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Draft : Port Stephens Estuary process study : issues relating to
the terrestrial ecology, land use and cultural aspects of the Port
Stephens and Myall Lakes Catchment



DRAFT

**PORT STEPHENS
ESTUARY PROCESS STUDY**

**ISSUES RELATING TO THE TERRESTRIAL ECOLOGY, LAND USE AND
CULTURAL ASPECTS OF THE PORT STEPHENS
AND MYALL LAKES CATCHMENT**

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SECTION 1

BACKGROUND

1.1 INTRODUCTION

The Port Stephens - Myall Lakes estuary is one of the largest estuarine waterways in NSW. It is located on the NSW mid north coast approximately 50 km north of the Hunter River entrance at Newcastle. The port lies at the confluence of the Myall River, Karuah River, Tilligerry Creek and the Ocean. The Port is essentially a drowned river valley with a total waterway area of approximately 160 km².

The Port Stephens - Myall Lakes Catchment is approximately 4 950 km². The catchment is located within the Dungog (9233), Bulahdelah (9333), Port Stephens (9332) and Newcastle (9232) 1: 100,000 scale map sheets.

The Port Stephens - Myall Lakes study area comprises of the catchments of the Myall Lakes, Myall River, Karuah River and Tilligerry Creek.

The Myall Lakes comprise a series of three interconnected water bodies lying between the coastal sand barrier of the Myall Lakes National Park to the east and the town of Bulahdelah to the west. The Myall River drains into Bombah Broadwater, flowing into Port Stephens at Corrie Island (WP Geomarine 1995).

The Karuah River drains a catchment of approximately 2 200 km². The estuarine section of the river broadens with distance downstream and eventually forms the inner estuary near Little Swan Bay (WP Geomarine 1995).

Tilligerry Creek lies within the inner barrier Pleistocene and outer barrier Holocene dunes of the Stockton Peninsula. The creek enters Port Stephens at Lemon Tree Passage. The total area draining to Tilligerry creek is 82 km² (WP Geomarine 1995).

1.2 CLIMATE

Climatic Data For The Newcastle 1:100,000 Scale Map Sheet

Climatic data are available for Newcastle, Williamtown, Maitland and Paterson (Bureau of Meteorology 1988). The prevailing climate of the area is warm temperate with a maritime influence. Summers are warm to hot and humid, winters are cool to mild.

Rainfall is summer-autumn dominated due to the predominance of easterly trade winds at this time of the year. Rainfall minimums occur during late winter and early spring. The average annual rainfall is highest at the coast, with 1142 mm at Nobbys Signal Station (Newcastle), and decreases inland with 913 mm at

Williamstown. The maximum average monthly rainfall occurs on the coast during the month of March, with 121 mm at Newcastle and 123 mm at Williamstown. The minimum average monthly rainfall is 33 mm which occurs during July and August at Paterson.

The average monthly maximum temperatures are highest in the west, with 29°C in December and January at Paterson and lowest on the coast, with 24°C at Newcastle. The average minimum monthly temperatures range from 4°C in July at Maitland to 8.2°C at Newcastle.

The prevailing winds are from the west in winter. Summer winds are from the east and south-east.

Climatic Data For The Port Stephens 1:100,000 Scale Map Sheet

Rainfall information for Nelson Bay is the only official climatic information available for the Port Stephens sheet.

Average rainfall on the coast is 1,341 mm at Nelson Bay. Rainfall is slightly winter dominated, with a maximum of 154 mm in June to a spring low of 73 mm in November.

1.3 LANDUSE

A detailed assessment of land use within the study area is provided in Section 4. A brief summary of these details are provided below. The land within the Port Stephens/Myall Lakes Catchment is used for a variety of purposes, including residential development, commercial areas, agriculture, industry, recreation, conservation, military installations and transport infrastructure.

Approximately 35% of the area of the catchment is cleared, with the remainder being naturally vegetated. The majority of the cleared land in the catchment is used for agricultural purposes.

Approximately 10.5% of the catchment is managed by NSW State Forests, while approximately 7% of the catchment is managed by the NSW National Parks and Wildlife Service.

Tourism is a major industry in the catchment. Tourism is focused around natural attractions such as Port Stephens and the Myall Lakes. Urban areas such as Hawks Nest, Tea Gardens, Nelson Bay, Karuah and Seal Rocks which are located close to significant natural features, are also significant focal points for tourism.

The catchment provides a wide range of attractions and recreational activities for tourists including:

- Four -wheel Driving
- Bushwalking
- Boating
- Water skiing
- Fishing
- Sporting activities
- Dolphin and whale watching
- Abseiling
- Canoeing
- Scuba diving
- Horse riding
- Wine tasting
- Historic and heritage sites
- Local arts and crafts
- Fun parks
- Joy Flights

1.4 VEGETATION OF THE CATCHMENT

It is estimated that approximately 65-70% of the catchment is naturally vegetated. A diverse range of natural vegetation communities are present in the catchment including Open Forest/Woodland, Swamp, Swamp Forest, Heath, Headland Complex and Estuarine Complex. These vegetation communities occur over the broad scale and further sub-division of these communities is possible subject to more detailed study. In addition to these natural vegetation communities, areas of Cleared Land and Pine Plantations are also present within the catchment. Detailed descriptions of these vegetation communities are provided in Section 2 while brief descriptions are provided below.

Open Forest/Woodland

The most common vegetation community in the catchment is the Open Forest/Woodland community, covering approximately 55% of the catchment. Within the catchment this community occurs from the coastal lowlands to the inland high altitude areas. The structural and floristic composition of this community is highly variable throughout the catchment. Areas of Closed Forest also occur within this community.

Estuarine Complex

The Estuarine Complex occurs only in areas adjacent to the estuary and covers approximately 3% of the catchment. The Estuarine Complex is actually comprised of a range of vegetation communities that occur in close association. The individual vegetation communities occurring in the Estuarine Complex include Mangrove Open Scrub, Saltmarsh, Rushland and Swamp Forest.

Swamp

The Swamp vegetation community only occurs in areas that are regularly inundated or in which the water table is at or above the land's surface. As a result of these limits to distribution, Swamp only occurs in the lower part of the catchment. The Swamp vegetation community covers approximately 2% of the

catchment. Much of the estuarine swamp areas are incorporated into SEPP 14 protected wetland areas. The extent of the SEPP 14 wetlands are identified in Appendix I.

Swamp Forest

Swamp Forest is restricted to coastal areas and occurs on alluvial plains and low-lying areas which are poorly drained. It occurs in close association with Swamp but occurs on land which is topographically above, and therefore more free draining, than areas in which Swamp occurs. Swamp Forest covers approximately 1% of the catchment.

Headland Complex

Headland Complex occurs only on headlands with a strong coastal influence, therefore it is restricted to the lowermost parts of the catchment. Headland Thicket includes a range of distinct vegetation communities including Open Forest, Rainforest, Broad-leaved Paperbark Swamp and Shrubland. Headland Thicket is the most uncommon vegetation community in the catchment, covering <1% of the catchment.

Pine Plantations

In addition to the natural vegetation communities described above, there are also areas in the catchment which are utilised for pine plantations. Pine plantations are located to the north of Port Stephens and cover approximately 3% of the area of the catchment.

Cleared Land

Approximately 30-40% of the catchment is cleared. Land uses within cleared areas include residential developments, transport infrastructure, recreational facilities agricultural activities, commercial developments, industrial developments and military facilities.

National Parks

Two National Parks occur in the catchment. Myall Lakes National Park, which is located around the foreshores of Myall Lake, Bombah Broadwater and adjacent to the Myall River, conserves an area of 31,571 hectares of diverse natural vegetation including swamp, swamp forest, open forest, heath and closed forest (NSW NPWS 1997). Myall Lakes National Park covers approximately 6.4% of the area of the catchment. Myall Lakes National Park occurs in close association with the Myall Lakes system and would be directly influenced by and would influence lacustrine processes in the area.

Tomaree National Park, which is located south of Nelson Bay on the Tomaree Peninsula conserves an area of 2,310 hectares of natural vegetation (NSW NPWS

1997) or approximately 0.5% of the area of the catchment. Tomaree National Park is located on the coastal side of the Tomaree Peninsula and therefore would not have a significant influence or be greatly affected by estuarine processes.

State Forests

Twelve state forests occur within the Port Stephens/Myall Lakes catchment, covering approximately 10.5% of the catchment or approximately 52,000 hectares. The predominant vegetation community within these state forests is Open forest/Woodland, although some areas of Closed Forest also occur. The state forests which occur in the catchment are listed below:

- Nerong State Forest
- Wallaroo State Forest
- Karuah State Forest
- Medowie State Forest
- Myall River State Forest
- Renwick State Forest
- Bulahdelah State Forest
- Chichester State Forest
- Avon River State Forest
- Trevor State Forest
- Dungog State Forest
- Craven State Forest

Most of these state forests are in the upper part of the catchment and while processes occurring in these state forests may have an effect on the estuary, estuarine processes would not have an effect on these state forests. Karuah, Nerong and Medowie State Forests are located in low-lying areas or adjacent to the estuary and lacustrine system. These state forests may be affected by estuarine processes and would be affected by processes occurring further up in the catchment.

1.5 THREATENED FLORA SPECIES OF THE CATCHMENT

Thirteen threatened plant species listed on Schedules 1 or 2 of the *Threatened Species Conservation Act* 1995 are recorded occurring in the catchment. Details on these threatened plant species are provided in Section 7.2 of the Appendix. The threatened plant species recorded occurring in the catchment are listed below:

- *Asperula asthenes*
- *Cryptostylis hunteriana*
- *Diuris pendunculata*
- *Eucalyptus camfieldii*
- *Eucalyptus glaucina*
- *Eucalyptus parramattensis*
ssp. *decadens*
- *Grevillea obtusifolia*
- *Melaleuca groveana*
- *Prostanthera densa*
- *Rulingia prostrata*
- *Syzygium paniculatum*
- *Tetradlea juncea*
- *Typhonium eliosorum*

None of these threatened plant species are known to occur in estuarine habitats or habitats closely associated to the estuary. It is therefore not expected that estuarine processes will have a significant impact on these threatened plant species.

1.6 THREATENED FAUNA OF THE CATCHMENT

Of the 51 threatened fauna species that are recorded on the National Parks and Wildlife Service Wildlife Atlas Database as occurring in the Port Stephens/Myall Lakes catchment, 2 are amphibian, 2 are reptiles, 27 are birds and 20 are mammals (NSW NPWS 1988a, 1988b, 1988c). Of these only 15 threatened species, 14 birds and 1 bat species occur in habitats associated with the estuary. These habitats include:

- Coastal open forests and woodlands;
- Coastal waters, inlets and estuaries;
- Off-shore islands, open beaches;
- Rocky coastlines and estuaries;
- Estuarine flats, wetlands;
- Mangroves and adjacent vegetation.

The threatened fauna species that are recorded in the catchment and which are considered to occur in estuarine and associated habitats are listed below:

- Square-tailed Kite
- Osprey
- Black-browed Albatross
- Gould's Petrel
- Flesh-footed Shearwater
- Little Tern
- Sooty Oystercatcher
- Pied Oystercatcher
- Black Bittern
- Black-necked Stork
- Superb Fruit-dove
- Comb-crested Jacana
- Red Goshawk
- Bush Thick-knee
- Large-footed Mouse-eared Bat
- Wallum Froglet

1.7 ABORIGINAL HISTORIC HERITAGE OF THE CATCHMENT

The heritage items in the Port Stephens/Myall Lakes catchment reflect the history of the area. Remaining heritage items reflect the past land uses of the catchment as a mining, agricultural and industrial area. Other heritage items reflect the area's strategic use for military operations or provide information on the previous social, economic and political characteristics of the catchment as well as information on the people and historic figures of the area.

Most of the heritage items recorded in the catchment are isolated from the estuary and are of little relevance to the estuary process study. Those heritage items which are located on or adjacent to the estuary and which may be relevant to processes affecting the estuary are listed below:

Tea Gardens

- Tea Gardens Shopping District, 215 Myall Street - Fishermen's Huts and Stores.

Tanilba Bay

- Wharf Road - Lee Wharf Group;
- Nobby's Beach - Soldiers Baths.

Carrington

- Cock Renoyo Point - Carrington Boat Harbour and Lime Kiln.

Allworth

- Allworth Wharf Remains.

Before the arrival of Europeans more than 200 years ago, the region covered by this study was home to the Worimi Aboriginal people. The lands of the Great Lakes region covered by the various Worimi nurras (local groups of the Worimi) extended from Maitland and the Hunter River in the south to Forster-Tuncurry in the north, and west to the Barrington Tops (Marr 1997). The Port Stephens / Myall Lakes area was the second place, after Botany Bay, of European / Aboriginal interaction in Australia (L. Anderson pers. comm. 1998).

There is still little information on the seasonal use of the area, and the movement patterns of the Worimi in response to seasonal conditions is still largely unknown, but it has been suggested that the tribes would move inland during winter and return to the coast in spring and early summer to fish (Marr 1997; Summers 1994).

A search of the NSW National Parks and Wildlife Service Aboriginal Sites Register gave a limited list of those sites which have been recorded in the catchment. The list is not comprehensive and many more sites could be found that have not been recorded. Many archaeological investigations have been carried out in the area, but these have been restricted to small areas concerned with urban or rural development and therefore there is a need for a more systematic survey of the area in order to quantify as much as possible the extent to which the area has been used by the Aborigines (DUAP 1989; Sullivan 1992).

The NPWS Aboriginal Sites Register search gave a total of 172 recorded sites within 500 metres of the water's edge of the estuary. This list comprised a variety of site types including axe grinding grooves, bora/ceremonial grounds, burials, fish traps, isolated finds, middens, natural mythological/ritual sites, open camp sites, rock engravings, scarred trees, shelters with art/deposits/middens, and stone arrangements.

1.8 SLOPES AND TOPOGRAPHY

(To be provided)

1.9 SOIL TYPES

(To be provided)

SECTION 2

FLORA AND FAUNA CHARACTERISTICS

2.1 VEGETATION

Determining the Extent of the Catchment.

The location and extent of the Port Stephens - Myall Lakes catchment was determined by initially grouping the Dungog, Bulahdelah, Port Stephens and Newcastle 1: 100,000 scale map sheets together. The catchment boundary was defined as the upper limit of all waterways flowing into Port Stephens and Myall Lakes. The vegetation of the study area is shown in Figure 1.

Determination of Vegetation Communities.

Reference was made to the following studies to determine the nature and extent of vegetation within the catchment:

1. The report "Electricity Supply System, Port Stephens Peninsula - EIS" (Forsite Landscape Architects and Planners 1989) examined in detail the vegetation on the Port Stephens Peninsula. This report identified seven distinct vegetation communities.
2. The EIS for the extraction of white silica sands at Tanilba (Outline Planning Consultants 1989) described the five identified vegetation communities of the Tilligerry Peninsula.
3. The reports "Soil Landscape of the Port Stephens 1:100,000 Sheet" (Murphy 1995) and "Soil Landscapes of the Newcastle 1:100,000 Sheet" (Mathei 1995) described the broad scale vegetation trends throughout these areas.
4. The "Northern Foreshores of Port Stephens - Regional Environmental Study" prepared by Mitchell McCotter and Associates (1986) identified a wide range of vegetation communities on the northern foreshores of Port Stephens.
5. The "Environmental Impact Statement for a Mineral Sands Mining Operation North of Tea Gardens, NSW" (Corkery R.W. & Co. 1985) identified fourteen distinct natural plant communities and a number of disturbed categories in an area located between the Myall River and the Pacific Highway, to the north of Tea Gardens.

6. The "EIS for Mineral Sands Mining in Tomago Sandbeds Water Supply Catchment Area" (Croft and Associates 1982) identified a range of vegetation associations within the study area.
7. The report "Flora of the Port Stephens and Myall Lakes Region New South Wales" (McNair 1992) identified a range of vegetation communities on the Tomaree Peninsula.
8. The "Tomaree Peninsula Landscape Study" (Browne *et al* 1986) identified seven different vegetation communities on the Tomaree Peninsula.
9. Colour aerial photography from the New South Wales Department of Lands (Port Stephens and Newcastle Series 1:25,000 scale flown in February 1993) was used to determine the extent of vegetation and where possible to delineate the boundaries of vegetation communities.

Although structure was the main characteristic used to differentiate between vegetation communities, other environmental factors were also used. The Dungog, Bulahdelah, Port Stephens and Newcastle 1:100,000 scale map sheets contain information on vegetation which was utilised for the present study. The extent of cleared land, the location of areas of swamp and swamp forest and the location of areas of mangroves were determined from these map sheets.

Classification of Vegetation Communities

The structure and floristics of the vegetation communities which had been identified in previous studies were examined. The structural and floristic similarities enabled the amalgamation of some of these communities to create a series of broad-scale vegetation communities at a scale suitable for description and mapping.

Mapping of Identified Vegetation Communities

The broad-scale vegetation communities within the catchment were mapped onto the Port Stephens, Newcastle, Bulahdelah and Dungog 1:100,000 scale map sheets and then reduced to the scale of the maps presented in this report. The resulting vegetation maps are a diagrammatic attempt to simplify the distributional patterns of plant communities within the Port Stephens - Myall Lakes Catchment. The 1:100,000 scale used as a base inherently oversimplifies the diverse vegetation communities found within the catchment. Plant communities do not have the clear cut boundaries that have been implied on the vegetation map but instead exhibit gradational changes. For mapping purposes vegetation community boundaries have been approximated to a line which is an accepted format in which to display information on vegetation over this large scale.

Vegetation of the Catchment

It is estimated that approximately 65-70% of the catchment is naturally vegetated. A diverse range of vegetation communities are present in the catchment. The vegetation communities described in the present study include: Open Forest/Woodland; Swamp; Swamp Forest; Heath; Headland Thicket; and Estuarine Complex. These vegetation communities have been identified over the broad scale and further sub-division of these communities would be possible in a more detailed study. A Closed Forest community has not been identified in the present study due to insufficient time and resources, although Closed Forest is known to occur within the catchment. Detailed descriptions of the vegetation communities are provided in this Section.

The most common vegetation community in the catchment is the Open Forest/Woodland community, covering approximately 55% of the catchment. Within the catchment this community occurs from coastal lowland areas to the inland areas at high altitudes. The structural and floristic composition of this community is highly variable throughout the catchment. Areas of Closed Forest also occur within this community.

The remaining five natural vegetation communities comprise approximately 7% of the catchment. These vegetation communities are restricted to coastal areas and areas around the estuary or areas which are poorly drained. An outline of these vegetation communities is provided below.

The Estuarine Complex occurs only in areas adjacent to the estuary and covers approximately 3% of the catchment. The Estuarine Complex is actually comprised of a range of vegetation communities that occur in close association. The individual vegetation communities occurring in the Estuarine Complex include Mangrove Open Scrub, Saltmarsh, Rushland and Swamp Forest.

The Swamp vegetation community only occurs in areas that are regularly inundated or in which the water table is at or above the land's surface. As a result of these limits to distribution, Swamp only occurs in the lower part of the catchment. The Swamp vegetation community covers approximately 2% of the catchment.

Swamp Forest is restricted to coastal areas and occurs on alluvial plains and low-lying areas which are poorly drained. It occurs in close association with Swamp but occurs on land which is topographically above, and therefore more free draining, than areas in which Swamp occurs. Swamp Forest covers approximately 1% of the catchment.

Headland Complex occurs only on headlands with a strong coastal influence, therefore it is restricted to the lowermost parts of the catchment. Headland Thicket includes a range of distinct vegetation communities including Open Forest, Rainforest, Broad-leaved Paperbark Swamp and Shrubland. Headland Complex is

the most uncommon vegetation community in the catchment, covering < 1% of the catchment.

In addition to the natural vegetation communities described above, there are also areas in the catchment which are utilised for pine plantations. Pine plantations are located to the north of Port Stephens and cover approximately 3% of the area of the catchment.

Approximately 35% of the catchment is cleared. Land uses within cleared areas include residential developments, transport infrastructure, recreational facilities agricultural activities, commercial developments, industrial developments and military facilities.

The majority of the cleared land in the catchment is used for agricultural purposes. Cleared agricultural land occurs mainly on land which is flat or with low gradients adjacent to creeks and rivers. Within the catchment extensive areas of cleared agricultural land occur along the floodplains of the Karuah and Myall Rivers and in the low-lying areas between these two rivers.

Within the catchment, residential land occurs is concentrated in townships and residential zones such as Karuah, Bulahdelah, Stroud, Medowie, Tea Gardens, Hawks Nest and along the southern and western foreshores of Port Stephens. Recreational facilities are usually located adjacent to residential areas to service the nearby populations. Similarly commercial and industrial zones are usually located close to residential zones. Transport infrastructure usually occurs as thin linear areas of cleared land, throughout all parts of the catchment, and therefore clearing for transport infrastructure is usually minimal. Williamstown Airforce Base is located at Williamstown and there are cleared areas of land associated with this facility.

Vegetation Communities

Six broad-scale vegetation communities have been identified in the catchment. These communities are Swamp, Swamp Forest, Headland Thicket, Open Forest/Woodland, Heath and Estuarine Complex. As well as these natural vegetation communities, areas which have been cleared have been identified, as well as those areas which are used for pine plantations.

The natural vegetation communities have been grouped predominantly on the basis of structural characteristics. Any broad-scale trends in floristics across the catchment within a vegetation community have been identified where possible. Detailed descriptions of the vegetation communities within the catchment are provided below:

SWAMP

Myerscough and Carolin (1986) provided a description of the Swamp community that occurs on the Eurunderee sand mass. The description provided here is a synthesis of the results of Myerscough and Carolin (1986), Forsite (1988) and Browne *et al.* (1986).

The Swamp community occurs in areas where the water table is at or above the surface or in areas which are regularly inundated with fresh water and poorly drained. It occurs in close association with the Swamp Forest community which occurs around the perimeter of the Swamp community on areas which are slightly higher and therefore have better drainage.

Structure:

Trees:

Generally absent or scattered thinly throughout the community. Trees become more dense towards the edges of this community, where there is an ecotone between this community and the Swamp Forest community.

Shrubs:

Shrubs are generally absent or occur scattered singly throughout the community. Shrubs are more common and the shrub layer becomes more dense towards the edges of the community.

Groundlayer:

The groundlayer is dense throughout the community and consists largely of restionaceous and cyperaceous species.

Floristics:

(Main Species Present)

Trees:

Melaleuca quinquenervia (Broad-leaved Paperbark), *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca styphelioides* (Prickly-leaved Paperbark).

Shrubs:

Banksia robur (Swamp Banksia), *Melaleuca ericifolia* (Swamp Paperbark), *Leptospermum juniperinum* (Prickly Tea-tree), *Melaleuca thymifolia* (Thyme Honey-myrtle), *Callistemon citrinus* (Red Bottle Brush).

Groundlayer:

Gahnia sieberana, *Restio tetraphyllus*, *Blechnum indicum* (Swamp Fern), *Gleichenia dicarpa* (Coral Fern), *Schoenus brevifolius*, *Lepyrodia muelleri*, *Restio complanatus*, *Empodisma minus* (Spreading Rope-rush), *Gymnoschoenus sphaerocephalus* (Button Grass).

Distribution:

Within the catchment swamp is a fairly uncommon community, restricted to coastal areas within about 15 km of the coastline. Areas of swamp occur along the Myall River, around Myall Lake and to the south of Bulahdelah on the Bulahdelah Plain. The largest area of swamp within the catchment occurs on the Eurunderee sand mass in the Myall Lakes National Park.

SWAMP FOREST

This community occurs in areas where the water table is high and where there is a high level of nutrients in the soil. Swamp Forest often occurs in association with areas of Swamp, on land with a slightly higher elevation than in areas where Swamp occurs.

Structure:

Trees:

Trees forming an open forest to a height of 20m. In some areas the canopy is more dense forming a closed forest.

Shrubs:

Generally absent.

Groundlayer:

A dense groundlayer consisting predominantly of sedges is present throughout the community.

Floristics:

(Main Species Present)

Trees:

Dominated by *Melaleuca quinquenervia* (Broad-leaved Paperbark) and *Eucalyptus robusta* (Swamp Mahogany).

Shrubs:

Callistemon citrinus (Red Bottle Brush), *Epacris obtusifolia* and *Sprengelia* spp.

Groundlayer:

Blechnum cartilagineum (Gristle Fern), *Blechnum camfieldii*, *Gahnia sieberana*, *Restio tetraphyllus*, *Empodisma minus* (Spreading Rope-rush), *Baumea athrophylla*, *Chorizandra sphaerocephalus* (Round-headed Bristle Rush).

Distribution:

Swamp Forest is scarce within the catchment and is restricted to low-lying coastal areas, adjacent to rivers, lagoons, lakes and estuaries. Within the catchment Swamp Forest occurs to the north of Tilligerry Creek, along parts of the Myall River, around Myall Lake, at Moffats Swamp and south of Salamander Bay.

HEADLAND COMPLEX

A community consisting of a mixture of rainforest and sand-dune species is found facing the sea on rocky headlands of Big Gibber, Yagon Gibber, Treachery Head, and some of the cliffs near Seal Rocks (Myerscough and Carolin 1986). Mitchell McCotter & Associates found a similar association at Yaacaba Head. Vegetation types within this community include a tall shrub community, Open Forest, Broad-leaved Paperbark swamp and rainforests (Mitchell McCotter & Associates 1986).

The diversity of vegetation within the Headland Complex is due to the range of soil and terrain types, aspects and exposures that are present in areas where this

community occurs (Mitchell McCotter & Associates 1986). The trees are usually severely affected by onshore winds, particularly towards the seaward side of the community, where relatively salt tolerant species are present. The less tolerant species occur in the more sheltered landwards locations (Myerscough and Carolin 1986).

Structure: Highly variable.

Trees:

Depending on the location, trees are either absent, form an open canopy to a height of about 12m or form a closed canopy to a height of approximately 20m.

Lesser Trees:

Lesser trees may be absent or may form an open or closed canopy to 8m.

Shrubs:

A dense shrub layer to a height of 3m is present.

Groundlayer:

The groundlayer is consistently dense however the composition is highly variable depending on location. The groundlayer consists predominantly of herbs and grasses.

Floristics:

(Main Species Present)

Trees:

Angophora costata (Smooth-barked Apple), *Eucalyptus pilularis* (Blackbutt), *Eucalyptus paniculata* (Grey Ironbark), *Corymbia gummifera* (Red Bloodwood),

Lesser Trees:

Cupaniopsis anacardioides (Tuckeroo), *Banksia integrifolia*, *Synoum glandulosum* (Scentless Rosewood) and *Acmena smithii* (Lilly Pilly)

Shrubs:

Cupaniopsis anacardioides (Tuckeroo), *Banksia integrifolia*, *Synoum glandulosum* (Scentless Rosewood) and *Acmena smithii* (Lilly Pilly), *Breynia oblongifolia* (Breynia), *Acacia longifolia* (Sydney Golden Wattle), *Correa alba* (White Correa) and *Westringia fruticosa* (Coastal Rosemary).

Groundlayer:

Hibbertia scandens (Golden Guinea Flower), *Oplismenus imbecillis* (Basket Grass), *Imperata cylindrica* (Blady Grass), *Themeda australis* (Kangaroo Grass), *Lomandra longifolia* (Spiny-headed Mat-rush), *Isolepis nodosa* and *Carpobrotus glaucescens* (Pig Face).

Distribution: Headland Complex is the most uncommon community identified in this study. It has a scattered distribution on prominent coastal headlands. Within the catchment areas of headland thicket occur at Yacaaba Head, Shark Island and along the headlands at Seal Rocks. The location of this vegetation community is too small to denote on the vegetation map due to the scale of the final maps.

HEATH

Within the catchment the Heath community occurs on exposed sand dunes close to the coast.

The Dry Heath and Wet Heath communities defined by Myerscough and Carolin (1986) have been included within this community. Several other vegetation studies of the area have defined heath communities which have also been included in this community.

Structure:

Trees:

Absent.

Shrubs:

A dense shrub layer to a height of 3m is present.

Groundlayer:

A dense low-lying shrub layer is present.

Floristics:

(Main Species Present)

Trees:

Absent.

Shrubs:

Dillwynia retorta (Heathy Parrot Pea), *Dillwynia glaberrima*, *Kunzea capitata*, *Melaleuca nodosa* (Ball Honey Myrtle), *Acacia longifolia* (Sydney Golden Wattle), *Acacia floribunda* (White Sallow Wattle), *Banksia serrata* (Saw-toothed Banksia), *Eriostemon australasius* (Pink Wax Flower), *Lambertia formosa* (Mountain Devils), *Persoonia levis* (Broad-leaf Geebung), *Persoonia linifolia* (Narrow-leaf Geebung), *Rhynchosarpis pinifolia* (Wedding Blush) and *Pimelea linifolia* (Slender Rice Flower).

Groundlayer:

Selaginella uliginosa, *Lomandra glauca*, *Hypolaena fastigata* (Tassel Rope-rush), *Restio tetraphyllus*, *Cheilanthes tenuifolia* (Rock Fern), *Imperata cylindrica* (Blady Grass), *Lomandra longifolia* (Spiny-headed Mat-rush), *Pteridium esculentum* (Bracken) and *Themeda australis* (Kangaroo Grass).

Distribution:

Within the catchment Heath is restricted coastal areas with a close proximity to waterbodies. Heath is common to the east of the Myall River immediately landwards of beach dunes. An extensive area of Heath occurs on the Tomago Sandbeds with smaller areas occurring at Anna Bay and at Snapper Point.

ESTUARINE COMPLEX

Benson (1986) described the Estuarine Complex occurring in the Gosford/Lake Macquarie District. The following description is from Benson but is also applicable to the estuarine Complex occurring in the Port Stephens/Myall Lakes catchment. Additional species occurring in the catchment have been added to Benson's description.

The estuarine Complex consists of zones of vegetation with different structural formations. The main factor in the explanation of plant distribution is the influence of tide and elevation on salinity in relation to the environmental requirements and tolerance ranges of the plant species. Plant zonation is closely associated with elevation above sea level, and very small differences in microtopography are involved.

The zonation is broadly as follows. On the outermost side of the mudflat is a zone of mangrove open-scrub, commonly 1 to 5 metres high and dominated by *Avicenna marina* or *Aegiceras corniculatum* in less saline up-stream environments. The mangrove zone is subjected to a relatively high number of high tides. Behind the mangrove zone is a zone of salt marsh, a herbland dominated by *Paspalum paspaloides* and succulent members of the Chenopodiaceae, such as *Sarcocornia quinqueflora* and *Suaeda australis*. These plants are less than 0.5m high and are inundated by saline water only during very high tides or flood periods. These areas are often waterlogged and have a high salinity. Behind this is a zone of rushland with *Juncus kraussii* and *Sporobolus virginicus*. These areas receive infrequent inundation. Finally there is a zone of swamp forest with *Casuarina glauca* and *Eucalyptus robusta*, often with an understorey of *Juncus kraussii* or *Phragmites australis*. This zone is not directly flooded.

Distribution:

The Estuarine Complex is restricted to low-lying areas on alluvial sediments which are regularly to sporadically inundated by saline to brackish water. Within the catchment the Estuarine Complex occurs exclusively in Port Stephens, extending along the Karuah River to a point approximately 6 km north of Karuah. The Estuarine Complex also extends a short distance along the Myall River and along the length of Tilligerry Creek.

OPEN FOREST/WOODLAND

Open Forest/Woodland is the dominant community within the catchment and occurs from coastal areas to inland areas. As a result there is considerable variation in the structure and floristics within this community. Vegetation surveys and other studies which describe this community are scarce, especially for inland areas. As a result it was not possible to split the Open Forest/Woodland community into sub-groups based on structure and floristics.

A generalised description of the Open Forest/Woodland community has been provided. This description is based on a synthesis of the findings of a range of

studies and includes the "Wet Sclerophyll Forest" and "Dry Sclerophyll Forest" communities described by Myerscough and Carolin (1986), the vegetation communities present on the "Anna Bay Land System", "Tomaree Land System" and the "Gangan Land System" (Browne *et al* 1986), the "Eucalyptus Dry Sclerophyll Forest" and the "Eucalyptus Savanna Woodland" (Forsite 1988) and the "Forest/Open Forest" and the "Woodland" communities described by Outline (1989).

Structure:

The density and height of the upper canopy, shrub and ground layers are highly variable within this community throughout the catchment.

Trees:

Trees between 10 - 25 metres in height with an open canopy (between 10 - 70% projective foliage cover) are present.

Shrubs:

A sparse to dense shrub layer ranging in height from 1.5 to 3m is present.

Groundlayer:

A sparse to dense ground cover of grasses, herbs and ferns is present.

Floristics:

(Main Species Present)

The following floristic description is a compilation of descriptions of Open Forest/Woodland from a variety of reports, and not all of the species listed here would be likely to occur in any one location.

Trees:

<i>Angophora costata</i>	(Smooth-barked Apple)
<i>A. floribunda</i>	(Rough-barked Apple)
<i>Corymbia gummifera</i>	(Red Bloodwood)
<i>C. maculata</i>	(Spotted Gum)
<i>Eucalyptus acmenoides</i>	(White Mahogany)
<i>E. agglomerata</i>	(Blue-leaved Stringybark)
<i>E. capitellata</i>	(Brown Stringybark)
<i>E. crebra</i>	(Narrow-leaved Ironbark)
<i>E. eugenoides</i>	(Thin-leaved Stringybark)
<i>E. gracilis</i>	(Yorrell)
<i>E. grandis</i>	(Flooded Gum)
<i>E. haemastoma</i>	(Scribbly Gum)
<i>E. microcorys</i>	(Tallow-wood)
<i>E. oblonga</i>	(Narrow-leaved Stringybark)
<i>E. paniculata</i>	(Grey Ironbark)
<i>E. pilularis</i>	(Blackbutt)
<i>E. piperita</i>	(Sydney Peppermint)
<i>E. punctata</i>	(Grey Gum)
<i>E. resinifera</i>	(Red Mahogany)
<i>E. saligna</i>	(Sydney Blue Gum)
<i>E. siderophloia</i>	(Northern Grey Ironbark)

Trees cont:

<i>E. tereticornis</i>	(Forest Red Gum)
<i>E. umbra</i>	(Bastard Mahogany)
<i>Syncarpia glomulifera</i>	(Turpentine)

Lesser Trees:

<i>Allocasuarina littoralis</i>	(Black She-Oak)
<i>A. torulosa</i>	(Forest Oak)

Shrubs:

<i>Acacia floribunda</i>	(White Sallow Wattle)
<i>A. longifolia</i>	(Sydney Golden Wattle)
<i>A. suaveolens</i>	(Sweet-scented Wattle)
<i>Aotus ericoides</i>	(Aotus)
<i>Banksia aemula</i>	(Wallum Banksia)
<i>B. serrata</i>	(Saw-toothed Banksia)
<i>B. spinulosa</i> var. <i>collina</i>	(Hill Banksia)
<i>Bossiaea rhombifolia</i>	(Appressed Bossiaea)
<i>Ceratopetalum gummiferum</i>	(Christmas Bush)
<i>Daviesia ulicifolia</i>	-
<i>Dillwynia retorta</i>	(Heathy Parrot Pea),
<i>Dodonaea triquetra</i>	(Common Hop Bush)
<i>Eriostemon australiasius</i>	(Pink Wax Plant)
<i>Gompholobium latifolium</i>	(Broad-leaf Wedge-pea)
<i>G. grandiflorum</i>	-
<i>Hakea sericea</i>	(Bushy Needlebush)
<i>Lambertia formosa</i>	(Mountain Devil)
<i>Leptospermum attenuatum</i>	(Paperbark Tea-tree)
<i>L. juniperinum</i>	(Prickly Tea-tree)
<i>Leucopogon lanceolatus</i>	(Lance Beard-heath)
<i>Oxylobium ilicifolium</i>	(Native Holly)
<i>Persoonia levis</i>	(Broad-leaved Geebung)
<i>Pimelea linifolia</i>	(Slender Rice Flower)
<i>Pultenaea villosa</i>	(Bush Pea)
<i>Ricinocarpus pinifolius</i>	(Wedding Blush)

Groundlayer:

<i>Doryanthes excelsa</i>	(Gynea Lily)
<i>Haemadorum</i> spp.	
<i>Blandfordia grandiflora</i>	(Christmas Bell)
<i>Pteridium esculentum</i>	(Bracken)
<i>Imperata cylindrica</i>	(Blady Grass)
<i>Panicum simile</i>	(Two Colour Panic)
<i>Gonocarpus teucrioides</i>	(Germander Raspwort)
<i>Xanthorrhoea</i> spp.	-
<i>Hypolaena fastigata</i>	(Tassel Rope-rush)
<i>Dianella caerulea</i>	(Blue Flax Lily)
<i>Lomandra</i> spp.	-
<i>Themeda australis</i>	(Kangaroo Grass)
<i>Cheilanthes tenuifolia</i>	(Rock Fern)

The general floristic trends of the Open Forest/Woodland community were determined by reference to a wide range of sources. Little information other than the composition of the upper canopy was available. The composition of the upper canopy throughout the catchment is described below:

- In the northern, north-western and central parts of the catchment (Myall River, Chichester, Avon River, Dungog, Trevor, Nerong and Bulahdelah State Forests) the upper canopy is dominated by variable association of *Angophora costata*, *Corymbia gummifera*, *C. maculata*, *Eucalyptus acmenoides*, *E. crebra*, *E. gracilis*, *E. microcorys*, *E. pilularis*, *E. resinifera*, *E. saligna* and *E. siderophloia*.
- In the north-eastern part of the catchment (Myall Lake National Park) the upper canopy is dominated by *Angophora costata* and *Eucalyptus pilularis*.
- North of Port Stephens the upper canopy is dominated by variable association of *Angophora costata*, *Eucalyptus acmenoides*, *E. capitellata*, *E. eugenoides*, *E. paniculata*, *E. siderophloia* and *E. umbra*.
- On the Port Stephens Peninsula the upper canopy is dominated by a variable association of *Angophora costata*, *Corymbia gummifera*, *C. maculata*, *Eucalyptus acmenoides*, *E. agglomerata*, *E. capitellata*, *E. crebra*, *E. eugenoides*, *E. grandis*, *E. haemastoma*, *E. oblonga*, *E. pilularis*, *E. punctata*, *E. resinifera*, *E. saligna*, *E. siderophloia* and *E. umbra*.

A Closed Forest community has not been mapped for this study. Some areas of Closed Forest are undoubtedly present within some of the areas mapped as Open Forest, however differentiating between Closed Forest and Open Forest using aerial photographs is difficult, and with the limited resources available for this study it was not possible to map areas of Closed Forest. Despite the fact that Closed Forest and Open Forest/Woodland have been mapped together these communities are structurally and floristically very different.

Distribution:

Open Forest/Woodland is the most common community in the catchment and covers the majority of the catchment. This community is distributed widely within the catchment and occurs from low-lying coastal areas to inland areas with a high elevation. It is restricted to areas which are freely drained. Within the Open Forest/Woodland community, Closed Forest would be likely to occur in gullies and in moist, sheltered locations with southerly to south-easterly aspects with nutrient rich soils.

PINE PLANTATION

Structure:

Pine plantations by nature have an uncomplicated and uniform structure. Usually the upper storey of pines is the only strata present. Regeneration of the understorey of native plants and pines is prevented by the lack of available light,

deep litter layer of pine needles and the alterations to hydrology and soil chemistry. The structure of pine plantations varies according to the age of the pine plantation with older plantations having a higher and more dense upper canopy.

Floristics:

Prior to the development of a pine plantation the native vegetation is removed and a monoculture of pines is established. Within a pine plantation one or more species of pine may be present.

Distribution:

Pine Plantations are uncommon within the catchment. The two areas of pine plantations which have been mapped in this study both cover large areas and occur to the north of Port Stephens, between North Arm Cove and the Myall River.

2.2 THREATENED FLORA SPECIES WITHIN THE PORT STEPHENS - MYALL LAKES CATCHMENT

Methodology

The occurrence and distribution of rare and threatened flora species was determined by referring to the National Parks and Wildlife Service Wildlife Atlas database for the Dungog, Bulahdelah, Newcastle and Port Stephens 1:100,000 map sheets (NSW NPWS 1998a, 1998b, 1998c and 1998d). This database records the known occurrences of threatened plants and animals.

It was not possible to restrict the Wildlife Atlas search to the area of the catchment exactly. In order to ensure that all threatened species known to occur within the catchment were identified, the scope of the search was made slightly larger than the size of the catchment. This may mean that some of the species listed have in fact been recorded just outside the catchment, however this is unlikely, as most of the species listed have a wide distribution within the catchment.

The distribution of each of the threatened plant species recorded in the catchment was determined by assessing for records of their presence on the Wildlife Atlas database for each of the 1:100,000 scale map sheets. Therefore the distribution of these threatened plant species has been determined on a fairly broad scale.

Threatened Flora of the Catchment

Thirteen threatened plant species listed on Schedules 1 or 2 of the *Threatened Species Conservation Act* 1995 are recorded occurring in the catchment (Table 2.1). None of these threatened plant species are known to occur in estuarine habitats or habitats closely associated with the estuary. It is therefore not expected that estuarine processes will have a significant impact on these threatened plant species.

TABLE 2.1 DISTRIBUTION OF THREATENED PLANT SPECIES
WITHIN THE PORT STEPHENS - MYALL LAKES CATCHMENT.

Species	Family	Reserves	Form	Flowering Period	Habitat	Occurrence (1:100,000 scale map sheets).	Distribution
<i>Asperula asthenes</i>	Rubiaceae	Wallis Island NR not known	Perennial herb	Spring	Riparian areas	Bulahdelah	Taree to Bulahdelah
<i>Cryptostylis hunteriana</i>	Orchidaceae	Ku-Ring-Gai Chase NP not known	Saprophytic terrestrial herb	Dec. - Feb.	swamp-heath on sandy soils	Bulahdelah	South from Gibraltar Range
<i>Diuris pedunculata</i>	Orchidaceae	Not known to occur within reserves	Terrestrial herb	Aug.-Sept.	Moist grassy areas in forest	Newcastle	Port Jackson to Tenterfield
<i>Eucalyptus camfieldii</i>	Myrtaceae	Brisbane Water NP unknown, Ku-Ring- Gai Chase NP < 1000, Royal NP < 1000, Sydney Harbour NP < 1000	Tree or Mallee	Nov-Dec.	Sandy soil on sandstone	Newcastle	Gosford to Royal NP.
<i>E. glaucina</i>	Myrtaceae	Selection Flat NR > 1000	Tree to 30m	Sep. to Nov.		Newcastle & Dungog	
<i>E. parramattensis ssp. decadens</i>	Myrtaceae	Not known to occur within reserves	Tree to 15m	Summer	Woodland on sandy soils, often moist sites	Newcastle	Tomago to Kurri Kurri
<i>Grevillea obtusifolia</i>	Proteaceae	Oxley-Wild Rivers NP < 1000	Spreading shrub	Spring and Summer	Forest or woodland on acidic substrates	Dungog	N/A

**TABLE 2.1 DISTRIBUTION OF THREATENED PLANT SPECIES
WITHIN THE PORT STEPHENS - MYALL LAKES CATCHMENT.**

Species	Family	Reserves	Form	Flowering Period	Habitat	Occurrence (1:100,000 scale map sheets).	Distribution
<i>Asperula asthenes</i>	Rubiaceae	Wallis Island NR not known	Perennial herb	Spring	Riparian areas	Bulahdelah	Taree to Bulahdelah
<i>Cryptostylis hunteriana</i>	Orchidaceae	Ku-Ring-Gai Chase NP not known	Saprophytic terrestrial herb	Dec. - Feb.	swamp-heath on sandy soils	Bulahdelah	South from Gibraltar Range
<i>Diuris pedunculata</i>	Orchidaceae	Not known to occur within reserves	Terrestrial herb	Aug.-Sept.	Moist grassy areas in forest	Newcastle	Port Jackson to Tenterfield
<i>Eucalyptus camfieldii</i>	Myrtaceae	Brisbane Water NP unknown, Ku-Ring- Gai Chase NP < 1000, Royal NP < 1000, Sydney Harbour NP < 1000	Tree or Mallee	Nov-Dec.	Sandy soil on sandstone	Newcastle	Gosford to Royal NP.
<i>E. glaucina</i>	Myrtaceae	Selection Flat NR > 1000	Tree to 30m	Sep. to Nov.		Newcastle & Dungog	
<i>E. parramattensis ssp. decadens</i>	Myrtaceae	Not known to occur within reserves	Tree to 15m	Summer	Woodland on sandy soils, often moist sites	Newcastle	Tomago to Kurri Kurri
<i>Grevillea obtusifolia</i>	Proteaceae	Oxley-Wild Rivers NP < 1000	Spreading shrub	Spring and Summer	Forest or woodland on acidic substrates	Dungog	N/A

TABLE 2.1 CONTINUED

<i>Melaleuca groveana</i>	Myrtaceae	Blacktown Tableland NP not known, Beerwah NP < 1000, Mount French NP not known, Six-B FLR < 1000, Tomaree NP < 1000, Yengo NP < 1000	Shrub or small tree	Spring	Heath on exposed areas north of Port Stephens	Port Stephens	Nelsons Bay to Beecroft Peninsula
<i>Prostanthera densa</i>	Lamiaceae	Royal NP not known	Erect compact shrub	Throughout year	Open forest and shrublands on coastal ranges	Port Stephens	
<i>Rulingia prostrata</i>	Sterculiaceae	Blond Bay WR < 1000, Holey Plains SP < 1000, Moormung FFR < 1000, Providence Ponds FFR < 1000, The Billabong FFR < 1000	Prostrate shrub	Spring	Escarpment gullies	Newcastle	South from Picton Lakes
<i>Syzigium paniculatum</i>	Myrtaceae	Wamberal Lagoon NR < 1000, Jervis Bay NP < 1000, Wyrabalong NP < 1000.	Shrub or small tree	Dec-March	Rainforest, moist gullies	Dungog & Bulahdelah	Bulahdelah to Jervis Bay

TABLE 2.1 CONTINUED.

<i>Tetradlea juncea</i>	Tremandraceae	Glenrock SRA > 1000, Awabakal NP < 100, Munmorah SRA < 1000, Lake Macquarie SRA not known	Prostrate Shrub	July to Dec.	sandy, swampy heath	Port Stephens, Newcastle & Bulahdelah	Bulahdelah to Lake Macquarie
<i>Typhonium eliosorum</i>	Araceae		Perennial herb	late spring to early summer	rainforest margins, riparian areas	Newcastle	Wyong to Nowra

2.3 RARE AND THREATENED FAUNA SPECIES IN THE PORT STEPHENS - MYALL LAKES CATCHMENT.

Methodology

The occurrence and distribution of rare and threatened fauna species was determined by referring to the National Parks and Wildlife Service (1998a; 1998b; 1998c; 1998d) Wildlife Atlas database for the Dungog, Bulahdelah, Newcastle and Port Stephens 1:100,000 map sheets (NSW NPWS 1998a, 1998b, 1998c and 1998d). This database records the known occurrences of threatened plants and animals.

It was not possible to restrict the Wildlife Atlas search to the area of the catchment exactly. In order to ensure that all threatened species known to occur within the catchment were identified, the scope of the search was made slightly larger than the size of the catchment. This may mean that some of the species listed have in fact been recorded just outside the catchment, however this is unlikely, as most of the species listed have a wide distribution within the catchment.

The distribution of each of the threatened fauna species recorded in the catchment was determined by assessing for records of their presence on the Wildlife Atlas database for each of the 1:100,000 scale map sheets. Therefore the distribution of these threatened fauna species has been determined on a fairly broad scale.

Threatened Fauna of the Catchment

Of the 51 threatened fauna species that are recorded on the National Parks and Wildlife Service (1998a; 1998b; 1998c; 1998d) Wildlife Atlas Database as occurring in the Port Stephens/Myall Lakes catchment, 2 are amphibian, 2 are reptiles, 27 are birds and 20 are mammals (Table 2.2). Not all of these species occur in habitats that are associated with the estuary. In fact only 15 threatened species, 14 birds and 1 bat species occur in habitats associated with the estuary. These habitats include:

- coastal open forests and woodlands;
- coastal waters, inlets and estuaries;
- off-shore islands; open beaches;
- rocky coastlines and estuaries;
- estuarine flats; wetlands; and
- mangroves and adjacent vegetation.

The threatened fauna species that are recorded in the catchment and which are considered to occur in estuarine and associated habitats are listed below:

- Square-tailed Kite;
- Osprey;
- Black-browed Albatross;
- Gould's Petrel;
- Flesh-footed Shearwater;
- Little Tern;
- Sooty Oystercatcher;
- Pied Oystercatcher.
- Black Bittern;
- Black-necked Stork;
- Superb fruit-dove;
- Comb Crested Jacana;
- Red Goshawk;
- Bush Thick-knee;
- Large-footed Mouse-eared Bat;

TABLE 2.2
RECORDED AND EXPECTED THREATENED FAUNA OF THE
PORT STEPHENS/MYALL LAKES CATCHMENT

COMMON NAME <i>Scientific Name</i>	PREFERRED HABITAT	OCCURRENCE IN CATCHMENT
Stuttering Frog <i>Mixophyes balbus</i>	Terrestrial inhabitant of rainforest and wet sclerophyll forests. Distribution Limit - N-Near Tenterfield. S-South of Bombala.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Wallum Froglet <i>Crinia tinnula</i>	Found in acidic paperbark swamps and wallum country with dense groundcover. Breeds in temporary and permanent pools and ponds of high acidity. Distribution Limit- N-Tweed Heads S-Kurnell.	Recorded in the catchment on the Bulahdelah & Port Stephens 1:100,000 scale map sheets.
Stephens Banded Snake <i>Holocephalus stephensii</i>	A nocturnal and partly arboreal species that inhabits open and closed forest communities sheltering under bark, in hollows and under exfoliating slabs of granite. Distribution Limit- N-Border Ranges National Park S-Gosford.	Recorded in the catchment on the Port Stephens, Bulahdelah & Dungog 1:100,000 scale map sheets.
Pale-headed Snake <i>Holocephalus bitorquatus</i>	Occurs in a range of habitats from rainforest to open woodland. Usually occurs in hollow trees and beneath loose bark along watercourses. Partly arboreal and may use hollows in trees. Distribution Limit- N-Border Ranges National Park S-Sydney.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Square-tailed Kite <i>Lophoictinia isura</i>	Utilises mostly coastal and sub-coastal open forest, woodland or lightly timbered habitats and inland habitats along watercourses and mallee that are rich in passerine birds. Distribution Limit - N-Goondiwindi. S-South of Eden.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Osprey <i>Pandion haliaetus</i>	Utilises waterbodies including coastal waters, inlets, lakes, estuaries and offshore islands with a dead tree for perching and feeding. Distribution Limit - N-Tweed Heads. S-South of Eden.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Black-browed Albatross <i>Diomedea melanophrys</i>	Inhabits the southern oceans and adjacent coastal areas. Distribution Limit - N-Tweed Heads. S-South of Eden.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Gould's Petrel <i>Pterodroma leucoptera</i>	A migratory bird inhabiting coastal areas and tropical and subtropical oceans. Nests in shallow burrows, crevices between boulders and under tangles of fallen palm fronds. Distribution Limit - N-Tweed Heads. S-South of Eden.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Flesh-Footed Shearwater <i>Puffinus carneipes</i>	A migratory bird that inhabits temperate and subtropical seas. Nests on level sites close to the sea. Distribution Limit - N-Tweed Heads. S-South of Eden.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Little Tern <i>Sterna albifrons</i>	An almost exclusively coastal species inhabiting open beaches, sheltered inlets, estuaries and occasionally lakes. Distribution Limit- N-North of Tweed Heads. S-South of Eden.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.

TABLE 2.2 (Cont.).

Sooty Oystercatcher <i>Haematopus fuliginosus</i>	Exclusively coastal in distribution foraging along rocky coastlines and estuaries. Distribution Limit- N-Tweed Heads S-South of Eden.	Recorded in the catchment on the Bulahdelah & Port Stephens 1:100,000 scale map sheets.
Pied Oystercatcher <i>Haematopus longirostris</i>	Inhabits coastal beaches and estuarine flats. Distribution Limit N-Tweed Heads S-South of Eden.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Black Bittern <i>Dupetor flavicollis</i>	Freshwater & brackish streams & ponds. Distribution Limit - N-Tweed Heads. S-South of Eden.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Black-necked Stork <i>Ephippiorhynchus asiaticus</i>	Occurs in tropical to warm temperate terrestrial wetlands, estuarine and littoral habitats. Distribution Limit - N-Tweed Heads. S-Nowra.	Recorded in the catchment on the Bulahdelah, Newcastle & Port Stephens 1:100,000 scale map sheets.
Rose-crowned Fruit-Dove <i>Ptilinopus regina</i>	Occurs in dense rainforests with a substantial understorey where it feeding entirely on fruit. Distribution Limit - N-Tweed Heads. S-Wollongong.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Wompoo Fruit Dove <i>Ptilinopus magnificus</i>	Inhabits large undisturbed patches of lowland and adjacent highland rainforest and moist eucalypt forests where it feeds on fruit. Distribution Limit - N-Tweed Heads. S-Sydney.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Superb Fruit-Dove <i>Ptilinopus superbus</i>	Rainforests, adjacent mangroves, eucalypt forests, scrubland with native fruits. Distribution Limit - N-Border Ranges National Park. S-Bateman's Bay.	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet
Comb-crested Jacana <i>Irediparra gallinacea</i>	Deep and permanent vegetation-choked tropical and warm temperate wetlands. Distribution Limit - N-Tweed Heads. S - Ku-ring-gai Chase National Park.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Barred Cuckoo-shrike <i>Coracina lineata</i>	Inhabits warm temperate to tropical rainforest and their margins, feeding mainly on fruit. Distribution Limit - N-Tweed Heads. S-Manning River.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Olive Whistler <i>Pachycephala olivacea</i>	Tall wet forest, woodlands and alpine heaths. Distributional Limits N - N-Border Ranges National Park S-South of Eden.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Swift Parrot <i>Lathamus discolor</i>	Inhabits eucalypt forests and woodlands with winter flowering eucalypts (Simpson and Day 1993). Distribution Limit - N-Border Ranges National Park. S-South of Eden.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Turquoise Parrot <i>Neophema pulchella</i>	Inhabits coastal scrubland, open forest and timbered grassland, especially ecotones between dry hardwood forests and grasslands. Distribution Limit - N-Near Tenterfield. S-South of Eden.	Recorded in the catchment on the Bulahdelah & Newcastle 1:100,000 scale map sheets.
Blue-billed Duck <i>Owyura australis</i>	A completely aquatic species occurring mainly throughout the Murray-Darling basin in cool to warm temperate deep permanent freshwater lakes, lagoons and swamps with extensive reed-beds. Distribution Limit - N-Tenterfield. S-Albury.	Recorded in the catchment on the Bulahdelah & Newcastle 1:100,000 scale map sheets.

TABLE 2.2 (Cont.).

Freckled Duck <i>Stictonetta naevosa</i>	Occurs mainly within the Murray-Darling basin and the channel country within large cool temperate to sub-tropical swamps, lakes and floodwaters with cumbungi, lignum or melaleucas. Distribution Limit - N- Tenterfield. S-Albury.	Recorded in the catchment on the Newcastle 1:100,000 scale map sheet.
Glossy Black Cockatoo <i>Calyptorhynchus lathami</i>	Open forests with <i>Allocasuarina</i> species and hollows for nesting. Distribution Limit - N-Tweed Heads. S-South of Eden.	Recorded in the catchment on the Port Stephens, Bulahdelah, Newcastle & Dungog 1:100,000 scale map sheets.
Red Goshawk <i>Erythrorichis radiatus</i>	Inhabits tall open forests and woodlands Breeds in tall trees adjacent to watercourses of wetlands. Distribution Limit - N-Border Ranges National Park S-Foster.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Grass Owl <i>Tyto capensis</i>	Inhabits grassland, coastal heath and lignum swamps, sheltering in dense grass tussocks by day. Distribution Limit - N-Tweed Heads. S-Lithgow.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Powerful Owl <i>Ninox strenua</i>	Forests containing mature trees for shelter or breeding & densely vegetated gullies for roosting. Distribution Limits - N-Border Ranges National Park. S-Eden	Recorded in the catchment on the Port Stephens, Bulahdelah, Newcastle & Dungog 1:100,000 scale map sheets.
Masked Owl <i>Tyto novaehollandiae</i>	Open forest & woodlands with cleared areas for hunting. Distribution Limit - N-Border Ranges National Park. S-Eden	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Sooty Owl <i>Tyto tenebricosa</i>	Tall, dense, wet forests containing trees with very large hollows. Distribution Limit - N-Border Ranges National Park. S-South of Eden	Recorded in the catchment on the Port Stephens, Bulahdelah, Newcastle & Dungog 1:100,000 scale map sheets.
Bush Thick-knee <i>Burhinus magnirostris</i>	Utilises open forests and savanna woodlands, sometimes dune scrub, savanna and mangrove fringes. Distribution Limit- N-Border Ranges National Park S-Near Nowra	Recorded in the catchment on the Port Stephens 1:100,000 scale map sheet.
Common Planigale <i>Planigale maculata</i>	Utilises a range of habitats including rainforest, dry open forest, grasslands and marshland with dense groundcover, a deep litter layer and log debris. Distribution Limit- N-Walgett S-Sydney.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Black-striped Wallaby <i>Macropus dorsalis</i>	Utilises forested country with dense scrub layer including Brigalow scrub. Forages in adjoining open grassy areas. Distribution Limit - N-South of Goondiwindi. S-Port Macquarie.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Red-legged Pademelon <i>Thylogale stigmatica</i>	Occurs primarily in rainforests but also moist hardwood forest and dry vine thickets. Shelters in buttress roots and feeds mainly on leaves and berries. Distribution Limit - N- Border Ranges National Park S- Newcastle.	Recorded in the catchment on the Dungog & Bulahdelah 1:100,000 scale map sheets.

TABLE 2.2 (Cont.)

Eastern Chestnut Mouse <i>Pseudomys gracilicaudatus</i>	Inhabits heathland including dense wet heath and swampy areas, occasionally in woodland with grassy understorey. Distribution Limit- N-Border Ranges National Park S-Brisbane Water National Park.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	A largely arboreal mammal of open forests and woodlands using hollows as nesting in hollow bearing trees. Distribution Limit - N-Border Ranges National Park. S-Eden.	Recorded in the catchment on the Dungog, Port Stephens, Newcastle & Bulahdelah 1:100,000 scale map sheets.
Southern Brown Bandicoot <i>Isoodon obesulus</i>	Utilises a range of habitats containing thick ground cover - open forest, woodland, heath, cleared land, urbanised areas and regenerating bushland. Distribution Limit - N-Kempsey. S-South of Eden.	Recorded in the catchment on the Bulahdelah & Dungog 1:100,000 scale map sheets.
Long-footed Potoroo <i>Potorous longipes</i>	Inhabits moist open forests with a dense ground cover, feeding on roots, tubers, fungi, insects and larvae that are contained in the soil. Distribution Limit - N- Dungog S- South of Eden.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Long-nosed Potoroo <i>Potorous tridactylus</i>	Coastal heath and dry and wet sclerophyll forests (Johnston 1988). Distribution Limit - N-Mt Warning National Park. S-South of Eden.	Recorded in the catchment on the Bulahdelah & Dungog 1:100,000 scale map sheets.
Parma Wallaby <i>Macropus parma</i>	Inhabits rainforests and wet and dry sclerophyll forests with a dense understorey and associated grassy patches. Distribution Limit - N-Border Ranges National Park. S-Morton National Park.	Recorded in the catchment on the Bulahdelah & Dungog 1:100,000 scale map sheets.
Brush-tailed Rock Wallaby <i>Petrogale penicillata</i>	Found in rocky gorges with a vegetation of rainforest or open forests to isolated rocky outcrops in semi-arid woodland country. Distribution Limit - N-North of Tenterfield. S-Bombala.	Recorded in the catchment on the Bulahdelah, Port Stephens, Newcastle & Dungog 1:100,000 scale map sheets.
Tiger Quoll <i>Dasyurus maculatus</i>	Dry and moist open forests containing rock caves, hollow logs or trees. Distribution Limit- N-Mt Warning National Park S-South of Eden.	Recorded in the catchment on the Bulahdelah, Newcastle, Dungog & Port Stephens 1:100,000 scale map sheets.
Koala <i>Phascolarctos cinereus</i>	Inhabits both wet & dry eucalypt forest on high nutrient soils containing preferred feed trees. Distribution Limit - N-Tweed Heads. S-South of Eden	Recorded in the catchment on the Bulahdelah, Newcastle, Dungog & Port Stephens 1:100,000 scale map sheets.
Squirrel Glider <i>Petaurus norfolcensis</i>	Mixed aged stands of eucalypt forest & woodlands including gum barked & high nectar producing species & hollow bearing trees. Distribution Limit - N-Lismore. S-Albury	Recorded in the catchment on the Bulahdelah, Newcastle, Dungog & Port Stephens 1:100,000 scale map sheets.
Yellow-bellied Glider <i>Petaurus australis</i>	Tall mature eucalypt forests with high nectar producing species and hollow bearing trees. Distribution Limit- N-Border Ranges National Park. S-South of Eden.	Recorded in the catchment on the Bulahdelah, Port Stephens & Dungog 1:100,000 scale map sheets.

TABLE 2.2 (Cont.).

Large-footed Myotis <i>Myotis adversus</i>	Rainforests and sclerophyll forests near creeks and lakes over which it feeds. Roosts in tree hollows, caves, mines and tunnels. Distribution Limit - N-Border Ranges Nation Park. S-South of Eden.	Recorded in the catchment on the Dungog 1:100,000 scale map sheet.
Little Bent Wing-bat <i>Miniopterus australis</i>	Roosts in caves, old buildings and tree hollows in the higher rainfall forests along the south coast of Australia. Distribution Limit - N-Border Ranges National Park. S-Sydney.	Recorded in the catchment on the Bulahdelah, Newcastle & Port Stephens 1:100,000 scale map sheets.
Common Bent Wing-bat <i>Miniopterus schreibersii</i>	Prefers areas where there are caves, old mines, old buildings, stormwater drains & well timbered areas. Distribution Limit - N-Border Ranges National Park. S-South of Eden.	Recorded in the catchment on the Bulahdelah, Dungog, Newcastle & Port Stephens 1:100,000 scale map sheets.
Greater Broad-nosed Bat <i>Scoteanax rueppellii</i>	Inhabits areas containing moist river & creek systems especially tree lined creeks. Distribution Limit - N-Border Ranges National Park. S-Pambula.	Recorded in the catchment on the Bulahdelah, Dungog, Newcastle & Port Stephens 1:100,000 scale map sheets.
Golden-tipped Bat <i>Phoniscus papuensis</i>	Rainforest and adjoining moist open forest habitats, roosting in tree hollows dense vegetation. Distribution Limit - N- Border Ranges Nation Park. S-South of Eden.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.
Eastern Little Mastiff-bat <i>Mormopterus norfolkensis</i>	Inhabits open forests and woodlands foraging above the canopy and along the edge of forests. Roosts in tree hollows, under bark and buildings. Distribution Limit - N-Woodenbong. S-Pambula.	Recorded in the catchment on the Bulahdelah 1:100,000 scale map sheet.

SECTION 3

LAND USE WITHIN THE CATCHMENT

3.1 LAND USE

The land use of the study area is a combination of the land cover and the utilisation of the land for various activities. To determine the broad scale and specific land uses the following procedures were followed:

- A broad land cover classification was determined (Figure 2) and a base map using available topographic maps at a scale of 1:100,000 was drafted for the total catchment of the Port Stephens/Myall Lakes area.
- The preparation of a land cover map was then compiled using the latest aerial photographs available from the Dept of Land & Water Conservation. The photo coverage of the four map sheets involved varied in time from 1992 to 1997 and in months from February to August.
- In order to indicate a sequence of occupancy in the area the most recent photographs (1992-1997) were then checked against the oldest available photographs (1963) giving a total coverage.
- In all cases, the scale of the photographs was greater than the scale of the base map necessitating some omission of detail or generalisations in mapping.
- Two land cover maps were prepared to enable some comparisons (a generalised total catchment map at the scale 1:100,000 and a detailed land cover map of the Tilligerry Peninsula at the scale 1:50,000). These maps were reduced to appropriate scales for reproduction purposes and are provided as Figures 2 and 3 of this Report.

This assessment indicates that while little change had taken place in the upper catchment over this 30 year period (1963-1993) significant changes have occurred in the Port Stephens estuary area with urban development.

In the Port Stephens/Myall Lakes catchment the land is used for a variety of purposes. About 30% of the area has been cleared for grazing and other purposes while the remaining 70% is still forested, almost half of this under the control of State Forests and 6.4% managed by the National Parks & Wildlife Service. The major land cover within the study area is described below and shown on Figure 2.

Forested Land

This is the dominant land cover of the catchment and includes the steep hill country in the north-west and the hilly country following the grain of the geology from north to south. It also includes some open woodlands, swamp forest and pine plantations near Tea Gardens/Hawks Nest. The swamp forests usually lie adjacent to rivers and lagoons or close to the estuary where *Melaleuca* species are common. The swales between dunes, such as near Shoal Bay, also provide high water table conditions for this type of land cover.

It was this land cover that provided the initial focus for human land activities in the area - the cedar cutters of 1816. Governor Macquarie granted James Smith the right to cut and transport cedar to Sydney on the 9th November, 1816. When the explorer/surveyor John Oxley passed through the area on 29th October, 1818 he noted that at least 9 ships had entered Port Stephens and carried away 100,000 super feet of sawn timber (Garland & Wheeler 1982). The cutters were mainly assigned convicts and worked along the waterways but made no permanent settlements. The timber industry, however, remained a dominant activity in the Myall Lakes area through to this century (See Map 3). The Crown Lands Act of 1839 licensed timber cutters and in 1861 33 licenses were issued and in 1862-3 licenses increased 50% p.a. Bullock teams and tramways took the timber to the lakes and rivers where punts and droghers continued the transport to Port Stephens where ships were loaded for Sydney. Duncan McRae's steam mill on Boolambayte Creek opened in 1862 and provided the first concentration of settlement in the Myall Lakes area. By 1866 he employed 100 people at the mill and shipyard. At this time Hawks Nest/Tea Gardens had a population of 150 when William Henderson built his steam mill. Karuah was originally called "Sawyers Point" from the timber cutters - a transshipment point for timber sent to Sydney.

Now much of the forested area is under the control of the State Forests of NSW. There are 11 State Forests within the catchment (the Avon River Forest in the north-west lying just on the watershed) covering nearly 30% of the catchment. Most of the State Forests lie in the upper catchment area and were dedicated between 1914 and 1917 (Figure 4), the two largest being Chichester and Myall River. Karuah, Medowie, Wallaroo and Nerong State Forests all lie in the lower catchment adjacent to the estuary.

Since the dedication of these State Forests only one has decreased in size (the Myall State Forest has decreased from 18,210ha to 17,648ha). All other State Forests have increased in area. This is particularly true of the Medowie State Forest which has increased in size by 300%. This is significant in terms of its location so close to the estuary. Forest cover can protect against run-off, erosion and fertiliser application which would otherwise impact negatively on the estuary.(NSW Government, 1992). Seven timber mills remain in the catchment - four at Bulahdelah and one each at Karuah, Booral and Stroud.

Two national parks also occur in the catchment: Tomaree National Park in the south east and Myall Lakes to the north-east of Port Stephens. The oldest, Myall Lakes was partially proclaimed in April 1972 and since that time has doubled in size to cover 31,571ha or 6.4% of the Port Stephens/Myall Lakes Catchment.

Tomaree National Park (2,310ha) extends south from South Head (Tomaree) to Fishermen's Bay. It was first proclaimed in 1983 in six separate parts covering 0.5% of the catchment. It is surrounded by urban areas (Fingal Bay, Shoal Bay, Nelson's Bay and Boat Harbour) and the Glover's Hill reservoir which provides the water supply for Nelson's Bay, Shoal Bay and Fingal Bay. Both of these Parks have played an important role in stabilising vegetation and reducing run-off since the times of the timber cutting and sand mining operations.

The pine plantations in the Tea Gardens area were established in 1963. These are currently being removed, especially near Pindimar, for rural grazing and urban settlement. The Myall River Downs development at Tea Gardens covers 490ha of former pine plantation of slash pine. (EDAW Aust. 1994). The Boral Company operates a forest residue timber plant east of Tea Gardens to process pines which are cleared to open up the land for grazing purposes.

Grassland - Rural Grazing

About 30% of the catchment has been cleared of forest. In the north the rolling hills and alluvial valleys are being used for grazing purposes with some broiler chicken sheds and goat, horse sheep and dairy farming.

During the early 1800's Governor Macquarie recognised the need to find an area for free settlement outside the Sydney Basin. Assistant Surveyor Dangan suggested that prospects for wool were good in the Karuah, Gloucester and Myall valleys. Rural grazing began as the timber cutters cleared the land. An Act of Parliament in England on 21 June 1824 established the Australian Agricultural Company (AAC). On the advice of Surveyor General, John Oxley, Robert Dawson selected Port Stephens to establish their activities and settlement began at Tahlee and Carrington in February 1826. By October, 250 people, 1000 head of cattle and 2000 sheep were on the land. (Richardson 1989). Moving north up the valley Dawson established Stroud in 1826 and Booral as a transshipment port. By 1829 the Company had 14,000 sheep and 1,700 head of cattle.

By 1854, however, the AAC had exchanged the land here for better land in the Peel River district.

"The idea of a rich agricultural hinterland behind the harbour of Port Stephens had been proved to be an illusion". (Armstrong 1989).

While volcanic rocks underlie the area with some outcrops at Yacaaba, Tomaree and Mt. Karuah they are acidic rhyodacite resulting in poor soil generally not well suited to agriculture. Large areas are also mantled by sand. In 1795 Captain.

William Broughton sailed into Port Stephens in the "Providence" and stated: (Garland & Wheeler 1982).

"The soil around Port Stephens is composed chiefly of sand and decayed vegetables, though in the swamps it is of a better kind; but upon the whole nature of the place is very barren and unfit for any great degree of cultivation."

Governor Macquarie came to the same conclusion during his visit in 1811 and abandoned plans for any settlement. The AAC had proved these conclusions in practice.

Nevertheless, what began with the timber cutters and established with the Australian Agricultural Company the grassland/grazing lands have extended particularly in the south since 1963 (See Map 1). Two thirds of the 60,000ha of pasture lands in the north have been improved while in the south only one quarter of the small area under pasture has been improved.

Cultivated Land

Besides small isolated patches of cultivated land in the northern valleys there is little farmed or cultivated land in the catchment. The most extensive cultivated area is in the south between Medowie, Salt Ash and Bobs Farm and Anna Bay where sheep, goats, beef and dairy cattle as well as turf farms can be found. There is no Prime Agricultural Land in the catchment (NSW Gov. 1982). Good agricultural land is very limited in the catchment and is restricted to fertile alluvial flats and intensively developed vineyard and horticultural areas. The Tomago Coastal Plain generally features immature heavily leached soils, often red-yellow podsolics with a pH 5-6 and some potential acid sulphate soil resulting in a high degree of limitation for cultivation. (Murphy 1995, Matthews 1995).

The Crown Lands Alienation Act of 1861 permitted free settlement before land was surveyed and it followed the surrender of AAC land grant in 1835. A number of portions of Crown Land were offered for lease between 1853 and 1856 but following the AAC experience none were taken up (Garland & Wheeler 1982).

Today the Port Stephens Winery near Bobs Farm, which was established in 1983 on sandy inner barrier dunes, carries on a tradition established by the AAC in 1831 (Richardson 1989). Lieutenant Caswell also planted vineyards next to his Tanilba House in 1831. It has been suggested that Tea Gardens owes its origin to the unsuccessful planting of tea by the AAC while the land between Oyster Cove and Tanilba Bay was cleared for dairying in the early 1900's.

Developed Land - Urban

This land use is concentrated in the townships providing commercial, residential, industrial and recreational facilities associated with cleared areas for infrastructure and services. There has been a rapid expansion of urban/rural residential areas in recent years with new subdivisions at Anna Bay, Salamander Bay, Boat Harbour and Tea Gardens.

On the Tilligerry Peninsula settlement began in 1831 with the Caswell grant of 50 acres while Lemon Tree Passage did not begin to develop until the 1920's. As indicated by Map 2, the Mallabula development did not occur until the late 1960's after sand mining operations had cleared the area. Soldiers Point, originally a military outpost to capture escaped convicts from the penal settlement at Newcastle, was settled by William Cromarty in 1834. The largest urban settlement in the area, Nelson's Bay, was first settled in 1862 by Glover, the lighthouse keeper (See Map 3) but by 1886 it still had a population of only 30 and it remained a small fishing village until the beginning of tourism.

Historically, the urban centres to the north of the estuary were the first to develop due to their association with the Australian Agricultural Company. Carrington became the 'capital' of the County of Gloucester and in 1820 it had 17 houses. Today five of the original houses remain.

A decentralisation conference in 1918 suggested the building of a railway from the New England to Port Stephens to aid the export of wool as Newcastle was considered an unsuitable port. 'Port Stephens City' (now North Arm Cove) was designed by Walter Griffin, the architect of Canberra, and approved by the Stroud Shire Council in 1918. 'Pindimar City' was also designed in the same way (Armstrong 1989). However, the rail connection was never built and developments never eventuated.

The first land grant in the Tea Gardens area was made in 1865 and it prospered with the timber industry until it declined in the 1880's. While the urban area was gazetted in 1921 it did not grow until sand mining began in the 1960's. In 1974 the connecting bridge to Hawks Nest was completed which has stimulated the development in the area.

The scattered nature of the urban land use pattern provides difficulties for the development of infrastructure and services such as water supply and sewerage which have become on going problems for the area (See Section d).

Wetlands and Swamps

Wetlands cover approximately 5% of the catchment. Some are associated with low lying areas of alluvium but most are estuarine mangrove and saltmarsh subject to tidal influences. They are particularly well developed in the lower Karuah estuary and around Tilligerry Creek with pockets in Salamander Bay and along the

northern shoreline at Tea Gardens, Pindimar, North Arm Cove and Tahlee. Fresh water and brackish wetland can also be found in the swales between the dune system such as at Shoal Bay and Tanilba Bay as well as behind Lemon Tree Passage and along the Tomago Coastal Plain extending to the Myall Lakes. Some of these areas are covered in natural vegetation while at Lemon Tree Passage they have been used for sand bed sewerage disposal.

Coastal Dunes & Blowouts

Active sandy beaches and coastal dunes fringe the coastline from north to south with several examples of tombolo formations at Providence Bay, Shoal Bay and Point Stephens. Since the Tomago Coastal Plain has been derived from Pleistocene and Holocene barrier dunes sand deposits are a feature of this estuarine area. Where they have been stabilised for some time humic and red/yellow podsollic soils have developed. Mineral Deposits Pty Ltd was granted authority to mine these sands in the Hawks Nest/Tea Gardens area in 1956 and the Myall Lake foreshores were mined from 1965. The National Park was formed in 1972 but mining was allowed between Mungo Brush and Seal Rocks although all sandmining ceased in the National Park in 1983. BHP Titanium, however, continue the operations in the Hawks Nest area today. ACI Industries have been extracting white sand for clear glass making in Newcastle and Sydney from the Tanilba dunes since 1977. Heavy metals were also mined at Swan Bay.

Blowouts are common along the coastal dune area and sand mining activities (such as those in the past near Big Gibber Headland now in the National Park) could add to the destabilisation of the sand without attention to detailed revegetation.

Extractive Industries

Most of these activities are dispersed throughout the areas covered by other forms of land use. The principal extractive industries of the study area are outlined below.

Coal Mining

There is only one open cut mine operating in the far north of the area in the Gloucester Shire. 'Stratford Coal' near the Craven State Forest lies just north of the watershed. It began operations in 1995 and employs 150 people. Lying just outside the catchment it should have little effect on the Port Stephens/Myall Lakes estuary.

The 'Duralie' open cut mine owned by CIM Resources, however, lies within the catchment quite close to the Stratford operation. It hopes to begin production strategies to be used as well as the vast distance from the estuary this too should have little impact.

Sand Mining

The mining of sand for heavy metals and silica began in the area at Burra Burra Point on the Myall Lakes in 1924 although it was not until 1956 that Mineral Deposits Pty Ltd was granted authority to mine in the Hawks Nest/Tea Gardens area and in 1965 along the Myall Lakes foreshore.

More info needed

RZM Pty Ltd has mined at Tomago and Big Swan Bay although mining has now ceased at the latter and regeneration is occurring. ACI has been extracting white sand for clear glass making from the Tanilba dunes since 1977. The Southern Dune mining near the golf course has ceased but mining on the Northern Dune continues to extract over 190,000 tonnes of sand. This company is also extracting sand from Salt Ash while BHP Titanium is mining heavy metals from the sand north of Hawks Nest.

However, at the moment there is no known potential for any additional mining of heavy metals in the area. (Port Stephens Council 1998).

Sand Extraction

Extraction of sand for the building and construction industry occurs in small areas along the dune field at Fern Bay.

3.2 WATER USE

The waterways and tributaries of the Port Stephens/Myall Lakes as well as the groundwater of the Anna Bay sandbeds are classified under the *Clean Waters Act* 1970 to preserve their water quality consistent with the needs of its users (Department of Planning, 1994). This resource is coming under increasing demands particularly by aquaculture and recreational pursuits.

The Fishing Industry

Fishing has been a major activity of people in the area for centuries. The Worimi aborigines were hunters and gatherers and enjoyed the fruits of the water. In the early eighteenth century Chinese fishermen settled in Nelson's Bay salting or drying their catch and curing lobsters. By the 1880's Europeans had taken over the industry but due to a lack of transport and storage technology for the demands of the fresh fish market they did not prosper. Readily accessible sea transport gave the area an advantage over other estuary fishing grounds that were not so accessible to sea going vessels but distance was a problem prior to the availability of ice. The fresh fish was occasionally sent to Salt Ash by open boat and then overland to Stockton.

In 1917 the Pindimar Ice Works opened shipping mullet, bream, blackfish and prawns to markets in Sydney and Newcastle. The Fishermans Co-Op with

refrigeration was built in 1956 and in 1972 the Fish Research Station near Anna Bay opened.

Port Stephens is the largest producer of estuarine fish on the NSW coast:

TABLE 3.1 ESTUARINE PRODUCTION (kg) IN NSW FOR 1992-3				
	Finfish	Mollusc	Crustaceans	All species
Manning	124,026	32	38,160	162,230
Wallis Lake	326,601	2,505	189,637	519,114
Smith Lake	28,184	134	13,628	41,946
Myall Lake	167,378	29	5,882	173,291
Port Stephens	413,666	4,922	35,477	454,090
Hunter	201,434	120	49,487	251,041
Lake Macquarie	34,149	14,176	28,423	383,927
Tuggerah	326,301	229	75,563	402,134
Hawkesbury	315,677	28,240	131,097	475,016
Sydney	11,223	1,595	21,662	135,713
Botany Bay	257,600	17,905	26,662	306,535

(Source: NSW Fisheries Statistics 1992-3 - NSW Fisheries 1996)

Port Stephens dominates in fin fish production especially mullet, bream, luderick and garfish. The Myall Lakes rank sixth in school prawn production and first in eel production. Port Stephens is also producer of ocean fish (as opposed to estuarine) ranking second after Newcastle in all ports from Tweed Heads to Eden.

The district has 84 licensed commercial fishermen with an additional 80 covered by block license provisions. (Dept. of Fisheries 1996)

TABLE 3.2 CHANGES IN FISH CAUGHT (kg) 1991-1997				
	1991	1992	1993	1997
Myall Lakes	131,259	126,025	173,291	193,111
Port Stephens	651,328	626,017	909,626	740,650

(Source: Great Lakes Council State of the Environment Report 1996-7 p35)

(The discrepancy in the Port Stephens figures for 1993 between the last two tables is due to the second table including both ocean and estuarine fish).

Commercial fish production is showing a steady increase even in the semi enclosed Myall Lakes system although the fish take is subject to fluctuations in seasons. In 1983-4, for example, there was an exceptionally high yield of 500,000 tonnes recorded from the Myall Lakes. The number of boats that were licensed by the Department of Fisheries in 1992-3 indicated that Port Stephens was ranked second to Iluka (in an area from Eden to Tweed Heads) in part because it is associated with ocean fishing as well as estuarine. Port Stephens was also ranked second after Newcastle in the weight (kg) received at the port of landing (Dept. of Fisheries, 1996). There has been no real change in species type taken over this period with mullet, bream and luderick still the dominant catch.

Prawns were not a popular seafood in the 1920's when the 'prawn run' down the Myall River was discovered. In 1932 the 'prawn sale' system was introduced for catching prawns allowing the organised setting of nets down river from Tamboy. This system continued until 1979 when the NSW Fisheries Department instituted a ballot system for the allocation of netting positions. Tamboy is now part of the Myall National Park and 11 commercial prawn trawlers are registered to operate in the Port Stephens/Myall Lakes area. Between 1981 and 1992 the prawn harvest remained fairly stable increasing from 4,621kg to 4,710kg.

Both natural and artificial effects do impact on the commercial fishing according to members. These impacts result from:

- The large numbers of recreational fishermen - up to 1000 boats a day at holiday times;
- Parking congestion near the Fishermen's Co-op for the workers, especially during the holiday season;
- The construction of marinas, boat ramps and other obstructions to current flow;
- Toxic waste from land and water such as automatic bilge pumping from long term leisure moorings.

Nevertheless, while the numbers of registered commercial fishermen may have declined the total fish catch has not and the area remains an important link in the NSW coastal fishing trade.

The Oyster Industry

The Aboriginal people made fish hooks from oyster shells and the piles of oyster shells left in middens were mined by early settlers as a source of lime for mortar. The old lime kilns at Tea Gardens were used for this purpose.

The commercial oyster industry in the district began in 1913 and by the mid 1980's there were 180 oyster growers in the Port Stephens area. This decreased to 120 in 1996 and to 111 in 1998 of whom only 80 or so are actually working the leases. Currently there are two sheds at Carrington with a third recently closing while the shed at North Arm Cove has also closed.

	No. Foreshore Leases	No. Offshore Leases	Production (dozens)	Value (\$)
Tea Gardens	34	100	79,520	222,976
Nelson's Bay	97	217	552,432	1,563,047
Karuah	187	216	559,456	1,587,980
TOTAL	318	533	1,191,408	3,374,003
Pacific Oysters		102	54,613	1,589,24

(Source: NSW Commercial Fisheries Statistics 1992-3 - NSW Fisheries, 1996)

Oyster production is a very highly valued part of the Port Stephens economy with most of the leases lying west of Soldiers Point in the Upper Basin and away from the most highly urbanised section of the Port (Figure 5). However, oysters are highly sensitive to pollutants as they are "filter feeders" and require clean water in order to be fit for human consumption. This was shown by the recent Wallis Lake problems and for Port Stephens it has been highlighted by the ABC Quantum program "*The Canary and the Lake*" (ABC, 8/6/98).

A number of difficulties are facing the Port Stephens oyster growers:

- It is becoming more labour intensive. Up until the mid 1940's Black Mangroves were cut for oyster sticks and by 1929 it was reported that all the Black Mangroves in the Port Stephens area were cut out (Musgrave, 1929). This was followed by a move to sawn timber and more recently to trays and vinyl slats. Unlike the sticks, the trays must be changed every 15 weeks resulting in more labour time.
- Port Stephens is the only NSW estuary where the Pacific Oyster can be farmed as it is considered to be predatory to the Sydney Rock Oyster. The Pacific Oyster was introduced in 1972 and had been firmly established by 1985. However, as the Sydney Rock Oyster takes 4 years to mature and the Pacific only 18 months the latter takes up less water area for the same return. Nevertheless, in terms of value, the previous table indicates that the Sydney Rock Oyster is the backbone of the industry.
- As urban development spreads around the Upper Port area, such as along the Tilligerry Peninsula, there will be increasing difficulties for the oyster growers.

Some consider seepage into Cromarty Bay could already be causing problems while land drainage along Tilligerry Creek produced acid sulfate soil resulting in the destruction of one oyster lease which is only now recovering after 15 years.

With increasing tourism in the area the oyster industry may have to take advantage of the situation. Moffats Oyster Barn is one example and the proposed 'Oyster Experience Resort' (Development Dynamics 1984) was an attempt in this direction.

3.3 POPULATION, TOURISM AND RECREATION

Port Stephens is the most popular and fastest growing tourist destination in the Lower Hunter Region with the majority of tourists preferring the sandy Lower Basin of the Tomaree Peninsula (Tourist Commission of NSW 1989). The ocean beaches (One Mile, Fingal, Wreck, Zenith) and the estuarine beaches (Shoal, Nelson and Salamander) have been the most popular areas (Figure 6). Additionally, activities like whale and koala watching, camping and walking in the National Park (eg. the 220km Mungo Track), historic houses (Tanilba), scuba diving to discover old ship wrecks, or just relaxing on the water in a houseboat are also well utilised by tourists.

Perhaps the initial tourist attraction was Legges Camp on the Myall Lakes. Legge began a permanent settlement here in 1909 and by 1920 had accommodation for 70 (Drake & Flemming 1988). The first tourists came to Tea Gardens by coastal boat or via Salt Ash and then up the Myall River by boat. Some, however, made the overland trip from Bulahdelah. The 'camp' was sold to the National Park in 1980. Certainly by 1924 the Port Stephens area was beginning to be a vacation destination (Newcastle Morning Herald 1924).

While tourist numbers tend to fluctuate with the seasons and economic conditions the Port Stephens/Myall Lakes area is an increasingly important destination for tourists, particularly from the Newcastle area and provide the basic source of income to the district:

	VISITS ('000)				NIGHTS ('000)				EXPENDITURE (\$MILL)			
	1985	95	96	97	1985	95	96	97	1985	95	96	97
Great Lakes	301	610	670	673	1058	1782	1873	1956	48	106	117	124
Port Stephens	418	614	675	763	1470	1795	2035	2304	66	111	132	151

(Source: Australian Bureau of Statistics 1997. Note - Great Lakes includes Foster/Tuncurry)

While the tourism industry may have begun quite early in the area it failed to expand until recent years mainly due to accessibility and with improvements in

water and sewerage services as well as the road network (Port Stephens Shire Council 1997) tourism can be expected to increase. However, because of the fragile nature of the Port Stephens environment and the limits placed on urban expansion ecotourism which is nature based and ecologically sustainable, (Artist 1997) will have to be given priority and ecological sustainable development strategies adopted. For example, the Tamboy boardwalk over wetlands was recently opened (13/7/1998) while indigenous tourist initiatives (tourism that involves Aboriginal cultural interpretation) may be developed in association with local Land Councils (Artist 1997) and a dolphin interpretative centre may be established at Nelson Bay as a tourist attraction. (Port Stephens Shire Council 1997).

The particular attractions of the coastal areas attract not only tourists but other recreation resource users as well as new residents and industries. Conflicting claims on the resource base result with implications for the stability and sustainability of the coastal ecosystem. Many examples have occurred where accelerated growth and the intrusion of incompatible land uses pose a threat to these resources. Urban development for residential and tourism purposes underlie many of these problems.

In spite of being discovered and named by Captain Cook in 1770 and being visited by a number of survey ships in the late Eighteenth century as well as the Surveyor general John Oxley in 1818, the first permanent settlement was not made until 1826 - the Australian Agricultural Company at Tahlee and Carrington. This Company even surrendered most of its land in the area in 1832. The initial stages of population growth were very slow.

Cook had suggested that the anchorage was suitable for large vessels and in 1928 a naval expert rated Port Stephens as the fifth best natural harbour in the world (PWD 1972 pC1-2). The Royal Australian Navy had suggested the area as a base for its submarine flotilla in 1911 and the Commonwealth Government resumed 1250ha of land at Salamander Bay for a base. Yet the first official survey by Grimes in 1795 suggested it was a poor port with a bar two thirds across the entrance; shoals in the north where the Myall River enters; the western half was shallow with mangroves in the south and west. Further, Sir Edward Parry, second manager of the AAC, regarded Carrington as a poor site as large vessels had to anchor at Salamander Bay (Armstrong 1989).

With poor soils, a poor harbour, poor accessibility and land locked up by the Government the attraction for population growth would have to wait until some of these problems were overcome. The urban area of Tea Gardens/Hawks Nest was gazetted in 1921 while North Arm Cove was considered as a possible site for the Australian Capital in 1909 and the planned city of Pindimar was drafted in 1918. The basic settlement pattern of today was established by this time.

In recent years with greater accessibility and the availability of land - such as the Commonwealth Government relinquishing the area at Salamander - the population

has grown at a very fast rate. Between 1991 and 1996 the Port Stephens shire, including Raymond Terrace grew at 3.6%, a similar growth rate to 1986-91. The Great Lakes Shire (including Foster-Tuncurry) at the same time grew by only 2.01% although in the 1986-91 period it was around 5.4%. (Great Lakes Council 1996).

Table 3.5 indicates the population growth for the major urban settlements in the catchment area of Port Stephens/Myall Lakes for the last three census -1986, 1991 and 1996. The great growth areas are around Soldiers Point/Salamander Bay/Corlette as well as the Hawks Nest/Tea Gardens areas where populations in the last intercensal period grew by between 30% and 90%. While it is expected that the former area may now stabilise, new developments at the latter will see further growth there. The great increase in population at Medowie (25%) could be related to its relative closeness to Newcastle and the Pacific Highway.

TABLE 3.5 POPULATION GROWTH FOR MAJOR SETTLEMENTS			
	1986	1991	1996
Allworth	278	393	447
Anna Bay/Boat Harbour	1109	2122	3045
Booral	120	156	223
Bulahdelah	1098	1092	1113
Bungwahl	-	-	413
Corlette	810	1471	2219
Fingal Bay	529	954	1390
Hawks Nest	1012	1251	2221
Karuah	777	1126	1235
Lemon Tree/Tanilba	1568	4925	5316
Medowie	3361	4344	5294
Myall Lakes	169	197	171
Nelson Bay	4847	4781	5076
North Arm Cove	-	226	274

Sources: ABS Census Population & Housing 2016.1; Port Stephens Shire Council 1988

If the main areas of settlement are combined into three broad geographic zones of high population growth it is evident that the most populated area is the Tomaree Peninsula which includes Nelson Bay and Shoal Bay. While this area was settled quite late compared to other areas around the Port, with access to Newcastle it is a desired area for both tourism and retirement. The Tilligerry Peninsula has only recently begun to develop (1976 figures) and has shown rapid growth in that time but the growth will slow compared to Tomaree which is expected to reach

34,400 by the year 2021. Tilligerry is restricted on three sides by water and wetlands cover much of the land area. Future developments on the northern edges of both Hawks Nest and Tea Gardens should see large increases in the population of this area.

**TABLE 3.6
POPULATION GROWTH BY SUB-REGIONS 1976-1996**

	1976	1981	1986	1991	1996
Tomaree Peninsula	6,640	9,370	11,250	14,185	17,895
Tilligerry Peninsula	1,040	2,280	3,950	4,927	5,316
Hawks Nest/ Tea Gardens	1,166	1,672	1,674	1,935	2,170

Source: Port Stephens Shire Council 1998b, Marr 1997
Hunter Valley Research Foundation 'This is Newcastle and the Hunter Region 1988'

The age-sex structure of the population gives an indication of the types of settlements in terms of the youth, working and old age component of the population. Medowie has a typically Australian type population pyramid although it is highly represented in the younger age groups with almost half the population under 25. On the other hand the Tomaree Peninsula has 28% of its population aged over 60. (State average is 16). The Tilligerry Peninsula, on the other hand has a relatively even age distribution with 24% over 55 and 26% under 14. In the Tea Gardens/Hawks Nest area there is also a high percentage of retirees with Hawks Nest having 44% of its population over 60 and only 6% under 12. Tea Gardens has 26% of its population over 60 but this is a decreasing figure (it was 34% in 1986) indicating new subdivision developments in this area are attracting a younger population.

Associated with the age structure of the population is the household occupancy rate. Table 3.7 indicates the total number of dwellings for some of the major urban centres and the number of those which were unoccupied at the last census. Clearly the areas further from the estuary (Bulahdelah, Medowie) have a greater dwelling occupancy than those closer to the coast. Over half of the dwellings at Hawks Nest are unoccupied while at Nelson Bay over one third are unoccupied.

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TABLE 4.7 DWELLING OCCUPANCY - 1996 CENSUS		
	Total Dwellings	Unoccupied Dwellings
Great Lakes Shire		
Bulahdelah	467	37
Hawks Nest	1,310	732
Karuah	375	60
North Arm Cove	245	118
Tea Gardens	544	126
Port Stephens Shire		
Anna Bay	885	169
Fingal Bay	872	352
Lemon Tree Passage	2,436	383
Medowie	1,712	70
Nelson Bay	5,010	2,031
Soldiers Point / Salamander Bay	2,290	619
(Source: ABS Census of Population and Housing 2016.1 1996)		

In terms of human impacts then it is evident that:

- There has been a rapid increase in the population of the estuary area in recent years after years of low growth and forecasts indicate a continuation of this growth;
- Some of the areas such as Hawks Nest and the Tomaree Peninsula are essentially retirement areas although there are indications of changes occurring such as around Tea Gardens;
- There is a large proportion of unoccupied dwellings in some sections of the study area indicating that it is indeed a holiday area and the area has the potential for a huge increase in population density on a permanent basis rather than a seasonal/holiday feature.

Limits To Urban Expansion

While there is potential for enormous urban growth around the estuary there are a number of severe restrictions to this growth and these vary in their geographic location. The Port Stephens Shire is the most highly developed part of the study area in spite of the lateness of its historic settlement. The Tomaree Peninsula has the highest population concentration but urban expansion is limited by:

- The Tomaree National Park;
- Flood liable land and wetland;
- Steep scenic areas with slopes over 30%.

Expansion on the Tilligerry Peninsula is also restricted by wetlands on three sides with potential acid sulfate soil problems and the water supply catchment areas of Tomago.

On the northern Great Lakes Shire side of the estuary the potential for development is much greater. Historically it was the first area settled but a geographic location away from Newcastle and a lack of supporting infrastructure has led to a lack of development. This may change with greater access. New developments at Pindimar, Tea Gardens, Hawks Nest and North Arm Cove could see urban expansion associated with population growth. Negotiations between land owners and Council concerning North Arm Cove relate to the provision of basic services like water and sewerage.

Further population growth may come not from the geographic expansion of the urban areas but due to an increase in density. Changing socio-economic conditions and an ageing population are indicating the need for smaller housing types encouraging medium density residential developments.

Human Impacts

To retain the quality of life and attractions of the estuary the environmental values need to be maintained in a long term sustainable manner. Particular environmental resources that could be threatened are:

- Beach and dune areas and similar recreational environments;
- Waterways;
- Wetlands and special habitats such as koala reserves; and
- Heritage features such as historic and archaeological sites.

Considering its early discovery in 1770 and settlement in 1826 the estuary and its surrounds is still coping with the increasing demands being placed upon it. When Deputy Surveyor Grimes first surveyed the Port in 1795 before any European settlement he noted the bar at the entrance; the shoals at the Myall River outlet; and the shallow mangrove areas of the Upper Port where the Karuah River and Tilligerry Creek enter the bay. This has not changed to any marked degree in 200 years!

However, in recent times as the population has begun to climb the impacts of people are starting to be seen:

1. The possibilities of sand drift and coastal erosion due to the Hawks Nest North developments. (ERM Mitchell and McCotter 1998).
2. Water contamination from land drainage and boat densities especially copper concentrations (Port Stephens Shire Council 1997). The quality of surface coastal water is critical to the local oyster and fishing industry as well as for tourism and recreation.
3. The occurrence of Potential Acid Sulphate Soils (PASS) associated with the occurrence of large areas of water logged land. (Department of Land & Water Conservation 1995 and Port Stephens Shire Council 1998). The drainage of these lands has caused problems for oyster growers along Tilligerry Creek in the past. These soils have also been identified as potential problems for development at Karuah and Tea Gardens. (Great Lakes Council , 1996).
4. As the population grows waste management will become a problem. Bulahdelah discharges its treated sewerage into Fry's Creek, a tributary of the Myall River. Stroud discharges to the Karuah River where there have been problems of higher than recommended rates of BOD and suspended solids (Great Lakes Council 1996). Booral, North Arm Cove North Karuah and Stroud Road are all non-sewered areas relying on septic tanks, biocycle or pump out systems. The impact of sewerage outfalls depends on treatment prior to discharge, however, and the upgraded Boulder Bay sewerage works (1993) servicing the Tomaree and Tilligerry peninsulas discharges after secondary treatment to the ocean.
5. Contaminated tip sites with high levels of toxic substances have been noted at Allworth, Stroud, Bulahdelah, Wards River, North Arm Cove, and Tea Gardens, the latter two to be closed during 1998. There has been no monitoring of the impact on ground water at this stage but run-off from the Soldiers Point tip is thought to be causing problems for the oyster growers in Cromarty's Bay.
6. Oyster racks, located mainly in Upper Port (See Map 5) are a concern for some water users. Several leases appear to be no longer in use around Garden and Snapper Islands while the boundaries of other leases are poorly defined. Since Pacific Oysters mature in half the time of the Sydney Rock and therefore require less area for the same output perhaps the number of oyster leases (and therefore racks) could be reduced in the future.
7. Constructions into the bay in the form of marinas and boat ramps need constant monitoring in order to assess the affects on current and sand movements and to ensure the flushing of semi-enclosed areas.

- 7 8. Historic sites should be registered and upgraded both for their historic values and interest for tourism. Tomaree House and Tahlee House are in very good condition but areas like the Winda Woppa and Nerani Beach sawmill sites and the prawn fishing huts at Tamboy are examples where more could be achieved.

There is no doubt that the Port Stephens/Myall Lakes Estuary will come under increasing pressure from developments associated with an increasing population in the future. The plans for a four lane dual carriage way from Newcastle to Nelson Bay and a car ferry from Tomaree to Tea Gardens (Port Stephens Shire Council 1997) will further increase demand for development such as the 1,000 homesite of the Myall Quays development at Tea Gardens.

Fortunately with 70% of the catchment under forest cover including State Forests and National Parks the catchment area should hold few problems for the riparian estuary. However, very close surveillance will be needed in estuary zone.

3.4 SERVICES

One of the key factors enabling the future growth of the area is the provision of service infrastructure to support any population increase. The existing services are detailed below.

Road and Rail

Transport studies indicate that private car travel will continue to be the dominant form of transport in the area (Department of Planning 1994). Both of the two main road linkages in the catchment - the Pacific Highway and the Newcastle-Nelson Bay road will be subject to much upgrading to the year 2015. The Pacific Highway between Bulahdelah and Coolongolook (30km) is currently being converted to a four lane dual carriageway although half of this is outside the catchment area. The Nelson Bay road will be upgraded to a four lane dual carriageway from Newcastle to Nelson Bay by the year 2015 (Port Stephens Council 1998) and a car ferry is proposed to link the Tomaree Peninsula with Tea Gardens. The Medowie/Pacific Highway road is unsealed for 6.1km and there are no plans to upgrade this. The Bulahdelah/Violet Hill Road is also unsealed. The Mungo Brush Road, maintained by National Parks, is unsealed in parts and is likely to be left in this state. There are no plans to upgrade the sealed Great Lakes Way from Bulahdelah to Bungwahl and beyond.

The only rail link in the catchment lies in the north-west - the Great Northern Line - between Dungog and Gloucester (both outside the catchment) via Stroud Road and Wards River.

Airport

The Williamtown RAAF and civil airbase lies on the south-west edge of the catchment near the upper reaches of Tilligerry Creek. Established in 1941 it has

over 1,000 weekly aircraft movements and employs 2,500 people. While some modifications will occur to the base, there are no plans to increase its size. However, aircraft noise necessitates an engine run-up buffer zone which is a restriction on future urban development in particular due to changing flight paths.

Water Supplies

Most of the water supply in the area is provided from underground aquifers even though the Grahamstown Dam is located nearby. The water supply is under the control of two separate organisations - the Great Lakes Council and the Hunter Water Corporation. The latter is administered from Nelson Bay for the eastern section and from Raymond Terrace for the western areas.

In the north the Hawks Nest/Tea Gardens area obtains its water from the sand borefields at Viney Creek north of Tea Gardens while most of the other settlements (Pindimar, North Arm Cove etc) have no serviced water supply and rely on tank water.

In the south the Tomaree Peninsula settlements are supplied with water from the Anna Bay sandbeds in the Tomaree National Park. This supply source could support a population of 40,000 (Port Stephens Council).

The Tilligerry Peninsula (population 5,316) receives its water from the Tomago sandbeds via the Tanilba Bay water treatment works which was completed in 1970 and which also supplies Karuah. This source has a population capacity of 9,000. Even though it is located adjacent to the Grahamstown Reservoir, Medowie also receives its water from the Tomago sandbeds.

Sewerage Disposal - Wastewater

As with water services, wastewater management is carried out by two agencies.

The Great Lakes Council controls waste disposal to the north of the estuary. Bulahdelah discharges treated sewerage into Frys Creek, a tributary of the Myall River. Stroud discharges into the Karuah River where there have been problems of higher than recommended BOD and suspended solid (Great Lakes Council 1996-7). Hawks Nest uses sandbed disposal and during 1998 this was upgraded to serve an extra 6,000 users (from 4,000 to 10,000). Booral, Bungwahl, North Arm Cove, Karuah and Stroud Road all use septic, biocycle or pump-out systems. North Arm Cove and Pindimar are not allowed onsite disposal (absorption tanks) and require pump out.

To the south of the estuary, the Tomaree Peninsula has been serviced by the large Boulder Bay treatment works which has an EP (equivalent population) carrying capacity of 67,000. The Tilligerry Peninsula was sewered in 1992 and uses absorption pits and sludge lagoons at Tanilba Bay.

Medowie is sewerred and has it own small treatment works although this is to be decommissioned in 1999 with the treatment being transferred to Raymond Terrace.

Karuah is currently dependant upon a pump-out system which is then taken by road to Raymond Terrace for treatment. However, it is expected to be connected to the sewerage scheme by the year 2000.

SECTION 4

HISTORIC/HERITAGE SITES IN THE PORT STEPHENS - MYALL LAKES CATCHMENT

4.1 METHODOLOGY

Reference was made to environmental planning instruments containing detailed lists of Historic/Heritage Sites in the area. The Historic/Heritage Sites for the Port Stephens Local Government Area are listed in the Hunter Regional Environmental Plan (DUAP 1989), while those for the Great Lakes Local Government Area are listed under Schedule 2 of the Great Lakes Local Environmental Plan (1996). The Historic/Heritage Sites in the area are classified into sites of state, regional and local significance.

4.2 HISTORIC/HERITAGE SITES

The Heritage/Historic Sites occurring in the Port Stephens/Myall Lakes Catchment as listed in the Hunter Regional Environmental Plan and the Great Lakes Local Environmental Plan are listed in Table 4.1 and Figure 7.

**TABLE 4.1
HISTORIC/HERITAGE SITES OF STATE SIGNIFICANCE IN THE
PORT STEPHENS/MYALL LAKES CATCHMENT.**

Location	Site
Tanilba Bay	
Caswell Crescent	Tanilba House
Hunter Street	Tech. College & Trades Hall Group (606 - 608)
King Street & Wheeler Place	City Hall
Laman Street	St. Andrews Church
Newcomen Street	Newcastle Club (40) and Claremont (42)
Nobbys Road	Boatman's Terrace
Pacific and King Streets	Newcastle Hospital North Wing
Parnell Place	Coal Memorial
Parry Street	City Incinerator
Perkins Streets	St Marys Star of the Sea
Scott Street	Former Woods Chambers (131) and Houses (88, 90, 92)
Stevenson Place	Stevenson Place Precinct
Stevenson Place and Zaara Street	House (Freestanding 2-storey)
The Terrace	The Terrace Group (No.s 2-40 excluding 34 & 36) and Shepherds Hill Group
Tyrell Street & The Terrace	Beacon Tower
Wharf Road	Lee Wharf Group (including No. 1 Bldg A & No. 2 Bldg. C) and Boat Harbour
Fletcher Park	Fletcher Monument
King Edward Park	King Edward Park Group
Nobbys Beach	Soldiers Baths
Bulahdelah	
Bulahdelah region	Kauri and Co's Railway
Horses Creek - Wang Wauk State Forest	Tramline Trestle Bridge
Carrington	
Tahlee Road - Part Portion 206 Parish of Carrington	Carrington Cemetery
Tahlee Road Lot 340, DP735514 and Lot 342, DP740621	Tahlee House
Cock Renoyo Point	Carrington Boat Harbour and Lime Kiln
Booral	
The Bucketts Way and Lowes Lane - Lot 1, DP47370 Lot 1, DP632812	Gundayne House Group, Residence Out and Schoolhouse

TABLE 4.1 Cont.

Port Stephens	
Port Stephens	Port Stephens Lighthouse Group
Nelson Head	Nelson Head Lighthouse Group
Bulahdelah	
Crawford Street - Part Lot DP226885	Former Courthouse
Bulahdelah Mountain - Railway from Simsville to Allworth	Former Aluminium Mine
Markwell Road - Cnr Red Gum Road and Mahogany Street	General Cemetery
Allworth	
Allworth River - Eastern Side of Karuah River, south of concrete boat ramp	Allworth Wharf (remains)
Booral	
The Bucketts Way - Parish Booral, Portions 55/154	Alderley House
Isaacs Lane - Portion 81, Parish Booral, Lot 1, DP632812	Booral House
Karuah River - about 1 mile south of Booral	Booral Wharf
Mulbrook Road	The Gables
Carrington	
Cock Renoyo Point	2 roomed brick cottage
Stroud	
Bridge Street	House - Bridge Street
Berkeley Street - Lot 1, DP745192 and Lot 1, DP782050	Former AA Co Cottages
Berkeley Street - Located between Broadway and Collins Streets	3 single storey residences
Cnr Broadway and Mallon Streets Lot 1, DP803474	St Columbines Church
Cowper Street - Lot 1, DP202634	Former Council Chambers
Cowper Street - Lot 5, Section 2	Post Office
Cowper Street - Lot 6B, DP709600	Former Courthouse
Erin Street - Lots 1-3, DP794878	Public School and residence
Silo Hill	Underground grain silos and cannon
Cowper Street - Lots 91 & 92 DP584892 and Lots 6 & 7 DP DP939759	St Johns the Evangelist Church Group including Quambi House
Cowper Street - Part Portion 75, Parish of Stroud	Stroud House
Karuah River - 7.5 km south of Stroud	Washpool
Hawks Nest	
Bennet Street	Timber Cottage

TABLE 4.1 Cont.	
Tea Gardens	
Facing water - 53 Marine Drive	Courthouse
Tea Gardens Shopping District - 215 Myall Street	General Cemetery
Booral	
The Bucketts Way - Parish Booral Part Portion 6	St Barnabas Church and Cemetery
Carrington	
Church St. - Lot 1, Section K, Carrington	Former St Andrews Church
Stroud	
Berkeley Street - "Thornleigh"	2 storey colonial house
Cowper St - 70 Cowper St	Baptist Church
Cowper St - 44 Cowper St	Bank of New South Wales
Cowper St - Lot 4 Section E	School of Arts
Erin Street - 25 Erin Street	St James Church
Mill Creek Road	House - Mill Creek Road
Stroud Road - Lot 1, DP770116	Methodist Church
Tea Gardens	
Tea Gardens Shopping District - 215 Myall Street	Fishermen's Huts and Stores

The heritage items in the Port Stephens/Myall Lakes catchment reflect the past landuses of the catchment as a mining, agricultural and industrial area. Other heritage items reflect the area's strategic use for military operations or provide information on the previous social, economic and political characteristics of the catchment as well as information on the people and historic figures of the area.

Most of the heritage items recorded in the catchment are isolated from the estuary and are of little relevance to the estuary process study. Those heritage items which are located on or adjacent to the estuary and which may be relevant to processes affecting the estuary are listed below:

Tea Gardens

- Tea Gardens Shopping District, 215 Myall Street - Fishermen's Huts and Stores.

Tanilba Bay

- Wharf Road - Lee Wharf Group;
- Nobby's Beach - Soldiers Baths.

Carrington

- Cock Renoyo Point - Carrington Boat Harbour and Lime Kiln.

Allworth

- Allworth Wharf Remains.

SECTION 5

ABORIGINAL ARCHAEOLOGY

5.1 ABORIGINAL SITES IN THE CATCHMENT

The NSW National Parks and Wildlife Service contains a register of all known Aboriginal Sites in NSW. An application was submitted to the NPWS Aboriginal Sites Registrar for information on all sites recorded within 500 metres of the water's edge for Port Stephens and Myall Lakes. Consultation was held with the relevant Local Aboriginal Land Councils (LALC's) of the Catchment who were asked to give an outline of the major issues confronting their organisations with regard to Aboriginal archaeological sites and site management. Relevant government authorities were also contacted for input regarding Aboriginal cultural heritage management and the estuary process study. A literature review was undertaken for information relevant to Aboriginal sites.

As little systematic survey work has been conducted in some parts of the catchment (DUAP 1989; Mitchell McCotter & Associates 1986; Summers 1994) and few sites have been located in these areas, it is pertinent to note the following broad areas which are considered to be archaeologically sensitive:

1. Areas adjacent to estuaries, lakes, lagoons, rivers and creeks.
2. Areas where disturbance to land has been minimal, eg. forest or woodland.
3. Other areas where some ground disturbance has occurred but where a remnant of the original land surface remains, eg. areas which have been logged, farmed or grazed.

After the system of State, Regional and Local Aboriginal Land Councils was set up in 1983, the Worimi were able to develop their own Council to provide services for Aboriginal self-help (Marr 1997). Today, the Port Stephens / Myall Lakes area is covered by three Local Aboriginal Land Councils: the Worimi, Karuah and Forster Local Aboriginal Land Councils. The Forster LALC covers the area north of the northern end of the Myall Lakes up to the Manning River. The Karuah LALC covers the area south of the northern end of the Myall Lakes to the northern shore of Port Stephens and west past Clarence Town. The Worimi LALC covers the area between the northern shore of Port Stephens and the northern bank of the Hunter River. This LALC area is bounded in the west by the Paterson River.

Middens

Middens are physical evidence of Aboriginal use of shell fish and other organisms including mammals and birds. Groups of people gathered shell fish from the sea then cooked and consumed them at a location not far from where they were

collected. Inspection of the elements within a midden can show a lot about the length of time the midden was used and for what purpose. Animal and bird bones, as well as stone artefacts can be found, and in a recent inspection of a midden in the Halidays Point area, fragments of whale bone were seen (Silcox 1998; Summers 1994).

The Sites Register search gave a total of 131 middens sites in the study area. Middens have been found extensively in the region including Fingal Bay, Morna Point, One Mile Beach, Fisherman's Bay, Broughton Island, Mallabula, Tilligerry Creek and Bagnalls Beach (L. Anderson, pers. comm. 1998; Shortland County Council 1988; Sinclair Knight Merz 1994).

Mythological Sites

This type of site has spiritual significance to the local Aboriginal people in a particular area. An example would be a rocky outcrop in a prominent location. Well known examples of these include Uluru (Ayers Rock) in Central Australia. A mythological site may resemble an animal or a bird and have a story that has been passed through generations. These stories may be about ancestors who used to live in that area. They can also be educational stories that teach young about the trials of life. Even though there is no hard evidence present that Aboriginal people used these areas, the NPWS do register Mythological sites. The mythical and religious significance of many features of the natural landscape is being revealed as more Aborigines regain contact with their culture. A search of NPWS site records by Silcox (1998) revealed a total of 49 recorded archaeological sites in the area between Carrington and the Ocean, and from the Bombah Broadwater to Port Stephens. Included in this list of sites was a mythological site - Yacaaba (North Head) Headland - in the Tea Gardens area, which is of considerable sacred significance. This is the only record of a Mythological site from the Sites Register search.

Open Campsites

This type of site has physical characteristics that indicate Aboriginal use of that area. Open campsites consist mainly of scattered artefacts along with shell material (in coastal regions), but they may also contain crudely constructed fireplace areas. These may have deteriorated through age, and also plant growth may have grown over the site making identification difficult (Kinhill Engineers 1990). Some open campsites can constitute large areas, as with one example being around 100 x 80 metres in area (M. Leon pers. com. 1998). Open campsites and occupation sites can be found in the region around the estuary and further up into the catchment. Such sites include Morna Bay and Morna Point, Broughton Island, Anna Bay, Fingal Bay and Fingal Point, One Mile Beach and Fisherman's Bay (Kinhill Engineers 1990; Summers 1994). The Sites Register search gave a total of sixteen open campsites in the study area.

Shelters

The Sites Register search gave total of 3 records for shelters in the study area. This comprised one shelter with art, one shelter with deposits, and one shelter with a midden. The nature of these shelters is not known but it is believed that they served a similar purpose to the open campsites.

Canoe, Shield, Container And Carved Trees

Canoe, shield and container trees are trees which show scars caused by the removal of bark or wood for making various artefacts.

Stone axes and wooden wedges were used to remove large sheets of bark for making canoes, or smaller sheets which were shaped into containers. Broughton Island contains evidence of Aboriginal use and by association, the use of canoes to get there (Summers 1994). Wood for shields, boomerangs and other wooden implements was similarly removed, leaving clear scars on the tree.

When first formed the scars on these trees would have been sharp and quite shallow, but in the years since they were cut the trees have grown many layers of bark, so that the margins of the scars are now deep and rounded (M. Leon pers. comm. 1998).

Carved trees had a ritual rather than an economic significance to the Aboriginal people. Ceremonial grounds and graves were often marked by trees carved with intricate geometric or linear designs. Some earlier observers claimed the carved designs were an indication of ownership of the grave or ceremonial ground marked by the tree. It is also possible that tree carvings on trees marking graves told of the totemic or kinship affiliations of the deceased. Whatever their significance these trees are important examples of a distinct Aboriginal art form. Although rare in the region, they have been found at Nelson Bay and Bagnalls Beach (Summers 1994). The Sites Register search gave a total of five scarred trees in the study area.

These old trees are quite common in the west of the state, but are rare in eastern NSW because of the frequency of bush fires, clearing and timber harvesting. Those that do remain are often standing dead, or have fallen. Whatever their state of preservation, the trees are very vulnerable to destruction.

Burial Sites

These sites are common in the region and are usually associated with sand dunes and spit formations along the coast and the inland foreshores. Burials have been found in isolation and in association with occupation and midden deposits (Summers 1994). Burial sites have been found at many locations including Morna Point, Anna Bay, Winda Woppa and Providence Bay (Sinclair Knight Merz 1994;

Summers 1994) The Sites Register search gave a total of six burial sites in the study area.

Bora / Ceremonial Sites

The Sites Register search gave one record of a bora / ceremonial site in the study area. These sites are particularly sacred and would have been used for special ceremonies and occasions.

Fish Traps

There is little evidence of this type of site within the region but one is located on Broughton Island. This island shows many signs of Aboriginal use including burial sites, stone artefacts and middens (Sinclair Knight Merz 1994)

Stone Artefacts / Grinding Stones

Stone artefacts are usually found in association with occupation sites and middens (see above). Many artefacts have been found in the region including stone tools and flakes. The most common types of artefacts found are the stone flakes which are either worked or unmodified (used on site or carried on site to use when required Kinhill Engineers 1994). There is one record of an axe grinding groove in the Sites Register. A rock engraving site has been recorded at Yagon Gibber Headland in the north of the study area.

Stone Arrangement

The Sites Register search resulted in a total of four stone arrangements in the study area. It is not known what purpose these arrangements serve.

Isolated Finds

The Sites Register search gave two records for isolated finds in the study area. The exact nature of these sites is not known.

5.2 ABORIGINAL CULTURAL SIGNIFICANCE

It is important to recognise that Aboriginal people today retain a strong attachment to their land and culture. Many of the sites and artefacts within the catchment are significant to the three LALC's as they provide a direct link with the traditional culture. The sites in the area suggest both male & female use of the natural surroundings. Evidence both oral and physical remain and each have reference to either sex (M. Leon pers. comm. 1998). It is the Aboriginal Land Council's policy that no information about the specific location of any of these sites be disclosed without prior consent. Information which can be used is general in order to protect spiritually and physically sensitive sites.

Today, the Aboriginal archaeological resources of the catchment are jointly managed by the New South Wales National Parks and Wildlife Service and the three Aboriginal Land Councils. The NPWS is responsible for administering the relevant legislation under the Minister for Planning and Environment. In the event of development encroaching onto known or potential sites, the NPWS may require a site survey by suitably qualified personnel. In this event, it is also likely that a member of the relevant LALC would be invited to attend the survey.

Listed below are the issues raised in consultation with the three LALC's.

Forster Local Aboriginal Land Council

- Attention needed to be directed to the fact that the Myall Lakes is still used as a traditional fishing ground, and for collecting native plants for food and medicine;
- Myall Lakes is an important cultural resource as it is still used as a meeting place for the different LALC's for meetings and discussions, and during fishing and plant collection times.

Karuah Local Aboriginal Land Council

- More protection needed around sites when considering development and recreation projects;
- Possibility that some EPA guidelines were not being adhered to in relation to development;
- Would like to see more notification of sites to Karuah LALC.

Worimi Local Aboriginal Land Council

- Tours of midden sites mismanaged, need for more Aboriginal input into tours and tour programs;
- Interpretation of sites / stories by non-Aboriginal people is not sufficient - can lose original meaning and proper interpretation without Aboriginal input;
- Government authorities, including National Parks and Wildlife Service, State Forests and Local Government, are not utilising local Aboriginal knowledge in formulating management plans, etc.

There are many other current issues and regulations pertaining to Aboriginal site protection. The following is an excerpt from the National Parks & Wildlife Service outlining the actions necessary when considering development on land of Aboriginal significance (M. Leon pers. comm. 1998).

Figure 1 - Vegetation

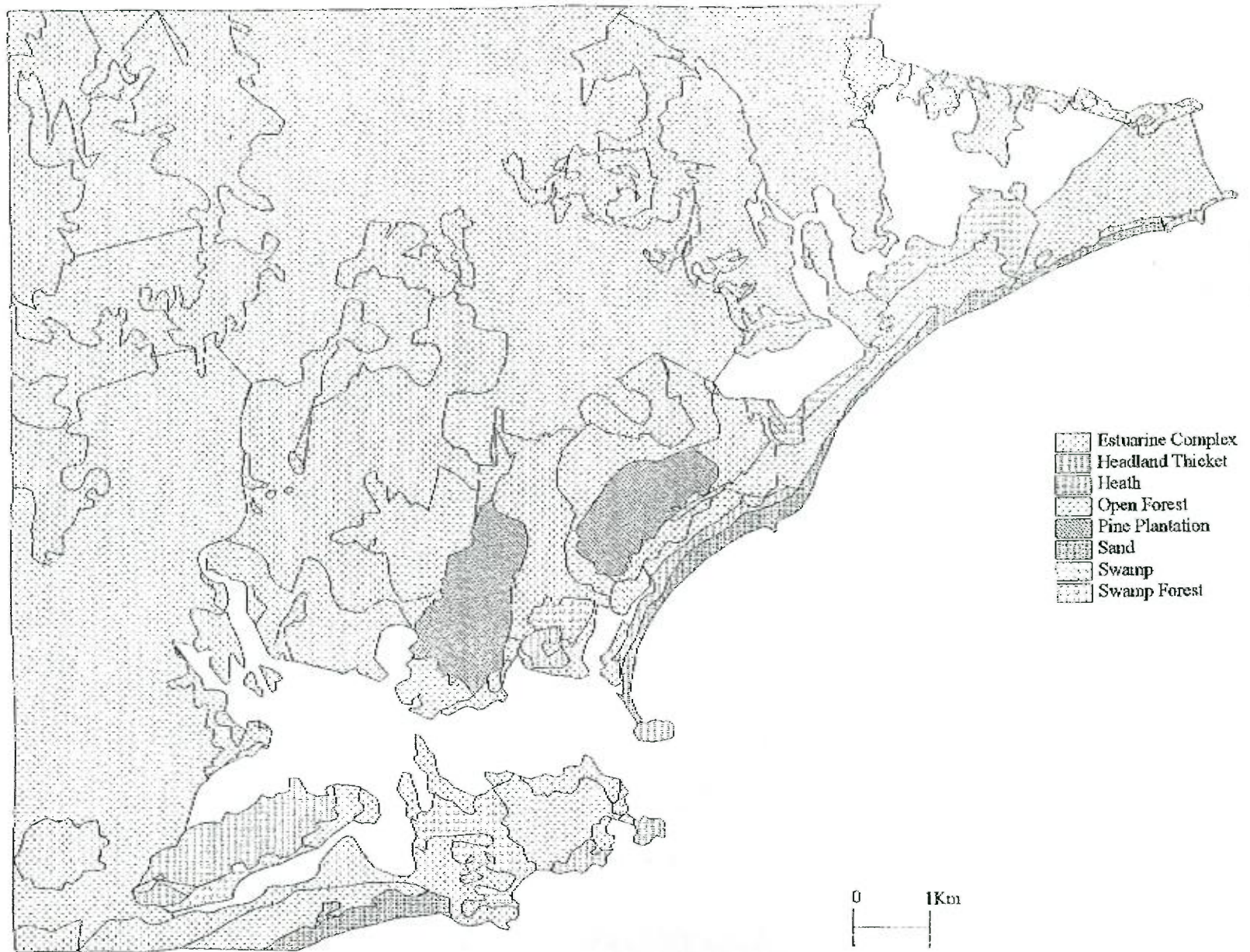


Figure 2 - Landcover Pattern

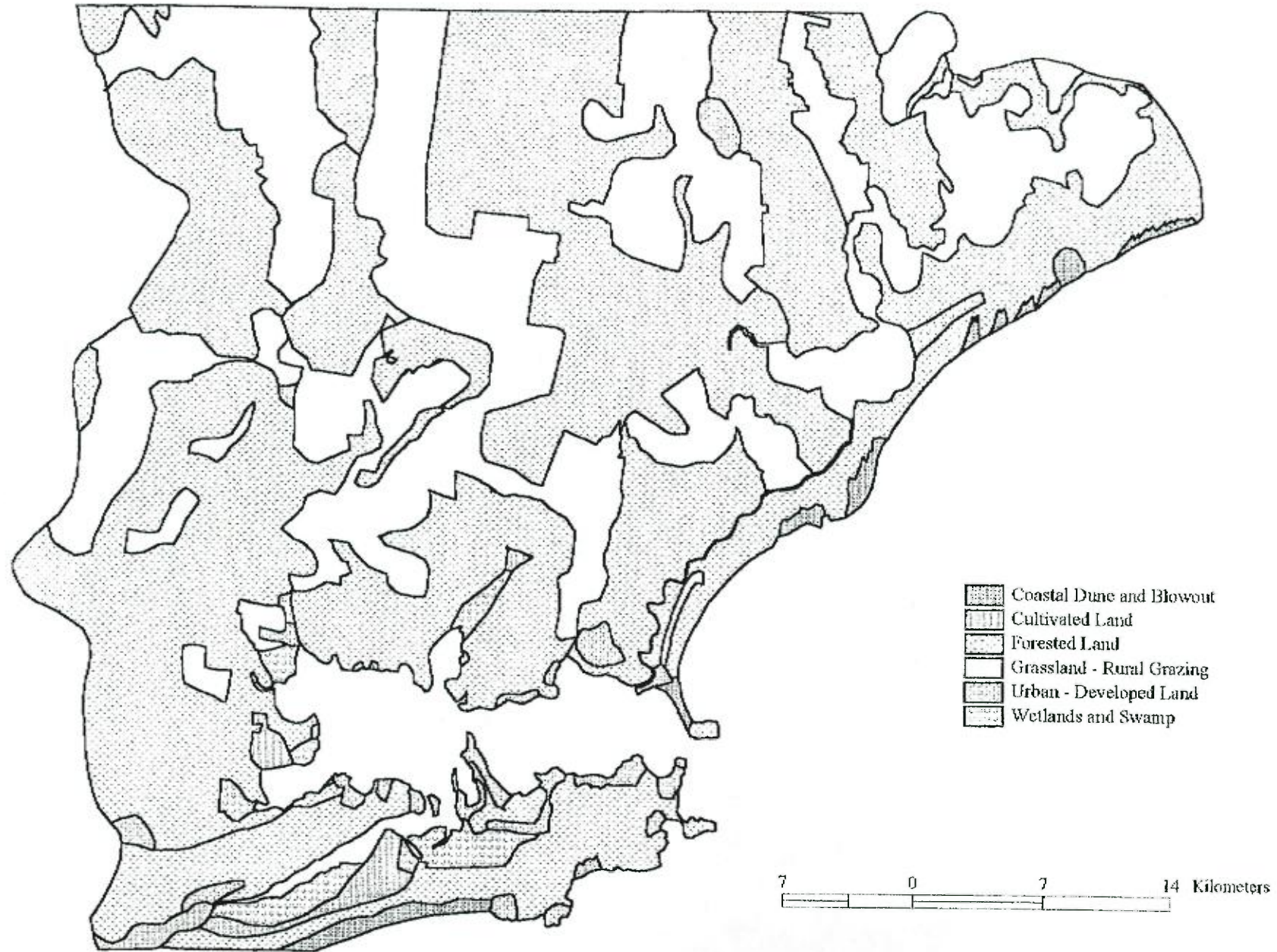


Figure 3(a) - Tilligerry Peninsula Landcover August 1963

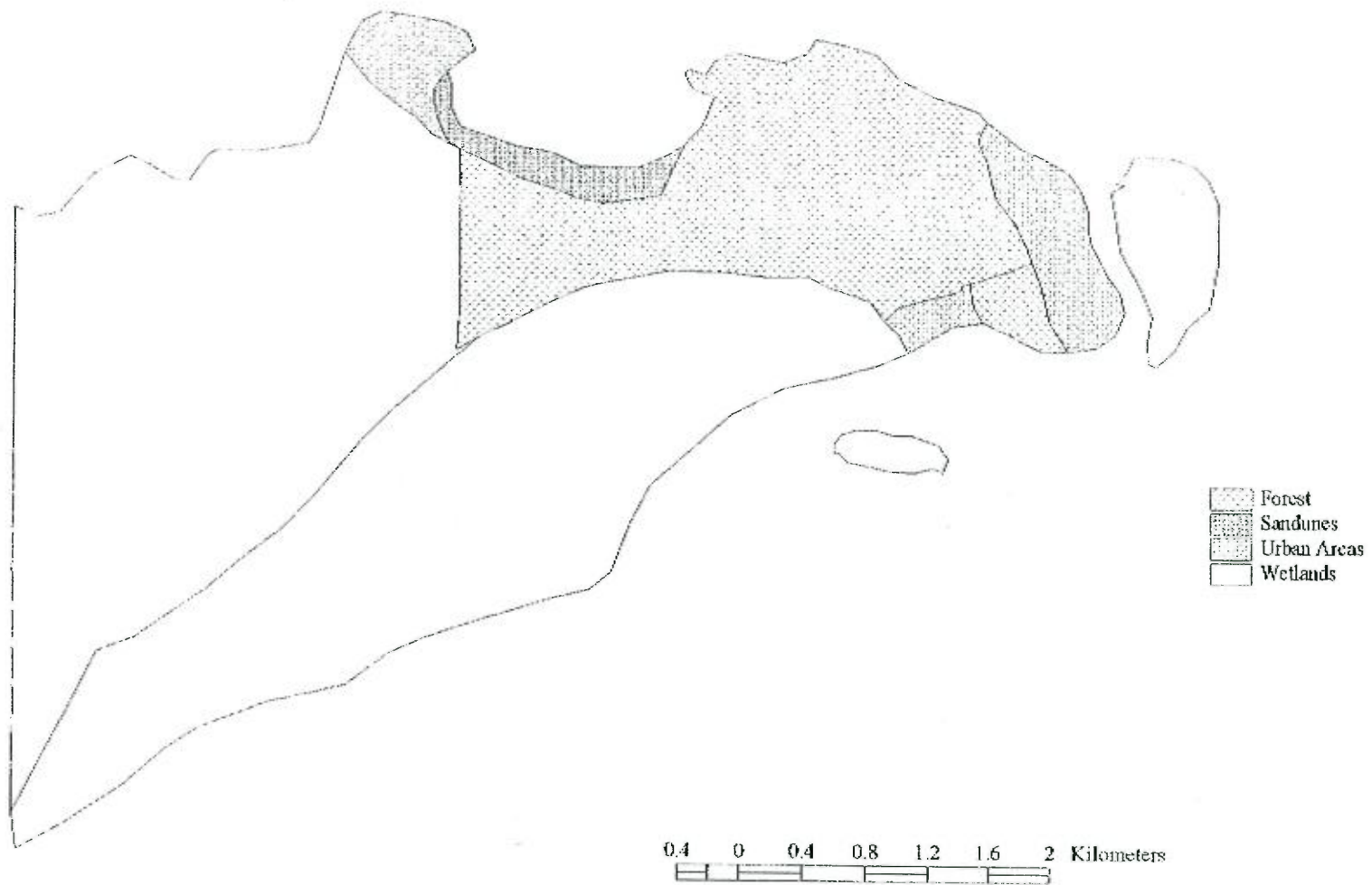


Figure 3(b) - Tilligery Peninsula Landcover February 1993

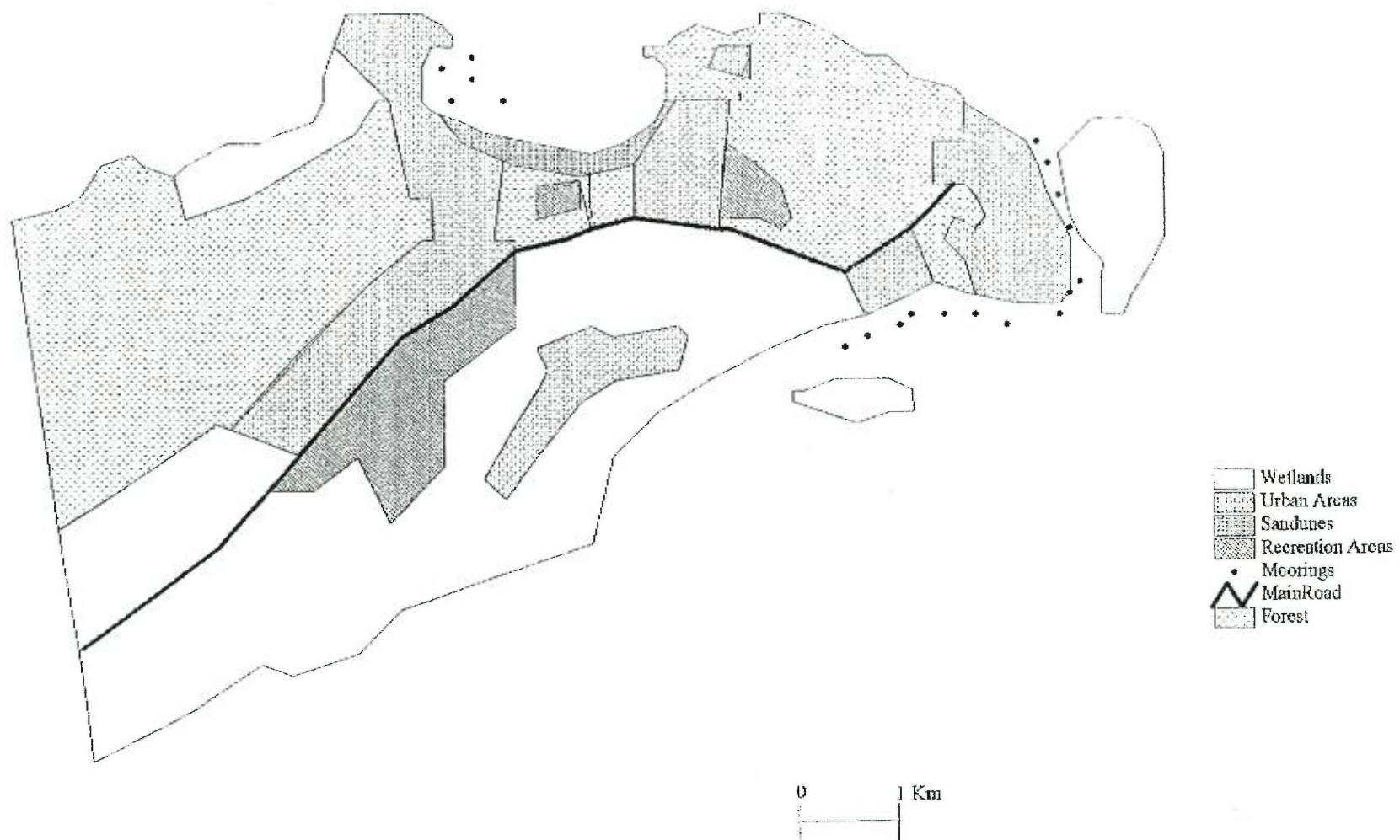


Figure 4 - State Forests and National Parks 1998 - Areas and Dedication Date

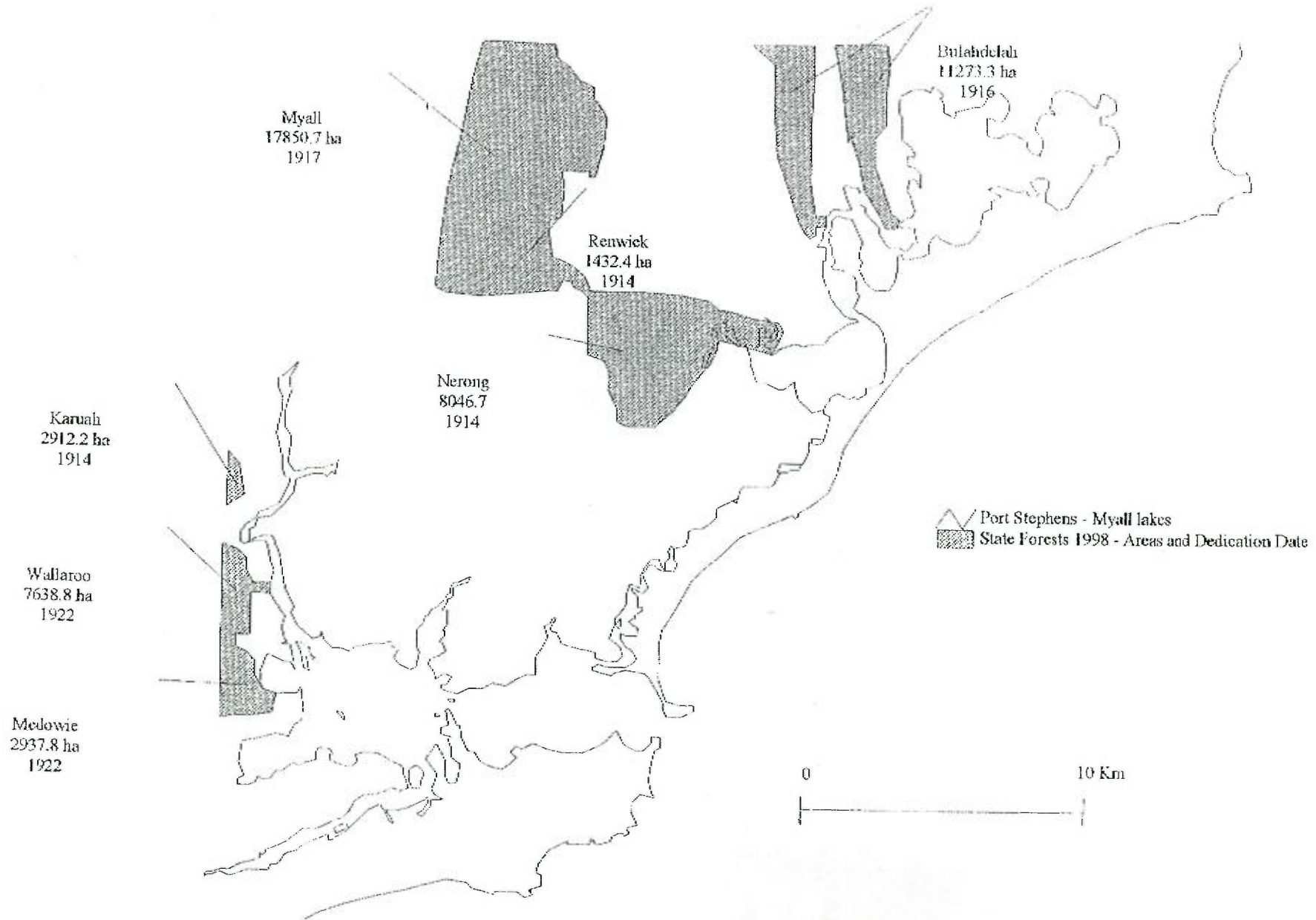


Figure 5 - Port Stephens Oyster Leases

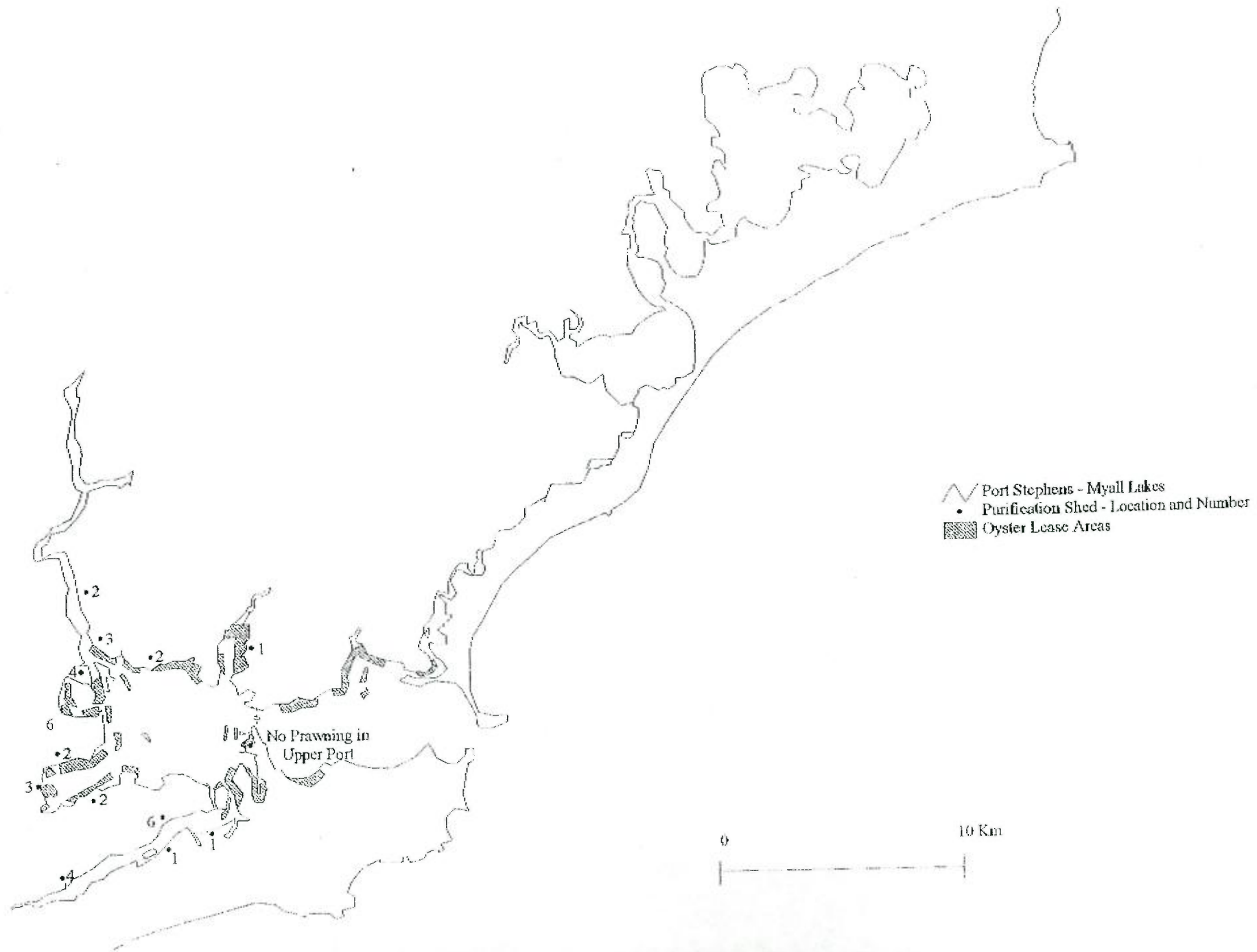


Figure 6 - Tourist Facilities

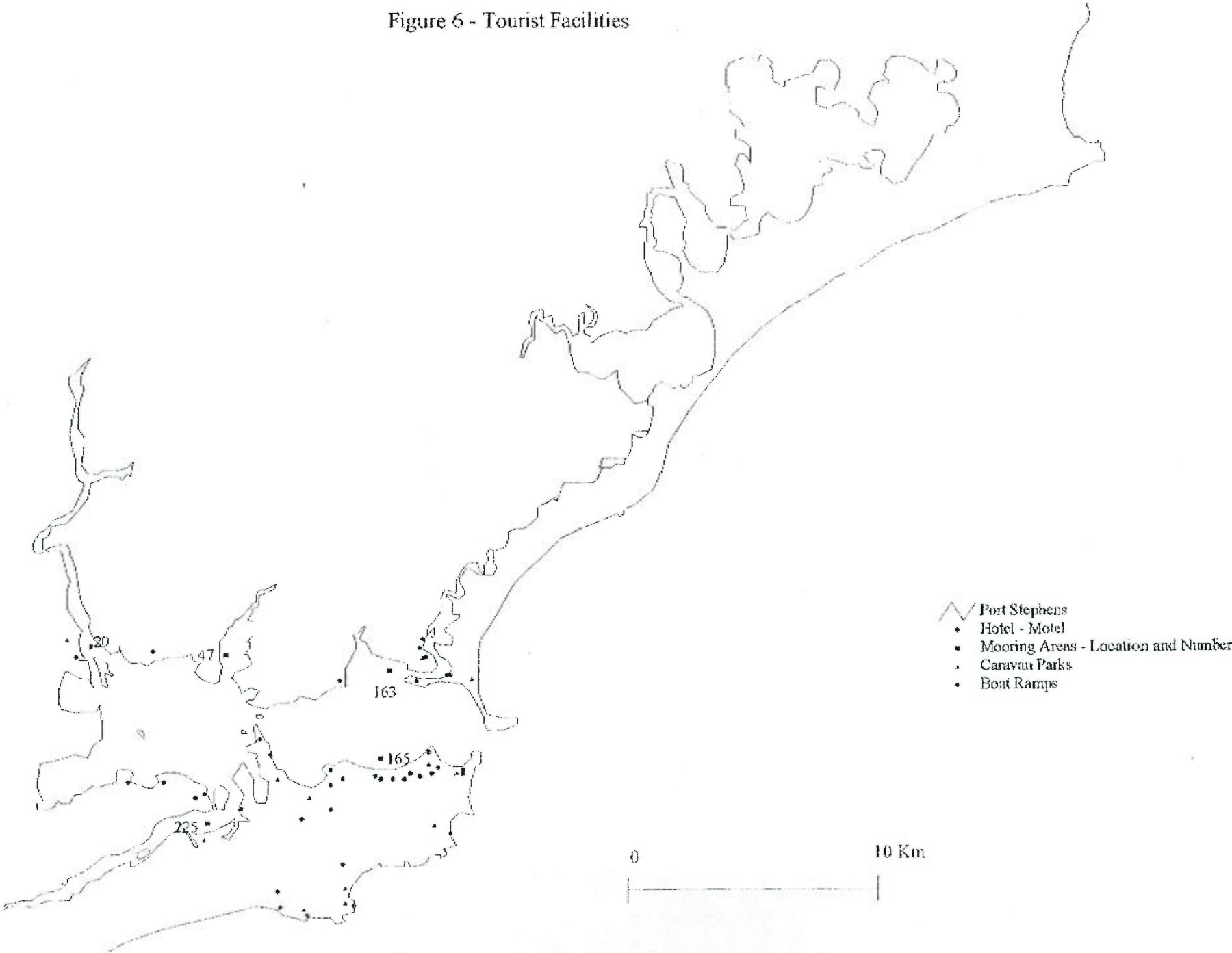
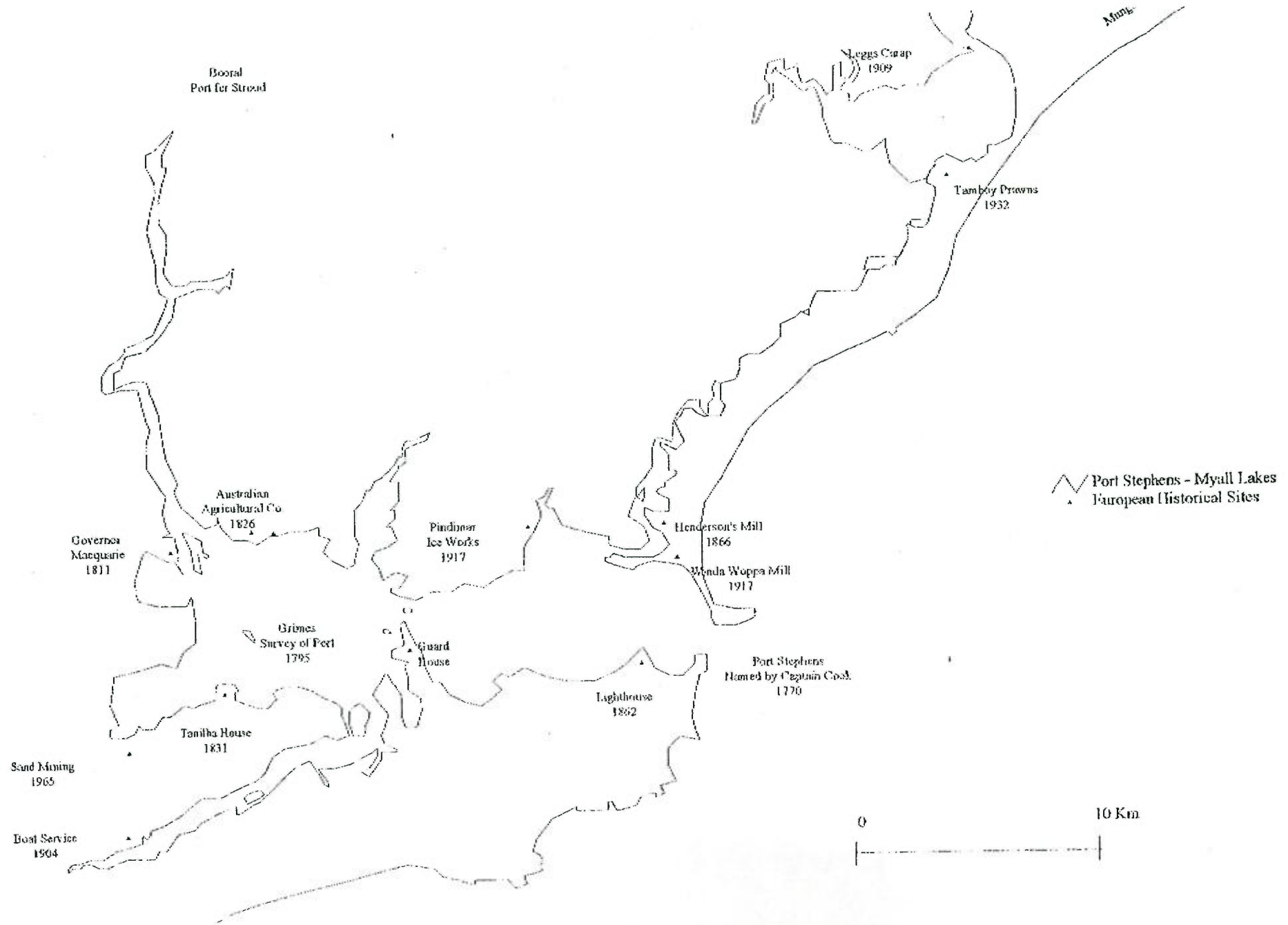


Figure 7 - European Historical Sites



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22 September, 1998
Our Ref: LRE6-00003

Telephone 02 9949 0200
Facsimile 02 9948 6185

**The General Manager
Integrated Site Planning and Management
PO Box 82
EAST GOSFORD NSW 2250**

Attention: Mr Phil Conacher

Dear Sir,

**RE: Port Stephens/Myall Lakes Estuary Processes Study;
Finalisation of ISPM Sub-consultancy Report**

Further to the copy of the draft report forwarded to your office on 13 August 1998 and subsequent discussions (Lord - Conacher), we have now received all review comment relating to the project from the Port Stephens Council.

We have also reviewed your report and our direct comments on that report are attached.

MHL Comments on ISPM Report

Several of these comments were raised in our initial review of 29 July and have not been addressed. These issues are in addition to those matters raised by Council/the committee and need to be addressed in your final report.

The standard of the mapping and the reproduction which we can achieve from those maps is not acceptable. This includes generally poor quality shading which is difficult to distinguish; little or no labelling and reference information; sources not shown; scales different on each map (several are obviously wrong); no north point; etc. Generally the legends are difficult to decipher and interpret. As this was a major aspect of your involvement it would be advantageous if the standard of these figures could be reviewed. We will simply take these figures and add them to the final report (from the hard copy which you provide). Specific comments relating to the mapping include:

- no acid sulfate maps provided;
- Figure 5 which shows State Forests and National Parks does not include any National Parks.
- Figure 6 Tourist facilities is not legible
- Figure 7 European Historical sites includes disjointed information and is not well related to the text
- No figures provided showing catchment slopes and soil mapping
- No map showing the SEPP 14 wetland mapping for the catchment

With regard to the final text provided and the layout, the following comments are provided:

- Section 1.1 areas of the waterway and catchment should be amended to agree with the figures presented in the main report by MHL.
- Sections 1.8 Slopes and Topography and 1.9 Soil Types are yet to be provided.
- Page 4 reference to Appendix 1 SEPP 14 wetlands which does not exist. Map is required also.
Section 1.7 Aboriginal and Historical Heritage needs to show locations of sites of significance on a plan.
- page 38 - Sand mining has been extensive and is very topical. Perhaps a map showing mined and regenerated areas is required. I suspect mining has been far more extensive in the catchment than indicated. Reference to sand extraction at Fern Bay is outside the catchment area. Sand extraction is occurring within the catchment at locations adjacent to the head of Tilligerry Creek and around Anna Bay. There may be other sites which need to be identified.
- P38 to p41 on the fishing industry and the oyster industry are probably outside your brief. These areas were addressed by TEL and we have used their words in the final report. You may wish to check that your summary is in accordance with their findings.
- p 46 Table 4.7 should be 3.7
- Mention of tip sites with high levels of toxic substances (p 48) is somewhat inflammatory. Statements regarding toxicity need to be referenced as we have not done sampling to establish these claims.
- Section 4 Many of the historical sites listed would appear to be outside the catchment area (e.g. Newcastle Hospital is not in Tanilba Bay). Many of the locations mentioned within the catchment need to be shown on a map. Table 4.1 needs careful revision and to be related to the plan of historical sites.
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It would appear that Great Lakes Council has expressed particular concern at statements relating to the catchment and the North Arm Cove area. It would probably be worthwhile for you to contact the Council rep directly to ensure that the changes you propose address their concerns satisfactorily.

Once you have completed all your corrections we would appreciate it if you could provide us with copies of your final report. These can have your covers on them but should acknowledge in the foreword that they have been prepared for NSW Department of Public Works and Services, Manly Hydraulics Laboratory for inclusion in the Port Stephens/Myall Lakes Estuary Processes Study being prepared for the Port Stephens Myall Lakes Estuary Management Committee. We will advise the committee that should they require additional copies than these could be obtained from you directly (at cost). The number of copies required to finalise your engagement is as follows:

MHL 2 copies

Committee 3 copies + 1 unbound master (we will forward these on).

We would also appreciate a copy of your text in Word 6 Format to facilitate our inclusion of the revised sections into our final report. We will do a cut and paste from your final figures to our report as required.

We are keen to finalise the report to Council by 10/10/98 and we would appreciate your final reports by the week starting 5/10 98 if this is possible.

Thank you for your input and assistance in this investigation. Please contact Mr Doug Lord should you have any queries regarding the changes required or the presentation of your final report.

Yours faithfully



Will Strachan
General Manager
Manly Hydraulics Laboratory

Enclosure: Copy of Committee comments with marked areas of concern.

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22 September, 1998
Our Ref: LRE6-00003

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- * • Section 1.7 Aboriginal and Historical Heritage needs to show locations of sites of significance on a plan. *New Plan.*
- * • page 38 - Sand mining has been extensive and is very topical. Perhaps a map showing mined and regenerated areas is required. I suspect mining has been far more extensive in the catchment than indicated. Reference to sand extraction at Fern Bay is outside the catchment area. Sand extraction is occurring within the catchment at locations adjacent to the head of Tilligerry Creek and around Anna Bay. There may be other sites which need to be identified. *New Info*
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W Strachan
Will Strachan
General Manager
Manly Hydraulics Laboratory

Enclosure: Copy of Committee comments with marked areas of concern.

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I.S.P.M.

P&CS

Port Stephens

C.O.U.N.C.I.L

SUSTAINABLE DEVELOPMENT DEPARTMENT

FACSIMILE ADVICE FORM

TO:

NAME:Doug Lord.....
 OF:Manly Hydraulics Laboratory.....
 FAX NO:(02) 9948 6185.....
 NO. OF PAGES INCLUDING HEADER: ...10.....

FROM:

NAME:Jenny Davies.....
 SECTION: **Environmental Services**
 DATE:03/09/98.....
 FAX: 02-49873612

MESSAGE:

.....Please find comments from Committee Members on the draft report on the Port Stephens / Myall
 Lakes Estuary Processes Study; Specification No T03/97.....

All correspondence to be addressed to PO Box 42 Raymond Terrace 2324. (DX 21406, Raymond Terrace) 116 Pacific
 Hwy, Raymond Terrace: Tel 02-49800255 :Fax 02-49873612

31000
R. Harris.

FACSIMILE COVER SHEET

DEPARTMENT OF LAND AND WATER CONSERVATION
HUNTER REGION

464 KING STREET NEWCASTLE WEST NSW 2302
PO BOX 2213 DANGAR NSW 2309

FAX NO. (02) 4929 6364



TO: PORT STEPHENS COUNCIL

ATTENTION: RICK HARRIS

FAX: 02 4987 3612

DATE: 2 September, 1998

SUBJECT: COMMENTS ON THE DRAFT PROCESSES STUDY

FROM: Ric Slatter

PHONE: (02) 4929 9823


Reply Required?

NO

NUMBER OF PAGES (Including this title page)

4

Attached are comments on the Draft Processes Study


J Bourke
A/Manager
Resource Access Works & Services

This facsimile transmission is to be regarded as an original document and no further copy will be forwarded.

The original document will be forwarded by mail.

DRAFT PORT STEPHENS/MYALL LAKES PROCESSES STUDY

General

The document needs to be checked for spelling, typing (capitals), names of both Councils, Corrie Island.

Additional information expected from the brief. Scope of works for the Management Study/Plan (Sect 5.15) and summary figures for water, water quality and nutrient budgets (Sect 5.14).

The report fails to reference to talk about the data contained in a number of MHL reports. Especially gauging reports - despite the statement in the report (and the brief) there has been a couple of gaugings done on the Lower Myall River. There has also been summary report titled "Lower Myall River - Compilation of Data", Report NO MHL622, May 1993. This report include sediment analysis, modelling etc. This report also attempted to do an analysis of the entrance to the Myall.

Groundwater info on Tomago Tomaree and Stockton area has been referred to the DLWC technical review by Wooley at el (1995). There are a number of potential point source and diffuse source contaminants that could have impact on the estuary.

- industries ie Al smelter at Tomago
- effluent disposal at RAF base, Tilligerry....
- mineral sand mining operations at Tomago and Fullerton Cove (release of Fe and As in to groundwater)
- Acid Sulphide soils and drainage system
- effluent irrigation at Karuah

No or little information on groundwater is given for the northern part of the study area. (Myall Lakes Area)

- Tea Gardens Hawks Nest Water Supply is from sand beds at Viney Creek
- mineral sand mining operations at Viney Creek
- STP at Hawks Nest
- application of chicken manure at golf course
- effect on acid soils and groundwater on developments in low lying areas.

Relevant References

Tomago-Tomaree-Stockton Groundwater Management Plan (DLWC)
Technical reports of HWC
Karuah Sewerage Study
Hawks Nest Sewage Study...

PAGE	SECTION	COMMENT
1	Section 1.1 para 2 & 4	Possible to show tidal limits in a Figure.
2	Section 1.1 para 1	Comment on the impact of the floodgates on the tidal limit of Tilligerry Creek.
2	Section 1.2	The Port Stephens/Myall Lakes Estuary Management Committee.
6	Figures 2.14 - 2.16	These figures are difficult to read.

6	Section 2.2.2	Temperatures given are from outside the catchment, possible explanation.
15	Figure 2.11	Figure is difficult to read, key or legend.
31	Section 2.10.3.2	Table 2.2 includes the koala, does the koala occur in the estuarine or associated habitat.
38	Figure 3.1	Need to define what is the area - the hatched, and/or the bold line sections.
38	Figure 3.2 - 3.6	The plots of the EPA data, are they needed. A table of means and standard deviation would impart the same data - especially as there is no spatial extent to the plots - hard to decipher.
40	Figure 3.8	The plot of water level in the Lakes is at such a scale that it is difficult to see if there is any tidal influence.
40	Figures 3.7	Difficult to read.
40	Section 3.1.3	It is not a gauging - there are no velocities or discharges involved. It states that there is little tidal influence on the Lakes, however in the next paragraph it states that the Lake is generally perched - isn't this a tidal effect even though there is negligible tidal range. The fact that there is salt recovery after a fresh shows that here is tidal effects.
44	Figure 4.1	There should be some difference in the key between Grassland and the water of the Lake or Port.
49	Section 4.1.7.2	As sand mining was so extensive in the Lakes area, it would be advantageous to map the mined areas with the date of mining included. Could also be included in the vegetation section to indicate revegetation sites.
50	Section 4.2.3	No towns higher in the catchment mentioned.
50	Section 4.2.4	Explanation of Karuah and Stroud Road.
50	Sections 4.2.3 & 4.2.4.	Mid Coast Water is now responsible for the Great Lakes Council area.
51	Section 4.2.4	Is there a need to mention the sewerage situation at the aboriginal community.
51	Section 4.3	Possible inclusion of the dolphin watching industry. Tourist facilities, Figure 4.5, near the Myall could be included.
62	Table 4.5	Table needs to be reviewed, Sites in Newcastle included in Tanilba Bay group, all sites at the one location should be grouped together.
64	Section 4.4.2.2	Sites in the estuary to be reviewed. Figure 4.6 may need to be reviewed.
65	Section 5	No mention of flood characteristics. Details in Lower Myall report, particularly characteristics under large floods. The Lakes fill and slowly empty via the Lower Myall. The impact of the high water level for a long period should be considered.
65	Section 5.1	A section on tidal processes is needed. Previous reports have dealt with tidal behaviour.
65	Section 5.1.1.2	Is the dominant NW wind a common feature of the coast? Does it represent a dominant weather pattern or the land breeze off shore (as the coast is NE orientation here).
73	Section 5.2.2	Change reference to professionals.
86	Section 5.7.2 para 3.	Grammar of last line.
92	Section 5.8.3	Para 1 states that inundation from waves and floods can occur, and that inundation levels are given in Table 5.3. However levels in Table 5.3 do not include wave action.

93	Section 5.8.4 Paras 2 & 4	"over recent years by GLC over the past twenty years" grammar "one" or once.
93	Section 5.8.4 Para 2 & 3	The behaviour of Jimmy's Beach as given to date seems not to consider the possible influence of the Myall River entrance. Isn't it possible that the tidal effects of the river entrance influences the sediment paths in the area. In the 1920's Myall Point was wiped out in a large storm. Up to that date Myall Point acted as a groyne separating the beach from the river system. Is it useful to do beach nourishment from the shoal developing in the old Myall Point area where a natural or artificial build up in this area may help Jimmy's Beach? Has this been investigated before by those responsible?
95	Section 5.8.8	The impacts of large floods on the sediment processes as water flows from the Lakes to the port could be considered.

PORT STEPHENS
- 2 SEP 1998
File No. SA580-02
Action by R. Harris
App. No.

31-8-98

Mr Rich Harris
Environmental Service Manager
Port Stephens Shire Council

Dear Sir Draft Estuary hours study

There are some matters that
I read in the report that do not
appear to me to recognise the impact
of their effects, and I realise that
these matters may come out of further
reports, however I will mention them
now as they concern me.

The resident Dalphin families, East
and west Port Stephens, some where between
fifty to eighty are territorial.
They range to all ways to the
west to the Myall Lake to the north
and are a major year round tourist
attraction. Schools and migration, June July
north bound, September October south bound,
a reduction to the minimum level
in the Myall Lake is considered prudent
to support the future of the Lake.
yet no comment is made about
maintaining the tidal flow into the
Lake from the Myall river to the
Greatwater.

Observations only indicate to
me that estuaries smothering tendency

sea grass is growing over greater areas of the Broadwater, slowly over the past ten years as tidal flow reduces due to sedimentation of the Myall river system, particularly the lower Myall, Sea Gardens, Bards Ness area.

Your comment is that towing craft require greater navigational depths. Current reefs are shallow, large small harbours, low water, private craft are deeper drafts, much greater harbours, far greater in number and not all, but most do great damage to the river banks.

Early attention to sediment build up is always the most efficient & mostly the most economical yet you are saying that large scale dredging is preferable but has environmental objections, small dredging causes ongoing problems. There is no evidence that I know of that supports your comment, poor attention to method with suction dredges, run off and bore fines may come less of sand sea grass but to some of the extent is not correct as I see an urgent need for major dredging

in specific areas to maintain the health of the lakes and ensure the slow sediment build up which is exponential does not have a great environmental & economic consequence.

Jilligey creek which has in some places 2-9 Two to three meters of silt is fed by a large system of drains from the surrounding lowlands.

This system has been ^{definitely} silted and other matter into the creek for years and requires a complete audit of the area.

Finally I understand that mechanical planting of red grasses is well developed. Britain shows 498,70930 (4000) is the consultant developing the machine and need to deposit the necessary material may be an answer to a lot of problems.

I apologise for the handwriting my computer is down and I cannot type.

Pete Dawson OBE

Dear Steve,

Thank you for the opportunity to comment on the study.

There are several issues that need correction or clarification in the document.

p.62 - TABLE 4.5 - many of the items listed under Tanilba Bay are actually found in Newcastle. See also P64.

Table 6.

Significant Issues.

sediment quality - the comment that mercury is found in higher levels near Nelson bay should be clarified or deleted. To make a bald statement with qualification would create much disquiet in the public.

Beach erosion - an area of major concern is the eastern end of Shoal Bay. There is a question about whether the vegetation works/stabilisation of the sand blow between Tomaree and the mainland has stopped the natural replenishment of the Shoal Bay beach by windblown sand from Zenith Beach. This would exacerbate the erosion of the foreshore as the sand is removed. Is there any historical evidence that may or may not support this theory?

Conflict of use- there are several statements in the report about the value of recreational fishing in the region, but there is no supporting \$ value given. Again there needs to be some comparative numbers included to show the relative importance if this fishery.

For further information please contact me on (02) 4980 4931.

Your sincerely

SCOTT CARTER
NSW FISHERIES

Facsimile to : Jenny Davies
Fax No. 02 4987 3612
1 September 1998
From : Ken Stacey
Subject : Draft Estuary Processes Study

(9)
" S9580-

My reaction to the draft of the Estuary Processes Study was that it did not lay out clearly area by area what the current situation is thought to be, what additional information if any, is required to confirm this prior to the study of its management needs and finally influences on each area which are likely to require more testing or monitoring now. I think all of the information is contained in the detailed study. It just has not been pulled together in a comprehensive way.

I also felt that some reference to Council's 30 Year Plan might be useful. Projections of population growth and where the increases might take place may need some reviewing as part of the Management Study or within the Council's planning process.

My problems could be resolved by a very simple tabulation as part of the executive summary.

I would like to attend the meeting with Mr. Hardy on the subject of storm water objectives.

On a completely different subject my home address has changed. It is now :-

14 Hairtail Close
Corlette 2315

Please note for future correspondence.

- noted

- updated

PACS

Port Stephens

C·O·U·N·C·I·L

SUSTAINABLE DEVELOPMENT DEPARTMENT

FACSIMILE ADVICE FORM

TO:

NAME: Doug Lord.....

OF: Manly Hydraulics.....

FAX NO: (02) 9948 6185.....

NO. OF PAGES INCLUDING HEADER: 10.....

FROM:

NAME: Jenny Davies.....

SECTION: **Environmental Services**

DATE: 04/09/98.....

FAX: 02-49873612

MESSAGE:

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All correspondence to be addressed to PO Box 42 Raymond Terrace 2324. (DX 21406, Raymond Terrace) 116 Pacific Hwy, Raymond Terrace: Tel 02-49800255 :Fax 02-49873612

Port Stephens Council

ADMINISTRATION BUILDING AND COUNCIL CHAMBERS

*Telephone Enquiries:
Environmental Services
Please Quote File No:
S9580-02*

Doug Lord
Manly Hydraulics Laboratory
110B King Street
MANLY VALE NSW 2093

Dear Mr Lord

Re: **Port Stephens/Myall Lakes Estuary Processes Study**

I refer to comments already faxed to you for the Port Stephens/Myall Lakes Estuary Processes Study. Please find final comments from Great Lakes Council. I have closed the period for comments and request you proceed with the preparation of the final document.

Yours faithfully



R.E. Harris
Environmental Services Manager
jrh0409 study.doc



4 September 1998



GREAT LAKES COUNCIL

Breese Parade, Forster
PO Box 450, Forster NSW 2428
DX 7110, Forster

Telephone: (02) 6591 6222
Fax: (02) 6591 6200

Port Stephens Council
116 Pacific Highway
RAYMOND TERRACE NSW 2324

Our Reference: L1/15
GT:SB

Attention: Rick Harris

Contact: Mr G Tuckerman
Telephone: (02) 65 916 274

2 September 1998

Dear Rick

RE: REVIEW OF DRAFT ESTUARY PROCESS STUDY

The study has been reviewed and the following comments are provided. The study generally seems to meet requirements of the brief within the budget provided **except for Section 4 of the report which contains inaccurate and misleading comments which must be addressed. In addition the subjective comments contained in this section should be avoided.** Please refer to attached comments.

Yours faithfully

G TUCKERMAN
Environmental Officer
Planning & Environmental Services

Enc.

REVIEW OF DRAFT ESTUARY PROCESS STUDY

COMMENTS

- Foreword: Reference needs to be made to Great Lakes Council i.e. invitation from Port Stephens Council on behalf of both Great Lakes Council and Port Stephens Council. Also work is for Great Lakes Council as well.
- Executive Summary (ii)
The total waterway area is about 100km² to 150km². A more accurate figure is required.
- Executive Summary (iv) - please note
The Karuah and Myall catchments have reasonably intensive poultry industries.
- Figure 1.4 Location of Boolambayte Creek required on this Figure. No other tributaries.
- Habitats - 1st line - page 15
- Some of the Figures e.g. 2.14 and 2.16 are difficult to interpret. Need to be larger or colour.
- Page 18 - Descriptions of dominant species in each broad vegetation type required. Reference required to Section 2.10.1.6.
- Pine plantations are historic and have mostly been removed except for some regrowth pine areas.
- Page 30 - add *Grevillea Guthrieana*
- Page 35 - add Eastern Blossum Bat *Syconycteris Australis* - Port Stephens 1.100,000 recorded at North Hawks Nest
- Page 35 - add Port Stephens 1.100,000 for large footed *Myotis*
- Page 17 - Consultant should have reviewed North Hawks Nest Local Environmental Study and draft vegetation maps prepared for Myall Lakes National Park

GENERAL NOTES

- Figures need to be in colour - final copy - difficult to read
- Sand bed sewage disposal occurs at Hawks Nest
- Page 49 - sand mining occurs to the North of Tea Gardens - Viney Creek area - the processing plant is at Hawks Nest
- Page 53 - Table 4.2 - Tea Gardens is not listed in table
- Page 55 - 4.3 limits to Urban Expansion

This section is considered to be most misleading as well as poorly addressing critical issues.

The 2nd paragraph must be altered in particular. Indeed while improved access with upgrade of the Pacific Highway may encourage more development the values and constraints of the area have not been discussed. Great Lakes Council has spent \$130,000 undertaking the North Hawks Nest Local Environmental Study. The consultant has not undertaken even basic research, as this document has not been referred to.

In addition appropriate independent studies have not as yet been undertaken at Tea Gardens however vast wetland areas and significant threatened species issues need to be documented as potential constraints to development. No reference is made to the Tea Gardens ecological studies. e.g. Myall Quays.

The statement "New developments at Pindimar" etc and negotiations between land owners and Council concerning North Arm Cove must be deleted. No significant urban expansion can occur in North Arm Cove without services. This is a significant impediment. Suffice to say the zoning does not permit such expansion and alterations are not planned.

I have concerns that little effort has been put into this section. It is not value of money. It would seem to be an important aspect of describing catchment characteristics. No mention is made of the coastal policy, SEPP 14, TSC Act, and acid sulphate soils which given the natural attributes of the area will have implications for the type and extent of development.

- Page 56 - see comments on page attached. They are too numerous to detail here.
- Page 56-57 - no mention is made of the impact of clearing for urban expansion or drainage of wetlands for urban expansion
- Page 37 - aboriginal archaeology

Need to refer to aboriginal site at North Arm Cove managed by National Parks & Wildlife Service - Baromee Hill

General:

Acid sulphate soil maps should be discussed and included. A separate section is required as this is a significant issue.

- Page 72 - some explanation of ecology epiphytes or seagrasses required.

Reference:

Mitchell McCotter - North Hawks Nest Local Environmental Study should be referred to.



In terms of human impacts then it is evident that:

- there has been a rapid increase in the population of the estuary area in recent years after years of low growth and forecasts indicate a continuation of this growth;
- some of the areas such as Hawks Nest and the Tomaree Peninsula are essentially retirement areas although there are indications of changes occurring such as around Tea Gardens; *This is subjective not objective. Evidence required.*
- there is a large proportion of unoccupied dwellings in some sections of the study area indicating that it is indeed a holiday area and the area has the potential for a huge increase in population density on a permanent basis rather than a seasonal/holiday feature.

4.3.1 Limits To Urban Expansion

While there is potential for enormous urban growth around the estuary there are a number of severe restrictions to this growth and these vary in their geographic location. The Port Stephens Shire is the most highly developed part of the study area in spite of the lateness of its historic settlement. The Tomaree Peninsula has the highest population concentration but urban expansion is limited by:

- the Tomaree National Park
- flood-labile land and wetland
- steep scenic areas with slopes over 30%.

Expansion on the Tilligerry Peninsula is also restricted by wetlands on three sides with potential acid sulphate soil problems and the water supply catchment areas of Tomago.

On the northern Great Lakes Shire side of the estuary the potential for development is much greater. Historically it was the first area settled but a geographic location away from Newcastle and a lack of supporting infrastructure has led to a lack of development. This may change with greater access. New developments at Pindimar, Tea Gardens, Hawks Nest and North Arm Cove could see urban expansion associated with population growth. Negotiations between land owners and Council concerning North Arm Cove relate to the provision of basic services like water and sewerage.

*See map
this is needed*

Further population growth may come not from the geographic expansion of the urban areas but due to an increase in density. Changing socio-economic conditions and an ageing population are indicating the need for smaller housing types encouraging medium density residential developments.

where does this relate to

4.3.2 Human Impacts

To retain the quality of life and attractions of the estuary the environmental values need to be maintained in a long-term sustainable manner. Particular environmental resources that could be threatened are:

- beach and dune areas and similar recreational environments
- waterways
- wetlands and special habitats such as koala reserves, and
- heritage features such as historic and archaeological sites.

*Also water quality
- Aquatic Ecosystem
- Biodiversity
- Dune*

Considering its early discovery in 1770 and settlement in 1826 the estuary and its surrounds is still coping with the increasing demands being placed upon it. When Deputy Surveyor Grimes first surveyed the port in 1795 before any European settlement he noted the bar at the entrance; the shoals at the Myall River outlet; and the shallow mangrove areas of the upper port where the Karuah River and Tilligerry Creek enter the bay. This has not changed to any marked degree in 200 years!

Wind indications are considered to advise of this conclusion.

However, in recent times as the population has begun to climb the impacts of people are starting to be seen:

But you have commented that it is coming. I would prefer such a statement to be deleted.

- The possibilities of sand drift and coastal erosion due to the Hawks Nest North developments (WP Geomarine 1995).
- Water contamination from land drainage and boat densities, especially copper concentrations (Port Stephens Shire Council 1997). The quality of surface coastal water is critical to the local oyster and fishing industry as well as for tourism and recreation.
- The occurrence of potential acid sulphate soils (PASS) associated with the occurrence of large areas of waterlogged land (Mathews 1995, Port Stephens Shire Council 1998). The drainage of these lands has caused problems for oyster growers along Tilligerry Creek in the past. These soils have also been identified as potential problems for development at Karuah and Tea Gardens (Great Lakes Council 1996). *Need to mention at 4.3. Also require maps showing location of PASS.*
- As the population grows waste management will become a problem. Bulahdelah discharges its treated sewerage into Frys Creek, a tributary of the Myall River. Stroud discharges to the Karuah River where there have been problems of higher than recommended rates of BOD and suspended solids (Great Lakes Council 1996). Booral, North Arm Cove, North Karuah and Stroud Road are all non-sewered areas relying on septic tanks, bio-cycle or pump-out systems. The impact of sewerage outfalls depends on treatment prior to discharge, however, and the upgraded Boulder Bay sewerage works (1993) servicing the Tomaree and Tilligerry peninsulas discharges after secondary treatment to the ocean. *Need May if not managed properly*
- Contaminated tip sites with high levels of toxic substances have been noted at Allworth, Stroud, Bulahdelah, Wards River, North Arm Cove and Tea Gardens, the latter two to be closed during 1998. There has been no monitoring of the impact on groundwater at this stage but runoff from the Soldiers Point tip is thought to be causing concern and/or problems for the oyster growers in Cromartys Bay. *Have they? I am not aware these sites have high levels of toxic substance*
- Oyster racks, located mainly in the upper port are a concern for some water users. Several leases appear to be no longer in use around Garden and Snapper Islands while the boundaries of other leases are poorly defined. Since Pacific Oysters mature in half the time of the Sydney Rock and therefore require less area for the same output perhaps the number of oyster leases (and therefore racks) could be reduced in the future.



- Constructions into the bay in the form of marinas and boat ramps need constant monitoring in order to assess the effects on current and sand movements and to ensure the flushing of semi-enclosed areas.
- Historic sites should be registered and upgraded both for their historic values and interest for tourism. Tomaree House and Tahlee House are in very good condition but areas like the Winda Woppa and Nerani Beach sawmill sites and the prawn fishing huts at Tambooy are examples where more could be achieved.

veg clearing & drainage of river Sept 18 wetland

There is no doubt that the Port Stephens-Myall Lakes estuary will come under increasing pressure from developments associated with an increasing population in the future. The plans for a four-lane dual carriage way from Newcastle to Nelson Bay and a car ferry from Tomaree to Tea Gardens (Port Stephens Shire Council 1997) will further increase demand for development such as the 1,000 homesite of the Myall Quays development at Tea Gardens.

Fortunately with 100% of the catchment under forest cover including State Forests and National Parks the catchment area should hold few problems for the riparian catchment. However, very close surveillance will be needed in estuary itself.

However Approx 35% is in private ownership **Reward**

4.4 Archaeology and Heritage

4.4.1 Aboriginal Archaeology

Aboriginal Sites in the Catchment

Native veg has been cleared however exemption exists that may result in some impacts

The NSW National Parks and Wildlife Service contains a register of all known Aboriginal sites in NSW. An application was submitted to the NPWS Aboriginal Sites Registrar for information on all sites recorded within 500m of the water's edge for Port Stephens and Myall Lakes. Consultation was held with the relevant Local Aboriginal Land Councils (LALCs) of the catchment who were asked to give an outline of the major issues confronting their organisations with regard to Aboriginal archaeological sites and site management. Relevant government authorities were also contacted for input regarding Aboriginal cultural heritage management and the estuary process study. A literature review was undertaken for information relevant to Aboriginal sites.

As little systematic survey work has been conducted in some parts of the catchment (DUAP 1989, Mitchell McCotter & Associates 1986, Summers 1994) and few sites have been located in these areas, it is pertinent to note the following broad areas which are considered to be archaeologically sensitive:

- areas adjacent to estuaries, lakes, lagoons, rivers and creeks
- areas where disturbance to land has been minimal, e.g. forest or woodland
- other areas where some ground disturbance has occurred but where a remnant of the original land surface remains, e.g. areas which have been logged, farmed or grazed.

After the system of State, Regional and Local Aboriginal Land Councils was set up in 1983, the Worimi were able to develop their own Council to provide services for Aboriginal self-help (Marr 1997). Today, the Port Stephens-Myall Lakes area is covered by three Local Aboriginal Land Councils: the Worimi, Karuah and Forster Local Aboriginal Land Councils.

	Conservation	<ul style="list-style-type: none"> The Myall Lakes and their catchment are largely pristine with limited development and agricultural use. The integrity of the system is protected through the existing system of national parks and state forest which occupy most of the catchment. The greatest risk to the ecology of the lake system will come from increased pressure for recreational use of the lakes and foreshores and possibly increased nutrient loads from the Myall River.
	Access	<ul style="list-style-type: none"> Access to the Myall Lakes by both land and water is restricted by the existing National Parks with limited freehold landing actually abutting the Lakes. Improved access or increased boat traffic would need to be <u>carefully controlled</u>.
	Recreation pressures	<ul style="list-style-type: none"> Recreation pressures are greatest over the summer holiday period. With a high rate of population growth in the region this pressure can be expected to increase. Management strategies to accommodate and service this itinerant usage are required if the natural ecology of the lake system is to be preserved.
Myall River	Water Quality	<ul style="list-style-type: none"> The lower Myall River is predominantly a tidal channel connecting the Broadwater and the lakes to Port Stephens. The water within the lower Myall River varies over comparatively short time periods from saline ocean water to almost freshwater following rainfall and flushing of the lake system. The water quality within the river reflects the water quality of the port and the lakes depending on the predominant flow directions. There is little development along the River and limited input to the river from the small local catchment below the Lakes.
	Shoaling and navigation in the lower reaches; entrance conditions	<ul style="list-style-type: none"> Shoaling has occurred along the length of the river channel over many years with repeated episodes of dredging to improve navigation. This is likely to be an ongoing process dependent on preceding flow conditions. There have been no changes in the overall estuary processes identified that would result in an increase in recent rates of sedimentation. The destruction of Myall Point and the shoaling of the Myall River entrance at Corries Island, which followed the dredging of the channel on the north side of the island to Duckhole Bay around the turn of the century has resulted in major changes to the entrance configuration. These adjustments are continuing. Significant changes include: <ul style="list-style-type: none"> -deterioration of the access form the upper port to the river on the eastern side of Corries Island; -increase in the size of a point shoal in the channel on the western side of Corrie Island
	Bank erosion	<ul style="list-style-type: none"> River banks in the lower Myall River are very fragile and erosion can result from boat wakes generated by traffic moving up and down the river.
	Conflict of usage	<ul style="list-style-type: none"> Myall River is a narrow and shallow channel with a variety of uses including: <ul style="list-style-type: none"> -Local fishing/prawning vessels; -Recreational vessels travelling to and from Myall Lakes -Tourist craft which require greater navigation depths taking visitors to the Lakes.
	Development pressures	<ul style="list-style-type: none"> Development pressure is largely confined to the lower reaches of the River, upstream of Tea Gardens. Development will result in both an increased risk of deterioration of water quality in the river and increased recreational pressures on the river itself (boating, fishing etc.).



7. Conclusions

IS it 65% or 70% Previous section indicated 70%

The Port Stephens-Myall Lakes estuary and catchment includes a diverse and complex combination of ocean, estuarine and fresh water habitat. The catchment is approximately 65% undisturbed and much of this remaining area is now protected in state forests and national parks. The catchment and estuary provides a habitat for endangered plant and animal species and is important as a bird nesting and roosting area. The estuary is very dynamic with significant variations in salinity and water quality depending on antecedent weather conditions.

This is not accurate. Much of primary forest.

Water quality in the estuary is influenced by the nutrient loads to the system and the flushing characteristics. In general water quality in the main water bodies is good although areas at the extremities (upstream in Tilligerry Creek, upper Myall River, Karuah River) show some indication of eutrophication. These areas are characterised by longer flushing times (order of days to weeks during dry periods) than the main water body (order of one day). The general health and water quality within the estuary is generally good at present. The large areas of fringing mangroves, wetlands and saltmarsh which are a significant component of the total state resource appear to be in a healthy condition. Seagrasses are prevalent within the port.

The Karuah catchment is used for logging

The Myall Lakes being such a large water body has the potential to assimilate a large proportion of any increased nutrient load entering via the Myall River, Boolambayte Creek and the adjacent wetland areas without much apparent change to the system. Although the upper Myall River shows signs of eutrophication this effect is probably confined to the river as the large biomass present in the lakes could take up any excess input nutrients at present. It is not possible to determine whether the biomass of the lakes has increased over the past few decades due to nutrient loads. Some measures to reduce or at least maintain at present levels the Myall River nutrient loads may be desirable for the future sustainability of the lakes.

Similarly, the Karuah River water quality is good at present but shows some indication that it is undergoing a gradual eutrophication process. The Karuah/Great Lakes Catchment Committee has plans to address the excess loads entering this system.

Tilligerry Creek is also in a reasonable state at present but needs to be monitored to ensure no adverse impacts arise. The STP discharge is currently monitored by Hunter Water Corporation and these data should be supplemented by measurements in the creek to regularly assess the health of the creek.

Increasing population and tourist usage will further exacerbate these aspects. Careful control of habitat is required to maintain the floral and faunal diversity of the system. Regular water quality monitoring is required to maintain the current level of water quality and to identify problems and problem areas as soon as possible.

Port Stephens

C.O.U.N.C.I.L

SUSTAINABLE DEVELOPMENT DEPARTMENT

FACSIMILE ADVICE FORM

TO:

NAME: Doug Lord.....
OF: Manly Hydraulics.....
FAX NO: (02) 9948 6185.....
NO. OF PAGES INCLUDING HEADER: 4.....

FROM:

NAME: Jenny Davies.....
SECTION: Environmental Services
DATE: 10 September, 1998.....
FAX: 02-49873612

MESSAGE:

...As discussed with Rick Harris please find enclosed comments from EPA.

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17.



Environment
Protection
Authority
New South Wales

NSW Government Offices
117 Bull Street Newcastle West NSW 2302
PO Box 488G Newcastle NSW 2300
Tel 02 4926 9971 Fax 02 4929 6712

PORT STEPHENS COUNCIL
10 SEP 1998
File No. S9580-02
Action by RH.
App. No.

Mr Rick Harris
Environmental Services Manager
Port Stephens Council
PO Box 42
RAYMOND TERRACE NSW 2324

Our Reference: 272123A2

Your Reference: S9580-02

Contact: Mitch Bennett

Dear Mr Harris

PORT STEPHENS ESTUARY PROCESS STUDY

I refer to your letter dated 6 August 1998 asking the Environment Protection Authority (EPA) to comment on the Draft Estuary Process Study for Port Stephens and the Myall Lakes.

The EPA has completed a general review of this document. While the EPA has not carried out a detailed review of the information and assumptions contained in the document, the attached general comments are offered for your consideration.

Please contact Mitch Bennett on 02 49269977 if you would like to discuss any matters raised in this letter.

Yours sincerely

Pam Dean-Jones
Head Regional Programs Unit - Hunter
for Director-General

EPA COMMENTS
DRAFT PORT STEPHENS - MYALL LAKES ESTUARY PROCESS STUDY

Nutrient Balance

The Draft Process Study states that total phosphorus concentration may be expressed by a balance of "sources" and "sinks" (page C1). This is not correct. Rather it is the rate of change of phosphorus concentration that is represented by the difference between inputs and outputs. This is correctly stated in formula C1 (page C1).

Using this formula and the limited data available, a P budget is developed for a year that received average rainfall (page 90). The budget shows that phosphorus export and settling exceeded inputs and remobilisation by 57 tonne (Table 5.10). This represents a loss of phosphorus from the water column of approximately 0.03 milligrams/litre/year.

If this were so, a significant decrease in phosphorus concentrations should be apparent in long term water quality data. Since this is not apparent, it appears that either a significant input has been underestimated or an output has been overestimated.

Revision of the assumptions underlying the nutrient budget is recommended. In particular the rate of settling appears to be poorly justified. Biological uptake and cycling should also be included in the nutrient balance estimations if they are considered to be significant (C3).

Given the problems identified with the nutrient budget, it is premature to make recommendations regarding the focus of future management actions (C4).

ANZECC Guidelines

The Australian Water Quality Guidelines for Fresh and Marine Waters (1992) state that it is not possible to recommend a single set of nitrogen and phosphorus concentrations that will prevent phytoplankton problems in lakes and reservoirs throughout Australia. Rather it is strongly recommended that site specific studies be undertaken to determine appropriate concentrations for each particular system. Instead of specific concentrations, ANZECC specifies a range of indicative values.

Throughout the study, data are compared with either the upper values or ranges of values (page 39 and Graphs 3.3 – 3.6). Instead the consultants should specify what they consider to be appropriate concentration values for the prevention of phytoplankton problems in Port Stephens.

Mercury in sediments

Elevated mercury concentrations in Nelson Bay are inconsistent with the EPA's understanding of the history of this site (page 101). These findings warrant further investigation to verify the results.

Pollution sources in Upper Port Stephens

The EPA is currently negotiating with Port Stephens Council with the aim of discontinuing the use of and rehabilitating the Salamander Bay Waste Disposal site. This could be noted on page 98.

In 1995, the EPA directed Port Stephens Council to discontinue use of and rehabilitate the Karuah Septic Effluent Ponds mentioned on page 98 of the Process Study. The EPA is investigating the current status of this site.

A recent study by Leonie Young, a University of Newcastle student working in conjunction with the EPA, suggests that rural runoff is dominant nutrient source in Karuah catchment. This document has been submitted to the Estuary Management Committee and information from it could be included on page 98.

Groundwater Monitoring

Hunter Water Corporation hold a licence from the EPA to operate the Tanilba Bay Sewage Treatment Facility at Malabulla. This licence stipulates quarterly groundwater monitoring of biochemical oxygen demand, pH, non-filterable residue, faecal coliforms, nitrogen as ammonia, nitrogen as nitrate and nitrite and total phosphorus. Hunter Water is also monitoring for viruses in groundwater between the treatment works and Tilligerry Creek. This monitoring could be noted on page 100 and the results of this monitoring could be included in the process study.

Bacteriological contamination

Considering the importance of the oyster industry to Port Stephens, the EPA considers that bacteriological data collected by the oyster industry, Port Stephens Council and the Hunter Water Corporation, should be analysed as part of the Process Study. The Process Study should at least contain an estimate of the relative contributions of bacteriological contamination from various sources. This would allow future management recommendations to be targeted at the primary sources.

Acid Sulphate Soils

Mapping by the Department of Land and Water Conservation shows that potential acid sulphate soils are found in low-lying areas surrounding Port Stephens and the Myall Lakes. This is a significant issue for the management of the estuary and should be analysed in greater depth in Chapter 5 of the Process Study.

Management Recommendations

Chapter 6 of the Process Study contains several management recommendations. These recommendations should be removed, as it is the role of the management study, not the process study, to propose management options.