey is useful in identifying those features of the estuary that are likely to be most important to the community. In addition, the survey results highlight areas in which more education and/or promotion of certain features may be useful (e.g. heritage), or where a cautious approach to management may be more appropriate (e.g. development).

5.7 Summary of Values and Significance

A summary of the local, regional, national and international significance of the Brisbane Water Estuary and values identified by the community is given in **Table 5.6**.

Table 5.6: Significance and Values of the Brisbane Water Estuary

Scale	Significance	Values
Human Usage		
Local	› Significance for the Gurringa Aboriginal people and the Darkinjung LALC, including Aboriginal heritage items; › Extensive usage of the estuary and foreshores by local people on a regular basis; › Place for activities for various water based clubs and organisations; › A range of non-Aboriginal heritage items which exist in the area; and › Mangroves, seagrasses and saltmarsh are associated with high rates of diversity and abundance of fish, birds and invertebrate fauna.	› Estuary water quality for the purposes of recreation; › Access to the estuary; › Safe use of the waterways and minimisation of user-group conflicts on the estuary; › Visual character and aesthetics, such as controlled, uncluttered and appropriate waterfront and foreshore development; › Minimisation of the impacts of natural processes (such as wave inundation, flooding, erosion and sea level rise); and › Transport operators and vessels providing public transport for use on a regular basis. › Managing pollution and sedimentation associated with creeks and stormwater outlets; › Water quality suitable for environmental conservation and aquatic health; › Native fauna species and biodiversity conservation; and › Estuarine habitat conservation (e.g. saltmarsh, mangroves and seagrass).
Regional	› Attractive destination for tourists, e.g. from Sydney; › The annual Brisbane Water Oyster Festival attracts people from other areas in NSW; and › Regionally significant fauna species include the Brahiminy Kite (*Haliastur indus*), the Mangrove Greygone (*Greygone levigaster*) and the Brown Honeyeater (*Lichmera indistincta*) (Robinson, 2006).	
National	› National Parks located in the vicinity include Brisbane Water National Park and Bouddi National Park; › Pelican Island and Rileys Island Nature Reserves are listed on the Register of the National Estate; and › 43 flora and fauna species are listed under the Commonwealth EPBC Act.	
International	› Endangered species are listed under bilateral and multilateral agreements (e.g. JAMBA and CAMBA).	

6 Management Issues

In addition to characterising the general values and significance associated with the Brisbane Water estuary, a range of management issues were identified.

6.1 Issue Identification

Management issues associated with the Brisbane Water Estuary were identified through both the program of consultation conducted during the development of the Study (refer to **Section 2**) and the preparation of the technical studies comprising the Estuary Processes Study (Cardno, 2008a).The issues identified covered a range of different aspects of the estuary including water quality issues, conflicts between different recreational users, navigational issues, erosion and sedimentation of the waterway, loss of riparian/foreshore vegetation, weeds, limited access to the foreshore and a lack of (or poor maintenance of) recreational facilities.

The full list of management issues identified is provided in **Appendix E**. A number of these issues were mapped to a specific location by community members in attendance at the Issues and Objectives Workshop (4 April 2009). Where possible, specific issues have been mapped to a particular location and the resultant maps have also been provided in **Appendix E**. To aid interpretation of the management issues identified, the mapping incorporates recent bathymetric survey for the estuary.

A total of 252 management issues were identified. An effort has been made to assign a ranking to high, medium or low importance on the basis of:

- The frequency with which that specific management issue occurs,
- The consequences associated with that issue (e.g. for estuarine ecology or human health/safety), and
- The spatial extent of the issue and/or the number of users affected by that issue.

Most of the issues were allocated a ranking of low or medium importance due to the limited scale of the issue. However, there were also a number of management issues identified that were considered to have a high level of importance because these issues impact on a large number of user groups and can have significant consequences. It is interesting to note that several issues recur at different locations throughout the estuary.

It is noted that many of the management issues outlined in **Appendix E** were identified by members of the community and are issues that they perceive to be occurring. The issues identified do not necessarily reflect the views of the Cardno study team, Council or DECCW. In many cases, further investigation may be warranted to verify the validity of the claims made.

Some of the identified management issues for the Brisbane Water estuary are discussed in more detail in **Sections 6.1.2-6.1.5**.

6.2 User-Group and Land Use Conflict

The variety of human uses of the estuary has resulted in a high potential for conflicts between user groups. These conflicts relate to differences in land use and enjoyment of the foreshore and waterways, as well as the degradation of the natural environment (KBR, 2005). In particular, recreational usage of the estuary peaks on weekends and over the summer period, and it is during these periods that the most pressure is placed on existing facilities and potential for conflict among users can increase. High population growth and tourism can further exacerbate these conflicts.

The conflicts between land use, recreational and commercial activities and the natural environment necessitate the implementation of specific management actions so that the values of the estuary and foreshores can be maintained. A practical way to manage the risk of conflict between users, as well as negative environmental impacts, is by partitioning of activities into designated areas. Zoned areas for different user groups within the estuary which incorporate the protection of environmentally sensitive areas could prove to be the best option.

At present 35% of the foreshore of Brisbane Water Estuary is held in public reserves, National Parks and Nature Reserves and the remaining 65% is privately owned/managed (Cardno, 2008a). It is understood that regulation of foreshore development has been a challenge and that many un-regulated activities have occurred, with associated impacts on recreational and commercial activities (such as through limiting foreshore access in many locations). Impacts on the visual character of the area are also associated with uncontrolled foreshore development. Future growth and development in the Gosford region will be focusing on existing medium density residential areas, and in particular, on revitalising the Gosford CBD (**Section 3.2.1**).

6.3 Land Use Conflict

There are a number of ways in which the use of the Brisbane Water estuary and foreshores by humans can conflict with the natural ecological processes that currently occur there. Mangroves, seagrasses and saltmarsh habitats are associated with high rates of diversity and abundance of fish and invertebrate fauna, and conservation of such biodiversity is integral for not only preserving and maintaining ecological function, but is also important in a commercial context for the fishing, aquaculture and tourism industries.

Over 50% of the Brisbane Water estuary foreshore is adjacent to substantially developed catchments and is considered disturbed to highly disturbed; the main cause of loss of intertidal habitats is the construction of seawalls, jetties and piers (Sainty and Roberts, 2007). While these structures enhance amenity for individual residential properties, they provide poor habitat value and can impact on sediment dynamics which may consequently lead to degradation of saltmarsh and mangrove communities. Foreshore development should be regulated and carried out in a systematic fashion.

Recreational activities may also impact on the estuary. Activities with potential environmental impacts include dog walking, boating activities. In addition to simple loss of

habitat, disturbance can also result in declining water quality, declining vegetation cover, introduction of weeds, predation by introduced species or disturbance related to the presence of people, increased availability of mosquito breeding habitat, declining productivity and alterations to the assemblage structure for flora and fauna communities (Sainty and Roberts, 2007).

6.4 Climate Change

The implications of global climate change and sea level rise should be considered in the ongoing management of recreational and commercial activities in and around the Brisbane Water Estuary. The limited potential for foreshore recovery after storm attack in conjunction with the impacts of various recreational activities may result in a synergistic effect on the surrounding environment. High potential for shoreline recession in Brisbane Water Estuary must be incorporated in future planning to ensure that open space and associated recreational infrastructure are retained. Mitigation measures such as the reservation of additional open space may be required. The implications of global climate change and sea level rise should also be considered in the ongoing management and conservation of both Aboriginal and non-Aboriginal heritage sites and artefacts.

6.5 Ecological Impacts of Current Management Practices

The ecological impacts of Council's current management practices was also considered as part of this study, with input provided by specialists in the area of estuarine ecology from the University of Newcastle. This was undertaken primarily through a review of Council's existing Plans of Management for various sites and various activities around the estuary.

The full report is provided in **Appendix C** (Gladstone, 2009).

A total of 21 Plans of Management were identified as being relevant due to their applicability to lands falling within the Brisbane Water catchment (Gladstone, 2009). Many of these Plans of Management relate to highly localised sites and only two Plans have wider implications for the Brisbane Water estuary:

- The *Brisbane Water Plan of Management* (GCC, 1995), which will be superseded by this document, and
- The *Foreshore Parks Plan of Management* (GCC, 1996).

A review of the Plans of Management suggested that there were no instances where the activities outlined under the specific Plan would result in a negative ecological outcome for the estuary. Most of the Plans (17 of 21) were considered likely to result in positive ecological outcomes and the remainder (4 of 21) were considered to result in a net neutral impact on estuarine ecology (Gladstone, 2009). In most cases, the positive ecological impacts resulting from implementation of a Plan related to re-vegetation works, weeding, water quality and/or a reduction in sedimentation.

Additionally, it is noted that there exists opportunity to improve environmental outcomes resulting from these Plans of Management through further consideration of the

implementation methodologies. For example, more general practices, such as imposing limits on mowing to ensure vegetation conservation for both ecological purposes and in order to reduce sedimentation. Similarly, where structural works such as seawalls are proposed, there are opportunities to incorporate environmentally friendly features, e.g. in accordance with the Environmentally Friendly Seawalls guidelines (SMCMA and DECC, 2009).

However, one feature that was identified as being lacking was identification of the relationship between the Plan of Management and an overarching Council policy or strategy relating to ESD or natural resource management and, therefore, it was considered unclear how the management of these local issues integrated with Council's broad aims and objectives for the management of the Brisbane Water estuary (Gladstone, 2009).

7 Management Objectives and Goals

This section of the Management Study introduces the management objectives and goals for the Brisbane Water estuary. The development of the objectives and goals has been informed by understanding:

- Consultation outcomes (**Section 2**);
- The regulatory and management context (**Section 3**);
- The processes occurring within the estuary (**Section 4**);
- The values and significance of the estuary (**Section 5**); and
- The issues facing the estuary (**Section 6**).

The management goals and objectives constitute the framework of the Management Plan and any options considered in this study or activities proposed as part of the Plan should address these goals and objectives.

7.1 Vision for Brisbane Water Estuary

The vision for the future of the Brisbane Water estuary is:

"To seek to preserve those physical, ecological and social features and uses of Brisbane Water Estuary that are valued by the community, by maintaining and improving (where possible) the estuary condition through the application of sustainable and adaptive management."

This vision seeks to encapsulate the feedback provided from the community and the Committee during the course of the consultation for this Study.

The purpose of the vision statement is to present an overarching aspirational goal for the estuary.

7.2 Overarching Management Objectives

The overarching management objectives of the Brisbane Water Estuary Management Study and the subsequent Plan are as follows:

- To provide a strategic framework for the future management of the Brisbane Water Estuary, now and into the future.
- To improve community awareness and understanding of the estuarine system through their involvement in the development and implementation of the Plan.
- To be consistent with the NSW Estuaries Policy and the principles of Ecologically Sustainable Development.
- To provide a framework for implementation such that all the objectives and desired goals set for the estuary may be achieved.

These management objectives represent the overarching principles developed by Council and under which the Management Study and Plan has been prepared.

7.3 Management Goals

In addition to the overarching management objectives, a series of more specific goals for management have been developed representing the specific, desired outcomes for the Brisbane Water estuary. These management goals have been used in the identification of management options (**Section 8**) and will be used to guide the development of the Estuary Management Plan. The full list of management goals are provided in **Table 7.1**.

Table 7.1: Management Goals for Brisbane Water

Goal	Notes
Water and Sediment Quality Goal: *To achieve a standard of water and sediment quality that protects and promotes a healthy aquatic ecosystem, and allows aesthetic enjoyment and appropriate recreational use.*	The following notes accompany this goal: • This goal aims to meet the appropriate guideline values for water quality objectives for dry weather (ambient) conditions at least 90% of the time (ANZECC and ARMCANZ, 2000). The relevant guideline values will need to be identified for the Brisbane Water estuary. • The ultimate goal is unlikely to be achieved in the short-term and therefore incremental objectives are required. • With respect to pollutant loads from the catchment, the ultimate goal is the development of a strategic framework within which development is planned so that waterbody values can be identified. Data to support this include a study of relevant catchment processes and limits on the total load a waterbody can receive. Chapter 6 of Australian Runoff Quality by Engineers Australia (Wong, 2003) provides a methodology for such an assessment. • In the short term the goal is to improve wet weather water quality for parts of the estuary impacted by catchment inflows via the improvement of stormwater runoff quality to values typical of a less heavily urbanised catchment. This goal should be implemented in accordance with the principles of Water Sensitive Urban Design.
Sedimentary Processes Goal: *To seek to:* • *Minimise estuary sedimentation and erosion of the foreshore caused by the effects of human activities;* • *Maintain access and amenity, as well as the navigability of the waterway, while recognising the natural sedimentary processes and the natural depth constraints that occur in the estuary; and* • *Minimise (where possible) erosion and sedimentation where natural sedimentary processes are impacting on public or private property.*	The following notes accompany this goal: • This goal requires recognition of the natural sedimentary processes occurring in the estuary. It is noted that these sedimentary processes are likely to undergo change over time in relation to climatic processes such as El Niño/La Nina (i.e. dry vs. wet periods) and climate change. • Furthermore, this goal requires recognition of the need to maintain the tidal prism within the estuary for the purposes of flushing. • In some specific locations natural sedimentary processes are impacting on human usages and it may be necessary to undertake works to address this issue. • Activities in the catchment (such as construction) can also contribute to sedimentation in the estuary. • The implementation of this goal requires the identification of agreed 'natural' rates of sedimentation for various embayments.

Goal	Notes
Foreshore Flooding Goal: *To minimise the impact of catchment flooding and foreshore inundation on existing and future development of the estuary foreshores, while maintaining ecosystem viability, and in accordance with Council's Floodplain Risk Management Plans.*	The following notes accompany this goal: • It is acknowledged that the Floodplain Risk Management Plans are the relevant plans to aid in the achievement of the management of foreshore flooding. • Therefore, the primary goal with respect to flooding is to ensure that any flood mitigation works proposed through the Floodplain Management Planning Process take under consideration estuarine processes such as estuarine water levels, wave attack, sedimentary geomorphology, ecological processes, and existing human uses. • The potential impacts of climate change on these estuarine processes, particularly catchment inflows and estuarine water levels, are key considerations in this respect.
Habitat and Species Conservation Goal: *To protect, retain and rehabilitate existing habitat for estuarine species, rehabilitate degraded habitat and provide for ecological connectivity throughout the estuary.*	The following notes accompany this goal: • In the achievement of this goal there is a need to recognise the existing constraints (e.g. land use). • The primary goal is to retain existing habitat, with a view to re-establishment of aquatic and foreshore habitat where possible. • A secondary goal is to provide suitable, "healthy" habitat for recreationally and commercially important species such as fish, prawns and shellfish.
Cultural Heritage Goal: *To acknowledge, conserve and commemorate (as appropriate) the Aboriginal and European heritage of the estuary and its foreshores.*	The following notes accompany this goal: • Commemoration should be undertaken as appropriate and with consultation, particularly for Aboriginal heritage items and places.
Visual Amenity and Landscape Character Goal: *To maintain or enhance the visual experience of the landscape from vantage points on the waterway and in the catchment.*	The following notes accompany this goal: • This goal is expected to be difficult to measure without baseline data or the use of 3D modelling.
Recreational Usage Goal: *To encourage and provide facilities for the appropriate recreational usage of the estuary waterways and foreshores while maintaining ecosystem viability.*	The following notes accompany this goal: • There is a need to balance the competing land- and water-based recreational uses. • This will include identification of environmentally sensitive areas for which less intensive uses may be more appropriate. • This goal has linkages with the Water Quality goal as parts of the estuary may not be suitable for primary contact recreational usage after rainfall events.

Goal	Notes
Foreshore Development Goal: *To undertake strategic planning for development adjacent to the Brisbane Water foreshore, taking into account:* • *The potential impacts of climate change;* • *Access and amenity; and* • *The preservation of important foreshore habitats.* *With respect to existing foreshore development, the aim is to:* • *Seek opportunities to implement environmentally sustainable modifications during the course of ongoing maintenance and repair.* • *Recognise and report on inappropriate foreshore development and take action to remedy where possible.*	The following notes accompany this goal: • For the purposes of this goal, foreshore development is defined as that occurring in the intertidal zone and up to 2m AHD. • Historically, many residents owning foreshore properties have sought the opportunity to modify their property boundaries to enclose adjacent accreting shoreline. This has often led to restrictions on public access to the foreshore. In addition, where the observed accretion has been the result of a short term process and subsequently reverses, property owners have then tended to implement foreshore protection works along the modified property boundary. In many cases these structures are inappropriate (see below). • It is recognised that in some locations in the estuary, the natural sedimentary processes have been modified as a result of ad-hoc construction of foreshore structures such as jetties, ramps and seawalls, thereby contributing to localised erosion and/or sedimentation. • In the achievement of this goal, there is a need for the recognition of processes such as climate change.
Commercial Development Goal: *To promote the Ecologically Sustainable Development of commercial activities and tourism within the estuary, recognising the finite capacity of estuarine ecosystems.*	The following notes accompany this goal: • For the purposes of this goal, development is defined as land and waterway development for residential, commercial and industrial uses, as well as tourist development. • Commercial development should be undertaken in accordance with Council's *Corporate Vision for the City of Gosford*. • This goal will seek to provide for appropriate development, as well as identifying and preventing inappropriate development. • The process of 'redevelopment' in accordance with ESD will generally result in a more sustainable outcome than that which can be achieved with existing development. • In the achievement of this goal, there is a need for the recognition of processes such as climate change.
Governance Goal: *To establish an appropriate organisational framework within the responsible agencies to ensure the Management Plan is implemented and to seek funding in order to facilitate ongoing implementation of the Plan.*	The following notes accompany this goal: • This goal will seek to ensure that the various Government agencies, authorities and other organisations involved in the different aspects of estuary management work together to allocate appropriate resources for implementation of the Plan. • It is recognised that ongoing liaison between these different groups will be an essential component of this goal.

Goal	Notes
Information, Communications and Education Goal: *To regularly provide information to the public about the estuary, including details of:* • *Current estuarine health (including aquatic ecosystem and human health indicators);* • *Current planning and development activities;* • *The impact that current and future land and waterway usage has on estuarine values; and* • *The contributions that the community can make toward reducing adverse impacts on, and enhancing the condition of, the estuary.* *To facilitate the active involvement of the community in implementation of the Plan wherever possible.*	The following notes accompany this goal: • It is recognised that there is a need for an emphasis on education to achieve all the goals. • Linkages between the Estuary Management Plan and State of the Environment reporting by Council are to be established. • There is a need to develop and maintain awareness within the community, public authorities and industry forums to communicate the objectives and goals for the management of the Brisbane Water Estuary.

8 Management Options

8.1 Overview

A total of 185 management options have been developed during the course of the preparation of this Estuary Management Study. In the first instance, an initial list of management options was developed by a team of environmental specialists from Cardno. This list was then presented to Council and the Committee for review (**Section 2.1**). The next step in the options development phase was to hold a series of workshops with the community to obtain their suggestions for management options (described in **Section 2.3.4**).

In many cases, a management option was developed to address a specific management issue observed by the study team, Council or the community (presented in **Table 5.2**). In other cases, a management option may have been developed to assist in the future implementation of the Brisbane Water Estuary Management Plan, or to address remaining gaps in the data. The consultation involved in developing the initial list of management options, and subsequent revision of the list following the public exhibition period, is outlined in **Section 2**. The options aim to fulfil the management goals and objectives (**Section 7**) identified for the Brisbane Water estuary.

Management options range from specific works to more overarching and long-term options. Management options have been categorised according to the following five management categories, which correlate generally with Council's organisational structure and are consistent with other estuary management plans to which Council is a stakeholder (e.g. Lower Hawkesbury River Estuary Management Plan):

- ***Planning*** – These options include development of a planning instrument, regulation, policy or guideline, plan of management, etc. (e.g. the development of an estuary-wide strategy for the management of aquaculture);
- ***Compliance*** – These options include enforcement of a planning instrument, regulation, policy etc. (e.g. ensuring the ongoing enforcement of Council's Tree Vandalism Policy);
- ***Works*** – These options include maintenance or actual "on-the-ground" works (e.g. the implementation of catchment based WSUD features to improve water and sediment quality);
- ***Education*** – These options include consistent information dissemination to increase public awareness of estuary issues and management approaches (e.g. the development of an education program which presents information about the biodiversity of Brisbane Water and the relationship between human use of the estuary and important underlying ecological processes); and
- ***Research/Monitoring*** – These options include further studies, surveys, investigations etc. (e.g. surveying recreational fishers to characterise demand, target species, gear type, etc.).

8.2 Options Assessment Methodology

Management options were compiled and collated via the following process:

- A preliminary options list was compiled by Cardno's environmental scientists/engineers and coastal engineers;
- The preliminary options list was discussed with Council and the CEMC;
- Community workshops were conducted (**Section 2.3.4**) to discuss preliminary management options, gain input on any additional options and obtain feedback and information from the community; and
- Review of the final draft list of management options during the public exhibition period (**Section 2.3.5**).

The assessment of management options incorporated the following key components:

- Multi-criteria matrix-based assessment;
- Catchment modelling; and
- Evaluation using a decision support system (for dredging related options only).

Further details on each of the three components are provided in **Sections 8.2.1 to 8.2.3**.

The options assessment framework adopted in this Study has been developed in order to make sound comparisons between each option and to rank options in a transparent and unbiased manner so as to identify those having the greatest overall benefit for estuary management. In recognition of the fact that the resources for implementation of these options are limited, the process of ranking management options will also assist in prioritising options for implementation.

8.2.1 Multi-Criteria Matrix Assessment

In broad terms, each identified management option has been assessed based on:

- Achievement of the management goals (i.e. if implemented, would the option achieve one or more of the goals for management set out in **Table 6.1**); and
- A qualitative evaluation of the impact of the option, if implemented, on estuary processes (positive or negative).

More specifically, each management option has been assessed using a multi-criteria matrix based framework that acts as a decision-support tool. The multi-criteria matrix incorporates the calculation of a cost-benefit index based on a three pronged approach (accounting for social, environmental and governance factors) in accordance with the requirements of the NSW Government's Estuary Management Policy. Economic factors are taken into account as capital cost and recurrent cost or recurrent revenue. However, Council requested that this factor be excluded from the ranking process outlined below.

The multi-criteria matrix also includes the following features to assist in the development of the Plan:

- Primary and secondary responsibilities for implementation;

- Cross-reference to other relevant options;
- Cross-references to other options where dependencies occur; and
- Identification of potential funding streams (where possible).

The full list of unranked management options are provided in **Appendix F**.

Scoring of Indicators

The benefit index assessment has been prepared using the following social, environmental and governance indicators:

- Water and Sediment Quality;
- Sedimentary Processes;
- Ecological Processes;

Environmental Factors

- Foreshore Flooding/Inundation;
- Cultural Heritage;
- Visual Amenity;
- Human Usage;

Social Factors

- Information, Communications and Education;
- Development; and
- Governance.

Governance Factors

Economic factors are taken into account as capital cost and recurrent cost or recurrent revenue. This is discussed further in the following sections.

For each of the above criteria, a score has been assigned to each option based on the descriptors detailed in **Tables 8.1 – 8.10**. The scores for each of the ten social, environmental and governance indicators are then summed to provide a Raw Benefit Index (**Appendix F**).

In assigning scores to each of the options it is assumed that construction impacts will be assessed prior to any physical works and that appropriate mitigation measures will be implemented to ensure minimal impacts during works.

Table 8.1: Scores and Descriptors for Assessment of Water and Sediment Quality

Score	Descriptor
+ / - 5	Long term*, direct** and multiple pollutants (dissolved and particulate) with significant concentration or load with positive or negative impact on estuary water and sediment quality.
+ / - 4	Long term indirect / multiple pollutant with significant load / concentration or direct / single critical pollutant with significant load / concentration positive or negative impact.
+ / - 3	Medium term, multiple or single critical pollutant with medium sized load positive or negative impacts.
+ / - 2	Short term indirect / multiple pollutant or direct / single pollutant and medium sized load concentration positive or negative impact.
+ / - 1	Indirect, single pollutant or small load positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such as the installation of gross pollutant traps and wetlands and indirect impacts would cover options like educational brochures or signage.

Table 8.2: Scores and Descriptors for Assessment of Sedimentary Processes

Score	Descriptor
+ / - 5	Long term*, direct** and large area positive or negative impact on sedimentary processes.
+ / - 4	Long term indirect / large area or direct / medium area positive or negative impact.
+ / - 3	Medium term, varying area, combination of direct and indirect positive or negative impacts.
+ / - 2	Short term indirect / large area or direct / medium area positive or negative impact.
+ / - 1	Indirect and small area positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such as foreshore stabilisation and indirect impacts would cover options like educational brochures or signage.

Table 8.3: Scores and Descriptors for Assessment of Ecological Processes

Score	Descriptor
+ / - 5	Long term*, direct** and large area positive or negative impact on ecological processes.
+ / - 4	Long term indirect / large area or direct / medium area positive or negative impact.
+ / - 3	Medium term, varying area, combination of direct and indirect positive or negative impacts.
+ / - 2	Short term indirect / large area or direct / medium area positive or negative impact.
+ / - 1	Indirect and small area positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct options would be actual works such as bush regeneration and indirect impacts would cover options like educational brochures or signage.

Table 8.4: Scores and Descriptors for Assessment of Foreshore Flooding/Inundation

Score	Descriptor
+ / - 5	Long term*, direct** and large area positive or negative impact.
+ / - 4	Long term indirect / large area or direct / medium area positive or negative impact.
+ / - 3	Medium term, varying area, combination of direct and indirect positive or negative impacts.
+ / - 2	Short term indirect / large area or direct / medium area positive or negative impact.
+ / - 1	Indirect and small area positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such as the construction of flood mitigation measures and indirect impacts would cover options like educational brochures or flood signage.

Table 8.5: Scores and Descriptors for Assessment of Cultural Heritage

Score	Descriptor
+ / - 5	Long term*, direct** and multiple heritage items with positive or negative impact on those items.
+ / - 4	Long term indirect / multiple heritage items or direct / single critical heritage item positive or negative impact.
+ / - 3	Medium term, multiple or single critical heritage item with positive or negative impacts.
+ / - 2	Short term indirect / multiple heritage or direct / single heritage item positive or negative impact.
+ / - 1	Short term, indirect, single heritage item positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct positive impacts would be protective or preservation works and indirect impacts would cover options like educational brochures or interpretative signage.

Table 8.6: Scores and Descriptors for Assessment of Visual Amenity

Score	Descriptor
+ / - 5	Long term*, direct** and large portion of a viewshed positive or negative impact on visual amenity.
+ / - 4	Long term indirect / large portion of a viewshed or direct / medium area positive or negative impact.
+ / - 3	Medium term, varying portion of a viewshed, combination of direct and indirect positive or negative impacts.
+ / - 2	Short term indirect / large portion of a viewshed or direct / medium portion of a viewshed positive or negative impact.
+ / - 1	Indirect and small portion of a viewshed positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct positive impacts would be protective or restorative works to improve visual amenity and indirect impacts would cover options like educational brochures or signage for iconic views around the estuary.

Table 8.7: Scores and Descriptors for Assessment of Human Usage

Score	Descriptor
+ / - 5	Long term*, direct** and large number of users positive or negative impact.
+ / - 4	Long term indirect / large number of users or direct / medium number of users positive or negative impact.
+ / - 3	Medium term, varying number of users, combination of direct and indirect positive or negative impacts.
+ / - 2	Short term indirect / large number of users or direct / medium number of users positive or negative impact.
+ / - 1	Indirect and small number of users positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such as foreshore access ways and indirect impacts would cover options like educational brochures or recreational signage.

Table 8.8: Scores and Descriptors for Assessment of Development

Score	Descriptor
+ / - 5	Long term*, direct** and large-scale development positive or negative impact.
+ / - 4	Long term indirect / large-scale development or direct / medium-scale development positive or negative impact.
+ / - 3	Medium term, varying scale development, combination of direct and indirect positive or negative development impacts.
+ / - 2	Short term indirect / large-scale development or direct / medium-scale development positive or negative impact.
+ / - 1	Indirect and small-scale development positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such as urban renewal and indirect impacts would cover options like brochures to promote eco-tourism.

Table 8.9: Scores and Descriptors for Assessment of Governance

Score	Descriptor
+ / - 5	Long term*, direct** and catchment-wide or estuary-wide policy positive or negative impact.
+ / - 4	Long term indirect / large policy or direct / medium policy positive or negative impact.
+ / - 3	Medium term, varying policy impact, combination of direct and indirect positive or negative policy impacts.
+ / - 2	Short term indirect / catchment-wide or estuary-wide policy or direct / medium policy positive or negative impact.
+ / - 1	Indirect and localised policy positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such as the formation of a Committee and indirect impacts would cover options like educational brochures.

Table 8.10: Scores and Descriptors for Assessment of Information, Communications and Education

Score	Descriptor
+ / - 5	Long term*, direct** and broad-scale information, communications and education positive or negative impact
+ / - 4	Long term indirect / broad-scale information, communications and education or direct / medium information, communications and education positive or negative impact.
+ / - 3	Medium term, varying information, communications and education impact, combination of direct and indirect positive or negative information, communications and education impacts.
+ / - 2	Short term indirect / broad-scale information, communications and education or direct / medium information, communications and education positive or negative impact.
+ / - 1	Indirect and local-scale information, communications and education positive or negative impact.
0	No / neutral impact.

*Long term 5 – 10 years, medium term 3 – 5 years and short term 1 – 2 years or less.
**Direct impacts would be actual works such undertaking a public awareness program and indirect impacts would cover options like educational signage.

The Net Present Value

The Net Present Value of each option was also calculated based on a function of the Preliminary Indicative Cost Estimate and Indicative Cost of Implementation over a 20 year period (**Appendix F**).

It is noted that these cost estimates are indicative only and further detailed costings would be required in the event an option is considered for implementation.

At the request of Council, the Net Present Value (i.e. economic indicators) have not been incorporated into the overall ranking and, therefore, the assessment reported represents a triple-bottom line evaluation and is reported as a Benefit Index accordingly.

Agency and Council Feedback

The multi-criteria matrix also incorporates a mechanism by which feedback from Council and the relevant government agencies can also be included. This mechanism is essentially a scoring process similar to that described above, with scores allocated on the following basis:

- Score +/- 3 = Strongly in favour of/opposed to the option;
- Score +/- 2 = Generally in favour of/opposed to the option;
- Score +/- 1 = In favour of/opposed to the option to a limited degree; or
- Score 0 = No opinion.

A score is allocated on the basis of a Council/DECCW Response. The Council/DECCW Response has been calculated based on an average of the scores provided by Council and the CEMC members (including DECCW). These scores are then summed with the Raw Benefit Index in order to calculate Adjusted Benefit Index (**Appendix F**).

Limitations of the Multi-Criteria Matrix Approach

Those management options that seek to address a management issue on a broad scale (e.g. on a catchment-wide or LGA-wide basis) will generally score higher than management options that seek to address a highly localised management issue (e.g. a site specific issue). This introduces an element of bias into the calculation of the Benefit Index.

An attempt has been made to address this issue through via the following means:

- The use of catchment modelling software to consider catchment-based controls (refer to **Section 8.2.2** and **Appendix G**), and
- The development of a CLAM decision-support tool that specifically examines the dredging related options (refer to **Section 8.2.3** and **Appendix H**).

Rankings

Once each option has been assessed using the methodology described above they can be ranked on the basis of the Adjusted Benefit Index.

In order to account for the inherent bias in the multi-criteria matrix approach, the management options have been ranked in two different ways. The first was to rank the full list of management options on the basis of both the Management Categories and the Adjusted Benefit Index. The second was to rank the full list of management options on the basis of both the Management Zone and the Adjusted Benefit Index.

The results of the options assessment are discussed in **Section 8.3**.

8.2.2 Catchment Modelling

Catchment modelling was undertaken as part of the options assessment using the computer software program MUSIC (Model for Urban Stormwater Improvement Conceptualisation) developed by the MUSIC Development Team of the Cooperative Research Centre for Catchment Hydrology (now the E-Water CRC). MUSIC provides the ability to simulate both quantity and quality of runoff from catchments, for a broad range of catchment sizes, and the effect of a wide range of stormwater treatment devices on the quantity and quality of runoff downstream.

MUSIC predicts the performance of stormwater quality management systems, and therefore can be used as an aid to decision-making. It is intended to help organisations plan and design (at a conceptual level) appropriate urban stormwater management systems for their catchments. By improving the quality of stormwater runoff, an improvement in the health of downstream water bodies, such as creeks and estuaries, and also downstream ecosystems can be achieved.

A MUSIC model for the Brisbane Water catchment was developed for the Brisbane Water Estuary Processes Study (Cardno, 2008a). This was used as the basis for further modelling undertaken in this Estuary Management Study (**Appendix G**). Five scenarios for the Brisbane Water estuary were modelled as part of the Estuary Management Study, which were:

- ***Scenario 1*** – Incorporates existing Gross Pollutant Traps (GPTs) into the existing *Estuary Processes Study* MUSIC Model, to simulate present day catchment conditions with details of known existing treatment devices.
- ***Scenario 2*** – Updates Scenario 1 to incorporate projected land use intensification for the year 2030 in Gosford and Woy Woy residential areas, and proposed new developments for the year 2030, using Council's existing lot-based water quality improvement targets as identified in Council's *Water Cycle Management Guidelines* (GCC, 2007b).
- ***Scenario 3*** – Updates Scenario 2 to incorporate DECCs proposed treatment targets for TSS, TP and TN of 85%, 65% and 45% (DECC and SMCMA, 2007), in place of Council's current stormwater requirements (GCC, 2007b).
- ***Scenario 4*** – Updates Scenario 3 to assess the potential for reducing pollutant loadings by implementing regional water quality treatment devices in the catchment. Treatment devices assessed include GPTs, Bio-Retention Systems and Rainwater Tanks for reuse and irrigation. All regional treatment devices modelled relate to management options listed that identify the need for stormwater treatment either at specific locations or catchment-wide. The full suite of treatment devices modelled has been cross-referenced and linked back to the management options.
- ***Scenario 5*** – Updates Scenario 4 such that it includes a subset of the full suite of regional treatment devices, focussing on those sub-catchments that contribute the most significant pollutant loads and/or drain to a part of the estuary that experiences longer flushing times. This will represent a more realistic scenario in terms of those regional treatment devices that may actually be put forward for implementation in the next 5-10 years.

Scenarios 4 and 5 are currently pending finalisation. The MUSIC catchment modelling report is provided in **Appendix G**.

8.2.3 CLAM Tools

The Coastal Lake Assessment and Management (CLAM) tool is a computer model developed to allow stakeholders to assess the social, economic and environmental trade-offs associated with management options within coastal lakes and estuaries. It was developed by the Integrated Catchment Assessment and Management Centre at the Australian National University as a decision support tool for natural resource managers. The system was originally designed as a tool to assist in the management of small coastal lakes and lagoons by using a Bayesian (i.e. probabilistic) approach to investigating potential outcomes from specified management scenarios.

The CLAM tool integrates existing knowledge on the ecological, social and economic functions of estuaries using a range of methods in such a way as to incorporate uncertainty (i.e. where knowledge gaps exist because of the scientific complexity of estuarine systems). When assessing a range of management options for estuaries (such as options for dredging) the CLAM tool identifies the likely trade-offs between ecological, social and economic values associated with the implementation of those management options. In this way, the CLAM tool explicitly incorporates a triple-bottom line approach.

The large number of management options identified for Brisbane Water has meant that it was not possible to develop a CLAM tool to encompass all management options. The CLAM tool may only be applied to the assessment of management scenarios or options on the scale of a small waterbody within which changes in physical processes (e.g. water quality) may actually be observed. Therefore, due to the large size and complexity of physical processes operating within Brisbane Water estuary, it is not possible to develop a CLAM tool covering the full spatial extent of the entire estuary. Rather, a series of CLAM tools have been developed for to assess location-specific dredging options.

The maintenance of navigation channels within the Brisbane Water estuary has been identified as a significant management need in the short to medium term. Each management option that relates to dredging for navigation-related purposes has been incorporated into a separate set of CLAMs. The Dredging CLAMs have been established in such a way as to consider all those dredging options relating to a specific part or zone of the estuary.

The Dredging CLAM tool examine in greater detail all of those options that propose dredging activities by incorporating:

- Recommendations regarding suitable dredge depths, configurations and volumes;
- Hydrodynamic computer modelling results;
- Mapping of sensitive aquatic habitat (i.e. seagrass beds); and
- Cost of implementation over a 30 year period of implementation.

The tool integrate quantitative and qualitative data collected during the *Estuary Processes Study* (Cardno, 2008a) to evaluate the identified options for management. Combining the CLAM tool with more traditional approaches such as the multi-criteria matrix (**Section 8.2.1**) can result in a more integrated assessment of management options. This is particularly important for a large system like the Brisbane Water estuary.

The CLAM tool does not identify a definitive 'result' as such. Rather, they permit a comparison of the relative impacts of different implementation scenarios in relation to each of the impact categories identified in the CLAM (in this case, water and sediment quality, ecological, social and economic impacts). The CLAM tool may also be used to run scenarios incorporating more than one option (e.g. implementing a suite of different dredging options within the one location), which may be considered in some regards to be a cumulative impact assessment.

Resource limitations may also be a factor, in which case the CLAM tool can be used by Council to assess which Option (or combination thereof) provides the greatest net benefit for the least expenditure – that is, to prioritise works. In addition, the CLAM tool incorporates a user friendly interface and may be used to assist in community consultation.

Appendix H includes the Dredging CLAM report which details the information that sits behind the CLAM interface. This report should be referred to prior to using the CLAM tool.

A *Sediment Management Plan* (Cardno, 2009) has been prepared to support the Dredging CLAM tool and provide Council with additional information regarding the implementation process for any dredging works. The Plan is provided in **Appendix I**.

8.3 Options Assessment Outcome

All management options were ranked using the decision-making framework defined in **Section 8.2.1**. A summary of the top ranking options (identified by Option ID) is given below. "Option ID" refers to an individual identification number which was assigned to each option prior to its assessment and can be used to distinguish each option.

The highest ranking management options relating to WSUD have been assessed further via catchment modelling (refer to **Section 8.2.2** and **Appendix G**). The highest ranking management options relating to dredging have been assessed in greater detail in the Dredging CLAM Tool (refer to **Section 8.2.3** and **Appendix H**).

8.3.1 Ranked by Management Category

The top 10 highest ranked management options for each management category are as follows:

- **Planning**
  - P41: Prepare a Brisbane Water Estuary Users Plan;
  - P43: Prepare a Sea Level Rise Study;
  - P53: Promote the Brisbane Water estuary for eco-tourism;
  - P04: Review and revise DCP 165 - Water Cycle Management to reflect current best practice;
  - P54: Promote the sustainable commercial development of the Estuary and its foreshores in accordance with Council's Corporate Strategy and the principles of Ecologically Sustainable Development;
  - P59: Adopt the Vision Statement (**Section 7.1**) for the Brisbane Water Estuary provided in the Estuary Management Study;
  - P01: Provide for the development, implementation and regular re-assessment of Riparian Zone and Bank Management Plans for the major tributaries draining into the Estuary;
  - P07: Develop formal standard designs for key navigational channels in Brisbane;
  - P45: Undertake a review of the existing foreshore development policies and plans for the Gosford LGA and assess the need to amend development controls to provide for controlled, sustainable development of the foreshore;
  - P49: Develop guidelines for foreshore stabilisation via the establishment of locally native estuarine plant species.
- **Compliance**
  - C13: Provide additional resources for enforcement of compliance with foreshore development controls;
  - C01: Establish a program of auditing to ensure best management practices for marinas around Brisbane Water Estuary;
  - C08: Enforce boating regulations within Brisbane Water;

- C14: Audit existing foreshore development and identify illegal or non-conforming development for retrospective enforcement of development controls;
- C02: Provide additional resources for Council officers to undertake audits of properties to ensure enforcement of policies and conditions of consent relating to water quality during both the construction and operational phases;
- C04: Ensure ongoing enforcement of fishing regulations;
- C05: Ensure the ongoing enforcement of Council's Tree Vandalism Policy;
- C15: Enforce littering restrictions and undertake parallel education programs about littering;
- C07: Consider opportunities to install additional dinghy storage racks at strategic locations around the estuary;
- C03: Work with private land holders / tenants to improve stormwater management practices in the industrial estate near Hawke Street.

- **Works**
  - W01: Investigate options for implementing catchment based WSUD features in the catchment in order to manage stormwater quality and quantity;
  - W34: Identify locations of bank erosion along creekline corridors and the Estuary foreshore. Design and implement remediation measures to address these issues, with re-establishment of native vegetation being the preferred option where feasible;
  - W29: Investigate options to improve existing shoreline protection works which incorporate environmentally friendly design features (Ettalong Beach);
  - W26: Rehabilitate the eroding foreshores on the eastern shores of Hardys Bay with natural vegetation typical of that naturally occurring in the area;
  - W71: Where appropriate, rehabilitate saltmarsh habitats, with saltmarshes at Saratoga, Empire Bay, Davistown and Rileys Island addressed as a priority;
  - W84: Provide boardwalks at sensitive foreshore locations to permit public access;
  - W02: Install additional sewage pump-out facilities to reduce water pollution;
  - W18: Dredge the navigation channel up to 50,000m^3 in the Estuary entrance as a priority;
  - W28: Undertake beach re-nourishment works at Ettalong Beach;
  - W83: Identify priority, privately owned/managed parcels of foreshore land for acquisition and/or incorporation into publicly accessible foreshore land.
- **Education** (eight options available in total)
  - E08: Give consideration to methods of detecting and informing the community of changes to sea levels and other potential climate change impacts;
  - E07: Establish a 'Clean Up Brisbane Water Day' with the dual objectives of removing rubbish from the Estuary foreshores and waterways, and of educating the public about the Estuary;
  - E09: Provide foreshore property owners with information/guidelines about what constitutes good and bad practice with respect to foreshore management;
  - E03: Develop a public awareness and education program relating to the estuary and its biodiversity;
  - E02: Label stormwater drain inlets in problematic areas "This drains to ……";

- E11: Conduct an education program for the boating community;
- E01: Distribute available NSW Maritime's Brisbane Water Boating Map to ensure waterway users are aware of the regulations;
- E14: Distribute I&I NSW's Saltwater Fishing Guides.

- **Research/Monitoring**
  - R37: Design an Estuary Monitoring Plan to include elements of the physical, social and biological environment to evaluate the success in meeting the objectives and goals outlined in the Estuary Management Plan;
  - R36: Establish an annual reporting mechanism to communicate progress towards achieving the goals and objectives of the Management Plan and Estuary Monitoring Plan;
  - R38: Research possible sources of funding and secure ongoing funding for implementation of the Plan;
  - R24: Investigate the use of constructed wetlands, sediment and detention basins and other WSUD options to minimise the effect of freshwater and sediment inflows;
  - R26: Develop a research partnership with universities to continue the scientific focus on Brisbane Water Estuary and support this with annual research grants;
  - R39: Develop and maintain a database of all environmental and ecological data available for the Brisbane Water Estuary with a view to providing a comparison between present and historic Estuary conditions;
  - R40: Provide for ongoing monitoring of estuarine water levels to provide a continuous long term data set;
  - R31: Conduct an audit of existing land-based and water-based infrastructure for boating;
  - R01: Conduct a review of the design and methodology employed in the existing water quality monitoring program;
  - R10: Conduct a condition assessment of existing stormwater outlets draining into the Estuary focusing on assessing impacts on natural sedimentary processes (e.g. erosion, accretion) and adjacent habitats.

The full list of management options as ranked by management category are provided in **Appendix J**.

8.3.2 Ranked by Zone

The top five highest ranked management options for each management zone are as follows:

- **Zone 1** (two available options in total)
  - P13: Geomorphological assessment required to develop options to address the bank erosion occurring upstream of Ann Close Reserve on Narara Creek;
  - W122: Construct an additional culvert under the rail line at Fagans Bay to enhance flushing and thereby improve water quality.
- **Zone 2**
  - P14: Continue to enforce prohibition of mowing to the water's edge in both public and private foreshore areas in order to minimise foreshore erosion and impacts on estuarine vegetation;

- W76: Rehabilitate the saltmarshes in Yattalunga Bay, to include the strategic removal of mangroves, weeding and control of nutrient inputs;
- R14: Investigate options for replacing or modifying the existing seawall along Dane and Mason Parades with an environmentally friendly seawall;
- W37: Remove disused pipes, posts, debris and other rubbish from the intertidal portion of the mudflats adjacent to Victory Parade, Tascott, where they are posing a risk to navigation;
- W77: Provide alternative dinghy storage arrangements and fence the Endangered Ecological Community (EEC) at Mason Parade, Gosford.

- **Zone 3**
  - W12: Provide for ongoing maintenance of the opening(s) under the Brisbane Water Drive causeway to prevent siltation and maintain flushing;
  - W04: Provide additional sediment traps for locations draining to Correa Bay. Sediment traps should target catchment inflows from the Bulls Hill Quarry and Garbage tip;
  - W07: Provide ongoing maintenance of existing sediment traps in locations draining to Horsfield Bay;
  - W11: Install an additional opening/culvert under the Brisbane Water Drive causeway with a view to increasing flushing of Woy Woy Inlet and Woy Woy Bay and promoting scouring of the adjacent navigational channels;
  - W59: Restore flows to Woy Woy Creek by de-commissioning the dam at the former abattoir site.
- **Zone 4**
  - W35: Design and construct appropriate sediment control works to address sediment accretion issues at St Huberts Island;
  - W46: Investigate the cause of erosion around the Blackwall Point boat ramp and develop measures to address this issue;
  - W13: Develop and implement measures to address stormwater quality issues associated with runoff from fire trails on Blackwall Mountain;
  - W43: Develop and implement a long term solution to replace the currently failing seawall in Memorial Park on Brick Wharf Road;
  - W45: Undertake foreshore stabilisation works to address erosion currently occurring in Palermo Reserve, Empire Bay Drive.
- **Zone 5**
  - C03: Work with private land holders/tenants to improve stormwater management practices in the industrial estate near Hawke Street,
  - W47: Seek to remediate scouring currently occurring behind the existing seawall in Illoura Reserve;
  - W15: Seal the Hawke Street car park to prevent erosion into Kincumber Creek;
  - W48: Implement foreshore stabilisation works to prevent further erosion of the Illoura Reserve foreshore between Lintern Street and 28 Molinya Road;
  - W110: Provide a shared pedestrian pathway/cycleway in the reserve near Carrak Road to improve recreational access and link with other areas.
- **Zone 6**
  - W29: Investigate options to improve existing shoreline protection works which incorporate environmentally friendly design features (Ettalong Beach);

- W26: Rehabilitate the eroding foreshores on the eastern shores of Hardy's Bay with natural vegetation typical of that naturally occurring in the area;
- R11: Assess options for shoreline protection works that will seek to address the long-term erosion issues at Ettalong Beach;
- W18: Periodically dredge the navigation channel up to 50,000m3 in the Estuary entrance to ensure safe navigation;
- W28: Undertake beach re-nourishment works at Ettalong Beach for the purposes of beach amenity and foreshore protection.

The full list of management options ranked by management zone are provided in **Appendix J**.

9 Conclusion

9.1 Recommendations

It is recommended that the *Brisbane Water Estuary Management Plan* (the next stage in the Estuary Management Process) adopt for consideration the full list of management options identified in **Appendices J and K**.

Once adopted in the Plan, the management options will become management items to be considered on a priority basis for implementation. Implementation of the Plan will involve considerable expenditure (an estimated $20 million in capital costs alone) and therefore implementation must have regard to resource availability and the priorities of Council and other agencies identified as being responsible for implementing identified tasks. Additionally, it is noted that all options identified in this Study may be subject to further detailed investigation prior to implementation and may therefore become subject to modification or further consideration.

In recognition of the fact that resources are limited, and that some options are dependent upon the implementation of other options, it is recommended that in the first instance the management strategy examine the highest ranking management options as identified in **Sections 8.3.1 and 8.3.2**. Where duplications are removed, this sums to a total of 70 highly ranking management options. However, in developing the management strategy, it is recommended that the Management Plan should retain sufficient flexibility such that Council may implement any of the management options at any time (e.g. upon receipt of funding).

The method of implementation should be developed in consultation with the community and the relevant agency stakeholders, and should take into account the more detailed information provided in the catchment modelling (**Section 8.2.2** and **Appendix G**) and CLAM Tool (**Section 8.2.3** and **Appendix H**). It is anticipated that the CLAM Tool will represent a useful resource to support any further community consultation.

9.2 Moving Forward

This final *Brisbane Water Estuary Management Study* will be presented to Council for adoption. A Draft *Brisbane Water Estuary Management Plan* will then be prepared in consultation with Council, the Committee, community and key stakeholders. The Draft Plan will present for adoption the recommended management actions for implementation and funding.

Following public exhibition of the Draft *Estuary Management Plan*, the final *Brisbane Water Estuary Management Plan* will be prepared based on the outcomes of the consultation period. This document will be presented to GCC for adoption and subsequently submitted to the Minister for Climate Change, Environment and Water for approval.

10 Qualifications

The following qualifications apply to this Management Study:

- The assessment of likely impacts associated with each option is preliminary in nature and it is assumed that the appropriate level of environmental impact assessment will be undertaken prior to the initiation of any physical works and that appropriate mitigation measures will be implemented to ensure minimal impacts during works.
- It has also been assumed that the relevant permits and approvals will be obtained for any works undertaken.
- The feasibility and sustainability of the options identified in this study have not been subject to detailed investigation.
- It should be noted that the cost estimates are indicative and have been used for comparative purposes only. Detailed cost estimates should be obtained prior to implementation.

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