Currarong Creek

Entrance Management Plan

SCC File No. 12406

adopted July 2007

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Preface

Shoalhaven City Council has prepared this Entrance Management Plan for Currarong Creek in consultation with the Shoalhaven community and NSW Government agencies.

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CONTENTS

APPENDIX 1. MANLY HYDRAULICS LABORATORY ANALYSIS OF WATER LEVEL, WAVE AND RAINFALL DATA

APPENDIX 2. FORM USED FOR 2004 COMMUNITY SURVEY

APPENDIX 3. SNOWY MOUNTAINS ENGINEERING CORPORATION REPORT ON CURRARONG CREEK ENTRANCE

1 Introduction

The City of Shoalhaven includes 14 substantial estuaries and coastal lakes, as well as a number of smaller creeks that drain directly to the sea. Entrance management is a major issue because a number of the waterways have entrances that are intermittently opened and closed to the sea. Currarong Creek is unusual however, in that although it is rarely, if ever, completely closed to the sea, there are significant entrance management issues associated with use of the entrance by small boats. Shoaling of the creek entrance is common and this limits the use of the creek for boating access to the sea. Most of the other estuaries in the City that have shoaled entrances are not considered to have navigable entrances most of the time.

Currarong is located in the City of Shoalhaven on the New South Wales south coast, by road approximately one hundred and ninety kilometres south of Sydney and thirty kilometres south-east of Nowra. Currarong village is built around the entrance to Currarong Creek and nestles at the southern end of the Crookhaven Bight, a twelve kilometre long sandy embayment to the north of the Beecroft Peninsula (see Figure 1).

Currarong's waterways and their catchments are characterised by many environmental, social, commercial and recreational values that make them popular places for a wide variety of activities. However, the pressure of these uses has sometimes resulted in competition for and degradation of the area's natural resources.

In response to this, Shoalhaven City Council prepared the Currarong Natural Resources Management Strategy (NRMS) which provides a comprehensive and integrated set of strategies to restore, protect and conserve the natural resources of Currarong's waterways and their catchments, to ensure that their use is ecologically sustainable in the long term. The Currarong NRMS was developed with considerable input from Government agencies and the broader community. It was adopted by Council in December 2001.

The preparation of this Entrance Management Plan for Currarong Creek was a high priority action in the NRMS. The NRMS included an interim entrance management strategy that proposed dredging to improve navigability when certain criteria were met. That is described in more detail in Section 5 of this document. This plan supersedes that interim entrance management strategy of the NRMS. A number of related actions from the NRMS are also dealt with in this Entrance Management Plan and these are set out in Table 1.

Currarong Creek below Mean High Water Mark is part of the Jervis Bay Marine Park and since the NRMS was adopted there have been significant changes to legislation affecting the creek. The Marine Park Zoning Plan came into force in 2002. It designated the tidal section of Currarong Creek and the adjacent ocean waters as Habitat Protection Zone, and Blacks Cave Creek, which flows into Currarong Creek upstream of the bridges, is zoned Sanctuary.

The issues involved in the management of Currarong Creek entrance are complex and the future of the creek is of great importance to many Currarong residents and visitors. For decades there has been much debate within the community and at Council meetings, with various courses of action having been supported over the years. Therefore it cannot be expected that this Entrance Management Plan will satisfy everyone. The plan provides background information on the nature of the creek, community desires and the current legislative and policy framework. A number of management options are described and assessed and the preferred course of future action is identified.

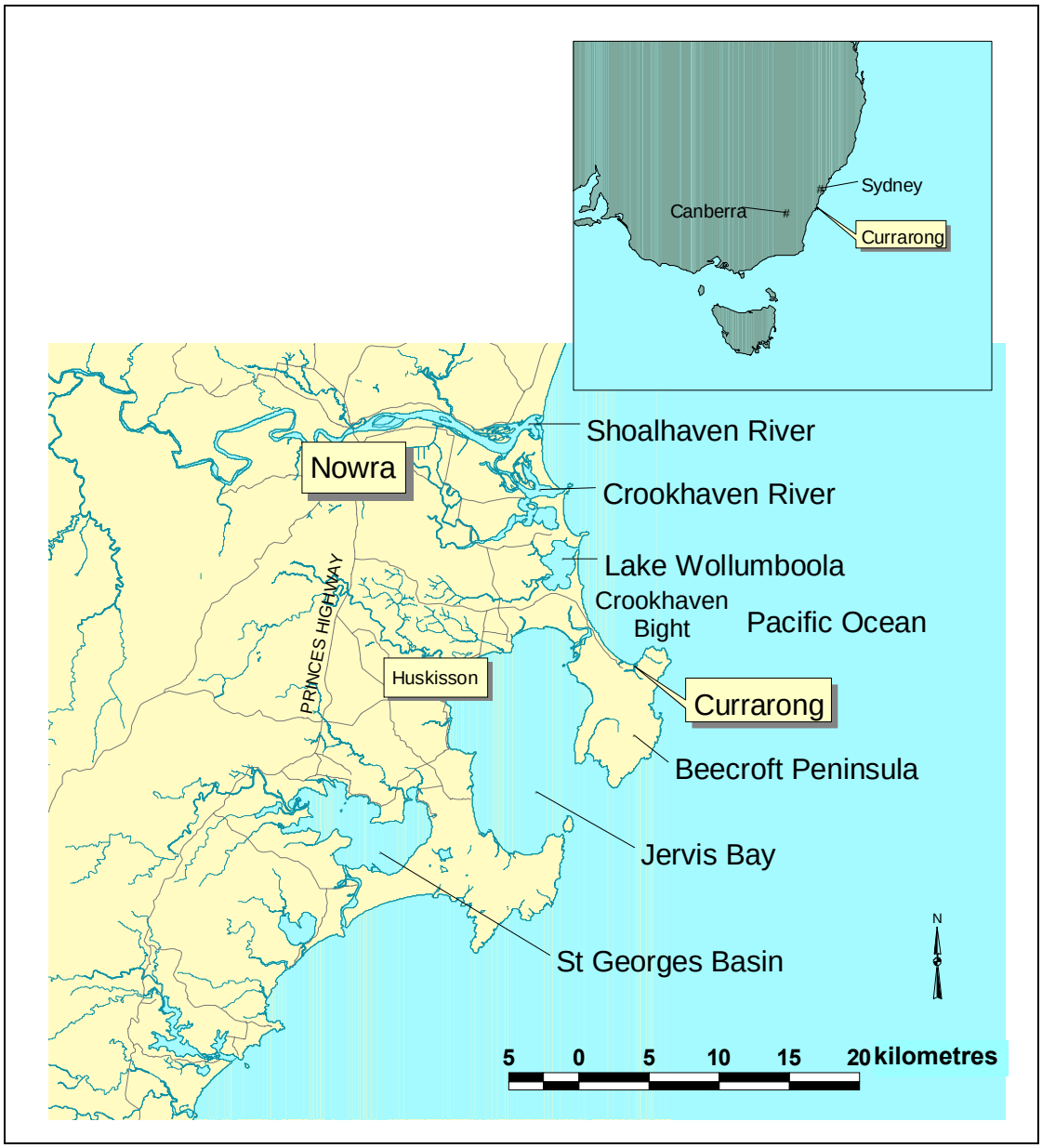


Figure 1. Location of Currarong.

Table 1. Actions from the Currarong Natural Resources Management Strategy that are dealt with in this plan.

Strategy	Action
WF3	46. Investigate effects of removal of sand spur
	47. Investigate effects of other man-made structures
CP1 & R3	82. Assess damage caused by vehicles passing over sand dune
	83. Review authority for beach launching and retrieval
R3	99. Prepare an Entrance Management Strategy
R5	103. Investigate ways of reducing conflict between swimmers and boaters in Creek entrance area

2 Management Responsibilities

A number of public authorities share responsibilities for management of the entrance to Currarong Creek. The main management functions are:

- development of legislation and policy;
- approval and regulation of activities; and
- funding and carrying out of work.

The management responsibilities and the legal and policy bases for each authority are summarised in this section.

2.1 Shoalhaven City Council

Under the Local Government Act 1993, the following relevant matters are included in Council's charter:

- to provide directly or on behalf of other levels of government, after due consultation, adequate, equitable and appropriate services and facilities for the community and to ensure that those services and facilities are managed efficiently and effectively
- to properly manage, develop, protect, restore, enhance and conserve the environment of the area for which it is responsible, in a manner that is consistent with and promotes the principles of ecologically sustainable development
- to have regard to the long term and cumulative effects of its decisions.

Chapter 5 of the Act summarises the many functions of Council. With regard to Currarong Creek entrance, Council exercises "service" functions (rather than regulatory, enforcement, administrative or revenue functions). Section 24 of the Act allows Council to provide goods, services and facilities, and carry out activities, appropriate to the current and future needs within its local community and of the wider public. Examples of Council's service functions identified in the act that are relevant to Currarong Creek entrance include:

- recreational services and facilities
- environment conservation, protection and improvement services and facilities
- tourism development and assistance.

At the request of sections of the community, Council has taken a leadership role in the management of the creek entrance in the past. This has included development of the Currarong Natural Resources Management Strategy and this Entrance Management Plan. Council has, in the past, consulted extensively with the community on appropriate management actions for the creek entrance and has at times made the difficult decision to respond to

strong community desires for dredging the channel to improve navigability, having considered also the strong community opposition to such dredging.

The following extract of a 1978 letter from Shoalhaven Shire Clerk to State Members describes Council's position:

> *"In support of this application it should be pointed out that the beds of these waterways are not Council property, however, Council must suffer complaints from users of the river regarding siltation. In these instances such siltation does not derive from Council operations, but is transported upstream or downstream from sources beyond Council's control. Both Currarong and Shoalhaven Heads are predominantly tourist areas catering for high influxes of visitors from the major cities of N.S.W. as well as from country and interstate. Council already contributes highly towards facilities for these tourists including picnic areas, camping facilities, toilet blocks and boat ramps. For Council to have to use revenue funds to remove silt which it did not cause, from waterways which it does not own and which receive high usage from visitors who do not pay rates, is a very evident anomaly. …. As these areas form part of the overall tourist attractions of N.S.W. and indeed represent some of its finest fishing locations, it is considered very reasonable that the State Government subsidise the cost of keeping such waterways attractive and navigable at all tides."*

The Minister for Public Works and Ports responded:

> *"As a matter of policy, the dredging of navigation channels for recreational craft is not undertaken at this time and I regret therefore that I cannot be of assistance…."*

Council carried out the dredging at its own expense and has done so ever since. However, the State Government has contributed to studies on and planning for the creek (including this plan).

Council has carried out dredging in the past under State Environmental Planning Policy No. 35 - Maintenance Dredging of Tidal Waterways. The effect of the Policy is to remove any requirement that may exist for development consent, although environmental assessment and consultation with government agencies are still required.

2.2 NSW Marine Parks Authority

2.2.1 Marine Parks Act 1997

The tidal section of Currarong Creek is part of the Jervis Bay Marine Park, declared under the Marine Parks Act 1997.

The objects of this Act are as follows:

(a) to conserve marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive system of marine parks,
(b) to maintain ecological processes in marine parks,
(c) where consistent with the preceding objects:
    (i) to provide for ecologically sustainable use of fish (including commercial and recreational fishing) and marine vegetation in marine parks, and
    (ii) to provide opportunities for public appreciation, understanding and enjoyment of marine parks.

The NSW Marine Parks Authority is the agency responsible for establishing and managing marine parks. The functions of the Authority are set out in section 30 of the Act:

(a) to investigate, assess and consider proposals for marine parks or variations of the areas of marine parks,
(b) to make recommendations as to the appropriate classification of areas within marine parks,
(c) to prepare an operational plan in respect of each marine park,
(d) to manage and control activities that may affect marine biological diversity, marine habitats and marine ecological processes in marine parks,
(e) to provide for and regulate the ecologically sustainable use (including commercial and recreational fishing) of marine parks,
(f) to disseminate information about marine parks,
(g) to encourage public appreciation, understanding and enjoyment of marine parks and, where consistent with the other functions of the Authority, public recreation in marine parks,
(h) to encourage and permit, when appropriate, scientific research into the ecology of marine systems.

Mining is generally prohibited in the Marine Park and it has been questioned whether dredging of the creek can be considered to be mining. The Mining Act 1992 defines mining as the extraction of material from land for the purpose of recovering *minerals* from the material so extracted or to rehabilitate land from which material has been so extracted, but does not include any activity declared not to be mining by a regulation under section 11A. *Minerals* are listed in Schedule 2 of the Mining Regulation 2003. The sand in Currarong Creek is not listed as a mineral and so its extraction is not mining.

The Marine Parks Act 1997 requires the development of two plans for the Jervis Bay Marine Park – a zoning plan and an operational plan.

2.2.2 Zoning Plan

The zoning plan, effective October 2002, details the location of sanctuary, habitat protection, general use and special purpose zones and the manner in

which activities operate within the marine park. The entrance of Currarong Creek is in the Habitat Protection Zone of the marine park (Figure 2).

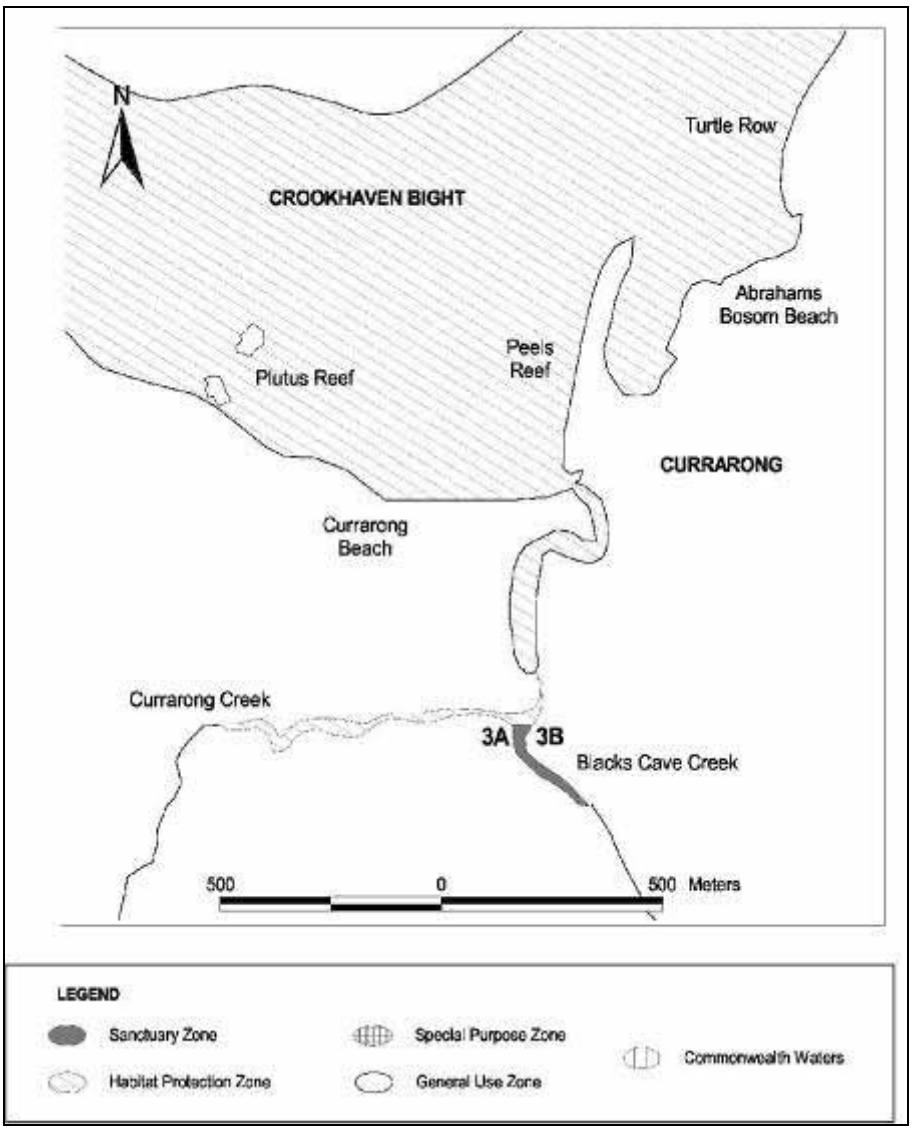


Figure 2. Marine park zoning for Currarong Creek

The objects of habitat protection zone, set out in clause 10 of the Marine Parks Regulation 1999, are:

(a) to provide a high level of protection for biological diversity, habitat, ecological processes, natural features and cultural features (both Aboriginal and non-Aboriginal) in the zone, and
(b) where consistent with paragraph (a), to provide opportunities for recreational and commercial activities (including fishing), scientific research, educational activities and other activities, so long as they are ecologically sustainable, do not have a significant impact on fish populations within the zone and have a negligible impact on other animals, plants and habitat.

Clause 11 of the regulation has significant implications for the future management of Currarong Creek entrance. It provides that:

(1) A person must not, while in the habitat protection zone of a marine park:
(a) harm, or attempt to harm, any animal (other than fish), or
(b) harm, or attempt to harm, any plant, or
(c) damage, take or interfere with, or attempt to damage, take or interfere with, any part of the habitat (including soil, sand, shells or other material occurring naturally within the zone),
except with the consent of the relevant Ministers.

(2) Consent is only to be given under subclause (1):
(a) for research, environmental protection, public health, traditional use or public safety purposes, or
(b) for the purposes of an ecologically sustainable use that does not have a significant impact on fish populations within the zone and has a negligible impact on other animals, plants and habitat.

This effectively prohibits dredging of the creek for the purpose of improving recreational boating or amenity of creek front property owners, unless it can be shown to be for one above purposes or to have a negligible impact. Slightly different restrictions apply to other zones in the marine park.

Further, clause 32D provides that consent for an activity must be refused if, in the opinion of the relevant Ministers, it is inconsistent with the objects of the Act or, except in emergencies, with the objects of the zone. Consent may be refused in certain other circumstances.

2.2.3 Operational Plan

The Jervis Bay Marine Park Operational Plan, adopted in October 2003, outlines the management intent of the Marine Parks Authority in providing for conservation and sustainable use of the Jervis Bay Marine Park. To achieve the objectives of the marine park it is essential that all activities be undertaken in a sustainable way that does not adversely impact on habitat or species viability.

The following management actions from the operational plan are particularly relevant to the management of the entrance to Currarong Creek.

2.1.5 In conjunction with Waterways Authority, assess the need for vessel management strategies in shallow seagrass habitat.

2.1.8 Provide comment on proposed developments that have the potential to impact on the Jervis Bay Marine Park.

2.1.10 Work with relevant organisations to prevent damage to marine habitats as a consequence of terrestrial land use and terrestrial and aquatic developments.

2.1.11 Liaise with National Parks and Wildlife Service, Shoalhaven City Council, Department of Defence, and other relevant agencies regarding signage and access to various areas of the marine park.

3.7.1 Consult with Shoalhaven City Council, National Parks and Wildlife Service, NSW Police Service, NSW Ambulance Service, State Emergency Service and commercial beach haul fishers to develop management arrangements to minimise impacts of vehicles on beach habitats.

6.4.1 Develop assessment guidelines for environmental impact assessment for developments within the marine park, with reference to other agencies in accordance with procedural and legislative requirements and management agreements, to ensure the requirements of the Environmental Planning and Assessment Act 1979 are met.

6.4.2 Undertake and require appropriate environmental assessment for all developments within the marine park.

6.4.3 Establish referral procedures and environmental impact assessment guidelines with Shoalhaven City Council, the Department of Defence, Environment Australia and the Department of Infrastructure, Planning and Natural Resources.

6.4.4 Comment on relevant environmental impact assessment and development applications in accordance with the requirements of the Marine Parks Act 1997, the Environmental Planning and Assessment Act 1979, and the Environment Protection and Biodiversity Conservation Act 1999.

6.4.5 Work with relevant agencies to ensure arrangements for environmental impact assessment of activities within and in the locality of the marine park are effective and are rigorously applied.

With regard to the Authority's responsibility to provide for the ecologically sustainable use of the marine park, public moorings are provided in some popular locations to limit anchor damage. No other waterways infrastructure is provided for in the operational plan.

2.3 Department of Lands

2.3.1 Crown Lands Act 1989

The Department of Lands administers Crown land below Mean High Water Mark under the provisions of the Crown Lands Act 1989.

Reserve 56146, the general tidal waterway reservation, notified 11 May 1923, affects the bed of Currarong Creek. This reservation applies to the beds of all waterways across New South Wales (unless excised) and prevents them from

being leased or sold, that is, they can only be reserved for another public purpose or licensed for a particular use.

2.3.2 Land Assessment

Prior to Crown land being licensed or reserved for a public purpose a land assessment must be carried out. The goal of the land assessment process is to ensure that the allocation of Crown land maximises the benefits to the people of New South Wales. The Department of Lands adopted a Crown Land Assessment for Currarong village, including the bed of the creek, in November 1999. The land assessment identifies preferred uses for the creek as Environmental Protection and Recreation (natural). These are the uses to which it is envisaged the land will be put and they indicate to the community and public authorities how the findings of the land assessment may be implemented.

2.3.3 Licences

The occupation, use, digging up of, or the construction of works on Crown Land must be authorised by a licence (formerly a Permissive Occupancy or PO) from the Department of Lands. For many years Council held a licence/PO for dredging (105317) that covered the area of Currarong Creek shown in Figure 3. This licence was terminated in May 2000. Separate licences for dredging granted in 2000 and 2002 were short term and only covered the period of the dredging in each of those seasons, and they were restricted to the specific area to be dredged. Any future proposal for dredging would require a new licence application to be made. The Department of Lands consults with other NSW Government agencies when considering whether or not to grant a licence.

2.4 NSW Maritime Authority

The NSW Maritime Authority (formerly NSW Waterways) has primary responsibilities to achieve the highest possible standards for the safety of commercial and recreational vessels and other users of NSW navigable waters, the protection of the marine environment, and the provision of waterways infrastructure for vessels.

In Currarong Creek, NSW Maritime is responsible for licensing of moorings, enforcement of marine safety and environmental legislation and regulations, installing new and replacement navigation aids and advisory signs, and possibly providing funding for infrastructure through the Waterways Asset Development and Management Program.

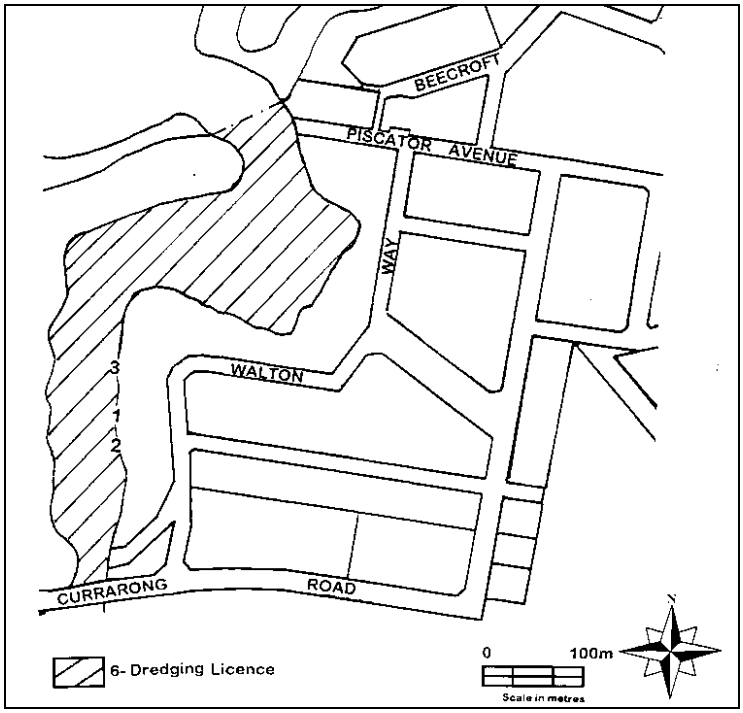


Figure 3. Area covered by Council's former licence to dredge, which was terminated in May 2000.

2.5 NSW Department of Primary Industries

In addition to regulating fishing activities in the creek, NSW Department of Primary Industries (previously NSW Fisheries) has responsibilities for protection of fish habitat. Section 200 of the Fisheries Management Act 1994 requires a local council proposing to undertake dredging works to obtain a permit from NSW Fisheries, unless the dredging is authorised under the Crown Lands Act 1989 or by another relevant authority (other than a local government). If marine vegetation (e.g. seagrass, mangroves, seaweeds) is to be harmed a permit under section 205 of the Act would be required.

2.6 Department of Environment and Climate Change

The Department of Environment and Climate Change (previously Department of Natural Resources) provides technical and policy advice and funding for estuary entrance management in New South Wales. The Department administers the Coastal Protection Act 1979.

2.6.1 Coastal Protection Act 1979

The objects of the NSW Coastal Protection Act provide for the protection of the coastal environment of the State for the benefit of both present and future generations. The CPAct contains a number of provisions relating to the use and occupation of the coastal zone, the carrying out of certain activities and coastal protection works, the preparation of coastal zone management plans and other matters relating to the coastal zone.

3 The Nature of Currarong Creek Entrance

3.1 Formation and Fate of the Estuary

Currarong Creek is a small, permanent creek with a catchment of about 1200 hectares (see Figure 4). The creek commences high up on the Beecroft Peninsula then flows generally to the north, draining a low-lying swampy catchment in the centre of headland. The creek extends about six kilometres across Beecroft Peninsula, the most seaward kilometre being tidal. The upstream section of the creek is near-natural and the downstream end is highly modified, with waterfront structures and alterations to the creek entrance.

The tidal part of the creek (the estuary) is a place where marine and terrestrial processes interact to produce particularly sensitive and complex coastal environments. The creek entrance is subject to various changes at time scales ranging from days, through months, years and millennia. The coast is a dynamic place that has a history of change and will continue to change in the future (Woodroffe, 2002). The changes that have occurred at Currarong are far greater than any living people, or even generations of people, have seen.

The coast at Currarong has not always been where it is now. Sea level has fallen and risen vertically over hundreds of metres many times and this translates to many kilometres of horizontal change in the position of the coast. During the most recent ice age, much of the water now in the oceans was locked up in polar ice caps, and consequently the land surface of our continent was much larger (Turner *et al*., 2004). As that ice age came to an end sea level began to rise (about 20,000 years ago) and reached its current level about 6,000 years ago (see Figure 5). Compared to that large rise, sea level has changed little in the last 6,000 years.

Currarong Creek, and other estuaries in New South Wales, formed around six thousand years ago when sea level rose to its present position, drowning coastal river valleys. Under this relatively stable sea level, the creek has evolved to its current basic form in response to coastal and catchment processes (though it still varies from day to day in response to these processes).

The large and, in geological terms, rapid rise in sea level rise also triggered shoreward transport of huge volumes of sand that accumulated as beaches, many of which blocked off bays and river mouths. This marine sand is moved around by wind, waves, tides and currents.

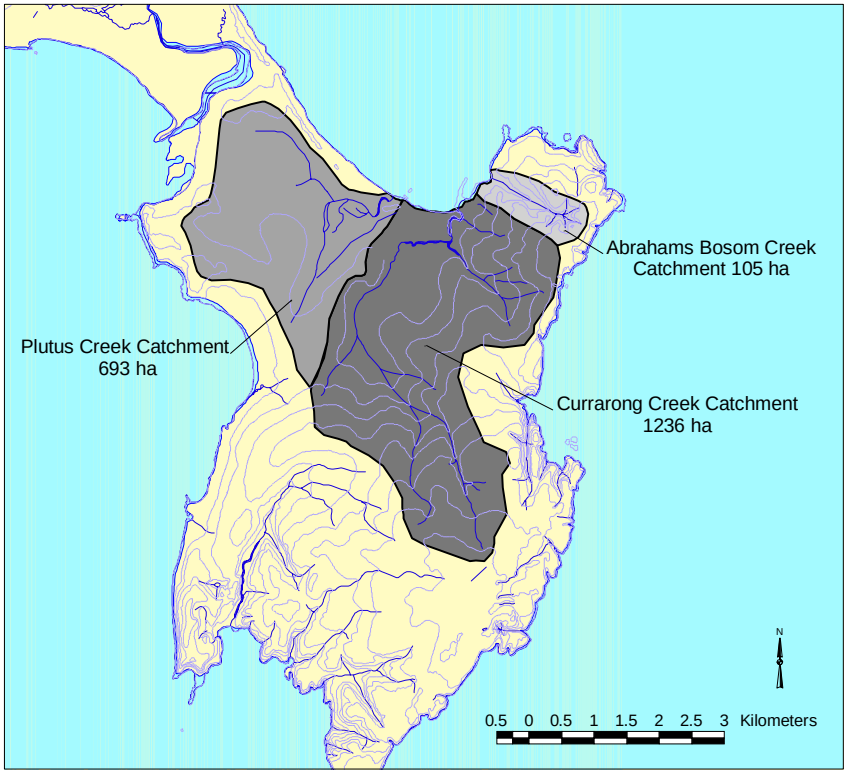


Figure 4. Beecroft Peninsula showing Currarong Creek catchment.

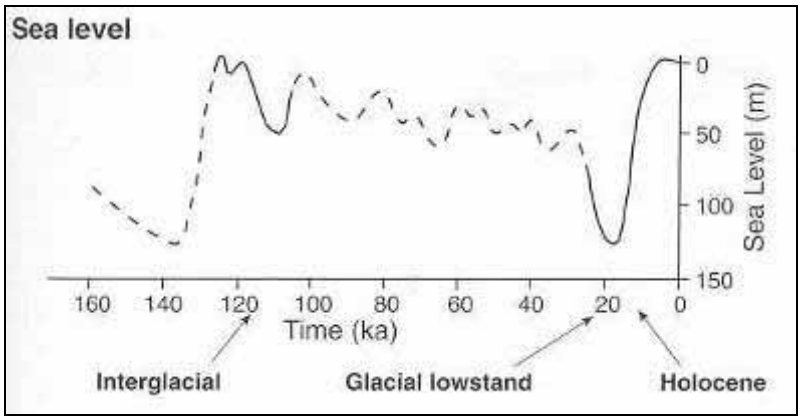


Figure 5. Recent (in geological terms) sea level changes. Note that about twenty thousand years ago (glacial lowstand) sea level was more than one hundred metres below where it is now. (from Woodroffe, 2002).

So long as sea level remains around its present height and there are no dramatic climatic changes, the destiny of most of our estuaries, including Currarong Creek, is to gradually be filled in by sediment. Each estuary is undergoing a decrease in water area and depth in response to (i) input of sand and shell from seaward, (ii) extension of the fluvial delta with sand and mud from landward and (iii) build up of mud through the central part of the estuary. The rate of infilling by sediment from the land has, in many cases, been increased by clearing in the catchment for urban development or other

uses. The time it takes for an estuary to reach a mature stage of infilling depends primarily on catchment characteristics (water and sediment discharge), together with the initial dimensions and configuration of the estuarine basin. To reverse the trend of estuary infill would involve significant ongoing cost to remove the sediment that is finding its way into the creek.

3.2 The Entrance

The entrance to Currarong Creek (Figure 6) is a naturally dynamic place and has many of the features typical of barrier estuaries in New South Wales. It essentially consists of a sand barrier (the spit) and sand shoals (the marine delta) with a tidal channel that changes its location from time to time as it meanders across the sand shoals to the ocean. To the east the entrance is confined by bedrock outcrops and the artificial rock training wall. A sand spur extends into the creek from the tip of the spit. The height of this spur has been artificially raised and the sand on it stabilised. Detailed surveys of the creek have been done on a number of occasions (Council plan ref. 1575).

To some extent the structures described in the previous paragraph constrain the movement of the tidal channel, but the condition of the entrance still changes at time scales ranging from days to years, depending on the interaction between rainfall, tidal flows, storm waves, storm surge, movement of sand along the beach and wind blown sand. That the creek has been heavily shoaled for as long as Europeans have been settled in the area is evidenced by the following note on a plan from the NSW Surveyor General's Office dated 1856:

> *"The creek is apparently an inlet from the sea at highwater at which time it can hardly be forded by a horse whereas it is almost dry at low water."*

The coastal processes that operate at Currarong have been described in two recent reports (WPGeomarine, 1995 and Coastal Engineering Solutions, 2003) and the following descriptions draw heavily from them.

Under natural circumstances and at a time scale of decades, sand spits at the entrances to creeks typically go through a cycle of growth and "breakthrough" as shown in Figure 7. Historically, the spit at Currarong has been breached by flood flows and/or severe wave attack - resulting in breakthroughs. A breakthrough in the 1950s reputedly occurred as a consequence of seepage through the sand (caused by the elevated flood levels in the creek) initiating instability and collapse of the sand barrier. Flood flows and wave action apparently then sweep the collapsed sand away, causing an opening to form and progressively widen through the sand spit. The older (1940s) aerial photographs in Figure 8 show the spit as having little vegetation - it was unstable and the sand would have been subject to movement by the forces of wind, the creek and the sea. The spit was subsequently reshaped and revegetated by Council and is now much more stable. It is worth noting that an absence of vegetation on entrance spits is also apparent in early aerial

photographs of other estuaries in NSW. Even though it may be that the natural state of entrance spits is to be unstable, the stabilisation of spits has been a goal of coastal management through the latter decades of last century and continues to be so.

Following stabilisation of the creek entrance by the training wall and the removal of the ebb tidal channel through the spit, the likelihood of future breakthroughs has been reduced. However, this is being counteracted by the erosion of the foredune. The width of the dune at high tide level was some 32 metres in 2001; compared to 42 metres in 1981; and 62 metres in 1944. This implies that the width of the narrow neck has been reducing at an approximate rate of 0.5 metres per year. Approximately 70% of the loss of the dune's width has occurred on the creek side of the dune - and only 30% on the seaward side. Since the infilling of the ebb channel in the creek in 1979, there has actually been accretion of the rear face of the dune. The long-term erosion of the seaward face of the dune is about 0.2 metres per year.

However, dune erosion and changes to the spit and dune are not steady. They are irregular in response to both ocean storm waves and flood events. The total loss of sand from the seaward face of this foreshore segment is estimated at less than 10,000cubic metres since 1944 (Coastal Engineering Solutions, 2003).

Behind the sand spit, Currarong Creek consists of a series of mobile sand shoals which may be partly exposed at low tide, and through which one or several channels flow. The sand is from marine and catchment sources.

Large amounts of sand can be deposited in the entrance area during storms. Under ambient sea conditions also, sand is transported westwards along the beach in front of the spit until it reaches the creek. Some sand is blown into the creek by wind. Some sand may also be washed into the creek from the east.

Sand moves more rapidly along the beach adjacent to Currarong Creek than it does in front of central Warrain Crescent. Monthly sediment transport movements of the order of 1,000 m3 occur regularly in both directions along the beach immediately to the west of Currarong Creek. The sediment transport rate in front of Warrain Crescent is typically 50% of this value (Coastal Engineering Solutions, 2003).

The reason for the accentuated sediment transport rates immediately to the west of Currarong Creek is the refraction effect of the offshore reefs. The location and orientation of these reefs means that the angle at which the approaching waves break on the beach is greater near the creek than further west and therefore they move more sand along the beach.

When it reaches the creek sand will be either transported into the entrance or be swept out depending on the tidal flow at the time. The action of waves at the entrance stirs up sand and makes it easier for a rising tide to move sand

into the creek than for a falling tide move it out. Sand that is stored in Currarong Creek has mostly been stored there as a result of erosion of Currarong Beach. There would be some sand coming off the catchment and possibly some sand ingested from the sea during flood tides. The grading of sand from Currarong Creek could be expected to be finer than the sand on the beach (Coastal Engineering Solutions, 2003). A lobe of sand, labelled "washover" in Figure 6, is often present at the creek entrance as a result of the processes described above. Coastal Engineering Solutions (2003) concluded that sand movement into and out of the creek cannot be readily quantified.

Once sand is in the creek, tidal and minor flood flows cause redistribution of sand and migration of channels within the entrance area. Since construction of the sand spur in late 1979, much has been said about the loss of the so-called "ebb tide" channel, across which the spur was built (compare 1979 with 1981 photos in Figure 8). Examination of the available air photographs shows that the "ebb tide" channel was a persistent feature through the 1970s, but that it has not always been there. Channels have migrated across the sand shoals much as a river meanders across a floodplain. At times there has been a single channel that followed a reasonably straight course hard against the back of the spit (1961). At other times the channel has meandered across to the southern shore and the straighter channel has virtually closed (1944, 1949, 1969). There have also been times when two or more channels have existed together (1964, 1972, 1975, 1979). The construction of the sand spur has constrained this migration of the channel (1980 onwards), but the absence of the spur would not guarantee the presence of the "ebb tide" channel.

The other main process that operates to affect the physical nature of entrance at any particular time is the scour caused by minor or major floods. During heavy rainfall events the creek will flood and discharge sediment that has accumulated inside the creek entrance. The frequency with which this occurs varies from year to year depending on climatic conditions. Observations are presented in Table 2. During periods of drought, not only would the entrance be expected to stay shoaled for longer periods, but the lack of freshwater influence would likely result in an expansion of seagrass in the creek.

Table 2. Summary of some of the works that have been done in the creek, along with observations of storm and rain events that have affected the entrance. The observations are not necessarily complete. They have been collated from Council files, community records (J. Dale) and other reports (including WP Geomarine, 1995).

Date	Works and Entrance Observations
1936?	bridge built over creek, including fill on western side
1940s or 50s	small training wall constructed by PWD
1959?	flood breached dune barrier
1972	new bridge built
1975	storm surge and storm waves removed part of dune barrier
1978/9	entrance training wall extended raised and capped
August-October 1979	channel dredged (dozer), spur built, spit reconstructed
1980?	extension of training wall removed
May 1980	shoaled by storm
May 1983	scoured by flood
pre-Christmas 1983	channel dredged entrance to boat ramp
6-7 August 1986	entrance swamped with sand by storm
October 1986	cleared by dragline
August 1989	scoured by flood
Early 1990s	training wall removed
April 1991	shoaled
June 1991	scoured by flood
April 1994	scoured by flood
September 1994	scoured by flood
February 1995	shoaled by storm
April 1995	dredged channel to end of spur
September 1995	scoured by flood
Late 1995 or early 1996	training wall rebuilt
April 1996	dredged, rock removed from ledge east of sand spur, 5m of rock removed from channel south of sand spur
August 1996	partially scoured by flood
pre-Christmas 1996	channel dredged, removed rock that had been placed on spur
March 2 1997	scoured by flood
May 10 1997	shoaled
June 26 1997	scoured by flood
June 30 1997	partially filled with sand
September 24 1997	scoured by flood
May 1998	shoaling
August 8 1998	scoured 30m wide, exposed rocks
August 18 1998	scoured - could get up creek at low tide for 3 weeks
February 13 & 27 1999	shoaled by storms
May 24 1999	shoaled to end of spur
May 2 2000	shoaled by storm
December 2000	dredged (excavator) to 51 Walton Way (sand used to nourish beach)
9-12 April 2001	Creek entrance filled with sand
May 4 2001	Large deposits of sand since Easter
July 7 2001	Big deposits of sand in creek
Sept 15 2001	Minor scour of creek from rain
February 5 2002	Medium scour of creek 7” of rain over 3 days
June 1 2002	Medium scour 6” of rain over 3 days
October 8 2002	Large seas put sand in creek
December 2002	Creek dredged (excavator) up to .51 Walton Way
March 18 2003	Large build up of sand at entrance over 2 weeks
May 14 2003	Good scour of creek. 12” of rain over 4 days and big seas
June 27 2003	Heavy seas filled creek channel with sand from spur
July 3 2003	Good scour of creek, 6” of rain over 3 days
February 26 2004	Creek full of sand from storm seas
March 6 2004	More sand in creek. Big seas
April 4-5 2004	Reasonable scour after 9.5” of rain

Figure 6. Currarong Creek entrance and surrounds, with some features of interest labelled.

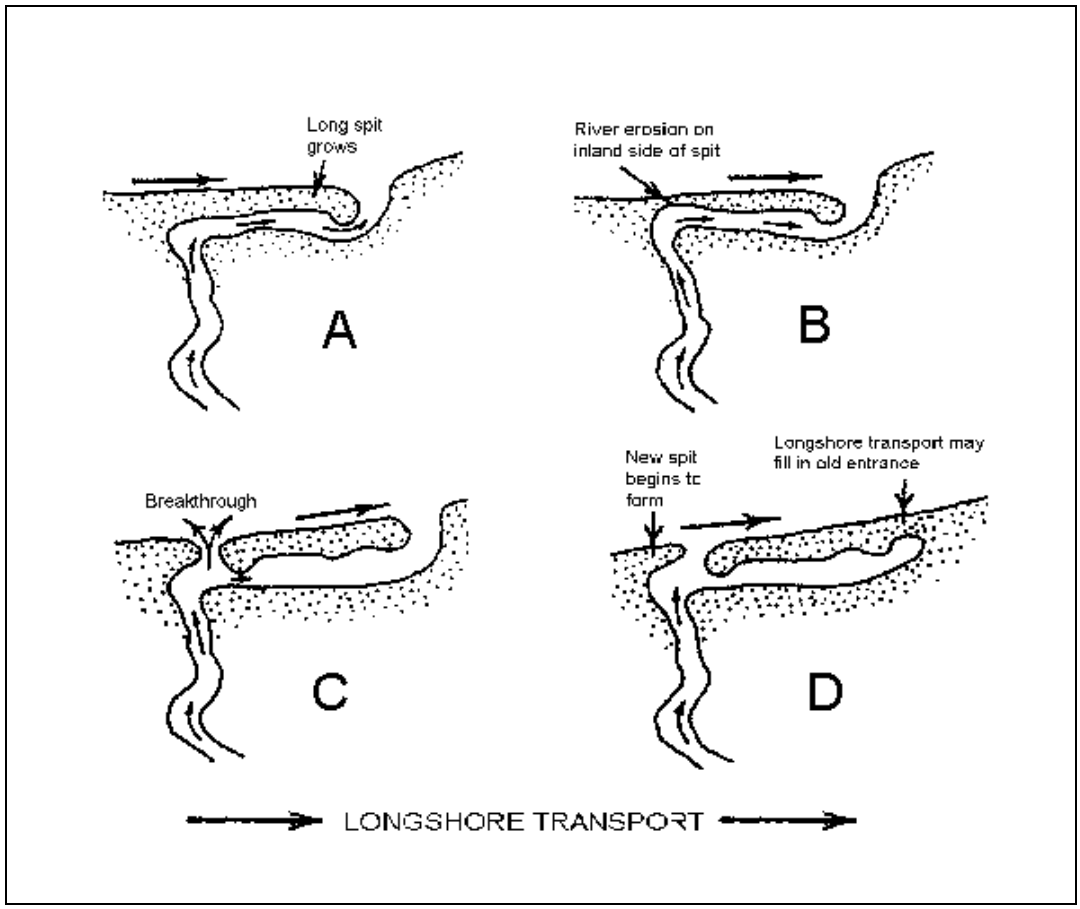


Figure 7. Typical cycle of entrance spit formation and breakthrough (adapted from NSW Coastline Management Manual).

1944

1949

1961

1964

Figure 8. Aerial photographs of Currarong Creek entrance from various years.
Note: These photographs have not been geo rectified and so should not be used for making measurements. They may be at slightly different scales and orientations, and they may each be distorted in different ways.

1969

1972

1975

1977

Figure 8, continued.

Note: These photographs have not been geo rectified and so should not be used for making measurements. They may be at slightly different scales and orientations, and they may each be distorted in different ways.

1978

1979

1980

1981

Figure 8, continued.

Note: These photographs have not been geo rectified and so should not be used for making measurements. They may be at slightly different scales and orientations, and they may each be distorted in different ways.

1986 March

1986 October

1987 July

1987 October

Figure 8, continued.

Note: These photographs have not been geo rectified and so should not be used for making measurements. They may be at slightly different scales and orientations, and they may each be distorted in different ways.

1993 February

1993 May

1996

2001

Figure 8, continued.

Note: These photographs have not been geo rectified and so should not be used for making measurements. They may be at slightly different scales and orientations, and they may each be distorted in different ways.

3.3 The Tide

Coastal water levels fluctuate in a regular and predictable fashion in response to the gravitational effects of the moon, sun and planets on the oceans of the earth. The tidal range varies from tide cycle to tide cycle in response to the ever changing relative positions of these bodies. Tides along the New South Wales coastline are semi-diurnal in nature, i.e. high water and low water occur about twice daily (the actual period of a tidal cycle is about 12.5 hours). However, the tidal range undergoes a regular fortnightly cycle, increasing to a maximum over a week (Spring Tides) and then decreasing to a minimum over the following week (Neap Tides), because of the monthly orbit of the moon around the earth. Solstice tides, or King Tides occur in June and December of each year, when the sun is directly over the Tropics of Cancer and Capricorn respectively.

In 1996, the NSW Government installed in Currarong Creek (adjacent 75 Walton Way) an automatic water level recorder and instruments for collection of data on water quality parameters (temperature, pH, conductivity, salinity and dissolved oxygen). The water level recorder has continued to collect data since then but the water quality instruments were removed in March 1997.

A report was prepared on the information collected in that initial 12 month phase (Department of Public Works and Services, 1998). A tidal harmonic analysis was carried out for the period and the results are shown in Table 3. For comparison purposes, tidal plane heights and tidal ranges for HMAS Creswell in Jervis Bay are included. A sample of the water level records for Currarong Creek has been plotted and is shown in Figure 9.

Examination of Figure 9 and Table 3 reveal a number of features of tides in Currarong Creek that are typical of small estuaries with somewhat constricted entrances. The water levels in the lower part of the creek show a strong tidal influence but the confined and shallow nature of the creek has a number of effects on the tidal movement of water into, along and out of an estuary. They are generally sinusoidal in shape and have a pronounced diurnal inequality (successive high tides differ markedly), but the restriction provided by the shallow entrance and/or the small tidal prism (volume of water exchanged with each tide) of Currarong Creek reduces the tidal range in the creek to less than that of the ocean. The amount of this reduction varies from time to time depending on the degree of shoaling at the entrance. For the year of analysis shown in Table 3, the mean tidal range at the water level recorder in the creek was about 54% of the mean range in Jervis Bay. In addition the mean water level in the creek is higher than in the adjacent ocean waters. It is also apparent from Figure 9 that there is distortion of the sinusoidal shape of the tidal ebb and flow, particularly towards the bottom of the tide. This may be due to a “weir effect” with either the creek entrance or the creek bed around the water level recorder holding up the outward flow of water.

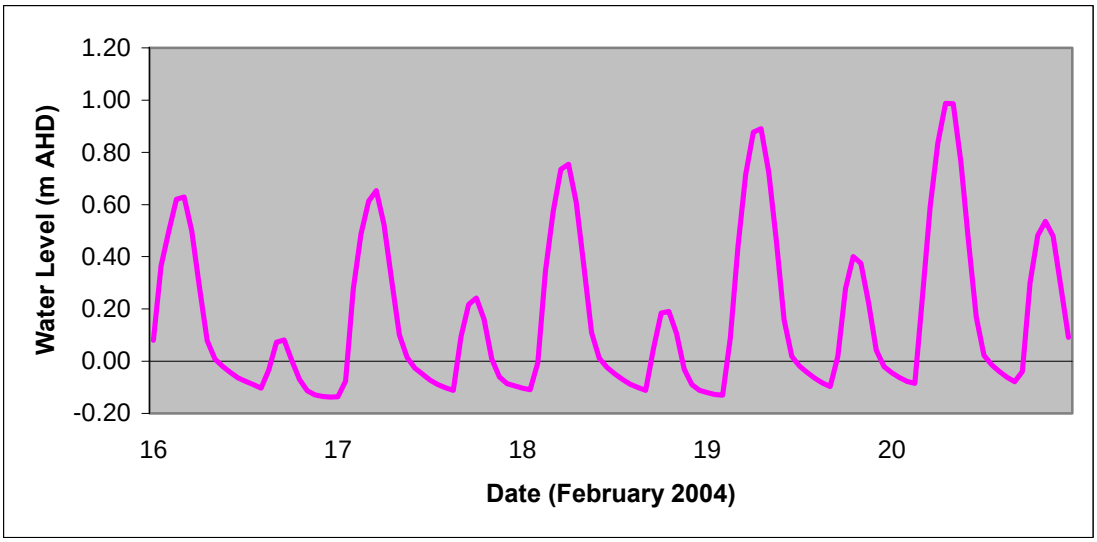


Figure 9. Five day sample of water level data for Currarong Creek.[1]

Table 3. Tidal planes calculated using data from 4 March 1996 to 3 March 1997 for Currarong Creek (Department of Public Works and Services, 1998) and HMAS Creswell in Jervis Bay (supplied by Manly Hydraulics Laboratory).[2]

TIDAL PLANE	ABBREVIATION	LEVEL IN CURRARONG CREEK (METRES AHD)	LEVEL AT JERVIS BAY (METRES AHD)
High Water (Solstice Springs)	HHW(SS)	0.810	1.019
Mean High Water Springs	MHWS	0.509	0.631
Mean High Water	MHW	0.444	0.511
Mean High Water Neaps	MHWN	0.379	0.39
Mean Sea (Creek) Level	MSL	0.153	-0.023
Mean Low Water Neaps	MLWN	-0.072	-0.437
Mean Low Water	MLW	-0.137	-0.557
Mean Low Water Springs	MLWS	-0.203	-0.678
Indian Spring Low Water	ISLW	-0.418	-0.954
Tidal Range	**Abbreviation**	**Metres**	**Metres**
Mean Spring Range	MHWS-MLWS	0.712	1.309
Mean Neap Range	MHWN-MLWN	0.451	0.827
Mean Range	MHW-MLW	0.581	1.068
Range	HHW(SS)-ISLW	1.228	1.973

[1] This information has been recovered directly from automatic recording equipment and has not been quality controlled by the Manly Hydraulics Laboratory (MHL). It should not be used for calculation or analysis without consulting MHL.

[2] This table is provided as an indication only. It is based on analysis of only one year of data, where normal definition of tidal planes is undertaken over 19 years of data. Not to be used for any property boundary matters.

3.4 Biological Environment

Just as the physical characteristics of estuaries such as Currarong Creek change from time to time, so too do the biological characteristics. The estuarine part of Currarong Creek downstream of the bridges provides a range of habitats in which a variety of plants and animals live. The distribution and abundance of these plants and animals changes from time to time in response to physical changes, interactions with one another and human influences.

There is a little saltmarsh downstream of the bridges occupying sand and mudflats at the junction of the sand spit and the spur. More extensive saltmarsh occurs upstream of the bridges. Saltmarsh occupies areas that are only reached by the highest tides.

The Grey Mangrove, *Avicennia marina*, lines the banks of the creek in places. There appears to have been some expansion of mangroves on the western foreshore downstream of the bridges, adjacent to the tourist park. Historical photographs show that there has been clearing of mangroves on the other shore for the construction of residential buildings and retaining walls (Wilton, 2000).

The bed of the creek is covered with dense seagrass (eelgrass - Zosteraceae) from just downstream of the bridges to just upstream of the spur. This can be seen in Figure 6 as the dark area within the creek. Typically in NSW estuaries, the density of plants and area covered by this eelgrass varies significantly from time to time in response to factors such as salinity, floods, sedimentation, grazing by herbivores and availability of seeds. It is not uncommon for patches of seagrass to disappear and for new patches to grow in new parts of the estuary. Eelgrass is a very important habitat for juvenile fishes and invertebrates.

A variety of algae (seaweeds) inhabit hard surfaces in the lower section of the creek. Occasionally large amounts of kelp and other seaweeds that have been ripped off the rocky reefs outside the creek will get washed into the creek by storm waves and tidal currents. These algae die in the estuarine environment and either rots in the creek or is flushed out by freshwater flows.

Other habitats in the estuarine section of Currarong Creek include the open water and the muddy and sandy beds of the channel, intertidal sand shoals and beaches and rocky outcrops.

All of the habitats in the creek support diverse communities of invertebrate animals and fish. The invertebrate fauna consists of a variety of worms, crustaceans, molluscs, etc, that may live amongst the vegetation, buried in sediments or attached to hard surfaces. Soldier crabs are a particularly conspicuous part of the creek's invertebrate fauna at low tide when they emerge from their burrows to roam around the sand flats in armies and feed. The fish fauna of a creek as small as Currarong is likely to consist more of juveniles than large numbers of adults and would include such typical

estuarine species as mullet, whiting, bream, flathead and gudgeons. Some waterbirds such as cormorants, pelicans, gulls and waders feed in the creek and on its exposed sand and mud flats. Penguins are reported to have come ashore at times near the creek entrance.

3.5 Analysis of Entrance Observations, Tidal Behaviour, Rainfall and Storm Waves

It has been shown for other estuaries in NSW that monitoring and analysis of tidal data can provide advance warning of entrance closure, which can allow appropriate actions to be taken according to an agreed management plan (Department of Public Works and Services. 2003). A harmonic analysis yields the principal lunar semi-diurnal tidal constituent M2 which has been shown for some estuaries to provide a good indicator of entrance constriction. The method overcomes the difficulty in identifying the slow decline in tidal range (due to shoaling) within tides that vary in range from tide to tide (McLean and Hinwood, 2000).

An analysis of the Currarong Creek water level records was carried out by the Manly Hydraulics Laboratory during preparation of this plan. Comparisons were also made using observation of the condition of the entrance, storm wave heights from the Port Kembla and Batemans Bay records, and rainfall records from Point Perpendicular. The tables are included as Appendix 1. The aim of the analyses was to see if these factors can be used to describe past entrance behaviour and predict future behaviour. In summary, the findings were:

- as a predictive tool the available data are not good;
- barometric pressure and the M2 constituent do not help describe entrance behaviour of Currarong Creek;
- a negative tidal range residual[3] may indicate the entrance shoaling up, but not necessarily always; there are cases where the range residual is negative but there were no observations of a shoaled entrance and there were also cases where observations of a shoaled entrance coincided with a positive range residual;
- there is no correlation between each storm wave event and the closest negative residual after the event; however there seemed to be marginally more negative range residuals (indicating perhaps silting entrance), after a storm event than positive range residuals;
- rainfall greater than 10mm may indicate the entrance will be scoured;
- more frequent and detailed entrance observations would be required to improve the analysis.

For the plots of storm waves two criteria were chosen:

[3] Residual is actual tidal range minus predicted daily tidal range; negative implies predicted range is bigger than actual range.

"severe" storms are those with significant wave heights[4] greater than 6 metres
"major" storms are those with significant wave heights from 3 to 6 metres in the case of E to S directions and 2.5 to 6 metres in the case of NE and ENE directions.

These are deep water wave heights recorded at Port Kembla and Batemans Bay.

The Sydney directional Waverider buoy indicates that significant wave heights in excess of 4 m are not generated from the NE quartile. The directional Waverider data indicate that severe storms are generated from the SSE to ESE quartiles but because of the effects of Beecroft Peninsula a SE storm would need to have much larger wave heights than a NE storm for it to affect Currarong Creek. At Currarong Beach, wave height would be reduced by about one half for a NE wave direction and by about four fifths for a SE wave direction when compared to the deepwater wave heights (Coastal Engineering Solutions, 2003).

As can be seen from the tables in Appendix 1, it is possible to attribute some of the observations of sand being deposited in the Creek entrance to particular storm events, but not in every case. Based on the information available it is not possible to say that a storm with waves of a certain height from a particular direction will result in blockage of the entrance. Unfortunately it is therefore not possible to estimate how frequently the entrance may become heavily shoaled in the future (and thereby estimate the required frequency and cost of dredging for maintenance of a navigation channel).

[4] Significant wave height (H_{sig}) is a statistical term frequently used by engineers and oceanographers to define the state of the sea during any particular time. Waves in the ocean have a somewhat random distribution in height, so the "significant wave height" is used to define the sea state. It is the average of the one-third highest waves occurring over the duration of the wave event being considered. Consequently waves with heights in excess of the reported significant wave height frequently occur during the particular wave event.

4 Human Use of Currarong Creek

Currarong Creek is appreciated for its scenic value by visitors, tourist park patrons, creek front property owners and other Currarong residents. Recreational uses of the creek are limited by the small size of the waterway. The entrance area of the creek is used for passive recreation and swimming. Small amounts of recreational fishing and bait collection are done in Currarong Creek but the small size of the waterway limits fish stocks.

Ocean fishing from boats is more common and is focussed on inshore reefs, sand and gravel areas, as well as on areas further offshore such as Sir John Young Banks which lie approximately seven kilometres north-east of Currarong. Some people access these areas by launching their boats in the creek and taking them through the entrance to the sea. A few moorings still exist in the creek and a number of creek front properties have private boat ramps and jetties.

There is no commercial fishing in the creek, though a few commercial fishermen launch and retrieve in Currarong Creek when fishing the ocean beaches and inshore reefs.

Recreational snorkelling, SCUBA diving and spear fishing are also done on the inshore reefs just outside the creek, both from the shore and from boats. Surfing, sailing and use of personal watercraft are other activities in the ocean waters adjacent to the creek entrance.

In general, waterway usage increases greatly during the summer months and holiday periods.

A number of community surveys have been carried out to collect information about how people use the creek.

Information on boats and boaters has been collected at Currarong by the Fishing Club and by the Currarong Creek Task Force in 1997. The information from those surveys could be useful in the designing of an upgraded boat launching facility at Currarong.

In 1999, during preparation of the Currarong Natural Resources Management Strategy, a discussion paper and questionnaire were widely distributed. The questions were designed to help prioritise those values that people considered important and the issues that people wanted addressed. Two hundred and forty five responses were received.

In May 2004, a survey was undertaken with the aim of value-adding on the 1999 NRMS survey by providing data on how people use the creek, number and types of boats, identification of management issues and ideas on options for entrance management.

The form was delivered to all households in Currarong and mailed to all non-resident ratepayers and people with on site caravans at the Currarong Tourist Park. One hundred and eighty six were completed and returned to Council.

A copy of the survey form is included in Appendix 2.

Activities undertaken by survey respondents are summarised in Table 4.

People were asked a series of questions about their boats and some of the information is summarised in Tables 5 to 10. Unfortunately the data collected regarding the draught of boats cannot be used. There was clearly some confusion amongst survey respondents as to what the draught of their boat was, with quite a few depths given that were unrealistic for the model of boat named.

Table 4. Summary of how survey respondents use the creek entrance area.

Activity	Proportion of Respondents	Average Days in Previous 12 Months
1 Wading across creek	82%	49
2 Swimming in the creek entrance	65%	38
3 Taking power boat between creek and ocean	45%	27
4 Using power boat in the creek only	7%	8
5 Mooring/working on boat	11%	27
6 Canoeing/kayaking	41%	24
7 Fishing in the creek entrance	25%	13
8 Collecting bait in creek entrance	9%	11
9 Shore-based snorkelling/SCUBA diving from/in the creek entrance	30%	24
10 Appreciating view in the creek entrance	78%	103
11 Bird/nature watching in the creek entrance	44%	124
12 Playing games	31%	37
13 Relaxing	60%	83
14 Socialising	44%	77
15 Commercial activity	3%	2
16 Other	11%	157

Table 5. Boat lengths (metres).

≤ 4.0	4.1 to 4.5	4.6 to 5.0	5.1 to 5.5	5.6 to 6.0	6.1 to 6.5	6.6 to 7.1
13%	31%	25%	20%	7%	2%	2%

Table 6. Hull material.

Fibreglass	Aluminium	Steel	Timber	Other
29%	68%	-	3%	-

Table 7. Engine type.

Outboard	Inboard
96%	4%

Table 8. Engine Size.(horsepower)

Minimum	Maximum	Most Common
4	175	50

Table 9. Location where boat normally kept.

Currarong Tourist Park	House at Currarong	House Elsewhere	Other
28%	57%	14%	1%

Table 10 Other boat ramps used.

Location of Ramp	Number of Respondents That Used It	Average Days Used in Previous 12 Months
Yalwal St Currarong	73	31
Bindijine or Long Beach	41	9
Callala Bay	36	5
Crookhaven or Orient Pt	22	5
Greenwell Pt	10	8
Other	3	10

5 Management Issues

5.1 Effects of Artificial Structures

Many opinions have been expressed over the years about the perceived impacts on Currarong Creek from artificial structures. To provide some answers on which to base this entrance management plan, the advice of one of Australia's most highly experienced coastal engineers was sought. The resulting expert report, provided in Appendix 3, uses estuarine hydrodynamic principles to identify probable effects of current dredging practices, the training wall, sand spur and the bridges on entrance stability.

In summary, the knowledge encompassed by the stability theories outlined in the report is applicable to Currarong Creek and can be summarised as follows:

- the creek has a relatively small tidal prism, which is why it has poor entrance conditions and low tidal flushing;

- when the creek entrance is swamped with large amounts of littoral drift (beach sand), which occurs during storms, there is a strong tendency for the inlet to trend towards closure (though there are no records of the creek having closed completely).

The creek has presented always "poor" entrance conditions; that is, channels that are not easily navigable and low tidal flushing.

Works undertaken in and around the margins of the estuary have impacted on its tidal flow and flood flow characteristics. Works that have enhanced the flow characteristics of the estuary would include the construction of the training wall on the south-eastern side of the inlet (though the asymmetrical configuration with a single wall would reverse some of the positive effects). Works that would have reduced the stability of the inlet would include the construction of the new access roadway and bridge to the village. Retaining walls and reclamations, if they have reduced the creek's tidal prism, would also have had an effect.

Dredging the creek would have little impact on estuary stability or tidal flushing unless considerable quantities of silt are taken out of the system *above the low tide level*.

Removal of the sand spur is unlikely to have any significant impact on tidal prism and, overall, the spur appears to have a positive impact on estuary stability by preventing the development of a two channel tidal regime.

Because there are strong community perceptions that artificial structures have had an impact on navigability of the creek entrance and amenity for creek front property owners, options for management are considered in more detail in the following sections.

5.2 Navigability of Entrance

5.2.1 Background

Residents and visitors to Currarong have long used Currarong Creek as a place to moor or launch their boats and, when possible, have taken their boats through the creek entrance to the sea. Currarong Creek is the only small estuary in the City of Shoalhaven that is regularly navigated for access to the sea. Only two other estuaries in the city, the relatively large Crookhaven River and Sussex Inlet, have entrances that provide routine navigation access to the sea. The entrance of Currambene Creek is also navigated but it is within the semi-protected Jervis Bay. These entrances, though considered navigable under reasonable sea conditions, are nevertheless dangerous at times.

The entrances of a few other estuaries in the City are used under clement conditions by a few specialised vessels, but they are not used by most vessels most of the time because they are usually heavily shoaled with moving sand and/or are exposed to rough sea conditions. Boating access to the sea on other parts of the coast is via ramps that have been built on the coast line itself, usually within semi-protected, north facing embayments, such as at Kioloa, Bendalong and Yalwal Street Currarong.

Though Currarong Creek entrance also is shoaled with moving sand, its northerly aspect means that it is usually protected from rough seas. Currarong Creek entrance was initially used by owners of small fishing boats as a passage between the sea and the safe *anchorage* of the creek. A small number of permanent moorings are still licensed near the creek entrance, but their use is declining, partly due to trends in boating and partly because of shoaling. The significant trend towards trailer boats over the last few decades has meant that few boats now need to be moored in the creek.

Given that the creek is now little used as a safe anchorage, the main historical reason for maintaining a navigable entrance has changed. The entrance is now primarily used as a passage between the sea and the safe *launching areas* (both public and private) in the creek. Within the creek there is a public boat ramp (Warrain Crescent) and a number of private ramps and jetties (see Figure 6).

As described in Section 3, the entrance of Currarong Creek is subject to shoaling with sand as a result of natural processes, possibly with some exacerbation as a result of developments in and around the creek. The sand is carried there by the wind and sea, both by incoming tides and by waves and storms. The sand is redistributed around the creek entrance area by tidal movement and can severely constrain navigation. In summary,

- much of the time the entrance is only navigable above mid tide
- it is rare for the entrance to be navigable during the lower part of the tidal cycle, even after dredging
- occasionally the entrance is not navigable during the higher part of the tidal cycle.

This is illustrated in the following extract from a letter to the South Coast Register in May 1980:

> *"I am a professional fisherman with some 37 years of local knowledge. For the past 28 years I have owned and operated a licensed fishing vessel out of Currarong Creek. In that 28 years I have never been able to get my boat into or out of the creek at low tide. We have this same problem (sand partially blocking creek entrance) periodically for the whole of that time. … we have to rely on rain to supply the scouring action in the creek to remove the sand and shells that are swept into and settle just inside the creek entrance…."*

When conditions have required it, boaters have worked around the constraints. For example, when the tide drops to a level such that the channel has become too shallow or narrow to allow passage of boats under power, people have either manhandled boats if there was sufficient water to allow this, or moored their boat in "the Gutter" just outside the creek and waited for sufficient water, or launched/retrieved elsewhere. Trailer boats can be launched/retrieved from the beach near the creek entrance or from the Yalwal Street ramp, although these both can be problematic. Other ramps near Currarong allow launching into Jervis Bay and access to the sea around Point Perpendicular. Further from Currarong, ramps at Greenwell Point and Crookhaven provide access to the sea via the Crookhaven River mouth.

Various attempts have therefore been made to modify the entrance so that it would be navigable more of the time and these are described in the following section.

5.2.2 Past Intervention

In an attempt to provide an open and navigable entrance channel Currarong Creek has had a degree of entrance training and "management" over the past 30 years (see Table 2). These works include:

- minor training wall installation at the eastern side of the creek mouth
- closure of the ebb channel by formation of the sand spur, installed on the basis to increase scouring of a single channel
- increasing the height and width of the sand spit to protect the inlet from storm wave wash over and increased shoaling
- occasional dredging of the navigation channel.

With regard to dredging, Council has done work from time to time to make the entrance more navigable prior to holiday periods when boating activity increases. Since the 1970s (Council's records only extend back to 1977), the creek has been dredged eight times: 1979,1983, 1986, 1995, pre-Easter 1996, pre-Christmas 1996, 2000, 2002 (see Table 2). No records were found of dredging happening prior to that time. The extent of dredging has varied from one occasion to another and so, therefore, has the cost. Recent works have been estimated to have cost about $20,000.

The purpose of the dredging is clear - Council's resolution in June1977 was "to deepen channels for navigation by fishing and recreational craft." Further, it has always been clear to Council that dredging would only provide temporary relief to the navigation problem at Currarong Creek entrance. The natural phenomena described in Section 3 would continue to shoal the entrance by deposition of sand after dredging has been done. It is unpredictable how soon shoaling would occur after dredging - it could be months or days.

Many Currarong residents and holidaymakers are boaters, but there are also many who are not, and Council has, over the years, received a large number of representations from them as well. There are many people in the Currarong community that are strongly opposed to further dredging of the creek. In December 1999 an extensive survey of Currarong residents, ratepayers and caravan park patrons, showed that the community was fairly evenly divided when asked the following:

"Do you think that the entrance to Currarong Creek should, if necessary, be maintained in a navigable state these coming summer holidays?"

Although access to ocean fishing grounds is an important thing to many people at Currarong, the attractions of the village do not just lie there. Contrary to claims that the economic base of the village may collapse as a result of the difficulties in navigability of the creek if nothing is done, indications are that this is not likely to be the case. Despite the boating situation that has existed for many years, caravan park occupancy rates have continued to increase and property values at Currarong have risen much more over recent years than the average for the Shoalhaven.

5.2.3 Future Management Principles

A clear statement of what Council wants to achieve for the community is required before an assessment can be made of management options. It is important to note that any of the proposed management options that would result in damage or interference with any habitat in the creek can only proceed if the Marine Parks Authority considers it is for research, environmental protection, public health, traditional use or public safety purposes, or if the impact would be negligible.

The following strategies for dealing with boat launching were adopted in the 2001 Currarong NRMS:

> *R2 - Provide a boat launching area at Currarong to a standard suitable for 2 wheel drive vehicles under appropriate sea conditions, if possible (refer to Section 5.10 below).*
> *R3 - Until new/improved facility provided, restore navigability of Currarong Creek entrance channel when criteria met.*
> *R4 - Following provision of new/improved facility, retain Warrain Crescent boat ramp for use when natural entrance conditions allow.*

The approach set out by those strategies in the NRMS is not altered by this entrance management plan. Currarong Creek entrance will change from time to time. It will almost never be navigable at low tide and will often not be navigable below mid tide. There will be times when the entrance becomes heavily shoaled and navigation will be difficult except near the top of big tides. It is these times when Council will consider intervention, if it will benefit a large number of creek users, such as at Christmas or Easter. Periodic dredging is not meant to ensure that there will be a navigation channel that is usable under all or even most tidal states. It is not meant to be a permanent solution to boat launching at Currarong. The goal is to remove severe constraints to navigation at busy times until an improved boat launching facility is provided.

A permanently wide open entrance to Currarong Creek that is navigable at all tidal states is an unreasonable expectation. As evidenced by major works that have been carried out at entrances to other estuaries, this is not only very difficult to achieve, it also costs millions of dollars, and would still require occasional maintenance dredging.

It is proposed that the creek should be managed for small boats. A summary of results from the 2004 survey on boats used in the creek is included in Section 4 of this plan. The largest boat size taken through the creek entrance by a survey respondent was 7.1 metres in length. Ninety percent of boats were less than 5.7 metres in length and more than fifty percent were 4.6 metres or less. Now there is a great variety of boat designs and shapes with some having a greater draught (depth underwater) than others of the same length. However, the most common type of boat in these areas these days is an open runabout or a semi-enclosed design (cuddy cabin, half cabin, etc.), with the great majority having outboard motors. Unfortunately the data collected in the survey regarding the draught of boats cannot be used. There was clearly some confusion amongst survey respondents as to what the draught of their boat was, with quite a few depths given that were unrealistic for the model of boat named. It is proposed that this plan take into consideration requirements for ‘typical’ boats up to 5.5 metres in length. Boats larger than that, or with unusually deep hull designs, may be able to use the creek from time to time if conditions permit. For example the owner of the largest boat in the survey (7.1m) indicated that he had taken his boat between the creek and the sea thirty times in the year. No action will be taken by Council to make the creek suitable for such vessels.

5.2.4 Management Options Considered

Prior to describing in detail the preferred management option, other management options that have been considered are discussed briefly in this section. Cost estimates include design, contract administration/supervision, environmental assessment/approvals and works.

Option 1. Do Nothing

The boat ramp in the creek would still be usable a lot of the time, dependant on storms dumping sand in and floods scouring sand out of the entrance. Boaters would have the option to use the creek for access to the sea when

possible, at times having to wait for suitable tides and/or manhandle boats. There would however be times when the creek was not usable at all for access to the sea and this might include the busiest times of year. At these times, other opportunities exist for trailer boat owners that want to access the coastal waters in the area (ramps in Jervis Bay and Crookhaven/Shoalhaven River). However, in Currarong itself, the only alternatives are the sand ramp at Yalwal Street and, at low tide, the beach at the creek entrance. The use of these is severely constrained by sea conditions. Obviously, there would be no direct cost to Council with this option.

Option 2. Remove the Sand Spur

Removal of the sand spur is unlikely to have any significant impact on tidal prism and, overall, the spur appears to have a positive impact on estuary stability by preventing the development of a two channel tidal regime (see Appendix 3). Removal of the spur might mean that a so-called ebb tide channel would develop from time to time. This channel was seen to be the preferred navigation channel for some users in the 1970s. However, analysis of historical air photos shows that removal of the spur would not guarantee that a navigable ebb tide channel would persist (see Section 3). Assuming that most of the material in the sand spur is suitable for use in nourishing the ocean beach and that vegetation could be mulched and used at Currarong, the estimated cost is approximately $50,000. If some material needed to be taken to the waste depot at West Nowra then costs would be greater.

Option 3. Widen Bridge Culverts

The original bridge over the creek, built in the 1930s, and the “new” bridge built in 1972 both may affect the flow of water in the creek, because the western approaches (causeways) to both bridges appear to have been built over the deepest part of the channel. A related factor is the raising of the western bridge approach road (south of the tourist park) above flood level so that all flood flows now need to pass under the bridge. Assessing the degree of impact is complicated by the fact that just upstream of the bridges there is a natural rock causeway that may also constrain flows. However, as described in Appendix 3, the bridge opening is considered to be a significant constriction to flood flows and would therefore reduce the potential scour of the entrance channel, particularly by large floods. The bridge might also be affecting tidal flows, but discussions with the author of Appendix 3 and officers of the then Department of Infrastructure Planning and Natural Resources indicate that the extent of this is less certain.

A proposal to cut a channel through the natural rock shelf upstream of the bridges was examined in the early 1980s. Engineers from NSW Public Works Department concluded that the benefits gained by the removal of the rock would only be marginal. It might result in minor increases in tidal prism but the resultant effects on the entrance channel would “defy perception and would not justify the necessary expenses involved.”

It is suggested in Appendix 3 that the constriction of the bridge might be reduced by extending some culverts under the western approaches. The degree of improvement would be difficult to predict. Adding culverts should not be seen as an option that would provide a *permanently* scoured creek entrance because after the creek is scoured by a flood it will still be subject to new deposition of sand within days or months as a result of coastal and tidal processes. The cost of doubling the size of the opening under the bridges would exceed $500,000, not including the cost of providing temporary access for residents that live east of the creek during construction.

Option 4 Scour Entrance by Dam and Release

It has been proposed in the past that if "flood gates" were installed on the bridge it might allow the occasional damming of creek waters so that a head of water builds up in the upstream section of the creek. When the water level was considered to have reached a suitable level, the gates could be opened and the resultant flow would scour sand from the entrance area. However, the rate at which water could be released and the duration of a single artificially induced "flood" (probably only a few hours, until the incoming tide significantly slows the flow) are not likely to be adequate to significantly scour the entrance. Presumably the gates could be operated a number of times in succession to create several moderate scours that might remove sufficient sand from a heavily shoaled entrance to allow navigation in the upper part of the tidal cycle. A potential negative consequence of this option is that, to create a structure against which the gates could seal, a structure in the bed of the creek would need to be created, which could further restricting normal day to day tidal exchange when the gates are open and hence reduced ongoing entrance scour. The environmental effects of damming of the creek could also be significant for the upstream saltmarsh, mangroves and the intertidal animals that live there. The cost of building the gates would vary greatly depending on the design. It is estimated at somewhere between $30,000 and $100,000.

Option 5. Dredge Between Bridges and Boat Ramp, or Other Intertidal Areas.

It has been suggested that dredging that section of the creek between the bridges and the boat ramp would result in increased scour of the creek entrance. This assumes that the dredging work would:

- increase tidal prism and hence result in greater scour of the entrance by tides, and/or
- result in less resistance to flood flows and hence allow greater scouring of the entrance by floods.

The tidal flows in the creek are complex and are affected by deflection and friction from the banks, bed, shoals and artificial structures. The speed of water flow and its capacity to scour sand is affected by the tidal prism (volume of water exchanged with each tide) and the size and shape of the entrance channels and shoal. The two interact in complicated ways (see Appendix 3) e.g., increase flow may lead to increased scour which can lead to reduced

friction and hence further increased flow. Alternatively, increased channel size at the entrance, without an increase in tidal prism, can result in decreased water velocities and hence less scour.

As shown in Figure 10, removal of sediment from that part of the creek that is already *below low water level* would not directly increase tidal prism, since that space would remain filled with water even at low tide. There could be a small effect on tidal prism as a result of reduced frictional resistance, though that has not been quantified. Floyd *et al*. (1994) demonstrated that deepening of the entrance of Narrabeen Lagoon to 3 to 5 metres below AHD by dredging may not have improved flushing of the lake. Indeed, modelling suggested that *decreasing* the depth of the entrance channel to its natural depth would improve flushing. However, if the channel became so shallow that friction effects dominated, then both the tidal range and tidal discharges would be reduced.

An increase in tidal prism may be achieved by removal of large amounts of material from the *intertidal* parts of the creek, i.e., parts of the bed above low water level. The intertidal areas in the creek that could be considered as candidate areas for dredging to increase tidal prism are presented in Table 11. This includes all possible areas, not just those between the bridges and the ramp. Most of these areas on their own may not be big enough to have a significant enough effect on tidal prism to improve entrance scour. The dredging would need to be carried out periodically, but without more detailed study it cannot be accurately predicted how often it would need to be done.

Disposal of material from dredging of some of these areas would be a difficult problem with which to deal because it would be very fine, have a high organic content and would need to be dewatered before it could be transported.

The effects on flood flows might not be as great as expected because, as described for option 3 above, it could be the bridge opening that is controlling the rate of flow of flood waters.

Dredging the section of the creek between the bridges and the boat ramp would improve the amenity for adjacent creek front property owners, though it may reduce it for others. This is considered in Section 5.4.

The cost of dredging between 5,000 and 10,000 cubic metres of material from the bed of the creek between the bridges and the boat ramp is estimated at $100,000 to $150,000. If disposal of the material requires significant treatment or haulage over long distances then this cost would increase significantly.

Table 11 Candidate Areas for Dredging to Increase Tidal Prism

Candidate Area	Comments
Entrance shoals	• short term solution as sand would re-enter • important recreation area at low tide • important ecological values (invertebrates, fish, wading birds) • would provide material that could be used for beach nourishment
Reclaimed areas behind retaining walls in private yards	• owners consent unlikely
Mangrove and silty area adjacent to the tourist park	• important ecological values - protected under Fisheries Management Act • disposal of mud may be difficult or expensive
Mangrove and saltmarsh areas upstream of the bridges	• important ecological values - protected under Fisheries Management Act and Threatened Species Conservation Act • disposal of mud may be difficult or expensive
Low-lying parts of the tourist park	• important ecological values • important recreational values • would probably require new culvert under main road

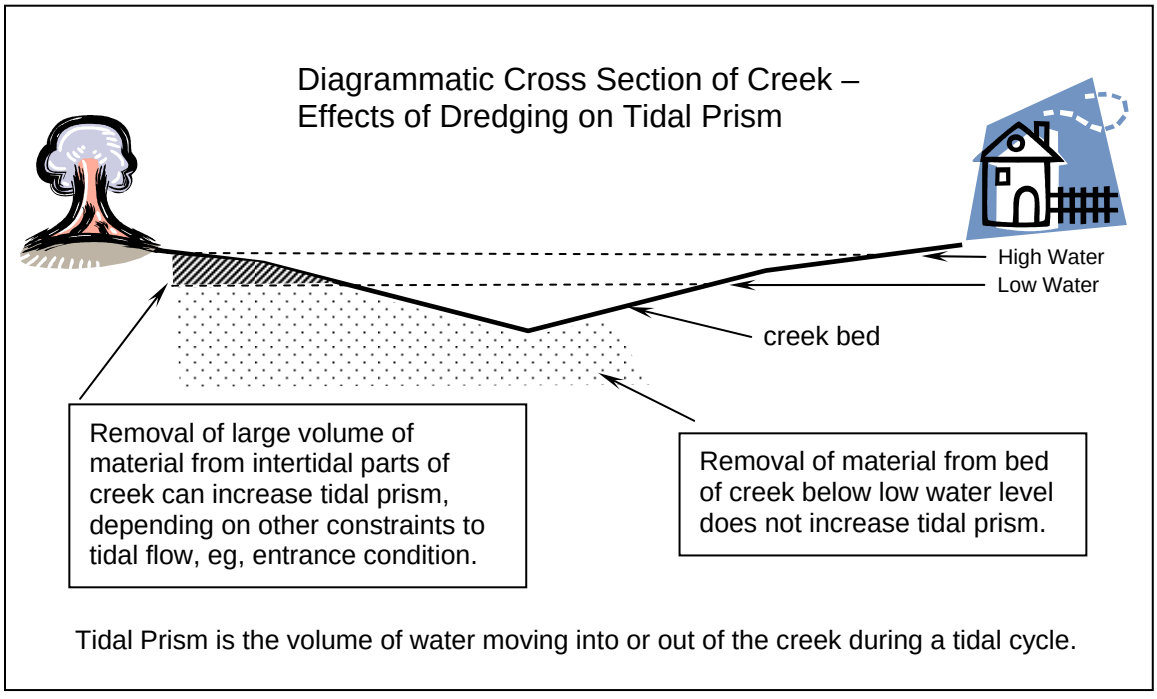


Figure 10. Diagram explaining effects of dredging on tidal prism.

Option 6 Large Scale Entrance Reconstruction

A number of options have been examined in the past for major works at the entrance to Currarong Creek

The Northern Jervis Bay Boat Launching Ramp Facility Study (Patterson Britton & Partners, 1989) investigated a major upgrade of the boat ramp in Currarong Creek which included options for significant entrance works, such as additional training walls and relocation of the entrance. The proposal was again considered in the Currarong Beach Foreshore Erosion and Management Options Study (Coastal Engineering Solutions, 2003) as option to combine beach stabilisation with improvement of Currarong Creek for boating purposes.

The upgrade of the ramp in the creek has not taken place for a number of reasons (e.g., it may not create a permanently navigable and safe entrance because of the small tidal prism; it might allow larger waves into the creek; it would be very expensive; it would require significant modification of both the creek entrance and the rest of creek up to the bridges; occasional maintenance dredging would still be required; there are significant environmental and social issues; there would be significant effects on creek front properties; community opposition).

For these and other reasons Council has since favoured investigating an upgrade of the Yalwal Street ocean ramp (Patterson Britton and Partners, 1998; Shoalhaven City Council, 2004). Funding for an investigation and concept development for an upgraded boat launching facility at Currarong is listed for consideration in Council's draft 2005/08 Capital Works Program.

The proposals for entrance works and creek boat ramp upgrade were estimated at between $1.5 million and $3 million in 1989.

5.2.5 Preferred Management Option

The preferred management option is as proposed in the Currarong NRMS, i.e., to intermittently dredge the entrance to improve navigability, when certain criteria are met (see section 5.2.3).

As described in the Currarong Beach Foreshore Erosion and Management Options Study, if dredging of the creek is carried out, sand should be recycled onto Currarong Beach, as has been done in the past. The sand from the creek should not be extracted then removed from the local beach system (Coastal Engineering Solutions, 2003), but consideration must also be given to the likelihood of sand being washed back into the creek if it is immediately west of the entrance (due to reversal of the direction of littoral drift caused by diffraction of waves around the reef).

Under strategy R3 of the NRMS the following action were proposed

95. Monitor entrance channel depth and width
96. When criteria in table 11-2 (reproduced as Table 12 below) are met, inform community and gauge public opinion
97. Undertake consultation with agencies according to requirements of SEPP 35 and environmental assessment according to requirements of Part V of EP&A Act.
98. Remove sand from shoaled areas of channel as agreed
99. Prepare an Entrance Management Strategy
100. Monitor effects of dredging and spoil disposal, refine criteria for when dredging would be considered and incorporate into Entrance Management Strategy

Table 12. Interim criteria for determining when to consider dredging of Currarong Creek entrance.

- Removal of sand from the entrance of Currarong Creek would only be considered:
    - within one month prior to Christmas and Easter **and**
        - if the narrowest point in the channel is less than 3 metres wide at mid-tide **or**
        - the shallowest point in the channel is less than 0.75 metres deep at mid-tide.
- Sand removal would not be done more than once at Christmas and once at Easter in any year, except under special circumstances.
- Sand removal and disposal would be subject to obtaining the necessary approvals, appropriate consultation and environmental impact assessment.

5.2.5.1 Review of NRMS interim entrance policy

Action 100 of the Currarong NRMS requires that this entrance management plan include refinement of the criteria for when dredging would be considered and so the following discussion is provided. There have been a number of misinterpretations of the interim criteria in the past and questions have been raised as to their appropriateness. For this reason, the following section clarifies the meaning of the criteria and assesses their appropriateness, should it be decided that dredging is to occur in the future.

That removal of sand from the entrance of Currarong Creek would only be considered within one month prior to Christmas and Easter acknowledges that these are the times of year when dredging would benefit the greatest number of boaters. Although this strategy does not guarantee that the entrance will be navigable at other times of year, it often will be. To consider dredging at

other times of year could greatly increase the amount of money that would potentially be spent on dredging of the creek. Therefore this criterion of maximising the benefits of dredging by considering it only at the busiest times of year is still appropriate.

The proviso that sand removal would not be done more than once at Christmas and once at Easter in any year, except under special circumstances, acknowledges that on some occasions a storm might fill the creek entrance with sand soon after dredging has occurred. If that happens, there are two considerations. Firstly there is the cost of redoing the dredging and secondly there is the practicality of being able to obtain new approvals and remobilise the resources (machinery and personnel) in time to redo the work. It is not clear what special circumstances (referred to in the interim criteria) might lead to dredging more than once in a season, so it is recommended that the words “except under special circumstances” be deleted. To limit potential costs, it is also recommended that the “once per Christmas and Easter” clause be changed to “once in any one financial year,” and only then if adequate funds are available.

The proviso relating to approvals, consultation and environmental assessment is still relevant and considered to be appropriate.

There has been uncertainty about the meaning of the term mid-tide as used in the interim criteria. Mid-tide is the water level half way between sequential high and low tides, but this changes with each tide because of the diurnal inequality (see Section 3.3). There are usually four “mid-tides” each day and they are usually all different from one another. They also vary from day to day because of the spring-neap pattern. Further, whilst the astronomic tidal effects are predictable, the actual water level can be different from what has been predicted for any particular mid-tide because the creek water level is also affected by freshwater flows, the condition of the entrance and the state of the sea.

An option that was considered was to choose a particular “mid-tide” at which to measure water depth, for example, the one that is halfway between the higher high tide and lower low tide on a day halfway through the spring/neap cycle. Clearly this makes the process complicated. Further, the measurements are made several weeks or even months prior to the peak boating period, at which time the mid-tide levels will be different.

When the measurement of the creek depth and width was being carried out in 2002 to see whether the interim criteria had been met, it was suggested by one observer that the reference to mid-tide should be interpreted as meaning that there is 0.75 metres depth when the water level in the creek is at mean sea level, which is approximately 0m AHD. That is, the bed of the creek should be surveyed and if it is higher than -0.75m AHD, then dredging would be triggered. This approach has some merit, but the use of mean sea level is inappropriate since, according to the analysis of water level records described in Section 3.3, the mean water level in the creek is 0.153 metres above AHD, not 0m AHD.

It is therefore proposed in this Entrance Management Plan that the criterion to be used in future is the depth of water relative to the mean creek level (0.153m AHD). Note that the depth criterion refers to the shallowest point along the creek, but at that point it is the deepest part of the channel in cross section that is measured (see Figure 11).

The depth criterion should be changed from 0.75 to 0.5 metres. Whilst a water depth of 0.75 metres may be desirable for ease of boating, it is nevertheless possible to get many boats through less water. Further, the criterion applies to mid-tide, with greater water depths then available for about six hours after that time. The 0.75m criterion would result in the dredging being triggered more often than not, and this is considered to be unreasonable. With the 0.75 metre criterion, even at mean low tide there would still be 0.46 metres water depth at the shallowest part of the creek, which some small boat owners would say is a navigable depth and a rare condition in the creek. If the depth criterion of 0.5 metres is used, there will be several hours each day when the creek entrance is navigable. It might sometimes be an inconvenience to some boaters, requiring them to manhandle their boat for a short distance or wait a short time for the water level to rise a little further. If adopted, the criterion should be monitored to establish how frequently it is likely to trigger dredging.

The width criterion of three metres of water at the narrowest point at mid tide is considered appropriate. Most recreational boats that are less than 6 metres in length have a beam (width) less than 2.5 metres. Again, this might mean that the biggest boats used in the creek cannot navigate the channel under power at each mid-tide. This is considered to be a reasonable compromise.

There has also been misinterpretation of the relationship between the width criterion of 3 metres and the prior depth criterion 0.75 metres. Some people have mixed the depth and width criteria together, thereby misreading the criteria to mean that dredging would be triggered if the channel was less than 0.75 metres deep for the full 3 metres width. This was never intended to be the case. The width and depth criteria are totally separate and are measured independently. An explanation of the criteria is shown in Figure 11. The criteria do not mean that the channel needs to meet the depth criterion for the full 3 metres but only at the deepest part of the cross section.

Based on the above considerations the proposed revised criteria are presented in Table 13.

It also needs to be clarified what action will be taken if the criteria are met. It does not necessarily mean that extensive dredging of the channel will be undertaken. It may be that minor works can be done cheaply and quickly to remove a blockage at a relatively localised part of the creek channel. This judgement will need to be made by Council on a case by case basis.

The cost of entrance dredging with nourishment of the toe of the dune on the ocean beach is estimated at approximately $20,000.

The revised criteria still indicate that environmental impact assessment would be required before dredging is carried out. Once the Entrance Management Plan has been adopted, a generic review of Environmental Factors could be prepared in advance to streamline the approval process. The Marine Parks Authority has advised that, amongst other things, the following potential impacts from dredging and spoil disposal would need to be considered:

- physical damage or change that may alter the habitat for existing biota from dredging works;
- physical damage or change that may alter the habitat for existing biota from turbidity plumes;
- lower light from above, implications for seagrass and marine organisms;
- acidification of the marine environment
- sedimentation or smothering of seagrass beds another sessile marine organisms; and
- release of toxins and nutrients into the food web.

If dredging is carried out, records should be kept of how much sand is removed, the cost, the locations of the dredging and of spoil disposal, and the length of time that the channel stays navigable.

Table 13. Revised criteria for determining when to consider dredging of Currarong Creek entrance.

- Removal of sand from the entrance of Currarong Creek would only be considered:
    - if Council considers it appropriate and there are sufficient funds available,
    - within one month prior to Christmas **or** Easter, and
    - if, at mid-tide, the channel is less than 3 metres wide **or** less than 0.5 metres deep.
- Sand removal would not be done more than once in any one financial year.
- Sand removal and disposal would be subject to obtaining the necessary approvals, appropriate consultation and environmental impact assessment.
- Mid-tide is defined as the mean creek water level of 0.153m AHD. Therefore, the water in the channel would be 0.5 metres deep at mid-tide if the bed of the creek is at -0.347m AHD.
- The depth of the channel will be measured by the surveyors by following the creek along the deepest part of the channel (called the thalweg). If, at any point in this longitudinal survey, the creek bed at the thalweg is higher than -0.347m AHD, then the depth criterion is satisfied.
- The width and depth criteria are totally separate and are measured independently.

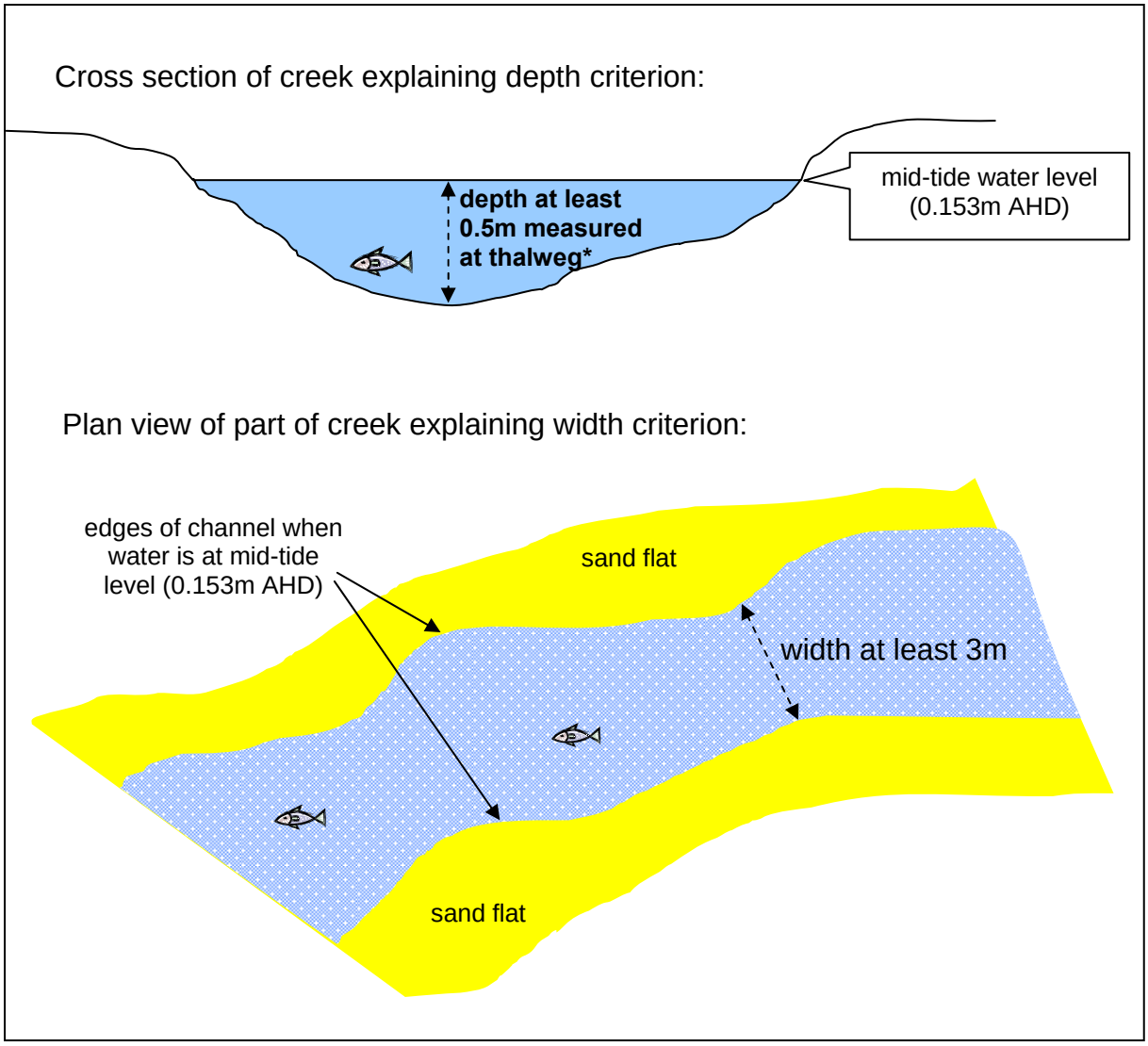


Figure 11. Diagrams Explaining Depth and Width Criteria for Considering Dredging. The width and depth criteria are totally separate and are measured independently. *The thalweg is the line that follows the deepest route along the channel.

Figure 12. Existing boat launching areas at Currarong. The dashed white line shows the route by which people drive to and from the beach launching site.

5.3 Beach launching and retrieval

At times boats are also launched or retrieved from the beach on the western side of Currarong Creek entrance. This area may be used in association with the ramp in the creek, thereby putting less constraints on the times that boaters must head out to or return from the sea. When the water level allows it, vehicles are driven onto the creek foreshore via the boat ramp, around the bend in the creek then over the sand spit onto the beach (see Figure 12). It is not generally possible to do this at high tide, but at that time the creek is usually navigable. However, at low tide when the creek entrance is not navigable, then the foreshore route to the beach is accessible. There are two actions in the Currarong NRMS that relate to this beach launching/retrieval activity:

Action 82. Assess damage caused by vehicles passing over sand dune.

Action 83. Review authority for beach launching and retrieval.

They are addressed in the following subsections.

5.3.1 Environmental effects

The potential environmental impacts from vehicles driving in the intertidal part of the creek include:

- compaction of the sand and mud, possibly leading to a change in ecological community
- direct killing of invertebrates that live on and in the sand and mud, eg, soldier crabs
- inhibition of colonisation by plants such as mangroves and saltmarsh.

The potential impacts of vehicles passing over the sand spit include:

- damage to dune vegetation
- erosion of dune
- conflicts with other beach users.

All of these impacts are localised and restricted to the single, narrow route that people use to get between the boat ramp and the beach. There is little scope for the affected area to expand because the intertidal part of the route is constrained between the steep bank and the water of the creek. The population of soldier crabs in the creek appears to be thriving, despite the losses that might result from crushing by vehicles. The route over the spit is also well-defined and shows no evidence of broadening, with no significant erosion of the track. Conflict with other beach users could occur, particularly during holiday periods, if people were unwilling to acknowledge the right of boat launchers/retrievers to be there. However there is a large length of beach available for other uses, and a relatively small area of beach is affected by the activity. Beach launching is carried out at other localities on the coast,

in some cases near busy swimming areas, eg, Gerroa where signage is used to help reduce conflict. Overall, the environmental impacts of the activity are not considered to be significant.

5.3.2 Authority for use of beach

Council has authorised the taking of vehicles onto the beach for launching and retrieval of boats by the erection of a sign at the boat ramp.

The Marine Parks Regulation now also provides for control of vehicles in the Jervis Bay Marine Park. The park extends to high water mark and so when vehicles are driven along the foreshore of the creek or below high water mark on the beach they are in the marine park.

Clause 27 of the Regulation states:

(1) The use, mooring and anchoring of motorised vessels, motorised vehicles and motorised equipment is permitted in a marine park, but only in accordance with the zoning plan for the marine park.
(2) A person must not, except with the consent of the relevant Ministers, use, moor or anchor any motorised vessel, motorised vehicle or motorised equipment in a marine park in contravention of the zoning plan for the marine park.

The zoning plan for the park (Schedule 1 Part 2, Clause 26 of the Regulation) states that:

(1) A person must not use a motorised vehicle in the marine park, except for the purpose of launching and retrieving vessels from *designated boat-launching facilities*.

(2) This clause does not apply to or in respect of:
(a) an *authorised vehicle*, a police vehicle or an emergency vehicle, or
(b) a commercial fisher (within the meaning of the Fisheries Management Act 1994) who may lawfully use a vehicle on a beach in connection with his or her fishing activities.

(3) In this clause:

authorised vehicle means a vehicle being used by an officer, employee or other authorised person acting on behalf of any of the following:
(a) the Marine Parks Authority,
(b) the National Parks and Wildlife Service,
(c) NSW Fisheries,
(d) Shoalhaven City Council,
(e) the Department of Land and Water Conservation,
(f) the Commonwealth Department of Defence.

designated boat-launching facility means a facility in the marine park designated by the Authority or another relevant government agency as appropriate for boat launching.

Therefore, for the activity of launching and retrieval on the beach at Currarong Creek entrance to continue, the Marine Parks Authority would need to designate the location as “appropriate for boat launching.”

5.4 Amenity[5] for Creek Front Property Owners

On the eastern bank downstream of the bridges, there are 32 creek-front properties in private ownership. All have been built on and a number have foreshore structures such as retaining walls, ramps and jetties.

Some owners of creek-front properties want additional weighting put on their opinions over the views of other members of the community on the grounds that they have a direct interest (in terms of amenity and financial contribution of higher rates and taxes) and a long term link to the creek.

There is a range of views amongst the owners of creek-front properties on how the creek should be managed. However, a group of owners of properties from the bridges downstream to the creek bend opposite the public boat ramp have jointly expressed concern about the amenity of that section of the creek adjacent to their properties. They believe that the creek has deteriorated over many years and is “dying,” with “weed” (seagrass) creeping further towards the banks and mangroves expanding into the creek. They indicated that the creek used to have a clean sand bottom adjacent to their properties where kids and residents would swim and snorkel. Now when they swim in the creek they come out covered in mud and this smells. They also indicated that in the past this part of the creek could sustain large, deep hulled boats, but now they cannot get even shallow hulled boats into and out of their properties because of the sedimentation.

A 1978 survey of the creek bed (Council Plan Ref. 1575.03) shows four cross sections of the creek at approximately 50 metre intervals, adjacent to numbers 63, 71 and 79 Walton Way and the public reserve (see Figure 13). The bed of the creek was described as dark brown sticky silt, with clay and rock below. On average, the bed was 0.3 metres below AHD, with the deepest point surveyed being 0.39 metres below AHD. The top of the clay/rock layer ranged from about 50 millimetres to about 1.2 metres below the top of the silt layer.

From Table 3, Mean Low Water in 1996 was approximately 0.14 below AHD. If that was the water level in 1978 then there would have been about 160 millimetres water depth, on average, at low tide. (Note, though, that the actual water level at low tide varies greatly from time to time - see Section 3.3).

[5] Amenity is made up of those qualities that increase the pleasantness or attractiveness of a place.

Figure 13. Cross-sections locations (dashed white lines) surveyed in 1978 were at approximately 50 metre intervals adjacent to house numbers 63, 71 and 79 and the public reserve near the bridge.

The property owners believe that the changes they are observing in the creek result from the decrease in both the velocity and volume of water flow, leading to a continual build up of sediment and weed (sea grass). They contend that the slowing of the currents results from human influences such as the sand spur, the training wall and the bridges. Further they suggest that if the total volume of water is less because of the build up in sedimentation then there would be less scour of the creek entrance.

The group of property owners believe that it is critical to dredge from the boat ramp to the bridges and that the seagrass must be gotten rid of, in order to increase both the volume and the velocity of the water.

The proposed approach is only partly correct. As described in Section 5.2.4, dredging of that section of creek between the ramp and the bridges *below low water level* would not increase tidal prism (volume of water exchanged with each tide), except to a small extent because of reduced frictional resistance. An increase in tidal prism may be achieved by removal of large amounts of material from the intertidal parts of the creek. The problems associated with this are described in Section 5.2.4.

Dredging the creek between the ramp and the bridges would improve the amenity for some adjacent property owners. However the cost to Council would be high when considered in relation to the relatively small number of people that would benefit. There would be little benefit to the broader community at Currarong and some may feel that amenity has been diminished. It would be possible for the adjacent property owners to apply to carry out the work themselves. The dredging would be temporary in its effect since the creek is subject to ongoing sedimentation (refer to Section 3) and would therefore have to be repeated at intervals that are difficult to predict, but are likely to be at a scale of decades.

The cost of dredging between 5,000 and 10,000 cubic metres of material from the bed of the creek between the bridges and the boat ramp is estimated at $100,000 to $150,000. This includes no allowance for disposal of the spoil, which is a major consideration. Much of the material would be fine, dark-coloured, sloppy mud, very high in organic content and likely to smell. If disposal of the material requires significant treatment or haulage over long distances then the cost would increase significantly.

As described in Section 2.2.2, the Marine Parks Regulation limits the purposes for which approval could be given for dredging between the boat ramp and the bridge.

5.5 Compatibility of Uses

Strategy R5 of the Currarong NRMS is to reduce conflict between recreational users, with action 9 being to investigate ways of reducing conflict between swimmers and boaters in Creek entrance area. The main potential for conflict is between:

1. boaters and swimmers in the entrance channel
2. boat launching/retrieving and people on beach
3. the desire for deep water by some boaters and desire for shallow water by people walking across the creek entrance.

The first two of these should result in little more than minor inconvenience. They require people to be sensible, considerate of others and aware of the limitations of each others activities. For example, swimmers need to be educated that boats operating in a shallow, narrow channel with fast currents have limited manoeuvrability and that they should therefore give way to boats. This is not a major inconvenience since each boat would generally pass by in less than a minute, and except when many boats might pass through the channel in a short time to “beat the tide,” there is generally much more time available for swimmers when there is no boat in the entrance channel than when there is one. Likewise, launching or retrieval on the beach are not extremely frequent activities and, provided that drivers are sensible and limit their activity to a small area, then it should be reasonable to expect the practice to continue. Signs could be erected to notify people that it is a boat launching area. There is a large length of beach still available to sunbathers.

The third potential problem listed above should not become an issue since this plan does not propose major entrance works. Dredging the creek to restore navigability above mid-tide for moderate sized boats would mean that people could still wade across the creek during the lower parts of the tidal cycle. Wading across the creek entrance was the most popular activity carried out by respondents to the survey carried out during preparation of this plan.

5.6 Water Quality

Shoalhaven City Council regularly samples Currarong Creek for faecal coliforms and dissolved oxygen levels. The locations of sampling sites in the creek are shown in Figure 14 and recent data are summarised in Figure 15.

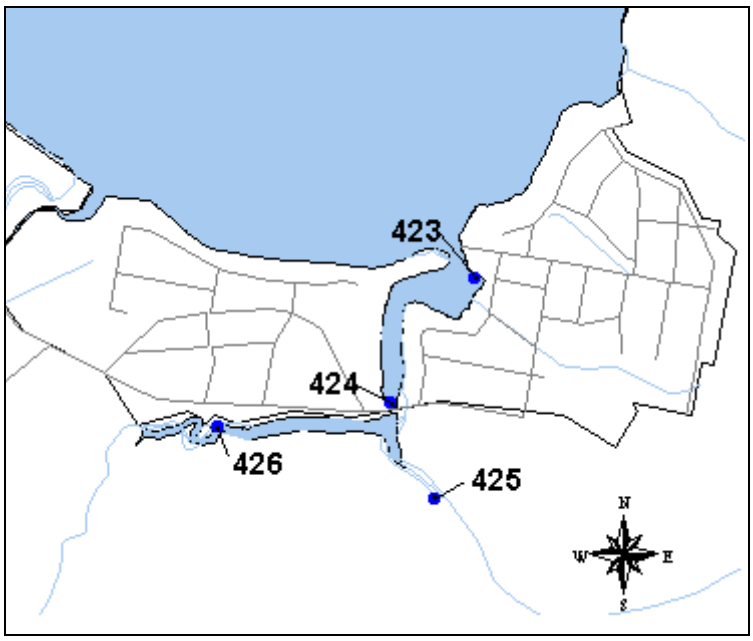


Figure 14. Location of Council's water sampling sites.

There two additional sampling points in stormwater drains at Currarong:

4A Currarong Parkway storm water drain
5A Merimbula Street storm water drain.

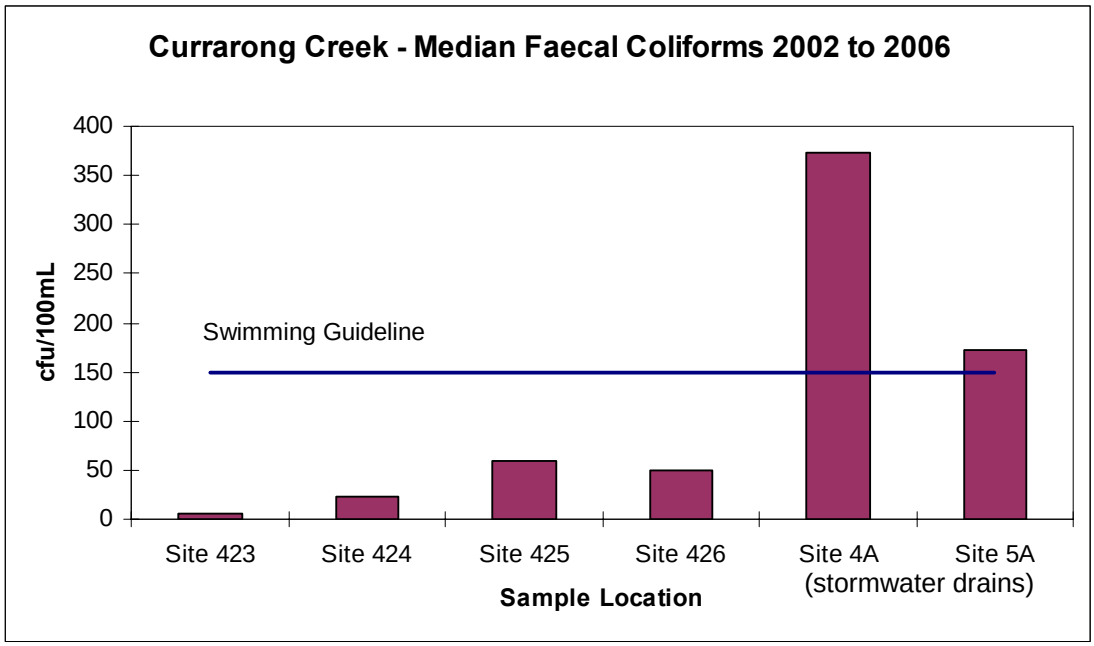
It is reported in Council's 2004 State of the Environment Report that Currarong Creek has had a history of faecal pollution especially after rainfall periods. The low levels of rainfall recorded for recent reporting periods have resulted in lower average faecal coliform results. As can be seen in Figure 15, the median values for all the sampling sites in the creek for the period 2002 to 2006 were well below the Australian swimming guidelines. As expected, the values in the drains are higher, but people do not swim there.

The optimal dissolved oxygen levels in an estuarine system is between 80 and 120% (ANZECC guidelines 2000), unless other specific values are set

based on specific characteristics of local waterways. Sites 423 and 424 are located within the section of the creek that may be considered an estuary and have generally been within the guideline range. However, sites 425 and 426 are in the upper reaches of the estuary where there is normally limited tidal exchange and would therefore be expected to have a lower dissolved oxygen level. At sites 425 and 426, the DO was frequently below the guideline levels.

Given that there is usually reasonable tidal exchange between the ocean and the lower part of the creek, it is considered that intervention in the condition of the entrance would not greatly improve water quality in the creek most of the time. However, if the creek were to close completely (and there are no records of this having happened), then water quality should be monitored and, if necessary for public health reasons, action should be taken. Actions might include the erection of warning signs and a campaign to raise public awareness about the potential hazards of contact with creek water. An attempt might also be made to open the creek entrance, although such attempts in other south coast waterways generally fail with the entrances soon closing again, unless they are carried out at a time of significant rainfall.

Construction of a mains sewerage system is likely to help reduce faecal coliform levels in the creek. Considerable planning has been carried out for a sewerage system for Currarong but construction will be subject to availability of NSW Government subsidies.



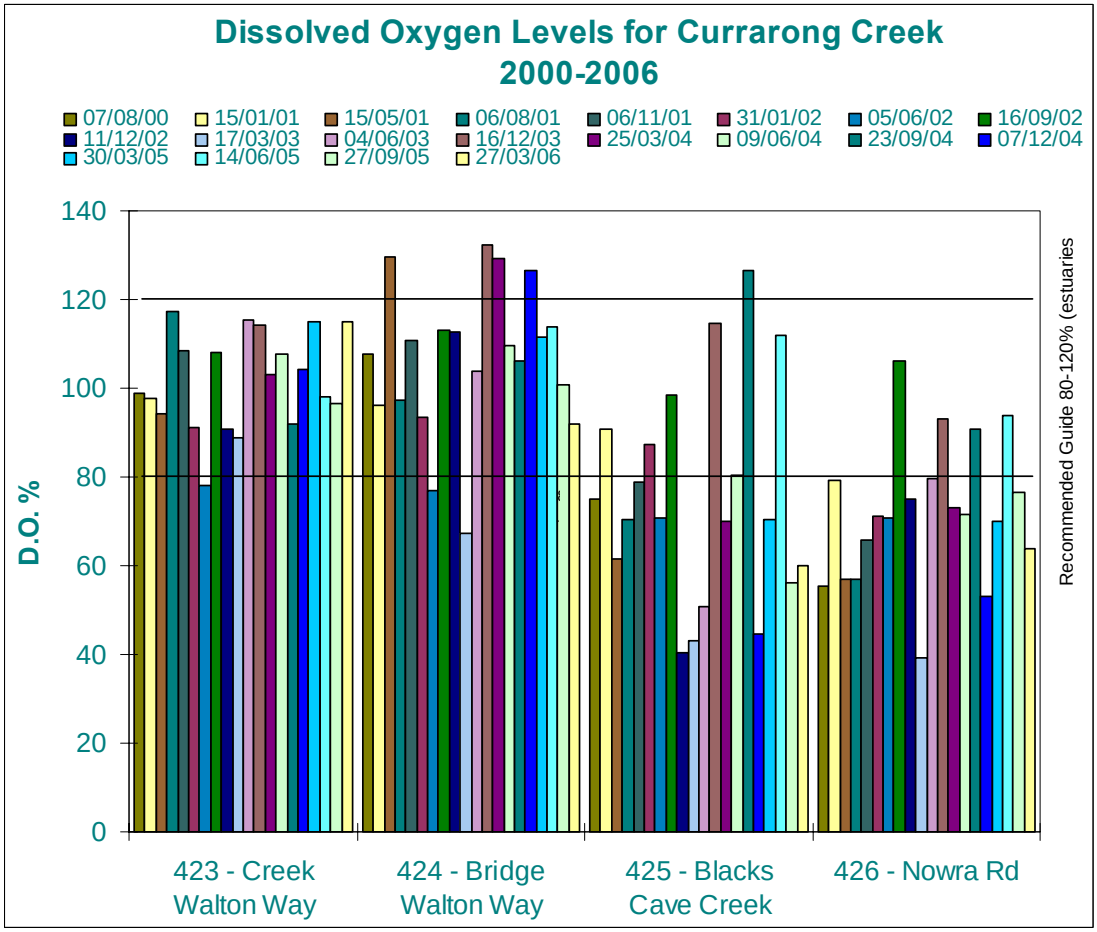


Figure 15. Summary of recent water quality data for Currarong Creek.

5.7 Flooding

Flooding of Currarong Creek is not a major problem for the village. There is occasional localised flooding in some parts of the village, including the caravan park but mostly this is not due to the creek breaking its banks. The "new" road bridge, and the section of Currarong Road that leads to it from the west, are built above the highest known flood level. At the start of a flood, the creek entrance is likely to act as a constraint to the flow of floodwater, particularly if it is heavily shoaled. As the entrance is scoured by floodwaters, then more water could flow through the entrance in a shorter period of time. However, as described in Appendix 3, the small opening under the bridge may then become the factor that determines the rate at which flood water escapes. The backing up of flood waters behind the road and bridge does not affect any assets. The influence of flooding on scour of the creek entrance and the effect that the bridges may have on this are addressed in prior sections of this plan.

5.8 Creek Bank Erosion

There is some erosion of the creek bank occurring near the Warrain Crescent boat ramp and further downstream. Fill material has been placed along this section of the creek bank downstream of the ramp, around the time the sand spit was rebuilt in the 1970s. There is some undercutting and slumping visible now but the rate of erosion does not appear to be very fast. In fact, the photogrammetric analysis reported in the Currarong Beach Foreshore Erosion and Management Options Study (Coastal Engineering Solutions, 2003) showed that, since the infilling of the ebb channel in the creek in 1979, there has actually been accretion of the rear face of the dune.

Erosion at the outside bank of a bend in watercourses is a natural process that can be observed at many locations. It should be allowed to proceed, unless it is considered that valuable assets need to be protected. Any attempt to stabilise erosion at one part of the creek bank will have consequences for other sections of creek bank, which may erode or build up at an accelerated rate.

5.9 Coastal hazards

Coastal processes operating at Currarong were the subject of the Warrain Beach Coastal Process Overview (WP Geomarine, 1995) and the Currarong Beach Foreshore Erosion and Management Options Study (Coastal Engineering Solutions, 2003). These addressed rates, causes and consequences of beach erosion and potential management options. A coastline management plan that specifies the preferred management option is to be prepared based on these studies.

The above studies are connected to this Entrance Management Plan in that, firstly, they describe the wave climate and the movement of sediment in the entrance area, and secondly, they present options for managing beach erosion that may also affect the creek entrance.

One of the beach remediation options described in the management study was a combination of beach nourishment with a training wall and improvement of Currarong Creek for boating access.

Considering creek entrance management alone, an additional training wall is not the option that is preferred in this Entrance Management Plan. However, the management of the creek entrance and the eastern end of Warrain Beach are interlinked. If a rock wall is the preferred option from a beach erosion perspective when the coastline management plan is prepared, then coincidental improvements to creek entrance conditions could be considered at that time.

5.10 Upgraded Boat Launching Facility

A review of past planning for an improved boat launching facility at Currarong revealed that a variety of proposals have been put forward over many years. All new sites have met with opposition from differing sectors of the local community and have also proven unviable on environmental and other grounds. The only locations that can be further developed are at Yalwal Street and Warrain Crescent.

Strategy R2 of the Currarong NRMS is “to provide a boat launching area at Currarong to a standard suitable for 2 wheel drive vehicles under appropriate sea conditions, if possible.” Council’s draft Asset Management Plan for Waterways Infrastructure provides an estimate of $450,000 over two years to provide an upgraded ramp and breakwall at Yalwal Street. Funding for an investigation and concept development for an upgraded boat launching facility at Yalwal Street is listed for consideration in Council’s draft 2005/08 Capital Works Program for 2006/7.

It is considered an urgent action to develop a project concept for Yalwal Street to provide at least a concrete boat ramp. Investigations for concept development will determine the extent of possible development at the location and grant funding then can be sought for project implementation.

6 Conclusions and Recommendations

The entrance to Currarong Creek is a naturally dynamic place and has many of the features typical of barrier estuaries in New South Wales. It essentially consists of a sand barrier (the spit) and sand shoals (the marine delta) with a tidal channel that changes its location from time to time as it meanders across the sand shoals to the ocean. The creek has a relatively small tidal prism, which is why it has poor entrance conditions and low tidal flushing. When the creek entrance is swamped with large amounts of littoral drift (beach sand), which occurs during storms, there is a strong tendency for the inlet to trend towards closure. The creek has presented always "poor" entrance conditions; that is, channels that are not easily navigable and low tidal flushing.

Works undertaken in and around the margins of the estuary have impacted on its tidal flow and flood flow characteristics. Works that have enhanced the flow characteristics of the estuary would include the construction of the training wall on the south-eastern side of the inlet (though the asymmetrical configuration with a single wall would reverse some of the positive effects). Works that would have reduced the stability of the inlet would include the construction of the new access roadway and bridge to the village. Retaining walls and reclamations, if they have reduced the creek's tidal prism, would also have had an effect.

Dredging the creek would have little impact on estuary stability or tidal flushing unless considerable quantities of silt are taken out of the system *above the low tide level*. Few suitable options exist for where this could be done.

The most significant management issues relate to navigability of the entrance, compatibility of creek uses (mainly swimming and boating), and amenity for creek front property owners.

The following strategies for dealing with boat launching were adopted in the 2001 Currarong NRMS:

> *R2 - Provide a boat launching area at Currarong to a standard suitable for 2 wheel drive vehicles under appropriate sea conditions, if possible (refer to Section 5.10 below).*
> *R3 - Until new/improved facility provided, restore navigability of Currarong Creek entrance channel when criteria met.*
> *R4 - Following provision of new/improved facility, retain Warrain Crescent boat ramp for use when natural entrance conditions allow.*

With regard to navigability of the creek entrance, the strategies outlined in the Currarong NRMS are supported in this Entrance Management Plan (see Section 5.2.3). However, the criteria which would trigger a consideration of dredging the creek have been revised (see Section 5.2.5).

Dredging the creek between the ramp and the bridges would improve the amenity for the adjacent property owners. However the cost to Council would be high when considered in relation to the relatively small number of people that would benefit. There would be little benefit to the broader community at Currarong and some may feel that amenity has been diminished. It would be possible for the adjacent property owners to apply to carry out the work themselves (see Section 5.4).

Boaters and other creek and beach users should be able to coexist in the creek entrance area. This requires people to be sensible, considerate of others and aware of the limitations of each others activities. Education may help to achieve this (see Section 5.5).

Any of the proposed management options that would result in damage or interference with any habitat in the creek would require environmental impact assessment and approvals from a number of NSW Government agencies.

The measures proposed in this plan may be eligible for funding through the NSW Government's Estuary Management Programme.

This document should be reviewed five years after it is adopted to allow for amendments based on monitoring of its effectiveness, or on ecological or social changes that may occur in that time.

7 References

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Appendix 1. Manly Hydraulics Laboratory Analysis of Water Level, Wave and Rainfall Data.

Appendix 2. Form Used for 2004 Community Survey

Appendix 3. Snowy Mountains Engineering Corporation Report on Currarong Creek Entrance.