Dee Why Lagoon Estuary Management Plan




Report Prepared For
Warringah Council
Report J2014/Rep2061/Version 3
March, 2004

Lawson and Treloar Pty Ltd
Level 2
27 Merriwa Street
Gordon NSW 2072
Australia

Telephone: 61 2 9499 3000
Facsimile: 61 2 9499 3033
Email: nsw@lat.com.au

A.B.N. 55 001 882 873
A.C.N. 001 882 873

REPORT STATUS

Version	Date	Status	Prepared by:	Reviewed by:	Approved by:
1	21 May 2003	Draft	LCH	PDT	PDT
2	24 October 2003	Final Draft	LCH	PDT	PDT
3	3 March 2004	Final	LCH	NVL	NVL

It is the responsibility of the reader to verify the currency of the version number of this report. All subsequent releases will be made directly to the Client.

REPORT COPY NUMBER: .....

COVER IMAGES (Clockwise from top left corner):
1 - Looking south-west at Lagoon from entrance after breakout
2 - Former tank trap at south-east corner of Lagoon
3 - Walking track around eastern boundary after unauthorised fire
4 - Walking track barrier/advice when Lagoon level was high

EXECUTIVE SUMMARY

Introduction

Dee Why Lagoon is an intermittently closed and open lake or lagoon (ICOLL). When closed, the lagoon covers an area of approximately 30 ha, has a maximum depth of the order of 1.5 m and has a beach berm with a managed level of 2.2 mAHD.

The lagoon itself has been described as a saline coastal lake with a seaward boundary of a coastal dune system (forming part of a barrier between Dee Why Beach and the Lagoon) which intermittently opens to the ocean. This occurs either as a result of heavy rain or by artificial means (authorised or unauthorised).

Open Entrance immediately after an Artificial Breakout

The Lagoon and a portion of its riparian area make up the 'Dee Why Lagoon Wildlife Refuge', which is bordered by Dee Why Beach to the east and Pittwater Road to the west. Warringah Council has designated the Wildlife Refuge as a 'Significant Area' (Warringah Council, 2000).

Beyond the Wildlife Refuge the lagoon is surrounded by highly urbanised land including the suburbs of Collaroy to the north, Dee Why to the south and Cromer to the west. Most of the land use in these areas is residential with some industrial development in the north-western parts of the catchment. The Dee Why Creek corridor is a key area of open space within the catchment.

Dee Why Creek and Corridor (During a regular wet weather event)

Vision

The following vision for Dee Why Lagoon has been defined by the Dee Why/Curl Curl Joint Estuary/Floodplain Management Committee:

"To provide a Lagoon and Wildlife Refuge that is suitable for a diverse range of endemic native flora and fauna species and which is protected and conserved according to the principles of Total Catchment Management by a process whereby the community works with Council to preserve and enjoy the Lagoon's natural environment and resources".

View from Inflow Point of Dee Why Main Drain to the Lagoon

The achievement of this Vision is ultimately the objective that this Plan serves to achieve.

It should be noted that this Vision is complementary to the one adopted for the Lagoon Wildlife Refuge (Warringah Council, 2002) which states that:

"The Vision for Dee Why Lagoon Wildlife Refuge is to preserve the natural appearance

of the Lagoon edge and its original natural perimeter and to:

- Conserve a significant natural area supporting a diversity of native aquatic and terrestrial flora and fauna
- Provide a range of low key, predominately passive, recreational and educational opportunities that are complementary to the Refuge's natural heritage values".

Lagoon Management Framework

The management of the Lagoon is undertaken primarily by Warringah Council with assistance from various stakeholder organisations including the Department of Infrastructure, Planning and Natural Resources.

The management plan process for the Lagoon is that set out in the NSW Estuary Management Manual (1992):

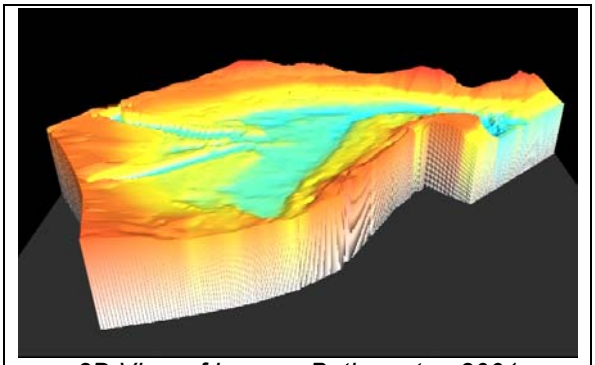
- form an estuary management committee;
- assemble existing data (data compilation study);
- undertake an estuary processes study;
- undertake an estuary management study;
- prepare a draft estuary management plan;
- public review of the draft plan;
- adopt and implement the estuary management plan; and
- monitor and review.

Council formed the joint Dee Why/Curl Curl Joint Estuary/Floodplain Management Committee for this study in 1994. The second stage of the estuary management process for Dee Why Lagoon was completed in 1997 (MHL, 1997). The third stage, the Estuary Processes Study, was completed in 2001 (AWT, 2001). The fourth stage, the Estuary Management Study, was completed in 2004 (Lawson and Treloar, 2004). Stages five and six saw the Draft Plan prepared and publicly exhibited in November 2003 and this plan for adoption represents the seventh stage of the process. It is expected the implementation of the Plan will occur over the next five years with a review period following this.

An overview of the findings of the various studies leading to the preparation of this draft plan is provided below. The plan has also been prepared within the framework of the Sydney Metro Catchment Management Authority 'Catchment Blueprint' (2002).

Lagoon Processes

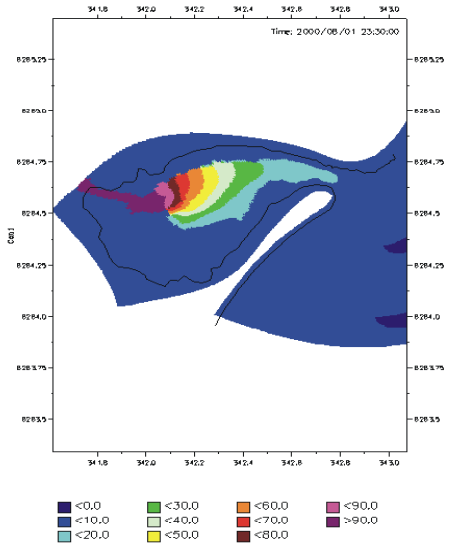
Dee Why Lagoon is a complex system with a significant number of interacting processes that are dependent on a number of factors, including: the state of the entrance; season; activities in the catchment; and past management actions. A detailed processes study has been completed for the Lagoon (AWT, 2001).



3D View of Lagoon Bathymetry, 2001 (Tributary channel bathymetry assumed)

The processes and functioning of an estuary require an understanding of the time scale over which each process occurs. For example, sedimentation rates need to be considered over a range of scales from recent geological time (of the order of thousands of years before present), through pre and post European settlement history (last 200 years), to the changes resulting from seasonal inflows of water and sediments from the catchment. Alternatively, from a biological perspective, the time scale of changes can range from decades through to daily fluctuations.

The intermittent opening of the Lagoon results in an ecosystem that, depending on the frequency of opening, may vary considerably between a more freshwater dominated system (in the closed condition) to a more saline dominated ecosystem (in the open condition). This opening action imparts a naturally variable character to the ecosystem. This behaviour was considered in detail in the preparation of this management plan.



Model Results of Tracer Release Showing Dispersion of Pollutants from Dee Why Creek During Wet Weather Events - Entrance Open

Issues Facing Dee Why Lagoon

The pressures of urbanisation of the surrounding areas have resulted in a number of impacts on the Lagoon.

Stormwater Runoff Carrying Pollutants from Dee Why Beach Carpark

In the last 50 years there have been several major disturbances to Dee Why Lagoon. They include:

- extensive clearing of the southern section of the Refuge around 1950 with the view to developing sporting facilities;
- fragmentation of the Wildlife Refuge, caused by extensive urban development throughout the catchment;
- construction of Pittwater Road, which involved changes to drainage, levels and extensive importation of fill;
- extensive damage to the dunes (during WWII and continuing into the 1970s);
- extensive dumping and 'reclamation' on the southern edge of the lagoon, between 1964 and at least 1973;
- clearing and filling around Clarence Avenue;
- construction of sewer lines;
- stabilisation of the lagoon entrance with a gabion wall on the northern side in 1979
- further stabilisation of the lagoon entrance with a low profile rock wall on the southern side in 1994.

The main issues for the Lagoon have been identified through a number of consultative approaches and through various management planning investigations. These are reported in detail in the Estuary Management Study (Lawson and Treloar, 2003) and in Section 3 of this Plan. Examples of issues for the Lagoon include:

- Need for additional education of the community about the Lagoon and appropriate catchment practices
- Impacts on Lagoon water quality from catchment runoff (laden with pollutants such as suspended sediments)
- Loss of connection of the Lagoon with remnant wetland areas over time and associated impacts on fauna
- Odour issues as a result of bed exposure following breakout and impact on local residents
- Walking tracks (unauthorised tracks as well as limitations on number of tracks)
- Weed invasion
- Accelerated changes to bathymetry (as a result of human impacts).

Dee Why Main Drain - A Modified Tributary (During a Dry Weather Period)

Consultation

An essential element of the preparation of any estuary management plan is consultation with both technical stakeholders and the community.

Prior to the commissioning of the Plan, a number of community consultation programs were undertaken for Dee Why Lagoon. Stakeholder workshops were undertaken at critical stages of the preparation of the Plan to identify management objectives and management options.

Stakeholders include:

- Warringah Council (Catchment Management, Reserves, Bush Regeneration, Councillors)
- Department of Infrastructure, Planning and Natural Resources (Estuary Management Program)
- Friends of Dee Why Lagoon
- Dee Why/Curl Curl Joint Estuary/Floodplain Management Committee
- National Parks and Wildlife Service
- NSW Fisheries
- Sydney Water Corporation.
- Anglers Action Group.

Stakeholder Field Inspections of Gross Pollutant Trap (Avon Road)

Values

The Lagoon has features that are valued at a local, regional and national level. These include the natural environment and visual amenity along with recreational, cultural and social values. The Lagoon offers educational opportunities and provides natural drainage and flood protection.

Management Objectives

Whilst the Lagoon is of significant value, in the case of such an urbanised catchment, unrealistic environmental objectives for the estuary are unlikely to be met because of existing, largely irreversible, conditions. It is not practical, given the proximity to such a highly urbanised area, to 'undo' much of the past damage and restore the estuary to its condition prior to European settlement. Accordingly, the Healthy Rivers Commission of Inquiry into Coastal Lakes (2002) identified that the management objective for Dee Why Lagoon is one of 'targeted repair'.

Jurisdictional and legislative issues result in a variety of management plans for a single catchment and estuary. This issue has been highlighted in the NSW Healthy Rivers Commission of Inquiry into Coastal Lakes (2002). Catchment processes heavily influence systems such as Dee Why Lagoon. The Commissions findings outlined that integrating all management plans in the catchment enables a 'whole of catchment' approach to be adopted for the management of a coastal lagoon. As such it is essential that all existing plans be integrated.

In light of this issue and given the historical approach to management of the entire system, management objectives were derived on a spatial unit (an area) basis. Eight such units were identified (see Figure 1). Where appropriate, the approximate boundaries of these units are shown as dotted lines as there are variations in these boundaries at times (due to changes each day and changes over a season).

The units are:

- *Community* - not mapped in Figure 1 since the community is not confined to a single group or a specific area
- *Catchment* - generally with fixed boundaries, except for some areas where high flow events can cause alternative flow paths to operate (e.g. south-east portion of the catchment), the definition of catchment is inclusive of stormwater assets within the areas referred to as the 'Wildlife Refuge' and 'Other Foreshore'
- *Tributaries and Corridors* - connecting Dee Why Lagoon with other natural resources such as Narrabeen Lagoon, Long Reef headland and Curl Curl Lagoon
- *Wildlife Refuge* - the majority of the area fringing the Lagoon proper

- *Other Foreshore Areas* - the south-east corner of the Lagoon foreshore
- *Waterbody* - the area covered by water when the Lagoon is filled and the entrance is closed
- *Entrance* - broadly that area dominated by mobile marine sediments
- *Monitoring/research* - encompasses all units.

The management objectives for each spatial unit are listed in detail in the Estuary Management Study (Lawson and Treloar, 2004) and are reproduced in Section 3 of this Plan.

Actions for Implementation

The management actions for implementation were derived from over 200 options that were identified for possible implementation. A decision-making framework was devised in order to prioritise these actions. This is reported in detail in the Estuary Management Study (Lawson and Treloar, 2004) and discussed in Section 4.

Action to be Implemented: Manage Lagoon Entrance using Artificial Breakout (Photograph: Warringah Council)

Overall, the options which proved to provide the greatest benefit were assigned the highest priority for implementation (identified as 'Major Actions'). This approach resulted in a concentration of actions in some areas over other areas. To overcome this issue, three options for each spatial zone were selected in order to allow for a spread of actions across the entire area rather than concentrating efforts in one area at the expense of another.

There are two types of actions within this plan:

- major actions - primarily major capital works or significant planning tasks which generally require significant financial investment (although there are some actions identified within this group that do not require significant capital investment)
- minor or planning actions - changes to Council planning documents, including approaches to better facilitate management of the Lagoon or planning for future works. These works generally require limited financial investment as compared with the major actions.

These two types of actions are to be implemented concurrently.

Figure 2 is a summary of the major actions for implementation in years 1 - 5 of the plan. The total capital expenditure required for these major actions for years 1 - 5 has been estimated at approximately $1.6 million and the total recurrent expenditure for the five year period is $0.6 million. Full details of the major actions and responsibilities are outlined in Table 1.

Table 2 provides a summary of the planning or minor actions for implementation within years 1 - 5 of the plan implementation.

Beyond the 5 year program there are medium and long term actions to be implemented. These are the remaining options identified in the Estuary Management Study (2004) phase. They are listed in Tables 3 (Medium-term, 5 - 10 years) and 4 (Long-term, 10-20 years).

Whilst the medium and long-term actions are identified in this Plan, it is imperative that the Estuary Management Plan be reviewed at the end of the five year period to consider the next five years of implementation actions.

Action for Implementation: Rehabilitation of Dee Why Creek (Source: Lawson and Treloar, 2004)

TABLE OF CONTENTS

FIGURES

APPENDICES

1. INTRODUCTION

The Estuary Management Plan for Dee Why Lagoon has been prepared to cover the area comprising the estuarine areas of Dee Why Lagoon. However, this biophysical system is interlinked with its catchment and tributaries. This includes the Lagoon foreshore, Wildlife Refuge areas surrounding the Lagoon, the remnant wetland within Cromer reserve, the tidal waterway, Lagoon entrance, dunes, tributaries and drainage features.

In developing this plan all values and uses of the estuary have been considered. This plan aims to create a balanced long-term management framework for the ecologically sustainable use of the Lagoon and its catchment. This Plan should be read in conjunction with the Estuary Management Study (Lawson and Treloar, 2004). The Estuary Management Study contains further information and descriptions of the actions identified for implementation in this Plan.

The Plan has been prepared with consideration of the range of Plans of Management for the catchment and estuary already in operation. The actions identified for implementation were derived from a synthesis of all the actions identified. Further details of the overall management framework in which this Plan has been developed can be found in Section 2.

Key details of the system are listed below.

Key Parameters for Dee Why Lagoon

Catchment and Tributaries	
Catchment area	571 ha
Catchment land use proportions	Residential 75.4% Commercial/Industrial 13.5% Native Vegetation 6.8% Open Space 2.5% State Roads 1.8%
Catchment soils	Dominated by erosional soil types
Number of identified sewer overflow points in catchment	27
Number of tributaries (not including stormwater inflows)	2 - Dee Why Main Drain (south-west) and Dee Why Creek (west)
Number of stormwater pipe discharge locations around Lagoon perimeter	14
Number of EPA Licenced Premises in Catchment	4
Lagoon Water Body and Riparian Zone	
Lagoon water surface area	30 ha (max - when entrance closed)
Depth of Lagoon	1.5 m (max when entrance closed)
Approximate minimum bed level of Lagoon	-0.95 m AHD
Approximate average bed level of Lagoon	0 m AHD
Approximate mean low water spring ocean tide level	-0.6 m AHD
Approximate mean high water spring ocean tide level	0.6 m AHD
Maximum tidal levels recorded when entrance is open	Between 0.5 - 0.8 m AHD
Total area occupied by Lagoon and Wildlife Refuge	68.5 ha
Width of riparian buffer from Lagoon shoreline	Varying between 20 - 100m

Entrance	
Approximate minimum bed level of entrance	0.35 mAHD (Controlled by a clay sill)
Height at which breakout occurs (natural or otherwise)	Ranging between 0.7 m - 2.25 m AHD (generally between 1.5 and 2.0 m AHD).
Berm level at which marine dominance commences to subside	0.75 mAHD
Proportion of time entrance is closed	Approximately 80 % of the time
Time to closure	2 - 45 days
Average number of openings per year	5 openings per year (from limited data)
Water Quality	
Key pollutant constituents and timing of delivery	Wet weather - Faecal bacteria, suspended solids, phosphorous Dry weather - Inorganic nitrogen
Conductivity range in main Lagoon body	55 mS/cm when open, 44 mS/cm just after initially closed, otherwise generally fresh conditions when closed (< 0.1 mS/cm)
Flora and Fauna	
Number of recorded bird species	87 (Core group of waterbirds considered to be regularly using the Lagoon comprises 21 species).
Number of threatened and/or protected species, populations and ecological communities	32 species (all birds) recorded at the Lagoon are listed as threatened and/or protected (under migratory provisions) under Commonwealth or NSW legislation. 10 of these species are listed as threatened under the NSW *Threatened Species Conservation Act 1995*. Two ecological communities are listed as threatened under the NSW *Threatened Species Conservation Act 1995*.

The plan consists of:

- details of the management framework for the Estuary (Section 2)
- a summary of the issues facing the Lagoon and the need for a Management Plan (Section 3)
- a series of implementation action lists for four types of actions (Section 4):
  - major actions to be implemented in the next five years
  - planning/minor actions to be implemented in the next five years
  - actions to be implemented in the medium term (5 - 10 years)
  - actions to be implemented in the long term (10 - 20 years).
- details of how options are to be funded (Section 5)
- details of how the performance of the implemented options will be measured (Section 6).

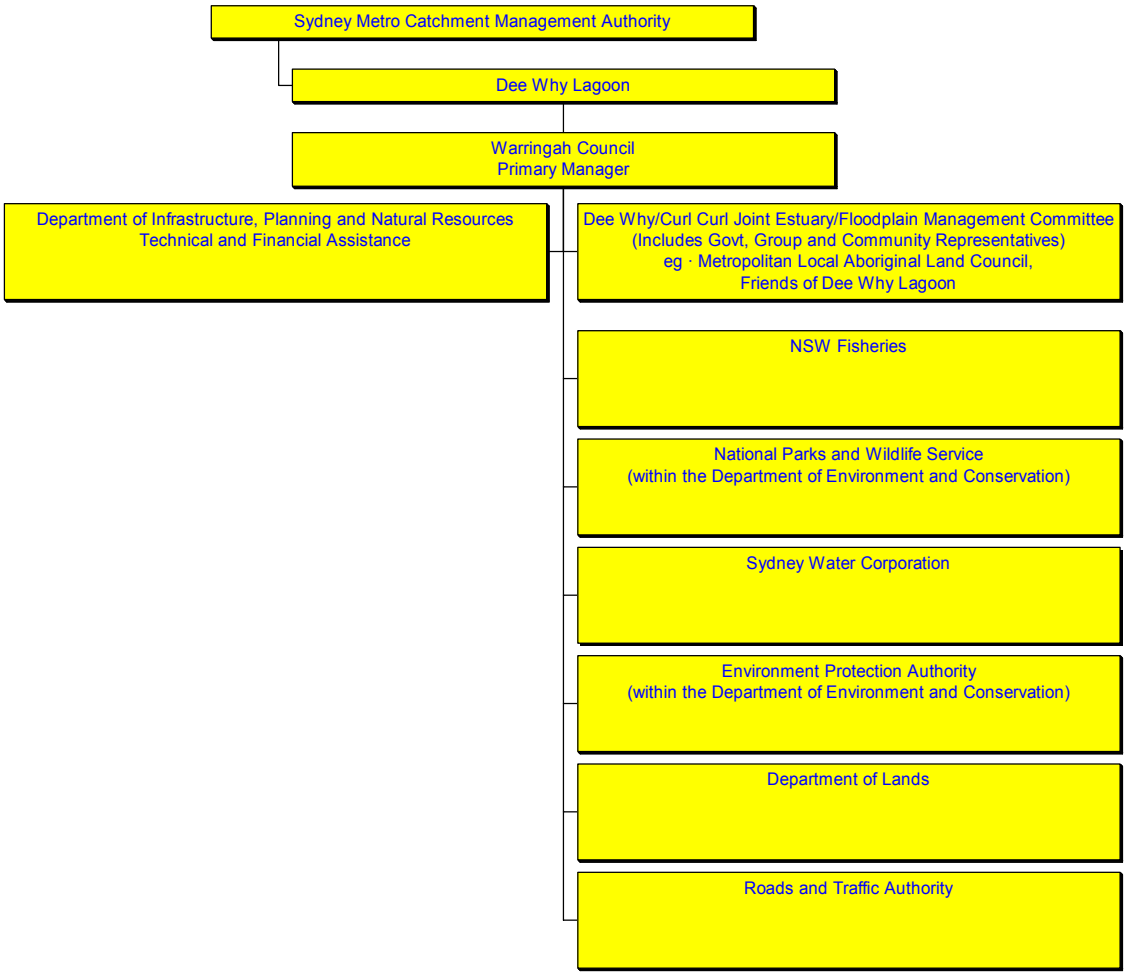
The appendices of this plan provide a glossary (Appendix A) and the details of the consultation associated with the preparation of this Plan (Appendix C).

This plan has been prepared by Lawson & Treloar (L&T) and Kellogg Brown & Root (KBR) for Warringah Council. The preparation of this plan was funded equally by Warringah Council and the Department of Infrastructure, Planning and Natural Resources.

2. MANAGEMENT FRAMEWORK

The management of Dee Why Lagoon is principally undertaken by Warringah Council with assistance from the Department of Infrastructure, Planning and Natural Resources. The strategic management of the Lagoon within a regional context falls under the Sydney Metro Catchment Management Authority.

Other important stakeholders are shown in the framework below.

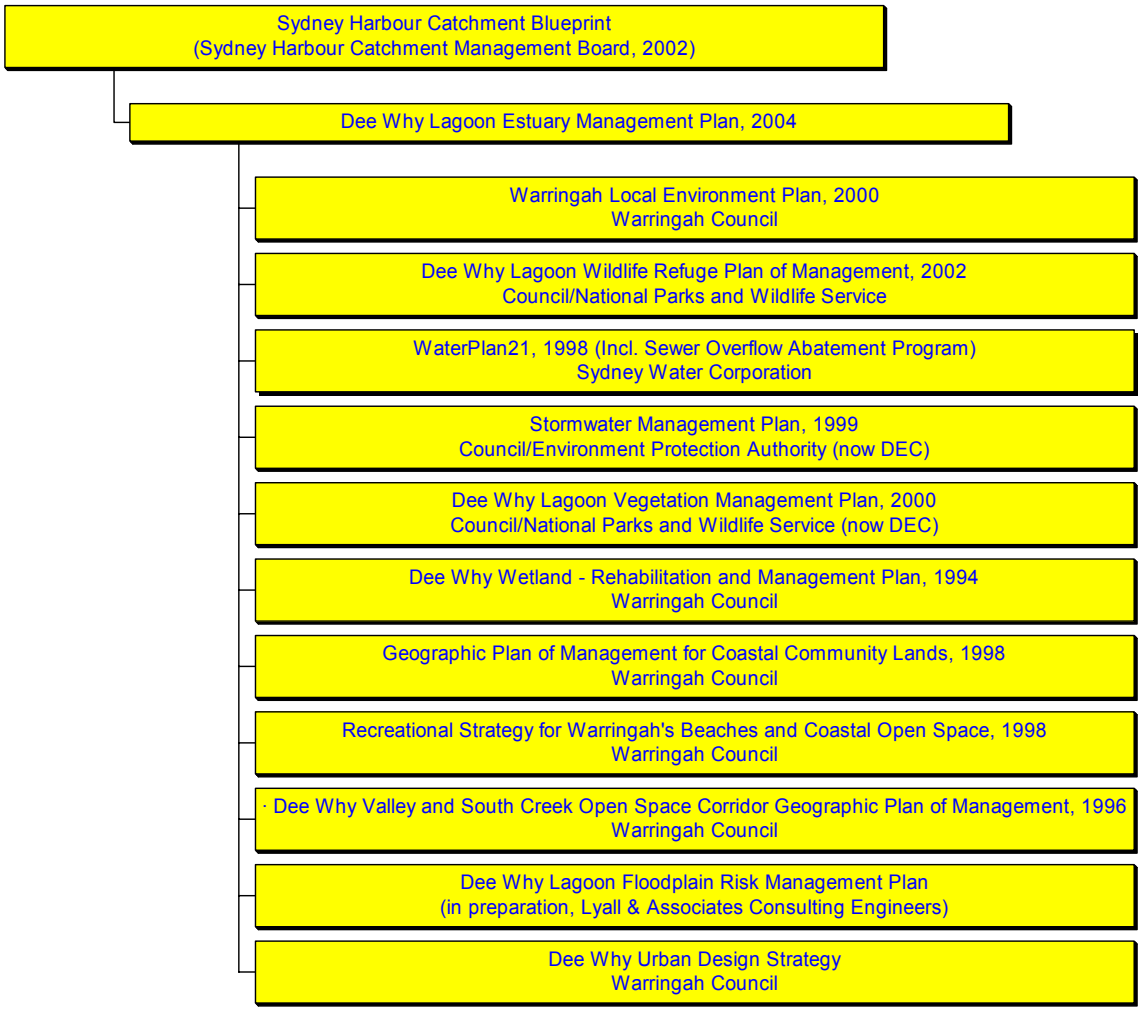


The Estuary Management Manual recommends an eight step process in order to implement an Estuary Management Plan, as follows: -

1. form an estuary management committee;
2. assemble existing data (data compilation study);
3. undertake an estuary processes study;
4. undertake an estuary management study;
5. **prepare a draft estuary management plan;**
6. **public review of the draft plan;**
7. adopt and implement the estuary management plan; and
8. monitor and review the management process as necessary.

Council formed the joint Dee Why/Curl Curl Joint Estuary/Floodplain Management Committee for this study in 1994. The second stage of the Estuary Management Process for Dee Why Lagoon was completed in 1997 (MHL, 1997). The third stage, the Estuary Processes Study, was completed in 2001 (AWT, 2001) and the fourth stage, the Estuary Management Study was completed in 2003 (Lawson and Treloar, 2004).

Other relevant plans of management and environmental planning instruments that have been considered in the preparation of this plan are shown below.



3. SUMMARY OF ISSUES AND OBJECTIVES IDENTIFIED

Through the Estuary Management Study phase, a range of issues were identified for the Lagoon through the process of stakeholder workshops. These issues are tabulated and depicted graphically below.

Additionally, a series of objectives for the Lagoon were developed through stakeholder workshops. These objectives were developed in response to the issues identified. The objectives are set out in two levels with a series of primary objectives in a spatially-based format, with sub-objectives being process-based (or discipline based). A separate unit for the community has also been created to ensure the critical community involvement is a specific objective along with a separate unit for monitoring/research. The primary objectives have been reproduced in this Plan and are tabulated below.

WATER QUALITY ISSUES INCLUDE:

- General catchment runoff (laden with pollutants such as suspended sediments)
- Leachate from old tip sites (potentially laden with pollutants such as nutrients)
- Impact of construction sites and newly landscaped areas (pollutant sources)

RECREATIONAL ISSUES INCLUDE:

- Walking tracks (unauthorised tracks as well as limitations on number of tracks)
- Water sports (e.g. Kite Surfing, Wind Surfing, Canoeing etc, potential impact on avifauna)

ENTRANCE MANAGEMENT ISSUES INCLUDE:

- Flooding (modified system and proximity of development resulting in flooding of some areas)
- Illegal breakout (an example of human intervention affecting Lagoon processes)
- Odour (issues as a result of bed exposure following breakout and impact on local residents)

EXAMPLES OF ISSUES FOR DEE WHY LAGOON

SEDIMENTATION ISSUES INCLUDE:

- Accelerated changes to bathymetry (as a result of human impacts)
- Toxicants contamination (as a result of road runoff and runoff from industrial areas)
- Excess nutrient loads from catchment (as a result of human impacts)

TRIBUTARY ISSUES INCLUDE:

- Connection with remnant wetland (loss of connection over time and impacts on fauna)
- Connection with other lagoons (also loss of connection over time and associated impacts on fauna)
- Rehabilitation of Dee Why Creek (community desire to see area rehabilitated)

FLORA AND FAUNA ISSUES INCLUDE:

- Migratory bird habitat (threatened by human impacts)
- Threatened species (threatened by human impacts)
- Weed invasion (ongoing management issues)
- Tree removal within Refuge for views (concern for illegal activity)
- Fire (appropriate use of fire within the Refuge)

Broad Issues for the Lagoon Identified through Stakeholder Workshops

Community Involvement:
- Education (need for additional education of the community on the Lagoon and appropriate catchment practices)
- Consultation (need for ongoing consultation)

Water Quality:
- General catchment runoff (laden with pollutants such as suspended sediments)
- Leachate from old tip sites (potentially laden with pollutants such as nutrients)
- Impact of construction sites and newly landscaped areas (pollutant sources)
- In-tributary processes (highly modified tributaries have limited natural processes)
- In-lagoon processes (effects of variations of key parameters on biota outside of the healthy range)
- Sewer overflows (a source of faecal contamination/nutrients for the Lagoon with human health/aquatic ecosystem impacts)
- Overflows from public toilets (also a source of faecal contamination for the Lagoon with human health and aquatic ecosystem impacts)
- Illegal dumping of waste (impacting on the refuge areas)
- Management of sports fields, golf courses and open space (sources of runoff potentially laden with pollutants such as nutrients and suspended sediments)
- Acid sulfate soils (potential for the exposure of potential acid sulfate soils and resulting acute reduction in pH if not managed)

Tributaries and Corridors :
- Connection with remnant wetland (loss of connection over time and impacts on fauna)
- Connection with other lagoons (also loss of connection over time and associated impacts on fauna)
- Rehabilitation of Dee Why Creek (community desire to see area rehabilitated)

Entrance Management:
- Flooding (modified system and proximity of development resulting in flooding of some areas)
- Illegal breakout (an example of human intervention affecting Lagoon processes)
- Odour (issues as a result of bed exposure following breakout and impact on local residents)
- Meander of entrance location (safety and protection of assets)
- Permits and approvals associated with SEPP35 (artificial entrance breakouts to be undertaken in a controlled and consultative manner)
- Links with prawn recruitment and recreational catches (limited knowledge of this process)
- Protection of clay sill (concern that artificial breakout may damage the clay sill and result in change to bed levels and associated impacts on Lagoon)

Recreational Uses*:
- Walking tracks (unauthorised tracks as well as limitations on number of tracks)
- Prawning (potential impact on foreshore area by users)
- Water sports (e.g. Kite Surfing, Wind Surfing, Canoeing etc, potential impact on avifauna)
- Bird watching (desire to preserve/enhance this activity)
- Swimming near entrance (safety and human health issues)
- BBQ/Picnic areas (potential negative impact on Wildlife refuge)
- Children's park (potential negative impact on Wildlife refuge)
- Litter associated with Long Reef and Dee Why Beach users (can be wind blown into Lagoon area)

Flora and Fauna:
- Migratory bird habitat (threatened by human impacts)
- Threatened species (threatened by human impacts)
- Weed invasion (ongoing management issues)
- Tree removal within Refuge for views (concern for illegal activity)
- Fire (appropriate use of fire within the Refuge)
- Revegetation of riparian areas (desire to see areas modified rehabilitated)
- Seagrass (loss of seagrass due to human impact)
- Saltmarsh (loss of saltmarsh due to human impact)
- Fisheries (both direct, on prawning and indirect, on the area as a juvenile habitat) (human impacts)
- Introduced predators (potential impacts on threatened species)

Sediments:
- Accelerated changes to bathymetry (as a result of human impacts)
- Toxicants contamination (as a result of road runoff and runoff from industrial areas)
- Excess nutrient loads from catchment (as a result of human impacts)

*Recreational uses, whilst of social benefit, may conflict with other values of the Lagoon, particularly in some areas of the Lagoon (See Estuary Management Study, 2004). Regardless of recreational use type, the use will require management to ensure all legislative requirements are met and environmental impacts are minimised.

Summary of Objectives Identified through Stakeholder Workshops

Spatial Unit	Objective
A Community	1. To increase the community education (knowledge) and improve community stewardship of the Lagoon and its catchment
	2. To facilitate ecologically sustainable use of the Lagoon waterbody and foreshore through a range of informal recreation activities which appeal to a wide range of people
B Catchment	1. To control and improve water quality in terms of managing inputs of sediments, nutrients and other contaminants
	2. Stormwater flow rates controlled to reduce flood issues (see also Floodplain Risk Management related studies)
	3. Ensure ongoing integration with the Stormwater Management Plan
C Tributaries and Corridors	1. To improve amenity, aesthetic value and ecological quality of the creek (tributary) and associated corridor environments
D Refuge	1. To maintain and improve the amenity, aesthetic and habitat value and associated biodiversity of the area
	2. No further degradation of vegetation, maintain threatened species, populations and ecological communities
	3. Rehabilitation of degraded vegetation native to Sydney coastal lagoon systems
	4. Ensure ongoing integration with Wildlife Refuge Plan of Management and Vegetation Plan of Management
E Other Foreshore Areas	1. Recreational use to be generally confined to areas including the SE corner, Southern boundary and Eastern walking tracks
	2. Amenities associated with the Lagoon to be harmonious with all of the refuge and waterbody objectives
	3. Ensure ongoing integration with Open Space Plans of Management and Warringah Coastal Management Strategy
	4. To recognise existing legislation
	5. Achievement/maintenance of a natural edge
F. Waterbody/ Central Bed Area	1. To maintain and improve the amenity, aesthetic and habitat value and associated biodiversity of the area
	2. No further loss of depth or extent and consideration of some restoration of depth
	3. Water Quality suitable for environmental role and incidental human contact
	4. Prime purpose is to complement wildlife refuge, detrimental recreational use discouraged
G. Entrance	1. Entrance to be managed considering ecological effects and flood control
	2. Entrance to be managed in accordance with Entrance Management Policy.
H. Monitoring and Research	1. To regularly monitor those aspects which are indicative of the long-term health of the Lagoon to allow for reporting of the effectiveness of management activities.
	2. To continue research into areas using regular monitoring data as well as one-off intensive investigations to increase knowledge of the Lagoon processes and allow for adaptive management of the Lagoon.

4. IMPLEMENTATION ACTION LIST

4.1 Review of Outcomes of Estuary Management Study

In order to develop an implementation action list, a review of the findings of the Estuary Management Study (Lawson and Treloar, 2004) was conducted.

The Estuary Management Study assembled all options for the estuary from a range of documents (including the various Management Plans listed in Section 2). Each option was then considered using a standard set of criteria and then scored on its likely or known performance against those criteria to produce a 'benefit index'. This process is referred to as a 'multi-criteria matrix assessment'. The outcomes of the multi-criteria matrix assessment were used to rank the options.

Two different approaches can be adopted to rank (or prioritise) the options:

- based on the 'benefit index' alone (the total score of the option for all criteria)
- based on a 'cost:benefit index' (the total score of the option for all criteria divided by the net present value of the option, a function of the likely capital cost, the recurrent cost and the expected life of the option).

Where the 'benefit index' alone is used, those options that rank highest are generally the costliest options (there are some exceptions). Where 'cost:benefit index' is used, those options that provide the best value for money (and are therefore usually considerably less costly than those ranked on benefit index alone), rank highest.

Recognising the traditional constraint to the implementation of actions associated with natural resources management is financial, ranking the options for implementation based on the 'cost:benefit index' alone is an attractive approach. However, major capital works, requiring significant financial commitment, rank poorly primarily due to the large number of options within the assessment (over 200 options) even though they often score highly with respect to the 'benefit index'.

Additionally, ranking options using either of these approaches does not allow for the recognition of the value in undertaking works across the range of spatial units simultaneously. For example, it is of limited value to attend to the weed issue within the Wildlife Refuge in isolation without considering complementary actions to reduce or intercept the elevated nutrient load derived from the catchment.

To overcome these issues, a combined approach to the prioritisation of options was developed. The decision criteria in the selection of priority for implementation are as follows:

- Split implementation time frame into five components:
  - short term major actions
  - short term minor/planning actions
  - medium term actions
  - long term actions
  - other actions for inclusion when the Plan is periodically reviewed.

- Prioritise short-term major actions into a series of 24 actions (three actions per spatial unit) based on 'benefit index' alone
- Prioritise short-term minor/planning type actions into a series of 20 actions based on 'cost:benefit index'
- Prioritise medium term actions into a series of 20 actions based on 'cost:benefit index' (acknowledging that the plan will be reviewed prior to this list being adopted)
- Prioritise long term actions into a series of 20 actions based on 'cost:benefit index' (acknowledging that the plan will be reviewed prior to this list being adopted).

4.2 Short, Medium and Long Term Actions

Based on the approach outlined above, five action lists are presented as a series of Tables. These action lists are for:

- major actions to be implemented in the next five years (Table 1)
- planning/minor actions to be implemented in the next five years (Table 2)
- actions to be implemented in the medium term (5 - 10 years) (Table 3)
- actions to be implemented in the long term (10 - 20 years) (Table 4)
- actions identified in the Estuary Management Study, but not included in this version of the Plan (Appendix B).

Each action has an identifier code and a brief description. The identifier codes relate to the spatial area shown in Figure 1 and were numbered in an arbitrary manner as part of the Estuary Management Study (Lawson and Treloar, 2004). Further details for each action can be found within the Estuary Management Study.

The approximate capital cost and approximate recurrent cost were also derived from the Estuary Management Study. It is important to note that these costs are indicative only and will require update and revision as more detailed preparations are made for their implementation.

The responsible authority has been assigned on the basis of current responsibilities borne by different agencies.

Details of the performance indicators to monitor the effectiveness of the implementation of the plan can be found in Section 6.

Example of information and education materials

Dune Management - An integral part of the overall system

Stormwater inflows - Need for ongoing management

Table 1 Major Actions Implementation Action List - Years 1 - 5 Program

Rank/ Priority	Identifier	Required Action	M'Ment Objective*	Approximate Capital Cost	Approximate Recurrent Cost	Responsible Authority(s)
1	Tri-1	Creek Rehabilitation of Dee Why Creek	C1	$1,000,000	$5,000	Council/DIPNR
2	For-3	Shoreline Management	F5	$150,000	$3,000	Council/DIPNR
3	Mon-27	Flora and Fauna	H2	$10,000	$2,000	NPWS
4	Com-11	General Signage	A1	$5,000	$1,000	Council
5	Ref-26	Planning	D1/D4	$10,000	-	Council
6	Ent-2	Mechanical Opening/Closing	G1	-	$10,000	Council/DIPNR
7	Mon-9	Development of a Lagoon Health Index	H1	$5,000	-	Council/DIPNR
8	Cat-1	Sediment, Litter and Debris Control	B1	$20,000	$5,000	Council/EPA
9	Cat-11	Fine Sediment and Nutrient Control	B1	$200,000	$5,000	Council/EPA
10	Cat-30	Catchment Flora	B1/C1	$15,000	$30,000	Council
11	Ref-6	Feral and Domestic Animal Control	D2	-	$5,000	Council/NPWS
12	Ref-25	Maintenance	D1	-	$2,000	Council/NPWS
13	Tri-4	Re-establish Indigenous Species and Habitats	C1	-	$10,000	Council
14	Tri-8	Removal and Control of Exotic Species	C1	$5,000	$1,000	Council
15	Com-1e	Coordinated Preparation and Distribution of Education/Information Materials	A1	-	$1,000	Council
16	Com-7	General Signage	A1	-	$4,000	Council
17	Wat-11	Creation of an Aquatic Reserve or Similar Protection under Fisheries Management Act	F1/F4	$50,000	$500	NSW Fisheries
18	Ent-3	Identify Kite Surfing Zones	E1	$3,000	$500	Council
19	For-5	Dune Management	E1	$5,000	$10,000	Council/DIPNR
20	Mon-10	Waterbody - Water Quality	H1	-	$20,000	Council/DIPNR
21	Ent-5	Policy and Planning	G2	$5,000	$500	Council/DIPNR
22	For-2	Flora	D1/E2	$5,000	$1,000	Council
23	Wat-8	Restoration/Maintenance of Saltmarsh	F1	$75,000	$5,000	Council/NSW Fisheries
24	Wat-6	Island Creation for Beach Nesting Birds	F1	$250,000	$2,000	Council/NPWS
TOTAL BUDGET (Recurrent reported for the five year period) (ex GST)				**$1,813,000**	**$617,500**	

*M'Ment Objective corresponds to those objectives identified in Section 3.

Table 2 Minor/Planning Actions - Implementation Action List Years 1 - 5 Program

Rank/ Priority	Identifier	Required Action	M'Ment Objective*	Approximate Capital Cost	Approximate Recurrent Cost	Responsible Authority(s)
1	Tri-18	Use paths as physical barrier between lawn and bushland areas.	C1	$1,000	-	Council
2	Tri-9	Prepare a programme of works which focuses on bush regeneration work to viable remnants of natural vegetation in riparian areas.	C1	$2,000	-	Council
3	Cat-16	Incorporate more specific and frequent litter collection procedures and conditions into special event/reserve hire approvals.	B1	$2,000	-	Council
4	Ref-8	Streamline approval process with the Warringah-Pittwater district fire committee. Plan ecological burns to be no larger than 5000m^2.	D1	$2,000	-	Council/DEC
5	Com-18	Use of constructed wetlands (if feasible) as an educational tool. Access to the pathways surrounding the wetland to be encouraged with educational notices.	A1	$2,000	-	Council
6	Com-19	Signage in southern foreshore areas regarding human waste disposal and control of gull populations.	A1	$2,000	-	Council
7	Cat-14	Review and alter if required application of Fertilisers and mowing practices. Service level agreements for sporting field operations.	B1	$2,000	-	Council
8	Com-10	Identify opportunities for interpretation of the local natural and cultural landscape evolution in a manner, which does not cause visual clutter.	A1	$2,000	--	Council
9	Cat-17	Develop Section 94 Levy upon developers to encourage minimisation of paving. Levy to be put in trust fund for Lagoon	B1/B2	$2,000	-	Council/EPA
10	Cat-25	Review maintenance of stormwater outlets, increase monitoring/maintenance as required.	B1	$3,000	-	Council
11	Cat-38	Review all Council and Contractor maintenance practices in the study area and make necessary amendments or retrain staff. Matters to be addressed include: avoiding whipper snipper damage to trees; mulching areas around groups	B1/C1	$2,000	$500	Council

Rank/ Priority	Identifier	Required Action	M'Ment Objective*	Approximate Capital Cost	Approximate Recurrent Cost	Responsible Authority(s)
		of trees to avoid mower damage; prevent encroachment of mowing into bush areas; increased frequency of mowing; and, retrain staff to avoid large quantities of clippings washing into the creeks				
12	Ref-24	Removal of old piles of wood and other debris at the shoreline in the south east corner (not tank trap feature)	D1	$2,000	-	Council/NPWS
13	Mon-11	Assist with funding of research into conservation and management requirements of floral communities	H2	$5,000	-	Council
14	Cat-37	Prepare a programme of works which focuses on bush regeneration work to viable remnants of natural vegetation.	B1/C1	$5,000	-	Council
15	Tri-2	Review of current zoning in riparian areas for potential rezoning of land to allow for inclusion of a riparian buffer zone corridor in the LEP	C1	$5,000	-	Council
16	Cat-39	Develop a programme of replacing mown access ways with paths and replanting locally indigenous plant species in order to reduce quantity of mowing required by and limiting lawn areas to parks.	B1/C1	$2,000	$500	Council/NPWS
17	Mon-22	Trial a pile burn to see if the seed bank is stimulated by fire.	H2	$2,000	-	Council/DEC
18	Ref-15	Gradual movement of mowing barriers to reduce amount of turfed area along Clarence Avenue	D1	-	$1,000	Council
19	Wat-7	Review of potential for trial seagrass planting in permanent wet areas**	F1/H2	$75,000	$5,000	Council/NSW Fisheries
20	Cat-2	Sediment, Litter and Debris Control	B1	$10,000	$500	Council/DEC
TOTAL BUDGET (Recurrent reported for the five year period) (ex GST)				**$128,000**	**$37,500**	

*M'Ment Objective corresponds to those objectives identified in Section 3.
** Budget for actual trial planting also included, contingent on outcomes of review.

Table 3 Medium Term Implementation Action List (5 - 10 Years)

Rank/ Priority	Identifier	Required Action	M'Ment Objective*	Approximate Capital Cost	Approximate Recurrent Cost	Responsible Authority/ Funding Sources
1	Cat-27	Sewer Overflows	B1	$3,000,000	$100,000	Sydney Water
2	Cat-18	Policy - Water Management	B1/B2	$40,000	$1,000	Council
3	Cat-20	Stormwater Drainage System Modifications	B1/B3	$400,000	$5,000	Council
4	Com-1a	Coordinated preparation and distribution of education/information materials	A1	$6,000	$1,000	Council
5	Ref-18	Flora - Weed Control	D2	-	$50,000	Council/NPWS
6	Com-1b	Coordinated preparation and distribution of education/information materials	A1	$6,000	$1,000	Council
7	Com-1d	Coordinated preparation and distribution of education/information materials	A1	$6,000	$1,000	Council
8	Com-2a	Coordinated preparation and distribution of education/information materials	A1	$6,000	$1,000	Council
9	Com-5	Coordinated preparation and distribution of education/information materials	A1	$3,000	$1,000	Council
10	Cat-7	Sediment, Litter and Debris Control	B1	$100,000	$5,000	Council/DEC
11	Cat-8	Sediment, Litter and Debris Control	B1	$100,000	$5,000	Council/DEC
12	Cat-10	Sediment, Litter and Debris Control	B1	$300,000	$5,000	Council/DEC
13	Cat-36	Catchment Flora - Fire Management	B1/C1	-	$5,000	Council/DEC
14	Cat-40	Weeds - in house training seminars for Council staff on the Noxious Weeds Act (1993)	B1/C1	$3,000	$1,000	Council
15	Tri-3	Weed Control - Manage source of weed seeds (Ludwigia) from Dee Why wetlands	C1	$5,000	$1,000	Council
16	Tri-5	Feral Animals - Continued control of Feral predators (including foxes, domestic dogs/cats)	C1/D1	-	$5,000	Council
17	Ref-13	Flora - Maintenance	D2/D3	$2,000	$5,000	Council/NPWS
18	Ref-16	Flora - Bush Regeneration Contract Guidelines	D2/D3	$10,000	$2,000	Council/NPWS
19	Ref-17	Flora - Revegetation	D1	-	$50,000	Council/NPWS
20	Mon-29	Aquatic Flora	H2	$25,000	-	NSW Fisheries
TOTAL BUDGET (Recurrent reported for a five year period) (ex GST)				**$4,012,000**	**$1,225,000**	

*M'Ment Objective corresponds to those objectives identified in Section 3.

Table 4 Long Term Implementation Action List (10 - 20 years)

Rank/ Priority	Identifier	Required Action	M'Ment Objective*	Approximate Capital Cost	Approximate Recurrent Cost	Responsible Authority(s)
1	Com-1c	Coordinated Preparation and Distribution of Education/Information Materials	A1	$6,000	$1,000	Council
2	Com-20	Trails and Linkages for Self-Guided Tours	A2	$15,000	$3,000	Council
3	Cat-3	Sediment, Litter and Debris Control	B1	$200,000	$5,000	Council/DEC
4	Cat-4	Sediment, Litter and Debris Control	B1	$300,000	$15,000	Council/DEC
5	Cat-9	Sediment, Litter and Debris Control	B1	$500,000	$30,000	Council/DEC
6	Cat-12	Maintenance	B1	-	$25,000	Council
7	Cat-26	Spill Management (eg roads, industry)	B1	-	$2,000	Council
8	Cat-39	Maintenance	B1	$2,000	$500	Council
9	Cat-42	Sediment, Litter and Debris Control	B1	$400,000	$10,000	Council/DEC
10	Tri-19	Maintenance	C1	$3,000	$500	Council
11	Ref-7	Fire Management - Policy	D4	$10,000	-	Council/NPWS
12	Ref-9	Flora - Revegetation	D1	-	$10,000	Council/NPWS
13	Com-16	Design, publicly exhibit and install an interpretation structure in the southern wetland remnant	A1	$3,000	$500	Council
14	Mon-14	Continue Monitoring by Pittwater House School for Dee Why Creek @ Pittwater Road - Link Data to Council's Website	H1	-	$1,000	Council/SWC
15	Tri-6	Review noxious weed list annually to amend "W4" weed listings	C1	-	$1,000	Council
16	For-1	Formalising of Temporal and Spatial Exclusion Zones (buoys in water, markers on land)	E1	$5,000	-	Council
17	Com-32	Prioritise areas for work and direct volunteers to those areas	A1	$1,000	$500	Council
18	For-7	Inspect twice yearly for weed outbreaks	D2	-	$1,000	Council
19	Ref-2	Nest boxes for Chestnut Teal/other duck species	D1	$2,000	$500	Council
20	Com-8	Rationalise signage and develop a consistent signage and interpretive/map system.	A1	$5,000	$500	Council
TOTAL BUDGET (Recurrent reported as an annual value) (ex GST)				**$1,452,000**	**$107,000**	

*M'Ment Objective corresponds to those objectives identified in Section3.

5. FUNDING

There are a number of sources available to fund the options identified in Section 4. They include:

Local Government	• Funds within Council's Capital Expenditure Budget (CAPEX) (for a range of actions identified) • Funds derived from Council's Environmental and Stormwater Special Rate (ESSR) (funding allocated by a committee within Council) (for a range of actions identified) • Funds levied by Council through Section 94 contributions (for development-related actions identified)
State Government	• Grant funding from the Department of Infrastructure, Planning and Natural Resources Estuary Management Program (generally requires funds to be matched on a dollar for dollar basis by Council) (www.dipnr.nsw.gov.au) (for a range of actions identified) • Grant funding from the Department of Infrastructure, Planning and Natural Resources Floodplain Management Program for actions identified that have joint estuary management and floodplain management objectives www.dipnr.nsw.gov.au • Grant funding from the Department of Infrastructure, Planning and Natural Resources Coastal Management Program for actions identified that have joint estuary management and coastal management objectives www.dipnr.nsw.gov.au • Grant funding from NSW EPA www.epa.nsw.gov.au/grants.htm including the NSW Environmental Trust Grants - For individual projects which involve: restoring degraded environmental resources; protecting rare and important ecosystems and habitats; preventing or reducing future environmental damage; or enhancing the quality of valuable environmental resources- (www.epa.nsw.gov.au/envtrust/envrestrehab.htm). • NSW Fisheries Saltwater Fishing Trust (from the sale of recreational fishing licences) - grants up to $5000 are available and must be on a dollar for dollar basis (for actions identified that are related to fisheries such as seagrass-related actions) www.fisheries.nsw.gov.au/recreational/guide_trust_applications.htm • Grant funding from the RTA's Stormwater Environment Improvement Program (linked to the Stormwater Management Plan) (for actions identified related to RTA road runoff) • Funds expended on sewer overflow projects specifically allocated by Sydney Water Corporation (www.sydneywater.com.au) • Metropolitan Greenspace Program (through DIPNR) funds available on a dollar for dollar basis to assist local government Projects include open space enhancements such as walking or bike trails, landscaping, tree-planting and bush regeneration (www.dipnr.nsw.gov.au).
Commonwealth Government	• Commonwealth Government Grants - www.grantslink.gov.au - • Australian Biological Resources Study Participatory Program -

	Grants Scheme - Grants and Contracts to taxonomic researchers through the Participatory Program Research Grants Scheme www.ea.gov.au/biodiversity/abrs • Natural Heritage Trust - Extension (requires a project to be identified within accredited, integrated natural resource management plan developed by the region) www.nht.gov.au/extension/guidelines/index.html • Fisheries Action Program www.affa.gov.au • Environmental Education Grants (under the National Action Plan for Environmental Education) www.ea.gov.au/education/nap/funding.html • Commonwealth Living Cities Program - Urban Stormwater Initiative (Part of the living cities program) www.ea.gov.au/coasts/pollution/usi/index.html • Australian Government Envirofund - local action component of the Commonwealth Government's Natural Heritage Trust - www.nht.gov.au/envirofund/index.html grants to community groups of up to $30,000 to carry out on-ground and other actions to target local problems • Waterwatch - A National Network of Water Quality Monitoring - www.waterwatch.org.au and www.waterwatch.nsw.gov.au - Coordinated by the Department of Infrastructure, Planning and Natural Resources in NSW. In the Sydney Region the program runs through Streamwatch which is coordinated by Sydney Water Corporation. Technical assistance with monitoring for community groups and schools is available. There are three sites within the Dee Why Lagoon catchment that either are currently monitored or are proposed to be monitored (groups involved are Dee Why Public School, Pittwater House School and Manly Environment Centre). • Green Corps - Council could draw labour resources by becoming a partner agency for the Green Corps to undertake projects such as land, water and wildlife survey, data collection, Landcare or Coastcare activities, access control, bush regeneration, habitat protection and restoration, environmental weed control, walking track construction, eco-tourism, restoration activities for environment and cultural heritage, Community education www.greencorps.com.au • Green Reserve - Council could also draw labour resources by becoming a partner agency for the Green Reserve www.greenreserve.com.au • Partnering with Major National Research Facilities or Universities www.dest.gov.au/MNRF/ for monitoring and research (eg the CRC for Coastal Zone, Estuary and Waterway Management www.coastal.crc.org.au).

6. MONITORING AND PERFORMANCE INDICATORS

The monitoring associated with the implementation of the Plan is an integral part of assessing the effectiveness of the actions to be undertaken.

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 adopted for assessing the effectiveness of the implemented management actions is based on the State of the Environment (SoE) system as outlined by the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000b). That document identifies a set of core indicators for *Estuaries and the Sea*. These indicators have been reviewed and modified to form an appropriate and manageable set of indicators for Dee Why Lagoon.

The first year of the implementation of the Plan will require establishing a baseline condition of each indicator. 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.

The adoption of this approach forms a portion of the implementation of action Mon-9 (Lagoon Health Index) as presented in the following table.

Indicator	Data to be Collected for Indicator
The length or area of the foreshore used for structures associated with activity.	Measurement of length from coastal surveillance aerial photography of modified foreshore on an annual basis.
Area of wetlands in catchment, both freshwater and estuarine	Measurement of area from coastal surveillance aerial photography of catchment on an annual basis.
Proportion of impervious area of catchment	Measurement of area from coastal surveillance aerial photography of catchment on an annual basis.
Area of marine habitat subject to: (a) trawling, (b) anchorage sites, (c) dredging (including dredge spoil dump sites), (d) navigation channels, (e) exploration, and (f) mining.	None of these disturbances are applicable to Dee Why Lagoon. Instead, recommend every three years vegetation surveys for Refuge and topographic surveys of fluvial delta areas.
The total catch of fish (excluding aquaculture) disaggregated into: commercial fish catch (by species where possible), discarded catch, landed bycatch and estimated recreational and subsistence catch.	Estimate of recreational prawning catch to be made by NSW Fisheries/Anglers Action Group on an annual basis.
Expert assessments of the status of wild stocks of fish, crustaceans and molluscs.	Fish/mollusc survey in closed condition once every three years.
The location and number of point-source discharges into the Lagoon including the types and loads of materials discharged.	Provision of information on volume and concentrations of discharges from EPA licenced sites to Council on an annual basis.
Number of pollution incidents reported to the EPA/Council.	Number of recorded pollution incidents within catchment on an annual basis.

Indicator	Data to be Collected for Indicator
Percentage exceedences of marine and estuarine water quality guidelines for a suite of microbiological and chemical water quality parameters relating to: • protection of aquatic ecosystems, and • primary contact recreation. (Exceedences to be reported separately for each use.)	Monthly sampling of TN, TP, FRP, NOx, NH_4, DO, pH, Turbidity, Enterococci within the Lagoon for at least two sites in association with continuous measurements of water level. Calculation of % exceedence of ANZECC (2000a) guidelines for each analyte.
The levels of major contaminants in biological accumulators in the estuaries, lagoons, bays and continental shelfs of the mainland and offshore islands.	Survey of bioaccumulator organisms once every three years.
The frequency of algal blooms, and dominant species of algae responsible for them.	Grab samples of Chlorophyll-a during closed entrance conditions on a three monthly basis at three sites.
The number of wastewater treatment plants, together with the volume of wastewater released to coastal and estuarine waters, disaggregated according to the level of treatment or filtration used.	Number of sewer overflows in catchment and number of overflow events within the catchment on an annual basis.
The area of potential acid sulfate soils disturbed by development resulting in acid drainage and impacts on aquatic organisms.	To be interpreted from measurements of pH outlined above.

It is recommended that an annual report card of these indices be developed for the estuary, 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.

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 Lagoon. 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).

7. REFERENCES

ANZECC (2000a) *Australian Water Quality Guidelines for Fresh and Marine Waters*. Australia and New Zealand Environment and Conservation Council (ANZECC).

ANZECC (2000b) *Core Environmental Indicators for Reporting on the State of the Environment*. Australia and New Zealand Environment and Conservation Council (ANZECC).

AWT (2001) *Dee Why Lagoon Estuary Processes Study*. Prepared for Warringah Council.

Coates, B., Jones, A. R. and Williams, R. J. (2002) Is 'Ecosystem Health' a Useful Concept for Coastal Managers, *Proceedings*, Coast to Coast 2002 Source to Sea, Tweed Heads, November.

Clouston (1996) *Dee Why Valley and South Creek Open Space Corridor - Geographic Plan of Management*. Prepared for Warringah Council, November.

Dickson Rothschild (undated) *Dee Why Urban Design Strategy*. Prepared for Warringah Council.

Healthy Rivers Commission (2002) *Independent Public Inquiry into Coastal Lakes: Final Report*, ISBN 0 9577 268 6 4.

Lyall & Associates (2002) *Dee Why and Curl Curl Lagoons Flood Study*, Prepared for Warringah Council, November.

Kate Low and Associates (2000) *Draft Vegetation Management Plan Dee Why Lagoon Wildlife Refuge*. Prepared for Warringah Council, 46p.

Lawson and Treloar (2004) *Dee Why Lagoon Estuary Management Study*, Prepared for Warringah Council.

Manly Hydraulics Laboratory (MHL) 1997. *Dee Why Lagoon Data Compilation Study*. Report MHL845 prepared for Warringah Council, May.

National Land & Water Resources Audit (2002) *Australian Catchment, River and Estuary Assessment*, Volumes 1 and 2, March.

New South Wales Government (1992) *Estuary Management Manual*. New South Wales Government: New South Wales, Australia.

Patterson Britton & Partners (1999) *Northern Beaches Stormwater Management Plan*. Report prepared for Warringah Council.

SWC. (1998a) *Volume 3 – Northern Suburbs, Licensing Sewerage Overflows EIS*.

SWC. (1998b) *Volume 2 – Sydney Harbour and Northern Beaches Geographic Area, Licensing Sewerage Overflows EIS*.

Sydney Catchment Management Board (2003) *Sydney Harbour Catchment Blueprint 2002*, February.

Warringah Council (1998) *Geographic Plan of Management for Coastal Community Lands*. Adopted 23rd June 1998.

Warringah Council (1998) *Recreation Strategy for Warringah's Beaches and Coastal Open Space*. Adopted 23 June 1998.

Warringah Council (2000) *Warringah PLAN 2000 - 2003* (Warringah Council Management Plan).

Warringah Council (2000) *Warringah Residential Development Strategy*. October 2000.

Warringah Council (2000) *Warringah Local Environmental Plan 2000*.

Warringah Council (2002) *Draft Dee Why Lagoon Wildlife Refuge Plan of Management* (2), 23 April 2002.

Winning, G. (1994) *Dee Why Wetland Rehabilitation and Management*. Report prepared for Warringah Council by Shortland Wetlands Centre Ltd and Ecological Management Consultancy, 30 pages.

APPENDICES

APPENDIX A

GLOSSARY

GLOSSARY

AASS	Actual Acid Sulfate Soil
Algae	Non-rooted aquatic plants, specifically non-vascular photosynthetic organisms with unicellular reproductive organs, including phytoplankton and seaweeds.
Advective Transport	The transport of dissolved material by water movement.
Aerobic Bacteria	Bacteria that obtain metabolic energy by aerobic (oxygen requiring) respiration.
Australian Height Datum (AHD)	A common national plane of level corresponding approximately to mean sea level.
Algal Bloom	The excessive growth of phytoplankton, generally caused by high nutrient levels. Can result in deoxygenation of the water mass, leading to the death of aquatic flora and fauna.
Amenity	Those features of an estuary that foster its use for various purposes, e.g. clear water and sandy beaches make beach-side recreation attractive.
Amphibian	Any frog or other member of the class amphibia that is native to Australia, including the eggs and the young thereof.
Amphipods	Laterally compressed crustacea, e.g. sand hoppers.
Anaerobic Bacteria	Bacteria that obtain metabolic energy by a variety of non aerobic (not oxygen dependent) pathways, including the reduction of nitrates ('denitrification') and/or sulfates.
ANC	Acid Neutralising Capacity
Animal	Any animal, whether vertebrate or invertebrate, and at whatever stage of development, but does not include fish within the meaning of the Fisheries and Oyster Farms Act, 1935, other than amphibians or aquatic or amphibious mammals or aquatic or amphibious reptiles'.
Annual Exceedence Probability (AEP)	Refers to the probability or risk of an event (e.g. a flood) of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence of being exceeded; it would be rare but it would be relatively large.
Anoxic Conditions	Conditions typified by very low to zero dissolved oxygen concentrations.
ANZECC Guidelines	Australian and New Zealand standards and parameters of water quality for protection of ecosystems and other aquatic environments.
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soil

Baseline Monitoring	A monitoring program aimed at determining long-term and possibly pre-disturbance levels and variation in some parameter of interest, e.g. dissolved oxygen.
BBQ	Barbeque
Bed Load	That portion of the total sediment load that flowing water moves along the bed by the rolling or saltating of sediment particles.
Benthos, Benthic Organisms	Organisms living in or on the bed of a waterbody.
Biological Oxygen Demand (BOD)	Oxygen required by aerobic bacteria in metabolising detritus.
Biomass	The mass of living material contained in a system of interest (includes both plant and animal matter).
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 thereof.
BOD	Biological Oxygen Demand
Calibration	The process by which the results of a computer model are brought to agreement with observed data.
CAMBA	China Australia Migratory Bird Agreement
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.
CD	Chart Datum
Degradation	A reduction in the area of estuarine habitat; or in the well-being, health and viability of estuarine ecosystems; or in estuarine amenity.
Denitrification	See anaerobic bacteria.
Depauperate	A condition which is generally poor or impoverished.
Detritus	All non-living organic material, including animal waste products and the remains of animals' plants and micro-organisms/ together with the associated microbial community (bacteria and fungi).
Detention	Detention systems have the effect of storing runoff and releasing it at a rate no greater than the pre-development peak discharge.
Diatoms	Single celled water plants.
Diffuse Source Pollution	Pollution originating from a widespread area, e.g. urban stormwater runoff, agricultural runoff.
DIP	Dissolved Inorganic Phosphorus

Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow which is a measure of how fast the water is moving rather than how much is moving.
Dispersive Transport	The transport of dissolved matter through the estuary by vertical, lateral and longitudinal mixing associated with velocity shear.
Dissolved Oxygen	Atmospheric oxygen that dissolves in water. The solubility of oxygen in water depends upon temperature and salinity.
Diurnal	A daily variation, as in day and night.
DLWC	Department of Land and Water Conservation
DO	Dissolved Oxygen
DON	Dissolved Organic Nitrogen
DPWS	Department of Public Works and Services
Ebb Tide	The outgoing tidal movement of water within an estuary.
Ecologically Sustainable Development	Development that does not interfere with the short and long term well-being, health and viability of estuarine ecosystems.
Ecosystem	A community of living organisms, together with the environment in which they live and with which they interact.
Eddies	Large, circular, swirling movements of water, often metres or tens of metres across.
EIS	Environmental Impact Statement
EMC	Event-Mean Concentration. The average concentration over a period of time. It is determined by measuring the concentration and flowrate of a particular chemical in a stream or creek, and then dividing the total load by the volume of water. It can then be used to evaluate long-term pollutant loads from a catchment.
Endangered Fauna	Protected Fauna of a species under Schedule 1 of the Threatened Species Conservation Act, 1995.
Entrance Bar	A deposit of sand or silt across the entrance to an estuary. The material may be either fluvial or marine in origin.
Environmental Impact Assessment	An assessment of the impact of a proposed development.
Epibiota	Organisms (plants and animals) attached to other organisms.
Epiphytic	(Of living organisms) attached to and growing on the surface of a plant, but not obtaining food or nutrients from the plant.
Estuarine Processes	Those processes that affect the physical, chemical and biological behaviour of an estuary, e.g. predation, water movement, sediment movement, water quality, etc.

Estuary	An enclosed or semi-enclosed body of water having an open or intermittently open connection to coastal waters in which water levels vary in a periodic fashion in response to ocean tides.
Estuary Management Process	A sequence of activities starting with the formation of an Estuary Management Committee and culminating in the implementation of an Estuary Management Plan that will foster the balanced and sustainable use of estuaries.
Eutrophication	The build-up of nutrient levels in a water body leading to the excessive growth of aquatic plants, which in turn depletes dissolved oxygen levels in the waterbody.
Fauna	Any mammal, bird, reptile or protected amphibian.
FC	Faecal Coliforms
Fish (In the context of the Fisheries & Oyster Farms Act, 1935)	AII or any of the varieties of marine, estuarine or freshwater fishes (whether indigenous or not) and their young, fry and spawn, and unless the contrary intention be expressly stated or the context otherwise requires, includes crustacea and oysters and all marine, estuarine and freshwater animal life, and any part of a fish as hereinbefore defined, but does not include any species of whales.
Flocculate	The coalescence, through physical and chemical processes, of individual suspended particles into larger particles ('floes').
Flood Mitigation Works	Structures that are designed to manage floodwaters (e.g. levees, retarding basins).
Flood Tide	The incoming tidal movement of water within an estuary.
Fluvial	Pertaining to non-tidal flows.
Fluvial Processes	The erosive and transport processes that deliver terrestrial sediment to creeks, rivers, estuaries and coastal waters.
Fluvial Sediments	Land-based sediments carried to estuarine waters by rivers.
Foreshore	The area of shore between low and high tide marks and land adjacent thereto.
Fortnightly Tides	The variation in half-tide levels caused by the monthly cycle of Spring and Neap Tides.
Geomorphology	The study of the origin, characteristics and development of land forms.
GPT	Gross Pollutant Trap
Habitat	The places in which an organism lives and grows. Many estuarine organisms require different habitats at different stages of their life cycles.
Half-Tide Level	The average of successive high tide and low tide levels.

Heavy Metals	Generally, those metals that occur in Groups IS to VIIIB of the Periodic Table with atomic numbers between 21 and 84, but excluding Rare Earth elements. Heavy metals generally have a specific gravity of 5.0 or more and include chromium, iron, nickel, copper, zinc, silver, cadmium, platinum, gold, mercury and lead. Although essential in trace concentrations, some heavy metals are toxic to aquatic organisms at higher concentrations, e.g. mercury, lead, copper and zinc. Even when present in sub-lethal concentrations, heavy metals may adversely affect the health of aquatic organisms.
Herbivores	Grazing animals.
H_s (Significant Wave Height)	H_s may be defined as the average of the highest 1/3 of wave heights in a wave record ($H_{1/3}$), or from the zeroth spectral moment (H_{mo}), though there is a difference of about 5 to 8%.
Humic Acid	Acidity resulting from the decomposition of organic materials.
HWOST	High Water Ordinary Spring Tides
Hydraulic Regime	The variation of estuarine discharges in response to seasonal freshwater inflows and diurnal tides.
Hydrolyse	Decompose by chemical reaction with water.
Hypersaline	Having a salinity greater than seawater (i.e. above 35 parts per thousand). (generally caused by salt concentration through evaporation).
ICOLL	Intermittently closed and open lake or lagoon
Induration	The cementing together of sand particles by natural physical and chemical processes.
Intertidal	Pertaining to those areas of land covered by water at high tide, but exposed at low tide, e.g. intertidal habitat.
Invertebrate	Animal without a backbone, e.g. jellyfish.
Isohaline	A line connecting parts of the water mass having the same salinity, i.e. a contour of equal salinity levels.
JAMBA	Japan Australia Migratory Bird Agreement
LEP	Local Environment Plan
Levee	A man-made embankment or wall built to exclude floodwaters, or a natural embankment adjacent to a waterway built by the deposition of silt from floodwaters.
LGA	Local Government Area
Littoral Zone	An area of the coastline in which sediment movement by wave, current and wind action is prevalent.
Littoral Drift Processes	Wave, current and wind processes that facilitate the transport of sediments along a shoreline.

Macroalgae	Small to large attached algae of several types (red, brown and green). Green algae may become detached and accumulate in shallow waters.
Macrophytes (aquatic}	Rooted aquatic plants, e.g. Eelgrass.
Mangroves	An intertidal plant community dominated by trees.
Marine Sediments	Sediments in coastal waters moved along the coast by littoral processes.
Mathematical/ Computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff and stream flow.
MHL	Manly Hydraulics Laboratory
ML	Megalitres
Mollusc	A large phylum of animals, mostly aquatic, including mussels, snails and octopus, which are soft-bodied, often with a hard shell, unsegmented, and having a head and muscular foot.
MSL	Mean Sea Level
MST	Mean Spring Tide
N/A	Not Applicable
NAGP	Net Acid Generating Potential
Neap Tides	Tides with the smallest range in a fortnightly cycle. Neap tides occur when the sun and moon lie at right angles relative to the earth (the gravitational effects of the moon and sun act in opposition on the ocean).
NPWS	National Parks and Wildlife Service
NSW	New South Wales
NTU	Nephelometric Turbidity Units
Numerical Model	A mathematical representation of a physical, chemical or biological process of interest. Computers are often required to solve the underlying equations.
NWQMS	National Water Quality Management Strategy
PASS	Potential Acid Sulfate Soil
Pelagic Organisms	Organisms living in the water column of the ocean and capable of moving independently of currents.
Phase Lag	Difference in time of the occurrence between high (or low water) and maximum flood (or ebb) velocity at some point in an estuary.

Phytoplankton	Microscopic free-floating aquatic plants (algae).
Pneumatophores	Air breathing roots.
Point-Source Pollution	Specific localised source of pollution, e.g. sewage effluent discharge, industrial discharge.
Polychaete	A segmented worm with bristles.
Protected Amphibian	An amphibian of a species in the NPWS Act, 1974
Protected Fauna	Fauna of a species under the NPWS Act, 1974
Protected Native Plant	A native plant of a species under the NPWS Act, 1974
PWC	Personal Water Craft
Receiving Waters	Waters into which effluent or waste streams are discharged or discharge.
Reptile	"A snake, lizard, crocodile, tortoise, turtle or other member of the class reptilia (whether native, introduced or imported), and includes the eggs and the young thereof and the skin or any other part thereof".
Residual Sediment Flux	The net upstream or downstream movement of sediment over a tidal cycle, often determined by tidal distortion and gravitational circulation.
Revetments	Walls built parallel to the shoreline to limit shoreline recession.
Riparian Vegetation	Vegetation growing along banks of rivers, including the brackish upstream reaches of an estuary.
RL	Reduced Level
Runoff	That proportion of rainfall that drains off the land's surface.
Salinity	The total mass of dissolved salts per unit mass of water. Seawater has a salinity of about 35 g/kg or 35 parts per thousand.
Salinity Limit	The landward limit of salinity intrusion along an estuary. The location of the salinity limit changes with freshwater discharge, high freshwater inflows moving the limit downstream, whilst low flows allow salt and the salinity limit to migrate upstream.
Saltation	The movement of sediment particles along the bed of a waterbody in a series of 'hops' or 'jumps'. Turbulent fluctuations near the bed lift sediment particles off the bed and into the flow where they are carried a short distance before falling back to the bed.
Saltmarsh	A coastal wetland subject to tidal flooding and vegetated by grasses, herbs and low shrubs that are tolerant of high salinity.
Sediment Load	The quantity of sediment moved past a particular cross-section in a specified time by estuarine flow.
Semi-diurnal	A twice-daily variation, e.g. two high waters per day.

Shear Strength	The ability of the bed to accommodate flowing water without the movement of bed sediments. The shear strength of the bed depends upon bed material, degree of compaction, armouring,
Shear Stress	The stress exerted on the bed of an estuary by flowing water. The faster the velocity of flow' the greater the shear stress.
Shoals	Shallow areas in an estuary created by the deposition and build up of sediments.
Slack Water	The period of still water before the flood tide begins to ebb (high water slack) or the ebb tide begins to flood (low water slack).
SOLP	Sydney Water Sewer Overflow Licencing Project
SPCC	State Pollution and Control Commission (now NSW EPA)
Spring Tides	Tides with the greatest range in a monthly cycle, which occur when the sun, moon and earth are in alignment (the gravitational effects of the moon and sun act in concert on the ocean)
SPS	Sewage Pumping Station
SQID	Stormwater Quality Improvement Device
SS	Suspended Solids
Storm Surge	The increase in coastal water levels caused by the barometric and wind setup effects of storms. Barometric setup refers to the increase in coastal water levels associated with the lower atmospheric pressures characteristic of storms. Wind setup refers to the increase in coastal water levels caused by an onshore wind driving water shorewards and piling it up against the coast.
STP	Sewage Treatment Plant
Stratigraphy	That branch of geology dealing with the ordering of rocks into their relative ages.
Sub-Aerial Sand Barrier	A sand barrier with crest level above high tide; usually vegetated.
Super-Elevation	See Storm Surge.
Surface Pollutants	Floating pollutants that do not mix effectively with water, e.g. Oil.
Suspended Sediment Load	That portion of the total sediment load held in suspension by turbulent velocity fluctuations and transported by flowing water.
Swale	A topographic depression that may retain water.
Tidal Amplification	The increase in the tidal range at upstream locations caused by the tidal resonance of the estuarine waterbody, or by a narrowing of the estuary channel.
Tidal Celerity	The speed of travel of the tidal wave along estuaries. Celerity depends upon the depth of water; the deeper the water, the greater the celerity.

Tidal Delta	The build-up of shoals in the lower reaches of an estuary due to the gradual accumulation of marine sands transported into the estuary through its entrance.
Tidal Distortion	The distortion of the tidal variation of water levels in shallow estuaries caused by the differences in the celerity of rising (faster) and falling (slower) water levels.
Tidal Exchange	The proportion of the tidal prism that is flushed away and replaced with 'fresh' coastal water each tide cycle.
Tidal Excursion	The distance travelled by a water particle from low water slack to high water slack and vice versa.
Tidal Lag	The delay between the state of the tide at the estuary mouth {e.g. high water slack) and the same state of tide at an upstream location.
Tidal Limit	The most upstream location where a tidal rise and fall of water levels is discernible. The location of the tidal limit changes with freshwater inflows and tidal range.
Tidal Planes	A series of water levels that define standard tides, e.g. 'Mean High Water Spring' (MHWS) refers to the average high water level of Spring Tides.
Tidal Prism	The total volume of water moving past a fixed point on an estuary during each flood tide or ebb tide.
Tidal Propagation	The movement of the tidal wave into and out of an estuary.
Tidal Range	The difference between successive high water and low water levels. Tidal range is maximum during Spring Tides and minimum during Neap Tides.
Tidal Trapping	The process whereby a discrete body of water is trapped over shallow shoal areas on the flood tide and separated from other water moving up the estuary. This facilitates mixing.
Tidally Averaged Models	Models that predict estuarine behaviour over periods greater than a tidal cycle, i.e. the temporal resolution is of the order of days, weeks or months.
Tidally Varying Models	Numerical models that predict estuarine behaviour within a tidal cycle, i.e. the temporal resolution is of the order of minutes or hours.
Tides	The regular rise and fall in sea level in response to the gravitational attraction of the sun, moon and planets.
Tributary	Catchment, stream or river which flows into a larger river, lake or water body
TKN	Total Kjeldahl Nitrogen (Ammonia + Oxidised Nitrogen)
TN	Total Nitrogen
Total Catchment Management	The coordinated and sustainable use of land, water, vegetation and other natural resources on a water catchment basis so as to balance resource utilisation and conservation.
TP	Total Phosphorus

TPR	Tidal Prism Ratio
Training Walls	Walls constructed at the entrances of estuaries to improve navigability.
Turbidity	A measure of the ability of water to absorb light.
T_z (Zero Crossing Period)	The average period of waves in a train of waves observed at a location.
Velocity Shear	The differential movement of neighbouring parcels of water brought about by velocity gradients. Velocity shear causes dispersive mixing, the greater the shear (velocity gradient), the greater the mixing.
Vertebrate	Animal with a backbone, e.g. fish, birds.
Water Quality	The suitability of the water for various purposes, as measured by the concentration or level of a wide variety of contaminants.
Well-Mixed Estuary	Estuary characterised by strong vertical mixing and weak or non-existent vertical salinity gradients.
Wind Shear	The stress exerted on the water's surface by wind blowing over the water. Wind shear causes the water to pile up, against downwind shores and generates secondary currents.

* A number of definitions have been derived from the Estuary Management Manual (1992).

APPENDIX B

ACTIONS IDENTIFIED IN THE ESTUARY MANAGEMENT STUDY BUT NOT INCLUDED IN THE ESTUARY MANAGEMENT PLAN

Option Identifier	Description
Mon-19	Investigation of Impact of Long Reef Toilets to be undertaken
Com-33	Involvement of community groups in management works (wetland planting, clean-up programs), (eg work undertaken by organisations such as OzGreen)
Com-35	Support volunteer efforts and promote increased involvement from schools and the local community
Com-28	Consider fencing portions of the refuge if parts are to be opened up with the bird watching walk.
Com-17	Entrance - Signpost legislation on entrance opening, penalties along with educational message
Mon-24	Monitor Clarence Avenue cleared area for growth of weeds and invasion of weeds into bushland. Allow weeds, including Pittosporum, to remain along the edge to Hawkesbury Avenue (to protect area from invasion of Pennywort and Ehrharta).
Mon-35	Contractors should use the standard format for record keeping that is currently under trial in Warringah. Encourage the Friends to use the same recording system. Maximise the use of Council's GIS and connected databases to develop useable, centralised records. Aim to have records on the GIS of: Conditions of bushland (record every 2 years), Plantings in bushland, Fauna sightings, Fire history, Areas worked by contractors and volunteers.
Ref-29	Incorporate fire history map into Council GIS, map every future fire on the GIS
For-11	Provide bicycle parking racks in highly visible locations with SLSC Carpark
Ref-3	Recommended locations for the proposed bird hide are provided in Smith and Smith (2000). It is also recommended that this bird hide be complemented by additional nearby perches to attract and enhance viewing opportunities and increase public awareness of the habitat value of the site to birds.
For-8	Assess dunes every 2 years for evidence of deterioration of vegetation communities. If vegetation is senescent, replant
Cat-15	Nutrients - Develop guidelines for new development areas in relation to DA's. Develop native planting guidelines to aid nutrient control and manage nutrient runoff from newly landscaped areas - distribute to body corporates.
Mon-36	Appropriate environmental assessment conducted to determine the impact of the current entrance opening regime
Com-6	Maintain, advertise and enhance Web Site (eg Living Waters Living Communities)
For-12	Enforce a curfew on the use of the Surf Club and the open areas of the Reserve; or impose noise limits
Ref-1	Providing additional waterbird perches above water level in the lagoon (which would benefit the birds and bird watchers)
Com-29	Development of an Eco-tour of Dee Why Lagoon in association with the Coastal Environment Centre as a fee for service
Ref-23	Cubby houses' and other dwellings are to be removed from bushland and the site rehabilitated within one month following detection
Tri-7	Hazard reduction and ecological fire program for the implementation of bush regeneration treatments following fire.
Mon-33	Set up a monitoring programme to watch spread of Watsonia
Tri-11	Stabilise eroding bank opposite the tributary with rock armouring
Tri-12	Stabilise tributary channel banks in area H (Fig 3.6) with reinforced grass and or benching to reduce height and slope of banks, use post and rail timber fencing in conjunction with appropriate dense shrubbery along top of tributary bank to minimise public risk.
Com-2b	Media Package (mail out and web access)
Mon-32	Encourage tertiary students to carry out further research by providing Council resources to assist in undertaking their project. Disseminate research information through Council's public outlets.
Ref-19	Use Smith and Smith Flora and Fauna of Major Warringah Council Reserves (Dec 1997), and Ondinea, Breeding Calendar for the Birds of Warringah (July 1999), to help determine whether any area is likely habitat prior to weed removal.
Wat-10	Design guidelines to direct the frequency and conditions for opening the lagoon to prevent

Option Identifier	Description
	flooding
Tri-10	Stabilise outlet to the concrete channel to the north of the wetlands
Com-3	Volunteer Manual (web access)
Com-15	Identify suitable high profile areas where bushland restoration activities are planned. Develop interpretive signs and/or leaflets which are to be erected or distributed in conjunction with restoration activity. Signs to be either permanent or relocated to new works as appropriate
Ref-30	Centralise records of all fauna species seen in the refuge, and location of sighting. Log these on Council's GIS
Cat-41	Run, or co-ordinate a series of workshops for identified Council officers which explains Council and its officers responsibilities under various acts and policies relating to bushland, particularly under SEPP 19. Regularly update this program as legislative changes are enacted or key staff are replaced
Ref-28	Provide a map to put onto the Council GIS showing location of plantings and species used.
Com-30	Use of anniversary days for information/education purposes such as a Threatened species day, Clean-up Australia Day and similar programs
Mon-28	A brief bi-annual bushland management report (in accordance with contracts) for Dee Why Lagoon Wildlife Refuge is to be produced to document All bush regeneration undertaken by contractors, Council and volunteers, Other bushland and dune management works, Bushland management objectives for the following year
Ref-27	Initiate three monthly formal site meetings between the Contractor and the Council Officer, with minutes. Invite a representative of the FoDWL to observe at these meetings
Com-9	Install signage to walking trails where trails cross roadways (say 10 locations)
Ref-4	Erect boundary fences, which are of similar design to existing boundary fences of the Refuge, on all remaining unfenced bushland perimeters. Priority should be given to those areas where recreational or bushland management activity has increased or usage changed. Inconspicuous accessways/gates should be included to allow for bush regeneration and other management activities and low-key use by the Friends of Dee Why Lagoon, Council staff and the public.
Tri-20	Co-ordinate revised management practices between Council departments on the following issues: Treatment of stormwater outlets, Treatment/piping of creeks
Com-14	Installation of components of the new signage and interpretive/map system proposed in the Recreational Strategy for Warringah Beaches and Coastal Open Space where appropriate.
Mon-23	Monitor the response of each burn with photographs and descriptions. Ensure that comprehensive records are kept in a form that will be accessible to Council officers
Mon-25	Monitor for invasion of Morning Glory and other weeds
Com-22	Upgrade formal walkway network around Southern and Eastern Perimeters
Com-23	Install seats between Hawkesbury Avenue and the beach
Tri-14	Undertake further hydrological work to estimate the creek low flow regime and thereby establish a viable pond size for the southern wetland area. It is also recommended that the distance and depth between the proposed pond bank and south west side of the island be increased to improve pond circulation and reduce the risk of channel closure due to sedimentation.
Mon-30	Undertake a fauna study of mammals, birds, reptiles and amphibians within the Dee Why Lagoon Wildlife Refuge. Existing records should be reviewed. The study should also identify feral animals, their impact upon wildlife and include wildlife management recommendations. Determine the requirements for on-going surveys (monitoring regimes)
Ent-4	Formalisation of access points for prawning/Identification and marking of areas for prawning
Cat-29	Continue feral bird eradication program
Cat-19	Develop and implement a Section 94 Plan for Dee Why town centre area which identifies and equitably apportions the cost of implementing public works associated with recommendations of the Dee Why Urban Design Strategy
Cat-35	Provide bicycle parking racks in highly visible locations where necessary.

Option Identifier	Description
Mon-17	Monitor lagoon fish stocks before and after a series of breakouts to assess recruitment and nursery characteristics
Com-4	Periodic Newsletter (mail out eg Warringah Council Coastal News and Warringah Environmental Education Newsletter - WEEN and web access) (eg for Water quality monitoring results and other indicators of Lagoon health)
Com-27	Informal access paths through bushland are to be blocked using cut vegetation and temporary fencing if required, within one month of detection
Com-34	Involving the community in partnership with the Council and other government bodies through the Dee Why/Curl Curl Joint Estuary/Floodplain Management Committee
For-9	Integrate additional trees and landscaping to soften appearance and improve aesthetics (within landscape masterplan process)
Mon-26	Sweep through of the entire Refuge twice a year to assess bushland condition, target any problem areas, and identify future works. Map the condition of bushland every 2 years using an independent assessor. Establish photo points in each vegetation community in each Zone, and in degraded areas and take photos annually.
Wat-1	Remains of WWII tank traps to be left in their present condition unless they become a safety hazard or require removal for improvement of the natural environment
Tri-15	Undertake feasibility study and concept design for the area west of Dumic Place generally along the lines proposed in the Dee Why Wetland Rehabilitation and Management Plan prepared by the SWC Wetlands and Ecological Management Consultancy (1994). The feasibility study should include a hydrological study to estimate the low flow regime in Dee Why Creek to assist in identifying the type and size of wetlands/ponds that would be viable. The northern wetland remnant is near the top of the catchment and because of low creek flows during dry weather it is considered likely that this would be an ephemeral wetland.
Mon-21	Inspect entire refuge twice yearly for new outbreaks of weeds, and to check that current methods are appropriate.
Ref-22	Establish understorey species in order to provide habitat for smaller bird species
Mon-34	Undertake a study of migratory and resident water birds utilising Dee Why Lagoon Wildlife Refuge.
Cat-31	Review public safety measures at all stormwater quantity and quality control structures. Improve signage and fencing if deemed necessary
Com-12	Research the most common non-English languages spoken by users/visitors. Develop multi-lingual advisory signs (eg First Aid and Toilets) in those non-English languages most commonly spoken by users/visitors.
Ref-21	Identify and where appropriate enhance wildlife corridors between the Dee Why Lagoon Wildlife Refuge, Long Reef Headland and other natural areas
Mon-31	Undertake a survey of selected aquatic and terrestrial invertebrates and fish utilising the Dee Why Lagoon Wildlife Refuge. The study is to include a review of existing records, an assessment of the impact of fishing and bait collection activities carried out by amateur fishermen and invertebrate management recommendations.
For-13	Instigate night patrol of the south-eastern area by Council Rangers
Mon-20	Monitor the following sites for erosion: The outlet from a tributary drain located between the tennis courts and residential development near the top of the reach of Dee Why Creek, unlined section of Dee Why Creek immediately downstream of the culvert crossing into the Cromer Soccer Club.
Mon-18	Identify depth to m AHD of clay sill layer below surface
Mon-7	Well targeted set of measurements of both water column and benthic nutrient remineralisation processes across the entire lagoon. Should be conducted over at least one annual cycle (12 months) and include aspects such as concomitant nutrient inputs via, for example, sewerage overflows and stormwater.
Com-21	Closure of maintenance access track and replacement with boardwalks where there is periodic inundation.
Mon-16	Periodic (annual?) monitoring of entrance breakout conditions (both width and depth and water quality through a breakout) to provide feedback data for entrance management

Option Identifier	Description
	policy
Tri-13	Clean out unlined channel between the soccer and bowling club and stabilise the creek with toe rocks and thick grass to complement new riparian tree planting.
Com-38	Instigate an annual working bee with Council officers (ideally from a number of departments) and the friends.
Mon-8	Improved understanding of seagrass dynamics be obtained so that rehabilitation work of the lagoon's seagrass meadows can be undertaken as a measure to improve lagoon health and to achieve better protection of its benthic biota (through the provision of habitat).
For-4	Continued control of Feral predators (including foxes, domestic dogs and cats) pose a threat to waterbirds.
Ref-5	Continued control of Feral predators (including foxes, domestic dogs and cats) pose a threat to waterbirds. Foxes the biggest threat to native terrestrial fauna. Maintain baiting, trapping and location of fox dens programs. Consideration must be given to the dynamic relationship between different feral species.
Com-24	Development of the multi-use access trail as proposed by Council (P&R Plan No 179-11&12) with amendments
Ref-14	Ongoing replacement planting of aging species.
Tri-23	Re-construct the piped drainage outlet on the western bank in Area H (Fig 3.6) as per Fig 7.2
Com-31	Information Bay at Dee Why shopping centre, libraries and other prominent locations.
Tri-16	Extend the pipe drain along the open channel running parallel to the Dee Why Bowling Club to minimise the risk of pollutants and grass clippings being dumped in the watercourse
Mon-2	Assessment of magnitude of issue of leachate from James Meehan Reserve, Cromer Soccer Club, Dee Why gardens (former tip for building waste). Monitor stormwater outlets from these sites as well as water quality upstream and downstream of sites to identify magnitude of load inflow from groundwater. Identify possible management options and implement.
Cat-28	Continued control of Feral predators (including foxes, domestic dogs and cats) pose a threat to waterbirds.
Com-36	Council to appoint a bush regeneration contractor for the study area whose role would include supporting and directing volunteer groups
Ent-1	Maintenance of entrance training works - gabion baskets on northern side and rock wall on southern side.
Ref-10	Implement hazard reduction and ecological fire program for the implementation of bush regeneration treatments following fire.
Ref-12	Progressively remove non endemic native species (such as Casurina glauca).
Wat-9	Continue to manage the lagoon waterbody level to maintain water levels below that of DY Creek stormwater pipes using existing water level recording system and real-time alarm system
Cat-24	Redesign drains to reduce impact on native vegetation
Com-37	Continued assistance for School education, Waterwatch, Streamwatch
Mon-3	Measurement of actual pollutant loads from the catchment to allow for a comparison of environmental conditions and develop a better understanding of the relationship between loads and prevailing catchment conditions
For-6	Reinstate foreshore adjoining James Meehan Reserve.
Mon-13	Continue Monitoring at all Sites with modifications in line with findings of WRL report on Water Quality Monitoring for Warringah
Mon-5	Establishment of a met-estuary station to measure local water temperatures, salinities and wind circulation patterns
Ref-20	Weed vines are to be regularly removed from boundary fences
Mon-4	Data collection to quantify groundwater characteristics and dynamics
Cat-13	Inspect for maintenance of soil and water management on building sites as part of the building inspection service.

Option Identifier	Description
Tri-21	Enhance the presentation and amenity of the drainage easement between Dee Why Parade and Oaks Avenue and improve the amenity and appearance of the drainage easement as a pedestrian through site link.
Com-39	Establish an advisory group (SCAG) as either a separate group to the Dee Why/Curl Curl Joint Estuary/Floodplain Management Committee or a subset of the EMC to meet twice yearly to report community comments to Council for their action and review the implementation of strategies. One of the meetings should be prior to Council's annual budget in order to address financial priorities. A Council officer should be designated as a permanent member of this group.
Cat-32	Incorporate opportunities for children's recreation such as playgrounds, sensory areas and children's art into the area where appropriate.
Com-26	Viewing platforms for low impact appreciation of Refuge.
Wat-5	Sediment capping - to control nutrient release and/or heavy metal release
Mon-15	Investigate the historic location of the lagoon entrance and implications for sand flow between Dee Why and Long Reef
Cat-6	Trash racks within existing sediment traps along Pittwater Road (SWMP Ref: DL-1)
Mon-12	Daily water quality monitoring in the lagoon and stormwater outlets
Wat-2	More storage will reduce flooding pressures prior to opening and address habitat loss issue after opening
Tri-22	Remove or reconstruct the culvert at Dumic Place to allow the creek to drain freely past this point
Cat-22	Consolidation of drains along Pittwater Road to reduce fragmentation of bushland and direct piping stormwater into the lagoon
Cat-34	Incorporate opportunities for young people's recreation such as skating/blading, cycling, basketball, beach volleyball and social spaces into the area where appropriate.
Tri-17	Pipe creek low flows (up to and including 5 year ARI flow) from Fisher Parade North to the small culvert west of Dumic Place. Retain a surface floodway for flows up to the 100 year ARI event. The surface floodway may be lined with rocks to allow easier recognition of its purpose
For-10	Incorporate youth recreation facilities on south-eastern foreshore open space area such as skating/blading, cycling, basketball, beach volleyball and social spaces (within landscape masterplan process)
Ref-11	Undertake regular tree lopping along the Refuge boundary (particularly at Pittwater Rd) to reduce public safety risk (and fence damage)
Com-25A	Bridge over Pittwater Road and viewing platform linking foreshore walk/bike ways with those west of the road. Provide view into core bushland without intruding on refuge. Provide safe community link with Lagoon southern foreshore areas and pathways.
Ent-6	Open lagoon entrance
Com-25b	Develop a pedestrian circulation system which does not compromise the creeks ecological integrity. Pathways to be of appropriate scale and material for the landscape they are traversing. For example, pathways through lawn could be bitumen, 900mm wide with timber edging. Pathways through bushland areas may be either gravel paths (using inert material), or simply a marked trail rather than a constructed pathway
Cat-23	Divert stormwater from some portions of the catchment to beaches instead of the lagoon
Wat-3	Harvesting - physical removal of plants. Ecological consequences of such removal should be carefully evaluated before adopting this option
Wat-4	Beach Cleaning - physical removal of weed deposited on an estuarine shoreline
Com-13	Utilise advertising/sponsorship on facility signage providing that it does not dominate the public amenity of, or signage for, the land.
Ent-7	Reinstate the lagoons entrance

APPENDIX C

ALL OPTIONS IDENTIFIED IN THE EMS

Report Prepared For
Warringah Council

Dee Why Lagoon Estuary Management Plan

Report J2014/R2061
March, 2004