HORNSBY SHIRE COUNCIL

BEROWRA CREEK
ESTUARY MANAGEMENT STUDY
AND
MANAGEMENT PLAN

March, 2002

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BEROWRA CREEK
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LIST OF ABBREVIATIONS

ANZECC	Australian and New Zealand Environment and Conservation Council
BCMC	Berowra Catchment Management Committee
BMP	Best management practice
BSMP	Berowra Catchment Stormwater Management Plan
BVRPT	Berowra Valley Regional Park Trust
BWPM	Berowra Waters Plan of Management
Chlor-a	Chlorophyll-a
DA	Development Application
DCP	Development Control Plan
DLWC	Department of Land and Water Conservation
DO	Dissolved Oxygen
DUAP	Department of Urban Affairs and Planning
EPA	Environment Protection Authority
ESD	Ecologically Sustainable Development
FC	Faecal coliforms
Fisheries	NSW Fisheries
Health	NSW Department of Health
HNCMT	Hawkesbury-Nepean Catchment Management Trust
HPP	Habitat Protection Plan
HSC	Hornsby Shire Council
LEP	Local Environment Plan
m AHD	metres above Australian Height Datum
MARLC	Metropolitan Aboriginal Regional Land Council
MHL	Manly Hydraulics Laboratory
NPWS	National Parks and Wildlife Service
NSWAg .	NSW Department of Agriculture
RACC	Regional Algal Coordinating Committee
REF	Review of Environmental Factors
REP	Regional Environment Plan
RTA	Roads and Traffic Authority
SEPP	State Environmental Planning Policy
SoJI	Statement of Joint Intent
SS	Suspended Solids
STP	Sewage Treatment Plant
SWC	Sydney Water Corporation
TCM	Total Catchment Management
TEL	The Ecology Lab
TP	Total Phosphorus
TN	Total Nitrogen
UWS	University of Western Sydney
Waterways	NSW Waterways Authority
WMA	Webb McKeown & Associates
WQMS	Berowra Creek Water Quality Management Strategy

EXECUTIVE SUMMARY AND ESTUARY MANAGEMENT PLAN

INTRODUCTION

This Estuary Management Study and Estuary Management Plan have been prepared under the NSW Government✪s Coastal Policy, as part of the Estuary Management Program. The aim of the Estuary Management Program is to achieve integrated, balanced, responsible and ecologically sustainable use of the State✪s estuaries within an overall catchment management perspective.

The NSW Estuary Management Program provides funding assistance to Local Government Authorities for the production of Estuary Management Plans in their areas. An Estuary Management Plan is developed through the following process:

THE ESTUARY MANAGEMENT PROCESS

1. FORMATION OF THE ESTUARY MANAGEMENT COMMITTEE
2. ASSEMBLY OF EXISTING DATA
3. ESTUARY PROCESSES STUDY
4. ESTUARY MANAGEMENT STUDY
   - Canvass community input
   - Identify essential estuary features
   - Identify current uses and conflicts of use
   - Identify possible future land uses and impacts
   - Assess need for nature conservation
   - Assess need for remedial measures
   - Identify and assess management objectives
   - Assess management options
5. DRAFT ESTUARY MANAGEMENT PLAN
   - Canvass community input
   - Management objectives
   - Recommendations
   - Implementation
6. DRAFT PLAN REVIEW
   - Public and Government
7. ADOPTION AND IMPLEMENTATION
   - Local Government planning controls
   - Restoration works
   - Monitoring programs
   - Education and awareness programs
8. MONITORING AND REVIEW OF MANAGEMENT PROCESSES

The study was managed by the Berowra Creek Estuary Management Committee, which was formed and is chaired by Hornsby Shire Council. The preceding Estuary Processes Study, which was also managed by the Committee, provided the technical basis for this Management Study and Plan.

Community involvement is an integral part of the estuary management process and has been encouraged during all stages. The Committee includes several members from the local community, as well as representatives from Council, the Berowra Catchment Management Committee and relevant Government Departments including:

- Department of Land & Water Conservation (DLWC),
- Waterways Authority,
- NSW Fisheries.

Community consultation has also been undertaken through a ⊙Contact Group⬡ which comprises over 50 individuals and community groups with an immediate interest in Berowra Creek estuary. This group was used to provide input and to review the Estuary Management Study.

PLANNING AND MANAGEMENT CONTEXT

There are a large number of Local, State and Commonwealth Government authorities involved in the management of the Berowra Creek estuary and its contributing catchment areas. The primary management control authority is Hornsby Shire Council.

Because of concerns over water quality in the catchment and the complexity of the management structure, Hornsby Shire Council and several key NSW government agencies have formally agreed to work together to ensure ecologically sustainable development is achieved and to recover the environmental health of the creek.

The agreement, known as the Statement of Joint Intent (SoJI), was signed in 1994 by:

- Department of Urban Affairs and Planning (DUAP),
- Environment Protection Authority (EPA),
- Hawkesbury-Nepean Catchment Management Trust (HNCMT),
- Sydney Water Corporation (SWC),
- Hornsby Shire Council (HSC).

The SoJI focuses on improving the environmental health of Berowra Creek. The initial goal is to achieve water quality in Berowra Creek estuary (downstream of Fishponds Waterhole) that is consistent with the pursuit of recreational activities such as swimming, canoeing and boating. A long term goal is for water quality to allow fishing with confidence and safety as well as protection of the shellfish industry.

A number of documents relating to the Berowra Creek estuary stem from the Statement of Joint Intent. Two Council documents of particular importance are:

- Berowra Creek Water Quality Management Strategy (WQMS),
- Berowra Catchment Stormwater Management Plan (BSMP).

Another Council Plan not directly related to the SoJI but also of particular importance to the estuary is the Berowra Waters Plan of Management.

Other government agencies with plans relevant to the estuary include:

- Department of Urban Affairs and Planning,
- Sydney Water Corporation,
- NSW Fisheries,
- NSW Waterways Authority,
- National Parks & Wildlife Service (NPWS),
- Hawkesbury-Nepean Catchment Management Trust,
- Department of Land and Water Conservation,
- Berowra Valley Regional Park Trust (BVRPT).

The three Council documents, as well as other planning controls have been thoroughly reviewed in the preparation of this Management Plan to avoid duplication and the possibility of adopting conflicting management strategies. For further details of these plans, refer to the relevant agency documents or the Estuary Management Study.

THE STUDY AREA

The Berowra Creek estuary and its catchment are situated entirely within the Hornsby Shire Local Government Area on the northern outskirts of the Sydney metropolitan area. Berowra Creek is a major tributary of the lower Hawkesbury River, entering the Hawkesbury River some 25 kilometres from the ocean.

The estuary itself extends for over 23 kilometres in a southerly direction from the Hawkesbury River to the tidal limit at Rocky Fall Rapids (refer Figure 1). The study area includes Marramarra Creek estuary which extends in a westerly direction from near the confluence with the Hawkesbury River for over 7 kilometres.

Berowra Creek estuary is a drowned river valley, consisting of steeply incised gorges with surrounding plateau areas. Because of its topography there is limited development directly adjacent to the waterway, most of which is only accessible by boat. In total there are 233 river settlement allotments with 169 residences. Most development is in the Berowra Waters/Calabash Bay area, although there are significant developments in Neverfail Bay, Coba Point and the entrance to Marramarra Creek (refer Figure 2).

In addition to residential development, Berowra Waters is the primary access point to the waterway. The area provides two marinas, restaurants, a public boat ramp and wharves, parking and other amenities. A significant feature is the vehicle ferry across the waterway. Crosslands in the upper estuary is the only other part of the estuary accessible by motor vehicle. Development at Crosslands consists of a Youth and Convention Centre, and a public reserve with picnic facilities. The estuary is popular for recreational boating and fishing. It is also used by commercial fishing operators. The lower estuary is used for oyster aquaculture, with Berowra and Marramarra Creeks providing areas for the growth and fattening of oysters.

The upper estuary, upstream of Woolwash, is very shallow with depths often less than 1 m. The channel becomes deeper and reaches a depth of approximately 5 m below AHD (Australian Height Datum) at Berowra Waters. Through the middle estuary, and particularly at Calabash Point, there are a number of deep holes to depths of 17 m. These deep holes have a significant influence on water movement in the system, slowing the water down and assisting the formation of algal blooms.

The lower estuary is generally around 5 m deep, although at the Hawkesbury River bar the depth is only 3 m below AHD. The lower west zone of the estuary, Marramarra Creek, is much shallower with depths of 2 m or less. The shallow muddy bays provide ecologically productive environments. Big Bay is one such area and has regional significance because of its mangrove community.

The catchment is highly developed in the south with the residential, industrial and commercial development of Hornsby and its surrounding suburbs. The north of the catchment is predominantly bushland and comprises Marramarra National Park, Muogamarra Nature Reserve and Berowra Valley Regional Park. The semi-rural areas of Arcadia, Galston and Glenorie are situated to the west of the creek.

There were nineteen EPA licenced discharges in the catchment, mainly related to sewage outlets. The catchment contains two sewage treatment plants (STP), Hornsby Heights STP and West Hornsby STP. Together these service about 76 000 people. The semi-rural areas around Arcadia, Galston and Glenorie as well as the river settlements are unsewered and rely on on-site treatment. Many of the river settlements such as Berowra Waters and Calabash Bay have reticulated water, but rely on on-site sewage treatment.

MANAGEMENT ISSUES AND OBJECTIVES

General

Issues specifically affecting management of the Berowra Creek Estuary were initially identified by the Estuary Management Committee as part of the Estuary Processes Study. These issues have been reviewed as part of the Estuary Management Study, firstly by the Estuary Management Committee and then by the wider community through the Estuary Management Contact Group.
To assist with the assessment and development of management objectives, the issues have been grouped into four categories covering Estuary Management, Water and Sediment Quality, Human

Use and Ecology. It should be noted that many of the relevant issues have already been addressed by Council as part of:

- Berowra Creek Water Quality Management Strategy,
- Berowra Creek Stormwater Management Plan,
- Berowra Waters Plan of Management.

Issues dealt with extensively by other plans have not been afforded detailed consideration by this Plan. For example, car parking and traffic problems were addressed by the Berowra Waters Plan of Management and have therefore not been included in this Plan.

Estuary Management

Data Collection Co-ordination: This issue relates to the various water quality testing procedures and approaches currently undertaken in the Berowra Creek catchment and the need to co-ordinate these between the Agencies involved. As part of the Statement of Joint Intent, Sydney Water, the NSW Environment Protection Authority, and Hornsby Shire Council formally agreed to develop a cooperative water quality monitoring program which was to include a joint database and reporting system.

Despite the establishment of monitoring programs by Sydney Water and Council, there is still a lack of co-ordination between the agencies. Greater co-ordination is required to maximise the relevance and value of the information gathered. The Berowra Catchment Management Committee has recently received a grant from the National Heritage Trust to develop a joint integrated data base. This initiative is likely to improve coordination between the agencies. It is important that the compiled data is easily accessible to the public, such as through an Internet site.

The management objective is to ensure a co-ordinated and integrated water quality monitoring program is established for the catchment and the estuary which is easily accessible to waterway managers and users.

Human Health and Safety: Algal blooms, high levels of faecal contamination and aquatic stingers in estuary waters, all pose a threat to human health and safety. This issue involves the management of the human health and safety problems. It does not address the environmental processes by which these problems occur which are either a natural phenomenon or are addressed in other sections.

In the past there has been confusion as to who is responsible for the proper management of algal blooms. This is partly because the management of algal blooms in estuaries has passed from EPA to DLWC in recent years and the roles and responsibilities of each body have been confused in the process. Algal bloom management falls under the responsibility of the Regional Algal Co-ordinating Committee (RACC) now chaired by the DLWC. A review of algal bloom management is currently being carried out by DLWC.

For each of the cases, algal blooms, faecal pollution and stingers, the issue relates to identification of the problem and response to the occurrence. The management of algal bloom and faecal pollution warnings is particularly significant in relation to primary and secondary human contact as well as oyster production and harvesting. Aquatic stingers are of concern for primary contact activities, such as swimming.

To properly inform and protect the public a recreational water quality program would need to be established. Recreational water quality monitoring requires a thorough monitoring schedule. The ANZECC guidelines require water quality testing to be carried out every 6 days.

In relation to the issue of warnings to the general public as to the health and safety of the waterway, the community consultation process identified widespread concern as to their implications and Council's legal responsibilities. Council's obligations arise from its duty of care, having provided waterway access facilities, yet knowing that on occasions the water is potentially not safe or healthy. The nature and extent of Council's obligations however, need to be clarified.

The management objective is to establish formal monitoring, identification and warning procedures as required, so as to safeguard public health and minimise disruption to recreational and commercial waterway users.

Estuary Management: As the estuary management program develops within Hornsby Shire Council additional human resources will be required to both develop estuary management plans and to then oversee implementation. Initially, Berowra Estuary Management Plan will need to be implemented. Following on from this, funding is now available for a Brooklyn Management Plan which will also need to be developed and then implemented. Two further areas, Cowan Creek and the main Hawkesbury River from Wisemans Ferry down to the Hawkesbury River Road Bridge, will need to be addressed in a similar way. Each of these plans may take up to 3 years to develop and will then require implementation.

There is a considerable risk that as there is no one person with defined ownership/responsibility for overseeing the estuary management program, these individual estuary plans and the overall integration of the plans will not be implemented properly and Council will not fully benefit from the funding available.

The management objective is to ensure that Berowra Creek and surrounding estuaries are managed effectively and that the estuary management plans are properly produced and implemented.

Water and Sediment Quality

Catchment Sourced Pollution: This issue relates to the adverse impacts on the estuary from catchment sourced pollutants, particularly nutrients and faecal material but also sediments and chemical pollutants generally. The highly developed urban areas of the catchment, and the two STP's that service these areas, are major sources of pollutants. Several disused waste disposal sites have also been identified as contributing to the overall pollution load. The Estuary Processes Study and other water quality studies have found that STP discharges, STP bypassing and urban catchment runoff combined have contributed to degradation of the estuary.

The management objective is to sufficiently reduce the level of catchment sourced pollutants so as to protect aquatic ecosystems, and allow for primary human contact and the production of edible fish, crustacea and shellfish.

Freshwater Inputs: The Estuary Processes Study identified the high volume of freshwater entering the upper estuary as a significant contributor to the reduced diversity and abundance of aquatic fauna in these areas. The high level of freshwater inputs is also associated with density stratification in the middle estuary after rain. The Estuary Processes Study identified this density stratification as a precursor to the formation of algal blooms.

The high volumes of freshwater have two separate sources. The main sources during dry weather are STP discharges which more than double mean catchment baseflows. During wet weather the sources are a combination of STP discharges and bypasses, plus increased runoff from hard surfaces in the urban areas.

The management objective is to reduce the volume of catchment sourced freshwater to a level suitable for the restoration of aquatic ecosystems in the upper estuary.

Boat Sourced Pollution: This issue relates to the discharge of faecal material and gross pollutants (rubbish) from vessels using the estuary. The issue was identified as a problem by the Estuary Management Committee and local residents. It mainly relates to "stay aboard" boat users and a lack of adequate disposal facilities (such as sewage pumpout facilities and waste skips) with inadequate policing of existing control. The problem applies to both commercial and recreational vessels including day trippers and overnight users.

The management objective is to eliminate boat sourced pollutants by providing appropriate infrastructure and controls.

River Settlement Sourced Pollution: The existing River Settlements have an average population of over 200 people and are a source of both faecal pollution and general house based water and gross pollutants. Most of the properties rely on boat access, and all of them rely on onsite sewage disposal and offsite waste disposal. A recent audit of onsite sewage management (October 1998) found that many systems failed to meet adequate health standards.

The management objective is to significantly reduce pollution sourced from the River Settlements by providing appropriate infrastructure, servicing and controls.

Heavy Metal Accumulations: The Estuary Processes Study found that there has been an accumulation of heavy metals particularly lead, zinc, copper and chromium in the bed sediments around the Berowra Waters area. The source of these metals is likely to be attributable to waterway access and boating through vehicle emissions, moored vessels, seepage and slipway scrapings. The deposition of fine sediments from the catchment in this area (with attached metals) is also likely to be a factor.

Note, there is also conflicting evidence on the presence of organochloride pesticides in the sediments. Based on evidence from other NSW estuaries this is unlikely to be a significant problem, and because of the banning of these chemicals in the 1970's and 80's any concentrations should be declining.

The management objective is to control inputs from known sources such as boat slipping antifouling activities and road surface runoff. Any other major sources of sediment pollutants are also to be identified and managed so as to prevent ongoing accumulations.

Oil Spills: Minor oil spills, which appear to be associated with diesel fuel, have occurred on a number of occasions in the vicinity of Berowra Waters. The spills are a form of visual pollution and detrimental to recreational use of the estuary. There is also the potential for spills to damage the ecology of the estuary.

There is some confusion as to the source of these spills. The source of the spills could be identified and prevented through a monitoring and education program. The monitoring program could start with active monitoring, leading to chemical sampling and analysis to establish the source if necessary. Education of oil users would also help in the prevention of further spills.

The management objective is to identify the source of the oil spills and to implement measures to manage and prevent further spills.

Human Use

Estuary Recreational Facilities: There are a number of issues relating to recreational use of the estuary. These are mainly associated with parking and waterway access at Berowra Waters and Crosslands Reserve because these are the only locations where vehicular access to the estuary is possible. Both sites are particularly popular picnic, walking and boating areas, and on sunny weekends, traffic on the narrow access roads, and the demand for parking near the waterway, far exceeds the available capacity. The amenity of the area for visitors is degraded by this over demand which also has a significant detrimental impact on residential use.

Access and parking are major issues which have largely been addressed by the Berowra Waters and the Berowra Valley Regional Park Management Plans (and are beyond the scope of this Estuary Management Plan).

The main management objective is to meet the reasonable requirements of recreational users of the waterway in a way that facilitates use whilst minimising the impacts on the environment, residents and users.

Estuary Tourism Facilities: The impacts and constraints associated with over demand for recreational access also impacts on estuary tourism. Because of this, use of the estuary for water based tourism is controlled by access difficulties at Berowra Waters, and limits opportunities for eco-based tourism such as canoe tours.

The land access difficulties also encourage seaplane operations (which service the restaurants in Berowra Waters). This has become a significant issue with local residents since the recent fatal crash. Deregulation of the aviation industry has placed the onus for safety on individual aircraft pilots. However, there are particular difficulties with landing (or going around) at Berowra Waters when landing from the north. The Civil Aviation Safety Authority (CASA) has the capacity to set aeroplane operational standards to address this problem, and the Waterways Authority has the capacity to control waterway use including defining landing areas.

The management objective is to provide increased opportunities for estuary based tourism by improving the available facilities and access/parking arrangements, in a way that ensures safety and minimises adverse impacts on the environment, residents and users.

Boat Moorings: There are a number of issues associated with both swing and fixed boat moorings in the estuary. One is the number of moorings in the Berowra Waters area and the possible impact moored vessels are having on heavy metal accumulations. Another is the current proposal to replace approximately 25 swing moorings with marina berths. There is also anecdotal evidence of an increased number of thefts and damage to moored vessels, and concern about vessel and mooring damage caused by the wakes of passing boat. Until recently, there has also been a problem with the insufficient number of berths available at the Berowra Waters residents✪ jetty and car park. The recently adopted proposal to extend the jetty to the south has apparently solved this problem.

The management objective is to provide boat moorings with adequate safety/security but without significant adverse impact on the ecology of the waterway or visual amenity of the area.

Sedimentation/Navigation: There has been an ongoing buildup of sediments in the upper estuary zone above Woolwash, as well as in several lower estuary bays and Marramarra Creek. The sedimentation is associated with erosion and disturbance in the Berowra Creek and Hawkesbury River catchments. Investigations undertaken for the Estuary Processes Study indicated that the buildup of sediments upstream of Woolwash is an ongoing process which has been occurring at a similar rate for hundreds of years.

The increased sedimentation has reportedly restricted navigation of some areas, but this is also linked to modern day time pressures which prevent boaters from waiting until high tide as was the practice in the past.

There have been several proposals for commercial sand extraction ventures at Crosslands in the past, with none eventuating. Since 1989, sand extraction in the estuary has been prohibited under the Sydney Regional Environmental Plan (REP) No. 20, except for essential works.

The management objectives are to reduce catchment sediment infeed rates, and to undertake remediation works (such as dredging) if feasible and desirable, in areas where navigation channels were available in the past.

Commercial and Recreational Fishing: A major concern to residents and recreational fishers is the volume of fish and bycatch, which is caught (particularly by visiting commercial fishers), and the impact this may have on the fishery generally, as well as on recreational fishing opportunities in particular. Part of the problem seems to be a lack of knowledge and confusion surrounding commercial fishing operations and catch reporting. Because of this, Council is currently undertaking a survey of commercial and recreational fishing methods and catch levels.

The fishing surveys involve monitoring actual commercial and recreational catches, and analysing NSW Fisheries catch statistics. On completion of the fishing survey more will be known on how to better manage the fishery. A number of possible management strategies will be reviewed, including closing some areas to fishing, rotating bait taking areas and regionalising fishing licenses to restrict fishing from visiting fishers.

The management objectives are to identify commercial and recreational fishing methods and assess catch levels through Council's current fishing survey, and to prepare a Fishery Management Plan specifically for Berowra Creek that addresses the issues of concern.

Aquaculture: Lower Berowra Creek and Marramarra Creek are important areas for growing and fattening oysters. The extent of the oyster leases is set at their current limit by NSW Fisheries.

Other potential opportunities for aquaculture may exist within the estuary. This could include fish farms or the restocking of waters with juvenile fish such as the Australian Bass. There are currently no such proposals for aquaculture development.

The management objective is to ensure aquaculture in the estuary is ecologically sustainable.

Heritage Protection: Most heritage items within the catchment are adequately protected from human damage by existing statutory controls. However, foreshore erosion at several sites in the middle estuary is damaging Aboriginal middens. The cause of this erosion appears to be natural wind waves exacerbated by boat wash. The NPWS and the Metropolitan Aboriginal Land Council (MARLC) have an important role to play in Aboriginal heritage protection in the area.

The management objective is to prevent further damage to the middens, either by controlling the damage source or by providing physical protection to the middens.

Ecology

Mangroves: Mangroves are a key ecological resource in the estuary system. Big Bay in lower Marramarra Creek has been identified as an area of particular significance in terms of mangrove habitat and its contribution to the ecology of the estuary as a whole.

There has been some dieback of mangroves in the upper estuary which has not been of major concern at this stage due to regrowth and the large areas of healthy mangroves elsewhere in Berowra Creek. Dieback would be of concern if problems continued to occur.

The management objective is to ensure that mangroves generally, and the ecology of Big Bay in particular, are protected and conserved.

Seagrasses: Seagrasses have been identified as important habitat areas, providing nursery areas for aquatic fauna. Work carried out as part of the Estuary Processes Study indicated seagrass areas have been reducing in size and extent over recent decades.

Seagrass beds can be damaged by natural processes, such as storm flows disturbing the creek bed. Boat propellers and other human disturbance can also damage the beds. NSW Fisheries Habitat Protection Plan No. 2 aims to protect seagrasses. The implementation of this plan and other measures are required to preserve the remaining beds from boating and other human impacts.

The management objectives are to preserve existing seagrass beds and to encourage the colonisation of suitable areas by improving water quality and reducing sedimentation.

Weeds: Intrusions of weeds are a problem at various locations along the estuary foreshore. Generally, weed seeds are sourced from further up the catchment and are carried into bushland by the Creek and its tributary streams. Increased soil nutrients and bushland disturbance add to the problem of weeds.

The management objective is to restore and maintain healthy native vegetation within the riparian zone.

Biological Monitoring: Although there is considerable water quality monitoring of Berowra Creek there is little monitoring of the ecology, an outcome strongly influenced by water quality. The Estuary Processes Study undertook limited investigations into the ecology of the estuary; mangroves, seagrasses, saltmarshes and the fauna that they support. To be of greater value this work needs to be followed by further sampling. Further work would identify changes in the ecology and aid in understanding the processes at work. The sampling program would be undertaken on a

four or five year basis at sites throughout the estuary and at reference locations in the Hawkesbury River.

The management objective is to monitor the biological health of the estuary by establishing a focussed and cost effective biological monitoring program.

MANAGEMENT OPTIONS AND DRAFT PLAN

To satisfy the objectives set out above, a wide range of management options were reviewed. The initial step was to evaluate the actions from other relevant management plans particulary the Water Quality Management Strategy and the Berowra Waters Plan of Management. Appropriate management actions were then adopted from these plans. These actions provided a framework for further management actions.

Management options unique to this Plan were then proposed. Some of the actions were specified by Council and the Estuary Management Committee, others were identified by consultation with community interest groups concerned about management of the estuary, and others arose out of the Consultants' assessment and consideration of the issues and objectives.

Each action has been grouped and assigned a code related to the Management Issues. Tables 1 to 4 summarise the actions in terms of their original source (e.g. Berowra Waters Plan of Management or Estuary Management Study), the agencies responsible for carrying out the work, an indicative public agency total cost and a Council cost, and a priority. The detail of each option, and particularly the relative priority, have been subject to comment by the Committee and the community. A community workshop was held on 22nd July 1999 to assist this process.

Following public display and community comment the draft Plan was amended to incorporate any significant comments. The Plan was then submitted to Council and other relevant government agencies for final adoption and implementation.

PLAN IMPLEMENTATION

Overseeing the implementation of this plan will be the responsibility of Hornsby Shire Council through the Berowra Creek Estuary Management Committee. The Management Plan shall be made available to government agencies and other interested individuals and organisations. The Plan implementation phase will be regularly monitored to review the effectiveness of the strategies adopted. As the level of baseline knowledge improves from further data collection and analysis, or as community and Government expectations change, formal review of the Plan shall be initiated.

It is expected that a detailed review of the management strategies to be implemented shall be carried out each year by the Estuary Management Committee. An annual program assigning responsibilities for funding applications and other necessary actions would then be prepared.

FUNDING PROGRAMS AND COMMUNITY PARTICIPATION

Implementation of the Management Plan will require financial and technical assistance from many sources. There are a range of suitable programs, particularly the State Government's Estuary Management Program and the Federal Government's National Heritage Trust (see Appendix A for details). These and other programs offer a range of funding opportunities which in combination can often reduce direct costs to Council. New, potential funding opportunities continue to be developed by both Governments.

Many of the management strategies suggested for Berowra Creek offer opportunities for community involvement particularly through activities such as bank stabilisation/revegetation projects, monitoring programs and environmental education, as well as general monitoring of plan implementation and effectiveness. Local groups are therefore encouraged to take an active role in the management of their estuary, to liaise regularly with the community representatives on the Estuary Management Committee, and seek out opportunities wherever possible for community participation in implementation of the strategies adopted.

CONCLUSIONS

Strategies for the management of Berowra Creek estuary are a mixture of planning controls, physical works and measures, community education and monitoring programs. Together these should fulfil the Estuary Management Policy goal of integrated, balanced, responsible and ecologically sustainable use of the estuary. Implementation of the strategies should ensure that the environment of Berowra Creek is adequately protected and that resource use and its impacts are managed in a sustainable manner.

Table 1: Estuary Management - Management Options

Issue	Objective	No.	Action	Source	Responsibility	Cost	Priority
Data Collection Co-ordination	The management objective is to ensure a co-ordinated and integrated water quality monitoring program is established for the catchment and the estuary which is easily accessible to waterway managers and users. *Some actions are complete, others require improvement and others are yet to be undertaken.*	DCC1	Develop a co-operative program to monitor results of STP upgrades and other catchment remediation works.	WQMS	SWC, EPA, HSC.	-	1995-1996 Completed
		DCC2	Establish monitoring stations for instream flow gauging and sampling.	WQMS	SWC, EPA, HSC.	-	1995-1996 Completed
		DCC3	Establish joint records and database system.	WQMS	SWC, EPA, HSC.	-	1995-1996
		DCC4	Present annual reports on the joint monitoring program to the community.	WQMS	SWC, EPA, HSC.	-	1995-1996 Ongoing
		DCC5	Ensure data collected by SWC, HSC, EPA and other sources are compiled together and are easily accessible to the public.	EMS	SWC, EPA, **HSC**, BCMC.	$19,000 set up ($3000)	High 2000-2002
Human Health and Safety	The management objective is to establish formal monitoring, identification and warning procedures so as to safeguard public health, and to minimise disruption to recreational and commercial waterway users.	HHS1	Council to monitor estuary surface waters and to be responsible for algal bloom testing.	EMS	HSC	$10,000 p.a. ($5000)	High 2000-2002
		HHS2	Put in place a method, such as a radio controlled chlorophyll-a monitor, that enables Council to remotely monitor the presence or otherwise of algal blooms.	EMS	HSC	$40,000 & $10,000 p.a. ($5000)	Medium 2003-2005
		HHS3	In case of algal bloom, Council to report to RACC, DLWC and Health Dept.	EMS	HSC	-	High 2000-2002
		HHS4	Sydney Water to continue to inform Council when STP's begin bypassing.	EMS	SWC	-	High Ongoing
		HHS5	Monitor recreational water quality after significant catchment rainfall or when notified of STP bypassing.	EMS	**SWC**, EPA, DLWC, HSC, Health Dept., HNCMT	$100,000 p.a. ($10,000)	High 2000-2002

Issue	Objective	No.	Action	Source	Responsibility	Cost	Priority
Human Health and Safety (cont)		HHS6	In case of algal bloom, Council to inform Oyster Farmers' Association, NSW Fisheries and other relevant groups, possibly through use of a "phone-tree".	EMS	HSC	-	High 2000-2002
		HHS7	In case of faecal pollution, Council to inform Oyster Farmers' Association, NSW Fisheries and other relevant groups, possibly through use of a "phone tree".	EMS	HSC, EPA	-	High
		HHS8	During summer, Council to respond to community concerns of aquatic stingers and carry out follow up monitoring.	EMS	HSC	($3000p.a.)	High 2000-2002
		HHS9	Inform the community of algal blooms, faecal pollution and aquatic stingers through warning signs near waterway access locations. When appropriate Council to communicate warning through newspaper, radio and the Internet.	EMS	HSC	($5000 pa)	High 2000-2002
		HHS10	Investigate the legal implications and responsibilities relating to warning signs.	EMS	HSC	($10,000)	High 2000-2002
Estuary Management	The management objective is to ensure that the Berowra Creek and surrounding estuaries are managed effectively and that the estuary management plans are properly produced and implemented.	EM1	Council appoint an 'estuary manager' to develop future management plans, administer and update existing management plans and access State, Federal and private industry funding sources. The manager would be responsible for the ongoing development of the estuary management program within Council.	EMS	HSC	$100,000 ($50,000)	High 2000-2002
		EM2	Council approach HNCMT to prepare an integrated Lower Hawkesbury Estuary Management Plan.	EMS	HSC, HNCMT	$80,000	Medium 2003-2005

NOTES:

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Table 2: Water and Sediment Quality - Management Options

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Catchment Sourced Pollution	The management objective is to reduce the level of catchment sourced pollutants so as to protect aquatic ecosystems, and allow for primary human contact and the production of edible fish, crustacea and shellfish. *Some actions are complete, others require improvement and others are yet to be undertaken.*	CSP1	Develop and implement a Catchment Management Plan aimed at achieving water quality objectives.	WQMS	DLWC, EPA, HSC, HNCMT, BCMC, SWC, DUAP, NPWS.	-	1997-2005 completed
		CSP2	Develop a water quality monitoring program.	WQMS	SWC, EPA, HSC.	-	1995-2005 completed
		CSP3	Determine pollutant loads from STP's and other developments.	WQMS	SWC, EPA, HSC.	-	1995-2005 ongoing
		CSP4	Control pollutant loads from Sydney Water STP's.	WQMS	SWC, EPA.	-	1995-2005
		CSP5	Improve management of leachate and runoff from disused waste disposal.	WQMS	HSC, EPA	-	1995-2005
		CSP6	Improve knowledge of existing stormwater drainage system.	WQMS	Schools, HSC, EPA, BCMC/HNCMT.	-	1995-2005 75% complete
		CSP7	Implement controls at building sites for stormwater and sediment control.	WQMS	HSC, DLWC, EPA.	-	1997-2005 ongoing
		CSP8	Control pollution from sewer overflows.	WQMS	EPA, SWC.	-	1997-2005 ongoing
		CSP9	Implement a plan of management for urban stormwater	WQMS	HSC, BCMC.	-	1995-2005 Plan produced, yet to be implemented
		CSP10	Reduce stormwater pollution from residential areas.	WQMS	HSC, BCMC/HNCMT.	-	1995-2005
		CSP11	Restrict or prevent development of sensitive sites.	WQMS	DUAP, HSC, SWC, EPA, HNCMT, NSWAg, DLWC.	-	1995-2005

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Catchment Sourced Pollution (cont)		CSP12	Reduce pollution from agricultural sites.	WQMS	HSC, EPA, NSWAg, DLWC, HNCMT.	-	1995-2005
		CSP13	Improve management of on-site sewage disposal in rural residential areas.	WQMS	HSC, BCMC/HNCMT.	-	1995-2005
		CSP14	Control impact of farm animals on water quality.	WQMS	HSC, NSWAg, BCMC.	-	1997-2005
		CSP15	Minimise overflows from private sewer connections in the catchment.	EMS	HSC, **landholders**	-	Medium 2003-2005
		CSP16	Place nutrient/ sediment and litter devices on major stormwater outlets into the estuary.	EMS	**HSC**, BCMC	$1 million ($500000)	Medium 2003-2005
Freshwater Inputs	The management objective is to reduce the volume of catchment sourced freshwater to a level suitable for the restoration of aquatic ecosystems in the upper estuary.	FI1	Sydney Water to investigate possible immediate implementation of re-use options.	EMS	**SWC**	$30,000	High 2000-2002 completed
		FI2	As a longer term solution, all STP discharge presently entering Berowra Creek be reused within the catchment or discharged outside the catchment.	EMS	**SWC**	>$50mill	Low 2005-
		FI3	Implement community water reduction schemes, possibly through the use of incentives.	EMS	HSC, **SWC**, EPA	$100,000 ($20,000)	High 2000-2002
		FI4	Council to develop policy that new development, including redevelopment of rural areas, provides for re-use of grey waters.	EMS	**HSC**, SWC, Health, EPA	-	High 2000-2002
		FI5	Implement Sustainable Water DCP requirement to "incorporate relevant measures to promote infiltration and ground water recharge where the site contains appropriate soil landscapes."	EMS	**HSC**, developer	-	High 2000-2002

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Freshwater Inputs (cont)		FI6	Educate the community on the need for on-site collection and use of stormwater, in keeping with Council's rainwater tank policy.	EMS	**HSC**, BCMC	$30,000 ($15,000)	High 2000-2002
		FI7	Review Council's DA approval process to include use of permeable surfaces as default condition (particularly for driveways).	EMS	**HSC**	-	High 2000-2002
Boat Sourced Pollution	The management objective is to eliminate boat sourced pollutants by providing appropriate infrastructure and controls.	BSP1	Enforce limits on permanent occupation of boats.	BWPM	Waterways	-	High
		BSP2	Investigate provision of a pumpout facility for houseboats and other vessels.	BWPM	HSC, Waterways.	$	Medium 2000-2
		BSP3	Establish litter control policy.	BWPM	HSC	-	High
		BSP4	Ensure solid waste collection is carried out regularly.	BWPM	HSC	$	High
		BSP5	Provide better waste disposal facilities for people aboard boats.	EMS	**HSC**, Waterways	$50,000 ($25,000)	High 2000-2002
		BSP6	Provide appropriate sewage disposal facility for commercial and recreational vessels at Berowra Waters.	EMS	Waterways, HSC, **DLWC**.	$200,000	High 2000-2002
		BSP7	Produce a brochure outlining the legal responsibilities of boat users not to pollute and provide advice on how to best protect the environment. Brochure to be provided by hire boat operators and marinas to all boat users.	EMS	HSC, **Waterways**, EPA, boat hire operators, marinas	$20,000	High 2000-2002
		BSP8	Investigate the environmental impacts of antifouling paints on Berowra Creek.	EMS	**HSC**, Waterways, EPA	$20,000 ($10,000)	Medium 2003-2005
		BSP9	If/ when pumpout facilities are installed in the Berowra Creek area all the estuary be declared 'no discharge'.	EMS	HSC, **Waterways**	-	Medium 2003-2005

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
River Settlement Sourced Pollution	The management objective is to significantly reduce pollution sourced from the river settlements by providing of appropriate infrastructure and controls.	RSP1	Improve management of on-site sewage disposal by providing information to residents and establishing a regular inspection program.	WQMS	HSC, EPA.	-	1995-2005 20% completed
		RSP2	Promote alternatives to use of septic tanks in sensitive locations. Identify sites unsuitable for septic tanks and provide information and incentive for alternative disposal methods.	WQMS	HSC, DLWC, BCMC/HNCMT.	-	1995-2005 none completed
		RSP3	Update River Settlements DCP to include improved water quality controls and requirements to prepare, implement and maintain a Soil and Water Management Plan.	BWPM	HSC	-	High Ongoing
		RSP4	Investigate feasibility of a pumpout facility at Berowra Waters for river settlements and boats.	BWPM	HSC, DLWC.	$40,000	Medium 2000-2002
		RSP5	New septic systems to comply with Council standard and require a geotech/soils report to verify site suitability.	BWPM	HSC	-	High 1999
		RSP6	Investigate conversion potential of existing and new septic systems to pumpout.	BWPM	HSC, DLWC.	-	Medium 2000-2002
		RSP7	Continue audit of septic systems to ensure compliance.	BWPM	HSC	$	High Ongoing
		RSP8	Ensure all septic systems are operating efficiently and are maintained through sludge removal on a 3-5 year basis.	BWPM	HSC	Annual Cost $50,000	High Ongoing
		RSP9	New development to provide for re-use of grey waters, where possible.	BWPM	HSC	-	High

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
River Settlement Sourced Pollution (cont)		RSP10	Best practice environmental management guidelines to be included in River Settlements DCP.	BWPM	HSC	-	High 2000
		RSP11	Apply actions RSP3-RSP10 to all river settlements not just in vicinity of Berowra Waters.	EMS	**HSC**	-	High 2000-2002
Heavy Metal Accumulation	The management objectives are to control inputs from known sources such as boat slipping anti-fowling activities and road surface runoff, and to identify any other major sources of sediment pollution and to manage these sources so as to prevent ongoing accumulations.	HMA1	Commercial marinas to progressively update existing boat maintenance systems.	BWPM	HSC	-	High Ongoing
		HMA2	Ensure all boat service areas have containment areas for antifouling waste.	BWPM	HSC, Commercial Operators.	-	High
		HMA3	Include drainage improvements on "Kirkpatrick Way". Install sediment traps at outlets as part of improvements.	BWPM	HSC	$30,000 to $50,000	Low 2002-2004
		HMA4	Provide drainage to eastern car parking areas and sediment trap/oil separator at drain outlets.	BWPM	HSC	$5,000	Low 2002-2004
		HMA5	Provide sediment trap and oil separation unit at Dusthole Bay car park.	BWPM	HSC	$10,000	Low 2002-2004
		HMA6	Maintain all sediment/oil traps to ensure proper functioning.	BWPM	HSC	-	Medium Ongoing
		HMA7	Use low residue herbicides and adopt practices to minimise inflow to the waterway.	BWPM	HSC	-	Medium Ongoing
		HMA8	Maintain and operate the ferry in a manner that prevents pollution.	BWPM	HSC, RTA.	-	Medium Ongoing
		HMA9	Identify major sources of heavy metal contamination.	EMS	**HSC**, EPA	$30,000	Medium 2003-2005

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
		HMA10	Establish a sediment monitoring program for the estuary concentrating on the Berowra Waters area.	EMS	**HSC**, EPA	$20,000 every 4 years	Medium 2003-2005
Oil Spills	The management objective is to identify the source of the oil spills and to implement measures to manage or prevent further spills.	OS1	Initiate a program to source the origin of oil spills on Berowra Waters and educate boat users.	EMS	**HSC,** Waterways, EPA	$10,000 ($5,000)	High 2000-2002
		OS2	Emergency spill management to be conducted as per HSC Emergency Spills Manual.	EMS	**HSC**, Fire Brigade	($10000pa)	High 2000-2002

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Table 3: Human Use Management Options

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Estuary Recreational Facilities	The main objective is to meet the reasonable requirements of recreational users of the waterway in a way that facilitates use whilst minimising the impacts on the environment, residents and users.	ERF1	Install radio controlled signage at Berowra and Berrillee to inform visitors of delays and parking restrictions.	BWPM	HSC	$50,000	High
		ERF2	Deck rear portion of Dusthole Bay car parking area.	BWPM	HSC	$1.95M	Medium
		ERF3	Investigate adequacy of public jetty on the western shore if parking is increased.	BWPM	HSC, Waterways, DLWC.	-	Medium
		ERF4	Undertake minor rock trimming of Berowra Waters Road and Bay Road.	BWPM	HSC, RTA.	$5,000	Medium
		ERF5	Make areas around the ferry terminals “shared” pedestrian and vehicle zones.	BWPM	HSC, RTA.	$3,000	Medium
		ERF6	Investigate the possibility of “reversing” the ferry so pedestrians do not have to cross vehicle path.	BWPM	HSC, RTA.	-	Low
		ERF7	Provide a separate pedestrian pathway at ferry terminals to segregate from cars.	BWPM	HSC, RTA.	-	Low
		ERF8	Provide heritage signage at strategic locations.	BWPM	HSC	$4,000	Low
		ERF9	Provide additional shade trees to picnic areas.	BWPM	HSC	$5,000	Medium 2002
		ERF10	Provide more planting and seating along foreshore.	BWPM	HSC	$10,000	Medium 2002
		ERF11	Develop pamphlets suitable for general visitor information and school projects.	BWPM	HSC, BVRPT.	$1,000	Medium
		ERF12	Provide information on the area on the Internet through Council’s home page.	BWPM	HSC, BVRPT.	-	Medium
		ERF13	Develop interpretive signs to explain key features of the area.	BWPM	HSC, NPWS.	-	Low

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Estuary Recreation Facilities (cont)		ERF14	Undertake surveys during peak periods to record visitor numbers.	BWPM	HSC	$3,000	High
		ERF15	Improve maintenance schedule for Sommerville Road.	EMS	HSC, BVRPT	$100,000	Moderate 2000-2002
		ERF16	Consider improved recreation/education facilities at Crosslands, such as an information and education centre.	EMS	HSC, **BVRPT**	$200,000	Medium 2003-2005
		ERF17	The boat ramp at Crosslands be restricted for use by non-trailable boats only.	EMS	HSC, **BVRPT**	$2,000	Medium 2003-2005
		ERF18	Personal watercraft use, except for through passage is banned upstream of Neverfail Bay.	EMS	**Waterways**	-	High 2000-2002
Estuary Tourism Facilities	The management objective is to provide increased opportunities for estuary based tourism by improving the available facilities and access/parking arrangements, in a way that ensures safety and minimises adverse impacts on the environment, residents and users.	ETF1	No commercial development to be permitted outside zoned areas, unless already approved.	BWPM	HSC	-	High
		ETF2	Permit modification to commercial floor space where environmental performance is improved.	BWPM	HSC, DLWC	-	Medium
		ETF3	Parking for commercial use to be in accordance with car parking strategy for Berowra Waters.	BWPM	HSC	-	Medium
		ETF4	Ensure commercial uses comply with lease restrictions and proposed management strategies. Review of Crown Land leases at expiry to ensure compliance with Plan visions & values.	BWPM	HSC, DLWC	-	High
		ETF5	Ensure changes to commercial uses/ leases conform to the proposed management study.	BWPM	HSC, DLWC	-	High
		ETF6	New buildings to be consistent with urban design strategy.	BWPM	HSC	-	High

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Estuary Tourism Facilities (cont)		ETF7	Investigate program of spotlighting and wildlife field trips run by NPWS volunteers.	BWPM	HSC, NPWS	-	-
		ETF8	Investigate the potential for tourist related eco-focused activities at Crosslands, such as canoe hire.	EMS	**BVRPT**	$15,000	Low 2005-
		ETF9	Construct an interpretive boardwalk through the wetland and mangrove areas in Crosslands Reserve, illustrating cultural and natural values.	EMS	**BVRPT**, HSC	$50,000	Medium 2003-2005
		ETF10	Investigate safety aspects of seaplanes in Berowra Waters area.		**CASA**, Waterways	$20,000	High
Boat Moorings	The management objective is to provide boat moorings with adequate safety/security but without significant adverse impact on the waterway or visual amenity of the area.	BM1	Maintain geographic and numeric limits on boat moorings.	BWPM	HSC/ Waterways	-	High
		BM2	No net increase in existing moorings/ berthings to be permitted in Berowra Creek. Additional berthings in marina only to replace existing swing moorings.	BWPM	HSC/ Waterways	-	High
		BM3	Increase boat security through upgraded lighting at water access and mooring locations.	EMS	Waterways, HSC, **Marina Operator**	$10,000	Medium 2003-2005
		BM4	Enforce existing no wash/ no wake zones in the estuary.	EMS	**Waterways**	$10,000	High 2000-2002

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Sedimentation/ Navigation	The management objectives are to reduce catchment sediment infeed rates, and to undertake remediation works (such as dredging) if feasible and desirable, in areas where navigation channels were available in the past.	SN1	Ensure current catchment management practices are implemented for upstream development at Berowra & Berowra Hts.	BWPM	HSC, BCMC	-	Medium
		SN2	Ensure new urban releases in catchment, implement sound soil and water controls, to minimise the transport of sediment, nutrients and weeds.	BWPM	HSC	-	High Ongoing
		SN3	Ensure fire access track maintenance is undertaken in accordance with accepted soil conservation practices.	BWPM	HSC, RFS, NPWS	-	High Ongoing
		SN4	Improve knowledge of existing stormwater drainage system.	WQMS	HSC, schools, EPA, BCMC/ HNCMT	-	1995-2005 75% complete
		SN5	Implementation of appropriate controls at building sites.	WQMS	HSC, DLWC, EPA	-	1997-2005 ongoing
		SN6	Implement a plan of management for urban stormwater.	WQMS	HSC, BCMC	-	1995-2005 Plan produced yet to be implemented
		SN7	Reduce stormwater pollution for residential areas.	WQMS	HSC, BCMC/ HNCMT	-	1995-2005
		SN8	Ensure application of BMP's to control stormwater pollution.	WQMS	HSC, DUAP, EPA, HNCMT, proponent	-	1995-2005 30% complete
		SN9	Restrict or prevent development of sensitive sites.	WQMS	HSC, DUAP, SWC, EPA, HNCMT, DLWC, NSWAg.	-	1995-2005
		SN10	Prevent loss of vegetation from highly sensitive sites.	WQMS	HSC, DLWC, BCMC/ HNCMT	-	1997-2005
		SN11	Improve management of runoff from degraded urban and peri-urban bushland.	WQMS	HSC, BCMC, Community groups, DLWC, HNCMT	-	1997-2005

Issue	Objective	No.	Action	Source	Responsibility	Cost *	Priority
Sedimentation/ Navigation (cont)		SN12	Prohibit sand extraction upstream of Woolwash as supported by Sydney REP20.	EMS	HSC, **DLWC**, Fisheries	-	High 2000-2002
		SN13	Minor dredging of navigation channels is supported subject to appropriate environmental approvals.	EMS	Waterways, **HSC**, DLWC	-	Medium 2003-2005
Commercial and Recreational Fishing	The management objectives are to identify commercial and recreational fishing methods and assess catch levels through Council's current fishing survey, and to prepare a Fishery Management Plan specifically for Berowra Creek that addresses the issues of concern.	CRF1	Prepare a management plan specifically for Berowra Creek that addresses local concerns regarding fishing practices, particularly visiting commercial fishers, overfishing and excessive bycatch.	EMS	**Fisheries**, HSC	$40,000	High 2000-2002
Aquaculture	The management objective is to ensure aquaculture in the estuary is ecologically sustainable.	A1	Any proposed new aquaculture development in the estuary such as fish farming would require a thorough EIS and the approval of NSW Fisheries.	EMS	**Developer**, Fisheries	-	Low 2005-
Heritage Protection	The management objective is to prevent further damage to the middens, either by controlling the damage source or by providing physical protection of the middens.	HP1	Investigate and implement appropriate protection measures for middens subject to erosion in the estuary.	EMS	**NPWS**, DLWC, BVRPT, MARLC	$30,000	Low 2005-
		HP2	Enforce existing no wash/ no wake zones in the estuary.	EMS	**Waterways**	see BM4	High 2000-2002

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Table 4: Ecology - Management Options

Issue	Objective	No.	Action	Source	Responsibility	Cost	Priority
Mangroves and Saltmarsh	The management objective is to ensure that mangroves generally and the ecology of Big Bay in particular are protected and conserved.	M1	Conserve and protect flora and fauna in public and private ownership through appropriate zoning measures and development controls. Amend River Settlements DCP to include flora and fauna protection.	BWPM	HSC	-	High 1999
		M2	Protect significant flora and fauna habitats. Identify and protect all threatened fauna habitats and minimise vegetation fragmentation.	BWPM	HSC	-	High
		M3	The sub-tidal and tidal areas of Big Bay to be incorporated into Marramarra National Park or as a marine protected area.	EMS	**NPWS**, Fisheries	-	High 200-2002
		M4	Monitor the extent of saltmarsh and mangrove areas and determine management actions.	EMS	**Fisheries**	$15,000	Medium 2003-2005
Seagrasses	The management objectives are to preserve existing seagrass beds and to encourage the colonisation of suitable areas by improving water quality and reducing sedimentation.	S1	Improve water quality through management strategies addressed in previous sections.	EMS	Refer to individual management actions	-	High 2000-2002
		S2	Ensure the requirements of Fisheries' HPP#2 (Seagrasses) are implemented and monitored.	EMS	**Fisheries**	$5,000 p.a.	High 2000-2002
		S3	Seagrass beds to be indicated on boating maps. Maps to be distributed by Waterways and hire boat operators.	EMS	**Waterways**, Fisheries	$10,000	High 2000-2002
Noxious Weeds	The management objective is to restore and maintain healthy native vegetation within the riparian zone.	NW1	Include provisions in River Settlements DCP for locating and protecting threatened plant communities and species and the control of noxious and invasive weeds.	BWPM	HSC, NPWS	-	High

Issue	Objective	No.	Action	Source	Responsibility	Cost	Priority
Noxious Weeds (cont)		NW2	Weed seed sources and infestations, particularly in residential properties and along road reserves to be controlled and action taken to remove.	BWPM	HSC	$10,000	High
		NW3	Undertake community education on the threat of weeds to bushland.	BWPM	HSC	$5,000 for materials	Medium Ongoing
		NW4	Provide information to local residents on suitable indigenous plants for gardens.	BWPM	HSC	$2,000	Medium
		NW5	Encourage the removal of exotic species and planting of indigenous species.	BWPM	HSC	-	Medium
		NW6	Liaise with local schools and educational establishments for students to undertake practical bush regeneration work in the park to assist in implementing the plan.	BWPM	HSC, NPWS	-	Low
		NW7	Continue Council efforts in encouraging local residents to participate in environmental and bush regeneration schemes.	BWPM	HSC	-	Medium Ongoing
		NW8	Bush regeneration works be undertaken around the wetlands area in Crosslands Reserve.	EMS	**BVRPT**, BCMC, Landholders	$20,000	Medium 2003-2005
Biological Monitoring	The management objective is to monitor the biological health of the estuary by establishing a focussed and cost effective biological monitoring program.	BioM1	Establish a biological monitoring program to assess seagrasses, mangroves, saltmarshes and the fauna they support. Program should include periodical mapping of aquatic habitats and quantitative sampling of key indicators.	EMS	**HSC**, SWC, Fisheries, NPWS	$60,000 every 4yrs ($30,000)	High 2000-
		BioM2	Investigate the possibility of involving universities, and/or the CSIRO in the monitoring program.	EMS	**HSC**	-	High 2000-2002

Issue	Objective	No.	Action	Source	Responsibility	Cost	Priority
		BioM3	Establish MOU's (Memorandums of Understanding) between Council and universities and other research organisations to encourage research into the estuary.	EMS	**HSC**	-	Medium 2003-2005

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ESTUARY MANAGEMENT STUDY

1. INTRODUCTION

1.1. This Management Study

This Estuary Management Study covers the broader water quality, ecological and human use issues affecting the estuary waterways and foreshores of Berowra Creek upstream from the Hawkesbury River including Marramarra Creek (see Figure 1). The study also includes the estuary catchment insofar as it affects the issues being addressed, such as nutrient inputs from catchment runoff.

The study was undertaken for the Berowra Creek Estuary Management Committee of Hornsby Shire Council, with funding assistance from the Department of Land & Water Conservation under the NSW Government✪s Estuary Management Program. The study was prepared by Webb, McKeown & Associates with input from The Ecology Lab, Manly Hydraulics Laboratory, and the Institute of Integrated Catchment Management (UWS).

1.2. The Estuary Management Program

The NSW Estuary Management Program has as its principal objective “integrated, balanced, responsible and ecologically sustainable use of the State’s estuaries”. The program achieves this through the principles of ecologically sustainable development (ESD) and total catchment management (TCM).

Ecologically sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their needs. In relation to the estuary this means that the natural and cultural environment are preserved for the benefit of future generations. Total Catchment Management is the coordinated and sustained use and management of land, water, vegetation and other natural resources on a catchment basis so as to balance resource utilisation and conservation.

The Estuary Management Program uses an eight step program which incorporates the principles of ESD and TCM.

Step 1: form Estuary Management Committee.
Step 2: assemble existing data.
Step 3: carry out Estuary Processes Study.
Step 4: carry out Estuary Management Study.
Step 5: prepare draft Estuary Management Plan.
Step 6: review draft Estuary Management Plan.
Step 7: adopt and implement Estuary Management Plan.
Step 8: monitor and review the management process.

This Study report and Plan represents **Steps 4 and 5** of the process. However, unlike many other estuaries, the preparation of a Management Plan for Berowra Creek is additionally complicated

because of its location on the outskirts of the Sydney urban area, and the need to co-ordinate planning and management of the estuary with planning and management of the catchment, as well as with wider local and regional requirements.

1.3. The Wider Planning Management Context

There are a large number of Local, State and Commonwealth Government authorities involved in the management of Berowra Creek Estuary and Berowra Creek Catchment. To help understand the broad management context specific to Berowra Creek the following schematic diagram has been prepared (see over). Details of the planning context are provided in Chapter 3.

1.4. Statement of Joint Intent

Because of the complexity of the management structure, Hornsby Shire Council and several key NSW government authorities involved in management of the Berowra Creek Catchment have formally agreed to work together to achieve ecologically sustainable development of the catchment and to recover the environmental health of the creek.

The agreement, known as the Statement of Joint Intent (SoJI), was signed in 1994 by:

- Department of Urban Affairs and Planning,
- Environment Protection Authority,
- Hawkesbury-Nepean Catchment Management Trust,
- Sydney Water Corporation,
- Hornsby Shire Council.

The SoJI focuses on improving the environmental health of Berowra Creek. The initial goal is to achieve water quality in Berowra Creek Estuary (downstream of Fishponds Waterhole) that is consistent with the pursuit of recreational activities such as swimming, canoeing and boating. A long term goal is that water quality will allow fishing with confidence and safety and the protection of the shellfish industry.

As part of the statement, the participating agencies agreed to a number of specific outcomes. These included:

- development of a Water Quality Management Strategy and Plan of Management. This Strategy and Plan were to be jointly prepared and implemented,
- Sydney Water to upgrade of West Hornsby Sewage Treatment Plant (STP) to reduce Total Nitrogen levels in the effluent,
- reduction of phosphorus and faecal coliforms in effluent at Hornsby Heights and West Hornsby STP's,

Diagram 1: Berowra Creek Planning Management Context

- preparation of an Options Study for Hornsby Heights and West Hornsby Heights STP's to further reduce the nitrogen levels,
- preparation of an Erosion and Sediment Control Code by Hornsby Council,
- preparation of a revised Stormwater Management Code, a revised Stormwater Design Manual and an Issues Report on the remediation of the existing stormwater system by Hornsby Shire Council,
- development of a public education strategy by the Hawkesbury-Nepean Catchment Management Trust,
- a survey of the catchment to identify and quantify pollution sources to be undertaken by Hornsby Council, Sydney Water and the Environment Protection Authority,
- development of a co-operative water quality monitoring program to be carried out by Sydney Water, Hornsby Council and the Environment Protection Authority,
- a commitment by the Department of Urban Affairs and Planning to not introduce planning measures incompatible with Ecologically Sustainable Development.

Most of these commitments have been or are being met, and now form the basis of how Berowra Creek Catchment is managed. Many of the commitments have specific relevance to the estuary, therefore the management strategies and actions arising from the SoJI have been incorporated into this Management Study and Plan. Details of these strategies and actions are provided in Chapters 3 and 5.

1.5. Community Consultation

Community consultation and input is a major part of the Estuary Management Study and Management Plan process. The formation of the Berowra Creek Estuary Management Committee (EMC) represented the initial stage of this consultation process.

The Berowra Creek EMC is a committee of Council which includes Councillors, State Government Authority representatives and seven community delegates. The community delegates were selected by Council (following advertisement within the local press), to provide a range of views representing the various community, environmental and business interests in the area.

Community consultation for the Berowra Creek Estuary Management Study included a broad based "Contact Group" plus a widely advertised workshop/public meeting. It will also include a public exhibition of the study report and Draft Management Plan if supported by Council.

Formation of the Contact Group began with the Estuary Management Committee, but was then expanded to include other community, user, environmental or industry groups with an interest or connection to the study area. This list was then expanded through existing networks to include other interested parties. The full contact listing is included at Appendix B.

Comment was sort from the Contact Group on matters related to management of the estuary, such as to identify significant features and issues of concern. Summaries of this work are included at the relevant sections.

The workshop/public meeting held on 22 July 1999 discussed the findings and comments of the Estuary Management Committee and the Contact Group, and examined in some detail management options and management strategies for the estuary. Again, the results of the workshop/public meeting are included at the relevant sections. A summary of the workshop comments is included in Appendix C.

The Draft Management Plan was placed on public display for four weeks in August 1999. The comments obtained and a summary of the changes made to the Management Study and Plan are included in Appendix D.

2. FEATURES OF THE STUDY AREA

This Chapter describes the Berowra Creek study area concentrating on the features of the estuary and catchment which potentially could affect management of the estuary. Readers requiring more detail should refer to the Berowra Creek Estuary Processes Study or the documents specifically referenced in the text. Copies of the Estuary Processes Study are available on loan through Council libraries.

For this study the estuary has been divided into four geographic/management zones, the upper, middle and lower zones of Berowra Creek and the lower west zone of Marramarra Creek. The divisions are shown on Figure 1.

2.1. Catchment

2.1.1. Location

Berowra Creek and its catchment are situated entirely within Hornsby Shire Local Government Area on the northern outskirts of the Sydney metropolitan area. Berowra Creek is a major tributary of the lower Hawkesbury River, entering the Hawkesbury River some 25 kilometres from the ocean.
The Berowra Creek catchment (including Marramarra Creek) has an area of 310 km^2. The estuary part of the waterway extends for over 23 kilometres from the Hawkesbury River in a southerly direction to the tidal limit at Rocky Fall Rapids (see Figure 1). The Marramarra Creek estuary extends in a westerly direction from near the confluence with the Hawkesbury River for over 7 km.

2.1.2. Topography and Soil Landscapes

Berowra Creek estuary is a drowned river valley, consisting of steeply incised gorges with surrounding plateau areas. Berowra Creek drains the Hornsby plateau to the south and east, while Marramarra Creek drains the Maroota Plateau to the west.

The plateaus are formed from Hawkesbury Sandstones topped in places by Wianammatta Shales. The soils derived from the sandstones are shallow sands, yellow sandy earths, and fine sandy clay loams. These soils are infertile, have poor water holding capacity and are highly erodible. The hard setting red brown clay loams derived from Wianammatta Shales are more fertile. They are heavier and have more water holding capacity, although they can become water logged.

In the lower freshwater sections of tributary creeks, and around the upper estuary, alluvial soils have been deposited. These soils include brown black sands and loams which are moderately erodible and of very low fertility with low available water holding capacity. In the lower mangrove and salt marsh areas of the estuary the soils are dark brown organic silty loams which have high wave erosion hazard, high acid sulphate potential, very low fertility and low permeability.

2.1.3. Climate and Climate Change

The climate of Berowra Creek catchment can be classified as a warm temperate climate. The average annual rainfall in the catchment is 1000-1100 mm, which is relatively high compared to Baulkham Hills, the neighbouring district, where the average annual rainfall is between 800 and 900 mm. The average maximum daily temperature in summer is 27 degrees, while during the winter months the average maximum temperature is 17 degrees.

Based on the latest research by the United Nations Intergovernmental Panel on Climate Change (IPCC, 1996), evidence is emerging on the likelihood of climate change and sea level rise as a result of increasing "green house" gases. The IPCC best estimate projected sea level rise for the year 2050 is 0.2 m, with a range of between 0.07 m and 0.39 m.

On a regional basis the CSIRO Climate Change Group predicted increased air and water temperatures, and greater frequency and intensity of severe storms for the NSW coastline (CSIRO, 1995). According to these predictions, east coast lows, which are the main causes of storms and floods in the Sydney region, would be more intense, leading to increased occurrence of gale force winds and flooding. However, in a more recent paper by the same group (CSIRO, 1996) the effects of sulphate emissions were also considered. The inclusion of these emissions in climate models has resulted in a possible reduction in the severity of storms.

2.1.4. Vegetation

The majority of the catchment, over 70%, is covered by largely undisturbed bushland, most of which is contained within either the Berowra Valley Regional Park, Muogamarra Nature Reserve or Marramarra National Park. There are also areas of comparatively undisturbed private land in the western part of the catchment around Arcadia and Glenorie.

The vegetation is mainly dry sclerophyll forests (woodlands, shrublands and heathlands) typical of sandstone areas around Sydney. The richer soils support remnants of blue gum high forest and turpentine and iron bark forests, with pockets of rainforest in the gullies. Along the creeks there are swamplands, with mangroves on the tidal flats.

2.1.5. Existing Development

The majority of the population living in the Berowra Creek catchment (some 85 000) is in the urban and industrial areas to the south and east of Berowra Creek. Major centres include Hornsby, Berowra Heights, Hornsby Heights, Mt Colah, Mt Kur-ing-gai, Normanhurst, Westleigh, Cherrybrook, West Pennant Hills, Castle Hill, Glenhaven and Berowra. To the west of the creek the development is semi-rural and includes the areas or Arcadia, Galston and Glenorie.

Residential development along the Berowra Creek estuary is largely restricted to river settlements, most of which are only accessible by boat. In total there are 233 allotments and 169 residences, most of which are in the Berowra Waters/Calabash Bay area, although significant developments

also exist at Neverfail Bay, Coba Point and the entrance to Marramarra Creek (see Figure 1). It is estimated that on average 200 people live adjacent to the waterway.

2.1.6. Future Development

In the past, Hornsby Shire has experienced rapid growth in its residential population. The 1991 census showed a growth rate for the area of 1.9% per annum. Recently, the Shire's residential areas have reached their zoning limits. Council's present general housing strategy is to redevelop existing residential areas rather than create new areas. It is therefore unlikely that there will be any major new residential areas released over the next 20 years (David Green, Hornsby Shire Council, pers. comm. 9/3/1999).

There are a few small areas in the catchment zoned residential that are yet undeveloped. These include 500 lots at Berowra owned by Landcom that are presently bushland and 60 vacant lots at Galston. Among the river settlements there are some 60 lots yet to be developed.

Industrial development is not expected to expand greatly in the near future. Mt Ku-ring-gai Industrial Zone is presently unsewered and this is limiting its growth. There are proposals to sewer this area, and an EIS is being prepared. If the area is sewered it may well become more attractive to light industry, thereby expanding industrial development, but potentially reducing estuary impacts.

2.1.7. Sewage Treatment

The catchment contains two sewerage treatment plants, Hornsby Heights STP and West Hornsby STP. Together the STP's serve about 76 000 people. West Hornsby STP serves the suburbs of Hornsby, Waitara, Normanhurst, Thornleigh, Cherrybrook and Pennant Hills. Hornsby Heights STP serves Hornsby Heights, Mt Colah, Mt Kuring-gai, Berowra and Berowra Heights.

The STP✪s currently discharge a total of 15.9 ML/day treated sewage into Berowra Creek tributaries (10.5 ML into Waitara Creek from West Hornsby STP and 5.4 ML into Calna Creek from Hornsby Heights STP). Waitara Creek flows into Berowra Creek in the freshwater zone upstream of Rocky Fall Rapids. Calna Creek flows into the estuary between Crosslands and Berowra Waters.

As part of the Statement of Joint Intent, Sydney Water made a commitment to improve the quality of the effluent from Hornsby Heights and West Hornsby STP's. In accordance with the agreement, Sydney Water is proceeding with upgrades for both the STP's. The upgrades are to produce effluent with a nitrogen load of 5 mg/L, and to reduce system bypassing to an average of 2.9 occasions per year (see Section 3.3.4).

The semi-rural areas around Arcadia, Galston and Glenorie are unsewered, as are the river settlements. These areas rely on on-site treatment, although many properties have reticulated water, such as Berowra Waters and Calabash Bay. Presently the on-site disposal of wastewater in the river settlements often fails to meet environmental and health protection standards (Berowra Creek Audit of Domestic Sewage Management Systems and Wastewater Disposal Practices, HSC, October 1998).

2.2. Estuary

2.2.1. Description

Upper Estuary Zone

The upper estuary zone extends from the tidal limit, at Rocky Fall Rapids, downstream to a point 500 m upstream of Berowra Waters (see Figure 1). The foreshores along this section of the estuary are within the Berowra Valley Regional Park, except for Council owned Crosslands Reserve, the Crosslands Youth and Convention Centre (near the tidal limit) and the Woolwash, a residence and historic building near the downstream limit of the zone. The tidal waters and the bed of the estuary do not form part of the Park, although land access to the estuary can only be gained through the Park.

A feature of the estuary in this zone is the very shallow depths. The waterway is generally less than 1 m below AHD, and rarely more than 2 m below AHD. The mean spring tidal range along this section of the estuary is around 1.3 m, which is similar to the ocean tidal range (MHL, 1995). As a result the ruling depth at low tide is around a quarter of a metre.

Upstream of the estuary there are a number of tributary creeks which drain the upper catchment including Tunks Creek, Waitara Creek and Pyes Creek in addition to Berowra Creek. There are also a number of tributary creeks which enter the estuary in this zone, including Sams Creek, Calna Creek, and Stills Creek. Waitara Creek and Calna Creek both carry STP discharges to the estuary.

Middle Estuary Zone

The middle zone covers the area from upstream of Berowra Waters downstream to approximately one kilometre upstream of Coba Point (see Figure 1). The area includes Joe Crafts Bay and Calabash Bay. The channel in this section is generally at least 5 m below AHD with a deep section around Calabash Point of over 17 m below AHD.

The foreshores along the middle zone are mostly covered by bushland although there is also some foreshore residential and commercial development, particularly along the western (left) bank between Berowra Waters and Calabash Bay. This development initially began as weekenders and shanty accommodation, but now largely consists of high quality homes, many with permanent residents. Berowra Waters is a popular tourist, picnic, boating and fishing area, with several restaurants and a marina/boat repair facility.

Lower Estuary Zone

The Lower Zone extends from upstream of Coba Point, downstream to the Berowra Creek confluence with the Hawkesbury River at Fishermans Point (not including Marramarra Creek). The zone includes Coba and Kimmerikong Bays and Peats Bight.

The main channel through the zone is generally around 5 m below AHD, with some deep holes to around 10 m. At the Berowra/Hawkesbury confluence there is a bar where the depth is only 3 m below AHD. Coba and Kimmerikong Bays and Peats Bight are shallow with depths of less than 2 m.

The creek foreshores on both sides are steep sandstone ridges covered in native bushland, with Marramarra National Park on the west and Muogamarra Nature Reserve to the east. There is some residential development at Coba Point, and a number of oyster leases, mainly in the entrances to the bays.

Lower West Estuary Zone

Marramarra Creek, including Kulkah Bay, Friendly Bay, and Big Bay, make up the lower west zone. The waterway is very shallow, with channel depths of less than 2 m, and shallow muddy bays which provide a productive environment for mangroves (particularly Big Bay). The foreshores beyond the mangroves are steeply incised sandstone gorges within Marramarra National Park.

There is a small river settlement along the southern (right) bank of Marramarra Creek near the entrance. There are also extensive oyster leases in the entrance area which extend up the creek over 2 km into Friendly Bay.

2.2.2. Hydrodynamics

Typical tidal, catchment runoff and STP discharge flows were calculated as part of the Sydney Water Corporation investigations into sewerage overflows (WMA, 1996 and CH2M, 1998), and for the Berowra Creek Estuary Process Study (MHL, 1998). The analysis period covered 21 months from May 1994 to February 1996.

The results of this analysis for median daily (typical dry weather) flows, and for peak daily (approximate 50% AEP) wet weather flows are shown in Table 5.

Table 5: Tidal and Fluvial Flows

Boundary Location	Volume of u/s Zone (ML)	Dry Weather Flows (typical) (ML/d)			Wet Weather Flows (typical) (ML/d)		
		Catchment	STP	Tidal	Catchment	STP	Tidal
Upstream of Estuary *(Rocky Rapid Falls)*	zero	8	10	zero	>1500	45	zero
Between Upper & Middle Zones *(u/s Berowra Waters)*	1600	11	15	1500	>1800	65	1500
Between Middle & Lower Zones *(u/s Coba Point)*	15200	15	15	7000	>2300	65	7000
Between Lower Zone & Hawkesbury River *(Fishermans Point)*	15600	26	15	21000	>2684	65	21000
Between Lower & u/s Lower West Zones *(Marramarra Creek)*	5200	6	0	4500	>1800	0	4500

Note: One ML or megalitre is 1000 m^3 or approximately the volume of a typical olympic pool.

Upper Estuary Zone

The upper estuary zone is very shallow and hence has a low total water volume. By comparison it has a large tidal range and hence large daily tidal movements. It also has comparatively large catchment inputs.

One important aspect of the hydrodynamics of the upper zone is the very high proportion of dry weather flows taken up by treated sewage discharges. These discharges greatly increase “fresh” water inputs (as well as sewage based pollutants). The table shows that dry weather tidal flows at the estuary limit are zero, and that sewage discharges are greater than catchment runoff. However, at the boundary between the upper and middle zones, tidal flows far exceed the catchment inflows.

In total, nearly half the water within the upper zone is moved into and out of the zone each day by tidal flows. In the downstream portion of the zone, close to Berowra Waters, daily tidal flows are over 60 times catchment inputs. (Even at Crosslands, near the tidal limit, daily tidal flows exceed 200 ML, more than five times the catchment inputs).

This situation changes during significant rainfall runoff events, such as a one in two year storm. For such events, catchment runoff is much greater in the upper estuary (such as at Crosslands) than tidal flows, and even at the downstream limit of the zone, near Berowra Waters, the level of catchment runoff is similar in magnitude to tidal flows. Further, the total volume of catchment runoff during such events is greater than or equal to the total volume of the water in the zone.

The above shows that under normal dry weather conditions the upper estuary zone is tidally dominated, but under wet weather conditions this zone quickly becomes catchment runoff dominated.

Middle Estuary Zone

This zone's hydrodynamics are substantially affected by the comparatively large volume of water (as a result of the deep and wide channel). The hydrodynamics are also affected by the interaction of freshwater inflows (from the upper estuary) and tidal waters (from the lower estuary/Hawkesbury River).

Under normal conditions, saline water from the Hawkesbury River moves into the middle estuary zone during tidal inflows, and due to its greater density sinks into the deep holes near Calabash Bay. After significant rain, less dense fresh water from the upstream catchment can become trapped above the lower salt water, and a "salinity wedge" is formed (see Diagram 2). The waters of the middle zone near Calabash Point are then stratified.

Diagram 2: Berowra Creek Salinity Stratification and Gradient Profiles

After rainfall runoff ceases, mixing between the fresh and salt water layers is restricted by the stratification barrier. In time, tidal movement gradually forms an area of brackish water and the stratified layer breaks down, forming a continuous salinity gradient along the creek. This gradient is marine in the lower estuary, progressively decreasing to fresh at the tidal limit.

Only with very large inflows of fresh water does the entire system flush out to the Hawkesbury. Usually, rainfall events only cause limited runoff and stratification in the middle estuary zone. As a result, runoff waters (and their pollutants) are trapped in the upper and middle estuary zones. Residence times in the middle zone can be quite high, between five to thirty days, depending on the stratification and tidal conditions.

Lower Estuary Zone

The hydrodynamics in the lower estuary are dominated by tidal flows from the Hawkesbury River. This can be seen from Table 5 where tidal flows are much greater than the fresh water inflows. Daily tidal flows exceed freshwater inflows in both wet and dry weather, and are much greater even than the total volume of water in the zone. Because of this residence times are short in comparison to the middle zone.

Lower West Estuary Zone

The hydrodynamics of Marramarra Creek are dominated by tidal flows. Dry weather flows from the catchment are only 6 ML/d compared to the tidal flows of 4500 ML/d, this means that most of the time freshwater flows are insignificant. During wet weather, daily tidal flows generally exceed catchment runoff, although the catchment flows can make up a significant proportion of the total.

The shallow depths and hence low total water volume, result in relatively short water residence times in Marramarra Creek. This improves the flushing of the creek.

2.2.3. Sediment Dynamics

Upper Estuary Zone

The upper estuary zone, as already mentioned is very shallow. These shallows form extensive shoals with deeper scour holes around the outside of the bends or against rock intrusions. The sediments in the upper reaches of the creek are predominantly fluvial sands, although there is a higher proportion of muds in the downstream reaches.

The Estuary Processes Study (MHL, 1998) identified the upper estuary zone as an area of increased fluvial deposition for coarse grained sands, muddy sands and charcoal from the local catchment as a result of human development and disturbance in the upper catchment. There is a common anecdotal belief that sediment buildup in the downstream part of this zone has also accelerated over recent decades. However, the Estuary Processes Study found an ongoing and gradual buildup of sediments over thousands of years, rather than a sudden increase.

Volumetric and radio isotope analyses of bed sediments undertaken for the Processes Study showed no increase in sediment rates due to catchment clearing or urbanisation in the downstream

section of the zone near Berowra Waters. The estimated rate of delta advance for Berowra Creek was found to be 1.3 m/yr over the past 460 years (MHL, 1998). This rate of advance indicates that will take hundreds rather than tens of years before sediment infilling reaches the Berowra Ferry.

It is possible that difficulties navigating the upper estuary over recent years have resulted from time pressures which no longer allow vessels to wait until an appropriate high tide, rather than an accelerated build up of additional sediments. The problem might also be exacerbated by changing channel locations due to increased catchment runoff.

Sediments in the upper estuary zone are low in nutrients and heavy metals. Phosphorus, nitrogen, total organic carbon, copper, lead and zinc measurements at Crosslands were found to be lower than elsewhere in the estuary.

Middle Estuary Zone

The sediments in the middle zone are sandy muds, rich in organic material (MHL 1998). These sediments are sourced from both the Berowra Creek Catchment and from the Hawkesbury River. Sediments from Berowra Catchment are mainly deposited above Calabash Point, and sediments from the Hawkesbury move upstream toward Calabash Point. The sediments also accumulate in protected embayments, forming muddy shores on which mangroves grow.

Bank erosion is not a major problem along Berowra Creek, although there are areas of some erosion between Woolwash and Joe Crafts Bay. This erosion is mainly the result of wave action on silty sediments in exposed locations. Occasionally these sediments contain shell middens. The causes of the erosion appeared to be a combination of wind waves, boat wake and foreshore changes.

Sediment toxicity in the zone was found to be low, although the surface sediments are enriched in nutrients (Nitrogen and Phosphorus) and heavy metals. The metals with the most significant increases are lead, zinc, copper and chromium. Metal levels peak at Berowra Waters. The heavy metal loadings arises from point source contamination (sewage discharges, slipway/boat cleaning operations, moored vessel antifouling paints) and non-point sources (urban runoff, dust, vehicular emissions).

Lower Estuary Zone

The sediments in the lower zone are predominantly organic sandy muds originating from the Hawkesbury River. The sediments are carried into Berowra Creek from the Hawkesbury River during floods and freshes in the river.

The sediments deposited between Coba Point and Fishermans Point are significantly nutrient enriched. This implies that Hawkesbury sediments are themselves rich in nutrients. The toxicity of the sediments was found to be very low. The sediments have raised levels of some heavy metals, but these levels are less than those around Berowra Waters.

Lower West Estuary Zone

The sediments in Marramarra Creek are organic rich muds in the downstream reaches and fluvial sands in the upstream reaches. The organic muds originate from the Hawkesbury catchment and are high in nutrients. The sediments also have some heavy metal loading, although less than other areas in Berowra Creek. Infilling by fluvial sediments has formed shallow deltas in the creek near Big Bay.

2.2.4. Water Quality

Water quality in Berowra Creek has been the subject of a large number of studies including those by Council and the Sydney Water Corporation (see *Water Quality Monitoring Program Annual Report 1997* (HSC, 1997), *Water Quality in Berowra Creek Catchment* (AWT, 1993) *Draft Sewerage Overflows EIS* (WMA, 1996) and the *Estuary Process Study* (MHL, 1998, etc.). From these studies it is clear that water quality in the estuary is largely determined by the volume and quality of the catchment inputs, and the degree of tidal exchange and mixing with Hawkesbury River/ocean waters.

During dry weather, catchment inputs predominantly consists of treated sewage effluent discharged from the STP's. During wet weather the inputs consist of STP discharges (often partially treated), sewerage system bypasses and overflows, urban runoff, and rural and natural bushland runoff. Analysis of estuary water quality data shows that conditions in the estuary are highly variable depending on the rainfall conditions (see Table 6).

Table 6: Typical Dry and Wet Weather Water Quality

Location	TN (mg/L)		TP (✚/L)		SS (mg/L)		Chlor-a (✚g/L)		DO (mg/L)		FC (cfu/100 mL)		Salt (mg/L)	
	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Upstream	14	6	80	60	3	24	1	2	10	10	163	9300	0	0
Upper Zone	1.3	20	18	180	3	27	30	2	6		42	6000	30	0
Middle Zone - top - bottom	0.3	3	17	170	2	50	8010	22	8	10	9	2000	3334	3
Lower Zone	0.25	0.7	21	70	5	16	16	2	5.5	9	2	39	35	12
Lower West	0.35	0.6	40	46	12	18	9	5	7.5	8	84	450	27	16
Hawkesbury River	0.3	1.3	12	100	2	160	13	2	6	9	1	31	35	12

Upper Estuary Zone

As discussed previously, the shallow nature and hence low total water volume of the upper estuary means that after rain this zone is usually flushed of saline water and becomes fresh. After the rainfall stops, salinity levels gradually increase as a result of tidal exchange with downstream waters. The table shows that during dry weather salinity levels in the upper estuary zone (at Crosslands) can be quite high, some 30 mg/L or over 85% ocean water levels.

The table also shows that nutrients (TN and TP), suspended solids (SS) and faecal coliforms (FC) all have major increases in the upper estuary after rain. These levels are often above recommended

Australian guidelines for the protection of estuary ecosystems, primary human contact, and for the production of edible fish and shellfish (ANZECC 1992).

Chlorophyll-a levels, or the amount of plant growth in the water, decreases after rain because of higher turbidity and freshwater flushing, and the fact that plant growth is dependent upon sunlight and long residence times.

Middle Estuary Zone

Water quality in the middle zone is a product of mixing and long resident times. High nutrient waters from the upper estuary mix with lower nutrient saline waters from the lower estuary/Hawkesbury River. These waters become stratified, as described in Section 2.2.2, which further increases residence times and can lead to de-oxygenation of bottom waters, increased nutrient release from bed sediments and hence algal blooms.

The macroalgae and phytoplankton which cause algal blooms are dependant on nutrients, light and temperature for rapid growth. They also need the stable conditions produced by long residence times to reach bloom proportions. The combination of long residence times in the middle zone, high nutrient loads after rain, and summer light and temperatures produce good conditions for such blooms. The growth of the algal bloom is generally controlled by environmental factors such as light and temperature. The growth being counteracted by flushing or zooplankton grazing. In Berowra Creek zooplankton alone do not seem to control blooms, unless there is a slowing in bloom growth due to reduced light (turbid waters, heavy clouds) (TEL, 1998).

Lower Estuary Zone

Due to the high levels of tidal flushing from the Hawkesbury River (Section 2.2.2), water quality in the lower estuary zone is not as affected by nutrient and faecal coliforms inputs from upstream as is the middle zone. However, even in the lower zone there is a significant drop in water quality after rain and nitrogen levels are generally above Australian guidelines.

High nitrogen levels in the lower estuary are due, at least in part, to the fact that waters from the Hawkesbury River are also nutrient enriched. Hawkesbury River waters also contain high levels of organic rich suspended sediments which produce ideal conditions for mangrove growth (and oyster aquaculture).

Lower West Estuary Zone

Nutrient enriched waters from the Hawkesbury enter the lower parts of Berowra Creek, increasing the nutrient load in Marramarra Creek. However, water quality in Marramarra Creek is better than the upper and middle zones of Berowra Creek due to the lower level of pollutant inputs from the catchment. Even so, faecal coliform levels in the upper reaches of the creek appear to be consistently higher than the Australian standard for the protection of edible fish and shellfish. This may be related to rural runoff and/or on-site sewage treatment in the catchment.

2.2.5. Ecology

Upper Estuary Zone

The ecology of the upper estuary zone generally reflects the water quality and sediment characteristics of the area. The bed of the creek is mainly muddy sands consolidated at the surface by biological activity, with small pockets of seagrasses (*Zostera* sp.) in some areas (see Figure 2). The banks of the creeks are lined with river and grey mangroves with fringing saltmarsh areas, except in areas where the sandstone bedrock is exposed as steep bluffs.

The variety and abundance of foreshore and bed faunal species is less than in the lower estuary reaches, probably reflecting the highly variable salinity conditions and high nutrient levels. Both mangrove species and the seagrasses provide valuable habitat for fish, shellfish and birds.

Some loss of individual mangrove trees has been observed along the upper zone, particularly in the area around Crosslands. This dieback has not affected the overall abundance of mangroves which reportedly have increased over recent decades, apparently at the expense of seagrasses in the Woolwash area (TEL, 1998), and saltmarsh in other areas.

The vegetation within Berowra Valley Regional Park, away from the immediate foreshore saltmarsh/mangrove areas mostly consists of dry sclerophyll forests, but also includes small pockets of littoral rainforest in sheltered gullies.

There are a number of rare terrestrial fauna species in the Regional Park which are listed in Schedule 12 of the National Parks and Wildlife Act, 1974. These include the Tiger Quoll, Koala, Red-crowned Toadlet, Origma, Superb Fruit Dove, Glossy Black Cockatoo, Peregrine Falcon, Turquoise Parrot, Powerful Owl, and the Masked Owl. A number of these species records are unconfirmed or historical and so may not be reliable.

Middle Estuary Zone

The shoreline along the middle zone is dominated by bedrock which is covered by algae in the intertidal zone. Levels of planktonic algae (phytoplankton) in the water column can also be high, particularly during extended sunny weather after rain, when blooms can occur.

The variety and abundance of foreshore and bed faunal species was found to be considerably less than in the other zones (TEL, 1998). There are no uncultivated oysters in this area. These patterns may be associated with the salinity regime and periodically low oxygen levels in this zone.

There are some small stands of mangroves between rock outcrops, and more substantial stands at the heads of bays backed by saltmarsh areas. However, the abundance and diversity of mangrove biota appears to be very low (TEL, 1998). Seagrass beds are found in Calabash Bay and provide an important nursery area for aquatic fauna.

The vegetation within the surrounding areas away from the immediate foreshores consists mostly of dry sclerophyll forests, but includes small pockets of littoral rainforest in sheltered gullies.

Lower Estuary Zone

The lower estuary zone is more productive than the upstream zones. This results from regular flushing by large volumes of predominantly marine water from the Hawkesbury River combined with the inflow of catchment nutrients and food particles from Berowra Creek, Marramarra Creek and the Hawkesbury River. The zone is very rarely affected by algal blooms.

There are large areas of mangroves, particularly in the heads of bays that contain abundant marine life. These mangroves appear to be colinising the fringing saltmarsh areas. There are also extensive mud flats which support great ecological diversity (MHL, 1998).

Lower West Estuary Zone

Marramarra Creek is rich in ecological productivity due to its physical environment and relatively good water quality. Big Bay is considered to be of regional ecological significance due to the large areas of mangroves which have increased over recent decades. The mangroves support an abundance of fauna species, especially shellfish (molluscs and crustaceans) within the mangrove mud and on the aerial roots of the mangrove trees.

Big Bay is particularly productive due to its physical characteristics, it is wide and shallow with a mud substrate. The Estuary Processes Study (MHL, 1998) found that because of its location and productivity, an increase in the mangrove area of Big Bay could potentially increase overall estuary productivity to a greater extent than mangrove expansion elsewhere.

2.2.6. Human Development

Upper Estuary Zone

Vehicle access to the upper estuary zone is limited to the Crosslands area, where there is a picnic area/reserve on the eastern foreshore, and a youth/convention centre on the western foreshore. Access to the remainder of the waterway is either by foot or shallow draft boat.

In excess of 150 people can be accommodated at the youth/convention centre, but average long stay visitation numbers (>4 hrs) are around 50 per day. Anecdotal evidence suggests that picnic area visitations are of a similar order and pattern.

Both the convention/youth centre and the picnic area have mains water supply with on-site septic tank sewage disposal. Available data from past testing and inspections provides no evidence that these systems are contributing to faecal contamination of the estuary.

The Berowra Valley Regional Park contains extensive walking tracks, including a section of the Great North Walk (Benowie Walking Track). The park has been listed as being of State significant in the Hornsby Shire Heritage Study.

Aboriginal sites found in the park are protected and are managed by the National Parks and Wildlife Service (NPWS). Details of the locations of the sites are contained within a register held by NPWS,

but is not available for publication. The Woolwash is the only non-indigenous historical site of value near the estuary in this zone.

Middle Estuary Zone

The area around Berowra Waters is the area of greatest human development, and the area of greatest human impact within the estuary. Berowra Waters is a regionally important tourist and boating centre, as well as the main access location for the river settlements along the estuary.

The area is approached by a single road from Berowra Heights in the east and from Berrilee in the west. Access across the estuary is via a vehicle ferry. Seaplane charters operate between Sydney and Berowra Waters on a fairly regular basis, although this service is mainly utilised by restaurant patrons.

Along the western creek bank between the Woolwash and the Berowra Ferry there are 36 residences, and between Berowra Ferry and Calabash Bay there are 68. There is also a settlement of 46 properties at Neverfail Bay. Most of the properties are only accessible by water and have very limited services and infrastructure.

Telephone and electricity services are available throughout the zone, and fresh water is supplied through mains supply to Berowra Waters and Calabash Bay. At Neverfail Bay, tank water is used as there is no mains water supply. There is no direct garbage disposal service for the settlements, but occupants can deposit garbage in a large bin provided by Council at Berowra Waters.

Waste waters and sewage effluent are treated on-site with septic tanks or package treatment plants. The effluent is either discharged to the estuary or seeps into the soils (which have relatively poor absorption capacity and are very shallow). A recent survey by Council showed that many on-site treatment systems are not working adequately (Berowra Creek Audit of Domestic Sewage Management Systems and Wastewater Disposal Practices, HSC, October 1998).

There are marina facilities on both the east and west side of the creek. Two public wharves exist at Berowra Waters and a boat launching ramp is located on the west side of the creek. The residents of Berowra Waters have a resident's wharf and adjoining resident's parking. Some 245 permanent swing moorings are available near Berowra Waters, although not all are in use. There are casual and visitor mooring areas at Deep Bay, Joe Crafts Bay, and Neverfail Bay.

Lower Estuary Zone

The foreshores of the lower estuary zone are mainly National Park or Nature Reserve, although there are 39 residential properties at Coba Point. There is also a restaurant, Peats Bight Restaurant, at Sunny Corner. Access is only by water, generally via Brooklyn on the Hawkesbury River as it is closer than Berowra Waters.

The Coba Point river settlements have limited infrastructure, with no electricity, mains gas or water supplied, although there is a phone connection. In general, electricity is generated through petrol generators or solar panels, tank water is used for fresh water, and bottled gas is used for cooking

and heating. As with the middle zone, there is no direct garbage disposal service for the settlements, but occupants can deposit garbage in large bins provided by Council at Brooklyn or Berowra Waters.

Sewage and waste water disposal is on-site (usually) following some treatment via septic tank systems. The effectiveness of these systems is currently being investigated by Council.

Lower West Estuary Zone

The lower west zone is within the Marramarra National Park although there is a small river settlement of 17 properties at the mouth of Marramarra Creek. Due to the remoteness of this settlement there is little infrastructure (similar to Coba Point in the lower estuary zone).

2.2.7. Human Use

Upper Estuary Zone

Navigation of the upper estuary is limited to vessels with very shallow drafts under most tide conditions. However, the tidal range in the upper estuary is similar to that in the ocean, and a ruling depth of over 1.0 m is available during spring tides.

Use of the upper estuary around Crosslands is mainly connected to recreational activities such as picnicking, walking, swimming and canoeing. There are formal picnic facilities and parking, and an earth boat ramp suitable for launching small boats and canoes.

As access to the downstream section of this zone is restricted to small boats, recreational fishing and canoeing are the main uses. After heavy rain, the upper estuary is affected by faecal pollution, due to STP bypasses and catchment runoff. Verbal reports to the EMC indicate that this causes problems for swimming and canoeing in the area, especially for visitors at the Crosslands youth/recreation centre, where canoeing is a popular activity.

There is no commercial fishing undertaken in the zone. There is evidence of the sand shoals being used to beach vessels for cleaning and antifouling.

Middle Estuary Zone

To facilitate residential, recreational and boating use of the area there are a number of Council and private industry developments at Berowra Waters. These include a boat launching ramp, public wharves and pontoons, picnic areas and a tidal swimming pool, marina and slipways, kiosks and restaurants.

Recreational and commercial fishing are both pursued in this area because of the ready access. Recreational fishing is undertaken by both shore-based and boat-based fishers. Council is currently undertaking a study of recreational fishing patterns and catch levels. Commercial fishing is mainly undertaken by visiting fishers and their catch is marketed either direct to the Sydney Fish Markets or through the Hawkesbury River Cooperative. Because of this there are no accurate statistics of fish catch levels, and Council is also currently undertaking a study into commercial fishing.

Swimming is undertaken in this zone, both in the tidal pool and off boats in bays downstream of Berowra Waters. During the past two summers, aquatic stingers have been found in the water and have resulted in bathers being stung. No action or warnings were provided as the stingers are a natural phenomenon and not life threatening.

Lower Estuary Zone

There are several oyster leases in the zone, particularly in Coba Bay, Kimmerikong Bay and Peats Bight. The lower zone is suitable for oyster fattening due to its good water quality and high ecological productivity. This also makes the lower zone popular for commercial and recreational fishing.

Lower West Estuary Zone

There are extensive oyster leases within the creek, mainly toward the creek mouth. The area is particularly productive for oysters, and is used for growing/fattening to improve the oyster meat prior to sale. There is very little boating in the zone as the waters are shallow and not easily navigable by most boats.

3. EXISTING CATCHMENT MANAGEMENT AND CONTROL

3.1. Management and Control Authorities

As indicated in the Introduction, there are a large number of government authorities involved in the management of the Berowra Creek catchment and hence are relevant to the management of the estuary. The context in which the key authorities operate is shown schematically in Chapter 1(see Diagram 1). An agreement between five of these authorities to work together to improve the environmental quality of Berowra Creek (the Statement of Joint Intent) is also outlined in Chapter 1.

Details of the statutory controls and roles of the government authorities involved in the management and control of Berowra Creek are as follows.

3.1.1. Local Government

Hornsby Shire Council is the major management and control authority within the Berowra Creek Catchment. Council is responsible for management of the catchment under the *Local Government Act (1993)* and under the provisions of the *Environmental Planning and Assessment Act (1979)*. Council already has several management planning documents which cover matters relevant to Berowra Creek Estuary. These include:

- Berowra Creek Water Quality Management Strategy (WQMS),
- Berowra Catchment Stormwater Management Plan (BSMP),
- Berowra Waters Plan of Management (BWPM).

To avoid duplication and possibly the adoption of conflicting management strategies, details of these planning documents and how they impact on the scope and findings of this study are addressed in the following Section 3.2.

Council also has several development plans which provide a framework for land use and environmental protection within the Berowra Creek catchment. The main document is the *Hornsby Shire Local Environmental Plan (LEP) 1994*. The LEP and associated relevant Development Control Plans (DCP✪s) are addressed more fully in Section 3.3.

There are also several Regional Environmental Plans (REP) and State Environmental Planning Policies (SEPP) of relevance to the Berowra Creek estuary for which Council is responsible, including:

- **Sydney REP20 - Hawkesbury/Nepean River**, which provides an overall framework to guide planning along the Hawkesbury/Nepean River including Berowra Creek.
- **SEPP19 - Bushland in Urban Areas**, which protects and preserves bushland within urban areas because of its value to the community.
- **SEPP32 - Urban Consolidation-Redevelopment of Urban Land**, which focuses on consolidating development through the redevelopment of urban land no longer required for its current purpose.

- **SEPP35 - Maintenance Dredging of Tidal Waterways**, which applies approval conditions for maintenance dredging should it be undertaken.

3.1.2. State Government

A number of State Government authorities, through various acts and statutory responsibilities, also have major roles in the management of Berowra Creek Estuary. Some of the more important roles are:

- **Department of Urban Affairs and Planning (DUAP),** which is a signatory to the Statement of Joint Intent, and has a general overview role under the planning provisions of the *Environmental Planning and Assessment (EPA) Act 1977.* DUAP also has a role within the planning framework and guidelines set out in the REP 20 for the Hawkesbury/Nepean River, which includes Berowra Creek.

- **Department of Land and Water Conservation (DLWC)** through the Statement of Joint Intent, and for management of the bed and banks of rivers under the *Rivers and Foreshores Act (1984),* for Crown Lands under the *Crown Lands Act (1989)*, for the coastal zone generally under the *Coastal Protection Act (1979),* and for catchment management and soil conservation and erosion under the *Catchment Management Act (1989) and Soil Conservation Act (1938).*

  The Department is also an important development approval authority under the provisions of the *EPA Act*, particularly for development on Crown Land, or for development on or near the bed and banks of waterways. SEPP 35, for the Maintenance Dredging of Tidal Waterways specifically refers to the Department as a necessary contact and approval authority.

  The DLWC is a major contributor to estuary management through their supervision of the State Government's Estuary Management Program, as well as other programs such as the Waterways Infrastructure Program or the Minor Ports Program.

- **Environment Protection Authority** as a signatory to the Statement of Joint Intent, and for water quality and the prevention of environmental damage under the *Protection of the Environment Operations Act (1997),* which comes into operation on July 1999 and replaces the *Clean Waters Act (1970)* and the *Environmental Offences and Penalties Act (1989)*.

- **Sydney Water Corporation** as a signatory to the Statement of Joint Intent, and for water supply, sewage treatment and sewage effluent discharges in the catchment under the *Sydney Water Act (1994)*.

- **Waterways Authority** for commercial and recreational boating regulation and management, plus navigation and boating safety considerations, under the *Maritime Services Act (1935).* The Authority also has boating infrastructure development capacity under their participation in the Government's Waterways Asset Development and Management Program.

- **NSW Fisheries** for management of the fishery, and commercial and recreational fishing conditions under the *Fisheries Management Act (1994)*, including the designation of *marine protected areas*. Fisheries are also an important approval authority under the *EPA Act,* as well as having a major role in the preservation and maintenance of SEPP 14 Coastal Wetlands, seagrasses and mangroves.

- **National Parks and Wildlife Service (NPWS)** through their responsibilities for heritage matters, threatened species conservation, migratory bird management, and ownership and management of the Regional and National Parks under the *National Parks and Wildlife Act (1974)*, the *Threatened Species Conservation Act (1995)*, plus the *Commonwealth Government's Japan-Australia and China-Australia Migratory Bird Agreements*.

  NPWS are also responsible for the management and preservation of Littoral Rainforest under SEPP 26.

- **NSW Agriculture**, for the control of noxious weeds under the *Noxious Weeds Act (1993).*

3.1.3. Commonwealth Government

The Commonwealth is not a major participant in management or control of the Berowra Creek estuary. However, the Commonwealth Government does have some potential interest in the estuary through the *Heritage Act (1997)* which is administered through the Heritage Council, and a possible interest through the *Commonwealth Native Title Act (1993)*.

There are also a number of Commonwealth programs administered through Environment Australia, particularly those related to the National Heritage Trust (funds from the sale of Telstra), which could be of relevance to future Estuary Management Plan funding. These programs generally provide two-thirds of the project cost and require significant community involvement.

3.1.4. Other Statutory Bodies

There are three important bodies with relevance to Berowra Creek which do not come directly under State or Commonwealth government due to their community representation. Each plays a particular role.

- **Hawkesbury-Nepean Catchment Management Trust (CMT) and the Berowra Catchment Management Committee (CMC)** through the Statement of Joint Intent, and their responsibilities under the *Catchment Management Act (1989)* to co-ordinate policies, programs and activities related to catchment management.

- **Berowra Valley Regional Park Trust Board (BVRPT)** are the management body for Berowra Valley Regional Park Trust. The board is comprised of Council representatives, NPWS representatives and community representatives. Under the Regional Parks Amendments to the

National Parks and Wildlife Act (1974) this body has responsibility for the Berowra Valley Regional Park.

3.2. Specific Council Estuary Management Plans

3.2.1. Berowra Creek Water Quality Management Strategy

The Berowra Creek Water Quality Management Strategy was prepared jointly by Hornsby Shire Council, DUAP, Sydney Water, Hawkesbury-Nepean CMT and the EPA following signing of the Statement of Joint Intent. The Strategy recognises the need for all the parties involved to co-ordinate their actions. The Berowra CMC has the role of reviewing the Strategy and ensuring that the actions laid out in it are being implemented.

The Strategy's main goal is to provide water quality in Berowra Creek, downstream of Fishponds Waterhole, that is consistent with the pursuit of recreational activities such as swimming, canoeing and boating. The Strategy outlines both the current and intended actions of the agencies involved in influencing water quality management within the Berowra Creek catchment.

The Water Quality Management Strategy is based on seven objectives:

- to develop appropriate water quality objectives including identifying achievable targets and defining timeframes for reaching a specified level,
- to increase understanding of aquatic ecosystems and water quality and quantity dynamics, gaining an understanding of the nature and health of the waterway as well as the hydrodynamics,
- to control "point-source" pollution; of particular importance being the two STP's in the catchment, but also direct discharge package STP's, leachate and contaminated runoff from waste disposal sites,
- to control "diffuse source" pollution from sources such as agricultural, urban, rural residential and degraded lands,
- to improve the health of creek and streambanks within the catchment, to remediate degraded or vulnerable stream banks and to prevent further erosion,
- to increase knowledge and understanding in the community of water quality issues, so that people will understand the consequences of their actions on water quality,
- to increase community involvement in improving water quality and in water quality management, so that the management actions reflect community aspirations.

For these objectives, strategies and actions have been developed. The strategies and actions relevant to the estuary and related to particular management issues are outlined in Chapter 5.

3.2.2. Berowra Catchment Stormwater Management Plan

A Stormwater Management Plan has been prepared by Hornsby Shire Council and other stormwater managers within the catchment, including Statement of Joint Intent signatories. The organisations involved were:

- NSW Environmental Protection Authority,

- Sydney Water Corporation,
- Department of Land & Water Conservation,
- National Parks & Wildlife Service,
- Department of Urban Affairs and Planning,
- Rail Access Corporation,
- Roads and Traffic Authority,
- Berowra Catchment Management Committee.

The aim of the Plan is to improve the management of stormwater within Berowra Catchment so as to sustain the agreed catchment values. A general outline of the Plan is as follows:

- a brief description of the catchment,
- definition of stormwater management objectives,
- identification of stormwater management problems and issues,
- evaluation of potential stormwater management practices to address the identified problems and issues,
- strategy implementation which includes prioritisation of specific actions for stormwater managers and timeframes for implementation,
- a monitoring program to assess the Plan's effectiveness and identify refinements,
- a mechanism for reporting the effectiveness of the Plan to stakeholders, including the community,
- a program for revising the Plan and linking it to the process of State of the Environment Reporting and Council Management Planning.

The Stormwater Management Plan is based on Total Catchment Management (TCM) and Ecologically Sustainable Development (ESD) principles. The objectives adopted for the Plan are the same seven objectives as outlined for the Berowra Creek Water Quality Management Strategy (previous section).

Each objective has been addressed by a number of strategies. These strategies cover catchment-wide, sub-catchments and specific issues. The strategies are taken from the Berowra Creek Water Quality Management Strategy and the actions follow on from the adopted strategies.

3.2.3. Berowra Waters Plan of Management

The Berowra Waters Plan of Management (Connell Wagner, 1999), which was in final draft form at the time of preparation of this study, was prepared for Hornsby Shire Council and the Department of Land and Water Conservation. The Plan addresses the particular concerns of the Berowra Waters area but in many respects is applicable for all the river settlements along Berowra Creek. The study area covers approximately a 4 km square in the immediate vicinity of the ferry.

The Management Plan addresses issues affecting water quality, the natural environment, scenic quality, and the social, cultural, heritage and recreational values of the area. The Plan identifies the features or ⊙values⬡ which are important or unique about the study area and develops goals and objectives to address the issues surrounding these. The goals for each of the values are as follows:

- **Social and Cultural:**
  - *Residential development:* to maintain and enhance existing residential areas to provide a safe and pleasant living environment whilst minimising impacts on the environment.
  - *Commercial development:* to maintain and enhance existing commercial areas to provide facilities for local residents, and opportunities for those visiting the area to experience its values whilst minimising impacts on the environment.
  - *Infrastructure and Support Functions:* to provide infrastructure and other facilities of an appropriate standard to support residential, commercial and recreational activities and provide for the protection of the aquatic and terrestrial scenic values.

- **Water Quality:**
  - To improve water quality emanating from development and human activities to achieve the catchment management objective of having water of a quality within ANZECC (and NH&MRC) guidelines for the protection of aquatic ecosystems and recreational waters.

- **Natural Environment:**
  - To maintain, protect and enhance the natural environment of the Berowra Waters area and improve the value and integrity of bushland.

- **Landscape and Scenic Quality:**
  - To preserve the views and scenic quality of the Berowra Waters area through preservation and conservation of bushland and other natural features as well as minimising the effects of urban development.

- **Heritage:**
  - To protect, maintain and enhance significant heritage features of the Berowra Waters area including the natural bushland and individual heritage items as well as maintaining the fabric and scale of the existing townscape elements.

- **Recreation:**
  - To provide a quality recreation experience for visitors to the Berowra Waters area whilst protecting the environment.

- **Education and Awareness:**
  - To increase awareness of the ecological, recreation and heritage value of the Berowra Waters area.

- **Resource Management:**
  - To improve the effectiveness of management of the Berowra Waters area.

For each of the goals specific strategies and actions were recommended. Specific recommendations in the Plan include that there should be no further residential or commercial development in the area, except on vacant allotments where the right to build currently exists. The

Plan also recommends that extensions to existing development should be limited so as to maintain the village atmosphere.

The Berowra Waters Plan of Management addresses the problems of parking and access to Berowra Waters, including pedestrian access and boat mooring. In terms of vehicle access and parking it recommends improvements and extensions to the existing facilities. It also recommends improvements to the pathway system and retention of the existing number of moorings, with any increase in the number of marina berths being matched by a reduction in swing moorings.

The Plan identifies the need to reduce the pollution load on Berowra Creek from human activity in the area by controlling sewage disposal, stormwater runoff, boat discharges and marina activities, but does not propose any strategies for dealing with these issues. The Plan does propose an upgrading of the existing household waste disposal procedures and the use of recycling and composting to reduce waste disposal problems.

The proposed management actions impacting on the estuary, are included under the relevant sections in Chapter 5.

3.3. Other Estuary Use and Control Plans

There are a large number of use and control plans which apply to the estuary waterway and catchment of Berowra Creek. These plans include the Hornsby Shire Local Environmental Plan, and a number of Development Control Plans prepared by Hornsby Shire Council which provide detailed guidelines for specific types of developments, issues and areas. It also includes plans prepared by the Berowra Catchment Management Committee and State Government authorities for the management of National and Regional Parks, sewage disposal, the fishery, and boating/navigation.

3.3.1. Local Environmental Plan

The Hornsby Shire LEP sets out the planning controls which apply to the entire Hornsby Shire area including the Berowra Creek estuary foreshore and catchment. Most of the estuary waterway is unzoned. The intertidal mangrove areas at the heads of bays are zoned for Environmental Protection, and the estuary foreshores are either zoned for National Parks and Nature Reserves, Open Space A & B (Public Recreation), or Environmental Protection B (River Catchment).

The relevant conditions which apply to the estuary foreshore zoning categories are:

- **National Parks and Nature Reserves**, which includes land which is dedicated or reserved as National Park under the *National Parks and Wildlife Act (1974)*. Development in these zones are limited to that authorised by the National Parks and Wildlife Act. This includes park management related developments such as picnic areas, walking tracks, fire trails or park administration/maintenance facilities.

- **Open Space A and B (Public Recreation)**, this zoning aims to provide adequate open space for the local and regional community as well as to preserve areas of urban bushland. Development that is allowed to proceed without consent includes bushfire hazard reduction (except ancillary buildings), gardening and landscaping.

- **Environmental Protection B (River Catchment)**, this covers the river settlements within the Berowra Creek (and Hawkesbury River) catchment. The zoning aims to protect the natural environment and the scenic qualities of the area. Development in these areas must not cause significant environmental impact, and must be sensitive to the existing land use and the visual quality of the area.

Most of the catchment away from the foreshores is zoned either as National Park and Nature Reserve, or as Open Space A and B. Of the total catchment area some 50% is National Park and Nature Reserve and 10% is Regional Park, with approximately 15% zoned for urban development and 25% zoned for rural development.

The urban development consists of a mix of residential, business, industrial and open space zones. Most of the areas zoned residential are low density (Residential A) although there are higher density residential areas in the centre of Hornsby. Residential A zones aim to meet the residential needs of the Shire in a low density environment. This restricts developments to less than 9 metres in height.

Rural development in the study area has progressively decreased over the past forty years, with more land being converted to urban use. Most of the remaining rural areas are now to the west of Berowra Creek and in the Marramarra Creek catchment. The main land uses are vegetable and flower cultivation, orcharding, grazing, poultry raising and rural residential.

3.3.2. Development Control Plans

A large number of Development Control Plans (DCP's) have been prepared by Hornsby Shire Council to support the Hornsby Shire Local Environmental Plan. The DCP's provide more detailed guidelines for specific types of developments. The Plans are divided into Zone Plans, Issue Plans and Area Plans.

Zone Plans exist for Rural, Residential, Business and Industrial Zones. The matters addressed relate to Berowra Creek estuary only insofar as they control/limit the type of development which can occur in the catchment and hence potentially influences the quality of the runoff waters and STP discharges.

Issue Plans include matters such as Car Parking, Heritage, Sustainable Water, Subdivision and Community Uses. Only the Heritage and Sustainable Water Plans are of particular relevance to the management of Berowra Creek Estuary.

The Heritage Plan applies to heritage items, heritage conservation areas and lands in the vicinity of heritage items and conservation areas. The DCP aims to conserve the heritage significance of the natural or built environment by ensuring new development is sympathetic to identified heritage

values, providing guidance for development in relation to heritage items and to encourage an understanding of heritage significance.

All developments that are listed as heritage sites in the Local Environment Plan are required to undertake a Heritage Impact Assessment when a development application is lodged. Heritage sites and areas in Berowra Creek estuary and its foreshores are:

- Berowra Waters vehicular cable ferry,
- Berowra Waters boatshed,
- Berowra Waters kiosk/ teahouse,
- Berowra Waters toilet block (on eastern shore),
- cemetery, church ruins and memorial on Bar Island,
- ballast heap at the junction of Berowra Creek and Marramarra Creek,
- ⊙Tarcoonee⬠ at Sunny Corner,
- remains of George Peat✪s farmhouse at Peats Bight,
- Old Road at Peats Bight.

Heritage sites also include sites significant to natural heritage.

- Berowra Valley Regional Park,
- Marramarra National Park,
- Muogamarra Nature Reserve.

The Sustainable Water Plan aims to achieve the implementation of sustainable water practices in the Hornsby Shire. Sustainable water practices address quantity and quality of runoff, stormwater drainage corridors, water conservation and reuse of stormwater. The plan provides development controls which were established using the principles of ecologically sustainable development. The Plan advocates a number of measures to improve water usage and management in the catchment. These measures include retaining stormwater on-site for reuse in rainwater tanks, and increasing groundwater recharge through the use of permeable surfaces in development, such as porous pavements.

There is only one Area Plan of direct relevance to Berowra Creek Estuary, the River Settlements DCP. This Plan provides controls and guidelines in order to maintain the unique nature of the river settlements. There are other Area DCP's for the Berowra Creek catchment, including DCP's for Berowra Cowan Precinct, Cherrybrook, Dural Service Centre, Dural Village, Hornsby Town Centre and Pennant Hills Commercial Centre. However, like the Zone DCP's these are only relevant when considering the effect of the wider catchment on Berowra Creek Estuary.

3.3.3. Berowra Catchment Management Committee Strategic Plan

The Berowra Catchment Management Committee is made up of Council and government agency representatives, and interested community members. The committee was formed in July 1994 under the Catchment Management Act, by the parent body the Hawkesbury-Nepean Catchment Management Trust. The Committee's responsibilities stemmed from the Statement of Joint Intent, and include facilitating information exchange, and monitoring and supporting the Statement's aims.

The BCMC Strategic Plan sets out how the Committee will address their responsibilities. It firstly reviews the environment of the area, concentrating on the biggest issues for the catchment. Of particular concern are stormwater management, sewage treatment and disposal, and water quality, other areas of concern are:

- environmental flows,
- groundwater management,
- geological resource management,
- land use planning/capability,
- population/carrying capacity,
- erosion and sedimentation,
- waste management,
- bushland management,
- fisheries management,
- scenic quality management,
- tourism and recreation,
- education and community involvement,
- information needs,
- funding.

Several of these areas of concern relate directly to the management of the Berowra Creek Estuary. The particular objectives and strategies relating to these areas are therefore of relevance to this study. The relevant objectives include:

- to effectively manage stormwater flows, which cause erosion, siltation and transfer of litter, pollutants and weeds into the stream system or catchment,
- to achieve a reduction in effluent nutrient levels until community-based water quality objectives are achieved,
- to minimise the impact of septic systems,
- to maximise effluent re-use of treated water within the catchment,
- development of appropriate water quality objectives,
- to increase understanding of aquatic ecosystems and water quality and quantity dynamics,
- to control pollution from point sources,
- to reduce pollution from existing urban areas,
- to reduce pollution from new urban developments,
- to reduce pollution from agricultural activities,
- to reduce pollution from rural residential activities,
- to control pollution from degraded sites,
- to improve health of creek and stream banks throughout the catchment,
- to increase knowledge and understanding in the community of water quality issues in Berowra Creek,
- to increase community involvement in improving water quality and in water quality management,
- to ensure that development is in accordance with the principles of Total Catchment Management, Ecologically Sustainable Development, the Statement of Joint Intent and the Intergovernmental Agreement on the Environment,

- to effectively utilise planning and regulatory processes to help address soil erosion and sedimentation,
- to engage everyone in efforts to address soil erosion and sedimentation control,
- to conserve and restore habitat to ensure diverse sustainable populations in the creeks and waterways of the Berowra Total Catchment Management area,
- to encourage the effective management of commercial and recreational fishing,
- to minimise the loss of vistas and the impact of development,
- to ensure that all tourist development is ecologically sustainable and does not create an adverse impact on the environment,
- to ensure the effective delivery of information,
- to know the health of the catchment and how and why this is changing,
- to identify new information needs and co-ordinate and facilitate its provision,
- to achieve optimal funding to address priority issues.

The strategies and actions in the plan set out how the Committee functions as part of the community. The Plan adopts the strategies and actions of the Berowra Creek Water Quality Management Strategy as well as creating other strategies and actions. Through the strategies and actions of the Plan, Berowra Catchment Management Committee provides advice and support to government departments and the community.

3.3.4. Sewage System Management Process

Management of the sewerage system, since 1994, has been founded on the Statement of Joint Intent in which Sydney Water agreed to upgrade the two STPs in the catchment. In addition to these plant upgrades Sydney Water has also aimed to reduce sewage overflows, as part of the Sewer Overflow Reduction Program.

Strategic management of the Hornsby Heights and West Hornsby STP's and sewage systems has been determined over the last few years by the preparation of three EIS's. One EIS is titled *Options for Sewage Treatment and Effluent Disposal for West Hornsby and Hornsby Heights Sewage Treatment Plants* (SMEC, 1997), and the other two are *Sewerage Overflows Licensing Project EIS for West Hornsby Sewage System* and *Sewerage Overflows Licensing Project EIS for Hornsby Heights Sewage System* (CH2MHill, 1998). These EIS✪s examine options for managing the sewage system so that discharge quality is improved and overflows are reduced such that the requirements of the Statement of Joint Intent are met.

To achieve this outcome Sydney Water proposes to undertake treatment plant upgrades and sewerage reticulation improvements. The aim is to reduce total nitrogen (TN) levels and dry weather (90 percentiles) discharge waters to 5 mg/L, and to limit the occurrence of untreated wet weather overflows to less than 3 per year on average.

To achieve the nutrient reduction, nitrogen removal tanks and methanol dosing facilities need to be constructed. This will be accompanied by substantial general upgrading and integration works to reduce the occurrence of overflows. Overflow reduction is being addressed by a 5.6 ML storage

lagoon for the West Hornsby STP, along with upgrading of pumping station storages and ongoing works to reduce the ingress of water to the pipe system during rain.

According to the EIS's, the implementation of these management strategies and ongoing system improvements, are expected to reduce and possibly eliminate the occurrence of algal blooms in the estuary. As well as make estuary waters suitable for primary and secondary contact on an annual basis. It is anticipated that the major upgrades to the STPs will be completed within the next five years.

The long term aim for Sydney Water under the Sydney Water Act is to eliminate dry weather discharges of sewage to waters. This therefore is the long term aim of Sydney Water for Berowra Creek.

3.3.5. Berowra Valley Regional Park Plan

Berowra Valley Regional Park was established in 1998, by the National Parks and Wildlife Service. It comprises the area previously known as Berowra Valley Bushland Park, as well as some areas that were previously Crown land. The legislation under which the Park is governed is a 1996 Amendment to the National Parks and Wildlife Act, 1974, covering Regional Parks.

The Plan of Management for the previous Berowra Valley Bushland Park has been adopted as an interim Plan of Management to the Berowra Valley Regional Park. Hornsby Shire Council is presently updating the Plan and has a draft Fire Management Plan for the park.

Under current arrangements the Regional Park is managed jointly by Hornsby Shire Council and the NPWS, through the Berowra Valley Regional Park Trust. The Trust Board which includes Councillors, the Council✪s Bushland Manager, the NPWS Northern Metropolitan District Manager, and two community representatives, is the ultimate consent authority for management decisions within the Regional Park. Council manages the day to day running of the Park, while NPWS undertakes the management of fire and endangered species.

Despite the recent change from a Local to a Regional Park the management of the Berowra Valley Regional Park is unlikely to change significantly, and there will be no significant effect on the estuary. Possible developments at the Crosslands Reserve, which could have very minor impacts on the estuary include construction of an Environmental/Visitors Centre and upgrading the existing on-site septic toilets to a package treatment system.

3.3.6. National Park and Nature Reserve Plan of Management

The National Parks and Wildlife Service produce a Plan of Management for each of their parks, under the National Parks and Wildlife Act, 1974. In the case of Marramarra National Park, Muogamarra Nature Reserve and Maroota Historic Site, one joint plan has been produced. This is because of the close proximity of the areas, the similar nature of the environments and also for ease of management. All actions undertaken within the reserves must comply with the Plan of Management.

The Plan details the objectives of management, and the policies and actions to achieve those objectives. The objectives covering Marramarra National Park and Muogamarra Nature Reserve are:

- the protection and preservation of scenic and natural features,
- the conservation of wildlife,
- the maintenance of natural processes as far as is possible,
- the preservation of Aboriginal sites,
- the conservation of historic features,
- the provision of appropriate recreation opportunities (only for Marramarra National Park),
- the encouragement of scientific and educational enquiry into environmental features and process, Aboriginal and historic features and park use patterns (only for Marramarra National Park).

In addition to the general objectives outlined above, the following more specific objectives apply:

- to manage the reserves as part of a system of national parks, state recreation areas, nature reserves and historic sites which together protect the natural and cultural heritage, water catchment and scenic values of the lower Hawkesbury River,
- to manage the reserves so that they complement other parks in northern Sydney in regard to public access and use,
- to provide opportunities within Marramarra National Park for bushwalking, bush camping and self-reliant recreation in a natural environment,
- to provide opportunities in Muogamarra Nature Reserve for education and research into the natural environment and cultural heritage on a controlled basis.

Actions arising from these objectives with particular relevance to Berowra Creek estuary include:

- The Service will work with Hornsby Council and other agencies to monitor the water quality of streams entering the National Park and Nature Reserve.

- The Service will seek the co-operation of the Berowra Catchment Management Committee and Hornsby Council to minimise the impacts of developments which compromise the protection of catchments or the scenic values of the reserve.

- The Waterways Authority will be approached to institute a maximum 4 knot speed limit on power boating in Joe Crafts Bay and to increase patrols of speed limits in Big Bay and along Berowra Creek so as to limit damage to the mangroves and seagrasses.

- Site protection works will be undertaken where necessary to protect Aboriginal sites from impacts by people or natural processes in conjunction with the Metropolitan Aboriginal Land Council.

- Signs will be erected at the beaches along Berowra Creek in Marramarra National Park indicating that no camping, fires or domestic animals are permitted.

- The garbage bins on Berowra Creek and at Marramarra Creek will be removed.

3.3.7. Hawkesbury-Nepean River System Habitat Protection Plan

NSW Fisheries under the Fisheries Management Act (1994) has prepared Habitat Protection Plans (HPP's). These Plans are for the protection of fish habitat, where the term "fish" includes finfish and all aquatic invertebrate animals.

The Hawkesbury-Nepean River System HPP is the third HPP to be developed in NSW. The first two plans concern state-wide issues, rather than particular river systems. HPP No.1 deals with dredging, reclamation, fish passage, mangroves, other marine vegetation and snags. HPP No.2 deals specifically with seagrasses. Both HPP No.1 and HPP No.2 are relevant to Berowra Creek.

HPP No.3 is specific in nature and applies to all waters and associated habitats within the Hawkesbury-Nepean catchment. Habitats essential for fish spawning, nursery, shelter and feeding are covered under this Plan. The Plan covers activities affecting these habitats, pollution, erosion and sedimentation, dredging and extraction, reclamation, construction of breakwaters, jetties, bridges, culverts, ramps and pontoons, construction and operation of aquaculture facilities, flood mitigation, drainage and river control works, clearing of riparian or floodplain vegetation, removal of snags, boulders or rock, fishing and collecting, water regulation, impeding of fish passage and boating.

The Plan outlines specific strategies for each of these activities. The strategies of the Plan aim to reduce the impact of the activities have on fish habitats and breeding grounds.

3.3.8. Berowra Creek Waterway Boating Map

There is no specific Waterway/ Navigation Plan for Berowra Creek, although there is a boating map, produced by the NSW Waterways Authority, which identifies the controls placed on boating in the

Berowra and Marramarra Creeks (see Figure 2). This map shows that Berowra Creek upstream of Berowra Point is a no wash zone and no water skiing or aquaplaning is allowed. There is a 4 knot speed limit upstream of Calabash Point. The map also indicates where boating facilities are located and where mooring is permitted.

Boat waste disposal in the Hawkesbury River system is covered by a voluntary code of practice which outlines suggested ways of dealing with wastes. This code identifies the specific no discharge areas, as:

- marinas,
- clubs,
- established mooring areas and regularly crowded anchorages,
- minimal tidal flushing inlets or bays,
- all 4 knot, 8 knot and no wash zones and within 100 m of the shore.

Under the existing voluntary code all of Berowra Creek is a no discharge area. It is worth noting that despite the voluntary nature of the code, legally boat owners are required to not pollute under the *Protection of the Environment Operations Act 1997*.

Given the potential for pollution and the recommended extent of the no discharge area, the major issue for boating on the estuary is pumpout facilities. At present, there are no sewage pumpout facilities for boats in Berowra Creek. This means raw sewage is regularly being discharged into the Creek, from commercial and recreational vessels alike. This practice is of concern amongst oyster farmers, recreational and commercial fishers, a number of government authorities and Council. There is therefore a definite need to address this issue as part of the management of boating on Berowra Creek.

At present, NSW Waterways Authority is developing a policy for regulating people staying on board boats. The policy is based on controlling practical use and avoiding nuisance while vessels are at rest. The policy if implemented would require people staying aboard vessels to comply with Council requirements as well as with strict noise, visual and pollution requirements.

4. ISSUES ASSESSMENT AND OBJECTIVES

4.1. General

Issues specifically affecting management of the Berowra Creek Estuary were initially identified by the Estuary Management Committee as part of the Estuary Processes Study. These issues have been reviewed as part of the Estuary Management Study, firstly by the Estuary Management Committee and then by the wider community through the Estuary Management Contact Group.

To assist with the assessment and development of management objectives, the issues have been grouped into four categories covering Estuary Management, Water and Sediment Quality, Human Use and Ecology. It should be noted that many of the relevant issues have already been addressed by Council as part of:

- Berowra Creek Water Quality Management Strategy,
- Berowra Creek Stormwater Management Plan,
- Berowra Waters Plan of Management.

Issues dealt with extensively by other plans have not been afforded detailed consideration by this Plan. For example, car parking and traffic problems were addressed by the Berowra Waters Plan of Management and have therefore not been included in this Plan.

4.2. Estuary Management

4.2.1. Data Collection Co-ordination

Issue: This issue relates to the various water quality testing procedures and approaches currently undertaken in the Berowra Creek catchment and the need to co-ordinate these between the Agencies involved. As part of the Statement of Joint Intent, Sydney Water, the NSW Environment Protection Authority, and Hornsby Shire Council formally agreed to develop a cooperative water quality monitoring program which was to include a joint database and reporting system.

Despite the establishment of the program, there is still a lack of co-ordination between the agencies. Greater co-ordination is required to maximise the relevance and value of the information gathered. It is important that the compiled data is easily accessible to the public. The data may be best displayed through an Internet site which can be easily updated.

Objective: The management objective is to ensure a co-ordinated and integrated water quality monitoring program is established for the catchment and the estuary which is easily accessible to waterway managers and users.

4.2.2. Human Health and Safety

Issue: Algal blooms, high levels of faecal contamination and aquatic stingers in estuary waters, all pose a threat to human health and safety. This issue involves the management of the human health and safety problems. It does not address the environmental processes by which these problems occur which are either a natural phenomenon or are addressed in other sections.

In the past there has been confusion as to who is responsible for the proper management of algal blooms. This is partly because the management of algal blooms in estuaries has passed from EPA to DLWC in recent years and the roles and responsibilities of each body have been confused in the process. Algal bloom management falls under the responsibility of the Regional Algal Co-ordinating Committee (RACC) now chaired by the DLWC. A review of algal bloom management is currently being carried out by DLWC.

For each of the cases, algal blooms, faecal pollution and stingers, the issue relates to identification of the problem and response to the occurrence. The management of algal bloom and faecal pollution warnings is particularly significant in relation to primary and secondary human contact as well as oyster production and harvesting. Aquatic stingers are of concern for primary contact activities, such as swimming.

To properly inform and protect the public a recreational water quality program would need to be established. Recreational water quality monitoring requires a thorough monitoring schedule. The ANZECC guidelines require water quality testing to be carried out every 6 days.

In relation to the issue of warnings to the general public as to the health and safety of the waterway, the community consultation process identified widespread concern as to their implications and Council's legal responsibilities. Council's obligations arise from its duty of care, having provided waterway access facilities, yet knowing that on occasions the water is potentially not safe or healthy. The nature and extent of Council's obligations however, need to be clarified.

Objective: The management objective is to establish formal monitoring, identification and warning procedures as required, so as to safeguard public health and minimise disruption to recreational and commercial waterway users.

4.2.3. Estuary Management

Issue: As the estuary management program develops within Hornsby Shire Council additional human resources will be required to both develop estuary management plans and to then oversee implementation. Initially, Berowra Estuary Management Plan will need to be implemented. Following on from this, funding is now available for a Brooklyn Management Plan which will also need to be developed and then implemented. Two further areas, Cowan Creek and the main Hawkesbury River from Wisemans Ferry down to the Hawkesbury River Road Bridge, will need to be addressed in a similar way. Each of these plans may take up to 3 years to develop and will then require implementation.

There is a considerable risk that as there is no one person with defined ownership/responsibility for overseeing the estuary management program, these individual plans and the overall integration of the plans will not be implemented properly and Council will not fully benefit from the funding available.

Objective: The management objective is to ensure that Berowra Creek and surrounding estuaries are managed effectively and that the estuary management plans are properly produced and implemented.

4.3. Water and Sediment Quality

4.3.1. Catchment Sourced Pollution

Issue: This issue relates to the adverse impacts on the estuary from catchment sourced pollutants, particularly nutrients and faecal material but also sediments and chemical pollutants generally. The highly developed urban areas of the catchment, and the two STPs that service these areas, are major sources of pollutants. Several disused waste disposal sites have also been identified as contributing to the overall pollution load. The Estuary Processes Study and other water quality studies have found that STP discharges, STP bypassing and urban catchment runoff combined have contributed to degradation of the estuary.

Objective: The management objective is to sufficiently reduce the level of catchment sourced pollutants so as to protect aquatic ecosystems, and allow for primary human contact and the production of edible fish, crustacea and shellfish.

4.3.2. Freshwater Inputs

Issue: The Estuary Processes Study identified the high volume of freshwater entering the upper estuary as a significant contributor to the reduced diversity and abundance of aquatic fauna in these areas. The high level of freshwater inputs is also associated with density stratification in the middle estuary after rain. The Estuary Processes Study identified this density stratification as a precursor to the formation of algal blooms.

The high volumes of freshwater have two separate sources. The main sources during dry weather are STP discharges which more than double mean catchment baseflows. During wet weather the sources are a combination of STP discharges and bypasses, plus increased runoff from hard surfaces in the urban areas.

Objective: The management objective is to reduce the volume of catchment sourced freshwater to a level suitable for the restoration of aquatic ecosystems in the upper estuary.

4.3.3. Boat Sourced Pollution

Issue: This issue relates to the discharge of faecal material and gross pollutants (rubbish) from vessels using the estuary. The issue was identified as a problem by the Estuary Management Committee and local residents. It mainly relates to "stay aboard" boat users and a lack of adequate disposal facilities (such as sewage pumpout facilities and waste skips) with inadequate policing of existing control. The problem applies to both commercial and recreational vessels including day trippers and overnight users.

Objective: The management objective is to eliminate boat sourced pollutants by providing appropriate infrastructure and controls.

4.3.4. River Settlement Sourced Pollution

Issue: The existing River Settlements have an average population of over 200 people and are a source of both faecal pollution and general house based water and gross pollutants. Most of the properties rely on boat access, and all of them rely on onsite sewage disposal and offsite waste disposal. A recent audit of onsite sewage management (October 1998) found that many systems failed to meet adequate health standards.

Objective: The management objective is to eliminate pollution sourced from the River Settlements by providing appropriate infrastructure, servicing and controls.

4.3.5. Heavy Metal Accumulations

Issue: The Estuary Processes Study found that there has been an accumulation of heavy metals particularly lead, zinc, copper and chromium in the bed sediments around the Berowra Waters area. The source of these metals is likely to be attributable to waterway access and boating through vehicle emissions, moored vessels, seepage and slipway scrapings. The deposition of fine sediments from the catchment (with attached metals) is also likely to be a factor. There is also some research indicating possible organochloride pesticide accumulations in the sediments, although this is not considered to be a significant problem (CSIRO, 1997)(Uni. of Sydney, 1997).

Objective: The management objective is to control inputs from known sources such as boat slipping antifouling activities and road surface runoff. Any other major sources of sediment pollutants are also to be identified and managed so as to prevent ongoing accumulations.

4.3.6. Oil Spills

Issue: Minor oil spills, which appear to be associated with diesel fuel, have occurred on a number of occasions in the vicinity of Berowra Waters. The spills are a form of visual pollution and detrimental to recreational use of the estuary. There is also the potential for spills to damage the ecology of the estuary.

There is some confusion as to the source of these spills. The source of the spills could be identified and prevented through a monitoring and education program. The monitoring program could start with active monitoring, leading to chemical sampling and analysis to establish the source if necessary. Education of oil users would also help in the prevention of further spills.

Objective: The management objective is to identify the source of the oil spills and to implement measures to manage and prevent further spills.

4.4. Human Use

4.4.1. Estuary Recreation Facilities

Issue: There are a number of issues relating to recreational use of the estuary. These are mainly associated with parking and waterway access at Berowra Waters and Crosslands Reserve because these are the only locations where vehicular access to the estuary is possible. Both sites are particularly popular picnic, walking and boating areas, and on sunny weekends, traffic on the narrow access roads, and the demand for parking near the waterway, far exceeds the available capacity. The amenity of the area for visitors is degraded by this over demand which also has a significant detrimental impact on residential use.

Access and parking are major issues which have largely been addressed by the Berowra Waters and the Berowra Valley Regional Park Management Plans (and are beyond the scope of this Estuary Management Plan).

Objective: The main management objective is to meet the reasonable requirements of recreational users of the waterway in a way that facilitates use whilst minimising the impacts on the environment, residents and users.

4.4.2. Estuary Tourism Facilities

Issue: The impacts and constraints associated with over demand for recreational access also impacts on estuary tourism. Because of this, use of the estuary for water based tourism is controlled by access difficulties at Berowra Waters, and limits opportunities for eco-based tourism such as canoe tours.

The land access difficulties also encourage seaplane operations (which service the restaurants in Berowra Waters). This has become a significant issue with local residents since the recent fatal crash. Deregulation of the aviation industry has placed the onus for safety on individual aircraft pilots. However, there are particular difficulties with landing (or going around) at Berowra Waters when landing from the north. The Civil Aviation Safety Authority (CASA) has the capacity to set aeroplane operational standards to address this problem, and the Waterways Authority has the capacity to control waterway use including defining landing areas.

Objective: The management objective is to provide increased opportunities for estuary based tourism by improving the available facilities and access/parking arrangements, in a way that ensures safety and minimises adverse impacts on the environment, residents and users.

4.4.3. Boat Moorings

Issue: There are a number of issues associated with both swing and fixed boat moorings in the estuary. One is the number of moorings in the Berowra Waters area and the possible impact moored vessels are having on heavy metal accumulations. Another is the current proposal to replace approximately 25 swing moorings with marina berths. There is also anecdotal evidence of an increased number of thefts and damage to moored vessels, and concern about vessel and mooring damage caused by the wakes of passing boat. Until recently, there has also been a problem with the insufficient number of berths available at the Berowra Waters residents' jetty and car park. The recently adopted proposal to extend the jetty to the south has apparently solved this problem.

Objective: The management objective is to provide boat moorings with adequate safety/security but without significant adverse impact on the ecology of the waterway or visual amenity of the area.

4.4.4. Sedimentation/Navigation

Issue: There has been an ongoing buildup of sediments in the upper estuary zone above Woolwash, as well as in several lower estuary bays and Marramarra Creek. The sedimentation is associated with erosion and disturbance in the Berowra Creek and Hawkesbury River catchments. Investigations undertaken for the Estuary Processes Study indicated that the buildup of sediments upstream of Woolwash is an ongoing process which has been occurring at a similar rate for hundreds of years.

The increased sedimentation has reportedly restricted navigation of some areas, but this is also linked to modern day time pressures which prevent boaters from waiting until high tide as was the practice in the past.

There have been several proposals for commercial sand extraction ventures at Crosslands in the past, with none eventuating. Since 1989, sand extraction in the estuary has been prohibited under the Sydney Regional Environmental Plan (REP) No. 20, except for essential works.

Objective: The management objectives are to reduce catchment sediment infeed rates, and to undertake remediation works (such as dredging) if feasible and desirable, in areas where navigation channels were available in the past.

4.4.5. Commercial and Recreational Fishing

Issue: A major concern to residents and recreational fishers is the volume of fish and bycatch, which is caught (particularly by visiting commercial fishers), and the impact this may have on the fishery generally, as well as on recreational fishing opportunities in particular. Part of the problem seems to be a lack of knowledge and confusion surrounding commercial fishing operations and catch reporting. Because of this, Council is currently undertaking a survey of commercial and recreational fishing methods and catch levels.

The fishing surveys involve monitoring actual commercial and recreational catches, and analysing NSW Fisheries catch statistics. On completion of the fishing survey more will be known on how to better manage the fishery. A number of possible management strategies will be reviewed, including closing some areas to fishing, rotating bait taking areas and regionalising fishing licenses to restrict fishing from visiting fishers.

Objective: The management objectives are to identify commercial and recreational fishing methods and assess catch levels through Council's current fishing survey, and to prepare a Fishery Management Plan specifically for Berowra Creek that addresses the issues of concern.

4.4.6. Aquaculture

Issue: Lower Berowra Creek and Marramarra Creek are important areas for growing and fattening oysters. The extent of the oyster leases is set at their current limit by NSW Fisheries.

Other potential opportunities for aquaculture may exist within the estuary. This could include fish farms or the restocking of waters with juvenile fish such as the Australian Bass. There are currently no such proposals for aquaculture development.

Objective: The management objective is to ensure aquaculture in the estuary is ecologically sustainable.

4.4.7. Heritage Protection

Issue: Most heritage items within the catchment are adequately protected from human damage by existing statutory controls. However, foreshore erosion at several sites in the middle estuary is damaging Aboriginal middens. The cause of this erosion appears to be natural wind waves exacerbated by boat wash. The NPWS and the Metropolitan Aboriginal Land Council (MARLC) have an important role to play in Aboriginal heritage protection in the area.

Objective: The management objective is to prevent further damage to the middens, either by controlling the damage source or by providing physical protection to the middens.

4.5. Ecology

4.5.1. Mangroves and Saltmarsh

Issue: Mangroves and saltmarsh are key ecological resources in the estuary system. Big Bay in lower Marramarra Creek has been identified as an area of particular significance in terms of mangrove habitat and its contribution to the ecology of the estuary as a whole.

There has been some dieback of mangroves in the upper estuary which has not been of major concern at this stage due to regrowth and the large areas of healthy mangroves elsewhere in Berowra Creek. Mangrove and freshwater reed colonisation of saltmarsh areas may be occurring.

Objective: The management objective is to ensure that mangroves and saltmarsh generally, and the ecology of Big Bay in particular, are protected and conserved.

4.5.2. Seagrasses

Issue: Seagrasses have been identified as important habitat areas, providing nursery areas for aquatic fauna. Work carried out as part of the Estuary Processes Study indicated seagrass areas have been reducing in size and extent over recent decades.

Seagrass beds can be damaged by natural processes, such as storm flows disturbing the creek bed. Boat propellers and other human disturbance can also damage the beds. NSW Fisheries Habitat Protection Plan No. 2 aims to protect seagrasses. The implementation of this plan and other measures are required to preserve the remaining beds from boating and other human impacts.

Objective: The management objectives are to preserve existing seagrass beds and to encourage the colonisation of suitable areas by improving water quality and reducing sedimentation.

4.5.3. Weeds

Issue: Intrusions of weeds are a problem at various locations along the estuary foreshore. Generally, weed seeds are sourced from further up the catchment and are carried into bushland by the Creek and its tributary streams. Increased soil nutrients and bushland disturbance add to the problem of weeds.

Objective: The management objective is to restore and maintain healthy native vegetation within the riparian zone.

4.5.4. Biological Monitoring

Issue: Although there is considerable water quality monitoring of Berowra Creek there is only limited monitoring of actual ecological impacts (by Sydney Water and Council). The Estuary Processes Study undertook some investigations into the ecology of the estuary; mangroves, seagrasses, saltmarshes and the fauna that they support. To be of greater value this work needs to be followed by further sampling. Further work would identify changes in the ecology and aid in understanding the processes at work. The sampling program would be undertaken on a four or five year basis at sites throughout the estuary and at reference locations in the Hawkesbury River.

Objective: The management objective is to monitor the biological health of the estuary by establishing a focussed and cost effective biological monitoring program.

5. MANAGEMENT OPTIONS

The aim of this section is to propose management options which address the issues and satisfy the objectives discussed in the previous chapter. The initial step when formulating the management options was to review other relevant management plans. Appropriate management actions from these plans were then adopted. Management options unique to this Plan were then proposed. Some of the options were specified by Council and the Estuary Management Committee, others were identified by consultation with community interest groups concerned about management of the estuary, and others arose out of the Consultant✪s assessment and consideration of the Issues and Objectives.

Each section below proposes a number of management actions to meet the objectives. (The organisations responsible for carrying out the action are indicated in brackets.)

The actions were tabulated for each of the Management Issues, with each action being assigned a code. The tables (Tables 1 to 4 can be found in the Executive Summary) summarises the actions, where they are sourced from (e.g. Berowra Waters Plan of Management or Estuary Management Study), the agency responsible for carrying out the work, the cost of the work and the priority assigned to the action.

In relation to Tables 1 to 4 it is worth noting, all costs provided are indicative only. The priorities given to actions from previous management plans were copied directly to this management plan. Actions unique to this Estuary Management Plan were assigned priorities in discussion with the Committee and the wider community.

5.1. Estuary Management

The following sections outline in full the management actions concerning each issue outlined in Section 4.2. A summary of the actions can be found in Table 1 in the Executive Summary and Plan.

5.1.1. Data Collection Co-ordination

The issue of co-ordination of water quality data collection was first raised in the Berowra Creek Water Quality Management Strategy. The Strategy includes the following management actions, applicable to Sydney Water, EPA and Hornsby Council:

DCC1: Develop a co-operative program to monitor results of STP upgrades and other catchment remediation works.

DCC2: Establish monitoring stations for instream flow gauging and sampling.

DCC3: Establish joint records and databases systems.

DCC4: Present annual reports on the joint monitoring program to the community.

The above actions have all been undertaken, each to differing degrees. Improvement can still be made in developing joint records and databases. Presently joint information is difficult to access and compile.

This Plan recommends:

DCC5: Ensure the data collected by SWC, HSC, EPA and other sources are compiled together and are easily accessible to the public (SWC, HSC, EPA, BCMC).

5.1.2. Human Health and Safety

To better manage algal blooms in Berowra Creek the following action are proposed:

HHS1: Council to monitor estuary surface waters and to be responsible for algal bloom testing (HSC).

HHS2: Put in place a method, such as a radio controlled chlorophyll-a monitor that enables Council to remotely monitor the presence or otherwise of algal blooms (HSC).

HHS3: When algal blooms detected, Council to report to RACC, as well as DLWC, EPA, Fisheries and if health problems exist contact the Department of Health (HSC).

To better manage faecal pollution in Berowra Creek the following actions are proposed:

HHS4: Sydney Water to continue to notify Council when STP bypassing begins (SWC).

HHS5: Council to monitor recreational water quality after significant catchment rainfall (such as >20 mm in a day at Council Chambers) or when notified of STP bypassing, and to undertake testing for indicator organisms. Sydney Water to provide funding support for subsequent recreational water quality testing (SWC, HSC, EPA, DLWC, Health Dept., HNCMT).

To improve communication between interest groups:

HHS6: In case of algal blooms, Council to inform Hawkesbury River Oyster Farmers' Association, NSW Fisheries (Brooklyn) and other relevant groups, possibly through use of a "phone tree" (HSC).

HHS7: In case of faecal pollution, Council to inform Hawkesbury River Oyster Farmers' Association, NSW Fisheries (Brooklyn) and other relevant groups, possibly through use of a "phone-tree" (HSC).

To better manage aquatic stingers in Berowra Creek the following action is proposed:

HHS8: During summer, Council to respond to community reports of aquatic stingers and carry out follow up monitoring (HSC).

In the case of algal blooms, faecal pollution and aquatic stingers the community needs to be informed.

HHS9: Inform the community of algal blooms, faecal pollution and aquatic stingers through the installation and maintenance of warning signs strategically placed near waterway access locations, particularly at Berowra Waters and Crosslands. When appropriate Council to communicate warning through newspaper, radio and the Internet (HSC).

HHS10: Investigate the legal implications and responsibilities relating to warning signs (HSC).

5.1.3. Estuary Management

In order to plan properly for future estuary management in the region, and to oversee the implementation of future estuary management plans, this Plan recommends:

EM1: Council appoint an "Estuary Manager" to develop future management plans, administer and update existing management plans and access State, Federal and private industry funding sources. The manager would be responsible for the ongoing development of the estuary management program within Council.

5.2. Water and Sediment Quality

The following sections outline in full the management actions concerning each issue outlined in Section 4.3. A summary of the actions can be found in Table 2 in the Executive Summary and Plan.

5.2.1. Catchment Sourced Pollution

The issues associated with nutrient and faecal pollution have been addressed in previous plans relating to Berowra Creek outlined in Chapter 3. The main plan which addresses nutrient and faecal pollution is the *Berowra Creek Water Quality Management Strategy*.

The actions in the *Water Quality Management Strategy* addressing this issue in particular are:

CSP1: Develop and implement a catchment management plan aimed at achieving water quality objectives. The implementation of the catchment management plan would be monitored and audited (DLWC, EPA, HSC, HNCMT, BCMC, SWC).

CSP2: Develop a water quality monitoring program to monitor the results of STP upgrades and other catchment remediation works (SWC, EPA, HSC).

CSP3: Determine pollutant loads from the STPs and to quantify pollutant loads in sub-catchments of different development types (SWC, EPA, HSC).

CSP4: Control pollutant loads from Sydney Water STP✪s:

- Sydney Water to prepare an EIS for nutrient reduction upgrade,
- Sydney Water to construct nutrient reduction upgrade,
- monitor effectiveness of nutrient reduction upgrade,
- prepare Ecological Risk Assessment (ERA) reports assessing environmental impacts of contaminants from STP's,
- assess and develop Pollution Reduction Programs (SWC & EPA).

CSP5: Improve management of leachate and runoff from disused waste disposal sites:

- develop inventory and audit waste disposal sites with regard to leachate and runoff problems (HSC & EPA),
- develop and implement management plans to control runoff and leaching at identified sites (HSC, EPA & DLWC),
- measure effectiveness of changes resulting from improved management and review plans (HSC & EPA).

CSP6: Improve knowledge of existing stormwater drainage system:

- identify and map stormwater drains (HSC, schools),
- educate the community on the relationship between stormwater systems and receiving water impacts (HSC, EPA, BCMC/ HNCMT),
- develop and implement litter reduction campaign (HSC).

CSP7: Implement appropriate controls at building sites for stormwater and sediment control (HSC, DLWC & EPA).

CSP8: Control pollution from sewer overflows by developing appropriate licence requirements addressing identification, monitoring and control where necessary of sewer overflows (EPA & SWC).

CSP9: Implement a Plan of Management for urban stormwater. This has begun to be executed in the Hornsby Shire Council's Stormwater Management Plan (HSC, BCMC).

CSP10: Reduce stormwater pollution from residential areas (HSC, BCMC/HNCMT):

- educate community on the adverse impacts of household and residential land use practices,
- encourage improved household and residential land use packages,
- investigate opportunities for on-site stormwater re-use.

CSP11: Restrict or prevent development of sensitive sites to ensure future development is ecologically sustainable and water sensitive (DUAP, HSC, SWC, EPA, HNCMT, NSWAg, DLWC).

CSP12: Reduce pollution from agricultural sites; problem sites and industries would be identified and appropriate best management programs would be implemented (HSC, EPA, NSWAg, DLWC, HNCMT).

CSP13: Improve management of on-site sewage disposal in rural residential areas by promoting the most suitable system for the site and ensuring on-site effluent disposal is consistent with appropriate BMP's (HSC, BCMC/HNCMT).

CSP14: Control impact of farm animals on water quality by developing and implementing an education program for small operators (NSWAg, HSC, BCMC).

The actions outlined above are at different stages; some are completed, others require improvement and others are yet to be undertaken.

The actions in the Water Quality Management Strategy should continue to be implemented to improve water quality in the estuary. This Estuary Management Plan adds the following additional management actions:

CSP15: Minimise overflows from private sewer connections in the catchment (HSC, SWC).

CSP16: Place nutrient/sediment and litter devices on major stormwater outlets into the estuary (HSC, BCMC).

5.2.2. Freshwater Inputs

The management objective for this issue is to reduce freshwater inputs. Many of the following proposed actions for reducing freshwater inputs have been covered by other management plans, although previously they have been developed to achieve different goals.

The management options are as follows:

FI1: Sydney Water to investigate possible immediate implementation of water re-use options (SWC).

FI2: As a longer term solution, all STP discharge presently entering Berowra Creek be reused within the catchment or discharged outside the catchment (SWC).

FI3: Implement community water reduction schemes, such as water saving devices in houses, with the use of incentives (HSC).

FI4: Develop a policy that requires new development, including the redevelopment of rural areas, to provide for re-use of grey waters (HSC, SWC).

FI5: Implement the Sustainable Water DCP requirement that development should incorporate relevant measures to promote infiltration and groundwater recharge where the site contains appropriate soil landscapes (HSC, BCMC).

FI6: Educate the community on the need for on-site collection and use of stormwater, in keeping with Council's rainwater tank policy (HSC, BCMC).

FI7: Review Council's DA approval process to include use of permeable surfaces as a default condition (particularly for driveways) (HSC).

5.2.3. Boat Sourced Pollution

Boat sourced pollution is briefly addressed by the Berowra Waters Plan of Management. Actions relating to this issue are as follows:

BSP1: Enforce limits on the permanent occupation of boats (Waterways).

BSP2: Investigate the provision of a pumpout facility for houseboats and other vessels in conjunction with the Effluent Disposal Feasibility Study (HSC, Waterways).

BSP3: Establish a litter control policy (HSC).

BSP4: Ensure solid waste collection is carried out regularly particularly at weekends during peak periods to minimise waste entering water. Provide a higher standard of storage and collection (HSC).

Boat sourced pollution causes great concern to much of the community (Section 3.3.8). Following on from the Berowra Waters Plan of Management, the Estuary Process Study and discussions with the Committee and community the proposed actions are to:

BSP5: Provide better solid and liquid waste disposal facilities for people aboard boats (HSC, Waterways).

BSP6: Provide appropriate sewage disposal facility for commercial and recreational vessels at Berowra Waters (Waterways, HSC, DLWC).

BSP7: Produce a brochure outlining the legal responsibilities of boat users not to pollute and provide advice on how to best protect the environment. Brochure to be provided by hire boat operators and marinas to all boat users (HSC, Waterways, EPA).

BSP8: Investigate the environmental impacts of antifouling paints on Berowra Creek (HSC, Waterways, EPA).

BSP9: If/when pumpout facilities are installed in the Berowra Creek area, all the estuary be declared no discharge (HSC, Waterways).

5.2.4. River Settlement Sourced Pollution

River settlement sourced pollution is addressed in the *Berowra Creek Water Quality Management Strategy* and the *Berowra Waters Plan of Management*.

The Water Quality Management Strategy does not specifically mention river settlements although a number of actions would definitely have impact on river settlement sourced pollution. These are as follows:

RSP1: Improve management of on-site sewage disposal:

- provide residents with information about management and maintenance requirements of on-site disposal systems (HSC),
- encourage better management of septic systems by establishing a regular inspection program (HSC),
- review licences for non-residential, on-site sewage effluent disposal, and develop Pollution Reduction Programs with operators as necessary (EPA).

RSP2: Promote alternatives to use of septic tanks in sensitive locations:

- identify sensitive sites that are unsuitable for use of septic tanks for effluent disposal (HSC, DLWC),
- provide information to the community about alternative on-site sewage effluent disposal systems for sensitive sites (HSC, BCMC/HNCMT),
- provide incentives for the most suitable systems (HSC).

The Berowra Waters Plan of Management addresses river settlement sourced pollution in the following actions:

RSP3: River Settlements Development Control Plan is to be updated to include improved water quality controls and requirements to prepare, implement and maintain a Soil and Water Management Plan (HSC).

RSP4: Council to investigate the feasibility and options for establishment of a pumpout facility at Berowra Waters for use by residential settlements as well as other boats (HSC, DLWC).

RSP5: New septic systems are to comply with current Council standards and require a geotech/soils report to verify suitability of site for on-site disposal (HSC).

RSP6: Investigate conversion potential of existing and new septic systems if pumpout facility is established (HSC, DLWC).

RSP7: Continue audit of septic systems to ensure compliance (HSC).

RSP8: Ensure all septic systems are operating effectively and require maintenance of systems through sludge removal on a 3-5 year basis (HSC).

RSP9: New developments to provide for re-use of grey waters (HSC).

RSP10: Best practice environmental management guidelines to be included in River Settlements DCP (HSC).

The above actions are in keeping with the findings of the Estuary Processes Study and this Management Study. It is therefore recommended that the above actions be included in the Management Plan and their applicability be expanded to all the river settlements in the study area, not just in the vicinity of Berowra Waters (**RSP11**).

5.2.5. Heavy Metal Accumulations

Management actions addressing heavy metal accumulations are those that restrict pollution, specifically in the Berowra Waters area. The Berowra Waters Plan of Management addresses these pollution sources with the following actions:

HMA1: Commercial marinas to progressively update existing boat maintenance systems. Encourage progressive upgrades for existing uses and require upgrade on redevelopment (HSC).

HMA2: Ensure all boat service areas have containment systems for anti-fouling wastes and these are collected for appropriate disposal (HSC, Commercial Operators).

HMA3: Include drainage improvements on “Kirkpatrick Way” in Catchment Remediation Program. Install sediment traps at outlets as part of improvements (HSC).

HMA4: Provide drainage to eastern car parking areas and sediment trap/oil separator at drain outlets (HSC).

HMA5: Provide sediment trap and oil separation unit at Dusthole Bay car park (HSC).

HMA6: Maintain all sediment/oil traps to ensure proper functioning (HSC).

HMA7: Where chemical herbicides are selected to contain weeds, use low residue herbicides (e.g. Glyphosphate based) and adopt practices to minimise inflow to the waterway (HSC).

HMA8: Undertake ferry maintenance and operation in a manner which prevents pollution of the waterway (HSC, RTA).

Further to the above management actions this Management Study proposes the following management action:

HMA9: Undertake investigations to identify major sources of heavy metal contamination in the Berowra Waters area (HSC, EPA).

5.2.6. Oil Spills

Management of the oil spills at Berowra Waters requires a number of steps, the first being to identify the source. This Plan recommends the following management options:

OS1: Initiate a program to source the origin of oil spills on Berowra Waters and educate boat users (HSC, Waterways, EPA).

OS2: Emergency spill management to be conducted as per HSC Emergency Spills Manual (HSC).

5.3. Human Use

The following sections outline in full the management actions concerning each issue outlined in Section 4.4. A summary of the actions can be found in Table 3 in the Executive Summary and Plan.

5.3.1. Estuary Recreation Facilities

The Berowra Waters Plan of Management deals particularly with requirements of recreational users of the waterway as they relate to Berowra Waters. The Plan of Management covers a large number of management actions relevant to Berowra Creek. This Estuary Management Study has chosen to include the actions most relevant to the estuary and its foreshores. These are as follows:

ERF1: Install radio controlled signage at Berowra and Berrilee to inform visitors of delays and parking availability/restrictions (HSC).

ERF2: Deck rear portion of the Dusthole Bay car parking area to increase car parking supply (HSC).

ERF3: Investigate needs for additional space on public jetty on western shore if additional car parking is provided (HSC, Waterways, DLWC).

ERF4: Undertake minor rock trimming of Berowra Waters Road and Bay Road to remove dangerous rock protrusions (HSC, RTA).

ERF5: Make the area around the ferry terminals "shared" pedestrian and vehicle zones to minimise potential conflict (HSC, RTA).

ERF6: Investigate the possibility of "reversing" the ferry so that the pedestrians do not have to cross vehicle paths to get to the passenger booth (HSC, RTA).

ERF7: Provide a separate pedestrian pathway at ferry terminals to segregate from cars (HSC, RTA).

ERF8: Provide heritage signage at strategic locations such as:

- the ferry terminals,
- Benowie Track heads,
- community hall (upon relocation),
- Dusthole Bay car park (HSC).

ERF9: Provide additional shade trees to picnic areas (HSC).

ERF10: Provide more planting and seating along foreshore (HSC).

ERF11: Develop pamphlets suitable for general visitor information and school projects (HSC, BVRPT).

ERF12: Provide information on the area on the Internet through Council's home page. This could also include graphical information on water quality (HSC, BVRPT).

ERF13: Develop interpretive signs to explain key features of the area (HSC, NPWS).

ERF14: Undertake surveys during peak periods to record visitor numbers on weekends in summer to include trailer boat use and picnic numbers (HSC).

The above actions focus on Berowra Waters. This is the main waterway access area, but the Estuary Management Study also considers the Crosslands area, the other area associated with recreational pursuits in the estuary. To facilitate better recreational use of the area the Plan recommends that:

ERF15: Improve maintenance schedule to the Somerville Road, the access road to Crosslands on the eastern shore (HSC, BVRPT).

ERF16: Consideration be given to providing improved recreation/education facilities at Crosslands, such as an information and education centre. The education centre would address both estuarine and terrestrial habitats. (HSC, BVRPT).

To prevent damage to the Crosslands area and to maintain the nature of the area. It is recommended that:

ERF17: The boat ramp at Crosslands be restricted for use by non-trailable boats only (BVRPT, HSC).

Another issue raised by the Committee is the use of personal water craft (i.e. jet skis). These craft are a source of nuisance to residents and other waterway users because of the noise and danger associated with them travelling at high speeds. They are however limited in their use as Berowra Creek upstream of Calabash Point is a 4 knot zone. It is recommended to minimise noise and nuisance that:

ERF18: Personal watercraft use, except for through passage, is banned upstream of Neverfail Bay (Waterways).

5.3.2. Estuary Tourism Facilities

A number of actions from Berowra Waters Plan of Management affect tourism in the estuary. In particular a number of constraints are placed on commercial development:

ETF1: No commercial development to be permitted outside zoned areas unless already approved (HSC).

ETF2: Permit modification of existing commercial floor space where improved environmental performance and controls are demonstrated (HSC, DLWC).

ETF3: Parking for commercial uses to be provided in accordance with the recommended car parking strategy for Berowra Waters (HSC).

ETF4: Ensure commercial uses comply with lease restrictions and proposed management strategies. Review of Crown Land leases at expiry to ensure compliance with Plan visions and values (HSC, DLWC)

ETF5: Where changes to commercial uses/leases are proposed, ensure conformity with the proposed management study (HSC, DLWC).

ETF6: New buildings to be consistent with urban design strategy (HSC).

A new tourism opportunity is proposed in the Berowra Waters Plan of Management:

ETF7: Investigate possibility of running a program of spotlighting and wildlife field trips run by NPWS volunteers (HSC, NPWS).

To further encourage the use of the community land at Crosslands by the community this Plan also includes the actions to:

ETF8: Investigate the potential for tourist related, eco-focused commercial activities at Crosslands, such as canoe hire (BVRPT).

EFT9: Construct an interpretive boardwalk through the wetland and mangrove areas in Crosslands Reserve, illustrating cultural and natural values (BVRPT, HSC).

5.3.3. Boat Moorings

Moorings are addressed in the Berowra Waters Plan of Management:

BM1: Maintain geographic and numeric limits on boat moorings (HSC, Waterways).

BM2: No net increase in existing moorings/berthings to be permitted in Berowra Creek. Additional berthings in marina only to replace existing swing moorings (HSC, Waterways).

The Estuary Management Plan proposes the following actions to provide improved safety/security for moored vessels:

BM3: Increase boat security through upgraded lighting at water access and mooring locations (Waterways, HSC, Marina operator).

It is of concern to some residents that boat wake has been damaging vessels and moorings. This plan recommends:

BM4: Enforce existing no wash/no wake zones in the estuary (Waterways).

5.3.4. Sedimentation/Navigation

This issue is addressed in two sections, reducing catchment sourced sediments, and addressing existing sediment build up in the creek.

Actions to reduce catchment sourced sediments are contained in a number of plans. The Berowra Waters Plan of Management, although concerned only with Berowra Waters has some actions affecting the wider catchment:

SN1: Ensure current catchment management practices are implemented particularly for upstream development in Berowra and Berowra Heights (HSC, BCMC).

SN2: Ensure new urban releases in the catchment have sound soil and water controls to minimise transport of sediment, nutrients and weeds (HSC).

SN3: Ensure fire access track maintenance is undertaken in accordance with accepted soil conservation practices (HSC, RFS, NPWS).

The Berowra Creek Water Quality Management Strategy addresses sedimentation through its stormwater management practices. The Berowra Catchment Stormwater Management Plan has been developed following on from the Berowra Creek Water Quality Management Plan. Both documents contain many actions that are directly relevant to reduction of sedimentation in the estuary:

SN4: Improve knowledge of existing stormwater drainage system:

- identify and map stormwater drains (HSC, schools),
- educate the community on the relationship between the stormwater system and receiving water impacts (HSC, EPA, BCMC/ HNCMT),
- develop and implement a litter reduction campaign (HSC).

SN5: Implementation of appropriate controls at building sites:

- require Soil and Water Management Plans to be submitted with DA's, BA's and applications to the EPA for Pollution Control Approval (HSC, DLWC, EPA),
- place appropriate pollution control conditions on BA's, DA's and Pollution Control Approval conditions (HSC, DLWC, EPA),
- develop ⊙Code of Practice⬡ for stormwater management on construction and building sites (HSC, DLWC, EPA),
- implement Code of Practice (HSC).

SN6: Implement a Plan of Management for urban stormwater:

- formulate and implement a Stormwater Management Plan which incorporates water sensitive urban design principles (HSC),
- investigate potential for "naturalisation" of constructed stormwater channels (HSC, BCMC).

SN7: Reduce stormwater pollution from residential areas:

- educate community on the adverse impacts of household and residential land use practices (HSC, BCMC/ HNCMT),
- encourage improved household and residential land use practices (HSC, BCMC/ HNCMT),
- investigate opportunities for on-site stormwater re-use (HSC).

SN8: Ensure application of BMP's to control stormwater pollution:

- maximise the retention of natural watercourse and buffer zones in new developments (HSC, DUAP, proponent),
- integrate drainage works with other community uses of watercourses and associated land (HSC, HNCMT, proponent),

- require proponents to submit Soil and Water Management Plans for subdivisions and DA✪s and to install BMP's for the control of both constructed stage and long-term runoff (HSC, EPA, proponent).

SN9: Restrict or prevent development of sensitive sites:

- ensure achievement of water quality objectives is not compromised when determining future State or Local planning instruments (HSC, DUAP),
- ensure integrated planning to ensure water quality objectives are met (DUAP, HSC, SWC),
- ensure ecologically sustainable and water sensitive future development (DUAP, HSC, SWC, EPA, HNCMT),
- ensure land management is consistent with land capacity (DUAP, HSC, NSWAg., DLWC).

SN10: Prevent loss of vegetation from highly sensitive sites. Identify most sensitive sites in terms of soil erosion and propose Protected Lands status under Soil Conservation Act (HSC, DLWC, BCMC/ HNCMT).

SN11: Improve management of runoff from degraded urban and semi-urban bushland:

- improve vegetation along drainage lines (HSC, BCMC, community groups),
- audit fire trails, walking tracks and other access routes for erosion problems (HSC, NPWS, DLWC),
- manage bushfire hazard reduction on a catchment basis with regard to erosion control and water quality (HSC, BCMC, DLWC),
- refine and enforce relevant law and policies (e.g. develop a vegetation preservation order which acknowledges the role of understorey in erosion control as well as canopy trees) (HSC, HNCMT, DLWC).

CSP12, an action introduced to minimise catchment sourced pollution, will also act to reduce the sediment entering the estuary.

In terms of the second issue, addressing sediment buildup in the estuary, there have been continued requests for dredging from Woolwash to Crosslands to remediate the environment and to aid navigation. The Estuary Process Study indicates that there has been no measurable increase in sediment loads during the past 50-100 years, and therefore, there are no grounds for dredging to maintain or restore navigation. Further, Sydney Regional Environmental Plan 20 for the Hawkesbury-Nepean, which is inclusive of Berowra Creek, prohibits any new sand extraction in the Lower Hawkesbury. This Plan therefore recommends an action to:

SN12: Prohibit sand extraction upstream of Woolwash as supported by Sydney REP20 (HSC, DLWC, Fisheries).

Anecdotal evidence suggest that there may be some siltation of navigation channels elsewhere in the estuary. Based on the need to maintain navigation channels this Plan recommends that:

SN13: Minor channel maintenance dredging is supported subject to appropriate environmental approvals (HSC, Waterways, DLWC).

5.3.5. Commercial and Recreational Fishing

At present, Council is undertaking a survey of the fishing practices in the estuary. Prior to completion of this study it would be unwise to advise specific management actions.

To address the management of commercial and recreational fishing, the following action is proposed:

CRF1: Subject to Council✪s current investigation into commercial and recreational fishing, prepare a management plan specifically for Berowra Creek which addresses local concerns regarding fishing practices, particularly visiting fishers, over fishing and excessive bycatch (Fisheries, HSC).

5.3.6. Aquaculture

It is vital that any expansion in the estuary✪s aquaculture industry be undertaken in an environmentally sensitive manner. This issue has not particularly been addressed by other management plans for the estuary. This Management Plan therefore recommends:

A1: Any proposed new aquaculture development in the estuary such as fish farming would require a thorough environmental assessment and the approval of NSW Fisheries (developer, Fisheries).

5.3.7. Heritage Protection

To address damage to middens the following action is proposed:

HP1: Investigate and implement appropriate protection measures for middens currently subject to erosion in the estuary (NPWS, DLWC, BVRPT, MARLC).

HP2: Enforce existing no wash/no wake zones in the estuary (Waterways).

HP2 apart from protecting middens also provides protection for boats on moorings and river settlement jetties which are also prone to damage from waves.

5.4. Ecology

The following sections outline in full the management actions concerning each issue outlined in Section 4.5. A summary of the actions can be found in Table 4 in the Executive Summary and Plan.

5.4.1. Mangroves and Saltmarsh

A number of management actions in the Berowra Waters Plan of Management relate to this issue:

M1: Conserve and protect flora and fauna in public and private ownership through appropriate zoning measures and development controls:
- amend River Settlements DCP to include flora and fauna protection (HSC).

M2: Protect significant flora and fauna habitats:
- ensure all threatened fauna habitats are identified and protected from adverse impacts (HSC),
- reduce impacts on vegetation links by minimising fragmentation through inappropriate development and vegetation clearing (HSC).

In recognition of Big Bay's importance as a mangrove habitat as illustrated by EPS and to provide greater control over access and fishing, it is recommended that:

M3: The sub-tidal and tidal areas of Big Bay be incorporated into Marramarra National Park or declared a marine protected area under the *Fisheries Management Act* (NPWS, Fisheries, Waterways).

To determine the extent of colonisation of saltmarsh areas by mangroves and/or freshwater reeds, and the possible impacts on the ecology of the area:

M4: Monitor saltmarsh and mangrove areas to ascertain changes over time and determine appropriate management actions.

5.4.2. Seagrasses

To better encourage growth and protect seagrasses in the area:

S1: Improve water quality through implementation of the management strategies identified in the previous sections (refer to individual management actions).

S2: Ensure the requirements of Fisheries HPP#2 are implemented and monitored, to protect seagrasses (Fisheries).

S3: Seagrass beds to be indicated on boating maps based on information provided by NSW Fisheries. Maps to be distributed by Waterways and hire boat operators (Waterways, Fisheries).

5.4.3. Weeds

The Berowra Waters Plan of Management proposes a number of weed control measures that apply specifically to Berowra Waters which are in keeping with the Noxious Weeds Committee Sydney North - Regional Weeds Strategy, and can be applied to the whole estuary. These are as follows:

NW1: Include provisions in River Settlements DCP for locating and protecting threatened plant communities and species and the control of noxious and invasive weeds (HSC, NPWS),

NW2: Weed seed sources and infestations, particularly in residential properties and along road reserves to be controlled and action taken to remove (HSC).

NW3: Undertake community education on the threat of weeds to bushland and the reserve system (HSC).

NW4: Provide information to local residents on suitable indigenous plants for gardens (HSC).

NW5: Encourage the removal of exotic species and planting of indigenous species (HSC).

NW6: Liaise with local schools and educational establishments for students to undertake practical bush regeneration work in the parks, to assist in implementing the plan (HSC, NPWS).

NW7: Continue Council's efforts in encouraging local residents to participate in environmental and bushland regeneration schemes (HSC).

In particular to improve the bushland around Crosslands, it is proposed that:

NW8: Bush regeneration works be undertaken around the wetland areas in Crosslands Reserve (BVRPT, BCMC, Landholders).

5.4.4. Biological Monitoring

To monitor the biological health of the estuary the following actions are proposed:

BioM1: Establish a biological monitoring program to assess seagrasses, mangroves, saltmarshes and the fauna they support at a number of sites throughout the estuary and at appropriate reference locations elsewhere in the Hawkesbury River estuary. The monitoring should include periodical mapping of aquatic habitats (especially mangroves, seagrasses and saltmarshes) and quantitative sampling of key indicators, such as fish and benthic invertebrates. The program to be designed and supervised by Council in conjunction with Sydney Water, NSW Fisheries and NPWS (HSC, SWC, Fisheries, NPWS).

BioM2: Investigate the possibility of involving universities, and/or the CSIRO in the monitoring program (HSC).

BioM3: Establish MOU's (Memorandums of Understanding) between Council and universities and other research organisations to encourage research into the estuary (HSC).

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APPENDIX A: FUNDING SOURCES

As indicated in the Management Study, there is a wide range of financial and technical assistance available to assist implementation of the Estuary Management Plan. The following descriptions of likely sources has been provided to assist Council and the Committee with the implementation process. Potential funding opportunities continue to be developed by State and Commonwealth agencies, particularly through their environmental programs.

Various coastal zone programs are administered by the Department of Land & Water Conservation and NSW Waterways. Five programs are relevant to estuaries that provide funding assistance to Local Government generally on a 50% subsidy basis. Grant applications can be lodged at any time during the financial year.

1. The DLWC **Estuary Management Program** provide technical advice, data collection and funding assistance for studies leading to the determination of a balanced estuary management plan. Strategies flowing from the management plan are funded, such as sediment controls, restoration of degraded wetlands, mangrove fencing or boardwalks, dredging, bank erosion protection, foreshore revegetation, new wetland creation, bird roosts, signage, community education programs and other measures such as monitoring.

2. The DLWC **Waterways Infrastructure Development Program** provides technical advice and funding assistance for planning studies and works to improve the recreational amenity of the waterways such as boat launching ramps, public wharves and jetties, dredging, and foreshore amenities.

3. The DLWC **Coastal Management Program** provides technical advice, data collection and funding assistance for design and construction of works and measures that reduce the potential damage from coastal processes, works that conserve or improve beaches and public reserves and for coastal studies and coastline management plans.

4. The DLWC **Floodplain Management Program** provides technical advice, data collection and funding assistance on a varying subsidy basis. Activities subsidised include studies, mitigation works and other measures that reduce the impact of flooding and flood liability on existing owners and occupiers of flood liable land (existing problems) or ensure that future development is compatible with the flood hazard (potential additional problems).

5. The **Waterways Asset Development and Maintenance Program** (by Waterways) provides funding assistance for works to improve the amenity and management of waterways similar to the WIDP above. Funding can be to 100% depending on the project.

The Natural Heritage Trust is administered by the Commonwealth Government to provide a means for Commonwealth, and other government and non-government stakeholders, to invest in Australia✪s natural heritage. The Trust provides funding assistance and management to projects which address the causes of environmental and natural resource degradation.

Projects funded by the Trust generally obtain two-thirds of the project costs. Greater funding provisions can be invoked for projects which provide long-term/permanent conservation management agreements for native habitats. Strategic or integrated projects with significant community involvement are preferred.

The Natural Heritage Trust is divided into numerous programs. The programs which may be of relevance to estuary related projects are as follows.

6. The **Bushcare Program** has national objectives to conserve Australia✪s biodiversity and remnant native vegetation, and to restore the environmental values and productive/ capacity of land and water through revegetation. The program is applicable to estuarine areas where there is declining vegetation quality and vegetation extent.

7. The **National Landcare Program** has national goals to develop and implement resource management practices. The program promotes sustainable use, and long-term productivity of natural resources. Estuarine environments comprise of soil, water and biological resources which can be enhanced through the program.

8. The **National Rivercare Program** has the national goal to ensure progress towards the sustainable management, rehabilitation and conservation of rivers outside the Murray-Darling Basin and to improve river health.

9. The **Endangered Species Program** has the national goal to protect and conserve Australia✪s native species and ecological communities. The estuarine environment represents habitat for fauna and flora species which may require protection or conservation under this program.

10. The **National Wetlands Program** promotes the conservation, repair and wise use of wetlands through raising stakeholder awareness, and developing and implementing best practice standards.

11. The **Fisheries Action Program** helps to achieve repairs to aquatic environments and assists in the conservation and sustainable use of fish resources. Freshwater, estuarine, and marine environments are applicable to the program.

The **Coast and Clean Seas Program** is funded under the Natural Heritage Trust, but is considered as a separate program. It supports the conservation, sustainable use and repair of Australia✪s coastal and marine environments. The target areas include coastal and marine pollution, threats to marine biodiversity and habitat degradation, and the sustainable use of coastal and marine resources.

Funding for most projects is on a dollar for dollar basis, with wages/volunteer time and equipment costs included as part of the non Trust contribution. Several programs are classified under the Trust's Coast and Clean Seas Program.

12. The **Clean Seas Program** supports better water management in coastal and marine environments. Program objectives are to reduce the impact of wastewater pollution from coastal cities and towns and other sources including maritime and industrial activities.

13. The **Marine Species Protection Program** aims to ensure that community, government and industry groups work together for the conservation and sustainable use of living marine resources.

14. **Coastcare** promotes community and local government partnerships to undertake coastal protection and rehabilitation works principally on local coastal areas on public land.

15. The **Coastal and Marine Planning Program** aims to stimulate coastal and marine planning that combines social, economic and environmental factors. Program objectives are to minimise the impact of uncoordinated developments around the coastal zone, and land developments which generate marine pollutants.

16. The **Capacity Building Program** can provide education, training and information on coastal environments for coastal managers in government, industry, and the community to enhance their management capabilities.

17. The **Coastal Monitoring and Vulnerability Assessment Program** evaluates and improves management approaches through monitoring coastal and marine environments and to manage potential impacts of climate change.

Funding is also available from the Commonwealth Government under the Green Corps and Work For The Dole schemes.

18. **Green Corps** projects involve environmental/infrastructure works. Funding of 100% is available from the Department of Employment, Education, Training and Youth Affairs for ten trainees between the ages of 17 and 20. Training periods last for six months.

19. **Work For The Dole** is funded by the Department of Social Security, and involves work on environmental/social projects for long term unemployed in selected trial areas.

APPENDIX B: CONTACT GROUP LISTING

Berowra Creek Estuary Management Committee Members:	
Clr Margaret McMurray	Chairperson
Ms Stella Whittaker	Exec. Manager, Environment Hornsby Shire Council
Mr Greg Wright	Berowra Waters Marina
Mr Ray Johnson	Secretary Oyster Farmers Association
Mr Bruce Coates	Dept. of Land & Water Conservation
Mr Rob Everett	Waterways Authority
Mr Peter Butcher	
Mr John Patten	Dept. of Land & Water Conservation
Mr Daylan Cameron	Berowra CMC
Mr Tony Bray	
Mr Roger Campbell	
Mr Michael Dean	
Mr Paul Schuetrumpf	NSW Fisheries
Hornsby Shire Council:	
Mr Ross McPherson	Team Leader Water Catchments Team Environment Division
Ms Polly Thompson	Hornsby Council Bushland Manager Environment Division
Mr David Green	Senior Strategic Planner Planning Division
Mr Rob Holliday	Waste Management Division
Mr Ron Patton	Executive Manager Works Division
Government Department Contacts:	
Mr Ray Jasper	Manager, Hornsby Sub District, NPWS
Mr Greg Wallace	Hornsby Sub District, NPWS
Mr Ken Blade	Hornsby Sub District, NPWS
Mr Owen Karsen	Sewerage Treatment Manager Inland Wastewater Sydney Water
Mr Peter Keane	Regional Environmental Scientist Northern Region Sydney Water
Mr Brian Hill	NSW Fisheries Office of Conservation

Mr Sean Hardiman	Environment Protection Authority Coastal Catchments Section
Mr Tony Church	Environment Protection Authority
Mr Geoff Withychombe Coordinator, Sydney Coastal Councils	
Community Groups:	
	Berrilee Progress Association
	Association for Berowra Creek (ABC)
	The Hawkesbury River Environment Protection Society
	Galston Area Residents Association
Ms Joclyn Powell	HNCMT
	Berowra Waters Progress Association
	Hornsby Conservation Society
	SHURE
	Berowra District Residents Association
Dr David Booth, Chairperson	Berowra Catchment Management Committee
Mr Paul Fredrickson	
	Local Agenda 21 Committee
Mr Keith Crumpton	
Mr Gordon Mandin	Macquarie Princess
Mr Hector McCleod	Bar Point Base Safe Boating, Rescue and Radio Communication Club, Inc.
Annie Eyers	Chase Alive, NPWS
Geoff Pratt	
Stephen Ranft	
Mr Earl Erling	Hawkesbury River Marina
Mr Geoff Gauslaa	Mooring Contractor
Mr John Arnott	Kuring-gai Motor Yacht Club
Mr John McCloskey	Royal Volunteer Coastal Patrol
Mr Wayne Saunders	
Mr Paul Davico	Western marina Charter
Mr Ian Ashcroft	Australian Volunteer Coast Guard
Mrs Joanne Cameron	Dangar Island Ferry Service
Mr Harold Morgan	The Boat Owners✪ Association
Mr Brian Healey	AVCG (Cottage Point)

APPENDIX C: SUMMARY OF COMMENTS FROM COMMUNITY WORKSHOP, 22/7/99

Issue	Existing Management Action	Comments	Response
ESTUARY MANAGEMENT:			
Data Collection Coordination	**DCC5** - Ensure data collected by SWC, HSC and EPA are compiled together and are easily accessible to the public.	Add Streamwatch, community, Oyster growers, Fisheries, HNCMT. Post data on a website and advertise on signs at Berowra Creek.	Other data collectors will be added to the action. Will be incorporated in to action.
Human Health & Safety	**HHS1** - Council to monitor estuary surface waters and to be responsible for algal bloom testing.	Why Council and not other agencies, eg. EPA?	DLWC through the Algal Bloom Contingency Plan assigns responsibility to Council.
	HHS2 - Put in place a method, such as a radio controlled chlorophyll-a monitor, that enables Council to remotely monitor the presence or otherwise of algal blooms.	Where should it be placed? More than one? What about ongoing maintenance? Vandalism?	These questions require further investigation by Council.
	HHS3 - In case of algal bloom, Council to report to RACC, DLWC and Health Dept.	Why Council?	Refer to response for HHS1.
	HHS4 - Inform the community of algal blooms through warning signs near waterway access locations. When appropriate Council to put out a media release.	Why Council? Communication also through radio, newspaper, internet.	Refer to response for HHS1. Will be included in action.
	HHS5 - In case of algal bloom, Council to inform Oyster Farmers' Association and NSW Fisheries.	Definitely inform fishers. Other relevant groups should be notified eg. Boat Owners Association ("Phone-tree" type chain of command to be put in place).	Will add other groups to action.
	HHS6 - Sydney Water to continue to inform Council when STP's begin bypassing.	Priority should be high. Needs to also incorporate the phone tree protocol.	Priority will be High, Ongoing. Phone tree will be incorporated in HHS9.
	HHS7 - Monitor recreational water quality after significant catchment rainfall or when notified of STP bypassing.	Could spend less money on monitoring and use it somewhere else. Sydney Water to account for monitoring bill following bypasses. Is $100,000 correct? Isn't this a per annum cost?	ANZECC standard water quality monitoring requires testing to be undertaken 5 times a month, monitoring is therefore costly. The costing given is per annum.

Issue	Existing Management Action	Comments	Response
ESTUARY MANAGEMENT:			
Human Health & Safety (cont)	**HHS8** - Inform the community of faecal pollution through warning signs near waterway access locations. Improve the swimming sign at Crosslands.	Signage to be responsive not fixed permanently (in relation to pollution) and needs to be strategically placed.	Will be incorporated into action.
	HHS9 - In case of faecal pollution, Council to inform Oyster Farmers' Association and Fisheries.	Join the "phone-tree" protocol.	Will add other groups to action.
	HHS10 - During summer, Council to respond to community concerns of aquatic stingers and jellyfish and carry out follow up monitoring.	Isn't it cost per annum?	Cost is per annum.
	HHS11- Inform the community of aquatic stingers and jellyfish through warning signs near waterway access locations.		
Estuary Management	**EM1** - Council appoint an 'estuary manager' to develop future management plans, administer and update existing management plans and access State, Federal and private industry funding sources. The manager would be responsible for the ongoing development of the estuary management program within Council.	This would be like the "river manager" concept. Getting someone committed to the estuary plan being implemented is worthwhile. Where is the funding coming from? Why isn't this an issue for DLWC or EPA etc.?	Funding as for many other actions could be 50% Council/ 50% DLWC. The Estuary Management Program is jointly run by Councils and DLWC.
WATER AND SEDIMENT QUALITY:			
Catchment Sourced Pollution	**CSP15** - Minimise overflows from private sewer connections.	Needs to be more clearly expressed. Good idea but how can it be checked? Lets look into the problem.	Action will be reworded. Council and landholder are responsible for checking.
	CSP16 - Place nutrient/ sediment and litter devices on major stormwater outlets into the estuary.	Include community education.	Community education is included in the WQMS and the Stormwater Management Plan.

Issue	Existing Management Action	Comments	Response
WATER AND SEDIMENT QUALITY:			
Freshwater Inputs	**FI1** - Sydney Water to investigate possible immediate implementation of re-use options.	SWC to decide which option is the best and implement.	
	FI2 - As a longer term solution, all STP discharge presently entering Berowra Creek be reused within the catchment or discharged outside the catchment.	Delete is a repeat of FI1. Residents of Berowra Waters and boaters really want to see this option implemented fully and quickly. Many members of the public see no sewage in Berowra Creek as the ultimate end point.	This action fully discussed at Committee meeting and wording reflects current situation. Agree no sewage ultimate end point.
	FI3 - Implement community water reduction schemes.	Add SWC to those responsible and EPA too. Include incentives.	SWC and EPA will be added. Modify action to include incentives.
	FI4 - Council to develop policy that new development, including redevelopment of rural areas, provides for re-use of grey waters.	Rural areas aren't sewered.	Re-use of grey waters does not require sewers, it is onsite.
	FI5 - Implement Sustainable Water DCP requirement to "incorporate relevant measures to promote infiltration and ground water recharge where the site contains appropriate soil landscapes."	Add developer in those responsible. Take out BCMC. Not sure on cost, possibly no cost as cost falls on developers.	Developer will be added and BCMC removed. Cost will be deleted.
	FI6 - Encourage on-site collection and use of stormwater, in keeping with Council's rainwater tank policy.	No comment.	
	FI7 - Review Council's DA approval process to include use of permeable surfaces as default condition (particularly for driveways).	No comment.	
Other suggestions	New action: Current EPA licensing agreements for STPs be reviewed to improve quality of discharge. Responsibility - EPA, HSC, SWC. Costings - All costs in this section should indicate allocation.		New action is already covered by CSP4.

Issue	Existing Management Action	Comments	Response
WATER AND SEDIMENT QUALITY:			
Boat Sourced Pollution	**BSP5** - Provide better waste disposal facilities for people aboard boats.	This makes it easier for people to leave their rubbish.	This action is strongly supported by the Committee and by other groups at the Workshop and so remains.
	BSP6 - Provide appropriate sewage disposal facility for commercial and recreational vessels at Berowra Waters.	Pumpout discharge point - is this really necessary? Most boaters are day use only. Needs to be investigated. What about a tanker to meet the boat for example?	It is considered important by the Committee, it also allows boat owners to chose not to pollute, a choice they cannot make now. The type of sewage disposal facility has not been decided, as there are a number of choices.
	BSP7 - Produce a brochure outlining the legal responsibilities of boat users not to pollute and provide advice on how to best protect the environment.	Put up a sign rather than a brochure? Costly, why not use the Waterways brochure? Those who profit from boat use should be responsible for educating boat users as to environmental guidelines. Use appropriate marketing strategy.	The brochure may be a Waterways brochure, but it will still cost the same amount to produce. Add to action: Brochure to be provided by boat hire businesses and marinas to all boat users.
	BSP8 - Investigate the environmental impacts of antifouling paints.	There is already research on this. Wording is unclear if intention is to examine impact of antifouling paints on heavy metals with other sources. Reduce cost to $3,000.	This action applies specifically to impact of antifouling on Berowra Creek. This action is a separate action from HMA9 as its objective is different. $3,000 would be insufficient to carry out action.
	BSP9 - If/ when pumpout facilities are installed in the Berowra Creek area all the estuary be declared 'no discharge'.	This is a desirable outcome which should be achieved through education and encouragement and not coercion and compliance. One group said "Keep priority medium" another "change to High".	Priority will remain at medium as the action firstly requires the installation of a waste disposal facility.
Other suggestions	New action: Establish free areas that can be used for the slipping of small boats where no antifouling is used.		This type of boat maintenance would be very hard to control.
River Settlement Sourced Pollution	**RSP11** - Apply actions RSP3-RSP10 to all river settlements not just in vicinity of Berowra Waters.	Investigate more fully onsite solutions. Lots of worries with pumpouts and barges. Innovative approaches to funding the upgrade of domestic systems are needed.	These comments will be dealt with during the implementation of the actions RSP1 - RSP10 (actions of Berowra Waters Plan of Management).
Heavy Metal Accumulation	**HMA9** - Identify major point sources of heavy metal contamination	Remove the word 'point' from the action. Include organochlorines.	'Point sources' will become 'sources'. Organochlorines have not been identified as a particular issue for Berowra Creek.

Issue	Existing Management Action	Comments	Response
WATER AND SEDIMENT QUALITY:			
Oil Spills	**OS1** - Initiate a program to source the origin of oil spills on Berowra Waters. This program would start with active monitoring, leading to chemical sampling and analysis to establish the source if necessary.	Educate owners re: spillages. Do fingerprinting of oil, fuel or tanks in the local area. Begin with the known report offence areas.	Will add education to the action.
	OS2 - Emergency spill management to be conducted as per HSC Emergency Spills Manual.	No comment.	
Other suggestions	All suppliers of oil should be responsible for its collection.		This issue is outside the scope of this Estuary Management Plan.
HUMAN USE:			
Estuary Recreation Facilities	**ERF15** - Improve maintenance schedule for Sommerville Road.	If for sediment traps and erosion prevention then good. Problem is increasing traffic on a residential road. Need to think about consequences. Needs further assessment, is permanent road access (for non-essential vehicles) necessary.	The action does not indicate major improvements to the road but to maintain the existing road. This is important for safety considering the number of visitors and the buses that currently use the road.
	ERF16 - Provide improved recreation/education facilities at Crosslands, such as an information and education centre and shop.	Use an informative walkway etc., no shop! Could include solar powered shower block. No shop! More rubbish, maintenance, etc. Yet very important to have education. Education - high priority, Shop - low priority.	The opinion of the community appears to be against a shop, so the action will not include a shop although it will include an education facility.
	ERF17 - The boat ramp at Crosslands be restricted for use by non-trailable boats only.	Is this necessary? Remove this item no other boats would use this boat ramp. Another group – good idea, strongly supported.	This action will remain as there is support for it and no particular problems will occur by keeping it.
	ERF18 - Personal watercraft use is banned upstream of Neverfail Bay.	Generally strongly agreed with, although there is a resident who commutes by jet ski from Coba Point to the car park and causes no annoyance or nuisance.	To overcome this problem, the action will ban use except for through passage at 4 knots.
Other suggestions	Add concept of sustainability to the objective.		The objective will also include minimising impacts on the environment. This is one of the overall objections.

Issue	Existing Management Action	Comments	Response
HUMAN USE:			
Estuary Tourism Facilities	**ETF8** - Investigate the potential for tourist related commercial activities at Crosslands, such as food and drink sales and canoe hire.	Replace "commercial" with "eco-focused". Priority - Low. No shop, although possibly canoe hire with no permanent infrastructure.	Will change action to "..eco-focused activities at Crosslands such as canoe hire."
	ETF9 - Construct an interpretive boardwalk through the wetland and mangrove areas in Crosslands Reserve.	Good idea, important. Broaden to include cultural and other natural values.	Will add to action "illustrating cultural and natural values."
Other suggestions	Objective needs to respond to ESD. Designate a landing area for seaplanes further down than Oaky Point or investigate banning altogether.		Will change objective to read "...in a way that minimises impacts on the environment, residents and users."
Boat Moorings	**BM3** - Transfer existing swing moorings to increase the number of marina moorings with upgraded security/ lighting. To compensate for loss of recognised fishing grounds, swing moorings would be removed to provide additional open water/ fishing areas.	Public are against this. Social issues go against boat owners. Strong community opposition. Remove HSC from this responsibility. Leads to more pollution as people utilise boat washing, etc., which they don't do on moorings. Not equitable to replace affordable swing moorings with marina moorings. Remove action.	Much of this action is Council Policy under BWPofM (BM2). This modified action will be removed.
	BM4 - Enforce existing no wash/ no wake zones in the estuary.	Consider 8 knot zones. How has cost been calculated?	Cost has been calculated from the cost of having a Waterways officer on duty at the Creek on a regular basis.
Sedimentation /Navigation	**SN12** - Any proposed dredging to require a thorough EIS, demonstrating economic viability and no significant adverse environmental impacts.	Don't want to leave dredging open to commercial developers. Delete due to irrelevance not supported by historical data. Add "only dredging if future environmental monitoring indicates a need to do so". No commercial dredging in Berowra Creek, refer to SREP 20 - no dredging in tributaries?	Will change in light of sand extraction prohibition in Sydney REP20.
	SN13 - Minor dredging of navigation channels is supported subject to appropriate environmental approvals.	Delete due to irrelevance not supported by historical data.	This action only supports minor dredging and has been added due to anecdotal evidence of channel siltation in the lower estuary.

Issue	Existing Management Action	Comments	Response
HUMAN USE:			
Commercial and Recreational Fishing	**CRF1** - Prepare a management plan specifically for Berowra Creek that addresses local concerns regarding commercial fishing practices, particularly visiting fishers, over fishing and excessive bycatch. Elements of the plan may include excluding boats from Calabash Bay intertidal seagrass area and the need to preserve or rotate bait taking areas.	Some areas to be identified and banned from commercial fishing. Fishing licenses should be regionalised and controlled in numbers. No commercial fishing in Calabash Bay.	These issues would all be considered during the development of the management plan.
Aquaculture	**A1** - Any proposed new aquaculture development in the estuary such as fish farming would require a thorough EIS and the approval of NSW Fisheries.	Delete – statutory regulation already. This action is not necessary. HSC to be part of control.	Inclusion of this action is supported by Council.
Heritage Protection	**HP1** - Investigate and implement appropriate protection measures for middens subject to erosion in the estuary.	Erosion of these middens is a natural process. Include in responsibilities - Metropolitan Aboriginal Regional Land Council (MARLC).	MARLC will be included under responsibility.
	HP2 - Enforce existing no wash/ no wake zones in the estuary.	Refer to BM4.	
Other suggestions	Erosion is a problem along the Creek. Also consider European heritage: stone wharves and ballast heap.		European heritage is covered by the LEP through the Heritage DCP.
ECOLOGY:			
Mangroves	**M3** - The sub-tidal and tidal areas of Big Bay be incorporated into Marramarra National Park.	Investigate other mangrove areas to be included into National Parks.	Mangrove management already covered through Fisheries Habitat Protection Plan (HPP) #1.
Seagrasses	**S1** - Improve water quality through management strategies addressed in previous sections.	No comment.	
	S2 - Ensure the requirements of Fisheries' HPP#2 (Seagrasses) are implemented and monitored.	No comment.	
	S3 - Shallow areas of seagrass should be clearly marked with bank signs to minimise damage due to boat propellers.	Investigate appropriate signage, keep to a minimum. Delete action. Signs detract from scenic value and are not effective, a brochure (S4) would do just as well.	Will delete action as S4 achieves the same objective.

Issue	Existing Management Action	Comments	Response
ECOLOGY:			
Seagrasses (cont)	**S4** - Seagrass beds to be indicated on boating maps.	Boating maps are a good idea. Educate people who use the waterway to protect it. Maps given to those hiring boats and houseboats by the hire boat operators.	Will add to action ".. Maps to be distributed by Waterways and hire boat operators."
Noxious Weeds	**NW8** - Bush regeneration works be undertaken around the wetlands area in Crosslands Reserve.	Priority depends on how invasive the weeds are.	
Other suggestions	If Council doesn't have a noxious weeds policy for the entire catchment, one should be developed. Nurseries have a responsibility to educate people as to suitable plants for gardens.		These actions are outside the influence of the Estuary Management Plan.
Biological Monitoring	**BioM1** - Establish a biological monitoring program to assess seagrasses, mangroves and benthic organisms at sites throughout the estuary and at reference locations elsewhere in the Hawkesbury River estuary. Program should include periodical mapping of aquatic habitats and quantitative sampling of key indicators.	Prioritise problem areas as part of strategy. Cost very unrealistic unless able to use students. HNCMT should be added.	Cost is given as a per annum cost although monitoring would only be carried out once every 3-5 years.
	BioM2 - Investigate the possibility of involving universities, and/or the CSIRO in the monitoring program.	No comment.	
	BioM3 - Establish MOU's (Memorandums of Understanding) between Council and universities and other research organisations to encourage research into the estuary.	No comment.	

General Comments:

COSTINGS

There needs to be some breakdown of cost estimates- use a key/ legend to highlight each proportion.

RESPONSIBILITY

Write the organisation with the greatest responsibility in bold.

APPENDIX D: SUMMARY OF COMMENTS FROM PUBLIC DISPLAY AUGUST 1999

The following summary addresses the substantive comments raised following public exhibition of the Estuary Management Study and Draft Estuary Management Plan by Council in August 1999. Minor items such as corrections to names, spelling etc have generally been included without comment.

In all sixteen submissions were received, mainly from state government agencies:

- Berowra Catchment Management Committee,
- Hawkesbury Nepean Catchment Management Trust,
- Hornsby Council Planning Branch,
- Northern Sydney Health,
- NSW Agriculture,
- NSW Fisheries,
- Sydney Water,
- Waterways,
- National Parks and Wildlife Service,
- Civil Aviation Safety Authority,
- Berowra Valley Regional Park Trust,
- Hawkesbury River Environment Protection Society,
- Association for Berowra Creek,
- Macquarie Princess Charter Ferry,
- Geoff Pratt (Berowra Resident),
- Margaret McMurray (ex Councillor and EMC Chair).

Berowra Catchment Management Committee

Comments

- General support for approach and funding of EMP (noted),
- Specific support for an ⊙Estuary Manager⬡ (noted),
- Request for reference list (added to EMS),
- CMC✪s role (see Section 3.1.4),
- EPA licenses (comment added),
- Data collection co-ordinator (comment added),
- Rural sediment sources (already covered),
- Nutrients from boats (a minor problem only),
- Organochloride levels (references included),
- Noxious Weeds (changes added),
- Biological Investigations (changes made),
- Definition of TCM (comment added).

Hawkesbury Nepean Catchment Management Trust

Comments

- Supports appointment of an ⬡Estuary Manager⬠ (noted),
- Further filtering of ⬡high priority⬠ items (priority set by EMC and workshop),
- Integrated Lower Hawkesbury Estuary Management Plan rather than an individual Berowra Creek EMP (new action EM2 added),
- Extensions to the monitoring programs (noted),
- Water and sediment quality (noted),
- Tightening of human use controls and protections (noted),
- Marine Reserve or Aquatic Reserve may be more suitable for Big Bay (change added as per NSW Fisheries),
- Plan implementation (noted).

Hornsby Shire Council Planning Branch

Comments

- General text clarification (changes made).

Northern Sydney Health

Comments

- Involvement of Council✪s Environmental Health Officer (noted).

NSW Agriculture

Comments

- Existing Regional Weeds Strategy (comment added).

NSW Fisheries

Comments

- Marine Protected Area may be more suitable for Big Bay (change added),
- Fishery Management (noted),
- Aquaculture developments approvals (change added).

Sydney Water

Comments

- Sydney Water✪s existing monitoring program (changes made),
- Swimming conditions (primary contact) monitoring after rain (Hawkesbury-Nepean Trust has existing program),

Waterways

Comments

- WADAMP funding (change added),
- Pollution elimination objectives (change made),
- No discharge requirement (noted),
- Clean up by Fire Brigade (change added),

- Personal watercraft (changes made),
- Security at moorings (noted),
- Seagrass mapping (change added).

National Parks and Wildlife Service

Comments

- Wildlife trips (change made).

Civil Aviation Safety Authority

No Comment

Berowra Valley Regional Park Trust

Comments

- Saltmarsh and mudflats (changes made and new action M4 added),
- Weed control (noted),
- Sumerville Road maintenance (changes made),
- Crosslands development (changes made).

Hawkesbury River Environment Protection Society

Comments

- Selection of priority actions for immediate implementation (action plan for implementation to be determined by EMC),

Association for Berowra Creek

Comments

- Car parking and traffic problems (noted),
- Seaplane landings (noted).

Macquarie Princess Charter Ferry

Comments

- Request for pumpout facility (noted).

Geoff Pratt

Comments

- Riverbank erosion (noted).

Margaret McMurray

Comments

- General support (noted).