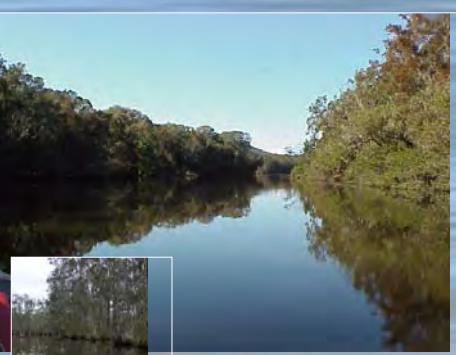
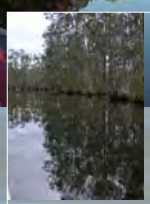
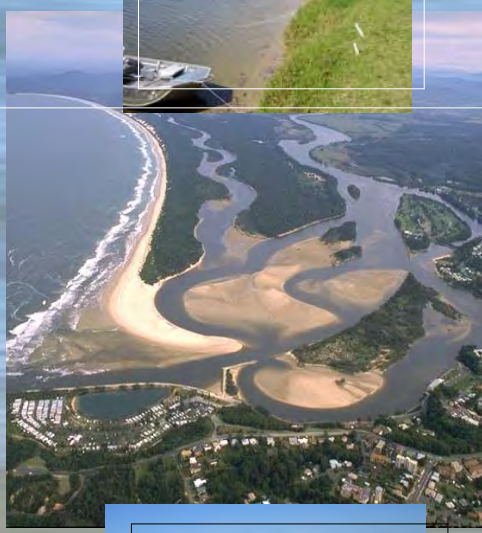
Nambucca River
Estuary Management Study
Final Report

October 2006







NSW Government
DEPARTMENT OF NATURAL RESOURCES

Australian Government
Department of Transport and Regional Services

BMT WBM

Nambucca River
Estuary Management Study

FINAL REPORT

Prepared For:	Nambucca Shire Council
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Synopsis:	This report presents the Estuary Management Study (EMS) for the Nambucca River estuary. This EMS consists of many components including a review of the estuary's environmental attributes, societal uses/values and existing management frameworks. Another component of the study uses this collated information to identify issues that require addressing. These issues have then been prioritised with assistance from the local community. The prioritised list of management objectives and options will form the basis for the Estuary Management Plan.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE	CHECKED BY		ISSUED BY	
0	15 September 2004	PEH		DCC	
1	21 February 2006	PEH		DCC	
2	20 October 2006	PEH		DCC	

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Nambucca Shire Council	1	10+pdf	25+pdf								
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EXECUTIVE SUMMARY

Australia has approximately 1,000 estuaries, of which about 28% are moderately or severely modified (most are along the east coast of Australia). Modifications have resulted from a range of natural and human pressures on estuarine systems.

In NSW, the estuaries provide a priceless natural resource, and collectively, represent immense value from an ecological, social and economic perspective. NSW has over 130 estuaries that vary in size from small coastal creeks and lagoons to large lakes and rivers. Estuaries contain diverse ecosystems that form a foundation of the coastal food chain. They provide important habitats for a variety of marine and terrestrial plants and animals.

Estuaries have a special place in the lives of most Australians. Many people want to live near estuaries and if they can't, they want to take their holidays there. Over 75% of the NSW population live and work in towns and cities near estuaries. A high proportion of the State's commercial activity occurs near estuaries as they provide an important focus for industry, tourism and recreational activities. This high level of development pressure means that estuaries are subject to a range of direct and indirect impacts due to land use in the catchment, changes to hydrology and tidal processes and the direct use of the estuary waterway.

The Nambucca River estuary has been and is currently being subjected to a range of direct and indirect pressures arising from current catchment land uses and waterway activities. These pressures typically result in a variety of impacts at both the macro- and micro-scale. To gain a thorough appreciation of the current estuarine condition and impacts resulting from current usage, an Estuary Management Study has been prepared, in accordance with the NSW Estuary Management Program.

This study details the biophysical condition of the estuary; community uses of and values of the estuary and the current institutional arrangements that govern how the estuary is managed. This study is a precursor to an Estuary Management Plan, which will provide a program of strategic actions for government authorities and other stakeholder groups to sustain or enhance the condition of the estuary through appropriate waterway, foreshore and catchment management initiatives.

The Catchment and Study Area

The Nambucca River is located within the Nambucca Shire, which is situated on the mid-north coast of NSW approximately 45 kilometres south of Coffs Harbour. The Shire has an approximate area of 1,491 km^2, while the Nambucca River has a total catchment area of 1,460 km^2. The river catchment is almost wholly contained within the Shire's boundary. The prominent waterways of the estuarine river system include the Nambucca River, Taylors Arm and Warrell Creek, which collectively have a waterway area of approximately 7.74 km^2.

The study area (i.e. the estuary) comprises the tidal waterways, foreshores and adjacent lands of the Nambucca River and has an area of 253.5 km^2 (approximately 20% of the total catchment). The tidal waterways of the estuary extend:

- From the entrance at Nambucca Heads along the Nambucca River to 250m upstream from Lanes Bridge at Bowraville;

- Along Taylors Arm for approximately 1.6km upstream from Boat Harbour Bridge on Taylors Arm Road at Utungun; and
- Along Warrell Creek 600m downstream from Pacific Highway Bridge just south of Warrell Creek hamlet.

Other minor tributaries to the estuary include, Blackbutt Creek, Newee Creek, Gumma Gumma Creek, Watt Creek, Bellwood/Swampy Creek, Teagues Creek, Tilly Willy Creek, Rhones Creek, Welshes Creek and Way Way Creek. The study area includes the entrance and Shelly Beach boat ramp. Consideration has also been given to the upper catchment areas (i.e. outside the study area) where relevant. In general, the upper catchment is mostly undeveloped with numerous State Forests and National Parks. Farming is generally limited to the fertile alluvial plains on the valley floors of the Nambucca River and its tributaries, which broaden out with distance downstream.

In 2001, the Nambucca Shire was estimated to have a population of 19,000 (ABS, 2001). Most of the populace resides within the four main urban areas of Nambucca Heads, Macksville, Scotts Head and Bowraville. Population growth in the Nambucca Shire to 2026 is predicted at 0.71%, nearly equivalent to the NSW State average of 0.59% (DIPNR, 2004) over the same period.

Major Historical Changes in the use of the Study Area

A number of events and activities over the last 150 years have helped define the current condition of the Nambucca River estuary, including (after Geco Environmental, 2005):

- Clearing of the Nambucca River's banks and floodplains for agricultural pursuits (e.g. timber production) prior to the 1900's leading to a reduction in bank strength. This combined with extreme flooding in the 1890's lead to extensive bank erosion, channel widening and downstream sedimentation;
- Construction of the breakwaters and training walls at the entrance and within the lower estuary between 1895 and 1918. A full scheme of training works was never implemented (i.e. the southern breakwater has not been built) meaning that the natural sediment dynamic interactions between the coastal and estuary processes have continued to occur. The construction of the causeway over to Stuarts Island, has resulted in changes in water flow and sedimentary patterns in this section of the estuary;
- Increased agricultural development within the catchment from the 1890's to mid 1940's coincided with relatively few floods of the same magnitude as those of the 1890's. The timing of these events corresponds with the hypothesis of Erskine and Warner (1988) that NSW coastal rivers experience alternating periods of Flood Dominated Regimes (FDR) and Drought Dominated Regimes (DDR), wherein the period 1857 – 1900 exhibited FDR, the period 1901-1946 exhibited DDR and the period 1947-1978 exhibited FDR;
- Connection of Macksville to the Statewide (Sydney – Brisbane) railway line in the late 1920's lead a rapid decline in shipping activity in the estuary with the closure of the Nambucca Port in 1940;
- Flooding between 1946 and 1954 (six in total) caused a second phase of channel expansion with huge quantities of gravel being liberated through bank erosion and deposited within the estuary;
- Continued widespread agricultural development on the floodplain has led to vegetation clearing making riverbanks more susceptible to both wind induced and boat wash erosion. Erosion has

lead to undermining and slumping of alluvial banks where riparian vegetation has been removed. Grazing of riverbank vegetation has also contributed to bank erosion problems along the river.

Study Area and Waterway Use

Today, current land use within the study area is approximately evenly divided between cleared lands (50.3%) and remnant vegetation (43.4%). A small portion of the study area is comprised of regrowth vegetation (1.9%), forest plantation (0.3%) and horticulture (0.6%). The remainder of the study area is waterway (3.5%).

Nambucca Shire Council's Local Environmental Plan (LEP) governs land use activities within the study area. The current LEP, developed in 1995, defines mostly agricultural use within the study area, with rural zoned lands (not including forestry) occupying three quarters of the total study area. Land use zonings for urban, industrial, commercial and other public/private recreational lands occupy less than 5% of the total study area.

It is estimated that approximately 80% of the study area is privately owned, with the remainder being owned by the Crown (managed by the Department of Lands or other bodies set up to manage the land on their behalf, State Forests or DEC-NPWS). Many Crown Land areas are located on the foreshores of the estuary and as such form part of the land/water interface of the estuary.

In terms of current waterway usage, community consultation has identified significant recreational usage with the most common activities being fishing (mainly from a boat), swimming and boating (i.e. waterskiing). A number of commercial activities also occur on the river including oyster production, commercial fishing and boat/houseboat hire. The estuary's high scenic and recreational amenity results in increased patronage and demands during summer and holiday periods.

Entrance Management

Primary concerns noted by the community during the consultation phase included ongoing sedimentation ('infilling') of the entrance and the perceived loss of navigable waterways within the active coastal zone which extends from the entrance to near Stuarts Island.

A review of historical records (i.e. hydrographic surveys dating back over a century) show that the lower estuary and entrance have always been subject to continual change and shoaling under the influence of natural coastal processes, resulting in navigation difficulties. The present day situation is a manifestation of historical attempts to control the natural coastal processes and improve and maintain navigation when shipping was a major avenue for trade.

The training walls and periodic dredging works have had a significant impact on the shoaling and sedimentary patterns in the lower estuary. A substantial quantity of sand has accreted behind walls and effectively been removed from the active sand-transport system. Sand has also moved into the entrance from the beach system resulting in some erosion of the open coast beaches, most likely to the north. A detailed investigation of the beach system was beyond the scope of this study.

The state of the entrance varies naturally in response to prevailing catchment runoff and coastal conditions. This can have a significant effect on the hydrodynamics of the river with follow on effects for tidal flushing sedimentation/erosion, ecological habitats and flooding. The present (2005) conditions of the lower Nambucca River estuary reflect substantial shoaling with marine sands due to

the lack of any recent major flood events. The dynamic nature of the channels can make navigation of the lower estuary difficult.

Analysis of tide level data indicates that the entrance is quite constricted at present, resulting in attenuated tidal range and flushing. It is estimated that the tidal range is presently somewhere near the lower limits of natural variability. Similar conditions are being observed in those NSW coastal rivers, which have recorded lower than average rainfall for a number of years. To date, reduced flushing in the Nambucca River estuary has not lead to major water quality issues.

Due to the current constricted nature of the entrance, flood levels in the river may be slightly higher. Previous flood studies (NSC, 1999) have shown that dredging within the lower estuary downstream of Stuarts Island would reduce upstream flood levels, further highlighting the importance of the entrance in controlling river hydrodynamics.

Boating and Waterway Usage

Community and stakeholder consultation completed as part of this study has been used to identify the types and locations of waterway usage within the estuary as well as areas of usage conflict and other issues.

Of most concern is the impact of boating (for fishing, waterskiing, etc) on the environmental values of the estuary. At present most boating effort (by local residents) occurs between the entrance and Macksville in the main branch of the Nambucca River. Levels of boating in Warrell Creek (particularly upstream of the first shoal) and all other minor tributaries were observed to be lower. Usage by tourists was not able to be determined as part of this study.

Waterskiing activities are mostly carried out in the lower estuary (operating between the southern entrance spit, Stuarts Island and lower Warrell Creek) and upstream of Macksville as far as "Devils Elbow" on the Bowraville reach of the Nambucca River.

The main impacts of boating on the estuary relate to boat wash effects. Boat wash can impact on oyster leases, riverbanks and sensitive vegetative communities (i.e. mangroves/saltmarshes). At present NSW Maritime has no controls in place to address the potential impacts of boat wash within the majority of the estuary.

In addition to the boat wash impacts, safety concerns have been identified in relation to the presence of swimming areas near boat access points (mainly Shelley Beach ramp) and in locations where dangerous currents may arise (such as in the channel near the "hole-in-the-wall").

Detailed field investigations have identified the locations and condition of all foreshore structures within the estuary, e.g. ramps, jetties, wharves, etc. Comparisons of access points to Department of Lands waterfront licence data have shown that there are many unlicenced private access points on private lands and numerous unlicenced public/private access points located on public lands. Unrestricted estuarine access to the estuary can lead to a range of usage impacts. Any proposal to alter existing access arrangements needs to ensure that an acceptable level of access for the public is maintained to the estuary, as ready access is a highly valued aspect of the Nambucca River estuary.

The existing types and locations of ramps and facilities provided in the estuary require improvement and future augmentation to cater for future expected demand and to encourage a greater range of recreational uses in locations less susceptible to environmental damage.

Habitat Management

The natural habitats of the Nambucca River estuary are ecologically diverse and productive ecosystems with various biological values and functions including habitat such as nursery and breeding grounds; buffers to catchment water quality; nutrient recycling; flood mitigation; groundwater recharge and foreshore protection. They also have recreational values. These habitats have significant conservation and estuarine value, potentially support a wide range of threatened species and most remaining communities on the floodplain are listed as threatened communities in NSW. The Nambucca River estuary supports habitats of regional, state and national conservation value including species and communities listed under the *Threatened Species Conservation (TSC) Act* 1995, *Environment Protection and Biodiversity Conservation Act* 1999, *Fisheries Management Act* 1994, and State Environmental Planning Policies (SEPPs).

Significant habitat within the Nambucca River estuary includes:

- Estuarine wetlands (Coastal saltmarsh and mangroves);
- Seagrass and intertidal habitats;
- Swamp oak floodplain forest;
- Swamp sclerophyll forest on coastal floodplains;
- Freshwater wetlands on coastal floodplains;
- Lowland rainforest on floodplains;
- SEPP 26 Littoral Rainforest (approx. 2% of SEPP 26 communities mapped in NSW);
- SEPP 14 Wetlands (approx. 1.3% of SEPP 14 communities mapped in NSW); and
- Habitat for threatened species, such as lower estuary habitat for migratory waders.

The sclerophyll woodlands, forests and communities on coastal sands of the study area also provide potentially suitable habitat for a diverse range of flora and fauna species of conservation significance and are important for maintaining biodiversity values within the study area. These communities have regional significance for fauna as native wildlife refugia and form part of the wildlife corridor network across the study area linking upland and lowland vegetation communities.

Despite the known values of the vegetative communities, significant areas of swamp oak forest and freshwater wetland along Warrell Creek and extensive areas of freshwater swamp in the Macksville area remain unprotected. There is a need for the improved recognition and protection of these habitats. The key habitat management priority for the study area is to protect habitats of high ecological and estuarine value, such as riparian corridors and endangered communities listed under the TSC, and to continue to protect habitats regulated by the Fisheries Act 1994 to ensure no net loss. It is considered more cost effective to protect these areas now to avoid future degradation, than to rehabilitate them in the future once habitats have deteriorated.

Whilst the study area does not currently support any wetland areas recognised by International Treaties, 100 Acre Swamp on Taylor's Arm is considered to satisfy several criteria for potential listing as a Wetland of International Importance under the Ramsar Convention (Blanch 2003 and Wetland Care Australia 2005). Blanch (2003) recommended that consideration be given to identifying a suite of candidate NSW North Coast Bioregion wetlands as part of a nested site nomination for the bioregion. In the case of the lower Nambucca River basin, Wetland Care Australia (2005), nominate the wetland complexes of Bellwood Swamp and the Warrell Creek estuary and catchment also be considered as part of this bioregional network.

Regrowth communities across the study area may provide important buffers to significant habitat and may also contribute to the wildlife networks across the study area. Buffers are the minimum width of vegetation retention or rehabilitation required adjacent to a habitat of high conservation/ecological value to ensure the values and functions of the habitat are restored and maintained.

A wide range of activities threatens the integrity and viability of existing habitats in the catchment, including:

- Clearing and habitat fragmentation;
- Weed and feral animal invasion;
- Drainage and exposure of acid sulphate soils. Of most concern are the impacts of flood mitigation measures on floodplain wetlands;
- Soil disturbance (stock impacts/erosion/nutrient and pathogen introduction);
- Poor water quality;
- Recreational activities (such as boat wave wash impacts on mangroves and 4WD impacts on wader habitat); and
- Inappropriate fire management.

Management priorities should be based on the area and condition of remnants and adjacent landuses in an attempt to maximise the potential benefit from the effort and expense exerted.

Fisheries and Oyster Aquaculture

Commercial fishing is undertaken within the Nambucca River estuary. Available data shows that the days of effort put into commercial fishing in the estuary have declined over the period of 1998 to 2004. This has been accompanied by a decrease in the overall weight of commercial catch from the estuary. Despite these declines, the direct value of the commercial fishery has remained relatively constant for the past few years at around $280,000 per annum. The relative current contribution of the Nambucca River estuary to the Region 3 estuary fishery and State estuary fishery are unknown, but are likely to have increased with the recent closures of other commercial estuary based fisheries within the State and Region.

Recent studies by DPI (Fisheries) have identified that the mid-North coast region of NSW has the third highest number of recreational fishers of all the regions in NSW. There are also high fishing participation rates in the region. The study identified that the key recreational species caught in NSW included flathead, bream, whiting, tailor and luderick. All of these species are present in the Nambucca River estuary. The study identified that the total recreational catch constitutes about 30%

of the total commercial catch (by weight). The study also identified that (by weight) the recreational fishing sector caught more of six prominent estuarine species than did the commercial fishers.

Apart from some limited commercial closure areas and recreational fishing bag limits, there are few controls on the extent and location of fishing activities within the estuary. Many local residents are concerned about perceived declines in fish catch within the estuary. There are numerous factors that could result in fish stocks varying in time (i.e. historical versus present-day impacting processes) and space (i.e. processes operating over regional scales, versus local estuary specific processes). These include:

- Habitat destruction over broad regional scales. Many estuarine fish species move between estuaries during part of their life-cycle, hence processes operating outside the estuary, such as habitat destruction in other estuaries, can result in loss of local fish stocks;
- Habitat destruction at local (within estuary) scales. This could include, for example, historical and present-day changes to seagrasses, wetland vegetation and entrance shoals, all of which represent critical spawning and nursery areas for estuarine fisheries species;
- Direct loss of fish stocks due to fishing. Commercial and recreational fishing pressures, both at local and regional scales, is quite high. The impacts of fishing activities on local fish stocks are unknown and needs to be quantified; and
- Declines in estuary condition/ecosystem processes, and associated flow-on effects to estuarine fish and higher order species.

Little is currently known regarding the relative fisheries values of the various habitats that exist within the estuary, as these may change depending on a number of factors including time in the year, or stage of the life-cycle of the species that use them. The processes that determine the 'value' of a particular habitat patch (and the spatial and temporal scales at which any patterns might exist) are not well understood, and require further investigation.

Only Sydney rock oysters are grown and harvested within the Nambucca River. Presently, there are a total of 52 commercial oyster leases within the estuary, designated as "current" (43 leases) or "former" (9 leases). Ten permit holders utilise the current leases. The yearly oyster sales of the Nambucca River estuary oyster industry are estimated to be approximately $500,000 to $700,000 per annum (or 2% for the State industry income) based on average production values and 2002/2003 prices for farm gate sales. This figure does not take into account any multiplying or ripple effects that this industry has on the local economy. The Nambucca River estuary is presently being classified as part of the NSW Shellfish Quality Assurance Program (SQAP). This process is expected to complete in early 2006.

Tourism

There has been a reported increase in domestic travel to the mid North Coast region (includes other centres such as Coffs Harbour and Port Macquarie) reported by NSW Tourism for the 2002/03 financial year. Local tourist operators consider that the estuary is potentially under-utilised, except during the peak holiday times. The usage of the estuary for passive recreational pursuits is low, despite it having many superb areas that are suitable for a wide range of passive recreation pursuits. There are also very few forms of commercial estuary based tourism. The amenity and usability of

the estuary for tourists (and local residents) may also be improved by enhanced recognition and usage of the existing Crown land areas around the estuary.

In terms of visitation to the North Coast NSW region, domestic overnight visitation is the second highest in the State after the Sydney region. People visiting the region tend to stay for a significant amount of time when compared to the State average. Statistics indicate an increase of 10% in the accommodation takings in the North Coast NSW region over the 2002 to 2003 financial year (Tourism NSW, 2004). The value of accommodation takings to the establishments (with more than 15 bedrooms) in 2003 alone was $84.3 million. This does not include takings from other forms of accommodation, e.g. caravan parks, B&Bs, small hotels/motels, etc.

Domestic visitor stays in the region peak during school holiday periods, with January being the highest peak accounting for 15% of the yearly total, followed by October (11%) and March/April (9%). Most other months accounted for about 7% of the yearly total, with February being the lowest month at 6%.

Day and overnight domestic visitors to the region undertake a variety of recreational pursuits including 'outdoor/nature activities' and 'sports and active outdoor activities' at levels well above the NSW State average. In the Nambucca Shire, it is expected that the Nambucca River estuary is one of the focal points for undertaking these outdoor and sports activities.

Tourism forecasts for domestic travel remains flat for the next 10-year period, however, there are potentially large increases in overseas visitors to Australia over this same period.

Water Quality

There have been a number of investigations into water quality in the Nambucca River estuary over the past five years. Two significant studies completed in 2000, identified a number of issues with water quality in the estuary and in part served as impetus for a number of subsequent changes in the study area (i.e. to reduce both point and diffuse source pollutant loads).

Examples of these improvements include the upgrade of the Macksville STP (mid-1998), the implementation of a land-based irrigation reuse scheme at the site of the old Midco Abattoir (circa. 1998) and the implementation of a land-based irrigation reuse scheme for effluent from the Bowraville STP (mid-2002). Other actions occurring within the study area that are likely to have had a positive impact on water quality include the implementation of a Stormwater Management Plan (since 2000) for the major urban centres, and the ongoing licencing of all on-site sewage management systems (e.g. septic tanks) of the Shire (since 1999).

In relation to the licencing of on-site systems, Council estimates that the initial inspection process of the Shire's 2000 (approximate) systems should have been finalised towards the end of 2005. It is further estimated that the upgrading process is 60 or 70% complete and should be finalised towards the end of 2006, depending on the success of implementation.

A review of more recent water quality monitoring data indicates that the recent changes have brought about some significant improvements in water quality during dry times. At the sites regularly monitored, most water quality indicators meet with, or are approaching the set water quality objectives. There are still, however, localised issues around Newee Creek and Bowraville. The reasons for this are unclear and require further investigation.

There also remains lack of information in regards to the impact of non-point source pollution on the Nambucca River estuary. Land-use information for the study area has identified that the major landuses in the study area are cleared lands (50%) and remnant forests (43%), whilst there were only small areas of intensive agricultural land-use such as horticulture.

Water quality data collected as part of the Shellfish Quality Assurance Program (SQAP) has identified issues through its event monitoring procedures. The SQAP monitors several sites win the harvest zones of the estuary. Water quality results indicate elevated levels of faecal coliforms associated with rainfall events. The water quality monitoring being performed as part of the SQAP, which will result in the classification of all oyster leases in the Nambucca River and is expected to be completed in late 2006. Individual growers who operate oyster leases in restricted zones will be required to conduct water quality monitoring as part of lease management. Water quality monitoring data collected by oyster growers need to be maintained on a central database, to ensure it contributes to future estuary management decision-making.

A major sediment plume in Warrell Creek following a rainfall event towards the end of 2004 suggests that erosion and sediment control practices on construction sites may not be at a standard suitable for protection of downstream receiving waters. Council's existing planning framework also has significant scope for the development and adoption water sensitive urban design (WSUD) practices to improve the overall environmental acceptability of future development (e.g. reduce potable water consumption, improved stormwater quality discharges, etc).

Overarching Management Objectives

In respect of the general goals of the Estuary Management Policy (NSW Government, 1992), the following overarching management objectives have been developed for the Nambucca River estuary. The objectives are based on community uses and values associated with the estuary (identified in consultation with the community and stakeholders) and from the technical reviews completed as part of this study. The objectives form the goal posts for estuary management and will serve as future measure against which to assess the success of the process.

Land Tenure and Usage (LTU) - Protect and enhance the existing uses and values of the estuary in both the short- and long-term by adoption of best practice land use planning and development controls.

Entrance Condition and Behaviour (EC) - Maintain navigation within the lower estuary for shallow draft vessels, consistent with current use, to maintain user amenity, safety and aesthetics, within the natural constraints of ocean and fluvial processes.

Boating and Waterway Usage (BWU) - Encourage waterway use that causes a minimum of environmental and social impact, and where possible, enhances user amenity through improved safety controls and reduced conflict. Improve the safety of swimmers of all ages within the estuary.

Water Quality (WQ) - Maintain and improve water quality within the estuary to support ecosystem function, commercial fishing/oyster production and tourism, and other forms of human recreation including swimming.

Habitat Management (HM) - Protect and enhance habitats to improve the health and biodiversity of the Nambucca River estuary.

Bank Erosion and Sedimentation (BE) - Improve overall riverbank condition on all major streams and waterways of the Nambucca Valley to limit future bank erosion and sedimentation.

Climate Change and Sea Level Rise (CCSLR) - Consider the potential implications of sea level rise on the estuary and its surrounds as a result of global scale climate change.

Cultural Heritage (CH) - Protect areas and items of Aboriginal and European cultural heritage within the estuary.

Community Liaison (CL) - Maintain open lines of communication with the community and local Aboriginal groups in relation to the ongoing management of the estuary.

Fisheries and Oyster Aquaculture (FOA) - Maintain and improve the viability of existing (and potential future) types of ecologically and commercially sustainable estuary-based aquaculture industries and enterprises.

Tourism Management (TM) - Maintain and improve the recreational and amenity values of the Nambucca River estuary, without resulting in deleterious impacts on the natural environment.

Prioritised Management Strategies

Through a process of community consultation a list of prioritised management strategies (26 in total) have been developed for the estuary. These strategies address the issues identified through community and stakeholder consultation, as well as those issues identified as part of the technical assessments. The priority and ranking provided to the management strategy provides an indication of the order in which they should be dealt with (with higher rankings, i.e. 1, 2, etc, being dealt with where possible sooner than lower ranked strategies).

The Estuary Management Plan (when prepared) will provide additional detail in respect of how to implement the strategies, as well as details of responsible organisation(s), timing, costs, etc.

Management Strategy	Priority	Rank
BE-1. Improve overall riverbank condition (including riparian habitats) on all major streams and waterways within the Nambucca Valley.	High	1
LTU-3. Minimise the environmental impact of new development by integrating best practice water management approaches (encompassing design, construction and operation) into Council's planning, approval and regulatory systems.	High	2
CH-1. Reinstate tidal flow through the Stuarts Island Causeway, whilst minimising risk to swimmers utilising the Bellwood Swimming Hole.	High	3
BWU-2. Raise community awareness as to the environmental impacts of boating within the estuary and boating techniques that could be employed to minimise them.	High	4
FOA-3. Support sustainable aquaculture industries within the Nambucca River estuary by application of the highest levels of catchment and waterway management to ensure that the estuary's water quality is sufficient to maintain this industry, in clearly identified areas.	High	5
HM-1. Protect habitats of high ecological and estuarine conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands), through appropriate landuse planning and development controls.	High	6
LTU-1. Incorporate riparian protection zones within Council's planning framework to safeguard them against potential future development and land-use change.	High	7
HM-2. Enhance condition of habitats of high ecological/ conservation value.	High	8
EC-1. Raise community awareness of coastal/estuary processes to increase the level of understanding of shoaling mechanisms and associated implications as well as the consequences of intervention measures.	High	9
BWU-1. Minimise the safety risk and environmental harm of boating on humans and other sensitive receptors of the estuary such as banks, vegetative habitats and oyster leases, via the use of sympathetic signage in strategic locations.	Medium	10
BWU-4. Rationalise access points, boat ramps and associated facilities to protect existing estuarine values and to provide quality public foreshore access to the estuary.	Medium	11
LTU-2. Incorporate river health goals and best practice design into future bank protection works (e.g. construction of future foreshore retaining walls) through an integrated and streamlined approvals process.	Medium	12
BWU-3. Improve swimmer safety in the lower estuary by a variety of means including improved signage / safety equipment, provision of new swimming areas and/or improving the safety aspects of existing swimming areas.	Medium	13

Management Strategy	Priority	Rank
EC-2. Address localised shoaling and erosion problems and improve navigable access where practical and most needed in the lower estuary giving consideration to the likely effectiveness, costs and benefits of works as well as the potential impacts.	Medium	14
CH-2. Ensure proposals that affect the estuary and surrounds afford an appropriate level of protection to items and areas of Aboriginal and European cultural heritage.	Medium	15
TM-1. Promote the values of the estuary in ways that promote its sustainable use and also support the valuable tourism industry of the Nambucca Shire.	Medium	16
FOA-1. Initiate fishing catch surveys on the Nambucca River estuary, which identify key fishing locations, fishing effort, catch quantities and species caught.	Medium	17
FOA-2. Obtain better understanding of fisheries habitat values and trends in fish communities over time in different parts of estuary.	Medium	18
WQ-1. Integrate and improve upon existing water quality monitoring activities occurring within the estuary to provide a better indicator of overall estuarine health, whilst addressing all existing licence and operational requirements.	Medium	19
CCSLR-1. Ensure climate change and sea level rise implications are incorporated into the current LEP and forward planning.	Low	20
BWU-5. Develop a formal Boating Management Plan for regions of the Nambucca River Estuary that are being excessively impacted upon by boating activities.	Low	21
HM-3. Protect habitats of moderate or local ecological value (eg areas of native regrowth).	Low	22
HM-4. Enhance condition of habitats of moderate or local ecological value.	Low	23
CL-1. Ensure adequate representation of local Aboriginal groups is maintained on the existing Estuary Management Committee and that issues are addressed via appropriate channels.	Low	24
LTU-4. Ensure all foreshore structures are appropriately licenced, designed and maintained to protect foreshore amenity and access.	Low	25
TM-2. Improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area.	Low	26

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

This document presents the Estuary Management Study for the Nambucca River Estuary. The EMS has been prepared by environmental consultants WBM Oceanics Australia ('WBM') and Geco Environmental Catchment Consulting ('Geco Environmental'), under the direction of the Nambucca Shire Estuary and Coastline Management Committee, Nambucca Shire Council and Department of Natural Resources (DNR) in accordance with the brief released by Nambucca Shire Council in February 2004. The establishment of an environmental levy (paid to Council as part of quarterly rates) has in part raised the required funds to complete the study. The amount raised by Council was matched by the DNR under the NSW State Estuary Program. This project was also supported by funding from the Australian Government under its Regional Partnerships programme through Department of Transport and Regional Services.

The estuary study is a precursor to the Estuary Management Plan. The estuary study contains a variety of information in relation to the biophysical condition of the estuary, community values, use and vision for the estuary, as well as current institutional arrangements which govern how and who manages aspects of the estuary.

The estuary study identifies issues facing the estuary and presents a number of management objectives specifically formulated to address the issues. The Nambucca Shire Estuary and Coastline Management Committee have prioritised objectives in conjunction with the community.

The Estuary Management Plan will be a "living document" that provides a program of strategic actions to assist government authorities and other stakeholder groups to sustain a healthy estuary through appropriate waterway, foreshore and catchment management. The estuary plan builds on the set of strategic objectives developed as part of the estuary study. It aims to provide clear direction regarding the implementation of these actions by assigning responsibilities and timeframes. Cost and funding implications of the proposed management actions are also detailed.

The estuary plan will be prepared in a manner that can be incorporated into the planning frameworks of those nominated as being responsible for its implementation. The creation of estuary study and plan will fulfil the requirements of the NSW Estuary Management Policy (1992) and the NSW Coastal Policy (1997).

As mentioned above, the management plan will be a "living document", meaning that as the needs or conditions of the estuary change over time, then the requirements and contents of the estuary plan must also change. It is intended that progress in implementing the estuary plan would be reviewed annually, while the entire estuary plan would be reviewed and updated every 5 years or so.

1.1 Study area

The Nambucca River is located within the Nambucca Shire, which is situated on the mid-north coast of New South Wales approximately 45 kilometres south of Coffs Harbour. The Shire has an approximate area of 1,491 km^2, while the Nambucca River has a total catchment area of 1,460km^2. The river catchment is almost wholly contained within local government of the Nambucca Shire. The prominent waterways include the Nambucca River, Taylors Arm and Warrell Creek, which collectively have a waterway area of approximately 7.74 km^2.

The study area (i.e. the estuary) comprises the tidal waterways, foreshores and adjacent lands of the Nambucca River. The tidal waterways of the estuary extend:

- From the entrance at Nambucca Heads along the Nambucca River to 250m upstream from Lanes Bridge at Bowraville;
- Along Taylors Arm for approximately 1.6km upstream from Boat Harbour Bridge Utungun; and
- Along Warrell Creek 600m downstream from Pacific Highway bridge to the south of the Warrell Creek Hamlet.

Other minor tributaries to the estuary include Blackbutt, Rhones, Welshes, Newee, Watt, Bellwood, Swampy, Teagues, Tilly Willy and Way Way Creeks.

The study area includes the entrance and Shelly Beach boat ramp. Consideration will be given to the wider catchment areas in this study if they are found to have a significant impact of the estuary.

The upper catchment areas (i.e. outside the bounds of the study area) are mainly undeveloped with numerous State Forests and National Parks. Farming and associated clearing exists along the length of river on the fertile alluvial plains, which broaden out in the lower catchment (and study area). Consequently, most of the study area has previously been cleared and it contains numerous rural properties, which supports a variety of small-scale agriculture pursuits such as dairying, beef cattle, and various forms of horticulture. Some areas of forest regrowth are now present within the lower catchment and study area.

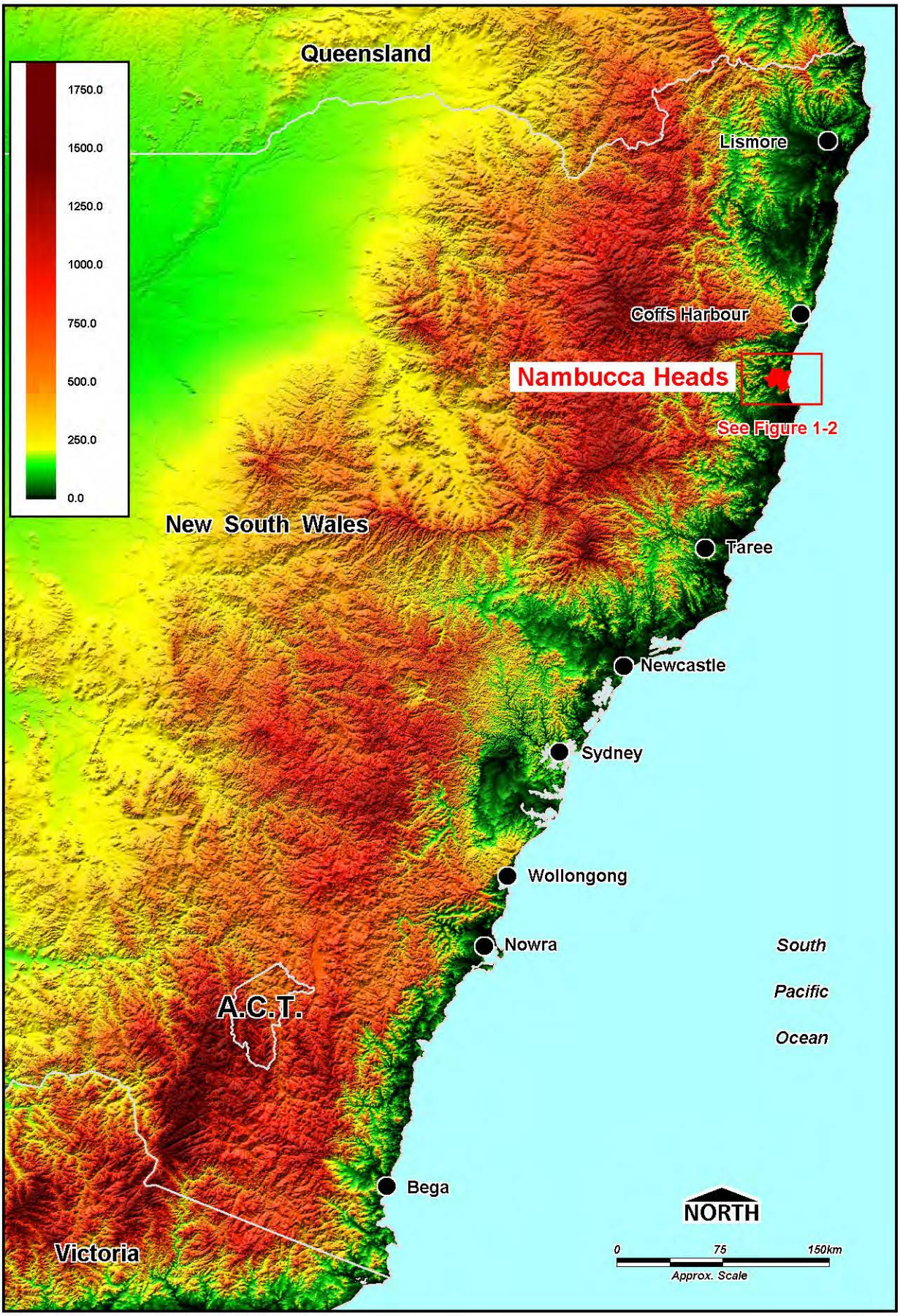
Figure 1-1 shows the locality of the Nambucca Shire, while Figure 1-2 shows the Nambucca River Estuary and other salient details of the study area.

The Nambucca Shire is reported to have a population of approximately 19,000 people (ABS, 2001) with most of these people residing within four main urban areas, which are all within the bounds of the study area:

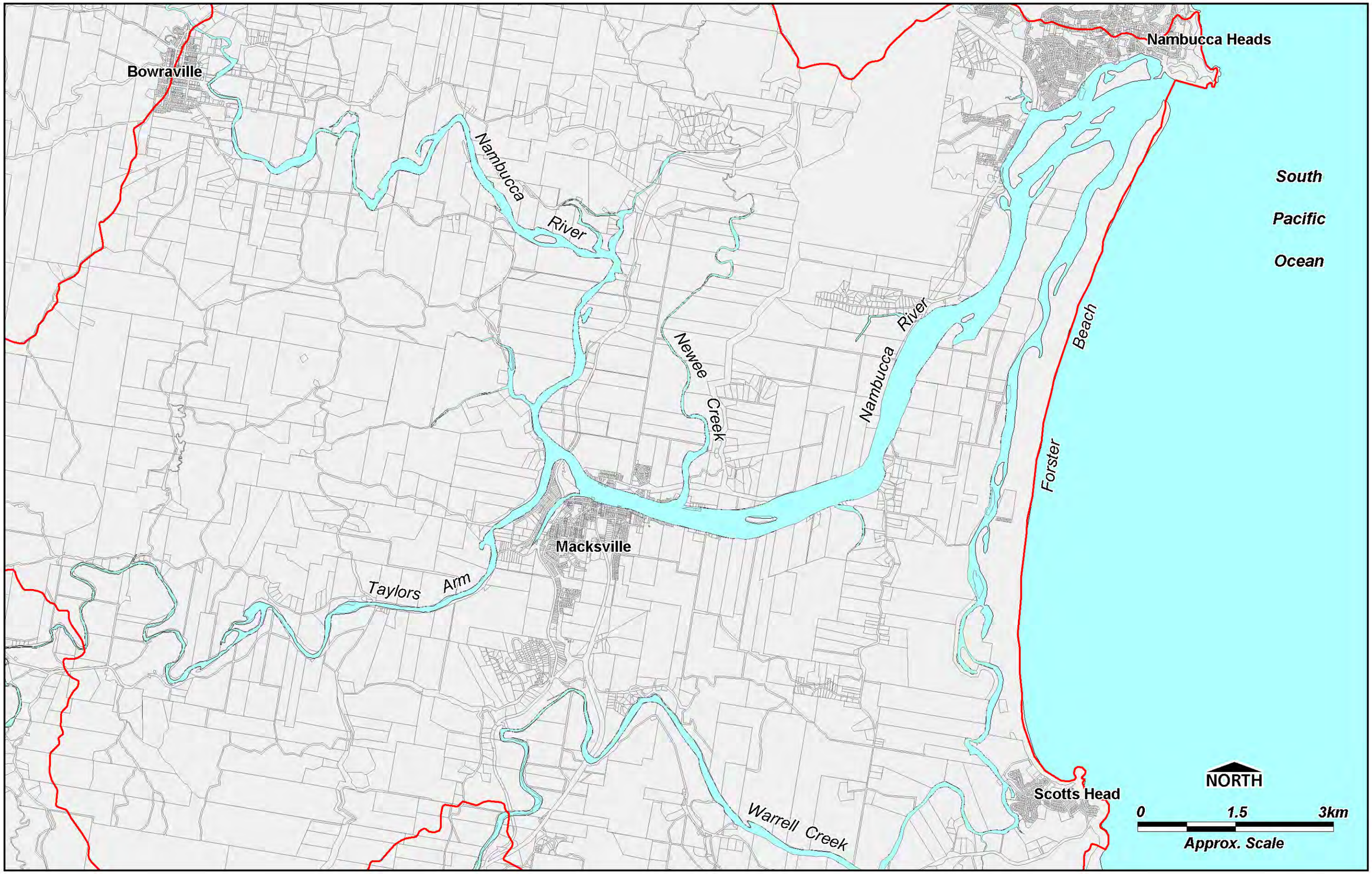
- Nambucca Heads – population 8,000;
- Macksville – population 6,000;
- Bowraville – population 2,400; and
- Scotts Head – population 900.

Demographic data compiled for the Comprehensive Coastal Assessments (CCA) has identified that for the Nambucca LGA its estimated resident population in 1981 was 11,550 and in 2002 was 18,171. The change over this period provides an average annual growth rate of 2.29%. The CCA report goes on to predict that the resident population in 2011 will be 19,700 and 21,700 by 2026 providing an average annual growth rate of 0.71%. Most of the population growth on a Shire-wide basis is expected to be in the coastal areas of Valla Beach, Nambucca Heads, Macksville and Scotts Head, which are becoming increasingly popular as retirement locations. The coastal townships are also popular holiday destinations with populations increasing dramatically during holiday periods.

The estuary is highly valued and utilised by locals at all other times of the year, primarily for recreational pursuits such as fishing. A number of commercial activities occur on the river including oyster production, commercial fishing and boat/houseboat hire.



Locality Plan **Figure 1-1**



Study Area Figure 1-2

1.2 Aim of the estuary management study and plan

In accordance with the brief the EMS and EMP must:

- Present strategies to be recommended for adoption by Council, State Agencies and key stakeholders which satisfy the objectives and resolve identified issues;
- Be prepared in consultation with all sections of Nambucca Shire Council, the Nambucca Shire Estuary and Coastline Management Committee and the community;
- Have a vision for the environmental, social and economic wellbeing of the estuary and its catchment;
- Provide guidance and recommendations for works and planning controls which can be implemented immediately by Council and key stakeholders; and
- Provide guidance that is clear and understandable.

1.3 Estuary management planning process

The estuary management planning process adopted for this study is outlined in Figure 1-3.

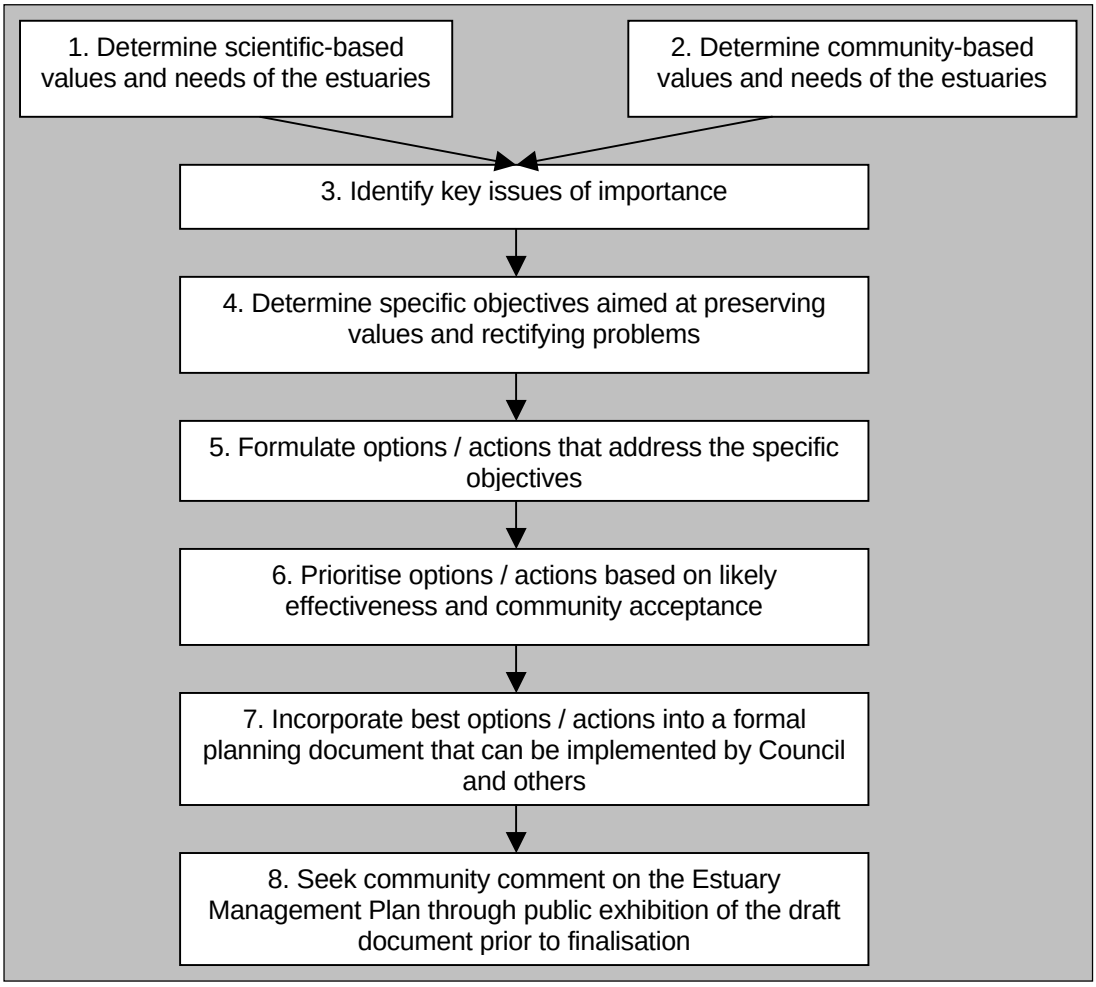


Figure 1-3 Estuary management planning process

The estuary management planning process will ultimately provide a series of strategic management actions that, if implemented, will result in the long-term sustainability of the Nambucca River Estuary with regard to ecological, economic and social values.

Items 1 to 6 will be addressed as part of this Estuary Management Study. Items 7 and 8 will be addressed as part of the Estuary Management Plan.

1.4 Estuary management study report structure

Presented below is a basic outline of the contents of each chapter of this document.

Section 2 presents a summary of Relevant Background Documents and provides a Description of Key Processes for the Nambucca River Estuary. The description of key processes discusses the fundamental physical, chemical and biological processes that currently occur within estuaries.

Section 4 includes a summary of the community consultation activities carried out with the stakeholders and the local community of the Nambucca River Estuary and details the Values and Uses of the estuary.

Section 5 presents a Review of the Statutory Context which discusses the key State and Local Government planning policies and practices which govern Estuarine Management.

Sections 6 through to 15 presents a variety of technical reviews or assessments of particular features/uses of the estuary. Much of the information included in these sections may traditionally be included in an Estuary Processes Study. However, due to the way that the study has unfolded, the information has been included in the Estuary Management Study:

- Assessment of Existing Land Use & Tenure (**Section 6**);
- Entrance Conditions (**Section 7**);
- Boating & Waterway Usage (**Section 8**);
- Stuart Island Causeway (Including Input From Aboriginal Community) (**Section 9**);
- Habitat Management (**Section 10**);
- Fisheries and Oyster Aquaculture (**Section 11**);
- Tourism Management (**Section 12**);
- Gumma Gumma Wetland (**Section 13**);
- Climate Change & Sea Level Rise (**Section 14**); and
- Water Quality (**Section 15**).

Section 16 presents a summary of the Regional Significance and Value of the Nambucca River Estuary. This step is important in order to broaden the focus of estuarine management decisions for this estuary, as it considers the estuary on a regional basis.

Section 17 presents the over-arching management objectives for the estuary. The section also includes a discussion of key management issues determined through the technical reviews and consultation and a set of prioritised management strategies developed to address them.

2 RELEVANT BACKGROUND INFORMATION

A number of documents describing various attributes and environmental processes of the Nambucca River Estuary have been prepared in recent years. This section provides a summary of the key findings of these studies, particularly, as they relate to the requirements for future management of the Nambucca River Estuary.

It should be acknowledged that the Estuary Management Study represents the first comprehensive management study performed on the estuarine portions of the Nambucca River. Significant previous investigations have been undertaken on the non-tidal portions of the catchment.

A variety of supporting information has been collected and reviewed as part of the study, details of this material are provided in later sections of this report.

2.1 Estuary Processes Study

The Nambucca River Estuary Processes Study was completed by WBM in 2000 (WBM, 2000). An overview of the Nambucca River Estuary environment, as documented in the Estuary Processes Study, is presented below. Full copies of the report are available from Council offices and libraries.

- **Waterway Usage** - The Nambucca Estuary is widely used for a variety of recreation and commercial uses. It has little industrial usage. There appears to be few usage conflicts in the area, with the possible exception of occasional issues arising between recreational boaters and oyster farmers in the lower estuary over peak holiday periods.

  Also, the Processes Study identified that unlike many other NSW estuaries, there appear to be few direct human usage impacts (eg. boating, fishing etc.) or issues in the estuarine areas. The principal issue identified was the direct relationship between the commercial oyster farming of the estuary and water quality degradation.

- **Sediment Characteristics** - A detailed analysis was not undertaken of sediments as part of the Processes Study. Consequently, detailed information regarding the grade, strength, nutrient enrichment and organic matter of the sediment remains unknown. However, a qualitative grab sample survey indicated that the Nambucca Estuary exhibits a typical longitudinal pattern of sediment facies, ranging from upstream deposits of coarse, riverine gravels prograding with passage to the middle reaches of the estuary containing finer sediments and muds and silts. With further passage downstream, evidence of marine sands becomes progressively more pronounced until by the entrance the system is entirely marine in nature,

  There is evidence (bank instability and other geomorphological artefacts) that upper (freshwater) catchment sand and gravel extraction and catchment clearing may be affecting estuarine sediment characteristics, which may in turn be affecting estuarine hydraulic processes and water column turbidities. The Processes Study recommended further investigations into the sediment characteristics of the Nambucca River Estuary, in order to understand the system's sediment characteristics. This would assist with determining the source of the various deposits, the causes of the erosion in these locations and methods to manage problem sources and deposits.

- **Bank Erosion** - In the case of the Nambucca Catchment, the effects of upstream land clearing and sand and gravel extraction have been shown to be significant (Lyall & Macoun 1999) and are considered to be the principle mechanism contributing to the bed and bank degradation processes being observed in the estuary.
- **Historical Changes in Estuary Depth** – The Estuary Processes Study identified that the change in estuary depth did not appear to be significant, however, these assessments were performed only at three locations using data from 1999 (MHL) and 1989 (NSW Public Works). It should be noted that there were no major floods during this period.
- **Shoaling / Erosion Patterns** – The Estuary Processes Study identified that the lower reaches of the estuary are prone to deposition of marine sands. The degree of such deposition varies depending on the incidence of major floods (which will tend to scour the entrance), and significant storm/wave extents (which will tend to mobilise near shores and deposits and enable their transport into the estuary). This sand deposition is a natural process, and any active management is unlikely to succeed, and is probably not warranted. It should be noted that no review of historical entrance conditions was performed as part of the study.
- **Tidal Processes** - The Estuary Processes Study identified that tidal processes in the Nambucca estuary and Warrell Creek in particular, are dominated by frictional losses caused by the relatively constrained nature of the rivers/creeks entrances. Outside this zone of influence, tidal ranges are relatively constant and tidal flows and velocities reduce with passage upstream. Modelling identified that the lower reaches of the Nambucca Estuary are relatively well flushed by tidal processes. The same cannot be said however for the upper estuary, and Warrell Creek. Both these areas have particularly long flushing times and as such, are susceptible to significant water quality degradation in the event of sustained pollutant loadings.
- **Flooding** – No review of the influence of flooding and estuarine processes was performed as part of the Estuary Processes Study.
- **Water Quality**- The Estuary Processes Study identified that the water quality in the Nambucca River Estuary generally did not meet the Interim Environmental Objectives set by the EPA. Regular exceedances of DO, turbidity and faecal coliforms were observed in the data reviewed. Less frequent exceedances of temperature, pH and chlorophyll-a were also observed.

  These exceedances indicate that some environmental values desired for the Nambucca Estuary may not be being achieved, particularly protection of aquatic ecosystems (DO, pH, turbidity, TP and chlorophyll-a criteria not always met), primary contact (temperature, pH, turbidity and faecal coliforms criteria exceeded) and consumption of cooked, aquatic foods (faecal coliforms criterion exceeded).

  The higher than desirable nutrient concentrations may be causing the elevated chlorophyll-a concentration as well as contributing to higher suspended solids and turbidity values and occasionally depressed oxygen levels. Elevated pH can also indicate high nutrients and algal conditions as the removal of carbon dioxide through photosynthesis raises the pH of the water column.

  The Estuary Processes Study identified the poor water quality may have been due to a range of catchment and point source pollutant loadings, with additional impacts also due to the effects of bank instabilities caused by upper catchment land clearing and sand and gravel extraction. The

degraded condition of estuarine water quality is also likely to be affecting other estuarine processes and attributes, especially with respect to ecological health and oyster/recreational fishing. A recommended water quality monitoring program was provided as part of the study.

- **Estuarine Ecology -** The Estuary Processes Study identified that the Nambucca River estuary contains a broad range of fringing terrestrial and aquatic habitats, many of which have high conservation and fisheries value. The estuary flows through lands that range from protected areas of native vegetation (State Forests) to areas that have been totally cleared for agricultural use. The estuary has an important role in the tourism industry of the region and supports small, but locally significant, commercial fishing and oyster growing industries.

  The Estuary Processes Study documents available information in relation to estuarine habitats including wetlands, sedimentary habitats, open water, reefs and intertidal rocky shores, riparian vegetation, floodplain habitats. The Estuary Processes Study also documents information in relation to fauna communities, fisheries and oyster farming. The ecological assessments identified a marked degradation in the ecological health of the estuary when compared to less severely impacted systems, principally related to degraded water quality. There are secondary impacts on estuarine ecology due to factors such as riparian zone clearing and increased human access. Information gaps and recommended further studies were also identified in relation fully understanding ecological processes of the estuary. Some of these recommendations have been addressed for inclusion in this Estuary Management Study.

- **Cultural (Human) Impacts** - The Estuary Processes Study identifies that the estuary and upstream freshwater systems have been disturbed through dredging (lower reaches) and the removal of rock, sand and gravel (upper reaches). Extensive vegetation clearing in the floodplains and stream banks is thought to have resulted in the erosion of banks (during periods of major floods), which in turn has changed river morphology, resulting in further river widening (Lyall and Macoun, 1999). Consequently, the surrounding areas of the river are adjusting to compensate for this removal of material. This has led to much bank erosion occurring in these areas. Grazing of cattle has had a further impact on the river with much of the stock being allowed access to the river's edge. Consequently much of the riverbank in these areas has become unstable and weed infested.

  The Estuary Processes Study indicates that the most significant human impacts on the estuary are probably associated with works in the entrance, and the influences of estuarine wastewater discharges. Both of these impact mechanisms will have/is having major effects on estuarine morphology, water quality and ecology.

- **Stormwater -** The Estuary Processes Study identified that little stormwater information was available and that the Nambucca Shire Council was in the process of preparing a Stormwater Management Plan for major urban areas of the Shire.

- **Estuary Entrance Conditions** – The Estuary Processes Study provides little information on the entrance/coastal processes.

2.2 Other key studies utilised

Details of some of the other key studies utilised in the preparation of the Estuary Management Study include:

Estuarine Geomorphology, Physical Condition and Mapping

GECO Environmental prepared this report in 2005 as part of the Estuary Management Study. The report provides a review of the geomorphology, bank and riparian management needs of the Nambucca River estuary. The content of this document forms a component of the material included in this Estuary Management Study and has been referenced to in various sections of this report.

The report provides an overview of the geomorphic history of the estuary to the present day. This has included a review of recent historical effects and their impacts on the sedimentary and geomorphologic patterns of the estuary. River styles have been identified and mapped for the estuary based on soil landscapes, hydrologic zones, channel morphology, sediment types and streamside vegetation.

Estuary riverbank and riparian vegetation condition for the estuary has been identified and mapped and calculated for the different reaches and river styles present in the estuary. Bank stability rankings were grouped into four categories including high, moderate, minor and insignificant. Bank vegetation conditions were grouped into four main categories including good, moderate, poor and not surveyed.

The types, extent and relative successful of various forms of bank protection works throughout the estuary have been identified and mapped.

The abovementioned factors were incorporated into an overall measure of estuary condition that has been mapped and calculated for the different estuary reaches and river styles. Condition ratings included near natural, good, moderate, poor and not surveyed.

The report concludes with the identification of specific estuary management issues and management objectives for inclusion as part of the overall Estuary Management Study and Plan.

Nambucca Catchment Vegetation Survey

In 2003, Kendall and Kendall Pty Ltd examined the broad vegetation communities and species within the entire Nambucca Catchment (except State Forest Areas). Information pertaining to this study has been documented in Section 10.

Nambucca River Estuary Inventory

The Nambucca River Estuary Inventory (Highfield, 2001) documents a variety of information pertaining to the estuary including: Estuary formation and geology; Aboriginal and European History; Water Quality; Aquatic Fauna; Aquatic Vegetation; Wetland Vegetation; Riparian Vegetation; and Warrell Creek.

In relation to water quality, the Nambucca River Estuary Inventory discusses the outcomes of the Nambucca CMC Community Water Quality Monitoring Project. This report has been addressed in Section 15. The vegetation and flora aspects of the report have been reviewed/covered in Section 10.

Healthy Rivers Commission North Coast Rivers Report

The Healthy Rivers Commission released the Final Report of the Independent Inquiry into the North Coast Rivers in March 2003. There was to be a Statement of Intent released for the North Coast Rivers, however, since this time the Healthy Rivers Commission has been disbanded.

The Inquiry has focused on how to maintain and enhance river and estuary health in the face of the regions diverse land use and increasing population.

The inquiry was conducted with a high degree of community input and has aimed to document community views in relation to a number of aspects of environmental features of these river systems. It has used these to define river health goals. The inquiry has also investigated a number of relationships between land and waterway uses, their synergies and conflicts. In particular, agriculture, aquaculture and fishing uses have been investigated in relation to their impact on river health. Furthermore the context of estuary management in local and regional planning frameworks has been identified.

The Inquiry makes special mention of the erosion issue in the "non-estuarine" portions of the Nambucca River. It makes several recommendations in relation to this issue, which are aimed at settling existing disagreements in relation to the assessments that have already been performed, obtaining consensus based agreements on approaches to address the issues and priorities for action. The report also identifies that additional funding sources are required to enable actions to get underway.

The Inquiry also provided an in depth analysis of estuary management and entrances with specific focus on the issue of estuary dredging and training walls. The Inquiry noted the existence of designated minor ports and the past history of government dredging. The continued maintenance of training walls and dredging of channels, may, in the absence of clear policy to the contrary, give the impression that the State is responsible for maintaining navigation across entrance bars and into estuaries at all times. The Commission considers that Government Policy on these matters needs to be more clearly defined.

The Inquiry provides ten high level recommendations to improve the health of the North Coast Rivers. These goals were to be implemented mainly through the various NSW State Government departments. This Estuary Management Study has maintained consistency with the recommendations of this report where possible.

Other reports

Numerous other reports have been utilised in the study. Full details of these have been included in the individual sections and are detailed in the References section at the rear of this report (see Section 18).

3 DESCRIPTION OF KEY PROCESSES

The physical, chemical and biological processes of estuarine environments, such as the Nambucca River Estuary, are highly inter-related.

The process interactions for the Nambucca River Estuary are shown schematically in Figure 3-1. The primary processes influencing external contributions to the system include *Catchment Inputs* and *Entrance Conditions*. These two factors, more than any others, tend to control the condition of the estuary and the habitats it supports.

In simple terms, the external processes influence the physical hydraulic processes, which in turn influence the chemical responses, which in turn, define the ecological structure of the system.

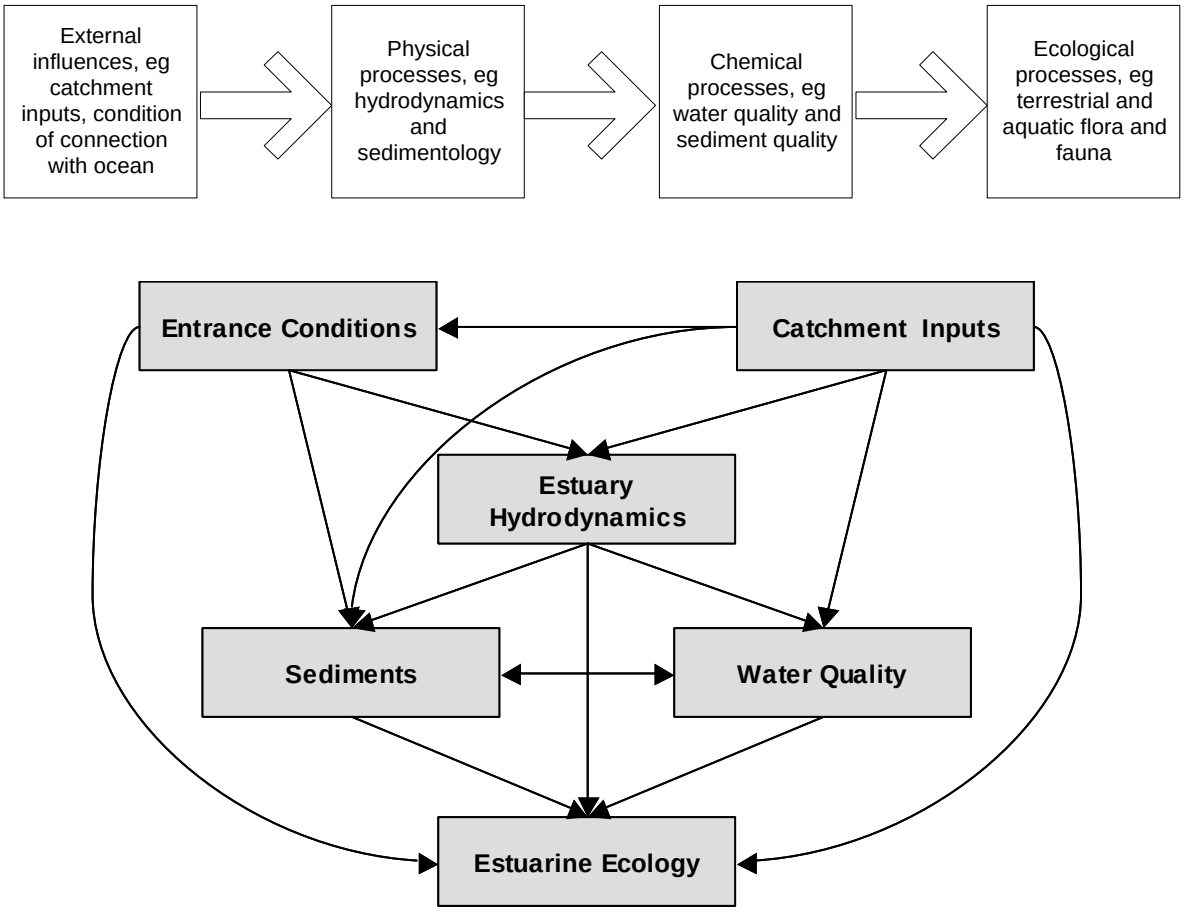


Figure 3-1 Interactions between estuarine processes

Based on the above structure, the overall result of changes to first order processes (i.e. inputs to the system) is a change to the ecological structure and communities supported by the estuary. Changes also manifest in other processes, such as hydrodynamics, sediments and water quality, in response to the change in inputs, however, these can be considered as intermediate links between the inputs and the resultant natural ecology.

Provided in the following sections are brief descriptions of the key estuarine processes operating within the Nambucca River Estuary.

Entrance conditions

The condition of the entrance to the Nambucca River estuary is a key control mechanism as shown in Figure 3-1. The state of the entrance has flow-on effects to estuary hydrodynamics, water quality and ecology. Review of available aerial photography has shown that the entrance to the Nambucca River has remained open (i.e. from 1942 to date) but has gone through significant changes as a result of coastal and flooding processes.

A full description of coastal conditions operating on the Nambucca River entrance are provided in Section 7.1. However, the following key points are made:

- The lower reaches of an estuary are typically in a form of dynamic equilibrium between the controlling forces of the tidal and fluvial activity of the river and the littoral processes of the adjacent beaches. As such, the configuration of the river and entrance channels as well as the adjacent coastline is continually changing under the natural variability of the prevailing conditions;
- During normal day-to-day tide and wave conditions, there is a general tendency for gradual sediment infeed from the beach system. The rate is typically increased following scour from a flood event and decreased at times when the entrance is shoaled. As shoaling of the entrance region continues, this has the effect of constricting the channel and reducing the tidal range with lower high tides and higher low tides; and
- Fluvial or flooding activity can have dramatic short-term effects with high flows and velocities transporting large quantities of sediment downstream and into the littoral drift beach system. These events have the ability to alter the bed characteristics of localised areas of the river and entrance due to the amounts of sediment that may be transported and redeposited over relatively short periods. Scour of river entrances is a typical characteristic of flood events. This results in a more hydraulically efficient entrance with a subsequent increase in tidal range and flow within the estuary.

Hydrodynamic/tidal investigations completed by State's Estuary Program and reviewed as part of the Estuary Processes Study (WBM, 2000) indicated that there was a significant reduction in tidal range across the entrance with predicted tidal variations being approximately 50% of the ocean tidal range 1km upstream from the entrance. The additional sand shoals present in the area between the Nambucca River and Warrell Creek cause a further reduction in tidal ranges within Warrell Creek. The tidal range in Warrell Creek just upstream of the junction with the Nambucca River (approx 4-5 km from the river mouth) is approximately 20% of the ocean tidal range.

Tidal flushing predictions indicate that flushing times in The Nambucca River are less than 5 days as far as the western end of Stuarts Island, 10 days at Wrights corner and around 20 days at Macksville. Flushing times increase significantly in the upper reaches of the estuary to over 60 days at the tidal limits. Similarly for Warrell Creek, flushing times at the entrance are less than 5 days, increasing to around 20 days at the campground and to around 60 days at Scotts Head (WMB, 2000).

In relation to water quality and flushing, it would be expected that when the entrance exists in a more closed state this would reduce the tidal flushing capacity of the estuary, which may result in lowered water quality.

Catchment inputs

This section considers two types of catchment inputs, those, which are dissolved in the water column, and those that are not. The dissolved inputs include suspended sediments, dissolved nutrients, acid runoff, etc. The non-dissolved (or particulate) portion of catchment runoff typically includes sediments. These catchment inputs may be derived from either the upstream (i.e. the non-tidal) portions of the estuary or from the immediate catchment areas of the estuary. These catchment inputs have a direct impact on the water quality of the estuary.

In relation to dissolved inputs, there are two main types, point source and diffuse. Information relating to point source inputs is relatively well known for key polluting industries such as sewage treatment plants (STP), however, there is little documented information available for diffuse catchment loads. Overall, it is expected that during the last 50 years the quantity of diffuse catchment loads will have decreased in line with decreases in the level of agricultural activity and increasing vegetation cover in the study area. In recent years there has also been some significant reductions in point source pollutant loads with STP upgrades and closure of the Midco Abattoir.

In relation to particulate catchment inputs, with the exception of the estuary mouth, the major source of sediment transported into the estuary is from riverbanks and low floodplains in the upper catchment areas (Geco Environmental, 2005). The increased rates of sedimentation (when compared to pre-European times) have resulted in changes river morphology and hydrodynamics, with river widening and straightening occurring in the catchment. The altered hydrodynamics is likely to have had impacts on tidal flushing and salinity regimes.

These changes as a result of catchment inputs are likely to have lead to significant impacts on the ecological systems within the estuary. For example, altered tide and salinity regimes will result in gradual shifts in the abundance and distribution of certain vegetative communities. Changes in turbidity levels will reduce the area of available habitat for seagrasses. Loss of holes and pool and riffle formations due to sedimentation is likely to have affected the distribution of certain fish species.

Future changes in catchment inputs may affect the viability of Nambucca River estuary's oyster industry.

Human interactions

It is clear from Figure 3-1 that any human interference with the inter-related processes of the estuary will have consequential effects. There have been numerous human impacts on the estuary since European occupation, many of these have occurred to the higher level processes which undoubtedly have lead to follow on impacts in lower order processes.

Some of the major human modifications to date include the extensive entrance training activities, construction of a northern breakwall/causeway and extensive dredging resulting in the formation of several sand islands near the entrance. These activities have had impacts on the hydrodynamic and tidal flushing characteristics of the estuary.

Other major changes in the estuary have included the broadscale clearing and land use change within the catchment of the estuary and further upstream. These changes are likely to have had impacts on the levels of catchment inputs to the estuary, increasing rates of sedimentation, further altering estuary hydrodynamics and established vegetative communities.

4 COMMUNITY CONSULTATION

Full details of the community consultation activities performed for this project are described in the Community Consultation Report (WBM, 2005).

4.1 Scope of consultation undertaken

Extensive community consultation was undertaken during the course of this Estuary Management Study, and involved the relocation of the Project Manager to the study area for a period of six weeks to undertaken community and stakeholder consultation activities. Activities that were conducted during this period (and after) are detailed below:

- **Start-up meeting** with the Nambucca Shire Estuary and Coastline Management Committee (NSECMC), to discuss the proposed study methodology and provide an avenue for discussion between members of the NSECMC and the study team;
- **Questionnaires** - community questionnaires were distributed to the local community during the course of the study which aimed to determine how and where the estuary is being used, what its values are, where conflicts and threats exist and its contribution to individual's quality of life;
- **Media coverage** – Several articles/editorials were run in various media including the Nambucca Shire Council Community Newsletter, Guardian News and ABC Radio National (Port Macquarie);
- **Free-call number** – a free call number (1800 79 70 79) was established to allow free phone contact to be made with project team members at any time;
- **E-mail address** - electronic mail ('e-mail') services were also made available for those wishing to make contact with project team members via the internet (dccavanagh@wbmpl.com.au);
- **Project website** - a project website was established to enable the community and stakeholders to download/view information in relation to the study. The website URL was www.nambucca-ems.com.au;
- **Consultation with community members** - consultation with community members was undertaken either via the telephone or via personal meetings (at the discretion of the individual). Approximately 30 personal meetings were undertaken with interested individuals, stakeholders and Government Departments with a management role in the study area, including:
  - NSW Fisheries (personal meeting);
  - Maritime Authority (personal meeting);
  - National Parks and Wildlife Service (phone conversation and letter);
  - Department of Infrastructure, Planning and Natural Resources (site inspections);
  - Department of Environment and Conservation (phone conversation);
  - NSW Food Authority (phone conversation);
  - Department of Lands (personal meeting); and
  - State Forests (phone conversation).

- **Addressing community groups** – some local groups were addressed by WBM in relation to the study, including the Offshore Fishing Club and Nambucca Heads Chamber of Commerce;
- **Shopping centre stalls** - shopping centre stalls were established at the major urban centres on Saturday/Sunday mornings in order canvass interest from individuals as they passed by the stall;
- **Closure meeting** - A closure meeting was held (at the end of the six week on-site consultation period) with the NSECMC regarding the outcomes of the consultation activities; and
- **Site inspections during Christmas Holidays** – An additional inspection of the estuary was made by the Project Manager in order to ascertain estuarine usage during this peak usage period.

4.2 Estuary uses, values and issues of concern

The following information has been summarised from the Community Consultation Report (WBM, 2005) and specifically relates to the findings of the questionnaire distributed to the local community.

4.2.1 Usage

The most common estuary usage types of respondents (to the questionnaire) are shown in Figure 4-1.

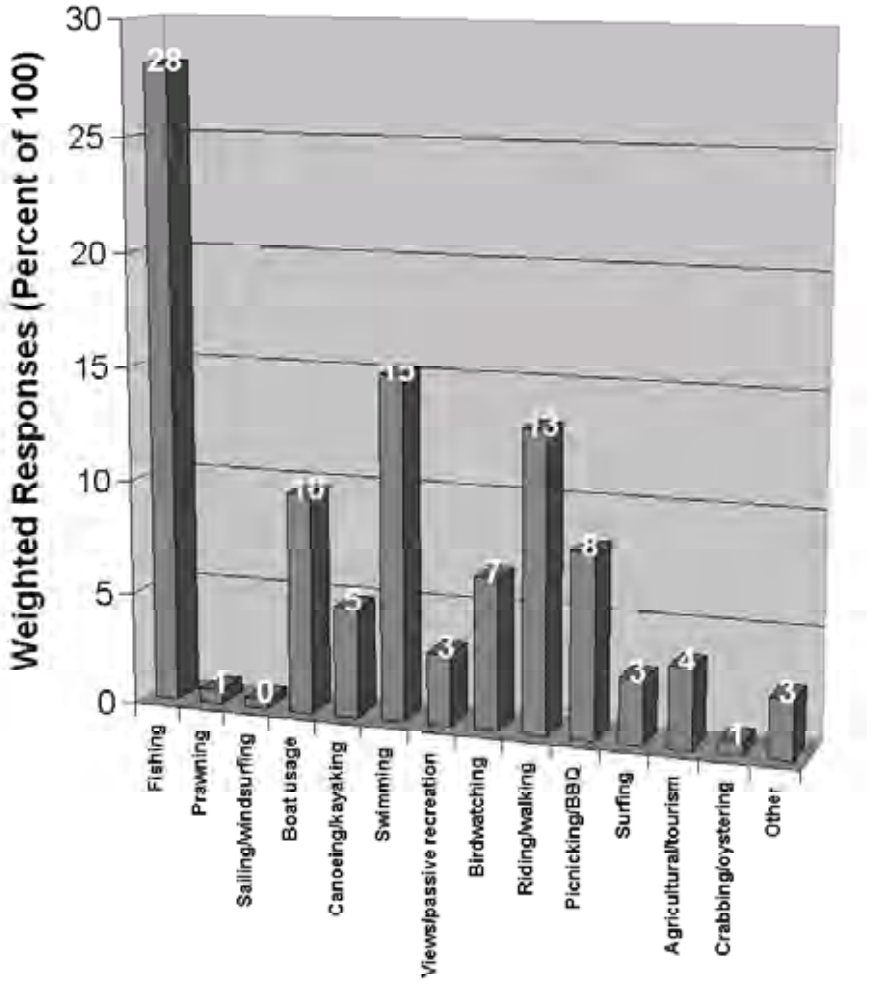


Figure 4-1 Estuarine usage

As shown in Figure 4-1, the weighted ranking of estuarine usage is provided below:

1 Fishing – 28%;	8 Agriculture/tourism – 4%;
2 Swimming – 15%;	9 Views/passive recreation – 3%;
3 Riding/walking – 13%;	10 Surfing – 3%;
4 Boat usage – 10%;	11 Other – 3%;
5 Picnicking/BBQ – 8%;	12 Prawning – 1%;
6 Bird watching – 7%;	13 Crabbing/oystering – 1%; and
7 Canoeing/kayaking – 5%;	14 Sailing/windsurfing – 0%.

These usage statistics indicate that the estuary is mostly used actively with some of the greatest uses being fishing, swimming and boat usage. Correspondingly, the estuary appears to be less used by respondents for passive uses such as picnicking, walking, canoeing and other forms of passive recreation.

It should be noted that the boat usage statistic provided above is likely to be low, as many of those who use the estuary for fishing are likely to use boats to travel to the places where they fish. Many fishermen did not indicate that they used a boat to go fishing. Accordingly, it is expected that the boat usage value provided is likely to be nearly equivalent to that for fishing.

The respondent's highest priority usage (i.e. the usage nominated above all other uses) was fishing, with this use scoring over 3 times the closest other priority usage, which was swimming. Fishermen not nominating that they have used a boat to undertake their fishing activities may again skew results.

These usage results are consistent with observations made by the study team during the six-week on-site consultation period.

4.2.2 Values

The most commonly stated values of the estuary to respondents (to the questionnaire) are shown in Figure 4-2.

As shown in Figure 4-2, the weighted ranking of estuarine values are provided below:

1 Water Quality – 19%;	7 Views – 7%;
2 Water Access – 16%;	8 Income/commercial – 4%;
3 Natural Surrounds – 15%;	9 Preservation – 2%;
4 Recreational Opportunities – 14%;	10 Navigable waters– 1%;
5 Peace and Tranquillity – 10%;	11 Preservation of the lakes – 3%; and
6 Wildlife – 8%;	12 Availability of fresh seafood – 0%.

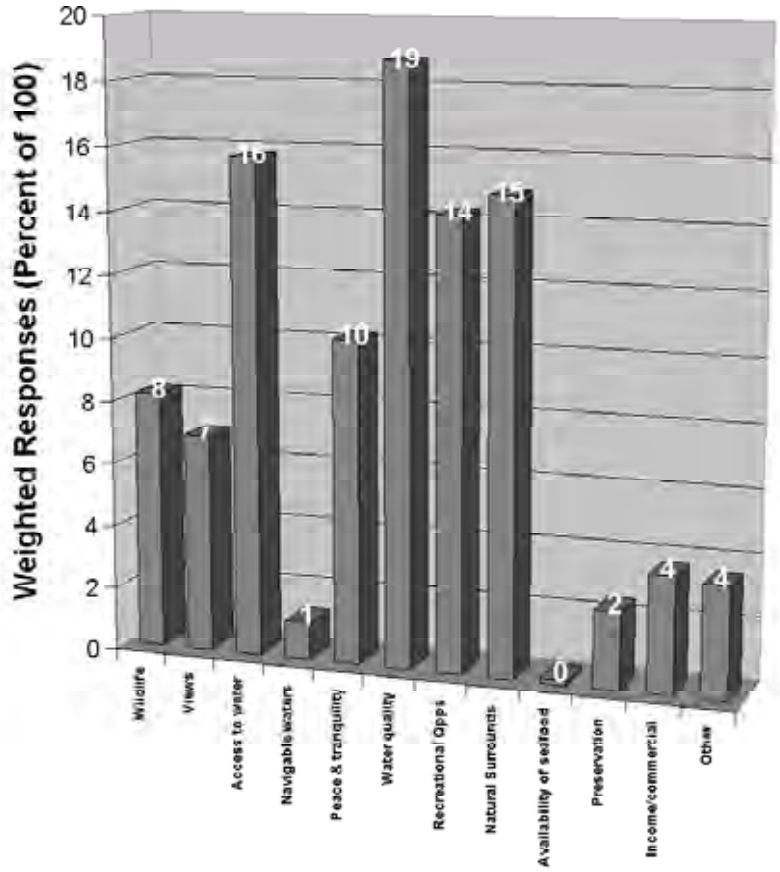


Figure 4-2 Estuary values

This ranking of values indicates that respondents want to be able to recreate/live (i.e. have ready water access and availability of recreational opportunities) near an estuary, which is healthy (i.e. high water quality) and remains in a predominantly natural state (i.e. natural surrounds, peace and tranquillity, presence of wildlife, etc). Further interpretation of the meaning of these results in provided in the Community Consultation Report (WBM, 2005).

The priority of values detailed above is consistent with the results of discussions of study team with community and stakeholder members made during the six-week on-site consultation period.

4.2.3 Issues of concern

The questionnaire included two questions, which asked respondents to provide written answers for:

- any present conflicts in the use of the estuary that they are aware of; and
- any threats they see facing the values of the estuary at present and over the next five years.

Respondent's answers to these questions were reviewed and were grouped into categories, which related to conflicts, issues or threats. In some instances interpretation has been applied to respondent's answers in order to assign responses to various categories, e.g. water quality, loss of tourism, etc. Figure 4-3 presents graphically community issues of concern in relation to the estuary.

Definitions of the various categories are provided below:

- **Sediment build up** – refers to sedimentation in any part of the estuary;
- **Loss of navigable water** – refers to restriction in, or loss of, navigable waterways;
- **Bank erosion** – refers to loss of banks due to various erosion processes initiated by floods, cattle, tree collapse, morphological processes, etc;
- **Water quality** – refers to degradation or reduction in water quality due to stormwater, sewage discharges, septic discharges, acid leachate from acid sulphate soils and agricultural runoff;
- **Commercial fishing impacts on fish stocks** – refers to the potential impacts commercial fishing in the estuary is having on the sustainability of fish stocks;
- **Recreational fishing impacts on fish stocks** – refers to the potential impact recreational fishing in the estuary is having on the sustainability of fish stocks;
- **Commercial fishing impacts on sea grasses** - refers to the potential impacts commercial fishing in the estuary is having on the seagrass colonies;
- **Inappropriate waterway use** – refers to any usage which is causing either social or environmental impacts, such as noise pollution, bank erosion, disruption to commercial activities, safety conflicts, etc;
- **Agricultural impacts** – refers to any impacts emanating from agricultural/pastoral pursuits in the catchment such as inappropriate agrochemical usage, inappropriate land or water management, etc but excludes running of cattle on banks which is covered by another category;
- **Stock grazing on banks** – refers to the stock grazing on riverbanks. Where respondents have indicated that this is a trigger for bank erosion, it has been counted within that category as well;
- **Riparian vegetation** – refers to any concern regarding the integrity or health of riparian vegetation within the estuary;
- **Sewage and septic system overflows** – refers to concerns that nominate these overflows as a concern to the estuary. Where stated these have also been counted in the water quality category;
- **Jet skiing and waterskiing** – refers to any specific concern regarding potential impacts of jetskiing and waterskiing such as safety, noise and bank erosion;
- **Degradation of key habitats** – refers to any concern relating to impacts to key habitats (e.g. wetlands) that exist in the study area;
- **Growth of mangroves** – refers to concerns regarding the increased abundance and distribution of mangroves in the estuary;
- **Unsafe bar crossing** – refers to concerns for boater safety when crossing the ocean bar;
- **Loss of tourism** – refers to any comments made about the status of the estuary affecting the tourism industry;
- **Inappropriate development** – refers to any concern regarding the location or style of development that may impact on the estuary; and
- **Four-wheel drive impacts on nesting birds** – refers to concerns raised for nesting bird areas as a result of inappropriate 4WD use.

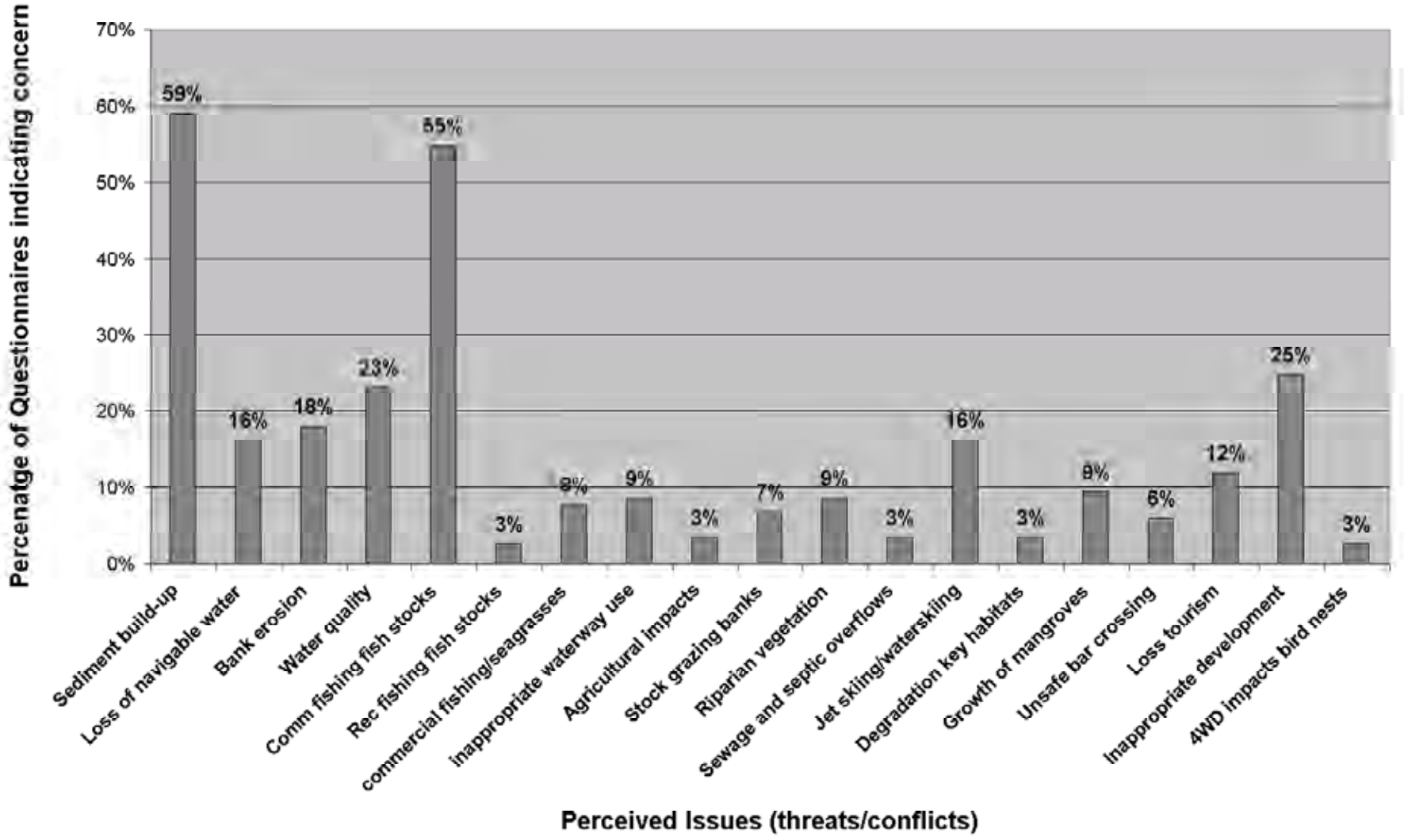


Figure 4-3 Issues of concern

As shown in Figure 4-3 significant conflicts/threats (i.e. greater than 10% of respondents) for the Nambucca River estuary are:

1. **Sediment build-up** (59% of respondents indicated that this was a concern for them) – sand build up near the entrance is of major concern in the local community. Many individuals have indicated that sand build-up has significantly worsened over the past five years. No study to date has clearly identified the coastal processes that affect the entrance of the Nambucca River Estuary. Upstream of the entrance many residents have raised concerns regarding the infilling of the river with sediments, particularly near the major urban centres of Bowraville and Macksville (where people would typically recreate);
2. **Commercial fishing impacts on fish stocks** (55%) – Fishing is a key usage of the estuary and recreational fish catches have been reported to be declining. This is of concern in this estuary since its primary usage is for fishing. The exact reasons for the perceived decline are unclear and the commercial fishermen are being held primarily responsible;
3. **Inappropriate development** (25%) - This is of concern in the study area, which appears to have recently been targeted by large land developers who would naturally be attracted to the area due to its existing low land prices and existing features (i.e. the estuary). Many residents feel that stronger planning controls should be enforced to control the extent and potential impact of any future development in the study area. Many residents indicated that they don't wish for Nambucca Heads to become the next Coffs Harbour;
4. **Water quality degradation** (23%) – This is of concern in the study area, most individuals were stated concerns with urban stormwater runoff and impacts of septic systems on the quality of the estuary's waters. The quality of effluent from existing Sewage Treatment Plants (STP) was also sited as a concern;
5. **Bank erosion** (18%) – This is of concern as significant proportions of the estuary foreshore have unstable/eroding banks and/or poor riparian vegetation condition. A number of major roads are also located immediately adjacent to the river, many of these are suffering significant damage during high flow events;
6. **Loss of navigable waters** (16%) – This is concern, mainly to boaters who over recent years have found it more difficult to navigate about the lower estuary due to the build up of sand;
7. **Jet skiing/waterskiing** (16%) - Issues associated with jet/skiing and waterskiing relate to their perceived impact on the banks (i.e. trigger for bank erosion), noise and potential safety impacts;
8. **Loss of tourism** (12%) – Loss of tourism was identified by many individuals who were concerned that the decline in recreational fish catch, degradation of water quality, reduction in navigable waters or existing values of the region may lead to (or has already caused) a decline in tourism to the area.

The issues of concern detailed above are consistent with the results of discussions of study team with community and stakeholder members made during the six-week on-site consultation period.

4.2.4 Stakeholder issues of concern

Outlined below are the main issues that were identified through consultation with stakeholder representatives. The following comments do not necessarily reflect true and accurate records

regarding the estuary, nor do they necessarily reflect the opinion of the study team responsible for preparing this Estuary Management Study.

- **NSW Department of Natural Resources**:
  - DNR were heavily involved in the formulation of the brief for this project and many of their issues have been incorporated into this document.
  - To ensure at the end of the assessment and management planning cycle to have clear direction of the necessary management and planning actions required by all parties to maintain and improve the health of the Nambucca River Estuary.
- **NSW Fisheries - now Department of Primary Industries (DPI)**
  - Bank stability is an issue along the urbanised areas of Tillywilly Creek and Taylors Arm. All foreshore structures need to be approved. Any future applications should avoid use of tyres. A consistent plan needs to be implemented to address this issue of bank erosion/stability. Plan needs to cover the range of bank issues present in the estuary and can possibly be related to river styles. Use of standard approaches will streamline approvals process between DNR/Lands Department/DPI (Fisheries)/Council etc.
  - Planning controls of Council need to prevent conversion of small creek systems in urban drainage lines, such as may be happening in Tilly Willy Creek to avoid the loss of the existing values of these systems.
  - DPI (Fisheries) promotes a 50/100m buffer on all waterways, with a priority for buffers on first order streams.
  - Any entrance modifications, such as dredging will need to carefully consider the implications of increased tidal flushing. Tweed estuary is being heavily impacted by recent growth of mangrove communities to saltmarsh (which is considered a more valuable ecosystem than mangroves mainly due to its increasing scarcity along the NSW coast) and other habitats in the estuary.
  - Fisheries tend to support dredging applications for the benefit of safety, life and property and tend not to support applications for commercial interests. Recent example of a poor dredging decision was made in the Evans River, whereby $250,000 was spent dredging sand only to have it all in-filled once month later.
  - There may be no real benefit in signing oyster leases to prevent theft, as thieves targeting oysters tend to be highly organised and appear to know which racks they want to hit and when.
- **NSW Department of Lands**
  - In NSW, Crown Land includes all areas below the Mean High Water Mark, i.e. the bed of all tidal waterways. Native Title is assumed to exist on the bed of all waterways, unless some extinguishing action has occurred, e.g. transfer of this land to freehold title. It is very difficult under the current legislative process to create freehold land in areas where Native Title has not been extinguished. Where Native Title has not been extinguished, land can only be reserved for passive uses, such as coastal protection, etc.
  - The Department of Lands licences the dredging of marine sands (in consultation with other departments like Primary Industries). Licensing for the purposes of maintenance dredging

(i.e. safety/navigation) is generally not problematic (avoids triggering the Native Title Act). Commercial dredging ventures of marine sands are very difficult to licence (mainly due to the Native Title issue, unless previously extinguished) and would require the support of the NSW Government. All such ventures would require extensive environmental investigations to identify potential impacts. There are no existing titles that will extinguish Native Title near the mouth of the Nambucca River.

- The Estuary Management Study should document Crown Lands in the study area, including what was previously known as Vacant Crown land (now called land for 'Future Public Requirements'). Future Public Requirements land does not typically show up in either the tenure or trust system land areas, consequently, it becomes difficult to manage. It may also represent an opportunity for Council to review their current trusts and potentially streamline all existing trusts in a single trust to facilitate more consistent management of these lands.
- All works or structures built below the Mean High Water Mark (i.e. on Crown Land) need to be licenced by the Lands Department. Consequently any bank works, plantings or otherwise (below the MHWL) should be approved/licenced by Lands prior to proceeding.
- Unauthorised river access needs to be addressed and Council should be the lead agency in respect of this. Department of Lands general policy is that individuals who have an access to the water must own the adjoining land parcel. This does not take into consideration the broader implications of the number of accesses to the estuary. The Department of Lands can be very proactive in administering the details of foreshore structures and may look to the Estuary Management Study/Plan for guidance.

- **Environmental Protection Authority (EPA) – now Department of Environment and Conservation (DEC)**
  - No comments provided.
- **Maritime Authority**
  - Most of the estuary is not speed limited, this is fairly common for most estuaries. However, for safety reasons the Maritime Authority is currently aiming to reduce boat speeds in Inner harbour to 4 knots (from 8 knots).
  - All changes to waterway signage are gazetted by the Maritime Authority and hence require high-level authorisation and all changes put forward need to be realistic and address actual issues (not perceived issues). Generally, amendments will be made when there are navigation and/or safety concerns, for recreational or commercial waterway users, while also taking into consideration the environmental interests of the waterway.
  - Any proposals to restrict boat usage in particular areas needs also to consider the recreational resource value of this natural asset. The Maritime Authority needs to be involved in any proposed waterway usage changes, such as regulations or restrictions (i.e. zonings), as the Authority ultimately need to gazette, implement and regulate the changes.
  - The Estuary Management Study should give consideration to the use of other approaches that do not require excessive regulation and enforcement, such as the use of Boating Codes of Practice, which are essentially an educational tool outlining acceptable boating locations and practices. Such an approach relies on a strong boating fraternity to implement and abide

by the Code. Codes may however not address issues arsing during peak usage times, such as during school holidays.

- Typically, the Nambucca estuary is not a high complaint area, only specific areas on specific days. Due to low numbers of complaints there is a poorly maintained system of recording complaints. Some complaints go to Council, while others go to the Maritime Authority. At present no complaints are received around Macksville area.
- The future upgrade of Macksville ramp should consider current parking issues. Also, upgrading of the ramp will bring additional boat uses into an urbanised section of the river, which over time, may become problematic. Similar problems have been observed in other NSW estuaries. Long-term vision should be applied to have ramps/accesses and associated facilities located/sized in ways that assist in regulating usage, e.g. high quality access points close to major urban centres will be highly used potentially leading to noise issues. However, if accesses are located in more rural locations these impacts are likely to lessen. The quality, type and location of ramps/accesses/facilities will dictate usage patterns and to some degree associated waterway impacts.
- The Maritime Authority has identified that mooring licences were available through their department, however, no formal mooring plan established for Nambucca Estuary. Lack of mooring plan may be problematic in the longer term, when further applications are received.
- Marking of oyster lease areas for tourists could be improved. When oyster leases are being granted, the Maritime Authority is required to comment on the navigational impact of the lease area. Disused leases need to be removed, particularly abandoned leases near the entrance to Warrell Creek.

- **Nambucca Shire Council**
  - Council's LEPs are soon to be "biodiversity certified" which will mean that in rural zonings Council will accept management of "threatened species" in rural zonings.
  - In residential zonings, Council oversee vegetation clearing, however no tree preservation orders in these zones.
- **Commercial Fishermen**
  - Commercial fish catches are seasonal, i.e. good some years, poor others. Entrance shallowing may be related, as its condition may affect fish movements into the estuary. The overall size of the entrance will vary according to tide, consequently fish movements into the estuary will also be affected by the tide at the time they pass by the entrance.
  - Further regulation of the fishing industry may be unwarranted, as it appears to be sustainable at present. The rivers and extent of seagrasses etc are probably the best they have been in 15 years. Although, some parts of the fishing industry could be improved, particularly in relation to its association with the environment.
  - Current numbers of commercial fishermen operating on the Nambucca Estuary are estimated at about five, which is less than there was before the buy-back of licences by NSW Fisheries and creation of recreational fishing havens in 2002. Commercial fishermen from others zones cannot legally fish the river. In around 2000, there was some competition as the Macleay had been shut for a period of time, hence a number of these fishermen came

to Nambucca. Due to the differences that exist in these two systems, most of these fishermen were unsuccessful and have not since returned.

- Most fish commercially caught are mullet. Historically, NSW Fisheries have shown fishing in the Nambucca Estuary to be sustainable. However, the system is unlikely to be as good as it once was. Many wetland areas where fish went to spawn are now inaccessible due to tidal gates (or removed entirely) thereby removing these nursery areas for use by many fish.
- Unusual winds this year have lead to a bad year for fishing in the river, this is the second year running (i.e. 2004 and 2005) that these unusual winds have resulted in bad fishing. The winds prevent the normal fish migration.
- Australian Salmon were present in the waters this year. Salmon are big eater of food and may be in some way affecting the local food chain.
- The prevalence of dams on farms means that there is less freshwater flow to the river, meaning that the salt water can travel further up the river than it may have historically. This may be affecting the breeding cycle of bass, which have to travel to brackish water to spawn. Hence, they are travelling to new territories in order to do this.
- Mullet potentially not coming up into Warrell Creek in same numbers as they may have once historically. This may water quality implications, as the mullet used to feed on seagrasses and now that they are not being removed, the lack of growth by the seagrasses means that there is an excess of nutrients in the water.
- There may be some other specific point sources of pollutants in the upper Warrell Creek area, which is known to have poor tidal flushing. Impacts in this region have been observed to worsen over the last five years.
- Soil dumping in Snakey Creek thought to be contributing pollutants to this creek as eels are dying after freshes.
- Ulceration in whiting, mullet, bream, flathead have been observed in upper reaches of creeks, i.e. from Macksville towards entrance in the Nambucca River and from Scotts Head towards entrance on Warrell Creek. In some instances, approximately 1/3 of catch had some form of ulceration. Similar ulcerations are observed to be common on the Macleay River. DPI (Fisheries) documents the occurrences of ulcerations on caught fish.
- Historically, there was a large seagrass bed extended from Newee Creek to top of Goat Island. This seagrass bed was decimated several years ago and may have been related to the repainting of the Macksville Bridge.
- There was a water quality issue in Warrell Creek around 1996/97, possibly due to a ground disturbance from nearby highway construction activities occurring at that time, consequently no fish were observed in upper Warrell Creek in 1996/97. There had not been any issues for the previous 8 years.

- **Oyster Growers**
  - Boat wash in the river can be a problem for oyster growers. Worst impacts typically occur in the holiday periods due to high levels of boat usage. Associated with this is also a high loss of seagrasses, which can be observed floating along the edges of the river and commonly gets caught up in the oyster racks. Zoning of river for various types of usage or

restricting/regulating usage may assist in reducing boat wash impacts. Boat wash also stirs up sediment along the side of the river can affect oyster quality. There should be no wake boarding on the river. Also further education of boaters regarding the adjustment of their "trim" (i.e. how far the boat sits in the water and hence how much bow wave it can put out) may assist in reducing bank erosion/sedimentation issues.

- **Input from Aboriginal Community**
  - The causeway disconnects the waters of the Nambucca River at Bellwood. Immediately to the south of the causeway is a rockface above a bend in the river, this area is known as a place where Aboriginal ancestors spirit's dwell. With the blocking of the causeway, sedimentation is filling existing holes, degrading water quality and blocking fish passage. The causeway needs to be opened to allow tidal flow to occur.
  - There is a need to introduce tidal flows back under the Stuart Island causeway. At a minimum four culverts are required under the causeway to reintroduce tidal flow. Grates should not be placed at the entrance/exit of culverts as these fill simply capture and trap floating material. There is also a need to keep the banks clean; historically there were white sandy beaches on the Stuart Island side of the Bellwood reserve, reopening the causeway may allow these beaches to return.
  - Swimmer safety in Bellwood reserve area needs to be preserved.

Specific issues requiring attention are addressed in the following in Sections 6 to 15 of the report.

4.2.5 Workshops/Forums

Three nighttime workshops were held within the local community in September 2005 to gain community feedback on the management strategies formulated for the estuary. See section 17.4.1 for more information in this regard.

4.2.6 Review of Preliminary Draft Report

A preliminary draft Estuary Management Study report was prepared and technically reviewed by various State and Local Government bodies including Nambucca Shire Council, Department of Lands, Department of Natural Resources, NSW Maritime Authority and DPI Fisheries prior to the preparation of this draft report. The aims of the review were multiple and included:

- Review of the report format and layout to ensure that the report was not overly cumbersome (given its size) and could still be read and used by the layperson;
- Review of technical elements of the report to ensure that it provided sufficient detail and resolution in respect of what is required within an Estuary Management Study;
- Review of the adequacy and breadth of proposed Management Objectives to ensure that these would form a solid foundation for the development of Management Strategies;
- Review of suggested wording of proposed Management Strategies to identify any significant contradictions between the requirements of the strategies and current Government policy, which would limit future Government support of the strategy. Proposed wordings were also reviewed to ensure that they were as specific to their requirements as possible, thereby reducing potential misinterpretation, as to what the strategy was aiming to achieve.

As a result, there have been some minor changes to the wording and priority ranking of some strategies since they were initially presented to the community in September 2005 (see Section 4.2.5). The wording and priority ranking of strategies presented within the draft EMS and this final EMS report have been developed by WBM based on consideration of both community and government feedback. All recommendations made to WBM have been considered based on their relative merits, rather than based on who made them. The original strategies presented to the community in September 2005 are contained in Appendix G of this report for reference.

4.2.7 Review of Draft Report

The comments received on the draft EMS report have been considered. The comments and additional information considered of importance to this study have been incorporated into the final EMS document (i.e. this document).

5 REVIEW OF STATUTORY CONTEXT

5.1 Estuary Management Process

The Nambucca River Estuary Management Study has been prepared under the NSW Government's Estuary Management Program. The Program is designed to fulfil the requirements of the NSW Estuary Management Policy 1992 (see Section 5.1.2) and the NSW Coastal Policy 1997 (see Section 5.1.3).

5.1.1 NSW Government's Estuary Management Program

In 1992, the NSW State Government introduced an *Estuary Management Policy*, aimed at managing the growing pressures on estuarine ecosystems. The policy is implemented through an Estuary Management Program, which is co-ordinated by the Department of Natural Resources (DNR), in co-operation with local government and the community.

The process of managing an estuary, in accordance with this Policy, is initiated by the establishment of an Estuary Management Committee. In compliance with the Policy, the Nambucca Shire has an active Estuary and Coastline Management Committee, which was formed in 1996. The Committee has overseen the first two stages of the process, including:

1. **Data Compilation Study** - This study completed in 1997, provided a desktop review of the scientific, social and economic information available for Nambucca River. Information compiled via this process formed a major platform for completion of subsequent stages.
2. **Estuary Processes Studies** - This study involved the preparation of a number of process studies to gain an understanding of the broad function and controls of the estuary. The Estuary Processes Study expanded the knowledge base on both physical and ecological processes occurring in the estuary sufficient to enable the later development of an Estuary Management Study. WBM completed the Estuary Processes Study 2000.

To assist the estuary planning process the NSW State Estuary Program through DNR commissioned Manly Hydraulics Laboratory MHL to undertake a full hydrodynamic and tidal gauging of Nambucca Rivers Estuary and its tributaries in May 2002. A time series water quality and water level data logger was placed at Macksville during 1999 to 2000 to provide background information.

The preparation of the Estuary Management Study and Estuary Management Plan represent the final stages in this process. The Estuary Management Study identifies the essential features and the current uses of the estuary, and determines the overall objectives required for management of the estuary. The Estuary Management Study also identifies options for meeting these objectives, and determines environmental impacts of the proposed options.

From the findings of the Estuary Management Study, an Estuary Management Plan is prepared. The Plan describes how the estuary will be managed, gives recommended solutions to management problems, and details a schedule of activities for the implementation of the recommendations. Once both the community and the relevant Government Authorities have accepted the Plan, the Plan can be implemented through planning controls, works programs, monitoring programs, and education

services. The general estuary management process, as established by the NSW Government, is shown in Figure 5-1.

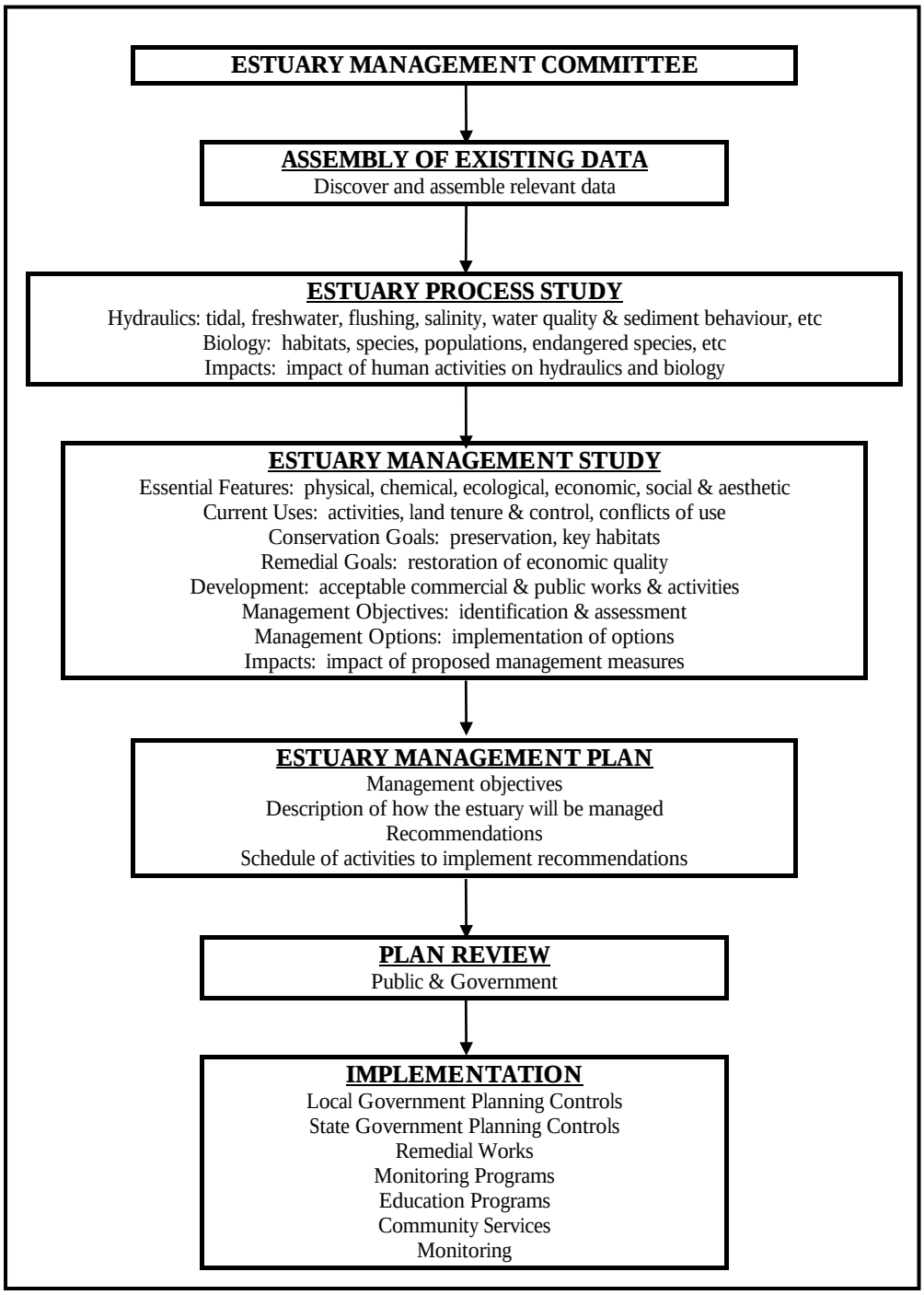


Figure 5-1 NSW government's estuary management process

The procedure of preparing an Estuary Management Plan is documented in the Estuary Management Manual (NSW Government, 1992). The manual broadly describes a systems-based approach to estuary management that includes process and condition definition, management planning and implementation, monitoring of outcomes and plan review.

5.1.2 Estuary Management Policy 1992

The NSW Estuary Management Policy is one of a suite of policies under the umbrella NSW State Rivers and Estuaries Policy. The Estuary Management Policy was developed as part of the State Government's recognition of the social and economic importance of estuaries. The specified general goal of the policy is "to achieve an integrated balance responsible and ecologically sustainable use of the State estuaries which form a key component of coastal catchments".

Specific objectives can be summarised as:

- Protection of estuarine habitats and eco-systems in the long term;
- Preparation and implementation of a balanced long term management plan for the sustainable use of each estuary and its catchment;
- Conservation of habitats;
- Conservation of aesthetic values;
- Prevention of further estuary degradation;
- Repair of damage to the estuarine environment; and
- Sustainable use of estuarine resources.

5.1.3 NSW Coastal Policy 1997

The NSW Coastal Policy is the State Government's response to the challenge of achieving a sustainable future for the NSW coastline while balancing environmental, economic, cultural and recreational needs. The policy is based on two fundamental principles: ecologically sustainable development (detailed below), and integrated coastal zone management (detailed below).

The NSW Coastal Policy 1997 applies to urban and non-urban areas along the NSW Coast, covering land:

- Three nautical miles seaward of the mainland and offshore islands;
- One kilometre landward of the open coast high water mark; and
- One kilometre around all bays and estuaries.

As such, the Nambucca River and its foreshores fall within the jurisdiction of the Coastal Policy.

The Coastal Policy has nine goals, each underpinned by objectives that are to be achieved by strategic actions. Responsibilities for these actions have been assigned to appropriate agencies, councils and other bodies. DNR is wholly or partly responsible for nearly half of the strategic actions in the Coastal Policy, with many of these involving a partnership with local councils.

The nine goals of the NSW Coastal Policy 1997 are:

1. To protect, rehabilitate and improve the natural environment;
2. To recognise and accommodate natural processes and climate change;
3. To protect and enhance the aesthetic qualities;
4. To protect and conserve cultural heritage;

5. To promote Ecologically Sustainable Development;
6. To provide for ecologically sustainable human settlement;
7. To provide for appropriate public access and use;
8. To provide information to enable effective management; and
9. To provide for integrated planning and management.

With regard to the Nambucca River Estuary, the Policy specifically recommends that detailed management plans for estuaries be prepared and implemented in accordance with the NSW Government's Estuary Management Manual (Strategic Actions d f g h).

Ecologically sustainable development

The four principles of Ecologically Sustainable Development (ESD) are:

- *The precautionary principle*: The lack of full scientific evidence should not be used as a justification for the postponement of the introduction of measures to prevent or mitigate environmental degradation. This principle is fundamental to adaptive management. Monitoring and prevention are central to the precautionary principle – monitoring to measure progress, and prevention to minimise costs and risks. Decisions can and should be refined as ongoing monitoring and research provides better understanding.
- *Intergenerational equity*: Each generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for future generations. This principle points to institutional and community responsibilities for integrated management, to ensure quality of life is maintained and enhanced.
- *Conservation of biological diversity and ecological integrity*: Measures should be taken to prevent and protect against the extinction or loss of viability of plant and animal species due to human activities.
- *Improved valuation and pricing of environmental resources*: The quality and value of environmental resources should be maintained and enhanced through appropriate management and pricing, preventing degradation and damage.

As the NSW Coastal Policy 1997 applies to the Nambucca River Estuary, Council is required to reflect the above principles of ecologically sustainable development in planning and management decisions. The Nambucca River Estuary Management Plan will outline a series of actions that are fundamentally aligned with the ESD principles. Therefore, the Plan will provide a framework for implementing these principles as they apply to the estuaries, and their associated catchments.

Integrated coastal zone management

NRMMC (2003) states, "The fundamental goal of Integrated Coastal Zone Management (ICZM) in Australia is to maintain, restore or improve the quality of coastal ecosystems and societies they support. A defining feature of ICZM is that it seeks to address both development and conservation needs within a geographically specific place – a single community, estuary or nation – and within a specified timeframe".

In essence, ICZM is a subset of ESD that relates specifically to the coastal zone. It seeks to protect essential ecological processes and biodiversity, accommodate orderly and balanced resource utilisation, and ensure greater harmony between physical processes and human activities (DNR, in prep.). Within Australia, Coastal Zone Management needs to consider key drivers influencing the sustainable use of the coastal zone, including population growth and demographic shifts; industry trends; protection of the coastal resource base; and climate change (NRMMC, 2003).

5.2 Other government initiatives for natural resource management

In addition to the NSW Estuary Policy and the NSW Coastal Policy, the Estuary Management Plan for Nambucca River Estuary is to consider other Government Initiatives that have been developed with the aim of protection and sustainable management of the State's natural coastal resources. In this regard, the Estuary Management Plan is to be a **fully integrated document**, consistent with the goals of broader natural resource management plans.

Other Government initiatives and programs that have been considered and incorporated into the Nambucca River Estuary Management Plan are listed below and are described in the following sections.

- *Environmental Planning and Assessment Act, 1979*, and associated State Environment Planning Policies (SEPPs);
- North Coast Regional Environmental Plan;
- EPA Stormwater Management Program;
- Coastal Protection Package; and
- Catchment Action Plan.

5.2.1 *Environmental Planning and Assessment Act,* 1979 (EP&A Act)

One of the key pieces of NSW legislation is the *Environmental Planning and Assessment Act*. 1979. This Act provides a system of environmental planning and assessment for NSW. A number of objectives are specified under the Act, as follows:

- Appropriate management, development and conservation of natural and artificial resources so as to promote the social and economic welfare of the community and a better environment;
- Facilitation of the orderly and economic use and development of land;
- Ensure appropriate provision and management of communication and utility services;
- Provide land for public purposes;
- Provide for and coordinate community services and facilities;
- Encourage the protection of the environment and facilitate ecologically sustainable development;
- Enable the provision and maintenance of affordable housing;
- Share the responsibility for environmental planning and management between the State and Local Government; and
- Facilitate increased opportunity for public involvement and participation.

5.2.2 State Environmental Planning Policies (SEPPs)

These planning policies are instruments under the *Environmental Planning and Assessment Act*, 1979. They deal with issues significant to the state and people of New South Wales.

SEPP 14 – Coastal Wetlands

Preservation and protection of coastal wetlands is the aim of this policy. It is recognised that coastal wetlands serve statewide environmental and economic interests. The policy applies to wetlands in the State identified as needing protection by the Department of Natural Resources (DNR). Any development that would involve clearing, construction of levies, draining or filling of wetlands requires consent of the local council and the concurrence of the Director of DNR. Restoration works also require the consent of the local Council and the concurrence of the Director. The Department of Environment and Conservation (DEC) must be notified of development proposals within SEPP 14 wetlands.

SEPP 14 wetlands in the study area are discussed in Section 10.2.9.3.

SEPP 26 – Littoral Rainforests

This policy was devised to provide a mechanism for the consideration of applications for development that were likely to damage or destroy littoral rainforest areas with a priority to preserve those areas in their natural state. The policy applies to land identified by DNR as containing littoral rainforests.

Once again the consent of the local council and the concurrence of the Director of DNR must be obtained for the purposes of erecting a building, carrying out work, use of the land, subdivision or any work that could disturb, change or alter the landform and/or remove, damage or destroy any native flora or other element of the landscape.

There are gazetted SEPP 26 littoral rainforest areas within the Nambucca River Estuary study area as discussed in more detail in Section 10.2.9.2.

SEPP 35 – Maintenance Dredging of Tidal Waterways

This policy was developed to facilitate the maintenance dredging of tidal waterways by public authorities provided the works were carried out in a timely, cost effective and environmentally responsible way. The aim of the policy is stated as being to rationalise the planning controls applicable to the carrying out of maintenance dredging of tidal waterways. In this regard public authorities can undertake maintenance dredging without the need to obtain development consent.

Maintenance dredging should not be undertaken until all environmental impacts are identified and assessed. As part of the process the public authority needs to consult with effective bodies including councils and to take into account the views of those consulted.

SEPP-35 has historically been used as a mechanism for Councils to carry out dredging works of tidal entrances in order to improve tidal flushing and to restore or improve navigation. In some instances, SEPP-35 has been used to allow Council's to artificially open coastal lagoons that are closed and have elevated water levels (possibly threatening public or private assets). Legal advice to DNR has

indicated that opening of ICOLL entrances for the purpose of flood mitigation is an unlawful use of SEPP-35 (Haines, 2004). It is expected that future amendments to the Water Management Act 2000 will prevent SEPP-35 from being used for this purpose, although the timeframe for this is unknown.

SEPP 71 – Coastal Protection

SEPP-71 is a relatively new policy (gazetted November 2002), which applies to the coastal zone of NSW including a large percentage of the Nambucca River Estuary. Under the policy the NSW Minister for Infrastructure, Planning and Natural Resources becomes the consent authority for State significant coastal development. State significant coastal development includes mining, extractive industry, industry, landfill, recreational establishments, marinas, tourist facilities (except bed and breakfast establishments and farm stays) and buildings greater than 13 metres in height above the natural ground level.

It also includes development comprising subdivision of land:

- within a residential zone into more than 25 lots;
- within a rural residential zone into more than five lots; or
- within any zone into any number of lots if effluent is proposed to be disposed of by means of a non-reticulated system.

The policy also defines sensitive coastal locations and generally requires development applications proposed for these areas to be referred to the Director General of DNR for comment.

Master plans are required to be approved by the Minister before some consents can be granted. Generally a master plan is a document consisting of written information, maps and diagrams that outline proposals for development of land.

Other SEPPs

There are a number of other State Environmental Planning Policies (SEPPs) that are applicable to developments within the study area, but are considered not to be of significance regarding the long-term management of the estuarine receiving waters. These SEPPs include:

- SEPP-5: Housing for older people or people with a disability;
- SEPP-6: Number of storeys in a building;
- SEPP-9: Group homes;
- SEPP-11: Traffic generating developments;
- SEPP-55: Remediation of Land;
- SEPP-62 : Sustainable Aquaculture;
- SEPP-64: Advertising and signage; and
- SEPP-65: Design quality for residential flat development.

5.2.3 North Coast Regional Environmental Plan 1988

The North Coast Regional Environmental Plan 1988 (NCREP) is an overarching planning document that has been prepared by the now DNR. It details a range of matters that Council's, including the Nambucca Shire Council, must consider when preparing draft Local Environmental Plans (LEPs) and when considering development applications (DAs). NCREP must be consistent with all relevant SEPPs, as discussed in Section 5.2.2.

Several Clauses within the NCREP address specific considerations relating to developments near waterways or environmental important or culturally significant areas, including for example Clauses 15, 29A, 32B, 33, 36A, 36B, 36C, 36D, 36E, 36F, 76 and 81.

5.2.4 Stormwater management planning

In April 1998 the NSW Environment Protection Authority (EPA) issued a directive under Section 12 of the *Protection of the Environment Administration Act* requiring councils to prepare stormwater management plans. The primary purpose of preparing urban stormwater management plans was to improve the health and quality of the State's urban waterways.

The stormwater management plans were to address environmental issues including stormwater quality, river flow, riparian vegetation and aquatic habitat management. A stormwater management plan was not intended to be a flood or drainage management plan. This program relates to the State Government's water reforms in that water quality and river flow objectives were to be established. These were expected to be the long-term objectives of the stormwater management plans.

The Nambucca Shire Stormwater Management Plan (2000) was prepared by Council in response to the EPA requirements. The Plan identifies stormwater issues, values, objectives, pressures, and responses strategies for the major urban areas within the Nambucca Shire and is described further in Section 15.2.

5.2.5 Mid North Coast Catchment Blueprint

The Mid North Coast Catchment Blueprint was prepared by the Mid North Coast Catchment Management Board (MNCCMB) in 2002 (the MNCCMB was replaced by the NRCMA in 2003 and a Catchment Action Plan has replaced the Blueprint, see Section 5.2.6). The Mid North Coast Catchment area encompasses the catchments of the Nambucca, Macleay, Hastings and Camden Haven Rivers within the Mid North Coast and Southern New England Tablelands regions of New South Wales. The blueprint provides a framework for natural resource management of the Mid North Coast Catchment Management Region. The blueprint sets targets and priorities for environmental action and investment in the region over the next 10 years. The MNCCMB is made up of representatives of primary producers, natural resource users, environmental groups, government and indigenous people.

The Blueprint consists of:

- **First order objectives**: which provide a statement of the community's values about the desired state and functioning of the region's natural resources;

- **Catchment targets**: which indicate what needs to be achieved across the landscape to meet the first order objectives. They are specific, measurable, achievable, relevant and time-bound. These measurable targets will provide a means of evaluating the effectiveness of the Blueprints and their management actions;
- **Management targets**: which state what has to be done to achieve the catchment targets. Again, they are specific, measurable, achievable, relevant and time-bound; and
- **Management actions**: which specify who is responsible for what by when, in order to meet the catchment and management targets.

The Mid North Coast Catchment Blueprint focuses on Landuse and Planning, Stream Health, Acid Sulphate Soils, Vegetation and Biodiversity. Each of these broad issues contains specific catchment and management targets.

The first order objectives for the Mid North Coast Catchment Blueprint include:

- "Healthy aquatic systems, with water quality and quantity meeting the needs of the environment and the community".

The catchment target for Land Use and Planning is:

- "By 2012 mechanisms in place for effective land use planning and management addressing human settlement, sustainable development, heritage and rural production issues in a natural resource management context".

The specific management targets for the Nambucca River Estuary:

- "By 2012 plans in place for management of the coastal zone in each of the three main coastal government areas";
- "By 2012 complete and implement and Estuary Management Plan"; and
- "By 2005 Adopt ASS LEP and DCP for Nambucca Council".

It should be noted that there are a host of other management items, which will relate to the Nambucca River Estuary study area and haven't been specifically listed above.

5.2.6 Northern Rivers CMA and Catchment Action Plan

In early 2004, the Catchment Management Boards of NSW were replaced with new Catchment Management Authorities, with delegation under the Catchment Management Act. The former Mid North Coast Catchment Management Board was incorporated in the Northern Rivers Catchment Management Authority (NRCMA). The first task of the NRCMA is to prepare a Catchment Action Plan (CAP) to outline how catchment management will be carried out within the NRCMA jurisdictional boundaries.

The NRCMA will be responsible for:

- Preparing a Catchment Action Plan (CAP) and associated investment strategies that integrate and enhance the Catchment Blueprints (see discussion above) and the regional vegetation management plans;

- Managing incentive programs to implement the CAP;
- Providing all landholders with access to data and relevant information to prepare Property Vegetation Plans (PVPS);
- Allocating funds to support the development of PVPs - including incentives;
- Providing education and training on natural resource management, especially in vegetation management; and
- Developing transparent procedures for handling local disputes related to implementing the CAPs.

The CMA Boards will be responsible for the creation and implementation of CAP, associated investment strategies and corporate governance. The CAP for the Northern Rivers is presently in its final stages of preparation and will soon be presented to the Minister and Natural Resources Commission for endorsement.

5.3 Existing council planning framework

5.3.1 Nambucca Shire Local Environmental Plan 1995 (LEP 1995)

In addition to the State Government Plans and Policies, the Nambucca River Estuary Management Plan needs to be consistent with, and fit into, the existing Nambucca Shire Council planning framework. The Council planning framework is based around a central Local Environment Plan, i.e. LEP, 1995 and a number of supporting Development Control Plans (DCPs). The Plan itself is not a definite statement for development control. The DCPs supplement the Plan and provide for more detailed controls relating to specific types and forms of development throughout the Shire. Generally, DCPs have been prepared to conserve particular values and attributes of the Shire and its natural environment.

The Nambucca LEP is consistent with the NCREP and defines landuse zones, which prescribes permissible developments throughout the LGA. The LEP also details a range of specific controls relating to development matters, such as subdivisions, height restrictions, clearing and offsets.

The actual waterway of the Nambucca River Estuary transects several landuse types (see Figure 6-1) including:

- 1(a): Rural;
- 2: Residential;
- 3(a): General Business;
- 5(a): Special Uses;
- 6(a) and (c): Recreation;
- 7(a): Environmental Protection; and
- 10: Low Density Tourist.

The Nambucca Shire Council is currently in the process of comprehensively reviewing its LEP as the plan is now ten years old and a number of anomalies have been identified. More detailed information in relation to the Nambucca LEP and land use zoning of the study areas is provided in Section 6.1.

5.3.2 Development control plans

Development Control Plans (DCPs) are non-statutory policies that provide specific Council requirements regarding various aspects of development within the LGA. Development Control Plans that are applicable to the Nambucca River Estuary study area include:

- DCP 10 – Guidelines for Exempt and Complying Development: Complements the provisions of the Nambucca LEP 1995 by providing details of present standards to be met by categories of exempt and complying development. Aims to ensure that development is environmentally responsible and compatible with the character and amenity of surrounding development. This DCP is largely overridden by SEPP-71 – Coastal Protection within the coastal zone.
- DCP 11 – Building Line Setback, Urban and Rural Areas: Controls building line setback requirements on all land zoned rural, environmental protection, residential, industrial or private recreation. Generally focus of DCP is on aesthetics and safety, not environmental protection.
- DCP 15 – Acid Sulfate Soils: aims to ensure the effective management of area affected by acid sulfate soils
- DCP – Rural Subdivision: applies to all subdivisions within rural and environmental protection zones identified under the Nambucca LEP 1995.
- DCP – Residential Development: Provides design controls and guidelines for urban housing and subdivision. One of the objectives of this DCP is to encourage innovative urban form that is environmentally sensitive.
- DCP – Urban Release Areas: Applies to those parts of the Nambucca Shire, which are Urban Release Areas and includes (within the study area) Bowraville, Congarinni/South Macksville and Scotts Head. The DCP extends the supports of the objectives of the 1(d) zone of the Nambucca LEP. The primary objectives of the DCP are:
  - To identify land which is to be investigated in respect of its suitability for rezoning at a later date for urban purposes;
  - To ensure that development within the zone is compatible with the anticipated urban development of the land;
  - To ensure that the development maintains the rural character of the locality and minimize disturbance to the landscape through clearing, earthworks and access roads;
  - To ensure that development does not create unreasonable or uneconomic demands, or both, for provision or extension of public amenities or services; and
  - To ensure that the release of land for urban purposes, by rezoning, shall not take place unless:
    a. Sufficient demand exists for the release of urban lands; and
    b. Appropriate urban infrastructure and facilities are available to the land or can be provided to the land in a manner which does not create an unreasonable or uneconomic demand, or both, for the provision or extension of such services.

6 ASSESSMENT OF EXISTING LAND TENURE AND USAGE

Land use within a catchment impacts on the health and condition of its downstream environments. The Nambucca River catchment is likely to have been completely forested prior to European settlement. Since then there have been numerous changes to the land use, i.e. vast areas of the catchment have been significantly altered by the clearing of trees for agricultural pursuits. This change in land use is likely to have had a significant impact on the extent of available habitats and their connectivity, which in turn is likely to have negatively affected the distribution and livelihood of a range of fauna. Also, the changed hydrology and water quality of runoff into the estuary is likely to have exacerbated bank erosion and sedimentation in the estuary. Other changes in land use, such as the establishment of urban areas, have also decreased the quality of catchment runoff, which is likely to have lead to a decrease in water quality in the estuary.

Land use in the study area is controlled by the Nambucca Shire Council's Local Environment Plan (LEP), which was produced in 1995. The LEP categorises land in the Shire into a variety of zones. These zones generally dictate what type of land use is acceptable in these locations. In recent years there has been a sharp increase in the number of Development Applications (including sub-divisions) received by the Nambucca Shire Council. Poor planning decisions made by Council may lead to inappropriate land use activities occurring in areas that may impact on the uses and values of the estuary.

The Nambucca Shire Council is soon to review its LEP. This review process represents an ideal way to integrate additional safeguards to ensure that the estuary remains suitable for its desired usage and that the existing values of the estuary are preserved or enhanced. It is the aim of the Estuary Management Study and Plan to support the planning processes of Council, by providing advice in relation to the most appropriate land use and development controls to protect the health of estuary, in recognition of its large contribution to residents quality of life and the support it provides to local commercial activities.

This chapter provides a summary of the land usage, tenure and development status of the catchment and river. Items considered includes current land use, areas of urban / rural / industrial development, open space dedications and environmentally protected areas. The status of foreshore land tenure and associated structures is also examined.

The layout of this section is as follows:

- Review of existing land use zoning (see Section 6.1);
- Review of existing land use (see Section 6.2);
- Review of existing land tenure (see Section 6.3); and
- Summary (see Section 6.4).

Sections 5.2 and 5.3 also provide a review some relevant statutory controls for estuarine management at both the State and Local Government level.

6.1 Review of Council's land use zoning

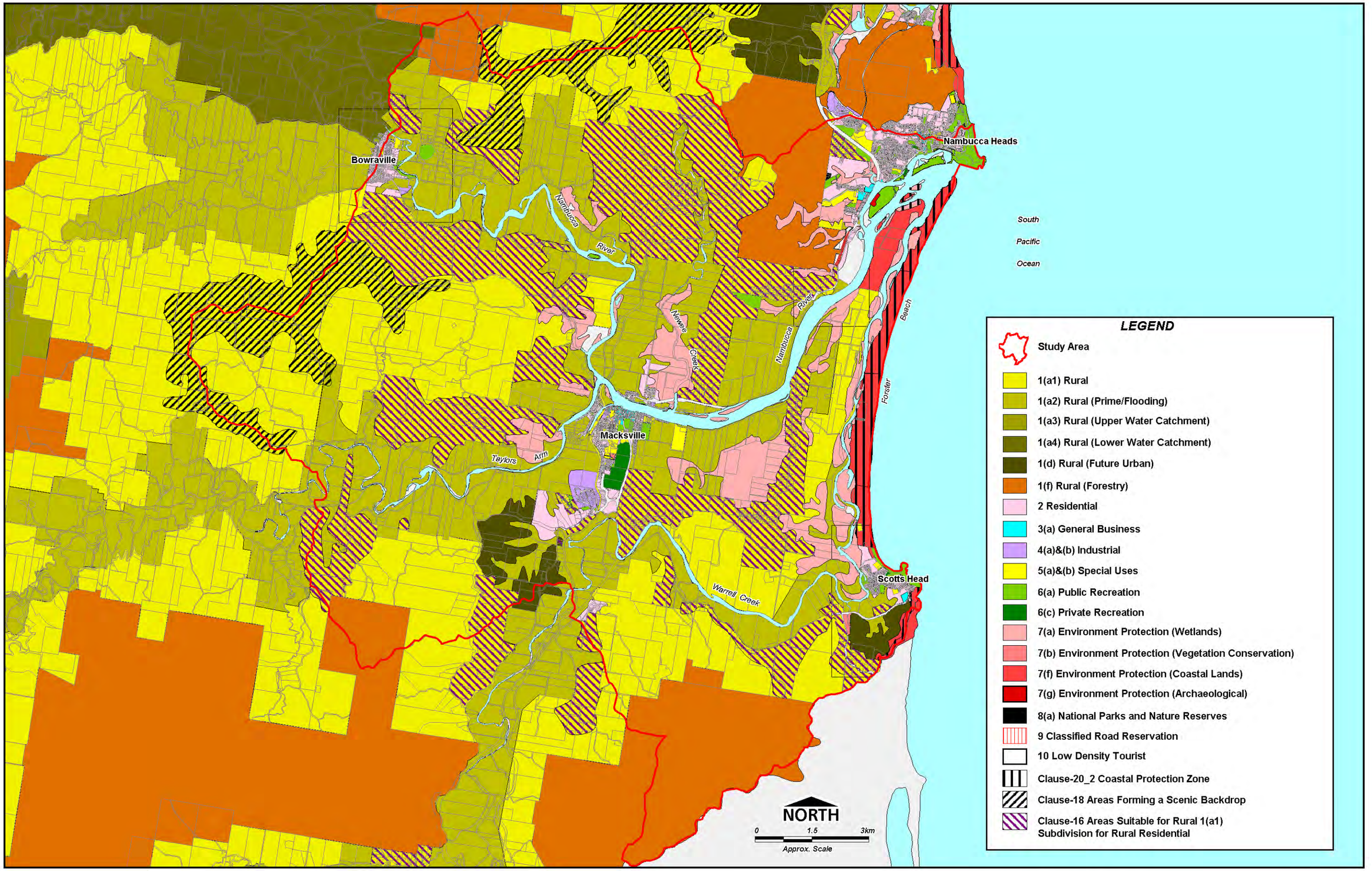
Permitted land use within the study area (and Shire) is detailed in the Nambucca Local Environment Plan (LEP), 1995. The LEP is the centrepiece of Council's planning framework, however, it is not a definitive statement for development control. Consequently, the LEP is supported by a number of Development Control Plans (DCPs), which provide more detail in relation to controls for specific types and forms of development throughout the Shire (see Section 5.3.2 for more detail on some of the more relevant DCPs). Generally, DCPs have been prepared to conserve particular values and attributes of the Shire and its natural environment or particular location within the Shire. A map of current land-use zonings as set out in the Nambucca LEP (NSC, 1995) is shown in Figure 6-1.

Table 6-1 details all zones in the LEP and the area of land they occupy in the study area.

Table 6-1 LEP land-use zonings in the study area

Zone	Description	Area in Study Area (km^2)	Percentage of Study Area *
1(a1)	Rural	120.00	47.34%
1(a2)	Rural (Prime/Flooding)	66.33	26.19%
1(a4)	Rural (Lower Water Catchment)	0.24	0.09%
1(d)	Rural (Future Urban)	3.90	1.54%
1(f)	Rural (Forestry)	24.19	9.54%
2(a)	Residential (Low-Medium Density)	4.18	1.65%
2(c)	Residential (Flood Liable)	0.11	0.04%
2(d)	Residential (Tourist)	0.45	0.14%
2(v)	Residential (Village)	0.89	0.35%
3(a)	General Business	0.30	0.12%
4(a)	General Industrial	0.65	0.26%
4(b)	Industrial (Business)	0.04	0.02%
5(a)	Special Uses	1.18	0.47%
5(b)	Special Uses (Railway)	0.15	0.06%
6(a)	Public Recreation	2.36	0.93%
6(c)	Private Recreation	0.60	0.24%
7(a)	Environment Protection (Wetlands)	14.25	5.62%
7(b)	Environmental Protection (Vegetation Conservation)	0.17	0.07%
7(f)	Environmental Protection (Coastal Lands)	5.46	2.15%
7(g)	Environmental Protection (Archaeological)	0.04	0.02%
8(a)	National Parks and Nature Reserves Zone	0.02	0.01%
9	Classified Road Reservation	0.03	0.01%
10	Low Density Tourist	0.10	0.04%
		Total	***96.97%***

* The total study area is 253.5 km^2.



LEP Zonings of the Study Area Figure 6-1

Areas zoned by Nambucca Shire Council account for 97% of the study area. Remaining areas not zoned principally include the waterway area, which is approximately 8 km^2 (or 3%) within the study area.

As can be seen from Table 6-1, the most common land zonings in the study area are:

- Rural 1(a1) – 47.3%;
- Rural (Prime/Flooding) 1(a2) – 26.2%;
- Rural (Forestry) 1(f) – 9.5%;
- Environment Protection (Wetlands) 7(a) – 5.6%; and
- Environmental Protection (Coastal Lands) 7(f) – 2.2%.

These top five land zonings account for over 90% of the study area, with rural lands occupying three quarters of the total study area. Urban, industrial, commercial and other public/private recreational lands occupy less than 5% of the total study area. It is clear from these basic statistics that land usage on the rural zoned lands will have a major influence on the health of the estuary. In stating this, it is important to recognise that the remaining parts of catchment, outside of the study area, are also likely to have a significant impact on the health of the estuary.

The following sections provide details of the various zonings included in the LEP, their intent and how they relate to the study area. It should be noted that the LEP contains 65 clauses. The relevant clause numbers of the LEP are noted in parentheses.

6.1.1 Residential land (clauses 25 to 30A)

Residential land zonings in the LEP include 2(a), (b), (c), (d) and (v) as described in Table 6-1. There are four main sites of residential (i.e. urban) development in the catchment including Nambucca Heads, Macksville, Bowraville and Scotts Head.

Nambucca Heads is characterised primarily by a mixture of 2(a) and 2(b) zonings, with the 2(b) zoning (i.e. medium-high density) generally occupying the higher or foreshore lands where people will be more willing to live in high density apartment and unit blocks. The low-medium density housing lots, i.e. those zoned 2(a), exist mainly in the northern and western regions of Nambucca Heads and include the housing areas of Bellwood Estate. During the time of site inspections, a large portion of land (approximately 40ha) to the north of the Bellwood Estate (on the other side of Swampy Creek) had been cleared for low-medium density housing as shown in Figure 6-2. There are also some small pockets of Residential (tourist) land, i.e. zone 2(d) located within Nambucca Heads.

Macksville is characterised by a medium-high residential density area to the south-west of the central business district. Low-medium density residential areas exist to the south (towards the industrial estate), east (towards the Donnelly Welsh Sporting Complex) and on the north side of the Nambucca River (i.e. North Macksville). A region of Residential (Flood Liable) land, i.e. zone 2c, exists to the west of Tilly Willy Creek (i.e. Jellicoe and Sturdee Streets).

Figure 6-2 Areas of cleared land near Swampy Creek

Scotts Head is similar to Nambucca Heads in that it has some medium-high density housing in the higher more scenic portions of the township with low-medium density housing surrounding it. A large tract of land (approx. 15 ha) to the north of the township is zoned 2(d). At the time of inspection this land had been cleared with a number of houses under construction.

The entire Bowraville township is designated Residential (Village) i.e. zone 2(v) land.

All of these urban areas are serviced with town water and sewerage facilities, however, there are some isolated parts of these townships that may be without these facilities (T. Pedlow NSC, Pers Comm., 2004).

6.1.2 Rural land (clauses 11 to 24)

Residential land zonings in the LEP include 1(a1), 1(a2), 1(a3), 1(a4) and 1(d) and 1(f) as described in Table 6-1.

Rural lands zoned 1(a1) encompass the majority of the study area, as designated in the LEP, are of secondary agricultural value to the lands zoned 1(a2), however this zoning aims to encourage and protect agricultural/commercial use of the land. Today, most agricultural pursuits on this zone are of a small-scale and include cattle grazing (mainly for beef production), horticulture and some plantation forestry areas as shown on Figure 6-3. Rural residential development is permissible in the Rural 1(a1) zone. Existing rural residential areas in the study area include:

- Alexandra Drive to the west of Nambucca Heads;
- Florence Wilmont Drive/Alfred Close in between Macksville and Nambucca Heads;
- Old Coast Road/Letitia Close and Mattick Road in between Macksville and Nambucca Heads;
- Pade Crescent/Hopewood Crescent area, Newee Creek;
- Boulton Close and Gumma Road area, Gumma; and
- Preston Drive, south of Macksville;

Generally, the rural residential lots are located in the more scenic elevated portions of the catchment. The number of lots in the existing subdivisions ranges from approximately 1 lot to 100 lots. These lots vary in size, but would be considered to be typically between 0.5 and 2 ha. The LEP allows subdivision down to 0.5 ha if sewered and 1 ha if unsewered.

From consultation with some of the stakeholders and landowners in the study area there are a number of rural residential subdivisions being proposed in the study area, many of which are yet to gain planning approval and thus are not yet in Council's mapping data.

The Rural (Prime/Flooding), i.e. zone 1(a2), lands are the second most common land use in the study area and comprise approximately one quarter of the study area. These lands are generally centred on the floodplains adjacent to the Nambucca River, Warrell Creek and its tributaries. These lands would have been cleared preferentially from 1860's onwards (Lyall & Macoun, 1999), owing to their fertility and proximity to the river which at that time was the only means of importing and exporting goods from the area. Today, most agricultural pursuits in this zone are of a small-scale and include cattle grazing (mainly for beef production), horticulture and some plantation forestry areas, as shown on Figure 6-3. Subdivision of these lands can have a minimum lot size of 40 ha.

Rural (Future Urban) lands, i.e. zone 1(d), are located about 5 km to the southeast of Macksville town centre and about 2 km to the south of Scotts Head town centre. Subdivision on these lands can have a minimum lot size of 20 ha prior to further subdivision for urban land.

Land zoned 1(f) Rural (Forestry) includes State Forest areas. Within the study area there are four State Forest regions. Immediately to the west of Nambucca Heads is the Nambucca State Forest. To the north of Bowraville is the southern end of Viewmont State Forest, while Eungai National Forest is located on the southern extents of the study area.

Clause 16 of the LEP applies to rural residential development which consists of subdividing land and erecting dwelling houses within Zone 1(a1) identified for rural residential development, as shown on Figure 6-1. Council cannot grant development consent unless the subdivision design complies with Schedule 1 of this clause. Schedule 1 provides a number of considerations for rural residential sub-divisions. Points of special note include:

- Minimum lot sizes can be 0.5 ha where connected to sewerage and 1ha where not connected;
- Land must be suitable for the disposal of effluent;
- The design of the allotments created by the subdivision is to be compatible with the suitability and capability of the land;
- The allotments shall not be affected by seasonally high water table, flooding, slopes exceeding 25% grade and significant vegetation areas;
- The proposed development will maintain, where possible, the existing amount, diversity and form of native vegetation and wildlife habitat areas;
- The proposed development will not lead to excessive runoff or erosion; and
- The aquatic environment and its water quality will not be detrimentally affected by the development.

Clause 18 of the LEP which describes the controls applying to the clearing of land within the rural zoned lands, i.e. 1a(1), 1(a2), 1(a3), 1(a4), and 1(d). The clause identifies the conditions under land in these zones may be cleared or logged. Figure 6-1 identifies lands in which, clearing or logging must be considered by Council, as this land is forms a scenic backdrop to urban areas.

Clause 20.2 of the LEP indicates that Council must not grant consent to development on land within zone 7(f) without appropriate approvals. This protected zone is shown on Figure 6-1.

6.1.3 General business (clauses 31 & 32)

The 3(a) zoning designates general business land (i.e. retail) areas in the LEP. General business lands in the study area exist at:

- Nambucca Heads – near the central business district (CBD) adjacent to Bowra St and near the Nambucca Plaza in Bellwood;
- Macksville – around the CBD of the Macksville; and
- Scotts Head – opposite the caravan park on Adin St. Another large area of land (approx. 3.4 ha) has been set aside as general business to the south of Scotts Head in the new development area bounded by Waratah St, Hill St and Scotts Head Road.

6.1.4 Industrial land (clause 33)

The LEP contains zones 4(a) General Industrial and 4(b) Industrial (Business).

The only General Industrial Land, i.e. zone 4a, within the study area is the Industrial estate at Macksville. There is another industrial zoned area just to the north of the study area (adjacent to the Pacific Highway on the western side of Nambucca Heads). The Macksville Industrial Estate comprises bulky goods retail outlets and light industry. Under the LEP, zoning the Macksville Industrial Estate has significant capacity to expand to the north. The ultimate potential extent of this Estate is bounded by the North Coast Railway Line to the east, Tilly Willy Creek to the north and vegetated low-lying land to the west.

There are some smaller areas of Industrial (Business), i.e. zone 4(b) land located along McKay and West Streets in Macksville. The old Midco site on Bellevue Drive, Macksville, is also zoned Industrial (Business).

6.1.5 Special uses (clauses 34 to 35A)

The LEP contains zones 5(a) Special Uses and 5(b) Special Uses (Railway).

The Special Uses, i.e. zone 5(a) land generally refers to lands, which are for community, or government uses (not including railway land.). Within the study area, these lands include schools, sewage treatment plants, places of worship, court houses, cemeteries, refuse tips, fire stations, libraries, post offices, telephone exchange, hospitals, police and ambulance stations, etc. Given the nature of the uses, land with this zoning is typically located near a major urban centre.

The Special Uses (Railway), i.e. zone 5(b) lands includes the easement of the North Coast Railway line.

6.1.6 Recreational open space (clauses 36 & 37)

The LEP contains zones 6(a) Public Recreation and 6(c) Private Recreation.

As described in the LEP, the Public Recreation lands, i.e. zone 6(a) lands are used for active and passive recreation. Land in this zone is either used by the Council, or under the care, control or management of Council or is in private or public authority ownership and is yet to be acquired by the Council or dedicated to the Council for use for Public Recreation. Some of the land with this zoning is Crown land managed by Council.

Lands with this designated include:

- Nambucca Heads - Council's Public Recreation areas include the headlands, most of Stuarts Island, public parks, sporting facilities, foreshore reserves and a number of sand islands in the lower estuary;
- Macksville - Council's Public Recreation areas include various parks and sporting facilities, e.g. pool, tennis courts, ovals, etc, as well as the North Macksville Environment Park. In between Nambucca Heads and Macksville there exists a area of Public Recreation land near the Florence Wilmont Drive rural subdivision (approximately 18 ha in size);
- Scotts Head - Council's Public Recreation areas include ocean foreshore areas and a riparian strip adjacent to Warrell Creek. Other areas include playing fields and parks; and
- Bowraville - Council Public Recreation areas include various riparian strips adjacent to the Nambucca River, parks and the racecourse.

As described in the LEP, the Public Recreation lands, i.e. zone 6(c) lands are privately owned lands used for recreational purposes such as licenced clubs, caravan parks, etc. Examples include the Macksville Country Club and Golf Course, White Albatross Tourist Park at Nambucca Heads.

6.1.7 Environmental protection areas

The LEP contains zones 7(a) Environment Protection (Wetlands), 7(b) Environmental Protection (Vegetation Conservation), 7(f) Environmental Protection (Coastal Lands) and 7(g) Environmental Protection (Archaeological).

The Environmental Protection (Wetlands), i.e. zone 7(a) lands in the study area are the fourth most abundant in the study area, comprising over 5% of the total area. This LEP designation covers wetland areas in the study area, which by the nature of wetlands are typically located adjacent to the Nambucca River (including Taylors Arm), Warrell Creek and their tributaries. Some of the most significant areas are the 100-acre swamp, Gumma Gumma wetland, lower Newee Creek, Bellwood Creek and the riparian portions of Warrell Creek as far as Scotts Head. The LEP states that zone 7(a) lands should cover all SEPP14 wetlands areas however, from a comparison of the extent of the zone 7(a) and SEPP 14 wetland areas, it is clear that this zoning fails to protect all SEPP 14 wetland areas. This issue is further discussed in Section 10 and is shown in Figure 10-10.

The Environmental Protection (Vegetation Conservation), i.e. zone 7(b) lands identifies natural scenic and bushland areas. Within the study area there are several areas with this designation ranging in size from approximately 1ha to 5ha.

The Environmental Protection (Coastal Lands), i.e. zone 7(f) lands identifies coastal foreshore areas, which are important environmental and recreational resources. In the study area these lands are primarily located along the coastal strip (i.e. lands between the ocean and Warrell Creek) starting just below Scotts Head (but not including the township of Scotts Head) and extending along the frontal dune as far as the south head of Nambucca Heads. Another portion of land exists (approx. 118ha) back from Warrell point.

The Environmental Protection (Archaeological), i.e. zone 7(g) lands identifies areas of significance to the local Aboriginal community. Within the study area there is a 3.5 ha site on the northern edge of Stuart's Island.

6.1.8 National parks and nature reserves (clause 38)

The LEP zone 8(a) is for National Parks and Nature Reserves. The zone applies to land administered by the National Parks and Wildlife Service. Within the study area there are no National Parks, however, there is a small Nature Reserve adjacent to the Nambucca State Forest.

There was a proposal to form the Warrell Creek Nature Reserve, however, this Nature Reserve can only be formed once Aboriginal Land Claims are determined in this area and more information is provided in Section 6.3.2.

6.1.9 Classified road reservation (clause 39)

The Classified Road Reservation, i.e. zone 9, applies to a section of roadway south of Teagues Creek in Lower Nambucca (approximately 1km long by 50m wide). The zoning protects this portion of land from any inconsistent usage.

6.1.10 Low density tourist (clause 40)

The Low Density Tourist, i.e. zone 10, applies to two parcels of land (approx. 10ha in size) adjacent to the Pacific Highway south of Teagues Creek in Lower Nambucca.

6.1.11 Heritage conservation (clauses 41 to 47)

This section of the LEP, describes Council's aims in relation to heritage and how items may be conserved and the implications of development that may occur near known or potential archaeological sites. A number of schedules under this clause identify:

- Heritage conservation areas including the Nambucca North Headland area;
- European heritage items of Macksville and Bowraville; and
- Potential archaeological sites in the Shire.

6.1.12 Special provisions (clauses 48 to 65)

This section of the LEP detail 'special provisions' that relate to land usage, some of these are detailed below:

- Development of land subject to bushfire hazards;

- Restrictions applying to development of flood prone land;
- Temporary use of land;
- Development for certain additional purposes on specific land;
- Restrictions applying to council works;
- Restriction applying to development near zone boundaries;
- Restrictions applying to development of Aboriginal Conservation areas and relics;
- Provisions applying to advertising;
- Provisions applying with respect to development adjoining extractive industries;
- Buffer provisions applying to other land use activities;
- Restrictions applying to development of classified roads;
- Provisions applying to acquisition and development of land reserved for classified road;
- Provisions applying to construction of dams;
- Classification and reclassification of public land as community land and operational land;
- Provisions applying to development below the high water mark; and
- Services required for the carrying out of residential development.

6.2 Current land usage

A map of current land usage within the catchment has been developed and is shown in Figure 6-3 and is supported by the land use statistics presented in Table 6-2.

Table 6-2 Land use in the study area

Landuse	Area in Study Area (ha)	Percentage of Study Area
Water	885	3.49%
Cleared / grazed (includes urban areas)	12,750	50.30%
Remnant vegetation	11,000	43.39%
Re-growth (weeds and native regeneration)	475	1.87%
Forest plantation (does not include native remnant held under State Forest)	80	0.32%
Horticultural	160	0.63%
TOTAL	***25,350***	***100%***

It is estimated that there is approximately 660 ha of urban land within the study area, which equates to approximately 2.5% of the total study area.

The study area is nearly evenly divided between lands that are cleared and may be being used for such uses such as cattle grazing and lands used for remnant vegetation, regrowth and waterway areas. There is also a small portion of the catchment used for forest plantation and horticulture.

Most of the existing remnant vegetation is discontinuous in the more western portions of the study area.

Land Use in the Study Area Figure 6-3

6.3 Current land tenure

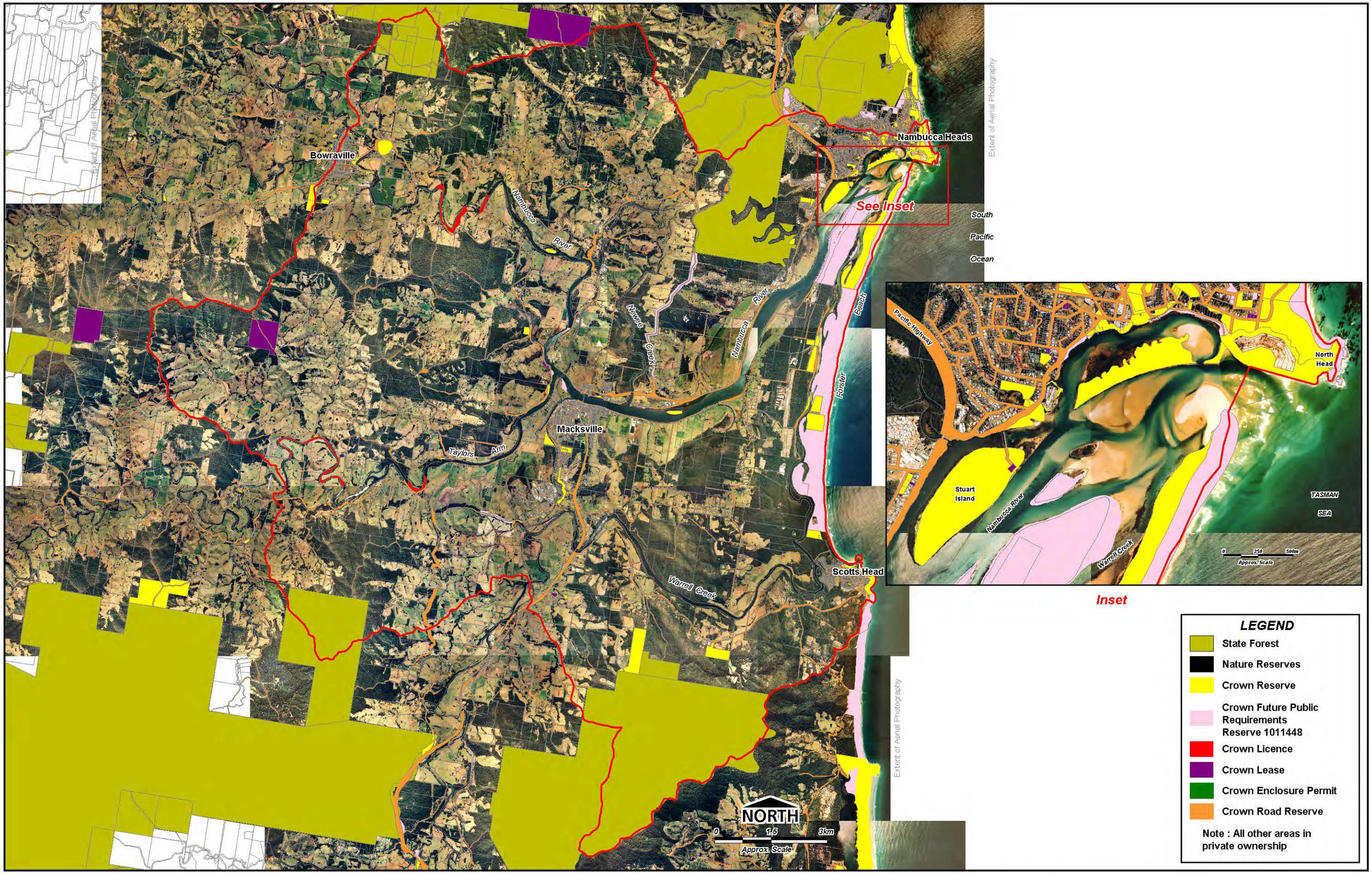
The current land tenure arrangements in the study area are depicted in Figure 6-4. From this it can be seen that the vast majority of the study area, i.e. over 80% is private freehold land (this includes Council owned lands), with the remainder being Crown Land.

6.3.1 Crown lands

Crown ownership of land within the study area was requested from the Lands Department for use in this study. The information provided to date has not been verified and does not include any details of who manages various parcels of crown lands or what the Crown land is currently being used for. Crown land areas in the study area are broken into a variety of categories and detailed below and as shown on Figure 6-4:

- **Crown Lease** - A Crown lease enables exclusive use over a particular piece of land for a specified term and purpose. Generally, leases are sought over Crown land where security of the tenure is an important factor to the user of the land, such as where commercial uses are proposed and major financial outlay is required. Examples include extensive agricultural initiatives, long-term extractive industries, irrigation, commercial and trading purposes, marina sites and caravan parks. Within the study area there are several isolated Crown Lease areas. Of interest is an area of Crown Lease adjacent to Wilson Road opposite the Macksville showground. It is believed that Council uses this area for storage of road construction material, e.g. gravel, etc.
- **Crown License** - Crown land licence is a contractual agreement that grants the licencee personal right to occupy and use Crown land for a particular purpose. It does not grant exclusive possession of the land, as is the case with a lease, and may permit the land to be used by other persons. The Department of Lands issues licences to individuals, businesses and community organisations for a number of purposes, including:
  - waterfront structures (e.g. jetties, boat ramps and slipways). Lands below the high water mark of foreshore properties are Crown lands and occupation of such lands must be authorised. Structures of this nature are called **Crown Licence Points** and are further discussed below;
  - grazing of stock (excluding areas with high environmental sensitivity);
  - extraction industry operations (e.g. quarries and dredging of sand and gravel from waterways);
  - agriculture and cultivation;
  - water supply and access (i.e. pumpsites and pipelines for domestic use and irrigation); and
  - short term purposes such as sporting events, minor extractive operations not covered by the Mining Act and site investigation associated with potentially acceptable development proposals.

  Within the study area, four principal areas of Crown License exist along Taylors Arm and the Nambucca River (north arm). These licences have been granted for extractive industry operations, e.g. dredging of sand and gravel from waterways. From the assessments performed there are noted to be bank stability and environmental weed issues in existing licence areas.



Land Tenure in the Study Area **Figure 6-4**

Only one Crown License, for the purposes of sand/gravel extraction in the North Arm of the Nambucca River, is currently active. From discussions with the Department of Lands (C. Sparks, 2006), it is apparent that extraction has not occurred at this site since November 2004, when the last return was lodged. This however, does not preclude the license holder from resuming full-scale mining operations at any stage. The maximum quantities of materials that may be extracted from the site form part of the holders license conditions and can only be exceeded by submission of a development approval to the Nambucca Shire Council.

- **Crown Reserve** - Crown reserves are land set aside on behalf of the community for a wide range of public purposes including environmental and heritage protection, recreation and sport, open space, community halls and special events. Reserves are created to protect and manage important community resources and are administered under the *Crown Lands Act*, 1989. Within the study area, there are numerous and often extensive tracts of land, which have been, designated Crown Reserve. These areas exist principally around the urban centres, e.g. the foreshore reserves around Nambucca Heads, various parks and other facilities such as the racecourse at Bowraville. Most islands within the estuary are Crown Reserve including Goat Island, Wirrimbi Island, Stuarts Island and the large sand island opposite the Inner Harbour at Nambucca Heads. Large areas of land adjacent to Warrell Creek are Crown Reserve including the Boultons Crossing/Gumma Reserve campground.

  Crown Reserves are typically managed by a corporate trust e.g. local councils or organisations (sports clubs, scouts, show societies) or a community trust board. Community trust boards are non-government and do not contribute to private profit. The trusts are responsible, under the direction of the Minister, for the care, control and management of specific Crown Reserves. Each trust has access to a reserve administrator within the Lands Department. A reserve trust enjoys a level of autonomy to determine all matters relating to the control and management of the Crown Reserve, usually within an approved Plan of Management. This includes entering into maintenance contracts, determining the development of the land (subject to Crown consent), setting entry fees, and employing people to work for it. Details of trust management arrangements for Crown Reserve Land was not available for use in this study.

  Assessments performed as part of this study have shown there to be issues with bank instability and environmental weeds in many of the Crown Reserves.

- **Crown Road Reserves** - Crown public roads generally provide lawful access to freehold and leasehold land where little or no subdivision has occurred since the original Crown subdivision of NSW. These roads are part of the State's public road network, and the majority have not been constructed. In some parts of the State, these roads contain significant native vegetation and provide a wildlife corridor in an otherwise cleared landscape. Most of the existing roads within the study area are designated Crown Public roads. It is expected that minor roads will be under the management of the Nambucca Shire Council, while the major roads, such as the Pacific Highway will be managed by the RTA.

  Within the study area approximately 15% of Crown Road Reserves are immediately adjacent to the estuary and includes the riparian zone. Assessments performed as part of this study have shown there to be issues with bank instability and environmental weeds in many of these Crown Road Reserves.

- **Crown Enclosure Permit** - An enclosure permit (previously known as a road permit) permits a property owner to enclose a Crown road or watercourse within their property by fencing. There are numerous Crown Enclosure Permits within the study area, mostly these exist for roads on private lands in the more rural portions of the study area.

Two other Crown land designations including **Crown License Points** and **Future Public Requirements land** were provided by the Department of Lands (DOL) as detailed below:

- Within the study area, there are numerous **Crown License Points**, all of which are located adjacent to the bank of the estuary and represent waterfront licences. Waterfront licences authorise the occupation and use of Crown land below the average high water mark and generally cover jetties, wharves, boatsheds, boat ramps, pontoons, slipways etc. adjoining waterfront properties. In total there are 23 licenced structures in the study area, which can be broken down into 9 jetties, 7 ramps, 3 buildings, 1 slipway and 3 other structures.

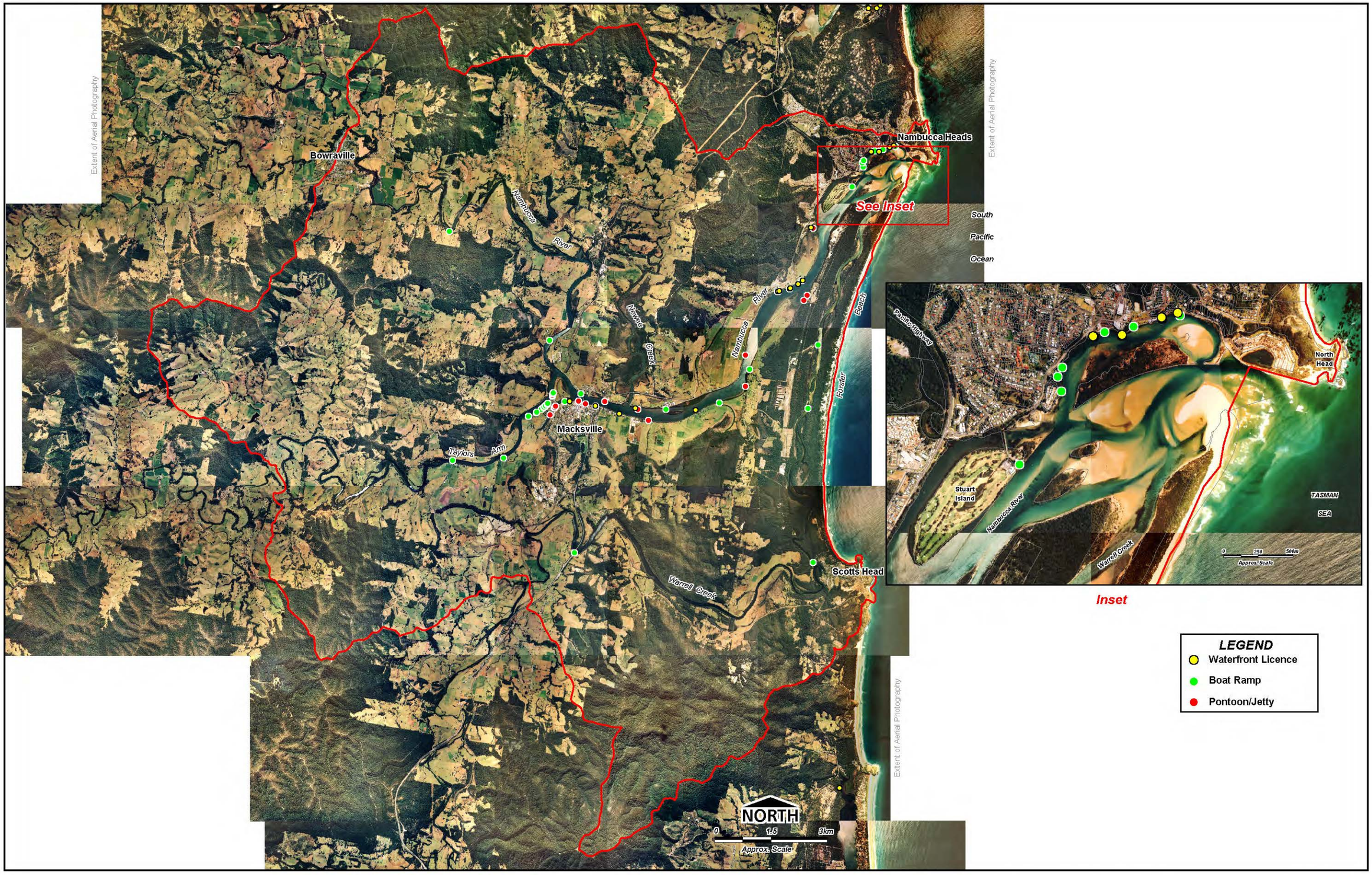
  This represents approximately one half of the total number of ramps and jetties noted during the field survey of the estuary conducted by Geco Environmental as part of this study, indicating that a number of waterfront structures have been built without being licenced by the DOL (structures displaying their Crown Licenses numbers were noted). Figure 6-5 shows an overlay of licenced waterfront structures and those structures observed during site inspections. From this it can clearly be seen that there are a number of structures in the estuary which require licencing.

  Previously the DOL has used the 'Unauthorised Structures Program' to identify illegal structures. This program requires Lands Department staff to travel around waterways identifying whether structures are licenced or not. All licenced structures should display their licence numbers in an obvious position to those on the water. It is not believed that this program has at yet been conducted in the Nambucca River estuary.

- There are vast areas of **Future Public Requirements** land within the study area. This designation refers to lands that do not have a current reservation, i.e. licence or lease. Up until March 2006 these lands were referred to as Crown Other and Vacant Crown Land. These lands at present are likely to be being used for the purposes of public recreation. The Future Public Requirements land would still remain under the management of the DOL. The management of the Future Public Requirements land in this estuary are important in that they form a significant portion of the interface between the waterway and estuary. Based on assessments performed as part of this study, some of this land may require more active management than it currently receives, i.e. in terms of protecting the riverbank and riparian vegetation, etc. When this occurs, the DOL aims to find a way of securing appropriate management for the land, e.g. by establishing a community trust, etc.

  With the study area the Future Public Requirements land primarily cover the frontal dune system between Forster Beach and Warrell Creek, and a smaller area back from Warrell Point. There are also several smaller areas of Future Public Requirements land within the study area including lands adjacent to the Old Coast Road, islands in the lower estuary, foreshore lands near Kings Point and some riparian lands on Snakey Creek.

  Areas of unreserved foreshore land in the study area are shown in Figure 6-4. Some Future Public Requirements land have moderate to high levels of bank instability and contain environmental weeds such as bitou bush.



Overlay of Waterfront Licences and Observed Foreshore Structures **Figure 6-5**

Vacant Crown land referred to land, which had not been dedicated or reserved and was not leased, licenced or otherwise occupied. Other terms used to describe this type of land are unallocated Crown land or unoccupied Crown land (and as mentioned above they are now called Future Public Requirements land). The capability of this type of land and its suitability for particular uses has not yet been assessed by the Lands Department and therefore has not been placed in either category of Crown Reserve or Crown Tenure lands (i.e. Crown License or Lease).

6.3.2 Native Title and Aboriginal Land Claims

Native Title Claims and Aboriginal Land Claims have been placed over parcels of land comprising an area approximately 1500ha between the townships of Scotts Head and Nambucca Heads on the North Coast of New South Wales. This area includes 11 km of undeveloped coastline and Warrell Creek, which forms the focus of the proposal. The creek comprises 13 km of intertidal waterway from the Southern boundary of the proposal to its northern extent where it junctions with the mouth of the Nambucca River (Highfield, 2001).

A series of Aboriginal Land Claims have been lodged over parts of this land since 1993. The *NSW Aboriginal Land Rights Act*, 1983, is used to determine whether Aboriginal Land Claims are successful or not and is administered by the NSW State Government. The intent of this Act is to return Future Public Requirements land, not required for essential purposes or for residential land, to Aboriginal peoples. The land will be returned as an Aboriginal freehold title granted to the local Aboriginal Land Council. If the claim is successful, it is likely that these lands will then be leased back to the NSW State Government to enable the formation of a Nature Reserve or National Park to protect these lands. It is understood that negotiations in relation to the Land Claims are active and advanced (Amy Barrett, Native Title Tribunal, Pers Comm. 2005).

In addition to the Land Claim, a Native Title Claim has also been lodged over the same area, with the National Native Title Tribunal. The Claim was lodged in 1996 and a determination is still pending. The *Commonwealth Native Title Act* 1993, is used to determine whether Native Title Claims are successful or not. The intent of this Act is to provide recognition of Aboriginal peoples traditional ownership of land and waters that have always belonged to them according to their traditions, laws and customs. These rights are different to and separate from the statutory right of Aboriginal Land Councils to make claims for land under the *NSW Aboriginal Land Rights Act* 1983.

From discussions with caseworkers with the Native Title Tribunal, the specifics of the Native Title Claim will need to be coordinated by the outcomes of the Aboriginal Land Claim (Amy Barrett, Native Title Tribunal, Pers. Comm. 2005) to ensure that the two are cohesive. In a practical sense, the Native Title Claim will allow traditional usage of the land in question, even though in reality it may be leased back to the NSW Government as a Nature Reserve or National Park area.

6.4 Summary

This section of Estuary Management Study provides a review of the status of the land use and tenure with the study area. It includes a review of the Nambucca Shire Council's Local Environmental Plan (LEP), which governs permitted land uses within the study area. The section also provides a review of current land use and tenure with a focus on Crown land holdings and their status.

In the current LEP, the top five land use zonings account for over 90% of the study area, with rural lands occupying three quarters of the total study area. Land use zonings for urban, industrial, commercial and other public/private recreational lands occupy less than 5% of the total study area. Most of the potential issues identified with the LEP relate to its ability to protect areas/aspects of the catchment important to the health of the estuary (e.g. riparian areas, significant vegetation communities) from inappropriate forms of development and land use. In part this relates to the age of the LEP (over ten years old now). It is understood that the LEP is soon to be updated as part of a statewide reform of local government planning practices.

In relation to actual land use, the study area is nearly evenly divided between lands that are cleared and may be being used for such uses such as cattle grazing and lands used for remnant vegetation, regrowth and waterway areas. There is also a small portion of the catchment used for forest plantation and horticulture.

In relation to land tenure approximately 80% of the study area is privately owned, the remainder is constituted of a variety of Crown lands and State Forests (owned by the Crown but managed by NPWS). Many of these Crown land areas exist in the form of reserves, however a significant portion of the study area was designated as Future Public Requirements Land (Reserve 1011448), indicating that these areas currently have no reservations on them. Many of the Future Public Requirements Land, were located on the foreshores of the estuary and formed part of the land/water interface of the estuary. Significant environmental issues were noted in many of these areas included invasive environmental weeds and bank instability/erosion, indicating they may require more active management.

7 ENTRANCE CONDITIONS AND BEHAVIOUR

7.1 Overview of General Processes

The Nambucca River estuary is an example of a wave dominated inter-barrier estuary that is often connected with low relief, coastal plain coasts (Roy *et al*, 2001). In terms of how the estuary was formed, Geco Environmental (2005) provides a historical account of the geomorphic and sedimentary influences and processes (coastal and fluvial) that are believed to have shaped the Nambucca River estuary.

Wave-dominated barrier estuaries typically have a tidal inlet that is naturally constricted by wave-deposited beach sand. These types of estuaries are often associated with larger rivers whose discharges tend to counteract the flux of wave-transported beach sand in the estuary mouths and occur behind sand barriers on the exposed sections of the coast. It is these natural processes occurring around the entrances of estuaries, up and down the coast of NSW, which are commonly believed to be in need of management, due to their often-constricted state.

In considering the influences and management options of the entrance to an estuary, it is essential to have an understanding of the complex interactions of the prevailing processes. The lower reaches of an estuary are typically in a form of dynamic equilibrium between the controlling forces of the tidal and fluvial activity of the river and the littoral processes of the adjacent beaches. As such, the configuration of the river and entrance channels as well as the adjacent coastline is continually changing under the natural variability of the prevailing conditions. As these changes occur, the associated hydraulic, water quality, sedimentation and erosion characteristics of the estuary also change in response. Figure 7-1 illustrates a typical cycle of entrance conditions and the influences of the various processes.

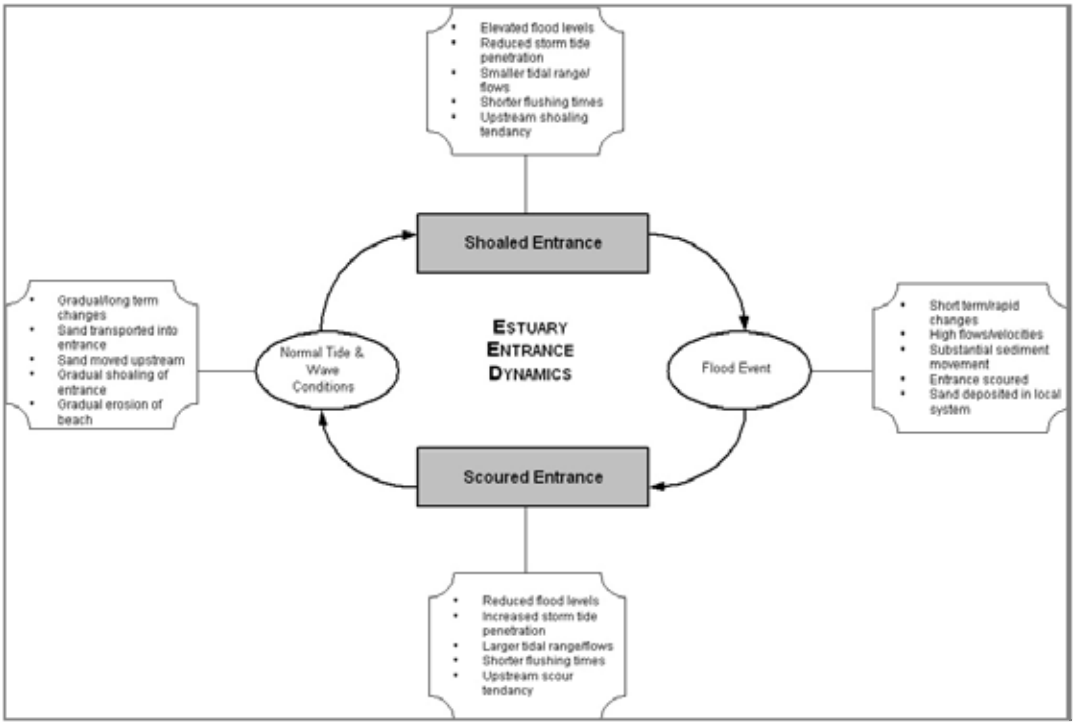


Figure 7-1 Flow chart showing the typical cycle of entrance conditions

Fluvial or flooding activity can have dramatic short-term effects with high flows and velocities transporting large quantities of sediment downstream and into the littoral drift beach system. These events have the ability to alter the bed characteristics of localised areas of the river and entrance due to the amounts of sediment that may be transported and redeposited over relatively short periods. Scour of river entrances is a typical characteristic of flood events. This results in a more hydraulically efficient entrance with a subsequent increase in tidal range and flow within the estuary. This then has follow on effects for tidal flushing, water quality, sedimentation and ecological habitats within the estuary.

A greater tidal range is typically reflected by higher high tides and lower low tides with potential influences on ecological habitats at the tidal extremities (eg mangroves and sea grasses). Increases in tidal flows can result in associated better (shorter) flushing times and improved water quality conditions. The larger flows may also induce scour in the upper reaches.

During periods with scoured or open entrance conditions, flood levels in the lower estuary as a result of river discharges may be reduced. However, the more efficient entrance may also allow greater penetration of elevated ocean storm tide levels into the lower estuary.

During normal day-to-day tide and wave conditions, there is a general tendency for gradual sediment infeed from the beach system, particularly following scour from a flood event. The waves and currents mobilise and carry the sediment into the entrance from where there is a general net upstream transport of sand into the lower estuary. This leads to an overall tendency of shoaling in the entrance and lower reaches of the estuary. Some localised areas of erosion will, however, occur as shoals develop and concentrate flows in some areas.

Sediment infeed to the estuary from the beach system is likely to occur gradually between flood events but is also likely to reduce in time as the entrance becomes shoaled. There is a balance between the tidal flows, the channel cross-sectional area and the coastal longshore transport of sand. If this balance is upset, for example by a major flood event scouring the entrance channel, the processes act to try and restore the balance by infilling the entrance channel again with sand generally coming from the adjacent beaches. For estuaries such as the Nambucca, the balance is such that the entrance will always be permanently open although the degree of shoaling will vary. Entrances to smaller estuaries on high wave energy coastlines can become intermittently closed and open depending on the prevailing conditions.

As shoaling of the entrance region continues, this has the effect of constricting the channel and reducing the tidal range with lower high tides and higher low tides and associated potential ecological habitat influences. Tidal flows will also decrease with associated worse (longer) flushing times and potentially poorer water quality. Lower estuary flooding as a result of river discharges will also tend to increase although this will be dependent on the size of the flood and extent of scour during the event. Conversely, a shoaled entrance will reduce the potential penetration of elevated ocean storm tide levels. During periods of high wave action, wave set-up will also tend to raise water levels within the lower estuary with associated follow on effects to the tidal hydraulics of the river.

There is also a general balance or equilibrium between the tidal flow or prism and the cross-sectional properties of the channels in the lower estuary. Where the flow is confined in width (e.g. by rock outcrops or constructed training walls), high velocities can lead to scour and deeper channels. Where

the flow in unconstrained and can break out or divide into more than one flow path, velocities can fall leading to shoaling and shallower channels.

Sediment carried into or out of a river entrance as a result of the abovementioned processes can have an impact on the adjacent coastline. The rate and extent of change along the coast depends on the sediment inflow/outflow rates as well as both the gross (upcoast + downcoast) and net (upcoast – downcoast) longshore transport rates. Large volumes of sand may be deposited in the offshore bar or delta of an estuary during a major flood event. Typically this sand will subsequently move onshore and be distributed along the coast via longshore transport processes as a pulse of accretion. Conversely, sand transported into the entrance and lower estuary from the beach system can contribute to subsequent periodic erosion of the beaches. However, in the absence of overall net sources or sinks of sediment, there will be a long-term balance on which intermediate shoreline fluctuations will be superimposed.

A detailed investigation of coastal processes has not been undertaken. A review of available aerial photography and knowledge of regional processes including dominant south-east winds and waves, indicates that the long term net coastal longshore transport of sand is likely to be towards the north. However, superimposed on this long-term trend may be extended periods with waves from north of east generating transport towards the south. With a long term net transport towards the north, coastline fluctuations associated with the sediment dynamics of the entrance and lower estuary are most likely to be experienced along the shoreline to the north of the entrance.

The Nambucca River estuary has exhibited natural variability in line with the general processes as outlined above. Furthermore, the entrance area has been influenced by human activities such as breakwaters, training walls and various dredging works. These can interfere with the processes as discussed below.

7.2 Historical Changes and Influences

7.2.1 General Considerations

A review and understanding of the historical changes in the lower estuary and the influences of past works can provide a valuable insight into present day trends and issues. Historical charts, documented reports, historical file records, aerial photography and anecdotal evidence have been used to gain this understanding. They provide information on the natural processes, the intended purpose of specific works and the resulting effectiveness of those works as outlined below. This information is valuable for consideration of future management options.

In viewing the information provided it is worth noting that the NSW coastal rivers experience alternating periods of Flood Dominated Regimes (FDR) and Drought Dominated Regimes (DDR), wherein the period 1857 – 1900 exhibited FDR, the period 1901-1946 exhibited DDR and the period 1947-1978 exhibited FDR (Erskine and Warner, 1988), which may have some impact on recorded bathymetry.

7.2.2 Early Natural Conditions

The lower estuary and entrance region have been subject to considerable changes over the last century. The earliest hydrographic survey charts depict the estuary in essentially its natural state as

illustrated by the 1891 chart (Figure 7-2). The inset box on the following page describes (select) observations made by Captain F. Howard in 1891 as part of his hydrographic survey work.

Entrance
...the passage in after crossing the outer bar is very dangerous...

The sand spit extending northward from South Head (northern end of Forster Beach) is generally awash at high water, the size and shape of which is constantly changing.

Inside the (entrance) the river opens out into a large basin about 3660ft (1096m) wide and 6,600 ft (1676m) long. The greater portion of this space is filled with large sand banks, the river finding its way through them in narrow winding channels, with less than 1 foot (300mm) at low water springs.

...the only navigable channel is close around the northern shore inside the Head...

Stuart Island
Stuart Island lies about 2 miles from the entrance. The channel on its north west side is used by droughers and carries about 9feet at low water. The River south east of Stewarts Island is mostly shallow. On the west bank is a red cliff point known as Red Bank. The river between Red Bank, Stewarts Island and the opposite bank is a shoal right across.

Stuart Island to Macksville
From Red Bank upstream is entirely free of any obstruction for vessels drawing under 9 feet of water up to the Government wharf at Macksville.

Macksville to Bowraville
A vessel drawing 7 feet could get 3 miles up the Bowra River above the junction (with Taylors Arm River). Above this point the river gradually decreases in widrth and depth up to the township of Bowraville, the head of navigation, 17.6 miles from the entrance.

Macksville to Utungun
A vessel drawing 6 feet could get to Government wharf at Congarinni, up Taylors Arm. 12 miles from the entrance, but only at high water, as there is only 4 feet at low water in the reach below it. For about 7 miles above Congarinni the river narrows, and there are numerous obstructions to navigation even by a (small) boat at low water.

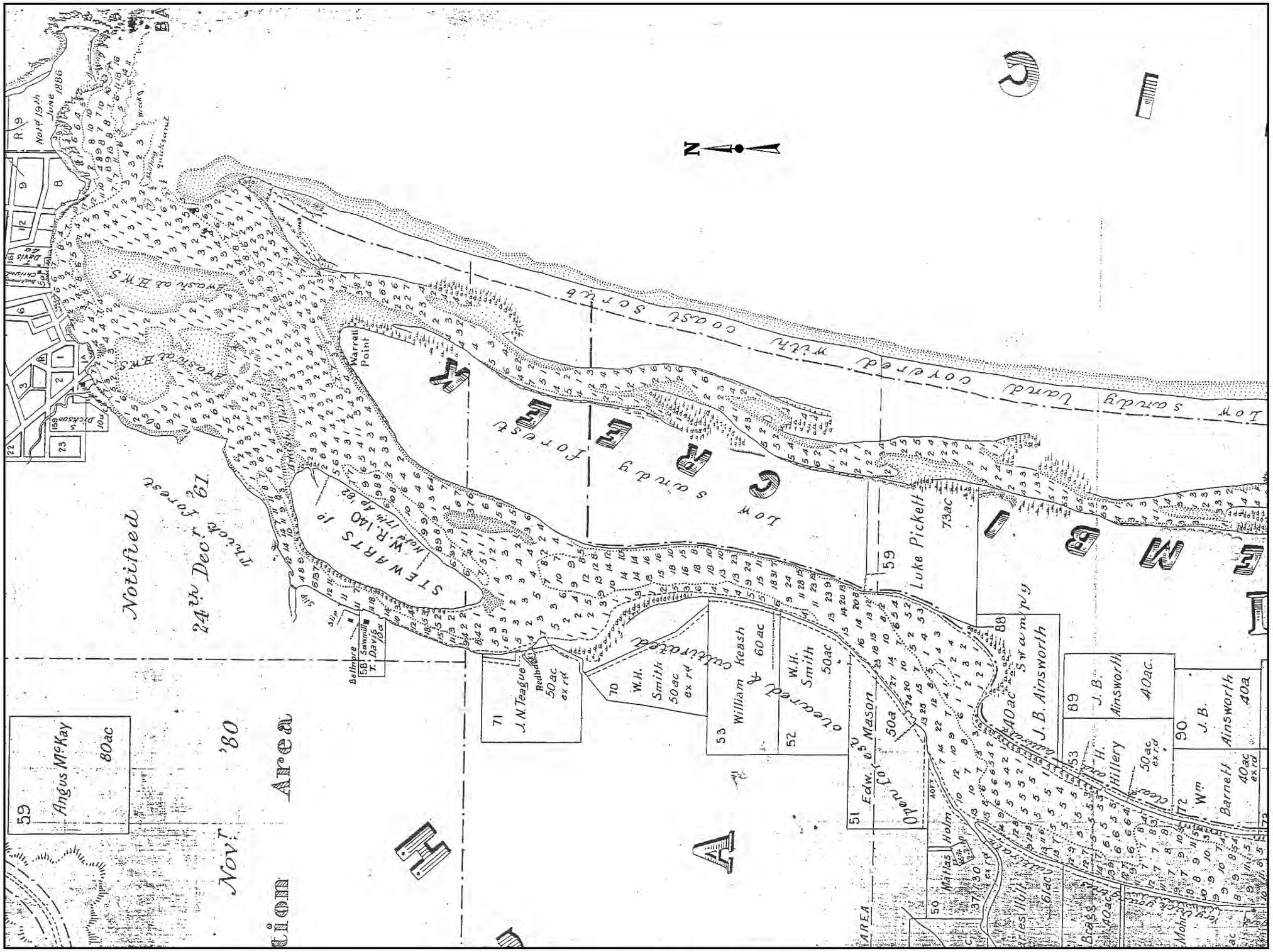
Warrell Creek
...navigation is much impeded in the lower 4 miles of its course by six sand bars formed at intervals right across...

Catchment
The whole of the country drained by the Nambucca and its tributaries appears to have been one unbroken forest, excepting a few small swamps near the entrance.

As can be seen from the Figure 7-2, the main entrance channel hugged the rocky cliffs of Nambucca Heads on the northern side with depths between 8 and 18 ft below low water. Depths on the outer bar are not shown although there are notes of shifting quicksand on the southern side of the entrance.

These features are indicative of the influences of the ocean waves with a net longshore transport of sand towards the north forcing the channel against the northern headland. The notes also indicate the rapid changing and infeed of sand from the beach system.

The lower estuary itself is depicted by a broad open water body with a complex network of channels and sand banks. There are a number of banks noted as being awash at half tide and high water spring tides. However, there were no permanently dry islands downstream of Stuarts Island and Warrell Point.



Nambucca River Estuary Hydrographic Survey - 1891 **Figure 7-2**

The channels were of varying widths and depths typically being deeper/narrower where they were constrained and broader/shallower where they divided or spread. This indicates the natural relationship between flow, velocity and cross-sectional area with a system of ebb tide and flood tide dominant channels and deltas. The shallow deltas occur at the ends of the deeper/narrower channels where the flow spreads out or divides and the velocities fall leading to shoaling of the bed.

There are two main channels through the lower estuary evident in the 1891 chart. The main entrance leads into a channel, which meandered along the northern bank past the township and between Stuarts Island and the mainland. Through the town reach it was typically up to 8 ft deep at low tide while to the north west of Stuarts Island it was typically 9 to 18 ft deep. Shallower sections 2 to 3 ft deep at low tide were also evident at various divides and unconstrained areas.

A secondary channel also led from the entrance towards Warrell Point on the southern side of the estuary and then across to Stuarts Island. This channel was typically up to 9 ft deep but again with shallower deltas where the flow divided or spread. The entrance to Warrell Creek was constrained by a shallow delta 2 to 3 ft deep at low tide. The creek channel itself was typically 5 to 6 ft deep on the outside of the bends and only 1 to 2 ft deep at low tide at the cross over points.

Upstream of Stuarts Island where the main river narrows from the broad lower estuary, the single channel was much deeper.

7.2.3 Original Need for Works

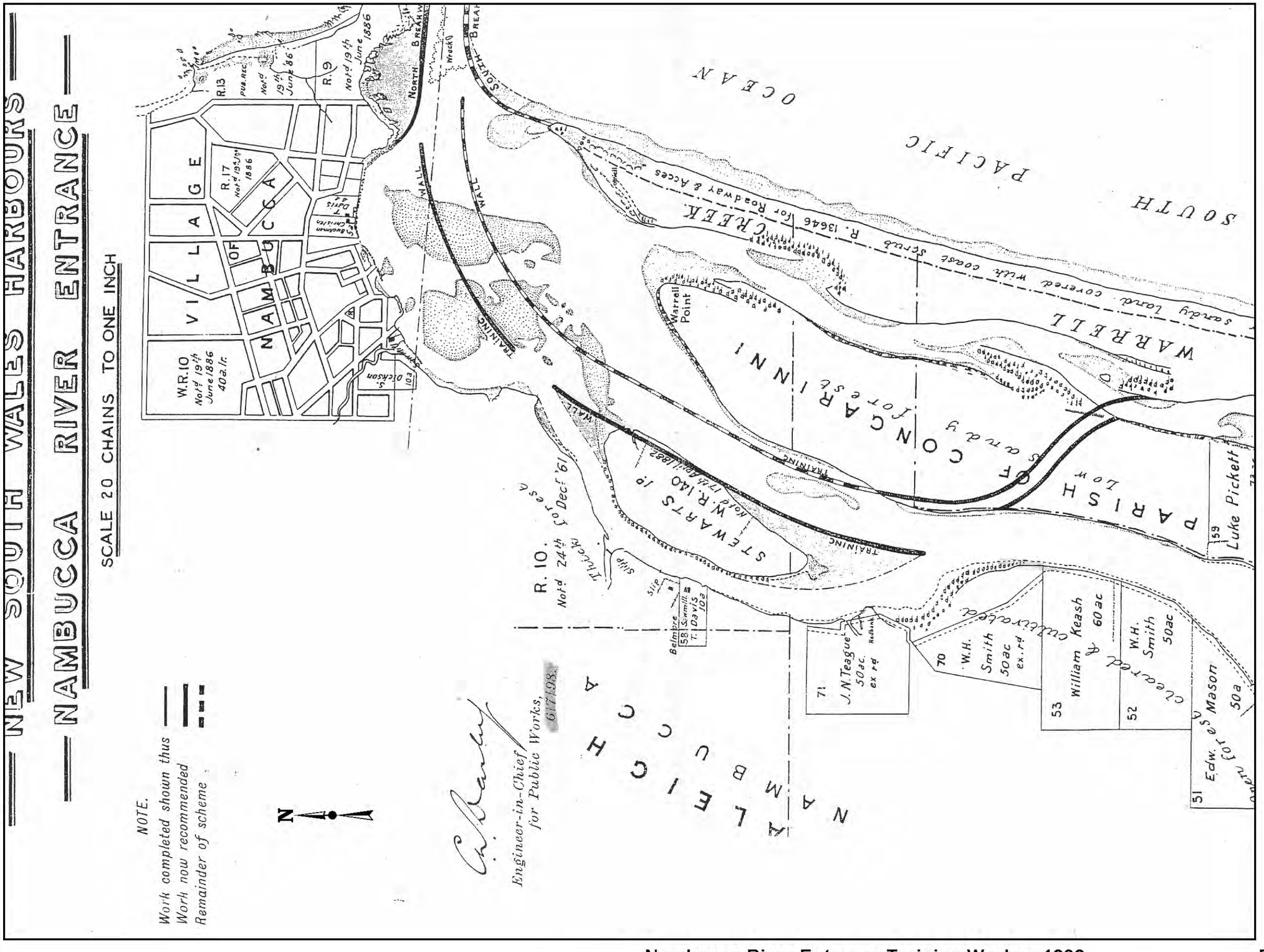
The early settlers to the region relied on shipping with associated navigation of the entrance/lower estuary for trade. The shallow ever-changing nature of the entrance was a major constraint to this shipping. Dredging was carried out but dredge masters at the time reported that the channels filled up again rapidly following the dredging. This indicates that the natural entrance was a major constraint to navigation.

A scheme of works was proposed in the 1890's involving two breakwaters and internal training walls (see Figure 7-3) as well as dredging with a view to confining the flow and maintaining a deeper, navigable and stable channel. Works commenced on the northern breakwater around 1895. The scheme was subsequently the subject of three Parliamentary Standing Committees in 1898, 1903 and 1913, which determined the course of action.

7.2.4 1898 Parliamentary Standing Committee

The first Parliamentary Standing Committee in 1898 confirmed the shallow and dangerous nature of the entrance and the need for works to improve the situation. However, it was determined that the expenditure for the full scheme was out of proportion with the resources/needs of the region. It was further believed that some relief could be gained from partial construction and that this should be tried in the first instance. The scheme (see Figure 7-3) was amended to include the:

- Northern breakwater;
- Northern training walls up to Stuarts Island; and
- Diversion of Warrell Creek to the upstream end of Stuarts Island.



Nambucca River Entrance Training Works - 1898 **Figure 7-3**

It was considered that the northern breakwaters and training walls would guide the ebb tide current and scour the channel adjacent to the walls. The diversion of Warrell Creek was to direct more flow (and hence scour potential) through the main channel in the lower estuary and remove the problems caused by the confluence near the main entrance.

It was generally considered that a perfect entrance could not be expected without the southern breakwater but with some dredging, the channel should be navigable. Some witnesses thought that two breakwaters would still be needed but this was not adopted on the basis of cost.

The proposed scheme also included gaps left in the northern training wall to retain a channel and allow shipping access to the wharves in the town reach. It was thought that the back channel and main channel would both scour and stay clear.

Construction of the northern walls proceeded while the Warrell Creek diversion was abandoned because the cost was going to be far greater (3 times) than the original estimate.

7.2.5 1903 Parliamentary Standing Committee

A second Parliamentary Standing Committee was held in 1903. It was found that the northern breakwater had created some improvement. It had removed the meandering channel from the rocky headland and created a straight channel along the wall. However, continual inflow of sand from the beach system to the south still caused problems. The sediment movement narrowed and forced the channel close to the wall at times resulting in dangerous conditions. Sand also continued to feed into the lower estuary causing further shoaling and navigation difficulties.

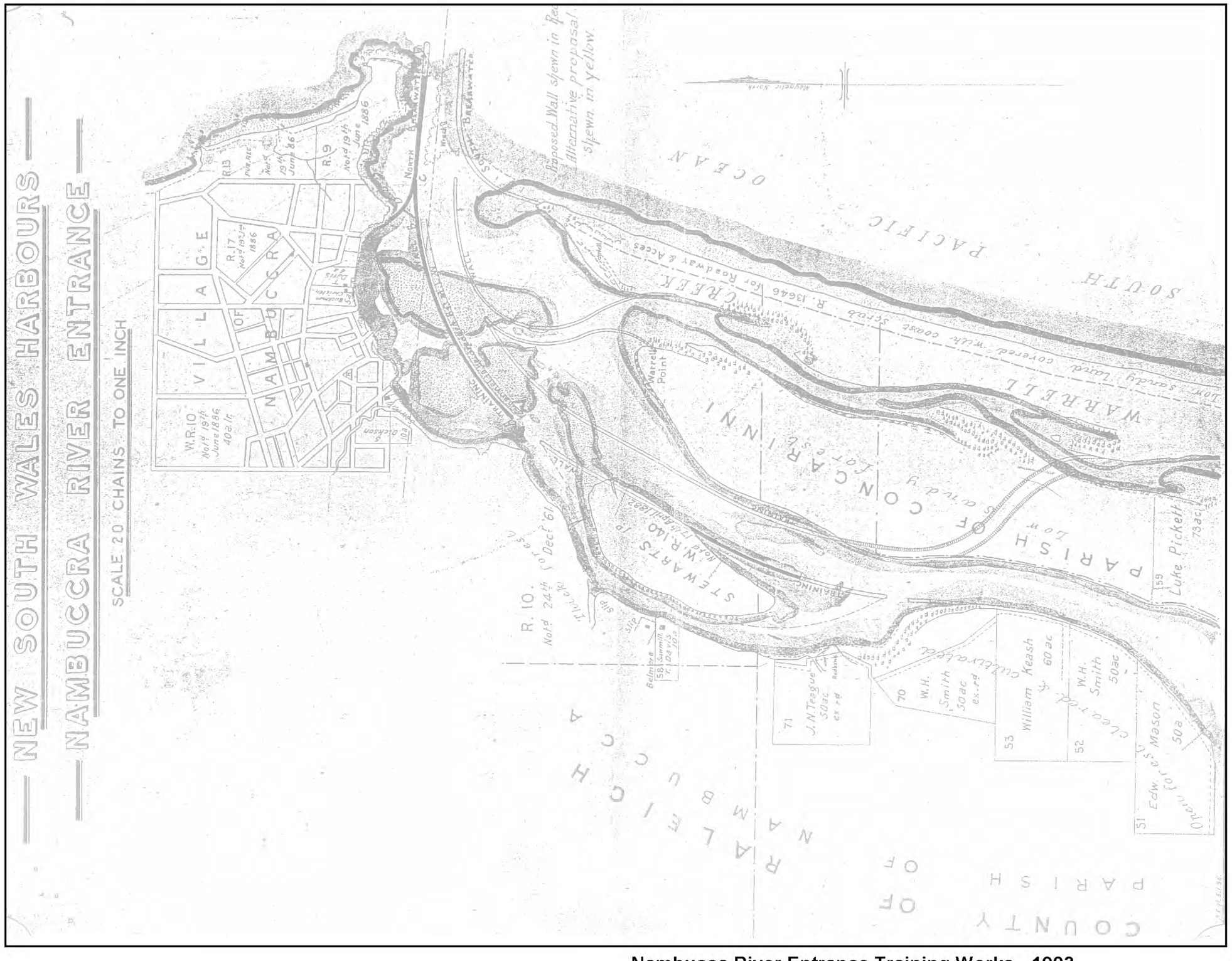
Much debate was held over what works should/should have been built. The Committee concluded that the southern wall should have been built first. It is interpreted that this conclusion related to the fact that with limited available funds, a southern wall would have prevented the inflow of sand with the natural rocky headland taking the role of the northern breakwater.

The Committee therefore recommended that the remaining funds for internal works be diverted to construct a southern breakwater. Various schemes with internal training walls connecting to Warrell Creek were proposed (see Figure 7-4). However, the cost of expending more money for a more complete scheme with full internal training walls was not justified.

While the 1903 Standing Committee recommended the construction of a southern breakwater, the works were not authorised by Parliament and did not proceed. Accordingly, no further improvements in the entrance conditions were achieved.

In completing the northern breakwater, there was a need to dispose of the small excess rock from the quarry. This was directed towards a training wall along the original line shown on the plan opposite Stuarts Island, which had been omitted. Again there was debate over whether there was in fact approval for the construction of this wall as funds were to be directed towards entrance works.

The influences of floods in scouring the entrance were raised in the proceedings with it being noticed that conditions improved following flood events and also that shoaling was particularly bad in the absence of major floods. Dredging works also planned to rely on floods to scour the last section of the channel.



Nambucca River Entrance Training Works - 1903 **Figure 7-4**

7.2.5.1 1913 Parliamentary Standing Committee

The conditions at the entrance to the Nambucca River continued to deteriorate. Although dredging was carried out, navigation became so difficult that trade was stopped for a considerable period.

A final Parliamentary Standing Committee was held in 1913 to ascertain the need for further entrance works. At this stage the northern breakwater and northern training walls were substantially completed.

The Committee concluded that, for the level of trade, it was not expedient to carry out an extensive scheme of improvements to the entrance given the development of Coffs Harbour and the North Coast Railway. The evidence indicated that even if the scheme was carried out, beneficial results would be extremely doubtful and there would be a need to spend as much money on dredging the bar as was already being expended.

However, the value to the existing industry of having a navigable entrance was recognised and it was recommended that the entrance be kept open for vessels of light draft by means of dredging.

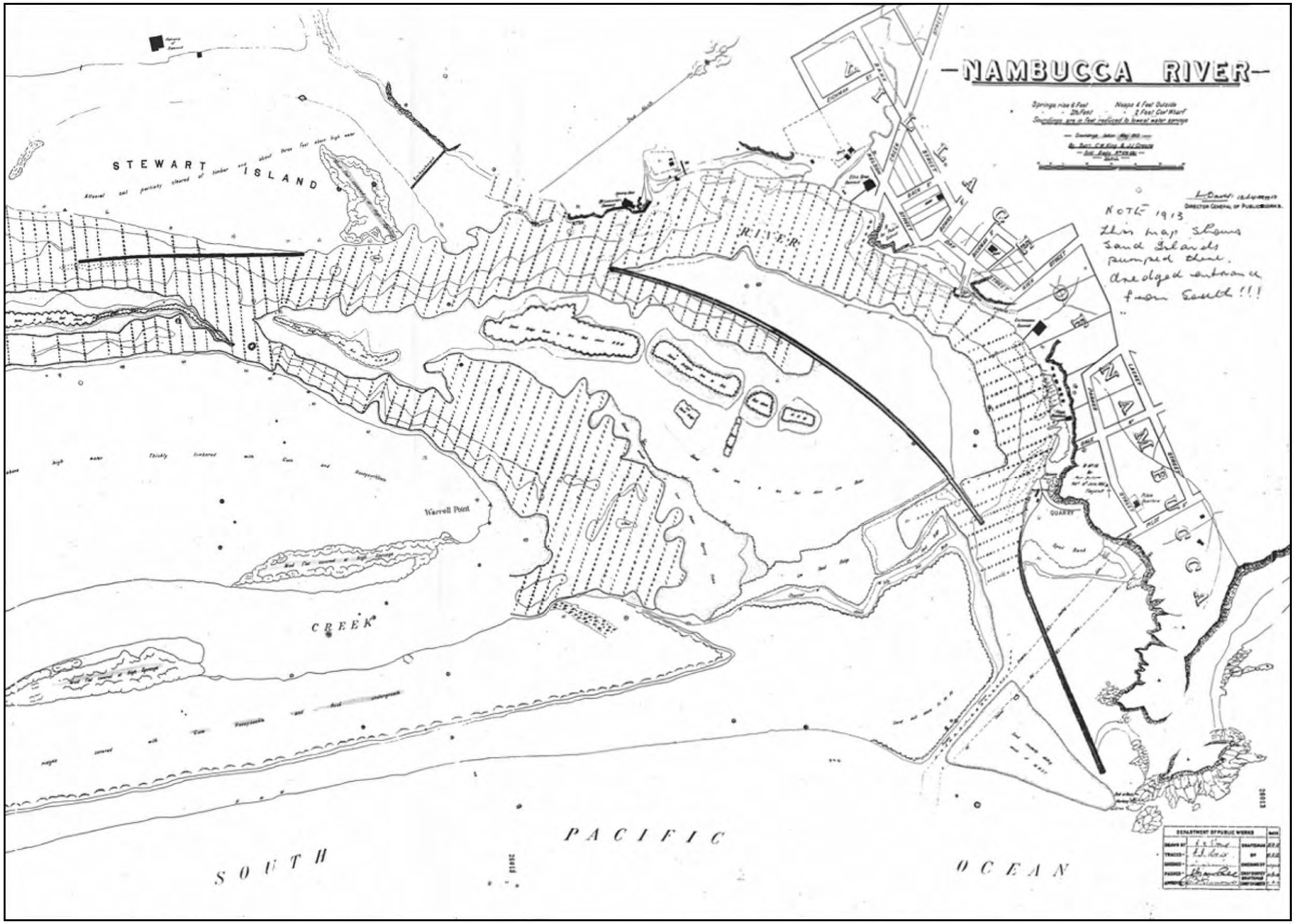
7.2.6 Subsequent Works

Dredging of the entrance continued on a regular, as needed, basis. This usually involved dredging of the outer bar and the inner crossing using different dredges. The channel was dredged adjacent to the inner training walls with sand being pumped over and behind the training walls and adjacent to the channel forming islands (see Figure 7-5) of the 1913 conditions. As sand continued to shoal the channels, subsequent dredging lead to further development of the islands, many of which remain today.

Reports of large quantities of moving sand and navigation constraints continued with consideration being given to other means of improving the situation. A stonewall was built between the mainland and Stuarts Island in 1914-1915 with the aim of blocking the back channel and confining the flow to the main channel to improve the scour potential. This aim was reported as being realised with an improved navigation channel in the river although the entrance still caused problems.

The training wall configuration at that time included two gaps providing shipping access and flow through the generated back channel adjacent to the town reach. A large gap remained downstream of Stuarts Island as the originally proposed training walls had not been completed. A gap between the upstream (landward) end of the northern breakwater and the training wall provided access along the original natural channel.

During the period 1914-1916 there was much discussion about blocking the back channel north of Stuarts Island (i.e. the town reach). It was considered that this would improve conditions by concentrating the ebb tide current and scour along the wall. Furthermore, it was considered that there would not be much prospect of keeping open the main channel along the southern side of the wall until such works were affected. It was also identified that the closing would need to be accompanied by initial dredging along the south side of the wall with the sand being placed over the wall on the north side.



Nambucca River Entrance Training Works - 1913 Figure 7-5

There was much discussion and consideration given to how/where the channel should be blocked and the consequences of those works. It was recognised that silting of the back channel would occur and an indemnity was sort and received from those who may be affected. It was also agreed to dredge the entrance to the inner basin.

The works were eventually carried out with the Stuarts Island training wall being extended along the originally proposed alignment to reduce the upstream gap. It was decided that the most cost effective way of closing the back channel was to construct a tie wall from the training wall to the mainland at the downstream end. These works were completed in 1918 forming the "vee" wall as it is now known. The new channel along the training wall then became the main channel. It was noted that the navigable depth on the bar improved by 2.5 ft and the direction and permanency was better than ever before.

Consideration was given around this time to a seaward extension of the northern breakwater but it was decided that this would not substantially improve the entrance without a southern breakwater.

Annual reports for subsequent years document ongoing dredging of the bar and inner crossing as well as repairs to the breakwater and training walls. Floods in 1921 reportedly scoured and improved the entrance channel and bar. Dredging of upper gravel shoals within the main arms was also reported from time to time.

The question of closing the port was under consideration in 1940 on the grounds that the remaining port traffic did not warrant the ongoing expenditure. The pilot station closed down on 27 July 1940. The entrance to the inner harbour (back channel) was dredged in 1948/49. The dredge was then moved to the north-eastern end of the back channel and commenced reclaiming the water hole in the old quarry.

Major dredging finally ceased in 1949/50.

7.2.7 Recent Past

Limited works have been carried out since regular channel dredging ceased in the 1940's. Vertical aerial photography, which commenced around that time, provides a record of the conditions and changes that have occurred since then. With the back channel blocked at the downstream end by the 'vee' wall and further upstream by the causeway to Stuarts Island, flow was carried primarily by the previously dredged main channel adjacent to the training walls.

Substantial sediment movement in the channel is evident in the early 1940's photography (refer Figure 7-6). The main entrance channel across the bar remained adjacent to the northern breakwater and was well defined through to the throat around the 'vee' wall. Opening out into the lower estuary, the channel tended to meander with various flood and ebb tide shoal formations being present.

Substantial shoaling of the remaining gap in the training wall downstream of Stuarts Island was also evident blocking navigation to the back channel. A dredge can be seen in the 1941 photography beginning to open up this entrance. The islands and various other deposition areas from previous dredging can also be seen with vegetation beginning to stabilise them.

Photography from the 1950's and 1960's confirm these trends with a reasonably well-developed main channel south of the training walls although shoal formations and meandering tendencies are still evident (see Figure 7-7). The back channel remained blocked by the 'vee' wall at the downstream end and substantial shoaling was still evident in the training wall gap downstream of Stuarts Island. Anecdotal evidence suggests siltation and deteriorating water quality conditions were occurring in the back channel.

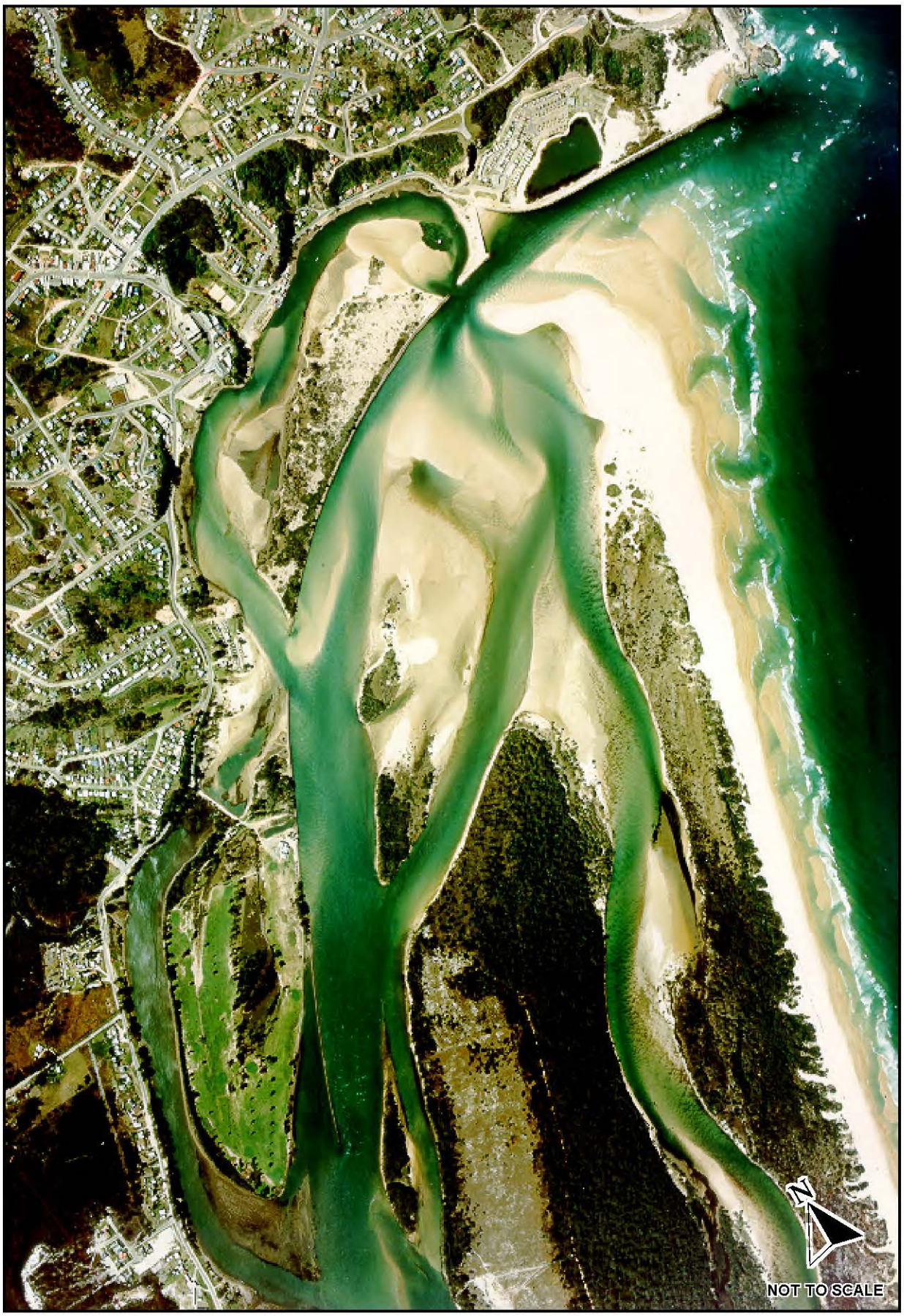
It is understood that a failure/breach in the 'vee' wall occurred during a major flood event 1974 opening up the back channel to through flow. This opening remains today and very high tidal velocities occur through this gap in the wall. As a result, sand has been transported into the back channel at both ends forming shoals. A channel of varying depth has also been maintained through the back channel. A dredge is evident in 1977 photography pumping sand from the back channels to the breakwater caravan park area (see Figure 7-8). Subsequent photography shows the dredge hole infilled rapidly.

The channels and shoals of the lower estuary have continued to fluctuate under the prevailing conditions with evidence of substantial sediment movement. Since the major flood event in 1974, aerial photography shows that flow in the main channel has been effectively divided into three flow paths downstream of Stuarts Island. Flow is split between the back channel (and breach in the 'vee' wall) on the north, a central channel adjacent to the training wall and a channel on the southern side, which connects up, with the Warrell Creek channel. These have changed over time with the central channel meandering to the south leaving a substantial shoal adjacent to the training wall. The southern channel has also shoaled and become more constricted at the downstream confluence with Warrell Creek.

The main entrance channel from the ocean has tended to remain well defined against the northern breakwater although a shallow outer bar is typically evident. At times, the outer part of the channel has migrated towards the south, most likely under the influence of an extended period of net southerly coastal longshore transport.

1940's Aerial Photograph of Lower Estuary Figure 7-6

1959 Aerial Photograph of Lower Estuary Figure 7-7



1977 Aerial Photograph of Lower Estuary Figure 7-8

7.3 Present Day Situation and Issues

7.3.1 General Conditions and Issues

As evidenced by the historical records, the lower Nambucca River estuary and entrance has always been subject to continual change and shoaling under the influence of natural processes making navigation difficult. The present day situation (see Figure 7-9) is a reflection of those natural influences and historical attempts to control the processes and improve navigation when shipping was the primary avenue for trade.

The various training walls and dredging works have had some influence in controlling the location and form of the channels in the lower estuary as discussed above. Furthermore, substantial quantities of sand have been isolated behind walls, formed into islands or effectively removed from the active system. Sand will have moved in from the beach system to replace any losses and maintain a dynamic balance in the lower estuary. These losses would have been distributed along the open coast beaches, most likely to the north. A detailed investigation of losses to the beach system is beyond the scope of this study.

Shoaling and continual fluctuation of the channels has always been and remains a characteristic of the lower estuary. The fact that the southern breakwater was never built means that the natural dynamic interactions between the coastal and estuary processes have continued to occur. As such, the configurations of the river and entrance channels, as well as the adjacent coastline, are continually changing under the natural variability of the prevailing conditions.

One commonly identified change is the observable increase in the extent of sand islands in the lower estuary. Early hydrographic mapping shows the existence of large submerged sand shoals, which were commonly exposed at low tide. Due to the extensive dredging and spoil placement, which occurred in the first part of the 19th century within the lower estuary, the size of many of these sand shoals has been increased. Today many of the islands in the lower estuary are vegetated. Despite the increase in the observable size of the islands, they are not necessarily the cause of any perceived reductions in tidal flow to and from the estuary. Rather, the formation of the islands is a function of major weather/coastal patterns/processes as well as some assistance provided by human (dumping of sand).

Artificial increases in island size will be generally compensated by decreases in bed levels elsewhere within the lower estuary in order to maintain a flow balance. Furthermore, any additional increases in height above high tide will not have any influences on tidal processes. Hence, it is unlikely that the artificial growth of the islands has had any significant long-term impact on the overall flow capacity of the lower estuary. The recent natural growth of the islands is most likely a result of continuing entrance restriction due to sand build up through the inflow of sand from the beach system (a function of large scale processes), which can in turn lead to a reduction in tidal energies and promotion of increased levels of sedimentation. The process can be reversed through flooding whereby large amounts of deposited materials (including entire islands, vegetated or not) can be removed from estuary systems.

The state of the entrance with respect to shoaling varies naturally and can have a significant effect on the hydrodynamics of the river with follow on effects for tidal flushing sedimentation/erosion,

ecological habitats and flooding as discussed in Section 7.1. The present (2005) conditions of the lower Nambucca River estuary reflect substantial shoaling with marine sands due to the absence of scouring from any recent major flood events. This is considered to be essentially a natural occurrence and is unlikely to be any worse than the situation if no training walls had been constructed at all. It should be recognised that the original training walls and dredging works were planned and carried out because of the shallow nature of the lower estuary.

The shallow ever-changing nature of the channels does make navigation of the lower estuary difficult as it always has. The present status is such that in some areas, navigation by even small recreational vessels is difficult at low tide downstream of Stuarts Island.

Available recorded data on tide levels indicates that the estuary is at a fairly constricted stage in terms of the dynamic cycle with the tidal range being towards the lower limits of natural variability (see Figure 7-10). However, the tidal influence is such that flushing in general terms is still likely to be adequate and no major water quality issues have been noted (see Section 15.5).

2003 Aerial Photography of Lower Estuary Figure 7-9

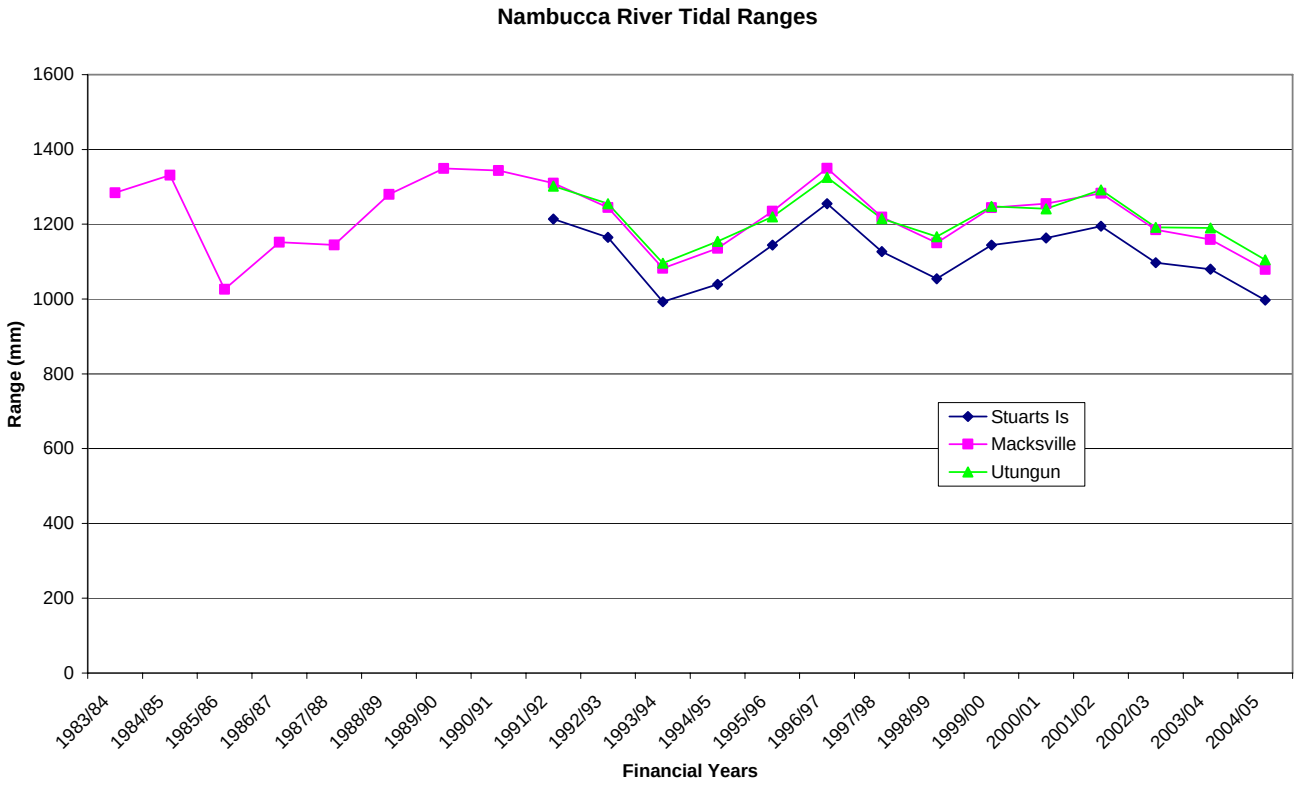


Figure 7-10 Historical Tide Range Variations

The constricted nature of the entrance is such that the potential exists for flood levels to be slightly higher in the next major flood event although this will be dependent on the size of the flood and the extent of scour during the event. Previous flood studies (NSC, 1999) have shown that dredging the lower estuary downstream of Stuarts Island will reduce the 1% AEP flood levels by approximately:

- 0.15m at Kings Point;
- 0.25m at Macksville; and
- 0.50m at Stuarts Island.

The above results indicate that the entrance of the river is an important hydraulic control for water levels in the river. It is also worth noting that dredging of the entrance may significantly increase the tidal range experienced up river. For example, following construction of the Gold Coast Seaway and associated dredging of the inner channels, the tidal range in the Southport Broadwater increased by about 0.3m.

Specific coastal and hydraulic process related issues associated with the entrance and lower estuary are outlined below and illustrated in Figure 7-9).

7.3.2 Specific Issues

7.3.2.1 Main Entrance Channel Region

The northern breakwater in combination with the generally dominant net northward longshore transport of sand along the coastline, usually force the main entrance channel to run along the breakwater. While the channel adjacent to the breakwater is typically deep, a shallow outer bar is generally present beyond the end of the breakwater. At times the channel does swing away from the breakwater towards the south under the influence of prolonged periods of southerly longshore sand transport.

The shallow outer bar, together with shoals in the lower estuary limit the draft of vessels that can enter/leave the estuary. Furthermore, during periods of moderate to high waves (which occur frequently), waves break on the outer bar making navigation difficult.

When conditions on the bar are unfavourable and/or inner shoaling restricts navigation to the entrance channel, alternative ocean access is gained by launching across the beach at Shelley Beach to the north of North Head. However, this is limited to vessels able to be trailed and launched from the beach. Furthermore, rocky outcrops offshore make navigation difficult and limit usage to those with local knowledge. Additional time is also required for emergency services to gain ocean access if required.

The state of the entrance is such that navigation is presently limited to relatively shallow draft vessels. These are mainly recreational boats with some small commercial fishing vessels. The historical works to improve navigation were centred on shipping being the primary mode of transport for trade at that time. With the demise of the need for shipping trade, the commercial justification for major entrance works to improve navigation is limited. However, the shallow, unstable and often dangerous nature of the entrance channel remains a major constraint to present users. It also limits the potential for the region to attract passing ocean vessels and development of associated tourist/commercial facilities.

7.3.2.2 Lower Estuary (Downstream of Stuarts Island)

As discussed above, the lower estuary is subject to the inflow of sand from the beach system and in the absence of a recent major flood, is reasonably constricted. The channels and shoals are continually changing and with the back channel carrying flow through the opening in the ‘vee’ wall, there are effectively three main flow paths. The spreading of the flow across the broad lower estuary results in shallower channels further exacerbating the navigational difficulties. On extreme low tides, even small recreation vessels can have difficulties navigating the main channels to the south of the training wall. Access to Warrell Creek is also constrained at low tide which can be an issue for emergency vessels if such access is needed.

Recent (2005) observations indicate that the south channel from Stuarts Island to Warrell Point is becoming the dominant flow path and channel with the central channel adjacent to the training wall becoming substantially shoaled.

Very high currents can also make navigation difficult and dangerous conditions for swimmers. Channel migrations have led to bank erosion in places such as at Warrell Point, where the development of the south channel has lead to a high erosion scarp and loss of trees.

7.3.2.3 Back Channel (Downstream of Stuarts Island)

With the breach in the 'vee' wall, substantial flow is presently being carried through the back channel downstream of Stuarts Island. On the flood tide, high velocities through the gap in the wall have carried substantial quantities of sand into the back channel forming a flood tide delta (see Figure 7-9) as the flow spreads out and velocities drop. The momentum of the flood tide flow through the gap is also now generating a flood tide channel against the bank of the island formed through spoil disposal from earlier dredging. Bank erosion is occurring along the downstream edge of the island as this channel is being formed.

On the ebb tide, sand is carried into the back channel at the upstream end shoaling the channel in this area and restricting navigation from time to time. The ebb tide current is concentrated on the outside of the bend at the downstream end maintaining a relatively deep channel around the recreational beach back to the opening in the 'vee' wall. Extremely high velocities and turbulence make navigation through the gap in the wall dangerous, especially for the inexperienced or for boats with limited power. However, it presently provides quick access from the back channel to the entrance for emergency vessels.

The high ebb tide velocities around the popular recreational beach area at the downstream end can also be dangerous with inexperienced swimmers being carried out through the gap and into the main channel. This has resulted in several fatalities and the need for numerous rescues.

7.3.2.4 Warrell Creek

The entrance to Warrell Creek can be extremely shallow at times and shoals at various locations along the creek constrain navigation, particularly at low tide. Bank instability and slips in the dunes along the creek have been identified as contributing to the shoaling in Warrell Creek. The main sand shoal control affecting deeper hulled boats at low tide is located just downstream of the primitive campground area at Gumma. Early descriptions of Warrell Creek from Captain F Howard's 1891 hydrographic survey are included in the inset box in Section 7.2.

7.3.2.5 Stuarts Island Region

The back channel behind Stuarts Island has been blocked since around 1915 when the causeway was first built. As such there is no through flow in the channel resulting in a calm environment. Some siltation of the back channel has occurred as a consequence while the reach immediately downstream of the causeway has been developed as a popular recreational swimming area.

The main channel adjacent to Stuarts Island generally remains navigable although some shoals are evident. This region is towards the upstream end of the inflow of marine sands. The training wall extending out from Stuarts Island into the main channel remains from the uncompleted original scheme of works a century ago. There is no specific evidence that this wall is having a major influence on present day processes.

8 BOATING & WATERWAY USAGE

8.1 Introduction

The Nambucca River Estuary has a long history of boating and waterway use. Prior to the establishment of the rail link to the area in about 1930, nearly everything that came and went from the area went via the Nambucca River. Accordingly, the major residential areas have centred near the river (i.e. Nambucca Heads, Macksville and Bowraville) and there were many accesses located onto the river for the shipping of timber and produce out and people and supplies in.

It was recognised by the first boaters to the area that the Nambucca River entrance was shallow and shifting (refer to Section 7.2.3) and treacherous for some boats. This ultimately led to the decision to build a northern breakwater and training wall in the 1895 to facilitate safe navigation into the entrance area. The major entrance and river training works were completed in 1903, although there were some additional components added at later dates, e.g. the V-wall which was commenced in 1915 and completed in 1918. Dredging of the entrance channel and other sections of the estuary continued until 1949 (G. Highfield, 2001). The maintenance dredging of the entrance channel has lead to the formation of numerous dredge spoil islands in the lower estuary. Since the time when maintenance dredging of the entrance ceased, aerial photographs show dredges operating in the estuary undertaking specific dredging activities.

During the 1980s Nambucca River Cruises and Charter Co. operated a tourist cruise boat between Nambucca Heads and Macksville. Its operation was hampered by shoaling between the wharf at Nambucca RSL club and the main river channel at Bellwood and approached Nambucca Shire Council in 1986 to dredge this section of river. It appears the proponents were happy to pay for the cost of dredging but saw the cost of an EIS to be prohibitive. After numerous representations to all levels of Government an EIS was eventually prepared and the DA approved by Council August 1990.

With the introduction of the rail, the usage of the river has changed dramatically. The desire to ship materials decreased, as the practice was dangerous and time consuming. Rail had introduced a faster and more economical means of transporting goods. Accordingly, the usage of the river has changed since these times.

Today, the primary waterway usage is recreational and is associated with fishing and boating. Other principal waterway uses include swimming, waterskiing (including jetskiing) and a variety of passive recreational uses such as walking, canoeing and birdwatching. The estuary is seen as one the major tourism drawcards for the Shire (see Section 12). Many residents are concerned about the ability of the estuary to sustain peak levels of waterway use (as may occur during holiday times) and also many are concerned that the greatness of the estuary is being eroded by the combined impacts of sedimentation, decreasing water quality, overfishing and impacts of inappropriate development.

The following sections outline:

- Existing waterway usage, types of usage (commercial and recreation) and key usage locations (Section 8.2);
- Current instruments controlling existing waterway usage, (Section 8.3);

- Existing waterway facilities, location and tenure and their current adequacy (Section 8.4);
- Possible future changes/trends in waterway usage, e.g. types and levels of usage and implications for waterway management and provision of foreshore facilities (Section 8.5); and
- Summary (Section 8.6).

8.2 Existing waterway usage

The Nambucca River Estuary provides for a range of commercial and recreational pursuits. Maximum patronage of the estuary from a recreational perspective occurs over the Christmas/New Year period (see Section 12.2). Other peak times occur during the school holiday periods particularly through January and Easter breaks.

Details of existing waterway usage were included in the Estuary Processes Study (WBM, 2000). However, this information was compiled based on only limited information and has been updated as part of this Estuary Management Study.

8.2.1 Methods used to obtain new usage information

In order to update and improve the quality of waterway usage information, e.g. principal usage types and locations the following activities were undertaken:

- Staff member present in the local area for six weeks between October and December 2004;
- Distribution of a community questionnaire to locals and tourists over the period end October 2004 to end January 2005, aimed at identifying key usage types and locations;
- Site inspections on the estuary during the peak usage period of early January 2005; and
- Numerous one-to-one discussions with long time residents and commercial operators.

Additional details of the community questionnaire and results from this process are detailed in Section 4. In relation to waterway usage, the questionnaire aimed to gather the following information:

- Most common usage types;
- Usage locations and frequencies; and
- Waterway usage issues (i.e. conflicts in waterway usage and threats to waterway health).

Summarised results for usage types, locations and frequencies are detailed in the following sections.

8.2.2 Most common usage types

Details on estuarine/waterway usage and values are detailed in Section 4.2, however, the top five uses and values as determined from the community questionnaire are detailed below:

1. Fishing;
2. Swimming;
3. Riding/walking;

4. Boat usage (may actually be higher as many fishers would have used boats to undertaken fishing, and may not have indicated that they actually did use boats); and
5. Picnicking/BBQ.

8.2.3 Most common usage locations and frequencies

8.2.3.1 Recreational usage

As detailed in the Community Consultation Report, the questionnaire included an A3 sized map, which requested respondents to indicate what parts of the estuary they primarily use for what purpose. The results of this are shown in Figure 8-1, which provides a comparative graph of the locations of estuarine usage, and in Figure 8-2, which provides this information diagrammatically. It is important to note that the graph and figure do not take account of the frequency of use.

The peak usage locations (for all uses) are in the Nambucca River between Macksville and the Entrance, and the Entrance area up Warrell Creek as far as the Gumma Reserve/Boultons Crossing.

In terms of usage frequency, the following indicative usage statistics have been generated from information provided on the questionnaire. It should be noted that these statistics have been generated from a small percentage of total estuarine users:

- Walking (or riding) – 170 days/year (based on 11 responses i.e., n = 11);
- Swimming – 106 days/year (n = 15);
- Birdwatching – 78 days/year (n = 6);
- Fishing – 68 days/year (n = 29);
- Boat usage – 41 days/year (n = 22);
- Canoeing/kayaking – 35 days/year (n = 5); and
- Picnicking/BBQ – 31 days/year (n = 4).

Despite the low numbers of questionnaires and low proportion of users providing usage data, the statistics generated are believable and indicate that walking and swimming are undertaken for the longest periods of time, followed by birdwatching (although this figure is only based on 6 respondents) followed by fishing and boat usage. The quality of these results would have been substantially improved by a larger number of correctly completed questionnaires being returned.

Figure 8-3 to Figure 8-8 shows graphically the number of respondents using the waterways for the various activities, based on data provided on the map by respondents. The darker shading indicates a higher number of respondents using the waterway in that area.

Figure 8-9 depicts typical waterskiing/wakeboarding locations in the estuary. This picture has been developed through consultation with the Maritime Authority and Rob Argent a local waterskier. PWC usage in the estuary is currently low, with most PWC usage occurring in the lower estuary.

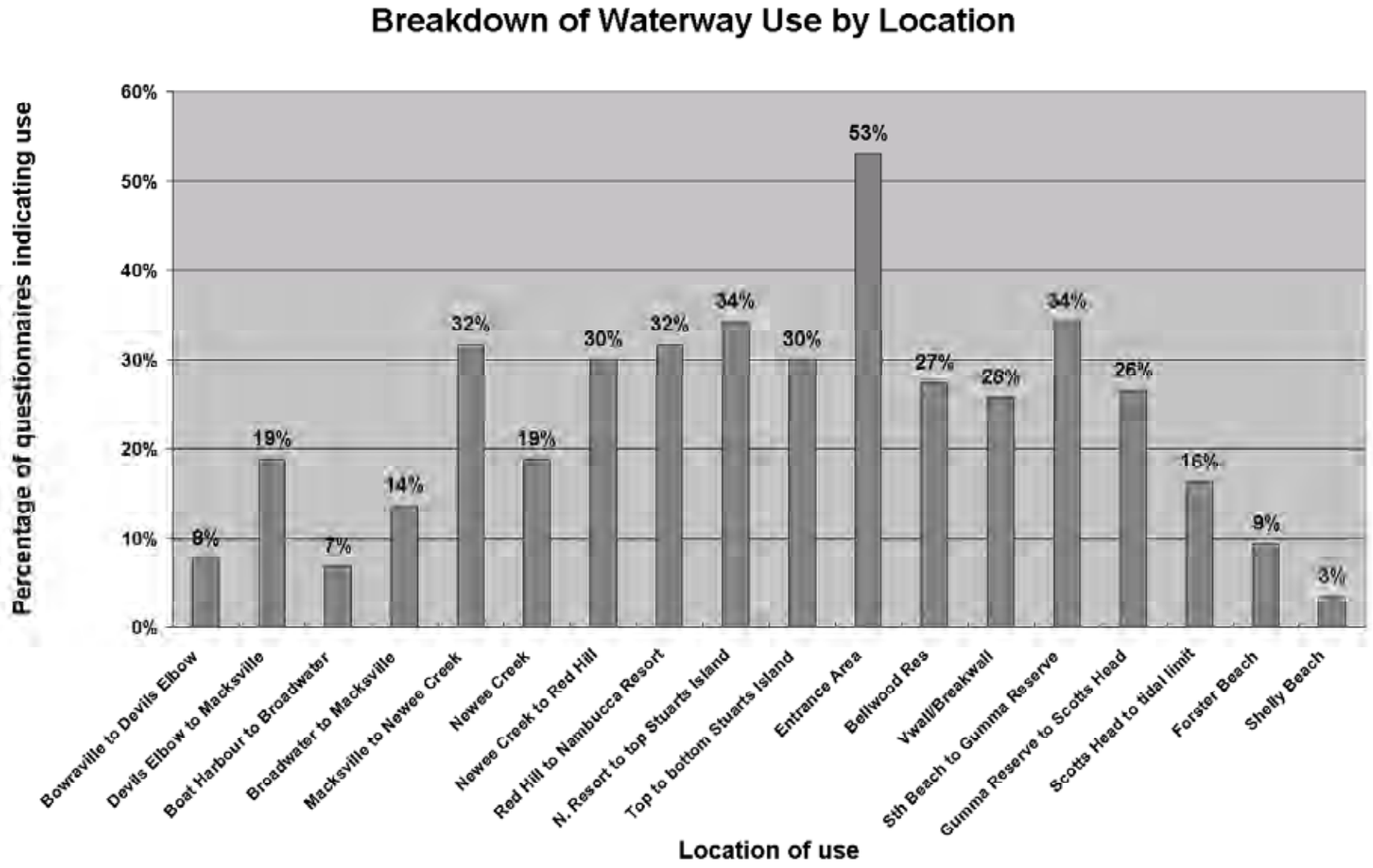


Figure 8-1 Estuarine Usage Locations

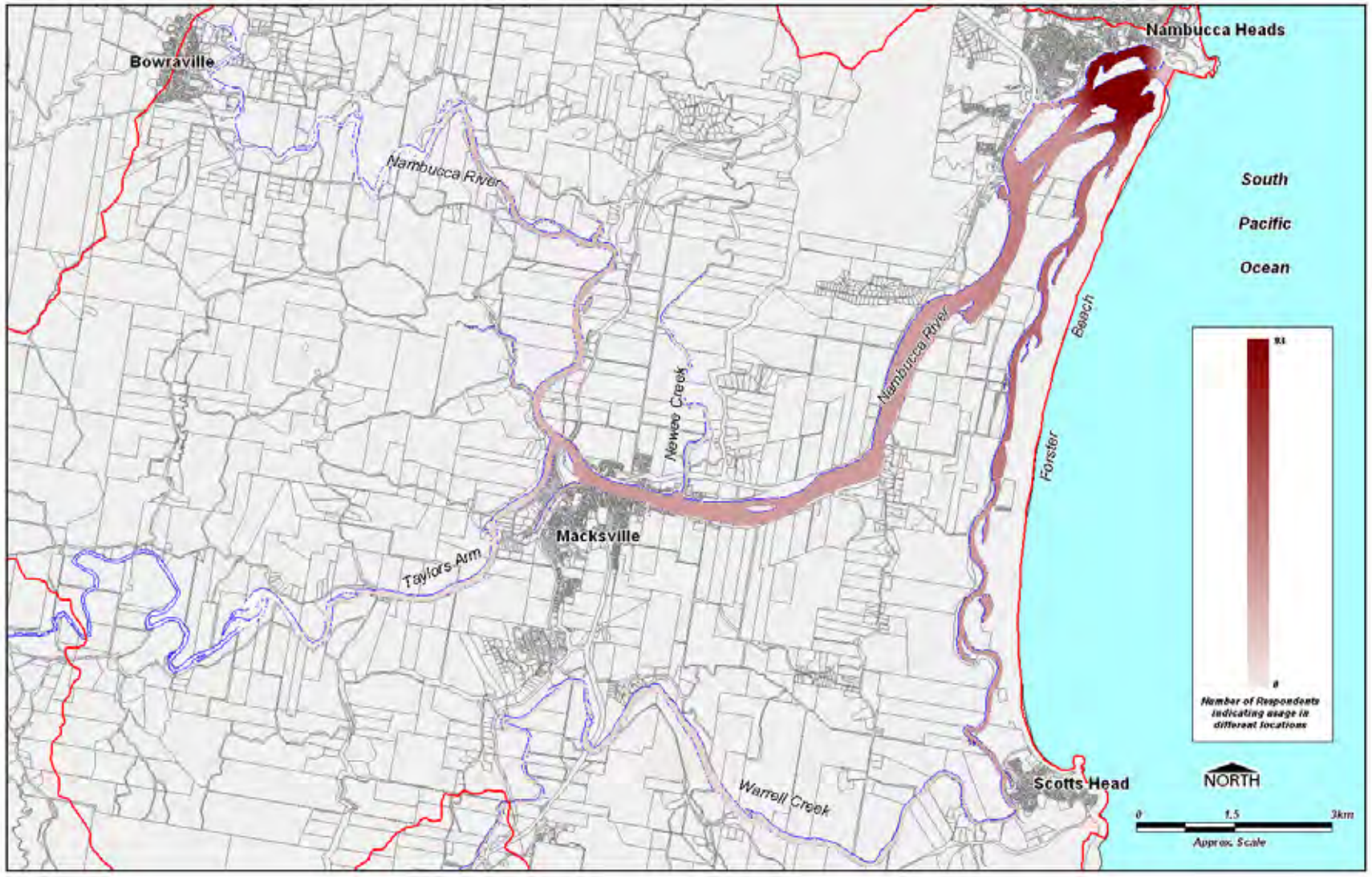


Figure 8-2 Entire Estuary Usage Locations – Nambucca River Estuary

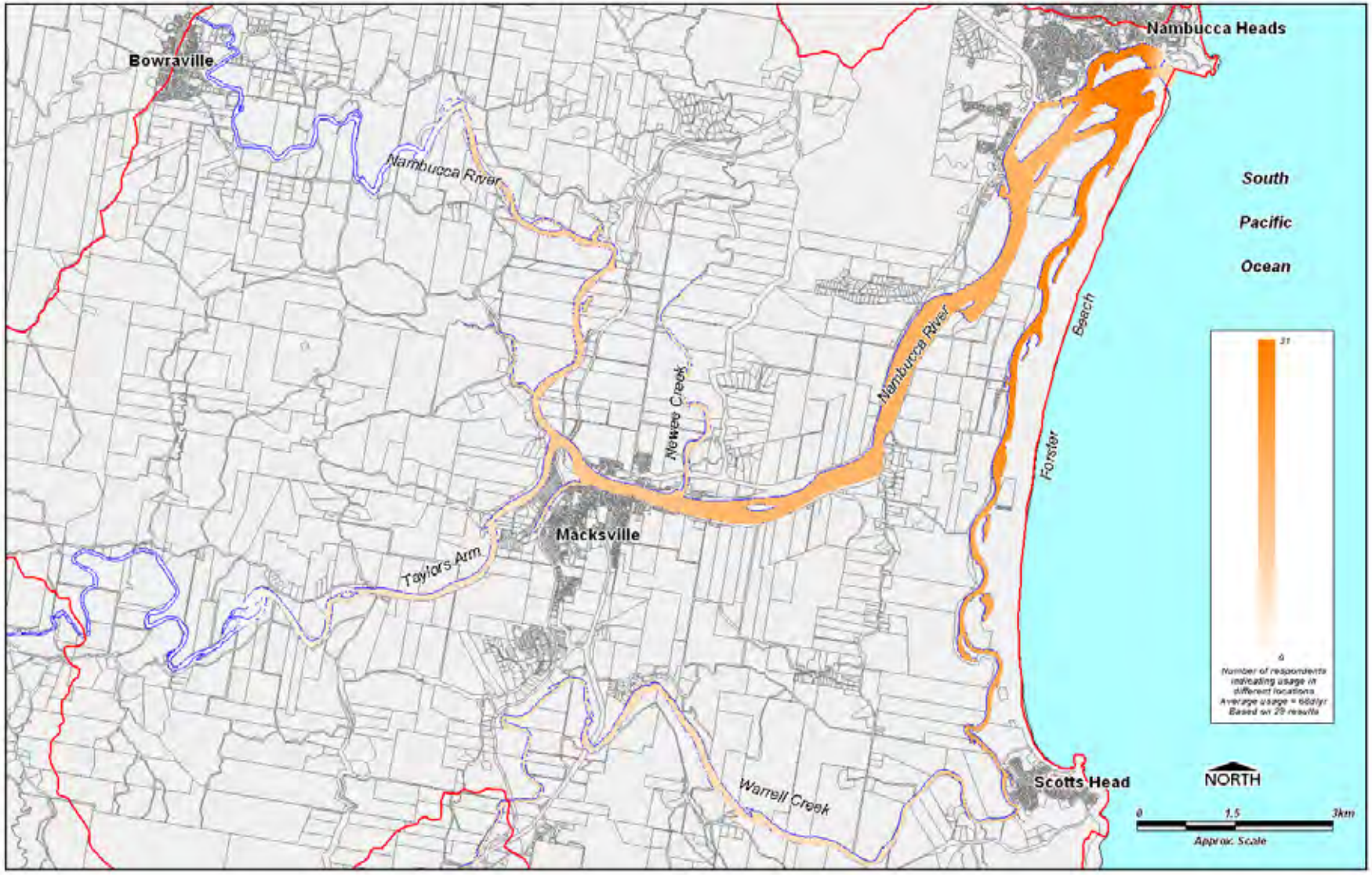


Figure 8-3 Fishing Usage Locations – Nambucca River Estuary

Figure 8-4 Boat Usage Locations – Nambucca River Estuary

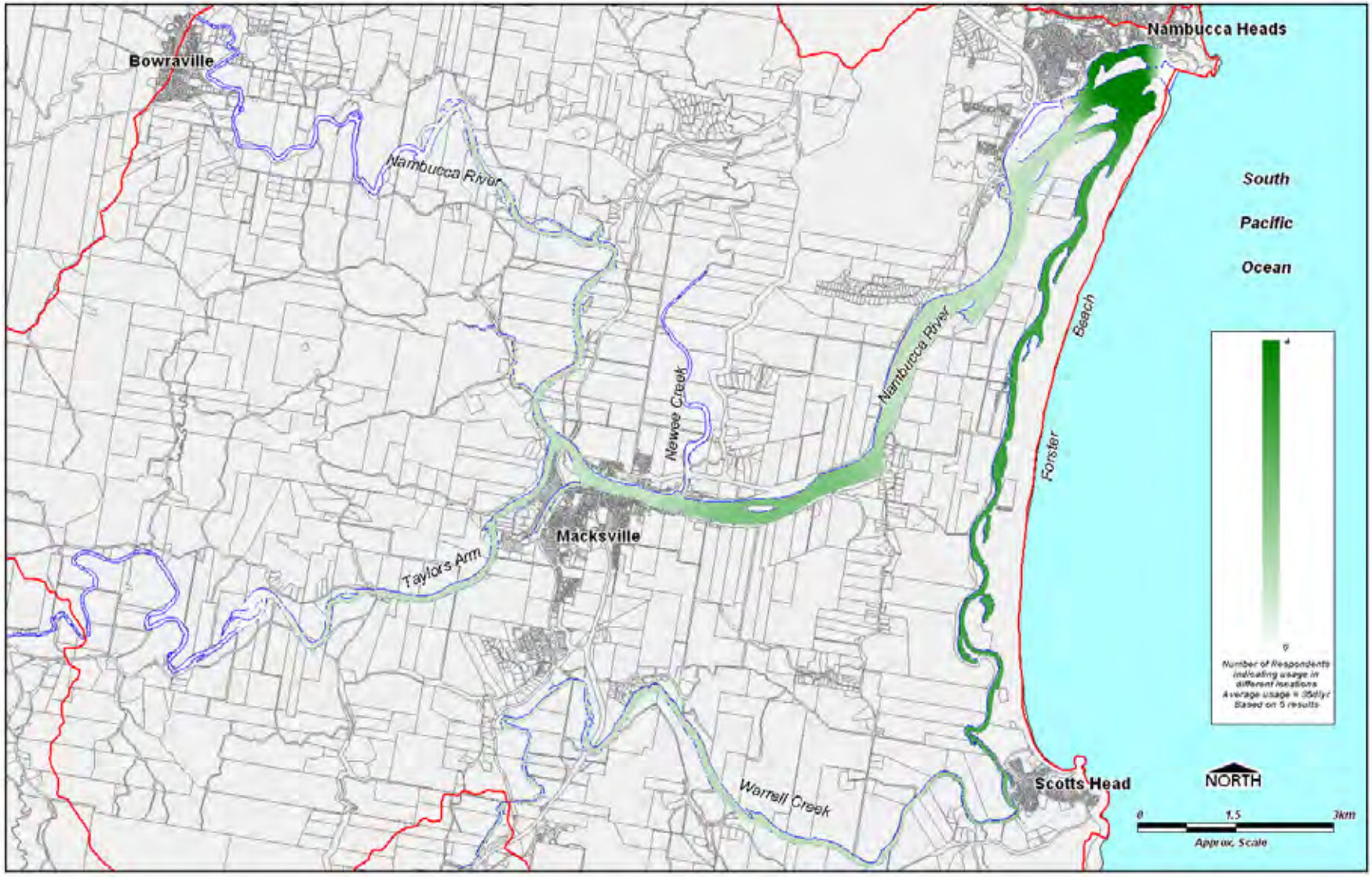


Figure 8-5 Canoeing and Kayaking Usage Locations – Nambucca River Estuary

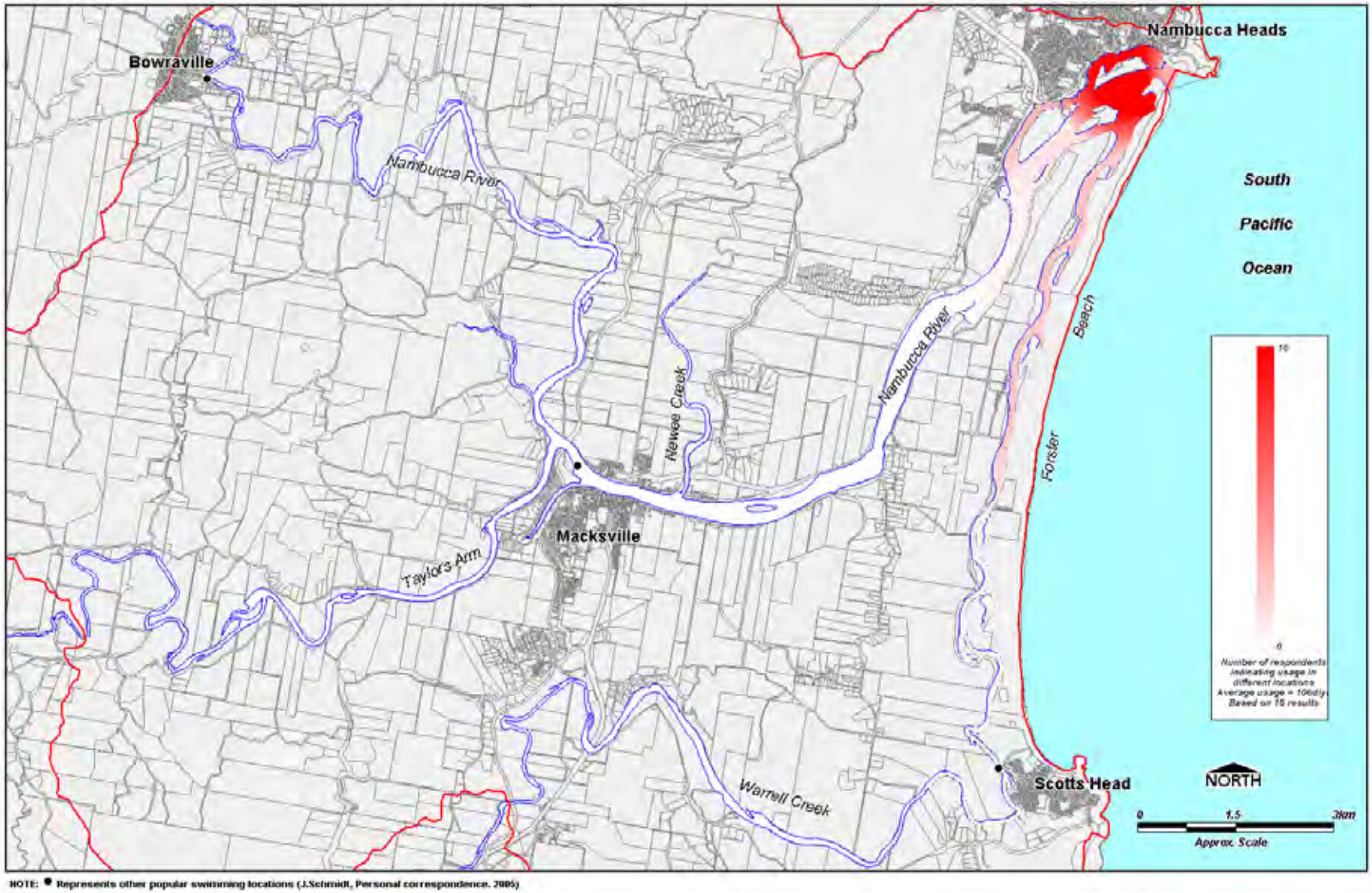


Figure 8-6 Swimming Usage Locations – Nambucca River Estuary

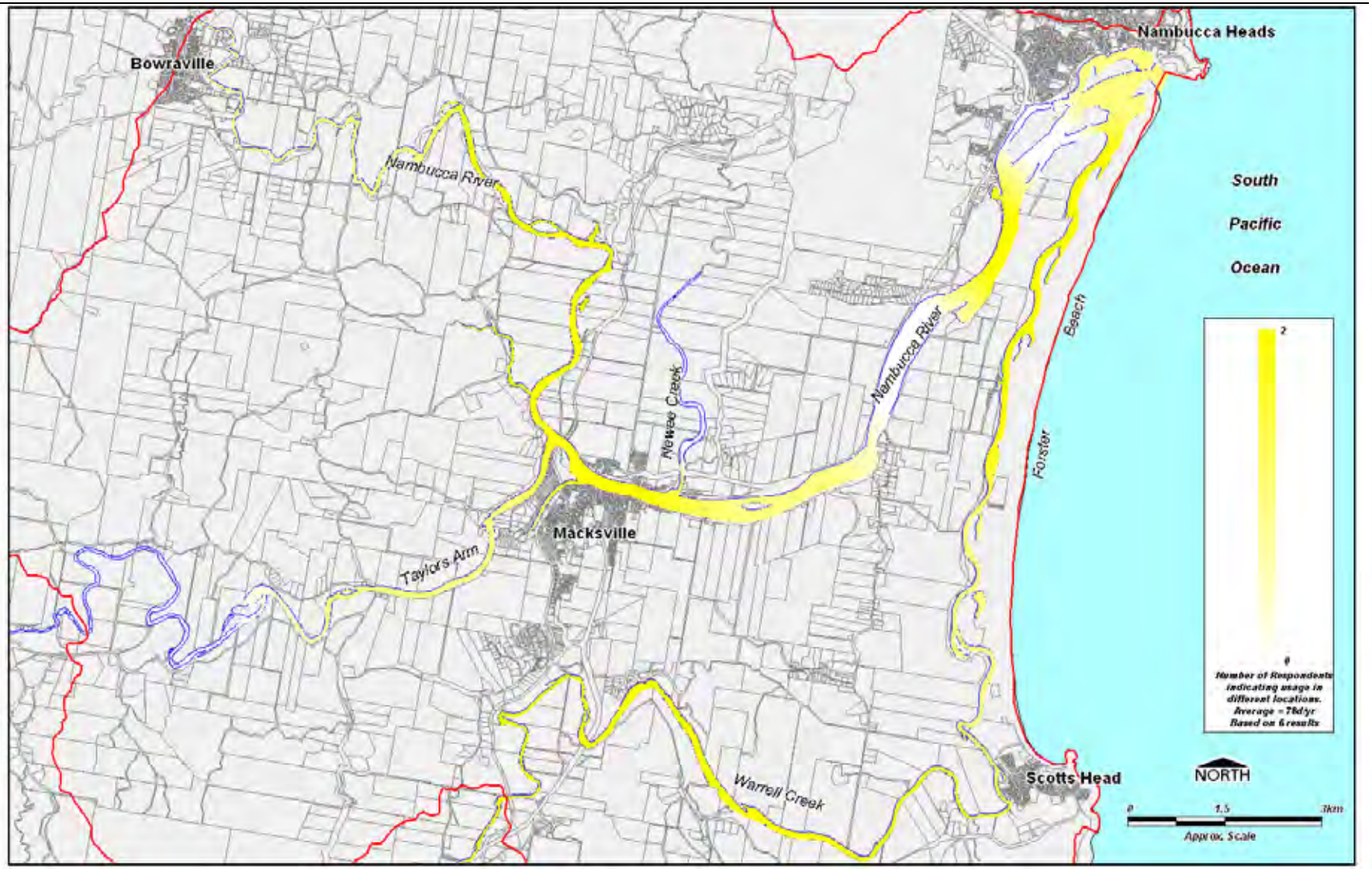


Figure 8-7 Riding and Walking Usage Locations – Nambucca River Estuary

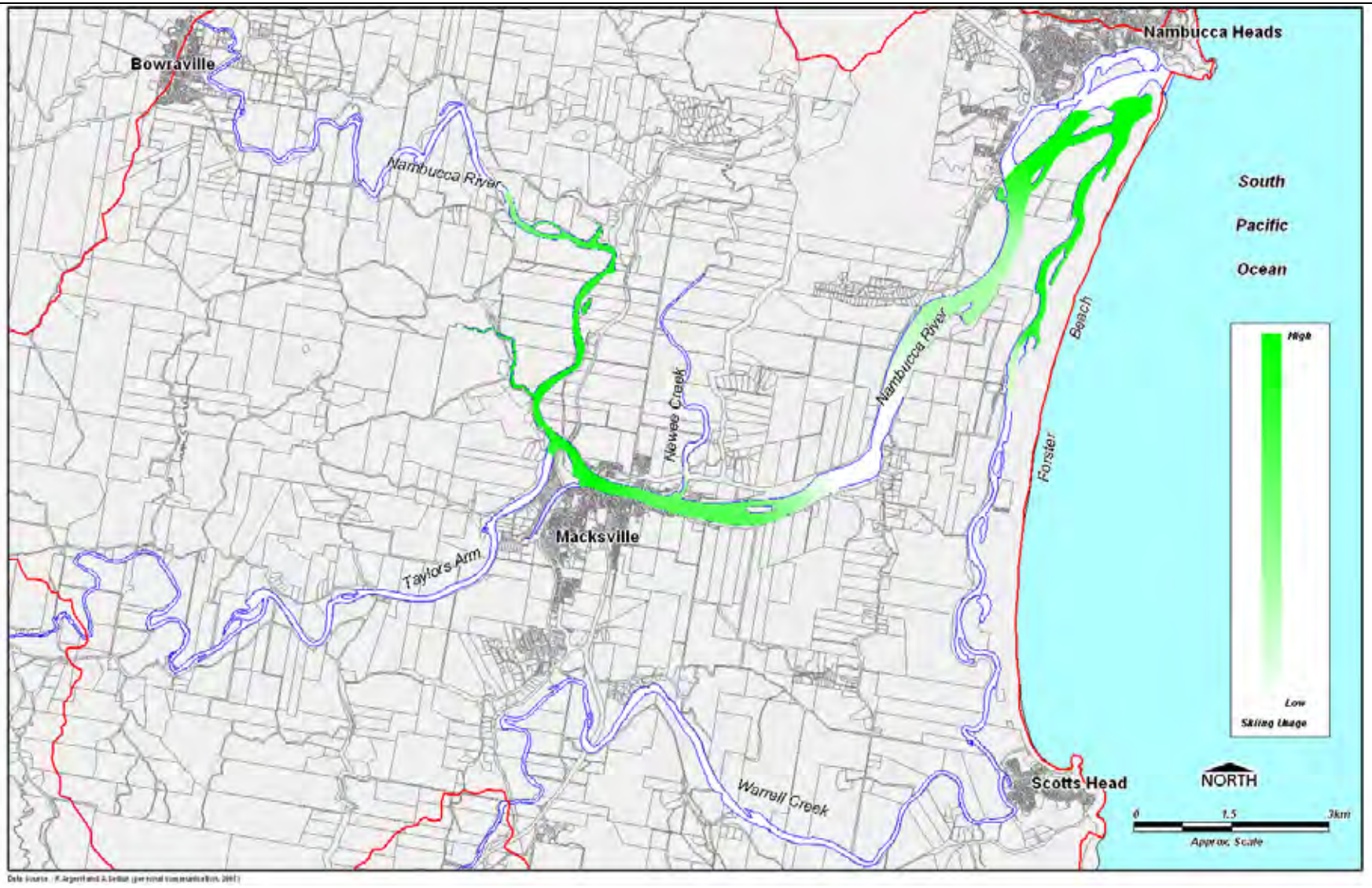


Figure 8-8 Birdwatching Usage Locations – Nambucca River Estuary

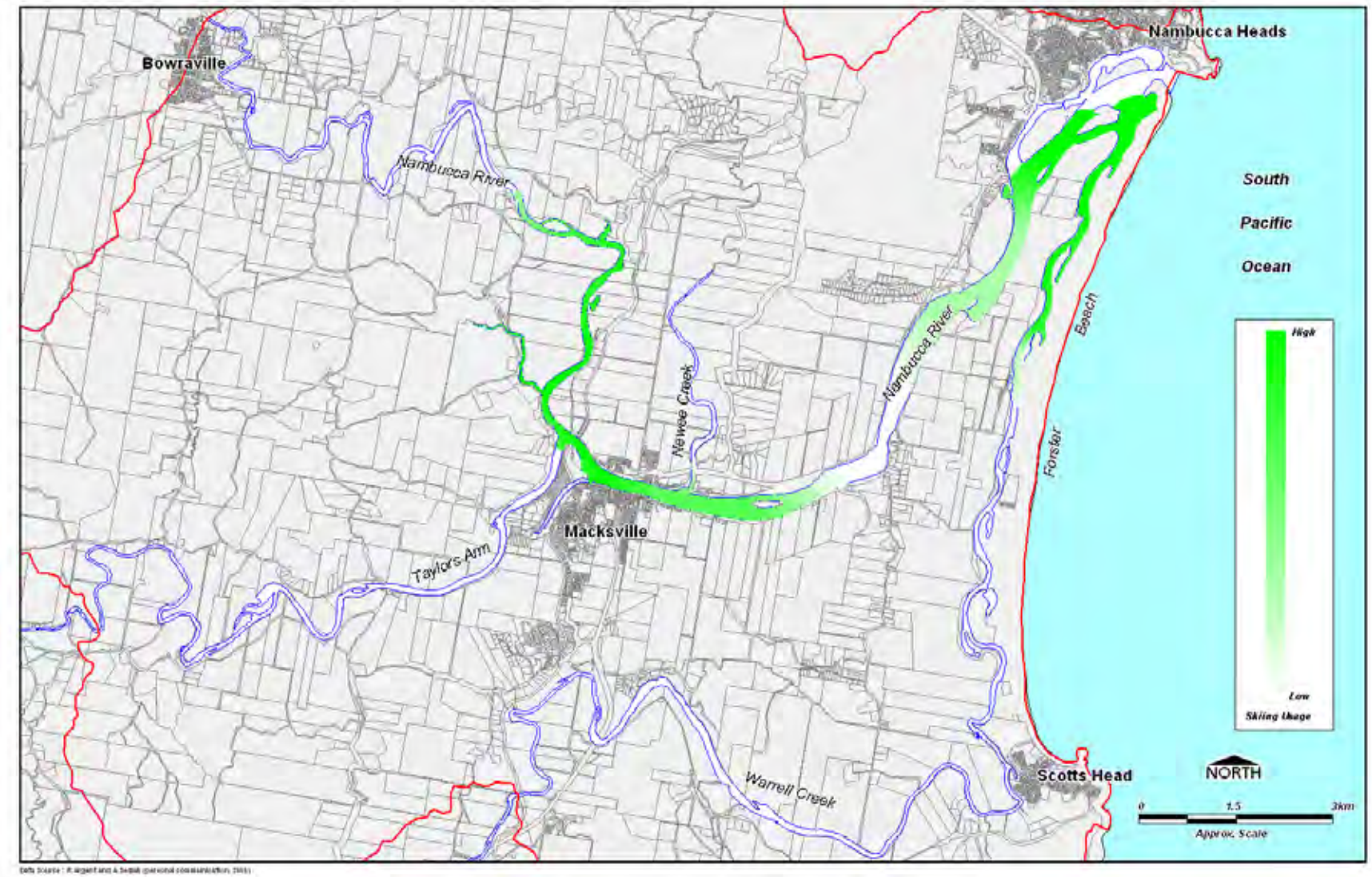


Figure 8-9 Water Skiing Typical Usage Locations – Nambucca River Estuary

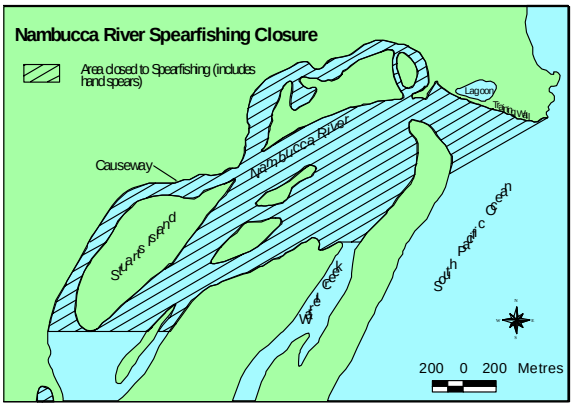


Figure 8-10 Nambucca River estuary spearfishing closure area

Spearfishing can be undertaken in the lower estuarine reaches where water clarity permits sufficient underwater vision to undertake this activity. DPI Fisheries restricts the undertaking of this activity in all shaded regions shown on Figure 8-10. No individuals indicated that they undertook this activity regularly on the community questionnaire.

8.2.3.2 Commercial usage

The estuary is also used for a variety of commercial uses including:

Commercial Fishing

The two main fishing techniques used within the estuary include trapping and netting. Trapping is used to catch crabs, while netting is used for fish.

Appendix C provides detailed information on the applicable commercial fishing regulations. However, in general, netting is not allowed in the entrance waters of the Nambucca River, nor upstream of the Scotts Head Boat Ramp (adjacent to Warrell Creek Reserve). Set mesh nets are not allowed upstream of Apex Park Reserve (Nambucca River) or upstream of a post marked "FD" in Taylors Arm (between 15 May and 31 August each year). Trapping is not allowed upstream of the Scotts Head Boat Ramp (adjacent to Warrell Creek Reserve). No commercial fishing is allowed on public holidays or weekends.

The main fish species caught within the system include mullet, bream, whiting, black fish (luderick) and flathead. Other minor species commercially caught include mulloway (jewfish) and tarwhine (see Table 11-4 for more information).

Section 11.1 provides further information in relation to the productivity and value of the Nambucca estuary for commercial fishing.

Oyster Farming

Commercial oyster production occurs in the lower reaches of the Nambucca estuary between Goat Island and the entrance to the Nambucca River with one oyster lease being located near the confluence of Warrell Creek with the Nambucca River.

Section 11.2.3 provides further information in relation to the productivity and value of the Nambucca estuary's commercial oyster industry.

Boat and Houseboat Hire

There is a boat hire company and a houseboat hire company both operating out of Nambucca Heads. The houseboat hire company opened in late 2003 and have two houseboats operating between the Pelican Caravan Park to Devils Elbow on the North Arm and the Broadwater on Taylors Arm. Wastewater from the houseboats is collected and pumped out at the facility in Macksville.

The "Nambucca Princess" tour boat used to operate between Nambucca Heads RSL Club wharf and Macksville, however, this ceased operations in *circa* 1993. It is understood that shoaling was a factor contributing to its closure.

8.3 Instruments controlling existing waterway usage

8.3.1 Boating

Boating for the purposes of fishing, travelling, waterskiing and other forms of boating such as jet skiing (i.e. Personal Water Craft) comprise the most active (as opposed to passive) use of the estuary. Boating as a usage also presents the highest opportunity for impacts to the estuary.

NSW Maritime currently controls waterway usage for the purposes of boating. The NSW Maritime boating maps provide detail of navigational controls, speed restrictions and other warnings for the Nambucca River estuary (the boating maps are included in Appendix D). This section provides a review of the current suitability of the NSW Maritime boating maps in relation to boat speed, waterway navigability and controls in place to reduce impacts on sensitive areas.

It is envisaged that information provided in the Estuary Management Study may be utilised by NSW Maritime when they prepare a Boating Management Plan for the estuary. Being a statutory document, only the NSW Maritime can legally prepare a Boating Management Plan.

8.3.1.1 Boat speed

The following controls in relation to boat speed and usage are shown on the Maritime boating maps:

- Back Creek / Inner Harbour and channel behind Stuarts Island is an 8 knot zone;
- "No wash" zone in Tilly Willy creek and lower portion of Taylors Arm (see text box on following page regarding 'no wash' zones); and
- Caution to minimise wash around oyster racks to avoid damaging them.

From discussions with NSW Maritime, the boat speed set for the Back Creek / Inner Harbour channel and the areas behind Stuarts Island are to be re-gazetted as a four-knot zone due to safety concerns for swimmers (A. Sedlak, Pers Comm., 2005).

Most shallow draft boats should be able to travel on the plane for most of the way up the estuary towards the tidal limit, until the presence of gravel/sand banks, at this time boat speed will be naturally limited by the presence of these underwater features.

Boat Wash and No Wash Zones (source NSW Maritime http://www.maritime.nsw.gov.au/wash.html)

Boat wash is the turbulence created by your boat as it moves through the water. Wash size and influence is affected by the amount of water your boat displaces, the boats speed, it's planing attitude and other factors such as water depth. This means that a large cruiser moving through the water at 8 knots will displace a large amount of wash - big enough to capsize small dinghies, damage moored boats and contribute to foreshore erosion. A high performance ski boat, however, will create almost no wash when it is planing.

NO WASH signs are placed in areas where wash from vessels can cause damage, injury or annoyance to other vessels, the shoreline or people. Every vessel operator must comply with these signs.

The way you achieve this will depend on the type of boat you are driving, however if in doubt about your vessel's wash it is recommended that you take the following action:

- as you approach the restricted area, reduce speed;
- at the start of the "NO WASH" zone, take your engine(s) out of gear;
- put the engine(s) back in gear and proceed with the engines giving just enough speed to provide you with steering control; and
- look behind you occasionally, to see if your boat is creating wash. If it is slow down - at a speed just above idle, no boat will produce wash.

When you see a "NO WASH" sign and a speed limit sign, do not automatically assume that you can travel at the maximum speed indicated. It may be necessary for you to travel at a slower speed to ensure your boat is not creating wash.

T

The following comments in relation boat speed were received during the community consultation phase:

- Despite the warnings provided in the boating maps regarding the presence of oyster leases in the estuary. Boat wash impacts are still being received by oyster growers, particularly during the peak holiday periods. Comments received from oyster growers indicate that these problems in part relate to the characteristics of the boat wash, which in turn are related to boat speed, size, trim and depth of water.
- Water-skiing near the end of Warrell Creek is a safety hazard due to the sometimes high number of boats using this area and the high speed at which these boats travel.
- Water skiing upstream of Scotts Head poses a safety hazard within a relatively narrow channel sections (<~30m in width).

8.3.1.2 Navigability

As detailed in the boating maps the estuary is generally considered to be navigable for shallow draft boats up as far as the tidal limits on all major tributaries, with caution being applied in the upper reaches of the major tributaries due to the presence of numerous unmarked gravel banks and submerged rocks. These recommendations on the boating maps are considered to be accurate based on site inspections undertaken on the estuary by the study team.

The following specific navigational comments were received during the community consultation phase:

- Illumination of leads into the Shelley Beach ramp is required for boats returning at night time;
- Improved signage of existing oyster leases/racks to safeguard both the racks (and boats) from accidental collisions, particularly during holiday periods when there are large numbers of tourists boating on the river; and

- Improved signage of Warrell Creek. Presumably in relation to the presence of sand banks.

The ocean bar is widely recognised to be very dangerous for boaters, and it unlikely addition signage or educational tools will improve its navigability or lessen the dangers of crossing the bar.

8.3.1.3 Boating controls in sensitive areas

Sensitive areas that may be affected by boating usage exist in the estuary and include seagrass beds, saltmarsh areas, eroding banks, oyster leases and urban areas.

Seagrass beds

Seagrass beds provide a highly productive fish nursery and feeding habitat. The disturbance or destruction of sub-tidal flora such as seagrass is considered possible when the underkeel clearance is reduced to less than 0.5m. Vessel access should be limited over these shallow areas. At present there is no signage warning boaters as to the presence of seagrass beds.

The quality of the historical seagrass mapping has made it difficult to ascertain if there has been any significant change in the health or distribution of seagrasses in the estuary over the past 20 years (refer to Section 10.2). Hence, it is has not been possible to identify if the increased levels of boating are having any significant impact on seagrass distribution in the estuary.

Based on the present seagrass mapping as shown in Figure 10-1 and a knowledge of the waterway depth, the critical areas for boating impacts, e.g. by disturbance by propellers, anchors, etc occurs in several places in the estuary including the "Broadwater" on Taylors Arm, the northern side of Stuarts Island and along all of Warrell Creek, from Warrell Point to the Weir Reserve at Scotts Head. The identification of exact areas of seagrass beds that are most likely to be impacted by boat run up and propeller action has not been possible due to a lack of detailed bathymetry for the estuary. Collection of detailed bathymetric information is planned for the Nambucca River in 2006.

As shown on Figure 8-3 and Figure 8-4 the current levels of boat usage in Taylors Arm are low in comparison to boating levels in Warrell Creek. There are no existing controls or warning on the NSW Maritime boating maps that limit potential impacts to seagrass beds.

Saltmarsh Areas

As identified in physical condition assessments (Geco Environmental, 2005), "*the erosion of saltmarsh areas is of particular concern in lower reaches of the Nambucca River and Warrell Creek. The saltmarsh communities are naturally fringed by mangrove communities, which prefer frequent inundation by the tides. This mangrove fringe with its various protruding pneumatophores and stems acts as an effective wave dissipater, protecting the saltmarshes from wave effects. Where the mangrove fringe is lost the saltmarshes are highly susceptible to undercutting by subsequent wave wash. These impacts are significant as saltmarsh communities are important fish nurseries and wader bird habitats and are known to be declining throughout eastern NSW*." There are no existing controls or warning on the NSW Maritime boating maps that limit potential impacts to mangrove areas that protect saltmarsh communities. The locations of mangroves and saltmarsh communities in the estuary are shown in Figure 10-2 and Figure 10-3.

Eroding banks

Whilst unlikely to be the principal mechanism for the bed and bank degradation processes being observed in the estuary, WBM (2000) and Geco Environmental (2005) have identified that boat wash is contributing to bank instability in the estuary. This finding reflects many of the concerns raised by the community and stakeholders in relation to the contribution of boating (including jet skiing, water skiing and wake boarding) to bank erosion in the estuary.

In most cases impacts are limited to areas of high use, for example where skiing and wave boarding is popular (see Figure 8-9). The most affected areas are lower Warrell Creek and North Arm from the Railway Bridge up to the adjacent to the Macksville showgrounds. Other areas of concern include Taylors Arm up to the where the 'no wash' sign is located and Warrell Creek between Boultons Crossing and Scotts Head. The existing controls on boat speed in the estuary are included in Section 8.3.1.1, however, none of them apply to areas identified to be suffering from boat wash at this time.

In terms of boat wash, there are limited definitive studies to date regarding the wakes produced by a broad range of vessels. Of these AMC (2002) is quite comprehensive and examines some typical boats types in the Brisbane and Noosa Rivers and assesses reasonable operating speeds based on a wave energy factor (height and period). Both sections of these rivers assessed, were similar in depth and width. The Noosa River section was 80m wide and around 6m deep, while the Brisbane River section was around 90m wide and 6m deep.

The AMC (2002) study concluded that wave energy criteria best represented the bank erosion potential from boat wash. For the Brisbane River, they used the criteria of 180J/m and for the Noosa River 60 J/m. These values are set just above the wind wave erosion criteria for each system. The difference in the criteria between the Noosa and the Brisbane River matches local experience, which suggests that the shoreline types found on the Brisbane River, would be more capable of withstanding higher wave energy levels, than the Noosa River.

The wave energy criteria for both river channels were tested for a range of boat sizes (the smallest being a jet-ski and the largest being a mono-hull ferry) for a range of speeds. All the measurements of were based on only one passing of each vessel type. Another issue with the assessments is that they cannot account for the potential impacts of some emerging recreational activities, such as wake boarding, which uses weighed down ski boats to maximise wake.

Table 8-1 and Table 8-2 below is taken from AMC (2002) and indicates the ranges of speeds for differing vessel types that are acceptable based on the energy and length criteria.

Table 8-1 Boat Wake Energy Compliance Criteria - Brisbane River

Vessel	Speed Range Tested (knots)	Energy Criteria		LWL * (m)	Period Criteria		Outcome
		Applied (J/m)	Speeds where Criteria Exceeded (knots)		Allowable LWL (m)	Pass/ Fail	
Houseboat	4.9	180	Nil	11.50	9.0	N/A	Able to operate at all attainable speeds
12' Aluminium Dinghy	4.7 to 10.7	180	Nil	3.35	9.0	Pass	Able to operate at all attainable speeds
River Ranger	5.2 to 26.4	180	**6 to 10**	3.90	9.0	Pass	Able to operate below 6 and in excess of 10 knots
Beam Trawler	3.9 to 7.4	180	Nil	7.30	9.0	N/A	Able to operate at all attainable speeds
Everglades Water Bus	7.4 to 26.6	180	**> 8**	8.20	9.0	Pass	Maximum speed limited to 8 knots
QBFP Vessel	5.4 to 28.0	180	**6 to 16**	4.50	9.0	Pass	Able to operate below 6 and in excess of 16 knots
QG Cowan	6.6 to 33.0	180	**7 to 28**	6.75	9.0	Pass	Able to operate below 7 and in excess of 28 knots
Ski Boat – Large	7.2 to 35.2	180	**6 to 21**	5.30	9.0	Pass	Able to operate below 6 and in excess of 21 knots
Ski Boat – Small	6.8 to 35.0	180	**6 to 13**	4.60	9.0	Pass	Able to operate below 6 and in excess of 13 knots
Jet Ski	4.9 to 41.2	180	Nil (almost)	2.70	9.0	Pass	Able to operate at all attainable speeds
Clark 16' Survey Vessel	7.0 to 21.2	180	Nil (almost)	4.45	9.0	Pass	Able to operate at all attainable speeds

* LWL = water line length of the vessel and J/m is an energy parameter joules per metre.

Table 8-2 Boat Wake Energy Compliance Criteria - Noosa River

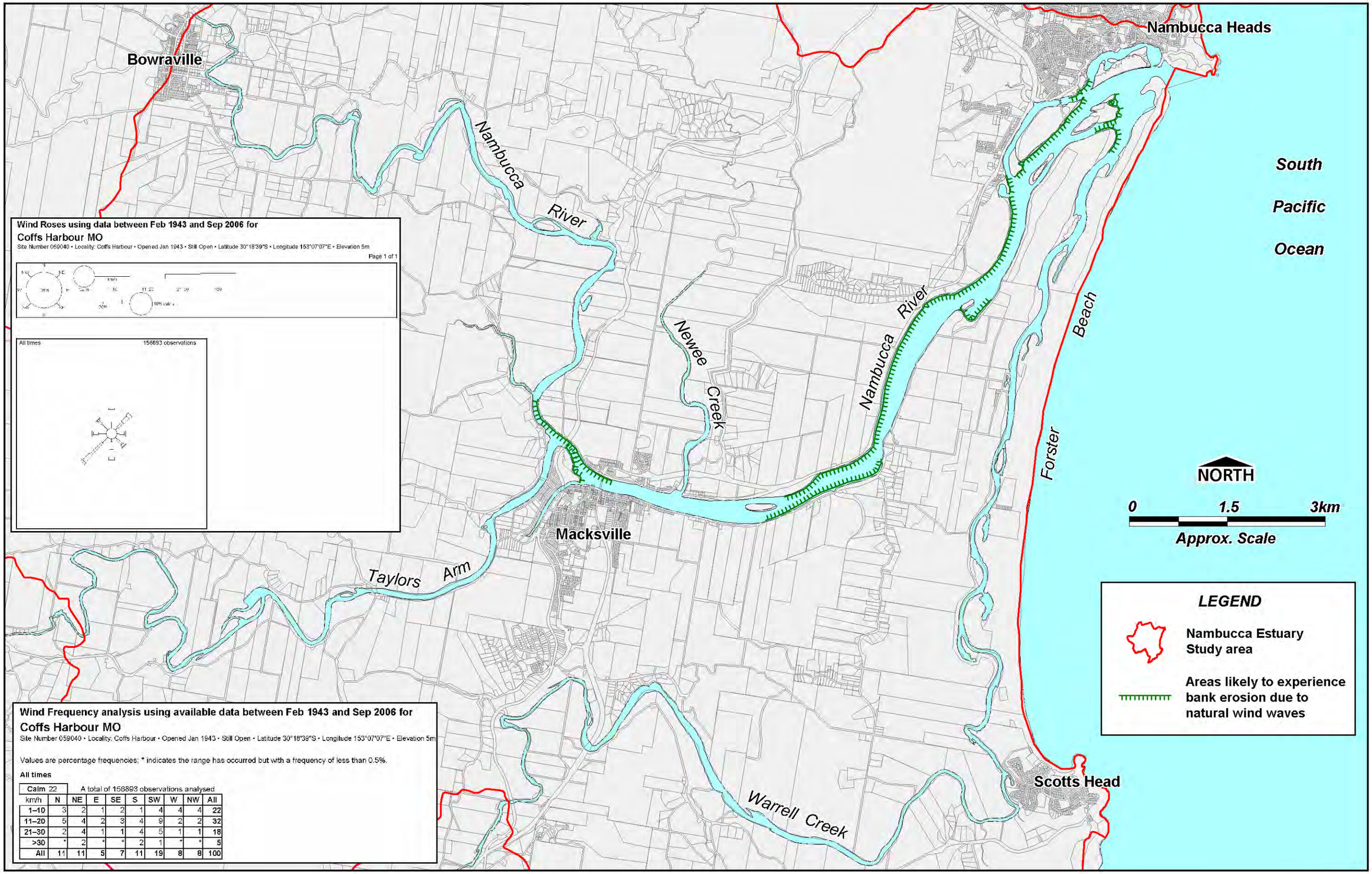
Vessel	Speed Range Tested (knots)	Energy Criteria		LWL * (m)	Period Criteria		Outcome
		Applied (J/m)	Speeds where Criteria Exceeded (knots)		Allowable LWL (m)	Pass/ Fail	
Houseboat	4.9	60	Nil	11.50	5.2	N/A	Able to operate at all attainable speeds
12' Aluminium Dinghy	4.7 to 10.7	60	Nil (almost)	3.35	5.2	Pass	Able to operate at all attainable speeds
River Ranger	5.2 to 26.4	60	**5 to 15**	3.90	5.2	Pass	Able to operate below 5 and in excess of 15 knots
Beam Trawler	3.9 to 7.4	60	**> 5 (against current)**	7.30	5.2	N/A	Maximum speed limited to 5 knots
Everglades Water Bus	7.4 to 26.6	60	**> 5**	8.20	5.2	**Fail**	Maximum speed limited to 5 knots
QBFP Vessel	5.4 to 28.0	60	**5 to 22**	4.50	5.2	Pass	Able to operate below 5 and in excess of 22 knots
QG Cowan	6.6 to 33.0	60	**> 6**	6.75	5.2	**Fail**	Maximum speed limited to 6 knots
Ski Boat – Large	7.2 to 35.2	60	**5 to 34**	5.30	5.2	**Fail**	Operation above 34 knots subject to period check
Ski Boat – Small	6.8 to 35.0	60	**5 to 20**	4.60	5.2	Pass	Able to operate below 5 and in excess of 20 knots
Jet Ski	4.9 to 41.2	60	**5 to 20**	2.70	5.2	Pass	Able to operate below 5 and in excess of 20 knots
Clark 16' Survey Vessel	7.0 to 21.2	60	**5 to 14**	4.45	5.2	Pass	Able to operate below 5 and in excess of 14 knots

* LWL = water line length of the vessel and J/m is an energy parameter joules per metre.

No energy criteria have as yet been developed for the different reaches of the Nambucca River estuary. However, from the results obtained for the Brisbane and Noosa River systems, which are of a comparable size to many reaches of the Nambucca estuary, i.e. parts of Warrell Creek, Taylors arm and the North Arm, it is apparent that there are speeds at which the various types of boats assessed will generate wash with sufficient energy to cause bank erosion.

Generally, the 12 ft dinghies (or less) and houseboats are acceptable. However, nearly all other boats including and jet-skis can potentially cause issues depending on the wave energy criteria of the river reach they are operating in. Common types of boat usage within the Nambucca River estuary include small and large ski-boats, particularly over holiday periods. Operation of these boats was observed in both the Brisbane and Noosa River assessments to exceed the energy criteria between around 5 and 20 knots. This has implications for the Nambucca River estuary in that these ski boats will be continually accelerating and decelerating through these speed ranges, and potentially some boats will not be able to attain an operating speed beyond which the wave energy criteria will not be exceeded, i.e. 34 knots for a large ski boat in the Noosa River.

It has not been possible to measure the relative contributions of boat and wind wash to bank instability as part of this study, however, wind wash will be more prevalent in certain locations of the estuary than in others. Figure 8-11 shows the location of areas likely to experience bank erosion due to natural wind waves. The susceptible locations have been determined based on the natural alignment of the estuary and on predominant wind directions. It shows that the areas likely to experience wind wash are located in the main section of the Nambucca River between the entrance and Macksville. Windwash is not expected to be a major contributing factor in Warrell Creek due to its relatively narrow width and extent of high quality riparian vegetation



km/h	N	NE	E	SE	S	SW	W	NW	All
1–10	3	2	1	2	1	4	4	4	22
11–20	5	4	2	3	4	9	2	2	32
21–30	2	4	1	1	4	5	1	1	18
>30	*	2	*	*	2	1	*	*	5
All	11	11	5	7	11	19	8	8	100

Bank Erosion Stress due to Natural Wind Waves

Figure 8-11

Oyster growing areas

As discussed in Section 8.3.1.1, excessive boat wash can cause oyster to clump together in racks, causing extra work for oyster growers. Boat wash is worst during periods of increased boat usage, e.g. over holiday periods. Comments received from oyster growers indicate that these problems in part relate to the characteristics of the boat wash, which in turn are related to boat speed, size and trim. With specific mention of the larger vessels and the bow wave they generate. There are warnings on the NSW Maritime boating maps for boaters to limit speeds in order to limit potential impacts to oyster racks, but there are no speed restrictions in place.

Urban areas

The NSW Maritime has advised that the Nambucca estuary is presently a low noise complaint area. Complaints that are received typically relate to activities occurring in the estuary in specific areas on specific days (Sedlak, A. Pers Comm., 2005). This implies that there are particular users of the estuary that generate too much noise on odd occasions; it is likely that these users are not from the local area. No records of existing complaints were available for review in this study.

The areas most likely to be recording noise complaints are those that are most exposed to the activities of boaters, these are likely to include residents around:

- Macksville – particularly along River St, Bellevue Drive, McKay Street and the Macksville end of Nursery and Gumma Roads. The lower end of Taylors Arm and Tilly Willy Creek are already "No Wash" zones. This designation relies on the understanding of the ship's master as to what speed their craft can travel without generating significant wash. This speed will varies for all craft and it does not restrict some craft from traveling on the plane through this zone; and
- Scotts Head – homes around River Oak Crescent may be exposed to the noise of boats traveling on Warrell Creek.

Due to the current designation of an 8-knot zone behind Stuarts Island and in the Inner Harbour, most boats generating noise will be a few hundred metres away from the urban areas of Nambucca Heads. It is likely that noise levels will be acceptable at this distance, unless there are unfavourable winds carrying the noise directly to the urban areas.

8.3.2 Swimming

The community and stakeholders have identified a range of issues in relation to swimming in the estuary. These concerns are relayed below:

- The river entrance, i.e. near the hole in the wall, should not be used as a swimming area as it is very dangerous with several drowning and numerous rescues occurring at this location;
- Recreational swimming, snorkelling or surfing in front of the boat ramp on Shelley beach is becoming problematic and dangerous for boats returning to shore; and
- The existing 8-knot speed limit in Inner harbour (i.e. opposite Wellington Drive in Nambucca Heads), presents a safety issue for local swimmers and people snorkelling.

Figure 8-12 shows the existing signage present on the Inner Harbour (left) and at Shelley Beach (right). The existing signs, although well worded may not be an obvious enough deterrent. Recently a number of local swimmers required rescue after they were washed out into the entrance area (Lawson, F. Pers Comm., 2005). This indicates that even local residents underestimate the severity of the safety risk at this location. It is also likely that some of the swimmers interfering with the return of boats to the Shelley Beach ramp are also from the local area.

From discussions with NSW Maritime, the boat speed set for the Back Creek / Inner Harbour channel and the areas behind Stuarts Island are to be re-gazetted as a four-knot zone due to safety concerns for swimmers (A. Sedlak, Pers Comm., 2005).

Figure 8-12 Existing signage on Inner Harbour (left) and Shelley Beach (right)

8.4 Existing waterway facilities

This section describes the existing waterway facilities in the estuary and provides a discussion of the likely adequacy of these facilities for their current and likely future usage.

8.4.1 Existing accesses and structures

As part of the fieldwork undertaken by Geco Environmental, they have prepared GIS based mapping which shows the locations of all accesses/structures, whether public, private or of unknown tenure, in the Nambucca River Estuary. In total, there were 195 structures/accesses recorded by Geco Environmental, as detailed below:

- 55 private foreshore structure – for example these include foreshore retaining wall works;
- 38 boat ramps – includes both formal (i.e. Council maintained) and informal ramps with higher usage;
- 2 historical features – includes historical ramps used for shipping in the estuary;

- 61 minor access or tracks – includes tracks and minor accesses to the estuary with lower usage;
- 6 park or reserves – includes locations of parks or reserves adjacent to the estuary;
- 16 pontoon/jetties – includes pontoons and jetties within the estuary;
- 3 recreational structures – includes rope swings and other structures used recreationally; and
- 14 road accesses – includes locations where access to waterways is available from roadways.

Figure 8-13 shows the locations of these structures and accesses onto the estuary, with all Crown land within the estuary highlighted in solid colour.

8.4.1.1 Boat ramps

Of the 38 boat ramps recorded, the Nambucca Shire Council maintains only 10 of these. Council maintained boat-launching facilities in the study area are detailed below:

Nambucca Heads

- Shelley Beach (ocean launch);
- Wellington Drive;
- Gordon Park;
- RSL (Riverside Drive); and
- Stuarts Island.

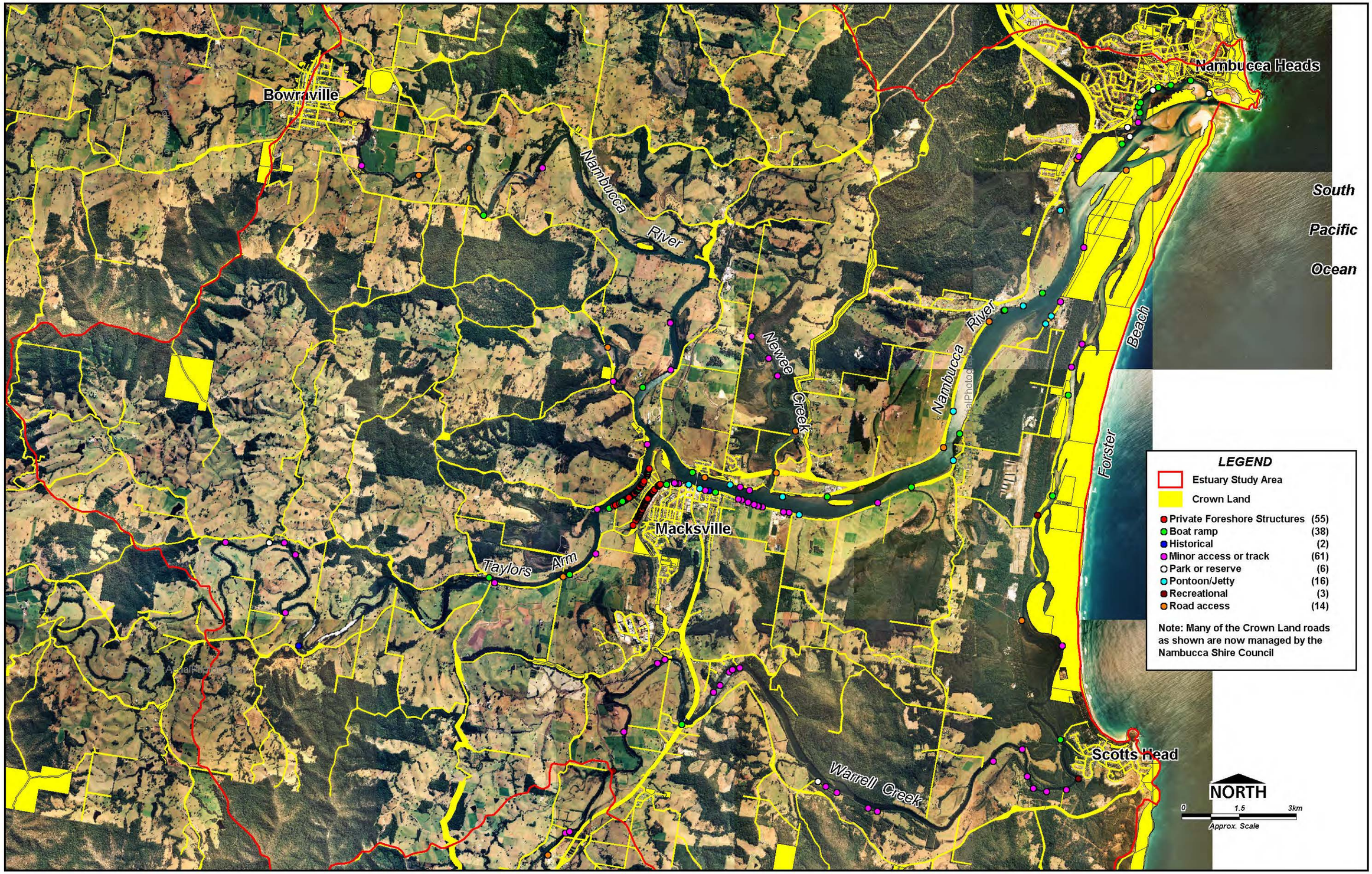
Warrell Creek

- Weir Reserve (South Pacific Drive), Scotts Head;
- Boultons Crossing/Gumma Reserve.

Macksville - Bowraville

- Lions Park (Rodeo Drive);
- McKay St (part of Surf Club on River St);
- Apex Park (Wilson Road), Bowraville; and

Most of these boat ramps are located either on Crown Reserve or Crown Road Reserves. Facilities available at these ramps are detailed in Appendix B.



Public Foreshore Land and Key Access Points **Figure 8-13**

Other ramps located on public lands were noted to exist at:

Warrell Creek

- Under the Pacific Highway Bridge; and
- At Kinnears Access.

Nambucca River

- On Bellevue Drive, Macksville (primary usage of this ramp is most likely associated with the nearby caravan park);
- Near the inlet to Gumma Creek, Gumma;
- Near Figtree Road on the Nambucca River, Gumma (this may be a private access);
- In front of the Foreshore Caravan Park, Nambucca Heads;
- In front of private residence along Riverside Drive adjacent to the Foreshore Caravan Park, Nambucca Heads;
- Near the white oyster shed opposite Riverside Drive in between Seaview St and Piggott St, Nambucca Heads (this ramp is used for oystering and has appropriate approvals from Lands Department); and
- Left bank Nambucca River off Bowraville road (Rodeo drive) about 600m past Wirrimbi Coldstores (the old Midco site).

Taylors Arm River

- Near the Congarinni Bridge, Congarinni;
- Off Taylors Arm road near end of Peterkins Lane, Congarinni; and
- Welshes Park, Talarm.

The tenure of the remainder of the boat ramps was private and often associated with private homesteads or caravan parks and resorts.

It should be noted that recently the Wright's corner ramp has been closed due to a realignment of the Pacific Highway and the existing River Street Ramp has also been removed as part of bank improvement works along River St. The remainder of the boat ramps and minor/road accesses or tracks recorded are located on both private and public lands. Generally these accesses to the river are located near to residences and population centres. All Council operated/maintained ramps are located on Crown Lands, apart from the Weir Reserve at Scotts Head, which is believed to be located on lands owned by the Nambucca Shire Council.

8.4.1.2 Minor accesses and tracks

Of the 61 minor accesses or tracks observed during the site inspections nearly all were located on Crown Lands, typically Crown Road Reserve (see Section 6.3.1 for more information on this designation). This is a function of the large percentage of the Nambucca River estuary, which has roads fronting onto the estuary. There were a number of accesses and tracks located on private lands

along Newee Creek and Warrell Creek. The relative levels of usage of all these structures could not be accurately gauged during the site inspections.

8.4.1.3 Private foreshore structures

All private foreshore structures observed were found to exist on the lower Taylors Arm and Tilly Willy Creek and have been used to protect the foreshore against bank erosion. Figure 8-14 is a picture taken in 2004 of some of the private foreshore structures on Taylors Arm.

Figure 8-14 Private Foreshore Structures on Taylors Arm at Macksville

8.4.1.4 Pontoons and jetties

Pontoons and jetties within the study area are generally for private use and are located on private lands. The pontoons and jetties are used for a variety of purposes including boat mooring/access and oyster operations. There are some pontoons/jetties located adjacent to Crown Road Reserves. There is one public pontoon/jetties located opposite River St in a reserve. This facility is used for a range of purposes including a water-skiing ramp and boat pump-out. There are no pontoon/jetty structures on the Bowraville branch of the Nambucca River, Taylors Arm or Warrell Creek.

8.4.1.5 Public foreshore reserves/parks

Major public foreshore reserves/parks located adjacent to the estuary include:

Nambucca River

- Apex Park in between Macksville and Bowraville;
- The foreshore reserve opposite River St at Macksville;
- Lions Park at Macksville;
- Gordon Park at Nambucca Heads;
- RSL ramp /Anzac Park at Nambucca Heads;

- Bellwood Reserve at Nambucca Heads;
- Stuarts Island Reserve (i.e. northeast corner of Stuarts Island) at Nambucca Heads;
- Vwall swimming/walking area at Nambucca Heads;
- Left bank just upstream of from Midco abattoir discharge point.

Warrell Creek

- Gumma Reserve/Boultons Crossing on Warrell Creek;
- Henstock Reserve on Warrell Creek (midway between Scotts Head and tidal limit).

Taylors Arm River

- Welshes Park on Taylors arm (near tidal limit);

A popular private foreshore park area available for public use is located at Gumma Dock. Facilities associated with some of these park/reserve areas are provided in Appendix B.

8.4.1.6 Historical features

Geco Environmental (2005) noted two historical features, including:

- Frank's wharf on Taylors Arm (upstream of Broadwater); and
- Old Government Wharf at Macksville.

Neither of these historical features are recognised as items of European cultural heritage in Schedule 3, Clause 41 of the Nambucca LEP nor appear in any other State Heritage Inventory held by the NSW Heritage Office or the Cultural Heritage Branch of the Department of Environment and Conservation.

It is considered that there may be other historical features located in the estuary including:

- Slipway at Kings Point Taylors Arm; and
- Drogher remnants Kings Point Nambucca River.

8.4.1.7 Recreational features

A few recreational items such as rope swings, etc were identified during the fieldwork component. All were located in Warrell Creek.

8.4.1.8 Road Accesses

Of the 14 road accesses to the estuary recorded during site inspections most were located on Crown Lands, typically Crown Road Reserve (see Section 6.3.1 for more information on this designation). This is a function of the large percentage of the Nambucca River estuary, having roads fronting onto the estuary. The relative levels of usage and quality of all these structures could not be accurately gauged during the site inspections.

8.4.1.9 Mooring

At present there are no dedicated mooring sites within the estuary. In general suitable mooring sites need to be in locations, which are:

- Close to facilities such as shoreline access, toilets, running water;
- Not visually obtrusive;
- Not impacting on general boating traffic and waterway use;
- Not impacting on seagrasses and other ecological systems.

Taking these factors into consideration, the following mooring locations are suggested for the major urban centres (note none have been provided for Scotts Head due to potential difficulties for boats in reaching this location):

Nambucca Heads

Upstream of Stuarts Island causeway, opposite Bellwood. This location provides a wide section of waterway, which has low usage due to the presence of the causeway and it close to amenities at Bellwood. Due to extensive riparian coverage, it is not expected that the mooring of boats in this location will affect aesthetics adversely. In the mid sections of this channel, there are no issues with seagrass shading. There are no issues with oyster leases at this location. Depth of water should be reviewed when the hydrographic survey is complete.

Macksville

Suitable sites exist in the lower reaches of Taylors Arm. This location provides a wide section of waterway that has low usage. It is close to Macksville and associated amenities. There may be some concerns raised by nearby residents, however, the boats could be moored on the far (western) bank to reduce these visual impacts. There are no depth or seagrass shading issues. There are no issues with oyster leases at this location.

8.4.2 Adequacy of existing facilities

Observations made during the site inspections on the estuary (during low and high season) and derived from community and stakeholder consultation indicate that most of the existing facilities are suitable for their current usage. The following comments are made in relation to the existing Council maintained boat ramps:

8.4.2.1 Lower Nambucca River

Shelley Beach boat ramp (ocean launch)

- It is considered to be well sited and essential to enable deep water access when the bar conditions are not favourable;
- Is dangerous for returning boats, due to the occasional presence of recreational swimmers, snorkellers, surfers, etc in this area (see Section 8.3.2);

- There is no electricity connected to the tractor shed, which has hampered previous boat rescue operations;
- The land based leads to the ramp require illumination at night time (the leads at this ramp were not installed and are not maintained by NSW Maritime);
- The location of the fish cleaning facilities promotes the disposal of fish offal and carcasses directly into the existing swimming area; and
- Other users of the area often park their cars in dedicated spaces for boats with trailers, leading to parking difficulties.

Wellington Drive boat ramp

- There is a poor road access and no parking available for this ramp;
- It should be promoted for small craft launching only; and
- A sharp drop off into the Inner Harbour limits the usability of the ramp and may need to be improved.

Gordon Park boat ramp

- Is considered well suited for its current usage; and
- May be benefited by a public wharf.

RSL boat ramp

- Is well sited, but in state of disrepair; and
- May be benefited by a holding pontoon.

Stuarts Island boat ramp

- Is considered well suited and located for its current usage;
- May be benefited by some form of nighttime lighting. Lighting provided at this location is unlikely to be a disturbance to local residents;
- Requires closer toilet facilities; and
- Some minor dredging required near jetty.

8.4.2.2 Mid-upper Nambucca River

Apex Park boat ramp (Wilson Road)

- This is the only public boat ramp on the north arm of the Nambucca River and its current position in the waterway limits the amount of usage it receives, as there are numerous sand/gravel shoals in this immediate section of the river; and
- The park has no facilities for visitors and has a very dangerous access to Wilson Road when exiting from the park, particularly if trailing a boat.

Lions Park boat ramp

- With the recent closure of Wrights corner and River Street ramps, the Lions Park boat ramp will be under added pressure to cope with the numbers of boats that use it. It is understood that this ramp is soon to be upgraded by Nambucca Shire Council, however, no plans for the future upgrade were available from the Nambucca Shire Council at the time this report was prepared. Any plans for upgrading should be take into consideration the increased usage this ramp is likely to receive; and include;
  - Provision of bollards for boat tie up facilities;
  - Beach area for boat parking and ski starts; and
  - Jetty area for fishing swimming boat access.

It is considered that during peak usage times there will be a lack of available parking facilities.

McKay Street boat ramp

- Is considered well suited for its current usage. The lack of facilities regulates its current levels of use.

8.4.2.3 Warrell Creek

Scotts Head Weir Reserve boat ramp

- This is the one of two Council maintained ramps on Warrell Creek and is considered well sited to serve residents of Scotts Head, as the majority of the populace is a considerable distance from the waterway, thereby reducing noise impacts associated with boating. However, some education in relation to boating is required in Warrell Creek due to higher sensitivity of this waterway to boat wash and related impacts;
- The reserve has only rudimentary facilities and could be improved by defined boat trailer parking area, redesigned ramp and boat access area accommodating the needs of boaters, fisherman, swimmers and picnickers. Additional facilities such as playground equipment, gas BBQs and picnic tables for visitors would also benefit the reserve.

Boultons Crossing boat ramp

- Is considered well suited for its current usage, however, some education in relation to boating is required in Warrell Creek due to higher sensitivity of this waterway to boat wash and related impacts;
- Has an informal waterway access at its northernmost extent, which should be blocked off;
- The access road to the campground is located close to a receding bank, which hampers the ability of riparian vegetation to establish and limit its recession.

Based on site investigations all ramps appear to cope with the current levels of usage during non-peak times. There is likely to be some peak loading of popular ramps such as Lions Park, Gordon Park and Stuarts Island during holiday periods, however, there have been no reports of these facilities being inadequate or there being a need for additional facilities.

The following additional inadequacies with current facilities are noted:

- There are no public wharfs/jetties at Nambucca Heads;
- There is a lack of dedicated beach areas (with suitable facilities, such as toilets, covered tables, etc) that can be used as water skiing base camps, hence water skiers are operating from inadequate facilities, such as the public wharf at Macksville;
- There are no dedicated mooring areas in the estuary. To address this situation NSW Maritime will need to prepare a Mooring Management Plan for the estuary. Suitable sites exist at Nambucca Heads and Macksville (see Section 8.4.1.9);
- There is a lack of facilities for canoeists and kayakers to place their craft in the river at Macksville or anywhere else in the estuary, hence canoeists and kayakers are forced to use public ramps or open banks to access the river; and
- Boat ramps and general river access facilities, jetties and pontoons are often poorly designed with little consideration given to single-handed boat user e.g. the ramp is confined on both sides by extensive rock riprap.

From discussions with NSW Maritime it was determined that due to the relatively low numbers of commercial and other recreational craft using the estuary, there was probably no need for any on-water refuelling facilities or an additional public pump-out/dump point at Nambucca Heads.

In providing the above recommendations, it should be noted that, there is no recorded information available on ramp usage levels during either low or high seasons. The collection of such data was outside the ability of the study to obtain, as it requires long-term monitoring of usage levels.

Further discussion regarding potential future waterway accesses is provided in Section 8.5.3. Priorities for the upgrade and addition of facilities are provided in the summary (see Section 8.6).

8.5 Potential trends in waterway usage

8.5.1 Boat ownership statistics

The Nambucca Shire has experienced a high rate of population growth over the previous 20 year period, and is expected to continue to increase in population to the 2026, as outlined in Section 1.1. The increased population is likely to result in increased levels of waterway usage.

Trends in boat registrations over the period of 1995 to 2005, in the postcodes of 2447, 2448 and 2449 shows significant increases in boat ownership (which is probably related to population growth) and suggests an increase in boat usage on the estuary. The information obtained from NSW Maritime has been represented graphically in Figure 8-15.

The figure shows that there has been a near linear increase in boat registrations for craft between 3 and 6 m in length over the period of 1996 to 2005, while the number of registrations for craft larger and smaller than this (i.e. below 3m and above 6m in length) has remained relatively constant. The highest growth has been observed to occur in the 3 to 4 m length craft (~15 craft/year), which during the period of recording has surpassed the slightly larger boat size of 4 to 5m. The growth in the 3 to 4 m craft accounts for approximately 60% of the average annual increase in boat registrations (~25 craft/year).

Figure 8-16 shows the distribution of ownership by locality for the most common registered boats in the study area. Nambucca Heads and Macksville regions contain the bulk of the registrations and these are relatively evenly distributed for most boat sizes.

The information available unfortunately provides no indication of the numbers and sizes of boats, which visit the estuary as a result of tourism and day visitation to the area.

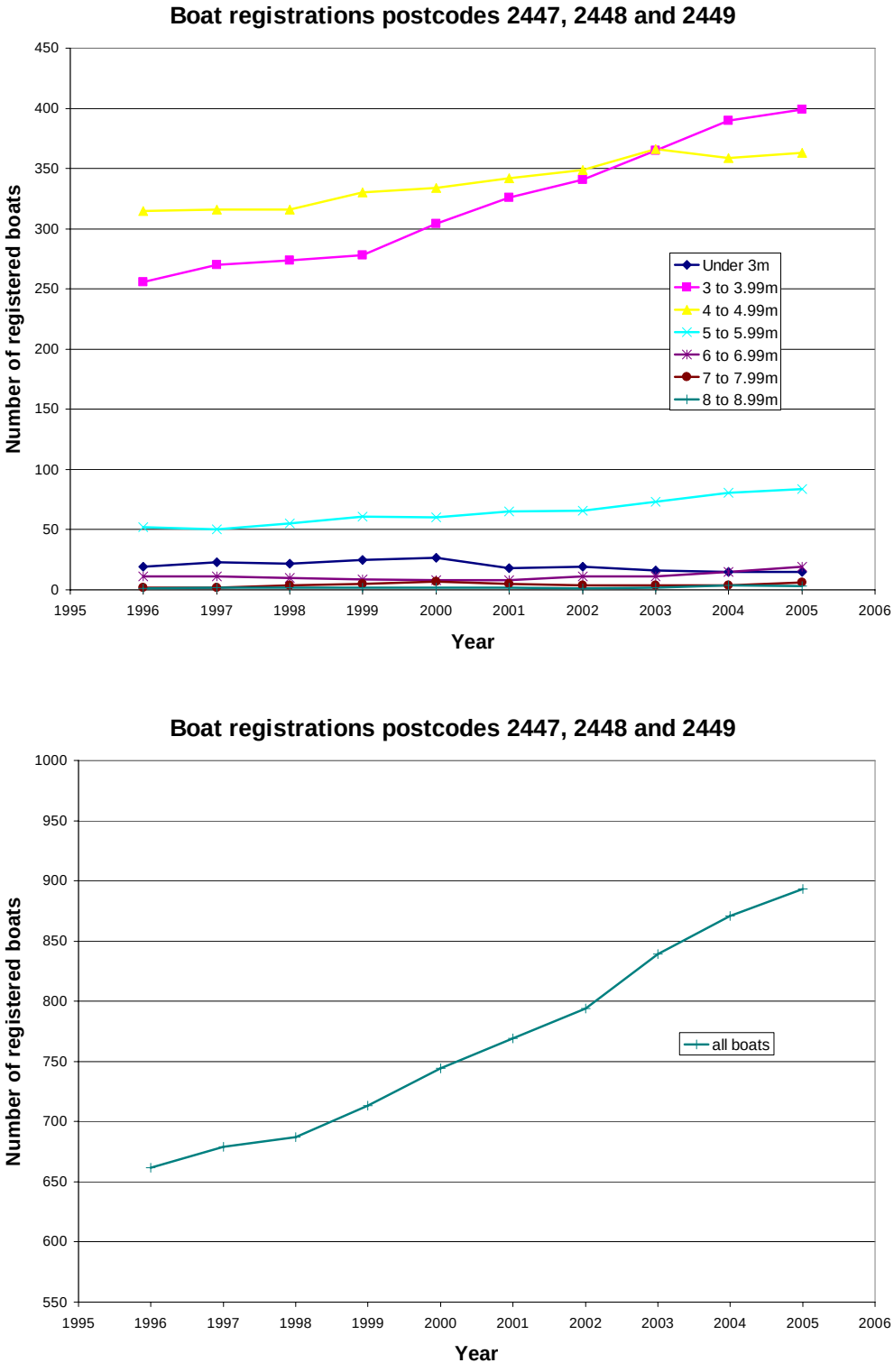


Figure 8-15 Boat Registrations in the study area from 1996 to 2005

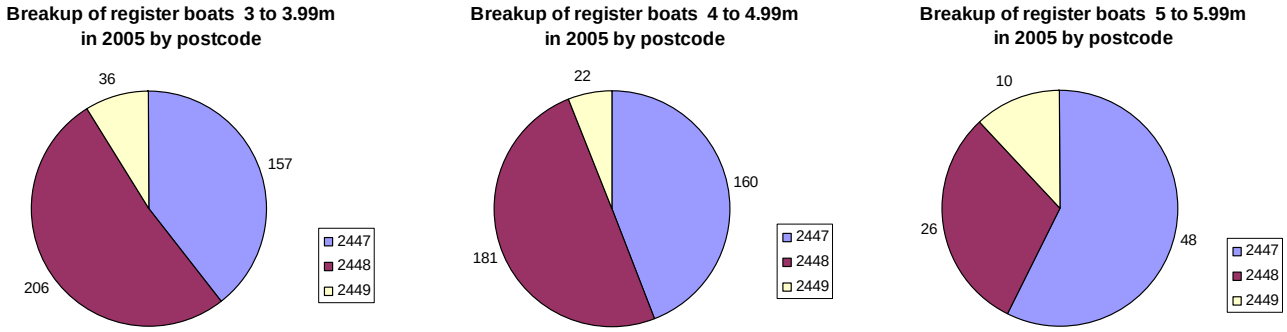


Figure 8-16 Numbers of registered boats by postcode

8.5.2 Other trends in waterway usage

Observations made during the site inspections on the estuary and derived from community and stakeholder consultation indicate that most of the existing boat usage is for the purposes of fishing and there are presently relatively low levels of usage of the estuary for water-skiing and wakeboarding. This is significant as the area around Macksville is just becoming recognised as one of the best regional locations for water skiing, owing to its relatively long and wide skiiable area, current low levels of usage and protection from winds (R. Argent, Pers Comm., 2004). Consequently, levels of water skiing in this area are likely to increase over time. NSW Maritime has indicated that increases in boat usage levels, particularly associated with water skiing and PWC usage may in the long-term lead to an increase in complaints in urban areas, as has occurred in other NSW estuaries (A. Sedlak, Pers Comm., 2005).

Also, the increased levels of boat ownership in the area and the continued popularity of the Nambucca region as a tourist destination, is likely to mean that the current levels of boat usage for fishing, water skiing (including tobogganing and wakeboarding) will increase over time and potentially over the holiday periods. This is supported by comments from the local boat hire company, which indicated that levels of boat hire have increased over recent years.

The commercial use of the estuary for commercial fishing, oystering and "houseboating" are all likely to continue at similar levels to what is currently occurring.

The estuary has great potential for passive recreational usage pursuits such as for canoeing, kayaking and bird watching. It is likely that all these pursuits will increase over time as the existing natural beauty and features of the Nambucca Estuary such as Warrell Creek become more widely recognised.

8.5.3 Potential future waterway access locations

The long-term vision for the Nambucca River estuary is for the provision of high quality, public waterway access (and associated facilities) in locations that promote sympathetic waterway use and minimise adverse environmental impacts.

Based upon the current types, levels and locations of use, combined with the current trends in increased boat ownership, it is considered that there is a need for altered and upgraded waterway accesses. Suggestions are provided for areas of the estuary:

Nambucca Heads

Nambucca Heads is experiencing strong population growth and tourism will remain a major industry. While current accesses are probably coping with levels of use being realised, it is likely that in the near future, usage of the existing ramps will exceed capacity.

Nambucca Heads is currently serviced by 4 estuary ramps and 1 ocean ramp. Three of these accesses enter in the Inner Harbour and is considered that there are probably a sufficient number of ramps into this body of water considering its size and any capacity increases of these ramps will most likely be limited by a lack of parking. The Shelley Beach ramp is also probably adequate for its level of use. It is considered that the Stuarts Island Ramp could be increased in capacity, i.e. to three or four parallel lanes or a new ramp. The reserve area would need to be redeveloped to provide a sufficient level of parking.

An alternative may be a new ramp in the road reserve adjacent to the Pacific Highway at Bellwood. If the location of the Pacific Highway changes as a result of bypass, then this area will see only light local traffic levels and hence road access may lessen as an issue. Boats accessing this part of the estuary enter into a region, which has relatively low levels of use (owing to the presence of the causeway) and are protected from currents. Aboriginal associations with the Bellwood area (in particular) would need to be taken into consideration in any proposal relating to the use of this area.

Macksville

The Lions Park ramp is already programmed for upgrade as a result of the loss of the existing ramp at Wrights corner. Another ramp on River St was also recently removed. Hence, there has been a reduction in the extent of public access to the estuary at Macksville. There are also issues with a lack of suitable waterway skiing areas within the estuary at this location, with waterskiers using substandard informal accesses or the existing wharf on River St. Ideally waterskiers will use a sandy beach type area to access the estuary. Access for canoeists/kayakers is also limited.

There are two locations on the Bowraville reach of the Nambucca River that may be suitable for the provision of future waterway access. These include:

- An area of Crown Lease (current lease details to be determined) less to 2km north-west of Macksville CBD on Wilson Road. The lease is located immediately adjacent to the existing Road reserve which is located adjacent to the estuary. This site could be developed into another ramp (with a range of facilities catering for canoeist and kayakers) or a dedicated waterskiing launch area.
- An area of Crown Road Reserve about 4 km to the north of Macksville CBD off Rodeo Drive near the sharp left hand bend in the river known locally as Devil's elbow. This site could be developed into another ramp (with a range of facilities catering for canoeist and kayakers) or a dedicated waterskiing launch area.

It should be noted however, that if waterskiing is promoted in this section of the river, work may need to be completed to stabilise or improve existing riverbank instabilities which are present at this location.

Taylors Arm

Upper Taylors Arm may benefit from the introduction of a ramp specifically designed for canoeists and kayakers. A suitable site may exist at Welshes Park reserve. These facilities may assist passive recreational usage of this section of the river.

Warrell Creek

The lower Warrell Creek area is sensitive to the impacts of boating. Boats accesses to the lower sections (i.e. Scotts Head to the entrance) of the estuary should be kept to a minimum, hence no new accesses are recommended and existing ramps should be limited to their current size.

However, upper Warrell Creek may benefit from the introduction of a ramp specifically designed for canoeists and kayakers. A suitable site may exist at the location under where the Pacific Highway crosses Warrell Creek (southern side adjacent to Scotts Head Road). These facilities may assist passive recreational usage of this section of the river.

Priorities for the upgrade and addition of facilities are provided in the summary (see Section 8.6).

8.6 Summary

This section of the Estuary Management Study presents a review of waterway usage in the Nambucca River estuary. The review was assisted by input from the community consultation phase, which helped identify the types and locations of existing waterway usage, as well as areas of conflict and other related issues.

The review of boating and waterway usage has identified a number of usage conflicts, safety/navigation concerns and boat related impacts. Boat usage impacts on the estuary include boat wash impacts on oyster growing areas, riverbanks and vegetative communities (i.e. seagrasses/saltmarshes). Further controls are required to reduce the impact of boating on the estuary. There are also some safety concerns associated with the locations of current swimming areas, as these can restrict or hamper boating activities.

Geco Environmental in their field investigations of the estuary identified all foreshore structures within the estuary, e.g. ramps, jetties, wharves, etc. Comparison of access points to Department of Lands waterfront licence data (who maintain the licences) has shown that there are many unlicenced private access points on private lands and numerous unlicenced public/private access points located on public lands. Unrestricted estuarine access to the estuary can lead to a range of usage impacts in susceptible locations. Any proposals to alter access arrangements needs to ensure that an acceptable level of access for the public is maintained to the estuary.

The trend of increasing boat ownership in the region of the estuary and the continued focus on the Nambucca Region as a tourist destination will probably mean that demand for high quality waterway access (and associated facilities) will continue. A review of existing access and foreshore facilities has identified:

- A number of inadequacies with Council maintained ramps. In general these relate to a lack of certain facilities. See Table 8-3 for priorities for upgrading. The designation of high, medium and low priorities are relative measures and not indicative of an overall priority when considered other aspects of the estuary requiring management; and
- A lack of access and facilities in certain locations of the estuary. See Table 8-4 for suggested priorities. Again the designation of high, medium and low priority is a relative measure and not indicative of an overall priority when considered other aspects of the estuary requiring management.

Recommendations to alter or increase the types, levels and locations of existing waterways use, have taken into consideration the potential impacts of these changes. Further details in relation to overall timing for implementation, responsibility and potential funding sources will be identified as part of the Estuary Management Plan.

Table 8-3 Suggested priorities for upgrading existing public ramp facilities

Boat Ramp	Requirement	Priority
Nambucca Heads		
Shelley Beach	Improve signage to reduce conflict between swimmers and returning boats	High
	Connect electricity to the tractor shed	High
	Relocate the fish cleaning facility to a position at the other end of the car park	Low
	Improve signage in dedicated trailers park to reduce inappropriate parking by non-trailered vehicles	Medium
Wellington Drive	Provide signage identifying that ramp is suitable for launching of small craft only (i.e. less than 4m).	High
Gordon Park	Investigate feasibility of a public wharf at this location	Low
RSL	Investigate feasibility of a holding pontoon at this location	High
Stuarts Island	Erect nighttime lighting	Medium
	Construct nearby toilet/amenities block	Medium
	Minor dredging required near jetty	High
Macksville/Bowraville		
Apex Park	Improve safety of road access and exit to Wilson Road	High
	Provide facilities, i.e. covered seats, binds, toilets, BBQs, etc, to promote park use.	Medium
Lions Park	Provision of bollards for boat tie up facilities	High
	Investigate feasibility of a beach area for boat parking and ski starts	High
	Investigate feasibility of a jetty/wharf area for fishing, swimming and boat access	Medium
	Additional parking facilities	Medium
Scotts Head (Warrell Creek)		
Scotts Head Weir Reserve	Provision of signage alerting boaters of the sensitivities of Warrell Creek to waterway to boat wash and related impacts	High
	Upgrade existing facilities by provision of defined boat trailer parking, redesigned ramp and boat access area (for boaters, fisherman, swimmers and picnickers), playground equipment, gas BBQs and picnic tables for visitors	High
Boultons Crossing	Provision of signage alerting boaters of the sensitivities of Warrell Creek to waterway to boat wash and related impacts	High
	Block access to an informal waterway access at its northernmost extent	Medium
	Relocate access road to campground away from edge of stream (at least a 50m setback)	Low

Table 8-4 Suggested priorities for provision of additional waterway access

Location	Requirement	Priority
Lower Nambucca River (Nambucca Heads)	Upgrade existing ramp to 3 or 4 lanes. An alternative of a new ramp at Bellwood could be investigated if upgrading of the existing ramp at Stuarts Island is not practical or possible.	Medium
Bowraville reach of Nambucca River (Macksville)	Investigate feasibility of additional ramps (to suit boaters, waterskiiers, canoeists, etc) at two potential Crown land locations on the Bowraville reach of the Nambucca River.	High
Upper Taylors Arm	Provide a canoe/kayak access ramp at Welsh's Park Reserve.	Medium
Upper Warrell Creek	Provide a canoe/kayak access ramp under Pacific Highway bridge location.	Medium

Requirements for upgrades at Shelley Beach may be addressed through a review of Council's Plan of Management for the Reserve. This review is programmed for 2006.

Although of relatively low priority NSW Maritime should prepare a Mooring Management Plan for the Nambucca River estuary. Potentially suitable sites have been identified at Bellwood and on the lower reaches of Taylors Arm.

9 STUART ISLAND CAUSEWAY

9.1 Introduction

The Stuarts Island causeway is located across the original main river channel of the lower Nambucca River, between what is now the Bellwood Reserve and the Stuarts Island golf course. A crossing to the island has been in existence since around 1913, however, today there are many concerns regarding the suitability of this structure. It is believed that the crossing is having a significant negative impact on the local Aborigine's ancestral connection with the area. The structure is also thought to have a range of deleterious environmental impacts, particularly in relation to reduced water quality and fish passage. There are also signs of increased sedimentation in the channel behind the causeway. Furthermore, the causeway as it is currently designed has limited tidal immunity and is inundated during "king" tides, restricting access to the island, which contains a reserve, boat ramp and golf course.

The history, features and impacts of the causeway on the environment and society are examined in the following sections. At the end of this section suggestions on ways to manage the causeway are provided with the ultimate aim of addressing the abovementioned impacts.

9.2 History of the causeway

A brief history of the causeway has been compiled by John Schmidt DNR and is represented below:

- The construction of the causeway formed part of the river entrance works. Approval was originally given by the Public Works Committee in 1913 to build a stonewall across the channel between Stuarts Island and the mainland to improve conditions within the entrance by confining the flow of waters to the main channel. This work was completed in 1915;
- The stonewall was capped by concrete in about 1929 (probably by The Public Works Department) and then in the early 1950's a road was built alongside the concrete wall by the Golf Club who had a special lease over Stuart Island;
- During the 1990s there was some lobbying by the Golf Club and Steering Committee for access upgrade; and
- In November 1990 and May 1995 the then Minister for Public Works and former Minister for Land and Water Conservation wrote to the Nambucca Island Golf Club advising that its proposal to either raise the causeway or construct a bridge did not demonstrate significant improvement to the amenity of the estuary and was unlikely to be eligible for funding assistance from the Estuary Program.

The causeway is presently a Council Public Road (gazetted on 21 February 1964) and hence managed by Nambucca Council. There are no native title or land claims over the causeway or in the immediate vicinity of it.

The potential impact that the causeway is having on Aboriginal cultural heritage, the environment and use of the island has meant that the suitability of the structure is once again in need of consideration and has consequently been included in the brief for the Estuary Management Study and Plan.

9.3 Features of the Causeway and Channel

9.3.1 Physical

Figure 9-1 shows the causeway as would be seen from the Bellwood Reserve side. From this photograph it can be seen that the causeway consists of a rock base capped by a concrete slab to form a road. Various service pipes including town water and sewer run adjacent to the causeway on the Bellwood Swimming hole side (the side visible in the photograph).

The crest of the causeway is at around 0.92m AHD. The causeway is known to overtop on certain tides and depending on their timing can cause disruption to public access to the golf course and other facilities on the Island.

The causeway is approximately 120m long and about 7m wide at the top and approximately 11m wide at the base. The road across the causeway is effectively single lane.

Figure 9-1 Stuarts Island Causeway

Figure 9-2 shows the proximity of the causeway to the entrance. This region of the estuary is part of the active coastal system and is dominated by ocean influences as well as local estuary conditions.

There is a predominantly marine sand substrate on the eastern side of the causeway and a fine mud dominated substrate on the western side. At some distance under the muddy substrates there is likely to be marine sands.

This silty material has been accumulating since the construction of the causeway, as it would have significantly reduced the tide and flood velocities in the channel. The tide and flood velocities control the ability of material to settle. When velocities are high enough, the fine sediments remain in suspension and will be carried out to the ocean. However, when velocities drop below a certain threshold, some of the finer materials can settle out and accumulate.

Figure 9-2 Stuarts Island Causeway in relation to estuary and entrance

9.3.2 Access

Access to Stuarts Island is through the car parking area for the Bellwood Reserve and swimming hole, which is a safe and popular spot for families, and is also commonly used for boating and fishing. The western side of the causeway is less used for recreational purposes, presumably due to the lower amenity, i.e. more turbid water and muddy bottom.

On Stuarts Island are the Nambucca Heads Island Golf Club (on the western side) and a much smaller Council Reserve (on the eastern side). Separating the Golf Club and Reserve is the road, which provides access to the Stuarts Island boat ramp.

The Reserve is a popular location for various forms of recreation including picnicking, walking and shore-based fishing.

9.3.3 Environmental

9.3.3.1 Seagrass

Seagrass exists in the channel on either side of the causeway as shown in Figure 10-1. The original construction of the causeway is likely to have significantly reduced tidal velocities, which tend to erode and scour sediments. The reduced current velocities in the sections around the causeway would have enhanced the sedimentation rates of marine sands and fluvial silts, shallowing this once deep part of the river to depths suitable for seagrass colonisation.

Within the channel reach there are presently large areas of seagrass at the following locations:

- To the immediate west of the causeway; and

- Along the northern and southern ends of Stuarts Island, particularly where it confluences with the main section of the Nambucca River.

Proposals to reintroduce tidal flow should aim to locate the crossing in locations that minimise impacts to seagrass. Assessments (see Appendix E) show how the siting of a proposed culvert have minimised impacts on existing seagrass beds through appropriate siting. The slightly increased velocities through the channel are not expected to cause any adverse impact on other seagrass colonies.

9.3.3.2 Water quality

There is no available water quality data from the region around the causeway, hence it is not possible to quantify the extent of impact it may have had on water quality.

However, it is known that the causeway has significantly reduced the tidal flushing in the western portion of the channel. The hydrodynamic model developed for the estuary as part of the Estuary Processes Study (WBM, 2000) was utilised to determine the tidal flushing rates on either side of the causeway. Assessments (see Appendix E) indicate that flushing times (i.e. time taken for the concentration of a pollutant to reduce to 37% of its original concentration) on the western side of the causeway is currently 3.5 days (worst case). This is expected to around 1.5 days with the installation of the culvert. This improved flushing time will result in improvements to the quality of water in the channel.

Reduced tidal flushing can allow for a build up of water quality pollutants such as suspended sediments and dissolved nutrients. In extreme cases, the combination of reduced tidal flushing, excessive pollutant loadings and meteorological events can lead to instances of excessive algal growth, which can have a variety of flow-on impacts, such as deoxygenation of waters and generation of "rotten egg" (hydrogen sulphide) gas.

9.3.3.3 Fish passage

The causeway forms a total block to fish passage up part of the estuary, except when inundated under large tides; however, this short period of connection is unlikely to provide for any significant fish passage. Given the age of the structure, aquatic animals that used to travel up the estuary have learnt to navigate around it.

9.3.4 Consultation in relation to the causeway

The Nyambaga Aboriginal Cultural Catchment representatives identified improving flow through the causeway as a high priority issue during an issue workshop convened by Councils Coast & Estuary Committee in 2003. Council subsequently included this issue as a priority for investigation within the Estuary Management Study brief.

WBM's on-site representative inspected the Stuart Island causeway with Terence Hudson and Nyambaga in November 2004 to gain a thorough appreciation of issues with the causeway. During this inspection, Nyambaga outlined their associations with the area and their issues with the causeway.

The causeway or "the wall" as the local Aboriginal people know it, is a solid barrier that disconnects the water of the Nambucca River at Bellwood. Immediately to the west of the wall is a rock face above a bend in the river. This area is Yuludarra Mirral[1], the place where Yuludarra's spirit dwells.

The causeway prevents the tide from flowing back and forth and the water on the Yuludarra's side is black and most often has a film of scum on the surface. The mirral is almost lost due to the loss of tidal movement and decline in the condition of the channel in this location. Nyambaga indicated that their only desired input to the Estuary Management Study and Plan was for tidal flow to be reintroduced through the Stuarts Island causeway.

In terms of the actual desired design of the causeway, the Nyambaga identified that their preference is for a singlewide opening (approximately 8m width by 1.8m high bridge style opening). Alternatively, a series of smaller culverts i.e. two of 3.6m by 1.8m, culverts would suffice. They did not wish for the swimming area adjacent to Bellwood Reserve to be adversely affected as a result of the introduction of the culverts.

During the course of the community consultation phase, numerous stakeholders indicated that the causeway required some form of alteration to improve its current function. No individuals or stakeholders indicated that they did not wish to see the issue of the causeway addressed.

[1] Yuludarra was the first man, Gawnggan his wife, Birrugan their son. These are the three main hero-ancestors central to the Gumbaynggir Dream. Gumbaynggir religious teaching is also the belief that there is only one God or creator and the only difference between the white man's God and theirs is the name. Different Aboriginal nations around the continent have many different religious beliefs. A mirral is a sacred place.

10 HABITAT MANAGEMENT

10.1 Introduction

In this chapter, we examine the key ecological values of the Nambucca River estuary and identify the key processes or activities known or likely to threaten these. Effort has concentrated on those features that provide a general indication of the condition of the estuary, and/or features of interest from an environmental management perspective, such as habitats and species of conservation significance. These include:

- Seagrasses;
- Mangroves;
- Saltmarshes;
- Wetlands;
- Sedimentary habitats (mudflats, sand and gravel substrates);
- Open water;
- Terrestrial and floodplain vegetation; and
- Riparian vegetation and macrophytes.

To address the key management issues raised by the community, habitat management recommendations have also been developed to maintain, improve and restore the conservation values of the Nambucca Estuary.

10.2 Assessment of Conservation Values and Threats

This section of the study describes the conservation values of the estuary and identifies current impacting factors to these.

Historical Context

As a result of high population growth in the catchment, the floodplain, riparian zone and receiving waters of the estuary of the Nambucca River have been subjected to various degrees of disturbance, particularly the direct and indirect effects of vegetation clearance during the past 150 years.

The major historical events over the last 150 years that have helped shape the current condition of the Nambucca River catchment included (after Geco Environmental, 2005):

- Clearing of the Nambucca River banks and floodplains for agricultural pursuits prior to the 1900's caused a reduction in bank strength. This combined with extreme flooding in the 1890's caused extensive channel change resulting in bank erosion, channel widening, and downstream sedimentation.
- Increase of agricultural development within the catchment from the 1890's to mid 1940's coincided with relatively few floods of the same magnitude as those of the 1890's.

- Between 1946 and 1954 a series of six large floods caused a second phase of channel expansion with huge quantities of gravel being liberated through bank erosion.
- During the 1970's the government sponsored a policy of removal of instream vegetation and snags from the channel and clearing of river banks. This further destabilised the freshwater reaches of the river.
- Large scale gravel extraction occurred in the freshwater reaches of the River in the 1980's.

The widespread agricultural development on the floodplain led to vegetation clearing and has made the riverbanks more susceptible to both wind and boat wave erosion. Both erosion types have lead to undermining and slumping of alluvial banks where protective riparian vegetation has been removed. Grazing of riverbank vegetation has also exacerbated and initiated these problems, in some locations.

Current Condition

The character and behaviour of the Nambucca River estuary changes along its length due to climatic influences, geological controls, landscape erosion and deposition, vegetation, and more recently landuse and estuary management practices (Geco Environmental, 2005). Using these parameters, Geco Environmental (2005) categorized the Nambucca estuary into six distinct styles including:

- Alluvial Deltaic Plains and Backswamps;
- Alluvial Deltaic Plains and Intertidal Flats (Marine Tidal Delta);
- Predominantly Dune Enclosed Interbarrier Flats;
- Intertidal Flats (Alluvia Infill);
- Partly Confined Gravel Bed River; and
- Bedrock Confined Gravel Bed River.

Refer to Geco Environmental (2005) for a detailed description of these styles. Within each of these styles a range of habitats occur, including:

- Seagrasses;
- Mangroves;
- Saltmarshes;
- Wetlands;
- Sedimentary habitats (mudflats, sand and gravel substrates);
- Open water;
- Terrestrial and floodplain vegetation; and
- Riparian vegetation and macrophytes.

The following provides a description of the distribution and ecological significance of these habitats in the Nambucca Estuary based on a review of existing data and a *study area* survey completed in December 2004. Factors impacting on the ecological values of these habitats are also discussed. WBM (2000) describes the key processes and controls which operate within these habitats. Seagrass

10.2.1.1 Distribution and Composition

Figure 10-1 and Table 10-1 outline the extent of seagrass within the Nambucca River mapped by New South Wales Fisheries (2004) at a scale of 1:1500.

Table 10-1 Seagrass Recorded In The Nambucca River (NSW Fisheries, 2004).

Tributary*	Area of *Zostera capricornia* (ha)	*Zostera capricornia (*% of estuary)	Area of *Halophila ovata* (ha)	*Halophila ovata (*% of estuary)
Blackbutt Creek	0.03	0.04		
North Arm	0.61	0.97		
Taylors Arm	4.00	6.39		
Nambucca River	30.38	48.53	0.14	100.00
Warrell Creek	27.72	44.28		
Total	**62.60**		**0.14**	

* based on NSW Fisheries no seagrass has been mapped in Newee Creek

Approximately 63ha of seagrass has been mapped in the estuary. Consistent with other estuaries on the NSW North Coast, seagrass in the Nambucca River estuary is dominated by *Zostera capricornia*. Minor fringes of *Halophila ovata* have also been recorded in the main arm of the Nambucca River approximately 1km south of Stuarts Island (NSW Fisheries, 2004).

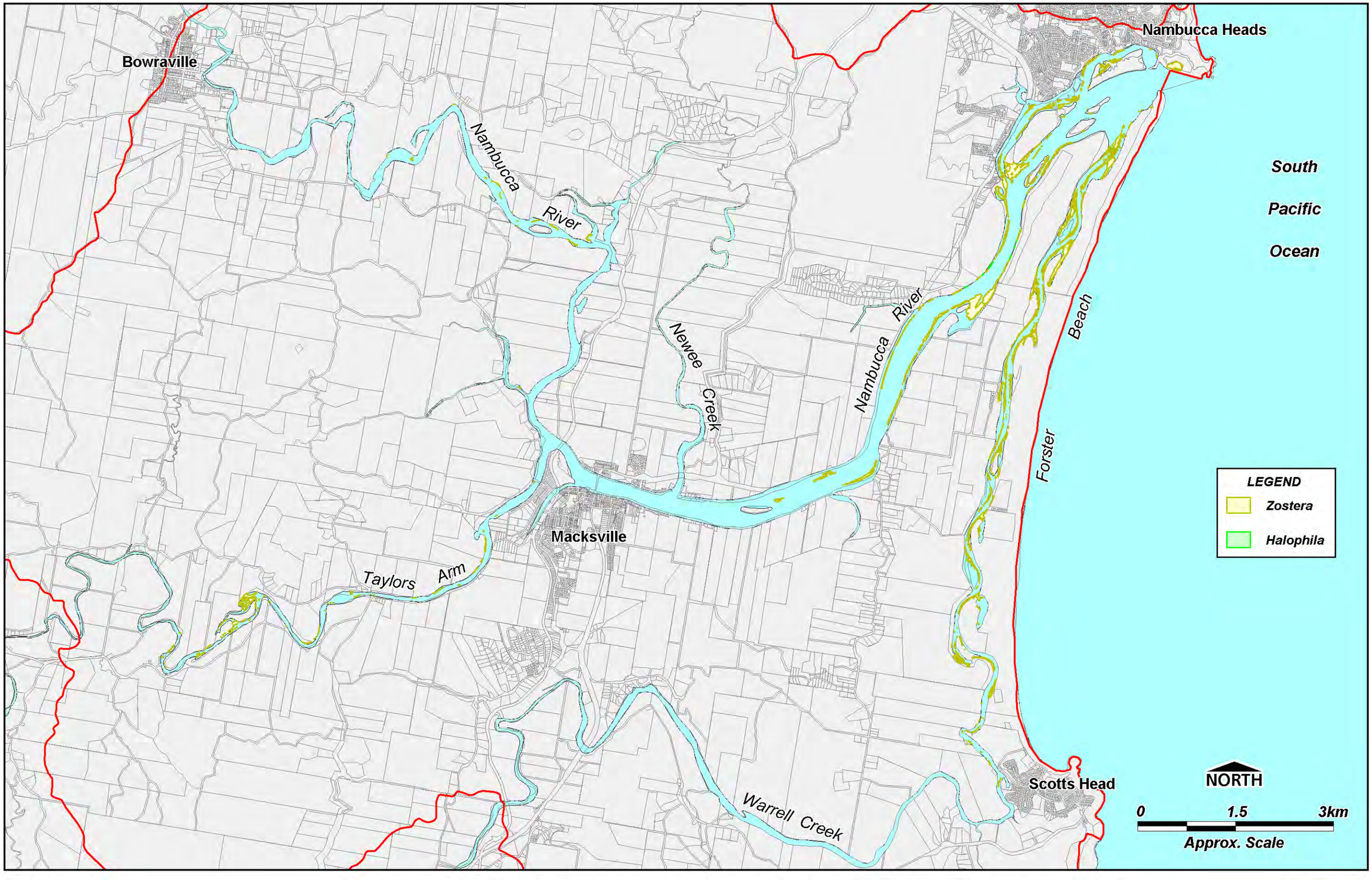
Seagrass is more abundant in the shallows with low physical energy and sedimentary environments within the intertidal zone. The major occurrences of seagrasses in the estuary include:

- Sparse to dense beds of *Z. capricorni* are present in the shallow waters along the Nambucca River from the mouth to approximately 10km upstream;
- Sparse to dense beds of *Z.capricorni* are present in the shallow waters along the mouth of Warrell Creek from the mouth to approximately 12km upstream near Scotts Head;
- Approximately 3ha of dense *Z.capricorni* beds are found in the Broadwater area of Taylor's Arm approximately 7km upstream of Macksville; and
- Isolated and minor beds of *Z.capricorni* beds are found on North Arm and along Blackbutt Creek.

10.2.1.2 Values

Seagrasses are productive, are thought to stabilise sediments, and they provide food and shelter for many species of fish and invertebrates including those of economic significance (Bell and Pollard 1989, Larkum *et al.* 1989, NSW Fisheries 2001).

There exist many studies in the scientific literature demonstrating variability in the patterns of abundance for various assemblages of biota at differing spatial scales, e.g. kilometres, to very small scales, e.g. just a few metres, and that this variation often differs throughout the year (e.g. see just about any paper by Underwood and/or Chapman; Ferrell *et al.* 1993, Worthington *et al.* 1995).



Seagrass Distribution In The Nambucca River Estuary (Source : New South Wales Fisheries, 2004) Figure 10-1

Clearly then, it is difficult to assign an environmental value to a particular vegetation type because we know that, for example, a particular bed of seagrass may have a greater or lesser value as habitat patch than adjacent seagrass beds. The processes that determine the 'value' of a particular patch of habitat (and the spatial and temporal scales at which any patterns might exist) are not well understood and require further investigation.

Notwithstanding this, for the purpose of this assessment, all remaining areas of estuarine vegetation in the study area have been assigned a high conservation value. Seagrass is protected under the *Fisheries Management Act 1994*. A permit to destroy or harm marine vegetation is required from NSW Fisheries for any development where effects on marine vegetation are considered likely.

10.2.1.3 Threats

Major threats to seagrass distribution within the *study area* include water quality, particularly sedimentation and increased wave action from boats and other watercraft. Mapping comparisons between current seagrass distribution (NSW Fisheries, 2004) and historical seagrass mapping (West *et. al.*, 1985), should be viewed with caution given the variation in mapping scale and intensity of ground truthing. However, the available mapping indicates that there has been a loss of minor seagrass beds, in the order of less than 1.0ha, within the Nambucca River adjacent to Macksville. Minor seagrass expansion (less than 2ha) may have also occurred within Warrell Creek.

10.2.2 Mangroves

10.2.2.1 Distribution and Composition

Figure 10-2 and Table 10-2 outline the extent and distribution of mangroves within the Nambucca Estuary mapped by New South Wales Fisheries (2004) at a scale of 1:1500.

Table 10-2 Mangroves Recorded In The Nambucca River (NSW Fisheries, 2004).

Tributary	Area (ha)	% of Estuary
Blackbutt Creek	2.55	1.79
North Arm	15.25	10.71
Taylors Arm	10.39	7.30
Nambucca River	46.66	32.76
Warrell Creek	32.22	22.62
Newee Creek	35.34	24.82
Total	**142.41**	

Approximately 142.4ha of mangroves have been mapped in the estuary. Consistent with other estuaries on the NSW North Coast, mangroves in the Nambucca River estuary are dominated by (in order of abundance) *Avicennia marina* and *Aegiceras corniculatum*. Isolated *Excoecaria agallocha* were recorded in Warrell Creek during the field survey conducted by WBM (December, 2004).

The mangroves are more abundant in habitats with low physical energy and sedimentary environments within the intertidal zone. The major occurrences of mangroves in the estuary include:

- Newee Creek supports the largest contiguous stand, in the order of 30ha, of *A. marina* and *A. corniculatum* in the estuary;

- Stands of *A. marina* and *A. corniculatum* fringe the main arm of Nambucca River, North Arm, Blackbutt Creek and Taylor's Arm from the mouth to approximately 22km upstream;
- Dense stands of *A. marina* and *A. corniculatum* fringe Warrell Creek from the mouth to approximately 10km upstream; and
- Minor, isolated pockets of *A. marina* and *A. corniculatum* fringe the southern bank of Warrell Creek east of the Pacific Highway.

Mapping comparisons between current mangrove distribution (NSW Fisheries, 2004) and historical mangrove mapping (West *et. al.*, 1985), should be viewed with caution given the variation in mapping scale and intensity of ground truthing. However, the available mapping indicates that there may have been a minor expansion of mangroves on Warrell Creek. In addition mangrove expansion is occurring at 100 Acre Swamp following the removal of the floodgates.

The impacts of mangrove expansion into saltmarsh communities in NSW are well documented, but the driving force for such expansion remains unclear, with processes controlling expansion varying among and within estuaries (Wilton 2002). It is possible that at least some of the increases in mangrove extent, which appear to have occurred at the seaward edge, are a response to increase in habitat availability due to localised sedimentation.

10.2.2.2 Values

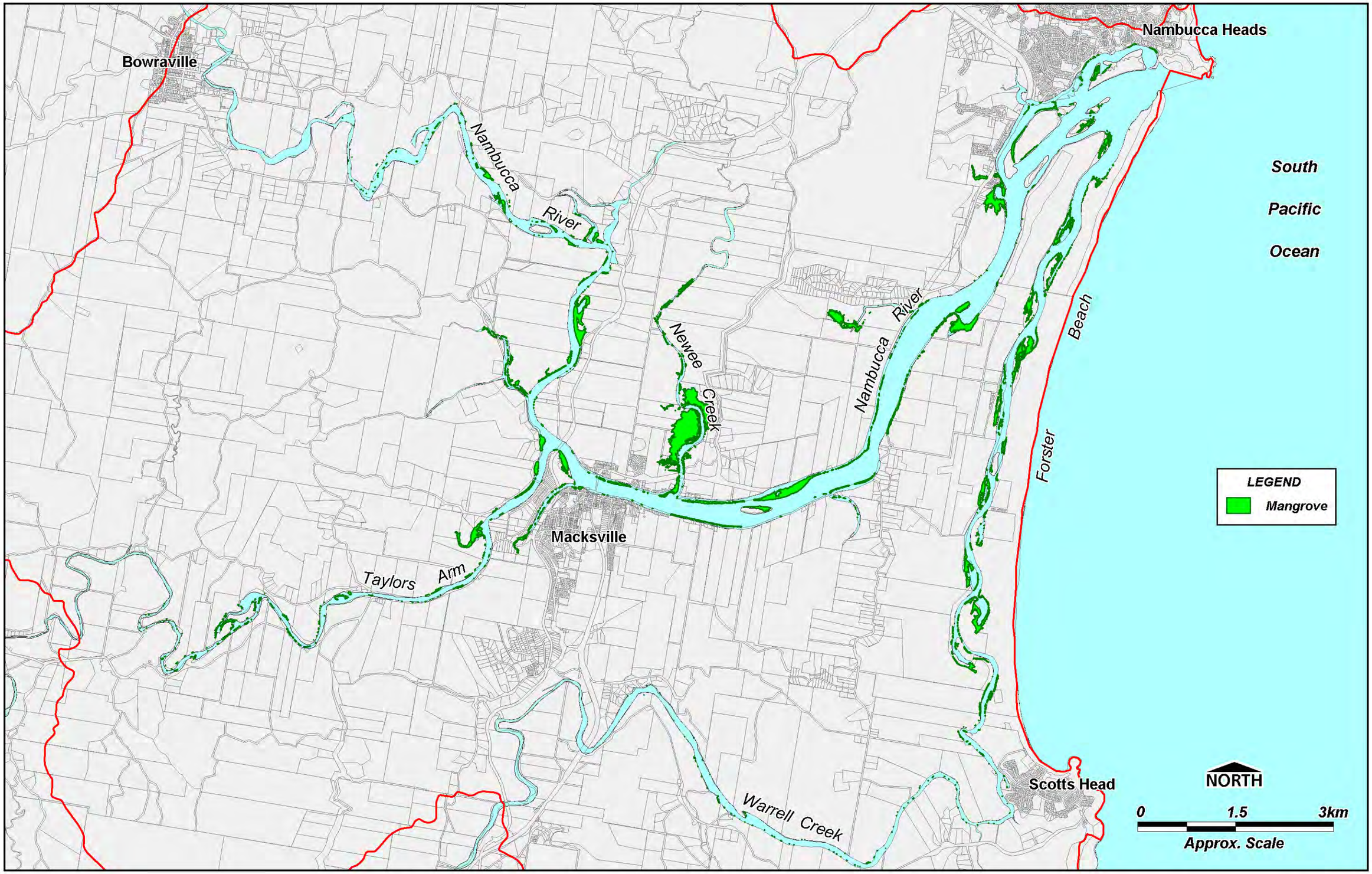
Mangroves provide habitats for a wide range of biota including species of fisheries value and conservation significance. Estuarine wetlands also play an important role in bed/bank stabilisation and are highly productive and important in the cycling of nutrients.

For the purpose of this assessment, all remaining areas of mangrove vegetation in the study area have a high conservation value. Clearing of mangroves is regulated by the *Fisheries Management Act*, 1994. A permit to destroy or harm marine vegetation is required from NSW Fisheries for any development where effects on marine vegetation are considered likely.

10.2.2.3 Threats

The major threats to mangrove distribution within the *study area* include:

- Clearing - particularly fronting private housing;
- Drainage and exposure of acid sulphate soils;
- Stock - mangrove reaches of North Arm are being heavily impacted by cattle, which access the riverbanks and river and are causing bank erosion and slumping and loss of mangrove vegetation, including mature canopy trees and regenerating propagules; and
- Boat wave wash.



Mangrove Distribution In The Nambucca River Estuary (Source : New South Wales Fisheries, 2004) Figure 10-2

10.2.3 Saltmarsh

10.2.3.1 Distribution and Composition

Figure 10-3 and Table 10-3 outline the extent and distribution of saltmarsh within the Nambucca Estuary mapped by New South Wales Fisheries (2004) at a scale of 1:1500.

Table 10-3 Saltmarsh Recorded In The Nambucca River (NSW Fisheries, 2004).

Tributary	Area (ha)	% Estuary
Blackbutt Creek	9.26	7.26
North Arm	2.34	1.84
Taylors Arm	1.87	1.47
Nambucca River	40.28	31.59
Warrell Creek	31.47	24.68
Newee Creek	42.30	33.17
Total	**127.52**	

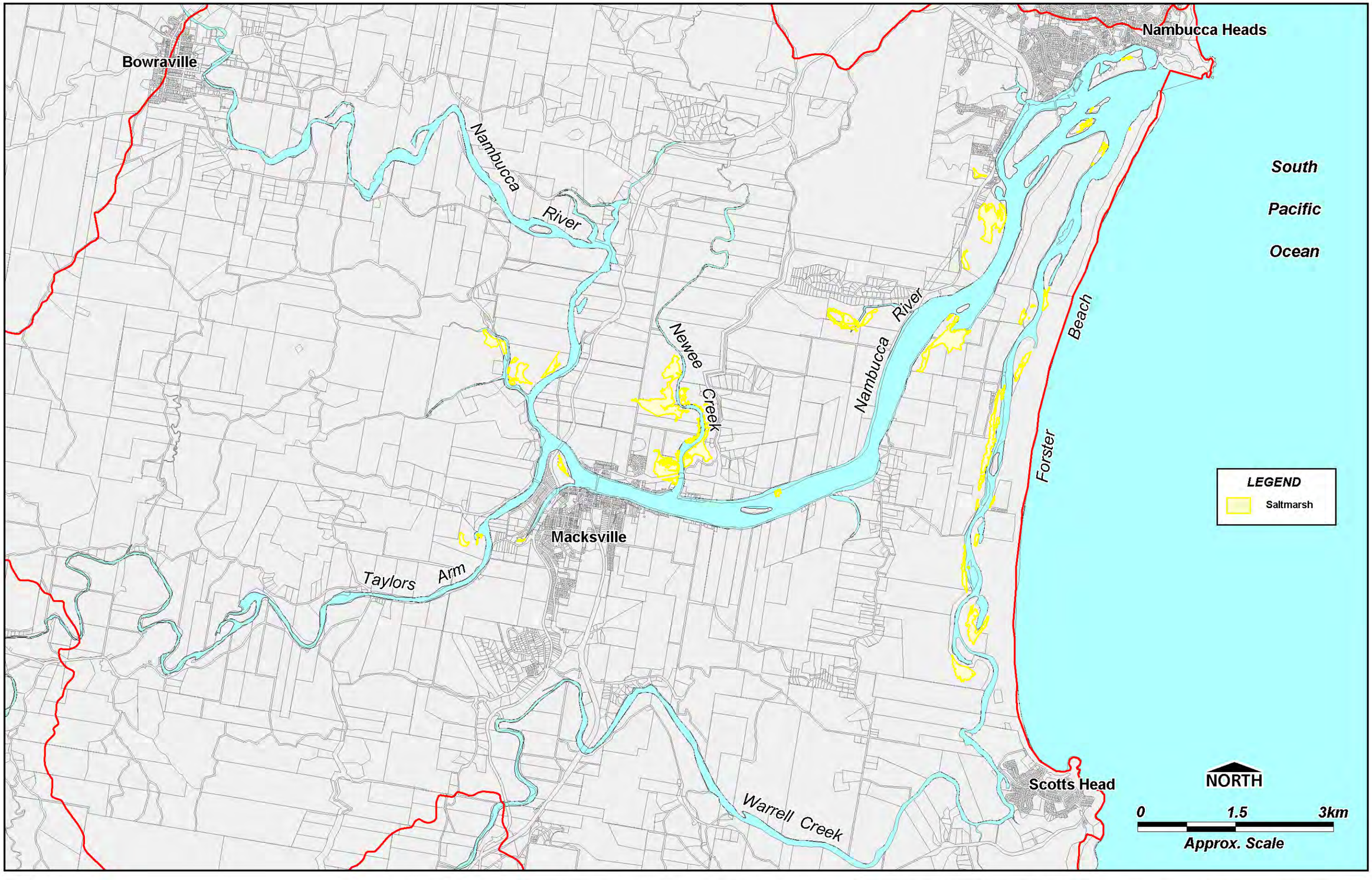
Approximately 128ha of saltmarsh has been mapped in the estuary. Typical species noted during the field survey were *Sarcocornia quinqueflora, Halosarcia indica*, *Suaeda australis* and *Sporobolus virginicus.* Other species that have been observed in the estuary have included *Baumea juncea* and *Triglochin striata* (WBM, 2002).

This intertidal wetland community relies on the periodic inundation of salt water and the most extensive saltmarsh areas occur on the landward side of mangroves. Newee Creek supports the largest contiguous stand, in the order of 40ha, of saltmarsh in the estuary. The intertidal flats of Warrell Creek and Nambucca River support the next largest areas of saltmarsh in the catchment, but these occur as isolated and discontinuous patches.

Throughout eastern Australia in recent decades there has been widespread invasion of saltmarsh by mangroves. The reasons are unclear. Mapping comparisons between current saltmarsh distribution (NSW Fisheries, 2004) and historical saltmarsh mapping (West *et. al.*, 1985), should be viewed with caution given the variation in mapping scale and intensity of ground truthing. However, the available mapping indicates that there may have been expansion of saltmarsh on Blackbutt Creek (in the order of less than 5ha) and Warrell Creek (in the order of less than 6ha) and a loss of saltmarsh on the tidal plains south of Watt Creek.

10.2.3.2 Values

Saltmarsh provide habitats for a wide range of biota including species of fisheries value and conservation significance. Estuarine wetlands also play an important role in bed/bank stabilisation and are highly productive and important in the cycling of nutrients. Coastal Saltmarsh in northern NSW is also protected as an Endangered Ecological Community under the TSC Act. For the purpose of this assessment, all remaining areas of saltmarsh vegetation in the study area have a high conservation value.



Saltmarsh Distribution In The Nambucca River Estuary (Source : New South Wales Fisheries, 2004) Figure 10-3

10.2.3.3 Threats

The major threats to saltmarsh distribution within the *study area* include:

- Weeds - Minor *Baccharis halimifolia* invasion has occurred in some saltmarsh patches.
- Drainage and exposure of acid sulphate soils;
- Foreshore development; and
- Filling of low lying areas; and Stock - saltmarsh communities along the main arm of the Nambucca River and south of Watts Creek are being impacted by cattle, which are causing soil disturbance and loss of groundcover. Stock grazing has been shown to substantially change the composition and structure of saltmarsh. Stock trampling can lead to loss of saltmarsh cover and localised changes in drainage patterns. Recovery of these communities is generally very slow.

10.2.4 Wetlands

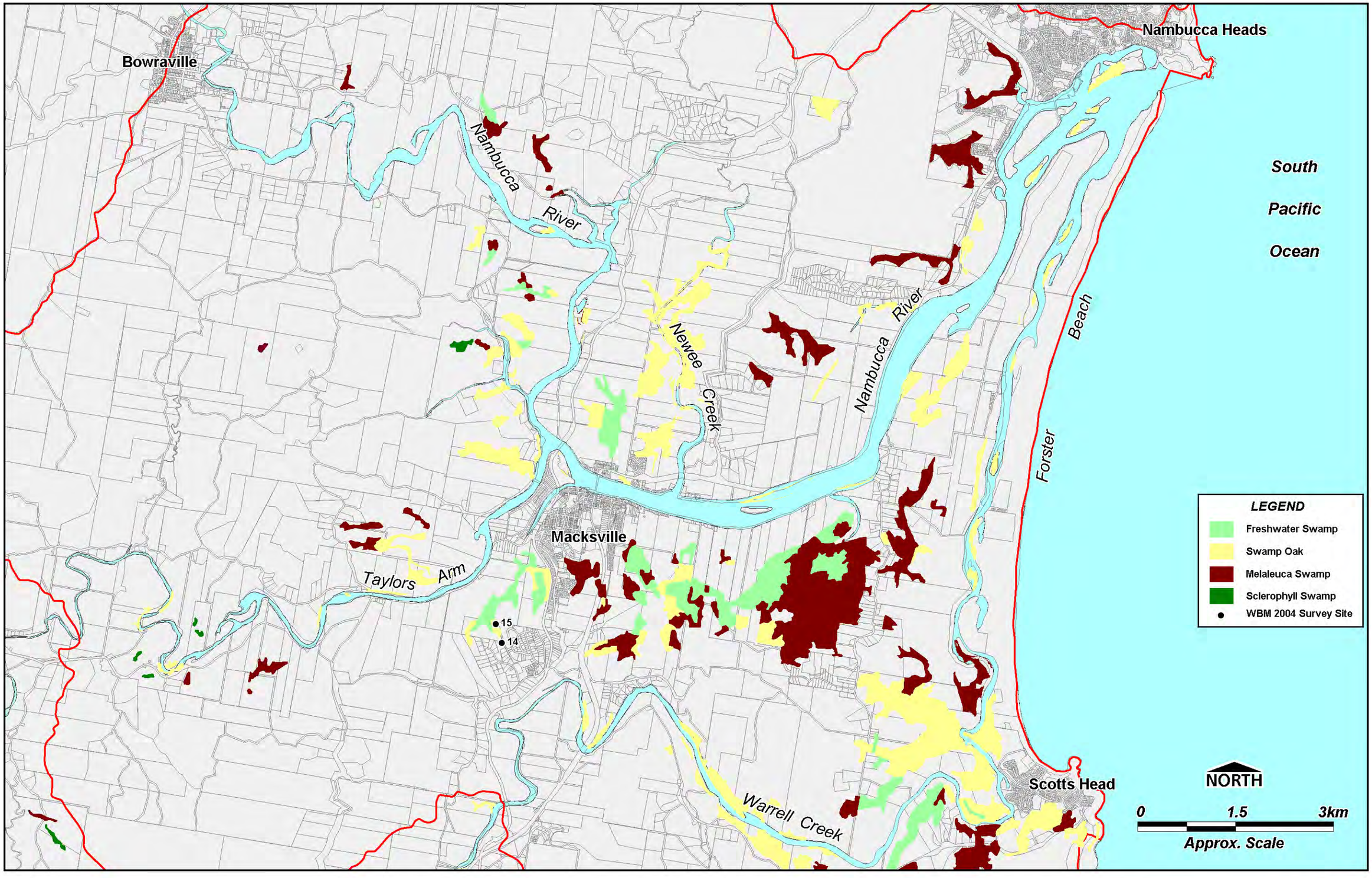
For the purposes of the NSW Wetlands Management Policy, one of the components of the "NSW State Rivers and Estuaries Policy", wetlands are defined as land that is:

- Inundated with water on a temporary or permanent basis;
- Inundated with water that is usually slow moving or stationary;
- Inundated with water that is shallow; and
- Inundated with water that may be fresh, brackish or saline.

10.2.4.1 Distribution and Composition

Figure 10-4 maps the distribution of wetland habitats (with the exception of saltmarsh and mangroves described separately above) within the Nambucca Estuary. The following communities are present in the study area:

- ***Swamp Oak*** (Ecosystem 143, Kendall, 2003). Generally consists of pure stands of *Casuarina glauca* but may contain *Melaleuca quinquenervia* as a sub-dominant or co-dominant. Occurs on very poorly drained sites in close proximity to saline waters. Extensive swamp oak communities occur along Warrell Creek in the vicinity of Scott's Head and east of the Pacific Highway, on Newee Creek and 100 Acre Swamp west of Macksville.
- ***Melaleuca Swamp*** (Ecosystem 112, Kendall, 2003). Dominated by *Melaleuca quinquenervia.* Other species may include *Casuarina glauca, Eucalyptus robusta, Eucalyptus resinifera* and *Corymbia* spp. Lower strata is generally absent or sparse and comprised of sedges and wet heath species with occasional rainforest elements.



Wetland Distribution In The Nambucca River Estuary (Source : New South Wales Fisheries, 2004) Figure 10-4

During the field survey dominant canopy elements observed within these communities included *Melaleuca quinquenervia, M. styphelioides, Eucalyptus tereticornis, Casuarina glauca, Glochidion ferdinandi* and *Ficus* spp. The groundcover was generally dominated by *Blechnum indicum, Gahnia sieberiana, Baloskion tetraphyllum, Philydrum lanuginosum* and *Lepironia articulata*. Other species included *Lomandra longifolia, Cynodon dactylon, Crinum pedunculatum, Persicaria* spp., *Ludwigia octovalvis* and *Carex appressa*. Common weeds were *Baccharis halimifolia, Ipomoea cairica* and *Senna septemtrionalis*. Sparse *Chrysanthemoides monilifera* was also noted in the wetlands of Teague's Creek.

The largest contiguous melaleuca swamp of the *study area* (approximately 165ha) occurs at the Gumma Gumma Wetlands. Isolated pockets of this community also occur along Warrell Creek and south of Macksville.

- ***Freshwater Swamp*** (Ecosystem 141, Kendall, 2003) dominated by sedges and rushes with sparse trees and shrubs. The largest individual freshwater swamp in the *study area* (approximately 74ha) occurs at the Gumma Gumma Wetlands.
- ***Sclerophyll Swamp*** (Ecosystem 302, Kendall, 2003). Wetland dominated by *Melaleuca styphelioides, M. linariifolia, M. nodosa* and/or *M. sieberi*. Only minor copses (approximately 1-4ha in area) of these communities occur in the Nambucca River Estuary *study area* on Taylor's Arm and Blackbutt Creek.

  Many of these communities occur as isolated stands, which are generally too small to map (<2ha). For example, survey sites 14 and 15 (currently mapped as swamp oak communities by Kendall (2003)) supported copses of *M. linariifolia, Melaleuca styphelioides* and *M. quinquenervia* wetland over a groundcover of *Blechnum indicum, Gahnia sieberiana, Baloskion tetraphyllus* and *Carex appressa*. The vine *Parsonsia straminea* was common and dense *Phragmites australis* and *Typha* sp. patches dominated the waterway. Other macrophytes observed were *Bacopa monnieri, Nymphae* sp. and the invasive environmental weed *Salvinia molesta.*

10.2.4.2 Values

Wetlands are ecologically diverse and productive ecosystems with various biological values and functions including habitat such as nursery and breeding grounds; buffers to catchment water quality; nutrient recycling; flood mitigation; groundwater recharge and foreshore protection. They also have recreational values. Wetlands within the Northern NSW bioregion have significant conservation value, potentially support a wide range of threatened species and are listed as significant communities under the TSC. These include:

- *Swamp Oak*

  Swamp Oak floodplain forest of the NSW North Coast is listed as an *Endangered* Ecological Community under the *TSC Act.*

  The NSW Scientific Committee has found that:

  - On the North Coast of NSW, swamp oak floodplain forest has been extensively cleared for grazing and canefields and it is likely that less than 3% of the original extent remains in this

area. In some areas, alterations of tidal flows may have lead to decreased soil salinity and localised expansion of *Casuarina glauca* into areas that previously supported saltmarsh or mangroves.

- Small areas of Swamp Oak Floodplain Forest of the NSW North Coast are contained within existing conservation reserves but these are unevenly distributed throughout the range and unlikely to represent the full diversity of the community.
- On saline soils the threatened grass species *Alexfloydia repens*, may occur in these communities. Swamp Oak Forests may also provide habitat resources for the Glossy Black Cockatoo (*Calyptorhynchus lathami lathami*) and Squirrel Glider (*Petaurus norfolcensis*).

- *Freshwater Wetlands*

Freshwater wetlands on coastal floodplains of the NSW North Coast are listed as an *Endangered Ecological Community* under the *TSC Act.*

The NSW Scientific Committee has found that:

- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast have been extensively cleared and modified. Large areas that formerly supported this community are occupied by grazing and canefields.
- Wetland habitats provide potential habitat for significant species such as *Aldrovanda vesiculosa*, Green and Golden Bell Frog (*Litoria aurea*), Great Egret (*Ardea alba),* Intermediate Egret (*Ardea intermedia*), Little Egret (*Ardea garzetta*), Black-necked Stork (*Ephippiorhynchus asiaticus*), Royal Spoonbill (*Platalea regia*), Japanese Snipe (*Gallinago hardwickii*) and Black-winged Stilt (*Himantopus himantopus*).
- Widespread degradation of Freshwater Wetlands has led to a regional decline in wetland dependent fauna including Magpie Geese (*Anseranas semipalmata*), Cotton Pygmy Geese (*Nettapus coromandelianus*), Hardhead (*Aythya australis*), Black-necked Stork (*Ephippiorhynchus asiaticus*) and Wandering Whistling Duck (*Dendrocygna arcuata*).
- Artificial wetlands created on previously dry land specifically for purposes such as sewerage treatment, stormwater management and farm production, are not regarded as part of this community, although they may provide habitat for threatened species.

- *Swamp Sclerophyll Forest On Coastal Floodplains*

Swamp sclerophyll forest on coastal floodplains of the NSW North Coast is listed as an *Endangered Ecological Community* under the *TSC Act.*

The NSW Scientific Committee has found that:

- On the North Coast of NSW, swamp sclerophyll forest has been extensively cleared for grazing and canefields and it is likely that less than 3% of the original extent remains in this area.
- These communities provide habitat for the endangered swamp orchids *Phaius australis* and *P. tancarvilleae*. In addition, they provide habitat for threatened fauna species such as Grey-headed Flying Fox (*Pteropus poliocephalus*), Yellow-bellied Glider (*Petaurus australis*), Regent Honeyeater (*Xanthomyza phrygia*), Swift Parrot (*Lathamus discolor*), Osprey

(*Pandion haliaetus*), Australasian Bittern (*Botaurus poiciloptilus*), Large-footed myotis (*Myotis adversus*), *Litoria olongburensis* and Wallum Froglet *(Crinia tinnula).*

10.2.4.3 Threats

Wide ranges of activities threaten the integrity and viability of existing wetlands in the catchment. These include:

- Drainage and exposure of acid sulphate soils. Of most concern are the impacts of flood mitigation measures on floodplain wetlands. In this regard, floodgates have been placed in a number of areas (e.g. Gumma Creek, Watt Creek, Congarinni etc.), which may effect the connectivity between estuaries and the floodplain habitats (particularly wetlands), impacting on aquatic fauna movements and hydraulic processes. There are currently poor corridor connections between the Nambucca River and wetlands south and east of Macksville.
- Clearing of wetland habitat on freehold land;
- Over extraction of water supplies from the catchment; and
- Stock impacts and weed invasion. Given their proximity to urban and agricultural lands, the wetlands of the *study area* are threatened by cattle and weed invasion. *Baccharis halimifolia* was commonly observed and *Salvinia molesta* was observed in water bodies in the vicinity of the industrial estate south of Macksville.

Specific threats to the various wetland communities identified by the NSW Scientific Committee also include:

- Swamp Oak
  - Remaining stands are severely fragmented and are threatened by continuing fragmentation and degradation, flood mitigation and drainage works, landfilling and earthworks associated with urban and industrial development, pollution from urban and agricultural runoff, weed invasion, overgrazing, trampling by stock, rubbish dumping and frequent burning.
  - Some areas of Swamp Oak Floodplain Forest are protected by State Environmental Planning Policy 14. However, this does not preclude impacts on these communities. In particular, they may be exposed to hydrological changes originating upstream.
  - Given their proximity to urban and agricultural lands, the swamp oak communities of the study area are threatened by fire, cattle grazing, weed invasion and hydrological changes originating from the upstream catchment. Weed threats which may encroach on swamp oak communities of the study area include, *Baccharis halimifolia Araujia sericifolia, Asparagus asparagoides, Cyperus eragrostis, Cinnamomum camphora, Conyza spp., Hydrocotyle bonariensis, Ipomoea cairica, I. purpurea and I. indica, Lantana camara, Paspalum dilatatum, Pennisetum clandestinum, Solanum nigrum* and *Verbena bonariensis.*
- Freshwater Wetlands
  - Remaining stands are severely fragmented and further threatened by degradation, flood mitigation and drainage works, filling associated with urban and industrial development, pollution and eutrophication from urban and agricultural runoff, weed invasion, overgrazing, trampling by livestock, acid sulphate soils, soil disturbance and rubbish dumping.

- The native fauna of freshwater wetlands is threatened by predation, particularly by mosquito fish and cane toads.
- Weed threats, which may encroach on freshwater wetlands of the study area, include, *Alternanthera philoxeroides, Baccharis halimifolia, Echinochloa crus-galli, Eichhornia crassipes, Hygrophila costata, Ludwigia peruviana, Nymphaea capensis* and *Pennisetum clandestinum.*

- Swamp Sclerophyll Forest On Coastal Floodplains
  - Remaining stands are severely fragmented by past clearing and are further threatened by degradation, flood mitigation and drainage works, landfilling and earthworks, pollution from urban and agricultural runoff, weed invasion, overgrazing, trampling and other soil disturbance, removal of dead wood, waste dumping and frequent burning.
  - Relatively few examples of Swamp Sclerophyll Forest on Coastal Floodplains remain unaffected by weeds. Given their proximity to urban and agricultural lands, the swamp sclerophyll communities of the study area are threatened by fire, cattle grazing, weed invasion and hydrological changes originating from the upstream catchment. Weed threats, which may encroach on swamp oak communities of the study area, include, *Baccharis halimifolia, Andropogon virginicus, Anredera cordifolia, Ageratina adenophora, Cinnamomum camphora, Lantana camara, Ligustrum sinense, Lonicera japonica* and *Ludwigia peruviana*.

10.2.5 Sedimentary Habitats

Subtidal soft sediment represents the second largest type of biotope by area (after water column) within the estuary. These subtidal soft sediments contain the assemblages that are critical for the maintenance of estuarine ecosystems (e.g. nutrient cycling, food resources for fish, sediment chemistry processes). Subtidal soft sediments are also used by a wide variety of fish species, many of which are of direct commercial value.

Intertidal soft sediments have a comparatively smaller surface area than the other major biotopes within the estuary. Intertidal soft sediment biotopes are utilised by a wide variety of organisms (e.g. invertebrates, fish and wading birds). Waders utilise intertidal flats for feeding and roosting. There is only limited development of intertidal flats in the Nambucca River estuary. The most extensive intertidal sedimentary habitats occur in the mouth of the estuary and at the downstream end of Warrell Creek (in the order of 0.6 ha – 1.0 ha).

Both subtidal and intertidal areas are inhabited by benthic microalgae (primarily diatoms). The microalgae communities can be highly productive, and together with other organisms, control sediment-nutrient dynamics. There are no data to determine the nature of sediment nutrient flux within the estuary. It would be expected, however, that denitrification would be higher in upstream areas and wetland biotopes containing a high proportion of organic sediments.

Intertidal sedimentary habitats also contain mangroves, saltmarshes and seagrasses, while seagrasses also extend into shallow subtidal areas. As discussed, these vegetation communities have high ecological values due to their importance in maintaining a range of estuarine functions.

See Section 10.2.11.3 for a discussion on the importance of these habitast for migratory waders.

10.2.6 Open Water

The water column represents the largest (by area) biotope in the estuary. There are no available data on the likely contribution of water column processes to estuarine productivity. However, even assuming that phytoplankton productivity is low, the overall biomass of phytoplankton in the estuary could exceed that of other vegetation types in the estuary given its greater overall abundance (due to the large surface area of the estuary). It is therefore likely that phytoplankton represents one of the key drivers of food webs within the estuary. The open water biotope is the habitat of nekton communities. Many species of fisheries value are nektonic, such as tailor, bream, tarwhine and blackfish. No open water biotopes are contained within conservation zones.

10.2.7 Terrestrial and Floodplain Vegetation

10.2.7.1 Distribution and Composition

Figure 10-5 and Table 10-4 map and describe the distribution of terrestrial and floodplain vegetation within the catchment of the Nambucca River Estuary as mapped by Kendall (2003)[2]. Note that this mapping does not include approximately 1390ha of native forest reserved in State Forest.

The Nambucca River catchment has been subjected to a high degree of catchment clearing. Approximately 50% of the catchment currently supports cleared landscape, including grazing and urban land use. Forty-three percent of the catchment supports remnant vegetation and of this:

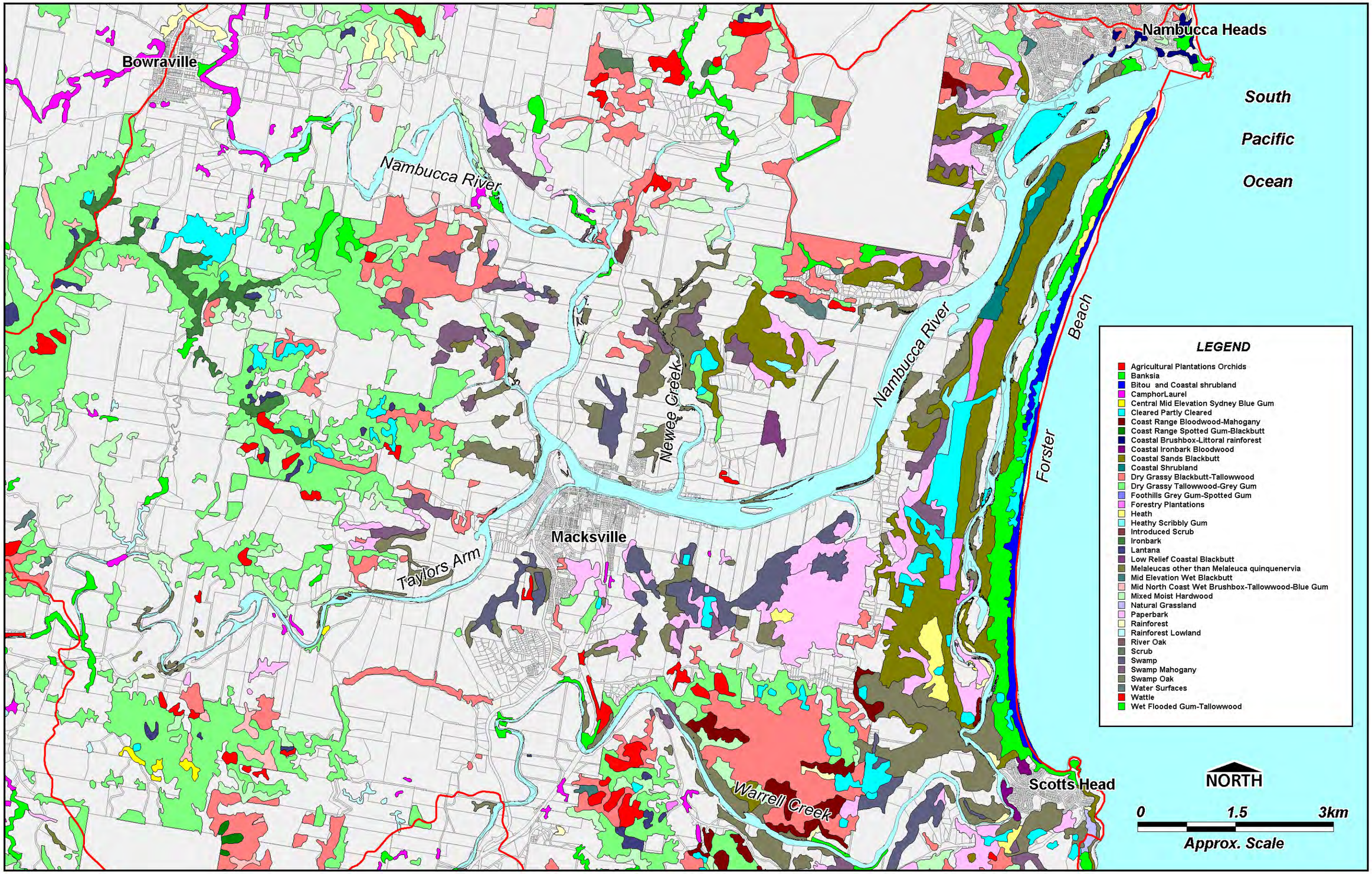
- 333ha is comprised of marine vegetation (1.3% of catchment);
- 1585ha is comprised of floodplain vegetation (6.3% of catchment); and
- 9082ha is comprised of terrestrial vegetation (35.8% of catchment).

10.2.7.2 Values

The sclerophyll woodlands and forests of the study area provide potentially suitable habitat for a diverse range of flora and fauna species of conservation significance and are important for maintaining biodiversity values within the study area. These communities have significance for fauna as native wildlife refugia and form part of the wildlife corridor network across the study area linking upland and lowland vegetation communities. Significant species potentially occurring within these communities include the Glossy Black Cockatoo (*Calyptorhynchus lathami lathami*), Squirrel Glider (*Petaurus norfolcensis*), and Koala (*Phascolarctos cinereus*).

Lowland rainforest and littoral rainforest are listed as Endangered ecological communities under the TSC Act and potentially support a number of threatened species such as *Acronychia littoralis, Cryptocarya foetida, Hicksbeachia pinnatifolia, Fontainea oraria, Ninox strenua* (Powerful Owl), *Dasyurus maculatus* (Spotted-tailed Quoll) and *Kerivoula papuensis* (Golden-tipped Bat).

[2] For the purposes of this study, NSW Fisheries Mapping (2004) has been used in place of Kendall's mangrove, saltmarsh and seagrass mapping.



Terrestrial Vegetation Distribution In The Nambucca River Estuary (Source : Kendall, 2003) **Figure 10-5**

Table 10-4 Terrestrial and Floodplain Vegetation within the Nambucca River Estuary Surrounds (Based on mapping by Kendall, 2003)

Vegetation Type[3]	Approximate Area (ha)	% of Cover	Description	Vegetation Type
36. Dry Grassy Tallowwood-Grey Gum	2254	24.21	Medium tall ecosystem which generally includes a mixed canopy of Tallowwood (*Eucalyptus microcorys*), Grey Gum (*E propinqua*), Grey Ironbark (*E. siderophloia*), Broad-leaved White Mahogany (*E. carnea*) and Turpentine (*Syncarpia glomulifera*).	Remnant
34. Dry Grassy Blackbutt-Tallowwood	1252	13.45	Tall open forest dominated by Coastal Blackbutt (*Eucalyptus pilularis*) with Tallowwood (*E. microcorys*) occurring as a sub-dominant. There is a mid-storey of Forest Oak (*Allocasuarina torulosa*) and there are often some straggly shrubs such as Coffee Bush.	Remnant
85. Mixed Moist Hardwood	945	10.15	Tall wet forest with a mixed composition containing some of the following species - Narrow-leaved White Mahogany (*Eucalyptus acmenoides*), Red Mahogany (*E resinifera*), Grey Ironbark (*E siderophloia* or *E paniculata*), Grey Gum (*E propinqua* or *E biturbinata*).	Remnant
143. Swamp Oak	728	7.82	Generally consists of pure stands of *Casuarina glauca* but may contain *Melaleuca quinquenervia* as a sub-dominant or co-dominant. Occurs on very poorly drained sites in close proximity to saline waters.	Remnant
27. Coastal Sands Blackbutt	688	7.39	Forest dominated by Coastal Blackbutt (*Eucalyptus pilularis*) which often includes Needlebark-Stringybark (*E. planchoniana*) and Smooth-barked Apple (*Angophora costata*) as sub-dominants. The ecosystem contains a relatively dense shrub layer.	Remnant
112. Melaleuca Swamp	587	6.30	Dominated by *Melaleuca quinquenervia.* Other species may include *Casuarina glauca, Eucalyptus robusta, Eucalyptus resinifera* and *Corymbia* spp.. Lower strata is generally absent or sparse and comprised of sedges and wet heath species with occasional rainforest elements.	Remnant
173. Cleared Partly Cleared	473	5.08	Predominantly cleared but may contain small patches of regrowth.	Regrowth
142. Swamp Mahogany	267	2.87	Swamp Mahogany dominates the community. Common associates include Red Mahogany, Bloodwood, Forest Red Gum, Paperbarks and Swamp Oak. The lower strata is generally dominated by wet heath or sedge species.	Remnant
141. Freshwater Swamp	263	2.82	Dominated by sedges and rushes with sparse trees and shrubs.	Remnant
154. Wet Flooded Gum-Tallowwood	217	2.33	Very tall forest dominated by Flooded Gum (*Eucalyptus grandis*) with Tallowwood (*E.microcorys*), Brushbox (*Lophostemon confertus*) and Turpentine (*Syncarpia glomulifera*) frequently present in subdominant proportions which occurs above a dense rainforest understorey.	Remnant
5. Banksia	201	2.16	Located on coastal sand dunes in close proximity to the ocean, common associates include Sheoak (*Allocasuarina littoralis*) bloodwoods and Swamp Mahogany.	Remnant
168. Rainforest Lowland	200	2.15	Rainforest identified in this project is a broad ecosystem, it is identified by the continuous canopy of rainforest species visible from the API and may contain Eucalypt or Brush Box Emergent strata. This ecosystem includes a variety of Floyd association.	Remnant
23. Coast Range Bloodwood-Mahogany	159	1.71	Dry forest dominated by Red Mahogany (*Eucalyptus resinifera* ssp *hemilampra*) and Pink Bloodwood (*Corymbia intermedia*). The ecosystem has a midstorey of Forest Oak (*Allocasuarina torulosa*) and a dry shrubby lower-storey.	Remnant
164. Agricultural Plantations Orchids	146	1.57	Fruit trees, Tea-trees etc	Plantation
151. Wattle	130	1.40	Generally regrowth dominated by various Acacia species.	Regrowth

[3] Number denotes Kendall Vegetation Type

Vegetation Type[3]	Approximate Area (ha)	% of Cover	Description	Vegetation Type
71. Ironbark	93	1.00	Narrow-leaved, Northern grey and Nambucca Ironbarks dominate this community. The understorey is sparse with dry shrub species and grasses.	Remnant
201. Camphor Laurel	89	0.96	Dominated by Camphor Laurel (*Cinnamomum camphora*). Other introduced and native species form a minor component of the canopy.	Disturbed
305. Bitou and Coastal shrubland	87	0.93	Shrubland dominated by Bitou but also containing *Allocasuarina, Banksia, Leptospermum, Persoonia* and other shrub species.	Disturbed
83. Mid Elevation Wet Blackbutt	78	0.84	Tall forest dominated by Coastal Blackbutt (*Eucalyptus pilularis*) with a variety of species which frequently occur as subdominants including Tallowwood (*E. microcorys*), New England Blackbutt (*E. campanulata*), Brushbox (*Lophostemon confertus*) and Turpentine (*Syncarpia* spp.).	Remnant
301. Lantana	75	0.81	Dominated by Lantana (*Lantana camara*). Native species form a minor component of the canopy.	Disturbed
165. Forestry Plantations	71	0.76	Plantations for timber production.	Plantation
84. Mid North Coast Wet Brushbox-Tallowwood-Blue Gum	66	0.71	Tall wet forest co-dominated by Tallowwood (*Eucalyptus microcorys*), Brushbox (*Lophostemon confertus*) and Sydney Blue Gum (*E. saligna*) occurring in approximately equal proportions over a very well-developed warm temperate rainforest understorey.	Remnant
64. Heath	60	0.64	Closed community of small shrubs generally <2m tall Located on Mt England in exposed areas with shallow soils and in coastal areas.	Remnant
65. Heathy Scribbly Gum	48	0.52	Medium forest dominated by Scribbly Gum (*Eucalyptus racemosa*) with either Red or Pink Bloodwood (*Corymbia gummifera* and *C. intermedia*) usually present as subdominants. There is a relatively dense heath understorey dominated by Black Sheoak (*Allocasuarina littoralis*).	Remnant
306. Coastal Scrubland	38	0.41	Scrubland with a mixed upper strata containing *Allocasuarina, Banksia, Leptospermum, Persoonia* and other shrub species.	Remnant
308. Coastal Brushbox-Littoral rainforest	16	0.17	Littoral Rainforest community dominated by Brushbox with rainforest species as a minor component of the upper strata but dominating the mid and lower strata.	Remnant
169. Scrub	16	0.17	Regrowth rainforest dominated by a variety of native rainforest species as well as pioneer species such as wattle.	Regrowth
72. Low Relief Coastal Blackbutt	15	0.16	Medium forest usually dominated by Coastal Blackbutt (*Eucalyptus pilularis*) with Pink Bloodwood (*Corymbia intermedia*) and Red Mahogany (*E. resinifera*) present as subdominants. There is a moderately dense paperbark understorey.	Remnant
19. Central Mid Elevation Sydney Blue Gum	13	0.14	Tall wet forest with an overstorey dominated by Sydney Blue Gum (*Eucalyptus saligna*) with Tallowwood (*E.microcorys*) frequently present as a sub-dominant species. The understorey is generally dense and contains warm temperate rainforest species.	Remnant
309. Coastal Ironbark Bloodwood	10	0.11	Coastal Ironbark Bloodwood.	Remnant
25. Coast Range Spotted Gum-Blackbutt	8	0.09	Dry forest characterised by Spotted Gum (*Corymbia henryi or C. variegata*) occurring as a co-dominant with either Large or Small-fruited Coastal Blackbutt (*Eucalyptus pyrocarpa* or *E. pilularis*). The ecosystem has a midstorey of Forest Oak.	Remnant
167. Introduced Scrub	8	0.09	Regrowth dominated by non-native species but not forming a monoculture.	Regrowth
302. Sclerophyll Swamp	7	0.08	Wetland dominated by *Melaleuca styphelioides, M. linariifolia, M. nodosa* and/or *M. sieberi*.	Remnant
96. Natural Grassland	4	0.04	Community dominated by Kangaroo Grass (*Themeda australis*) and other native grasses. In the Nambucca catchment this community is confined to the coastal headlands.	Remnant

Communities on Coastal Sands support a high diversity of threatened species restricted to these habitat types such as wallum froglets. Other threatened species recorded in these habitats include, bush stone curlew, swift parrot, regent honeyeater and squirrel glider. Provide habitat for wallum froglet, Eastern Blossom Bat, Long Nosed Potoroo, Ground Parrot, Grass Owl, Common Planigale and Squirrel Glider. Refer to Section 10.2.11 for further details.

10.2.7.3 Threats

Threats are specific to each broad vegetation community as follows.

Littoral Rainforest

Threats to these communities include weed invasion, loss of canopy integrity as a result of clearing; clearing and disturbance of understorey; illegal plant collection (such as epiphytes); inappropriate fire regimes; soil disturbance (erosion / pathogen introduction) and rubbish and green waste dumping. Major weed threats in the study area are likely to be *Ambrosia artemisiifolia, Anredera cordifolia, Arecastrum romanzoffiana, Asparagus* spp., *Cardiospermum grandiflorum, Chrysanthemoides monilifera, Gloriosa superba, Ipomoea* spp; *Impatiens walleriana, Lantana camara, Macfadyena unguis-cati, Rivina humilis, Pennisetum clandestinum, Schefflera actinophylla, Senna septemtrionalis, Solanum mauritianum, Thunbergia alata* and *Tradescantia fluminensis.*

Lowland Rainforest on Floodplains

The major cause of loss of lowland rainforest on floodplains has been clearing for agriculture which remains a potential threat to remnants on private land. Subsequent to clearing, the disturbed and exposed edges of remnant stands are vulnerable to invasion by exotic plant species and most surviving remnants are subject to this threat (www.nationalparks.nsw.gov.au). The effects of clearing, fragmentation and isolation on these communities have been little studied, but impacts on plant regeneration (including pollination and seed dispersal) are likely (www.nationalparks.nsw.gov.au). Other threats include fire, grazing, rubbish dumping, clearing for competing land uses (including clearing of understorey) and dissection by vehicular and foot tracks.

Major weed threats to these communities within the study area are likely to be *Ambrosia artemisiifolia, Anredera cordifolia, Arecastrum romanzoffiana, Asparagus spp., Cardiospermum grandiflorum, Ipomoea spp; Impatiens walleriana, Lantana camara, Macfadyena unguis-cati, Rivina humilis, Pennisetum clandestinum, Schefflera actinophylla, Senna septemtrionalis, Solanum mauritianum, Thunbergia alata* and *Tradescantia fluminensis*. Other threats may include illegal plant collection and fire.

Mixed Sclerophyll Communities

These communities are threatened by:

- Clearance for agricultural development of the fertile plains;
- Removal of high value timber;
- Inappropriate fire regimes; and

- Weeds; green waste dumping of the garden escapee *Sphagneticola trilobata* was observed in Bellwood State Forest. Exotic vines and scramblers may lead to alterations in fire behaviour and regime and the abundance and diversity of plant-dwelling invertebrates. Dense thickets of exotic vines may also restrict some fauna movement.

Communities on Coastal Sands

As relatively large areas of this community are reserved within the study area threats are generally limited to weed invasion and fire.

Environmental weeds are widespread along the coastal zone in northern NSW and have impacted on both disturbed and undisturbed ecosystems. The major impact of coastal weeds is their displacement and replacement of native plant species and alteration of habitat values for native fauna. The most widespread environmental weed in the northern NSW coastal zone is bitou bush (*Chrysanthemoides monilifera*). This species is listed as a weed of national significance, a threatening process under the *Threatened Species Conservation Act*, and a W3 declared noxious weed throughout the region.

The Coastal Weeds Regional Weed Management Plan developed by the NSW North Coast Weeds Advisory Committee was prepared to reduce the spread and increase awareness and control of other high priority environmental weeds in the coastal zone. The environmental weeds targeted in the plan were selected due to:

- High ranking in the North Coast Environmental Weed Risk Assessment, undertaken in 2002 by the NSW North Coast Weeds Advisory Committee;
- Current rate of spread and distribution within the region, particularly following control of bitou bush;
- Current impacts and future threat to high conservation value lands and biodiversity in general;
- Difficulty of control.

Priority weeds targeted within the coastal zone on the north coast, which are known or are liely to occur in the study area, include:

- *Gloriosa superba* (Gloriosa lily);
- *Asparagus* spp. (Ground & climbing asparagus & Asparagus fern);
- *Ochna serrulata* (Mickey mouse plant, Ochna);
- *Ipomoea* spp. (Common & purple morning glory & Mile-a-minute);
- *Schefflera actinophylla* (Umbrella tree);
- *Senna* spp. (Winter senna & Smooth senna);
- *Acetosa sagittata* (Turkey rhubarb);
- *Sphagneticola trilobata* (Singapore daisy);
- *Euphorbia cyathophora* (Painted spurge); and
- *Cenchrus echinatus* (Mossman river grass).

In the banksia woodlands on the coastal dunes of Warrell Creek, weed invasion was common on the edges of cleared access tracks and at the campground. Dominant weeds noted were *Chrysanthemoides monilifera, Ipomoea* spp., *Lantana camara, Chloris gayana, Senna septemtrionalis, Baccharis halimifolia* and *Setaria sphacelata.* The foredunes supported a rehabilitated canopy of *Casuarina equisetifolia* and *Acacia sophora* over a groundcover of *Hibbertia scandens, Dianella caerulea and Scaevola* sp.. Common weeds noted were *Chrysanthemoides monilifera, Lantana camara, Ipomoea cairica, Schefflera actinophylla, Asparagus densiflorus* and *Gloriosa superba.* The dunes of the ocean foreshore and along Warrell Creek also supported a high density of *C. monilifera*.

Figure 10-6 indicates general weed distribution mapped within the catchment.

10.2.8 Riparian Vegetation and Macrophytes

10.2.8.1 Distribution and Composition

The high level of interaction between the riparian fringe, the watercourse and adjacent floodplain makes defining a riparian zone difficult. Various definitions for the riparian zone include:

- the area from the low flow level up to the highest point on a bank, which marks the transition between channel and flood plain;
- all land directly adjacent to a watercourse including floodplains and wetlands; and
- an interface between terrestrial and aquatic.

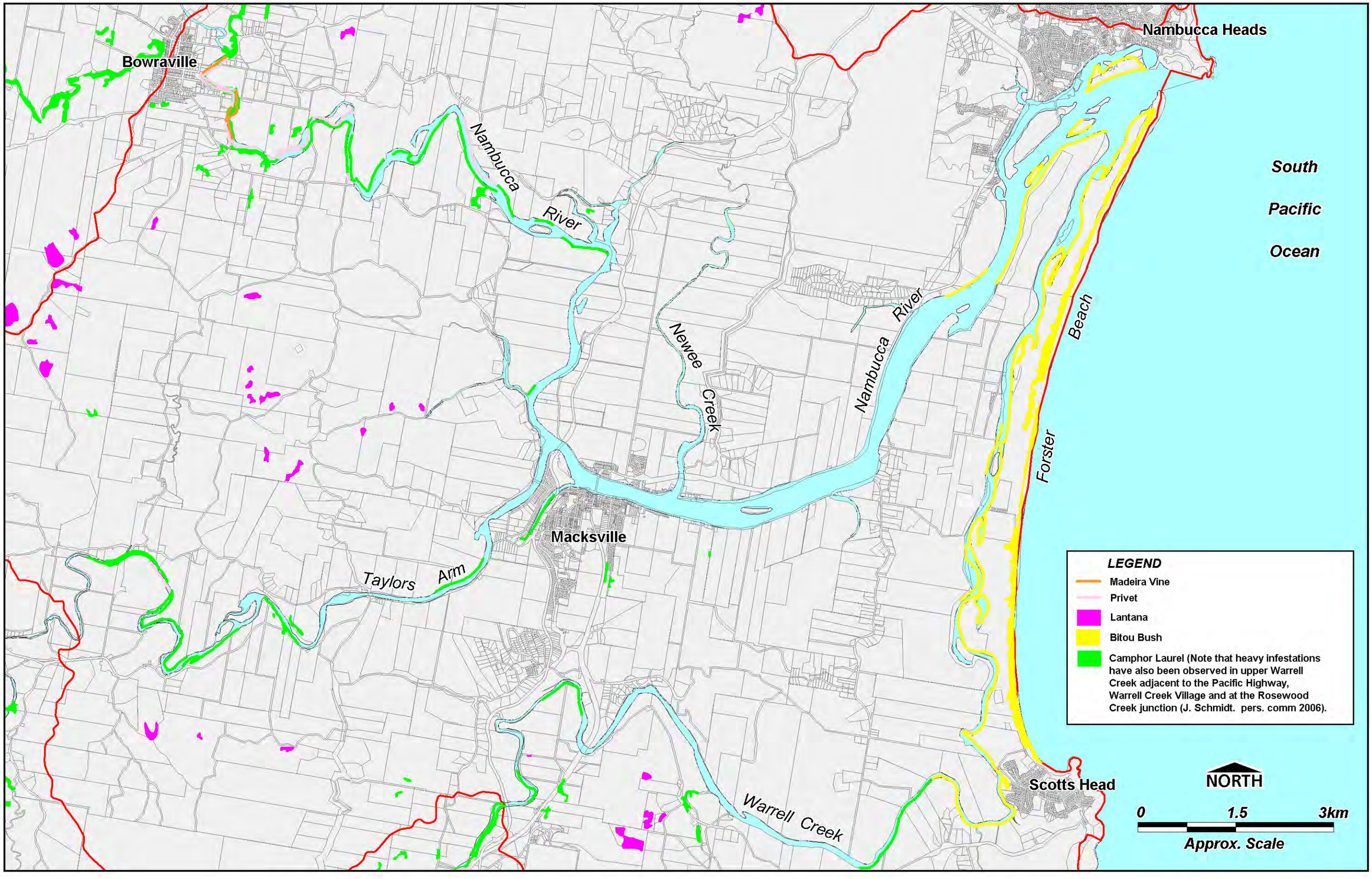
For the purposes of this study, riparian vegetation includes all land within 50m of the high water mark of the Nambucca River.

An assessment of the condition of the estuary riverbank and riparian vegetation was conducted by Geco (2005) based on interpretation of historical and recent air photo records (1956, 1980 and 1997) and field reconnaissance undertaken by boat over 12 days in September 2004. Based on Geco (2005), the estuary systems with the most instability are North Arm, Nambucca River, and Taylors Arm. This is most likely due to the combination of:

- the alluvial nature of many banks making them susceptible to erosion when disturbed;
- the generally high degree of development for agriculture and grazing resulting in high riparian and bank disturbance;
- ongoing responses to sediment imbalances related to gravel extraction in upper reaches;
- higher flow energies in the upper reaches of the estuary; and
- in lower reaches, increased susceptibility to wave wash effects from the wind and boats.

The two least affected systems are Newee Creek and Warrell Creek (Geco Environmental, 2005). Both these systems are more stable due to the reduced incidence of erodible seams in the bank profiles and more consistent vegetative cover on the banks (Geco Environmental, 2005).

The upper riparian reaches of Warrell Creek were generally dominated by a narrow fringe of *Casuarina cunninghamiana* and *Cinnamomum camphora* with copses of *Melaleuca quinquenervia* and *M. styphelioides*.



Weed Distribution In The Nambucca River Estuary Catchment (Based on Kendall, 2003 and Geco Environmental, 2005) Figure 10-6

Other canopy species included *Eucalyptus tereticornis, E. pilularis, Lophostemon confertus, Lophostemon suaveolens* and rainforest elements such as *Livistona australis* and *Glochidion* spp.. Sparse to dense *Baccharis halimifolia, Lantana camara, Ipomoea cairica, Cyperus exaltatus* and *Arundo donax* invasions were noted.

The banks and shallows of the upper headwaters generally supported patches of *Bacopa monnieri, Baumea rubiginosa* with *Nymphae* sp., occurring in deeper waters. These upper waters supported a high density of fallen timber and stags and provided good quality fauna habitat. During the field survey common species observed on the banks of the estuarine reaches and within the riparian fringe of the freshwater and brackish reaches of North Arm and Taylor's Arm included, *Eucalyptus tereticornis, Corymbia intermedia, Eucalyptus siderophloia* and *E. carnea* canopy trees. *Cinnamomum camphora* often dominated the upper canopy.

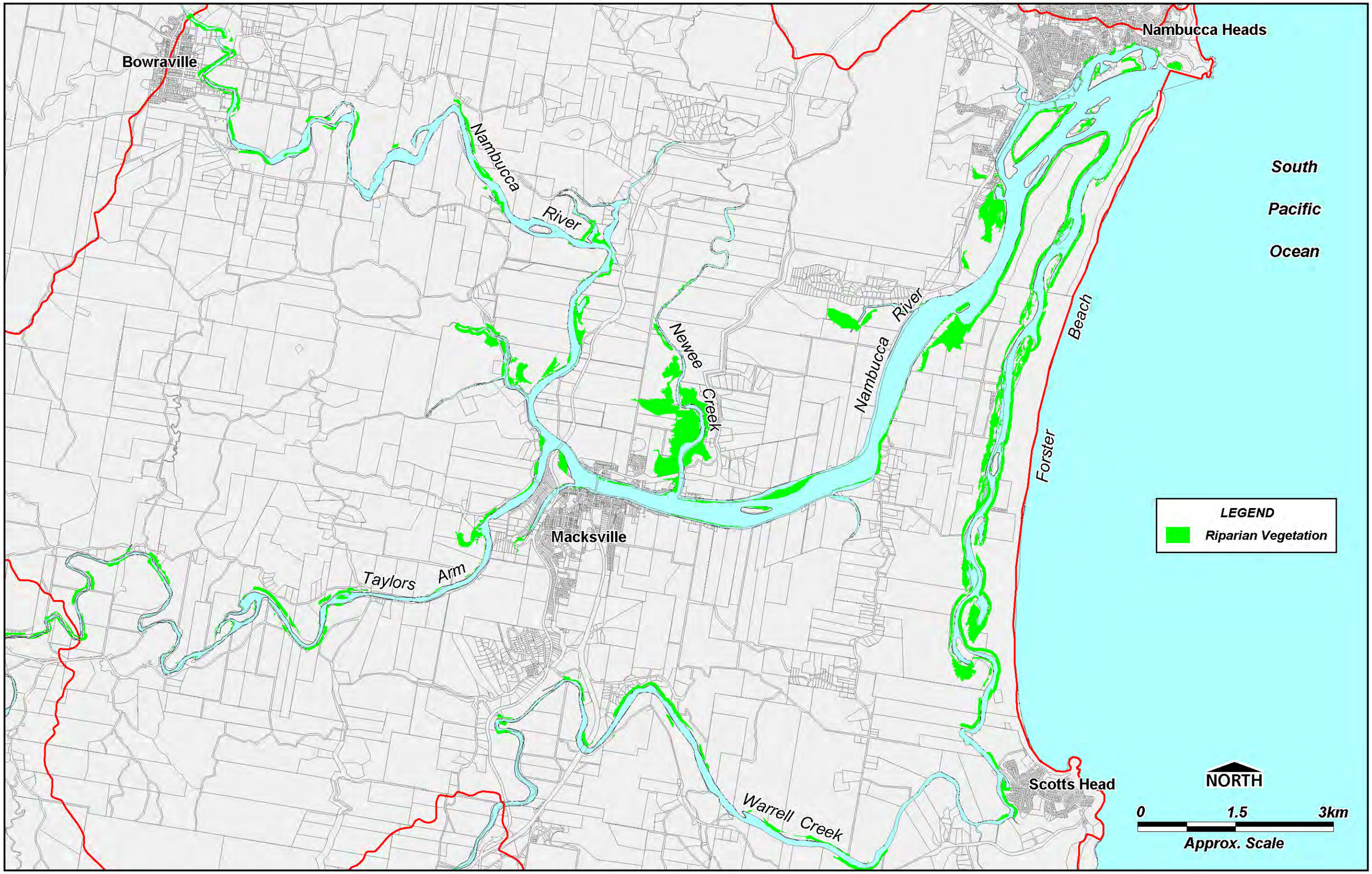
North Arm had the worst riparian vegetation condition, followed by Taylors Arm and the Nambucca River due to clearing and reduction of ground and shrub layers as a result of stock impacts and the invasion of exotic species particularly camphor laurel and small-leaved privet in upper reaches and bitou bush in lower reaches of the River and Warrell Creek (Geco Environmental, 2005).

The subcanopy was generally comprised of *Casuarina cunninghamiana, Cupaniopsis anacardioides, Callistemon salignus, Waterhousea floribunda, Guioa semiglauca, Glochidion sumatranum, Glochidion ferdinandi, Lophostemon confertus, Acacia irrorata, Acacia maidenii, Commersonia bartramia* and *Pittosporum undulatum*. *Lantana camara* often dominated the understorey.

Common groundcovers included *Imperata cylindrica, Panicum maximum* and *Ottochloa gracillimus.* In the upper freshwater reaches the groundcover often comprised *Lomandra longifolia. Crinum pedunculatum* was widespread as isolated individuals throughout the estuary. Other groundcovers recorded included *Persicaria* spp., *Ludwigia octovalvis* and *Carex appressa*.

Dominant weeds recorded in the riparian zone included *Cinnamomum camphora, Lantana camara, Ligustrum sinense, Senna septemtrionalis, Ipomoea* spp., *Chloris gayana, Verbena* spp., *Bidens pilosa, Ambrosia artemisiifolia* and *Canna indica.* Sparse *Rubus sp., Salix* sp. and *Jacaranda mimosifolia* were also noted on North Arm and Taylor's Arm. Common macrophytes observed in freshwater pools in the upper reaches of North Arm included *Bacopa monnieri, Potamogeton tricarinatus, Ruppia megacarpa, Nymphae* sp. and *Vallisneria sp.. Typha sp., Phragmites australis* and *Lepironia articulata* were noted in freshwater and brackish waters usually in association with a canopy of *Melaleuca* spp.. At survey sites 14 and 15 located in the industrial estate south of Macksville, dense infestations of the invasive environmental weed *Salvinia molesta* were noted.

Inappropriate clearing along the foreshore was observed at several locations, including the left bank downstream of the highway bridge on Warrell Creek in a rural residential area and in road reserves on both banks downstream of the Macksville highway bridge. Environmental weeds and garden escapees such as umbrella trees, asparagus fern, mother-in-laws tongue, and mother-of-millions were noted in urban foreshore areas.



Riparian Vegetation Distribution In The Nambucca River Estuary Catchment (Based on : Kendall, 2003 and Fisheries, 2004) Figure 10-7

Table 10-5 Riparian Vegetation within 50m either side of the Nambucca Estuary (Based on mapping by Kendall, 2003 and Fisheries, 2004)

Vegetation Type[4]	Description	Vegetation Type
5. Banksia	Located on coastal sand dunes in close proximity to the ocean, common associates include Sheoak (*Allocasuarina littoralis*) bloodwoods and Swamp Mahogany.	Remnant
19. Central Mid Elevation Sydney Blue Gum	Tall wet forest with an overstorey dominated by Sydney Blue Gum (*Eucalyptus saligna*) with Tallowwood (*E. microcorys*) frequently present as a sub-dominant species. The understorey is generally dense and contains warm temperate rainforest species.	Remnant
23. Coast Range Bloodwood-Mahogany	Dry forest dominated by Red Mahogany (*Eucalyptus resinifera* ssp *hemilampra*) and Pink Bloodwood (*Corymbia intermedia*). The ecosystem has a midstorey of Forest Oak (*Allocasuarina torulosa*) and a dry shrubby lower-storey.	Remnant
308. Coastal Brushbox-Littoral rainforest	Littoral Rainforest community dominated by Brushbox with rainforest species as a minor component of the upper strata but dominating the mid and lower strata.	Remnant
309. Coastal Ironbark Bloodwood	Coastal Ironbark Bloodwood.	Remnant
27. Coastal Sands Blackbutt	Forest dominated by Coastal Blackbutt (*Eucalyptus pilularis*) which often includes Needlebark-Stringybark (*E. planchoniana*) and Smooth-barked Apple (*Angophora costata*) as sub-dominants. The ecosystem contains a relatively dense shrub layer.	Remnant
306. Coastal Shrubland	Shrubland with a mixed upper strata containing *Allocasuarina, Banksia, Leptospermum, Persoonia* and other shrub species.	Remnant
34. Dry Grassy Blackbutt-Tallowwood	Tall open forest dominated by Coastal Blackbutt (*Eucalyptus pilularis*) with Tallowwood (*E. microcorys*) occurring as a sub-dominant. There is a mid-storey of Forest Oak (*Allocasuarina torulosa*) and there are often some straggly shrubs such as Coffee Bush.	Remnant
36. Dry Grassy Tallowwood-Grey Gum	Medium tall ecosystem which generally includes a mixed canopy of Tallowwood (*Eucalyptus microcorys*), Grey Gum (*E propinqua*), Grey Ironbark (*E. siderophloia*), Broad-leaved White Mahogany (*E. carnea*) and Turpentine (*Syncarpia glomulifera*).	Remnant
64. Heath	Closed community of small shrubs generally <2m tall Located on Mt England in exposed areas with shallow soils and in coastal areas.	Remnant
65. Heathy Scribbly Gum	Medium forest dominated by Scribbly Gum (*Eucalyptus racemosa*) with either Red or Pink Bloodwood (*Corymbia gummifera* and *C. intermedia*) usually present as subdominants. There is a relatively dense heath understorey dominated by Black Sheoak (*Allocasuarina littoralis*).	Remnant
85. Mixed Moist Hardwood	Tall wet forest with a mixed composition containing some of the following species Narrow-leaved White Mahogany (*Eucalyptus acmenoides*), Red Mahogany (*E resinifera*), Grey Ironbark (*E siderophloia* or *E paniculata*), Grey Gum (*E propinqua* or *E biturbinata*).	Remnant
168. Rainforest	Rainforest identified in this project is a broad ecosystem, it is identified by the continuous canopy of rainforest species visible from the API and may contain Eucalypt or Brush Box Emergent strata. This ecosystem includes a variety of Floyd associations.	Remnant
168. Rainforest Lowland	Rainforest identified in this project is a broad ecosystem. It is identified by the continuous canopy of rainforest species visible from the API and may contain Eucalypt or Brush Box Emergent strata. This ecosystem includes a variety of Floyd association.	Remnant
142. Swamp Mahogany	Swamp Mahogany dominates the community. Common associates include Red mahogany, Bloodwood, Forest Red Gum, Paperbarks and Swamp Oak. The lower strata is generally dominated by wet heath or sedge species.	Remnant
154. Wet Flooded Gum-Tallowwood	Very tall forest dominated by Flooded Gum (*Eucalyptus grandis*) with Tallowwood (*E. microcorys*), Brushbox (*Lophostemon confertus*) and Turpentine (*Syncarpia glomulifera*) frequently present in subdominant proportions which occurs above a dense rainforest understorey.	Remnant
151. Wattle	Generally regrowth dominated by various Acacia species.	Regrowth
167. Introduced Scrub	Regrowth dominated by non-native species but not forming a monoculture.	Regrowth
173. Cleared Partly Cleared	Predominantly cleared but may contain small patches of regrowth.	Regrowth

[4] Number denotes Kendall Vegetation Type

Vegetation Type[4]	Description	Vegetation Type
165. Forestry Plantations	Plantations for timber production.	Plantation
305. Bitou and Coastal shrubland	Shrubland dominated by Bitou but also containing *Allocasuarina, Banksia, Leptospermum, Persoonia* and other shrub species.	Dominated by introduced species
201. Camphor Laurel	Dominated by camphor laurel (*Cinnamomum camphora*). Other introduced and native species form a minor component of the canopy.	Dominated by introduced species
Mangrove	Dominated by *Avicennia marina* and *Aegiceras corniculatum*. Isolated *Excoecaria agallocha* have also been recorded in Warrell Creek.	Remnant and Regrowth
Saltmarsh	Typical species include *Juncus kraussii, Sarcocornia quinqueflora, Sporobolus virginicus, Phragmites australis, Baumea juncea* and *Triglochin striata.*	Remnant and Regrowth

10.2.8.2 Values

The values and functions of riparian vegetation can broadly be summarised as follows:

- maintenance of biological diversity;
- stream bank stability and channel integrity;
- water quality buffering and filtering, including the removal of nutrient and sediment run-off;
- preservation of significant vegetation types (e.g. lowland rainforest);
- provision of habitat for aquatic and terrestrial fauna, including food sources and corridors and drought refugia for terrestrial fauna; and
- recreational and aesthetic values.

10.2.8.3 Future Threats

Riparian communities of the study area are threatened by:

- Clearing:
- Stock: Uncontrolled access of stock leading to back slumping, erosion and loss of riparian vegetation. Along much of the length of North Arm, vegetation has been cleared to the edge of the riverbank for cattle grazing and other agricultural practices. Only a narrow strip of riparian vegetation has been retained in areas and there is high pressure on this from grazing stock.
- Invasion and degradation by environmental weeds. The major impact of weeds is their displacement and replacement of native plant species and alteration of habitat values for native fauna. Invasion and degradation by environmental weeds, particularly vines and creepers is a serious threat. *Cinnamomum camphora* (ranked 4: NCEWS, 2000) is a common component of the riparian corridor in the upper reaches of the estuary along Taylor's Arm, North Arm and Warrell Creek Isolated patches of *Ligustrum sinense* (ranked 2: NCEWS, 2000) also occur along Taylor's Arm, North Arm and the tributaries of Warrell Creek. Isolated patches of *Anredera cordifolia* (ranked 1: NCEWS, 2000) have been recorded in the upper reaches of North Arm. *Lantana camara* (ranked 4: NCEWS, 2000) has been recorded in disturbed and remnant communities throughout the catchment.

  Other weeds recorded in the riparian zone included *Senna septemtrionalis, Ipomoea* spp., *Chloris gayana, Verbena* spp., *Bidens pilosa, Ambrosia artemisiifolia* and *Canna indica*. Sparse *Rubus* sp., *Salix* sp. and *Jacaranda mimosifolia* were also noted on North Arm and Taylor's Arm; and.
- Boat wash wave impacts.

10.2.9 Significant Vegetation Communities

10.2.9.1 Threatened Species Conservation Act 1995 (TSC Act)

The purposes of the *Threatened Species Conservation Act* 1995 (*TSC Act*) are to:

- conserve biological diversity and promote ecologically sustainable development;
- prevent the extinction and promote the recovery of threatened species, populations and ecological communities;

- protect the critical habitat of those species, populations and ecological communities that are endangered;
- eliminate or manage certain threatening processes;
- ensure proper assessment of activities impacting threatened species, populations and ecological communities; and
- encourage the conservation of threatened species, populations and ecological communities through co-operative management.

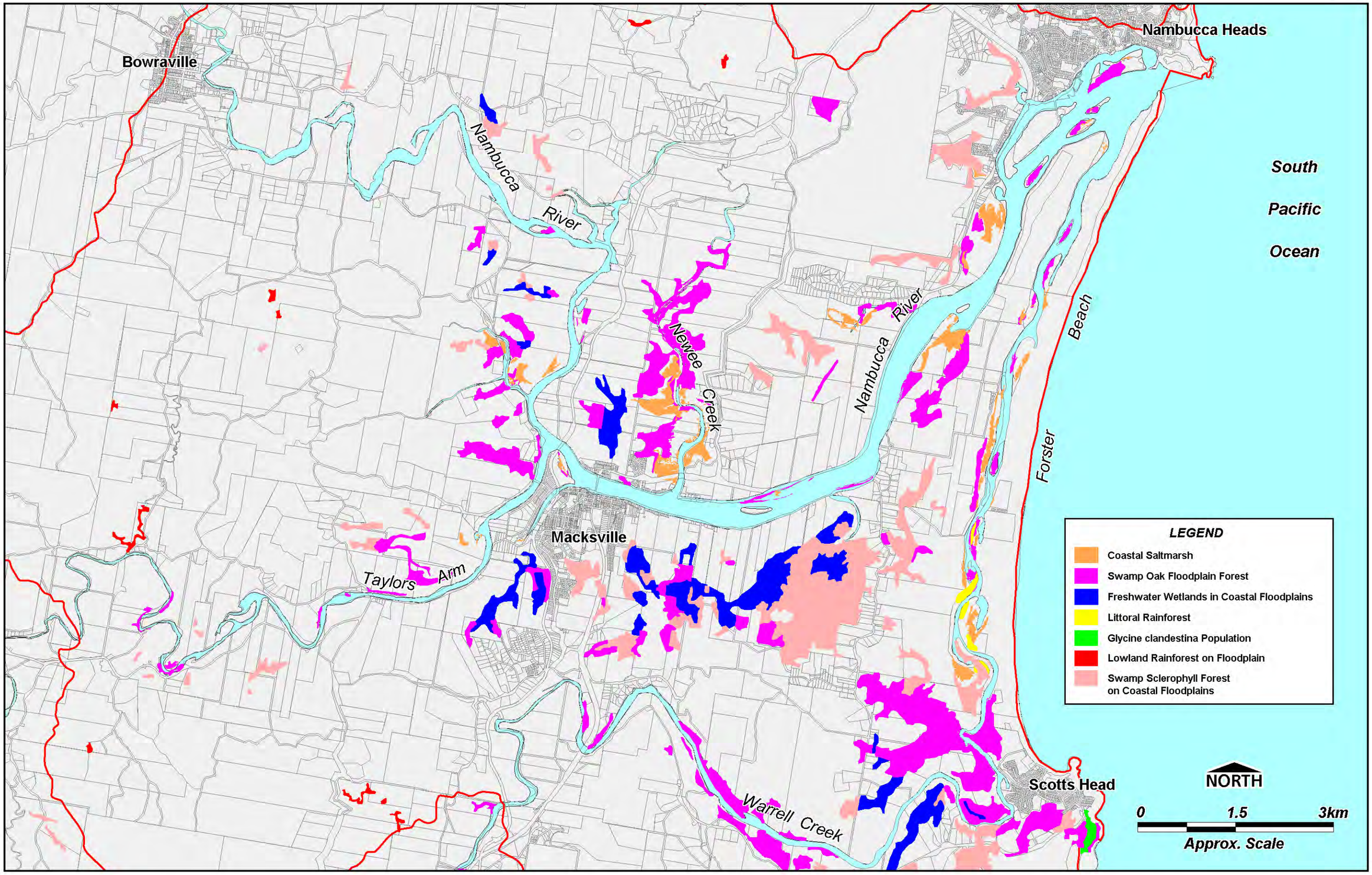
Certain legislative amendments and procedural changes have been made to the Act under the *Threatened Species Legislation Amendment Act 2004*. Some of the major provisions of the Amendment Act are:

- The criteria for listing a population as 'endangered' have been modified. Under the Amendment Act a population is eligible for listing as 'endangered' if it is facing a high risk of becoming extinct in nature in New South Wales, and it is of conservation value at the State or regional level for one or more of the following reasons:
  - it is disjunct or near the limit of its geographic range;
  - it is or is likely to be genetically, morphologically or ecologically distinct; or
  - it is otherwise of significant conservation value.

  The intention of this amendment is to exclude from listing local populations that are of lesser importance to the conservation of the species across its regional or state-wide distribution. The protection of locally important populations that are not eligible for listing under the *TSC Act* is more appropriately provided for through existing mechanisms such as, plans of management, conservation agreements, regulatory and strategic planning processes and other natural resource management legislation.
- The criteria for listing a community as 'endangered' has also been modified. An ecological community is eligible to be listed as an endangered ecological community if, in the opinion of the Scientific Committee:
  - it is likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival cease to operate; or
  - it might already be extinct.

The following section describes the habitats within the Nambucca Catchment listed under the *TSC Act* Schedule 1 (17th December, 2004).

Figure 10-8 maps the distribution of these communities within the Nambucca River catchment based on Kendall (2003) and DIPNR (2004) and limited ground truthing.



TSC Act Endangered Communities and Populations In The Nambucca River Estuary (Source : Kendall, 2003 and DIPNR, 2004) Figure 10-8

Coastal Saltmarsh

Coastal saltmarsh of the NSW North Coast is listed as an *Endangered* Ecological Community under the *TSC Act.*

The NSW Scientific Committee has found that:

- Saltmarshes are globally threatened and in recent decades there has been widespread invasion of saltmarsh in southeast Australia by mangroves but the factors driving this encroachment remain unclear.
- Coastal saltmarsh occurs in the intertidal zone on the shores of estuaries and lagoons and is frequently found as a zone landward of mangrove stands. Characteristic species can include, *Baumea juncea, Juncus kraussii, Sarcocornia quinqueflora, Sporobolus virginicus, Suaeda australis* and *Triglochin striata.*
- Saltmarsh provides habitat for a diverse invertebrate fauna and during tidal flooding a number of fish species utilise these habitats. Some coastal saltmarshes provide important high tide roosts for migratory wading birds. Grazing by macropods may occur between tidal events and diversity of macrofauna in mangrove forests adjacent to saltmarsh has been found to be greater than in mangroves that do not border saltmarsh.
- Many of the threatening processes to these communities include infilling, modified tidal flow, weed invasion, damage by domestic and feral animals, human disturbance, altered fire regimes and climate change. Damage to saltmarshes by recreational vehicles is widespread and deep wheel ruts persist for many years. Grazing and trampling by domestic stock and feral herbivores is also widespread. Stock grazing has been shown to substantially change the vegetation composition and structure while on muddy substrates trampling can cause loss of plant cover and modify drainage patterns. Communities are at risk from waterborne pollution and catchment runoff. Upper saltmarsh stands dominated by *Juncus kraussii* and *Baumea juncea* have high flammable fuel loads and although incidence of fire is low, recovery is slow.

Saltmarsh communities along the main arm of the Nambucca River and south of Watts Creek and Newee Creek are being impacted by cattle, which are causing soil disturbance and loss of groundcover. *Baccharis halimifolia* is the major weed threat to saltmarsh in the *study area.* Other potential weeds which may encroach on saltmarsh of the *study area* include *Cortaderia selloana, Phragmites australis* and *Hydrocotyle bonariensis.*

Swamp Oak Floodplain Forest

Swamp oak floodplain forest of the NSW North Coast is listed as an *Endangered* Ecological Community under the *TSC Act.*

The NSW Scientific Committee has found that:

- Swamp Oak Floodplain Forests are associated with grey-black clay-loams and sandy loams, on waterlogged or periodically inundated flats, where the groundwater is saline or sub-saline, drainage lines, lake margins and estuarine fringes associated with coastal floodplains. They have a dense to sparse tree layer in which *Casuarina glauca* dominates. The understorey is characterised by vines such as *Parsonsia straminea, Geitonoplesium cymosum* and *Stephania*

japonica var. *discolor*, sparse shrubs and a continuous groundcover including species such as *Baumea juncea, Juncus kraussii* subsp. *australiensis, Phragmites australis* and other saltmarsh species.

- On saline soils the threatened grass species *Alexfloydia repens*, may occur. This species is currently known from less than ten locations in a small area south of Coffs Harbour. Swamp Oak Forests may also provide food resources for the Glossy Black Cockatoo (*Calyptorhynchus lathami lathami*) and habitat for the Squirrel Glider (*Petaurus norfolcensis*).
- On the North Coast of NSW, swamp oak floodplain forest has been extensively cleared for grazing and canefields and it is likely that less than 3% of the original extent remains in this area. In some areas, alterations of tidal flows may have lead to decreased soil salinity and localised expansion of *Casuarina glauca* into areas that previously supported saltmarsh or mangroves.
- Small areas of Swamp Oak Floodplain Forest of the NSW North Coast are contained within existing conservation reserves but these are unevenly distributed throughout the range and unlikely to represent the full diversity of the community. Some areas of Swamp Oak Floodplain Forest are protected by State Environmental Planning Policy 14. However, this does not preclude impacts on these communities. In particular, they may be exposed to hydrological changes originating upstream.
- Remaining stands are severely fragmented and are threatened by continuing fragmentation and degradation, flood mitigation and drainage works, landfilling and earthworks associated with urban and industrial development, pollution from urban and agricultural runoff, weed invasion, overgrazing, trampling by stock, rubbish dumping and frequent burning.

Given their proximity to urban and agricultural lands, the swamp oak communities of the *study area* are threatened by fire, cattle grazing, weed invasion and hydrological changes originating from the upstream catchment. *Baccharis halimifolia* was commonly observed and *Salvinia molesta* was observed in water bodies in the vicinity of the industrial estate south of Macksville. Other weed threats which may encroach on swamp oak communities of the *study area* include, *Araujia sericifolia, Asparagus asparagoides, Cyperus eragrostis, Cinnamomum camphora, Conyza* spp., *Hydrocotyle bonariensis, Ipomoea cairica, I. purpurea* and *I. indica, Lantana camara, Paspalum dilatatum, Pennisetum clandestinum, Solanum nigrum* and *Verbena bonariensis.*

Swamp Sclerophyll Forest On Coastal Floodplains

Swamp sclerophyll forest on coastal floodplains of the NSW North Coast is listed as an *Endangered Ecological Community* under the *TSC Act.*

The NSW Scientific Committee has found that:

- Swamp sclerophyll forest are associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains. The structure of the community is typically open forest but also includes scrubland, fernland, tall reedland or sedgeland, where trees are very sparse or absent. They often fringe floodplain lagoons or wetlands with semi-permanent standing water.
- They generally have an open to dense tree layer of eucalypts and paperbarks, which may exceed 25 m in height, but can be shorter. Dominant trees include *Eucalyptus robusta* and *Melaleuca quinquenervia.* Other trees include *Callistemon salignus, Casuarina glauca, Eucalyptus*

resinifera subsp. hemilampra, Livistona australis and *Lophostemon suaveolens*. A small tree layer may be present, species include *Melaleuca linariifolia* and *M. styphelioides*. Shrubs include *Melaleuca* spp.. Occasional vines include *Parsonsia straminea* and *Stephania japonica* var. *discolor*. The groundcover is composed of abundant sedges, ferns, forbs, and grasses.

- These communities provide habitat for the endangered swamp orchids *Phaius australis* and *P. tancarvilleae*. In addition, they provide habitat for Grey-headed Flying Fox (*Pteropus poliocephalus*), Yellow-bellied Glider (*Petaurus australis*), Regent Honeyeater (*Xanthomyza phrygia*), Swift Parrot (*Lathamus discolor*), Osprey (*Pandion haliaetus*), Australasian Bittern (*Botaurus poiciloptilus*), Large-footed myotis (*Myotis adversus*), *Litoria olongburensis* and Wallum Froglet *(Crinia tinnula).*
- On the North Coast of NSW, swamp sclerophyll forest has been extensively cleared for grazing and canefields and it is likely that less than 3% of the original extent remains in this area.
- Remaining stands are severely fragmented by past clearing and are further threatened by degradation, flood mitigation and drainage works, landfilling and earthworks, pollution from urban and agricultural runoff, weed invasion, overgrazing, trampling and other soil disturbance, removal of dead wood, waste dumping and frequent burning.
- Relatively few examples of Swamp Sclerophyll Forest on Coastal Floodplains remain unaffected by weeds.

Given their proximity to urban and agricultural lands, the swamp sclerophyll communities of the *study area* are threatened by fire, cattle grazing, weed invasion and hydrological changes originating from the upstream catchment. *Baccharis halimifolia* was commonly observed and *Salvinia molesta* was observed in water bodies in the vicinity of the industrial estate south of Macksville. Other weed threats which may encroach on swamp oak communities of the *study area* include, *Andropogon virginicus, Anredera cordifolia, Ageratina adenophora, Cinnamomum camphora, Lantana camara, Ligustrum sinense, Lonicera japonica* and *Ludwigia peruviana.*

Freshwater Wetlands On Coastal Floodplains

Freshwater wetlands on coastal floodplains of the NSW North Coast are listed as an *Endangered Ecological Community* under the *TSC Act.*

The NSW Scientific Committee has found that:

- Freshwater Wetlands are associated with periodic or semi-permanent inundation by freshwater, although there may be minor saline influence in some wetlands. The structure of the community may vary from sedgelands and reedlands to herbfields, and woody species of plants are generally scarce.
- Common grasses and sedges include *Paspalum distichum, Leersia hexandra, Pseudoraphis spinescens, Carex appressa, Baumea articulata, Eleocharis equisetina* and *Lepironia articulata*. Common herbs and macrophytes can include, *Hydrocharis dubia, Philydrum lanuginosum, Ludwigia peploides* subsp. *montevidensis, Marsilea mutica, Myriophyllum* spp., *Azolla filiculoides* var. *rubra, Ceratophyllum demersum, Hydrilla verticillata, Lemna* spp., *Nymphaea gigantea, Nymphoides indica, Ottelia ovalifolia* and *Potamogeton* spp..

- Wetland habitats provide potential habitat for the following significant species, *Aldrovanda vesiculosa,* Green and Golden Bell Frog (*Litoria aurea*), Great Egret (*Ardea alba),* Intermediate Egret (*Ardea intermedia*), Little Egret (*Ardea garzetta*), Black-necked Stork (*Ephippiorhynchus asiaticus*), Royal Spoonbill (*Platalea regia*), Japanese Snipe (*Gallinago hardwickii*) and Black-winged Stilt (*Himantopus himantopus*).
- Artificial wetlands created on previously dry land specifically for purposes such as sewerage treatment, stormwater management and farm production, are not regarded as part of this community, although they may provide habitat for threatened species.
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast have been extensively cleared and modified. Large areas that formerly supported this community are occupied by grazing and canefields. Remaining stands are severely fragmented and further threatened by degradation, flood mitigation and drainage works, filling associated with urban and industrial development, pollution and eutrophication from urban and agricultural runoff, weed invasion, overgrazing, trampling by livestock, acid sulphate soils, soil disturbance and rubbish dumping.
- The native fauna of freshwater wetlands is threatened by predation, particularly by mosquito fish and cane toads. Widespread degradation of Freshwater Wetlands has led to a regional decline in wetland dependent fauna including Magpie Geese (*Anseranas semipalmata*), Cotton Pygmy Geese (*Nettapus coromandelianus*), Hardhead (*Aythya australis*), Black-necked Stork (*Ephippiorhynchus asiaticus*) and Wandering Whistling Duck (*Dendrocygna arcuata*).

Given their proximity to urban and agricultural lands, the freshwater wetlands of the *study area* are threatened by cattle and weed invasion. *Baccharis halimifolia* was commonly observed and *Salvinia molesta* was observed in water bodies in the vicinity of the industrial estate south of Macksville. Other weed threats which may encroach on freshwater wetlands of the *study area* include, *Alternanthera philoxeroides, Baccharis halimifolia, Echinochloa crus-galli, Eichhornia crassipes, Hygrophila costata, Ludwigia peruviana, Nymphaea capensis* and *Pennisetum clandestinum.*

Floodgates have been placed in a number of areas, notably Gumma Creek, which affect the connectivity between estuarine and wetland habitats, fauna movements and hydraulic processes. There are currently poor corridor connections between the Nambucca River and wetlands south and east of Macksville.

Littoral Rainforest

Littoral rainforest of the NSW North Coast bioregion is listed as an *Endangered Ecological Community* Under the *TSC Act.*

The NSW Scientific Committee has found that:

- Littoral rainforest occurs on sand dunes and soils derived from underlying rocks and most stands occur within 2 km of the sea. A number of species characteristic of these communities reach their geographic limits in the vicinity of the Nambucca. In addition, littoral rainforest provides habitat for a number of threatened species such as *Acronychia littoralis, Cryptocarya foetida, Hicksbeachia pinnatifolia, Fontainea oraria, Ninox strenua* (Powerful Owl), *Dasyurus maculatus* (Spotted-tailed Quoll) and *Kerivoula papuensis* (Golden-tipped Bat).
- Threats to these communities include weed invasion, loss of canopy integrity as a result of clearing; clearing and disturbance of understorey; illegal plant collection (such as epiphytes);

inappropriate fire regimes; soil disturbance (erosion / pathogen introduction) and rubbish and green waste dumping.

Figure 10-9 maps the distribution of Littoral Rainforest within the Nambucca Estuary, based on SEPP 26 mapping produced by DIPNR (2004). The SEPP 26 maps do not necessarily map all stands of littoral rainforest particularly regrowth or regenerating communities.

The major occurrences of littoral rainforest mapped in the Nambucca catchment occur along the dunes fringing Warrell Creek[5]. Five isolated patches, ranging from 1.5 to 5ha in area, have been recorded on the banks approximately 2km north of Scott's Head. Based on limited ground truthing conducted in December 2004, these communities were comprised of a closed canopy of *Livistona australis, Cupaniopsis anacardioides, Acronychia littoralis, Podocarpus elatus* and *Ficus* spp..

Given their relative isolation from land development, the littoral rainforest communities of the *study area* remain in good ecological condition. The major threat to these communities is likely to be weed invasion. Major weed threats are likely to be *Ambrosia artemisiifolia, Anredera cordifolia, Arecastrum romanzoffiana, Asparagus* spp., *Cardiospermum grandiflorum, Chrysanthemoides monilifera, Gloriosa superba, Ipomoea* spp; *Impatiens walleriana, Lantana camara, Macfadyena unguis-cati, Rivina humilis, Pennisetum clandestinum, Schefflera actinophylla, Senna septemtrionalis, Solanum mauritianum, Thunbergia alata* and *Tradescantia fluminensis.* Other threats may include illegal plant collection and fire.

Lowland Rainforest on Floodplains

Lowland Rainforest on Floodplains in the NSW North Coast bioregion are listed as *Endangered Ecological Communities* under the *TSC Act.*

Lowland rainforest on the Nambucca floodplain is limited in distribution and the mapped extent is likely to be an overestimate (Kendall, 2003). Due to the restricted and limited distribution of this community, the precautionary principle was applied to mapping all potential areas of lowland floodplain rainforest and includes areas of disturbed wet sclerophyll forest and river oak where the upper strata has been removed but rainforest elements dominate (Kendall, 2003). Within the *study area*, lowland rainforest occurs as sparse, isolated patches (in the order of 1-6ha in area) on tributaries of Warrell Creek and Taylor's Arm.

The major cause of loss of lowland rainforest on floodplains was clearing for agriculture. Subsequent to clearing the disturbed and exposed edges of remnant stands were vulnerable to invasion by exotic plant species and most surviving remnants are subject to this threat (www.nationalparks.nsw.gov.au). The effects of clearing, fragmentation and isolation on these communities has been little studied, but impacts on plant regeneration (including pollination and seed dispersal) are likely (www.nationalparks.nsw.gov.au). Other threats include fire, grazing, rubbish dumping, clearing for competing land uses (including clearing of understorey) and dissection by vehicular and foot tracks.

Although not observed during the field survey, the major weed threats to these communities are likely to be *Ambrosia artemisiifolia, Anredera cordifolia, Arecastrum romanzoffiana, Asparagus* spp., *Cardiospermum grandiflorum, Ipomoea* spp; *Impatiens walleriana, Lantana camara, Macfadyena*

[5] Note that the Kendall (2003) vegetation mapping (refer to Figure 10-5) has not mapped the littoral rainforest on the dunes along Warrell Creek.

unguis-cati, Rivina humilis, Pennisetum clandestinum, Schefflera actinophylla, Senna septemtrionalis, Solanum mauritianum, Thunbergia alata and *Tradescantia fluminensis.* Other threats may include illegal plant collection and fire.

Glycine clandestina (broad leaf form) Population

The *Glycine clandestina* (broad leaf form) population located in coastal native grassland from Scott's Head to the catchment boundary is listed as an *Endangered Population* under the Act. The *Glycine clandestina* (broad leaf form) population is restricted to grassland south of Scott's Head.

The coastal grassland habitat at Scott's Head has been reduced in extent by past development and is at risk of invasion by *Chrysanthemoides monilifera* and from further development (Kendall, 2003).

10.2.9.2 SEPP 26 Littoral Rainforest

The aim of State Environmental Planning Policy 26 (SEPP 26) – Littoral rainforests is to ensure that littoral rainforests are preserved and protected. Development consent is required for any of the following activities within an area of protected littoral rainforest, as mapped by the Department of Infrastructure, Planning and Natural Resources (DIPNR): erecting a building; carrying out work; using littoral rainforest for any purpose; or disturbing native flora or any other element of the landscape. These activities are considered to be designated development and require the agreement of the Director General of the Department of Infrastructure, Planning and Natural Resources.

Figure 10-9 maps the distribution of SEPP 26 Littoral Rainforest within the Nambucca Estuary. The major areas of SEPP 26 occur along the dunes fringing Warrell Creek. Five isolated patches, ranging from 1.5 to 5ha in area, have been recorded on the banks approximately 2km north of Scott's Head.

10.2.9.3 SEPP 14 Wetlands

The aim of State Environmental Planning Policy 14 (SEPP 14) – Coastal Wetland is to ensure that the coastal wetlands[6] are preserved and protected. Under SEPP 14, land clearing, levee construction, drainage work or filling may only be carried out within these wetlands with the consent of the local council and the agreement of the Director-General of the of the Department of Infrastructure, Planning and Natural Resources

Figure 10-10 maps the distribution of SEPP 14 Wetlands within the Nambucca Estuary.

The major occurrences of SEPP 14 Wetlands in the estuary include:

- Warrell Creek (approximately 430ha);
- Gumma Gumma Wetlands (309ha);
- Newee Creek (212ha);
- Bellwood State Forest (125ha);
- 100 Acre Swamp (81ha);
- Blackbutt Creek (59ha);
- Taylor's Arm (38ha);

[6] as mapped by Department of Infrastructure, Planning and Natural Resources

- South of Blackbutt Creek (19ha); and
- Nambucca River (minor areas).

10.2.9.4 7(a) Environment Protection (Wetlands)

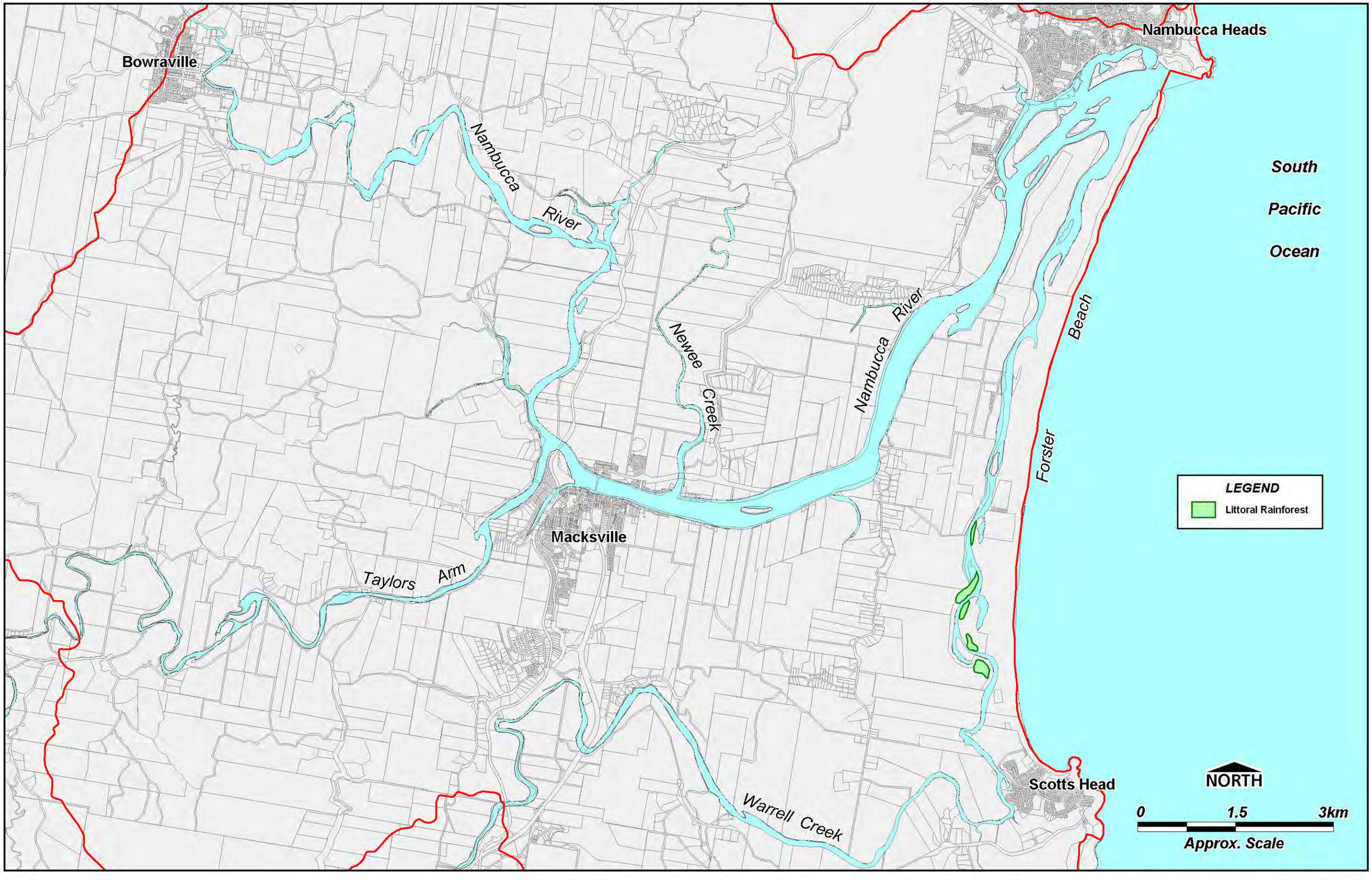
The Nambucca Shire Local Environmental Plan 1995 (LEP 1995) provides for Zone 7(a) Environment Protection (Wetlands).

The objectives of this zone are:

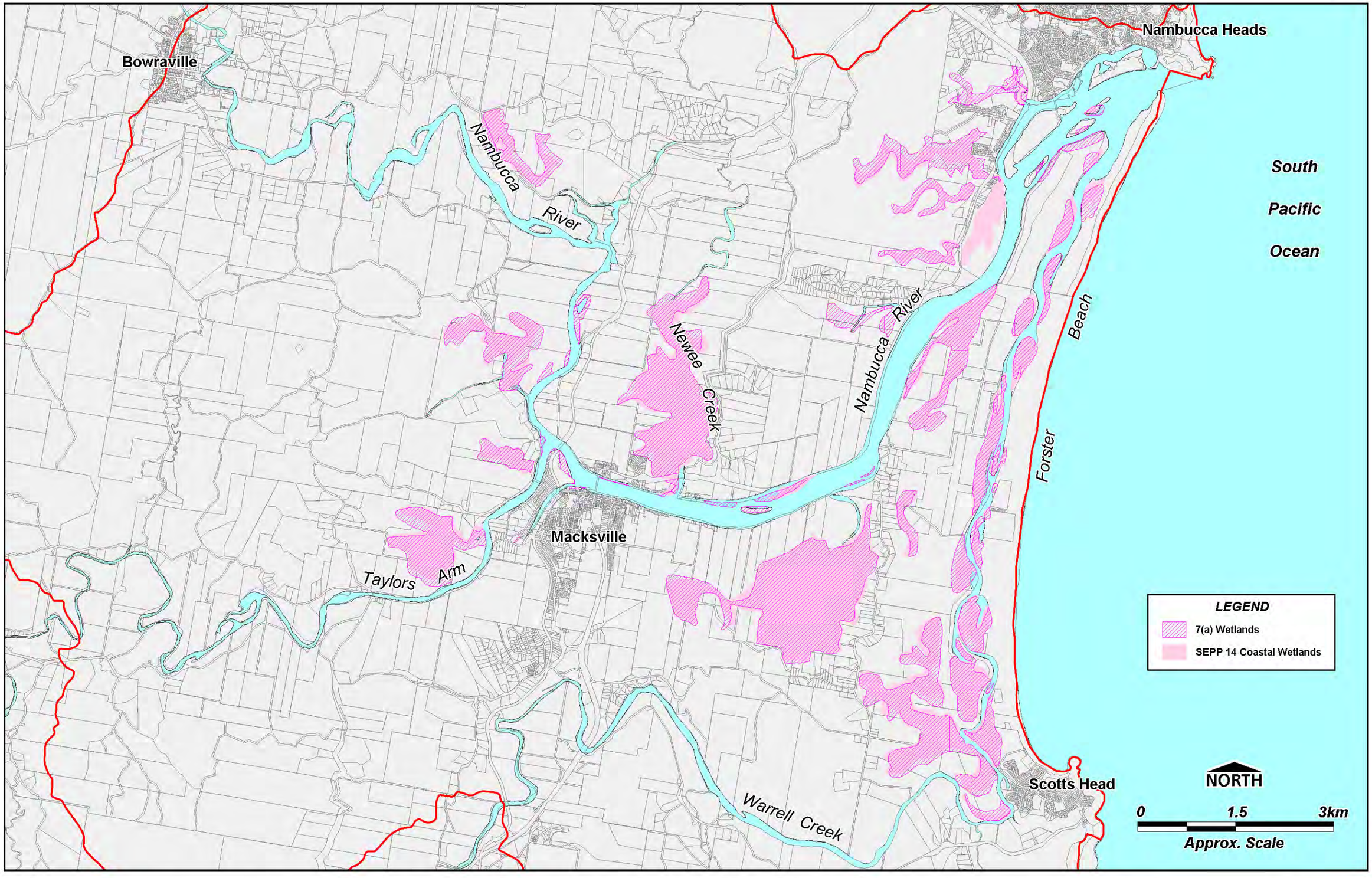
- to protect and conserve estuaries and wetlands to enable them to continue to function as breeding and feeding areas for birdlife, fish and shellfish;
- to ensure the ecological, scenic and other environmental attributes of functioning wetlands are not altered;
- to encourage and promote rehabilitation of previously disturbed wetlands; and
- to contribute to the implementation of State Environmental Planning Policy No 14 – Coastal Wetlands.

The Environment Protection (Wetlands) zone contains all wetlands within the area of Nambucca identified in State Environmental Planning Policy No 14 - Coastal Wetlands and by NSW Fisheries. Figure 10-9 maps the distribution of 7a Coastal Wetlands within the Nambucca Estuary. The major occurrences of 7a Coastal Wetlands include all SEPP 14 Wetlands and minor areas of marine vegetation located on Taylor's Arm and the Nambucca River.

Within these zones development consent is required for the purpose of agriculture (other than animal establishments and intensive livestock keeping establishments); aquaculture; bed and breakfast establishments; building of levees; bushfire hazard reduction; camping grounds without buildings; clearing of native vegetation; drainage; dwelling-houses; environmental facilities; extractive industries; filling; home activities; recreation areas; roads and utility installations. Development outside these purposes is prohibited.



SEPP 26 Littoral Rainforest Distribution In The Nambucca River Estuary (Source : DIPNR) Figure 10-9



SEPP 14 and 7a Coastal Wetland Distribution In The Nambucca River Estuary (Source : DIPNR-2005 and Nambucca Council) Figure 10-10

10.2.9.5 7(b) Environment Protection (Vegetation Conservation)

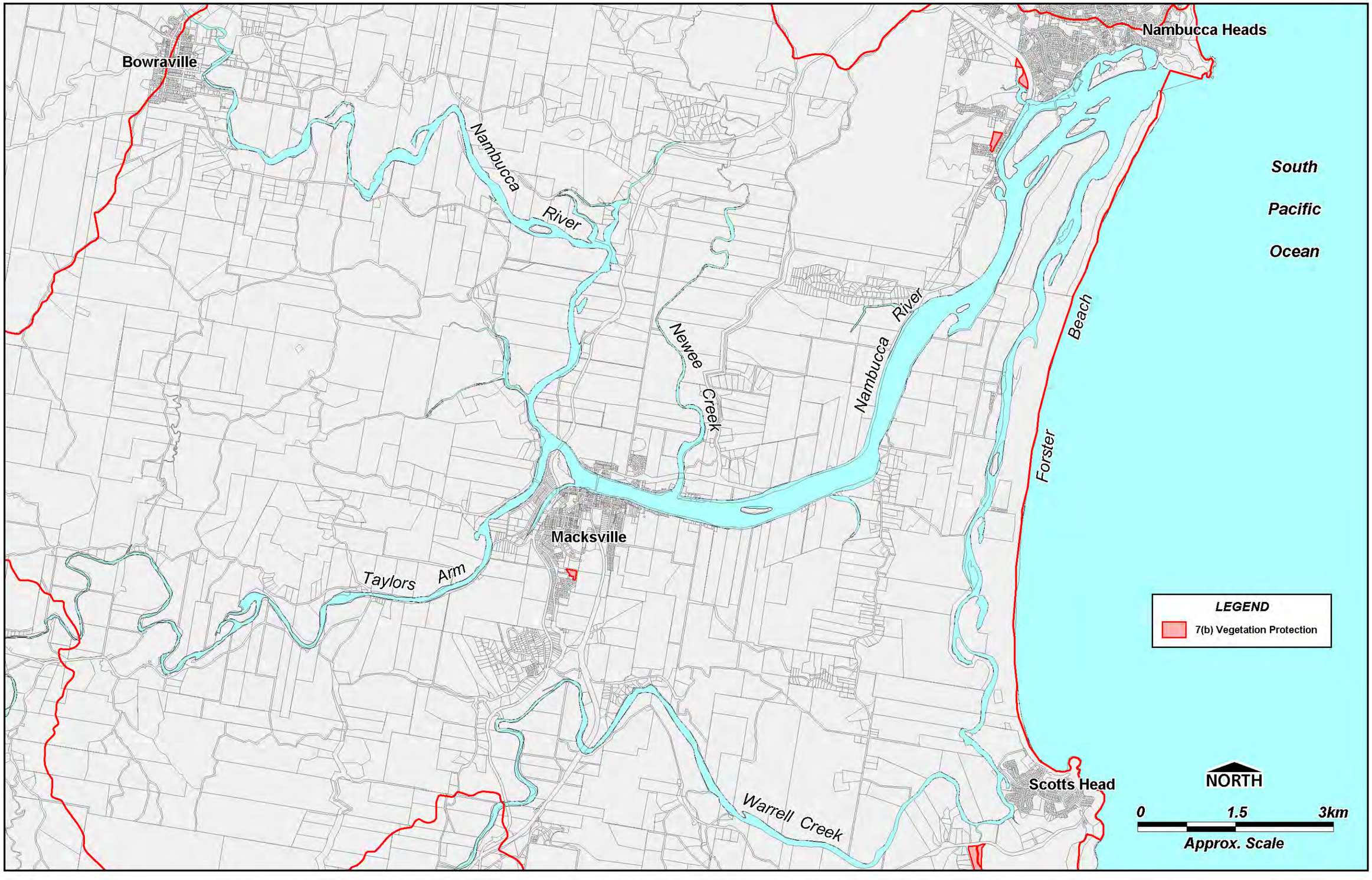
The Nambucca Shire Local Environmental Plan 1995 (LEP 1995) provides for Zone 7(b) Environment Protection (Vegetation Conservation).

The objectives of this zone are:

- to promote the preservation, conservation and enhancement of significant indigenous fauna and flora and landscape features in the area of Nambucca;
- to prohibit development within this zone which is likely to have a detrimental effect on the habitat, landscape and/or scenic quality of the locality; and
- to enable the development of public works and ancillary recreation amenities where such development does not have significant detrimental effect on the habitat, landscape or scenic quality of the locality.

This zone identifies natural scenic and bushland areas of the Nambucca area not suitable for urban development. Such areas need to be protected and preserved for their value to the community as part of the natural heritage, their aesthetic value and value as a recreational, educational and scientific resource. Figure 10-11 maps the distribution of 7(b) Environment Protection (Vegetation Conservation) within the Nambucca Estuary. Four isolated vegetation patches, approximately 11ha in area, have been zoned 7(b) within the catchment.

Within these zones development for the purpose of bushfire hazard reduction does not require development consent. Development consent is required for the purpose of agriculture (other than animal establishments and intensive livestock keeping establishments); bed and breakfast establishments; clearing of native vegetation; community buildings; dwelling-houses; drainage; environmental facilities; home activities; recreation areas; roads; utility installations. All other development within these zones is prohibited.



7(b) Environment Protection (Vegetation Conservation) within the Nambucca River Estuary (Source : Nambucca Shire) Figure 10-11

10.2.9.6 Ramsar

This section describes the criteria for designating Ramsar sites and potential opportunities for Ramsar wetland declarations within the *study area.* There are currently 11 wetlands in New South Wales listed under the Ramsar Convention. To be listed as a Ramsar site, the site must meet one or more internationally accepted criteria.

The Criteria for Identifying Wetlands of International Importance as adopted by the 4th, 6th, and 7th Meetings of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971) to guide designation of Ramsar sites can be summarised as follows;

Group A of the Criteria. Sites containing representative, rare or unique wetland types

- Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Group B of the Criteria. Sites of international importance for conserving biological diversity

Criteria based on species and ecological communities;

- Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
- Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Specific criteria based on waterbirds;

- Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
- Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Specific criteria based on fish;

- Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
- Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

100 Acre Swamp

100 Acre Swamp (see Figure 10-12) is a shallow estuarine wetland, in the order of 80ha in area, located immediately west of Macksville on the Taylor's Arm. The majority of this swamp is currently listed under SEPP14. The site has been assessed against Ramsar nomination criteria 1 (Blanch, 2003) and 4 and 8 (Wetland Care Australia, 2005) to assess its potential nomination for listing as a Wetland of International Importance under the Ramsar Convention.

The swamp has undergone a series of modifications including the installation of floodgates in the early 1900's, drainage, decommissioning of floodgates, excavation and levee bank construction, grazing, clearing and upper catchment water extraction and clearing. Natural flow patterns have occurred over the last 35 years and it could be expected that the wetland could undergo succession back towards a more freshwater system (Wetland Care Australia, 2005).

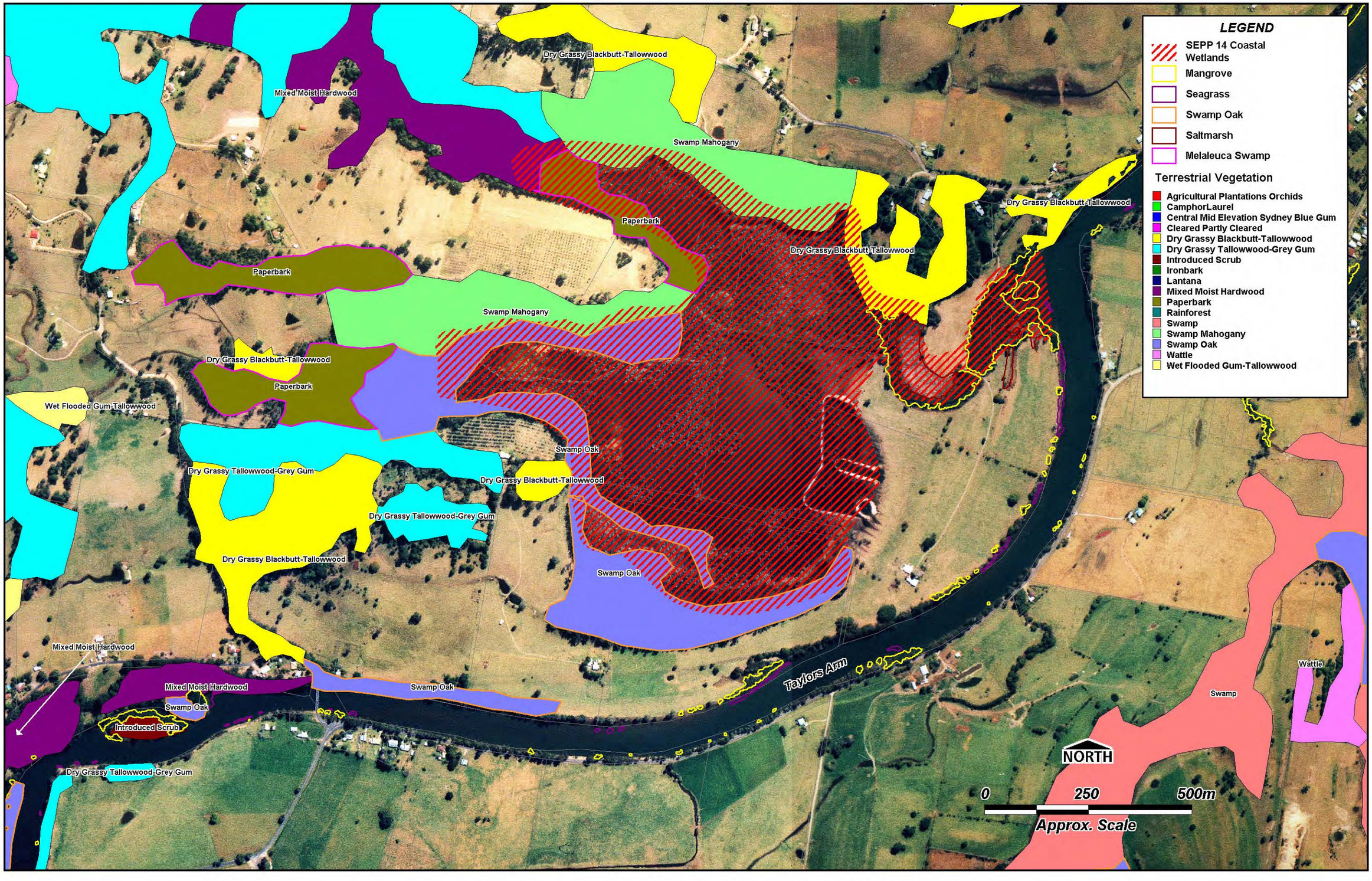
Drainage channels were dug through much of the wetland and the spoil heaps have been colonised by *Juncus* spp. with a canopy of *Casuarina glauca* and *Avicennia marina. Aegiceras corniculatum* also occurs. Patches of *Melaleuca quinquenervia* wetland occur on the western and northern floodplains subject to freshwater inflow and saltmarsh dominated by *Juncus* spp., *Sporobolus virginicus* and *Sarcocornia quinqueflora* occurs on land subject to periodic saline flooding. The wetland is bounded by dry sclerophyll forest with rainforest elements in the gullies.

The water depth across the swamp averages 0.5-1m. Low pH and high organic loading and anoxic bottom sediments potentially limit the diversity of aquatic biota (Wetland Care Australia, 2005). A dense macrophytic cover of *Ruppia* sp. and charophytes has been recorded in these shallows. The presence of charophytes is often an indicator of good water quality (Sainty and Jacobs, 2003). Waterbirds, such as swans, feed on charophyte stems and rhizoids and beds of charophytes have been known to support vast populations of waterbirds (Sainty and Jacobs, 2003). One Hundred Acre Swamp is considered one of the most significant waterfowl habitats in the Nambucca catchment (Blanch, 2003). The wetland supports a range of waterbirds, including migratory species and at leaset one State threatened species. The site is also an important breeding habitat for Black Swans.

Blanch (2003) concluded that the site meets Criteria 1 as it is a representative wetland of those found wihin the Nambucca catchment and the broader NSW North Coast Bioregion. Blanch (2003) also concluded that further investigations would be required to determine if the site satisfied Criteria 3, 4 and 8 of the Ramsar Convention.

Wetland Australia (2005) considered that the site meets Criteria 8 and 4, whereby:

- 100 Acre Swamp's importance as a fish nursery was demonstrated by the predominance of juvenile and sub adult of the economically important Sea Mullet *Mugil cephalus* and evidence of its use as a nursery by school Prawn *Metapenaeus macleayi.* The site was also considered to function as a spawning ground for Empire Gudgeon *Hypseleotris compressa* and forms part of the species life cycle migration path.
- Sheltered habitats provided by refugia and nursery areas such as 100 Acre Swamp are essential to the overall viability of these species.



100 Acre Swamp (Source : Kendall, 2003 and NSW Fisheries, 2004) Figure 10-12

In addition, it was noted that the sites' contribution to regional habitat connectivity, and the potential presence of the threatened communities within the catchment, including, swamp sclerophyll forest on coastal floodplains, swamp oak floodplain forest and coastal saltmarsh, would also support Criteria 3 of the Ramsar Convention (Wetland Australia, 2005).

Blanch (2003) recommended that consideration be given to identifying a suite of candidate NSW North Coast Bioregion wetlands as part of a nested site nomination for the bioregion. In the case of the lower Nambucca River basin, Wetland Care Australia (2005), nominate the wetland complexes of Bellwood Swamp and the Warrell Creek estuary and catchment be considered as part of this network.

10.2.10 Threatened Flora Species

A number of threatened plant species occur or potentially occur in the Nambucca Catchment (see Table 10-6). Most of these are threatened by: competition with weeds, notably *Cinnamomum camphora* and *Lantana camara* in terrestrial and riparian habitats, *Chrysanthemoides monilifera* on dune habitats and *Baccharis halimifolia* in wetland habitats; clearing; erosion of habitat; and inappropriate fire regimes.

Table 10-6 Threatened Flora Species Known or Potentially Occurring in the Nambucca River Catchment (Based on Kendall, 2003 and NSW NPWS)

Species	*TSC Act* Status	*EPBC Act* Status	Recorded In Catchment	Preferred Habitat
Acacia chrysotrichum	E		x	Rainforest and wet sclerophyll in steep narrow gullies.
Acronychia littoralis	E	E	x	Littoral rainforest, wet sclerophyll forest and dry sclerophyll forest.
Aldrovanda vesiculosa	E			Freshwater wetlands on coastal floodplains
Alexfloydia repens	E			Swamp Oak Floodplain Forest on saline soils
Amorphospermum whitei	V		x	Gully and littoral rainforest below 600m.
Anetholea anisata	V		x	Gully rainforest
Arthraxon hispidus	V	V		Littoral rainforest, dry rainforest, subtropical rainforest, warm-temperate rainforest, cool-temperate rainforest, wet sclerophyll forest, riparian forests (including gallery rainforests), at no particular altitude. (www.nor.com.au, February 2005).
Callistemon pungens		V		In or near rocky watercourses, usually in sandy beds on granite or basalt.
Chamaesyce psammogeton	E		x	Foredunes and exposed sites on headlands. (www.nationalparks.nsw.gov.au, February 2005)
Cryptostylis hunteriana	V	V		Swamp heath.
Cynanchum elegans	E	E		Dry rainforest and its ecotone, sclerophyll forest and woodland communities.
Diuris venosa	V	V		Not described
Glycine clandestina (broad leaved form)	E		x	Coastal grasslands around Scott's Head.
Hicksbeachia pinnatifolia	V	V		Subtropical rainforest on basalt derived soils.
Hydrocharis dubia		V		Freshwater bodies and swamps.
Lindsaea incisa	E			Damp sandy areas in open forest.
Marsdenia longiloba	E	V	x	Lowland wet sclerophyll forest especially rainforest ecotones.
Melaleuca groveana	V		x	Heath and woodland in exposed locations.

Species	*TSC Act* Status	*EPBC Act* Status	Recorded In Catchment	Preferred Habitat
Neoastelia spectabilis	V	V		Rock crevices near waterfalls, rocky seepage areas.
Parsonsia dorrigoensis	V	E	x	Sub tropical and warm temperate rainforest and their ecotones and wet sclerophyll forest.
Phaius australis	E	E		Wetlands.
Phaius tancarvilleae	E	E		Wetlands.
Quassia sp. Mooney Creek	E	E		Rainforest and west sclerophyll in gullies.
Sarcochilus fitzgeraldii	V	V		Rocks and cliff faces and tree bases in deep rainforest ravines usually near streams.
Sarcochilus hartmannii	V	V		Rock cliffs and boulders in shallow soil in sclerophyll forest often in exposed locations.
Tasmannia glaucifolia	V	V		Not described.
Thesium australe	V	V		Grassland and woodland.
Tylophora woollsii	E	E		Rainforest and wet sclerophyll forest.
Zieria lasiocaulis	E	E		Rocky escarpments and rainforest.

E = Endangered: V = Vulnerable: X = Present.

10.2.11 Fauna

10.2.11.1 Zooplankton and Benthic Macroinvertebrates

Polychaetes, molluscs and crustaceans are the predominant groups of benthic macroinvertebrates located in surveys of the estuary. This is consistent with benthic communities of other New South Wales estuaries. While overall density appears to be low (possibly as a result of seasonal influences) the biological integrity of the benthic communities within the estuary is sound and indications are that estuarine ecological processes are functioning properly. There have been no studies of the species, abundance or distribution of zooplankton in the estuary.

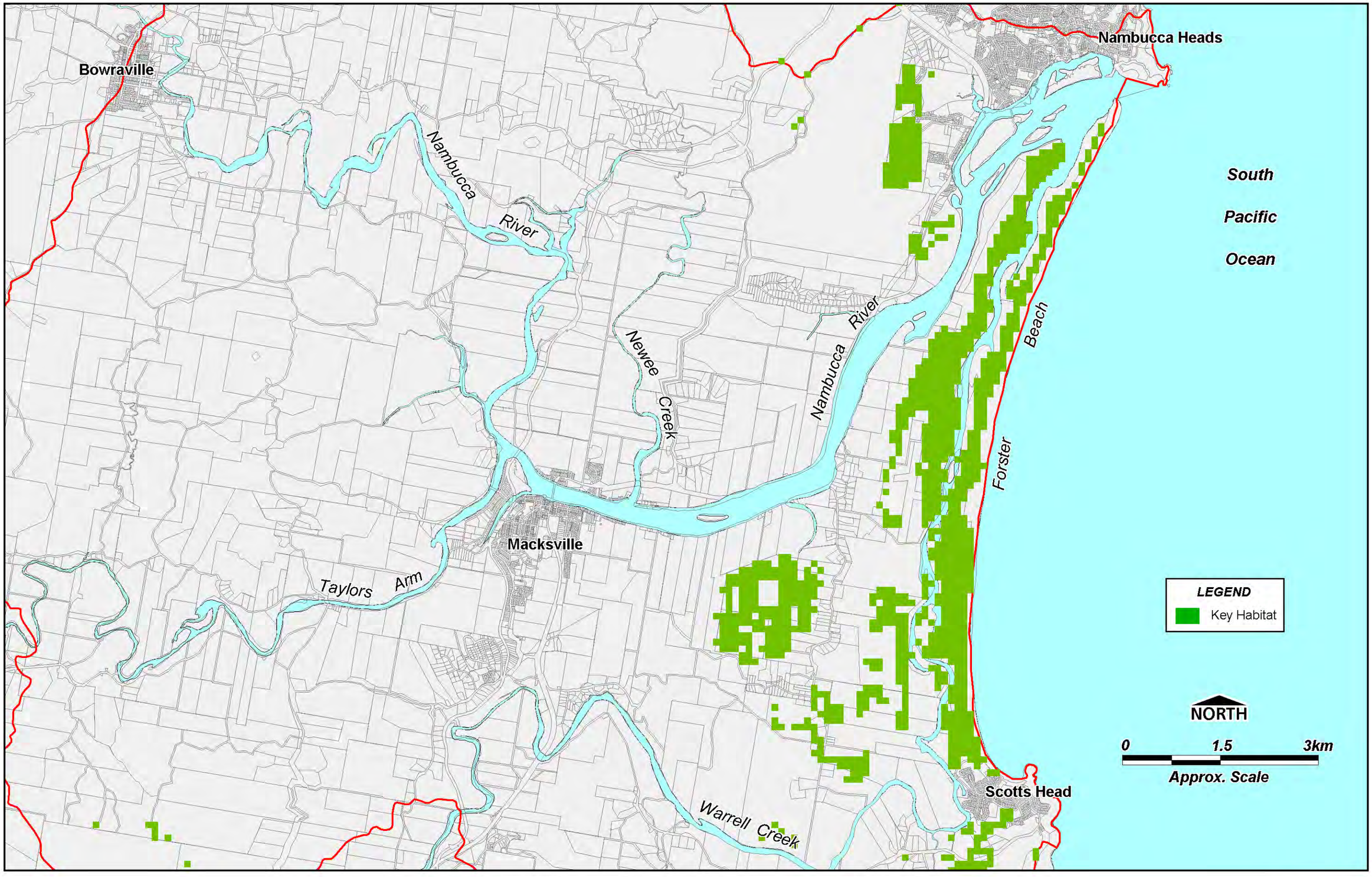
10.2.11.2 Fish

Gibbs *et al* (1999) recorded a total of 56 fish species from 27 families in Warrell Creek. This is unlikely to be an exhaustive species list for the entire estuary. Of the species recorded, approximately 22 are of direct economic value. Consistent with other estuaries in NSW (eg. Milledge 1980, West and Miller 1998), the most specious family was Gobiidae (9 species). Seagrass beds in the region have been shown to support a greater diversity and abundance of fish than unvegetated areas, highlighting the need for seagrass to be appropriately managed and protected.

The Nambucca estuary lies between the biogeographical zones of the Eastern Tropical Zone and the Eastern Warm Temperate Zone. Many of the species recorded in the estuary are at the limits of their southern (eg mangrove jack, moses, perch lion fish, lontom) or northern (e.g. salmon, southern herring) distribution limit.

10.2.11.3 Terrestrial Fauna

The Department of Environment and Conservation (DEC) has mapped at a regional scale Key Habitats in northern NSW (refer to Figure 10-13). The DEC has mapped the Gumma Wetlands and Warrell Creek system as key habitats within the State. Based on a review of regional fauna data records, the terrestrial fauna habitat features of the study area are described below.



Key Habitats In The Nambucca River Estuary (Source : NSW DEC, 2005)

Figure 10-13

Estuarine Wetlands

The Nambucca River estuary is characterised by a mosaic of intertidal habitats including salt marsh, sand berms, intertidal banks, mangroves, and sandy beaches. The estuarine wetlands of the Nambucca River catchment provide habitat for a large number of migratory waders including threatened species. Waders are a group of wetland birds that forage for a variety of invertebrate and plant food on wet, tidal and/or non-tidal, mud and sand flats. In tidally influenced areas, waders forage across the exposed sand and mudflats at low tide (both day and night). At high tide, they move to higher ground to roost on beaches, salt marshes, claypans and artificial ponds.

Floodplain and Lowland Habitats

The wetlands of the Nambucca River catchment are likely to provide habitat for a wide range of wetland dependant species including the Giant Barred Frog, Green Thighed Frog, Eastern Freshwater Cod, Oxylean Pygmy Perch and Jabiru. Other species of conservation significance which may occur in the wetlands of the study area include, Painted Snipe, Brolga, Magpie Goose, Australasian Bittern, Magpie Goose, Bush Hen, Comb Crested Jacana, Black Bittern and Osprey.

Rainforest Habitat

The rainforests reserved in the catchment may provide habitat for a limited diversity of threatened species including the Spotted Tail Quoll, Wompoo Fruit Dove, White Eared Monarch, Stephens Banded Snake, Sooty Owl, Marbled Frogmouth, White-eared Monarch, Albert's Lyrebird, Pouched Frog and Giant Barred Frog.

Mixed Sclerophyll Habitat

This forms the largest area of contiguous habitat within the catchment. These communities are likely to support a high diversity of threatened species including Bush Stone Curlew, Swift Parrot, Regent Honeyeater, Squirrel Glider, Powerful Owl, Spotted Tailed Quoll, Koala and Yellow Bellied Sheathtail Bat.

Riparian Vegetation and Wildlife Corridors

The riparian vegetation of the Nambucca River catchment may support a high diversity of threatened species including Square Tailed Kite, Large Footed Myotis, The Golden Tipped Bat and Koalas.

In general, wildlife corridors have varying degrees of 'value' and 'significance'. Specifically, 'value' pertains to the intrinsic quality of the corridor (i.e. a combination of the size, health, ratio of edge to core habitat, etc.), where the 'significance' relates to the corridor's relationship to other vegetation remnants (i.e. does it join core habitats). As such, a long narrow strip of native vegetation that is unconnected at either end and is surrounded by modified agricultural or pastoral lands may have a high intrinsic biodiversity value but a relatively low significance. This is in comparison to a smaller strip in poorer condition but which provides the only linkage between two areas of remnant vegetation and hence would have a low intrinsic biodiversity value but high connectivity significance.

Terrestrial wildlife corridors, to be of high significance, must provide a link between relatively large patches of remnant vegetation and should accommodate a variety of species. For example, a narrow,

densely vegetated corridor that runs along a creek will not be suitable for most macropods. However, if a wider area was provided on either side of the creek it would produce a higher quality corridor, suitable to a variety of species.

The DEC has mapped at a regional scale Corridors in northern NSW to provide a framework of key linking habitat corridors. The DEC recognize that regional corridors are connections between larger important areas of habitat, are generally > 500m in width and provide for dispersal of individual species and habitat for a range of species. Regional corridors typically connect along major ecological gradients such as altitudinal and/or latitudinal migratory pathways (e.g. coast to hinterland).

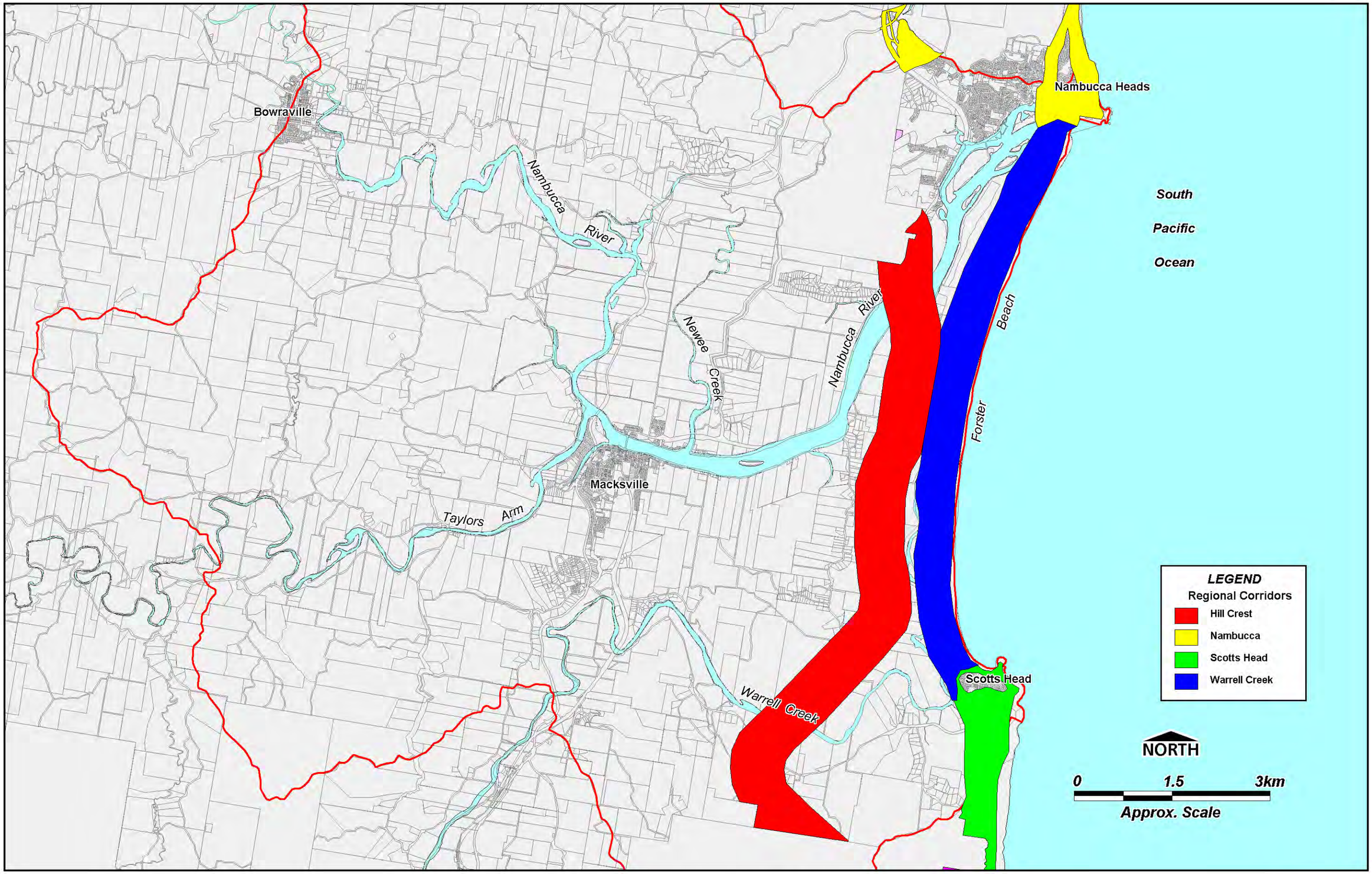
The DEC has identified regional ecological corridors in the study area, which may provide north to south linkages, particularly for key or indicator species. Refer to Figure 10-14. A regional link occurs along the coast through Warrell Creek. This is recognised as part of a coastal corridor habitat for Squirrel Gliders. In addition, a regional corridor has been mapped to the east of this through Gumma Gumma Wetlands and linking State Forest remnants to the north and south of the Nambucca River. This linkage is considered to support the threatened Eastern Chestnut Mouse.

On a local scale, riparian linkages are recognised as important for rainforest dependant fauna and as movement corridors for small mammals and avifauna through grasslands, cultivation and pasture. Within the lowlands, flood mitigation measures have effected connectivity to the Nambucca River. Floodgates have been placed in a number of areas (e.g. Gumma Creek, Watt Creek, Congarinni etc.), and are likely to effect the connectivity between estuaries and the floodplain habitats (particularly wetlands), impacting on aquatic fauna movements and hydraulic processes. There are currently poor corridor connections between the Nambucca River and wetlands south and east of Macksville.

10.2.11.4 Threatened fauna

The Nambucca River is one of the most significant and productive areas for shorebirds on the NSW coast (cited in Marshall, 2001). Twenty four waterbird species recorded by Clarke and Pressey (in GHD, 1981) have been recorded on the mud flats and sandbanks of the *study area*. The Nambucca Estuary Data Compilation Study (Allen, 1997) highlighted the presence of 3 pairs of Osprey recorded in 1981. The NSW National Parks and Wildlife Service and Marshall (2001) have also recorded the following threatened waterbird species in the *study area*:

- Little Tern (*Sterna albifrons*);
- Beach Stone-curlew (*Esacus neglectis*).
- Sooty Oystercatcher (*Haemotapus longirostris*)
- Osprey (*Pandion haliaetus*)
- Black tailed Godwit (*Limosa limosa*)
- Pied Oystercatcher (*Haematopus longirostris*); and
- Terek Sandpiper (*Xenus cinereus*).



Wildlife Corridors In The Nambucca River Estuary (Source : NSW DEC, 2005)

Figure 10-14

The sandbars at the mouth of the Nambucca River and Warrell Creek have been used as nesting sites by Little Terns for at least 40 years, making the area the most important nesting site in the Dorrigo District. Numbers have varied between 3 and 22 pairs however the breeding success rate of the colony is low (NSW NPWS). Recent records show depletion in the breeding success of the Little Tern and Beach stone curlew in the *study area* due to competition for nesting, roosting and foraging areas with humans (Marshall, 2001). Marshall (2001) has identified the following threats and management priorities and actions for shorebirds within the lower Nambucca Estuary.

Little Tern

Threats:

- Nesting at flood prone locations;
- Predation of eggs by foxes, gulls, ravens and whimbrels;
- Human disturbance by coastal recreational activities;
- Four-wheel drive vehicles, trail bikes and pedestrian disturbance to eggs and chicks; and
- Susceptibility to pollution notably pesticides and oil spills.

The major threat for the species is that too few young are raised to flying stage.

Management Actions:

A Draft Recovery Plan for the species has been developed by NSW NPWS. The following strategies are being carried out within the *study area:*

- Protection zones around habitat;
- Erection of fences and interpretive signs to minimise disturbance;
- Displacing birds from flood-prone sites by flagging beaches with bunting or raising nests on sandbags;
- Introduced animal control; and
- Education and monitoring.

Beach Stone-curlew

Threats:

- Breeds in habitats sunbject to significant human and natural disturbance;
- Predation dogs, foxes and cats;
- Human disturbance by coastal recreational activities;
- Roost deterioration via erosion from boat wash and mangrove encroachment;
- Pollution effects on benthic food resources;
- Human disturbance.

The major threat for the species is that too few young are raised to flying stage.

Management Actions:

The following strategies have been recommended*:*

- Monitor and survey breeding sites;
- Fox and cat control (baiting / fencing) at breeding sites;
- Signs and fencing to exclude human disturbance (pedestrians and vehicles);
- Protection and relocation of eggs:
- Development of Habitat Protection Plan under *Fisheries Management Act 1994.*

Pied Oystercatchers

Threats:

- Disturbance and reduction in breeding sites;
- Predation by cats and foxes;
- Human disturbance.

Management Actions:

The following strategies have been recommended*:*

- Annual fox control program
- Monitor and survey breeding;
- Community education program:

Osprey

Threats:

- Loss of habitat (net trees)
- Disturbance and reduction in breeding sites;
- Reduction in food resources.

Management Actions:

The following strategies have been recommended*:*

- Environmental protection zones around roosting trees, to be implement through LEP;
- Tree preservation orders over living or large trees withn 1km of coastal waters;
- Annual monitoring;
- Community education program.

In addition to the species noted above, Table 10-7 lists other threatened fauna species that have been recorded in or near Warrell Creek (Nambucca Valley Landcare, 2000) and which are known or potentially occur throughout the Nambucca River catchment.

Table 10-7 Threatened Fauna Species Known or Potentially Occurring in the Nambucca River Catchment (Based on Nambucca Valley Landcare, 2000)

Species	Common Name	Status under *TSC Act 1995*	Status under *EPBC Act 1999*	Recorded sightings in the *Study Area*	Recorded Habitat
Amphibians					
Litoria aurea	Green and Golden Bell Frog	E	V	11	Inhabits marshes, dams and stream sides, particularly those containing *Typha* spp. or *Eleocharis* spp. Optimum habitat includes water bodies which are unshaded, free of predatory fish (*Gambusia holbrooki)*, have a grassy area nearby and diurnal sheltering sites available such as vegetation (www.nationalparks.nsw.gov.au).
Mixophyes iteratus	Giant Barred Frog	E	E	7	Beside shallow, rocky rainforest streams and adjacent to slow-moving rivers in lowland open forest (www.deh.gov.au)
Philoria sphagnicolus	Sphagnum Frog	V		22	Little is known about the habitat requirements of this species other than its preference for higher altitudinal rainforest streams and bogs, and surrounding foraging habitat in leaf litter (www.nationalparks.nsw.gov.au)
Reptiles					
Caretta carota	Loggerhead Turtle	E	E	2	Inhabit sub tidal and intertidal coral and rocky reefs and seagrass meadows as well as deeper soft-bottomed habitats of the continental shelf (www.gbrmpa.gov.au).
Hoplocephalus stephensii	Stephen's Banded Snake	V		2	Rainforests, moist forests, heaths and vine thickets (www.qmuseum.qld.gov.au)
Birds					
Anseranas semipalmata	Magpie Goose	V		1	Floodplains and wet grasslands.
Atrichornis rufescens	Rufous Scrub-bird	V		9	Temperate Rainforest
Calidris alba	Sanderling	V	M	2	Occur in coastal areas on low beaches of firm sand, near reefs and inlets, along tidal mudflats and bare open coastal lagoons. Prefers open sandy beaches exposed to open sea-swell, exposed sandbars and spits (www.nationalparks.nsw.gov.au).
Calyptorhynchus banksii	Red-tailed Black-Cockatoo	V		6	Open woodland, riparian forests, rainforest and cultivated lands.
Calyptorhynchus lathami	Glossy Black-Cockatoo	V		57	Characteristically inhabits forests on sites with low soil nutrient status, reflecting the distribution of key *Allocasuarina* spp.. The drier forest types with intact and less rugged landscapes are preferred by the species (www.nationalparks.nsw.gov.au).
Coracina lineata	Barred Cuckoo-shrike	V		10	Dry rainforest.
Grus rubicunda	Brolga	V	M	3	Inhabits expansive open wetlands, grassy plains, coastal mudflats, irrigated croplands and less frequently, mangrove lined creeks and estuaries (www.amonline.net.au).
Irediparra gallinacea	Comb-crested Jacana	V		1	Lagoons, billabongs, swamps, lakes, rivers, sewage ponds and dams, providing there is adequate floating vegetation (www.amonline.net.au).
Ixobrychus flavicollis	Black Bittern	V		9	Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, this species may occur in flooded grassland, forest, woodland, rainforest and mangroves (www.nationalparks.nsw.gov.au).
Lophoictinia isura	Square-tailed Kite	V		15	Typically inhabits the coastal forested and wooded lands of tropical and temperate Australia. In NSW, it is often associated with ridge and gully forests dominated by Woollybutt *Eucalyptus longifloria*, Spotted

Species	Common Name	Status under *TSC Act 1995*	Status under *EPBC Act 1999*	Recorded sightings in the *Study Area*	Recorded Habitat
					Gum *E. maculata* or Peppermint Gum *E. elata* and *E. smithii*. The species has also been sighted in forests containing other eucalypts, *Angophora* spp. and *Callitris* spp. with a shrubby understorey and Box-Ironbark woodland (www.nationalparks.nsw.gov.au).
Ninox connivens	Barking Owl	V		1	Nests in tree hollows and occurs primarily in woodlands but also occurs in forests, partially cleared areas and occasionally near or in rural towns and well-treed suburbs (www.nationalparks.nsw.gov.au).
Ninox strenua	Powerful Owl	V		9	Tall open moist forests, drier forest types and occasionally woodland and riparian habitats. Prefers open forest structure for hunting. Roosting sites include dense canopy and understorey trees within closed forest and open forest, often in gullies and canopy trees in woodland (http://www.hotkey.net.au).
Pachycephala olivacea	Olive Whistler	V		1	Cool subtropical forest and rainforest.
Podargus ocellatus	Marbled Frogmouth	V		2	Rainforest
Pterodroma solandri	Providence Petrel	V	M	1	Marine pelagic (http://www.nationalparks.nsw.gov.au).
Ptilinopus magnificus	Wompoo Fruit-Dove	V		26	Rainforest
Ptilinopus regina	Rose-crowned Fruit-Dove	V		2	Rainforest
Ptilinopus superbus	Superb Fruit-Dove	V		1	Rainforest
Tyto novaehollandiae	Masked Owl	V		9	Occupies a home range of 5-10 km^2 within a diverse range of wooded habitats that provide large hollow-bearing trees for roosting and nesting and nearby open areas for foraging. This can include forests, remnants within agricultural land or almost treeless inland plains. Nests and roost sites are usually in hollows of large trees, often in riparian forest (www.deh.gov.au).
Tyto tenebricosa	Sooty Owl	V		17	Prefers rainforests, particularly in areas with south to south-east facing gullies overtopped by eucalypts (http://www.hotkey.net.au).
Xenus cinereus	Terek Sandpiper	V	M	2	Has been recorded on coastal mudflats, lagoons, creeks and estuaries. Records indicate that the species favours muddy beaches near mangroves but may also be observed on rocky pools and coral reefs and occasionally up to 10km inland around brackish pools (www.nationalparks.nsw.gov.au).
Mammals					
Aepyprymnus rufescens	Rufous Bettong	V		2	Coastal eucalypt forests and a variety of other habitats, from tall wet sclerophyll forests to dry open woodlands. It seems to dwell only in areas with sparse or grassy understorey (www. lamington.nrsm.uq.edu.au).
Dasyurus maculatus	Tiger Quoll	V		12	Utilises a variety of habitats including sclerophyll forest and woodlands, coastal heathlands and rainforests. Occasional sightings have been made in open country, grazing lands, rocky outcrops and other treeless areas. Habitat requirements include suitable den sites (such as hollow logs, tree hollows, rock outcrops or caves) and an abundance of food (such as birds and small mammals). Individuals also require large areas of relatively intact vegetation through which to forage (www.nationalparks.nsw.gov.au).
Falsistrellus tasmaniensis	Great Pipistrelle	V		11	Roosts in caves, tree hollows and old buildings. Feeds on insects, possibly collected from foliage and tree stems as well as being caught on the wing (http://www.nor.com.au).
Kerivoula papuensis	Golden-tipped Bat	V		2	Riparian rainforest provides key roosting habitat and sclerophyll forest on upper slopes provide important foraging habitat (www.publish.csiro.au)
Macropus parma	Parma Wallaby	V		8	wet sclerophyll forests with thick scrubby understoreys and grassy patches (http://www.nor.com.au).

Species	Common Name	Status under *TSC Act 1995*	Status under *EPBC Act 1999*	Recorded sightings in the *Study Area*	Recorded Habitat
Miniopterus australis	Little Bent-wing Bat	V		19	Nest in caves and tree hollows and feed on small insects that fly beneath the canopy of thick forests (www.amonline.net.au).
Myotis adversus	Large-footed Mouse-eared Bat	V		2	Always associated with permanent, usually slow-flowing, water bodies. It has been recorded foraging over small creeks, coastal rivers, estuaries, lakes and inland rivers and can utilise farm dams and other smaller water bodies. Records come from a wide range of vegetation communities associated with water (www.dlwc.nsw.gov.au).
Nyctophilus bifax	Eastern long-eared Bat	V		1	
Petaurus australis	Yellow-bellied Glider	V		37	Preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows and year round food resources are available from a mixture of eucalypt species. In north-east NSW, favoured habitat is predicted to occur in the cold to warm mixed sclerophyll forests of the coastal plains and mid to high elevation moist and dry escarpment forests. Critical elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types (www.nationalparks.nsw.gov.au).
Petaurus norfolcensis	Squirrel Glider	V		3	Inhabits dry sclerophyll forest and woodland and is generally absent from rainforest and closed forest. In NSW, potential habitat includes Box-Ironbark forests and woodlands in the west. Requires abundant hollow-bearing trees and a mix of eucalypts, acacias and banksias. Within a suitable vegetation community at least one flora species should flower heavily in winter and one or more of the eucalypts should be smooth-barked (www.nationalparks.nsw.gov.au).
Phascogale tapoatafa	Brush-tailed Phascogale	V		4	Preferred habitat is dry sclerophyll open forest with a sparse ground cover of herbs, grasses, scleromorphic shrubs or leaf litter. Individuals may also inhabit heathland, swamps, rainforest and wet sclerophyll forest (www.nationalparks.nsw.gov.au).
Phascolarctos cinereus	Koala	V		107	Species also protected under State Environmental Planning Policy 44 (SEPP44). Inhabits eucalypt forest and woodland. Throughout NSW, Koalas have been observed to feed on approximately 70 species of eucalypt and 30 non-eucalypt species. Some preferred species in NSW coastal areas include tallowwood (E. microcorys) and Swamp Mahogany (E. robusta) (www.nationalparks.nsw.gov.au).
Physeter macrocephalus	Sperm Whale		M	1	Marine waters.
Potorous tridactylus	Long-nosed Potoroo	V		2	Inhabit coastal heath and dry and wet sclerophyll forests and shrublands. Requires relatively thick ground cover growing on friable soils where they dig small holes in search of roots, tubers, fungi and soft-bodied soil-dwelling animals (www.nationalparks.nsw.gov.au).
Scoteanax rueppellii	Greater Broad-nosed Bat	V		2	Woodlands and rainforest, though it does not occur at altitudes above 500 metres.
Syconycteris australis	Queensland Blossom Bat	V		1	
Thylogale stigmatica	Red-legged Pademelon	V		2	Preferred habitat is rainforest. Also feeds on forest edges.

10.3 Summary of Habitat Values and Key Threats

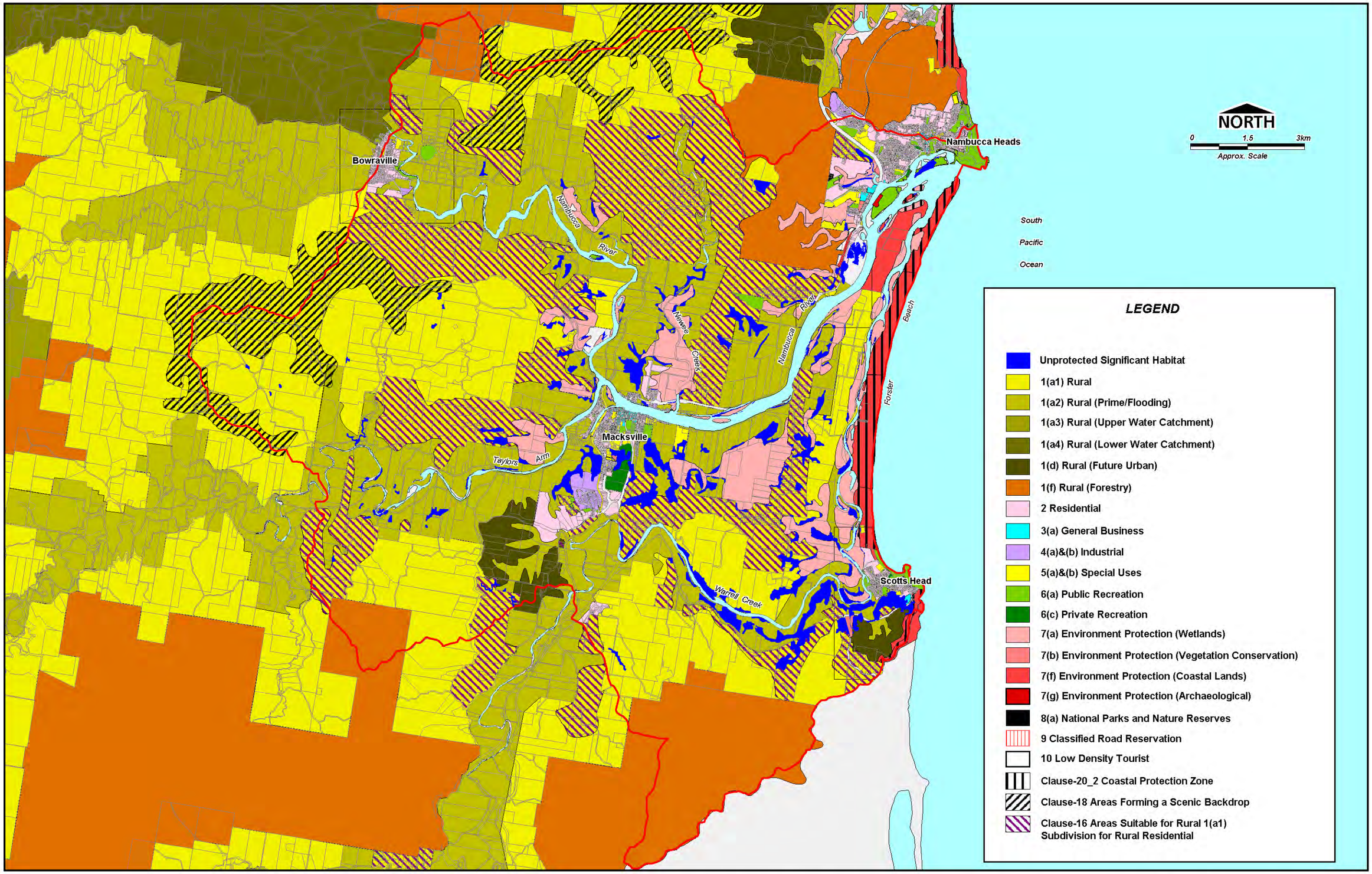
The habitats of high ecological and estuarine value in the Nambucca River estuary include species or communities listed under the *Threatened Species Conservation Act* 1995, *Environment Protection and Biodiversity Conservation Act 1999*, *Fisheries Management Act 1994*, and/or State Environmental Planning Policies. These include:

- Coastal Saltmarsh;
- Swamp Oak Floodplain Forest;
- Swamp Sclerophyll Forest On Coastal Floodplains;
- Freshwater Wetlands On Coastal Floodplains;
- Littoral Rainforest;
- Lowland Rainforest on Floodplains;
- SEPP 26 Littoral Rainforest;
- SEPP 14 Wetlands; and
- Habitat for threatened species.

Table 10-8 and Figure 10-15 summarise the current extent of habitats of high ecological value based on available mapping against current Council LEP protection zoning. Significant areas of swamp oak forest and freshwater wetland along Warrell Creek and extensive areas of freshwater swamp in the Macksville area remain unprotected. There is a need for the improved recognition and protection of these habitats within Council's planning framework, including the Local Environment Plan and Development Control Plans.

Table 10-8 Unprotected Significant Habitat in the Nambucca River Estuary

Community	Total area in Nambucca Catchment (ha)	% Protected in study area by LEP zones 7(a), 7(b) or 8(a)	Management Recommendation	Mgt. Priority
Coastal Saltmarsh	128	75	All areas of unprotected Coastal Saltmarsh be re-zoned under LEP 7(a) or 7(b)	High
Swamp Oak Floodplain Forest	797	52	All areas of unprotected Swamp Oak Floodplain Forest be re-zoned under LEP 7(a) or 7(b)	High
Swamp Sclerophyll Forest On Coastal Floodplains	642	52	All areas of unprotected Swamp Sclerophyll Forest On Coastal Floodplains be re-zoned under LEP 7(a) or 7(b)	High
Littoral Rainforest (SEPP 26)	15	39	All areas of unprotected Littoral Rainforest (SEPP 26) be re-zoned under LEP 7(a) or 7(b)	High
Freshwater Wetlands On Coastal Floodplains	264	33	All areas of unprotected Freshwater Wetlands On Coastal Floodplains be re-zoned under LEP 7(a) or 7(b)	High
Lowland Rainforest on Floodplains	29	0	All areas of unprotected Lowland Rainforest on Floodplains be re-zoned under LEP 7(a) or 7(b)	High



Unprotected Significant Habitat in the Nambucca River Estuary **Figure 10-15**

The sclerophyll woodlands and forests and communities on coastal sands of the study area also provide potentially suitable habitat for a diverse range of flora and fauna species of conservation significance and are important for maintaining biodiversity values within the study area. These communities have regional significance for fauna as native wildlife refugia and form part of the wildlife corridor network across the study area linking upland and lowland vegetation communities.

Regrowth communities across the study area may provide important buffers to significant habitat and may also contribute to the wildlife networks across the study area.

A wide range of activities threatens the integrity and viability of existing habitats in the catchment, including:

- Clearing and habitat fragmentation;
- Weed invasion;
- Drainage and exposure of acid sulphate soils. Of most concern are the impacts of flood mitigation measures on floodplain wetlands.
- Soil disturbance (stock impacts/erosion/pathogen introduction);
- Poor water quality; and
- Inappropriate fire regimes.

11 FISHERIES AND OYSTER AQUACULTURE

The information included in this section has been divided in Fisheries Management and Oyster Aquaculture. The sections include a review of available information, issues of concern to these industries and management objectives/options to address the identified issues.

11.1 Fisheries management

This section aims to provide an overview of the current management arrangements relating to the Nambucca River estuary's usage for commercial and recreational purposes. A discussion is provided in relation to the following aspects of the estuary:

- Recreational fishing havens and how they were established;
- Attributes of the estuary critical to breeding and development cycle of fishes;
- Commercial estuary fishing in the Nambucca River Estuary; and
- Recreational fishing in the Nambucca River Estuary.

11.1.1 Recreational fishing havens

From 1 May 2002, some 30 estuaries and coastal lakes, i.e. 27 per cent of estuarine waters of NSW were declared recreational fishing havens and are now substantially free of commercial fishing.

The purpose of recreational fishing havens was to improve recreational fishing by changing commercial fishing practices in areas popular with large groups of anglers. Commercial fishing methods could be changed or removed or completely stopped in an area under this scheme. Recreational fishing areas may be over small or large portions of estuaries.

Commercial fishers, whose entitlements were acquired as part of this process, were offered compensation. This compensation came from the Recreational Fishing Saltwater Trust, which is funded by the general recreational fishing fee.

A transparent selection process was developed to ensure the communities social, economic and ecological issues are considered. The five principles developed to guide the community selection of recreational fishing areas were:

1. The process will be conducted in an open and transparent manner and with full public and stakeholder consultation;
2. Recreational fishing areas are only to be created where there are benefits to recreational fishing;
3. The social, economic and ecological issues of the communities affected will be considered before decisions are made;
4. The selection of areas should maximise the opportunities to share the resource amongst recreational fishers; and
5. Where commercial fishing effort is removed, commercial fishers will be fairly compensated for acquired entitlements.

An issues paper was prepared in 2001 for the Region 3 estuaries, which extends from Woolgoolga to Port Macquarie and includes the Nambucca River Estuary. This paper provided 4 major proposals for consideration as listed below:

1. Close the Hastings River to commercial fishing to improve the quality of recreational fishing;
2. Close the Bellinger River, Nambucca River and Deep Creek to commercial fishing to improve the quality of recreational fishing;
3. Close the Macleay River to commercial fishing to improve the quality of recreational fishing; and
4. Continue existing commercial fishing in Region 3 with no recreational fishing areas created.

The issues paper also provided an overview of the expected local/regional social, economic and fisheries impact of each of the proposals. The summary paper did not provide a recommendation on which proposal (or combination of proposals) should be adopted, but encouraged local communities to develop their own proposals for consideration. These four proposals were presented to the local community in a public meeting on 12 September 2001 in Nambucca Heads.

An independent consultation report was then prepared that summarised the outcomes of the community meetings and the submissions received in Region 3. The report was then reviewed by a number of groups including the Fisheries Resource Conservation and Assessment Council (FRCAC) to ensure that all stakeholder views were appropriately reflected prior to presentation of a preferred proposal for the Region to the Minister for Fisheries for a determination.

The outcome of the process was that the Nambucca River estuary was kept open to commercial fishing, while the following estuaries were declared recreational fishing havens and completely closed to commercial fishing:

- Bellinger River (including Kalang River);
- Deep Creek; and
- Hastings River.

It is understood that one of the major reasons why the Nambucca River estuary was kept open to commercial fishing was that a local petition was established to keep it open. Some 1500 signatures were received on the petition (C. Davis, Pers Comm., 2004).

Other estuaries in which commercial fishing continues to be carried out in the Region 3 estuaries include (from north to south):

- Moonee Creek;
- Coffs Creek;
- Boambee Creek;
- Bonville Creek; and
- Macleay River.

11.1.2 Fish Habitat Values

11.1.2.1 Key Fisheries Habitat Values

The Nambucca River estuary contains a suite of habitats that are utilised by species of direct fisheries value, including: open waters, unvegetated river channel, ephemeral floodplain wetlands, swamp forests, seagrass beds, mangroves, saltmarshes, inter-tidal sand flats and rocky reefs. The use of different habitat types can vary depending on the stage of the life-cycle (Table 11-1). For example, juvenile mullet are commonly found in freshwater reaches of tidal creeks and around shoals, whereas adults are more common in river channel habitats. Other species only occupy estuaries during their juvenile phase, such as King prawns, snapper and tarwhine, whereas other species such as Australian bass migrate from their primary freshwater habitat into the estuary to spawn. Species such as Yellowfin bream, flathead and whiting spend most of their life cycle in estuaries, only moving to nearshore areas to spawn [Kailola, 1993 #986].

Table 11-1 Key fisheries species in the estuary and their habitats at different stages of the life-cycle (data: Kailola *et al.* 1993)

Species	Estuary					Coastal/Oceanic		
	Mangroves	Seagrass	Shoals	Deep channel	Freshwater/ Floodplain	Inshore	Offshore	Reef/seawall
Dusky flathead	Juv.	Spw.,Juv., Ad.	Spw., Juv., Ad.,	Ad.		Spw.		
Sand whiting	Juv.	Juv.	Juv., Ad.	Juv., Ad.		Spw.		
Tailor		Juv., Ad.	Juv., Ad.	Juv.,Ad.		Spw., Juv., Ad.		
Yellowfin bream	Juv.	Juv., Ad.	Juv., Ad.	Ad.		Spw.		Ad.
Mulloway				Juv., Ad.		Spw.		
Bully mullet			Juv.	Juv., Ad.	Juv.		Spw.	
Luderick	Juv.	Juv.		Ad.		Spw.		Ad.
Long-finned eel		Ad.	Ad.	Ad.	Juv., Ad.		Spw.	
Blue swimmer crab				Juv., Ad.				
Mud crab	Juv., Ad.		Juv.				Spw.	
King prawn		Juv.	Juv.	Juv.			Ad., Spw.	
Greasyback prawn			Juv., Ad.	Juv., Ad.		Spw.		
School prawn			Juv., Ad.	Juv., Ad.			Spw.	

Juv. = Juvenile, Ad. = Adult, Spw. = Spawning

As shown in Table 11-1, vegetated wetland habitats (i.e. mangroves, seagrass, saltmarsh) are utilised by many fish species of direct commercial and recreational fisheries value, particularly as juveniles. It is generally thought that intertidal vegetation provides a 'nursery' function, with the complex vegetative structures providing shelter from predators [Bell, 1989 #1804]. In terms of these key harvested species, Dusky flathead is the only species that spawns in seagrass, although it is also known to spawn in a range of shallow water habitats [State Pollution Control Commission, 1982 #2441].

Estuarine wetland vegetation is protected under legislation (*Fisheries Management Act* 1994) in recognition of the importance of these areas as potential habitat resource to harvested species, as well as observations of changes in estuarine vegetation in response to a range of human pressures. As discussed below, however, it is difficult to state, *a priori*, that one particular habitat type has a greater/lesser environmental value than another type. Moreover, it is also not possible determine

whether one patch of a particular habitat type has greater/lesser value as a fish habitat by simply examining structural habitat conditions.

For example, studies done in tropical and sub-tropical areas have recorded rich and abundant fish assemblages in mangroves forests (eg. Blaber *et al.*, 1990 a, b; Salini *et al.*, 1990; Morton 1990; Brewer *et al.*, 1991; Laegdsgaard and Johnson 1995; Halliday and Young, 1996; Kathiresan and Bingham 2001). Comparatively few studies have been done in temperate Australian mangrove forests (eg. Bell *et al.* 1984; Clynick and Chapman 2002). Based on these studies, there is an emerging view that not all mangrove habitat patches have higher fish habitat values, than, for example, unvegetated mudflats (e.g. Clynick and Chapman 2002).

Seagrasses are also widely thought to represent ecologically important components of aquatic ecosystems as they are highly productive, stabilise sediments and provide food and habitat for many species of fish and invertebrates including those of commercial importance (Bell and Pollard, 1989; Larkum *et al.*, 1989; NSW Fisheries, 2001). Several studies have been done on the patterns of abundance of fish and crustaceans in seagrasses temperate regions. These studies demonstrated variability in the patterns of abundance for various assemblages of biota at differing spatial scales, e.g. kilometres, to very small scales, e.g. just a few metres, and that this variation often differs throughout the year (e.g. see most papers by Underwood and/or Chapman; Ferrell *et al.*, 1993; Worthington *et al.* 1995, etc).

McNeil *et al* (1992), for example, found enormous variation in fish assemblages among and within (temporal) seagrass beds in Botany Bay, New South Wales. McNeil *et al* (1992) also found that one seagrass bed in particular received larger numbers of recruits (up to 73 times greater) than nearby beds, and thus may function as a population 'sink' for fish. This 'hotspot' for recruitment was thought to be particularly important in terms of its conservation value over nearby sampled areas. Other studies have also found that abundances of some fishes varied inconsistently with factors such as canopy height and density between different seagrass species (Bell and Westoby, 1986b) and that patterns of variation of abundance of selected taxa were not explained by environmental factors such as the grain size of sediments, size of the beds or a gradient from the mouth of the estuary (Bell and Westoby, 1986c). Based on this, Bell and Westoby (1986a) argued that larvae randomly selected particular seagrass beds (i.e. independent of habitat features). Skilleter (1998) therefore argues that the available data does not support the simplistic assumption that all sites containing a particular type of habitat are of equal value as fish habitat.

Based on the above, it is difficult to assign a fisheries value to a particular habitat patch within an estuary because we know that, for example, a particular patch of seagrass may have a greater value as habitat or a lesser value, compared to a structurally similar patch nearby, and this can depend on the time in the year, or stage of the life-cycle. The processes that determine the 'value' of a particular habitat patch (and the spatial and temporal scales at which any patterns might exist) are not well understood, and require further investigation.

For the purpose of this study, all remaining areas of estuarine wetland vegetation should be considered as potentially important fish habitats. Based on Table 11-1, it is also apparent that unvegetated areas also represent important fish habitats. For example, shoals and river mouth environments represent important feeding areas for fish and many invertebrates of fisheries value (e.g. yabbies), as well representing important spawning sites for numerous harvested species (bream, flathead, whiting). Deep channel environments also represent habitats for most harvested species

(e.g. mulloway, flathead), whereas floodplains also contain a suite of habitats that are used by estuarine/freshwater fish at different stages of their life-cycle.

11.1.2.2 Key Life-Cycle Attributes

Table 11-2 summarises key life history periods of harvested species. In Table 11-2, the differentiation into the various categories is dependent on whether the particular life history event is known or likely to occur in the Nambucca estuary and adjacent near shore waters.

Table 11-2 shows that the Greasyback prawn (*Metapenaeus bennettae*) was the only species that may spawn year-round, however it is acknowledged that the reproductive biology of this species is not well understood and requires further study (Kaioloa et al. 1993). Other species have a more discrete spawning season. Dusky flathead and whiting tend to spawn in the warmer months, whereas Yellowfin bream tends to spawn in cooler months.

All species except flathead (which spawns in the estuary) spawn in adjacent to nearshore waters or at river mouth (Table 11-1). Blue swimmer crab is known to have a punctuated spawning season in Moreton Bay, with a major peak occurs from around August to October, with a lesser peak occurring around April. During these periods of breeding activity, most egg carrying females are found in the oceanic currents at and just offshore of the entrances to Moreton Bay. It is not known whether similar situation occurs at Nambucca estuary. All other key harvested species spawn outside of the study area (Table 11-1).

Table 11-2 Summary of timing of key spawning and migratory patterns of important fisheries species that may be affected by activities in the Nambucca estuary (Data: Kaioloa *et al.* 1993)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dusky flathead	Sp	Sp	Sp, M	M	M			M	M	M	M	
Sand whiting	Sp	Sp	Sp	Sp							Sp	Sp
Tailor			AM	AM			AM	AM	AM	AM	AM	
Yellowfin bream					AM, Sp	AM, Sp	AM, Sp	AM, Sp				
Bully Mullet					AM	AM						
Luderick			AM	AM	AM	AM						
Long-finned eel	JM	JM, AM	JM, AM	JM, AM	JM, AM				JM	JM	JM	JM
Blue swimmer crab			Sp	Sp	Sp			Sp	Sp	Sp		
Mud crab	M	M	M						M	M	M	M
King prawn	M								M	M	M	M
School prawn	AM	AM	AM	AM						AM	AM	AM
Greasyback prawn	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?	Sp?

Sp = spawning; AM = adult migration, JM = juvenile migration

11.1.3 Commercial estuary fishing

Commercial fishing can be legally undertaken within the lower reaches of Warrell Creek and along the Nambucca River as far the tidal limit. The main fish species caught within the system include mullet, bream, whiting, black fish (luderick) and flathead. Other minor species commercially caught include mulloway (jewfish) and tarwhine. Figure 11-1 shows the allowable extent of commercial fishing in the estuary as derived from the DPI (Fisheries) fishing closures for the Nambucca River Estuary (refer Appendix C).

11.1.3.1 Allowable fishing techniques, equipment, locations and times

The Nambucca River supports a small, but locally important, commercial fishing industry. The two main fishing techniques used within the estuary include trapping and meshing. However, the following fishing techniques are allowable in this estuary, hauling net (general purpose); prawn net (hauling); hoop or lift net; push or scissor net; fish trap; eel trap; hand gathering; garfish net (bullringing); meshing net; hand hauled prawn net; dip or scoop net; crab net and hand lining.

The fishing closures presently in place for the Nambucca River estuary are detailed below:

- Closure 1. Weekend and public holidays. Further details of this closure are provided in Appendix C.
- Closure 2. Nambucca River Entrance Waters. Further details of this closure are provided in Appendix C, see also Figure 11-1 that depicts the entrance waters.
- Closure 3. Warrell Creek Nets and Traps - Further details of this closure are provided in Appendix C, see also Figure 11-1 that depicts the locations of net and trap closures in the Nambucca River.
- Closure 4. Set Mesh Nets - Further details of this closure are provided in Appendix C.

From discussions with local commercial fishermen, no commercial prawning occurs in the Nambucca River estuary (C. Davis, Pers Comm., 2004). All nets used by commercial fishermen are licenced by the DPI (Fisheries).

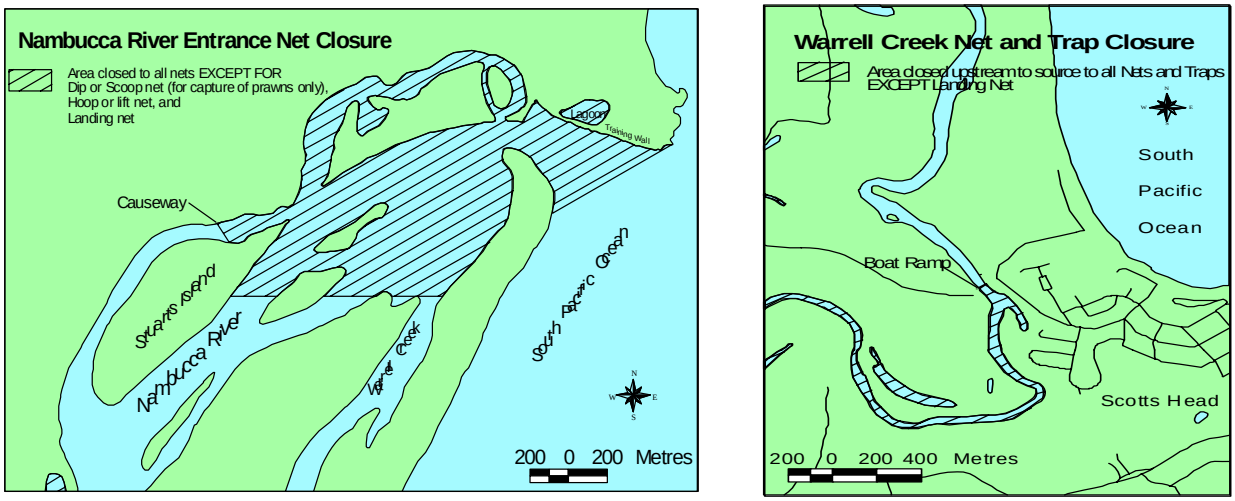


Figure 11-1 Commercial fishing closures in the Nambucca River Estuary

DPI (Fisheries) has indicated that other than the commercial fishing closures described above are no other habitat conservation areas in this area (Riches, M., DPI Fisheries, Pers Comm., 2004).

11.1.3.2 Commercial catch

There is currently estimated to be five commercial fishermen operating on the Nambucca Estuary (C. Davis, Pers Comm. 2004), which is less than there was before the buy-back of licences by NSW Fisheries and creation of recreational fishing havens in May 2002. From discussions with DPI

(Fisheries), Region 3 currently contains 83 fishing businesses and a total of 76 commercially licenced estuary fishers. However, DPI (Fisheries) has not been able to provide any further information on which particular estuaries these fishers operate and how much effort is being put into fishing.

There is also reported to be little competition occurring with other commercial fishermen from within Region 3. However, in 2001, the Macleay River was closed for several months to all fishing following a major fish kill event following flooding. Several commercial fishermen from this estuary came to the Nambucca estuary. Due to the differences that exist in these two systems, most of these fishermen were unsuccessful (C. Davis, Pers Comm., 2004) and have not returned to fish the Nambucca River estuary in any great numbers since (C. Davis, Pers Comm., 2004).

Data from the commercial catch section of the DPI (Fisheries) for the Nambucca River estuary over the past several years is presented in Table 11-3 and is shown in Figure 11-2 to Figure 11-4. The information shows that the days of effort put into commercial fishing in the estuary have actually declined over the period of 1998 to 2004. This has been accompanied by a decrease in the overall weight of commercial take from the estuary. Despite these declines, the value of the fishery has remained relatively constant at around $280,000/annum for the past few years.

The recreational fishing closures do not appear to have had a significant impact on the commercial fishing effort or catch in the estuary. There was however, a spike in 2003, which may have been due to a good fishing year, or extra commercial fishermen operating in the estuary, however in 2004 effort and catch appeared to return to a normal level. Commercial fishermen have indicated that unusual winds this year have lead to a bad year for fishing in the Nambucca River estuary as the winds have prevented the normal fish migration (C. Davis, Pers Comm., 2004).

Table 11-3 Reported commercial fishing catch (1998 to 2004)

Method	Years recorded	Years	Total effort	Average effort	Total catch	Average catch	Total value	Average value
			days	days/yr	kg	kg/yr	$	$/yr
Crab pot	1998 to 2004	7	5,317	760	40,029	5,718	$543,656	$77,665
Eel trap	1998 to 2004	7	620	89	12,422	1,775	$36,280	$5,183
Fish trap (bottom/demersal)	1998 to 2004	7	3,947	564	29,095	4,156	$289,069	$41,296
Hand gathering	1998 to 1999	2	10	5	3	2	$60	$30
Handline	1998 to 2003	6	147	25	1,912	319	$11,763	$1,961
Hauling net - general purpose, trumpeter whiting or garfish	1998 to 2004	7	262	37	19,571	2,796	$53,151	$7,593
Hoop or lift netting	2003	1	6	6	70	70	$463	$463
Mesh net (flathead)	2001 and 2003	2	45	23	2,771	1,385	$6,210	$3,105
Mesh net, top set bottom set or splashing	1998 to 2004	7	6,359	908	386,754	55,251	$886,921	$126,703
Other or ambiguous	1998 and 2002	2	189	95	59,144	29,572	$40,124	$20,062

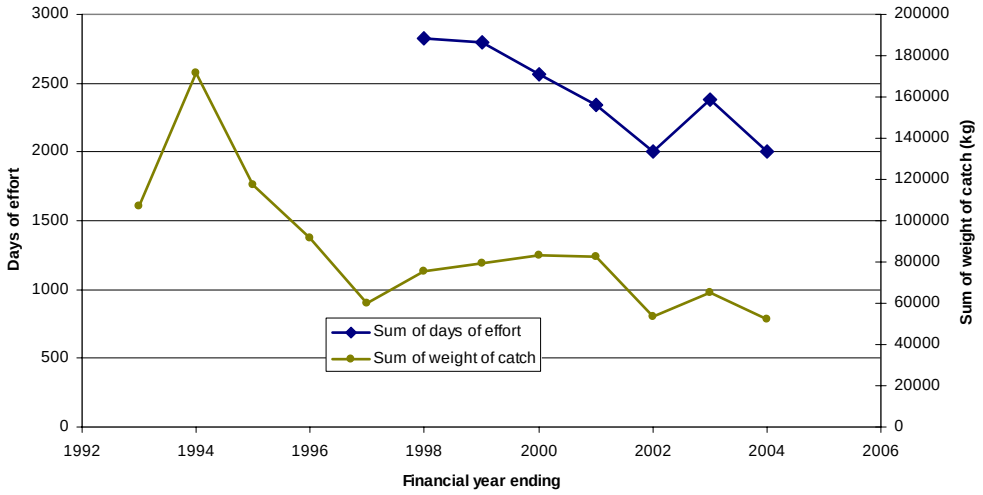


Figure 11-2 Commercial fishing effort and weight of catch 1992 to 2004

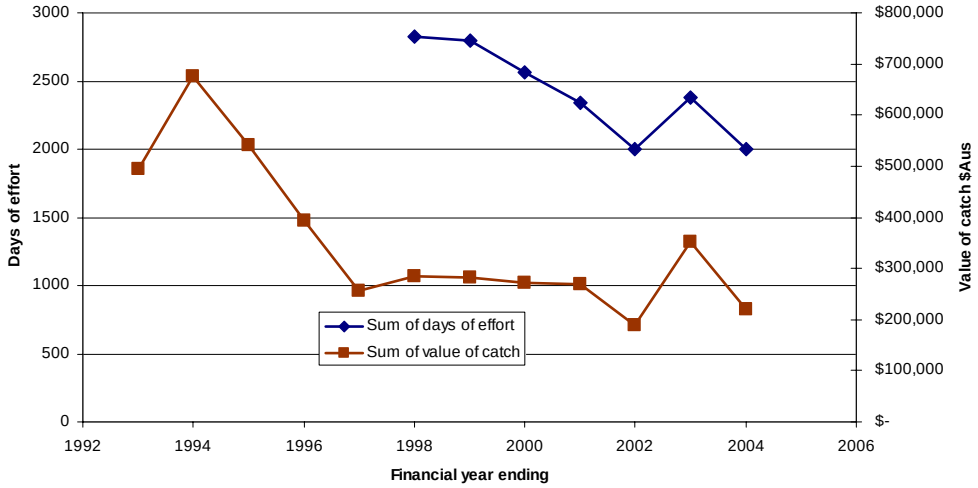


Figure 11-3 Commercial fishing effort and value of catch 1993 to 2004

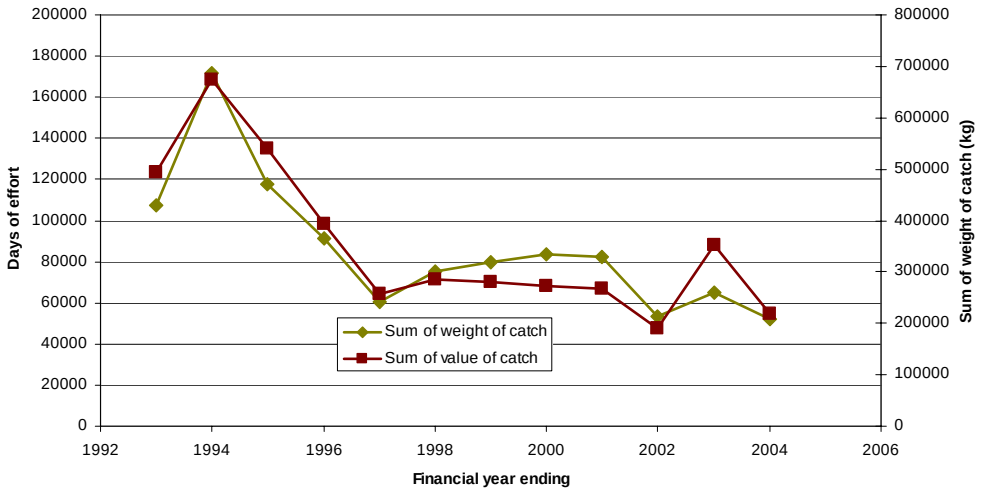


Figure 11-4 Commercial fishing catch and value 1993 to 2004

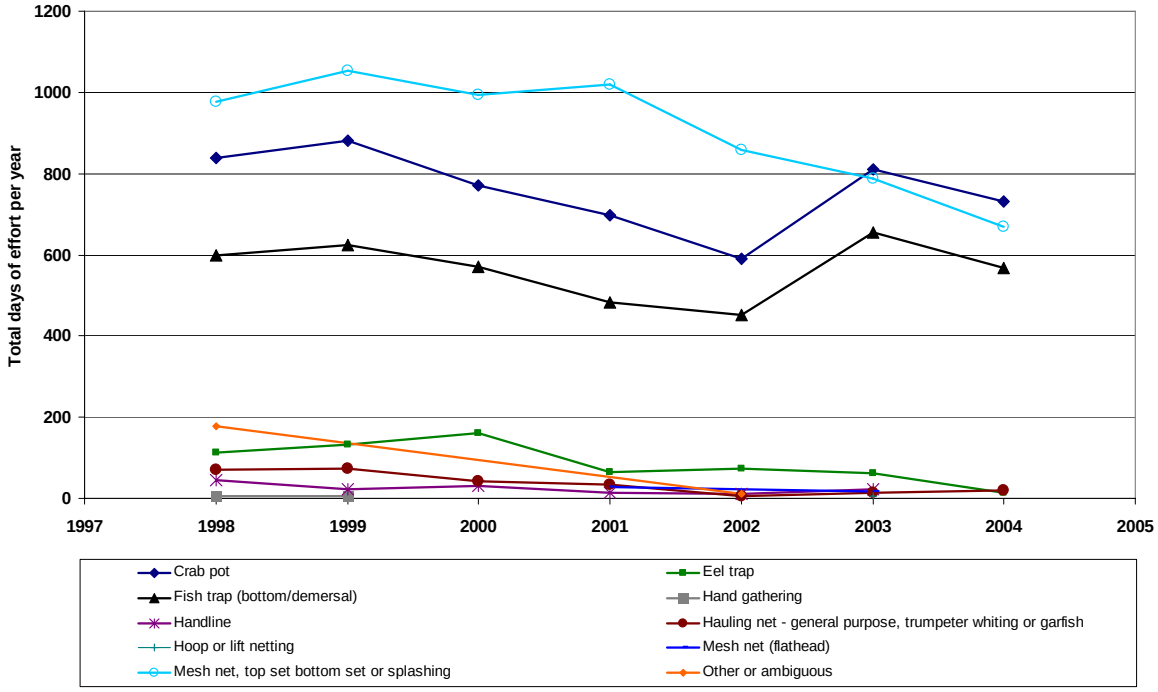


Figure 11-5 Days of fishing effort by fishing method 1998 to 2004

Figure 11-5 shows the days of fishing effort by various methods and as is expected by the overall decline in fishing effort, there is a notable decline in some methods such as mesh netting, and eel trapping. Effort put into crab potting and fish trapping appear to have remained relatively constant over the past several years.

Table 11-4 shows the commercial catch above 1 tonne over the period of 1998 to 2004.

Table 11-4 Weight and value of commercial catch by species over 1998 to 2004

SPECIES NAME	Total weight caught (kg)	Total value of catch ($A)
Mullet, Sea/Bully/Hardgut	253,992	$436,404
Luderick/Blackfish	104,262	$152,362
Crab, Mud/Black	53,939	$801,792
Bream, Black & Yellowfin Mixed	44,221	$378,899
Mullet, Flattail/Fantail/Jumping	24,512	$26,949
Whiting, Sand	12,713	$123,792
Eel, Longfin/River/Spotted	9,198	$23,855
Mullet, Sand	8,579	$8,666
Flathead, Dusky/Black/River	7,452	$35,594
Mulloway/Jewfish	7,109	$53,783
Whitebait (Mixed Small Fish)	4,081	$14,104
Mullet, Pink Eye	2,945	$3,689
Eel, Mixed/Unspecified	2,435	$9,561
Eel, Short-finned Conger	2,278	$3,819
Crab, Blue Swimmer	2,143	$13,792
Trevally, Silver	1,827	$5,202
Fish, Estuary Mixed/Unspecified	1,731	$5,516
Shark/Flake/Mixed/Unspec	1,522	$3,393
Old Maid/Butterfish	1,113	$1,985

From this table, it is clear that sea mullet is the most caught fish in the estuary. Crab and eels catches are also significant in the estuary. In terms of value, the fish species, which returns the highest value

per weight, include mud crabs, prawns (eastern king and school) and then finfish (including sand whiting, bream, flathead, mulloway and tailor) and then eels and sharks. Mullet and blackfish, which are the most commonly caught species, have a very low return per unit catch.

11.1.3.3 Relative importance of the Region 3 estuaries

Information included in the Region 3 - South of Woolgoolga to Port Macquarie, Issues Paper Summary (NSW Fisheries, 2001) identified that the annual catch of Region 3 estuarine fisheries:

- Was approximately 273 tonnes with an economic value of approximately $1.06 million to $1.28 million at first point of sale (note that this value does not take into consideration multiplier effects);
- Comprised around 1.4% of the total commercial (estuarine and ocean) catch in NSW jurisdiction (of approximately 19,000 tonnes) and around 1.5% of the total value (of approximately $80 million); and
- Comprised around 4.7% of the total estuarine commercial catch in NSW (of approximately 5,710 tonnes). It accounted for less than 1% of total seafood consumption in NSW (estimated at 125,000 tonnes).

From the above statistics, it is clear that the Region 3 estuaries constitute only a minor portion (approx. 5%) of the total state catch and an equally minor contribution to the total value of the industry.

It is important to note that this information is current to 2001. With the recreational fishing havens being opened in 2002, some of the local estuaries which would have been used commercially, have been made unavailable, e.g. the Bellinger/Kalang and Hastings River estuaries. It is now unclear what the contribution of the Region 3 estuaries is to the State total.

In 2001 the Nambucca estuary produced approximately 82 tonne of catch, which is approximately 30% of the total contribution of Region 3 in that year.

11.1.4 Recreational fishing

In 2000-01 NSW Fisheries conducted a twelve-month survey of recreational fishing in New South Wales. The survey was part of a broader national initiative to obtain fisheries statistics on non-commercial components of Australian fisheries. The survey obtained estimates of the level of participation, fishing effort and catch by recreational fishers. Key findings from this study's interim report, released in December 2002 are detailed below:

- NSW had an estimated 998,501 ± 33,686 recreational fishers. Of this total the mid-North Coast region has approximately 74,441 recreational fishers which places it third in the State after Sydney (482,739 fishers) and the Hunter (131,348 fishers);
- It is estimated that the proportion of the NSW population that participated in recreational fishing was 17.1% over the survey year, with participation rates in the mid-North Coast region coming in at 29.9%, well above the State average (and second highest in the State);

- Recreational fishing activity was greatest in estuarine waters (47% of total events) followed by coastal waters (28% of events), freshwater rivers (15% of events), lakes and dams (10% of events) and offshore waters (1% of events);
- Recreational fishing in saltwater (offshore, coastal and estuarine waters) accounted for 76% of the NSW recreational fishing effort while freshwater fishing (freshwater rivers, lakes and dams) accounted for 24% of the effort;
- Line fishing methods (lines, lures, jigs, fly, setlines) accounted for 90% of the recreational activity in NSW. Bait gathering and fishing with pots and traps each accounting for 4% of the total, respectively, while recreational spear fishing accounted for (1%);
- Fishing from the shore attracted a greater level of activity (59% of events) than fishing from boats (41% of events). Of the boat-based fishing effort, more than 92% of fishing events were conducted from private fishing boats with 4% from charter vessels and 4% from hire boats;
- The NSW average was 6.9 days fishing per person per year;
- Key recreational species caught in the NSW recreational catch included flathead, bream, whiting, European carp, tailor and luderick. Generally, these species were relatively abundant and broadly distributed, particularly in coastal and estuarine waters adjacent to large urban populations;
- Abalone, squid, prawns, lobsters and crabs were important to recreational fishers. Prawns were harvested in greater numbers than any other recreational species while yabbies and blue swimmer crabs were harvested in larger numbers than most fish species;
- Species forming the bulk of the commercial catch were generally taken from coastal or offshore waters, while the major portion of the recreational catch was taken from estuarine waters;
- Recreational and commercial fishers harvested about 200 species of fish, but the total recreational catch was about 30% of the total commercial catch. About 6 of the prominent species harvested by both fishing groups were taken in greater numbers by recreational fishers, as shown by the highlighted cells of Table 11-5. These species were generally common estuarine species taken in metropolitan waters where the number of recreational fishers and their fishing effort was greatest; and
- Recreational fishers in NSW spent more than $550 million on fishing related items during the survey year, of which boat and trailer expenses ($276 million) was the largest component. Other major components included travel costs related to fishing ($118 million), accommodation on fishing related trips ($54 million) and fishing gear ($46 million) followed in importance. More than $26 million was spent on the charter/hire of boats and $12 million on bait/burley/ice.

In summary, the recreational sector as a whole has the potential to impact aquatic resources. As noted above, the recreational catch of several common estuarine species is larger than the commercial catch; many of these species are caught commercially/recreationally in the Nambucca River estuary. Overall, the NSW commercial catch is substantially greater than the total recreational catch.

Table 11-5 Harvest of key species by fishing sector #

Key fishing species	Recreational catch (kg)	Commercial catch (kg)*
Whiting	394,081	1,181,793
Flathead	886,824	496,335
Bream	728,752	365,383
Garfish	22,672	97,875
Tailor	252,736	190,675
Australian salmon	221,977	790,143
Snapper	116,967	273,159
Trevally	87,530	273,884
Leatherjackets	107,966	117,034
Wrasse/tuskfish/gropers	52,373	69,810
Luderick	280,130	503,600
Mackerels	128,627	443,567
Cod (various)	8,133	35,835
Catfish	94,222	28,965
Mulloway/jewfish	273,703	63,796
Morwong	139,929	429,606
Tuna/bonitos	844,480	1,000,500
Sharks/rays	60,186	441,090
Yellowtail kingfish	180,003	137,349
Prawns (saltwater)	104,833	2,346,976
Blue swimmer crab	154,831	165,461
Squid/cuttlefish	65,717	824,183
Mud crab	30,000	135,144
Lobsters	7,398	120,000
Abalone	10,570	304,000
Nippers	15,167	.
Other Saltwater Species	77,633	12,800,300

Source: DPI Fisheries Survey of Recreational Fishing in NSW
Data derived from a range of Commonwealth and State sources. Other species data based on a 5 year average of ocean fishery landings into NSW

11.2 Oyster Aquaculture

The oyster industry is a uniquely valuable indicator of environmental health of rivers and estuaries. Oysters have been referred to as the "canary of the estuary" as a decline in their health can be an early warning sign of river health problems (HRC, 2003a).

The Sydney Rock oyster is a native oyster found from Moreton Bay in southeast Queensland to Flinders Island in Bass Strait. It's ability to survive out of water for periods of up to 3 weeks in wet hessian bags makes it a unique product, highly suited to export. The two main commercial oyster species grown in NSW are the Sydney Rock oyster and the introduced Pacific oyster (HRC Oysters, 2003).

The Nambucca Estuary has a reputation for producing high quality Sydney Rock oysters, which are recognised nationally for their texture and taste. Some growers believe this is due to the highly mineralised waters found in the Nambucca River. The reputation of the Nambucca River oysters is of significant value to the local oyster industry and indirectly the local community. It is also

important to note that there have been limited observations of the Pacific Oyster and/or QX disease in the Nambucca River estuary.

11.2.1 Location and tenure of oyster leases

Commercial oyster production occurs in the lower reaches of the Nambucca estuary between Goat Island and Entrance on the Nambucca river with one oyster lease being located near the confluence of Warrell Creek with the Nambucca River as shown in Figure 11-6.

As can been seen from this figure the majority of oyster leases are located between Wrights Corner and the Nambucca Resort. It is understood that some leases are used to fatten mature oysters that have been grown in other areas of northern and central New South Wales, with the remainder supplying locally grown product. Oyster spat is also collected near the entrance by some growers.

There are a total of 52 commercial oyster leases within the estuary, either "current" or "former". Of the 52 leases, 9 are presently classified as former, leaving 41 current leases. Ten permit holders utilise these current leases.

Six of the former leases are located along the training wall between the southern tip of Stuarts Island to the "hole in the wall". Of the remaining three former leases one is located at the entrance to Warrell Creek (Lease No. OL70/175) and the other two are located approximately 500 m upstream (westward) of the Stuarts Island Ramp (Oyster Lease No. OL69/473 and OL66/231).

While the "former" designation indicates that it is not a current lease, it is unknown whether new lease options are being sort for these lease areas or whether the areas have simply been abandoned and require cleanup. NSW Maritime have indicated that one of these former leases which is located near the entrance to Warrell Creek (Lease No. OL70/175) requires some form of cleanup (Sedlak, A. NSW Maritime, Pers, Comm., 2004).

In total the area of oyster leases designated as current is 64.3 ha and the total of former leases is 2.4ha providing a total lease area of 66.7ha (or approximately 7 to 8% of the total waterway area in the study area). It is not believed that the entire amount of the current lease areas is actively used for oyster production.

11.2.2 Methods of oyster growing

Tray culture is the main method of oyster growing applied in the Nambucca estuary. Tray culture is popular due to the increased portability and ease of handling of other culturing methods.

Spat can be collected at the entrance of the Nambucca River. This aspect of the oyster growing industry is as yet in its infancy in the Nambucca River with only a couple of growers collecting their own spat.

Different areas of the estuary are more suited to different stages of oyster growth as detailed below:

- Entrance – suitable for spat collection;
- Bellwood to Murrays Bay – good for growing oysters, typical production period of approximately 3 months (September to December);

- Murrays Bay to approximately Wrights Corner– good for fattening oysters, typical production period of approximately 6 to 7 months (June to around January or December); and
- Upstream of Wrights Corner 10 to 12 months production period from June – March.

Figure 11-6 shows the approximate location of the abovementioned landmarks.

11.2.3 Commercial oyster production

The NSW DPI Fisheries website states that NSW has a current annual production of around 106 million oysters (approx. 4000 tonne) worth about $30 million, which makes it the most valuable aquaculture industry in New South Wales (and has been for over 100 years). Oyster farming now employs many different techniques, all of which take place on selected sites held under about 3,200 aquaculture leases, with a total current area of about 4,300 hectares, which are administered by the NSW Fisheries. Commercial production in the State occurs in 41 estuaries between Eden in the south to the Tweed River in the north. Wallis Lake and the Hawkesbury River are the main producing areas. Pacific oysters (*Crassostrea gigas*) have been commercially cultivated in Port Stephens since 1991, but are declared a noxious fish in all other NSW waters.

The Nambucca River oyster industry is an important local industry, providing employment, income and recognition for the Nambucca Shire. In the mid 1980's annual production topped 200 tonne (approximately 3% of the State wide production), however this rate has fallen over the past 20 years in-line with state wide trends and has averaged 80 tonne/yr over the past eight years (or 2% of the State total).

Table 11-6 shows the oyster production for the Nambucca River estuary over the past eight years based on data provided by DPI (Fisheries). Figure 11-7 shows annual oyster production from 1931 to 2004 again using DPI (Fisheries) data. A decline in the annual production can be seen from these figures, however, there has been a decline in the number of permit holders and available lease area.

Nambucca Oyster growers are concerned at the number of days of river closure their industry faces due to poor water quality after rainfall events. NSW Food Authority has found from its sampling over the past 6 years that the Nambucca harvest area has generally good water quality when dry, but poor following significant rainfall events (NSW Food Authority, 2006). Analysis of available water quality data is presented and discussed in more detail in Section 15.

Sub-catchments with direct influence on the oyster production harvest zone include Watt Creek, Gumma Gumma, Newee Creek and localised catchments containing the urbanised areas of Macksville and Nambucca Heads. The upper catchment can also contribute to the overall water quality during rainfall events.

The 2002/2003 Aquaculture Production Report by DPI Fisheries for the NSW oyster industry indicates that one bag of 'Plate Grade' oysters fetched $611.06, 1 bag of 'Bistro Grade' oysters fetched $486.30 and 1 bag 'Bottle/Cocktail Grade' oysters fetched $427.75 at the farm gate. The yearly oyster sales of the Nambucca River estuary oyster industry are estimated to be approximately $0.5 to 0.7 million/year (or 2% of the State total income) based on average production values and 2002/2003 prices for farm gate sales. This figure does not take into account any multiplying or ripple effects of this industry.

Oyster Lease Location and Status (Source : DPI Fisheries - 2005) Figure 11-6

Table 11-6 Sydney rock oyster production for the Nambucca River estuary

	1997	1998	1999	2000	2001	2002	2003	2004
Current leases	50	50	48	47	47	48	43	41
Lease area (ha)	71.8	71.8	66.3	69.8	69.6	70.1	68.2	64.3
Permits	18	15	14	13	11	11	9	10
Production (dozens)	185,699	191,870	140,236	128,846	113,332	102,732	61,448	91,731
Production (bag) *	1,643	1,698	1,241	1,140	1,003	909	544	812
Production (tonne) *	117	121	89	81	72	65	39	58

* Based on 113 dozen Sydney rock oysters/bag and 14 bags/tonne.

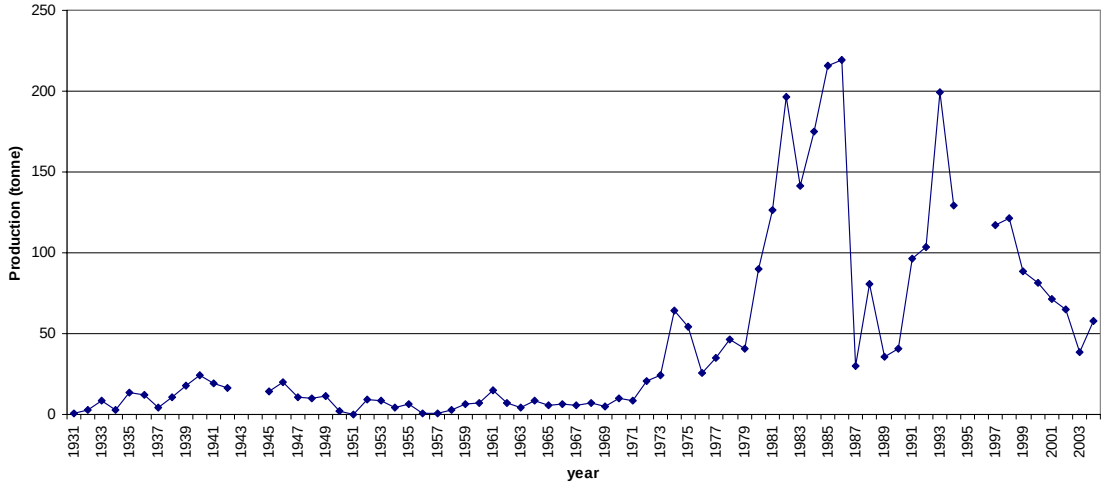


Figure 11-7 Oyster production of the Nambucca River estuary 1931 to 2004

Oyster theft has occurred in this and surrounding oyster growing areas in recent years, affecting total production figures. From discussions with DPI (Fisheries) it appears that the thieves are highly organised and know which leases/racks they want to target and when. DPI (Fisheries) did not consider there to be any real benefit in signing oyster leases to prevent this theft from occurring (Riches, M., Pers Comm., 2004).

11.2.4 NSW Shellfish Quality Assurance Program

The NSW Shellfish Quality Assurance Program (SQAP) is administered by the NSW Food Authority, which regulates the harvesting of all oysters in the state of NSW. The Nambucca River estuary oyster harvest zone has been given a draft classification of "conditionally restricted" as part of this program and all produce harvested for sale must go through a depuration process prior to sale.

The SQAP aims to provide high quality produce to consumers. This can be best achieved by rectifying potential pollution point sources in shellfish producing areas, assessing and controlling production methods at all levels of industry and educating shellfish producers in their responsibilities. This is a mandatory industry funded program designed to ensure that oysters are only harvested under strict water quality and product guidelines that seek to ensure that public health and high industry standards are observed and promoted.

At present there are some water quality issues present in the Nambucca River. Ambient monitoring of the river during predominantly dry periods shows the estuary to have relatively high water quality, however, a link still exists between catchment runoff and reduced water quality during rainfall events (see Section 15). Another potential influencing factor is the location of the Macksville Sewerage Treatment Plant outfall, which is located just 1200m upstream of the current harvest zone. This is the closest sewerage discharge point to any commercial harvest zone in NSW (NSW Food Authority, 2006).

Mandatory depuration of all oysters before sale was introduced in all NSW estuaries in 1978. This process makes use of the fact that food taken in by the oyster, including bacteria, will be excreted within a short period of time. A depuration plant provides a controlled environment in which oysters spend the final 36 hours before sale in high quality water, allowing any possible contaminants to be removed by purging. The most common method of obtaining water of appropriate quality is by exposing the water to high intensity, germicidal ultra-violet light twice every hour. In a well-designed depuration plant, salinity, temperature and dissolved oxygen levels of this water are controlled for maximum efficiency. The classification process will review the need for the mandatory depuration of all oysters from the Nambucca River estuary.

The NSW Food Authority expects the classification process to be completed in late 2006. At present there are four harvest zones in the Nambucca River, they propose to replace the current four harvest zones with two as shown in Figure 11-8. If this classification is introduced, oysters will only be able to be harvested for sale from within the marked harvest areas.

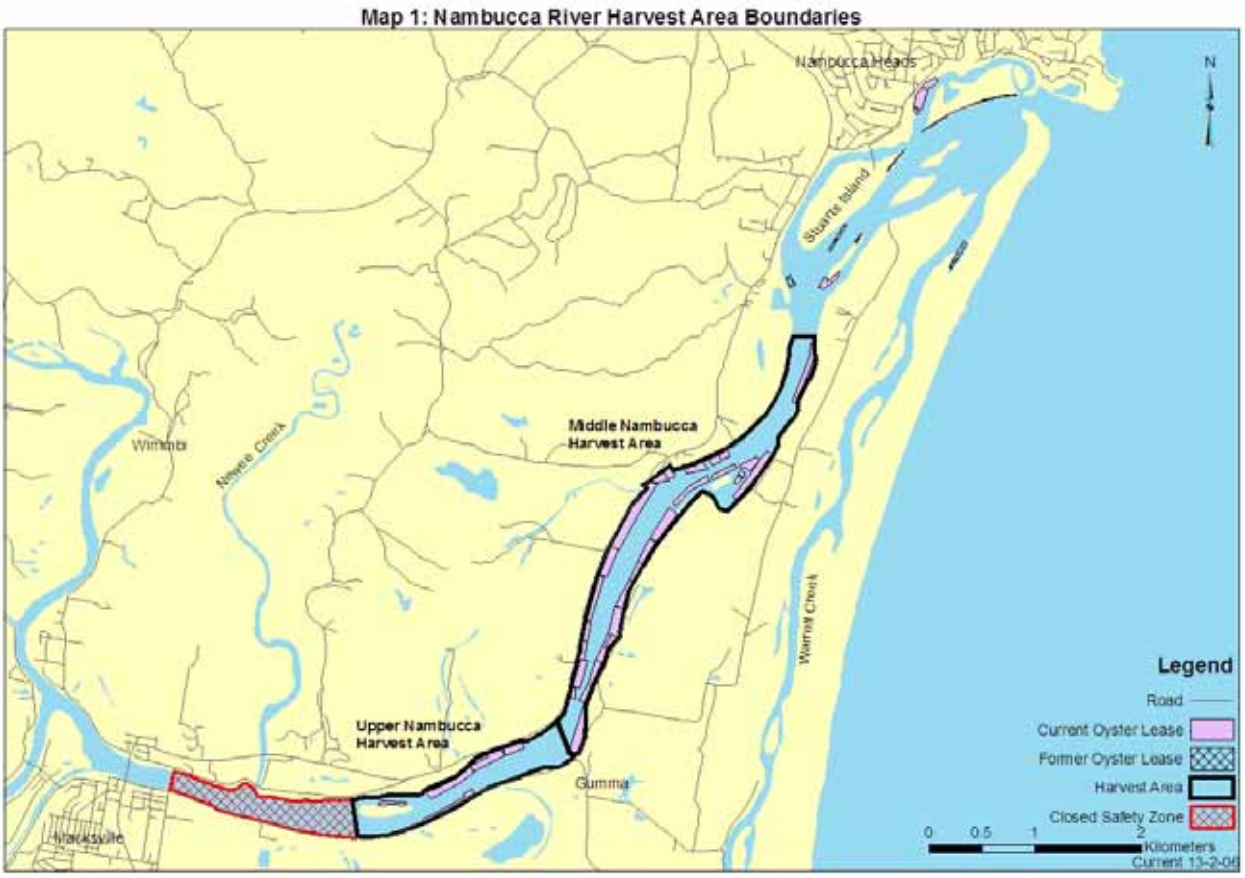


Figure 11-8 Nambucca River Harvest Area Boundaries (NSW Food Authority, 2006)

As part of the classification process, a representative of the NSW Food Authority collects fortnightly water quality samples for analysis from the Nambucca River estuary. The results of this testing are described in Section 15.4.

In the interim to safeguard all oyster consumers, water and oyster growers undertake oyster meat quality testing after rainfall events. The testing determines the quality of oyster meat and the water they were harvested from. If the samples pass the prescribed limits, then the oyster grower can harvest and sell their oysters.

A rainfall event is defined as 25mm of rainfall within the catchment over a 24-hour period. Individual growers must then do their own water and oyster meat testing in order to "reopen" their lease area for harvest. Oyster meat samples must achieve an upper 10 cfu/gram limit and the water must contain less than 70 cfu/100mL. All testing must be undertaken at NATA registered laboratories.

11.3 Land based Aquaculture

At the time this report was prepared, there were no known land based aquaculture activities occurring within the Nambucca River estuary. The Nambucca River estuary is, however, expected to be a prime site for potential future aquaculture industries given the high water quality present within the estuary and the wide available of land immediately adjacent to the estuary amongst other factors.

In anticipation of future growth in this industry, the NSW Government in 2000, released the NSW North Coast Aquaculture Strategy. The Strategy was developed to guide the development of the industry to avoid it becoming ecologically unsustainable. The Strategy applies to three types of intensive land based aquaculture including:

- Estuarine pond aquaculture for endemic species of prawns and finfish;
- Freshwater pond aquaculture; and
- Tank based high intensity recirculation aquaculture (saline and fresh water).

The Strategy consists of two main components, a best management component and an integrated approvals component so that projects can be established and operated in an efficient sustainable manner. The level of approval required will relate to the potential impact of the proposed development. A methodology has been developed under SEPP62 – Sustainable Aquaculture to assess the potential impacts of proposed aquaculture projects.

In support of the Strategy a series of maps have been provided which outline suitable areas for aquaculture within the North Coast estuaries. While this map has not been reproduced in this report (it is available from the DPI Fisheries website) suitable sites, also referred to as 'Tier 1 suitable sites' have been identified within the Nambucca River estuary. These sites exist (within distance of 1km from the bank) from the entrance of the estuary up to Devil's Elbow on the Nambucca River, Broadwater on Taylors Arm and as far as Boulton's Crossing campground on Warrell Creek.

11.4 Summary

Commercial fishing continues in the Nambucca River estuary despite the recent conversion of numerous commercial estuarine fishing areas across NSW into Recreational Fishing Havens. It is

apparent from the available data that the days of effort put into commercial fishing in the estuary have actually declined over the period of 1998 to 2004. This has been accompanied by a decrease in the overall weight of commercial take from the estuary. Despite these declines, the direct value of the commercial fishery has remained relatively constant at around $280,000/annum for the past few years. The relative contribution of the Nambucca River estuary to the Region 3 estuary fishery and State estuary fishery at the present time are unknown, but are likely to have increased with the recent closures of other commercial fisheries to form Recreational Fishing Havens.

Recent studies by DPI (Fisheries) have identified that the mid-North coast region of NSW has the third highest number of recreational fishers of all the regions in NSW (NSW Fisheries, 2002). There are also high fishing participation rates in this region. The study identified that the key recreational species caught in the NSW included flathead, bream, whiting, tailor and luderick. All of these species are present in the estuarine waters of the Nambucca River estuary. The total recreational catch constitutes about 30% of the total commercial catch, with about 6 of the prominent species being taken in greater numbers by recreational fishers than commercial fishers.

Apart from some limited commercial closure areas and bag limits, there are few controls on the extent and location of fishing activity that can occur within the estuary. Many local residents are concerned about perceived declines fish catch within the estuary and much blame is being laid upon the commercial fishing sector (see Section 4.2.3). There are numerous factors that could result in fish stocks, varying in time (i.e. historical versus present-day impacting processes) and space (i.e. processes operating over regional scales, versus local estuary specific processes). These include for example:

- Habitat destruction over broad regional scales. Many estuarine fish species move between estuaries during part of their life-cycle, hence processes operating outside the estuary, such as habitat destruction in other estuaries, can result in loss of local fish stocks;
- Habitat destruction at local (within estuary) scales. This could include, for example, historical and present-day changes to seagrasses, wetland vegetation and entrance shoals, all of which represent critical spawning and nursery areas for estuarine fisheries species;
- Direct loss of fish stocks due to fishing. Commercial and recreational fishing pressures, both at local and regional scales, is quite high. The impacts of fishing activities on local fish stocks are unknown and needs to be quantified; and
- Declines in estuary condition/ecosystem processes, and associated flow-on effects to fish and their prey.

Little is currently known regarding the relative fisheries values of the various habitats that exist within the estuary, as these may change depending on a number of factors including time in the year, or stage of the life-cycle of the species that use them. The processes that determine the 'value' of a particular habitat patch (and the spatial and temporal scales at which any patterns might exist) are not well understood, and require further investigation.

The Sydney rock oyster is grown and harvested within the Nambucca River There are a total of 52 commercial oyster leases within the estuary, either "current" or "former". Of the 52 leases, 9 are presently classified as former, leaving 41 current leases. Ten permit holders utilise these current leases. The yearly oyster sales of the Nambucca River estuary oyster industry are estimated to be approximately $0.5 to $0.7 million/year (or 2% for the State industry income) based on average

production values and 2002/2003 prices for farm gate sales. This figure does not take into account any multiplying or ripple effects that this industry has on the local economy.

The Nambucca River estuary is presently being classified as part of the NSW Shellfish Quality Assurance Program (SQAP).

The Nambucca River estuary oyster harvest zone is subject to periodic episodes of poor water quality, primarily influenced by catchment runoff during rainfall events. To ensure that the oyster industry remains viable in the long term, it will be of high importance that those processes impacting on the harvest zone are identified, such that informed decision-making can be regarding the possibility of modifying or rectifying the issues. Future impacting activities within the catchment need to be avoided through a combination of appropriate planning and design.

During the consultation process a number of comments were received from the local community regarding the visual impacts of this industry on the estuary, particularly in terms of floating debris, old sheds and other structures.

12 TOURISM MANAGEMENT

12.1 Introduction

The Nambucca River estuary is one of the most significant features of the entire Shire. It has been an important source of food and place for ceremony for the local Aboriginal tribes and it was also the 'lifeblood' of the early European settlers to the area. It provided the means upon which permanent settlements established in the region.

In relatively recent times there has been a major shift in the focus of how the Nambucca River estuary is used. With the advent of rail in the late 1920s, the use of the river for the shipping of goods gradually declined, mainly due to its lower reliability and potentially longer transport times. Also, the primary industries upon which European settlement was established have declined or disappeared. This trend has continued to the modern day, whereby there is now very little primary industry remaining in the catchment, none of which utilises the estuary. This combined with other broader social changes, whereby residential living near the ocean has become highly popular, has seen the principal usages of the estuary change to what they are today, primarily recreational.

Tourism is a major industry in the Nambucca Shire, with tourists being drawn to the many idyllic coastal towns situated near beautiful beaches and rural character towns such as Bowraville. The Nambucca River estuary is a key component in this tourist appeal as it provides for a variety of recreational opportunities for visitors to the area.

Tourism is however a double-edged sword. Uncontrolled tourism, particularly in ecologically sensitive areas such as an estuary, can result in a range of social and environmental conflicts and impacts. These impacts may significantly reduce the amenity of the estuary for a range of users and result in a decline in tourism. On the other hand, many local businesses and services have been established around tourism related industries and there is likely to be a demand for greater levels of tourism to the area to allow for the gradual growth of existing and new tourist related industries.

This section provides an overview of the role of the estuary in present day tourism and whether current facilities (and planning behind the facilities) will be sufficient to cater for future expected tourism needs in the area, and whether the planning behind the provision of facilities safeguards the estuary against unnecessary usage conflicts and other social and environmental impacts.

12.2 Status of tourism in the region

Information provided below has been sourced from Tourism NSW for the year ending June 2003. Tourism NSW divides NSW into several regions. The Nambucca River Estuary study area falls within the "North Coast NSW region", which is bounded by the east coast of Australia, the Northern Rivers, New England and Hunter regions. Tourism NSW have divided NSW into 15 regions. The North Coast region includes the major centres of Hastings (Port Macquarie), Coffs Harbour, Bellingen, Great Lakes (Forster), Greater Taree, Kempsey, Nambucca and Port Stephens. This region has a permanent population of just over a quarter of a million people. Relevant information obtained from this publication is detailed in the following sections.

Number of visitors and nights stayed

In the North Coast NSW region during the year ending June 2003 there were:

- 3.6 million domestic overnight visitors (13% of visitor nights spent in the state) who stayed for total of 13.9 million nights (15 per cent of visitor nights spent in the state). On a statewide basis these results (both categories) are significant as they are second only to the Sydney region, which accounted for 31% and 25% respectively of the State totals. The region is well above the average of other regions, which typically account for 5% of the state total (for both categories excluding Sydney's contribution). There was an 8% increase in both categories between 2002 and 2003; no figures are as yet available for 2004.
- 153,000 international visitors (6% of all international visitors to the state). Nearly all international visitors focus on Sydney. The North coast region is on par with most other coastal regions in terms of international visitations and nights stayed.

Origin of visitors

The origins of visitors to the region are detailed below:

- The majority of the domestic overnight visitors were sourced from within the State (53% from Sydney and 32% from regional NSW);
- The countries that contributed the most international visitors were the UK, Germany and USA.

Reasons for visit

Principal reasons for visiting the region include:

- 60% of domestic overnight visitors travelled for the purpose of holiday or leisure, following by visiting friends and relatives (28%) and business (8%); and
- A large majority of international visitors travelled for the purposes of holiday (87%), with 11% visiting friends and relatives.

Accommodation sought by travellers and its value

Principal forms of accommodation sought by visitors to the region include:

- The home of a friend or relative accounted for a third of domestic visitor nights (34%) followed by a hotel, resort, motel or motor inn (24%), a caravan (18%) and a rented property (16%);
- The main type of accommodation used in the North Coast NSW region by international visitors was a hotel, resort, motel or motor inn (45%), followed by a caravan (23%) and a backpackers or hostel (22%); and
- Most domestic travel is performed with the use of a private or company vehicle.

A survey of tourist accommodation establishments (with 15 or more rooms) in the north coast region identified that there was an increase in the rooms nights were occupied and nearly a 10% increase in the accommodation takings over the 2002 to 2003 financial years. The value of accommodation takings to these establishments in 2003 was $84.3 million.

Length of stay

The most common length of stay by visitors to the region were:

- Domestic overnight visitors stayed for an average duration of 3.9 nights, and the median length of stay was 2 nights; and
- International visitors stayed for an average duration of 4.3 nights, while the median length of stay for 2 nights.

Demographic of domestic visitors

The demographic of visitors to the region were:

- 53 % were male; and
- Predominant age groups were those aged 25 to 44 years and 45 to 64 years, with each age group accounting for 35% of domestic overnight visitors.

Day travellers

Day visitation to the region is also significant, during the year ending June 2003, the North Coast NSW region received 3.0 million domestic day visitors with 84% of these from regional NSW and only 16% from Sydney. On a statewide basis the north coast region (with 6% of the state total) ranks fifth after Sydney (35%), Hunter (10%), Illawarra (7%) and Central Coast (7%). These regions are benefited by their proximity to the major population centre of Sydney.

Time of domestic visitors travel

Domestic visitor stays in the region peak around the school holiday periods, with January being the highest peak accounting for 15% of the yearly total, followed by October (11%) and March/April (9%). Most other months accounted for about 7% of the yearly total, with February being the lowest month at 6%.

Activities of domestic visitors

Table 12-1 identifies the principal activities undertaken by domestic overnight and day travellers to the region.

Results in this table show that the region is well above the NSW state average for both overnight and day visitation in relation to recreational pursuits including ‘outdoor/nature activities’, ‘sports and active outdoor activities’. This indicates the use of the estuary could form an important component of domestic overnight and day travellers to the region.

Table 12-1 Activities undertaken by overnight and day visitors

Main leisure activities participated in	Overnight visitors		Day visitors	
	NSW North Coast region 2002-2003	NSW State 2003-2003	NSW North Coast region 2002-2003	NSW State 2003-2003
Outdoor or nature activities	**53**	**30**	**29**	**17**
Go to the beach (including swimming, surfing or diving)	47	22	22	11
Visit national parks or state forests	13	10	6	5
Go whale or dolphin watching (in the ocean)	2	1	2	0
Visit botanical or other public gardens	1	2		
Sports or active outdoor activities	**30**	**22**	**15**	**10**
Go fishing	13	7	4	2
Play golf or other sport	10	7	7	3
Other outdoor activities	8	8	5	3
Exercise, gym or swimming at a local pool, river or creek	4	4		
Arts, Heritage or festival activities	**7**	**10**	**4**	**6**
Visit history or heritage buildings, sites or monuments	3	3	2	2
Visit museums or art galleries	2	4		
Visit art of craft workshops or studios	2	1		
Attend festival, fairs or cultural events	1	2	1	1
Local attractions or tourist activities	**13**	**12**	**4**	**5**
Going to markets (street, weekend or art craft)	5	4	2	2
Charter boat or cruise or ferry ride	3	3		
Visit wildlife parks or zoos or aquariums	2	2		
Visit amusement or theme parks	2	1		
Social and others	**84**	**82**	**77**	**78**
Eat out at restaurants	50	47	39	42
General sight seeing	35	30	24	21
Visit friends and relatives	29	37	20	28
Go shopping (pleasure)	27	25	25	21
Pubs, clubs and discos etc	26	23		
Picnics or BBQ	10	9	11	8
Total '000	**3,615**	**27,275**	**3,031**	**49,876**

12.3 Tourism forecasts

In terms of tourism forecasts Australia wide, the December 2004 forecasts indicate that:

There is a positive outlook for global tourism activity, with an expected 12% increase in total worldwide outbound visits.

- The Tourism Forecasting Council's forecast for international visitor arrival in 2004 was for 5.2 million representing a 10.5% increase after three years of consecutive declines. There is expected to be a moderate growth in 2005 of 5.9%. This is in line with the long-term annual average growth rate of 5.7% predicted for Australia (to year 2013); and
- In terms of domestic travel, there is expected to be little overall growth in this industry over the period to 2013 (approximately 1% per annum). Competition from outbound travel destinations (partly due to the strong Australian dollar) as well as other areas of expenditure is expecting to limit domestic activity.

12.4 Key estuary based facilities utilised by tourists

Detailed in the following sections are the key estuary based facilities that may be utilised by visitors to the region.

12.4.1 Boat ramps, accesses, parks and reserves

A review of available estuary based facilities including wharfs, boat ramps, campgrounds etc has been undertaken as part of the waterway usage assessments detailed in Section 8.4. A more detailed discussion on the Boultons Crossing/Gumma Reserve campground has been provided below.

12.4.1.1 Boultons Crossing/Gumma Reserve campground

The campground is located on a section of Crown Reserve adjacent to Warrell Creek. The campground is approximately mid-way between Nambucca Heads and Scotts Head and it is accessed via a combination of sealed and unsealed roads from Macksville.

The campground is designated as a "rustic campground" which defines the carrying capacity of the campsite and the way it is managed. For instance, it has a first come first served system, as there is no booking/reservation system and there is a maximum limit of 20 to 30 campsites that can be used at any one time (Robinson, K. Pers Comm., 2005). The reserve has toilets and tanks for water, however, it has no showers and no electricity/phone connection. Despite its apparent lack of facilities, the campground is very popular and is typically totally full over the Christmas and New Year period.

The Crown Reserve land is managed under a Plan of Management established by the Nambucca Shire Council. There is a local committee (6 members) that manages the reserve on behalf of Council, under a Plan of Management.

The Committee manages the campground with a non-profit arrangement. Parts of the collected fees are paid back to Council to cover their costs, with the remainder being put into campsite facility maintenance and improvement. The Committee recently spent $22,000 upgrading facilities in the toilet block at the campground (Robinson, K., Committee Member. Pers Comm., 2005).

The Committee recently introduced some new rules including a maximum limit of a month stay at the campground, a ban on the keeping of dogs at the campground and slightly increased overnight fees.

Responsibilities of the committee generally relates to the management of campers and ensuring that available facilities are in working order and suitable for usage demands:

- Collection of camping fees (@ $8.00 per campsite per day) on a twice per week collection roster;
- Management of campers, i.e. ensuring length of stay regulations are kept, not allowing dogs to the campground, ensuring that not too many campers try to utilise the campground at any one time, etc; and
- Management of facilities. Committee members oversee what needs to be done and when, e.g. emptying of septic system, replacement of damaged or broken equipment.

Responsibilities of Council include (note that they may be required to vary their regular maintenance schedules over peak holiday times as notified by the Committee):

- Maintaining the boat ramp;
- Waste collection;
- Maintaining the toilet block including cleaning and provision of disposables, such as toilet paper.
- Grass/tree cutting;
- Provision of water to the water tanks as required;
- Provision of firewood; and
- Emptying septic tanks as required.

From discussions with Committee members, there are no major issues with the campground and it appears to be suitable for its current level and range of usage. The foreshore in front of the campground is unstable, however, no camping is allowed within 10 m of the edge of the bank. The current septic system, although old, is regularly checked and emptied by pumpout truck prior to it overflowing. The level of the septic system is checked regularly over holiday periods.

To limit numbers of campers to this campground, it is important that it does not appear in road touring maps as a stop over location. Those who know about it, jealously guard the location of the campground. Further usage pressures, may facilitate changes that detract from what the campground currently offers. These types of campsites are becoming increasingly uncommon along the coast of NSW.

Items to be attended to include:

- Revising of the Plan of Management for the campground;
- Certification of the suitability of the setup and capacity of the existing septic tank needs to be performed by an appropriately qualified plumber. Consideration should be given to the implementation of a high level alarm on the tank. Formal procedures for the emptying of the septic tank are required and should be documented in the Plan for Management;
- Closure of the northern access to Warrell Creek to allow for regeneration;
- Regrading and protection of the unstable bank in front of the campground to promote improved access to the Creek;
- Installation of bins, which cannot be overturned by wild animals, dogs or accessed by birds.

12.4.2 Hotels, motels and caravan parks

The Shire is well serviced with a wide variety of accommodation styles ranging from:

- Hotels;
- Motels;
- Caravan Parks;
- Backpackers;

- Bed and Breakfasts;
- Holiday houses; and
- Rustic Campsites, i.e. Boultons Crossing/Gumma Reserve.

The locations and facilities provided in the Shire are widely available from the internet and from local publications such as the Nambucca Visitor Guide which is published by the Guardian News on behalf of Nambucca Valley Tourism. This publication is updated annually.

As mentioned in Section 12.2 there was an increase in domestic overnight travellers in the North Coast NSW region over the years of 2002 to 2003, producing a 10% increase in the yearly takings of larger guesthouses.

12.4.3 Quality of existing published tourism information

Estuary based facilities

The Nambucca Visitor Guide contains a page, which describes in text, features of the Nambucca River estuary for boaters. The locations of major ramps are provided, however, it does not describe in detail facilities that are provided at the ramps. The maps provided in the Visitor Guide focus on the town centres and do not show the locations of non-urban ramps. There is little information available showing the extent or type of available facilities.

The NSW Maritime boating maps provide a better graphical base of where certain facilities are located in the estuary, however there is little information available showing the extent or type of available facilities.

A separate brochure that shows the locations and types of facilities available within the estuary will be prepared as part of the study. A similar quality of information should be adopted and integrated into other publications such as the Visitor Guide.

Fishing

Various internet sites have been located that contain maps and details of where to go for fishing in the estuary, such as http://www.marinews.com/exploring/exploring/maps/fm_nambucca.html. There is also a brief write up in the Nambucca Visitor Guide along with a variety of local contact points.

Birdwatching

Birdwatching is a popular passive recreational pursuit in Australia. To assist birdwatchers in the region, there is an information pamphlet available at the Nambucca Tourist Office called 'Birds of the Nambucca Valley'. This double-sided A4 brochure has been produced by the Nambucca Valley Birdwatchers. The brochure is to be used in conjunction with the Nambucca Tourist Guide (a free publication of the Nambucca Guardian News), which contains a reference map to identify bird watching locations for a range of species.

Other material

There is a wide variety of other published information available in the Tourist Office and on the internet in relation to activities and accommodation available in the Nambucca Shire.

12.5 Summary

Community and stakeholder consultation undertaken for this project (see Section 4) identified a general community concern that the condition of the estuary was declining and this was leading to a loss of tourism to the area. Approximately 1in 8 respondents indicated that they thought the current and potential future condition of the estuary would lead to a gradual decline in tourism to the area, this perception however, is not matched by current regional tourism trends which saw a large increase in the numbers domestic travel to the region over 2002 and 2003. It is acknowledged that the regional information includes other centres such as Coffs Harbour and Port Macquarie, however, based on discussions with local tourist officers, it is apparent that trends in the region are fairly consistent between all centres (Walden, M. Coffs Coast Tourism. Pers Comm., 2005).

Despite the fact that the natural beauty of the Nambucca River estuary is widely recognised, there appears to be a lack of tourism promotion of this and other estuarine values. Local tourist operators have identified that the estuary is potentially under-utilised, except during the peak holiday times. The usage of the estuary for passive recreational pursuits is low, despite it having many suitable areas for different forms of passive recreation. There are also very few forms of commercial estuary based tourism and there may be many opportunities for the future establishment of sympathetic tourism industries. A greater usage of existing Crown land areas around the estuary may also increase the amenity and usability of the estuary for tourists.

In terms of visitation to the North Coast NSW region, domestic overnight visitation is the second highest in the State after the Sydney region. People visiting the region tend to stay for a significant amount of time when compared to the State average. Whilst not a focal point for international tourists, the region appears to be on a par with other coastal regions to which most international travellers go.

Statistics indicate an increase of 10% in the accommodation takings in the North Coast NSW region over the 2002 to 2003 financial year. The value of accommodation takings to the establishments (with more than 15 bedrooms) in 2003 alone was $84.3 million. This does not include takings from other forms of accommodation, e.g. caravan parks, B&Bs, small hotels/motels, etc.

Domestic visitor stays in the region peak around the school holiday periods, with January being the highest peak accounting for 15% of the yearly total, followed by October (11%) and March/April (9%). Most other months accounted for about 7% of the yearly total, with February being the lowest month at 6%.

Day and overnight domestic visitors to the region tend to utilise the region to undertake a variety of recreational pursuits including ‘outdoor/nature activities’ and ‘sports and active outdoor activities’ at levels well above the NSW state average. In the Nambucca Shire, it is likely that the Nambucca River estuary is one of the focal points for undertaking these outdoor and sports activities.

Tourism forecasts for domestic travel remains flat for the next 10-year period, however, there are potentially large increases in overseas visitors to Australia over this same period.

13 GUMMA GUMMA WETLAND

The Gumma Gumma wetland is located in Gumma, which is approximately 4km east of Macksville Town Centre.

As part of the consultation activities, WBM's on-site representative inspected the floodgate. At this time (approximately Nov 2004) the floodgates were observed to be in an advanced state of disrepair. As part of the consultation activities, WBM's on-site representative inspected the floodgate. The floodgates have since been removed as a component of construction of a bridge replacement (July 2006). Removal of this barrier provides improved fish passage and habitat access within the small estuary of Gumma Gumma Creek and its wetland.

Wetland Care Australia has been engaged by Nambucca Shire Council to deal with the issues and management of this wetland area . The recommendations of their study are included in Appendix A.

The continued implementation of the proposed wetland management options and monitoring established for the Gumma Gumma Wetland by Wetland Care Australia is endorsed by the Estuary Management Study (see Strategies **HM-1** and **HM-2** in Section 17).

14 CLIMATE CHANGE & SEA LEVEL RISE

14.1 Introduction

Internationally, there has been general acceptance by the scientific community that sea levels will rise as a result of global warming. Whilst there is still some debate about the rate of change, it seems that there is little doubt that low lying coastal lands are at a greater risk of inundation from storm surge and extreme tides. Understanding the risk associated with sea level rise will have ramifications for land-use planning.

14.2 Sea level rise prediction and impacts

There are uncertainties as to the actual magnitude and rate of rise of sea level as a result of thermal expansion of the oceans and melting of glaciers and ice-sheets. This has lead to various scenarios being adopted by the Intergovernmental Panel on Climate Change (IPCC). They are based on the range of model results available and dependant upon the amount of future emissions assumed. The Institution of Engineers, Australia, National Committee on Coastal and Ocean Engineering recommends that these values be used for planning and design.

Table 14-1 presents the latest low, mid (best), and high estimates of global mean sea level rise from IPCC (2001) for the years 2040 and 2100, relative to 1990.

Table 14-1 Anticipated Future Sea Level Rise (metres), relative to 1990

Year	Low	Best Estimate	High
2040	0.03	0.12	0.30
2100	0.09	0.48	0.88

Figure 14-1 presents the 2001 IPCC estimates of global mean sea level rise for six future emissions scenarios with allowance for climate uncertainty. The figure indicates the range of global average sea level rise from 1990 to 2100 to be between 0.09 and 0.88m with a central average value of 0.48m.

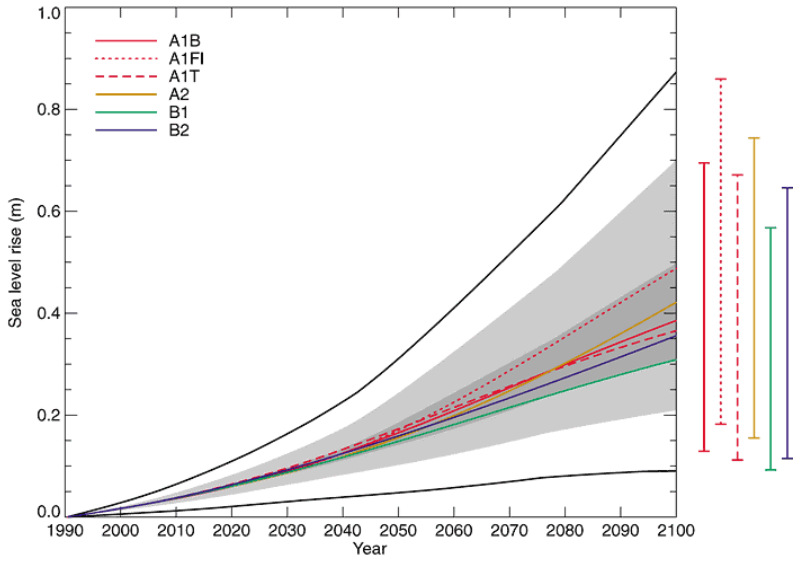


Figure 14-1 Global Average Sea Level Rise 1990 to 2100 (IPCC, 2001)

14.3 Potential impacts of sea level change

The likely impact of these predicted sea level rises include a general rise in the mean water level in the estuary which may translate to an increase in 'wet areas', increased inundation under flooding, altered hydrodynamics, altered geomorpholgoy and altered ecological functioning.

The increase in the estuary's mean water levels will allow tides to propagate further up the estuary changing tidal velocities. The increased tidal velocities (i.e. altered hydrodynamics) will bring about minor changes to the geomorphology of the estuary, e.g. positioning and size of shoals. The heightened water levels may also have some localised impacts on bank stability, erosion and the extent of inundation during flooding events (as a result of higher ocean water levels).

The increased tidal range and tidal velocities would be expected in increase salinity levels in upper reaches of the estuary. This would be expected to impact on the ecology of these areas. The extent of this impact is unknown, but is likely to relate to changes in the distributions of vegetative communities; particularly those which tend to exist in certain salinity bands. Also increased inundation of certain areas will force out certain species, but may also open up this area for colonisation by other species.

Also, there are likely to be a range of impacts on humans including, the relocation or altering of various foreshore structures such as boat ramps, revetment walls, house, roads, pipes and other infrastructure.

The preparation of detailed inundation maps to show the extent of potential inundation under normal and flood conditions has not been possible as part of the Estuary Management Study due to the lack of sufficiently accurate ground level information. Accurate ground level data should be collected by low level aerial photography with ground control to provide information with a vertical accuracy of approximately 0.1m. This information is essential to map the potential impacts of various levels of sea level rise and allow for the preparation of any required mitigation strategies.

15 WATER QUALITY

Water quality is regarded as one of a number of estuarine 'health' indicators. Degraded estuarine water quality affects the look, feel and safety of a waterway and should be of major concern for a region relying heavily on tourist income. Its impact on various commercial ventures, such as oystering may at times be significant and may potentially affect the long-term viability of such ventures.

The aim this section of the Estuary Management Plan is to "flesh-out" the main issues with water quality, to enable the identification of appropriate management techniques to ensure that estuarine water quality remains sufficient for current and future expected usage.

Community consultation activities (see Section 4) in relation to the estuary identified that water quality is one of their key values, and many were concerned with in regards to current and potential future water quality degradation, as a result of a variety of point and diffuse catchment inputs. Furthermore, one of the key visions or aspirations of the community was to maintain clean water within the estuary for its continued health.

15.1 Water quality pollutant sources

Water quality pollutants sources for an estuary are typically comprised of both point source and diffuse (i.e. catchment) derived pollutants. The likely sources of these pollutants in the Nambucca River Estuary are described in the following sections.

15.1.1 Point sources

Sewage treatment plants (STPs)

There are three (3) licenced sewage discharges to the Nambucca Estuary and consequently it is important that the treated effluent is of the best possible quality to ensure minimal impact on receiving waters. Comment on these discharges is provided below:

- **Macksville STP** - STP was upgraded in July 1998 and utilises extended aeration, nitrogen and phosphorus removal and UV disinfection. This significantly improved the quality of effluent being discharged to the Nambucca River adjacent to the confluence of Newee Creek with the Nambucca River. The plant has a licence discharge limit of 9500m^3/day of effluent and effluent must comply with the following EPA licence limits detailed in Table 15-1.

Table 15-1 Macksville STP discharge licence limits

Parameter	Units	90 percent limit	100 percent limit
Total-N	mg/L	15	25
N-NH_3	mg/L	5	10
Total-P	mg/L	1	3
pH	-	-	6.5-8.5
Faecal Coliforms	cfu/100mL	200	600
Biological Oxygen Demand	mg/L	15	20
Total Suspended Solids	mg/L	20	40
Grease and Oil	mg/L	-	10

- **Bowraville STP** - Bowraville STP discharges onto agricultural lands near Bowraville, but will discharge to the Nambucca River at times when this effluent cannot be irrigated. The Bowraville STP has the following EPA licence limits:
  - BOD < 20mg/L (100 percentile concentration limit);
  - TSS <30mg/L (100 percentile concentration limit);
  - Oil and Grease <10mg/L (100 percentile concentration limit); and
  - Discharge limit of 1500m^3/day.
- **Scotts Head STP –** Scotts Head STP does not discharge to Warrell Creek. Its effluent is directed to sand dunes between Warrell Creek and Forster Beach, downstream of Scotts Head. The Scotts Head STP has the following EPA licence limits:
  - BOD < 20mg/L (100 percentile concentration limit);
  - TSS <30mg/L (100 percentile concentration limit);
  - Oil and Grease <10mg/L (100 percentile concentration limit); and
  - Discharge limit of 2500m^3/day.

It should be noted that there is a fourth STP servicing Nambucca Heads, however it discharges into Deep Creek to the north of the study area. There are numerous pump stations that service this STP located around Nambucca Heads that can potentially impact on Nambucca estuary.

Industrial sources

The Public Register maintained by the Department of Environment and Conservation (i.e. Environment Protection Authority) identified 12 current activities within the Nambucca Shire LGA, which have licences issued under the Protection of the Environment Operations (PEO) Act. These included the four STP (discussed above), the Nambucca Tip and Landfill Site (operated again by the Nambucca Shire Council) and four sawmills (Newee Creek, Bowraville, Warrell Creek and Nambucca Heads). Other licenced operations included the Abattoir at Wirrimbi and the Quarry along Scotts Head Road.

There were five other previously licenced activities (mainly concrete batching plants) which used to operate under a licence, but these have since been surrended, as these activities are no longer licenced through the EPA. The operating conditions for these industries are not known.

The Midco abattoir at Wirrimbi closed its operations near Macksville in mid 1998. The property and facilities currently operate as a rendering facility.

Septic overflows and pump station spills

The Nambucca Shire Council has indicated that all pump stations in the urban areas cope with the current flows and do not overflow as a result of minor rainfall events. The oyster growers of the Nambucca River have identified the following recent sewage spills/overflows:

- 30 November 2005 sewage spill by Macksville STP discharge outlet into river due to heavy rainfall (resulted in river cloure until 16/12/2005);

- 3 March 2006 East Street Macksville, sewer manhole overflow (river closed in zones 2 and 3 til 22/3/06, zone 1 til 24/3/06); and
- 31 August 2006 East Street Macksville, sewer manhole overflow (river closed until 20/9/06).

The event in November 2005 coincided with heavy rainfall, the rainfall conditions at the time of the sewer manhole overflows is unknown. Given the proximity of the overflows at Macksville to the oyster harvest zone, further work is required to define acceptable rainfall immunity levels for these devices to prevent undue closures within the Nambucca River oyster harvest zones. It will be difficult and perhaps cost prohibitive to provide a high level of rainfall immunity to the entire system, hence, those systems, which present the highest risk, should be prioritised for attention.

In relation to septic overflows from private properties, Nambucca Shire Council is in the process of quality assuring the status of septic systems. In 1998 legislation was introduced into NSW requiring landowners/Councils to licence all on-site waste systems, e.g. septic tanks. Council commenced this process is 1999.

The process requires an initial inspection, after which a risk rating (high, medium, low) is applied to the system, depending on its potential to cause environmental harm, e.g. pollute local waterways. As a result of the initial inspection, Council may require the existing system to be modified, upgraded or replaced prior to a licence being issued. The period of the licence relates to the level of risk they pose, with high risk systems being granted the shortest period licence, i.e. 1 year and the lowest risk systems being granted a 5 year licence. Council reinspects the systems when the period of the licence expires and a new licence is required.

The initial inspection process is estimated to be 95% complete and should be completed end 2005 (Gall, P. NSC, Pers Comm., 2005). It is further estimated that the upgrading process is 60 or 70% complete and should be completed towards the end of 2006, depending on the level of implementation issues that are experienced with septic system owners.

The management plans that Council operate under are soon to be updated to recognise secondary treatment systems, which effectively reduce the risk that these systems may pose.

15.2 Non-point (diffuse) sources

Urban Stormwater

Stormwater is discharged from four major urban centres to the Nambucca River estuary including Scotts Head, Macksville, Bowraville and Nambucca Heads. Council has prepared a Stormwater Management Plan (NSC, 2000) to address the issues of stormwater runoff from these major urban centres. The plan, which includes a prioritised implementation strategy for stormwater management in the Shire, is currently being implemented by Council. One of the recommendations included within the report is for water quality monitoring, however, these options has not yet been implemented and there is no data on stormwater pollutant load changes to the estuary. The Plan is due for revision in 2005/06.

This is of concern as stormwater can have significant impacts on the health of receiving waters. For example, in October 2004, Warrell Creek showed a large sediment plume running from the urban area of Scotts Head. It is believed that this incident occurred as a result of poor erosion and sediment

control practices during urban sub-division construction works coupled with a poorly designed stormwater management system for the newly developed urban residential area. Figure 15-1 shows the sediment plume observed in Warrell Creek (photos courtesy of John Schmidt, DNR).

Figure 15-1 Sediment plume in Warrell Creek October 2004

Warrell Creek at Scotts Head is more sensitive to the impacts of enhanced pollutant loading, than other locations closer to the entrance as a result of its lower tidal flushing i.e. ~60 days at Scotts Head versus a few days at the entrance (WBM, 2000).

Stormwater runoff from other landuses

As detailed in Section 6.2, the major landuse within the study area are cleared lands at 50.3%, followed by remnant vegetation at 43.4%. Other landuses including regrowth, horticulture and forest plantation make up less than 3% of the total study area.

The quality of stormwater is known to vary according to the land use which occurs upon it. This is clearly articulated in the Cooperative Research Centre for Catchment Hydrology's review of stormwater quality (Duncan, 1999). This study analysed stormwater quality data form over 500 Australian and overseas studies. In general it was found that the quality of stormwater runoff from forested lands was the lowest in suspended sediment and nutrients (i.e. phosphorus and nitrogen), which are common waterway pollutants. The quality of stormwater from other land uses such as agricultural, rural residential and urban residential was significantly decreased in comparison to the forested land-use. There are also a number of site-specific factors, which influence the quality of stormwater runoff such as soil characteristics, local rainfall patterns and the degree of riparian buffering.

In general, the high proportion of forested and grassed lands, combined with the relatively small areas of intensively farmed lands (i.e. horticulture and cropping) is expected to have a significant positive impact on the quality of stormwater entering the Nambucca River estuary. However, there was insufficient amount of information available to gain a thorough understanding of the relationship between catchment runoff and receiving water quality. Detailed modelling tools have become available within the past few years which can provide estimates of nutrient and sediment export from catchments based upon its landuse, topography, meteorology, etc.

15.3 Water quality objectives

As described in the Estuary Processes Study, the Department of Environment and Conservation (DEC) has developed Interim Water Quality Objectives (WQOs) for the Nambucca River Catchment. The WQOs have been developed to protect various environmental values set for the estuary, as summarised in Figure 15-2.

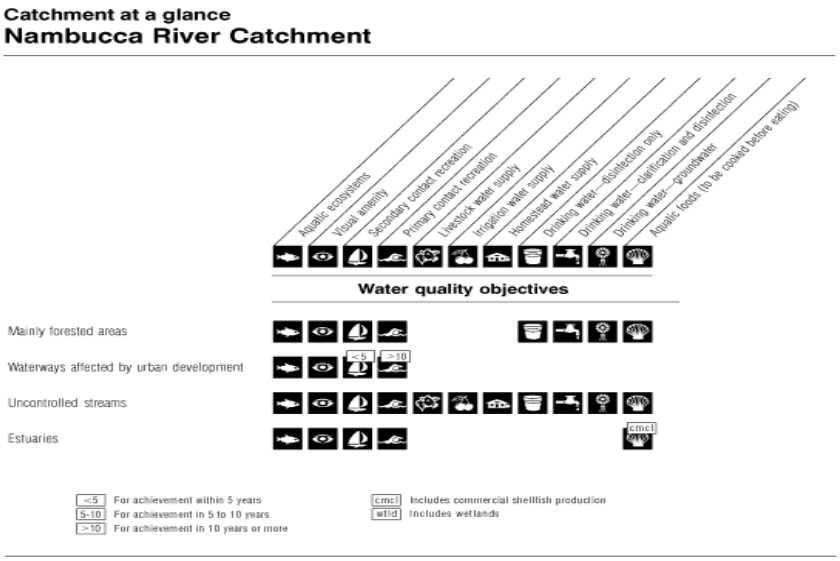


Figure 15-2 Water Quality Objectives for the Nambucca River Catchment

As estuaries typically require protection of several environmental values at once, a set of water quality objectives can be derived to ensure all values are protected by the adoption of the most stringent value for each key indicator. The water quality criteria for each value and the collated water quality objectives (WQO) are summarised in Table 15-2 for the estuarine regions. Only quantitative criteria for key indicators have been included such that comparison against water quality data can be made.

Table 15-2 Interim Water Quality Objectives (WQO) for the Estuarine Regions of Nambucca River Catchment

	Temperature (°C)	DO (mg/L)	pH	Turbidity (NTU)	Chlorophyll-a (µg/L)	Faecal Coliforms (per 100 mL)	TP (µg/L)	TN (µg/L)
Aquatic Ecosystems	<2°C change	>6 (80-90%)	6.5-9.0 – fresh <0.2 pH change - saline	<5	<10		<20	<300
Secondary Contact Recreation						<1000		
Primary Contact Recreation	15 – 35		5 - 9	<6		<150		
Visual Amenity								
Aquatic foods (cooked before eating)						<14		
Water Quality Objectives	15 – 35	>6 (80-90%)	5 - 9	<5	<10	<14	<20	<300

15.4 Historical water quality data

Water quality data for the Nambucca River Estuary has been collected by a number of sources at different times over the previous 15-year period. The following sections outline what water quality information is available and relevant to this study.

15.4.1 Estuary Processes Study

The Estuary Processes Study reviewed two of the identified sources of water quality data including:

- Nambucca Shire Council (NSC) data collected adjacent to Bowraville and Macksville STPs between 1991 and 2000; and
- Manly Hydraulics Laboratory (MHL): Water Quality survey 27th and 28th September 1999.

Outcomes from these previous investigations are detailed below:

General comparisons to Environmental Values and WQO

- Water quality generally does not meet the Interim Environmental Objectives set by the EPA, indicating that some of the environmental values desired for the Nambucca Estuary may not be being achieved, particularly protection of aquatic ecosystems, primary contact recreation (i.e. swimming) and consumption of aquatic foods.
- Regular exceedances of the DO, turbidity and faecal coliforms WQO were observed in the data reviewed. The faecal coliform WQO was exceeded 200m upstream and downstream of the Bowraville and Macksville STPs and 3km upstream of the Macksville STP. Less frequent exceedances of temperature, pH and chlorophyll-a were observed.
- Despite a general lack of nutrient data, available information revealed high phosphorous levels in the Nambucca River. Chlorophyll-a criteria (representative of algae) were exceeded in the upper reaches of the Nambucca River, probably contributed to by the high nutrient levels observed. It was hypothesised that these high nutrient levels were due to the discharges from the STPs at Bowraville and Macksville, with some contribution by catchment runoff (from rural and urban areas).

Water Quality Trends - Relationships between Water Quality and Rainfall data

- Turbidity levels at Bowraville appeared to vary with rainfall;
- Turbidity levels within the river around Macksville remained fairly constant with rainfall;
- No clear relationship between rainfall and the pH levels in the Nambucca River were observed. However, a general trend in pH levels across all sites was observed, with increasing and decreasing levels coordinated between all sites. A cause for the trend was not identified;
- Higher levels of total phosphorus in the Nambucca River during periods of lower rainfall were observed. This may be attributable to there being lower flows in the river providing a lower capacity to dilute the total phosphorus loads from STP's; and
- Higher levels of faecal coliforms generally occur during periods of high rainfall.

15.4.2 Nambucca CMC Community Water Quality Monitoring Project

Nambucca CMC Community Water Quality Monitoring Project, prepared by Ben Luffman for the Nambucca Shire Council, April 2000. This project collected data from 30 sites, 22 of which were monitored by volunteers. Water quality parameters included total phosphorus, total nitrogen, nitrate, nitrite, faecal coliforms, total suspended solids, electrical conductivity, pH, turbidity and temperature. Data collection was initiated in March 1998 and continued for 2 years.

Of the sites monitored, 13 were within the study area. Water quality data was compiled and used to compare against the water quality objectives for the various environmental values set for the Nambucca River estuary. A summary of the results is as follows:

- **Protection of Aquatic Ecosystems**: 3 good, 7 fair, 2 poor and 1 very poor. The site in Newee Creek recorded the very poor result, while the poor result was recorded at Wrights corner. The sites in the upper reaches of the Nambucca River estuary recorded the good results. The report identified that the Nambucca River estuary recorded considerable more sites with good and fair rankings than others in the North Coast region including the Tweed, Richmond, Brunswick and Clarence Rivers, based on the results of a study conducted by the EPA in 1996.
- **Primary Contact Recreation**: 9 good, 2 fair, 2 poor. Excessive faecal coliform levels were identified as the reason for the fair and poor results, which were obtained at sites near the tidal boundaries on the North arm of the Nambucca River and Warrell Creek.
- **Secondary Contact Recreation**: 13 good.
- **Edible Seafood – Shellfish**: 1 good, 4 fair, 3 poor, 2 very poor, 3 not relevant. The very poor results were obtained in Newee Creek and Upper Warrell Creek. Oysters are not grown in either of these locations (see Figure 11-6). Typically better results were obtained at locations closer to the mouth of the estuary.

The report identified that particular areas and sources of pollution required further investigation including:

- The source of faecal coliforms in the lower floodplains of the freshwater sections;
- The source of excessive TP at site 5 (Newee Creek); and
- The source of the high TSS and nutrient levels in the estuary overall.

Flood event sampling conducted as part of the study showed deterioration in water quality during high flow periods. The water quality data collected from the Nambucca River showed a distinct first flush characteristics with the poorest water quality being observed prior to the peak in the flood levels. Concentrations of water quality pollutants, such as suspended solids and nutrients were observed to decrease after this peak.

15.4.3 Other water quality monitoring data

Other recent water quality monitoring programs in the Nambucca River estuary are briefly discussed in the following sections.

DPWS Water Quality Monitoring at Nambucca River, Macksville

This report prepared by Manly Hydraulics Laboratory on behalf of the NSW Department of Land and Water Conservation in February 2001. This project collected water quality data from the public wharf at Macksville (i.e. on River St to the immediate west of the Pacific Highway Bridge) over the period February 1999 to February 2000. Key water quality results collected from this water quality logger are shown in Table 15-3.

Table 15-3 Key water quality results from MHL monitoring

Parameter	Unit	N, N', N"	Mean	Median	Std. Dev.	25%ile	75%ile	Max	Min
Level	m	34727 647 35374	0.27	0.23	0.3	0.06	0.45	2.14	-0.34
Conductivity	mS/cm	34354 1020 35374	24.77	27.70	11.32	17.70	33.20	49.60	0.15
pH	-	34356 1018 35374	7.57	7.63	0.35	7.30	7.80	8.26	6.28
Temperature	°C	34360 1014 35374	21.55	21.59	3.58	18.66	24.69	29.40	13.25
DO*	mg/L	31296 4078 35374	4.76	4.55	2.09	3.30	6.00	14.79	0.08
Turbidity*	NTU	31285 4089 35374	7	0	15	0	7	164	0

* No attempt was made to affect data which may have been affected by probe fouling, hence results may be inaccurate.

Salient findings include:

- Conductivity varies according to tidal movement and responded to rainfall and floods events.
- pH recorded was typical of saline water and varied varies according to tidal movement and responded to rainfall and floods events.
- Temperatures varied throughout the day and seasons.
- DO levels were typically lower than the ANZECC (2000) guideline value of 6 mg/L and DO levels varied with the movement of the tide.
- Turbidity was shown to increase with rainfall and flood events.

Nambucca Shire Drinking Water Quality Monitoring Project

This report prepared by Nambucca Shire Council (July – December 2002) and prepared for NSW Department of Health, February 2003. This project includes water quality data from four sites. Water quality parameters include aluminium, antimony, arsenic, barium, boron, cadmium, calcium, chloride, chromium, cobalt, copper, cyanide, *e. coli*, electrical conductivity (*in situ* & lab.), fluoride, iodine, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, nitrite, organochlorine pesticides, organophosphate pesticides, ph (*in situ* & lab.), potassium, selenium, silver, sodium, sulphate, synthetic pyrethroids, temperature (*in situ*), thermotolerant coliforms, total coliforms, total

dissolved solids, total nitrogen, turbidity and zinc. This report has not been sited, but the location of the monitoring sites may be outside the bounds of the estuary.

15.5 Recent water quality data

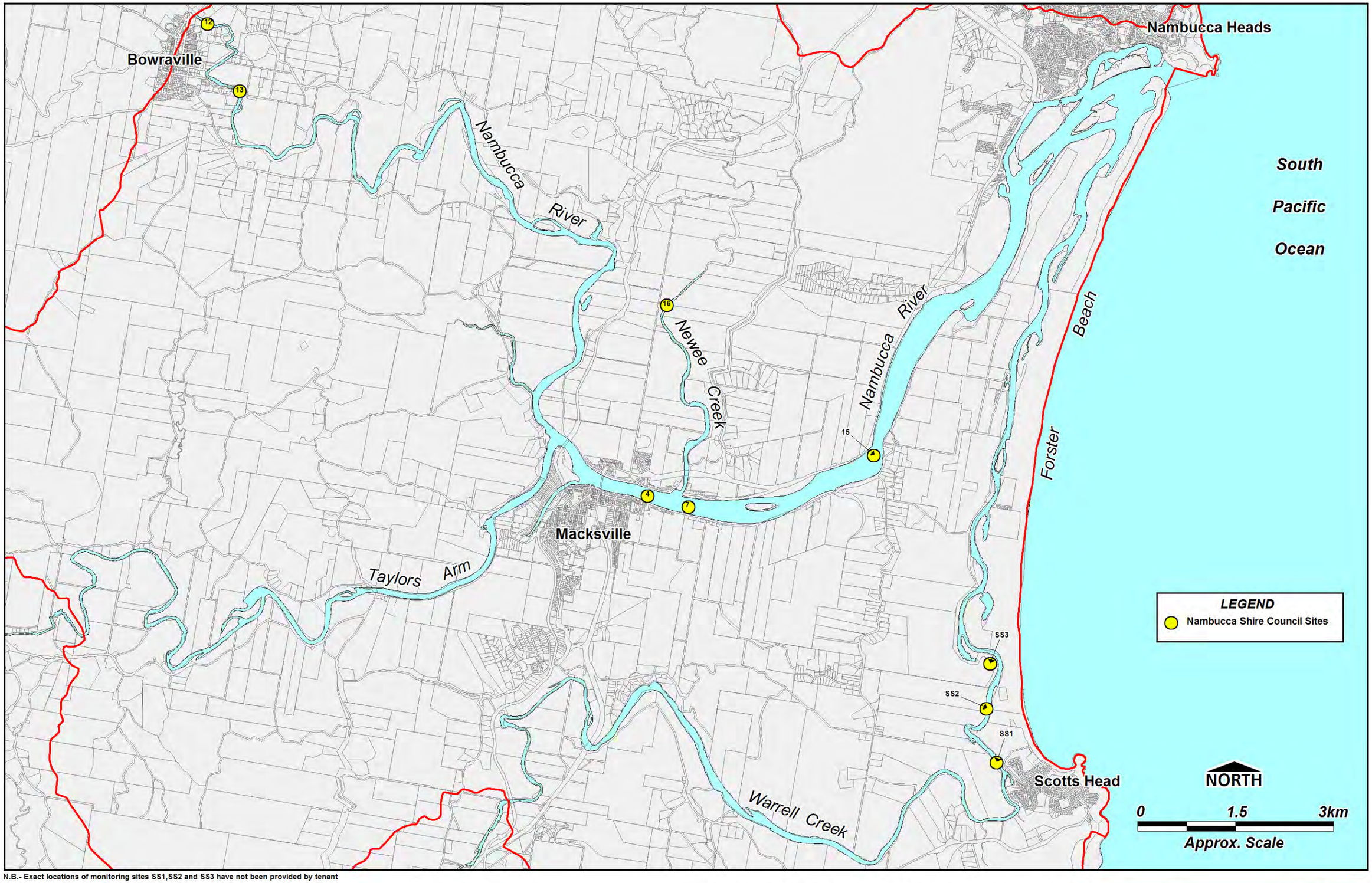
15.5.1 Nambucca Shire Council monitoring data

The Nambucca Shire Council currently monitors water quality in the Nambucca River Estuary as part of the conditions of Environmental Protection Licences with the DEC. Monitoring is currently undertaken for all activities, which require it in accordance with the conditions of the licence under the *Protection of the Environment Operations Act*. As such Council monitors receiving water quality near the sewage treatment plants (STP) and landfill site.

In relation to water quality monitoring for STP discharges, Council monitors the following sites:

- Bowraville STP and reuse site:
  - Monthly water quality data from the STP;
  - Monthly water quality data in the Nambucca River at locations 200m upstream and downstream of discharge point. Data is available since 2002;
  - Monthly water quality data in the Nambucca River at locations adjacent to upstream and downstream property boundary.
  - Sporadic water quality data from three groundwater bores located on the reuse site.
- Macksville STP:
  - Monthly water quality data from the STP;
  - Monthly water quality data in the Nambucca River at locations 200m upstream and downstream of discharge point. Data is available from 1991.
- Scotts Head STP:
  - Monthly water quality data from the STP;
  - Monthly water quality data in Warrell Creek River at three locations near the STP. Data is available from 2002; and
  - Monthly water quality data from four groundwater bores located near the STP. Data is available from 2002.
- Wrights Corner – Monthly water quality data is available since 1992;
- Newee Creek - Monthly water quality data is available since 1992.

The locations of the monitoring sites are shown on Figure 15-3.



N.B.- Exact locations of monitoring sites SS1,SS2 and SS3 have not been provided by tenant

Nambucca Shire Council Water Quality Monitoring Sites **Figure 15-3**

Council's water quality datasets have been provided for use in the study. Data was available up until around mid-2004. Water quality parameters tested by Council vary between sites and includes biological oxygen demand, total suspended solids, total nutrients, chlorophyll-a, oil and grease, pH, ammonia, dissolved nutrients, faecal coliforms, enterrococci, pH, electrically conductivity, turbidity, dissolved oxygen, temperature and salinity. The majority of testing was carried out on monthly basis with the primary STPs being sampled fortnightly.

Water quality data has been presented in Table 15-4 and Figure 15-4, Figure 15-5 and Figure 15-6 with the specific aims of:

- Assessing the impact of the reuse scheme being utilised at the Bowraville STP (Sites 12 and 13). Data has been presented at both locations pre and post reuse scheme introduction (i.e. 2002);
- Assessing the impact of the Macksville STP upgrade (Sites 4, 7 and 16). Data has been presented at both locations pre and post upgrade (i.e. 1998);
- Assessing the impact of the Macksville STP upgrade and changes in the management of the existing abattoir at Wirrimbi which now irrigates its waste (Sites 15). Data has been presented at both locations pre and post upgrade (i.e. 1998); and
- WQ near Scotts Head STP since 2002 (Sites SS1, SS2 and SS3).

Data presented in Table 15-4 shows the maximum, minimum, median, mean and total number of data points in the sample sets. The actual value being compared against the WQO is in bold and varies between a mean and median depending on the parameter in question. Pre- and post-upgrade data sets have been provided. In the case of Sites 4, 7, 15 and 16, a data set has been provided for pre and post August 1998. Sore Sites 12 and 13 data has been provided for pre and post August 2002. Cells highlighted in yellow are above the WQO. Figure 15-4 to Figure 15-6 are box and whisker plots showing the same data, a description of box and whisker plots is provided in Appendix G.

The data obtained from the sites in Warrell Creek (since April 2002) indicate that this system has high water quality and nearly meets all of it WQO. At some sites it has marginally exceeded its turbidity and total nitrogen requirements. The reported median faecal coliform level of 10 cfu/100mL is likely to be lower as the analysis used has a lowest observable limit (LOL) of 10 cfu/100mL.

Water quality data for sites 4 and 7 (near Macksville) show improvements in the TSS and TP levels when the pre-1998 data is compared to post-1998 data (see Figure 15-5 and Figure 15-6). TP and turbidity levels at both sites in the post-1998 are above the WQO, but only marginally. TN levels at both sites meet the objective, but there are only limited (i.e. 3 samples) upon which this result is based. A very small increase in median faecal coliform levels is noted, but this is expected to be a result of LOL of the analysis used.

Site 15 (Wrights Corner) water quality data show improvements in the TSS and TP levels when the pre-1998 data is compared to post-1998 data (see Figure 15-5 and Figure 15-6). TP levels post upgrade are above the WQO, but only marginally. Turbidity levels post upgrade are marginally above the WQO. TN levels meet the objective, but there are only limited (i.e. 3 samples) upon which this result is based. A very small increase in median faecal coliform levels is noted, but this is expected to be a result of LOL of the analysis used.

Table 15-4 Nambucca Shire Council Water Quality Monitoring Data

		Temperature	DO	pH	Turbidity	Chlorophyll-a	Faecal Coliforms	TP	TN
		(°C)	(mg/L)	-	(NTU)	(mg/L)	(per 100 mL)	(mg/L)	(mg/L)
		15 – 35	>6	5 to 9	<5	<10	<14	<0.02	<0.3
SS1	max	29.2	8.3	8.7	12.0	13	110.00	0.05	0.76
(April 2002 on)	min	12.9	3.4	7.0	0.0	2	0.00	0.00	0.22
	mean	**20.5**	**5.6**	**7.7**	**2.9**	**6**	20.00	**0.02**	**0.44**
	median	19.9	5.6	7.6	2.0	4	**10.00**	0.02	0.41
	n	21	16	21	19	4	22	22	22
SS2	max	29.0	9.0	8.9	10.0	10	100	0.05	0.67
(April 2002 on)	min	13.3	3.6	7.0	0.0	1	0.00	0.00	0.17
	mean	**20.6**	**5.9**	**7.8**	**3.1**	**4**	16.36	**0.02**	**0.41**
	median	19.8	5.7	7.7	3.6	2	**10.00**	0.02	0.39
	n	21	16	21	19	4	22	22	22
SS3	max	29.1	9.6	8.8	37.0	8	60	0.05	0.68
(April 2002 on)	min	13.6	3.7	7.0	0.0	1	0.00	0.00	0.17
	mean	**20.7**	**6.0**	**7.8**	**5.2**	**4**	13.64	**0.02**	**0.43**
	median	19.8	6.1	7.8	4.4	3	**10.00**	0.02	0.41
	n	21	16	21	21	4	22	22	22
Site 4	max	28.5	8.8	8.6	15.2		307.00	0.29	
(pre Aug 1998)	min	14.5	5.6	6.2	0.5		0.00	0.00	
	mean	**21.8**	**7.0**	**7.7**	**5.6**		35.79	**0.09**	
	median	22.1	7.1	7.8	5.1		**8.50**	0.08	
	n	51	49	52	54		68	72	
Site 4	max	28.0	16.8	9.3	27.0		267.00	0.30	0.36
(post Aug 1998)	min	14.2	3.1	6.8	0.0		0.00	0.01	0.25
	mean	**21.3**	**6.7**	**7.9**	**7.1**		30.94	**0.04**	**0.30**
	median	21.9	6.1	7.8	6.4		**10.00**	0.03	0.30
	n	72	57	68	65		72	72	3
Site 7	max	28.6	8.9	9.0	16.3		585.0	0.29	
(pre Aug 1998)	min	14.4	5.6	6.6	0.1		0.0	0.00	
	mean	**21.7**	**7.0**	**7.9**	**5.8**		36.8	**0.10**	
	median	22.2	7.1	7.9	5.5		**9.0**	0.08	
	n	52	50	52	55		67	72	
Site 7	max	28.1	16.8	11.3	28.0		252.0	0.84	0.32
(post Aug 1998)	min	14.0	0.9	6.8	0.0		0.0	0.01	0.28
	mean	**21.3**	**6.7**	**8.0**	**7.1**		30.0	**0.04**	**0.30**
	median	21.9	6.4	7.9	6.6		**10.0**	0.03	0.31
	n	70	54	68	67		71	71	3
Site 15	max	28.6	8.8	9.2	11.3		273.0	0.33	
(pre Aug 1998)	min	14.8	5.7	4.4	0.7		0.0	0.01	
	mean	**21.4**	**7.0**	**8.0**	**5.8**		30.9	**0.09**	
	median	21.6	7.0	8.0	6.0		**9.0**	0.08	
	n	51.0	46.0	49.0	50.0		67.0	68	
Site 15	max	27.8	16.9	11.9	19.0		165.0	0.14	0.31
(post Aug 1998)	min	14.1	0.2	7.2	2.0		0.0	0.00	0.25
	mean	**21.0**	**6.9**	**8.1**	**7.6**		19.4	**0.03**	**0.28**
	median	21.4	6.6	8.0	6.7		**10.0**	0.02	0.29
	n	71.0	54.0	64.0	64.0		72.0	72	3
Site 16	max	27.6	10.8	8.8	26.2		2733.0	0.66	
(pre Aug 1998)	min	14.2	1.1	6.4	3.6		0.0	0.00	
	mean	**21.3**	**5.2**	**7.5**	**12.2**		180.8	**0.17**	
	median	21.5	4.5	7.5	10.6		**42.0**	0.14	
	n	39	34.0	39	39		53	53	
Site 16	max	29.5	11.7	11.4	100.0		4081.0	0.29	1.14
(post Aug 1998)	min	12.4	1.2	6.5	1.0		4.0	0.00	0.44
	mean	**21.5**	**4.5**	**7.6**	**13.9**		178.5	**0.09**	**0.72**
	median	21.8	3.9	7.5	11.0		**20.0**	0.06	0.59
	n	72	54	65	67		72	72	3
Site 12	max	25.6	20.4	11.9	200.1		10865.0	0.31	
(pre Aug 2002)	min	14.3	1.1	6.3	0.0		16.0	0.00	
	avg	**19.2**	**8.0**	**8.2**	**11.3**		685.8	**0.05**	
	median	19.3	7.9	8.1	4.4		**190.0**	0.03	
	n	82	70	67	75		53	112	
Site 12	max	24.8	9.8	8.1	113.0		2000.0	0.05	0.49
(post Aug 2002)	min	13.3	3.0	6.5	0.0		20.0	0.01	0.11
	avg	**18.5**	**7.2**	**7.4**	**21.6**		205.6	**0.02**	**0.30**
	median	18.0	7.7	7.5	6.1		**85.0**	0.02	0.30
	n	25	22	23	24		26	26	2
Site 13	max	25.4	91.0	11.6	200.1		21600.0	0.59	
(pre Aug 2002)	min	14.3	3.5	6.5	0.0		27.0	0.01	
	avg	**19.1**	**9.1**	**7.9**	**11.3**		1034.9	**0.09**	
	median	19.4	8.0	8.0	5.0		**233.0**	0.06	
	n	82	70	66	76		49.0	112.0	
Site 13	max	26.1	9.2	8.2	25.0		370.0	0.90	0.30
(post Aug 2002)	min	13.2	3.7	6.5	0.0		20.0	0.01	0.09
	avg	**18.6**	**7.1**	**7.2**	**7.7**		119.1	**0.06**	**0.20**
	median	18.5	7.6	7.2	5.8		**82.0**	0.02	0.20
	n	25	22	23	21		26	26	2

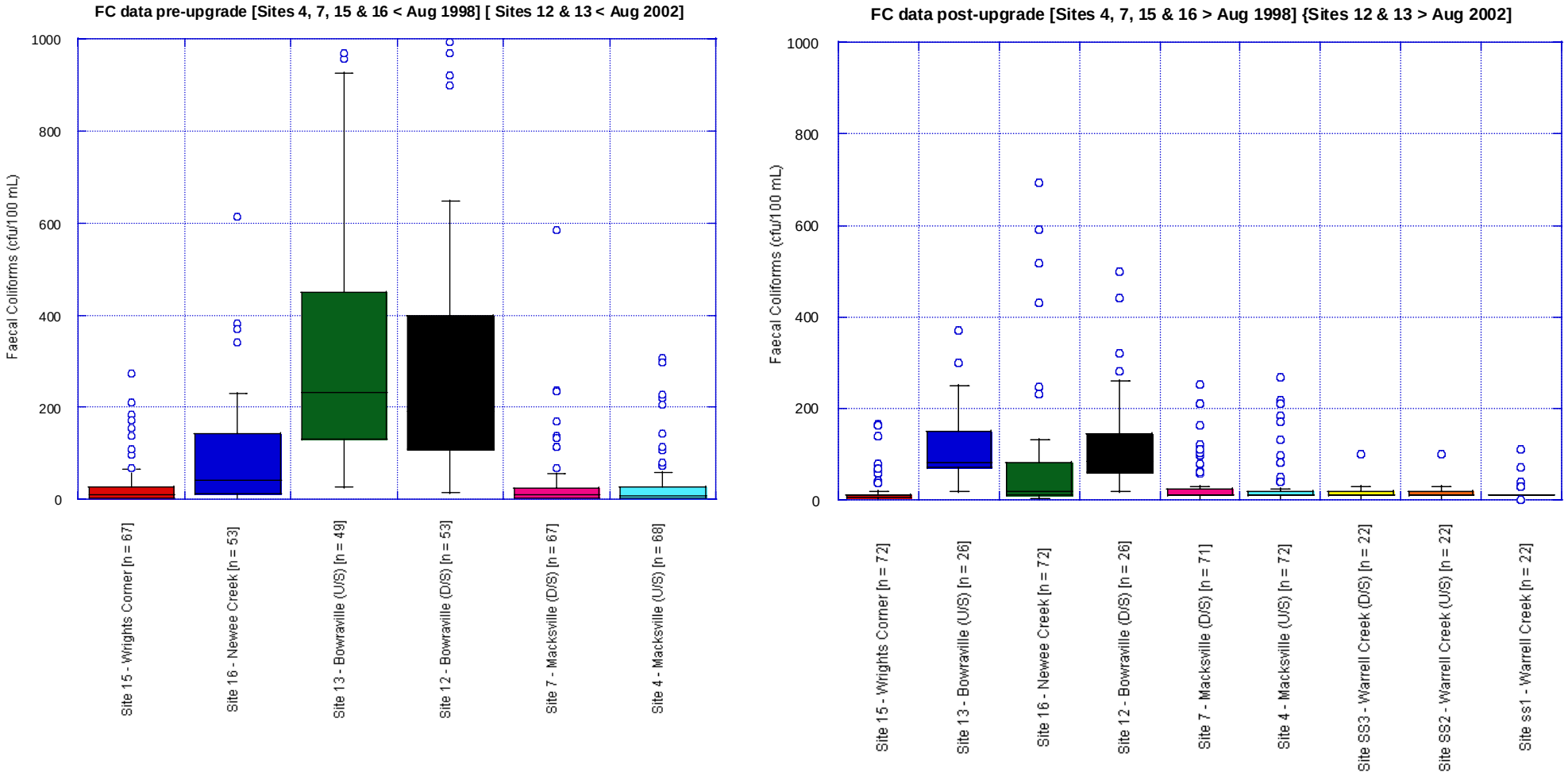


Figure 15-4 Faecal Coliform Box and Whisker Plots (Pre- and post-upgrade scenarios)

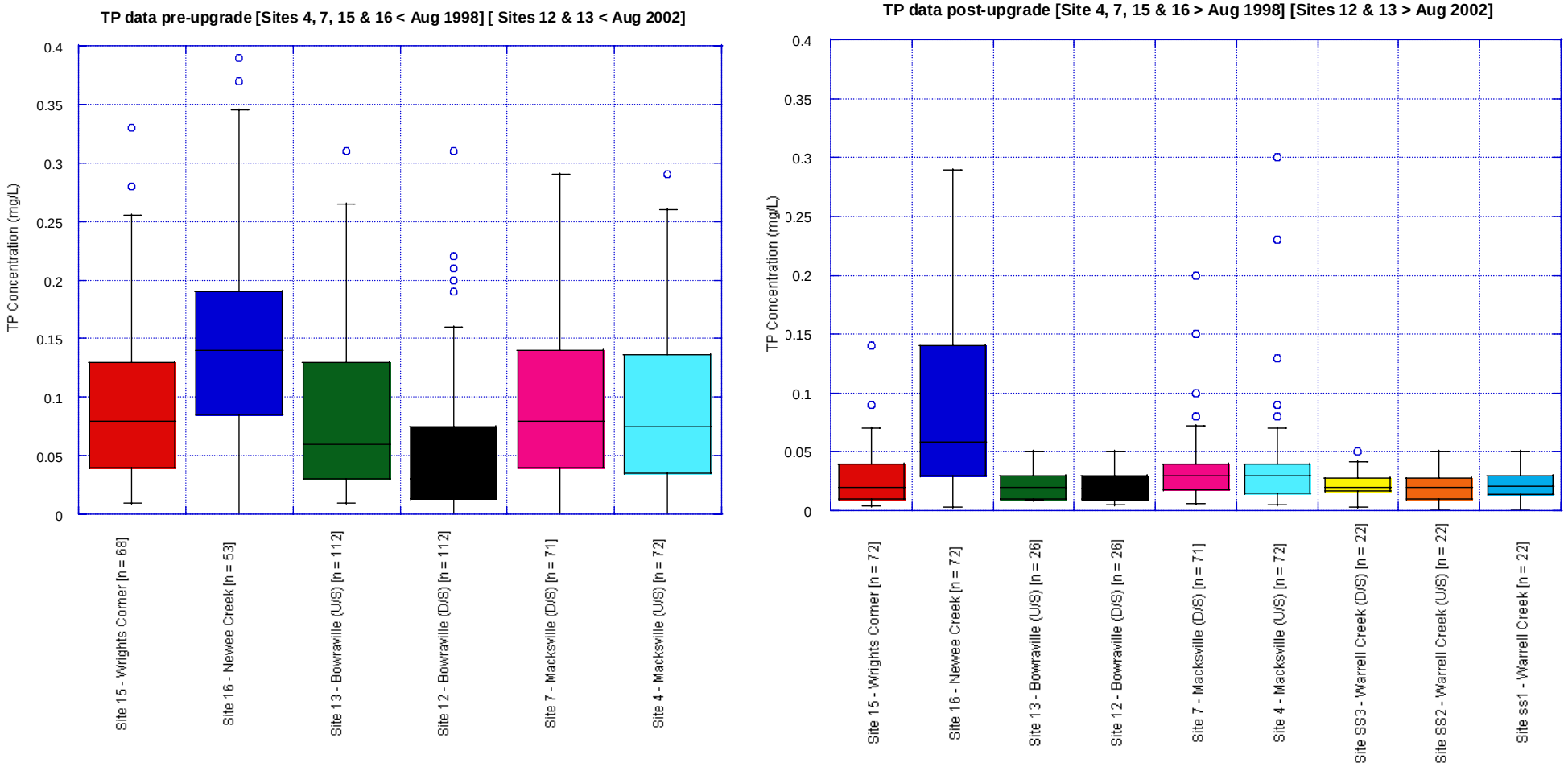


Figure 15-5 TP Box and Whisker Plots (Pre- and post-upgrade scenarios)

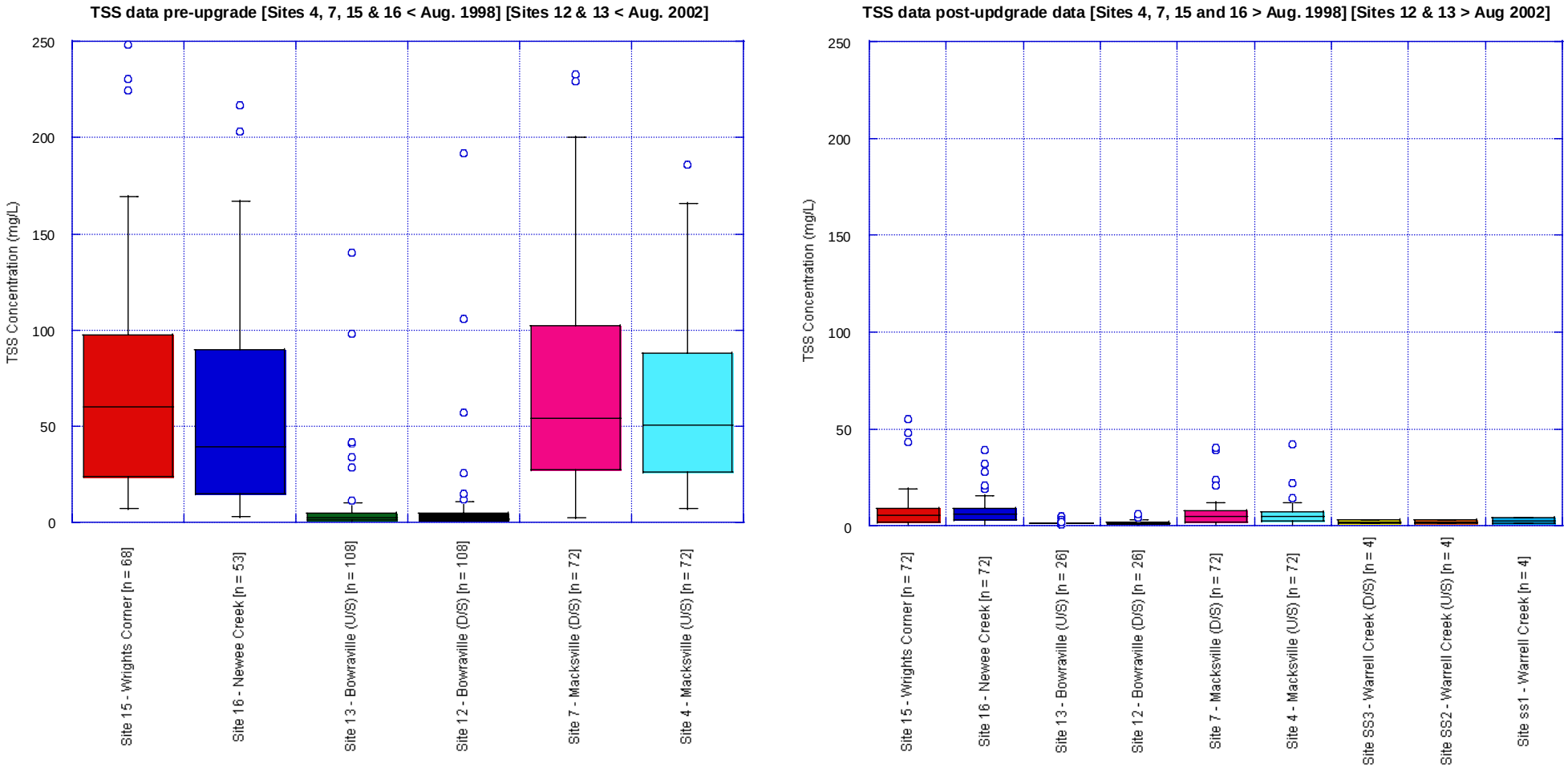


Figure 15-6 TSS Box and Whisker Plots (Pre- and post-upgrade scenarios)

Site 16 (Newee Creek) water quality data reveals that DO levels have decreased in Newee Creek when the pre-1998 data is compared to post-1998 data, however, the mean and median levels are below the WQO. Turbidity levels remain well above the WQO, however, there have been dramatic improvements in the TSS concentrations recorded during the pre/post 1998 period (see Figure 15-6). There have been some significant reductions in the median faecal coliform levels which have reduced from 42 down to 20 cfu/100mL. TP median values have also nearly halved across the pre/post 1998 period by reducing from 0.17 mg/L to 0.09 mg/L. However, both the faecal coliform and TP levels post upgrade are above the WQOs. TN values are also well above the objective at 0.72 mg/L, however, this result is only based on three samples.

Water quality data at Sites 12 and 13 (Bowraville) show that most water quality parameters have varied as a result of the reuse scheme. Of note was an increase in turbidity level at Site 12 and a decrease at Site 13. No explanation is provided for this change; regardless both sites are above the WQO. There were significant reductions in faecal coliform levels at both sites (see Figure 15-4), however, results remain above the WQO for edible seafood, but are sufficient for primary and secondary contact recreation. TP levels have dropped at both locations and Site 12 achieves the WQO, while Site 13 is marginally above it (see Figure 15-5). TN levels at both sites appear to meet the WQO (post upgrade only) but with only 2 samples being collected it is difficult to draw any firm conclusions from this.

General notes on Council's water quality sampling are:

- Sampling does not appear to have been conducted at the same time on the tide, this can influence water quality results, particularly in the lower estuary which experiences significant tidal flushing;
- The LOL for some parameters has hindered comparisons. Data collected since around mid-2001 has a LOL of 10 cfu/100mL where previously values were provided down to 1 cfu/100 mL;
- Council's water quality probe for salinity has provided erroneous results since the start of 2002. The water quality monitoring instruments need to be fully calibrated prior to each use; and
- Sampling does not occur at some locations used for swimming, such as those around Nambucca Heads and there is no data for Taylors Arm.

General comments on water quality in the Nambucca River estuary:

- The estuary overall appears to have high water quality, with the highest water quality being observed at the three monitoring sites in Warrell Creek. It is important to note that the majority of the sampling will have been undertaken during dry weather periods.
- There have been significant improvements in the concentrations of faecal coliforms, TP and TSS at a number of sites. TN levels appear to meet the WQO, but another couple of years of data will be required before any meaningful interpretation can be made;
- There are still issues with water quality in Newee Creek despite its improvement since August 1998. Data shows that Newee Creek's water quality is above the WQO for a number of parameters. It is not clear however, what the source of the water quality pollutants may be and further targeted sampling should be performed, particularly given the proximity of Newee Creek to oyster growing area; and

- There are still issues with water quality around Bowraville despite the improvements made as a result of the reuse scheme. The recorded water quality data is above the WQO for a number of parameters. It is not clear however, what the source of the water quality pollutants are and what their zone of impact is (i.e. does the impact zone extend to the lower estuary?). To address this knowledge gap, further targeted sampling should be performed.

15.5.2 Effect of entrance condition on water quality

The community consultation component of the study (see Section 4) identified a perception that water quality within the estuary was being adversely affected by the entrance condition, i.e. the gradual infilling of the entrance is causing a decline in water quality within the estuary.

Whilst, the infilling which causes a gradual reduction in the cross-sectional area of the entrance will restrict the resultant tidal range and hence flushing of the estuary. Water quality data presented in Section 15.5.2 shows that water quality over the past several years have significantly improved. Further, Figure 15-7, shows a plot of recorded rainfall (averaged between Bowraville and Macksville) versus recorded electrical conductivity at Wrights Corner (site 15) over the past several years. From this plot is can be seen that at Wrights Corner, the electrical conductivity is near that of oceanic waters and there does appear to have been any significant decreases as a result of entrance infilling.

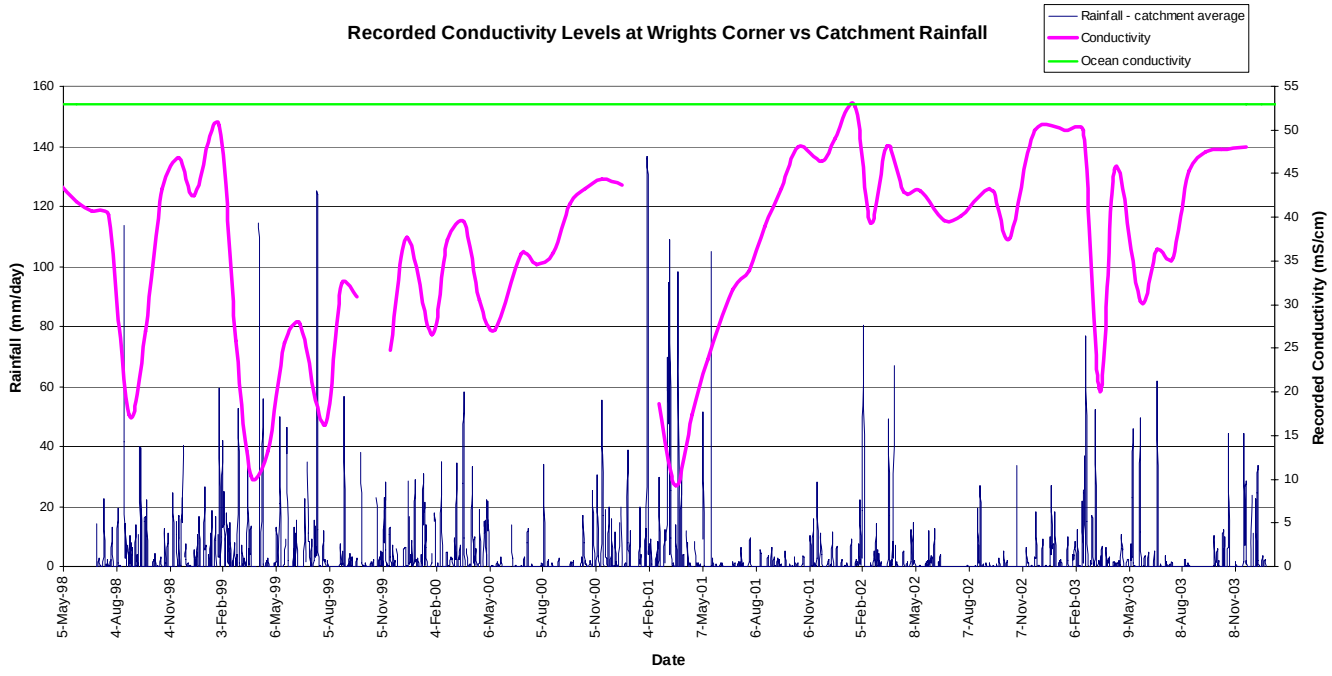


Figure 15-7 Conductivity data at Wrights Corner for period mid-1998 to end-2003

15.5.3 Effect of catchment runoff

The Estuary Processes Study (WBM, 2003) and Nambucca CMC Community Water Quality Monitoring Project (NSC, 2000) both found relationships between estuarine water quality and catchment runoff.

Faecal coliforms have been chosen for investigation, as a clear relationship was previously established between their presence in the estuary and rainfall (WBM, 2000). Figure 15-8 shows a plot of faecal coliform levels at several sites in the estuary versus rainfall over the period of mid-1998 to end-2003.

From this figure it is observed that the relationship was more pronounced in the earlier periods, i.e. 1998 through to 2001, than in the later periods. The plot also shows that in the later periods, typically only one site i.e. Newee Creek, continued to show a relationship between rainfall and faecal coliform levels, whereas in the earlier periods all four sites appeared to show a relationship.

The reasons for the improvements may include the STP upgrades, adoption of land based effluent reuse strategies (with provision for wet weather storage) for STP and other industries and/or upgrades to on-site sewage systems across the Shire.

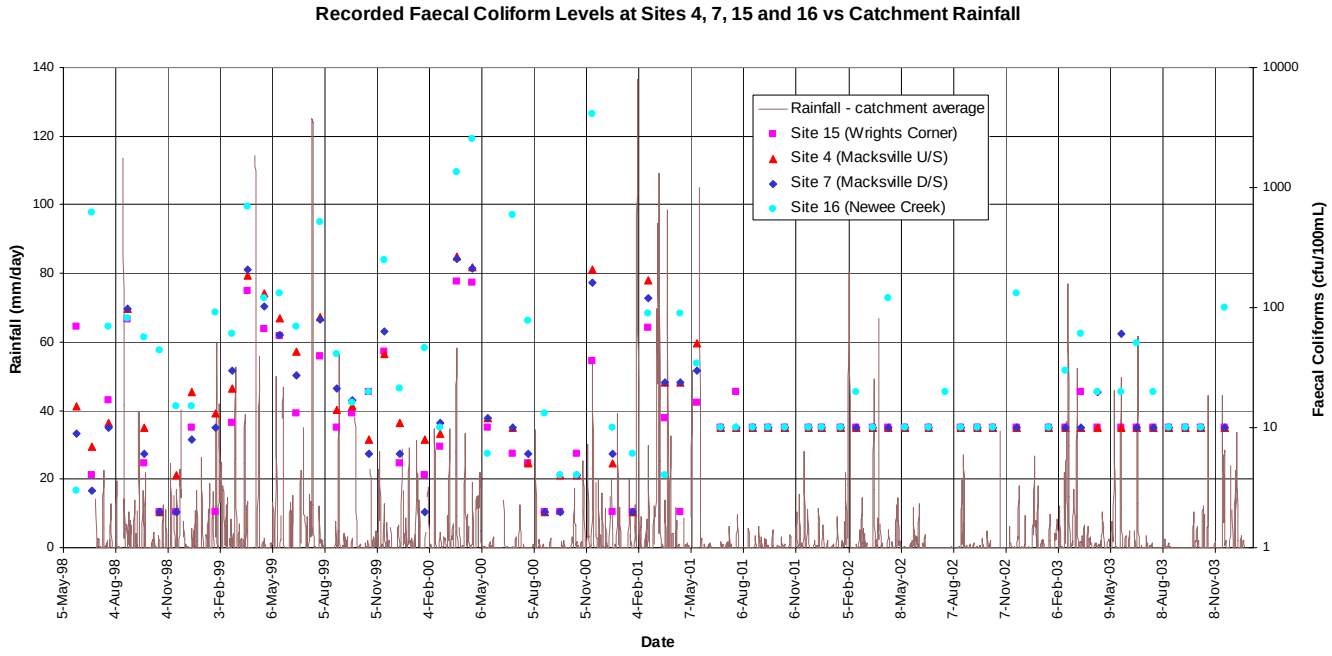
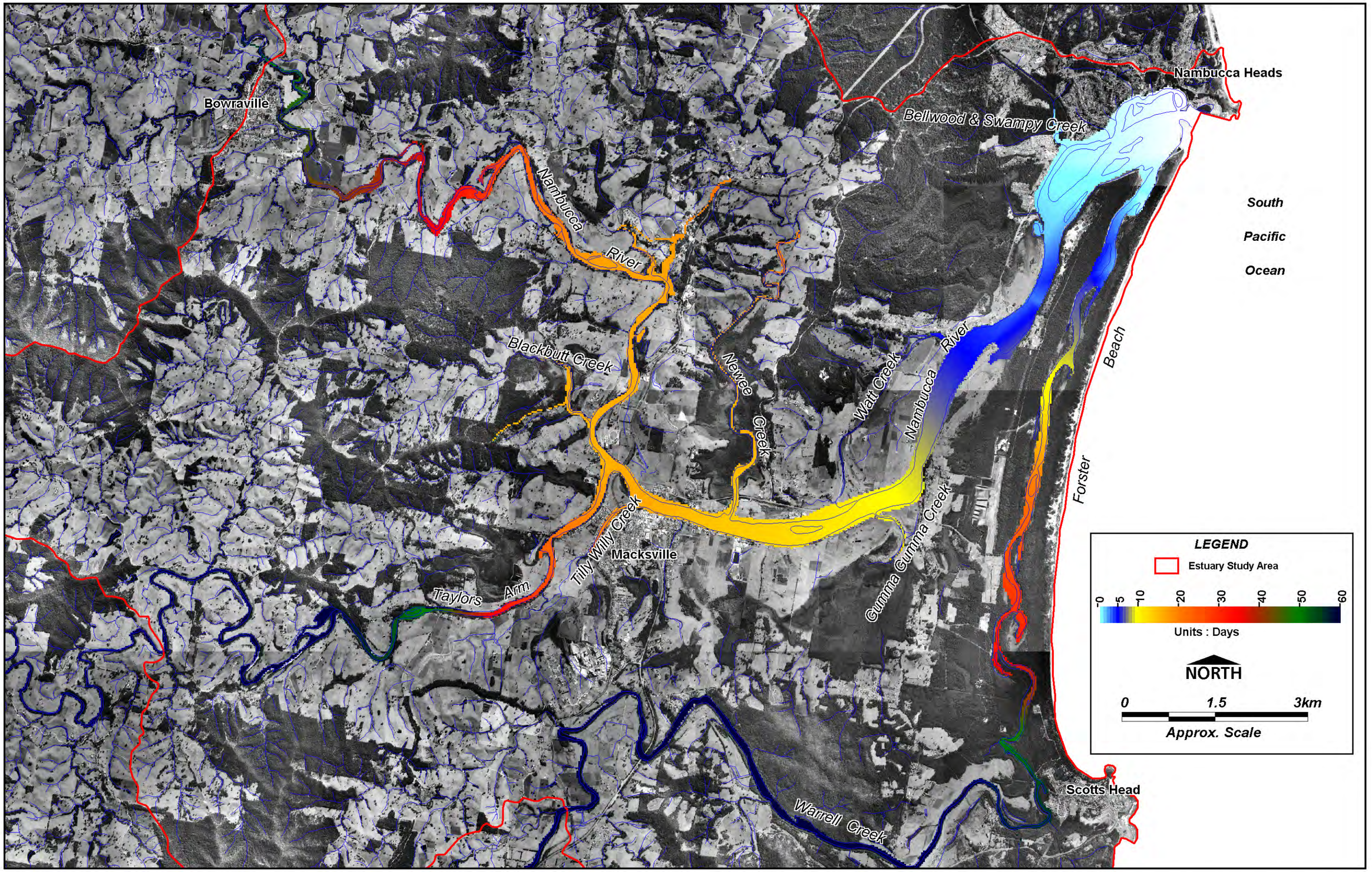


Figure 15-8 Faecal coliform levels at selected site versus catchment rainfall

Other water quality pollutants such as nitrogen and phosphorus exhibit a relationship between rainfall/runoff and enhanced levels in the estuary (WBM, 2003; DPWS, 2001; NSC, 2000). Increased levels of nutrients and other pollutants in the estuary can negatively impact on its ecological value and aesthetics. Effects are typically amplified in locations that are poorly (tidally) flushed. The longer residence times provide greater opportunity for additional loading, which may 'tip-the-scale' and facilitate conditions that may cause harm or other problems e.g. an algal bloom.

Figure 15-9 shows estuarine flushing (WBM, 2000) within the estuary. While there is no definitive information regarding the ability of certain flushing times to reduce water quality issues, it is considered that flushing times over about 2 weeks may present a higher risk of issues with water quality. Locations with lower flushing times are at a lower risk of developing associated water quality issues due to the increased tidal flushing at that location.



Predicted Estuary Flushing Plot **Figure 15-9**

High-risk locations are locations from wehere runoff will enter portions of the estuary with lower tidal flushing, and consequently present higher risks for the development of water quality issues. Other high-risk locations are those where discharges enter directly into sensitive receiving waters, such as oyster harvest zones. Stormwater and other discharges from high-risk zones need to have a high level of control implemented to ensure receiving water quality is not adversely impacted.

15.5.4 Oyster industry water quality monitoring data

15.5.4.1 Water quality monitoring data

Oyster production in New South Wales is monitored by the New South Wales Shellfish Quality Assurance Program (SQAP) to ensure that the product meets specific quality standards and that the estuarine waters in which production occurs meet environmental standards (see Section 11.2.4).

Water quality data collected for the Nambucca River estuary compiled under this program have been included in the NSW Aquaculture Shellfish Harvest Area Water Bacteriology and Phytoplankton Survey Data reports (NSW Food Authority, 2004).

Water quality data has been obtained and is included in Table 15-5. Data represented in this table has been collected over periods from year 2000 to 2006 and it includes all data (i.e. ambient and adverse condition data).

Table 15-5 Water quality monitoring results for oyster production areas in the Nambucca River

Sampling Location	Period of sampling	Number	Median cfu/100mL	Mean cfu/100mL	Max. cfu/100mL	10th perc cfu/100mL	90 perc cfu/100mL	Sampling Body
1 (zone 1)	May 03 – March 06	64	6.0	127.2	5000	0.6	107.0	Food authority
2 (zone 1)	May 03 – March 06	69	3.0	130.0	6200	0.0	74.0	Food authority
3 (zone 2)	May 03 – March 06	58	2.0	135.1	4600	0.0	55.8	Food authority
4 (zone 3)	May 03 – March 06	61	1.0	77.8	2300	0.0	33.0	Food authority
5 (zone 3)	May 03 – March 06	57	2.0	111.7	2900	0.0	27.4	Food authority
6 (zone 2)	May 03 – March 06	62	2.0	129.6	5600	0.0	83.4	Food authority
7 (zone 1)	May 03 – March 06	67	5.0	144.7	7000	0.0	85.4	Food authority

The data shows high maximum values have been observed throughout the estuary, these are typically associated with catchment runoff events. These higher values are affecting the geometric mean values. Median (or mid point) values are relatively low at around 1 to 6 cfu/100mL. 10^{th} percentile values are typically very low, while the 90^{th} percentile values are for many sites relatively high. It is interesting to note that the lowest median and mean values were recorded in zone 3 which receives the highest levels of tidal flushing.

The "scores" within each class (i.e. mean, median, 10 and 90^{th} percentile values) are used to classify the harvest areas within the Nambucca River. The NSW Food Authority performs their own statistical assessments on the data presented above to arrive at the classifications in accordance with

the standards that the industry operates to. The water quality monitoring locations are shown in Figure 15-10..

Additional data was obtained on oyster meat quality from several monitoring locations around the estuary. Data represented in this table has been collected over periods from year 2000 to 2006 and it includes all data (i.e. ambient and adverse condition data).

Table 15-6 Oyster meat quality monitoring results for oyster production areas in the Nambucca River

Sampling Location	Period of sampling	Number	Median cfu/gram	Mean cfu/gram	Max. cfu/gram	10th perc cfu/gram	90 perc cfu/gram	Sampling Body
8	May 03 – Feb 06	56	0.50	1.58	17	0.5	3.8	Food authority
9	May 03 – Feb 06	51	0.49	5.86	151	0.5	7.5	Food authority
10	May 03 – Feb 06	53	1.50	4.82	56	0.5	9.7	Food authority
11	Aug 03 – Feb 06	43	0.50	2.00	18	0.5	4.4	Food authority
12	May 03 – Feb 06	56	0.50	6.40	100	0.5	9.5	Food authority

The "scores" within each class (i.e. mean, median, 10 and 90th percentile values) are used to classify the harvest areas within the Nambucca River. The NSW Food Authority performs their own statistical assessments on the data presented above to arrive at the classifications in accordance with the standards the industry operates to. The water quality monitoring locations are shown in Figure 15-10..

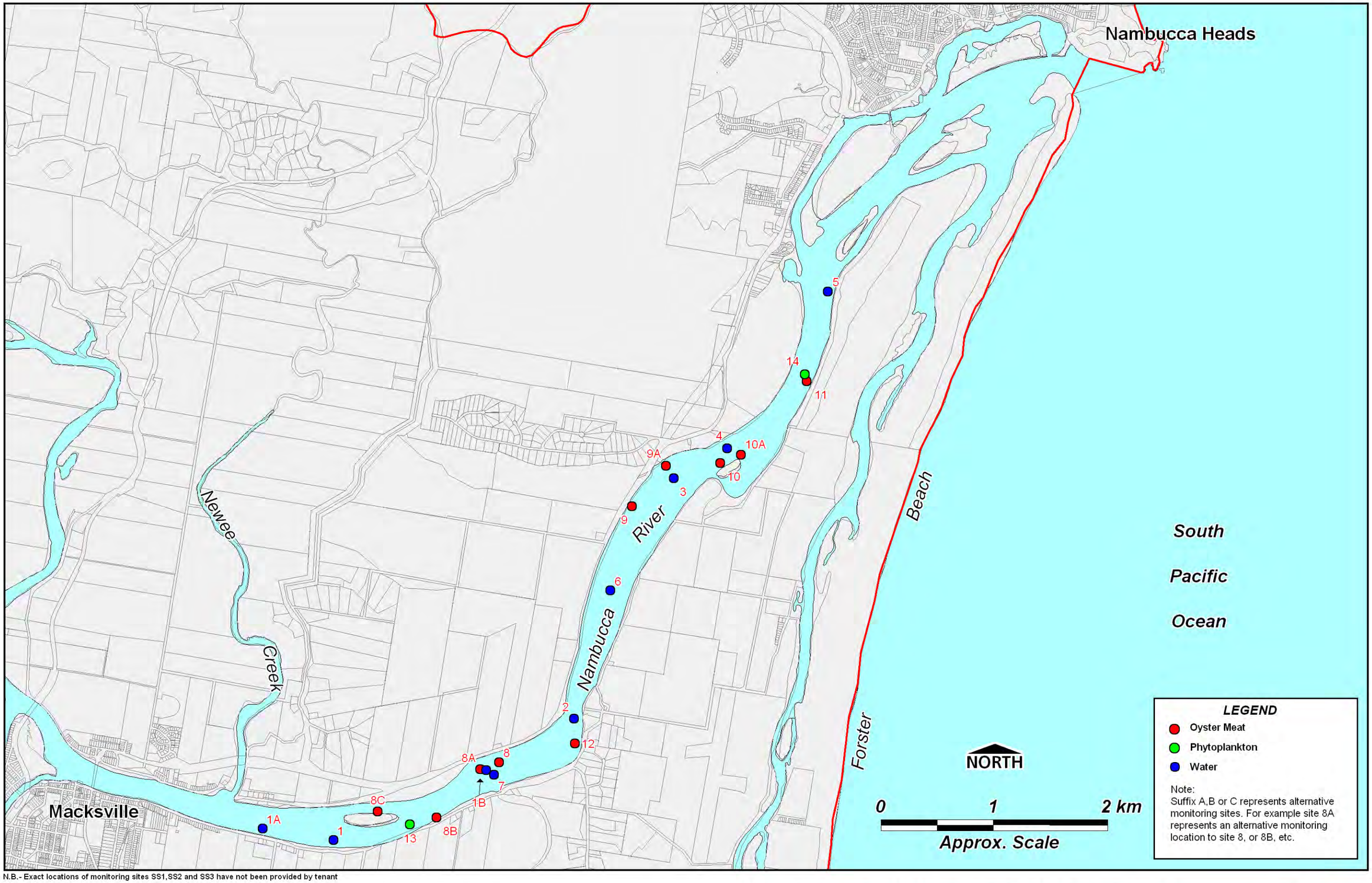
Additional water quality plots showing antecedent rainfall records have been included in Appendix I. These graphs indicate:

- That water quality in the Nambucca River Oyster harvest zone is high quality during fine weather, but is generally poor following significant rainfall events. This suggests a relationship exists between catchment rainfall and high levels of recorded faecal coliforms within the harvest zone;
- That there are also other factors causing high levels of faecal coliforms which aren't related to rainfall (note high values recorded on 21 October 2004); and
- That there are a high number of river closure days (see Table 15-7) imposed on the oyster growers, which suggests that there are water quality issues to be dealt with within the catchment.

15.5.4.2 Oyster lease closure data

Oyster closure data has been obtained from the NSW Food Authority for the years of 2001, 2002, 2003 and 2004.

A review of this data has provided a range of oyster harvest closure statistics for the various harvest zones of the Nambucca, Bellinger/Kalang and Richmond River estuaries as shown in Table 15-7.



N.B.- Exact locations of monitoring sites SS1,SS2 and SS3 have not been provided by tenant

Locations of Oyster Harvest Area Monitoring Sites Figure 15-10

Table 15-7 Oyster closure data for the Nambucca River estuary (days)

	Nambucca			Bellinger			Richmond		
Year	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 1**	**Zone 2**	**Zone 3**
2001	97	88	88	95	83	83	-	316	-
2002	20	84	50	35	47	17	-	240	-
2003	102	101	77	228	5	123	-	262	-
2004	119	93	89	199	153	119	-	311	144
Average	**73**	**92**	**76**	**139**	**72**	**86**	**-**	**282**	**144**

In the Nambucca River estuary Zone 1 is the uppermost harvest zone and it extends from around Goat Island to near Wrights Corner, zone 2 extends from near Wrights Corner to near the entrance of Watt Creek, zone 3 extends from near the entrance of Watt Creek to the westward end of Stuarts Island.

It can be seen from the results included in Table 15-7 that the zones of the Nambucca River estuary are closed on average for around 2 to 3 months of every year, with some individual closures lasting for over 2 months. Information provided by the NSW Food Authority has identified rainfall as the primary cause for closures and is estimated to conservatively account for over 80% of the closures in any given year. The reason that rainfall causes the closures is expected to relate to the impact of rainfall on faecal coliform or salinity levels, i.e. the rainfall triggers a response in estuarine water quality, which continues the closure. Other cited reasons for closures included sewage spills, diesel spills, microbial issues in water quality, microbial issues in oyster meat quality and low salinity levels. The Shellfish Program Manual, requires that the estuary meet the following prior to reopening after a closure event:

- Water quality standards (typically less than 70 cfu/100mL water);
- Shellfish quality standards (typically less than 10 e.coli/gram oyster meat);
- Salinity greater than 18 ppt for over 48 hours (measured mid-tide); and
- Other environmental or food safety criteria outlined by NSW Food Authority.

The closures observed for the Nambucca River estuary are comparable or better than those obtained for other estuaries in the same region and on the North Coast of NSW.

The longest closure period reported by NSW Food Authority for the Nambucca was 66 days (Zone 2, 26 August 2002 to 31 October 2002). The cited reason was localised rainfall, however, it is likely that the initial rainfall (and potentially subsequent rainfall events) caused an increase in faecal coliform levels (for instance), which has kept that harvest zone closed for that extended period. After large rainfall events, oyster farmers indicate that it takes about 4 weeks for the estuary to recovery (Ford, C., Oyster Farmer, Pers. Comm. 2004).

15.5.5 Adequacy of planning controls for stormwater and water quality

There was no stormwater quality data available for review as part of this study. Water quality data within the estuary was available at several sites (mostly located near STP discharge locations) and this has been reviewed earlier in this Section. Overall, it appears that the estuary has relatively high water quality (at or marginally above the WQO) with the highest water quality being observed within Warrell Creek (near Scotts Head). The latest data represents a significant improvement on the water quality data presented as part of the Estuary Processes Study (WBM, 2000).

However, there remain a few localised issues, particularly within Newee Creek and near Bowraville. The exact causes (i.e. urban stormwater, agricultural runoff, point source discharges, etc) of these issues are unknown and should be determined to enable appropriate actions to be taken.

Given the lack of stormwater quality data from urban centers and lack of water quality data in vast areas of the estuary, it is not possible to comment fully on the likely adequacy of current planning controls in regards to improving stormwater and protecting water quality. There does appear to be some inadequacy in development controls with a large sediment plume being observed in Warrell Creek in 2004 and still in 2006 (see Figure 15-1) arising from new urban development in Scotts Head.

The current Local Environment Plan and supporting Development Control Plans that regulate new (and retrofit) urban development are several years old. The control of stormwater and water quality is an emerging field and there have been significant knowledge gains made in just the past few years, many of these coming out of the Cooperative Research Centre for Catchment Hydrology. There has also been many policy and procedural improvements in recent years and the Department of Environment and Conservation is soon to release a new series of guidance documents in relation to managing urban stormwater.

In particular, Water Sensitive Urban Design is an emerging way to holistically integrate the water supply, wastewater and stormwater components of within urban development programs. The results can include reduce potable water consumption, reduced stormwater generation, improved stormwater quality and potentially reduced wastewater generation (if wastewater reuse schemes are adopted).

When these guidance documents become available, relevant components of these documents should be adopted and integrated into relevant Council planning legislation and practices.

The existence of the oyster industry within the estuary needs to be taken into account in Council's planning policies. If this industry is to be fully supported by Council, further consideration and adoption of appropriate planning controls needs to be occur, to prevent land use changes from occurring which are likely to have an detrimental impact on water quality (HRC, 2003a).

15.6 Summary

There have been a number of investigations into water quality in the Nambucca River estuary over the past five years. Two significant studies completed in 2000 both identified a number of issues with water quality.

These water quality assessments were however, not able to take fully into consideration the impacts of a number of water quality improvement schemes, which occurred just prior to or just after the reports, were released. A review of recent water quality data (maintained by NSC) indicates that the changes have brought about some significant improvements in water quality within the estuary.

The changes were mostly aimed at reducing the point source pollutant loads being received by the estuary and examples include the upgrade of the Macksville STP in mid-1998, the adoption of a land-based effluent irrigation scheme at the old Midco Abattoir site (which is now a rendering facility) and adoption of a land-based effluent irrigation scheme for the Bowraville STP in 2002.

Furthermore, the NSC has prepared and is in the process of implementing a Stormwater Management Plan (commenced 2000) for the major urban centres and has nearly completed the process of licencing all on-site sewage management systems in the Shire (commenced 1999).

Despite the improvements made to point source polluters, there remains a general lack of information in relation to the impacts of non-point source polluters on the Nambucca River estuary. This poses a serious limitation to any discussion of the likely adequacy of NSC's current planning controls for improving stormwater and protecting water quality. Regardless NSC's planning controls are now several year old (or more) and do not take into account many of the recent gains made in the fields of Water Sensitive Urban Design. The NSW Department of Environment and Conservation is soon to release a new series of guidance documents in relation to managing urban stormwater and relevant components of these documents should be adopted and integrated into the appropriate LEPs and DCPs of NSC.

Land-use information for the study area has identified that the major landuses in the study area were cleared land (50%) and remnant forest (43%) with only small areas of intensive land-use such as horticulture. In general, the further lands move away from their natural vegetated condition and the more intensively they are used, the worse the quality of the resultant stormwater runoff. Hence, the water quality of the Nambucca River estuary is likely to be somewhat protected by its relatively large areas of surrounding remnant forest and the low intensity of landuse in most areas. This is of major importance to the Nambucca River estuary's oyster industry, which is dependent upon high water quality to maintain the industry. If this industry is to be fully supported by NSC, further consideration and adoption of appropriate planning controls needs to be occur, to prevent any land use change from occurring that may have an detrimental impact on water quality (HRC, 2003a).

Water quality data collected as part of the Shellfish Quality Assurance Program (SQAP) has identified that overall there is good water quality within the harvest zone during predominantly fine weather, however, high faeceal coliform levels can be established after catchment runoff events. Water quality monitoring performed as part of the SQAP has resulted in the Nambucca River oyster harvest zone receiving a provisional "conditionally restricted" classification. The final classification should be confirmed late in 2006. At this time, water quality monitoring as part of this program will cease. Individual growers who operate oyster leases in restricted zones will still be required to perform their own water quality monitoring to enable harvesting to recommence.

A process of systematically recording all water quality data results obtained by the oyster farmers must be developed to improve the quality, extent and duration of water quality information being recorded for the Nambucca Shire Council. This data represents a significant investment by farmers, and is instrumental for water quality scientists and other to identify the success or otherwise of

schemes to improve water quality and identify issues before they become problematic. It is imagined that a Memorandum of Understanding or something similar, is established between Council and the growers to facilitate the transfer and recording of this information.

There is also a lack of holistic ecosystem health reporting for the Nambucca River estuary and all estuaries up the coast of NSW. This presents issues for funding organisations such as the Northern Rivers Catchment Management Authority (NRCMA) in identifying problem estuaries, which should become priorities for funding and subsequent improvement.

A system established in South East Queensland (SEQ), called the Ecosystem Health Monitoring Program (EHMP) delivers a year-by-year regional assessment of ambient ecosystem health (i.e. an assessment of background environmental condition) for the waterways of SEQ, via a report card type system. With its 'catchment to coast' philosophy, the program targets freshwater and estuarine/marine environments from Noosa in the north south to the NSW border and west to Toowoomba. It uses innovative science to measure waterway health through a range of biological, physical and chemical indictors, of which water quality is a key component. A similar system is required for the NSW estuaries and preliminary discussions are underway between the NRCMA and State and Local Governments to introduce such a scheme. If adopted regionally, the Nambucca River estuary should be included.

In the interim, until such as scheme is formally established for the Nambucca River estuary, Council needs to adopt the water quality monitoring previously proposed in the Estuary Processes Study (WBM, 2000), as the current statutory water quality monitoring is insufficient in its coverage and detail.

16 DEFINITION OF REGIONAL SIGNIFICANCE AND VALUES

This section describes the significance of the Nambucca River estuary in a national and regional sense. The local significance of the estuary, which is essentially a measures of the values and contribution to the communities quality of life have been derived from consultation activities conducted as part of this study are detailed in Section 4.

16.1 Values of estuary

16.1.1 Tourism values

The Nambucca Shire presents a style of tourism that is distinct from neighbouring areas, such as Coffs Harbour in its lack of overdevelopment. Many in the community value this difference in itself.

Regardless of its development status, the Nambucca Shire is still a popular tourism destination. It is part of the North Coast Region of NSW, which is one of the most visited regions of NSW by domestic visitors (Tourism NSW, 2004). The region also attracts its fair share of overseas visitors. It is known that many visitors to this region undertake outdoor activities during their stay, hence scenic places offering a variety of recreational pursuits, such as the Nambucca River estuary are likely to be a drawcard for tourism.

16.1.2 Commercial values

Commercial fishing continues in the Nambucca River. In May 2002 number numerous estuaries (or portions thereof) were closed to commercial fishing. Hence, the commercial fishing value of the Nambucca River estuary has become more significant to the State's finfish aquaculture industry. No data was available however to identify the contribution of the estuary to the Region 3 or State total. The direct value of the commercial fishery is estimated at approximately $280,000/annum (based on the past few years of catch value data).

The value of the Nambucca River estuary oyster industry is estimated to be approximately $0.5 to $0.7 million/annum (or 2% for the State industry income) based on average production values (over the last several years) and 2002/2003 prices for farm gate sales. This figure does not take into account any multiplying or ripple effects that this industry has on the local economy.

There are a few small local commercial boat and houseboat hire companies that operate on the estuary.

16.1.3 Recreational values

The most common recreational uses of the estuary include fishing (with much of this being done from boats), swimming, riding/walking and other forms of boating such as waterskiing.

These values of the estuary would be found in most other estuaries in the region and are not considered to be of regional importance. However, some sections of the north arm of the Nambucca River estuary are believed to present some of the best opportunities for water skiing in the region (R. Argent, Pers Comm., 2005).

16.1.4 Scenic values

Warrell Creek is the best-preserved arm of the Nambucca River, so well preserved in fact that it has been listed on the Register of the National Estate. In June 1996, the Australian Heritage Commission issued an Official Statement of Significance, which reads:

"*Warrell Creek is one of the largest and least disturbed examples in New South Wales of a contemporary estuary embedded in a beach barrier system and closely paralleling the present day beach. The place is a discrete tract of coastal landscape comprising a sand mass developed by beach progradation since the last major rise in sea level. The most distinctive geomorphological feature is the estuary of Warrell Creek, which flows northward just behind the beach for the entire 10km length of the beach. This phenomena is paralleled a kilometer further inland by the much larger estuary of the Nambucca river. The place is an outstanding scenic waterway, which exhibits a high degree of visual integrity, with more than 10km of waterway being lined almost entirely by a diversity of undisturbed coastal forest and dunes. In the New South Wales context it compares only with the much larger coastal estuarine waterways of the Myall and Esk Rivers.*

It supports a diversity of coastal vegetation communities, including several patches of littoral rainforest, which is a rare plant community in New South Wales. Six plant species are at or nearing their natural geographical limits of distribution in the Warrell Creek area, and one species is present which rarely occurs on the coast." (Gretchen, H., 2001).

16.1.5 Aboriginal Cultural Heritage

The estuaries, river valleys and coastline of the Nambucca region are resource rich areas that are likely to have had a significant influence on Aboriginal settlement of the area. Coastal land, estuaries and marine resources were and are still of major economic, spiritual and cultural importance to Aboriginal communities. Although, Aboriginal sites and places have been lost over time as a result of European settlement and natural environmental factors (e.g. weathering of rock art), the Nambucca region is rich in existing Aboriginal sites and places, which are of great cultural value and importance to the Aboriginal people of the area.

Sites and places of significance

There are a number of Aboriginal sites and places of significance located within the Nambucca region. Aboriginal sites and places are found in towns, on beaches, along riverbanks and tracks, on open plains and in dense forests. Different environment and different practices produce different sites. Sites of significance typically include:

- Art sites
- Axe grinding grooves
- Burial sites
- Camp sites
- Carved trees
- Caves and overhangs and rock shelters
- Contract sites, e.g. massacres
- Dreaming tracks: land and sky
- Fertile sites Fish traps
- Fishing and hunting areas
- Increase sites
- Initiation grounds
- Middens/Open middens
- Natural fossil beds
- Natural mythological sites Ovens/mounds Quarry sites
- Scarred trees
- Stone arrangements
- Totem sites (including birth sites)
- Water hole, waterfalls, spring and wells

A number of these sites exist in the study area, however, due to potential sensitivities in mapping specific sites and locations of Aboriginal significance, they have not been included in this report. More detailed (i.e. personal) consultation would be required with the Aboriginal communities to identify sites suitable to put out into the public domain, as this may place certain sites at greater risk of willful destruction (particularly if mapped). This level of consultation was not possible as part of this study.

Presently, identified sites and locations of local, regional and State significance are managed through various pieces of State Government legislation, including:

- *National Parks and Wildlife Act 1974* – This Act provides statutory protection for all Aboriginal objects and places in NSW. Areas are gazetted as Aboriginal places if the Minister is satisfied that there is enough evidence to show the area is, or was, of special significance to Aboriginal culture.
- *Heritage Act 1977* – This Act protects the State's natural and cultural heritage. Aboriginal places or objects that are recognized as having high cultural value are listed on the State Heritage Register.
- *Environmental Planning and Assessment Act 1979* – This Act provides protection by considering impacts on Aboriginal heritage in land use and planning decisions. The three main areas are:
  - Planning instruments allow particular uses for land and specify constraints. Aboriginal heritage is a value which should be assessed when determining land use;
  - Section 79C of the Act lists matters, which must be considered before development approval is granted. Aboriginal Heritage is one of the issues considered under the terms of Section 79C; and
  - State government agencies act as the determining authority on the environmental impacts of proposed activities and must consider a variety of community and cultural factors, including Aboriginal heritage, in their decisions.

Fishing

The estuaries and ocean beaches of the Nambucca region contain areas of cultural importance to Indigenous people (NSW Fisheries, 2001). Fishing is an important part of Aboriginal culture and in the local area fishing is undertaken in Nambucca Heads, Bellwood and Macksville (amongst others). Indigenous fishing is undertaken using a variety of methods and equipment, including hand gathering, lines, rods and reels, nets, traps and spears. Indigenous fishing targets a range of species of fish, shellfish, crabs and worms that are used for food, medicine or bait. Target species include (but are not limited to) mullet, flathead, whiting, tailor, bream, blackfish, mud crab, oysters, pipis, prawns, beach worms and river worms. Beach worming and shellfish gathering are recognised as an important part of the Aboriginal fisheries.

Summary

Many parts of the study area are likely to be of cultural importance to local Aboriginal groups. Any proposals to alter the estuary or land use within the catchment should take into consideration potential impacts of the proposal upon items and areas of Aboriginal cultural heritage.

16.1.6 European Cultural Heritage

Items of European cultural heritage significance typically encompass physical objects that have been left behind (although they may still be being used) from a bygone era that represent certain aspects of life and society typical of that era and assist in telling the story of European settlement in the region.

Cedar getters founded the beginning of permanent European settlement in the Nambucca. Cedar getting commenced in around 1833 and was still being carried on in 1871. The entrance to the Nambucca River presented significant difficulties for the transport of cedar out of the estuary to the Sydney and Brisbane markets. There is unfortunately little remaining of the sites of the timber mills, which were established in the Inner Harbour of Nambucca Heads in about 1870 to mill the cedar (and other timbers) extracted from the catchment. There are numerous wrecks in the area of the entrance to the estuary, such as the 'Wellington', which in November 1892, was wrecked on what was afterwards called Wellington Rock.

The site of Nambucca Village was proclaimed in 1870, at this time it is estimated that there were some 132 selectors taking up 175 positions on the Nambucca (population approximately 400). Almost half the selections were in the parishes of Bowra, Congarinni, Nambucca, Missabotti, Buckrabendinni and North Arm. Warrell Creek was exceedingly marshy, very low lying and flood prone (Ussher, G. Pers, Comm, 2005). The development of these areas and township has provided many examples of historic buildings including schools, churches, houses, etc, which are culturally significant.

Land clearing for timber and also agriculture commenced from this time and continued to the mid 1940's. It is believed that dairying became the predominant agricultural industry and the first butter factory was reportedly constructed in Macksville near the turn of the 20th century. The dairy industry declined in the 1930's with a gradual shift over to beef cattle grazing, and other small crops such as tomato, banana and carrots. This agricultural land use remains common in the area today. Unfortunately there are are few intact remnants within the study area associated with this period. The remains of some old wharf structures, which would have been used for the loading of produce onto ships, still exist in the study area.

To assist in navigation across the entrance, a breakwater was commenced on the northern shore of the Nambucca River in 1895. The breakwater was completed in 1907. Other subsequent works, such as the construction of the Stuarts Island Causeway in 1914/1915 and v-wall in 1915/1918, and continued maintenance dredging were completed right up to 1949. These works have left behind the breakwater, training walls and a number of sand islands (dredge spoil dumping locations).

Trains came to the area in the 1920's with the connection of Macksville (1919) and Nambucca Heads (1923) to the North Coast railway line. The North Coast Railway line was completed in about 1930. The use of trains has seen a gradual decline in the use of boats for commercial shipping. Associated with this historical period are a number of railway related features such as bridges, sidings and railway stations.

There are reports of some mining activities occurring in the study area in the period between 1920 and 1940; associated with this may be old well working equipment and structures.

European cultural heritage items in the study area are documented in a variety of sources including:

- **North Coast Regional Environmental Plan** - contains schedules (lists) of buildings and places that have been identified as having heritage significance.
- **Nambucca Shire Local Environmental Plan** - Heritage studies are conducted by Councils to identify items of heritage significance within their Shires. From here items, depending on their level of significance, i.e. local, State or National, will be afforded an appropriate level of heritage protection and will be included upon the relevant heritage register (different types of heritage listings are described further below). At a minimum, sites of local heritage value will be listed in the Shire's Local Environment Plan (LEP). No heritage study has been completed for the Nambucca Shire.
- **State Heritage Inventory/Register** - The State Heritage Inventory contains information about more than 20,000 heritage items listed on local Council's LEPs or on the State Heritage Register. While, the Heritage Office seeks to keep the State Heritage Inventory up to date, the most recent listings in LEPs may not yet be included.

  The State Heritage Register lists a diverse range of over 1,500 items, in both private and public ownership. To be listed, an item must be significant for the whole of NSW. The Heritage Council has developed criteria to help establish whether an item is State significant. Listing on the State Heritage Register means that the heritage item:

  - Is of particular importance to the people of NSW and enriches our understanding of our history and identity;
  - Is legally protected as a heritage item under the NSW Heritage Act;
  - Requires approval from the Heritage Council of NSW for major changes; and
  - Is eligible for financial incentives.

  The State Heritage Register lists a diverse range of places, buildings and objects including Aboriginal places, buildings, objects, monuments, gardens, natural landscapes, archaeological sites, shipwrecks, relics, streets, industrial structures, public buildings, shops, factories, houses, religious buildings, schools, conservation precincts, jetties, bridges and movable items such as church organs and ferries.

  Statutory registers provide legal protection for heritage items. In NSW legal protection generally comes from the *Heritage Act*, 1977 (amended 1998) and the *Environmental Planning and Assessment Act* 1979.

  An online database can be accessed to identify listed heritage items in the study area (www.heritage.nsw.gov.au). The search results identify the name of the item and its address, suburb, LGA and where the item listing came from, i.e. LEP, Government gazette, etc. No mapping data is available from the Inventory search.
- **National Trust** - The National Trust of Australia (NSW) maintains a register of landscapes, townscapes, buildings, industrial sites, cemeteries and other places, which the Trust determines, have heritage significance and are worthy of conservation. The Trust's Register is advisory and educational. A listing of a place or a building has no legal force, however it is recognised as an authoritative statement of the heritage significance of a place.

- **Register of the National Estate** - The Australian Heritage Commission is a Federal Government body that maintains the Register of the National Estate. This Register, like that of the National Trust has an advisory and educational role.

Summary

The Nambucca River estuary contains a wide variety of cultural heritage items owing to the rapid changes in key industries such as forestry, agriculture and the associated transportation networks development to support the industries, i.e. shipping and then rail. There are many listed heritage items within the study area, which occur primarily around the urban centers, e.g. heritage buildings. A comprehensive heritage study is required to better define European cultural heritage items within the study area. Site of importance will ultimately be included in the State Heritage Inventory and may depending on their level of importance be listed on the State Heritage Register (or similar).

16.1.7 Habitat values

The Nambucca River estuary supports habitats of regional, state and national conservation value including species and communities listed under the *Threatened Species Conservation Act* 1995, *Environment Protection and Biodiversity Conservation Act 1999*, *Fisheries Management Act 1994*, and/or State Environmental Planning Policies. These include:

- Coastal Saltmarsh;
- Swamp Oak Floodplain Forest;
- Swamp Sclerophyll Forest On Coastal Floodplains;
- Freshwater Wetlands On Coastal Floodplains;
- Littoral Rainforest;
- Lowland Rainforest on Floodplains;
- SEPP 26 Littoral Rainforest;
- SEPP 14 Wetlands;
- Lower estuary habitat for migratory waders; and
- *Glycine clandestina* (broad leaf form).

Based on data provided by DIPNR (2004), the Nambucca River catchment supports approximately 2% of SEPP26 littoral rainforest communities mapped in NSW, and approximately 1.3% of SEPP14 wetlands mapped in NSW.

The Nambucca River is one of the most significant and productive areas for shorebirds on the NSW coast (cited in Marshall, 2001) and several threatened waterbird species have been recorded here. The sandbars at the mouth of the Nambucca River and Warrell Creek have been used as nesting sites by Little Terns for at least 40 years, making the area the most important nesting site in the Dorrigo District. Recent records show depletion in the breeding success of the Little Tern and Beach stone curlew due to competition for nesting, roosting and foraging areas with humans (Marshall, 2001).

The study area supports the only known population of the endangered *Glycine clandestina* (broad leaf form). Currently there is no data available to determine the regional extent of other communities listed under the TSC Act within northern NSW.

Table 16-1 provides estuarine vegetation statistics for the northern NSW coast based on Russell (2005) and Fisheries (2004). Based on currently available mapping data, the Nambucca River estuary supports a high proportion (36%) of coastal saltmarsh in northern NSW and 17% of the estuarine vegetation mapped in northern NSW.

Table 16-1 Estuarine vegetation statistics for several north coast estuaries, after Russell (2005) and Fisheries (2004)

Estuary	Mangrove (ha)	Estuary % Mangroves in Northern NSW	Saltmarsh (ha)	Estuary % Saltmarsh in Northern NSW	Seagrass (ha)	Estuary % Seagrass in Northern NSW	Total (ha)	Estuary % Estuarine Vegetation in Northern NSW
Tweed River	398	30	76	21	81	38	555	29
Cudgen Creek	14	1	5	1	1	0	20	1
Cudgera Creek	15	1	7	2	3	1	25	1
Mooball Creek	11	1	1	0	2	1	14	1
Brunswick River	123	9	31	9	4	2	158	8
Belongil Creek	7	1	8	2	0	0	15	1
Richmond River	602	45	61	17	61	28	724	38
Evans River	37	3	40	11	1	0	78	4
Nambucca River	**142**	**11**	**128**	**36**	**63**	**29**	**333**	**17**

Whilst the study area does not currently support any wetland areas recognised by International Treaties, 100 Acre Swamp on Taylor's Arm is considered to satisfy several criteria for potential listing as a Wetland of International Importance under the Ramsar Convention (Blanch 2003 and Wetland Care Australia 2005). Blanch (2003) recommended that consideration be given to identifying a suite of candidate NSW North Coast Bioregion wetlands as part of a nested site nomination for the bioregion. In the case of the lower Nambucca River basin, Wetland Care Australia (2005), nominate the wetland complexes of Bellwood Swamp and the Warrell Creek estuary and catchment also be considered as part of this network.

The Manning Shelf marine bioregion extends from north of the Hunter River at Stockton to north of Nambucca Heads and includes all estuarine, coastal and offshore waters to the edge of the continental shelf. Australian marine bioregions and provinces provide a national framework for consistent, ecologically based planning of marine protected areas (MPA's). There are no current or nominated MPA's within the Nambucca River estuary, but a broad-scale biodiversity assessment of the Manning Shelf marine bioregion concluded that Warrell Creek had high conservation value and was one of the least impacted subcatchments of the major estuaries in the bioregion (Breen et. al., 2004). This site was recognised of conservation value within the bioregion for the adjacent wetlands, importance to bird fauna (including the threatened Little Tern) and its low degree of disturbance (Breen et. al., 2004).

16.1.8 Water Quality values

The Nambucca River estuary has relatively high water quality (being at or marginally above the objectives set for it by the Department of Environment and Conservation). This is of significant

importance for the local oyster industry which is solely dependent upon high water quality for its continued survival. It is also of importance for tourism and recreation as the high water quality of the estuary also makes it suitable for primary contact recreation (swimming), secondary contact recreation (i.e. sailing or windsurfing) and it also adds to the scenic values of the locality.

17 MANAGEMENT OBJECTIVES AND STRATEGIES

This section presents a set of overarching management objectives for the estuary (Section 17.1) and a prioritised list of management strategies to achieve them (see Section 17.2). As described in Section 17.2, the prioritisation process is an important step in focusing activities and funding towards addressing those issues which will potentially provide benefit to the many aspects of the estuary. Typically the highest priorities for implementation are those, which have the greatest potential to bring about required change within the estuary.

A series of tables are also provided (see Section 17.5) which provides further brief discussion in relation to what the focus of the management strategies are. Further detail will be provided in relation to each management strategy within the Estuary Management Plan (see Section 17.6).

17.1 Management Objectives

The general goal of the NSW State Government's Estuary Management Policy, 1992 is to achieve an integrated, balanced, responsible and ecologically sustainable use of the State's estuaries, which form a key component of coastal catchments. Specific objectives of the policy are:

- Protection of estuarine habitats and ecosystems in the long-term, including maintenance in each estuary of the necessary hydraulic regime;
- Preparation and implementation of a balanced long-term management plan for the sustainable use of each estuary and its catchment, in which all values and uses are considered, and which defines management strategies for:
  - Conservation of aquatic and other wildlife habitats;
  - Conservation of the aesthetic values of estuaries and wetlands;
  - Prevention of further estuary degradation (e.g. water quality, bank erosion, etc);
  - Repair of damage to the estuarine environment; and
  - Sustainable use of estuarine resources, including commercial uses and recreational uses.

In respect of the general goal of the Estuary Management Policy, the following overarching management objectives have been developed for the Nambucca River estuary, based on community uses and values association with the estuary (identified in consultation with the community and stakeholders) and from the technical reviews completed as part of this study.

Land Tenure and Usage (LTU)

Protect and enhance the existing uses and values of the estuary in both the short- and long-term by adoption of best practice land use planning and development controls.

Entrance Condition and Behaviour (EC)

Maintain navigation within the lower estuary for shallow draft vessels, consistent with current use, to maintain user amenity, safety and aesthetics, within the natural constraints of ocean and fluvial processes.

Boating and Waterway Usage (BWU)

Encourage boating use within the estuary that minimises its social and environmental impact, whilst not significantly reducing the amenity or safety of those boating on the estuary.

Improve the safety of swimmers of all ages within the estuary.

Water Quality (WQ)

Maintain and improve water quality within the estuary to support ecosystem function, commercial fishing/oyster production and tourism, and other forms of human recreation including swimming.

Habitat Management (HM)

Protect and enhance habitats to improve the health and biodiversity of the Nambucca River estuary.

Bank Erosion and Sedimentation (BE)

Improve overall riverbank condition on all major streams and waterways of the Nambucca Valley to limit future bank erosion and sedimentation.

Climate Change and Sea Level Rise (CCSLR)

Consider the potential implications of sea level rise on the estuary and its surrounds as a result of global scale climate change.

Cultural Heritage (CH)

Protect areas and items of Aboriginal and European cultural heritage within the estuary.

Community Liaison (CL)

Maintain open lines of communication with the community and local Aboriginal groups in relation to the ongoing management of the estuary.

Fisheries and Oyster Aquaculture (FOA)

Maintain and improve the viability of existing (and potential future) types of ecologically and commercially sustainable estuary-based aquaculture industries and enterprises.

Tourism Management (TM)

To preserve and improve the recreational and amenity values of the Nambucca River estuary, without resulting in deleterious impacts on the natural environment.

17.2 Management Strategies

A number of issues have been identified for the Nambucca River estuary. In response to these issues, management strategies have been developed to address them and achieve the requirements of the overarching management objectives. Provided below (by section heading) are summaries of the major issues and corresponding management strategies. Further information in relation to the issues can be obtained from a review of the various technical sections of this report (i.e. Sections 6 to 15) and from the '*Estuarine Geomorphology, Physical Condition and Mapping Report'* (Geco Environmental, 2005).

17.2.1 Land tenure and usage (LTU)

The following land use related issues have been identified as representing current and potential future threats to the health of the estuary.

Issue LTU-1

Site inspections of the overall condition of riparian lands (including banks and vegetation) within the estuary has identified that a significant portion of them exist in a moderate or poor condition (Geco Environmental, 2005). The reasons for this are numerous and in part relate to over clearing of riparian vegetation (e.g. for farm land or urban/rural development) and incompatible landuse (e.g. grazing on unfenced riverbanks which allows cattle access to the waterway), which cause ongoing damage to these lands.

In relation to land use control in these areas, there is a need for the improved recognition and protection of riparian lands within Council's planning framework, including the Local Environment Plan and Development Control Plans. In this context, "riparian lands" mean any land (and its associated vegetation) that adjoins, directly influences, or is influenced by a watercourse, wetland, or waterbody. The spatial extent of this land should be sufficient to provide the following core riparian function: bed and bank stability, water quality, aquatic and terrestrial habitat, riparian connectivity and protective buffer. The width of the riparian land should largely be determined by management objectives (and specific merits of a waterway) and supports the core riparian functions and management zones including core riparian zone and vegetated buffer (DNR, 2005).

The core riparian zone extends both sides from a watercourse, and landward from a wetland or other waterbody. The width of the core riparian zone should vary according to the management objective desired for that water feature. The following widths are suggested:

- Environmental corridor – a width greater than 50m;
- Terrestrial and aquatic habitat – a width greater than 30m; and
- Bed and bank stability and water quality – a width usually 10m.

Mapping of riparian widths based on the management objectives for the watercourse it contains would be required for integration into Council's planning framework to allow for future interrogation and use.

Strategy LTU-1. Incorporate appropriate riparian protection zones within Council's planning framework to safeguard them against potential future development and land-use change.

Issue LTU-2

There are numerous unlicenced foreshore structures within the estuary. Many of these structures were historically constructed by landowners to protect their property against bank erosion. The existing structures have inconsistent designs (i.e. size, shape and function) and detract from the overall aesthetics of the riverbanks e.g. Tillywilly Creek and Lower Taylors Arm (as shown in Figure 8-14). Due to the materials they have been constructed of, the foreshore structures when they finally erode may present an enduring ecological impact (e.g. loss of car tyres to the river bed). Unlicenced foreshore structures continue to be erected within the estuary. It is considered that the current multi-agency approvals process for foreshore structures inhibits individuals from attempting to obtain the appropriate approvals. Furthermore, there is a lack of suitable guidance available for individuals (and others) in the design of foreshore structures to ensure appropriate engineering standards and river health goals are being taken into account.

Strategy LTU-2. Incorporate river health goals and best practice design into future bank protection works (e.g. construction of future foreshore retaining walls) through an integrated and streamlined approvals process.

Issue LTU-3

Environmental harm has been noted to occur recently within the estuary as a result of new urban development (see Figure 15-1). These impacts are unacceptable and should be addressed through appropriate water management approaches:

- design measures for the construction and operational phases of developments that require the developer and future land owners to implement controls that prevent or reduce potential environmental impacts, e.g. use of effective sediment and erosion features such as sediment fences and ponds during the construction stage, use of Water Sensitive Urban Design (WSUD) to reduce the impacts of urban development during its operation, etc;
- monitoring and enforcement of requirements during the construction stage; and
- maintenance during the operational phase.

Solutions being adopted by other rural Councils at the design stage include the adoption of a Development Control Plan (DCP) which for WSUD. This DCP outlines the requirements for various types of development occurring on land with particular zonings. For example, a rural subdivision would trigger the code, which will require the applicant to address the requirements of the DCP as part of their development application.

At the construction and later stages, regular involvement and inspection by Council offices is an appropriate way to ensure compliance and provide long-term positive outcomes.

Strategy LTU-3. Minimise the environmental impact of new development by integrating best practice water management approaches (encompassing design, construction and operation) into Council's planning, approval and regulatory systems.

Issue LTU-4

There are numerous waterway structures, including ramps, jetties, etc in existence on the estuary, which are not accounted for in existing waterfront licences issued by the Lands Department. This has implications for managing waterway usage.

Strategy LTU-4. Ensure all foreshore structures are appropriately licenced, designed and maintained to protect foreshore amenity and access.

17.2.2 Entrance Conditions and Behaviour (EC)

The following entrance condition related issues have been identified:

Issue EC-1

Shoaling of the lower estuary in general is perceived as being a major issue. The shoaling is the result of a complex interaction of natural coastal and estuarine processes and while it varies with the prevailing conditions, the lower estuary has always been subject to shoaling.

The extent of shoaling influences the hydraulic characteristics of the estuary and has follow on effects for other estuary processes and values. Similarly, any measure undertaken to address the shoaling issue has the potential to impact upon other processes. For example, maintaining a deeper entrance channel may improve navigation and increase tidal flushing, but this may have environmental impacts associated with an increased tidal range in the extensive wetland areas around the estuary.

The interaction and complexity of the processes are such that there are many competing and potentially conflicting issues making management a complex and potentially expensive matter. A broad understanding of the processes as well as the potential implications and effectiveness of various works may assist in addressing existing community perceptions/expectations and acceptance of the ultimate management strategies adopted.

Strategy EC-1. Raise community awareness of coastal/estuary processes to increase the level of understanding of shoaling mechanisms and associated implications as well as the consequences of intervention measures.

Issue EC-2

Shoaling, changing and dangerous conditions of the entrance and lower estuary channels presently constrain navigation. Recreational boating and fishing has been recognised as a high use/priority which is affected by the degree of shoaling. Commercial boating and ready access for emergency vessels as well as future development potential are also affected by the shoaling and dangerous conditions. The degree of shoaling may also influence tidal flushing and flooding behaviour. Accordingly, measures to reduce the degree of shoaling and maintain deep navigable channels may have some other benefits. However, the interaction of the processes is such that there may be some conflicting adverse consequences.

The highly mobile nature of the sediments in the lower estuary is such that measures to provide and maintain permanently deep navigable channels would need to be substantial. They would be likely to

involve various training and ongoing dredging works at high costs. The commercial justification alone for such high costs is likely to be limited.

In relation to dredging activities, it should be noted that any proposals to sell the dredged sands would trigger the Native Title Act, as the entire entrance area is currently Crown Land. Further to this, sands in the entrance, although presently building up, remain part of the active coastal zone and should not be permanently removed from the system as it may result in corresponding erosion of adjacent ocean beaches as dredged areas try to re-fill under natural processes.

While options for providing overall long-term solutions to the shoaling, erosion and navigable safety may be cost and/or impact prohibitive, consideration could be given to minor works to improve localised issues in the lower estuary. However, such works may have limited benefit and/or be temporary in nature. The likely effectiveness, cost and potential benefits of such works need to be assessed as well as the potential impacts (social and environmental).

These works could involve various dredging and minor training/revetment wall schemes or alternatively removal of existing training walls. Appendix F includes a qualitative review of potential management options that could be implemented within the lower estuary.

Strategy EC-2. Address localised shoaling and erosion problems and improve navigable access where practical and most needed in the lower estuary giving consideration to the likely effectiveness, costs and benefits of works as well as the potential impacts.

17.2.3 Boating and Waterway Usage (BWU)

The following boating and waterway usage related issues and strategies have been identified:

Issue BWU-1

There were a number of usage conflicts and boat related impacts noted by the community in relation to existing waterway usage patterns. Boat usage impacts on the estuary include boat wash impacts on oyster growing areas, bank stability and saltmarsh communities, impacts of propellers on seagrasses and boat noise impacts on urban areas. There are also concerns regarding the lack of dedicated passive recreational areas and dedicated areas for other types of uses such as waterskiing and jetskiing.

Strategy BWU-1. Minimise the safety risk and environmental harm of boating on humans and other sensitive receptors of the estuary such as banks, vegetative habitats and oyster leases, via the use of sympathetic signage in strategic locations.

Issue BWU-2

The boating fraternity using the Nambucca River estuary may not be aware of the environmental impacts of their activities on the estuary. The social acceptability and community ownership of this type of waterway usage could be improved by increasing the knowledge base of all boat users in relation to acceptable and safe forms of boating and where various types of boating will be most appropriate within the estuary.

Strategy BWU-2. Raise community awareness as to the environmental impacts of boating within the estuary and boating techniques that could be employed to minimise them.

Issue BWU-3

There are presently safety issues and usage conflicts with recreational swimming at the V-wall and Shelley Beach. These issues should be addressed by a variety of means as appropriate for the situation.

Strategy BWU-3. Improve swimmer safety in the lower estuary by a variety of means including improved signage / safety equipment, provision of new swimming areas and/or improving the safety aspects of existing swimming areas.

Issue BWU-4

Council maintains a number of public ramps around the estuary with a variety of facilities. There are numerous unlicenced private access points on private lands and unlicenced public/private access points located on public lands. Regulation of the number and location of accesses (and associated facilities) to the estuary is recognised as a mechanism that can be employed to limit (social or environmental) usage impacts in susceptible areas. Any decision to alter the current access arrangements to the estuary needs to ensure that an acceptable level of access and facilities are maintained. Alterations to current waterway accesses should consider any zoning of waterway use, if this is adopted (see **Issue BWU-1**).

Strategy BWU-4. Rationalise access points, boat ramps and associated facilities to protect existing estuarine values and to provide quality public foreshore access to the estuary.

Issue BWU-5

Strategies BWU-1 to BWU-5 have aimed to avoid the use of heavy regulation of most portions of the estuary. However, if these strategies are failing to prevent excessive impacts as a result of boating, then a Boating Management Plan should be developed by NSW Maritime for those areas of the Nambucca River estuary that are being severely impacted. In support of such a plan it is likely that scientific information that clearly identifies the impact of boating, not just in general, but in specific reaches of the estuary, will be required to assist NSW Maritime in enforcing extra or heavier controls (see **inset** below). Some tools, amongst others that can be used in this process include: No boating, No Wash, 4 knot, no-tow, no water-skiing, etc.

Strategy BWU-5. Develop a formal Boating Management Plan for regions of the Nambucca River Estuary that are being excessively impacted upon by boating activities.

Inset: In proposing any form of restrictions on current boating within the estuary, e.g. boat speed and allowable locations of operation, it is important to recognise that formal changes need to be gazetted by NSW Maritime. Generally, amendments can be only made when there are navigation and/or safety concerns for recreational or commercial users, or when the environmental interests of a waterway are under threat. Given, the effort required on behalf on NSW Maritime to implement change through their department and then enforce it, only realistic and in certain instances, scientifically supported amendments could be considered. This means that speculative claims regarding the causes of conflict or environmental harm to the estuary will not be considered.

17.2.4 Bank Erosion and Sedimentation (BE)

Issue BE-1

Work completed by Geco Environmental (2005) identified that most of the major reaches of the Nambucca River estuary are suffering from riverbank instability. In the upper reaches of the estuary fluvial processes (i.e. floods) are believed to be the dominant processes driving channel change, while in the lower estuary wave action (from wind and boats) can also be a significant contributor. Bank stability can be affected by other human actions, such as clearing or damage of riverbank (i.e. riparian) vegetation and uncontrolled gravel extraction. These actions either limit the ability of the bank to remain stable against the impacts of wave action and floods flows, or lead to responses in the estuary bed which leads to further bank erosion and sedimentation.

Strategy BE-1. Improve overall riverbank condition (including riparian habitats) on all major streams and waterways within the Nambucca Valley.

17.2.5 Cultural Heritage (CH)

Issue CH-1

There are many concerns regarding the suitability of the Stuarts Island Causeway in its current form. One of the principal concerns is the negative impact it is having with a sacred Aboriginal site located immediately upstream of the causeway. The structure is also thought to have a range of deleterious environmental impacts, particularly in relation to reduced water quality, prevention of fish passage and enhanced sedimentation.

Hydrodynamic modelling of options to reintroduce tidal flow under the causeway has been performed and is further detailed in Appendix E.

Strategy CH-1. Reinstate tidal flow through the Stuarts Island Causeway, whilst minimising risk to swimmers utilising the Bellwood Swimming Hole.

Issue CH-2

There are a significant number of Aboriginal and European cultural heritage items and areas within the bounds of the estuary. These sites should be protected according to their level of significance. Many sites will be listed in Nambucca Shire Council's LEP, NSW State Heritage Inventory and Register and other heritage registers. However, our societal base of sites and items of significance is ever increasing as new studies are completed and time goes on. It is important that due care is taken to avoid damage to known cultural sites and sites that may be culturally significant.

Strategy CH-2. Ensure proposals that affect the estuary and surrounds afford an appropriate level of protection to items and areas of Aboriginal and European cultural heritage.

17.2.6 Community Liaison (CL)

Issue CL-1

There is a need to continue to engage and involve Aboriginal groups and the broader community in the future management of the estuary, particularly in addressing or resolving major issues or proposed developments. Representation of the broader community and local Aboriginal groups on the Estuary Management Committee is important, however, it may not always be the most appropriate to discuss or understand issues. In these instances, other consultation techniques may need to be pursed, as appropriate to the situation.

Strategy CL-1. Ensure adequate representation of local Aboriginal groups is maintained on the existing Estuary Management Committee and that issues are addressed via appropriate channels.

17.2.7 Habitat Management (HM)

In order to protect the health and values of the estuary, habitat management will need to focus on:

- Maintaining a network of native communities to retain and protect habitat and native biodiversity, to enhance water quality, and to provide visual amenity and intrinsic values;
- Recognising and protecting habitats and communities of conservation value;
- Maintaining a continuous intact and healthy native riverbank vegetation; and
- Reducing impacting factors which threaten the integrity of the estuary's habitats including stock and weed control.

The proposed actions in the Estuarine Geomorphology, Physical Condition, and Mapping for Nambucca River Estuary (Geco Environmental, 2005) targeting protection and rehabilitation of habitats should be implemented to protect and enhance habitats to improve the overall health and condition of the Nambucca River estuary.

Broad management strategies to address issues relating to habitat management are provided below.

Issue HM-1

The key habitat management priority for the study area is to protect habitats of high ecological and estuarine value, such as riparian corridors and endangered communities listed under the TSC, and to continue to protect habitats regulated by the Fisheries Act 1994 to ensure no net loss. It is more cost effective to protect these areas now than to rehabilitate them in the future if habitats are allowed to deteriorate.

All Council planning controls should be updated to ensure new developments utilise best practice in relation to water, fire, soil and weed management to protect significant habitat. For example clauses 16 to 20 of the LEP relate to the rural subdivision of zone 1(a1). The allowable areas for rural residential subdivision in the study area need to be revised in light of the potential long-term impact these land use changes may have on downstream SEPP 14 wetlands, such as 100 Acre Swamp, and communities listed as threatened under the TSC Act. One control option will be to specify no net

change in the hydrological regimes from upstream developments, including, no alterations to peak flows and volumes and no increases in the total pollutant loads.

It should be ensured that all existing significant habitats in the study area, and buffers to these, be protected. Buffers are the minimum width of vegetation retention or rehabilitation required adjacent to a habitat of high conservation/ecological value to ensure the values and functions of the habitat are restored and maintained.

Implementation of habitat protection and rehabilitation could be implemented through environmental covenants using legislative mechanisms, such as the *Native Vegetation Act 2003.* For example, all sites with high quality riparian vegetation (see Geco Environmental, 2005) should be protected and rehabilitated. In accordance with Geco Environmental (2005) the estuary management committee should seek to work in conjunction with government agencies to develop incentives for the long-term protection of areas of important riparian vegetation along the estuary. Mechanisms for protecting riparian vegetation will be available through the *Native Vegetation Act 2003* and regulations which allow for financial payments to landholders who develop Property Vegetation Plans which protect riparian lands (Geco Environmental, 2005). In addition, incentives could be targeted towards private landholders who wish to preserve or improve areas of vegetation adjacent to estuary including wetlands (Geco Environmental, 2005).

Implementation of these strategies would also require Council to integrate and update requirements into the LEP and relevant DCPs.

Strategy HM-1. Protect habitats of high ecological and estuarine conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands), through appropriate landuse planning and development controls.

Issue HM-2

Wide ranges of activities threaten the integrity and viability of existing habitats of high conservation and ecological value in the catchment, including:

- Weed invasion. The major impact of weeds is their displacement and replacement of native plant species and alteration of habitat values for native fauna. Weed control efforts should target newly introduced species which have the potential for environmental harm. . For example, madiera vine is a major environmental weed species which is just commencing to get a hold in the valley (Geco Environmental, 2005). The estuary management committee should seek assistance from the North Coast Weed Advisory Committee to develop a program of control with a minimum 3 year commitment for madiera vine. For other major environmental weed species such as camphor laurel, small leaved privet, and bitou bush targeted removal and control should also be undertaken in areas of otherwise good quality riparian vegetation. Follow-up control is essential.
- Rehabilitation: Management priorities should aim to rehabilitate sites of high ecological and estuarine value where degradation has occurred. Management priorities should be based on area and condition of remnants and adjacent landuses. For revegetation projects site-specific assessments will be required to determine appropriate planting species, densities, planting techniques and maintenance requirements, such as weed control. Site assessments should determine the condition of the habitat to be rehabilitated, documenting the extent and

composition of vegetation; fauna habitat features; site condition; adjacent land uses and impacting factors (weeds, fire). It would be prudent to target areas of known habitat value where possible.

- Drainage and exposure of acid sulphate soils. Of most concern are the impacts of flood mitigation and drainage measures on floodplain wetlands.
- Soil disturbance (stock impacts/ erosion / pathogen introduction);
- Poor water quality; and
- Inappropriate fire regimes. Although some vegetation communities in the Nambucca River Estuary catchment may be able to recover following fire, they may not benefit from it. Within the Nambucca River Estuary catchment, fire exclusion rather than use is the recommended management approach for most communities, but detailed site based assessments are required to identify the appropriate method and level of fire management.

Strategy HM-2. Enhance condition of habitats of high ecological or conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands).

Issue HM-3

Approximately 80% of the study area is privately owned, the remainder is constituted of a variety of Crown lands and State Forests. The regrowth communities of the study area provide potentially suitable habitat for a diverse range of flora and fauna species and may contribute to maintaining biodiversity values within the study area by providing wildlife refuge and forming part of the wildlife corridor network across the study area linking upland and lowland vegetation communities. Many of these sites occur on rural residential land and remain unprotected and prone to development pressure. The management priority for these habitats is to protect those that buffer significant ecological habitat or those that contribute to the wildlife network across the study area.

Strategy HM-3. Protect habitats of moderate or local ecological value (eg areas of native regrowth).

Issue HM-4

The majority of habitats of potential moderate to low ecological value occur on rural residential land and are prone to existing and future land uses. Significant environmental issues are likely within these lands including poor water quality, clearing and weed invasion, and may require more active management.

Strategy HM-4. Enhance condition of habitats of moderate or local ecological value (eg areas of native regrowth).

17.2.8 Fisheries and Oyster Aquaculture (FOA)

Specific issues and strategies in relation to fisheries and oyster aquaculture are detailed below:

Issue FOA-1

Fishing is the most popular recreational pursuit undertaken on the Nambucca River estuary. There exists a high degree of tension between the recreational and commercial fishing communities, with each believing the other to be responsible for perceived or actual declines in fish catch. Statistical records from the past several years indicate that the commercial fish effort and catch has remained relatively constant. However, little is known about the impact of recreational fishing on the fish stocks of the Nambucca River estuary. A recent Statewide survey of recreational fishing has identified that this sector accounts for a significant portion of the total yearly catch (30%) and actually exceeds the commercial sector in the catch of several key estuarine species. Further information is required on the habits and relative impacts of each fishing sector.

Strategy FOA-1. Initiate fishing catch surveys on the Nambucca River estuary, which identify key fishing locations, fishing effort, catch quantities and species caught.

Issue FOA-2

As described in FOA-1 there are community perceptions of declining fish stocks within the estuary. Numerous suggestions were received during the consultation phase to restrict or ban commercial and recreational fishing activities in certain areas of the estuary to help improve fish stocks. At present there is little information available on the relative fisheries values of the various habitats that exist within the estuary or trends in fish communities throughout the estuary over time.

For any form of Fish Habitat Protection Plan or Fishing Closure to be implemented, a thorough scientific understanding of the fisheries values and trends in fishing communities over time will need to be obtained for the estuary. Otherwise, sections of the estuary could be closed or restricted to fishing that may provide little or no benefit in terms of increasing or protecting fish stocks.

Strategy FOA-2. Obtain better understanding of fisheries habitat values and trends in fish communities over time in different parts of the estuary.

Issue FOA-3

Despite the implementation of the NSW Shellfish Quality Assurance Program which facilitates the safe oyster production, there remains no explicit requirement for other land and water planning and management decisions to have regard to the classification categories afforded to the oyster growing areas. Hence over time other planning decisions may be made with serious implications for the classified growing areas (HRC, 2003a). This objective overlaps with many issues/strategies in Land Tenure Use (LTU) and Water Quality (WQ).

Strategy FOA-3. Support sustainable aquaculture industries within the Nambucca River estuary by application of the highest levels of catchment and waterway management to ensure that the estuary's water quality is sufficient to maintain this industry, in clearly identified areas.

17.2.9 Tourism

Specific issues and strategies in relation to fisheries and oyster aquaculture are detailed below:

Issue TM-1

Visitor statistics indicate that the North Coast region of NSW is the second most popular destination other than Sydney for domestic travellers. The North Coast region also does well at attracting international visitors. Most of the visitors to the region come for tourism and leisure related activities, much of which focuses on the outdoor environment.

However, consultation has identified that there is a community perception that the ailing health of the estuary is causing a decline in tourism to the area. The reasons for any decline are likely to be multiple and unlikely to simply relate to river health. The Nambucca estuary like most estuaries offers a range of recreational opportunities, many of which are not fully utilised. Opportunities exist to promote tourism centred on the values of the estuary and the recreational opportunities it presents. However, any such promotion should aim to encourage only sustainable uses of the estuary and unsustainable uses may further damage this also impacted system.

Strategy TM-1. Promote the values of the estuary in ways that promote its sustainable use and also supports the valuable tourism industry of the Nambucca Shire.

Issue TM-2

There are extensive Crown land areas in the lower estuary, many of these are under-utilised or are restricted in way that they may promote connectivity and tourist related usage of the area. For instance, the boardwalk around the river from Gordon Park to the RSL is very popular, however, pedestrian are forced to walk beside the road if they want to get to the Bellwood Reserve area, despite the presence of Crown land fronting the Foreshore Caravan Park (see Figure 6-4 for tenure information).

Strategy TM-2. Improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area.

17.2.10 Climate Change and Sea Level Rise (CCSLR)

The following issue and strategy in relation to climate change and sea level rise has been developed for the estuary:

Issue CCSLR-1

It is predicted that mean sea levels will increase by as much as 0.88m by 2100. This will mean that some intertidal areas may be permanently inundated. This is likely to have some flow on effects to existing vegetative communities (especially saltmarsh communities), estuarine morphology and on a variety of human based infrastructure situated around the estuary. It will also allow for tides to propagate up estuaries to a larger extent and thereby affect existing salinity regimes, which will have impacts on existing vegetative communities. During flood events the ocean surge levels may also be heightened, potentially increasing flood levels and extent. Opportunities exist at the present to

address potential impacts through appropriate forward planning. Critical to this is having accurate surface elevation data available.

Strategy CCSLR-1. Ensure climate change and sea level rise implications are incorporated into the current LEP and forward planning.

17.2.11 Water Quality (WQ)

The following issue and strategy in relation to water quality has been developed for the estuary:

Issue WQ-1

The existing water quality monitoring regimes being performed within the estuary are solely focused on addressing their particular limited requirements, e.g. Council monitors water quality near discharge locations, while oyster growers monitor water quality near leases to enable reopening of harvest sites. At the moment there is no co-ordinated method of storing and using both data sets. Furthermore, the water quality monitoring, which is being completed, provides limited information upon which an overall estuarine ecosystem health assessment could be based. Consequently, Council's monitoring regime should be altered to enable additional information to be obtained to assist in developing a measure of ecosystem health.

If such schemes are implemented in other Northern NSW estuaries (as is presently being discussed), this will assist the Catchment Management Authority in prioritising funding for estuary improvements.

Strategy WQ-1. Integrate and improve upon existing water quality monitoring activities occurring within the estuary to provide a better indicator of overall estuarine health, whilst addressing all existing licence and operational requirements.

17.2.12 Summary of strategies by topic (unranked)

Land Tenure and Use

LTU-1. Incorporate riparian protection zones within Council's planning framework to safeguard them against potential future development and land-use change.

LTU-2. Incorporate river health goals and best practice design into future bank protection works (e.g. construction of future foreshore retaining walls) through an integrated and streamlined approvals process.

LTU-3. Minimise the environmental impact of new development by integrating best practice water management approaches (encompassing design, construction and operation) into Council's planning, approval and regulatory systems.

LTU-4. Ensure all foreshore structures are appropriately licenced, designed and maintained to protect foreshore amenity and access.

Entrance Condition and Behaviour

EC-1. Raise community awareness of coastal/estuary processes to increase the level of understanding of shoaling mechanisms and associated implications as well as the consequences of intervention measures.

EC-2. Address localised shoaling and erosion problems and improve navigable access where practical and most needed in the lower estuary giving consideration to the likely effectiveness, costs and benefits of works as well as the potential impacts.

Boating and Waterway Use

BWU-1. Minimise the safety risk and environmental harm of boating on humans and other sensitive receptors of the estuary such as banks, vegetative habitats and oyster leases, via the use of sympathetic signage in strategic locations.

BWU-2. Raise community awareness as to the environmental impacts of boating within the estuary and boating techniques that could be employed to minimise them.

BWU-3. Improve swimmer safety in the lower estuary by a variety of means including improved signage / safety equipment, provision of new swimming areas and/or improving the safety aspects of existing swimming areas.

BWU-4. Rationalise access points, boat ramps and associated facilities to protect existing estuarine values and to provide quality public foreshore access to the estuary.

BWU-5. Develop a formal Boating Management Plan for regions of the Nambucca River Estuary that are being excessively impacted upon by boating activities.

Cultural Heritage

CH-1. Reinstate tidal flow through the Stuarts Island Causeway, whilst minimising risk to swimmers utilising the Bellwood Swimming Hole.

CH-2. Ensure proposals that affect the estuary and surrounds afford an appropriate level of protection to items and areas of Aboriginal and European cultural heritage.

Community Liaison

CL-1. Ensure adequate representation of local Aboriginal groups is maintained on the existing Estuary Management Committee and that issues are addressed via appropriate channels.

Habitat Management

HM-1. Protect habitats of high ecological and estuarine conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands), through appropriate landuse planning and development controls.

HM-2. Enhance condition of habitats of high ecological/ conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands).

HM-3. Protect habitats of moderate or local ecological value (eg areas of native regrowth).

HM-4. Enhance condition of habitats of moderate or local ecological value.

Fisheries and Oyster Aquaculture

FOA-1. Initiate fishing catch surveys on the Nambucca River estuary, which identify key fishing locations, fishing effort, catch quantities and species caught.

FOA-2. Obtain better understanding of fisheries habitat values and trends in fish communities over time in different parts of estuary.

FOA-3. Support sustainable aquaculture industries within the Nambucca River estuary by application of the highest levels of catchment and waterway management to ensure that the estuary's water quality is sufficient to maintain this industry, in clearly identified areas.

Tourism Management

TM-1. Promote the values of the estuary in ways that promote its sustainable use and also support the valuable tourism industry of the Nambucca Shire.

TM-2. Improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area.

Climate Change and Sea Level Rise

CCSLR-1. Ensure climate change and sea level rise implications are incorporated into the current LEP and forward planning.

Water Quality

WQ-1. Integrate and improve upon existing water quality monitoring activities occurring within the estuary to provide a better indicator of overall estuarine health, whilst addressing all existing licence and operational requirements.

Bank Erosion

BE-1. Improve overall riverbank condition (including riparian habitats) on all major streams and waterways within the Nambucca Valley.

17.3 Initial prioritisation of management strategies

Having developed an initial list of management strategies, the next step in the process has been to rank (i.e. prioritise) them. This has been done to provide a logical starting point in the process of implementing positive change within the estuary. If there is no clear order in the actions to be taken, money, time and effort may be put into addressing issues that aren't significant or don't provide a good return for the investment outlaid. Also there are usually only limited funding resources available to address issues, and funding bodies need to be able to justify why money is being spent addressing issues. If it can be shown that the issue will provide a high degree of benefit to the estuary, then funding will become easier.

The process of ranking the management strategies is complex. The reasons for this include:

- There are many different aspects of the estuary which can be improved, and it can be difficult to determine whether commercial benefits are more important than ecosystem benefits, etc; and
- The likely level of benefit of some strategies is difficult to estimate. This is often a function of how easy or how well implemented the objective is.

Despite this, a lot is known about the condition of the estuary and the community's uses/values and aspirations for it. Based on this knowledge, the study team has performed an initial prioritisation of management strategies.

To assist the study team in the process of ranking all of the identified strategies, the study team developed a scorecard system whereby all strategies were rated against criteria, as detailed below:

- Likely ecosystem benefit of the strategy;
- Likely commercial benefit of the strategy;
- Likely social/recreation benefit of the strategy;
- To what degree does the strategy addresses the public's concerns regarding the estuary?;
- What degree of educational benefit does to the strategy provide?;
- What is the likely ratio of cost to benefit, i.e. will the strategy provide good results for little cost or vica versa?;
- To what degree is the strategy consistent with the community's values in respect of the estuary, i.e. having clean water, water access, etc?;
- What will be the likely success for implementing the strategy based on experiences gained with other estuary management projects?; and
- What is the degree of need or urgency for the strategy?

Each strategy was then scored against the above criteria, with higher scores being achieved when the objective was aligned with the benefit ratings and a lower score when it was not. The scores were then summed, with the highest scoring strategies being set (initially) as the priorities for implementation. In total 23 management strategies were identified for the estuary and the initial rankings have been included in Appendix G.

17.4 Final prioritisation of management strategies

The initial list of management strategies discussed in the previous section was presented at a series of community workshops for discussion. Input obtained from these meetings has been taken into account in the final prioritisation of management strategies. The community workshops are discussed below.

17.4.1 Community Workshops/Forums

Three community workshops were undertaken in Macksville, Scotts Head and Nambucca Heads on the nights of the 6, 7 and 8th September 2005, respectively. Attendance sheets indicate that the Macksville meeting was attended by 21 people, the Scotts Head meeting by 15 people and the

Nambucca Heads meeting by 13 people. Actual attendances are thought to be higher due to a number of late arrivals at these meetings.

The purpose of the workshops was two-fold. The first and primary aim of the workshops was to present the initial list of prioritised management strategies for the estuary (see Section 17.1). The second aim of the workshops was to present an overview of coastal processes, their effect on entrance dynamics and implications for management. During this presentation several potential alternate entrance configurations, including the 'do nothing', 'full training', 'dredging', 'blocking the hole in the wall' options were presented (see Appendix F). Options were discussed in terms of their capital and operating costs, level of social benefit and potential environmental impacts.

During the first part of the presentation a handout was provided to those who attended the meeting (as included in Appendix G). The handout contained the full list of initially prioritised management strategies. Attendees were asked to review the list of management strategies and identify an alternate prioritisation if they had one.

Twenty-three (23) completed responses were received in relation to the initial prioritisation provided by WBM. Six (6) written responses were also received by letter or e-mail. The community responses have been taken into consideration and the final prioritisations are included in Table 17-1.

Table 17-1 Summary list of prioritised strategies

Management strategy	Priority	Rank
BE-1. Improve overall riverbank condition (including riparian habitats) on all major streams and waterways within the Nambucca Valley.	High	1
LTU-3. Raise community awareness as to the environmental impacts of boating within the estuary and boating techniques that could be employed to minimise them.	High	2
CH-1. Reinstate tidal flow through the Stuarts Island Causeway, whilst minimising risk to swimmers utilising the Bellwood Swimming Hole.	High	3
BWU-2. Introduce a Code of Practice for boating users of the estuary to reduce the erosion problems and environmental harm of boating, whilst improving this group's understanding of the issues associated with boating.	High	4
FOA-3. Support sustainable aquaculture industries within the Nambucca River estuary by application of the highest levels of catchment and waterway management to ensure that the estuary's water quality is sufficient to maintain this industry, in clearly identified areas.	High	5
HM-1. Protect habitats of high ecological and estuarine conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands), through appropriate landuse planning and development controls.	High	6
LTU-1. Incorporate riparian protection zones within Council's planning framework to safeguard them against potential future development and land-use change.	High	7
HM-2. Enhance condition of habitats of high ecological/ conservation value.	High	8
EC-1. Raise community awareness of coastal/estuary processes to increase the level of understanding of shoaling mechanisms and associated implications as well as the consequences of intervention measures.	High	9
BWU-1. Minimise the safety risk and environmental harm of boating on humans and other sensitive receptors of the estuary such as banks, vegetative habitats and oyster leases, via the use of sympathetic signage in strategic locations.	Medium	10
BWU-4. Rationalise access points, boat ramps and associated facilities to protect existing estuarine values and to provide quality public foreshore access to the estuary.	Medium	11
LTU-2. Incorporate river health goals and best practice design into future bank protection works (e.g. construction of future foreshore retaining walls) through an integrated and streamlined approvals process.	Medium	12
BWU-3. Improve swimmer safety in the lower estuary by a variety of means including improved signage / safety equipment, provision of new swimming areas and/or improving the safety aspects of existing swimming areas.	Medium	13
EC-2. Address localised shoaling and erosion problems and improve navigable access where practical and most needed in the lower estuary giving consideration to the likely	Medium	14

Management strategy	Priority	Rank
effectiveness, costs and benefits of works as well as the potential impacts.		
CH-2. Ensure proposals that affect the estuary and surrounds afford an appropriate level of protection to items and areas of Aboriginal and European cultural heritage.	Medium	15
TM-1. Promote the values of the estuary in ways that promote its sustainable use and also support the valuable tourism industry of the Nambucca Shire.	Medium	16
FOA-1. Initiate fishing catch surveys on the Nambucca River estuary, which identify key fishing locations, fishing effort, catch quantities and species caught.	Medium	17
FOA-2. Obtain better understanding of fisheries habitat values and trends in fish communities over time in different parts of estuary.	Medium	18
WQ-1. Integrate and improve upon existing water quality monitoring activities occurring within the estuary to provide a better indicator of overall estuarine health, whilst addressing all existing licence and operational requirements.	Medium	19
CCSLR-1. Ensure climate change and sea level rise implications are incorporated into the current LEP and forward planning.	Low	20
BWU-5. Develop a formal Boating Management Plan for regions of the Nambucca River Estuary which are being excessively impacted upon by boating activities.	Low	21
HM-3. Protect habitats of moderate or local ecological value (eg areas of native regrowth).	Low	22
HM-4. Enhance condition of habitats of moderate or local ecological value.	Low	23
CL-1. Ensure adequate representation of local Aboriginal groups is maintained on the existing Estuary Management Committee and that issues are addressed via appropriate channels.	Low	24
LTU-4. Ensure all foreshore structures are appropriately licenced, designed and maintained to protect foreshore amenity and access.	Low	25
TM-2. Improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area.	Low	26

17.5 Management strategy descriptions

Table 17-2 Land Tenure and Use

Management Strategy	Priority	Strategy definition (outline of potential actions)
LTU-1. Incorporate riparian protection zones within Council's planning framework to safeguard them against potential future development and land-use change.	High (Rank 7)	This management strategy requires the establishment of riparian zone buffers within the appropriate planning policies and GIS mapping resources of Council. The width of riparian zone buffers should be determined by the characteristics (i.e. environmental values or management objectives) of the waterway in question. The riparian buffer should include a core riparian zone and may require an additional buffer on the outside of this core. The core riparian zone extends both sides from a watercourse, and landward from a wetland or other waterbody. The following widths are suggested: • Environmental corridor – a width greater than 50m; • Terrestrial and aquatic habitat – a width greater than 30m; and • Bed and bank stability and water quality – a width usually 10m.
LTU-2. Incorporate river health goals and best practice design into future bank protection works (e.g. construction of future foreshore retaining walls) through an integrated and streamlined approvals process.	Medium (Rank 12)	This management strategy requires Council to take into consideration river health when constructing (its own) or approving development works or improvements of others on lands which front the waters of the Nambucca River and its tributaries. The locations of subject waterways should be mapped and included in the Council's planning framework and GIS resources. In relation to approving development work undertaken by others, the management strategy is likely to require Council's Development Control Plan (DCP) Number 10 to identify that development, is not exempt development, if it is carried out on lands fronting the waters of the Nambucca River and its tributaries. This will then trigger the need for an approval from Council. Council can then act as the referral agency for all other agencies (I.e. DNR, DoL, NSW Maritime, DPI (Fisheries). A range of engineering guidelines will need to be prepared by Council and made available to those wishing to undertake foreshore works, including the appropriate works departments within Council.
LTU-3. Minimise the environmental impact of new development by integrating best practice water management approaches (encompassing design, construction and operation) into Council's planning, approval and regulatory systems.	High (Rank 2)	This management strategy requires Council to update or provide new planning controls and guidelines to promote: • Best environmental practice for stormwater/water/wastewater management. The best practice requirements should be incorporated through all stages of new development (and redevelopment of existing areas). Development applications should detail all approaches to be taken during the construction and operational phases; • Best environmental practice for the construction phase of developments, particularly in relation to erosion and sediment control. It is expected that this will involve Council regularly monitoring construction sites and enforcing requirements as required; • Review the building height, setbacks and design restrictions detailed in the relevant Development Control Plans in order to reduce the aesthetic impacts of development from the estuary. Solutions being adopted by other rural Councils (as input to the design process) include the adoption of a Development Control Plan (DCP) for Water Sensitive Urban Design. This DCP outlines the requirements for various types of development occurring on land with particular zonings. For example, a rural subdivision would trigger the code, which will require the applicant to address the requirements of the DCP as part of their development application. The development of a similar code for the Nambucca Shire should be considered.
LTU-4. Ensure all foreshore structures are appropriately licenced, designed and maintained to protect foreshore amenity and access.	Low (Rank 25)	This management strategy requires a review of the licencing conditions for existing foreshore structures. The review should be conducted by or in conjunction with the Department of Lands. Unlicenced structures should be licenced with the Department of Lands. Uncontrolled accesses on public or private lands, which will not be licenced, should be removed. Activities should where required by coordinated with **Strategy BWU-4.**

Table 17-3 Entrance Conditions

Management Strategy	Priority	Strategy definition (outline of potential actions)
EC-1. Raise community awareness of coastal/estuary processes to increase the level of understanding of shoaling mechanisms and associated implications as well as the consequences of intervention measures.	High (Rank 9)	This management strategy requires development of appropriate methods and materials to raise community awareness and understanding of the complex shoaling processes and the consequences/effectiveness of options to deal with it. This should also include promoting the use of appropriate shallow draft vessels in the lower estuary where navigation is constrained. Such methods and materials could include: • Public forums and/or displays; • Mass media TV coverage; • Brochures and educational material for school and interest groups; and • Signage at boat ramps and key locations in the estuary.
EC-2. Address localised shoaling and erosion problems and improve navigable access where practical and most needed in the lower estuary giving consideration to the likely effectiveness, costs and benefits of works as well as the potential impacts.	Medium (Rank 14)	This management strategy seeks to address shoaling/erosion problems and associated navigation issues of the lower estuary. Recognition needs to be given to the complexity of the processes, the practicality of implementation and likely effectiveness of works as well as the associated benefits and costs/impacts. Major permanent works are unlikely to be justified on economic grounds. Smaller, albeit temporary, works such as minor dredging may be considered where problems become critical (refer Appendix F for options discussion). While shoaling in general is perceived as being problematic, no specific critical issues have been identified at present (i.e. when navigation by shallow draft vessels is taken into consideration). Closing of the gap in the V-wall (with appropriate culverts to maintain flushing) has been put forward as an option to improve the water depth in the main channel. This may have other benefits for swimmer safety (see **Strategy BWU-3**) but it also has implications for navigable access for the Back Channel, which needs to be considered, particularly for the local Volunteer Rescue Association (refer to **Appendix F**).

Table 17-4 Boating and waterway usage

Management Strategy	Priority	Strategy definition (outline of potential actions)
BWU-1. Minimise the safety risk and environmental harm of boating on humans and other sensitive receptors of the estuary such as banks, vegetative habitats and oyster leases, via the use of sympathetic signage in strategic locations.	Medium (Rank 10)	This management strategy requires: • Use of sympathetic signage to minimise boating impacts in impacted areas of the estuary. Key areas include Warrell Creek near extensive seagrass beds and selected saltmarsh areas. Other areas to target include impacted oyster leases and others areas suffering extensive bank erosion; Although the focus of the strategy is not on the use of regulatory mechanisms, NSW Maritime indicated that they indented to change the following speed regulations: • Inner harbour – replacing 8 knot zone with 4 knot zone; and • Dedication of a no-towing zone between Stuart Island ramp, south to the end of the training wall (i.e. southern end of Stuarts Island).
BWU-2. Raise community awareness as to the environmental impacts of boating within the estuary and boating techniques that could be employed to minimise them	High (Rank 4)	This management strategy requires the use of techniques that will reach the users of the estuary, including locals and tourists, and inform them of the environmental impacts of boating within the estuary and boating techniques that could be employed to minimise them. Tools that could be employed include: • Public displays at key community centres; • Mass media TV coverage (focussing on holiday periods); • Brochures and educational material for school and interest groups (may include field visits and on water education); and • Signage at boat ramps and key locations in the estuary.

Management Strategy	Priority	Strategy definition (outline of potential actions)
BWU-3. Improve swimmer safety in the lower estuary by a variety of means including improved signage / safety equipment, provision of new swimming areas and/or improving the safety aspects of existing swimming areas.	Medium (Rank 13)	This management strategy aims to address a range of current usage conflicts and identified safety hazards within the estuary. In particular the following issues were noted: • The existing warning signs at the V-wall and Shelly Beach are not visible enough. They need to be made more obvious by increasing their size and improving their position; • Identify suitable options for restricting flow through the V-wall in order to improve swimmer safety at this location. Feasible options must demonstrate a large benefit to the local community and must have an acceptable level of impact on shoaling/erosion patterns in the lower estuary, water quality in the Back Channel, aesthetics of the V-wall area and boating activities including VRA operations. [see also **Strategy EC-2**]; • Lack of readily accessible safety and rescue equipment (e.g. buoys and patrols) near the V-wall and breakwater.
BWU-4. Rationalise access points, boat ramps and associated facilities to protect existing estuarine values and to provide quality public foreshore access to the estuary.	Medium (Rank 11)	This management strategy aims to bring about an improvement in the overall quality and usability of the existing network of public boat ramps and associated facilities. A variety of management strategies may be implemented as follows: • Actions and priorities for upgrades/additions to existing public ramp facilities has been outlined in Table 8-3; and • Actions and priorities for the provision of additional waterway access have been outlined in Table 8-4. A review of Council Plans of Management is planned for 2006 (this will include Shelley Beach and the Boultons Crossing campground areas). As part of these reviews, the following actions should be considered for Boultons Crossing campground: • Certification of the suitability of the setup and capacity of the existing septic tank needs to be performed by an appropriately qualified plumber. Consideration should be given to the implementation of a high level alarm on the tank. Formal procedures for the emptying of the septic tank are required and should be documented in the Plan for Management; • Closure of the northern access to Warrell Creek to allow for regeneration; • Regrading and protection of the unstable bank in front of the campground to promote improved access to the Creek; • Installation of bins, which cannot be overturned by wild animals, dogs or accessed by birds. Notes: • Recommendations provided are based on limited information. Additional information on boat ramp usage levels and patterns during normal and peak season times at existing major ramps may improve recommendations. . • The promotion of waterskiing in certain locations of the estuary (i.e. by provision of access and facilities) should be considered in the context of works that may be required to stabilise eroding banks in this location. For example waterskiing is popular in the Bowraville reach of the Nambucca River, however riverbanks there are riverbank instabilities in this location, hence some works may be required to make this section of the river more suitable for this use [See Strategy BE-1].
BWU-5. Develop a formal Boating Management Plan for regions of the Nambucca River Estuary which are being excessively impacted upon by boating activities	Low (Rank 21)	If other strategies have proven, over the longer term (i.e. 3 to 4 years), to be unsuccessful in preventing excessive impacts as a result of boating, then a Boating Management Plan should be developed by NSW Maritime for those areas of the Nambucca River estuary which are being severely impacted. This process is likely to require scientific assessments of boat wash impacts to justify actions. Based on these outcomes NSW Maritime may decide to enforce extra or heavier regulation of boating activities in certain locations of the estuary, e.g. Warrell Creek. Some tools, amongst others that can be used in this process include: No boating, No Wash, 4 knot, no-tow, No water-skiing, etc.

Table 17-5 Bank Erosion

Management Strategy	Priority	Strategy definition (outline of potential actions)
BE-1. Improve overall riverbank condition (including riparian habitats) on all major streams and waterways within the Nambucca Valley.	High (Rank 1)	This management strategy aims to improve the overall riverbank condition of all major streams and waterways within the Nambucca Valley. Actions and requirements in relation to the strategy will be as per the recommendations developed by Geco Environmental (2005).

Table 17-6 Cultural Heritage

Management Strategy	Priority	Strategy definition (outline of potential actions)
CH-1. Reinstate tidal flow through the Stuarts Island Causeway, whilst minimising risk to swimmers utilising the Bellwood Swimming Hole.	High (Rank 3)	This management strategy relates to maintaining open communication with Nyambaga on their issues of importance in relation to the estuary. For this estuary management study, the only item they wish to have addressed is the reinstatement of tidal flow under the Stuarts Island causeway to protect a nearby sacred site (Mirral). In respect of this the management options being considered for reinstating flow under the causeway should: • Consider potentially suitable flow structures, e.g. culverts, that may be implemented under the causeway to reinstate tidal flow; • Conduct appropriate hydrodynamic modelling of the impact of the flow structures to determine their potential impacts on water movements in the Bellwood Swimming Hole. Other potential impacts of the structure should be considered, such as flooding, sedimentation, flushing, swimmer safety near the flow structures, etc.
CH-2. Ensure proposals that affect the estuary and surrounds afford an appropriate level of protection to items and areas of Aboriginal and European cultural heritage.	Medium (Rank 15)	This strategy requires that Council's LEP is kept up to date with listings of Aboriginal and European cultural heritage. The LEP should be updated as soon as practicable as new listings are determined. Mechanisms are required with Council's planning framework to ensure that appropriate controls are triggered when proposals affecting the estuary are assessed.

Table 17-7 Community Liaison

Management Strategy	Priority	Strategy definition (outline of potential actions)
CL-1. Ensure adequate representation of local Aboriginal groups is maintained on the existing Estuary Management Committee and that issues are addressed via appropriate channels.	Low (Rank 24)	This strategy requires that local Aboriginal group representation be maintained on the Estuary Management Committee (at least one but preferably two members from the local Aboriginal Land Council). This should serve as a starting point for the identification of issues. If required or appropriate additional consultation should be engaged with the Aboriginal Community outside of the normal operation of the Estuary Management Committee to gain a better understanding of issues. This may entail site inspections, meetings with Elders and others in specific locations, etc.

Table 17-8 Habitat Management

Management Strategy	Priority	Strategy definition (outline of potential actions)
HM-1. Protect habitats of high ecological and estuarine conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands), through appropriate landuse planning and development controls.	High (Rank 6)	This management strategy includes: • Protection of estuarine habitats including endangered communities listed under the TSC Act to ensure no net loss; and • Protection habitats regulated by the Fisheries Act 1994 to ensure no net loss. Protection of these habitats will require changes within Council's planning framework, including the Local Environment Plan and Development Control Plans. For example clauses 16 to 20 of the LEP relate to the rural subdivision of zone 1(a1). The allowable areas for rural residential subdivision in the study area need to be revised in light of the potential long-term impact these land use changes may have on downstream SEPP 14 wetlands and communities listed as threatened under the TSC Act. One control option will be to specify no net change in the hydrological regimes from upstream developments, including, no alterations to peak flows and volumes and no increases in the total pollutant loads.
HM-2. Enhance condition of habitats of high ecological or conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zone and floodplain wetlands).	High (Rank 8)	This management strategy includes: • Rehabilitation of sites of high ecological value where degradation has occurred. Weed invasion should be a targeted management priority. The NSW Scientific Committee, established by the Threatened Species Conservation Act, supports a proposal to list invasion and establishment of exotic vines and scramblers as a Key Threatening Process in Schedule 3 of the Act. The estuary management committee should seek assistance from the North Coast Weed Advisory Committee to develop a program of weed control within the estuary. • Using environmental covenants where possible for the protection and rehabilitation of habitats. Implementation of these strategies would also require Council to integrate and update requirements into the LEP and relevant DCPs. • Identify opportunities for funding through existing programs such as the Natural Heritage Trust, to provide funds for rehabilitation projects. However, it is likely that widespread rehabilitation could be better achieved through the provision of targeted financial and labour assistance to private landholders wanting to commit to long-term habitat management.
HM-3. Protect habitats of moderate or local ecological value (eg areas of native regrowth).	Low (Rank 22)	Protect communities that buffer significant ecological habitat or those that contribute to the wildlife network across the study area, for example regrowth communities.
HM-4. Enhance condition of habitats of moderate or local ecological value.	Low (Rank 23)	The majority of habitats of potential moderate to low ecological value occur on rural residential land and are prone to existing and future land uses. Significant environmental issues are likely within these lands including poor water quality, clearing and weed invasion, and may require more active management to rehabilitate.

Table 17-9 Fisheries and Oyster Aquaculture

Management Strategy	Priority	Strategy definition (outline of potential actions)
FOA-1. Initiate fishing catch surveys on the Nambucca River estuary, which identify key fishing locations, fishing effort, catch quantities and species caught.	Medium (Rank 17)	This management strategy aims gain an improved understanding of the level and potential impact of fishing within the estuary. The recreational survey would need to be performed using local residents as volunteers and be coordinated through DPI Fisheries to ensure the validity of the outcomes. The commercial fishing survey would require further consultation with this sector to ascertain the required information. Outcomes from the survey will help to identify the potential impacts of these fishing sectors, which can then be used to improve management approaches for all. The survey will also provide additional information on the ecology and health of the estuary.
FOA-2. Obtain better understanding of fisheries habitat values and trends in fish communities over time in different parts of estuary.	Medium (Rank 18)	This management strategy aims to gain a more thorough scientific understanding of the fisheries values and trends in fishing communities over time within the Nambucca River estuary, taking into account various micro and macro scale effects which may affect fish communities within the Nambucca River alone (e.g. local water quality, etc), and also external to the Nambucca River estuary (meteorological events, etc). Presently, very little is known about the relative values and trends in the various communities that exist within the estuary. If issues are found, this scientifically based and validated information could be used to apply to the DPI (Fisheries) for various types of Fish Habitat Protection Plan, or even Commercial Fishing closures to protect some areas (or parts of areas) with very high fishery values. The assessments would also provide additional information on the ecology and health of the estuary.
FOA-3. Support sustainable aquaculture industries within the Nambucca River estuary by application of the highest levels of catchment and waterway management to ensure that the estuary's water quality is sufficient to maintain this industry, in clearly identified areas.	High (Rank 5)	This management strategy relates to the need for appropriate land use decisions to be made to protect this fragile industry. At present land use management decisions within the catchment of the estuary are not required to take into consideration the potential implications on water quality and hence the oyster industry it supports. If the oyster industry is to be maintained and/or enhanced over time methodologies need to be incorporated into Council's planning framework to safeguard the industry when land use management decisions are made, e.g. granting of development approvals, etc. This management strategy relates to **Strategy LTU-1** and **Strategy LTU-3**.

Table 17-10 Tourism Management

Management Strategy	Priority	Strategy definition (outline of potential actions)
TM-1. Promote the values of the estuary in ways that promote its sustainable use and also support the valuable tourism industry of the Nambucca Shire.	Medium (Rank 16)	This management strategy aims to promote the many values of the estuary, which in turn encourages its use. Promotion of estuarine values should at all times encourage sustainable forms of usage, i.e. usage types and levels which are within the capacity of the waterway (including water quality, ecology, social amenity) to accommodate. Promotion of estuarine values should also be used to educate the community in relation to estuaries, their functioning, values and sensitivities. A variety of mechanisms may be used to promote the values of the estuary including print media (e.g. information handouts), internet (pages attached to Council, Nambucca Tourism websites, NSW Tourism), school education programs (e.g. bugwatch, waterwatch, etc.)
TM-2. Improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area.	Low (Rank 26)	This management option aims to improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area: • Investigate feasibility of a connected riverbank walk between Anzac Park and Bellwood Reserve. Consultation with land owners, caravan park operators and oyster growers will be required to identify a suitable design for the this section of the walkway; and • Investigate options for establishment of a dedicated walking/cycle track between the Nambucca Plaza and the existing boardwalk section along Nursery Road/Bellevue Drive, Macksville (which is currently poorly used). With the future diversion of the Pacific highway, existing traffic levels will be substantially reduced making the option more feasible.

Table 17-11 Climate and Sea Level Rise

Management Strategy	Priority	Strategy definition (outline of potential actions)
CCSLR-1. Ensure climate change and sea level rise implications are incorporated into the current LEP and forward planning.	Low (Rank 20)	Management strategies to address this objective should include: • Obtaining sufficiently accurate land height information from which to generate potential inundation maps under a variety of sea level change scenarios. • Developing strategies to relocate existing assets that are likely to be inundated as a result of sea level rise. The strategy should identify priority items and locations. • Including inundation areas within Council's LEP and DCPs to avoid potential future land use conflicts and unnecessary asset relocation, e.g. having coastal development located in areas which suffer inundation or other effects.

Table 17-12 Water Quality

Management Strategy	Priority	Strategy definition (outline of potential actions)
Objective WQ-1. Integrate and improve upon existing water quality monitoring activities occurring within the estuary to provide a better indicator of overall estuarine health, whilst addressing all existing licence and operational requirements.	Medium (Rank 19)	Management strategies should aims to streamline and enhance existing water quality monitoring being undertaken within the estuary to reduce duplication of effort and provide additional information that may be used to provide an overall measure of ecosystem health. Strategies that may be employed to meet the objective include: • Developing a central database of water quality information that collects and maintains all water quality data that is collected. • Enhancing or augmenting Council's existing monitoring regime to better characterise the entire estuary and provide an overall measure of estuarine health. • Integration of Council's data with a regional estuarine ecosystem health monitoring program to provide a relative measure of the health of the estuary in comparison to other estuaries along the NSW East Coast. **Strategy FOA-3** also relates to Water Quality

17.6 Outline of Estuary Management Plan

Table 17-2 to Table 17-12 present a discussion of the management strategies that are to be implemented as part of the future management of the Nambucca River Estuary. The Estuary Management Plan will provide additional detail in regards to the individual actions that will be required to implement the strategies. In particular the Estuary Management Plan will provide the following information for each strategy (where possible):

- Concise descriptions of the particular actions required;
- Potential impacts of the action (positive and negative);
- Approximate capital and operational costs;
- Responsible organisations;
- Identified constraints or opportunities likely to be realised in their implementation;
- Timing considerations;
- Funding sources; and
- Other considerations.

In addition to the above, Implementation Tables will be developed which outline the order for implementing management strategies and actions, based on the prioritisation of the management strategies outlined in Section 17.4. Maps and other interpretive material will be prepared to assist in interpreting the meaning of actions and locations where actions are required.

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18.1 Glossary of Terms and Acronyms

Algae	Single celled aquatic organisms, that grow by uptaking nutrients
Alluvial	Relating to the sedimentation process resulting from catchment erosion
Aquatic	Relating to the water
Aquatic community	The ecological community that exists within the water
Artificial opening	Opening of a closed estuary entrance using manual techniques, such as bulldozers, excavators etc
Bacteria	Water-borne microscopic organisms
CAMBA	China Australia Migratory Bird Agreement
Catchment	Total area that drains to a particular receiving waterbody
Catchment Action Plan	Formal plan outlining objectives and strategies for long term management of a catchment (
CMA	(Northern Rivers) Catchment Management Authority
Contaminant	Substance that can contaminate or influence an environment
Critical habitat areas	Areas within the catchment and around a waterway that provide essential value to the ecological communities that reside within the area
DEC	Department of Environment and Conservation (formerly Environment Protection

	Authority and National Parks and Wildlife Service)
Degraded sensitive areas	Sensitive areas that are degraded through a lack of vegetation for example
Depositional zone	Part of an estuary where sediment from the catchment settles to the bed because of slow water movement
DNR	Department of Natural Resources (formerly Department of Infrastructure Planning and Natural Resources)
DPI (Fisheries)	formerly NSW Fisheries
Ecologically Sustainable Development (ESD)	Development within or around an environment that is designed to ensure that the environment is not degraded in the future by the development specifically
Environmental Flows	Minimum flows within a waterway that required to maintain ecological functions
Estuary	Coastal waterway that is subject to tidal processes either permanently, or on an intermittent basis
Estuary Processes Study	A study carried out under the NSW Government's Estuary Management Program that describes all estuary processes and their interactions
Estuary Management Plan	A formal planning document prepared under the NSW Government's Estuary Management Program that describes a series of strategies to improve the long-term sustainability of an estuary
Estuary Management Study	A study carried out under the NSW Government's Estuary Management Program that formulates and assesses a range of options to improve the long-term sustainability of an estuary
Estuarine processes	The physical, chemical and biological processes that occur within an estuary
Faecal contaminants	Contaminants that are derived from faeces
Fin-fish	Aquatic fauna species that contain fins (ie fish) – differs from other species such as crustaceans
Flora and fauna	Plants and animals
Hydrology	Relating to the movement of water
Hydrological range	The range that water levels can vary within an estuary. This is different from the tidal range as it pertains to not just tidal processes, but also bulk water storage when the estuary entrance is closed
Implementation	The carrying out of strategies or actions
Implementation schedules	A series of tables that outline the specific details of how strategies and actions are to be carried out
Intertidal zone	Part of an estuary that is located between high tide and low tide (and thus is inundated intermittently and regularly)
JAMBA	Japan Australia Migratory Bird Agreement
Key Management Issues	Issues of significant concern that have been identified for the estuary that require future management
LEP	Local Environment Plan (Primary Council planning instrument)
Littoral rainforest	Rainforest that is located along the coast and contains specific coastal species
Management Objectives	The main targets for the Estuary Management Plan
Management Strategies	The actions required to fulfil the Estuary Management Plan)
Mangrove	Large aquatic plant that lives within the intertidal zone
Maritime Authority	Formerly Maritime Authority Authority
Measurables	Tools to measure the success of implementation of the management strategies and actions
Midden	Aboriginal archaeological site that contains an accumulation of shells and other artefacts
Multi-criteria	Assessment whereby information is considered against a number of different

assessment	criteria
Nutrients	Water quality parameters that are the basic building blocks of carbon-based life
On-site sewage treatment	The treatment of sewage waste by individual on-site systems *(see also septic system)*
Pollutant	Substance that has a degrading influence on the environment
Recreational amenity	The value of an environment that is afforded to recreational pursuits
Recreational Fishing Haven	Area established by NSW Fisheries (now DPI) that have no commercial fishing and are dedicated to enhancing recreational fishing
Reticulated sewerage system	System used in urbanized areas where sewage is transported via sewer pipes to a central treatment facility
Riparian vegetation	Vegetation that is contained within the riparian zone
Riparian zone	The area around the fringe of a waterway (with vegetation communities usually related to the presence of the adjacent waterway)
Runoff	The flow/drainage of water (and other substances) from an area (usually a catchment)
Seagrass	Aquatic plants that grow from the bed of an estuary
Sedimentation	The accumulation of sediment
Semi-urban	Rural-residential development (typically 1 acre lots or larger)
Sensitive areas	Areas within the catchment and around the waterways that are naturally sensitive, due to steepness, soil type etc *(see also degraded sensitive areas)*
SEPP-14	(NSW) State Environmental Planning Policy No. 14 – Coastal Wetlands
SEPP-26	(NSW) State Environmental Planning Policy No. 26 – Littoral Rainforest
SEPP-35	(NSW) State Environmental Planning Policy No. 35 – Maintenance Dredging of Tidal Waterways
SEPP-62	(NSW) State Environmental Planning Policy No. 62 – Sustainable Aquaculture
Septic system	Form of sewage treatment utilized by individual developments (see also on-site sewage treatment)
SEWQP	South East Water Quality Project
Shoaled entrance	Entrance of an estuary that is 'choked' by sand *(see also scoured entrance)*
SoE	State of Environment (report)
Northern Rivers CMA	Northern Rivers Catchment Management Authority
Northern Rivers CAP	Northern Rivers Catchment Action Plan
Sustainability	To ability of a system to remain healthy and viable in the long-term
Terrestrial	Relating to the land
Terrestrial vegetation	Vegetation that cannot tolerate sustained inundation by water
Tidal flushing	The ability of an estuary to exchange water with the ocean via tidal processes
Tidal range	The variability in water level within an estuary that is related to tidal processes
Turbidity	Dissolved ands suspended sediment within the water
Water extraction	Removal of water (usually freshwater) from a waterway for external use (eg irrigation, stock watering, domestic supply)
Water Sharing Plan	A Plan between water extractors that is designed to ensure equitable use of water resources, including maintaining environmental flows
WSUD	Water Sensitive Urban Design

APPENDIX A: GUMMA GUMMA WETLAND MANAGEMENT

Gumma Gumma Wetland

Management Issues and Options

Information Bulletin

Draft 30 July 2004

Introduction
WetlandCare Australia (WCA) has been commissioned by Nambucca Shire Council to undertake a preliminary assessment of management issues and options for the Gumma Gumma wetland. This Information Bulletin summarises WetlandCare's Australia initial findings.

Site description
Gumma wetland extends 4 km from the mouth of Gumma Gumma Creek to the outskirts of Macksville. It is 1.5km across at its widest point (see figure 1). The majority of the wetland is SEPP 14 Wetland # 388.

Figure 1: Location of Gumma Gumma SEPP 14 Wetland

Project Aims
The Department of Infrastructure Planning & Natural Resources (DIPNR) provided an overview for the project aims, issues and background information (Schmidt, 2003). This is summarised below.

The Gumma Gumma Wetland Project seeks to reinstate:
a) Productive values of backswamp for both grazing landuse and wetland flora and fauna
b) Natural water level characteristics in backswamp wetlands
c) Fish passage and estuarine habitat linkage to Nambucca estuary
d) Improved river estuary water quality discharge from the backswamp

Issues
The main issues raised by various stakeholders in the Gumma Gumma wetland include:
a) Floodgate structure (10 floodgates) in disrepair
b) Road bridge crossing over Gumma Gumma Creek due for replacement
c) Salt intrusion damaging productive pasture land and impacting on wetland values in backswamp area
d) Over-drainage of soils resulting in salt scalds and poor water quality discharge during wet events
e) Freshwater wetland degradation with loss of birdlife and deterioration of swamp grasses and rushes
f) Gumma Gumma Creek being partially isolated from main river by floodgate structure

Background
Background information relevant to the management of the Gumma Gumma wetland is outlined below:
a) Floodgates were erected in 1926 by Gumma Progress Association
b) Responsibility for floodgates handed to Nambucca Council 1940s
c) Local working group formed by Council in August 2000, in response to landholder concerns raised at public meeting
d) Approximately 25 landholders have frontage to Gumma Gumma Creek and its backswamp area.

Gumma Gumma Catchment
The main features of the Gumma Gumma wetland include:
a) Catchment area ~ 13 sq km
b) Gumma backswamp ~ 5.5 sq km (~ 20% coastal floodplain of Nambucca River and ~ 40% of total area of backswamp on coastal floodplain)
c) Backswamp has organic soils, low wet-bearing strength, high erodibility, low permeability, potential acid sulfate soils (ASS), strong acidity, sodicity, high aluminium toxicity and salinity, poor drainage, high flood hazard and seasonal water logging
d) Vegetation includes sedgeland and wet meadow as well as open Swamp Sclerophyll – Swamp Oak alliance with Paperbark
e) Macksville Sewerage Treatment Plant to the west of the wetland discharges directly into Nambucca River estuary from a pipe in the bed of the river

Photo #2: Built in 1926, the Gumma Gumma Creek floodgates were totally non-functional by 2004. The floodgate culverts need to be removed to allow construction of a new bridge.

Environmental Planning
The Gumma Gumma wetland is:
a) Mapped as SEPP 14 Coastal Wetlands
b) Zoned 7(a) Environmental Protection (wetlands) in Nambucca LEP
c) Mapped by DIPNR as high-risk acid sulfate soils

1

Looking Back

The construction of the floodgates at the mouth of Gumma Gumma Creek, and digging of drains across the wetland early last century, would have had dramatic impacts on the wetland. Recent research (Johnston et al 2003) has shown that these impacts are likely to have included:

- *the rapid lowering of surface water levels in the swamp with most water removed in a matter of weeks compared with many months previously*
- *the increased frequency and severity of fires across the swamp, killing the reeds and burning the surface peat*
- *the invasion of the swamp by Swamp Oaks in response to drier conditions, burning, and associated soil acidification*
- *the gradual loss of grazing value as the reeds and rushes were replaced by Swamp Oak*
- *the increased aeration of the acid sulfate soils (ASS) producing large volumes of sulphuric acid*
- *the sulphuric acid dissolved iron, aluminium and other metals in the soil, producing a toxic groundwater*
- *the toxic groundwater making its way into constructed drains and onto the ground surface*
- *the floodgates 'pumping' this acid water into the river under tidal influence*
- *the toxic water killing most aquatic life in Gumma Gumma Creek and having adverse impacts downstream in the Nambucca River*
- *the Gumma Gumma wetland subsiding due to the loss of the peat layer and shrinkage of the ASS, making it more difficult to drain*
- *the floodgates falling into disrepair and salt water rewetting the wetland, displacing fresh water grazing species that had established on former intertidal salt marsh areas.*

Existing farm crossing acts as a water control structure

Management options for discussion:

The following options are presented to promote discussion about the future management needs of the Gumma Gumma wetland. Some likely impacts of the option and impediments to adoption are listed. A combination of options may be required to satisfy short and long-term goals.

1. Replace culvert with bridge
- *Unlikely to increase tidal inundation of grazing land **
- *Likely to marginally increase flood discharges**

**Needs engineering study to confirm*

2. Remove farm crossing - replace with a floodgated culvert
- *Requires EIS*
- *Destroys Salt Marsh (listed as Threatened Habitat)*
- *Blocks fish passage*
- *Perpetuates water quality problems*
- *Highly unlikely to gain approval*

3. Remove all impediments to natural flows
- *Requires land acquisition or incentive payments to landholders (for lost production)*
- *Requires fencing and removal of grazing animals from parts of wetland*
- *Allows extensive natural regeneration of estuarine wetland*
- *Becomes very important habitat for fish and birds*
- *Results in extensive reduction of Swamp Oak*

4. Leave as is
- *Natural regeneration of estuarine wetland will continue to occur (but on a limited area)*
- *Wetland will continue to improve as fish and bird habitat*
- *Some reduction of Swamp Oak will continue*

Where to from here?
WetlandCare Australia has been commissioned to:
a) convene a planning focus meeting to i) sort out the process to be followed in development of management options ii) seek confirmation of issues iii) gauge willingness of landholders to seek solutions / explore options.
b) assess the site and scope out the issues to be dealt with in exploring possible options to achieve the aims of project
c) outline an approach that would be a practical way of addressing the needs and concerns of landholders whilst accommodating the broad objectives of State legislation.

See back page for further details

2

Photographs Illustrating Gumma Gumma Wetland Management Issues

Dry seasons contribute to acid / iron discharges and the formation of seasonal scalds associated with ASS and saline tidal water inundation *(Mangroves)*

Fresh meadow has been replaced by Salt Marsh and inter-tidal mud flats – valuable fish and bird habitat and little grazing (Dyer) *(Sea Rush)*

Constructed levee limits natural flows into wetland (Dyer) *(Swamp Oak)*

Full tidal exchange via the old floodgates and a constructed drain has displaced fresh meadow with the loss of grazing (Dyer) *(Sea Rush, Salt Marsh, Water Couch, Common Couch)*

Old farm crossing acts as weir (0.5 m high) - limits tidal inflows and retains upstream water levels (Dyer) *(Mangroves)*

Swamp Oak dieback and Salt Marsh establishment has followed floodgate failure (Mioni)

Extensive fresh meadow – seasonally impacted by ASS and salt scalds (Soft Rush)

Massive invasion of former reed swamp by Paperbark and Swamp Oak is likely to increase acid formation and transport (Ainsworrth) *(Water Couch and Soft Rush)*

Old farm crossing through wetland is an impediment to natural overland flows (Ainsworrth) *(Water Couch, Soft Rush, Paperbark and Swamp Oak)*

Same location following extended dry season – note salt water intrusion and salt / acid scald at left

Loss of peat layers due to drainage, fire and grazing has increased the formation and transport of acid (Dyer) *(Swamp Oak)*

Abundant snail population in intertidal area indicative of high level of marine productivity

Gumma Gumma Wetland

Water Management Trial

Information Bulletin #2

20 September 2004

Removal of old floodgate culvert

About 30 stakeholders attended an on-site meeting on 17 September 2004, to discuss the need to remove the old floodgate culvert on Gumma Road to allow for construction of a new road bridge spanning Gumma Creek.

There was consensus within the group of the need for removal of the culvert, provided that a new water control structure was first built further up the Gumma Creek. This was considered necessary to reduce saltwater damage to freshwater wetlands that has been occurring since failure of the old floodgates over the last decade or so.

Trial Temporary Structure

A site for the new temporary structure is located about 500 m upstream from the mouth of Gumma Creek adjacent to the old farm crossing on Mathew Dyer's land *(Photo #1 below)*.

Photo #1: Proposed location of new water control structure upstream of existing farm crossing and typical water levels when operational (see Information Bulletin #1 30 July 04)

It was agreed that the new structure should be able to be set at an elevation sufficiently high to keep out spring high tides during extended dry periods.

However, in order to allow fish passage and preservation of the salt marsh and mangroves upstream, a dropboard culvert will need to be fitted to the sill, to allow tidal and fresh water exchange to be maintained at current levels at all other times *(Photo #1)*.

The new structure will be constructed in the form of a low-set sandbag sill and will need to be about 20 m in length by 0.5m high and fitted with a dropboard weir *(illustrated below)*. It is proposed to locate the new structure immediately upstream of the existing farm crossing on Dyer's land. The existing farm crossing already acts as a significant barrier to salt and fresh water movement, but the new structure will allow better seasonal control.

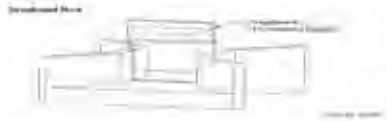

Figure 1: Illustration of low-set dropboard to be installed in sandbag sill

Management Team

It was agreed that a management team needs to be established to oversee the trial. Initial nominees include:

Bob Smith	(WetlandCare Australia)
Cr John Ainsworth	(Nambucca Shire Council)
Mathew Dyer	(Landholder)
John Schmidt	(DIPNR)
Bruce Redman	(Nambucca Shire Council)

Trial Water Management Program

It is proposed to install the new structure and trial it for up to 3 years to ensure that it:

- Prevents salt damage to freshwater grazing areas during dry periods
- Allows regular fish passage
- Maintains healthy salt marsh and mangrove communities upstream

Site monitoring will need to be undertaken and should include:

- water level
- water quality
- vegetation change
- benthic (marine organisms) sampling

A review of the success or otherwise of the trial structure will be undertaken annually and a report sent for comment to NSW Primary Industries (Fisheries), Department of Infrastructure Planning & Natural Resources, and Nambucca Shire Council.

Longer Term

A long-term strategy for the Gumma wetland may need to be developed taking into account:

- the results of the 3-year trial
- possible continuing impacts of poor water quality discharges to the estuary
- possible future needs for the wetland as a backup to the Macksville sewage treatment plant
- the need to fully rehabilitate the wetland to stabilise acid deposits and to reverse the invasion by tea tree and sheoaks
- the potential to offer landholders 'development offsets' or other incentives to manage the wetland for environmental rather than agricultural purposes.

Tasks

There are a number of tasks that need to be completed before the trial water control structure can be installed. These include:

- Design and costing of the trial structure, including detailed assessment of the level required to keep tides out
- On-ground elevation survey to set heights
- Seeking special consideration under SEPP 14 to forgo the need to undertake an EIS to commence the trial and monitoring
- Preparing a Review of Environmental Factors for licensing and approval purposes
- Seeking approvals from NSW DPI (Fisheries) and Department of Infrastructure Planning & Natural Resources (Planning)

In addition, landholders downstream from the proposed trial water control structure will need assistance in developing complimentary wetland management strategies on lateral drains.

Funding

Before the pilot project can be progressed, Wetland**Care** Australia will need to secure ongoing funding to commence the next detailed stage of the project. Potential funding sources include the Catchment Management Authority and the NSW Government Floodplain and Estuary programs.

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This project was commissioned by Nambucca Shire Council with assistance provided by the NSW Government's Estuary Management Program

Wetland Care Australia is a not-for-profit organisation dedicated to maintaining the health of Australia's wetlands.

APPENDIX B: FACILITIES PROVIDED AT COUNCIL OPERATED RAMPS

NAMBUCCA HEADS

Ramp Name	Shelley Beach	Gordon Park	Wellington Drive	RSL	Stuarts Island
Number of Lanes	1	2	1	1	2
Holding pontoon/jetty	No	No	No	No	Yes
Affected by current	Mostly affected by waves	Yes - Partially sheltered	Yes	Yes	Yes
Lighting	No	Yes	Partial from street	Partial	No
Pump out facilities	No	No	No	No	No
Access to open water	Yes	Via bar	Via bar	Via bar	Via bar
Picnic tables/chairs	Yes	Yes - Several	No	No[a]	Yes[b]
BBQ facilities	Yes - 2 BBQs (wood fired) and 2 tables	Yes – two gas BBQ's	No	No[a]	Yes – wood fired[b]
Showers	No	No	No	No	No[b]
Waves/swell protection	Yes - Partially protected from SE swell	Yes	Yes	Yes	Yes
Vessel wash down	No	No	No	No	No
Wheel chair access	Yes	Yes	Yes	Yes	Yes
Fish cleaning facilities	Yes	No	No	No[a]	No
Fuelling facilities	No	No	No	No	No
Children's playground	No	Yes	No	No	No[b]
Toilets	Yes	Yes	No	No	No[b]
Kiosk	No	Shops nearby	No	Yes	No – Approximately 500m to Bellwood Shop
Parking	Yes - approximately 100 spaces	Yes – approximately 10 boat trailers & 30 cars	No	Yes 5 dedicated for trailers and approx 150 cars (most of these for RSL)	11 dedicated trailer park, many other spaces for trailers and cars.
Approximate distance to major center	2.0 km to Nambucca Town Center	0.5km to Nambucca Town Center	700m to Nambucca Town Center	0.5km to Nambucca Town Center	2.0 km to Nambucca Town Center

a - About 100m walk to Anzac Park, which has gas BBQs, picnic tables and fish cleaning facilities

b - About 500m walk to Bellwood Reserve with seats, gas BBQs, playground, showers, toilets and swimming area.

MACKSVILLE / SCOTTS HEAD / GUMMA / BOWRAVILLE

Ramp Name	Lions Park	McKay St	Weir Reserve	Apex Park	Boultons Crossing
Number of Lanes	2	1	1	1	1
Holding pontoon/jetty	No	No	No	No	No
Affected by current	Yes	Yes	No	No	No
Lighting	Partial	No	No	No	No
Pump out facilities	On opposite side of river approximately 80m	Approx. 100m downstream	No	No	No
Access to open water	Via bar	Via bar	Via bar	Via bar	Via bar
Picnic tables/chairs	Yes	No	No	No	Yes
BBQ facilities	Yes – wood fired	No	Yes –wood fired (old)	No	Yes – wood fired
Showers	No	No	No	No	No
Waves/swell protection	Yes	Yes	Yes	Yes	Yes
Vessel wash down	No	No	No	No	No
Wheel chair access	Yes	No	No	No	No
Fish cleaning facilities	No	No	No	No	No
Fuelling facilities	No	No	No	No	No
Children's playground	Yes	No	No	No	No
Toilets	Yes	NO	Yes	No	Yes
Kiosk	200m into Macksville	100m into Macksville	No	No	No
Parking	Yes 4 dedicated trailer park and space for approximately 20 cars	Only on-street parking available	Yes	Yes	Yes
Approximate distance to major center	200m to Macksville town centre	100m to Macksville town centre	1km to Scotts Head town centre	4km to Bowraville and 7km to Macksville	Approximately 7km to Macksville town centre

APPENDIX C: COMMERCIAL FISHING REGULATIONS FOR THE NAMBUCCA RIVER ESTUARY

Extract from: http://www.fisheries.nsw.gov.au/gen/closures/location/Nambucca_River.htm

Date of Notification: 18 June 2004 and 6 August 2004
Government Gazette: 98 and 131
F99/134
FISHERIES MANAGEMENT ACT 1994
Section 8 and Section 11 Notification - Fishing Closure
Nambucca River and Warrell Creek

I, Steve Dunn, prohibit the taking of fish by the methods of fishing specified in Column 1 of Schedules 1 to 5 of this notification, from the waters shown opposite in Column 2 respectively, of those schedules.

Fishing is further subject to the time periods as specified with respect to any Schedule of this notification.

This prohibition is effective for a period of up to five years from the date of publication, unless sooner varied or revoked by notification of Director-General of NSW Fisheries.

Note: The word 'Regulation', where appearing in this notification, refers to the Fisheries Management (General) Regulation 2002.

Steve Dunn
Director-General, NSW Fisheries

Schedule 1 - Weekend and public holiday

Column 1 - Methods	Column 2 - Waters
By means of nets of every description, other than the prawn net hauling, hand-hauled prawn net, dip or scoop net (when used for the capture of prawns only), and the landing net, as prescribed by Regulation.	The whole of the waters of the Nambucca River and Warrell Creek together with their creeks and tributaries, which are not closed to netting under any other notification.
Time Period: 6pm Friday to 6pm Sunday, or to 6pm Monday if Monday is a Public Holiday, in any week. On any weekday Public Holiday (except Monday) throughout the year, the closure will apply from 6am to 6pm on that day.	

Schedule 2 - Nambucca River Entrance Waters

Column 1 - Methods	Column 2 - Waters
By means of nets of every description, except the dip or scoop net for the capture of prawns only, the use of five (5) hoop nets per person and the landing net, as prescribed by Regulation.	The whole of the waters of that part of the Nambucca River and Pacific Ocean from the eastern extremity of the northern breakwater (including the spur wall) to its western extremity: by a line drawn north-westerly to the easternmost foreshore corner of Oyster Lease No. 83-148 by the line of mean high-water mark on the north-western bank of Nambucca River generally southerly and south-westerly to the causeway, by the causeway: south-easterly to Stuarts Island: by the mean high-water mark easterly and southerly to the southern boundary of Oyster Lease No. 72-190 by a line easterly to the most northerly point of the western entrance to Warrell Creek to a post marked "FD" by a straight line to the eastern bank of the aforementioned creek to a post marked "FD" by the line of mean high-water mark generally north-easterly to the southern bar entrance: by the line of mean high-water mark generally easterly and southerly 805metres to a post marked "FD" and thence by a line north-easterly to the point of commencement. The whole of the tidal waters of the Inner Harbour of the Nambucca River being the waters lying northerly of the northern training wall and north-easterly of a line drawn north-westerly from the south-western extremity of that wall to the north-western bank of the Nambucca River at the eastern most foreshore corner of Oyster Lease No. 83-148. The whole of the waters of a lagoon known locally as Siberia Lagoon adjoining the northern breakwater.
Time Period:For a period of five years from the date of this notification	

Schedule 3 - Warrell Creek Nets and Traps

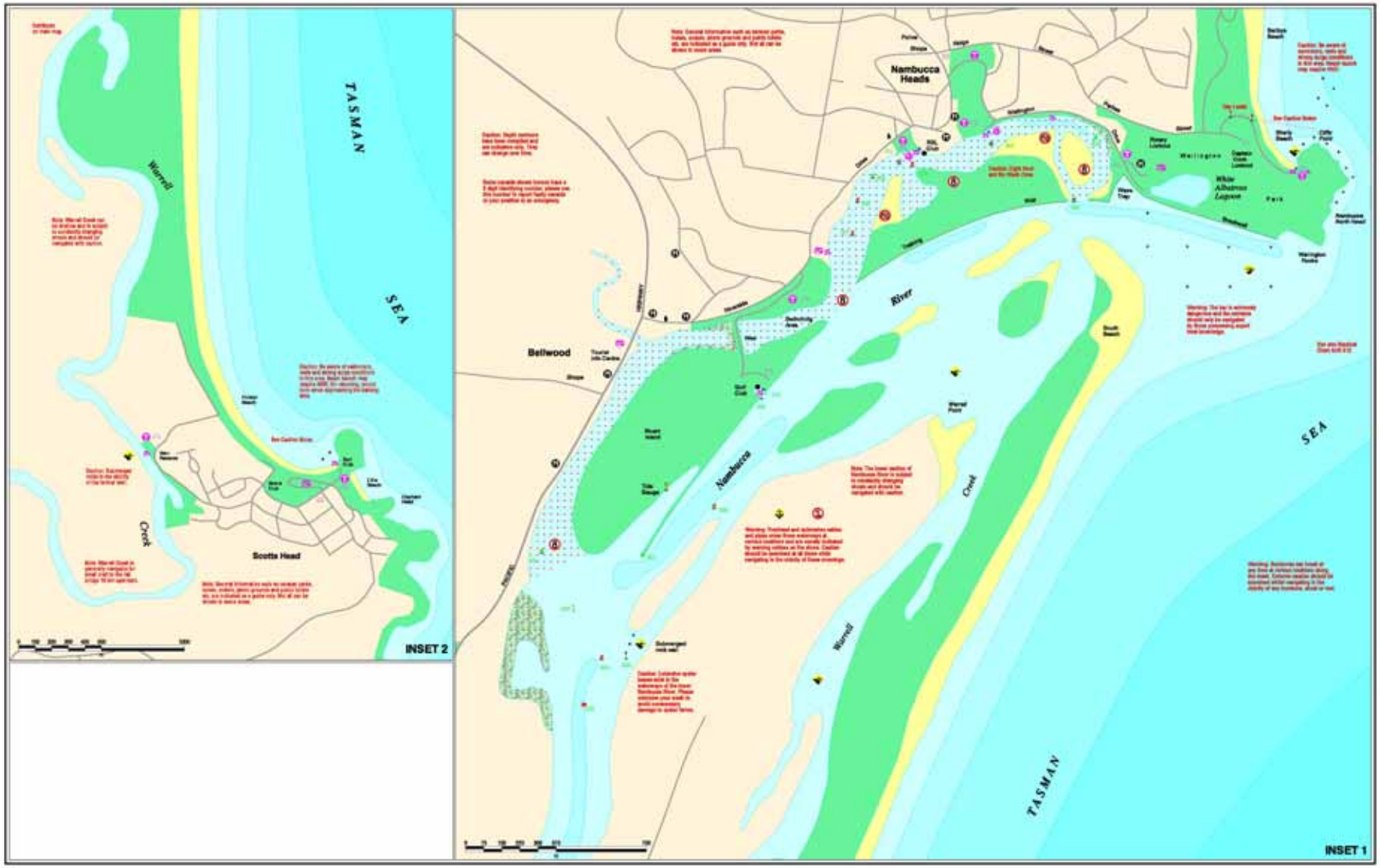
Column 1 - Methods	Column 2 - Waters
By means of nets and traps of every description, except the prescribed eel trap upstream to the Warrell Creek Rail Bridge, and the landing net and bait trap, as prescribed by Regulation.	The whole of the waters of that part of Warrell Creek together with all its creeks and tributaries upstream to its source from Scotts Head Boat Ramp adjacent to Warrell Creek Reserve.
Time Period:For a period of five years from the date of this notification	

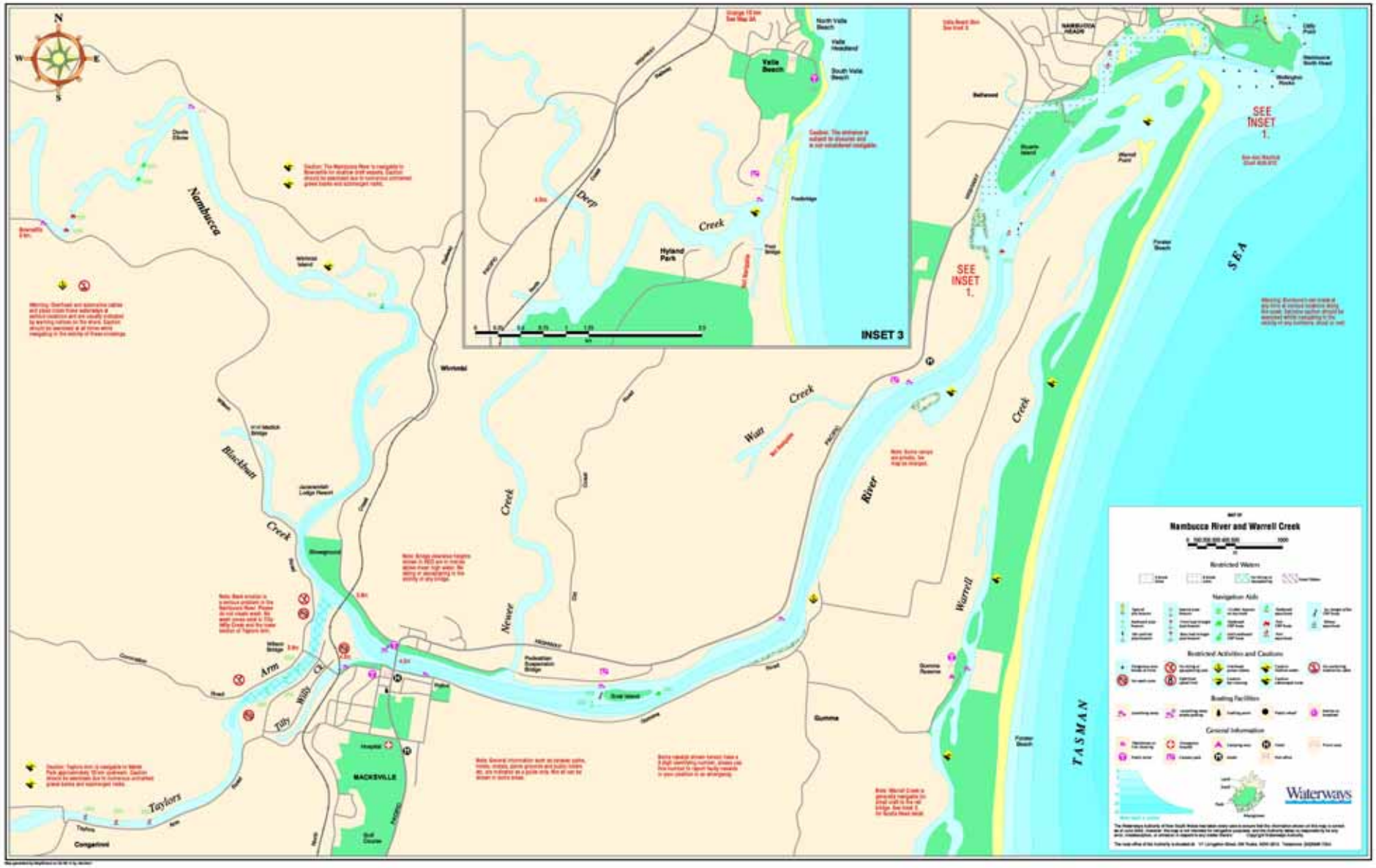
Schedule 4 - Set Mesh Nets

Column 1 - Methods	Column 2 - Waters
By means of meshing nets, except when such nets are used by the method of 'splashing', as prescribed by Regulation.	Nambucca Arm upstream of an imaginary line across those waters bearing north from the western side of the boat ramp at Apex Park Reserve, Wilsons Road, Parish of Bowra, County of Raleigh. Taylors Arm upstream from an imaginary line drawn north-east across those waters, from a post marked "FD" on the south-eastern corner of land portion 40, Parish of Congarinni, County of Raleigh.
Time Period: This closure will only apply from 15 May to 31 August in each year.	

Note: This closure applies to commercial and recreational fishers. The purpose of this closure is to protect fish stocks and to share the resource between recreational and commercial fishers and other users of these waters.

APPENDIX D: NSW MARITIME BOATING MAPS FOR THE NAMBUCCA RIVER ESTUARY




N
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Creek
River
Warrell
Creek
SEE INSET 1.
SEE INSET 1.
SEA
TASMAN
INSET 3
Valla Beach
North Valla Beach
Valla Headland
South Valla Beach
Deep
Creek
Hyland Park
Bellwood
Forster Beach
Nambucca Heads
Nambucca River and Warrell Creek
Restricted Waters
Navigation Aids
Restricted Activities and Cautions
Boating Facilities
General Information
Waterways

APPENDIX E: ASSESSMENT OF STUART ISLAND CAUSEWAY RECONFIGURATION

Introduction

WBM was commissioned to assess the impacts on tidal flows of changes to a causeway on a branch of the Nambucca River, between Stuarts Island and the mainland. The assessment was undertaken using detailed two-dimensional hydraulic modelling of the study area.

This section of estuary is currently blocked by a causeway, which has resulted in degraded water quality conditions in the vicinity due to lower tidal flushing. One option being considered is to install culvert(s) under the causeway in order to return this arm of the Nambucca River estuary to something closer to its natural flow regime. This will address multiple objectives including Aboriginal cultural connections to the area, water quality concerns and provide fish passage.

The purpose of this study was to determine the effects on tidal flows and velocities of installing culverts under this causeway. The primary design considerations for the culverts were the safety of nearby bathers and that suitable tidal flushing occurred so as to improve water quality.

Methodology

A one-dimensional (1D) MIKE-11 hydraulic model of the tidal reaches of the Nambucca River has been developed and calibrated as part of the Estuary Processes Study (WBM, 2000). Due to the 1D nature of this model, it is not able to accurately quantify local tide velocities in the vicinity of culvert inlet and outlets.

In order to better quantify these velocities, a two-dimensional (2D) TUFLOW model of the study area was developed. The extent of this model is shown in Figure E-18-1. However, this local model requires boundary conditions to drive flow into and out of it. These were derived from the broader and more extensive 1D MIKE-11 model.

The calibrated tidal MIKE-11 model was then modified to include the causeway and the proposed culverts. Water level time series were then extracted from the results of the modified MIKE-11 model at locations at either end of the 2D domain, which extends for a couple of hundred metres east and west of the causeway. These were used as boundary conditions at either end of the TUFLOW model.

As 2D modelling is generally more computationally intensive than 1D, it was decided only to run the TUFLOW model for a shorter period of time than the MIKE-11 model, focusing on the time where the head difference across the 2D domain was greatest, as this would produce the greatest velocities through the culverts and in the estuary itself. This occurred during a spring tide.

As can be seen in Figure E-18-2, the tidal range of the boundaries used in the TUFLOW model is much smaller than that at the end of the MIKE-11 model, which is located over 1.5km downstream of the study area.

The three options investigated were:

- Option 1: Three (3) barrels of 1.8m wide by 0.6m high rectangular culverts;
- Option 2: One (1) barrel of 3.6m wide by 1.8m high rectangular culvert; and
- Option 3: One (1) 8m wide by 1.8m high bridge section.

The recommended option is Option 2, as it is more than large enough for any individual to pass through. These results are discussed in more detail further on.

The Option 2 culvert was simulated in the 2D model at a level of –0.5m AHD. The location of the culvert, shown in Figure E-18-3, is recommended to be approximately one third of the way across the causeway from the north, as this should minimise impacts on seagrass and mangrove populations in the area. The bathymetry of the estuary also lends itself to the conclusion that this is the most appropriate place for the culvert, as it connects the areas that are approximately deepest on either side of the causeway.

A comparison of the flow through the culvert was made between the 1D MIKE-11 model and the 2D TUFLOW model in order to verify the 2D model. The results are presented in Figure E-18-4 below. As can be seen the match in timing / shape is quite good and the match of flow magnitude was adequate. Differences in the magnitude of the flow are believed to be a result of more accurate representation of the bathymetry in the TUFLOW model. Overall, this was deemed to be a satisfactory verification of the 2D model performance.

Figure E-18-1 Extent of TUFLOW Model

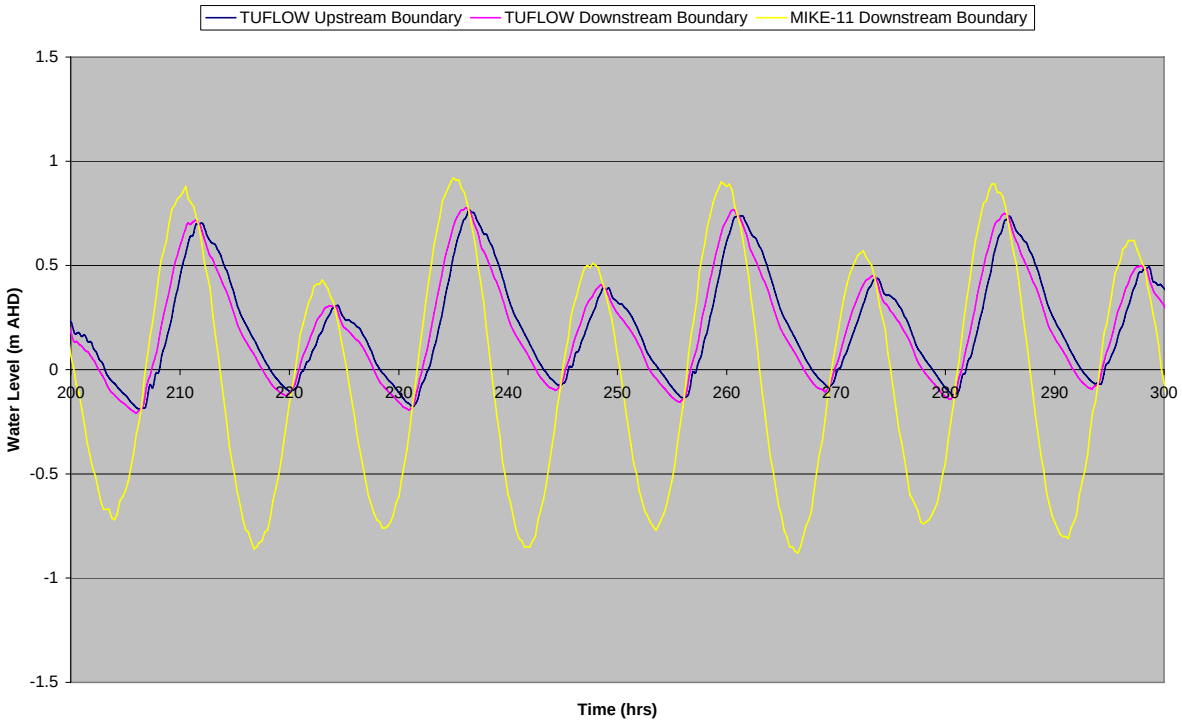


Figure E-18-2 – Water Level Boundary Comparison

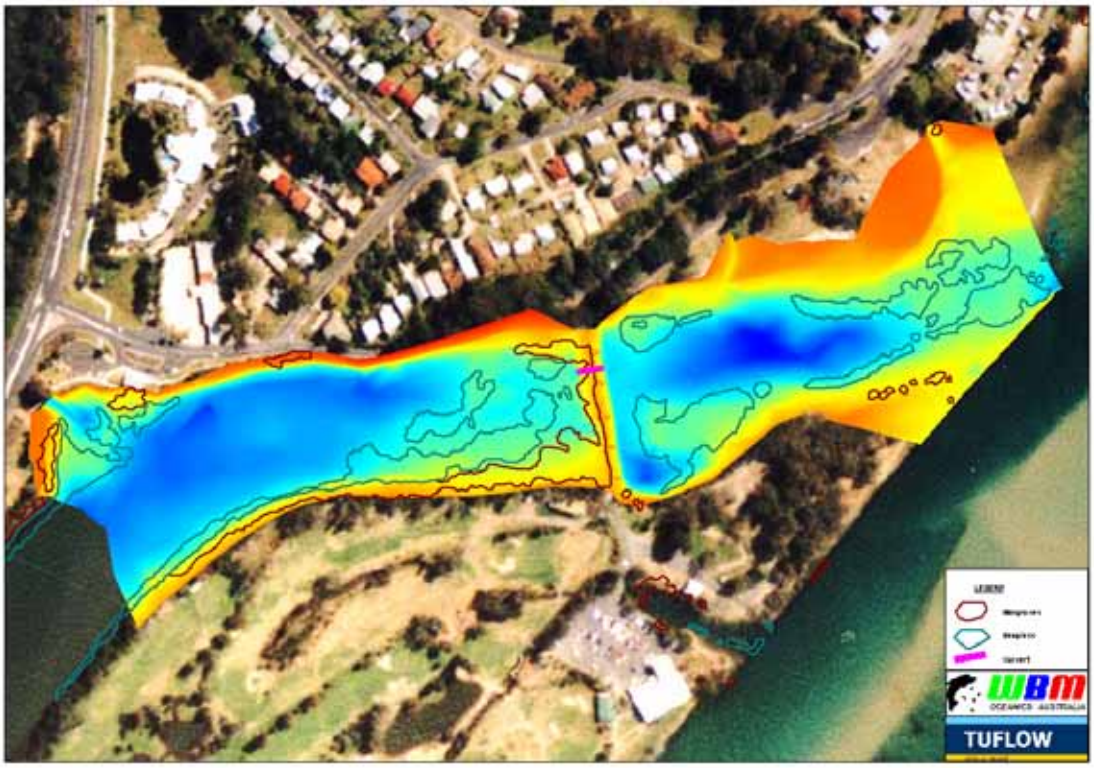


Figure E-18-3 – Location of Culvert with Local Topographic & Ecological Features

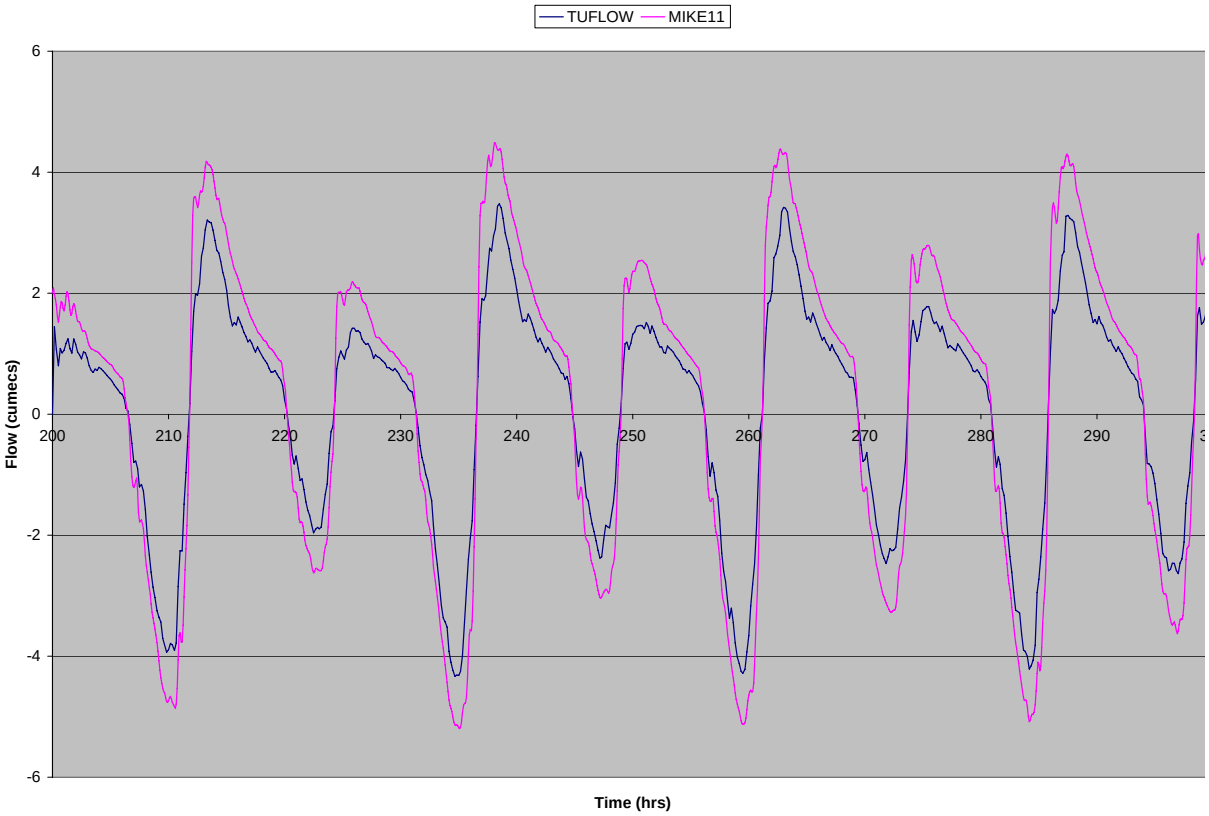


Figure E-18-4 – MIKE11 vs. TUFLOW - Flow Through Culvert

Results

With the Option 2 culvert constructed, the model predicted that the depth-averaged velocities in most of the model domain are generally under 0.1m/s, as can be seen in Figure E-18-5. This is estimated to be the swimming speed of a child aged 9 to 12 years with poor swimming ability (Hydro Tasmania, 2003).

Velocities in the culvert are predicted to reach up to 1.3m/s for the tidal range considered (spring tide). Near the culvert, the velocities are predicted to decrease to 0.1m/s over approximately 70m at the western end of the culvert and over approximately 30m at the eastern end.

The shallow area at the eastern end of this side branch (at the junction with the main Nambucca River) already experiences velocities exceeding 0.2m/s, as can be seen in Figure E-18-6. Installation of the culverts causes an increase in velocity of less than 0.05m/s in this area.

The velocity inside the culvert is relatively high and would be difficult to swim against (especially for young people and/or poor swimmers). However, the size of the culvert is considered large enough for individuals to pass through unimpeded. Specifically, the culvert height has been chosen to be sufficiently high, even at times of high tide, that there is a gap between the water surface and the top of the culvert. This would ensure that anybody passing through the culvert has the opportunity to keep his or her head above water. Hence, if anybody was dragged towards the culverts, it is likely that they would pass through the culvert and out the other side.

However, there is a possibility that if the culvert is in someway blocked (eg. tree branch debris) then an individual could be caught on that blockage. This situation could result in injury or death. We are not able to quantify the probability of this scenario.

In order to completely minimise the probability of this occurrence, options should be considered by Council to prevent any swimmers from being dragged into or willingly entering the culverts (eg. grate or bars on either end of the culvert). However, as part of these considerations, it should be noted that the addition of the grates would detract from the aesthetic of the area and will require regular cleaning and maintenance (ie. removal of seagrass and other floating debris).

Alternatively, the number of culverts could be increased to result in a velocity that would not potentially drag swimmers through the culverts. The costs of this size structure are probably prohibitive, as it would involve bridging of a significant proportion of the entire causeway length.

It is also worth noting that velocities in the area in the vicinity of the culverts are in the range considered to be "Low Hazard" (NSW Government, 2001) for the depths of water in which they occur; these depths being in the range 0.1 to 1.0m at the time when the velocity is predicted to be greatest. Velocities are generally smaller in deeper water.

Flushing times will be greatly improved by the installation of the culverts. It is calculated that the flushing time upstream of the existing causeway is currently 3.5 days. This is expected to decrease by approximately 2 days with the installation of the culvert. This improved flushing time will result in improvements to the quality of water in the channel.

There is potential for this redistribution of tidal flows to result in changes to the sediment transport regime of the river. However, the main branch of the Nambucca River conveys a peak flow of 240m^3/s on the ebb tide and 420m^3/s on the flood tide (during the spring tide assessed). The peak flow through the culverts is in the order of 4m^3/s (refer to Figure E-18-4). Hence, it is concluded that the culverts will not have any significant impact on the sediment transport regime of the river.

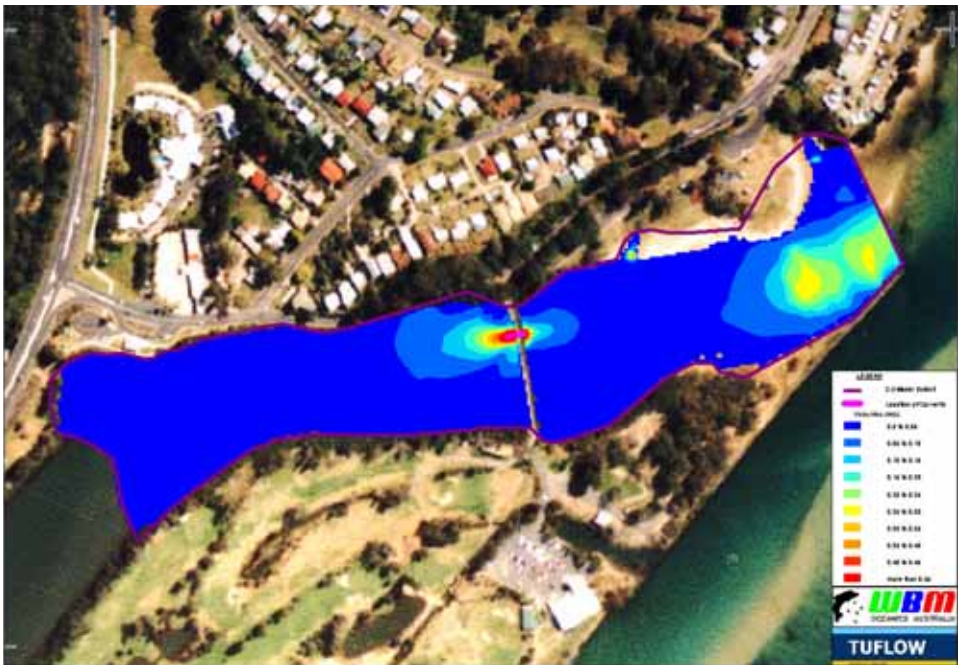


Figure E-18-5 – Maximum Predicted Velocities in Estuary After Installation of Culvert

Figure E-18-6 – Maximum Predicted Velocities in Estuary Under Existing Conditions

Recommendations

Of the three options considered for a constricted opening under the causeway, the best option for swimmer safety, according to the modelling performed and consultation with community members, is to install a single 3.6m wide by 1.8m high culvert at a bed level of -0.5mAHD under the causeway. This option has an obvert of the culvert at 1.3m AHD, which is above Highest Astronomical Tide and, hence, allows room for breathing space within the culvert under non-flood conditions.

However, in the event that the culvert becomes obstructed with debris, the resulting velocities through the culvert could pose a threat to the safety of swimmers in the vicinity of the culverts. The risk of this occurrence has been considered and lowered by choosing a culvert that allows the opportunity for swimmers to keep their heads above water inside the culvert.

It is recommended that appropriate signage be installed above the culvert on either side of the causeway alerting individuals to the dangers of the culvert. As well, in order to completely minimise this risk, options for preventing the passage of swimmers into the culvert should be considered by Council (eg. grate or bars on either end of the culvert). In the absence of these measures, it is recommended that Council consider monitoring of the area following construction of the culverts to ascertain the degree of risks associated with recreational swimming in the vicinity of the culvert.

It is believed that the specified culverts will greatly improve water quality and amenity on the upstream side of the causeway by significantly changing flushing times in this area. Associated with this will be some short-term localized relocation of sands/muds near the near inlet and outlet of the culvert. In the longer term there may be some reductions in mud levels on the upstream side, however, relocation of these substances would only be associated with high flow events which are likely to increase flow velocities throughout the entire estuary.

APPENDIX F: MANAGEMENT OPTIONS FOR ENTRANCE CONDITION MANAGEMENT

General Considerations

Most of the present issues relate to sediment infeed and shoaling of the lower estuary with associated navigation considerations. Management options to address these issues need to consider their likely effectiveness, practicality of implementation and the potential effects on other processes and the natural environment. The community consultation process highlighted the importance of entrance shoaling issues and a number of alternative management options have been put forward. These are discussed below in broad terms to aid consideration of appropriate management strategies to meet the objectives. Management options include:

- 'hard' options such as structural works (eg training walls) with other associated works such as initial dredging in an attempt to generate a 'permanent' solution;
- 'soft' options such as dredging which typically requires ongoing maintenance to maintain adopted minimum cross-sections;
- a combination of the two with some structural works aimed at minimising the amount of ongoing maintenance; or
- planning options aimed at accepting the natural processes and implementing strategies to work within the constraints of natural variability.

It should be recognised that structural options are typically expensive and can lead to other problems unless properly designed and implemented with appropriate strategies. They also typically require some ongoing maintenance as well. The costs of such works need to be weighed up against the benefits.

'Soft' options such as regular maintenance dredging can be viewed as working with the natural processes but again need to be properly designed and implemented to minimise adverse effects. They also have the disadvantage of being required on an ongoing basis with associated disturbances and costs.

Planning or management strategies aimed at accepting the natural processes need to be able to accommodate natural variability and the associated implications, for example shoaling and reduced flushing at times. This has the advantage of not 'interfering' with the natural processes, but may with the disadvantage of having to accept the issues.

As outlined above, the major issue in the Nambucca River entrance region relates to the desire to improve waterway access around the lower estuary. Flushing and water quality are not a major concern at this inlet. However, there is a need to ensure that any proposed works do not have any adverse impacts with respect to other issues such as:

- changes to the tidal hydraulic regime and associated environmental concerns;
- potential for erosion of the ocean beaches; and
- potential increased flooding in the lower estuary.

The waterway access and poor navigability of the Nambucca River entrance are a reflection of hydraulic, wave and sediment transport characteristics. Although a northern training wall was constructed, the processes are such that the entrance has migrated naturally to and from the south and is often broad and shallow. Sediment flow to and from the beach system creates continually changing shallow bar formations which are dangerous for navigation.

At times, such as after flood events or following a sustained period of northerly longshore transport along the beaches, the entrance channel is hard up against the northern training wall and tends to be more confined and deeper.

Options to improve waterway access need to achieve a channel which is stable in location and maintained at a sufficient depth. An important consideration in this regard is the type of vessel that is to be catered for and it's associated draft. For example, non-powered vessels (canoes etc), small outboard runabouts ("tinnies" etc) and jet-powered vessels typically need less than 1m of water depth. Mid-sized runabouts may need between 1m and 2m of water depth while larger pleasure craft, commercial vessels and yachts may need in excess of 2m of water depth for safe navigation.

The time frame and consequences of being constrained with a shallower channel preventing navigation are also important considerations. For example, waiting a short period of time for a higher tide level can often be used to allow navigable access for deeper draft vessels into shallow areas. However, such a constraint would not be appropriate for emergency vessels. Similarly, if a navigation channel is provided and relied upon and subsequently becomes shoaled, the time frame to reinstate the navigable depth may be a major constraint.

As discussed in section 8.5.1 the vast majority of vessels currently using the river are less than 5m in length and would typically need less than 2m of water depth for safe navigation. Such vessels have access to most of the estuary, albeit with a need to rely on higher tide levels in some places. Larger draft vessels are constrained in some areas and deeper channels would need to be maintained in the lower estuary/entrance region if such vessels are to be catered for and/or encouraged. These aspects are considered below in discussing management options for the entrance region.

Options Considered

A range of specific options have been considered to address the issues outlined above including:

1. Do nothing;
2. Remove training walls (or sections);
3. Full training (southern and internal) walls with associated dredging;
4. Major dredging alone;
5. Minor dredging in key areas;
6. Extend northern breakwater;
7. Block gap in vee wall; and
8. Other training wall reconfigurations.

These options are summarised in Table F1 in terms of their main components, aims and considerations.

Table F-1 Entrance Modification Options

Option	Aims	Benefits/Costs	Considerations
1. Do Nothing - Entrance retained in existing condition with no specific works.	• Accept present situation with no expenditure.	• No direct costs • No ecological disturbances • Navigation continues to be restricted	• Accept present variable conditions and restricted navigability. • Promote usage of appropriate boats for conditions. • Flushing and water quality remain acceptable.
2. Remove Walls - Partial or complete removal of existing training walls.	• Return estuary to natural conditions.	• High initial disturbance • High initial cost • Natural processes will continue • Navigation continues to be restricted	• Unlikely to make significant improvement to navigation and may cause it to become worse. • Natural entrance was shallow and dangerous leading to construction of walls.
3. Full Training - Dual training walls and dredged channels with associated maintenance / artificial sand bypassing	• Prevent channel migration and provide a safe navigable entrance. • Confine flows to maintain a deeper channel. • Prevent/minimise sand inflow to maintain navigable channel.	• Very high capital and ongoing maintenance costs • High initial ecological disturbance • Will provide navigable access for a wide range of vessels • Increased artificial modification to estuary	• Appropriate design required to minimise sand inflow and to accommodate floods. • May alter natural tidal hydraulic regime with follow on ecological implications. • Ongoing maintenance dredging/sand bypassing required at cost to maintain navigation.
4. Major Dredging - Dredging a major navigation channel through the entrance and lower estuary.	• Provide a deep navigable entrance channel.	• High initial costs and ongoing maintenance costs required • Temporary ecological disturbance • Temporary improvement to navigation	• Ongoing sediment inflow may quickly shoal channels. • Ongoing maintenance dredging will be required on a regular basis to maintain navigation. • Dredged sand will need to be placed back in the active coastal system (eg adjacent beaches).
5. Minor Dredging - Dredging isolated areas of lower estuary where navigation constraints are greatest.	• Provide a navigable channel where most needed in the lower estuary.	• Modest initial costs and ongoing maintenance costs required • Temporary ecological disturbance • Temporary improvement to navigation • Will not change main entrance constraints	• Ongoing sediment inflow may quickly shoal channels. • Ongoing maintenance dredging will be required on a regular basis to maintain navigation. • Dredged sand will need to be placed back in the active coastal system (eg adjacent beaches). • Will provide minimal disturbance but likely to have limited/short term benefits.
6. Extend Northern Breakwater - Extend northern breakwater to the extremity of the northern rocky headland.	• Provide a control to train flows and maintain a deeper channel across the outer bar.	• Modest initial cost • Temporary ecological disturbance • Limited improvement to navigation	• Existing rocky headland provides similar control. • Unconstrained southern side means that flows can still spread out and sediment inflow will continue • Unlikely to result in any substantial improvement.

Option	Aims	Benefits/Costs	Considerations
7. Block Gap in V-Wall - Close existing breach in training wall to block most flow while still allowing sufficient exchange through (say) culverts for tidal flushing.	• Restrict flow through back channel and push more flow down main channel to scour a deeper section. • Maintain enough flow through back channel to maintain water quality. • Reduce current velocities to improve swimmer safety in back channel	• Modest initial cost • Temporary ecological disturbance • May slightly improve channel depth in main channel • Velocities will decrease in back channel improving swimmer safety • Siltation may occur at upstream end of back channel • Direct navigation from back channel to ocean entrance blocked	• Detailed design required to assess sizes of culverts to maintain sufficient flow and minimise adverse water quality, flooding and other related impacts. • Improvement to depth of main channel may only be small. • A commitment will be required to maintain a navigable channel from the back channel to the main channel and the ocean (as the existing route through the gap in the V-wall will be blocked). • Even with a maintained channel as above, the time for access to the ocean from the back channel will be greater. • As well as improving swimmer safety, the concept could provide access to the island.
8. Block South Channel - Construct training wall across south channel opposite Stuart Island joining small islands.	• Block flow through south channel to Warrel Point and force this flow along the central channel adjacent to the existing training wall to scour a deeper channel.	• High initial cost • Temporary ecological disturbance • Limited zone of improvement to navigation	• Sedimentation likely at downstream end where flows can spread out still constraining navigation and requiring maintenance dredging. • Would limit further scour of Warrel Point

A range of options were considered for dealing with the shoaling processes and associated navigation issues as summarised in Table F-1. It needs to be recognised that such processes are natural and will continue to occur. Furthermore, some options will be less effective than others in providing a long-term benefit while others would be very costly. This limits the range of likely viable options.

The potential inflow of sand from the beach system into the river and the development of a shallow ebb tide delta off the entrance are key constraints to maintaining a navigable entrance. One method to address this issue is the construction of a southern training wall and an artificial sand bypassing system. Such a scheme would collect sand from the littoral drift system and pump it across the entrance thereby preventing the sediment inflow and maintaining a deep channel.

Such systems have been implemented at river entrances where there is a clear cost/benefit in maintaining navigable access and/or ensuring there are no adverse effects to the beach processes. While such a system could be considered for the Nambucca River, the capital cost and ongoing operational costs are very high and would require economic justification e.g. the Tweed River Sand Bypass system will have cost about $50M to build and operate over its 20 year design life. Typically a strong commercial boating and/or tourist development market is necessary to justify such works.

Other dredging related options would have limited long-term benefit and would require regular maintenance dredging (at cost) to provide ongoing navigable access. Similarly, other structural options may have limited local improvements but will not address the overall issue of shoaling restricting navigation.

It is clear that understanding and acceptance of the natural shoaling processes and associated navigation constraints is a critical matter. This together with promoting appropriate boating usage (shallow draft vessels) is a viable option under the knowledge that flushing and water quality of the lower estuary is adequate. As outlined above, improving navigation across the entrance to the ocean is complex and costly (>$20M) and would be subject to a detailed cost/benefit analysis. In the absence of major commercial boating and tourist developments, it is unlikely that such works will be justified.

Smaller works could be considered to address localised shoaling and erosion in the lower estuary where problems become critical. The highly dynamic nature of the processes and ever changing conditions need to be understood in considering the practicality, benefits, costs and likely effectiveness of such works as well as the potential impacts. Minor dredging works may be considered where it becomes critical to provide navigable access. However, it would need to be recognised that such works may only provide a temporary improvement.

Blocking the gap in the V-wall (with appropriate culverts to maintain adequate flushing and water quality in the back channel) has been put forward as an option which may slightly improve the navigable water depth in the main channel. It would also have the benefits of improving swimmer safety and providing access to the island for other recreational usage. However, appropriate design would be required to ensure no adverse flooding impacts arise. Furthermore, it would block direct downstream navigation from the back channel to the ocean and increase the time frame for emergency vessels, presently located in this area, to reach the entrance. There would also need to be a commitment to maintain (dredge) a navigable channel connecting to the main channel at the upstream end to provide such alternative access.

APPENDIX G: SUGGESTED MANAGEMENT OPTIONS PRIORITISATION

Management Strategy	Priority	Rank
BE-1. * Improve overall riverbank condition (including riparian habitats) on all major streams and waterways within the Nambucca Valley.	High	1
LTU-3. Minimise the environmental impact of new development by integrating best practice water management approaches (encompassing design, construction and operation) into Council's planning, approval and regulatory systems.	High	2
SIC-1. Reinstate tidal flow through the Stuarts Island Causeway, whilst minimising risk to swimmers utilising the Bellwood Swimming Hole.	High	3
BWU-2. Introduce a Code of Practice for boating users of the estuary to reduce the erosion problems and environmental harm of boating, whilst improving this group's understanding of the issues associated with boating.	High	4
FSM-3. Support sustainable aquaculture industries within the Nambucca River estuary by application of the highest levels of catchment and waterway management to ensure that the estuary's water quality is sufficient to maintain this industry, in clearly identified areas.	High	5
HM-1. Protect habitats of high ecological and conservation value (eg saltmarsh, wetlands, littoral rainforests, riparian zones and floodplain wetlands).	High	6
LTU-1. Incorporate riparian protection zones within Council's planning framework to safeguard them against potential future development and land-use change.	High	7
HM-2. Enhance condition of habitats of high ecological/ conservation value.	High	8
EC-1. Raise community awareness of coastal/estuary processes to increase the level of understanding of shoaling mechanisms and associated implications as well as the consequences of intervention measures.	High	9
BWU-1. Maximise the amenity of all waterway users whilst addressing the potential environmental impacts of current usage types on sensitive receptors such as banks, key habitats, oyster leases, etc.	Medium	10
BWU-4. Consolidate access points, boat ramps and associated facilities to protect existing estuarine values and to provide quality public foreshore access to the estuary.	Medium	11
LTU-2. Incorporate river health goals and best practice design into future bank protection works (e.g. construction of future foreshore retaining walls) through an integrated and streamlined approvals process.	Medium	12
BWU-3. Improve swimmer safety in the lower estuary by a variety of means including improved signage / safety equipment, provision of new swimming areas and/or improving the safety aspects of existing swimming areas.	Medium	13
EC-2. Address localised shoaling and erosion problems and improve navigable access where practical and most needed in the lower estuary giving consideration to the likely effectiveness, costs and benefits of works as well as the potential impacts.	Medium	14
TM-1. Promote the values of the estuary in ways that promote its sustainable use and also support the valuable tourism industry of the Nambucca Shire.	Medium	15
FSM-1. Initiate fishing catch surveys on the Nambucca River estuary, which identify key fishing locations, fishing effort, catch quantities and species caught.	Medium	16
FSM-2. Obtain better understanding of fisheries habitat values and trends in fish communities over time in different parts of estuary.	Medium	17
WQ-1. Integrate and improve upon existing water quality monitoring activities occurring within the estuary to provide a better indicator of overall estuarine health, whilst addressing all existing licence and operational requirements.	Medium	18
CCSLR-1. Ensure climate change and sea level rise implications are incorporated into the current LEP and forward planning.	Low	19
HM-3. Protect habitats of moderate or local ecological value (eg areas of native regrowth).	Low	20
HM-4. Enhance condition of habitats of moderate or local ecological value.	Low	21
LTU-4. Ensure all foreshore structures are appropriately licensed, designed and maintained to protect foreshore amenity and access.	Low	22
TM-2. Improve recognition of Crown Land areas in the lower estuary, particular those around existing facilities that may promote greater connectivity and tourist related usage of the area.	Low	23

The asterisk (*****) designation indicates that these objectives have been derived from the Estuarine Geomorphology, Physical Condition and Mapping Report (Geco Environmental, 2005) as this report forms part of the overall estuary management study.

Also, it has been assumed that Council and other parties will continue to support the proposed wetland management options established and currently being implemented for the Gumma Gumma Wetland by Wetland Care Australia.

Please return these at end of the workshop, or post by **16th September** to:

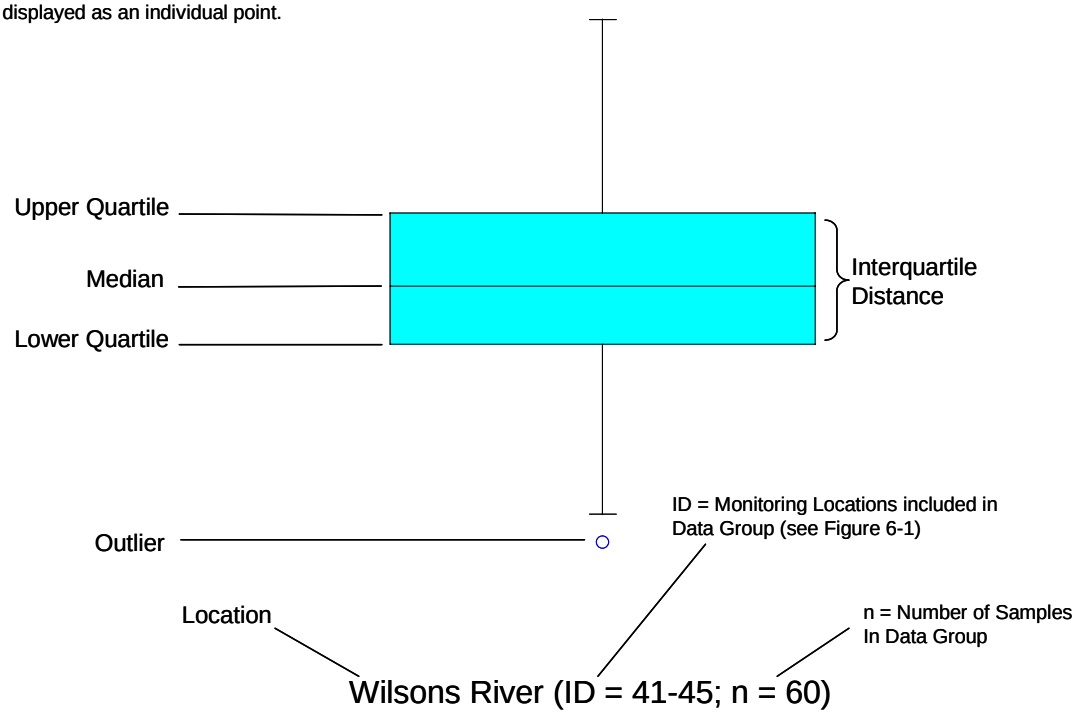
Damion Cavanagh
WBM Oceanics Australia
PO BOX 203
SPRING HILL QLD 4004

You can call Damion on **1800 79 70 79** if you require clarification on objectives and their meaning. Additional information can be obtained from the website www.nambucca-ems.com.au

APPENDIX H: BOX AND WHISKER PLOTS

The figure below provides further explanation of how a box and whisker plot should be interpreted.

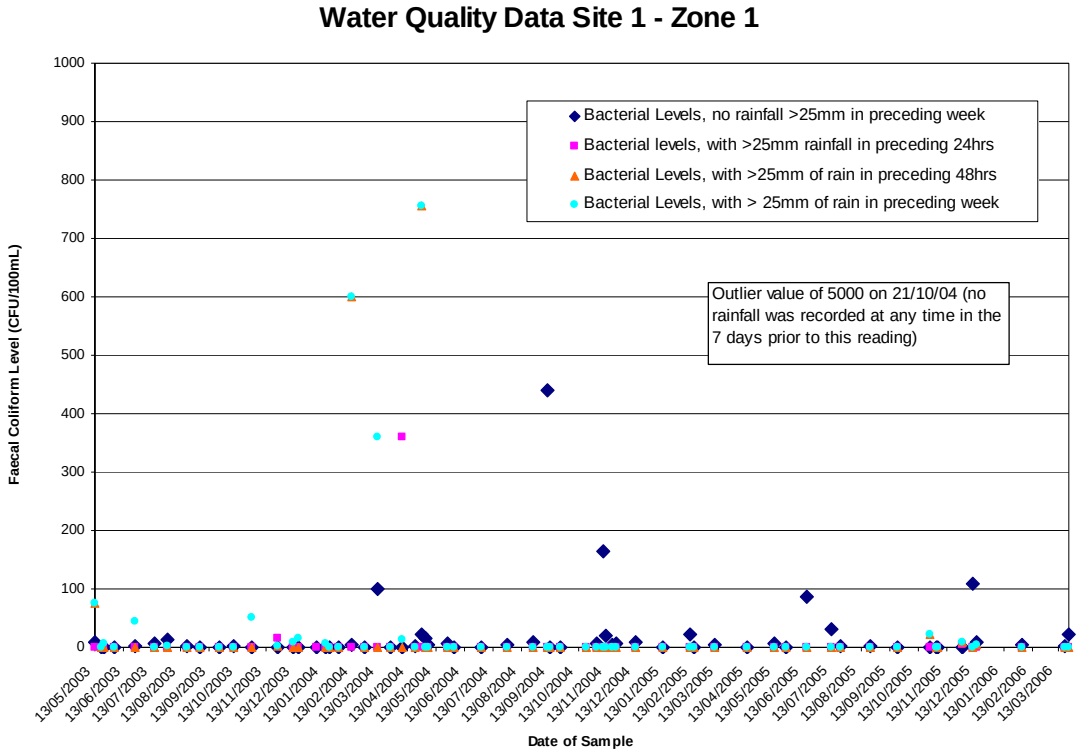
Each box encloses 50% of the data with the median value of the variable displayed as a line. The top and bottom of the box mark the limits of ± 25% of the variable population. The lines extending from the top and bottom of each box mark the minimum and maximum values within the data set that fall within an acceptable range. Any value outside of this range, called an outlier, is displayed as an individual point.

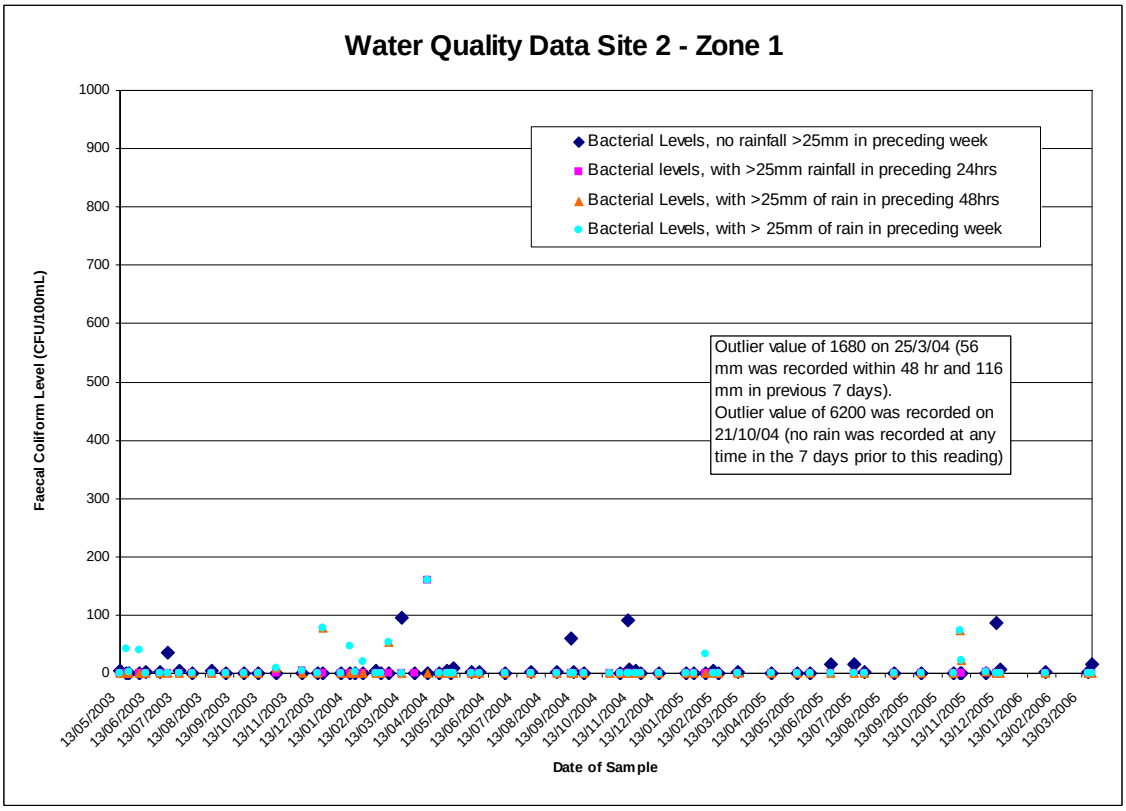


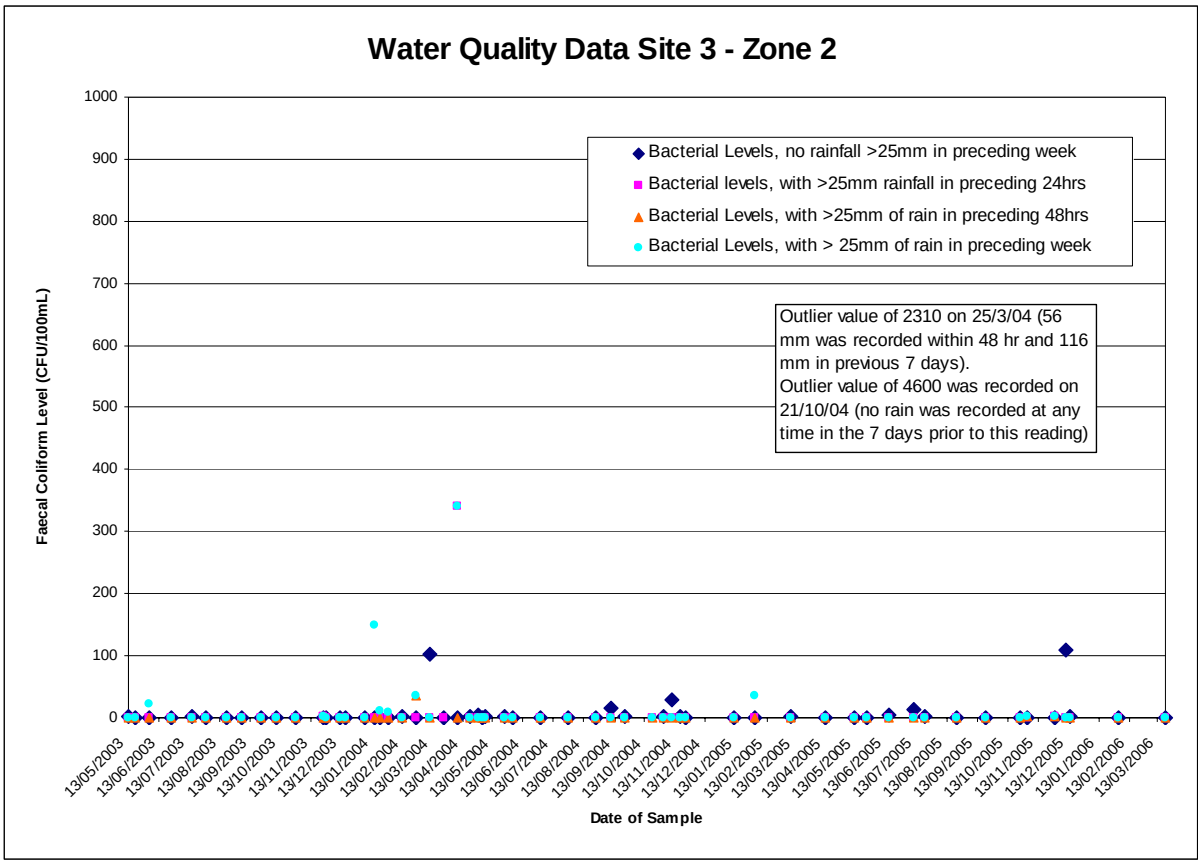
Median – The 50th Percentile. The data value located halfway between the smallest and largest values.
Upper Quartile (UQ) – The 75th Percentile. The data value located halfway between the median and the largest data value.
Lower Quartile (LQ) - The 25th Percentile. The data value located halfway between the median and the smallest data value.
Interquartile Distance (IQD) – The distance between the Upper and Lower Quartiles (UQ - LQ).
Outliers – Points whose value is either: greater than UQ + 1.5 * IQD or less than LQ - 1.5 * IQD.

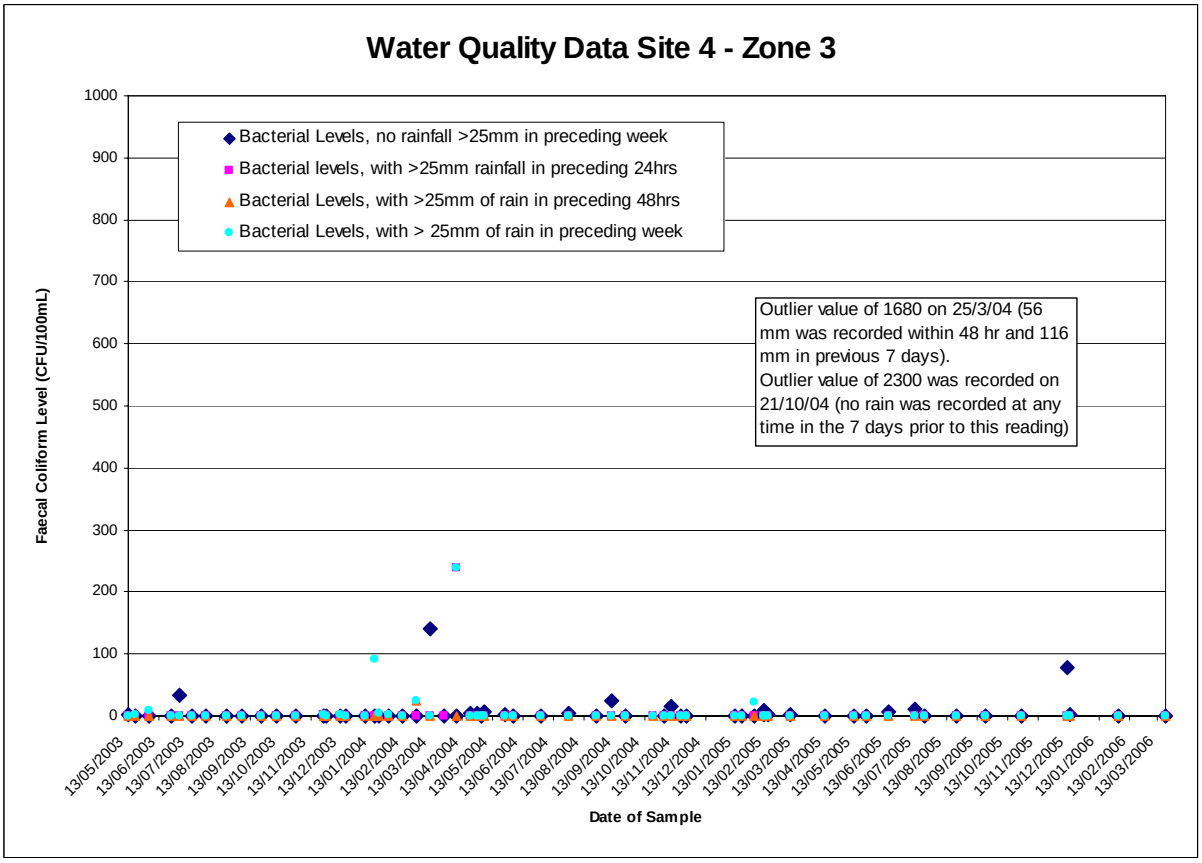
Source: KaleidaGraph 3.5

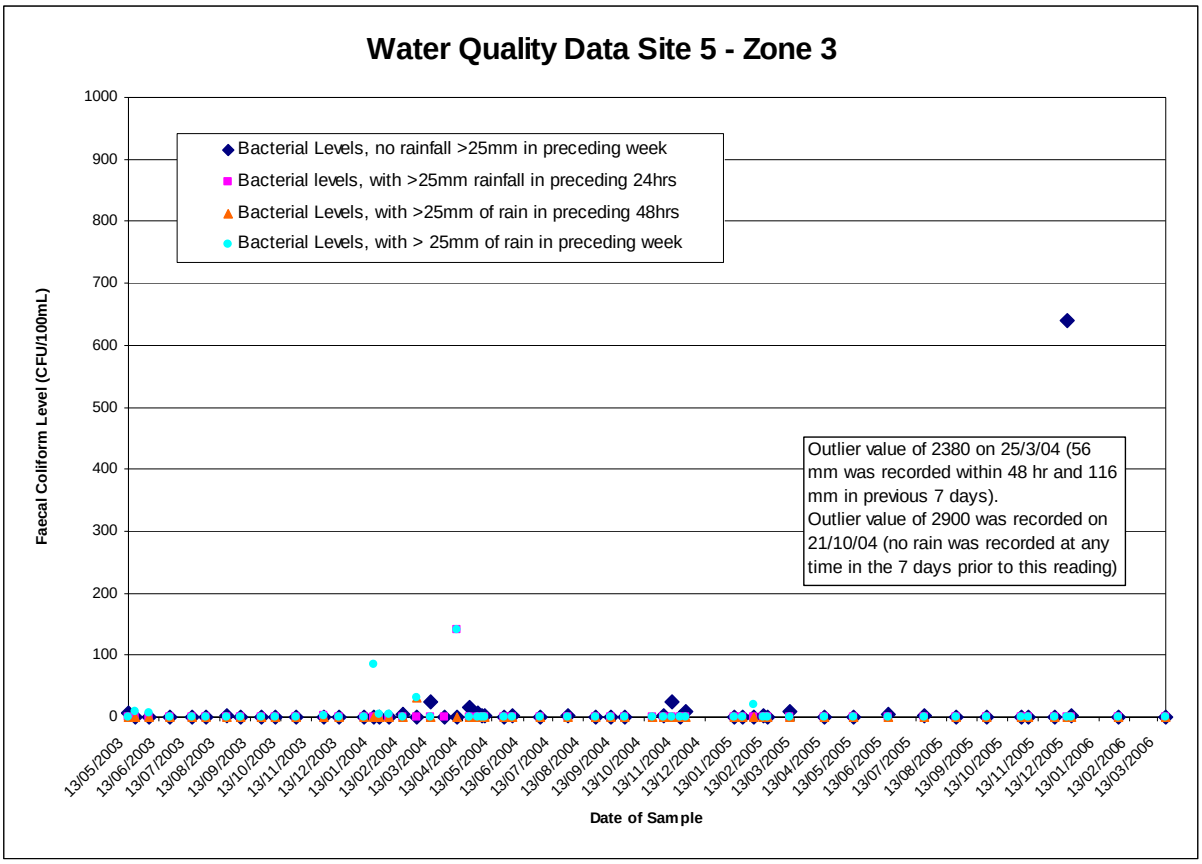
APPENDIX I: WATER QUALITY PLOTS

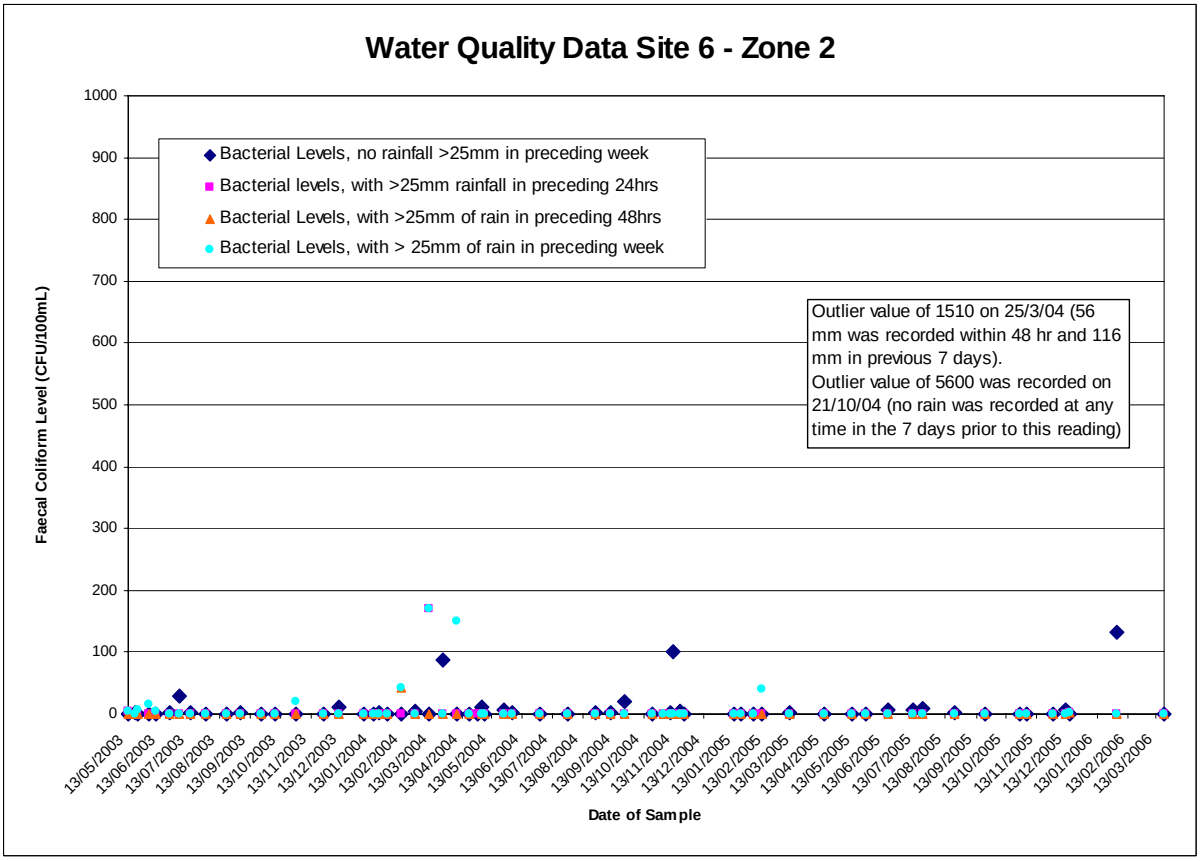


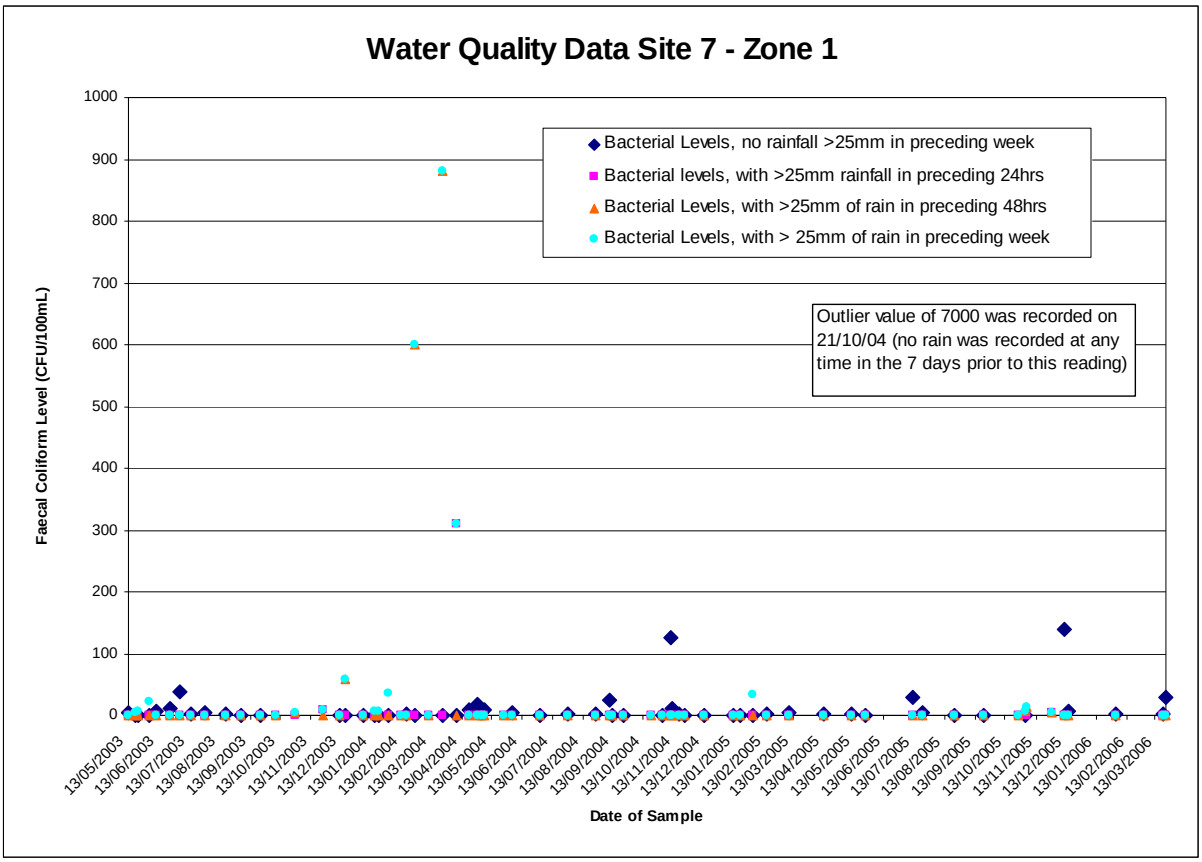



Water Quality Data Site 3 - Zone 2
Faecal Coliform Level (CFU/100mL)
Bacterial Levels, no rainfall >25mm in preceding week
Bacterial levels, with >25mm rainfall in preceding 24hrs
Bacterial Levels, with >25mm of rain in preceding 48hrs
Bacterial Levels, with > 25mm of rain in preceding week
Outlier value of 2310 on 25/3/04 (56 mm was recorded within 48 hr and 116 mm in previous 7 days).
Outlier value of 4600 was recorded on 21/10/04 (no rain was recorded at any time in the 7 days prior to this reading)
Date of Sample


Water Quality Data Site 4 - Zone 3
Faecal Coliform Level (CFU/100mL)
Bacterial Levels, no rainfall >25mm in preceding week
Bacterial levels, with >25mm rainfall in preceding 24hrs
Bacterial Levels, with >25mm of rain in preceding 48hrs
Bacterial Levels, with > 25mm of rain in preceding week
Outlier value of 1680 on 25/3/04 (56 mm was recorded within 48 hr and 116 mm in previous 7 days).
Outlier value of 2300 was recorded on 21/10/04 (no rain was recorded at any time in the 7 days prior to this reading)
Date of Sample


Water Quality Data Site 5 - Zone 3
Bacterial Levels, no rainfall >25mm in preceding week
Bacterial levels, with >25mm rainfall in preceding 24hrs
Bacterial Levels, with >25mm of rain in preceding 48hrs
Bacterial Levels, with > 25mm of rain in preceding week
Outlier value of 2380 on 25/3/04 (56 mm was recorded within 48 hr and 116 mm in previous 7 days).
Outlier value of 2900 was recorded on 21/10/04 (no rain was recorded at any time in the 7 days prior to this reading)
Faecal Coliform Level (CFU/100mL)
Date of Sample


Water Quality Data Site 6 - Zone 2
Bacterial Levels, no rainfall >25mm in preceding week
Bacterial levels, with >25mm rainfall in preceding 24hrs
Bacterial Levels, with >25mm of rain in preceding 48hrs
Bacterial Levels, with > 25mm of rain in preceding week
Outlier value of 1510 on 25/3/04 (56 mm was recorded within 48 hr and 116 mm in previous 7 days).
Outlier value of 5600 was recorded on 21/10/04 (no rain was recorded at any time in the 7 days prior to this reading)
Faecal Coliform Level (CFU/100mL)
Date of Sample


Water Quality Data Site 7 - Zone 1
Faecal Coliform Level (CFU/100mL)
1000
900
800
700
600
500
400
300
200
100
0
Bacterial Levels, no rainfall >25mm in preceding week
Bacterial levels, with >25mm rainfall in preceding 24hrs
Bacterial Levels, with >25mm of rain in preceding 48hrs
Bacterial Levels, with > 25mm of rain in preceding week
Outlier value of 7000 was recorded on 21/10/04 (no rain was recorded at any time in the 7 days prior to this reading)
13/05/2003
13/06/2003
13/07/2003
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Date of Sample