TOWRADGI LAGOON
ENTRANCE MANAGEMENT POLICY
REVIEW OF ENVIRONMENTAL FACTORS

Report Prepared for

WOLLONGONG CITY COUNCIL

16 April 2007
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GLOSSARY AND ABBREVIATIONS

Ambient Noise	The all-encompassing noise within a given environment. It is the composite of sounds from many sources, both near and far.
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)
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
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.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
CEMP	Construction Environment Management Plan
Colluvial	A loose deposit of rock debris accumulated through the action of gravity at the base of a cliff or slope.
dB	Abbreviation for decibel – a scale used in sound measurement. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.
dB(A)	A value used for 'A-weighted' sound pressure levels. 'A' frequency weighted is an adjustment made to sound-level measurement to approximate the response of the human ear.
DCP	Development Control Plan
DEC	Department of Environment and Conservation (incorporating EPA, NPWS).
DECC	Department of Environment and Climate Change. This recently created department has absorbed DNR, DEC and some functions of Fisheries (DPI).
DIPNR	Department of Infrastructure, Planning and Natural Resources (now Department of Planning and Department of Natural Resources).
DNR	Department of Natural Resources (Previously DIPNR)
DOP	Department of Planning (Previously DIPNR)
Ecosystem	A community of living organisms, together with the environment in which they live and with which they interact.
EIA	Environmental Impact Assessment. An assessment of the impact of a proposed development.
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
Endangered Fauna	Protected fauna of a species under Schedule 1 or 2 of the *Threatened Species Conservation Act*, 1995.
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act, 1979*
EPBC	*Environmental Protection and Biodiversity Conservation Act, 1999*.
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development. Development that does not interfere with the short and long-term well-being, health and viability of ecosystems.
Extraneous Noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods. Normal daily traffic is not extraneous noise.
Fauna	Any mammal, bird, reptile or protected amphibian.
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 state or the context otherwise requires, includes crustacean and oysters and all marine, estuarine and freshwater animal life.
FM Act	*Fisheries Management Act 1994*
Habitat	The places in which an organism lives and grows.
Invertebrate	Animal without a backbone.
L_{A10}	The A-weighted sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{A90}	The A-weighted sound pressure level that is exceeded for 90% of the time for which the given sound is measured.
L_{Aeq}	Equivalent continuous noise level. The level of noise equivalent to the energy average of noise levels occurring over a defined measurement period.
L_{Amax}	The A-weighted sound pressure level that represents the maximum noise level measured over the time that a given sound is measured.
LALC	Local Aboriginal Land Council
LEP	Local Environment Plan
LGA	Local Government Area
LMP	Landscape Management Plan
L_w	Sound power at source
NPWS	National Parks and Wildlife Services
NSW	New South Wales
NV Act	*Native Vegetation Act, 2003*
PAD	Potential Archaeological Deposit
PASS	Potential Acid Sulfate Soils
PEMP	Project Environmental Management Plan
PoEO Act	*Protection of Environment Operations Act, 1997*
Receiver	The boundary or façade of a noise sensitive location.
REP	Regional Environment Plan
Reptile	A snake, lizard, crocodile, tortoise, turtle or other member of the class reptilian (whether native, introduced or imported), and includes the eggs and the young thereof and the skin or any other part thereof.
RFI Act	*Rivers and Foreshores Improvement Act, 1948*
Riparian Vegetation	Vegetation growing along banks of rivers.
RTA	Roads and Traffic Authority
Runoff	That proportion of rainfall that drains off the lands surface.
SEPP	State Environmental Planning Policy
Sedimentation	The act or process of depositing sediment, especially by mechanical means of matter suspended in a liquid.
TMP	Traffic Management Plan
TSC Act	*Threatened Species Conservation Act, 1995*
Vertebrate	Animal with backbone.
VMP	Vegetation Management Plan
WARR Act	*Waste Avoidance and Resource Recovery Act, 2001*
Water Quality	The suitability of the water for various purposes, as measured by the concentration or level of a wide variety of contaminants.

CERTIFICATION

This Review of Environmental Factors (REF) assesses the potential environmental impacts associated with the proposed entrance management policy for Towradgi Lagoon, Wollongong. The REF has been prepared primarily based on the information available from secondary sources.

This REF has been prepared with regard to Section 111 of the *Environmental Planning and Assessment*, 1979 and has taken into consideration the range of matters of relevance to the proposed policy.

Assessment of Significance (seven part tests) were conducted in accordance with the *Threatened Species Conservation Act*, 1995 for:

- The SSFCF, SOFF, ILGW and CSM Endangered Ecological Communities (EECs),
- Terrestrial threatened species such as the Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot, Grey Headed Flying Fox and Green and Golden Bell Frog, and
- Aquatic species such as the Black Cod, Australian Grayling and Sygnathids.

It was determined that the proposed policy is not likely to have a significant impact upon these EECs and threatened species.

Certified by:

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Manager - Environment

Dated: 16 April 2007

EXECUTIVE SUMMARY

Towradgi Lagoon is located at the southern end of Corrimal Beach, within the northern part of the Wollongong LGA.

Towradgi Lagoon Entrance Looking East Toward the Ocean

Towradgi Lagoon can be described as an intermittently closed and open lake or lagoon (ICOLL).

The greater Towradgi Lagoon catchment has an area of 7.50km^2, which extends west to the Illawarra escarpment, and is bound by Towradgi Road to the south, and a ridge that runs through Corrimal to Corrimal beach to the north.

An informal entrance management policy was implemented for Towradgi Lagoon prior to 2003, which involved opening the entrance mechanically when inundation was experienced in the road areas (eg Lake Parade) (which is set at approximately 1.9mAHD). This informal entrance management policy was implemented in response to resident concerns about access and property flooding. However, this policy was suspended in 2003 and has been under review since the formation of the Estuary Management Committee in order for due consideration of potential ecological impacts to occur (CLT, 2005a).

As an action item from the Estuary Management Plan for Towradgi Lagoon, a new entrance management policy has been devised (CLT, 2006). This entrance management policy has been devised to be complementary to the closely linked floodplain risk management process for the Lagoon.

Flood mitigation works, such as mechanical opening of the entrance, undertaken or commissioned by Council can be undertaken without development consent under Schedule III of the Wollongong Local Environment Plan (1990). Therefore the proposed Entrance Management Policy requires an environmental impact assessment under Part 5 of the EP&A Act, 1979.

This Review of Environmental Factors has been prepared to address the requirements of the EP&A Act and outlines the statutory context and identifies the range of potential environmental impacts associated with the entrance management policy. It considers the need for the policy (including the location of existing assets) and identifies proposed mitigation measures for sustainable environmental outcomes.

Towradgi Lagoon at Sunset – A Location for Recreational Usage

Consultation was undertaken concurrently with the preparation of this document. Agencies consulted include:

- NSW Department of Primary Industries (NSW Fisheries),
- NSW Department of Planning (DP),
- NSW Department of Natural Resources (DNR) (Now DECC),
- NSW Department of Environment and Conservation (DEC) National Parks and Wildlife Service (Now DECC),
- Department of Lands,
- Roads and Traffic Authority (RTA),
- Wollongong City Council, and
- Members of the Estuary Management Committee.

Assets potentially affected include the Surf Club

Fringing Vegetation and Properties

Key findings of the REF include:

- the estuary is most likely to have 'adapted' over the last 15 years to the present and proposed conditions. Consequently, since the proposed trigger level for entrance opening is similar to the maximum average level observed in the Lagoon over the past 15 years it is not expected that the Lagoon ecology will substantially alter as a result of the proposed policy. Nonetheless, assessments of significance (seven part tests) were prepared for a range of endangered ecological communities and threatened species outlined in Section 6.
- Water leaving the Lagoon may pose a hazard to swimmers at Corrimal beaches, as this water may be of a low quality and may also pose a risk with strong currents during the height of the main breakout period.
- Human health impacts will be managed by consultation with the responsible groups such as the Corrimal Beach Lifeguards in conjunction with the Corrimal SLSC respectively.

Looking Upstream at Riparian Zone along Parker Road Arm

An important part of the Policy implementation will be ongoing monitoring of the Lagoon and its environs to evaluate the impacts.

1. INTRODUCTION AND BACKGROUND

1.1 Introduction

Estuaries have been identified as having vast social and economic value, as they provide important habitat for native species, and are an important focus for recreational activities, tourism and the fishing industry. In an attempt to better manage estuaries in NSW, a coordinated planning approach was developed through the Estuary Management Policy and Manual (NSW Government, 1992).

The Estuary Management Manual sets out a structured management process that is followed in order to implement an Estuary Management Plan (NSW Government, 1992) through the following steps:

1. Form an estuary management committee;
2. Assemble existing data;
3. Undertake an estuary processes study;
4. Undertake an estuary management study;
5. Prepare a draft estuary management plan;
6. Public review of the draft plan;
7. Adopt and implement the estuary management plan; and
8. Monitor and review the management process as necessary.

The Estuary Management Plan for Towradgi Lagoon was adopted by Council (CLT, 2005a). Recommendations from the Plan placed a high priority on the development of an Entrance Management Policy for the Lagoon. As a result of these recommendations, Wollongong City Council commissioned the preparation of an Entrance Management Policy for Towradgi Lagoon, as part of the seventh step in the estuary management process.

This Review of Environmental Factors (REF) assesses the environmental impacts of assisted breakout of Towradgi Lagoon under the associated Management Policy (CLT, 2007).

1.2 Background

Towradgi Lagoon is located at the southern end of Corrimal beach within the northern part of the Wollongong LGA (Figure 1). Towradgi Lagoon can be described as an intermittently closed and open lake or lagoon (ICOLL). Towradgi Creek has a catchment area of 7.50km^2, which extends west to the Illawarra escarpment, and is bound by Towradgi Road to the south, and a ridge that runs through Corrimal to Corrimal beach to the north (Figure 2). Land uses within the Towradgi Creek catchment include residential, business, special use, light industrial, public recreation, environmental protection and state recreation areas. The Towradgi Creek catchment is mostly developed, with the exception of the escarpment and scattered patches of remnant vegetation.

The behaviour of the lagoon entrance can greatly impact on the water level, water quality and ecology of the lagoon. During extended periods of entrance closure and heavy rainfall, water levels within the Lagoon may pose a threat to assets, prompting substantial public pressure on Council to undertake assisted breakout of the Lagoon entrance.

An informal entrance management procedure has historically been implemented by Council's Works Division involving lagoon breakout following complaints from residents associated with street flooding in Lake Parade and surrounding areas.

Maximum water levels at the Towradgi Creek gauge, which is located further upstream on Pioneer Road, were analysed for the period of record (since 1992), and it was found that water levels generally have not exceeded 1.6mAHD, consistent with the informal opening strategy (CLT, 2005a).

Figure 1 Towradgi Lagoon

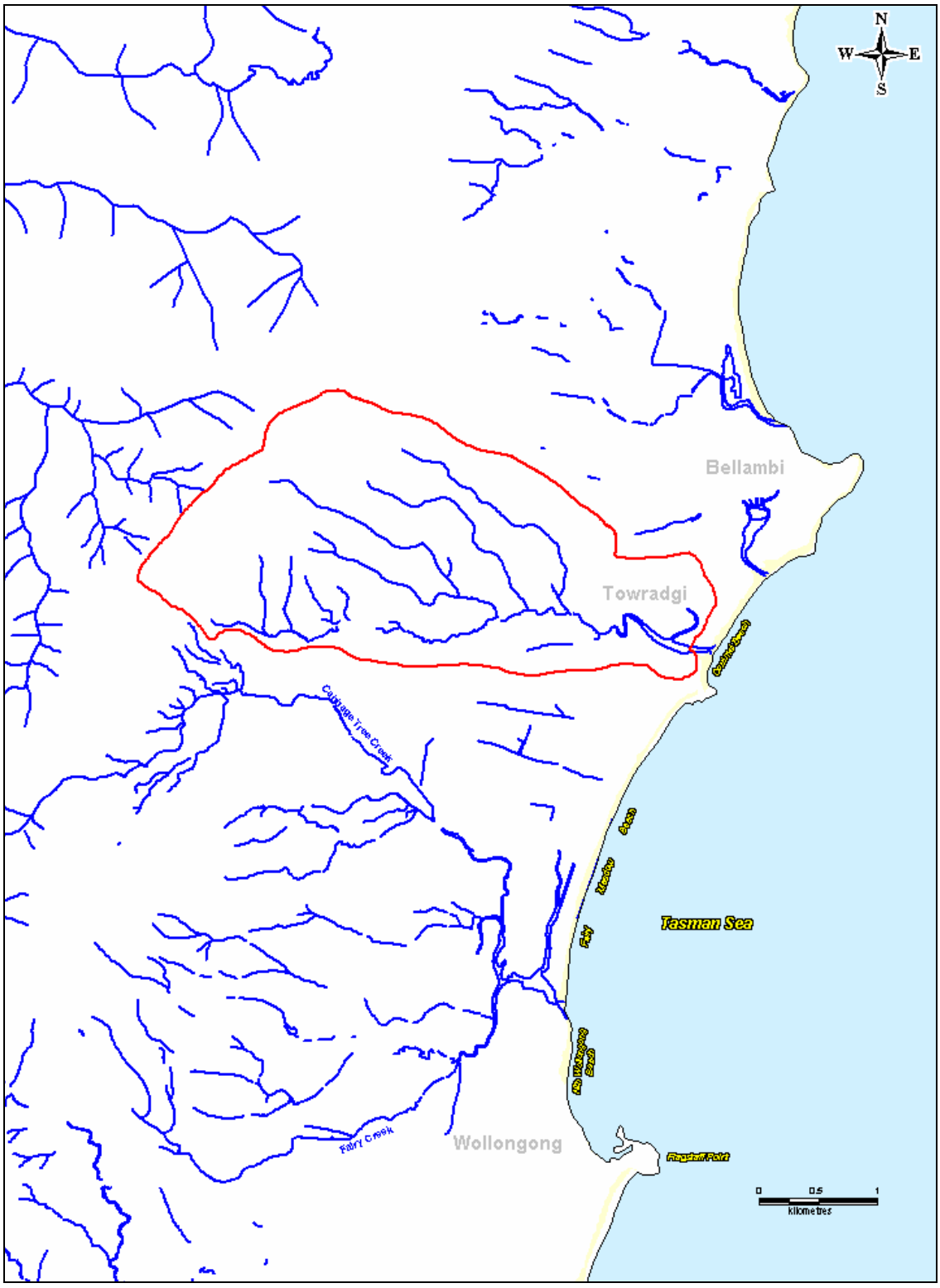


Figure 2 Towradgi Creek Catchment

1.3 Study Area

The study area comprises the tidal waterways, foreshores and the immediate surrounding open space and adjacent lands of Towradgi Creek, including its tributary to the north,

referred to in this document as the Parker Road Arm. The limits of the study area are defined at its upstream reaches by the tidal limit and Corrimal Beach at the downstream limit. The extent of the study area on the adjacent lands is defined by the 3.5 mAHD contour (Figure 3). This is considered to be beyond the maximum height that the berm could reach and therefore includes all potentially affected lands.

The main waterway (from the beach to Pioneer Road) is referred to as Towradgi Lagoon. Upstream of the Lagoon is referred to as Towradgi Creek. The tributary to the north of the lagoon area is referred to as the Parker Road Arm.

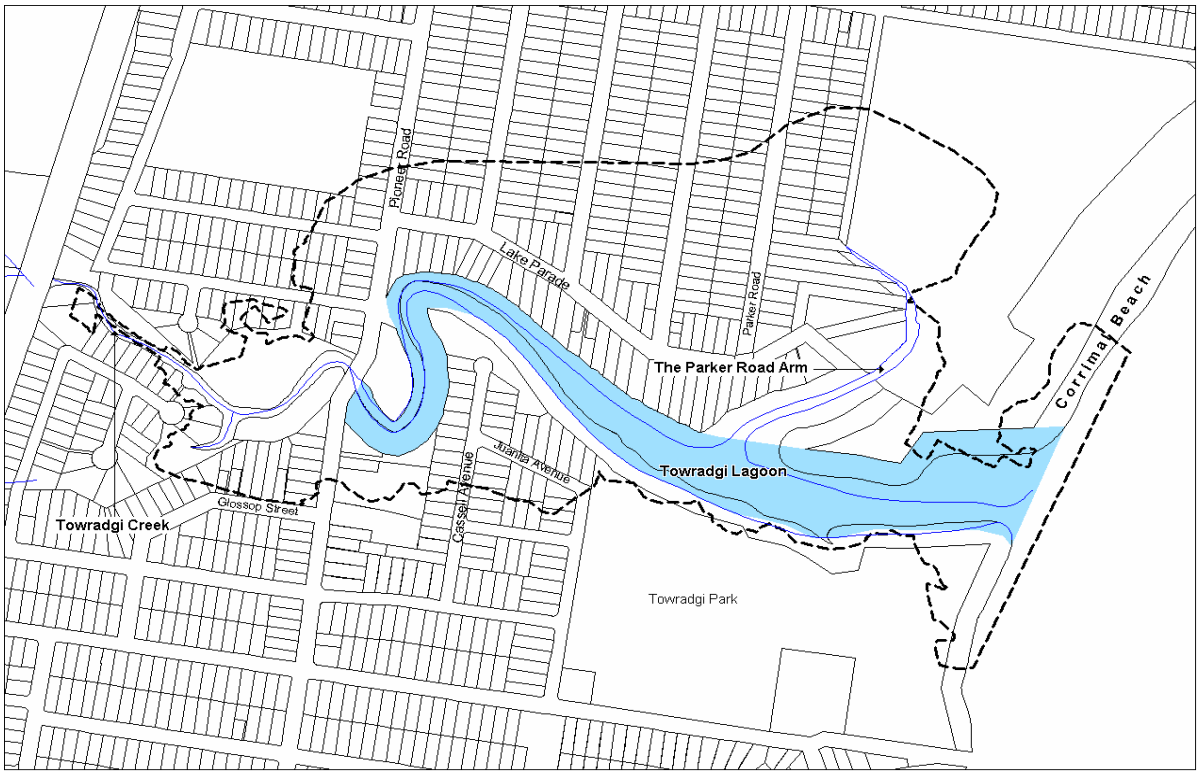


Figure 3 Study area

1.4 Confirmation of Part 5 Position Under the EP&A Act

Entrance management works for the purposes of floodplain mitigation undertaken or commissioned by Council can be undertaken without development consent. Therefore the proposed Entrance Management Policy requires assessment under Part 5 of the EP&A Act. Further details are outlined in Section 2.

1.5 Methodology

The method of preparation of this document is as follows:

- Discussions were held with members of Wollongong City Council and DECC at the inception of the project – 24 October 2006.
- Stakeholder Consultation was undertaken via formal correspondence with the following agencies:
    - NSW Department of Primary Industries (NSW Fisheries),
    - NSW Department of Planning (DP),
    - NSW Department of Natural Resources (DNR; now DECC),

- NSW Department of Environment and Conservation (DEC) National Parks and Wildlife Service (now under the DECC),
- Department of Lands,
- Roads and Traffic Authority (RTA),
- Wollongong City Council, and
- Members of the Estuary Management Committee

Consultation is discussed further in Section 3.2 (Table 4) and relevant correspondence can be found in Appendix B.

A search was conducted of the following databases to identify any potential issues:

- Australian Heritage Places Inventory;
- Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List; Register of the National Estate);
- State Heritage Inventory (which incorporates listings on Local Environmental Plans);
- DEC Aboriginal Heritage Information Management System (AHIMS);
- DEC NPWS Wildlife Atlas Threatened Fauna Records;
- DEC Wildlife Atlas Threatened Flora Records;
- DEH (EPBC Act) Databases; and
- NSW DPI – Fisheries (Fish Files) Database.

An appropriate background and literature search, including an Internet search was conducted, to identify and address relevant environmental issues pertaining to the proposed policy area.

1.6 Document Structure

This REF takes the following form:

- Legislative, Policy and Planning Context (Section 2)
- Consultation (Section 3)
- Identification of Alternatives (Section 4)
- Overview of Proposed Entrance Management Policy (Section 5)
- Assessment of Environmental Impacts of Proposed Policy (Section 6)
- Summary of Proposed Environmental Safeguards (Section 7).

2. LEGISLATIVE PLANNING AND POLICY CONTEXT

2.1 Environmental Planning Instruments

2.1.1 Local Environment Plan (LEP)

The Wollongong City Council Local Environment Plan (LEP) as amended shows the land within and surrounding Towradgi Lagoon is generally zoned 6(a) Public Recreation, 3(e) Research and Development Business, 4(a) Light Industrial and 2(c) High Density Residential (Figure 4).

The proposed activities largely fall within the entrance of Towradgi Lagoon, which is identified as zoned Crown Land. The access route for 4WD backhoes to the Lagoon entrance will traverse land zoned 6(a) Public Recreation (See Section 5). The objectives of land zoned 6(a) as outlined in the Wollongong LEP 1990 are:

a) To identify areas where recreation facilities for the general use of the community for active and passive recreation may be developed, and
b) To cater for the development of a wide range of facilities for the benefit of nearby communities.

Section 11 of Schedule 3 of the LEP states that the carrying out of flood mitigation works by Council does not require development approval. Therefore, the assisted breakout of the Lagoon is an activity under Part V of the Environmental Planning and Assessment Act (EP&A Act, 1979).

The construction of an access route appears to be inconsistent with the objectives for land zoned 6(a). However, under Part 3 – Special Provisions of the Wollongong LEP, section 10B activities carried out by or on behalf of Council, for the purpose of flood mitigation, may be carried out on any land without consent, provided that it is not land within a heritage conservation area or containing a heritage item or subject to State Environmental Planning Policy No. 58 – Protecting Sydney's Water Supply. Section 2.1.3 indicates that SEPP 58 does not apply to this location. Additionally, no heritage conservation areas were identified at this location.

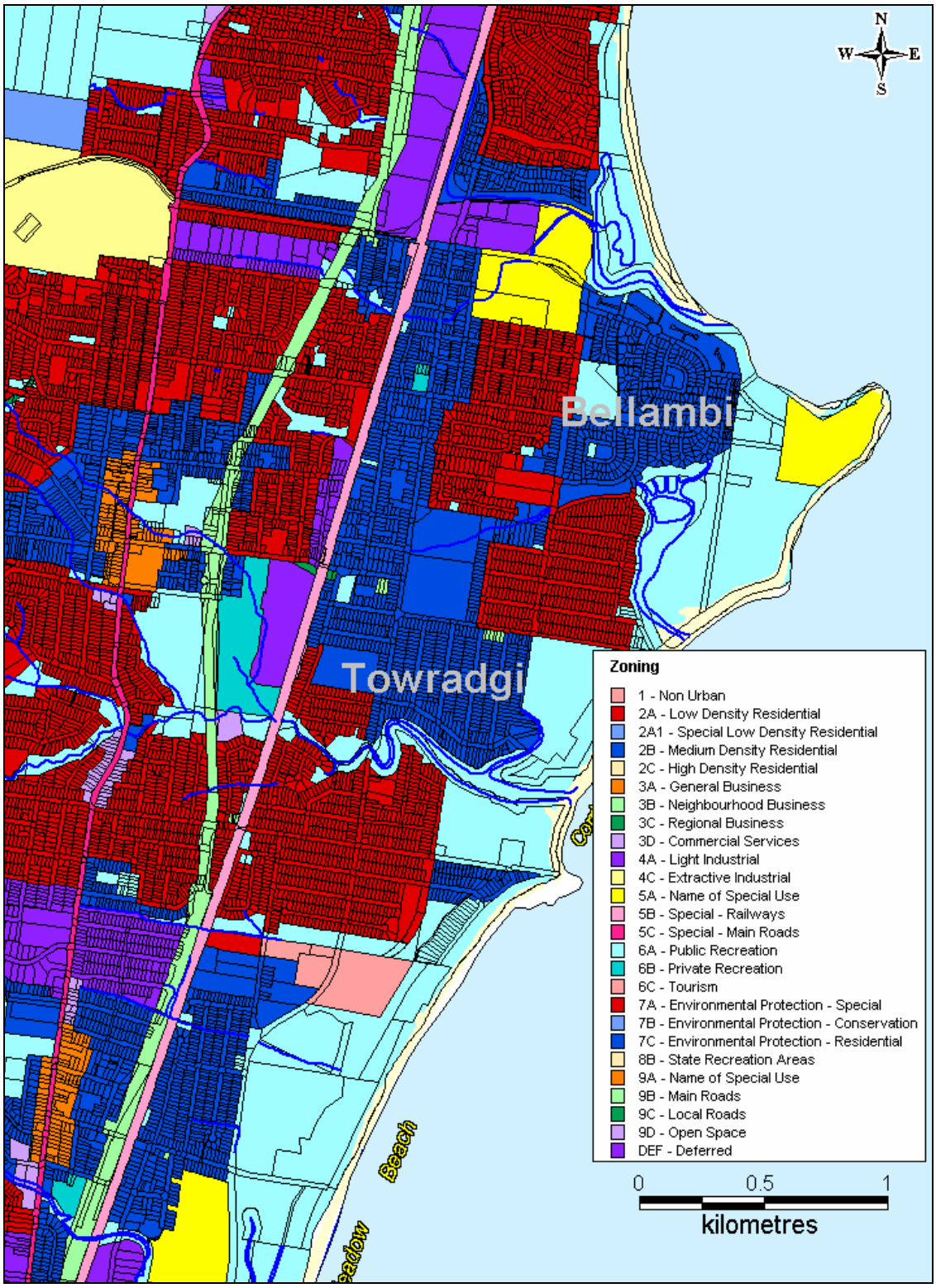


Figure 4 Land Use and Tenure for Area of Proposed Activity at Towradgi Lagoon

2.1.2 Regional Environmental Plans

Illawarra Regional Environment Plan No. 1

While the Illawarra Regional Environmental Plan (REP) No. 1 does apply to the Wollongong Region and covers coastal lands, wetlands and other water bodies, its focus is not related to the proposed activity, as it outlines planning objectives and provides guidelines for local environmental plans and development applications. Therefore, consideration of this REP is not required.

2.1.3 State Environmental Planning Policies

There are several State Environmental Planning Policies (SEPP) that may apply to the proposed activity. Each of these SEPPs and their relevance to the proposed policy are outlined below.

SEPP No. 14 Coastal Wetlands

The aim of SEPP No. 14 is to preserve and protect coastal wetlands in the environmental and economic interests of the state. A review of digital mapping prepared by the Department of Planning and provided by Wollongong City Council indicated that there are no SEPP 14 wetlands mapped in the Towradgi Lagoon area. Therefore SEPP 14 does not apply to this proposed policy.

SEPP No. 26 Littoral Rainforest

A review of digital mapping prepared by the Department of Planning and provided by Wollongong City Council indicates that there are no SEPP No. 26 Littoral Rainforest areas surrounding Towradgi Lagoon.

SEPP No. 35 Maintenance Dredging of Tidal Waterways

The objective of SEPP No. 35 is to allow for the maintenance dredging of waterways by public authorities in an appropriate and timely manner, without the need to obtain development consent. This SEPP applies to all land within the state except to land which SEPP No. 14, SEPP No. 26, Sydney Regional Environment Plan (SREP) No. 17, SREP No. 20, SREP No. 24 and SREP (Sydney Harbour Catchment) 2005 apply.

However, SEPP No. 35 indicates that if the primary purpose of dredging operations is to mitigate flood impacts, even where an incidental feature of the dredging is to open the waterway and allow tidal influence, the activity is not classified as “maintenance dredging” and development consent is required. As one of the primary purposes of the proposed policy is flood mitigation, SEPP 35 does not apply.

SEPP No. 44 Koala Habitat Protection

A review of digital mapping prepared by the Department of Planning and provided by Wollongong City Council indicates that the areas surrounding Towradgi Lagoon fall under SEPP No. 44. However, according to Kevin Mills and Associates (2002), Koalas are no longer found on the coastal plain in the Wollongong district. Therefore it is unlikely that the proposed policy will affect potential koala habitat.

SEPP No. 71. Coastal Protection

The objective of SEPP No. 71 is to protect and manage coastal zones in an appropriate and sustainable manner. A review of this policy confirms that there are no clauses relevant

to this proposed policy other than that any works should be conducted with reference to Part 8 'Matters for Consideration'.

2.2 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (*EPA Act 1979*) requires that the determining authority (in this case Wollongong City Council) must consider the impact of a proposed activity. Section 111 of the *EPA Act 1979* outlines the considerations that must be made by the determining authority. The impact of a proposed activity is generally assessed through the preparation of an environmental impact assessment report (i.e. a Review of Environmental Factors), which will determine whether or not the proposed activity is likely to have a significant impact on the environment including conservation agreements and related matters, critical habitat, and threatened species, populations or ecological communities or their habitats or other protected fauna or protected native plants. If the proposal is unlikely to have a significant impact, the activity can proceed in line with any specified measures to ensure protection of the environment. If the proposal is likely to have a significant impact on the environment, an Environmental Impact Statement must be prepared to further assess impacts and determine the effectiveness of potential mitigation measures. If the proposed activity will affect land determined to be critical habitat, or is likely to significantly affect threatened species, populations or ecological communities or their habitats, a species impact statement must be prepared.

2.3 Statutory Framework

2.3.1 Protection of the Environment Policies

Table 1 outlines the relevant protection of the environment policies relating to this project.

Table 1 NSW Protection of the Environment Policies

Policy	Objectives
Estuary Management Policy (1992)	Specific objectives of the Estuary Management Policy (NSW Government, 1992) are: • the protection of estuarine habitats and ecosystems in the long-term, including maintenance in each estuary of the necessary hydraulic regime; • the preparation and implementation of a balanced long-term management plan for the sustainable use of each estuary and its catchment, in which all values and uses are considered, and which defines management strategies for: • conservation of aquatic and other wildlife habitats • conservation of the aesthetic values of estuaries and wetlands • prevention of further estuary degradation • repair of damage to the estuarine environment • sustainable use of estuarine resources, including commercial uses and recreational uses as appropriate.
NSW Coastal Policy (1997)	The 1997 Coastal Policy has as its central focus the ecologically sustainable development (ESD) of the NSW coastline. The definition of the coastal zone includes a one kilometre strip along the coastline, three nautical miles seaward and all coastal rivers, lakes, lagoons, estuaries and islands.
NSW Biodiversity Strategy (1999)	This strategy proposes a framework for coordinating and integrating government and community efforts, ensuring that available resources are efficiently and effectively applied. The actions in the Strategy detail a balanced response for the integration of ecological, social and economic objectives. The Strategy outlines proposals to protect the high quality natural environment of NSW and enable the benefits of biodiversity to be shared by all.
NSW Wetlands Management Policy (1996)	The goal of the *NSW Wetland Management Policy* is the ecologically sustainable use, management and conservation of wetlands in NSW for the benefit of present and future generations. The policy aims to minimise any further loss or degradation of wetlands and where possible, restore degraded wetlands. To achieve its goal the Policy adopts nine principles, see *NSW Wetland Management Policy* for details.
NSW Groundwater Policy Framework Document – General (1997)	The purpose of the Groundwater Framework Policy document is to provide a clear NSW government policy direction on the ecologically sustainable management of the State's groundwater resources for the people of NSW. The focus of the Policy is on water below the ground surface in a geological structure or formation, and on the ecosystems from which these waters are recharged or into which they discharge.

Policy	Objectives
NSW Groundwater Quality Protection Policy (1998)	This Policy adopts the principles outlined in the *NSW State Groundwater Policy Framework Document*. In relation to Groundwater Quality Protection, this policy outlines nine specific principles, see *NSW Groundwater Quality Protection Policy*.
NSW Groundwater Dependent Ecosystem Policy (2002)	The *State Groundwater Dependant Ecosystems Policy* is specifically designed to protect our valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependant ecosystems are maintained or restored, for the benefit of present and future generations. This policy provides guidance, including five principles, to enable effective and practical management of valuable natural systems.
NSW Flood 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.
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 Fishnote 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.
Water Quality and River Flow: Interim Environmental Objectives	This document outlines the Water Quality and River Flow Objectives for different catchments. Achieving water quality objectives and river flow objectives will mean improving poor water quality and maintaining existing good water quality.

The National Strategy for Ecologically Sustainable Development (NSESD) has been formulated to ensure ESD is accounted for in all Proposals. There are three core objectives:

- To enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations
- To provide for equity within and between generations
- To protect biological diversity and maintain essential ecological processes and life-support systems.

Table 2 outlines the principles of ESD applied to this proposed policy.

Table 2 Principles of ESD Applied to the Proposed Policy

Principle	Application to the Proposed Policy
Precautionary Principle	Potential hazards and risks stemming from construction and operation of the proposed activity have been considered throughout the design aspect of this proposed policy. No issues have been identified that would cause any serious or irreversible environmental damage. The implementation of mitigative measures described in Section 7 of this report would ameliorate potential environmental impacts.
Intergenerational Equity	The proposed policy would reduce flood risk to surrounding low-lying areas and improve water quality within the Lagoon. Consideration and

Principle	Application to the Proposed Policy
	minimisation of impacts to the local environment through the introduction of measures will ensure the integrity of natural and social values of the environment for future generations.
Conservation of Biological Diversity & Ecological Integrity	Thorough assessment of the local ecology, along with consultation with key stakeholders, has been undertaken to identify and manage any potential environmental hazards or risks associated with the proposed policy. Mitigative measures outlined in Section 6 of this report would ensure biological diversity and ecological integrity are not compromised by this proposed policy.
Improved Valuation & Pricing of Environmental Resources	The integrity of the local environment is recognised as a valuable resource. The Proposed policy addresses issues relevant to the water quality and ecological integrity of the Towradgi Lagoon and mitigation measures have been provided to ensure the value of this resource is maintained.

2.3.2 Other Relevant Legislation

Table 3 lists the range of environmental protection legislation at Commonwealth and State levels relevant to the proposed policy.

Table 3 Environmental Protection Legislation Summary

Act	Objective	Relevance to Project
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* provides for the protection of the environment and the conservation of biodiversity for those aspects of the environment that are matters of national environmental significance.	Several species listed as being threatened under the Act, such as the Grey-Headed Flying Fox, Green and Golden Bell Frog and Swift Parrot, or migratory species, such as the Painted Snipe, White Bellied Sea Eagle, Bar-tailed Godwit and the Eastern Reef Egret, may occur in the area.
Crown Lands Act 1989	The objects of this Act are to ensure that Crown land is managed for the benefit of the people of New South Wales and in particular to provide for: • A proper assessment of Crown land, • The management of Crown land having regard to the principles of Crown land management contained in this Act, • The proper development and conservation of Crown land having regard to those principles, • The regulation of the conditions under which Crown land is permitted to be occupied, used, sold, leased, licensed or otherwise dealt with, • The reservation or dedication of Crown land for public	The proposed policy falls within Crown Land.

Act	Objective	Relevance to Project
	purposes and the management and use of the reserved or dedicated land, and • The collection, recording and dissemination of information in relation to Crown land.	
Rivers and Foreshores Improvement Act 1948	The *Rivers and Foreshores Improvement Act 1948 (RFI Act)* aims to control excavations, the placement of fill and other works in or near rivers, estuaries and lakes. The Act is administered by DECC. At the time of the preparation of this report, licences and approvals associated with this Act were still in force and the Water Management Act (2000) had not yet become operational with regard to licences and approvals.	The proposed policy involves works within an estuary.
Threatened Species Conservation Act 1995 (TSC Act)	The objects of this Act are as follows: • To conserve biological diversity and promote ecologically sustainable development; • To prevent the extinction and promote the recovery of threatened species, populations and ecological communities; • To protect the critical habitat of those threatened species, populations and ecological communities that are endangered; • To eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities; • To ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed; and • To encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.	The proposed policy may impact endangered ecological communities, such as Swamp Sclerophyll Forest on Coastal Floodplains, Swamp Oak Floodplain Forest, Illawarra Lowlands Grassy Woodland and Coastal Salt Marsh and threatened species such as the Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot, Grey Headed Flying Fox and Green and Golden Bell Frog, which are protected under the TSC Act.
Fisheries Management Act 1994	The objects of this Act are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. In	The proposed policy may impact upon threatened species and protected such as the Black Cod, Australian Grayling

Act	Objective	Relevance to Project
	particular, the objects of this Act include: • To conserve fish stocks and key fish habitats; • To conserve threatened species, populations and ecological communities of fish and marine vegetation; • To promote ecologically sustainable development, including the conservation of biological diversity, and, consistently with those objects: • To promote viable commercial fishing and aquaculture industries; • To promote quality recreational fishing opportunities; • To appropriately share fisheries resources between the users of those resources; and • To provide social and economic benefits for the wider community of New South Wales.	and Sygnathids, which are protected under the FM Act, and commercial and recreation fish stocks.
National Parks and Wildlife Act 1974 (NPW Act)	The objects of this Act are as follows: • The conservation of nature, including, but not limited to, the conservation of: • Habitat, ecosystems and ecosystem processes; Biological diversity at the community, species and genetic levels; Landforms of significance, including geological features and processes; Landscapes and natural features of significance including wilderness and wild rivers, • The conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to: • Places, objects and features of significance to Aboriginal people; Places of social value to the people of New South Wales; Places of historic, architectural or scientific significance, • Fostering public appreciation,	The proposed policy could potentially have a significant impact upon the ecology of Towradgi Lagoon, and species dependant upon this resource, by interfering with a natural process. Additionally, there are numerous known items of indigenous significance surrounding the Lagoon.

Act	Objective	Relevance to Project
	understanding and enjoyment of nature and cultural heritage and their conservation, • Providing for the management of land reserved under this Act in accordance with the management principles applicable for each type of reservation.	
Coastal Protection Act, 1979	The objects of this Act are to provide for the protection of the coastal environment of the State for the benefit of both present and future generations and, in particular: • to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality, and • to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development, and • to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including: o benefits to the environment, and o benefits to urban communities, fisheries, industry and recreation, and o benefits to culture and heritage, and o benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, and • to promote public pedestrian access to the coastal region and recognise the public's right to access, and • to provide for the acquisition of land in the coastal region to promote the protection,	The proposed policy relates to the CP Act as it could potentially affect the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality. Ultimately, in the long term the Entrance Management Policy will attempt to bring a return to more 'natural' regime of entrance opening, which will have follow on effects for associated ecosystems and biodiversity.

Act	Objective	Relevance to Project
	enhancement, maintenance and restoration of the environment of the coastal region, and • to recognise the role of the community, as a partner with government, in resolving issues relating to the protection of the coastal environment, and • to ensure co-ordination of the policies and activities of the Government and public authorities relating to the coastal region and to facilitate the proper integration of their management activities.	

Landowner consent from the Department of Lands will be required for the proposed policy as the policy affects Crown Land. A Part 7 Permit under the Fisheries Management Act will not be required if a Department of Lands licence is issued.

3. CONSULTATION

The following stakeholder groups were contacted as part of the consultation process:

- NSW Department of Primary Industries (NSW Fisheries),
- NSW Department of Planning (DP),
- NSW Department of Natural Resources (DNR now DECC),
- NSW Department of Environment and Conservation (DEC now DECC) National Parks and Wildlife Service,
- Department of Lands,
- Roads and Traffic Authority (RTA),
- Wollongong City Council, and
- Members of the Estuary Management Committee.

The agencies were contacted in November 2006 and asked to provide comments on the proposed policy. The various issues raised are outlined Table 4. A copy of the correspondence is provided in Appendix B.

Table 4 Stakeholders Contacted During the Consultation Process

Issue	Addressed in REF
Department of Planning Cardno Lawson Treloar spoke to Grahame Tower from the Department of Planning on 30 November 2006. Grahame highlighted the need determine whether any zoning changes would be necessary due to the findings of our study. The Department of Planning would seek involvement only if zoning changes were necessary, and had no specific requirements for the Entrance Management Policy or the REF.	NA
Department of Primary Industries (NSW Fisheries) The DPI provided an outline of general requirements in relation to the structure of the REF: • Description of the aquatic environment of Towradgi Creek and its regional significance • Analysis of any impacts of artificial entrance openings upon aquatic environments and species • Proposed safeguards to mitigate any impacts upon aquatic environments and species • Predictions of any impacts upon water quality and aquatic threatened species, populations and ecological communities listed under the Fisheries Management Act 1994 (both temporary and permanent) • Proposed safeguards to mitigate any impacts upon water quality and aquatic threatened species, populations and ecological communities • Provide an assessment of the potential impacts of artificial entrance openings on recreational fishing in Towradgi Creek The DPI support the following issues for the construction of the Entrance Management Policy and REF: • Minimum interference with ICOLL entrance barriers, and when needed, factual data must be used to justify a mechanical breakout • Consistent consultation with relevant authorities during the construction and implementation of the	Section 6

Issue	Addressed in REF
Entrance Management Policy • Analysis of surrounding infrastructure • Appropriate consultation procedures in order to gain approval to carry out a mechanical breakout The DPI requested a copy of both the Entrance Management Policy and the REF. Draft copies were provided for comment in February 2007 and comments received were incorporated into this document.	
Department of Lands Cardno Lawson Treloar spoke to Grant Merinuk from the Department of Lands on 29 November 2006. He highlighted the following concerns: • The need for asset mapping during the study, and assessment of the impacts on environmental assets • The determination of trigger levels- analysis of how they were derived and the impacts that they might have The Department of Lands requested a draft copy of the Entrance Management Policy and REF.	Section 6
Department of Natural Resources (now DECC) Particular concerns of the DNR were as follows: • The flood studies for Towradgi Creek are thoroughly reviewed in the development of the policies and the policies are informed by (and complementary to) the findings of those studies • The policies identify and discuss strategies to return to a more natural opening regime • The importance of the environmental values of the lagoon is given appropriate weighting The DNR requested a draft copy of the Entrance Management Policy and REF. Comments received were incorporated into this document.	Section 6
Department of Environment and Conservation (NPWS now DECC) Jamie Ershen from the New South Wales National Parks and Wildlife Service was contacted on 7 December 2006. The area under consideration for this study is not within close proximity to any National Parks so the NPWS had no comments.	NA
Sydney Water Corporation Cardno Lawson Treloar contacted Steve Znautas on 30 November 2006. He requested a draft copy of the Entrance Management Policy and REF, but did not have any comments.	NA
Wollongong City Council Wollongong City Council expressed concerns for the levels at which artificial opening would commence. Specifically, a request was made that the beach bar should not exceed a maximum level of 2.0m AHD, and that this be incorporated into the trigger levels determined by Cardno Lawson Treloar. Wollongong City Council requested further consultation with their Works and Services Division, which was undertaken and incorporated into this document.	Section 6

4. ALTERNATIVES

4.1 Entrance Management

A range of feasible alternatives were considered and are outlined below.

4.1.1 Option 1 – Do Nothing

While this option would allow for a return to a more natural regime of entrance opening, it would not address issues associated with flooding and recreational water quality (discussed further in Section 6).

The intention of this approach is to allow the lagoon to open with no assistance. However, the consequences of adopting this approach has the potential to result in nuisance flooding of numerous residential properties (yard and overfloor flooding) and the flooding of local infrastructure (such as Lake Parade and Parker Road). However, based on recent observations (particularly following the severe floods of 1998 and 1999), it is expected that in the absence of intervention, an unassisted opening is likely to result in intervention by concerned residents as flood waters rise would take it upon themselves to open the entrance manually. An example of such intervention occurred in 2005 (reported in the Illawarra Mercury) where inundation of Parker Road (associated with a high water level in a closed Lagoon) prompted residents to open the Lagoon.

Several assets are located within the study area, which may be affected by Lagoon flooding. These include commercial and residential properties, Towradgi and Corrimal Beach parks, roads, sewerage and stormwater.

Floor level data indicates that the lowest floor level in the study area is 1.97mAHD, while there are 6 properties below 2.5mAHD and 17 properties below 3mAHD. There were 66 properties with ground levels below 1.6mAHD and 70 properties with ground levels below 1.9mAHD. Therefore, at a water level of 1.6 mAHD, limited property inundation would occur. However, as the lake level increases the extent of property inundation increases significantly. If water levels were allowed to exceed 2mAHD, significant property inundation would be observed. Such flooding may pose a hazard for residents in these lower lying areas.

Towradgi Park is generally above 3.5 mAHD. However, the easement connected to Towradgi Park along the rear of the Juanita Avenue properties, which is used for recreational purposes, has a ground level of between approximately 1.5 to 2.6 mAHD. Similarly, the foreshore areas along Towradgi Lagoon and the Parker Road Arm vary between 1.15 and 2 mAHD. A significant area upstream of the Lake Parade bridge on the left bank of the Parker Road Arm is below 1.6 mAHD, as is the left bank at the confluence of the Parker Road Arm and Towradgi Lagoon. If water levels were to exceed 2mAHD, then significant flooding would be experienced in these areas, which could pose a hazard to public safety.

There are numerous roads and pedestrian areas surrounding Towradgi Lagoon which have low points below 3mAHD. These include Pioneer Road (2.89mAHD), Carrol Road (2.23mAHD), Parker Road (1.94mAHD), Lake Parade (2.30mAHD), the Cycle Way (2.30mAHD) and the Footbridge near the Lagoon outlet (2.23mAHD). If water levels exceed 2mAHD, inundation of Parker Road would be expected, while several other road and pedestrian area would be at threat of inundation.

A review of Sydney Waters Sewerage infrastructure shows that there are several junctions located below 1mAHD. Therefore it is not feasible to select a trigger level

which will protect these assets. There are 2 pumping stations and a vent shaft which could be potentially impacted upon by lagoon levels. However, all of these structures are located above the 2mAHD inundation extent. Therefore they are unlikely to control the selection of the trigger level.

In the past the area around Towradgi Lagoon has experienced stormwater and sewerage overflows associated with elevated Lagoon levels and flooding. This problem is expected to be rectified in the near future as a wet weather pumping station is currently under construction by Sydney Water Corporation and additional backflow valves have also been placed on low lying assets by Sydney Water Corporation.

Stormwater pits in Parker Road have lip levels of 1.64 mAHD and 1.7 mAHD, while the Lake Parade bridge crossing of the Parker Road Arm has a pit with an invert of 0.41 mAHD and a lip level of 1.7 mAHD. If Lagoon levels were allowed to rise beyond these levels then the pits would start to be inundated and this may cause street drainage issues, even for very minor rainfall events.

The impact of not having an adopted entrance management policy is twofold. Firstly, a public perception that both private and public assets are not being adequately protected by Council from flooding. As outlined above, this may result in illegal opening of the lagoon. This could potentially result in the lagoon being mechanically opened more frequently than if an entrance management policy was in place. This could have negative impacts on lagoon ecology and recreational uses.

The second impact is related to the need for the most prudent flood-risk management as within the adopted Floodplain Risk Management Plan (Bewsher Consulting, 2003b). Adopting a do-nothing approach is inconsistent with the adopted Floodplain Risk Management Plan.

4.1.2 Option 2 – Mechanically Open the Lagoon Entrance

The modification of the Towradgi Lagoon entrance system and the modification of the local catchment through the process of urbanisation has altered the natural (Pre-European) opening conditions. Given the flood risks to property and infrastructure in the Towradgi Lagoon floodplain, the entrance may need to be mechanically opened from time to time. The advantage of an Entrance Management Policy, is that it provides certainty for all affected stakeholders and the wider community of when, where, how and under what conditions Towradgi Lagoon will be mechanically opened.

The lagoon entrance would be opened only when a pre-defined set of criteria are met. These criteria include a 'trigger' lagoon water level and berm height coupled with the prediction of continuing rainfall and therefore an expected further increase in lagoon water levels. There would also be an emergency 'trigger' level which would result in immediate opening of the lagoon even if continuing rainfall is not predicted. This emergency level would be defined by the level of the lowest critical asset.

Once all the criteria are met, a mechanical breakout of the lagoon entrance is initiated on the first suitable mid-outgoing tide. This would involve the deployment of equipment, such as a 4WD backhoe, to dig a 'pilot' channel (a narrow, shallow channel to facilitate the commencement of outflow from the Lagoon). Details of the means of access of equipment to the beach are outlined in Section 4.2. The pilot channel would be approximately 1m wide and to a depth such that the base of the pilot channel meets the lagoon water level. Once the pilot channel has been created, the machinery is removed from the beach and water in the lagoon will start to flow through the pilot channel, the flow will increase as it scours the channel deeper and wider. The mechanism of the scour process is natural from this point onwards, driven by ocean tidal behaviour and catchment inflow. This generally

results in a three phase process, taking of the order of 4 - 6 hours and is described in Gordon (1981 and 1990).

The procedure for the mechanical opening of the Lagoon entrance is outlined below:

- Day to day operation of the Lagoon is likely to see the Lagoon closed for the majority of the time and opening up to 16 times a year.
- Water level in the Lagoon is monitored via routine checks of the water level gauge at Pioneer Road. The information on this webpage is normally only updated on a daily basis, usually between 4 – 6am. Note that this gauge can show information of limited assistance for entrance management once the entrance is open.
- (http://www.mhl.nsw.gov.au/htbin/map_data_display.com?SITE=TOWR)
- Rainfall in the locality can be monitored via routine checks of the local rainfall gauge at Russell Vale. The information on this webpage is normally only updated on a daily basis, usually between 4 – 6am.
- (http://www.mhl.nsw.gov.au/htbin/map_data_display.com?SITE=RUSS)
- An alarm can be created in the monitoring system operated by MHL to send an automated email, fax or telephone a pre-registered list of telephone numbers (eg Area Works Depot Manager or Duty Operator) with a recorded message when a threshold level has been exceeded. It is recommended that Council contact MHL via DECC to have such an alarm system developed and activated. In the case of Towradgi Creek it is recommended that this threshold be set at **1.6 mAHD** given the issues with road inundation in the Lake Parade and surrounding areas. This is consistent with the proposed flood planning assessments being undertaken for the Floodplain Risk Management Study and Plan. Consideration of the addition of a standby alarm to be triggered when the level reaches a lower level to indicate to Council to prepare for the opening may also be prudent.
- Once the threshold level is exceeded and rainfall is continuing in the catchment or expected in the following 24 hours, Area Works Manager to decide on whether to mobilize a 4WD backhoe operator to undertake an assisted breakout. The estimated time to mobilise an operator is of the order of one hour during business hours and 2 hours during non-business hours.
- Once a decision has been made to undertake an assisted breakout, advice to DPI (NSW Fisheries), DECC and the local media should be issued advising of the breakout with details of potential health impacts on recreational swimmers on the adjacent beach areas for the three days following the cessation of rain.
- On arrival the 4WD backhoe operator to dig a 'pilot' channel from the ocean-ward end toward the entrance approximately a bucket-width wide (commonly 1 m or less). The last section of the channel (at the entrance end) should be opened at the time of the next possible outgoing mid tide (i.e. following the highest possible tide of the day). Ocean tide information in the form of predicted tides can be accessed at http://www.mhl.nsw.gov.au/www/sydp_tide.htmlx). Initiation of a breakout at this time is likely to result in the most effective and sustained assisted breakout due to the increasing head difference through the course of the breakout.
- Figure 8 shows the recommended access point for the 4WD backhoe operator to access the beach and the recommended orientation of the excavated channel and location of the material excavated from the pilot channel.
- Where access to the internet is not available (due to power loss associated with a storm event), checking of a water level marker (a 'tide board') at a visible location from the footbridge at the entrance (to be installed on the upstream side of footbridge) should be undertaken and white pole markers be placed in the dune system adjacent to the entrance (on the northern side) to direct the 4WD backhoe operator as to the most appropriate pilot channel location and orientation.

As part of this procedure, provided that water levels do not exceed 1.95mAHD, mechanical opening would occur at the mid outgoing tide so that the opportunity for berm reestablishment will be maximised following mechanical breakout. The impacts of opening the Lagoon at this time will be monitored, to assess the level of scour achieved by opening the Lagoon at this tide. If the level of scour is found to be insufficient, then mechanical opening will take place at high tide, which is generally when mechanical opening is prescribed. This technique would be reviewed after a sufficient number of openings have occurred (as determined by Council) to allow for proper assessment of this technique.

It should be noted that Option 3 - Installation of an Inlaid Rubber Access Path is considered in the impact assessment sections of this REF.

4.1.3 Option 3 – Berm Height Management

The berm height at the entrance of the lagoon can be managed such that it does not exceed a pre-determined level. This is sometimes known as maintaining a 'dry notch' (ie a low or 'saddle' point in the beach adjacent to the entrance which the Lagoon can preferentially flow across). The purpose of the notch is to dispense with the need to mechanically open the Lagoon when a flood arrives. If maintained correctly, the notch would breach without intervention when the Lagoon water level reaches the appropriate level. The flow from the Lagoon to the ocean will increase as it scours the channel deeper and wider (ie the same three phase process described above by Gordon, 1981 and 1990).

Managing the berm height to sustain the presence of the 'dry notch' would involve regular monitoring of the berm height via regular survey and/or the use of observation height markers. A combination of lagoon water levels and volume of the overall sand berm would be considered to determine if a berm 'shaping' to maintain the notch is required. The 'shaping', potentially to be undertaken on frequent basis (ie of the order of monthly or bi-monthly dependent on coastal processes), would be undertaken using some form of sand moving machinery, such as a bulldozer or excavator. As part of the 'shaping' process, the required depth of sand would be moved from the entrance to a location on the beach (close to the entrance) and spread out to 'match in' with the existing beach profile such that the sand remains in the beach system.

Berm height management would be expected to involve more frequent access of machinery onto the beach than the mechanical opening approach (Section 3.3). Therefore there may be increased impacts associated with access and machinery. A formalised access path (Section 3.5) would be required to limit the erosion impacts on the bank. Under the mechanical breakout option, a less formal access path may be suitable.

4.1.4 Consideration of Long Term Options

The analysis of the maximum water levels at the Towradgi Creek gauge at Pioneer Road show that the maximum water level rarely exceeded 1.6 mAHD during the period when the informal policy applied (until 2003), which would be expected, as 1.6mAHD was roughly the trigger level for this informal policy. Since the cessation of this policy, maximum levels of 1.66 – 1.94 mAHD have been observed (for continuous periods of between 1 – 18 days) (Source: MHL Data for Towradgi Gauge supplied 12 December 2006). Nonetheless, means of progressively raising the intervention level beyond 1.6 mAHD have been considered.

The review of assets and asset levels within the Study Area (Section 6.5) indicates that inundation of Parker Road would limit the trigger level being raised any higher than 1.9 mAHD. The floor level survey also indicates that overfloor flooding becomes likely at this level. Floor levels could be raised in the future. However, raising of Parker Road is likely to be an expensive and complex exercise.

Property inundation is considered to be the greatest limiting factor to an increase in the Towradgi Lagoon trigger level. At 1.6 mAHD only very limited property inundation is occurring, most of which is on public land. Residential private property inundation starts to become increasingly significant at levels greater than 1.6 mAHD (Figure 5).

Due to the nature of the catchment and rainfall patterns in the area, the high rate of rise within the lagoon is a significant factor in determining trigger levels for Towradgi Lagoon (Section 6). As such, any raising of the trigger level must take into consideration the rate of rise of the lagoon and the limited response time available during a rainfall event.

If property inundation could be alleviated via mechanisms such as levees or bunding without impacting on flood levels, the trigger level could potentially be raised to a maximum of 1.9 mAHD. Above which, Parker Road becomes inundated.

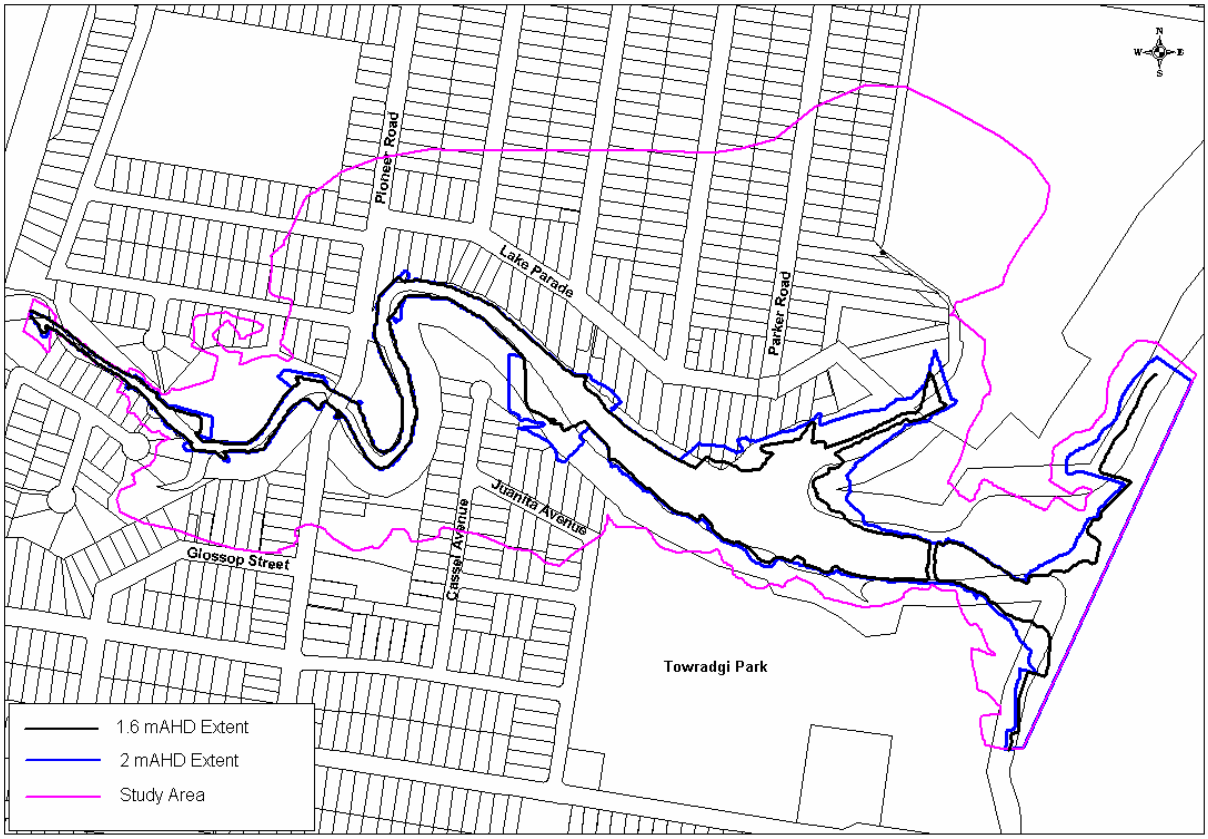


Figure 5 Comparison of 1.6 mAHD and 2 mAHD Extent in Towradgi Creek

4.2 Access Path

Several alternatives have been assessed for the proposed access path, which are described below. The approximate location of this path is indicated in Figure 6. It should be noted that Option 3 - Installation of an Inlaid Rubber Access Path is considered within the impact assessment sections of this REF.

4.2.1 Option 1 - Do Nothing

The major concern with not creating an access path for machinery to use during mechanical opening of the Lagoon or the maintenance of berm height, is that there will be increased erosion of the banks of Towradgi Lagoon, as access paths will not be stabilised, and there will be no designated route, which may result in machinery using several entrance and exit points, spreading the risk of erosion. This is especially the case with the berm management option, as this option is likely to result in more frequent access to the Lagoon entrance being required.

4.2.2 Option 2 - Installation of a Gravel Access Path

A gravel access path for 4WD backhoes to gain access to the entrance area has been considered, to minimise disturbance of turfed areas in Towradgi Park associated with the movement of machinery. This will most likely take the form of a gravel based path, lined with geofabric, with a base of approximately 200 – 300mm deep. Issues raised associated with this form of path include the fragmentation of riparian vegetation and visual impacts. This would have to be used in tandem with a flexible plank decking, similar to that used for pedestrian access through sand dunes, where sand is encountered on the access path.

4.2.3 Option 3 - Installation of Inlaid Rubber Access Path

The installation of an inlaid rubber grid, which allow for turf to grow overtop of the stabilisation material, is another option that has been considered. Figure 7 provides an example of this type of grid. The use of this product would minimise erosion impacts associated with the movement of machinery. Additionally, this would minimise fragmentation by allowing the growth of grasses, and would reduce any visual impacts. Such a product would have to be used in tandem with a flexible plank decking, similar to that used for pedestrian access through sand dunes, where sand is encountered on the access path.

4.2.4 Option 4 - Use of Temporary Access Stabilisation

The use of transportable access stabilisation is an option that would help minimise erosion and avoid fragmentation. This would involve the use of a portable rubber stabilisation structure that can be rolled out prior to machinery accessing the Lagoon entrance, to protect sensitive areas.

The main issues associated with the use of a portable temporary structure are the length of material required, which may make the portable structure quite large, which would pose problems with transport and storage. Additionally, the structure may take considerable time to set up. This will be an issue during mechanical breakout, as the process of laying out the temporary structure will be time consuming, and water levels may be rising rapidly.

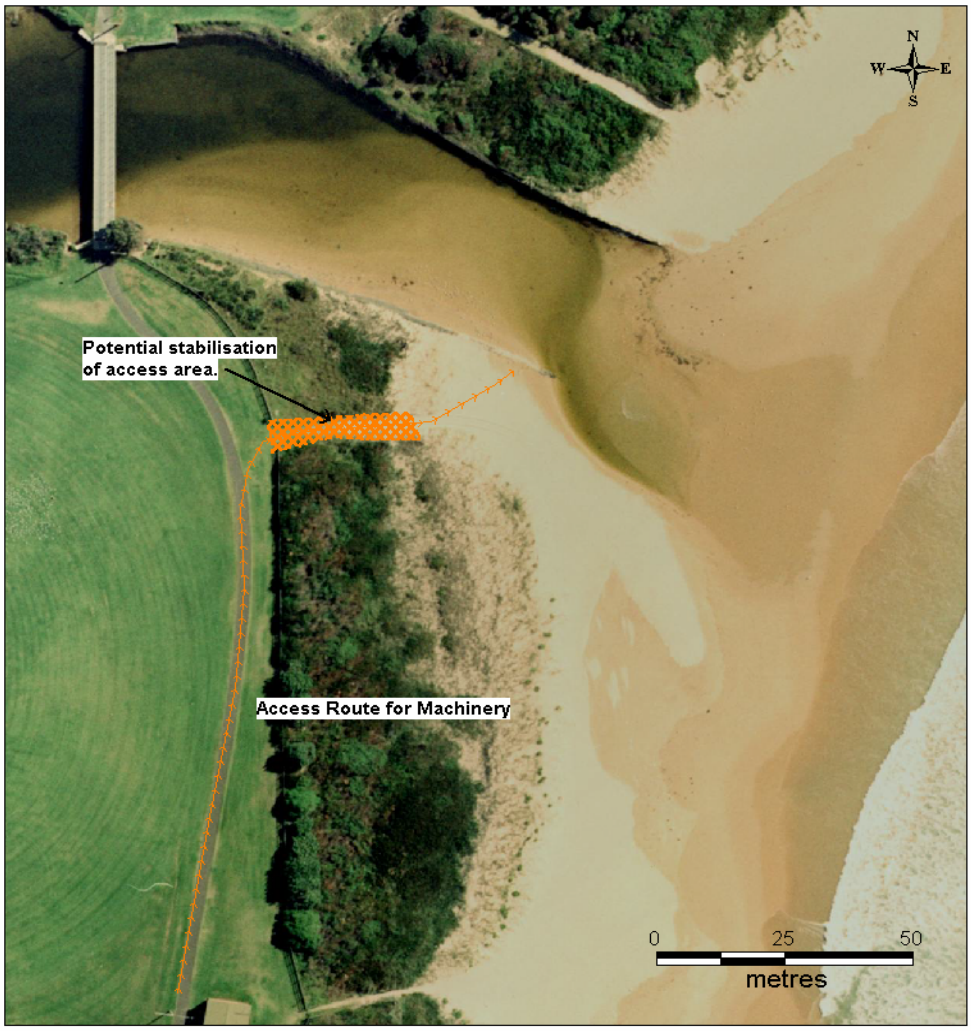


Figure 6 Approximate Location of Access Path

http://www.elmich.com.au/turfpave/turfpave.html

Figure 7 Example of Typical Turf Stabilisation Product

5. PROPOSED ENTRANCE MANAGEMENT POLICY

5.1 Introduction

This REF has been prepared to evaluate the environmental impact of Option 2 – Mechanical Breakout and Option 3 for the Access Path, out lined in Sections 4.1.2 and 4.2.3 respectively and shown in Figure 8, being the proposed Entrance Management Policy. A detailed out line of the Options is provided below, and the evaluation of the impacts is provided in Sections 6 and 7.

Details of the proposed Entrance Management Policy are listed in Section 4.2.

Consideration of numerous factors was undertaken when developing the Entrance Management Policy, which are outlined in the following sections.

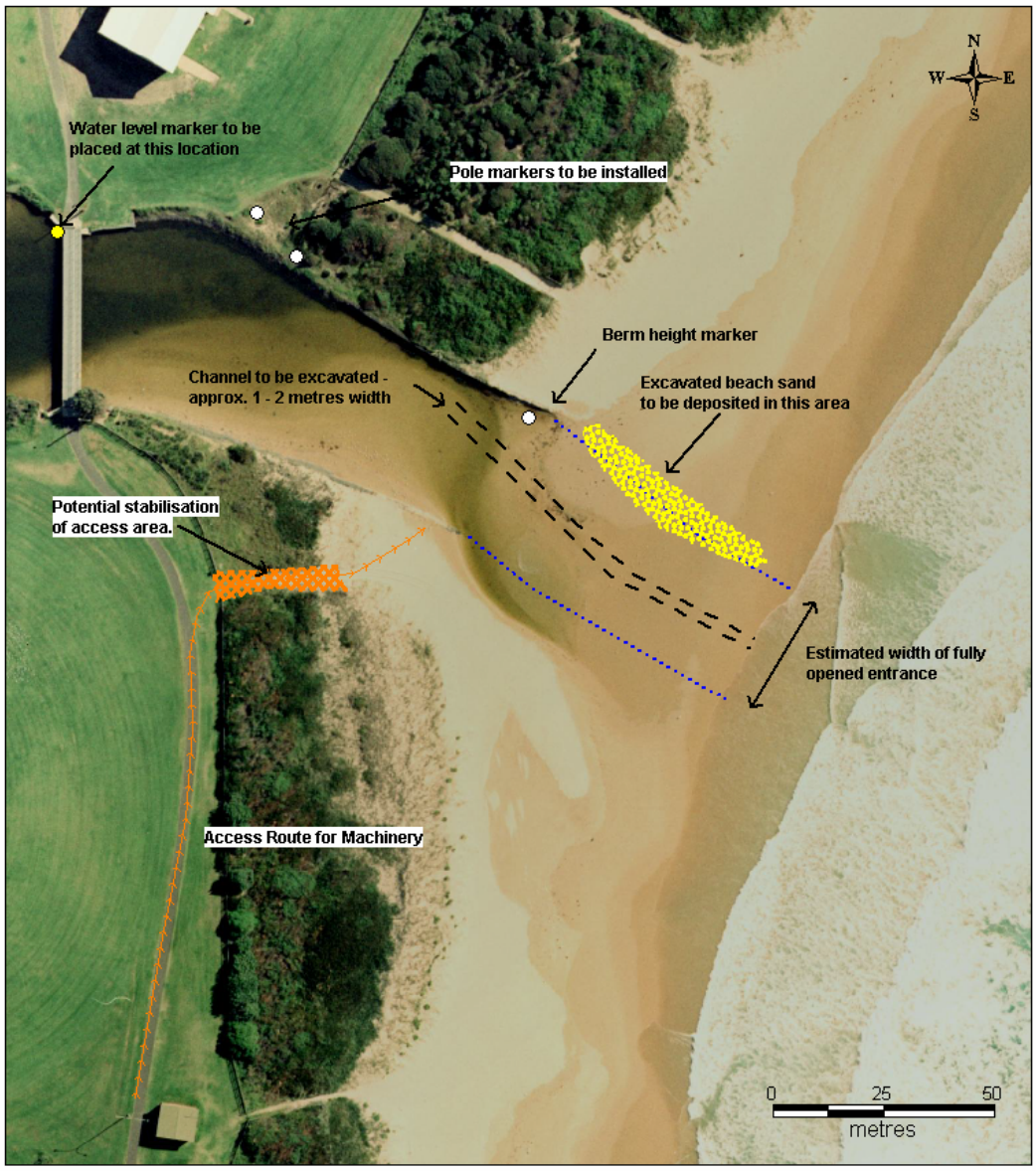


Figure 8 Recommended Breakout Channel Alignment and Access for Towradgi Lagoon

5.2 Flooding

A flood study was completed for Towradgi Creek in 2003 (Bewsher Consulting, 2003). The berm level was assumed to be at 2 mAHD in this assessment of design flood levels.

The conclusions of the Flood Study indicate during large rainfall events (5 Year ARI and greater) the lagoon and berm levels do not impact upon peak flood levels in properties adjacent to the lagoon. This is due to the limited storage area in the lagoon and the relatively large catchment size compared to the Lagoon size. This results in an efficient entrance breakout mechanism.

Consequently, flood behaviour and floodplain risk management options presume a berm level of 2 mAHD. Therefore a trigger level of lower than 2 mAHD is a controlling factor for this assessment.

5.3 Lagoon Response to Opening

In the event of a rainfall event occurring, with the entrance closed, water will build up behind the berm until water levels exceed the berm height. The flow will then exceed the berm and start to scour a channel which becomes progressively deeper and wider as the rainfall event continues. The rate of increase in the channel depth and width during the opening will be affected by the ocean tide and wave conditions and the amount of rain that continues to fall in the catchment. Under fully open entrance conditions at the start of a rainfall event, the catchment flow would exit the lagoon, solely controlled by ocean tide and wave conditions. With sand to scour (ie the entrance closed or partly open), the rate of discharge slows as the scouring process occurs. The greater the volume of sand to scour, the longer it takes, except under relatively rare catchment flood conditions. Further details are outlined in Section 6.

5.4 Lagoon Response to Elevated Ocean Levels

The level of ocean at any point in time is subject to the following factors:

- Astronomical Tide
- Barometric Pressure
- Wave/Wind Setup
- Wave Runup
- Medium Term Sea Level Variations (e.g. those associated with climate change).

If ocean levels were greater than the trigger level and the Lagoon entrance was opened, ocean waters would flow into the lagoon, rather than the lagoon draining, and the lagoon level would rise. Therefore, an assessment has been undertaken of Highest Astronomical Tides (commonly referred to as King Tides), historical tide data and predicted ocean levels in storm conditions.

It should be noted that all ocean levels below are reported in mAHD, ocean levels for navigation purposes are often reported from the Lowest Astronomical Tide (LAT) which is approximately 1m below 0 mAHD, resulting in tide levels reported as 1m higher than those in mAHD.

The highest astronomical tide (HAT) or King Tide for the region is 1.17 mAHD. While HAT is the highest level of normal tides inundation may exceed this level (eg storm surges). If the trigger level is set above this level, the king tide will not increase lagoon levels when the lagoon entrance in opened.

Due to the extensive data set from tide gauges such as Fort Denison (operational since the late 1880's), recorded water levels can be reported in terms of the probability of exceedance of a specific level at some locations. For example, the water level that is exceeded for only 1% of the time at Fort Denison is ~1.0 mAHD. This level would relate to ocean levels at Towradgi Lagoon. As described above, if the trigger level is set above 1.0 mAHD, the ocean level will not increase lagoon levels if an assisted opening is undertaken.

The maximum water level associated with oceanic inundation at the Towradgi Creek water level station (Pioneer Road) between 1992 and 2003 was 1.74 mAHD.

The estimated 100 Year ARI ocean level for the study area is 2.7 mAHD. GHD have divided this into 1.6 mAHD for tidal, barometric and wind setup components, +0.8m for wave setup and +0.3m for climate change sea level rise for a 50 year planning period. GHD (1989) have also estimated a 20 Year ARI ocean level of 2.4 mAHD. These values are estimates for the beach not within the lagoon. Wind and wave setup would not be able to propagate through the entrance at these same heights. Therefore, the resulting lagoon levels as a result of elevated ocean levels would be significantly lower.

6. ENVIRONMENTAL IMPACT ASSESSMENT

This Environmental Impact Assessment focuses on the impacts of the construction of the formal access path through Towradgi Park and the proposed Entrance Management Policy within Towradgi Lagoon. The study area comprises the tidal waterways, foreshores, the immediate surrounding open space and adjacent lands of Towradgi Creek, including its tributary to the north, referred to in this document as the Parker Road Arm. The limits of the study area are defined at its upstream reaches by the tidal limit and Corrimal Beach at the downstream limit. The extent of the study area on the adjacent lands is defined by the 3.5 mAHD contour (Figure 3). This is considered to be beyond the maximum height that the berm could reach and therefore includes all potentially affected lands.

The impacts of the construction of the formal access path are not considered in the sections relating to Hydrology and Hydraulics, Assets, Lagoon Ecology, Commercial and Recreational Fishery, Tree Failure, Non-Indigenous Heritage and Cumulative Environmental Impact as these works are minor and have been identified not to have a significant impact upon these aspects.

6.1 Geology, Soils and Topography

Existing Environment

Towradgi Lagoon is located within the Gwynneville soil landscape group, consisting of residual soils typically located on the footslopes of the Illawarra escarpment and isolated rises of the Wollongong Plain. The upper slopes of this landscape group consist of shallow brown podsolic soils and xanthozems, simple slopes consist of lithosols and midslopes and lower slopes consist of shallow brown earths. The entrance to Towradgi Lagoon is comprised of Wollongong marine sands (Hazelton et al., 1990). This soil group is associated with extreme erosion and mass movement, local flooding, reactive subsoils and impermeable, low wet bearing strength clay subsoils (Hazelton et al., 1990).

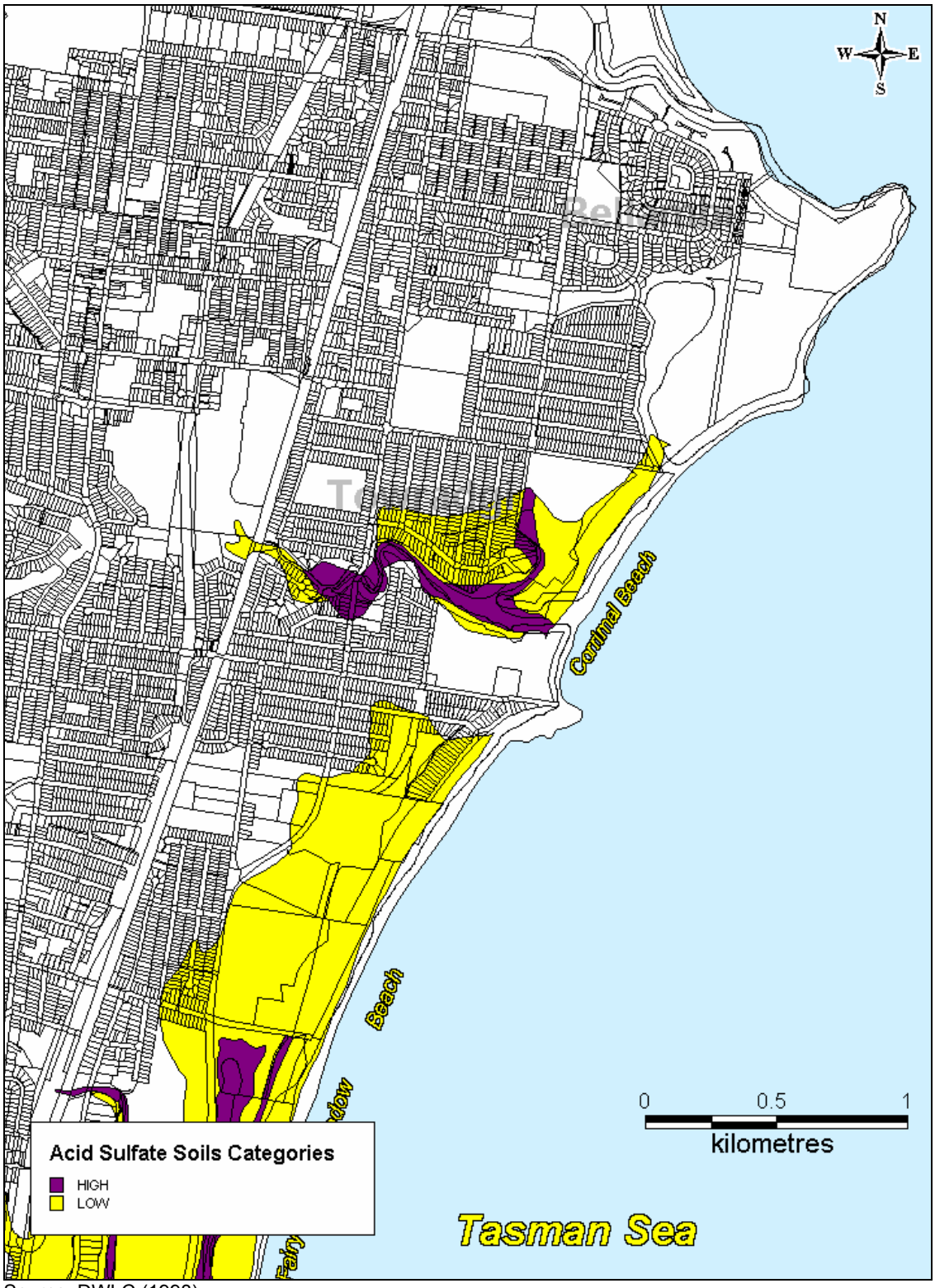
Sediment sampling has been undertaken by Figgis (2001) and CLT (2005b) within Towradgi Lagoon. Figgis (2001) took one sample approximately 600m upstream from the Lagoon entrance, which showed levels of Zinc and Lead that slightly exceeded ANZECC (2000) trigger levels. Sediment samples taken by CLT (2005b) recorded elevated levels of Zinc and Lead, as well as Copper.

Contamination

A search of the EPA contaminated lands register on 2 November 2006 indicated that there have been no recorded notices issued for Towradgi Lagoon or surrounding areas. Clarkson (1995) recorded contaminated sites within Towradgi Lagoon. However, his sampling sites were not located in the entrance where material will be removed.

Acid Sulfate Soils

There is a high probability that bottom sediments in and around Towradgi Lagoon are acid sulfate soils. Disturbance of these bottom sediments through activities such as dredging has been identified as posing a risk to the environment (DLWC, 1998). However, excavation works for assisted breakout will be focused within the entrance of the Lagoon, which is primarily clean beach sand with little or no potential of being acid sulfate in nature as is depicted in Figure 9.



Source: DWLC (1998)

Figure 9 Potential for Occurrence of Acid Sulfate Soils

Potential Impacts

Construction of Access Path

The excavation and stockpiling of material to facilitate the construction of the access path has the potential to facilitate erosion and the movement of sediment, which may be transported into Towradgi Lagoon or coastal waters with runoff.

In the long term, the formalised path will prevent erosion associated with heavy machinery gaining access to the Lagoon entrance.

Acid Sulfate Soils

Figure 9 indicates that the proposed formal access path will not fall within identified acid sulfate risk areas.

Entrance Management

Excavation works within aquatic systems have the potential to disturb sediments and facilitate their movement, which may result in increased turbidity and/or the deposition of sediment onto aquatic flora and benthic organisms. The proposed activity will be undertaken during periods of heavy rainfall, any disturbed materials will be flushed from the Lagoon into coastal waters along the southern end of Corrimal beach. Impacts upon aquatic flora and fauna and the amenity of the beach are expected to be insignificant as:

- the amount of material to be excavated for the pilot channel is small (in the order of 100 m^3);
- the beach area is exposed to wave action under normal conditions and therefore subject to frequent wave action which will naturally disturb such material; and
- natural breakouts would disturb a similar amount of material.

Mitigation measures

Construction of Access Path

It is recommended that an Erosion and Sediment Control Plan be developed for the construction of the access path.

Entrance Management

It is anticipated that no mitigation measures will be required.

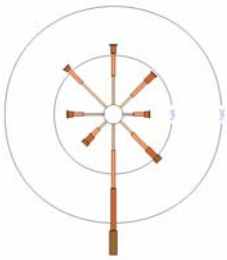
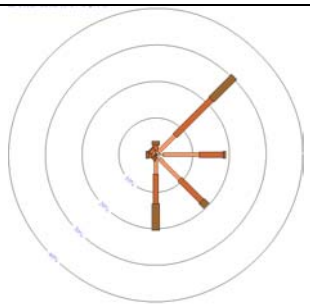
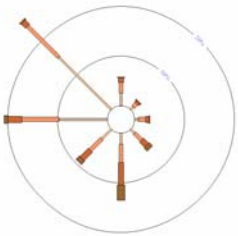
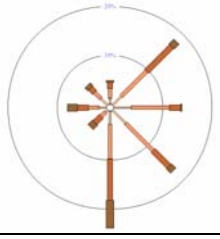
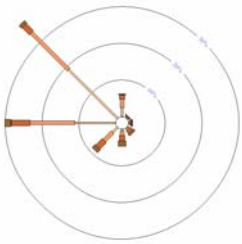
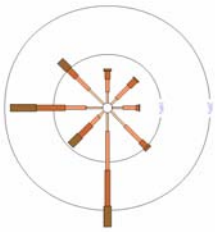
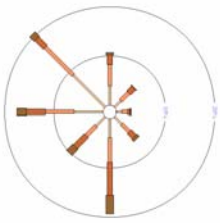
6.2 Climate

Existing Environment

Rainfall is the primary climatic factor that will affect the entrance management operations as it will control water levels in the Lagoon during closed conditions. Annual average rainfall for the Wollongong area as recorded at the University of Wollongong weather station is 1343.8 mm. March is typically the wettest month with an average of 171mm, while July is the driest month with an average of 60.4mm (BOM, 2006).

Figure 10 is derived from data from the Sydney Airport AMO gauge, which is the closest wind gauge to the area affected by the proposed policy for which data is readily available, to give a guide to the varying degree in wind direction and velocity for morning and

afternoon for each of the seasons. Stronger winds are typically experienced during the afternoon periods.

	
Summer 9am	**Summer 3pm**
	
Autumn 9am	**Autumn 3pm**
	
Winter 9am	**Winter 3pm**
	
Spring 9am	**Spring 3pm**

Source: Bureau of Meteorology (2006)

Figure 10 Wind Roses for Study Area

Potential Impacts

Construction of Access Path

Strong winds and rainfall have the potential to facilitate the transportation of sediment from exposed soils and stockpiled material into sensitive areas such as Towradgi Lagoon and coastal waters during the construction of the access path.

Entrance Management

There is the potential for dust pollution to be generated by strong winds during the excavation of the pilot channel. However, this is not likely to be an impact as the activity

would be generally undertaken during periods of heavy rainfall, which would prevent dust particles from becoming airborne by wetting excavated material.

The response of berm heights to sea level change has been discussed by Hanslow et al. (2003). In summary, it is believed that increased sea level will lead to beach recession, which will be accompanied by landward and upward movement of beach berms (Dean and Maurmeyer, 1983 and SCOR, 1991, referenced in Hanslow et al 2003). Therefore, climate change may result in berm height at the entrance of Towradgi Lagoon becoming progressively higher. The implications this has for the entrance management policy is that it will need to be receptive to such change as this process may occur over time.

Mitigation measures

Construction of Access Path

Issues associated with erosion and sedimentation would be addressed in the Erosion and Sediment Control Plan. Construction works should not be undertaken during periods of strong winds and heavy rainfall. Stockpiled material should be protected by sediment fencing to prevent material from entering Towradgi Lagoon.

Entrance Management

The impact of sea level rise should be assessed in subsequent reviews of the Entrance Management Policy.

6.3 Hydrology and Hydraulics

Existing Environment

Key Processes

The hydraulics of Towradgi Lagoon are primarily controlled by a number of characteristics and forcing mechanisms including:

- bathymetry (characterised by total volume or ‘storage’ of the estuary)
- ocean tides (when open),
- catchment (freshwater) inflows
- evaporation from the Lagoon surface
- groundwater inflows and outflows, and
- wind and wave driven flows.

When the entrance is closed, the water level of Towradgi Lagoon (as is common to most other ICOLLs) is generally influenced primarily by rainfall, runoff, evaporation and the level of the berm. The stage storage curve (level versus volume) shown in Figure 11 indicates that water levels increase rapidly with increased estuary volume up to a water level of approximately 2 mAHD. After this level the estuary volume increases fairly significantly without a significant increase in water level.

The northern arm of the Towradgi Creek Estuary (the Parker Road Arm), has an accumulation of sediment, resulting in inverts in the range of 0.55 to 0.6 m AHD. This area is therefore likely to be inundated when the berm is closed. However, in an open berm condition (under tidal influence), this area is inundated to only a small degree at high tide.

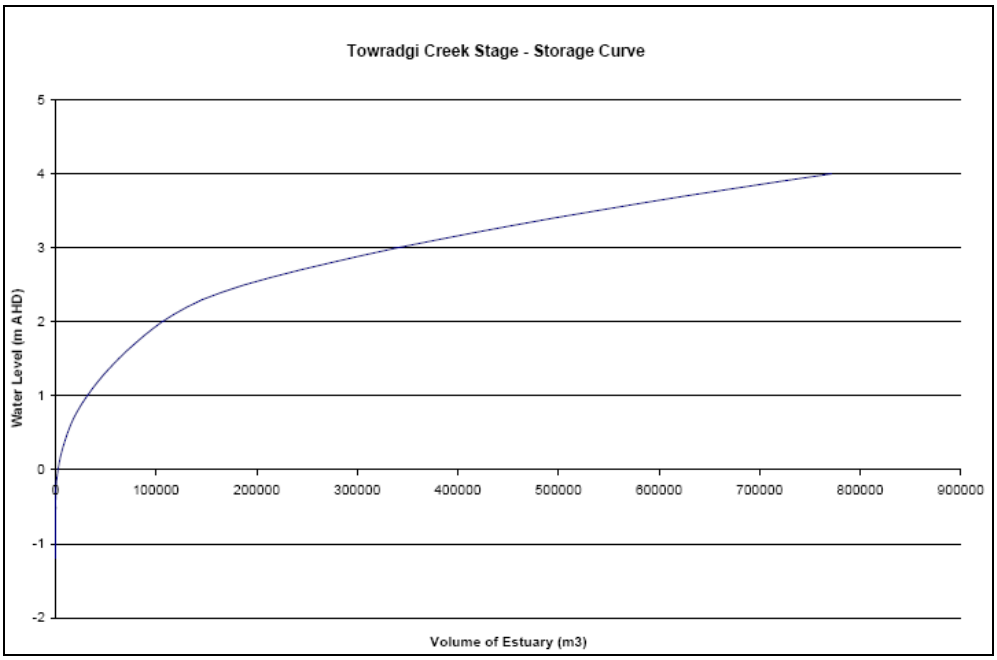


Figure 11 Towradgi Lagoon Stage Storage Curve

Hydrological Processes

Under the present levels of catchment urbanisation, Towradgi Lagoon is receiving greater water input as a result of runoff from urbanised areas, as urbanised areas are far more impervious than natural vegetated areas.

A preliminary calculation of the runoff volumes from the catchment indicate that the 24 hour duration design storm produces the critical volume of runoff in the 1 year ARI design storm event, with a total volume of 490,000 m^3 after taking into account losses (as a guide this corresponds to a 24 hour period with a continuous 5.4 mm/hr of rainfall).

The analysis undertaken in the Data Analysis and Review (Lawson & Treloar, 2005) of the water level data recorder for Towradgi Lagoon indicates that the estuary beach berm reached a maximum level of 1.76m AHD between 1993 and 2003 (inferred from water level data). At this water level, the volume in the estuary is approximately 83,500m^3 (Figure 11).

A 1 Year ARI design storm (24 hour duration) will therefore produce a volume of nearly 6 times the volume of the estuary if the berm is at a height of 1.76m AHD. This multiple will be even greater if the level of the berm is below 1.76 mAHD. This volume of flow will result in a significant displacement of any water held in the estuary at the commencement of the event.

The rainfall excess (i.e. the amount after infiltration is deducted from the total rainfall) required to produce a runoff volume equal to the volume of the estuary when the berm level is at 1.76m AHD is estimated at 11 mm. This indicates that in the absence of complex hydrodynamic features, complete displacement of the estuary is likely to occur in relatively frequent storm events.

Issues such as eutrophication (measured via consideration of the frequency of algal blooms) commonly associated with limited flushing of estuaries, is therefore likely to be influenced by this frequent displacement of the volume of flows entering the estuary.

Observed Lagoon Conditions (1993 – 2003)

A water level gauge has been operated on the downstream side of the Pioneer Road (near Blue Divers) on Towradgi Creek since February 1992. An analysis of water level data from Towradgi Creek indicates that a water level at the gauge has ranged from 0.51m AHD to 4.32m AHD during the 11 year monitoring period (Lawson and Treloar, 2005). The average daily water level was calculated for this site (Figure 12). Readings of 0m AHD indicate periods of reduced data return, presumably because of instrument malfunction or service.

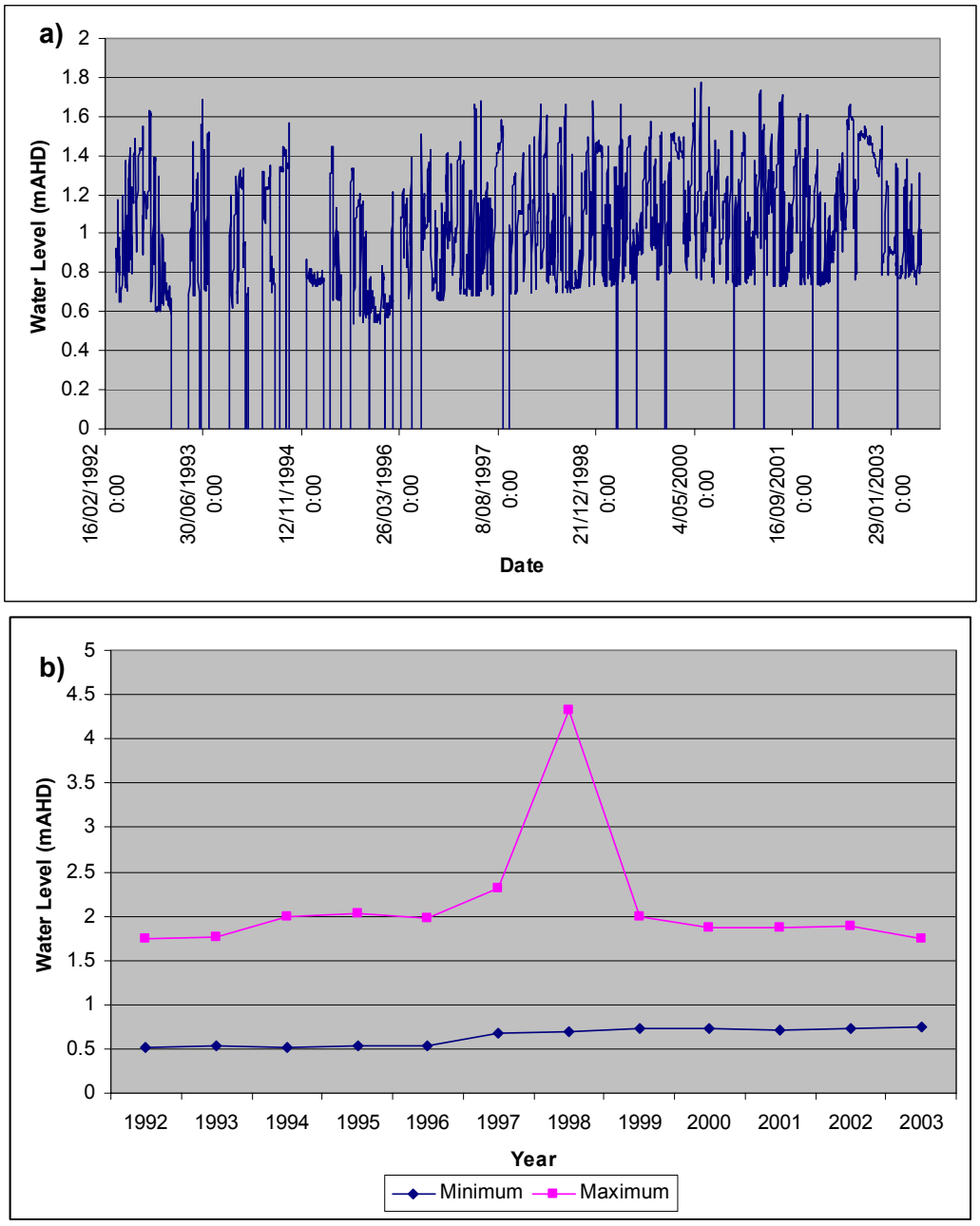


Figure 12 a) Average Daily Water Level for Towradgi Creek Gauge and **b)** Annual Minimum and Maximum Water Levels.

Berm height plays a very important role in determining the maximum water level reached in Towradgi Lagoon. As outlined above, Lawson and Treloar (2005) estimated maximum berm height to be 1.75m AHD based on water level gauge data. More recent data

suggests that the berm height since 2003 may have increased to levels of the order of 2 mAHD.

Time history plots of water level data for the Towradgi Lagoon water level gauge were analysed (Lawson & Treloar, 2005) to provide an inferred summary of lagoon opening information. Observations of water level time history data were used to determine annual trends for lagoon openings and periods of tidal exchange with the ocean. The following annual statistics were derived for the lagoon:

- Number of lagoon openings
- Number of openings which resulted in tidal exchange
- Maximum water level associated with tidal exchange
- Number of distinct episodes of tidal exchange
- Minimum duration for tidal exchange
- Maximum duration for tidal exchange.

The results are shown in Table 5.

Table 5 Summary of Water Level Analysis for Towradgi Creek

YEAR	**TOWRADGI**						
	Break-Outs			**Tidal Inundation**			
	n/year **	Scoured to Tide #	Max Level *	n/year	Duration of tidal exchange (days)		
					Min	Max	Average
1992	11	5	1.64	8	0.5	3.5	1.5
1993	8	5	1.6	6	0.5	1	0.7
1994	2	1	1.55	1	2.5	2.5	2.5
1995	6	4	1.45	13	0.5	8.5	1.5
1996	14	6	1.76	7	0.25	4.25	1.4
1997	17	8	1.67	9	0.5	2	0.8
1998	12	8	1.66	12	0.25	2.75	0.8
1999	23	12	1.58	17	0.3	1.5	0.7
2000	17	9	1.75	10	0.5	1	0.7
2001	21	11	1.72	11	0.5	1	0.7
2002	7	0	1.66	3	1	2	1.3
2003	6	2	1.31	7.0	0.5	2.5	1.25
Overall Statistics: ***							
Min	7	0	..	3	0.25	..	..
Max	23	12	1.75	17	..	2.75	..
Average	**16**	**8**	**..**	**10**	**..**	**..**	**..**

Notes:

Shaded areas indicate data represent <90% of the analysis period
* Max Level is the highest annual level associated with a Lagoon break out event
** Only break outs showing level change of >0.4m were counted
# Scoured To Tide – Tidal Inundation was recorded after the breakout
- No Data
.. Not calculated
*** Total period stats are only reported for years when data return exceeded 90%

Based on the findings reported in Table 5, it was estimated that the Towradgi Lagoon breakout frequency varies between 7 and 23 times a year. The average frequency (for years with greater than 90 percent data return) is 16 times a year.

Opening (Breakout), Tidal Dominated and Closing Behaviour

Two main mechanisms can result in the lagoon opening to the sea:

- Water overtopping from the lagoon and scouring a channel;
- Mechanical opening.

Typically breakouts take approximately 2 to 6 hours from commencement of overtopping until the channel is fully scoured, depending on a number of factors including the height and dimensions of the berm and the intensity of the wet weather event (Lawson & Treloar, 2005).

Following the lagoon opening, further rainfall and hence catchment flow may maintain the outlet channel and therefore continue to outflow from the lagoon, prolonging the breakout period.

During periods of open entrance tidal exchange can occur between the Lagoon and the Ocean. Analysis of water level data by Lawson and Treloar (2005) indicated that approximately 50% of breakouts were followed by a period of an average of one week of tidal exchange. The entrance then closes as the effects of catchment flow are overcome by the onshore transport of sediment from the active beach zone.

Figure 13 provides a series of historical snapshots of the entrance condition since 1946 with the entrance clearly open in the 1966, 1977, 1986 and 2001 images and closed in 1946 and 1955. When open, the entrance channel appears to generally be directed to the south of the overall opening.

Figure 13 Aerial Photography Showing Snapshots of Historical Entrance Condition

Potential Impacts

The potential impact that the proposed entrance management policy would have on water levels within Towradgi Lagoon requires consideration as this potentially will have the greatest impact upon Flora and Fauna inhabiting the Lagoon and its surrounds (Section 6.6) and the social and economic value of the Lagoon. An analysis of the average daily water level data suggests that water level has rarely been greater than 1.6 AHD over an extended period of time over the 11 years between 1992 and 2003 (Figure 12). More recently (in the absence of intervention since early 2003), maximum levels of 1.66 – 1.94 mAHD have been observed (for continuous periods of between 1 – 18 days) (Source: MHL Data for Towradgi Gauge supplied 12 December 2006). The value of 1.6mAHD is likely to

have been largely influenced by the previous informal entrance management policy. The slight increase in water levels associated with the cessation of the informal policy has from time to time resulted in minor inundation of areas causing inconvenience to residents (Section 6.5).

Therefore, the proposed entrance management policy of using a trigger level of 1.6 mAHD is not likely to have an impact upon the present hydraulics of the system.

A return to a 'natural' or un-interfered regime of entrance openings has been identified by the community as desirable. However, as outlined above, it should be noted that due to the altered nature of the catchment (i.e. an increase in impervious surfaces) there will be greater volumes of runoff entering tributaries of the catchment. It is unlikely that the hydrology of the system will ever return to a truly 'natural' state and therefore the concept of returning the entrance regime to a 'natural' state is not an objective that can be managed under the present land use scenario.

Mitigation measures

Construction of Access Path

Issues associated with altered hydrology associated with the construction of the access path would be marginal given the small nature of the additional impervious surface compared with the proportion of impervious area across the catchment.

Entrance Management

As outlined above, given the previous management of the entrance at a similar maximum water level over the past 15 years, it is unlikely any impacts will be observed and therefore no mitigation measures have been identified.

6.4 Water Quality

Existing Environment

Water quality processes within estuaries are generally determined by catchment inputs (surface and groundwater), oceanic inputs and in estuary processes such as biological interactions and interactions with sediments and the atmosphere. Catchment Inputs include point sources (e.g. licenced premises and scheduled premises) and diffuse sources (e.g. urban areas, agricultural areas, leachate from landfills) (Lawson and Treloar, 2005). The catchment that drains into Towradgi Lagoon is highly urbanised, which influences water quality within the Lagoon as runoff from these areas can contain pollutants (Lewis, 2003; Bell, 2006).

Those parameters of particular concern under existing conditions are nutrients (total nitrogen, Oxidised nitrogen, ammoniacal nitrogen, total phosphorus, filterable reactive phosphorus) and faecal coliforms, which were found to regularly exceed ANZECC (2000) guidelines.

Potential Impacts

Construction of Access Path

The construction of the access path may result in increased turbidity associated with erosion and sedimentation (See Section 6.1)

Entrance Management

The excavation of material from the Lagoon entrance during an assisted breakout may result in increased turbidity within surrounding waters (See Section 6.1).

There will be an increase in salinity during open entrance conditions following breakout. However, as the program will follow a similar pattern to that implemented over the past two decades, it is expected that the periodic changes in salinity will be similar to those experienced in the recent past.

Water quality within Towradgi Lagoon appeared to improve when the Lagoon entrance was open, with approximately 70% of water quality problem being recorded between August 2000 and July 2003 occurring during closed entrance conditions (Bell, 2006). While opening the entrance may promote better flushing of a Lagoon, it does not necessarily mean that water quality within the Lagoon will improve consistently over time as the Lagoon can be closed for a substantial period of time. For example, Bell (2006) found that in Fairy Lagoon almost 80% of water quality problems occurred when the Lagoon entrance was open. Additionally, O'Connell and Wiltshire (2005) have also indicated that entrance conditions will not solely control water quality within ICOLL's, and that other factors such as rainfall intensity and duration, season, drought and catchment discharges will affect water quality. Tidal flushing of areas further away from the entrances of Lakes and Lagoons may take considerable time (tens to hundreds of days). Therefore, in systems in which open entrances are short lived, such as Towradgi Lagoon, such flushing will be limited (O'Connell and Wiltshire, 2005).

During unassisted Lagoon breakouts associated with rainfall, an effective hydraulic gradient will be developed at the Lagoon entrance, which will allow for more effective flushing of poor quality water from the creek system (WCC, 2006). As the proposed Entrance Management Policy will generally occur when Lagoon during periods of rain when water levels are rising, or prior to significant rainfall events, it would be expected that this will allow for efficient flushing of the Lagoon when open.

Mitigation measures

Construction of Access Path

Issues associated with erosion and sedimentation would be mitigated through the implementation of an Erosion and Sediment Control Plan (See Section 6.1).

Entrance Management

Due to uncertainty of the response of water quality within the Lagoon it is difficult to recommend mitigation measures. However, it is recommended that water quality monitoring currently being undertaken by Wollongong City Council continues, and that monitoring plan recommended in the Further Processes Study (CLT, 2005b) be implemented (See Appendix D). Adaptive management principles should be used to evaluate the effect of the entrance opening.

6.5 Assets

Existing Environment

Infrastructure

A "Dial Before You Dig" query was undertaken to establish the utility assets in the area and the following data was returned.

Visionstream

No response was issued with regards to assets within the study area. It is assumed that this indicates there are no assets of concern.

Agility Gas

- Secondary Main along Pioneer Road.
- Nylon inserted into Cast Iron Main along Juanita Avenue, Cassell Avenue, Pioneer Road, Augusta Street, Gregory Avenue, Lake Parade, Payne Road, Spinks Road, Carroll Road, Parker Road and Cawley Street.

Although these assets were identified within the Study Area (i.e. within the 3.5 mAHD extent), none of these assets are within the 1.6 mAHD extent (Figure 5).

Integral Energy

No plans were provided for this service. A response was received which state that underground cables were located within the Road Reserve. As only underground cables were identified within the study area. It is assumed that these assets would have been designed to withstand lagoon levels of 1.6 mAHD as this level has been reached a number of times in the recent past.

Optus

No response was issued with regards to assets within the study area. It is assumed that this indicates there are no assets of concern.

Commercial and Residential Properties

Floor Levels and associated ground levels were provided by Council for all properties with the Study Area (Figure 3). A review of this data showed the following:

- The lowest floor level surveyed was 1.97 mAHD. This was the only property surveyed with floor levels below 2 mAHD.
- 6 properties were surveyed with floor levels below 2.5 mAHD
- 17 properties were surveyed with floor levels below 3 mAHD
- 42 properties were surveyed with floor levels below 3.5 mAHD
- The ground levels surveyed show that there are 66 properties with ground levels below 1.6 mAHD and 70 properties with ground levels below 1.9 mAHD.
- It is not known where the ground level survey points were taken or if they represent the lowest point on the property. Therefore, the number of properties with overground flooding may be greater than those number reported above.

At a water level of 1.6 mAHD, limited property inundation is likely to occur. However, as the lake level increases the extent of property inundation increases significantly. The inundation extents for lagoon levels of 1.6 mAHD and 2 mAHD are shown below in Figure 14. It should be noted that limited survey was available for the Parker Road Arm to support the preparation of Figure 14. However, survey downstream of Lake Parade shows fairly significant inundation of surrounding land at 2mAHD and ground survey for properties on Parker Road, show that there is property inundation after levels in the Lagoon exceed 1.8 mAHD. The reserve at the rear of the Juanita Avenue properties is inundated to some degree at 1.6 mAHD and is significantly inundated at 2 mAHD. Figure 14 shows inundation at various water levels.

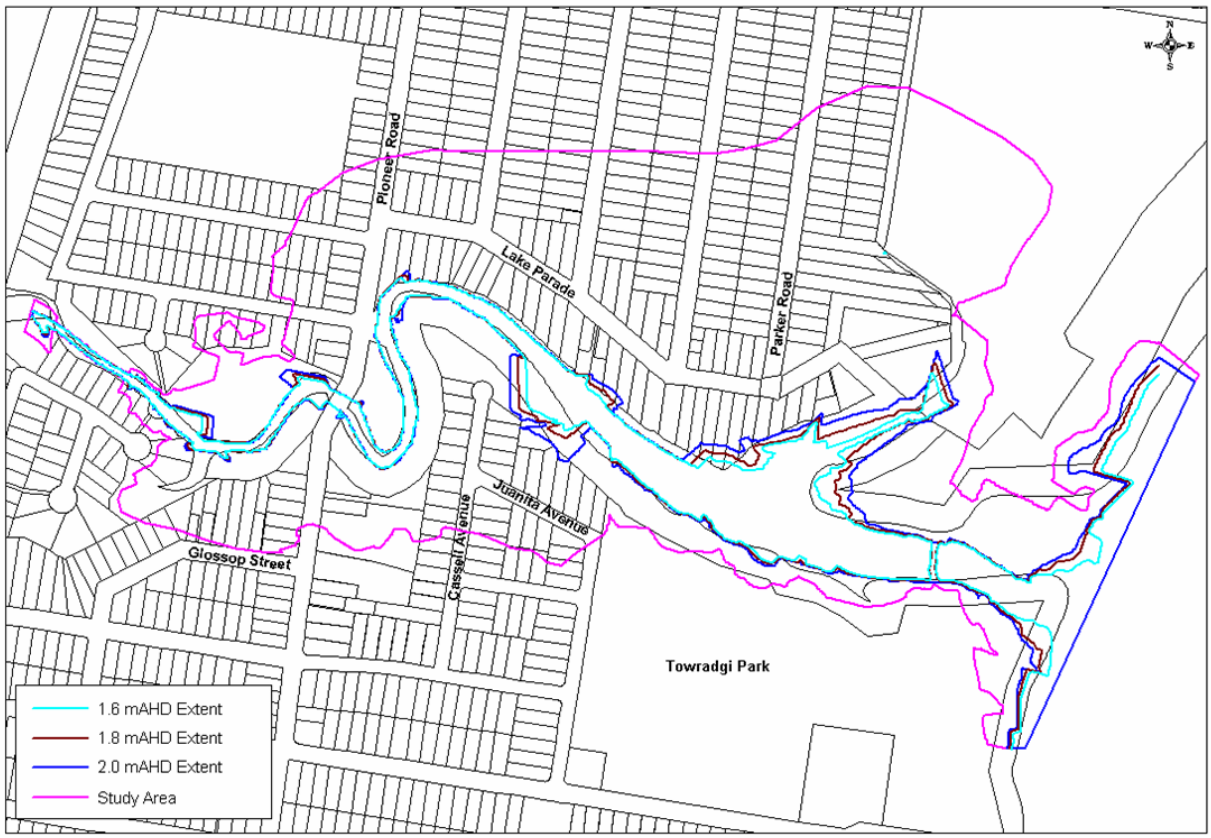


Figure 14 Comparison of 1.6 mAHD and 2 mAHD Extent

Towradgi Park

Towradgi Park is generally above 3.5 mAHD. The area along the creek has a fairly steep slope down to the lagoon. The easement connected to Towradgi Park along the rear of the Juanita Avenue properties is used for recreational purposes. Generally this includes pedestrian access to the beach and the adjacent lagoon foreshore. The ground level of this area varies from approximately 1.5 to 2.6 mAHD.

Corrimal Beach Park

Corrimal Beach Park is generally above 2 mAHD. The foreshore areas along Towradgi Lagoon and the Parker Road Arm vary between 1.15 and 2 mAHD. A significant area upstream of the Lake Parade bridge on the left bank of the Parker Road Arm is below 1.6 mAHD, as is the left bank at the confluence of the Parker Road Arm and Towradgi Lagoon.

Roads and Other Crossings

Table 6 provides a list of all the road and access path crossing over Towradgi Lagoon (including the Parker Road Arm). The minimum level is provided for each (as reported in the Flood Study, Bewsher Consulting 2003).

Table 6 Creek Crossing Sag Level Data

Location	Crossing Sag Level (mAHD)
Towradgi Lagoon	
Pioneer Road	2.89
Footbridge Near Outlet	2.23
The Parker Road Arm	
Carroll Road	2.23
Parker Road	1.94
Cycle Way	2.30
Lake Parade	2.30

Potential Impacts

Infrastructure

For those assets and services located within the Study Area but outside of the 1.6 mAHD extent, they would not be impacted by inundation of lagoon waters on a day to day basis (except during major flood events). There could potentially be some hydrostatic pressure on the assets due to elevated groundwater levels in response to elevated lagoon levels. However, it is assumed that the pressure exerted by lagoon levels reaching a maximum of 1.6 mAHD would be within the design considerations for such assets.

Visionstream

No assets identified within the study area.

Agility Gas

Although these assets were identified within the Study Area (i.e. within the 3.5 mAHD extent), none of these assets are within the 1.6 mAHD extent.

Integral Energy

Only underground cables were identified within the study area and within the 1.6 mAHD extent. It is assumed that these assets would have been designed to withstand lagoon levels of 1.6 mAHD, as this level has been reached a number of times in the recent past.

Optus

No assets identified within the study area.

Commercial and Residential Properties

At 1.6 mAHD only limited property inundation is likely to occur. Anecdotal evidence from the local area suggests that this is not the case. However, not all residents were available during consultation to confirm this observation. At 2 mAHD significant property inundation would occur. However, no overfloor flooding would occur when the lagoon level is at 1.6 mAHD.

Towradgi Park

The easement connected to Towradgi Park along the rear of the Juanita Avenue properties would only experience limited inundation at lagoon levels of 1.6 mAHD. At levels greater than this the area would become inundated, limiting recreational usage.

Corrimal Beach Park

The majority of the usable areas of Corrimal Beach Park are above 1.6 mAHD. Some inundation at the boat ramp would be observed near the footbridge over Towradgi Lagoon. In addition to this there would be inundation along the foreshore of The Parker Road Arm.

Roads

No roads would be inundated when the lagoon level is at 1.6 mAHD. However, stormwater lip levels indicate that Parker Road and Lake Parade would be inundated at 1.64 and 1.7 m AHD respectively. When the lagoon level reached this point, nuisance road flooding can be expected. It should be noted that this varies from the levels reported in the flood study (Bewsher Consulting, 2003), also shown in Table 6.

Summary of Impacts

It is suggested that any inconvenience of inundation to a level of 1.6 mAHD could be tolerated for a short time. Only minor property and road inundation would be experienced.

Mitigation Measures

The key mitigation measure will be the implementation of the Entrance Management Policy as outlined in Sections 4.1.2 and 5.

6.6 Lagoon Ecology

A desktop study was undertaken to establish the existing environment and ascertain the terrestrial and aquatic issues in relation to the proposed policy. The desktop study included a review of available literature and searches of relevant databases.

Available literature reviewed in this study included:

- Chafer, J. (1997) *Biodiversity of Wetlands in the Illawarra Catchment: and Inventory*. Illawarra Catchment Management Committee.
- Centre for Estuarine and Coastal Catchment Studies (1998) *Shallow Water Fishes of Illawarra Wetlands*. University of Wollongong.
- Kevin Mills and Associates (2002) *Flora and Fauna Assessment: Master Plan Wollongong Innovation Campus, University of Wollongong.* Prepared for Forbes Rigby.
- Illawarra Bushland Restoration (2005) *Towradgi Creek, Towradgi Riparian Restoration Works.* Prepared for Wollongong City Council.

Chafer (1997) documents the extent of wetlands within the Illawarra catchment, and provides an inventory of species recorded within each wetland based upon scientific publications, unpublished reports, personal databases, public databases, EISs and LEPs. Species lists contained in this report are primarily derived from this document.

Databases searched as part of this study included:

- NSW NPWS Wildlife Atlas;

- EPBC Database; and
- NSW Fisheries Fishnote Database.

It is important to note that these databases are only indicative records of flora and fauna species and are not the result of a systematic flora and fauna survey.

6.6.1 Flora

Existing Environment

The landscape surrounding Towradgi Lagoon is largely cleared, with remnant patches of vegetation being located on the hind dunes of Corrimal beach, at the end of the Parker Road Arm and just downstream of the Pioneer Road Bridge.

Vegetation communities located within the study area include (Figure 15):

- Alluvial Swamp Mahogany Forest, which is classified as Swamp Sclerophyll Forest on Coastal Floodplains (SSFCF), an Endangered Ecological Community under Schedule 1 of the TSC Act 1995,
- Escarpment Blackbutt Forest,
- Coastal Grassy Red Gum Forest, which is classified as Illawarra Lowlands Grassy Woodland (ILGW), an Endangered Ecological Community under Schedule 1 of the TSC Act 1995,
- Coastal Swamp Oak Forest, which is classified as Swamp Oak Floodplain Forest (SOFF), an Endangered Ecological Community under Schedule 1 of the TSC Act 1995.
- Estuarine Alluvial Wetland,
- Beach Sands Spinifex,
- Coastal Sand Scrub, and
- weeds and exotics.

Several additional communities have been identified by studies in the area including seagrass (*Zosteraceae* sp) (West et al. 1985), Grey Mangroves (*Avicennia marina*) (Bell, 2006) and salt marsh (Chafer, 1997).

Seagrass mapping undertaken by West et al. (1985) indicates that *Zosteraceae* sp is present in Towradgi Lagoon.

There is a small population of Grey Mangroves (*Avicennia marina*) within Towradgi Lagoon at the mouth of Parker Road Arm, which is dominated by young individuals (Illawarra Bushland Restoration, 2005; Bell, 2006).

Coastal Salt Marsh (CSM) may also occur within Towradgi Lagoon (See Section 6.6.2), which is an Endangered Ecological Community under Schedule 1 of the TSC Act 1995.

Riparian vegetation plays an important role in both terrestrial and aquatic ecosystem health as it stabilises river beds and banks and protects against erosion and bank slumping, it acts as a filter for sediments and nutrients entering a watercourse and it provides shade and shelter and creates habitat for fish (DPI, 2006). Riparian vegetation surrounding Towradgi Lagoon is primarily made up of SSFCF, SOFF and ILGW. Vegetation along Towradgi Lagoon and Parker Road Arm is considered to be sparse (Figure 15).

Four endangered ecological communities (EEC) occur within the study area, namely Swamp Sclerophyll Forest on Coastal Floodplains (SSFCF) of the NSW North Coast, Sydney Basin and South East Corner Bioregions, Swamp Oak Floodplain Forest (SOFF) of

the NSW North Coast, Sydney Basin and South East Corner Bioregions, Illawarra Lowlands Grassy Woodland (ILGW) in the Sydney Basin Bioregion and Coastal Salt Marsh (CSM) in the NSW North Coast, Sydney Basin and South East Corner Bioregions.

SSFCF incorporates Alluvial Swamp Mahogany Forest (MU35) (See Figure 15), and occurs within coastal floodplains on humic clay loams and sandy loams within alluvial flats and drainage lines that are waterlogged or periodically inundated (NPWS, 2004b). The composition of this community is determined by the frequency and duration of waterlogging and certain characteristics of the soil including texture, salinity and moisture content. A major threat to this community is change to the natural flow regimes of rivers, streams, floodplains and wetlands (NPWS, 2004b).

SOFF incorporates Coastal Swamp Oak Forest (MU36) and Estuarine Alluvial Wetland (MU53) depicted in Figure 15 and fringes the Parker Road Arm. SOFF is associated with clay and sandy loams, with saline-influenced groundwater, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains (NPWS, 2004a). The composition of SOFF is determined by the level of salinity in groundwater and the frequency and duration of inundation (NPWS, 2004a). Changes to the natural flow regimes of rivers, streams, floodplains and wetlands has been identified as a threat to this community (NPWS, 2004a). An assessment of this vegetation community undertaken by Illawarra Bushland Restoration (2005) indicated that changes in the hydrology of the creek and drainage channels would result in changes in the floral composition of this ecosystem. In particular, increases in salinity were identified as having the potential to negatively impact upon some of the plant species.

SOFF and SSFCF may adjoin with each other, or other endangered ecological communities of the coastal floodplain. Changes in the boundaries of these communities may occur as a result of changes in hydrological regimes, fire regimes and land management practices (NPWS, 2004a).

The ILGW EEC includes Coastal Grassy Red Gum Forest (MU23) (See Figure 15). This community occurs on gently sloping lands below 200m elevation. Threats to this community include clearing, grazing, weed invasion, selective logging, rubbish dumping, development and physical damage resulting from recreational activities (NPWS, 2006).

A CSM community is located along the landward bank of the Parker Road Arm, downstream of the bridge along Parker Road. CSM in the NSW North Coast, Sydney Basin and South East Corner bioregions is listed as being an Endangered Ecological Community under Schedule 1 of the TSC Act 1995. CSM typically occurs on the shores of estuaries and Lagoons, in areas of tidal influence, and provides habitat for a diverse array of fauna. Modification to tidal flow and altered salinity as a result of stormwater discharge may threaten this community (NPWS, 2004b).

A report on the biodiversity of wetlands within Illawarra catchments, which compiled data from various sources, found that there have been 63 plant species recorded within Towradgi Lagoon, 21 of which are weeds or introduced species (Chafer, 1997). A complete list of these species is contained within Appendix C. None of these species are listed under Schedules 1 or 2 of the *TSC Act 1995* or the *EPBC Act 1999*.

Illawarra Bushland Restoration (2005) recorded three species of flora within the SOFF at the end of the Parker Road Arm that are considered to be regionally threatened in the Illawarra. These are the Rat's Tail Orchid (*Dendrobium teretifolium*), Snow-in-summer (*Melaleuca linariifolia*) and Bangalay (*Eucalyptus botryoides*). The impacts of the proposed Entrance Management Policy on these species will largely be dependant upon the impact it has on the SOFF vegetation community that supports these species.

A search of the NSW NPWS Wildlife Atlas was undertaken on 12 December 2006. One threatened flora species has been recorded within the 10km by 10km search area surrounding Towradgi Lagoon since 1980, the White-flowered Wax Plant. It is unlikely that the White Flowered Wax Plant will occur near Towradgi Lagoon as it occurs in or near rainforest (Kevin Mills and Associates, 2002).

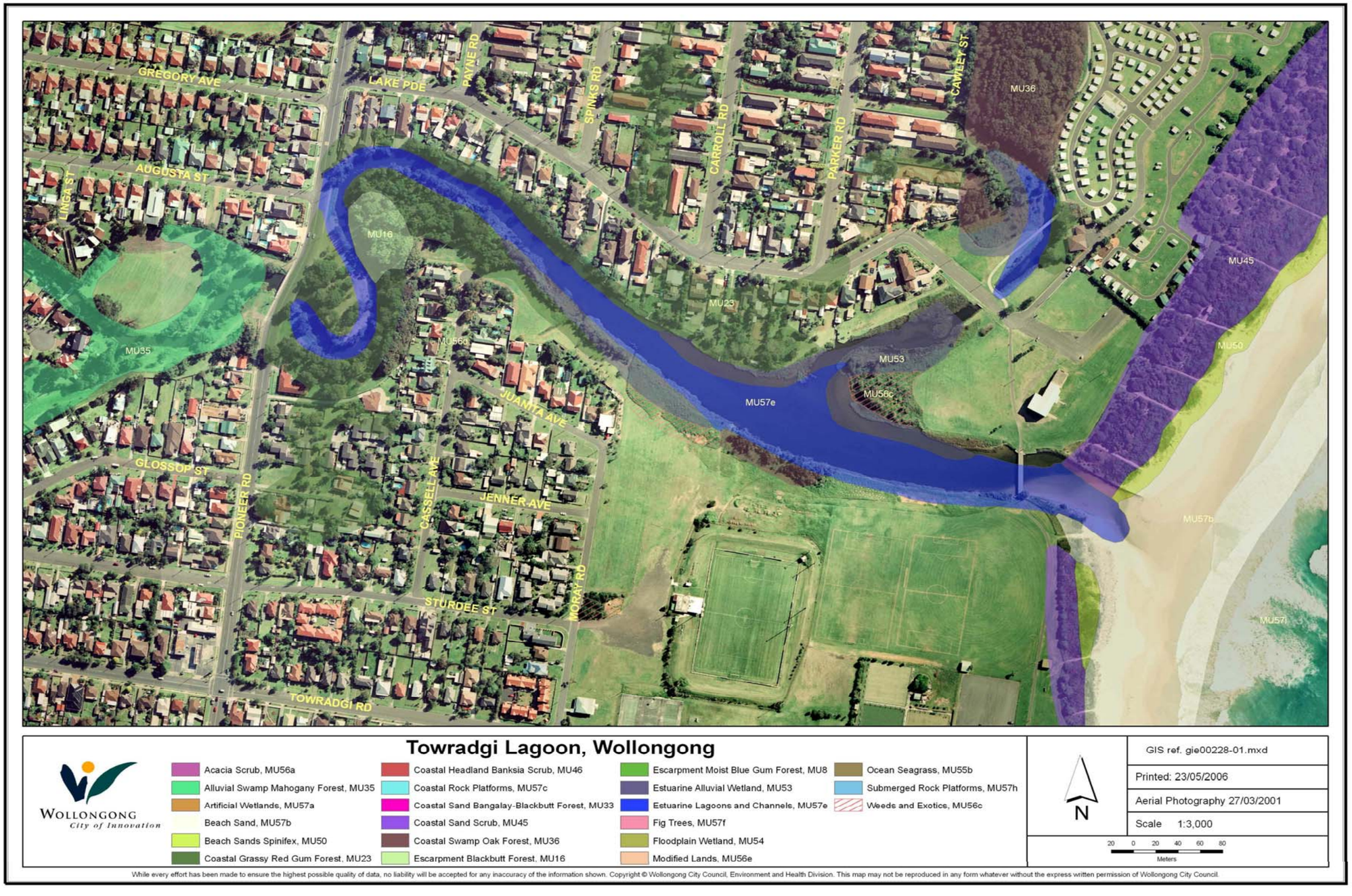


Figure 15 Vegetation Communities Surrounding Towradgi Lagoon

Potential Impacts

Flora species that are likely to be impacted by the proposed policy are those that occur in vegetation communities within or fringing upon Towradgi Lagoon, such as seagrass communities, riparian vegetation, mangroves and ILGW, SSFCF and SOFF endangered ecological communities.

Seagrass (*Zosteraceae sp*) beds within Towradgi Lagoon may be impacted upon by the proposed policy, as the opening of the entrance will temporarily lower water levels within the Lagoon, which may expose these seagrass beds at low tide. As a comparison, the artificial opening of Lake Conjola was found to result in the loss of a large seagrass bed (Jones and West, 2005). Seagrass monitoring conducted by The Ecology Lab (2003) within Narrabeen Lagoon before (September 2002 and April 2002) and after (September 2002 and January 2003) the artificial opening of the Lagoon entrance in 2002 found that the distribution and total areas of the seagrass beds only fluctuated slightly, and that the maintenance dredging of the Lagoon entrance had no significant impact on the distribution and density of seagrass beds. It is therefore quite difficult to determine exactly what impact artificially opening the entrance of Towradgi Lagoon will have on these seagrass beds. As water levels will not be greatly altered from those experienced in the past two decades (See Section 6.3), it is not expected that the proposed entrance management policy will have a significant impact upon the distribution and health of seagrass beds.

Riparian vegetation may potentially be affected by the Entrance Management Policy as it could result in changes to water levels. However, as water levels will not be greatly altered from those experienced in the past two decades (See Section 6.3), it is not anticipated that the proposed entrance management policy will have a significant impact upon the current distribution of riparian vegetation.

The proposed entrance management policy is likely to have a positive impact upon *Avicennia marina* communities located within Towradgi Lagoon. While these mangroves are tolerant to a range of salinities, they are sensitive to long-term periods of flooding. Water levels of the order of 1.3m AHD to 1.6m AHD have been common during extended periods of closed entrance conditions within Towradgi Lagoon. These water levels are well above the height of mangrove pneumatophores (Bell, 2006) and result in extended periods of complete inundation of pneumatophores, which is tolerable but not optimal. The proposed entrance management policy would continue to ensure that periods of extended mangrove inundation are limited by ensuring the system is tidal on a semi-regular basis (ie the average 16 times per year of opening).

Generally, *Avicennia marina* grows best at soil salinities of between 10 and 20ppt, but it has been observed to grow as a scrub under hypersaline conditions (Alongi, 1998). The Data Analysis and Review report (Lawson and Treloar, 2005) shows that records of salinity downstream of Pioneers Road over a 12 month period (August 2002 to July 2003) was generally 20 ppt during open entrance conditions (over a four month period), with fluctuations ranging between 25ppt (immediately after entrance closure) and 5 ppt (briefly during fresh water events) following entrance closure. The proposed entrance management policy would allow for increases in salinity that would favour the growth of this species.

As the distribution and composition of SOFF is largely determined by the level of salinity in groundwater and the frequency and duration of inundation, the proposed policy has the potential to affect this community as they may alter salinity within the Lagoon and the frequency and duration of inundation of this community. Following breakout, salinity levels in the main Lagoon body are expected to be slightly elevated in the short term (of the order of 25 ppt, compared with a common value of around 20 ppt during closed periods). It is difficult to determine whether salinity levels within groundwater will noticeably change as a

result of the Entrance Management Policy. Analysis of average daily water levels from 1992 to 2003 indicates that average daily water levels has only infrequently been greater than 1.6m AHD (See Section 6.3), which would be the trigger level for assisted breakout, which suggests that the frequency and duration of inundation experienced by this community over the past two decades will not noticeably change. Therefore it is unlikely that the proposed Entrance Management Policy will greatly affect the current distribution of SOFF surrounding Towradgi Lagoon. A seven part test was conducted for SOFF, which concluded that the proposed policy was unlikely to have a significant impact upon this EEC (Appendix E).

Similarly, the distribution of SSFCF is largely determined by frequency and duration of waterlogging. It is not anticipated that the frequency and duration of waterlogging will be significantly altered from those experienced over the past two decades as a result of the proposed policy. A seven part test was completed to determine the impact of the proposed policy upon SSFCF, and concluded that the proposed policy would not have a significant impact upon this EEC (Appendix E).

ILGW has not been identified as being at risk to altered hydrological regimes (NPWS, 2006). However, due to the location of this community in relation to the Lagoon, it is believed that it may be influenced by hydrological characteristics of the Lagoon and Towradgi Creek. A seven part test determined that ILGW community was unlikely to be significantly impacted by the proposed policy (Appendix E).

CSM may be impacted upon by modified tidal flow and altered salinity (i.e. a decrease in salinity) as a result of stormwater discharge (NPSW, 2002b). The mechanical opening of the entrance will result in tidal inundation and an associated increase in salinity, which will be beneficial to this community. A seven part test was undertaken to assess the impact of the proposed policy on this community. It was found that the policy was unlikely to significantly affect this community (Appendix E).

Mitigation measures

As the exact impacts of the proposed entrance management policies on seagrass beds, riparian vegetation and mangrove communities are non-definitive, it is recommended that regular monitoring of the health and distribution of select areas of this vegetation community take place in accordance with the recommendations of the Further Processes Study (See Appendix D) to assess whether the assisted breakout of the Lagoon is having an adverse impact on these communities. The most appropriate management of these communities will be a return to a more natural opening regime, which may be possible in the long term through the raising of assets and changes in zoning, as recommended by the Entrance Management Policy (CLT, 2006). However, it should be noted that due to changes in the Towradgi Creek catchment, such as urbanisation, the hydrology of this system has been substantially altered from that that would be considered ‘natural’ (See Section 6.3).

6.6.2 Wetlands

Existing Environment

Approximately 70% of wetlands in the Illawarra have been destroyed since European settlement. Human pressures such as urban and Industrial activity have a significant impact upon wetlands and can result in reductions in the total area of wetlands, pollution of groundwater and surface water, changes in water flow regimes and hydrodynamics and invasion by pest plant and animal species (Merrin and Chafer, 2000).

The Towradgi Lagoon wetland has an area of approximately 8.2ha, and includes alluvial forest and salt marsh communities (Chafer, 1997). Areas surrounding the Lagoon entrance area largely cleared, with some fringing vegetation located along the banks of the Lagoon and its tributaries.

The Towradgi Lagoon Wetlands provide habitat for a diverse array of avian species, with 50 species of bird having been recorded within these wetlands.

Potential Impacts

The proposed entrance management policy has the potential to impact the wetlands and salt marsh located within Towradgi Lagoon as it will alter the natural hydrodynamic process of the wetland (DNR now DECC, 2006). Productivity of these systems may be affected by the alteration of water regimes. For example, prolonged inundation of wetlands can decrease the rate of breakdown of organic matter, which can in turn alter the composition of plant species (DNR now DECC, 2006). Additionally, changes to salinity may alter the distribution of salt marshes and estuarine species (Bell, 2006).

The proposed entrance management policy is unlikely to significantly impact upon the current wetland and salt marsh structure, distribution and health, as it will not greatly alter water levels from those that have been experienced in the past two decades. Analysis of the current location of wetlands and the water level at which the Lagoon will be generally broken out at (i.e. 1.6m AHD), suggest that the proposed entrance management policy would allow for the inundation of wetlands (Figure 16) as well as cyclic dry periods, which are also important for these communities (DLWC, 1996).

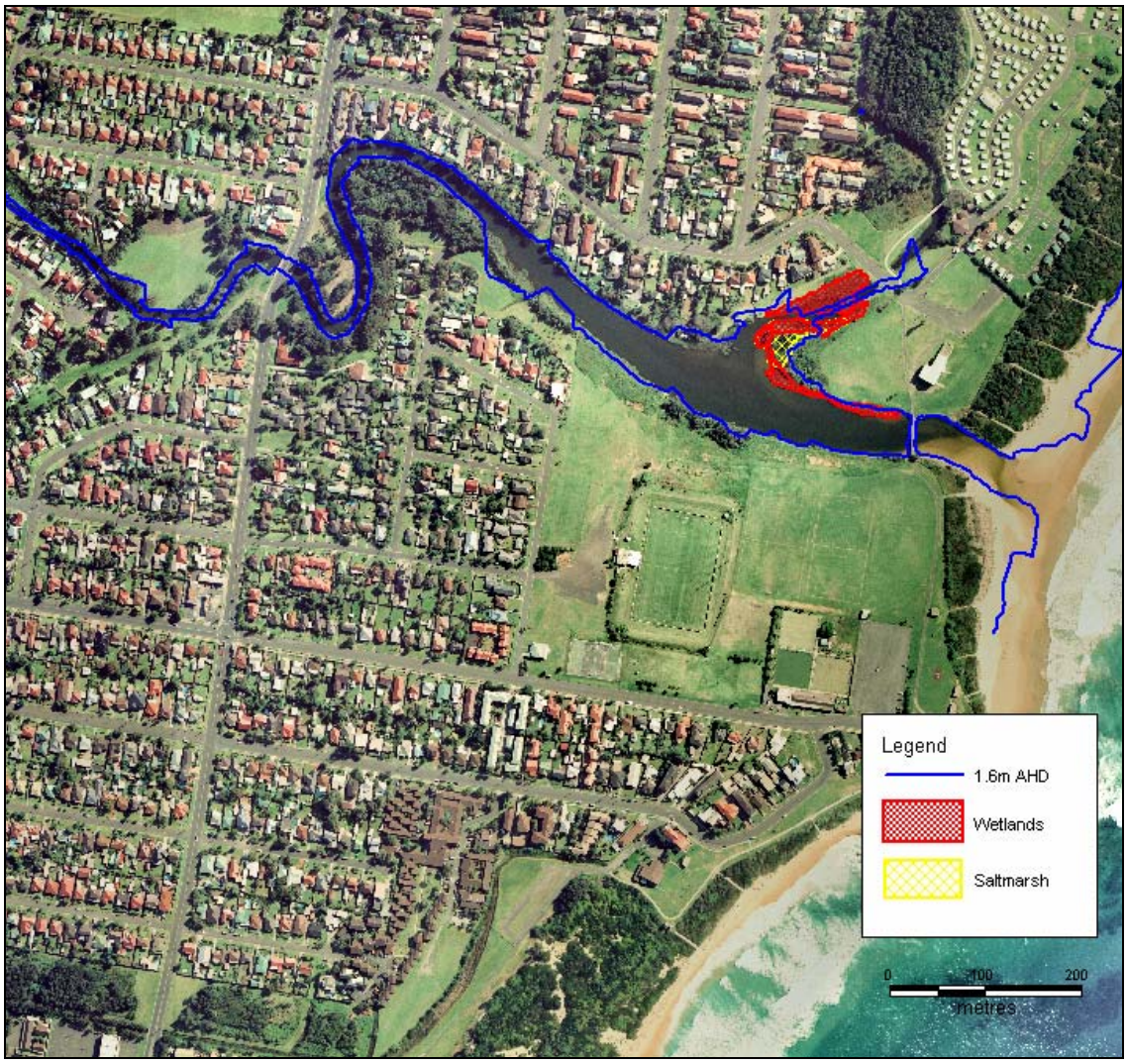


Figure 16 Location of Wetlands, Salt Marsh Community and 1.6m AHD Water Level (adapted from Chafer, 1997 and Bell, 2006).

Mitigation Measures

Ultimately, the most effective mitigation measure will be the return to a more natural or unassisted entrance breakout regime, which can be achieved gradually through the raising of assets and zoning changes as suggested by the Entrance Management Policy. However, changes in hydrology as a result of urbanisation and the presence of the entrance gabion 'training walls' will prevent this system from returning to a truly natural water level pattern and breakout regime. In the interim period, it is recommended that monitoring of select areas of wetlands be undertaken (See Appendix D).

6.6.3 Fauna

Existing Environment

Forty eight species of bird and 11 fish species have been recorded within and surrounding Towradgi Lagoon (Chafer, 1997; Centre for Estuarine and Coastal Catchment Studies, 1998). Three species of bird listed under Schedule 2 of the *TSC Act 1995* have been observed, the Australasian Bittern (*Botaurus poiciloptilus*), Black Bittern (*Ixobrychus flavicollis*) and Brolga (*Grus rubicunda*).

A search of the NSW NPWS Wildlife Atlas was undertaken on 12 December 2006. Twenty one threatened species have been recorded within a 10km by 10km search area surrounding Towradgi Lagoon. The likelihood of these species occurring within or surrounding Towradgi Lagoon is assessed in Table 7, which has been adapted from a previous assessment undertaken by Kevin Mills and Associates (2002).

The Bar-tailed Godwit and the White-bellied Sea Eagle are the only two migratory species listed under the Commonwealth EPBC Act that have been recorded within Towradgi Lagoon and its surrounds in Chafer (1997).

A search of the NSW Fisheries Fishnote Database was undertaken to determine which species listed as being threatened under the NSW Fisheries Management Act 1994, or are protected in NSW, could potentially occur within or around Towradgi Lagoon. It was determined that the Eastern Blue Devilfish (*Paraplesiops bleekeri*), Black Cod (*Epinephelus daemelii*), Estuary Cod (*Epinephelus coioides*), Elegant Wrasse (*Anampses elegans*), Giant Queensland Groper (*Epinephelus lanceolatus*), Australian Grayling (*Prototroctes maraena*) and a variety of Syngnathids may inhabit waters within and around Towradgi Lagoon. A search of the EPBC Act was undertaken to determine whether any federally threatened species could potentially inhabit waters surrounding Towradgi Lagoon. It was found that the Australian Grayling (*Prototroctes maraena*), which is listed as being vulnerable could possibly occur in the area, and may be impacted upon by the proposed Entrance Management Policy. A search of the Bionet Database was undertaken on 18 December 2006 to determine whether any of these listed species have been recorded in waters surrounding Towradgi Lagoon. It was found that the Eastern Blue Devilfish, Giant Queensland Groper and numerous Syngnathids, including *Hippocampus whitei*, *Lissocampus runa*, *Phyllopteryx taeniolatus* and *Solegnathus spinosissimus* have been recorded in the waters in the northern suburbs of Wollongong.

Table 7 Threatened Species (adapted from Kevin Mills and Associates, 2002)

Species	TSC Act	EPBC Act	Potential to Occur in or around Towradgi Lagoon
Mammals			
Grey Headed Flying Fox	V	V	High. Grey-headed Flying-foxes are common in the local area, and there is suitable habitat on and near the Brandon Park and Campus East sites. *
Southern Right Whale	V	M	Low. Breed in inshore areas (5 – 10m mark) of south east Australia during the winter months. Unlikely to be affected by the works as impact will only extend to surf zone.
Australian Fur Seal	V		Low. Preferred habitat is rocky parts of islands (DEC, 2006).
Birds			
Australasian Bittern	V		High. There is suitable habitat in the area for Australasian Bitterns, and the species has been seen in Towradgi Creek and in the Wollongong Botanical Garden. *
Barking Owl	V		Low. Uncommon in Southern Australia, rarely occurs in coastal and escarpment forests (DEC, 2006).
Barred Cuckoo-shrike	V		Low. Barred Cuckoo-shrikes are not expected to occur at Wollongong; although the Wildlife Atlas contains one record from the local area, none of the main references mention local sightings. *
Black Bittern	V		High. There is suitable habitat in the area for Black Bitterns, and the species has been seen nearby, in lower Towradgi Creek and in the Wollongong Botanical Garden. *
Black-browed Albatross	V	V	Low. Black-browed Albatrosses occur only offshore, well out to sea. *
Brolga			Low. Generally not found in the south east of Australia (DEC, 2006).
Gang-gang Cockatoo	V		Low. Generally occur in tall mountain forest and woodlands in the summer, particularly in heavily timbered wet sclerophyll forests. May be present in lower more open forests and woodlands, and even urban areas (DEC, 2006). Majority of sightings located west of the escarpment.
Glossy Black Cockatoo	V		Low. While SOFF may occasionally be used as a foraging resource for this species as it contains Swamp Oaks, Black She Oak woodlands are preferred for foraging in south east Australia.
Masked Owl	V		Low. Lives in dry eucalypt forests and woodlands. Forest Owl with a large home range (500-1000ha). Known to occur in forested wetlands in the southern rivers region. Requires tree hollows for nesting (DEC, 2006). Unlikely to occur near Towradgi Lagoon due to its fragmented nature and regenerating habitat which will provide few hollows.
Pied Oystercatcher	V		Low. Occurs around the entire Australian

Species	TSC Act	EPBC Act	Potential to Occur in or around Towradgi Lagoon
			coastline. Thinly scattered on the NSW coast. Habitat consists of intertidal flats of inlets and bays, open beaches and sandbanks. Forages on exposed sand, mud and rock at low tide, for molluscs, worms, crabs and small fish. Nests mostly on coastal or estuarine beaches although occasionally they use saltmarsh or grassy areas (DEC, 2006). There have only been two sightings in the study area.
Regent Honeyeater	E1	E, M	Low. Species requires >10% vegetation cover within a 20km radius of the site for suitable breeding, foraging and sheltering/roosting/refuge habitat (DEC, 2006). Fragmented vegetation surrounding Towradgi Lagoon unlikely to fulfil these requirements.
Sanderling	V	M	Low. Forage in coastal areas on low beaches, tidal mudflats and open coastal lagoons. Only two sightings in the search area.
Sooty Owl	V		Low. There is not suitable habitat on or near the site. Sooty Owls occur in rainforest. The Wildlife Atlas contains several records from the local area, but all of the records are from locations along the escarpment, to the west. *
Sooty Oystercatcher	V		Medium. Usually forages on rocky headlands, shelves and exposed reefs. Occasionally visits and forages on sandy beaches between headlands (Morcombe, 2003). Common in the Wollongong area.
Southern Giant Petrel	E1	V, M	Low. Habitat is generally over open seas.
Superb Fruit-Dove	V		Low. This vagrant species from the rainforest of North Queensland could turn up in almost any patch of trees in the Wollongong district, including gardens in residential areas. However, occurrences are rare. *
Swift Parrot	E1	E	Medium. Swift Parrots have been recorded in the Wollongong district several times. The species is quite likely to be attracted to the winter-flowering banksias in this area, if only occasionally. *
Wandering Albatross	E1	V, M	Low. Like the Black-browed Albatross, the Wandering Albatross occurs offshore. *
Amphibians			
Green and Golden Bell Frog	E1	V	Moderate. This species can occupy estuarine habitats (DEC, 2005b). In the past sightings of this species have been made in and around Fairy and Bellambi Wetlands (DEC (2005b).

** Taken from Kevin Mills and Associates (2002).*
V – Vulnerable. E – Endangered, M - Migratory

Potential Impacts

The impact of artificially opening ICOLLs on aquatic fauna has been poorly investigated in Australia (Griffiths and West, 1999). Artificial opening of the Coila Lake entrance has been observed to allow juveniles of marine species to be introduced into the Lake (Jones and West, 2005). However, Jones and West (2005) found that the artificial opening of Lake Conjola, which is situated south of Jervis Bay, resulted in the loss of a large seagrass bed. Consequently, there was a large decrease in the recruitment of economically important fish species to the Lake. It is therefore difficult to predict what impact artificially opening the entrance of Towradgi Lagoon will have upon aquatic fauna. It should be noted that aquatic fauna inhabiting these ICOLLs are adapted to fluctuating water levels and entrance conditions.

Table 8 assesses the impact of the proposed policy upon species potentially occurring within and around Towradgi Lagoon.

The proposed policy has the potential to significantly impact upon several threatened species including the Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot and Grey Headed Flying Fox. Table 9 provides a description of these species habitat requirements and an assessment of the likely impact of the Entrance Management Policy. The Black Bittern and Australasian Bittern are most likely to be impacted upon as they are reliant upon wetlands and water edge vegetation for habitat (DEC, 2006; Morcombe, 2003). The impact of the proposed entrance management policy on the current distribution, composition and health of wetlands is not expected to be significant as it will not greatly alter water levels from those experienced over the past two decades (See Section 6.3). Therefore, it is not expected that vegetation composition and distribution or aquatic and terrestrial food sources will change drastically. Seven part tests were completed for Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot, Grey Headed Flying Fox, Green and Golden Bell Frog, Black Cod, Australian Grayling and Sygnathids (Appendix E). It was concluded that the proposed policy would not have a significant impact upon these species.

The proposed policy is unlikely to have an impact upon the White-bellied Sea Eagle as there is abundant foraging habitat (ocean and nearby ICOLL's) for this species if the proposed policy did have a negative impact on fish stocks in Towradgi Lagoon. The Bar Tailed Godwit is present in Australia between August and May, following breeding in the Northern Hemisphere. This species inhabits mud flats, beaches and mangroves. Foraging occurs in the shallows and on mud flats where they probe their beaks into the mud for fine food. The proposed Entrance Management Policy could potentially benefit this species, and other shorebird that utilise mudflats, as it would result in the exposure of foraging habitat inundated by high waters.

Mitigation measures

It is anticipated that the proposed Entrance Management Policy will not have a significant impact upon the current distribution, composition or health of vegetation communities within or surrounding Towradgi Lagoon which may support fauna species such as the Australasian Bittern and Black Bittern, as the hydrological regime will not be significantly altered from that experienced over the past two decades. Monitoring of aquatic and terrestrial species is recommended to assist in determining if the proposed entrance management policy is having an impact upon these species and their habitats, which will help improve entrance management policies in the future.

Table 8 Potential Impact upon Threatened and Protected Aquatic Species

Species	Habitat	Likelihood of habitat disturbance
Estuary Cod	• Commonly found in the lower reaches of estuaries and protected silty reef habitats • Juvenile estuary cod are common in shallow waters of estuaries over sand, seagrass, mud and gravel and among mangroves, • However, species unlikely to occur in Towradgi Lagoon as they are generally a more tropical fish	Low. Species is unlikely to occur within the Wollongong area as it is generally a tropical species.
Elegant Wrasse	• Elegant wrasse can be found in different habitats depending on life cycle stage. • Juveniles are found among seaweed in coastal bays and harbours. • They are most common around inshore islands on the coast of NSW. Large juveniles are found in small aggregations on coastal rocky reefs. • Subtropical species	Low. Not specified as an estuarine species, therefore unlikely to occur within the Lagoon. May occur in waters surrounding Towradgi Lagoon such as at Towradgi Point. Impacts as a result of sedimentation are likely to be insignificant due to the small amount of material to be excavated (See Section 6.1).
Eastern Blue Devilfish	• Eastern blue devil fish are a benthic, inshore reef inhabitant. They occur in shallow waters in estuaries as well as in deep waters offshore ranging from 3 to 30 metres. • Species has been recorded within the Wollongong LGA.	Low. Habitat may be present around Towradgi Point. Impacts as a result of sedimentation are likely to be insignificant due to the small amount of material to be excavated (See Section 6.1).
Black Cod	• Adult black cod are usually found in caves, gutters and beneath bommies on rocky reefs. • Small juveniles are often found in coastal rock pools, and larger juveniles around rocky shores and sometimes in estuaries. • Impacts on juvenile black cod may occur due to the loss or degradation of estuarine nursery habitats.	Moderate. Juveniles may inhabit estuaries.
Giant Queensland Groper	• Generally occurs near coral reefs and rocky areas, and may take up residence in rocky caves (Prokop, 2000). • Species has been recorded within the Wollongong LGA.	Low. This species does not usually inhabit estuaries. Impacts as a result of sedimentation are likely to be insignificant due to the small amount of material to be excavated (See Section 6.1).
Australian Grayling	• Occurs in south east Australia (DEH, 2006). • Migrates between freshwater streams and the ocean (DEH, 2006). • Spawning occurs in freshwater. Following hatching juveniles are swept downstream towards the ocean. Larvae have a marine stage in which they	Moderate. The proposed Entrance Management Plan may impact upon the life cycle of the Australian Grayling by disturbing estuary habitats.

Species	Habitat	Likelihood of habitat disturbance
	occupy estuaries or the ocean, before they return to freshwater rivers when they are approximately 6 months old (NSW DPI, 2006).	
Syngnathids	• Off the NSW coast syngnathiformes are found in a variety of habitats ranging from deep reefs to coastal algae, weed or seagrass habitats, or around man made structures such as jetties or mesh nets. • Several Syngnathids have been recorded in the Wollongong LGA.	Moderate. As some of these species occupy estuaries, reefs and coastal areas, habitat may be disturbed by the proposed policy.

Table 9 Potentially Impacted Threatened Species Habitat Requirements and Potential Impacts of Entrance Management Policy

Species	Distribution	Habitat and Ecology	Threats	Potential Impact
Australasian Bittern	The Australasian Bittern is a migratory species that is found in southeast and south west Australia. It is uncommon in NSW, except for the Murray Darling (Morcombe, 2003).	Occupies freshwater wetlands, favouring those with tall dense vegetation. Forages mostly at night on frogs, fish, yabbies, spiders, insects and snails. Breeding occurs from October to January (DEC, 2006).	Threats include drainage of wetlands and ponds, reduced water quality due to sIltation, pollution and salinity, predation by foxes and cats, use of herbicides and pesticides near wetlands and grazing and burning of wetlands (DEC, 2006).	The proposed policy could potentially negatively impact this species habitat by altering the extent and composition of wetlands. However, this is considered unlikely as water levels fluctuations are not anticipated to be altered greatly from those experienced in the past two decades. Similarly, the abundance of aquatic species that make up this species foraging resource are not expected to drastically change for the same reason.
Black Bittern	The Black Bittern occurs in southeast Asia, New Guinea and Australia. Distribution within Australia extends along the coast from southern NSW, north to Cape York and west to the Kimberly (DEC, 2006).	Preferred habitat are areas of permanent water and dense vegetation within terrestrial and estuarine wetlands. Feeds upon frogs, reptiles, fish and aquatic and terrestrial invertebrates. Feeding generally takes place at dusk and night. Roosts in trees or amongst dense ground vegetation. Builds nest in branch overhanging water. Breeds from December to March. (DEC, 2006).	Threats include clearing of riparian vegetation, predation of eggs and juveniles by foxes and feral cats and grazing and trampling of riparian vegetation by stock (DEC, 2006).	The proposed policy could potentially alter this species habitat by altering the composition and extent of the wetlands. Additionally, food resources could be affected. However, this is considered unlikely as water levels fluctuations are not anticipated to be altered greatly from those experienced in the past two decades. Similarly, the abundance of aquatic species that make up this species foraging resource are not expected to drastically change for the same reason.
Swift Parrot	Swift Parrots breed in Tasmania in spring and summer, and migrate to south east Australia during autumn and winter months (DEC, 2006).	On mainland Australia, Swift Parrots occur where there are winter- flowering eucalypts such as Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens* (DEC, 2006).	On the mainland, this species is threatened by clearing of land for agriculture and urban and industrial development (DEC, 2006).	The proposed policy may affect foraging trees, such as Swamp Mahogany (*Eucalyptus robusta*) which are present in vegetation communities such as SSFCF, by altering water levels.
Sooty Oystercatcher	Sooty Oystercatchers are found around the entire Australian coast, including offshore islands, being most common in the Bass Strait. Small numbers of the species are evenly distributed along the NSW coast (DEC, 2006).	Prefers rocky headlands and shelves, exposed reef with rock pools, beaches, and muddy estuaries. Forages on exposed rock or coral at low tide for foods such as limpets and mussels. Breeds in spring and summer, almost entirely on offshore islands, and occasionally on isolated promontories. Nests in a shallow scrape on the ground or in small mounds of pebbles seaweed or shells (DEC, 2006).	Threats include disturbance to coastal feeding by recreation activities, predation of eggs and chicks by foxes, dogs, cats, rats, and raptors, habitat destruction as a result of development, hydrological changes to estuaries causing modification or removal of important areas of suitable habitat (DEC 2006).	While there may be an impact upon this species, there is abundant known foraging habitat located on the rock platforms at the southern end of North Wollongong beach that would negate this impact.

Species	Distribution	Habitat and Ecology	Threats	Potential Impact
Grey Headed Flying Fox	Grey Headed Flying Foxes are found within 200km of the east coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria (DEC, 2006).	Occur in subtropical and temperate rainforests, heaths and swamps as well as urban gardens and cultivated crops. Roosting camps are generally located within 20km of a reliable food source, and are common in gullies, close to water, in vegetation with a dense canopy. Annual mating commences in January and a single young is born each October or November. Food sources include nectar and pollen of native trees, particularly Eucalypts, Melaleuca, and Banksia, and fruits of rainforest trees and vines (DEC, 2006).	Threats to the Grey-headed Flying-fox include loss of foraging habitat, disturbance of roosting sites, unregulated shooting, and electrocution on power lines (DEC, 2006).	The proposed Entrance Management Policy is not expected to result in a significant change of composition or distribution of vegetation surrounding Towradgi Lagoon, which may provide foraging trees for this species. Therefore the policy should have no impact upon this species.
Green and Golden Bell Frog	Distribution from coastal areas in north east NSW to northeast Victoria, and into the the more eleated southern tablelands and central slope of Bathurst.(DEC, 2005b).	This species may require a number of different habitats to complete its lifecycle. This species has been observed utilising coastal swamps, marshes, dune swales, lagoons, lakes and other estuary wetlands as well as riverine floodplain wetlands and billabongs. Man made waterbodies such as stormwater detention basins, drains, ditches and other excavations capable of catching water may also provide suitable habitat. It has also believed that complex vegetation structure may be an important habitat attribute (DEC, 2005b).	Threats to this species include habitat loss, habitat modification and disturbance, fragmentation mand isolation of habitat, predation by introduced fish, disease and water quality and pollutant issues (DEC, 2005b).	The proposed policy has the potential to affect the hydrological regime of Towradgi Lagoon, which may inturn impact upon the Green and Golden Bell Frog. Additionally, the complexity of vegetation may be altered.

6.7 Commercial and Recreational Fisheries

Existing Environment

ICOLL's are very important systems for many aquatic species that are important to both commercial and recreational fishers. It has been estimated that 60% by weight and 70% by value of the NSW commercial fish catch consists of species dependant upon estuaries during some part of their lifecycle (Edgar, 2001 cited in O'Connell and Wiltshire, 2005).

Towradgi Lagoon has been noted as having low fish diversity (Centre for Estuarine and Coastal Catchment Studies, 1998). Of the 11 different fish species recorded within Towradgi Lagoon by the Centre for Estuarine and Coastal Catchment Studies (1998), 6 were identified as being commercial species. The most common of these species caught within the Lagoon were the Sea Mullet (*Mugil cephalus*) and Sand Mullet (*Myxus elongatus*).

Potential Impacts

As discussed in Section 6.6.3, the impact of assisted breakout of the Lagoon entrance on aquatic species is largely unknown, and may be dependant upon the impact that breakout has upon aquatic vegetation communities such as *Zosteraceae sp*, which plays an important role in providing shelter and foraging resources for fish species. However, the hydrodynamics of the Lagoon are not expected to change significantly from what has been experienced over the past two decades. Therefore it can expected that current distribution of seagrass beds will remain relatively unchanged in response to the Entrance Management Policy (See Section 6.3).

Mitigation Measures

Monitoring of commercial and recreational fish species is recommended to attempt to gauge the impact of the proposed entrance management policy. The Department of Primary Industries identified the following fish species for monitoring:

- Yellowfin bream
- Dusky flathead
- Sand whiting
- Tarwhine
- Mullet
- Ludderick
- Trevally
- Eels
- Eastern king prawn and school prawn (when present in the Lagoon).

6.8 Tree Failure

Existing Environment

Assessment of recent aerial photographs indicates that there are numerous trees surrounding Towradgi Lagoon and its associated tributaries within the study area (Figure 17), which may be subject to tree failure as a result of extended periods of elevated water levels or erosion of the estuary banks (i.e. undermining). There are very few trees on the north and south banks of Towradgi Lagoon (Figure 17). The majority of trees are located in a narrow strip along Towradgi Creek and at the end of The Parker Road Arm (Figure 17).

Figure 17 Tree Assessment

Potential Impacts

Tree failure associated with water level change in the estuary can occur due to two different mechanisms; either extended periods of elevated water levels or increased frequency of wetting and drying due to increased opening of the estuary.

Some dieback is expected following relatively long periods of inundation, but it is a process of natural reclamation of flood prone areas by water and indicative of the highly dynamic nature of intermittently opening lake ecosystems (Eurobodalla Shire Council, 2000). Allowing the lake water level to rise is a natural phenomenon. Previous manual openings of the estuary at a low level may have modified the environment to the extent that trees have grown in areas where they would not normally have grown. If these trees die because of elevated lake levels then this would be considered a natural process and should not be of environmental concern.

Erosion of the estuary banks (and therefore undermining of nearby trees) could potentially worsen should the estuary be opened on a significantly more regular basis. The increased opening of the estuary entrance would increase the alternate wetting and drying of banks. This could weaken the soil structure in the banks, which is then easily scoured by either seepage flows from the near bank areas and/or creek flows.

It is impossible to quantify the likely impact of the entrance management policy on tree failure based on available information and data, potentially this issue could worsen or in fact improve due to the entrance management policy. However, the location of any potential safety issues can be identified and assessed.

Fringing trees which could potentially be undermined are predominately located along Towradgi Creek. These trees could present a threat to residents and recreational users along Towradgi Creek is tree failure was to occur.

It should also be noted, that a negative impact of the use of On-site Detention Policies (as in place in Wollongong LGA), is that the base flow is often prolonged over an extended period of time, increasing the risk of the erosion of banks and potentially undermining banks. This further illustrates the fact that tree failure could not solely be attributed to entrance management nor is it possible to quantify the impact that the policy may have on increased tree failure.

Mitigation Measures

Inspection of trees showing the potential for tree failure should be monitored at frequent intervals by Council within areas along Towradgi Creek.

6.9 Air Quality

Existing Environment

Air Quality appears to be improving within the Wollongong area, with the number of High Regional Pollution Index values recorded in 2004-05 having decreased since 2001-02 (WCC, 2005). There are no major sources of air pollution such as industrial activities located in close proximity to the site, which contributes to the relatively good air quality. However, there are several industrial sites in the Wollongong area that may contribute to poor air quality during certain conditions, including Port Kembla Steelworks, Port Kembla Coal Terminal and Corrimal Coke Works. The most common sources of air pollution in close proximity to Towradgi Lagoon are associated with road traffic in and around Towradgi, such as along Pioneer Road, Towradgi Road, Lake Parade, Murray Road and adjacent streets.

Potential Impacts

Construction of Access Path

The main air pollutants emitted as a result of the construction of the access path will be those associated with the operation of equipment (eg 4WD backhoes and trucks) and dust generated from excavation. However, as the works are relatively minor, they would have a minimal effect upon air quality.

Entrance Management

Potential impacts on air quality during assisted breakout are expected to be localised, and will consist mainly of emissions from vehicles and machinery. However, as the amount of material to be excavated is quite small, and the works will only be short in duration, emissions from machinery will be insignificant. Dust pollution associated with the excavation of the pilot channel is unlikely as the excavated material will be damp.

Mitigation measures

Construction of Access Path

Exhaust emissions would be minimised by only using properly maintained machinery.

Entrance Management

Exhaust emissions would be minimised by only using properly maintained machinery.

6.10 Noise and Vibration

Existing Environment

Towradgi Lagoon is surrounded by numerous potential noise receptors including residents surrounding the Lagoon, Corrimal Surf Lifesaving Club, Corrimal Holiday Park, Towradgi Park Bowls and Recreation Club and users of Towradgi Park and Corrimal beach. Sources of ambient noise surrounding Towradgi Lagoon include users of Towradgi Park and Corrimal Beach, Corrimal Holiday Park and traffic along Lake Parade and Towradgi Road.

Potential Impacts

Construction of Access Path

When assessing the impact of noise and vibration generated by the excavation works, consideration of the following factors is necessary:

- Existing land uses and ambient noise levels
- Noise source level, mode of operation, duration of operation
- Location of noise receptors in relation to earth works and the presence of noise softening measures (e.g. barriers in the form of buildings or variations in topography) between the source and receptor; and
- Sensitivity of the receiving environment.

Due to the relatively low level of human activity within and immediately surrounding the area, it is expected that the ambient noise levels will be low. As most receptors are located greater than 100m away from the proposed works, and the works are expected to be short

in duration, it is anticipated that the works will have no significant impact upon potential receptors provided that the recommended mitigation measures are followed.

Entrance Management

The nature of a mechanical breakout is such that it generally coincides with times of high rainfall and stormy weather. Therefore, recreational users and ultimately potential receptors are expected to be at a minimum. The duration of the assisted breakout would be of the order of a few hours, so the time of possible noise and vibration disturbance would also be limited.

Mitigation measures

Construction of Access Path

It is recommended that the construction of the access path be undertaken during the winter period when users of Corrimal beach and Towradgi Park will be lowest. Works should be undertaken between the following hours:

Monday to Friday	7am to 6pm
Saturday	7am to 1pm
Sunday or Public Holidays	No construction work to take place

Entrance Management

The primary source of noise and vibration during a mechanical breakout would be due to 4WD backhoe. Heavy vehicles that are associated with transporting the 4WD backhoe may also be a source. However, both sources are expected to be short in duration, and relatively unobtrusive to receptors.

6.11 Heritage

The potential impact of the proposed Entrance Management Policy on items of heritage significance requires great consideration as there are numerous heritage items and places located in close proximity to Towradgi Lagoon, including the Towradgi Park area, which has been identified as a heritage area under the Wollongong City Council LEP.

6.11.1 Indigenous Heritage

Existing Environment

A desktop search of places and items of Indigenous heritage was undertaken as part of this study. This included a search of the Aboriginal Heritage Information Management System (AHIMS) for areas surrounding Towradgi Lagoon, and a review of relevant literature including:

- A History of Aboriginal People in the Illawarra (DEC, 2005),
- Wollongong City Council State of the Environment Report (WCC, 2005),
- Wollongong LEP.

Numerous different indigenous heritage site types have been identified within the Wollongong LGA, including (WCC, 2005):

- engravings,
- painting or drawing sites,

- open camp sites,
- quarries,
- stone arrangements,
- scarred or carved trees,
- burial sites, and
- middens.

Lake Towradgi (burials), Flats Rock; Towradgi (Midden), Corrimal Holiday Park and Murray Road were identified as sites of Indigenous heritage significance recorded on the AHIMS.

Potential Impacts

Construction of Access Path

The proposed access path will be located in close proximity of several known Indigenous heritage items including sites known as Corrimal Surf Lifesaving Club and Towradgi Lagoon sites. Construction of this path will most likely involve the removal of the top 200 – 300mm of topsoil. Therefore, there is the possibility that indigenous heritage items will be disturbed.

Entrance Management

Excavations associated with the digging of the pilot channel to facilitate breakout of the Lagoon are within close proximity to known Indigenous sites. However, as the material which is to be excavated will have only been recently deposited (i.e. since last infilling of the Lagoon entrance) it is unlikely that any items of indigenous heritage will be disturbed.

Fluctuating water levels also have the potential to expose buried items of indigenous heritage significance by facilitating erosion of banks surrounding the Lagoon. Erosion of the estuary banks could potentially worsen should the estuary be opened on a significantly more regular basis. The increased opening of the estuary entrance would increase the alternate wetting and drying of banks. This could weaken the soil structure in the banks, which is then easily scoured by either seepage flows from the near bank areas and/or creek flows. Additionally, lowering of water levels may expose the banks of Towradgi Lagoon to wind driven erosional processes, which may expose buried indigenous items.

Mitigation measures

Construction of Access Path

It is recommended that an indigenous heritage study be undertaken when the exact route of the access path is known, to determine whether excavations associated with this structure are likely to disturb any items of Indigenous heritage.

Entrance Management

It is unlikely that items of Indigenous Heritage will be disturbed during the digging of the pilot channel, so no mitigation measures are required for this process.

The impact of the Entrance Management Policy upon creek bank erosional processes is difficult to determine, and it is therefore difficult to prescribe mitigation measures. However, regular inspection of the Lagoon banks (incorporated in with the tree inspection – Section 6.8) is recommended to identify erosional issues and the need for mitigative measures such as bank stabilisation.

6.11.2 Non-Indigenous Heritage

Existing Environment

A desktop search was undertaken on 2 November 2006 to identify items of heritage significance within and surrounding Towradgi Lagoon. This desktop study included searches of:

- Australian Heritage Database,
- State Heritage Inventory, and
- Wollongong LEP.

No items of heritage significance were identified around Towradgi Lagoon.

6.12 Hazards

Existing Environment

The main hazards associated with Towradgi Lagoon and its surrounds are poor water quality and flooding.

Potential Impacts

Construction of Access Path

The main hazards associated with the construction of the access path will be the movement of construction vehicles and machinery, which may pose a hazard to recreational users of Towradgi Park.

Flooding may pose a hazard to any machinery that is left on site during the works period. However, as the proposed Entrance Management Policy will be in place during this period, it would be expected that flooding would not significantly affect machinery temporarily parked within Towradgi Park.

Entrance Management

During the excavation of the pilot channel, 4WD backhoes may pose a hazard to users of Towradgi Park and Corrimal beach. However, as assisted breakout will generally occur during periods of rainfall, it is unlikely that there will be a large number of recreational users within the area.

Following breakout, water leaving the Lagoon may pose a hazard to swimmers at Corrimal beach, as this water may be of a low quality. However, this policy does not aim to address the provision of a safe swimming area for the public at the entrance. As a semi-natural system, people should be aware that they swim in the entrance area at their own risk. Responsibility for signage in regard to strong current flows is the responsibility of Corrimal beach Lifeguards in conjunction with Corrimal SLSC.

Mitigation measures

Construction of Access Path

Appropriate signage to warn motorists and pedestrians of the works, and fencing off of the works area will help mitigate such hazards.

Entrance Management

Signage to warn pedestrians of the works will help mitigate such hazards.

6.13 Visual Landscape

Existing Environment

Visually, Towradgi Lagoon and its surrounds are typical of an open recreational area. To the North of the Lagoon, there exists a grassed area, Surf Life Saving Club, car park, and playground, as well as the natural dune system. To the South, a grassed area exists, as well as the dunes.

Potential Impacts

Construction of Access Path

There will be minor visual impacts associated with the construction of the access path associated with heavy vehicles and machinery. However, as these works are relatively minor, this impact will be short lived.

Following the construction of the access path, there will be no visual impact as the path will be covered with turf (Figure 7).

Entrance Management

It is predicted that there will be relatively minor visual impacts due to an assisted breakout. During the excavation of the pilot channel, visual impacts associated with heavy machinery will be present. However, as this work will be short in duration, the visual impact should be minimal. Post breakout, the visual landscape will be altered, however the open entrance is expected to assume a 'natural' profile quite rapidly (ie in less than one day). Consequently, evidence of human intervention will be temporary.

Mitigation measures

Construction of Access Path

No mitigation measures will be required.

Entrance Management

No mitigation measures will be required.

6.14 Socio-Economic Considerations

Existing Environment

Towradgi Lagoon is valuable for a number of social and economic reasons. The cycleway that crosses over Towradgi Lagoon is frequently used, so is a valuable public facility that increases the appeal of the area. The large carpark, playground, and barbeques, as well as the protection provided by the Surf Life Saving Club increase the recreational value of the area. Additionally, Towradgi Lagoon is used for model boat sailing. Essentially, the existing public facilities increase the economic value of the area.

There are a number of properties fringing Towradgi Creek that could be threatened by flooding in high rainfall. This is a major social and economic issue for the management of

Towradgi Lagoon. Currently, flooding has the potential to generate economic losses in the form of damaged property and reduced land value.

Potential Impacts

The aim of mechanical breakout is to provide flushing for the lagoon ecosystem, and reduce the risk of flooding on properties. Therefore, it is predicted that mechanical breakout can reduce economic losses.

The process of mechanical breakout poses a hazard as it involves heavy machinery, rapidly moving water, and unstable sand. This can provide a hazard for both children and adults due to the fast flowing nature of water at the height of the outflow from the Lagoon.

Mitigation measures

To reduce the risk to people from the dangers associated with mechanical breakout, it is suggested that the area be restricted to the public while earthworks are occurring, and for the hours following mechanical breakout. Community advisory information, via media releases will be issued where possible to announce an impending mechanical breakout in order to minimise the social impact of earthworks.

6.15 Traffic and Access

Existing Environment

The main access to Towradgi Lagoon is via Lake Parade for vehicles, and a cycleway for pedestrians. Both routes experience frequent traffic, especially on weekends, and throughout the summer months. The beach is popular for exercising, and this constitutes a proportion of the pedestrian traffic in the area.

Potential Impacts

The main access route for machinery to Towradgi Lagoon is expected to be Towradgi Road. Heavy vehicle movements might provide delays for local traffic and pedestrians, however it is expected to be relatively minor. Mechanical opening of the Towradgi Entrance may provide some disruption to pedestrian traffic on the beach. As aforementioned, Towradgi is used for exercising, and an open lagoon entrance can fragment the beach.

Mitigation measures

Traffic controls should be implemented in order to ensure that movement of heavy machinery is not threatening to local traffic. Signage should also be implemented to inform pedestrians of an impending mechanical breakout. Information should include a description of the mechanical breakout process, and notification of any hazards that are relevant to the public.

6.16 Demand on Resources

A mechanical breakout will require resources that are typical of construction activities which are abundant. The nature of a mechanical breakout is such that it requires immediate attention as soon as trigger levels are reached. Therefore, resources (i.e. 4WD backhoe and operator) must be continually available or available on request.

6.17 Cumulative Environmental Effect

Assisted breakout of Towradgi Lagoon has been undertaken for several decades. However, without detailed baseline information, it is difficult to ascertain what cumulative impact this has had on the environment as there has been little monitoring focused upon this aspect of the Lagoon. The Further Processes Study (CLT, 2005b) has recommended that monitoring of key indicators of environmental health be undertaken to help determine such impacts and assist with recommendations for adaptive management.

7. ENVIRONMENTAL SAFEGUARDS AND MANAGEMENT

7.1 Summary of Proposed Safeguards

A summary of the proposed safeguards is provided below.

Geology, Soils and Topography	• An ESCP would be prepared and implemented for the construction of the access path in accordance with *Managing Urban Stormwater – Soils and Construction* (the Blue Book) (NSW Department of Housing, 2004) as part of the Contractors Environmental Management Plan (CEMP) for the site and approved by Council's Superintendent before works commence. • Regular inspection of the work site would be undertaken for the duration of construction of the access path to ensure that the ESCP is implemented and maintained.
Climate	• The impacts of sea level rise on berm location should be assessed during subsequent Entrance Management Policies (Section 6.2).
Water Quality	• Monitoring of water quality as recommended by CLT (2005b) (Appendix D) to assess the impact of the Entrance Management Policy.
Assets	• Implementation of the Entrance Management Policy
Lagoon Ecology	• Seven part tests for SSFCF, SOFF and ILGW Endangered Ecological Communities (EECs), Terrestrial threatened species such as the Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot and Grey Headed Flying Fox, and Aquatic species such as the Black Cod, Australian Grayling and Sygnathids confirmed no impact. • Implementation of monitoring programmes as recommended in CLT (2005b) to assess the impact of the Entrance Management Policy upon flora, fauna and important habitats such as seagrass beds riparian vegetation, mangroves and wetlands (Appendix D).
Commercial and Recreational Fishery	• Monitoring of commercial and recreational fish species, which could be incorporated in the monitoring of aquatic fauna discussed in Section 6.6.1.
Tree Failure	• Monitoring of trees that have potential for tree failure could be incorporated in monitoring for erosion and sedimentation that have been recommended in CLT (2005b).
Air Quality	• The generation of exhaust particle dust would be minimised during the construction of the access path and assisted breakout of the Lagoon by using well maintained machinery and operating in an efficient manner.
Noise and Vibration	• Construction of the access path should take place during winter when recreational use of the area will be lowest.
Indigenous Heritage	• An indigenous heritage assessment for the proposed access path should be undertaken prior to construction. • Erosional impacts upon the Lagoon banks should be incorporated into the erosion and sediment monitoring recommended in CLT (2005b).
Non-Indigenous Heritage	• No specific requirements.
Hazards	• Signage should be erected warning pedestrians and motorists during both the construction works and an assisted breakout.

7.2 Clause 228 and EPBC Act (1999) Checklist

7.2.1 EPBC Act (1999) Factors

The EPBC Act requires that the following matters of National Environmental Significance (NES) be considered:

Matter	Impact
a) Any environmental impact on a World Heritage property? There are no World Heritage properties within the vicinity of the area affected by the proposed policy.	Nil
b) Any environmental impact on National Heritage Properties? There are no National Heritage properties within the vicinity of the proposed policy.	Nil
c) Any environmental impact on Ramsar wetlands of international significance? There are no wetlands of international importance located within the study area.	Nil
d) Any environmental impact on Nationally listed or threatened species and communities? Several nationally listed threatened species may occur within the study area, including the endangered Swift Parrot, vulnerable Green and Golden Bell Frog and vulnerable Grey Headed Flying Fox. Seven part tests (Appendix E) indicate that the proposed policy is unlikely to have a significant impact upon these species.	Nil to negative
e) Any environmental impact on Nationally listed migratory species? There have been four avian species listed as being migratory on the EPBC Act that have been observed in the Towradgi Lagoon region. It is not anticipated that the proposed Entrance Management Policy will significantly affect these species as the works should not significantly alter their habitat. There is also the opportunity for these species to utilise adjacent habitat. It is therefore unlikely that this proposed policy would affect migratory species.	Nil

Matter	Impact
f) Any environmental impact on Commonwealth marine areas? There would be no Commonwealth marine areas directly impacted upon as a result of the Proposed policy. Any indirect impacts would be minimised by implementation of mitigation measures described in Sections 7.1.	Nil
g) Does any part of the Proposal involve nuclear action? The Proposed policy would not involve any nuclear action.	Nil

7.2.2 Clause 228 Factors (NSW Environmental Planning and Assessment Regulation, 2000)

Factor	Impact
a) Any environmental impact on a community? The proposed Entrance Management Policy will have a positive impact upon the community as it will mitigate the impacts of flooding during high rainfall events.	Long term Positive
b) Any transformation of a locality? The proposed Entrance Management Policy will result in the opening of the Lagoon entrance which will assist in the flushing of the Lagoon, potentially resulting in improved water quality in the Lagoon.	Mid term Positive
c) Any environmental impact on the ecosystem of the locality? The proposed Entrance Management Policy has the potential to impact upon the Towradgi Lagoon ecosystem, as water levels may be altered as a result of this policy. However, the pattern of water level fluctuations is not expected to be significantly different from those experienced over the past two decades. Therefore, it would be expected that the Entrance Management Policy will not significantly affect these ecosystems as they will have adjusted to these conditions.	NIL

Factor	Impact
d) Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality?	
The improvement of water quality will increase the Lagoons aesthetic and recreational quality.	Short term Positive
Intervention in the natural breakout process diminishes the scientific value of the system since an element of 'naturalness' has been lost. However, many ecological processes will continue to operate and the locality could still be suitably used for a wide range of scientific purposes. Mechanical breakout of the Lagoon has been occurring informally over several decades, therefore it is believed that the proposed policy will not further diminish the scientific value or environmental quality of the Lagoon. Additionally, it should be noted that the entire catchment has been environmentally altered, and as such the effect of the policy should be considered with this in mind.	Neutral
e) Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations?	
A number of heritage items have been identified around Towradgi Lagoon, including Lake Towradgi (burials), Flats Rock; Towradgi (Midden), Corrimal Holiday Park and Murray Road, which are indigenous heritage items.	Mid Term NIL
Excavation for the construction of the access path may disturb some indigenous heritage items. However, an indigenous heritage assessment should be undertaken to determine the impact of the works.	Negative
The proposed entrance management policy may enhance erosional processes, which may expose buried indigenous heritage items. Monitoring of erosion sites should be undertaken to identify areas at risk and mitigation measures developed.	Negative
The proposed Entrance Management Policy will help prevent the inundation of non-indigenous heritage items surrounding the Lagoon.	Positive

Factor	Impact
f) Any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)? The proposed Entrance Management Policy is not expected to have a significant impact upon flora or fauna as it will not be greatly altering conditions from those experienced over the past two decades.	NIL
g) Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air? The proposed Entrance Management Policy is not expected to have a significant impact upon flora or fauna as it will not be greatly altering conditions from those experienced over the past two decades. Seven part tests were conducted for SSFCF, SOFF, ILGW and CSM EECs and the threatened Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot, Grey Headed Flying Fox, Black Cod, Australian Grayling and Sygnathids. It was concluded that the proposed policy was unlikely to have a significant impact upon the communities and species.	NIL to negative
h) Any long-term effects on the environment? The long term effects of the proposed Entrance Management Policy on the environment is difficult to determine as there has been little research into the impacts. It is anticipated that there will be no significant impact upon the environment as the Entrance Management Policy will not change conditions drastically from those experienced in the past two decades. However, if is difficult to determine whether the conditions experienced over the past two decades are having a long term effect on the environment as there is little data available. The implementation of monitoring programmes for flora and fauna, water quality, heritage, sediment and erosion and flooding as recommended by CLT (2005b) (Appendix D) should assist in determining whether this Policy is having a negative impact.	NIL
i) Any degradation of the quality of the environment? Mitigation measures in Section 7.1 would minimise potential impacts with the local environment for the construction of the access path. The proposed Entrance Management Policy will not alter conditions significantly from those experienced over the past	Short term Managed

Factor	Impact
two decades, therefore no degradation of the environment is expected. Additionally, the entire catchment has been altered and somewhat degraded, so the environmental quality of the area is already slightly degraded.	NIL
j) Any risk to the safety of the environment? There would be some risk of safety to the aquatic environment during the works period, however with the implementation of mitigative measures outlined in Section 7.1, this impact should be negligible.	NIL
k) Any reduction in the range of beneficial uses of the environment? The proposed policy will not reduce the range of uses of the environment.	NIL
l) Any pollution of the environment? Mitigation measures outlined in Section 7.1 of this report would reduce or eliminate the potential for impacts to air, waterways and soil.	Short term Managed
m) Any environmental problems associated with the disposal of waste? The proposed access path construction and Entrance Management Policy would not generate significant amounts of waste	NIL
n) Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply? The proposed policy would not increase demand on resources, natural or otherwise, which are, or likely to become in short supply.	NIL
o) Any cumulative environmental effects with other existing or likely future activities? No.	NIL

8. CONCLUSION

The assessment of environmental impacts suggest that the proposed policy can be implemented over the short term. There is a need for monitoring programs to be implemented to determine what impact the policy is having upon flora and fauna, commercial and recreational fishing, water quality and erosion along the banks of the Lagoon. An adaptive management approach will be applied to this policy, and data obtained from the monitoring programs can be used to improve future entrance management policies when the review stage occurs.

Assessment of Significance (seven part tests) were conducted for Swamp Sclerophyll Forest on Coastal Floodplains, Swamp Oak Floodplain Forest, Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion and Coastal Salt Marsh endangered ecological communities and the threatened Black Bittern, Australasian Bittern, Sooty Oystercatcher, Swift Parrot, Grey Headed Flying, Green and Golden Bell Frog, Fox, Black Cod, Australian Grayling and Sygnathids. These tests indicated that the proposed entrance management policy is unlikely to have a significant impact upon these species.

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APPENDIX A

Photolog

Figure A1: East view of closed entrance, 2 May 2005.

Figure A2: South view of closed entrance, 23 October 2003.

Figure A3: North view across Lagoon showing grassed area near carpark, 23 October 2003.

Figure A4: North-East view across the closed entrance, 23 October 2003.

Figure A5: South-West view of Lagoon from carpark, 23 October 2003.

Figure A6: North-East view across the closed entrance, 23 October 2003.

APPENDIX B

Consultation

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

13 November 2006

To	ERM
Date	14-11-06

Emma Maratea
Cardno Lawson Treloar Pty Ltd
Level 3, 910 Pacific Highway
GORDON NSW 2072

Dear Ms Maratea

Re: Entrance Management Policy and Review of Environmental Factors for Fairy and Towradgi Creeks

I refer to your letter of 27 October 2006 and accompanying information requesting Department of Primary Industries (DPI) comments for the preparation of entrance management policies and Review of Environmental Factors (REFs) for Fairy and Towradgi Creeks, Wollongong. Thank you for referring this matter to the Department for comment.

Issues Related to Fisheries

The responsibilities of the Department of Primary Industries (DPI) include conserving fish stocks and fish habitat, marine vegetation, threatened fish species, and aquatic biodiversity. As such the Department is concerned about any potential impacts that proposed artificial entrance openings of Fairy and Towradgi Creeks may have on aquatic species and habitats in the vicinity.

REF Requirements

The Department advises that the entrance management policy and REF should include consideration of the following issues:

- Description of the aquatic environments of Fairy and Towradgi Creeks (including marine and riparian vegetation such as seagrass, mangroves, saltmarsh, wetlands and fish species) and their regional significance.
- Analysis of any impacts of artificial entrance openings upon aquatic environments and species (including marine and riparian vegetation such as seagrass, mangroves, saltmarsh, wetlands and fish species).
- Proposed safeguards to mitigate any impacts upon aquatic environments and species.
- Predictions of any impacts upon water quality and aquatic threatened species, populations and ecological communities listed under the *Fisheries Management Act 1994* (both temporary and permanent).
- Proposed safeguards to mitigate any impacts upon water quality and on aquatic threatened species, populations and ecological communities.

Aquatic Habitat Protection, Fisheries Management Branch
NSW Department of Primary Industries
PO Box 17 Batemans Bay NSW 2536
1st Floor, Cnr Beach Road and Orient Street

ABN 51 734 124 190
www.dpi.nsw.gov.au
Tel: 02 4478 9103
Fax: 02 4472 7542

- Provide an assessment of the potential impacts of artificial entrance openings on recreational fishing in Fairy and Towradgi Creeks.

DPI Approvals for Artificial Entrance Openings

Any works within an ICOLL entrance by an organisation other than the owning or controlling body require 'landowners consent' as a minimum. The entrance to ICOLLs are often under various ownership, and tenure needs to be clearly established to determine responsibility for entrance management and required approval processes. The majority of ICOLL entrances are Crown land under the jurisdiction of the Department of Lands, but some are managed as public reserves under the control of local councils.

The State Environmental Planning Policy for Maintenance Dredging of Tidal Waterways (SEPP 35) allows works to be carried out by, or on behalf of, public authorities (including local councils) **without the need to obtain development consent.** This includes the removal of sand from an ICOLL entrance to '**enable the waterway to resume its function as a tidal waterway**'. Schedule 2 of SEPP 35 requires that authorities who are proposing dredging works must consult with affected bodies (i.e. other local, State and Federal government agencies as appropriate) by giving written notification prior to undertaking the works, and to take the views of those bodies into account. A period of 28 days is allowed for response. However, it should be noted that if an authority considers a significant environmental impact to be likely, then an EIS is required.

An approval for dredging and reclamation (under sections 199-201 of the *Fisheries Management Act 1994*) may be required from DPI if any excavation or reclamation in a waterway is to occur unless the work is specifically authorised under the *Crown Lands Act 1989* or by a NSW public authority other than a local government authority (e.g. NSW Maritime or Department of Natural Resources DNR). These sections of the Act apply to any dredging works carried out in **water land** other than dredging for mining, dredging for restoration or maintenance of a navigation channel under approval from the Minister administering the *Public Works Act 1912,* or dredging on land under the control of the NSW Maritime. For public authorities, other than local councils, the FM Act requires **prior referral** of dredging works to the Minister for Primary Industries. For local councils or persons the Act requires the **approval** of the Minister for Primary Industries (unless the work has already been authorised under the *Crown Lands Act 1989).*

DPI Guidelines on Management of ICOLLs

In general DPI:

1) supports minimum interference with ICOLL entrance barriers and advocates natural processes being allowed to operate to the greatest extent possible.
2) does not support the artificial opening of an ICOLL where there is little threat to public health or safety from flooding or water quality deterioration.

3) supports using estuary management plans and environmental assessment processes to analyse the issues relating to opening a particular ICOLL, and to develop an entrance management plan or policy. Proposals for artificial openings which are to be carried out according to a formulated entrance management plan or policy are more likely to be approved.

DPI recommends that ICOLL entrance management policies include the following guidelines:

a) DPI should be contacted prior to an artificial opening event to seek approval or concurrence under the Fisheries Management Act.
b) Illegal openings should be guarded against by the erection and maintenance of signs near the ICOLL entrance warning people that unauthorised opening is illegal and may result in prosecution.
c) The decision to open a lagoon should be made on the basis of **factual data** on:
   - **verified water levels** and the nature and extent of associated flooding impacts - which should be referenced to a standard datum (e.g. Australian Height Datum) obtained from appropriately sited staff gauges, or automatic water level recorders, and
   - **quantitative** evidence of changes to relevant water quality parameters (especially nutrient and bacterial levels) produced by monitoring programs designed specifically to assess water quality pre- and post-opening.
d) Entrance management policies should be made in consultation with all relevant natural resource management agencies, representatives of local community interest groups and affected landholders and provide a clear guide to where, when and under what conditions to open the ICOLL entrance. Criteria to be met may include:
   - a preset water level above which a breach is recommended;
   - a preset range between which a breach is recommended if heavy rainfall is predicted;
   - a preset duration of high water level and/or wetland/pasture inundation over which a breach may be recommended;
   - other environmental parameters where relevant to the location (e.g. avoiding the breeding season of threatened birds such as the Little Tern).
e) In the event that the criteria for an artificial opening are met, breaching should be conducted during a falling tide (if possible, around a spring tide) so that the potential for establishing an entrance channel long enough to flush the water body is achieved.
f) In the long-term, local councils and government agencies should aim to reduce the need for artificial manipulation by taking active measures to remove, relocate or otherwise manage items of low-lying infrastructure that currently necessitate breaches below the natural breakout range, and adopting catchment management practices that:
   - reduce the inputs of nutrients and pollutants from point and diffuse sources,
   - prevent transfer of flood prone and riparian land on the margins of lagoons into private ownership,

- prevent the future development or subdivision of flood-prone and riparian lands by adopting appropriate zonings and buffers in planning instruments,
- implement community awareness campaigns to gain broad based understanding and support for the environmentally responsible management of ICOLLs.

Once the draft entrance management policies and REFs have been prepared could you please forward a copy to this office for our review and further comment.

If you require any further information, please contact me on 02) 4478 9103.

Yours faithfully

Trevor Daly

Trevor Daly
Fisheries Conservation Manager, South Coast

WOLLONGONG
City of Innovation

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To	ERM
Date	9-11-06
File	
Circulation	

Ms Emma Maratea
Cardno Lawson Treloar
Level 3
910 Pacific Highway
GORDON NSW 2072

Your Ref	
Our Ref	D.RD:DL
File	SU20059
Date	6 November 2006

Dear Ms Maratea

Fairy and Towradgi Lagoons – Estuary Management Policies and REF

Reference is made to your letter dated 27 October 2006 regarding your engagement by Wollongong City Council to prepare the above and seeking any specific requirements to be incorporated into the documents.

With respect to flooding considerations, our primary area of concern relates to the level at which artificial opening of each of the lagoons shall commence. Based on flood studies carried out for both the Fairy Creek and Towradgi Creek catchments, we provide the following recommendation:

- Artificial opening for both lagoons shall commence at (or prior to) a threshold beach bar level of 2.0m AHD. That is, the level of the beach bar at both locations shall not exceed a maximum level of 2.0m AHD.

We understand that as part of your work, investigations will be undertaken to determine a final adopted level at which artificial opening will occur. This will include among other factors, consideration of the frequency at which opening may be required and associated maintenance needs. Consultation with Council's Works and Services Division should be undertaken to obtain any comments they may have regarding this matter.

Should you have any queries regarding the above, please contact me on the telephone number below.

Yours faithfully,

R. Dinaro

Robert Dinaro
Floodplain Management Engineer
Wollongong City Council
Direct Line (02) 4227 7485

To	ERM
Date	29-11-06
File	
Circulation	

NSW Government
DEPARTMENT OF NATURAL RESOURCES

Contact: Gabrielle Wiltshire
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Fax: (02) 4224 9651
Email: gabrielle.wiltshire@dnr.nsw.gov.au

Our ref: WOL1919624
Your ref: LJ2578/L9956a :ERM/LC
File: Entrance management response to stakeholder letter.doc

Ms Emma Maratea
Cardno Lawson Treloar
Level 3, 910 Pacific Highway
Gordon NSW 2072

24 November 2006

Dear Ms Maratea

Subject: Fairy & Towradgi Lagoons Entrance Management Policies and Review of Environmental Factors

Thank you for your letter dated 27th October requesting any specific requirements we have for the Fairy & Towradgi Lagoons Entrance Management Policies and Review of Environmental Factors (REF).

The Department's requirements have been written into the brief for the project, as we developed it in consultation with the Wollongong City Council. However, I would like to highlight some of the issues we are particularly interested in seeing adequately addressed in the policies:

- The flood studies for Fairy (draft document) and Towradgi Creek (final) are thoroughly reviewed in the development of the policies and the policies are informed by (and complementary to) the findings of those studies.
- The policies identify and discuss strategies or techniques to return to a more natural opening regime (e.g. asset raising, improvements to infrastructure).
- The importance of the environmental values of the lagoons is given appropriate weighting in determining appropriate artificial entrance opening levels.
- The REF adequately refers to each of the Lagoons individually wherever the physical/ ecological characteristics or potential response to policy implementation is different.

If you would like clarification of the above points or require input from the Department into any aspect of the policies and REF, please contact me on the above telephone number or by email.

Yours sincerely

Gabrielle Wiltshire
Natural Resource Project Officer,
Coast & Estuaries, Landscapes and CMA Support

APPENDIX C

Species Recorded in Towradgi Wetlands

Common Name	**Scientific Name**	*Status*	
		TSC Act 1995	*EPBC Act 1999*
Indigenous Species			
Angled Lobelia	*Lobelia alata*	U	U
Austral Seablite	*Suaeda australis*	U	U
Bangalay	*Eucalyptus botryoides*	U	U
Bare Twig-rush	*Baumea juncea*	U	U
Basket Grass	*Oplismensus aemulus*	U	U
Bearded Tylophora	*Tylophora barbata*	U	U
Bleeding Heart	*Omalanthus nutans*	U	U
Blue Grass Lilly	*Caesia vittata*	U	U
Blue Gum Hybrid	*Eucalyptus saligna/botryoides*	U	U
Bracken Fern	*Pteridium esculentum*	U	U
Breynia	*Breynia oblongifolia*	U	U
Cabbage Gum	*Eucalyptus amplifolia*	U	U
Cheese Tree	*Glochidion ferdinandii*	U	U
Climbing Guinea Flower	*Hibbertia scandens*		
Coast Banksia	*Banksia integrifolia*	U	U
Coastal Wattle	*Acacia longifolia*	U	U
Common Devils Twine	*Cassytha pubescens*	U	U
Common Milk Pod	*Parsonsia straminea*	U	U
Common Reed	*Phragmites australis*	U	U
Common Stinkweed	*Opercularia aspera*		
Creeping Brookweed	*Samolus repens*	U	U
Creeping Monkey Flower	*Mimulus repens*	U	U
Cunjevoi	*Alocasia brisbanensis*	U	U
Devil's Needles	*Solanum stelligerum*	U	U
Dusky Coral Pea	*Kennedia rubicunda*	U	U
Eastern Nightshade	*Solanum pungetium*	U	U
Fireweed	*Senecio glomeratus*	U	U
Five Leaf Water Vine	*Cissus hypoglauca*	U	U
Forest Red Gum	*Eucalyptus tereticornis*	U	U
Glycine	*Glycine tabacina*	U	U
Golden Mistletoe	*Notothixos subaureus*	U	U
Grass	*Paspalidium aversum*	U	U
Grey Ironbark	*Eucalyptus*	U	U

	paniculata		
Grey Mangrove	*Avicennia marina*	U	U
Grey Saltbush	*Atriplex cinerea*		
Hedgehog Grass	*Echinopogon ovatus*	U	U
Hill Fireweed	*Senecio hispidulus ssp. hispidulus*	U	U
Hop Goodenia	*Goodenia ovata*	U	U
Hop Wattle	*Acacia stricta*	U	U
Ivy Leaved Violet	*Viola hederacea ssp hederacea*	U	U
Kangaroo Apple	*Solanum aviculare*	U	U
Kidney Weed	*Dichondra repens*	U	U
Knobby Club-rush	*Isolepis nodosa*	U	U
Lesser Joyweed	*Alternanthera denticulata*	U	U
Meadow Rice Grass	*Microlaena stipoides*	U	U
Mistletoe	*Muellerina eucalyptoides*	U	U
Muttonwood	*Rapanea variablis*	U	U
Narrow-leaved Vetch	*Vicia augustifolia*	U	U
Native Cherry	*Exocarpos cupressiformis*	U	U
Native Geranium	*Geranium homeanum*	U	U
Native Sea-berry	*Einadia nutans*	U	U
New Zealand Spinach	*Tetragonia tetragonoides*	U	U
Northern Boobialla	*Myoporum acuminatum*	U	U
Oxalis	*Oxalis sp.*	U	U
Panic Grass	*Entolasia marginata*	U	U
Paroo Lily	*Dianella caerulea*	U	U
Pastel Flower	*Pseuderanthemum variabile*	U	U
Pennywort	*Hydrocotyle peduncularis*	U	U
Pigface	*Carpobrotus glaucescens*	U	U
Poison Peach	*Trema tomentosa v. viridis*	U	U
Pollia	*Pollia crispata*	U	U
Pratia	*Pratia pedunculata*	U	U
Prickley-leaved Paperbark	*Melaleuca styphelioides*	U	U
Purple Twining Pea	*Hardenbergia violacae*	U	U
Rat's Tail Orchid	*Dockrilia teretifolium Syn. Dendrobium teretifolium*	U	U
Samphire	*Sarcocornia*	U	U

	quinqueflora		
Saw Sedge	*Gahnia sieberiana*		
Scrambling Lily	*Geitonoplesium cymosum*	U	U
Scurvy Weed	*Commelina cyanea*	U	U
Sea Celery	*Apium prostratum var prostratum*	U	U
Sea Rush	*Juncus kraussii*	U	U
Sedge	*Cyperus polystachyus*	U	U
She-oak Mistletoe	*Amyema cambagei*	U	U
Shinning Sedge	*Cyperus laevigatus*	U	U
Slender Knotweed	*Persicaria decipiens*	U	U
Slender Sedge	*Baumea juncea*	U	U
Small-leaved Fig	*Ficus obliqua*	U	U
Snake Vine	*Stephania japonica v. discolour*	U	U
Snow in Summer	*Melaleuca linariifolia*	U	U
Spiny-headed Mat-rush	*Lomandra longifolia*	U	U
Spreading Nut-heads	*Epaltes australis*	U	U
Streaked Arrowgrass	*Triglochin striatum*	U	U
Swamp Dock	*Rumex brownii*	U	U
Swamp Lily	*Crinum pedunculatum*	U	U
Swamp Mahogany	*Eucalyptus robusta*	U	U
Swamp Oak	*Casuarina glauca*	U	U
Swamp Paperbark	*Melaleuca ericfolia*	U	U
Swamp Pennywort	*Centella asiatica*	U	U
Sweet Pittosporum	*Pittosporum undulatum*	U	U
Sydney Golden Wattle	*Acacia longifolia v. longifolia*	U	U
Sydney Golden Wattle	*Acacia longifolia v. sophorae*	U	U
Tall Sedge	*Carex appressa*	U	U
Triangular Seaberry	*Einadia hastata*	U	U
Tufted Hedgehog Grass	*Echinipogon caespitosus*	U	U
Warrigal Spinach	*Tetragonia tetragonioides*	U	U
Water Buttons	*Leptinella longipes*	U	U
White Cedar	*Melia azedarch*	U	U
Woollybutt	*Eucalyptus Longifolia*	U	U
Yellow Pittosporum	*Pittosporum revolutum*	U	U
Introduced Species			
African Olive	*Olea europaea ssp africans*	U	U

Arrow Head	*Syngonium sp.*	U	U
Asparagus	*Asparagus officinalis*	U	U
Asparagus Fern	*Protasparagus aeithiopicus*	U	U
Barnyard Grass	*Echinochloa crus-galli*	U	U
Bitou Bush	*Chrysanthemoides monilifera ssp. rotunda*	U	U
Black Passion Fruit	*Passiflora edulis*	U	U
Blackberry	*Rubus sp.*	U	U
Blackberry Nightshade	*Solanum nigrum*	U	U
Bladder Ketmia	*Hibiscus trionum*	U	U
Blue Butterfly Bush	*Psoralea pinnata*	U	U
Blue Passion Fruit	*Passiflora caerula*	U	U
Boneseed	*Chrysanthemoides monilifera ssp. monilifera*	U	U
Brazilian Nightshade	*Solanum seaforthianum*	U	U
Bridal Creeper	*Myrsiphyllum asparagoides*	U	U
Buffalo Grass	*Stenotaphrum secundatum*	U	U
Bushy Starwort	*Aster subulatus*	U	U
Busy Lizzy	*Impatiens sultanii*	U	U
Camphor Laurel	*Cinnamomum camphora*	U	U
Canary Island Date Palm	*Phoenix canariensis*	U	U
Cape Ivy	*Delairia odorata*	U	U
Cassava	*Manihot flabellifolia*	U	U
Cassia	*Senna pendula*	U	U
Castor Oil Plant	*Ricinus communis*	U	U
Cat's Ear	*Hypochaeris radicata*	U	U
Climbing Morning Glory	*Protoasparagus plumosus*	U	U
Coastal Morning Glory	*Ipomea cairica*	U	U
Cobblers Peg	*Bidens pilosa*	U	U
Common Sow-thistle	*Sonchus oleraceus*	U	U
Coastal Morning Glory	*Vicia sativa*	U	U
Coral Tree	*Erythrina x sykesii*	U	U
Crofton Weed	*Ageratina adenophora*	U	U
Curled Dock	*Rumex crispus*	U	U
Dandelion	*Taraxacum officinale*	U	U

Dune Onion Weed	*Araujia hortorum*	U	U
Fat-hen	*Chenopodium album*	U	U
Flea Bane	*Conyza sp.*	U	U
Greater Plantain	*Plantago major*	U	U
Honeysuckle	*Lonicera japonica*	U	U
Indian Cotton Bush	*Gomphocarpus fruiticosus*	U	U
Indian Shot	*Canna indica*	U	U
Ink Weed	*Phytolacea octrandra*	U	U
Jerusalem Cherry	*Solanum pseudocapsicum*	U	U
Kikuyu Grass	*Pennisetum clansdestinum*	U	U
Knotweed	*Persicaria capitata*	U	U
Kurnell Curse	*Hydrocotyle bonariensis*	U	U
Lantana	*Lantana camara*	U	U
Large Leaf Privet	*Ligustrum lucidum*		
Maderia Vine	*Anredera cordifolia*	U	U
Mickey Mouse Plant	*Ochna serrulata*	U	U
Mirror Bush	*Copromosa repens*	U	U
Moth Vine	*Araujia sericifolia*	U	U
Mulberry	*Morus sp.*	U	U
Native Tobacco	*Solanum mauritanium*	U	U
New Zealand Flax	*Phormium tenax*	U	U
New Zealand Pitosporum/Karo	*Pittosporum crassifolium*	U	U
Norfolk Is. Hibiscus	*Lagunaria patersonii*	U	U
Paddy's Lucerne	*Sida rhombifolia*	U	U
Pampas Grass	*Cortaderia selloana*	U	U
Panic Veldt Grass	*Ehrharta erecta*	U	U
Parramatta Grass	*Sporobolus africanus*	U	U
Paspalum	*Pasoalum dilatatum*	U	U
Peach Tree	*Prunus sp.*	U	U
Pennywort	*Hydrocotyle bonariensis*	U	U
Petty Spurge	*Euphorbia peplus*	U	U
Plantain	*Plantago lanceolata*	U	U
Prairie Grass	*Bromus cartharticus*	U	U
Prickly Pears	*Optunia species*	U	U
Purple Top	*Verbena bonariensis*	U	U
Rambling Dock	*Acetosa sagittata*	U	U
Red Flower Mallow	*Madiola caroliniana*	U	U
Sacred Bamboo	*Nandina domestica*	U	U
Silky Oak Grevillia	*Grevillia robusta*	U	U
Slender Celery	*Apium leptophyllum*	U	U

Small Leaf Privet	*Ligustrum sinense*	U	U
Sow Thistle	*Sonchus oleraceus*	U	U
Spear Thistle	*Cirsium vulgare*	U	U
Stinking Roger	*Tagetes minuta*	U	U
Summer Grass	*Digitaria sanguinalis*	U	U
Swedish Ivy	*Plectanthus australis*	U	U
Tall Fleabane	*Conyza albida*	U	U
Turkey Rhubarb	*Acetosa sagittata*	U	U
Wandering Jew	*Tradescantia albiflora*	U	U
Waterbuttons	*Cotula coronopifolia*	U	U
Whitetip Nightshade	*Solanum chenopodiodes*	U	U
Wild Aster	*Aster subulatus*	U	U
Wild Strawberry	*Duchnesea indica*	U	U

Common Name	**Scientific Name**	**Listing**	
		TSC Act 1995	**EPBC Act 1999**
Birds			
Australasian Bittern	*Botaurus poiciloptilus*	***V***	U
Australasian Grebe	*Tachybaptus novaehollandiae*	U	U
Australian Pelican	*Pelecanus conspicillatus*	U	U
Australian White Ibis	*Threskiornis molucca*	U	U
Azure Kingfisher	*Alcedo azurea*	U	U
Bar-tailed Godwit	*Limosa lapponica*	U	***M***
Black Bittern	*Ixobrychus flavicollis*	***V***	U
Black Fronted Plover	*Elseyornis melanops*	U	U
Black Swan	*Cygnus atratus*	U	U
Brolga	*Grus rubicunda*	***V***	U
Buff-banded Rail	*Gallirallus philippensis*	U	U
Caspian Tern	*Sterna caspia*	U	U
Cattle Egret	*Ardea ibis*	U	U
Chestnut Teal	*Anas castanea*	U	U
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	U	U
Common Greenshank	*Tringa nebularia*	U	U
Common Tern	*Sterna hirundo*	U	U
Crested Tern	*Sterna bergii*	U	U
Curlew Sandpiper	*Calidris ferruginea*	U	U
Double Banded Plover	*Charadrius bicinctus*	U	U
Dusky Moorhen	*Gallinula tenebrosa*	U	U
Eastern Curlew	*Numenius*	U	U

	madagascariensis		
Eurasian Coot	*Fulica atra*	U	U
Golden-headed Cisticola	*Cisticola exilis*	U	U
Great Cormorant	*Phalacrocorax carbo*	U	U
Great Egret	*Ardea alba*	U	U
Grey Teal	*Anas gracilis*	U	U
Kelp Gull	*Larus dominicanus*	U	U
Latham's Snipe	*Gallinago hardwickii*	U	U
Lewin's Rail	*Rallus pectoralis*	U	U
Little Black Cormorant	*Phalacrocorax sulcirostr*	U	U
Little Egret	*Egretta garzetta*	U	U
Little Grassbird	*Megalurus gramineus*	U	U
Little Pied Cormorant	*Phalacrocorax melanoleuc*	U	U
Masked Lapwing	*Vanellus miles*	U	U
Pacific Black Duck	*Anas superciliosa*	U	U
Pacific Gull	*Larus pacificus*	U	U
Purple Swamphen	*Porphyrio porphyrio*	U	U
Red-capped Plover	*Charadrius ruficapillus*	U	U
Royal Spoonbill	*Platalea regia*	U	U
Sacred Kingfisher	*Todiramphus sanctus*	U	U
Sharp Tailed Sandpiper	*Calidris acuminata*	U	U
Silver Gull	*Larus novaehollandiae*	U	U
Southern Emu-Wren	*Stipiturus malachurus*	U	U
Swamp Harrier	*Circus approximans*	U	U
Whistling Kite	*Haliastur sphenurus*	U	U
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	U	***M***
White-faced Heron	*Egretta novaehollandiae*	U	U
White-fronted Tern	*Sterna striata*	U	U
Yellow-billed Spoonbill	*Platalea flavipes*	U	U

Common Name	**Scientific Name**	***Status***	
		FM Act 1994	***EPBC Act 1999***
Flathead Gudgeon	*Philypnodon grandiceps*	U	U
Long-snouted Flounder	*Ammotretis rostratus*	U	U
Sand Whiting	*Sillago ciliata*	U	U
Sandy Sprat	*Hyperlophus*	U	U

	translucidus		
Sea Mullet	*Mugil cephalus*	U	U

APPENDIX D

Monitoring and Performance Indicators

8. MONITORING AND PERFORMANCE INDICATORS

8.1 Performance Indicator Selection

The effectiveness of management actions in achieving the adopted management objectives for the estuaries and the associated need for adaptive management of estuarine systems is underpinned by the appropriate selection of performance indicators. Measurements to assist with the evaluation of performance indicators are required within the context of an overall monitoring plan.

The development and use of estuarine and marine indicators for regional natural resource management monitoring is directed by two national documents:

- *National Framework for Natural Resource Management – Standards and Targets* (Natural Resource Management Ministerial Council, 2003); and
- *National Natural Resource Management Monitoring and Evaluation Framework* (Natural Resource Management Ministerial Council, 2003).

A wide variety of estuarine health indicators are reported in the literature (e.g. see discussion in Coates et al, 2002 and ANZECC, 2000b), and have been utilised for various purposes including the assessment of estuaries on a national scale as part of the *National Land and Water Resources Audit* (2002).

The performance indicators identified for assessing the effectiveness of the implemented management actions have been derived through consideration of the *Users Guide to Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring* (CRC for Coastal Zone and Waterway Management, 2004). The document identifies a framework for selecting indicators and the associated monitoring requirements.

Appropriate indicators have been selected based on the management objectives adopted by the Estuary Management Committee (See Section 7 of the *Estuary Management Study and Plan*, Cardno Lawson Treloar, 2005b).

8.2 Potential Performance Indicators

The *Users Guide to Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring* (CRC, 2004) provides an extensive range of potential indicators for inclusion in a natural resource management monitoring framework.

The indicators framework is designed to encourage the selection of indicators based upon regional situations. There are numerous indicators which can be utilised in estuary monitoring. The complete list outline by the CRC (2004) is detailed below:

- Algal Blooms
- Animal disease/lesions
- Animal Kills
- Animal or plant species abundance

- Animals killed or injured by litter (entanglement, starvation, suffocation)
- Benthic microalgae biomass (in intertidal sand/mudflat communities)
- Biomass or number per unit area, of epiphytes (in seagrass or mangrove communities)
- Biomass, or number per unit area, of macroalgae (in rocky shore, rocky reef or coral reef communities)
- Chlorophyll a
- Coral bleaching
- Death of marine mammals, endangered sharks and reptiles cause by boat strike, shark nets or drum lines
- Dissolved Oxygen (DO)
- Estuary mouth opening/closing
- Extent/distribution of key habitat types
- Extent/distribution of subtidal macroalgae
- Faecal Coliforms
- Occurrence of imposex
- Pest species (number, density, distribution)
- pH
- Presence/extent of litter
- Salinity
- Seagrass: depth range
- Sedimentation/erosion rates
- Total nutrients in sediments with dissolved nutrient in the sediments
- Total nutrients in the water column with dissolved nutrients in the water column
- Toxicants in biota
- Toxicants in sediment
- Turbidity/water clarity
- Water-current patterns
- Water soluble toxicants in the water column
- Water temperature.

This list has then been refined and added to through the review of the Management Objectives (listed above) and a consideration of the specific environmental stressors for the estuaries.

8.3 Current Monitoring Systems

Baseline data has been collected since November 2000 at 36 sites in the Wollongong LGA under the Wollongong Wide Water Quality Study (WWWQS). Sites relating to the study estuaries have been included in Figure 8.1. This program considers the following parameters:

- pH
- Salinity (ppt)
- DO (% Sat)
- Redox (mV)
- Conductivity (uS/cm)
- Temperature (ºC)
- Total Suspended Solids (mg/L)
- Faecal coliforms (cfu/100mL)
- Total Phosphorous (mg/L)
- Total Nitrogen (mg/L)
- TKN (mg/L)
- Ammonia (mg/L)
- Nitrate (mg/L)
- Copper (ug/L)
- Zinc (ug/L)
- Lead (ug/L)
- Manganese (ug/L)
- Arsenic (ug/L)
- Iron (ug/L).

8.4 Management Objectives and Monitoring Requirements

The following management objectives have been fundamental in the selection of estuarine performance indicators:

- Habitat and Species Conservation
- Water Quality
- Sediment and Erosion
- Sustainable Development
- Recreation
- Flooding
- Visual Amenity
- Estuary Entrance
- Information, Monitoring and Review

Table 8.1 details the issues associated with each objective and the performance indicators and monitoring requirements selected to assist in achieving management objectives. The proposed monitoring plan has been essentially divided into:

- Regular Monitoring, and
- Opportunistic Monitoring.

Table 8.1 Proposed Monitoring Plan Based on Management Objectives

Objective	Issues	Performance indicators and Monitoring Plan Specifications
Habitat and Species Conservation	• Degradation of existing pockets of valuable habitat. • Discontinuity of Habitats • Loss of native aquatic, wetland and foreshore species.	• An annual systematic photographic or satellite image analysis of each of the catchments to investigate any changes in vegetative cover, particularly riparian vegetation, that occurs within the catchments. Such an analysis would enable an assessment to be made of the efficacy of active riparian rehabilitation works and statutory mechanisms designed to protect riparian vegetation. • It would be costly and extremely time consuming to attempt to undertake habitat and species studies across the entire estuary. As such, a specific area or a discrete selection of areas within each estuary should be selected to appropriately represent the habitat and species types typically found within each estuary. Regular monitoring of these regions should be undertaken to assist in identifying any changes to species and habitat conditions. Sampling should include rapid biological assessment, species identification and counts and other habitat and species parameters. • As part of a Riparian Rehabilitation works the establishment of a standardised monitoring plot at selected rehabilitation sites at which details describing the species composition and structure of the vegetation is collated on an annual basis, including information concerning the pre-rehabilitation works vegetation condition. Standardised fauna surveys could also be carried out on a six monthly basis to collate information concerning the native fauna species utilising the subject areas and their response to changes induced by the rehabilitation works. The information collated from these selected monitoring sites would enable an evaluation to be made, over time, of the effectiveness of the rehabilitation works in enhancing the natural integrity of degraded riparian areas and their functional fauna habitat values. • Establish an Incident Register for each catchment for the recording of any of the following indicators "Algal Blooms, Animal Disease/Legions/Animal Kills or Injuries". These are most likely to be observed by the public rather than as part of a formal monitoring campaign. This register would need to be administered and promoted by the Council, as public reporting of such events is likely to be the most cost effective. Relevant information should be obtained from the person reporting the incident and when necessary it may be prudent for Council to establish protocols for verification inspections by relevant Council officers. An annual analysis of the data contained on the register should also be carried out. Over time the register will assist in monitoring and identifying the causal factors associated with any improvement/deterioration in the health of the estuary, or parts thereof, and the success or otherwise of management measures implemented. • A comparison of habitat and species sampling taken (see above) for both open and closed conditions will assist in determining the impacts of opening the lagoons on the ecological health of the estuaries.
Water Quality	• Water quality that does not protect and promote a healthy aquatic ecosystem. • Water quality that does not allow aesthetic enjoyment. • Water quality that does not allow for appropriate recreational use.	• Regular sampling of water quality parameters should be undertaken at the WWWQ sites, including additional sites and parameters suggested in Section 8.6. • Establish baseline conditions to compare performance against (localization of ANZECC (2000) guidelines. • Number of times water quality parameters exceed ANZECC (2000) guidelines for aquatic ecosystems. • Number of times water quality parameters exceed ANZECC (2000) guidelines for primary recreation use. • During sampling for water quality parameters, general notes should be made by the sampler to identify any surface scum, litter or other visual water quality issues. • Gross pollutant loads removed from GPTs or from estuaries on 'Clean up Australia Days' should be monitored when appropriate.
Sediment and Erosion	• Estuary sedimentation and erosion caused by the effects of human activity in the catchment. • Estuary sedimentation and erosion caused by the effects of human activity along stream banks.	• Determination of sediment composition and historical sedimentation rates (ANSTO currently undertaking study). • Turbidity and suspended solids monitoring can assist in monitoring the effects of sedimentation and erosion control works and policies. These parameters should be sampled at control works locations and in the regular sampling campaign carried out at existing and proposed WWWQ sites (Figure 8.1). • As a means of monitoring the impacts of bank works, it may be prudent to increase the priority of one bank rehabilitation work that is located near to an existing WWWQ site. This would enable the impacts of the works to be monitored against available baseline data, which would then enable reassessment of future bank works if necessary.
Cultural Heritage	• Indigenous and European heritage of the estuary and foreshore is largely unrecognised. • Degradation of Indigenous and European heritage of the estuary and foreshore.	• Database of non-indigenous heritage sites. • "Limited access" database of indigenous heritage sites • Databases should also include any loss or damage to sites. This could be monitored by a regular (annual) inspection of the sites by a nominated Council officer or heritage specialist.
Sustainable Development	• No sound mechanism in development process to recognise the finite capacity of the estuarine ecosystems. • Inappropriate past developments.	• Any improvement of estuarine health through the policies and practice of sustainable development can be monitored through the regular water quality sampling campaign at WWWQ sites, rapid biological assessment, and incident register and flora and fauna surveys. These parameters would be monitored as outlined above for the Habitat and Species Conservation and Water Quality Objectives. • Additional sampling of the above mentioned parameters could be undertaken at discrete sites to highlight the impacts of poor development practices or to monitor particular sustainable development practices implemented. • Inappropriate development should be recognised and reported through appropriate existing Council mechanisms (e.g. audits of compliance with consent conditions). This process should be reviewed to ensure it allows for public notification as with the above mentioned Incident Register, regular inspections on sites by Council officers and access by all appropriate divisions.
Recreation	• Limited facilities for appropriate recreational use of the estuary, foreshore and catchment • Recreational facilities often degrade ecosystem viability	• Additional WWWQ sites have been recommended in the Lagoon sections of the estuaries (Section 8.6). These areas are the most regularly used for recreation purposes. • Number of times water quality parameters exceed ANZECC (2000) guidelines for recreation use. • Algal sampling should be undertaken in popular recreation locations during the summer months. Appropriate notification measures (such as warning signs at access points) should then be implemented if guideline exceedence is recorded.
Flooding	• Flooding impacts on existing development. • Flood mitigation works often do not recognise ecosystem viability	• Automatic water level gauges are currently located in Fairy and Towradgi Estuaries, continued recording of this data will assist in assessing flood management options (see flood study). • Automatic water level gauges could also be installed at Hewitts and Tramway Creeks. • A trigger level should be set for each estuary (based on floor levels or some other flooding issue). During the annual review of water level data, the number of times the trigger level is exceeded should also be noted. • Number of properties flooded per event should be assessed against entrance management actions taken at the time of the event.
Visual Amenity	• Reduced natural integrity and visual experience of the landscape from the waterway and from catchment vantage points.	• The Committee agreed that the achievement of this objective is a lower priority area for management action. As such, no specific monitoring requirements have been set to monitor this objective. However, it is recognised that monitoring of performance indicators such as habitat extent and gross pollutants for other objectives will provide a method for monitoring the visual amenity of the estuaries.
Estuary Entrance	• Inappropriate opening regimes in terms of flooding. • Inappropriate opening regimes in terms of water quality. • Inappropriate opening regimes in terms of ecological concerns.	• The automatic water level recorders described above would be used with the automatic notification system for entrance opening. • Periodic surveys in open and closed conditions (immediately before and after entrance opening)
Information and Communications	• Regularly provide information to the public associated with the estuary	• Annual telephone survey of a random group would assist in monitoring the success of education campaigns and the community's knowledge and awareness of estuary processes and concerns. • Number of hits on performance indicator page of Council's website.

8.5 Possible Indicators and Monitoring Requirements

Table 8.2 lists the indicators identified from Table 8.1. The indicators were chosen based upon the resources available, the complexity of the indicator (in terms of data collection and data interpretation and analysis) and whether Wollongong City Council may already collect data for this indicator. Where indicators are additional to those already collected by WCC (at WWWQ sites) the first year of the implementation of the Plan will require establishing a baseline condition of each indicator. Once baseline data has been established subsequent years will involve comparing the indicators with the baseline condition to assess whether an improvement has been observed. It should be noted that some processes may not be reliably indicated with only one year of data and therefore some interpretation of the comparisons will be required.

Table 8.2 Possible Indicators and Performance (Alphabetically Ordered)

Indicator	Monitoring Requirements
Algal Blooms	Algal monitoring should be carried out during the summer months, in conjunction with the water quality monitoring campaign, near popular recreational sites. Additional samples should be taken during the monthly sampling at WWWQ sites following visual evidence of blooms. Sampling may be required following a report logged into the "Incident Register" (see Table 8.1 for details). **Performance:** Number of exceedences of 15,000 cells/mL annually.
Animal Disease/Lesions	Animal disease/lesions will most often be reported by the public through the "Incident Register". Monitoring may also be carried out, as necessary, at locations where environmental stressors are known/thought to be impacting on the animals present. **Performance:** Number of incidents per year.
Animal Kills	Animal kills will most often be reported by the public through the "Incident Register". Monitoring may also be carried out, as necessary, at locations where environmental stressors are known/thought to be impacting on the animals present. **Performance:** Number of incidents per year.
Animal or plant species abundance	Species abundance monitoring should be undertaken in a specified area which is considered representative of the estuary (this should be done

Indicator	Monitoring Requirements
abundance	for each estuary). The monitoring should be carried out monthly for an annual cycle to determine variability with a repeat of the process once every five years or at a rate to be determined depending on the outcomes of the first annual monitoring period. Where possible the monitoring should be undertaken at at least one fully open condition and one fully closed condition. The establishment of a standardised monitoring plot at selected rehabilitation sites at which details concerning the species composition and structure of the vegetation is collated on an annual basis, including information concerning the pre-rehabilitation works vegetation. Standardised fauna surveys could also be carried out on a six monthly basis to collate information concerning the native fauna species utilising the subject areas and their response to changes induced by the rehabilitation works. **Performance:** Change in composition of structure from baseline data and reference site.
Animals killed or injured by litter (entanglement, starvation, suffocation)	Animals killed or injured by litter will be reported by the public through the "Incident Register". In addition to this if any of such incidences are noted during Council sampling campaigns, these can also be included in the Database. **Performance:** Number of incidents per year.
Benthic microalgae biomass (in intertidal sand/mudflat communities)	Monitored within the specified 'representative' areas (as with Species Abundance Sampling), which can be intertidal. The monitoring should be carried out monthly for an annual cycle to determine temporal variability with a repeat of the process once every five years or at a rate to be determined depending on the outcomes of the first annual monitoring period. **Performance:** Change in biomass from baseline data and reference site.
Biomass or number per unit area, of epiphytes (in seagrass or mangrove communities)	Monitored at least once during both the summer and spring seasons every five years. Monitoring should be undertaken at known mangrove locations in Fairy Creek (Towradgi Arm). **Performance:** Change in biomass from baseline data and reference site.
Chlorophyll a	Monitored monthly at all WWWQ sites. **Performance:** Number of exceedences of localised guideline per year.
Dissolved Oxygen (DO)	Monitored monthly at all WWWQ sites (mid-depth of water column) **Performance:** Number of exceedences of localised guideline per year.
Estuary mouth	All estuary opening and closing should be recorded by visual inspection

Indicator	Monitoring Requirements
opening/closing	(to form part of the entrance management policy). The automatic water level gauges can be used to trigger a visual inspection of the entrance. **Performance:** Annual number of times entrance inspected, manually opened and annual number of resident complaints for nuisance flooding.
Extent/distribution of key habitat types	An annual systematic photographic or satellite image analysis of each of the catchments to investigate any changes in extent/distribution of key habitat and vegetation types that occurs within the catchments. **Performance:** Change in condition from baseline data.
Faecal Coliforms	Monitored monthly at all WWWQ sites. Faecal coliforms should also be monitored during/after known sewer overflow events. Sydney Water holds a register of both wet and dry overflow events which can be checked to trigger monitoring (see "Sewer Overflows" indicator). **Performance:** Number of exceedences of localised guideline per year.
Heavy Metals in the water column (Cu, Zn, Pb, Mn, As and Fe).	Monitored monthly at all WWWQ sites. **Performance:** Number of exceedences of localised guidelines per year.
Heavy Metals in sediments (Cu, Zn, Pb, Mn, As and Fe).	Three sites within Fairy Creek, two sites in Towradgi Creek, one site in Tramway Creek and one site in Hewitts Creek once every five years. **Performance:** Number of exceedences of localised guidelines per year.
pH	Monitored monthly at all WWWQ sites (mid-depth of water column). **Performance:** Number of exceedences of localised guidelines per year.
Load of Gross Pollutants Removed from Traps and on 'Clean up Australia Day'	As a minimum, this program should be run in conjunction with the annual Clean up Australia Day campaign. **Performance:** Change in Gross Pollutant load over time.
Properties flooded	After all flood events all overfloor and overground flooding should be recorded. Additional details such as depth and duration of flood should be included as available. **Performance:** N/A – used for interpretation of other data.
Salinity	Monitored monthly at all WWWQ sites. **Performance:** N/A – used for interpretation of other data.

Indicator	Monitoring Requirements
Sedimentation/erosion rates	Bed sediment composition and comparison with historical sedimentation rates evaluated by ANSTO.
Sewer Overflows	Transfer of Sydney Water records of dry and wet weather sewer overflows to a Council Database for comparison with water quality data. **Performance:** Number of overflows per year.
Total nutrients in sediments with dissolved nutrient in the sediments	Studies completed by DEC should be undertaken on a five yearly cycle. **Performance:** Change in baseline data.
Total nutrients in the water column with dissolved nutrients in the water column (TN, TKN NO_x, NH_4^+, TP and TRP)	Monitored monthly at all WWWQ sites and automatic sampling triggered by a wet weather event at at least one location in each catchment. **Performance:** Number of exceedences of localised guidelines per year.
Turbidity/water clarity	Monitored monthly at all WWWQ sites. Turbidity should be measured at the surface and bottom of the water column. **Performance:** Number of exceedences of localised guidelines per year and change in baseline data.
Water temperature	Monitored monthly at all WWWQ sites (at mid depth). **Performance:** Any significant variation from local baseline data. Generally used for the interpretation of other data.

Comments received during the public consultation period indicated that a number of the indicators listed above were considered to be unrealistic, for example, 'benthic microalgae biomass' and 'biomass or number per unit area, of epiphytes'. There are no available 'standard methods' for these indicators and they require a high level of technical expertise to analyse the samples (i.e. they are not currently being routinely analysed by laboratories). Comments also indicate that it is debatable that meaningful results would be obtained by considering these indicators. Consequently, they have been removed from the list transferred to the Estuary Management Plan (Cardno Lawson Treloar, 2005b).

Additionally, comments received during the public consultation period suggested that although the indicators listed may provide data to assess the long-term health and integrity of the estuaries, they are unlikely to provide an evaluation as to the effectiveness of implementation of individual management actions. In addition, it would be necessary to carry out pilot studies to assess the spatial and temporal variability of many of the indicators as the natural variability may be such that long term trends may not be detectable.

It should be noted that ANZECC (2000) makes reference to indicators of global processes of sea level and sea surface temperature. These have not been included specifically in the performance indicators for the Estuaries. It is recommended that consideration of the impacts of these processes be included on a periodic basis (once every 5 years). Reports on sea level change can be obtained from a range of groups (including the National Tidal Facility) and reports on sea surface temperature can be obtained from the CSIRO (Division of Marine Research).

This monitoring plan provides a framework and guidelines for a comprehensive and integrated biophysical monitoring program. The overall goal of the monitoring program is to assess the long-term health and integrity of the Estuaries, and the effectiveness of the implementation of the Estuary Management Plan initiatives. The program will collect and build upon monitoring efforts that are ongoing.

8.6 Additional Regularly Monitored Parameters and Sites

It is recommended that the WWWQ program continue in its current form at the identified sites (Figure 8.1) and be expanded to include the following sites (Figure 8.1) and additional parameters:

Additional sites (site locations shown in Figure 8.1):

- Towradgi Arm (mid-way)
- Fairy Lagoon – downstream of confluence with Towradgi Arm in the main estuary body (could relocate site WCC21 (Figure 8.1) rather than adding an additional site)
- Towradgi Lagoon – downstream of confluence with Parker Road Arm
- In the lagoon area of both Hewitts Creek and Tramway Creek.
- Automatic Water Level Gauges at Hewitts Creek footbridge (at entrance) and Tramway Creek sewer pipeline crossing.

Additional Parameters:

- Turbidity (NTU)
- DO (mg/L)
- Total reactive Phosphorous (mg/L)
- Algal samples to be taken during summer months at sites which are near recreational waters (four sites in main lagoon areas).

Faecal coliforms and Algal sampling could be directly linked to a Council public alert system of establishing signage at designated locations if sampling indicates unsafe levels.

It is recommended that an annual report card of these indices be developed for the each of the estuaries, which should ultimately link with Council's State of the

Environment Report. It is also recommended that Council form links with appropriate research groups to aid in the collection and analysis of data.

APPENDIX E

Seven Part Tests

(Prepared by Wollongong City Council)

Assessment of Significance for Towradgi Creek

Seven-part tests have been conducted for the biota listed below and no significant impact of a mechanical opening of the entrance is predicted for the occurrence of this biota in the Towradgi Lagoon area.

Threatened Ecological Communities:

- Swamp Sclerophyll Forest on Coastal Floodplains
- Swamp Oak Floodplain Forest
- Illawarra Lowlands Grassy Woodland
- Coastal Salt Marsh

Threatened Terrestrial Species

- Black Bittern
- Australasian Bittern
- Sooty Oystercatcher
- Swift Parrot
- Grey Headed Flying Fox
- Green and Golden Bell Frog

Threatened Aquatic Species

- Black Cod
- Australian Grayling

Protected Aquatic Species

- Sygnathids – 7-part test not required but has been completed.

Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions

Conservation Status: Endangered Ecological Community under the TSC Act (1995)

Occurrence in the Study Area

In the Illawarra, Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (SSFCF) includes Alluvial Swamp Mahogany Forest (vegetation map unit MU35) of NPWS (2002). This community consists of a low canopy of *Eucaplyptus robusta, E. botryoides, Casuarina glauca* and stands of *Melaleuca linariifolia*. The vine *Parsonsia straminea* streams down from the canopy above a thick ground cover of *Gahnia clarkei, Carex appressa* and *Phragmites australis*. In lower abundance are present the moist forest species consisting of *Synoum glandulosum, Glochidion ferdinandi, Ficus coronata and Pittosporum* spp. (NPWS, 2002). Its occurrence in the study area consists of a 2.31 ha area on both sides of Towradgi creek between Pioneer Road and the railway line to the west of the Pioneer Road. The EEC is surrounded on all sides by a large area of weeds and exotics which is mapped as MU56d (NPWS, 2002). Downstream stretches of the creek are surrounded by Illawarra Coastal Grassy Woodland (Map Unit MU23), another endangered ecological community (NPWS, 2002).

The next occurrence of the Alluvial Swamp Mahogany Forest to the south is a 0.43 ha at Wollongong Surf Leisure Resort; to the north, it is a 0.03 ha at Bellambi lagoon and further areas around Rothery Street in Bellambi. The community at Towradgi Creek of 2.31 ha makes up about 7% of 35.45 ha of this EEC in the Wollongong LGA.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising the Alluvial Swamp Mahogany Forest is individually listed as a threatened species in the Threatened Species Conservation Act (1995).

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising the Alluvial Swamp Mahogany Forest is listed as a threatened community in the Threatened Species Conservation Act (1995).

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

The mechanical works associated with entrance opening will be carried out about 800 m from the location of the Alluvial Swamp Mahogany Forest and therefore direct physical disturbance of the forest is unlikely. However, possible long term changes in the forest habitat as a result of frequent mechanical openings needs consideration.

Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions occur in soils which are usually waterlogged, stained black or dark grey with humus, and show little influence of saline ground water (DEC, 2004a). These conditions would be supported by prolonged closure of the lagoon entrance, enhancing the inundation of upstream areas with freshwater. Frequent entrance openings can drain freshwater out of these soils, reduce their humus content through oxidation, and allow saline water to migrate into them. Depending on the extent of these changes, there can be an alteration in the distribution of the swamp sclerophyll forest.

In the case of the swamp sclerophyll forest along Towradgi Creek, the above habitat changes are unlikely to be significant. Firstly, the entrance management policy recommends that the lagoon entrance should be opened only when the water level is 1.6 m AHD and when there is a possibility of a further increase in water level from impending rainfall. Under such wet weather conditions, soils in the flat coastal areas where these forests occur, are likely to remain saturated. In addition, saline water is unlikely to reach parts of the creek upstream of Pioneer Road as water quality monitoring by Wollongong City Council over a period of 6 years shows that this area is not saline, even on occasions when the entrance was open, whether naturally or mechanically (WCC, 2006).

Another reason why the SSFCF community is unlikely to be significantly affected is that when the entrance at Towradgi lagoon is breached, it normally remains open for less than a week, and usually only for a few days. Therefore, subsequent entrance closure will quickly restore the habitat to a condition which is prevalent under non-open conditions. Furthermore, in lagoons such as Towradgi which is an example of an Intermittently Closed and Open Lake or Lagoon (ICOLL), entrances can open naturally and the surrounding areas and habitats are likely to have adapted to the hydrological changes associated with lagoon opening. The assisted opening of the lagoon is to be carried out under conditions which closely mimic natural conditions and as such should not present a significant change from the situation under a natural opening.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Changes in the composition of the community can arise from natural events such as prolonged drought conditions or flooding. As soils become less waterlogged, SSFCF may be replaced by another EEC, the River-Flat Eucalypt Forest of Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions which is known to

occur in Wollongong. This community is characterised by a dominance of other eucalypt species such as *Eucalyptus tereticornis* (forest red gum) and *E. amplifolia* over *E. robusta.* And if soil salinity increases as a result of saline water intrusion, then SSFCF can be replaced by the EEC, the Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions (SOFF), which is characterised by a dominance of *Casuarina glauca* (swamp oak).

Mechanical opening of the lagoon is unlikely to cause significant changes in hydrological or salinity conditions over natural openings (for the reasons given in (i) above) and therefore it is highly unlikely that species change or distribution will arise on account of mechanical creek openings.

4. **In relation to the habitat of a threatened species, population or ecological community:**

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   The entrance works are proposed for an area which is 800 m away from the occurrence of the SSFCF and, as indicated above, there will be no direct disturbance of the habitat. However, long term impacts of any hydrological and/or salinity regime changes need to be considered. As outlined above, these effects are unlikely to be significantly different from those occurring under natural opening conditions. Therefore, changes as a result of mechanical opening are unlikely to be significant.

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   The SSFCF is surrounded by weeds and exotics and does not constitute an environmental corridor with other important vegetation stands. Therefore, isolation and fragmentation of habitats is unlikely even if there were significant modification of the SSFCF. However, no significant modification of the SSFCF habitat is predicted.

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

   There is unlikely to be any significant removal, modification, fragmentation or isolation of the SSFCF at Towradgi Creek as a result of the proposed action. This area of SSFCF makes up about 7% of the total area of this EEC in the Wollongong LGA (NPWS, 2002) and therefore constitutes a small proportion of the SSFCF in the locality. About a quarter of the total SSFCF in the Wollongong LGA is present in Council reserves where they are afforded a greater level of protection.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   Two of a number of threats identified for the survival of SSFCF are flood mitigation and drainage works, and management of water and tidal flows. As the entrance policy deals with the mechanical opening of the entrance as a flood mitigation measure, the action can be construed as being inconsistent with threat abatement. However, the policy recommends entrance opening under very strict criteria which simulate a natural opening and one of the policy's objectives is to deter the public from unauthorised openings. The policy also recommends that in the long term entrance, opening should be allowed to revert to the natural situation by adopting strategies such as floor raising and other interventions. In this respect, the proposal can be viewed as being consistent with the threat abatement.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   Although the proposed action constitutes actions which are relevant under the key threatening processes of flood mitigation and drainage works, and management of water and tidal flows, the implementation of these actions under conditions that mimic a natural opening would minimise the impact of the key threatening process.

Conclusion

The proposed action is unlikely to have a significant effect on the SSFCF in the Towradgi catchment.

Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

Conservation Status: Endangered Ecological Community under TSC Act (1995)

Occurrence in the Study Area

In the Wollongong LGA, Swamp Oak Floodplain Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions is mapped as the Coastal Swamp Oak Forest (vegetation map unit MU36) and as Estuarine Alluvial Wetland (map unit MU53) by NPWS (2002).

Coastal Swamp Oak Forest consists of dense stands of *Casuarina glauca* which is the only major tree in this community. The understorey consists of the rush *Phragmites australis* and the sedges *Juncus kraussii* and *J. australiensis*. Groundcovers are also present which consist of *Cynondon dactylon, Commelina cyanea, Samolus repens,* and *Alternanthera denticulata* (NPWS, 2002). In the study area, this community is present in two locations. The first, consisting of 0.17 ha, occurs on the south bank Towradgi lagoon, about midway between the entrance and Pioneer Road. This area is surrounded to the south and both sides by a large area of weeds and exotics, mapped as MU56d (NPWS, 2002). The second, a 2.07 ha community, is located along the northern end of the Parker Road arm of Towradgi Lagoon and west of the Corrimal Caravan Park. This area connects to the south with Estuarine Alluvial Wetland, and to the north with Coastal Grassy Wetland Forest (map unit MU23, which is also an EEC classified as the Illawarra Lowlands Grassy Wetland).

The next major occurrence of Coastal Swamp Oak Forest to the south is near the Wollongong Surf Leisure Resort along Pioneer Road and to the north at Bellambi Lagoon. The total area of this community in the Towradgi Creek area of 2.24 ha makes up less than 1% of the 241.35 ha of this EEC present in the Wollongong LGA (NPWS, 2002).

Estuarine Alluvial Wetland occurs on the fringes of permanent water bodies such as lagoons and drainage channels and it consists primarily of *Phragmites australis* and *Typha orientalis*. Other species can include *Rumex brownie, Carex appressa, Eleocharis sphacelata, Isolepis nodosa, Juncus kraussii, J. australiensis, Gahnia sieberiana* and *Cladium procerum*. The understorey shares many species with Coastal Swamp Oak Forest. Isolated small trees of *Casuarina glauca* and *Melaleuca styphelioides* can occur in drier margins of the community. This community is also present in two locations along Towradgi lagoon. The first is a 0.40 ha area along the south bank of the lagoon in the reserve behind Juanita Avenue. Further upstream, this site connects with Coastal Grassy Wetland Forest. The second location of 1.24 ha occurs on both sides of the Parker Road bridge.

The next major occurrence of Estuarine Alluvial Wetland to the south is in Puckey's Estate in the Fairy Lagoon catchment; and to the north it is at Bellambi lagoon. The total area of Estuarine Alluvial Wetland in Towradgi Creek of 1.64 ha makes up about 5% of this community in the Wollongong LGA.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising Coastal Swamp Oak Forest or Estuarine Alluvial Wetland is individually listed as a threatened species in the Threatened Species Conservation Act (1995).

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising the Coastal Swamp Oak Forest or Estuarine Alluvial Wetland is listed as a threatened community in the Threatened Species Conservation Act (1995).

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   The mechanical works associated with entrance opening will be carried out at least 300 m from the location of the nearest Coastal Swamp Oak Forest and Estuarine Alluvial Wetland and therefore direct physical disturbance of the communities is unlikely. However, possible changes in their habitats and the impact on the communities need to be considered.

   Coastal Swamp Oak Forest and Estuarine Alluvial Wetland occur in grey-black clay loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains (DEC, 2004b). These are conditions associated with parts of a waterway which are periodically inundated by saline water, and an entrance opening, whether through natural or mechanical means, would ensure that saline conditions are maintained. These communities are tolerant to a range of salinity conditions and the salinity changes that are likely to arise during a closed-open cycle are unlikely to have a significant effect on the extent of these communities. As mechanical opening mimics a natural opening that would occur with a lower sand berm, the impact of a mechanical opening is unlikely to be significantly different to that of a natural opening.

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Within a SOFF community, there is a great deal of variation in the community structure depending on soil water and salinity conditions. In drier and less saline conditions, *Casuarina glauca* is the dominant tree species and the ground stratum can comprise plants such as the forbs *Centella asiatica, Commelina cyanea*, *Persicaria decipiens* and *Viola banksii*; graminoids such as *Carex appressa, Gahnia clarkei, Lomandra longifolia, Oplismenus imbecillis*; and the fern *Hypolepsis muelleri*. Where the soils are more saline, the ground layer comprise more salt tolerant species such as *Alexfloydia repens, Baumea juncea, Juncus kraussii, Phragmites australis,* and *Selliera radicans*. In soils which are more periodically inundated, the structure of the community can change with *Casuarina glauca* giving way to predominance of scrubs and reeds. This variation in the community structure means that the community at Towradgi Creek will remain a SOFF, even if there were minor changes in the structure in response to changes in soil water and salinity conditions. However, these changes are unlikely given that the community is likely to have adapted to a history of entrance openings and closure.

4. **In relation to the habitat of a threatened species, population or ecological community:**

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   The entrance works are proposed for an area which is at least 300 m away from the nearest SOFF and, as indicated above, there will be no direct disturbance of the habitat. Hydrological and/or salinity regime changes in the habitat as a result of mechanical opening are unlikely to be significantly different from a natural opening and therefore the impact on the habitat is not likely to be significant.

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   No significant modification of the SOFF in the area is predicted and therefore the community is unlikely to become fragmented or isolated from other surrounding areas of habitats.

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

   There is unlikely to be any significant removal, modification, fragmentation or isolation of the SOFF at Towradgi as a result of the proposed action. In any case, the sub community of Coastal Swamp Oak Forest at Towradgi makes up less than about 1% of the total Coastal Swamp Oak Forest community in the Wollongong LGA (NPWS, 2002) of which about 20% is present in Council reserves. In the case of Estuarine Alluvial Wetland, the Towradgi community represents 5% of this community in the Wollongong LGA, of which 30% is present in Council reserves. Therefore the Towradgi community is not critical to the survival of these communities in the Wollongong LGA.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   One of the threats identified for the survival of SOFF is flood mitigation and drainage works. As the entrance policy deals with the mechanical opening of the entrance as a flood mitigation measure, the action can be seen to be inconsistent with threat abatement. However, the policy recommends entrance opening under very strict criteria which mimic natural conditions and one of its objectives is to deter the public from unauthorised openings. The policy also recommends that in the long term entrance opening should be allowed to revert to the natural situation by adopting strategies such as floor raising and other interventions. In this respect, the proposal can be viewed as being consistent with the threat abatement.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   Although the proposed action constitutes actions which are relevant under the key threatening process of flood mitigation and drainage works, the implementation of these actions under conditions that mimic a natural opening would minimise the impact of the key threatening process.

Conclusion

The proposed action is unlikely to have a significant effect on the SOFF in Towradgi Lagoon catchment.

Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion

Conservation Status in NSW: Endangered Ecological Community under TSC Act (1995)

Occurrence in the Study Area

In the Wollongong LGA, Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion (ILGW) is mapped as Coastal Grassy Red Gum Forest (map unit MU 23) and Lowland Woollybutt-Melaleuca Forest (map unit MU24) by NPWS (2002). However, only Coastal Grassy Red Gum Forest is present in the immediate surroundings of Towradgi Creeek.

Coastal Grassy Red Gum Forest consists of *Eucalyptus tereticornis* as the dominant species and this occurs in combination with *E. eugenioides, Angophora floribunda* and *E. bosistoana*. There is a dense ground cover of grasses and herbs, including *Dichondra repens, Desmodium varians, Microlaena stipoides* var. *stipoides, Oplismenus imbecillis, Commelina cyanea, Pratia purpurascens, Poa labillardieri* var. *labillardieri, Entolasia marginate, Themeda australis, Eragrostis leptostachya* and *Echinopogon ovatus* (DEC, 2005a).

This community is dominant alongside the creek between the Parker Road Arm and Pioneer Road, with the closest stand located at a distance of about 400 m from the entrance. It is also present in smaller areas at the north of the Parker Road Arm. The area that is habitat to this community around Towradgi Creek is 4.88 ha which represents less than 1% of this vegetation community in the Wollongong LGA.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising ILGW is individually listed as a threatened species in the Threatened Species Conservation Act (1995).

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising the ILGW is listed as a threatened community in the Threatened Species Conservation Act (1995).

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

The mechanical works associated with entrance opening will be carried out at least 400 m from the location of the nearest ILGW and therefore direct physical disturbance of the communities is unlikely. However, possible habitat changes and the impact on the community need to be considered.

In the Illawarra, ILGW occurs in close proximity to waterways as well as in areas that are further removed and are not adjacent to any waterway. This suggests that soil water and salinity does not have a major impact on its distribution and other soil factors are important. The distribution has been affected more by land clearing than any other factor and the community now occurs as scattered fragments through out the Wollongong LGA. This suggests that the opening of the entrances is unlikely to have a major impact on this community.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The composition of the ILGW is unlikely to be modified as a result of further entrance openings as the community is likely to have adapted to a history of entrance openings and closure

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The entrance works are proposed for an area which is at least 400 m away from the nearest ILGW and, as indicated above, there will be no direct disturbance of the habitat. Hydrological and/or salinity regime changes in the habitat as a result of mechanical opening are unlikely to be significantly different from a natural opening and therefore the impact on the habitat is unlikely to be significant.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

No significant modification of the ILGW in the area is predicted and therefore the community is unlikely to become fragmented or isolated from other surrounding areas of habitats.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is unlikely to be any significant removal, modification, fragmentation or isolation of the ILGW at Towradgi as a result of the proposed action. This community makes up

less than 1% of the ILGW community in the Wollongong LGA (NPWS, 2002). Therefore the Towradgi community is not critical to the survival of these communities in the Wollongong LGA.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   Not related to any of the threat abatement activities which are listed as land clearing; degradation and disturbance associated with heavy recreational use; frequent burning; selective logging; rubbish dumping; and weed invasion.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   Entrance opening does not represent a key threatening process for the Illawarra Lowlands Grassy Woodlands community.

Conclusion

The proposed action is unlikely to have a significant effect on the ILGW community in the Towradgi catchment.

Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions

Conservation Status in NSW: Endangered Ecological Community under TSC Act (1995)

Occurrence in the Study Area

A coastal saltmarsh community is present in the Towradgi Lagoon area. This community is present along the landward bank of the Parker Road Arm, downstream of the bridge along Parker Road. The community is dominated by *Sporobolus virginicus,* with *Sarcoconia quinqueflora, Phragmites australis, Samolus repens* and *Zoysia macrantha* present in lower densities. The saltmarsh community in this location is about 0.10 ha and makes up less than 1% of the 48 ha that occurs in the Wollongong LGA

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising Coastal Saltmarsh EEC in Towradgi Lagoon is individually listed as a threatened species in the Threatened Species Conservation Act (1995).

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   None of the species comprising the Coastal Saltmarsh EEC is listed as a threatened population in the Threatened Species Conservation Act (1995).

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   The mechanical works associated with entrance opening will be carried out at least 200 m from the location of the Coastal Saltmarsh and therefore direct physical disturbance of the community is unlikely. However, possible habitat changes as a result of the opening and its impact on the Coastal Saltmarsh community needs to be considered.

Coastal Saltmarsh occurs in the intertidal zone on the shores of estuaries and lagoons including when they are intermittently closed. Therefore the maintenance of an appropriate salinity regime is important for their survival. Entrance opening has the potential to alter this regime and the impact is considered under Part 4 (i).

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

There can be wide variation in the composition of a Coastal Saltmarsh community depending on the salinity regime. Therefore changes in the composition can occur without placing the community at risk of extinction. Mechanical opening of the entrance is not likely to substantially alter the salinity or flooding regimes from what is experienced under natural openings, therefore composition changes are unlikely.

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The saltmarsh is present in an area which under a natural opening and closing regime can vary in its salinity levels and be submerged or exposed depending on the water level in the lagoon. However, as water level rises in response to catchment runoff which is primarily non-saline in nature, prolonged closure can cause salinity levels in the salt marsh area to decrease below its tolerance level. This could have an adverse effect on the salt marsh. Mechanically opening the entrance to decrease water levels and allowing tidal inundation therefore represents a situation that assists in maintaining a suitable salinity regime for the salt marsh. Mechanical opening could therefore be beneficial rather than detrimental for the community.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

No other significant stands of salt marsh are present in the area and therefore the issue of isolation or fragmentation from other areas is not relevant.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is unlikely to be any significant removal, modification, fragmentation or isolation of the salt marsh at Towradgi as a result of the proposed action. The community makes up less than 1% of this community in the Wollongong LGA (NPWS, 2002). Therefore the Towradgi community is not critical to the survival of this community in the Wollongong LGA.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   Restoration of the natural hydrological regime by removing barriers to tidal flow is one of the threat abatement plans for coastal salt marsh. Mechanically opening the lagoon at conditions under which the lagoon would normally open naturally can be seen as an action that is removing a barrier to tidal flow. In that sense, the mechanical opening is consistent with the actions of a recovery plan.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   Not part of a key threatening process which includes infilling, modified tidal flow, weed invasion, damage by domestic and feral animals, human disturbance, altered fire regimes and climate change.

Conclusion

The proposed action is unlikely to have a significant effect on the Coastal Saltmaesh community in the Towradgi lagoon catchment.

Terrestrial Fauna:	**Australasian Bittern** (*Botaurus poiciloptilus*) **Black Bittern** (*Ixobrychus flavicollis*)

Conservation Status in NSW: The Australian Bittern and the Black Bittern are listed as vulnerable species under Schedule 2 of the TSC (1995).

Occurrence in Study Area

The Review of Environmental Factors suggests that the potential for occurrence of the Australasian Bittern, the Black Bittern is high as these species have been sighted in the area and suitable habitats for these species also occur in the area.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Australian Bittern and the Black Bittern inhabit wetlands which have a dense vegetation stand of sedges, rushes and reeds and such a habitat is present around the lower reaches of Towradgi Lagoon. These species are reported to build their nest within the dense vegetation over shallow water or on a branch overhanging water (Marchant and Higgins, 1990). The proposed action of opening the lagoon entrance will not directly interfere with the nesting habitat as the entrance works are to be conducted in the sand dune area away from the wetlands. On the contrary, entrance opening can allay risk of flooding of any nests that may be present from rising waters. The action is therefore not likely to have an adverse effect on the life cycle of this species.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Australian Bittern or the Black Bittern does not constitute an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The Australian Bittern or the Black Bittern does not constitute an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   The proposed action will not result in significant modification or removal of the wetland which the Australian Bittern can potentially inhabit as the entrance works will be carried out under conditions which closely resemble a natural opening and to which the local habitats are likely to have adapted from a history of entrance openings, both natural and mechanical.

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   Wetlands along Towradgi lagoon are already present in fragments and the issue of fragmentation or isolation is not relevant. However, it is unlikely that these fragments will be further fragmented or isolated as a result of the mechanical opening of the entrance.

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

   There is little likelihood for the relevant wetlands to be removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   The proposed action is not specifically mentioned in management plans for protection of the species although development of appropriate guidelines for wetland management is. The development of an entrance management policy could be viewed as a management strategy to protect the lagoon environment including the wetlands against adverse impacts of unauthorised openings of the entrance. In that sense, the proposed action is consistent with threat abatement plans.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

The key threatening process relevant to the proposed action is alteration of flooding regimes as a result of the regulation of waterways, thereby reducing the suitability and availability of wetlands. However, the wetlands in the area are likely to have adapted to the changed hydrological conditions as there has been a history of the lagoon being opened under these conditions.

Conclusion

The proposed action is unlikely to have a significant effect on the potential occurrence of the Australian Bittern or the Black Bittern in the study area.

Terrestrial Fauna: Sooty Oystercatcher (*Haematopus fuliginosus*)

Conservation Status in NSW: Listed as a vulnerable species under Schedule 2 of the TSC Act (1995).

Occurrence in the Study Area

The Sooty Oystercatcher is known to be common in the Wollongong area and there is a medium potential for it to be present in the study area.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Sooty Oystercatcher usually inhabits rocky headlands, shelves and exposed reefs and may occasionally also forage amongst rocky pools, beaches and muddy estuaries at low tide. The species breeds in spring and summer, mostly on offshore islands and occasionally on isolated promontories (DEC, 2005d). The species has been sighted in the Wollongong area and there is a medium probability that it could be present in the study area. It is unlikely that the proposed action will interfere with the breeding cycle of the species as the shore area in Towradgi is a popular beach area and is widely used and is unlikely to be a foraging site. There is small chance, however, that the scouring of the sand dunes that follow an entrance breach could temporarily remove a potential foraging site. However, it is unlikely that the impact of this would be sufficiently significant or long lasting to place the Sooty Oystercatcher at the risk of extinction.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Sooty Oystercatcher does not represent an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   The Sooty Oystercatcher does not represent an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   The proposed action will not result in significant modification of the intertidal foreshore area that the Sooty Oystercatcher can potentially forage in since the sand deposition rapidly restores the intertidal environment.

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   Entrance opening is not likely to fragment or isolate any potential foraging habitat from other surrounding foraging habitats.

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

   There is little likelihood for the foraging habitats to be permanently removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   One of the recommended actions for the protection of this species is the management of estuaries and the surrounding landscape to ensure the natural hydrological regimes are maintained. The proposed action is consistent with this management action as it proposes to open the entrance under conditions which closely resemble a natural opening.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   One of the key threatening processes for this species is hydrological changes to estuaries causing modification or removal of important areas of suitable habitat. The proposed action is relevant to this threatening process only in the sense that it will cause a temporary change in the hydrological regime. As this is not a permanent change, the action is not likely to cause a significant impact

Conclusion

The proposed action is unlikely to have a significant effect on the potential occurrence of the Sooty Oystercatcher in the study area.

Terrestrial Fauna: Swift Parrot (*Lathamus discolor*)

Conservation Status: Listed as endangered under both the TSC Act (1995) and the EPBC Act (1999)

Occurrence in the Study Area

Swift Parrots have been sighted in the study area and there is a medium potential for the species to be present in the study area at Towradgi.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Swift Parrot breeds in Tasmania during spring and summer, migrating in autumn and winter to south-eastern Australia where they feed on trees such as Eucalyptus which are flowering profusely or are infested by lerp (DEC, 2005c). Swift Parrots have been recorded in the Wollongong area and there is some likelihood that they could be attracted to the study area. The proposed opening of the lagoon entrance will not directly interfere with the foraging habitats of this species as the entrance works are to be conducted in the sand dune area away from tree habitats. In addition, no significant change in the tree habitats is likely to occur from the entrance opening. The action is therefore not likely to have an adverse effect on the life cycle of this species.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Swift Parrot does not constitute an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   The Swift Parrot does not constitute an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action will not result in significant modification or removal of the tree habitats which the Swift Parrot can potentially inhabit as the entrance works will be carried out under conditions which closely resemble a natural opening and to which the local habitats are likely to have adapted over a history of such openings.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Tree habitats along Towradgi lagoon are already present in fragments and the issue of fragmentation or isolation is not critical. However, it is unlikely that these fragments will be further fragmented or isolated as a result of the mechanical opening of the entrance as no significant on these communities is predicted.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is little likelihood for the relevant tree habitats to be removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   The proposed action is not specifically mentioned in management plans for protection of the species although protection of winter flowering tree species is. The development and implementation of an entrance management policy could be viewed as a management strategy to protect the lagoon environment, including the winter flowering trees, against adverse impacts of unauthorised openings of the entrance. In that sense, the proposed action is consistent with the objectives of a threat abatement plan.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   The proposed action is not part of a key threatening process for this species.

Conclusion

The proposed action is unlikely to have a significant effect on any potential occurrence of the Swift Parrot in the study area.

Terrestrial Fauna: Grey Headed Flying Fox (*Pteropus poliocephalus*)

Conservation Status in NSW: Listed as a vulnerable species under the TSC Act (1995) and the EPBC Act (1999)

Occurrence in Study Area

The Grey headed Flying Fox is believed to be common in the study area and suitable habitats are known to be present near Brandon Park and the Campus East sites.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Grey Headed Flying Fox can inhabit a wide range of habitats including tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and fruit crops (DEC, 2005b). This species, which is believed to be common in the study area, generally roosts within 20 km of a food source and in dense vegetation canopies. They can also feed on the nectar and pollen of native tress, in particular Eucalyptus, Melaleuca and Banksia. The proposed opening of the lagoon entrance will not directly interfere with the roosting or foraging habitats of this species as the entrance works are to be conducted in the sand dune area away from tree habitats. In addition, no significant change in the tree habitats is likely to occur from the entrance opening. The action is therefore not likely to have an adverse effect on the life cycle of this species.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Grey Headed Flying Fox does not constitute an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   The Grey Headed Flying Fox does not constitute an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action will not result in significant modification or removal of the tree habitats which the Grey Headed Flying Fox can inhabit as the entrance works will be carried out under conditions which closely resemble a natural opening and to which the habitats are likely to have adapted with a history of such openings over the years.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Tree habitats along Towradgi lagoon are already present in fragments and the issue of fragmentation or isolation is not critical. However, it is unlikely that these stands will be further fragmented or isolated as a result of the mechanical opening of the entrance as no significant impact on these communities has been predicted.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is little likelihood for the relevant tree habitats to be removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   The proposed action is not specifically mentioned in management plans for protection of the species although identification and protection of foraging and roosting sites are. The development and implementation of an entrance management policy could be viewed as a management strategy to protect the lagoon environment including the tree habitats against adverse impacts of unauthorised openings of the entrance. In that sense, the proposed action is consistent with the objectives of a threat abatement plan.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   The proposed action is not part of a key threatening process for this species.

Conclusion

The proposed action is unlikely to have a significant effect on the occurrence of the Grey Headed Flying Fox in the study area.

Terrestrial Fauna: Green and Golden Bell Frog (*Litoria aurea*)

Conservation Status: Listed as an endangered species under the TSC Act (1995) and vulnerable under the EPBC Act (1999)

Occurrence in the Study Area

There are historical records for the presence of the Green and Golden Bell Frog in the Towradgi Creek area although the exact location where it was present is not known. The species has not been sighted in the Towradgi Creek catchment in recent years, with the only surviving population in Northern Illawarra being at Woonona in the Bellambi Gully catchment (Ross Wellington, pers. comm.).

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Green and Golden Bell Frog inhabits water bodies such as marshes, dams and stream sides, particularly those which contain bulrushes *Typha* spp. or spikerushes *Eleocharis* spp. The potential for its occurrence is higher in water bodies which are unshaded, free from the predatory fish *Gambusia holbrooki*, have a grassy area nearby and have diurnal sheltering sites such as vegetation or rocks. It is also known to be present in areas which are highly disturbed such as disused industrial sites, brick pits, landfill areas and even cleared land (DEC, 1999). Salinity appears to be an important factor controlling its breeding habitat, as tadpoles of this species do not appear to tolerate salinity values higher than 10 ppt (Pyke and White, 2001). The salinity in the lower reaches of Towradgi Lagoon is hardly ever lower than this value (WCC, 2006) and therefore these parts of the lagoon are unlikely to be breeding sites for the species. In the upper fresher water reaches of the creek, there is a high likelihood of the predatory fish *Gambusia* to be present as this fish has been recorded in a number of other surrounding wetlands (Chafer, 1997). These observations suggest that the potential for the occurrence of the Green and Golden Bell Frog in the Towradgi Lagoon is very low. Nevertheless, the significance of the proposed works on any potential occurrence of the species in the Towradgi Lagoon area must be considered. The proposed opening of the lagoon entrance will not directly interfere with those parts of the wetlands where the species can potentially be present, as the entrance works are to be conducted in the sand dune area away from these habitats. However, frequent water level fluctuations arising from entrance opening could potentially affect the extent and composition of the wetlands. This is however unlikely given that the mechanical opening is to be conducted under conditions similar to a natural opening and the surrounding wetlands are likely to have adapted to a history of entrance openings under similar conditions.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered**

population such that a viable local population of the species is likely to be placed at risk of extinction,

The Green and Golden Bell Frog does not represent an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   The Green and Golden Bell Frog does not represent an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   The proposed action will not result in significant modification or removal of the wetland habitats which the Green and Golden Bell Frog can potentially inhabit as the entrance works will be carried out under conditions which closely resemble a natural opening and to which the habitats are likely to have adapted over a history of such openings.

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   Wetlands along Towradgi Lagoon are already present in fragments and the issue of further fragmentation or isolation is not critical. However, it is unlikely that the wetlands will be further fragmented or isolated as a result of the mechanical opening as no significant impact on these communities has been predicted.

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

   There is little likelihood for the wetlands to be removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   The proposed action is not specifically mentioned in management plans for protection of the species, although development of catchment management approaches to improving stormwater quality and habitat retention and management are. The development of an entrance management policy could be viewed as a management strategy to protect the lagoon environment, including the wetlands, against adverse impacts of unauthorised openings of the entrance. In that sense, the proposed action is consistent with threat abatement plans.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   The key threatening process relevant to the proposed action is alteration of drainage patterns and stormwater runoffs, and changes to water quality. However, the wetlands in the area are likely to have adapted to the changed hydrological conditions as there has been a history of the lagoon being opened under these conditions.

Conclusion

The proposed action is unlikely to have a significant effect on any potential occurrence of the Green and Golden Bell Frog in the study area.

Aquatic Fauna: Black Cod (*Epinephelus daemelii*)

Conservation Status in NSW: Listed as a vulnerable species under the Fisheries Management Act (1994).

Occurrence in Study Area

The occurrence of Black Cod in the study area has not been reported but suitability of habitats in the area needs to be investigated.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Black cod are a large, reef-dwelling, carnivorous grouper species but their juveniles can often be found in coastal rock pools, and around rocky shores in estuaries (DEC, 2005e). The likelihood of their occurrence in the Towradgi lagoon is very low, firstly because there are no rocky enclaves within or just outside the lagoon and secondly, the lagoon is more often closed than open and therefore there is limited opportunity for the juveniles to migrate into the lagoon. Should they have migrated during a previous opening, a subsequent opening should provide an opportunity for the larger juveniles to migrate back to sea or allow young juveniles to enter the lagoon. The proposed action is therefore unlikely to have an adverse effect on the life cycle of the species.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Black cod does not represent an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   The Black Cod does not represent an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The estuarine habitat around Towradgi lagoon that juveniles of the Black Cod can potentially inhabit is unlikely to be significantly impacted as the mechanical opening is a simulation of a natural opening to which the habitat is accustomed.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Entrance opening is not likely to fragment or isolate any potential nursery habitats from other surrounding nursery habitats.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is little likelihood for the nursery habitats to be removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Lagoon.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   One of the recommended actions for the protection of this species is conserving and promoting the restoration of estuarine nursery habitats. The proposed action is consistent with this management action as it proposes to open the entrance under conditions which closely resemble a natural opening so that adverse effects on the estuarine ecology are avoided.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   One of the key threatening processes for this species is the loss or degradation of estuarine nursery habitats. The proposed action will be conducted under conditions that closely resemble a natural opening therefore its impact on any potential nursery habitats would be minimal.

Conclusion

The proposed action is unlikely to have a significant effect on any potential occurrences of the Black Cod in the study area.

Aquatic Fauna: Australian Grayling (*Prototroctes maraena*)

Conservation Status in NSW: Listed as a protected species by the NSW Department of Primary Industries (Fisheries); vulnerable under the EPBC Act (1999)

Occurrence in the Study Area

The Australian Grayling has not been reported in the study area but the suitability of habitats in the study area needs to be investigated.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Australian Grayling inhabits freshwater streams and rivers on the eastern and southern flanks of the Great Dividing Range from Sydney southwards to the Otway ranges in Victoria. The species prefer clear gravely streams with moderate flow (DPI, 2006a) so their occurrence in the freshwater sections of the Towradgi Creek is unlikely given that there are no suitable habitats within these reaches. The juveniles of the species need to migrate to the sea to complete their life cycle and given that Towradgi lagoon is closed more often than open, it is unlikely that the Australian Grayling is a common inhabitant of this environment. Therefore the proposed action is unlikely to have adverse effect on the life cycle of this species.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   The Australian Grayling does not represent an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   The Australian Grayling does not represent an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The estuarine habitat around Towradgi lagoon is unlikely to be a suitable potential habitat for the Australian Grayling and, as the mechanical opening is a simulation of an opening under natural conditions, there is unlikely to be any significant modification of a habitat, should these be present.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Entrance opening is not likely to fragment or isolate any potential habitats from other surrounding potential habitats.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is little likelihood for any potential habitats to be removed, modified, fragmented or isolated as a result of the mechanical opening.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Lagoon area.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   The proposed action is not directly related to any of the conservation actions underway for this species.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   The proposed action does not constitute or is part of a key threatening process.

Conclusion

The proposed action is unlikely to have a significant effect on any potential occurrences of the Australian Grayling in the study area.

Aquatic Fauna: Syngnathiformes

Conservation Status in NSW: All species within Syngnathiformes are protected under the NSW Fisheries Management Act (1994).

Occurrence in the Study Area

Syngnathiformes can be present in a wide range of habitats and there is a strong possibility they could be present in the study area.

Seven-Part Test

1. **In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**,

   Syngnathiformes includes seahorses, seadragons, pipefish, pipehorses, ghostpipefish and seamoths. They are in high demand for traditional Chinese medicines and for tourism and ornamental purposes. These creatures can occur in a range of habitats ranging from deep reefs to coastal algae, weed and seagrass habitats, or around man made structures such as jetties or mesh nets (DPI, 2006b), and so they are likely to occur in parts of Towradgi lagoon where such habitats are present. However, the habitats in the study area are not likely to be crucial for the survival of the species in the locality. The proposed action is therefore unlikely to be a significant threat to the survival of the species in the Wollongong locality.

2. **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction**,

   Syngnathiformes do not represent an endangered population in the study area.

3. **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   Syngnathiformes do not represent an endangered ecological community in the study area.

4. **In relation to the habitat of a threatened species, population or ecological community:**

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

As the mechanical opening is a simulation of an opening under natural conditions, there is unlikely to be any significant and permanent modification of any suitable habitats for Syngnathiformes that may be present in the Towradgi Lagoon area.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Entrance opening is not likely to fragment or isolate any potential habitats from other surrounding potential habitats.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

There is little likelihood for any potential habitats to be removed, modified, fragmented or isolated as a result of the mechanical opening. Many other suitable habitats are present in the locality.

5. **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**,

   No critical habitats are present in the Towradgi Creek catchment.

6. **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**,

   The proposed action is not directly related to any of the conservation actions underway for this species.

7. **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process**

   The proposed action does not constitute or is part of a key threatening process for this species.

Conclusion

The proposed action is unlikely to have a significant effect on any potential occurrences of Syngnathiformes in the study area.

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