Townsville City Council

Ross Creek Scoping Study

1994

by

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EXECUTIVE SUMMARY

This scoping study was commissioned by the Townsville City Council as a baseline for future management of Ross Creek. The creek, which extends 5km from close to Ross River through the central business district of Townsville to Cleveland Bay, is an urban tidal waterway which is a focal point for tourism, recreation, culture and commerce. The study involved a review of existing documentation of issues affecting Ross Creek such as commercial and recreational use, aesthetic value, current pollution loadings and sources, and existing biological diversity; and field surveys of impacts, ecology and community interests and concerns.

The study outlines the history of the creek, and the course of urban and commercial development during which the creek became a separate tidal estuary when cut off from Ross River to safeguard against local flooding. Extensive land use change over the past 100 years has resulted in the alteration of creek morphology to provide land for parklands and commercial developments such as the Townsville Port, the central business district, and the rail yards. The character of the creek has been significantly influenced by a series of land fills and dumps along its course during the last 40 years. However, its current shape has remained relatively constant since the mid-1970's.

This study identified three distinct land use areas along Ross Creek which were referenced throughout the report:

Area 1: extending from Cleveland Bay to Lowths Bridge and dominated by the Townsville Harbour and the central business district;

Area 2: extending from Lowths Bridge to Boundary Street and dominated by the rail yards on both sides of the creek; and,

Area 3: extending from Boundary Street to Bicentennial Park and predominantly residential.

Ross Creek offers some recreational value, by providing venues for walking, jogging, picnicking and fishing, and aesthetic and educational values. These values are greatest in Area 3 because of the increased number of parks and open spaces, and the close proximity of residents and schools to the creek. The commercial developments and the altered tidal margins evident in Areas 1 and 2 will benefit from future developments that complement the creek and attempt to beautify the surrounds and thereby enhance the recreational and aesthetic values.

Input to this study was sought from the Townsville community through a call for public submissions, questionnaires directed to businesses surrounding Ross Creek, questionnaires to home owners along the creek boundaries, and a random telephone survey of 100 Townsville residents. All respondents voiced a concern for the creek's future and the maintenance of recreation, conservation and aesthetic values. Concern about continuous visible pollution along the creek's banks and waterways, the provision for further recreational facilities, and the conservation of wildlife and vegetation was a clear reflection of positive local perception regarding the importance of the creek.

The creek supports a variety of estuarine and terrestrial flora and fauna. Impact along the creek's margin in Area 1 is high with the presence of rock and concrete walls, and the port and associated infrastructure. The consequent loss of intertidal vegetation and habitat has reduced the biodiversity of estuarine fauna in this area. Areas 2 and 3 are less impacted with significant stands of mangroves and associated mudflats. It is important that mangroves and mudflats in these areas are maintained, and where possible enhanced, to increase the visual and recreational appeal of the creek, and maintain habitats for intertidal and marine fauna, including birds.

Ross Creek is affected by waste disposal and pollution which result from a number of sources such

as industrial and commercial waste discharge, the mooring of commercial and pleasure vessels, urban stormwater runoff, and leachate from industrial dumps and land reclamation. The sparse data for water quality in the creek indicate that it is greatly influenced by urban stormwater runoff providing significant concentrations of refuse and litter, hydrocarbon and bacteriological pollution, and nutrient loading. Sediment contamination is more likely to occur in Area 1 as the port and its related infrastructure produce contaminants resulting from industrial discharge, wastewater inflow, and general harbour activity. Regular monitoring of the water and sediment quality, including the use of bio-indicators, will detect serious impacts to the creek and allow for immediate remedial action ensuring the visual and recreational appeal of Ross Creek.

Suggestions for future management actions for Ross Creek include:

1. Review and monitor land use around Ross Creek, particularly upstream of Lowths Bridge, to ensure park lands and open space remain available to allow recreational, educational and aesthetic enhancement of the area.

2. Increase recreational facilities to enhance public and community use of the creek.

3. Increase the aesthetic value of the creek by implementing building, landscaping and parkland developments downstream of Lowths Bridge that are compatible with the waterway and complementary to the character of the Townsville central business district; and by undertaking landscaping and parkland development upstream of Lowths Bridge (including the proposed rail yards redevelopment).

4. Enhance the educational value of areas upstream of Lowths Bridge as they represent different tidal environments which are useful as an educational resource.

5. Control access to the creek to prevent erosion of the creek banks and other associated impacts to the tidal environment, especially the deposition of refuse and litter.

6. Develop the potential of Bicentennial Park by expanding the ponded areas, increasing the recreational facilities and landscaping.

7. Manage estuarine and non-estuarine vegetation along the banks of Ross Creek to increase the appeal of the creek; improve the habitat for marine intertidal fauna and birds by maintaining current mangrove stands and increasing their coverage; improve the planting strategies in non-estuarine areas to complement the creek surrounds, and increase its resource potential; and control exotic weeds.

8. Enhance faunal diversity by ensuring adequate parkland and creek margin vegetation; and produce a current species list of fish and birds in Ross Creek and associated waterways, to foster public appreciation of the creek.

9. Clean up existing refuse and litter along the banks of Ross Creek, and formulate guidelines for water and sediment quality monitoring to facilitate regular assessments of the environmental status of Ross Creek.

1. INTRODUCTION

The Townsville City Council recognises the importance of Ross Creek as a water resource in the heart of the city. This scoping study was commissioned as the first step towards the management of the creek area, which will ensure its sustainable development and enhance its recreational use and environmental potential in the future.

1.1 Aims and Objectives of the Study

The aim of this study is to identify the range of issues, both social and environmental, needed for consideration by the Townsville City Council in their development of a management plan for Ross Creek. The study has a number of objectives:

1. identify current commercial, industrial and domestic uses of the creek;

2. identify issues affecting the aesthetic value of the creek and its role in the Building Better Cities and Streetscape Projects;

3. identify areas with potential value for environmental education;

4. identify areas of community recreation use and future opportunities for use;

5. identify current pollution loadings of the creek;

6. identify the different zones of use associated with the creek, and assess their biological diversity and environmental status;

7. produce a document for the Townsville City Council, highlighting the environmental issues associated with Ross Creek, and to provide source material for management purposes.

1.2 Location

Ross Creek is situated in the central district of the city of Townsville (Latitude 19° 14' S, Longitude 146° 49'E). The creek stretches for a length of about 5km from Ross River through the central business district to Cleveland Bay (Plate 1, Figure 1).

1.3 Climate

Townsville is a tropical, coastal city which lies in a rain shadow below Hervey's Range to the south-west and Mount Elliot to the south-east. Most of the rain occurs during the monsoon season, November to March (annual average 1195mm; wettest month February - mean 319mm; driest month, September - mean 10mm); however, major departures from monthly and annual averages may occur in any year depending on the strength of the wet season. Heavy rains associated with the wet season and cyclonic activity can produce local flooding.

The warmest month in Townsville is December (mean 28.1°C at 9:00am) and the coolest month is July (mean 19.1°C at 9:00am). Diurnal temperature ranges are greater in the winter months while humidity is higher in the summer months. Townsville experiences predominantly south-easterly to north-easterly winds. Strong prevailing winds are not prevalent, although afternoon breezes are stronger than the morning breezes. Tropical cyclones may occur between November and May and can cause widespread flooding.

Figure 1 Location Map of Ross Creek study area

1.4 Study Area

The study area extends from the mouth of Ross Creek to Ross River at Bicentennial Park. For the purposes of biological and land use mapping, the study area extends laterally from the creek to either the first built structure or the first street encountered. The study area is extended to include the whole of the Ross Creek catchment area for the purposes of the pollution study (Figure 1).

1.5 Report Outline

The results of this study are presented in five sections which address the objectives listed in Section 1.1.

The first section presents an overview of historic and present land use. Recreational use and land features are reviewed and areas of educational value are identified. It examines plans for the future use of the creek area by Queensland Rail, the Port Authority and the Townsville City Council Building Better Cities program.

In the second section, the results of community surveys on present use of the creek and ideas for future use are presented and discussed.

The third section discusses the biological diversity of Ross Creek and conservation issues.

The fourth section presents an overview of information concerning pollution in the creek. It is based on studies which have been carried out in the creek, knowledge of potential pollution sources with the Ross Creek catchment area, and anecdotal evidence.

The final section provides some actions to be considered in the future management of Ross Creek based on the information collected throughout the study.

2. LAND USE OF ROSS CREEK AND ITS SURROUNDS

2.1 Morphology of the Creek

It is probable that Ross Creek was once the main channel and river mouth of Ross River. Normal erosion, probably associated with wet season flooding, led to the development of the current river mouth and the abandonment of Ross Creek as the main channel. Ross Creek became a tidal anabranch of Ross River and operated as an overflow channel during times of flood. The creek remained connected to Ross River providing mutual overflow during medium and high tides. This effectively created a large island (Ross Island) bordered by the river on the eastern side and the creek on the western side. This island and the extensive mangroves associated with it are illustrated in an 1884 map (Figure 2). During low tide the creek and river interconnection was broken by a sand bar at Sandy Crossing (Figure 3).

The creek's current course is slightly different from that in 1884. A large meander once flowed around the northern perimeter of Reid Park, the eastern perimeter of Railway Estate Park, the southern side of Townsville High School, and back to where Boundary Street crosses the creek. Sometime before the 1940's this meander was cut off, probably during a flood, and became an auxiliary channel forming Monkey Island (Figure 3). Such flooding of the creek, which occurred during major wet seasons and periodic cyclones, continued until the early 1960's at which time the creek was effectively cut off from the Ross River by the Queens Road levee bank.

Today the creek is a tidal estuary which receives freshwater flow only during the wet season (generally November to March). However, the monsoon may fail, so a "good" wet season is expected only intermittently. During such wet seasons, the high volume of stormwater runoff may result in Ross Creek exhibiting a "salt-wedge" type of estuary, in which the freshwater output rides over the saltwater.

2.2 History

Ross Creek became the commercial centre of Townsville more than 100 years ago when Melton Black chose the delta of Ross River and Ross Creek as a new harbour to provide an outlet for pastoral production in the Burdekin and further west. With the assistance of Kanaka labour from Captain Robert Towns' properties, construction of the first wharf commenced in Ross Creek in 1865 (Taylor 1980). Cleveland Bay was proclaimed as a Port of Entry and Clearance under the Customs Act in 1865 and thereafter the maintenance and development of the harbour became the responsibility of the Queensland Government (Taylor 1980).

Today the port has grown to be the third largest industrial port in Queensland and the Ross Creek now provides a focus for tourism, recreation, culture and commerce in Townsville. Built structures along both banks of the creek reflect the character of Townsville. These include, along the southern shore, the large buildings and cranes of the port, the Townsville Motor Boat Club, the Maritime Museum, and the Townsville Civic Theatre. On the northern shore are the Townsville Entertainment Centre, the Sheraton Breakwater Casino and Hotel, the Coast Guard and Reef Wonderland complex and restaurants. The creek is popular for recreational fishing, walking, and informal meeting.

2.3 Land Use Change Since 1941

The history of land use around Ross Creek is one of dramatic change. From the earliest aerial photographs available (1941) it can be seen that from Victoria Bridge to the Port, the creek was mostly built in, with the exception of some small mangrove stands and an open area in the vicinity of where Tomlins Street is today (Figure 3). The Port, associated ship industries, the business area, and housing had encroached up to the water's edge and much of the creek's banks had been converted to rock or concrete walls.

Figure 2 Ross Creek in 1884

Figure 3 Land-use around Ross Creek in 1941

The creek, below the high tide level, was mostly in its original state upstream from Victoria Bridge in the early 1940's. Housing development and some businesses had completely surrounded the creek environs above the extreme high tide levels and local flooding heights (Figure 3). The only significant land use change directly affecting the creek was the northern rail yards development which involved the reclamation of the creek tidal zone and the construction of rock walls for the creek banks. Extensive mangroves, saltpans and salt-marsh vegetation existed between Morey Street and Saunders Street, Ingham Road and Philp Street, most of the Reid Park area to First Street, and most of the Bicentennial Park area (Figure 3). Today all this has gone with the exception of a small area in front of the railway Maintenance Rail Yards and the north side of the mouth of Woolcock Street Canal (Figure 4).

Land reclamation of the creek tidal zones from George Roberts Bridge upstream began around the 1940's and continued for the next 50 years. Fill for the maintenance rail yards was obtained from industrial waste (e.g. ash from the Hubert Wells Power House) or purchased from the goldmine mullock heaps from Charters Towers. Other fill for areas outside the rail yards consisted of domestic and commercial garbage and imported soil. The mangrove inlet area between Morey and Saunders Streets became the Townsville general dump in the late 1940's (Figure 5). The area later became Central Park and Dean Park. Several houses were built on the banks of the creek where Central Park now is, and around the northern side of Monkey Island inlet next to the rail lines. Monkey Island at the time was used as a pineapple farm by a Chinese family.

By the early 1960's the south bank maintenance yards had been established, Dean Park had been created, there were still houses along Central Park and the Lowth's Bridge end had been filled. The Townsville dump was established on Monkey Island, filling from near the dump entrance at the corner of an extended Third Avenue and First Street and working toward the banks of the creek. At this time there were sports fields on the island where the pineapple farm use to be. The Queens Road crossing had been built to replace the old Sandy Crossing causeway, partly ponding the remnant tidal channels in Bicentennial Park.

Even though the natural creek environment had been severely damaged by land reclamation, a most significant factor of change occurred in the early 1960's with the building of the Queens Road levee bank. The levee ran parallel to Queens Road across Bicentennial Park to Rooneys Bridge (Figures 6 and 16). For the first time, this provided the city centre with effective flood control from any overflow from Ross River. At the same time Ross Creek was cut off permanently from Ross River and became a separate tidal estuary.

By the early 1970's the Monkey Island area had been filled but some finishing work continued around the creek side of Civic Theatre (Figure 5). The houses around the island inlet had gone. Boundary Street was completed, joining Railway Avenue with Charters Towers Road and crossing Ross Creek as a causeway ponding the upper reaches of the creek (Plate 5).

In 1971, Cyclone Althea caused considerable damage to Townsville creating a huge mass of vegetation and building material refuse. Consequently, the area around the mouth of Woolcock Street Canal and the John Herbert Sports Field was filled within a matter of months. Townsville's new general dump became the park area parallel to Philp Street. By 1976 the Woolcock Street Canal was completed, work on the Civic Theatre begun, and all old dump sites had become well grassed. Most of the Philp Street park area had been filled, with the exception of the area around Queens Road. The new Townsville dump had begun on the river side of Sandy Crossing with the general entrance being from Fifth Street (Figure 5). Filling had taken place up to the levee bank covering all the old creek channels. A ponded area had been dug expanding the shape of the original creek (Plate 2). The excavated soil was used to cover refuse fill and the resultant pond was intended to be a model boat recreation area.

Figure 4 Land-use around Ross Creek in 1989

Figure 5 Dump areas created since 1968

By the early 1980's the Civic Theatre was completed and the dump at Bicentennial Park had filled to the height of the levee wall from the junction of Queens Road and Clayton Street to the Rooneys Bridge end. Dumping continued on top of the fill to form a hill which was completed around the late 1980's (Plate 3). The hill not only proved to be a convenient means of disposing of a greater amount of rubbish but was also intended to be a viewing site for a number of sports fields that were planned for the area (Figure 6).

The shape of the creek today is the same as that formed in 1976. The areas that were used as dump sites are now well grassed and several parkland areas have been planted out, although the majority of these areas remain as open spaces with little or no recreational or aesthetic value. Apart from the Civic Theatre, and the small Model Engineers Fun Park, there have been no constructions built in close proximity to the creek since the early 1960's.

In summary, the major land-use influences on the character of Ross Creek from Lowths Bridge upstream are the series of land-fill dumps from Dean Street Park to Bicentennial Park (Figure 5), the construction of the Queens Road levee which cut off tidal flow from the Ross River, and the building of the Boundary Street and Queens Road causeways.

2.4 The Causeways and Tidal Hydrodynamics

As an estuary, the hydrological and ecological functioning of Ross Creek are strongly dependent on tidal circulation. The Townsville region experiences a mesotidal regime (i.e. tide range on normal spring tides is between 2-4m) with the actual tide range being from 0.73m at mean low water to 3.07m at mean high water spring tides.

Survey work was undertaken to take accurate height readings of Queens Road and Sandy Crossing causeways and culverts. Data was also obtained from the Townsville City Council's Engineering and Survey maps. Tidal information was taken from the 1994 Tide and Boating Guide, Queensland Department of Transport.

The tidal regime is interrupted by a series of roads and causeways which divide the creek into 4 basins:

Basin 1 Cleveland Bay to Boundary Street causeway
Basin 2 Boundary Street causeway to Queens Road causeway
Basin 3 Queens Road causeway to Sandy Crossing causeway
Basin 4 Sandy Crossing causeway to Bicentennial Park

Basins 2, 3, and 4 are essentially ponded areas while Basin 1 is unrestricted and flows freely into Cleveland Bay. Connections between these basins are maintained through a series of culverts. Three 1.2m reinforced concrete pipes (RCP) form the culverts under Boundary Street (Plate 4), two 1.2m RCPs under Queens Road, and one 0.60m RCP under Sandy Crossing. Water flows into Basin 2 when the tide level reaches 1.8m, Basin 3 at a tide level of 2.3m and Basin 4 at a tide level of 2.73m. Water flows over the Sandy Creek causeway at a tidal level of 3.31m (Figure 7). The tide charts indicate that for ¾ of the year the tide will actually flow in and out of Basin 4 while for the remaining ¼ of the year the flow will only reach Basin 3. Only for a few days per year will there be no flow past Basin 2.

Figure 6 Contour map of Queens Road dump site

Figure 7 Tidal hydrodynamics of Ross Creek

2.5 Current Land Use

As Ross Creek is a tidal estuary the Port Authority has full jurisdiction of the waterway from Cleveland Bay to Bicentennial Park. However, the adjacent land has a number of different land tenures. The Port lands, the rail yards, and some other service facilities are on State Government land. Most of the commercial and residential areas are under the jurisdiction of Townsville City Council.

The Ross Creek area is dominated by four major land uses, namely the Townsville Port and associated industries, the Central Business District, the north and south bank Rail Yards, and the Residential Areas. Three separate land use areas can be recognised along the creek:

Area 1 extending from Cleveland Bay to Lowths Bridge and dominated by the port and the central business district;

Area 2 extending from Lowths Bridge to Boundary Street and dominated by the rail yards;

Area 3 extending from Boundary Street to Ross River and predominantly residential including the suburbs of Hermit Park and Railway Estate.

In this report each area has been mapped and the current Townsville City Council Planning Scheme Zones have been incorporated to show the existing land-use and likely type of development. The City Council has finalised a draft Planning Scheme which will replace the existing 1982 Planning Scheme. It is anticipated that the draft plan, which includes the council's first Strategic Plan, will be gazetted shortly. Figures 8-10 show existing zoning of these lands while Figures 11-13 show the zonings under the 1994 draft Planning Scheme. The principal aim of the draft Planning Scheme is to provide guidance for future development so that "...community benefits are maximised while at the same time meeting the community expectation for the preservation and improvement of its amenity and access to and the provision of community facilities" (Townsville City Council 1993a). The aims of the Planning Scheme include: encouraging growth and progress while safeguarding and protecting the environment; ensuring the city is an attractive place to live, work, and recreate; preserving the dominant visual features of the city and upgrading the general appearances; and continuing the improvement of the physical environment.

2.5.1 Area 1 (Figure 8)

The majority of land adjacent to the creek in Area 1 is State Government owned and under the jurisdiction of the Townsville Port Authority (Figure 15). However, the Council's Planning Scheme Zoning provides guidance for a number of different types of development that are compatible with the aims of the scheme. It is not mandatory for the Port Authority to follow this zoning, although in most cases there are no conflicts of interests.

Beside the specially zoned Port land, the other major land use zones in this area are the tourist facilities such as shops, clubs, restaurants, museums, and services. Particular Development 9 zone (within the Townsville City Council Planning Scheme) is the Fisherman Wharf restaurants and entertainment area and Particular Development 8 zone is the Museum, Omnimax Theatre, Aquarium, Ferry Terminal, shops and services. There are building allotments still designated for Central Park which remain from the original subdivision patterns. Figure 11 details the Townsville City Council Planning Scheme and shows these allotments. The allotments will not apply as the Park is expected to remain Open Space.

Within the draft Planning Scheme for Townsville there are special Development Control Plan (DCP) Areas. These areas have detailed planning controls applied to them as they are parts of the city which ".....warrant particular consideration due to the special circumstance or complex nature of the planning issues" (Townsville City Council 1993a). Two such areas adjacent to the creek are

the Ross Creek DCP No. 1, which extends along the creek from George Roberts Bridge to the harbour breakwater, and the South Townsville DCP No. 4, from Lowths Bridge to Archer Street. The South Townsville DCP No. 4 has been prepared to provide guidance for the Building Better Cities plans (see Sections 2.8.1 and 2.8.2).

Some of the objectives of the Ross Creek DCP of particular interest to this study are: to ensure greater pedestrian access to and along the banks of the creek; to preserve, as far as possible, the use of water front lots for marine dependent uses; and to enhance the image of the city by landscaping, streetscaping, control of signage, and architectural style.

2.5.2 Area 2 (Figure 9)

This area has only two land-use type zones, Special Purpose and Open Space. The Special Purpose areas are State Government land and belong to the northern rail yards and the maintenance yards. The Open Spaces are mostly park areas, such as Reid Park, and are undeveloped except for the park west of Woolcock Street Canal which is well maintained. Civic Theatre, in Reid Park, is the only major structure on park lands. These details are presented in Figure 12 which shows the complete town planning scheme for this area.

2.5.3 Area 3 (Figure 10)

The only land-use zoning in this area is public Open Space which is surrounded by residential development. Most of these areas are open grassed fields of little recreational or other development. The exception for recreation is the sports field adjacent to Brodie Street and the Model Engineers Fun Park next to Townsville State High School. Again there are many house allotments marked in for all the public open space areas, left over from the subdivision patterns. This is an unlikely type of development in these areas as they are all old dump sites. The detail of these areas is shown in a copy of the present town planning scheme map in Figure 13.

The Open Space is the parkland of Bicentennial Park which is mostly undeveloped. Open Space areas have restriction on sports activities. There are designated street and housing blocks south of Sooning Street. These are no longer relevant as the pond would have to be filled in and the housing blocks may be too close to the old dumping area (Figure 13).

2.6 Present Recreational, Aesthetic and Educational Value

2.6.1 Recreational Value

Most of the present recreation uses are mentioned in the community use survey (see Section 3). Activities that are popular around the creek include walking, jogging, resting, picnics, bait-fishing and rod fishing. Bait fishing is mostly undertaken from Bicentennial Park to Lowths Bridge (Plate 6). Rod fishing is conducted along the length of the creek including the ponded area at Bicentennial Park.

There are four formal parks along Ross Creek. Lennon Drive has a small park directly outside the main entrance to the Port. This is a popular spot for parking a car, having lunch, and rod fishing. The small park next to Fishermans Wharf is well kept and has a few park benches, but is used infrequently. Hanran and Central Parks are well used by Aborigines as meeting and resting places, although there are very few facilities apart from toilets and a shelter at Hanran Park. The Victoria Bridge end of Hanran Park is a popular spot, particularly around lunchtime.

The informal parklands from the rail yards to Bicentennial Park have no recreational facilities. Reid Park is not fenced, but the park areas upstream from Boundary Street are pole fenced to prevent vehicular access. Bicentennial Park can be accessed by vehicles from Queens Road sports fields and consequently there has been much track damage, especially around the top of the hill.

There are some rubbish bins and water taps in the informal parks but no shelters, seats, tables or barbecue areas.

Figure 8 Current zoning and land-use around Ross Creek - Area 1

Figure 9 Current zoning and land-use around Ross Creek - Area 2

Figure 10 Current zoning and land-use around Ross Creek - Area 3

Figure 11 1994 Draft planning scheme zoning map - Area 1

Figure 12 1994 Draft planning scheme zoning map - Area 2

Figure 13 1994 Draft planning scheme zoning map - Area 3

2.6.2 Aesthetics

Much of the built environment around the central city area of the creek has little architectural relationship to the waterway. Many buildings and industry, while no doubt practical, exhibit little attractiveness and have made scant attempt to landscape the surroundings, the current exceptions being the River Quays building area (Plate 7), the Ferry Terminal along Sir Leslie Thiess Drive, and Fishermans Wharf (Plate 8). Much of the inner city landscape is characterised by dirty and stark car park areas, hard unattractive building shapes and lines, bare and dilapidated concrete creek bank walls, and non-landscaped pathways or grassed strips (Plates 9 - 11). Only the small stands of mangroves provide some respite from the hard and ugly lines of the rock and concrete walls of the creek.

The rail yards are a very unattractive, heavily industrial land use. The buildings, rail lines, rubble and fill provide an ugly vista to the creek surrounds (Plate 12). No attempt has been made at beautification or landscaping. These aspects will be greatly improved by the planned relocation of the rail yards and redevelopment of the site into attractive residential, commercial, and recreational land use.

Very little attempt has been made to conserve and enhance the natural beauty of the creek as a whole or improve the large areas of grassed open spaces. Park landscaping by clump or strip planting of native trees has been practiced upstream of Lowths Bridge. Planting behind the Civic Theatre is for the purpose of screening out the rail yards and the trains on the northern line. Clump plantings around the pond at Bicentennial Park provide an attractive setting (Plate 13).

2.6.3 Educational Value

There are a number of schools within easy access to Ross Creek (i.e. Townsville State High School, South Townsville State School, Railway Estate State School). Only Townsville High School is known to have actively used the creek for its educational and recreational activities. The Marine Studies Department of the school has used the creek for boat exercises and safety training. The Geography Department have undertaken water quality surveys, mangrove studies and litter surveys. Canoeing activities are included in the Physical Education program and the Wednesday afternoon activity group also use the creek for canoeing and fishing. Most of the canoeing activities are held on Basin 2 upstream of Boundary Street. The Town High Environment Club participated in the 1993 Clean Up Australia campaign along the creek and recovered 18 bags of litter and a utility load of hard garbage from a 150m stretch of the creek from the Boundary Street causeway downstream.

2.7 Future Land Use

2.7.1 Plans For Future Land Use

In the last few years, several plans which propose changes to the land use of the Ross Creek area have been presented by (or for) the Townsville Port Authority, Queensland Rail and the Townsville City Council. A brief summary of these plans follows.

2.7.2 The Townsville Port Authority (TPA)

In January 1994, the TPA issued a Draft Port Plan which details a number of short, medium and long term proposals to the year 2015. The most significant of the long term proposals is the development of a new outer harbour which will involve the reclamation of land in Cleveland Bay to the east and the north.

A number of the key short term proposals relate to the future aesthetic and recreation values of the Ross Creek area. The first is the development of a buffer strip, comprising heavy landscaping and

mounding, between the port and residential areas in South Townsville. The plan also states that "increased maintenance and perimeter planting (where feasible) will be undertaken to improve visual amenity" (TPA 1994, p.28). The Port Authority notes in the draft plan that although they are "conscious of its [the port's] proximity to tourist and recreation uses around Ross Creek ..... the general public must recognise that the Port is an industrial operation and that there will always be visual impacts, particularly where the Port interfaces with the City" (TPA 1994, p.28).

Secondly, the TPA will continue to maintain and control facilities such as public boat ramps, jetties and small harbours in Ross Creek, but is working towards introducing a "user pay" strategy for these facilities which "more closely reflects the costs of providing these facilities" (TPA, 1994, p.27). It is not clear whether any fee system would discourage the present recreational use of the creek, or whether fees might be scaled according to income of the users.

Thirdly, the TPA is planning to "rationalise" existing lands identified as non-strategic. They are expected to come under the control of the Townsville City Council when new legislation is enacted to replace the *Harbours Act, 1955*. Existing lessees of these lands are not expected to be disadvantaged by the change.

The remaining proposals relate mainly to developments relevant to the port only, or not immediately affecting the Ross Creek area. The Draft Plan was under public review until 21 March 1994. After consideration of the ensuing submissions, the amended plan was submitted to the Queensland Government.

2.7.3 Queensland Rail

In March 1992, Queensland Rail and the Townsville City Council jointly commissioned a study to examine the site redevelopment opportunities if the Townsville railway yards were moved from the city to Stuart. The consultant's report, *Townsville Railway Landuse Study,* was released in July 1993 (Ove Arup and Partners 1993). The report details both full and partial redevelopment concepts.

There are three main areas presently occupied by Queensland Rail which will become available for redevelopment when present operations are moved to the suburb of Stuart: the northern bank of Ross Creek where the passenger station is presently located; the southern bank where the civil maintenance area currently exists; and the southern yards which are located south-east of Saunders Street.

The State Government has now approved the relocation proposal. The relocation of the northern yards has already begun, and it is expected that the land will be clear by the turn of the century. The relocation of the maintenance yards is part of a ten year plan.

(a) The Northern Rail Yards

The redevelopment plan for this area involves physical changes to the banks of the Ross Creek (shifting the northern bank south), resulting in a considerable narrowing of the creek, with the aim of increasing the amount of land available for development as well as improving visual appeal. The plan also recommends the relocation of the passenger station to a site adjacent to the Townsville Civic Theatre, with a small part of the area (including the historic railway station) being retained for use by Queensland Rail.

The north-western area is located along a main roadway (Flinders St), is close to the commercial centre of the city and has a number of contaminated sites (see Section 5.4.3 for more detail). The concept for this area includes a number of commercial allotments along Flinders Street, which are considered to be suitable for light industrial use, support facilities, personal services and food outlets. A service road and a landscaped buffer will separate the commercial area from a medium density residential development to the rear. To the north-east a group title residential

development has been identified which has the potential in some parts for higher density, but not in close proximity to the railway station. The western part of the area has been identified as suitable for recreation, either commercial, such as water sports, or as open parkland. The area could otherwise be suitable for commercial development including parkland. Site contamination may limit use of specific areas.

(b) The Maintenance Yards

This area is also identified for mixed development. Commercial sites are proposed along Saunders Street with larger allotments to accommodate retail showrooms and, if the need arises, a service station. Residential development is also proposed consisting of "high quality townhouses and small unit style development". Tourist accommodation is proposed for the area in the vicinity of Lowths Bridge.

(c) The Southern Rail Yards

In this area the land along Saunders Street is identified as suitable for commercial development. The remainder of the area is proposed for low density (single dwelling and duplex) residential development, with an area also set aside for a retirement village.

Extensive landscaping and open space areas are incorporated in the redevelopment concept for all sites, with 50 metre buffer zones around remaining railway lines. Areas of open space and pedestrian and bike paths are proposed for the banks of the creek so that full public access to the creek will be provided.

2.8 Townsville Development Control Plans, Building Better Cities and Streetscape Plans

2.8.1 Development Control Plans

As part of the Planning Scheme the Townsville City Council has produced Development Control Plans (DCPs) which prescribe specific development guidelines for particular areas of the City (Townsville City Council 1993a, 1993b). The DCPs divide areas of the city into precincts of particular land use, character or development potential. They provide guidelines which prescribe such things as the character of the precinct, height control, plot ratios, useable open space, aesthetics such as signage and lighting, and control for problems such as shadows and wind effects.

DCP nos. 1 and 4 provide guidelines for development of the land around Ross Creek. The management considerations in this report are consistent with the requirements of the DCPs.

2.8.2 Building Better Cities

DCP no. 4 for the South Townsville area incorporates the objectives of the Building Better Cities Program, which aims to promote a more integrated approach to urban development and deal with problems such as traffic congestion, urban sprawl, pollution, and lack of easy access to employment and services. The management issues in this report are consistent with the objectives of the South Townsville Development Control Plan.

2.8.3 Streetscape Plans

The Draft Streetscape plan prepared for the Townsville City Centre in 1993 contains some recommendations which are relevant to Ross Creek. In particular, Points 5 and 6 of the overall strategy recommend the enhancement of the "permeability and accessibility of the city for pedestrians and cyclists", as well as the initiation of a "city greening program which creates a green, shady and lush image for the city centre" (Gillespie, Peddle and Thorp 1993). They also

recommend, in Point 9, that the banks of Ross Creek be reclaimed "for uses which positively enhance the attractiveness and enjoyment of the city and work towards the accessibility of a linear access route to both banks".

2.8.4 Ross River Recreation Masterplan

This plan was produced for the Ross River Aquatic Park Development Committee and included examination of the recreation potential of the Ross Creek area (Ross River Aquatic Park Development Committee 1986). For example, it identifies possible sites for bicycle and pedestrian pathways and boardwalks around the creek foreshores, provision of a ferry service from Victoria Bridge to the Casino, and general enhancement of the area through landscaping. It also recommends development of a barbecue area in Lou Litster Park (Hermit Park) with a playground, tables and chairs and off-street parking accessed from Boundary Street. Some of the recommendations in this study are now outdated by the developments associated with the relocation of the Railway yards.

3. COMMUNITY USE OF ROSS CREEK: THE PRESENT, AND IDEAS FOR THE FUTURE

3.1 Introduction

Input to this study was sought from the Townsville community in four ways.

First, an advertisement was placed in the local papers calling for public submissions to the scoping study (Appendix A).

Second, letters and questionnaires were distributed to known and potential users of Ross Creek and to residents whose homes backed on to the creek (Appendix B). Information sought included details of present creek usage, likes and dislikes of the creek area, ideas for future improvements, and particulars of any pollution and wildlife observed, including fish or bait caught in the creek.

Third, a limited random survey (100 persons) of the Townsville population was carried out by telephone to establish how much of the population currently used the creek. Respondents were asked whether they might use the creek in the future if amenities and facilities in the creek area were upgraded, and what ideas they had for its future development (Appendix C).

Fourth, attempts were made to obtain representations from the Townsville Aboriginal and Islander community. After an initial inquiry to the Aboriginal and Torres Strait Islander Commission (ATSIC), the ACTFR study team was referred to the Townsville City Council's Community and Cultural Services Department. Through this department arrangements were made for one of the project team members to meet with members of a Townsville Aboriginal community group. The aim of meeting with this group was to establish the preferred method of obtaining representation from aboriginal people about Ross Creek issues, and hopefully to make contact with some people who would be willing to speak on behalf of the Aboriginal community in general. Unfortunately, mainly for political reasons, this could not be achieved. Some members of the community took offence at being consulted after the terms of reference for the study had already been decided. They also felt that the whole issue of aboriginal use of the creek area was tied to the location of the diversionary centre and provision of aboriginal housing, and therefore could not be considered in isolation. More progress on consultation with the Aboriginal community may have been possible with more time and resources to devote to it. Experience of some other researchers at James Cook University dealing with Aboriginal communities indicates that a considerable amount of time is needed to gain entry to the community before progress can be made on answering research questions.

3.2 Current Use of Ross Creek by the Townsville Community

3.2.1 General information

As outlined above, present use of the creek by the community was determined by a combination of direct contact with known users, a survey of businesses and residences along the creek banks, and a random telephone survey of 100 Townsville residents. Submissions in the form of completed questionnaires were received from 77 individuals, and in the form of letters from seven groups and organisations. Of the 100 telephone respondents, 12 identified themselves as current users of Ross Creek.

3.2.2 Representations from Individual Users

In this section, the response of users in the random telephone survey are combined with those from the purposive (non-random) survey.

(a) Description of Users

Of the total of 89 individual users 62% were male, 34% were female and 2% of responses were from families. Forty-one percent were aged between 17 and 35 years, 35% between 36 and 50 years; and the average number of years' residence in Townsville was 20. The majority of respondents resided in the suburbs closest to the creek (partly because of the targeted nature of the sampling). Of the users from the random sample alone, 50% resided in the suburbs closest to the city. Occupation of survey respondents was diverse, the main categories being management/administration, professional, trade, small business, and retired. The high proportion of small business owners was again due to the purposive nature of the survey (none of the random survey respondents were small business owners).

(b) Nature of Use of/Interest in Ross Creek

The main uses of the creek were owning a business or living near the creek, fishing, observing nature, bait collecting, exercising and boating. Most of the respondents engaged in multiple use of the creek. It is interesting to note that 51% of respondents were interested in the conservation of the creek, and 39% were interested in the development of the creek.

Only six representations were made by persons mooring their boats in the creek. Use of the creek for this purpose is in fact much higher than this suggests. In the Townsville Motor Boat Club, most of the 91 berths available are currently in use. A further 123 moorings in the creek are administered by the Townsville Port Authority, most of which are currently occupied.

(c) Frequency and Location of Use of Ross Creek

Forty per cent of the respondents use the creek at least once per week and a further 10% used it at least once per fortnight, providing a major focus for recreation or other use for a significant proportion of its users. The most frequently used areas are in the suburbs of Hermit Park and Railway Estate, with a significant proportion using all parts of the creek from the harbour through to Bicentennial Park.

(d) Things Enjoyed Most and Least about Ross Creek

The creek enhances the quality of life for a number of Townsville residents through its provision of recreational opportunities, its aesthetic value and the opportunity it provides to appreciate the natural environment.

Respondents were asked to list the things they enjoy most and least about the creek. Most liked the creek's visual appeal, living near a marine/natural environment, recreation, observing nature, the enhancement it provides for business, and provision of a safe harbour for boats.

Despite the positive values attributed to the creek, respondents also identified a number of problem areas. The most often mentioned were rubbish, water pollution, lack of amenities (particularly at boat ramps), lack of walking/bicycle paths, lack of shade, mosquitoes and conflict with other users. Lists of likes and dislikes are shown in Tables 3.1 and 3.2 respectively.

(e) Concern About Pollution and Observations of Wildlife

Summaries of respondents' concerns about pollution and observations of wildlife are included in Sections 4.2 and 5.8.

3.2.3 Representations From Non-Users

(a) General Information

Of the 100 respondents to the random telephone survey, 88 did not use Ross Creek for recreation or any other purpose. These respondents were asked if there were any particular reasons they did not use the creek, whether they had any ideas for how the area might be improved, whether they would use the creek and its surrounds if more amenities were provided, and whether they had any other comments to make about the creek.

(b) Description of Non-users

Of the 88 non-users, 46% were male and 55% were female, 43% were aged between 17 and 35 years and 33% between 36 and 50 years, and the average number of years residence in Townsville was 21.

(c) Reasons for Non-use of the Creek

The Ross Creek is not currently regarded by the general Townsville population as a focus area for recreation. The most frequently mentioned reasons for non-use of the creek were: there is nothing there of interest; it is too far away; and not enough time for use. Many people (32%) said they had no reason for not using it, but they simply never thought about it.

(d) Likely Future Use

Respondents were asked "do you think you would be more likely to use the creek area if there were improved amenities such as bicycle or walking paths, barbecues or environmental educational facilities?" Thirty eight per cent said they would, 44% said they would not and 17% were undecided. An analysis was made of the relationship between the likelihood of future use and proximity of residence to the creek to see whether those living closer to the creek were more likely to want to use it in the future. Those respondents living closest to the creek actually showed less interest in future use of the creek than other respondents. It is interesting to note from some of the responses to the survey, support for future development of the creek is likely to be found throughout Townsville, rather than just around the city area.

(e) Other Comments

Respondents were asked whether they had any other comments to add about the creek. The majority (67%) did not; however, a few mentioned concerns about safety, untidiness and water quality.

3.2.4 Representations from Groups and Organisations

(a) Queensland Department of Transport

The Regional Harbour Master, Northern Region, Townsville, responded mainly in relation to navigation matters. He advised that Ross Creek has reached saturation point and the number and size of vessels should not be increased. Exception should be made only to the Maritime Museum in its endeavour to display historic vessels. He also advised that "recreation activities should be restricted to certain areas, preferably upstream" due to the responsibility of duty of care already carried by commercial operators.

(b) Queensland Department of Primary Industries (North Region) - Land Use and Fisheries

The Queensland Department of Primary Industries (QDPI) users of the creek are the Boating and Fisheries Patrol who have their jetty and docking facilities on a Ross Creek site. This site will be used indefinitely and also includes an upgrade of wharf facilities to allow for the docking of a new patrol vessel. The QDPI interest in the creek is generally confined to research and management of tidal lands.

The QDPI stated some concern with creek pollution, in particular, tributyltin (TBT) contamination from larger vessels, such as "RAN vessels and overseas commercial shipping, which may still be using TBT anti fouling". The QDPI suggested enhanced pollution control on all marine uses including an audit of all fuel supply systems, the control of sand-blasting on slipways and the containment of waste from all industrial and recreational facilities near Ross Creek.

The Department was also interested in detrimental inputs to the creek and tidal margins from adjacent land uses. They recommended the retention of mangroves, marine plants and fish habitats, and where appropriate, their establishment. Trash racks and sediment traps on drainage inputs to the creek were also recommended to minimise urban waste, litter and nutrient input to Ross Creek.

In regard to improving the aesthetic values of the creek, the QDPI suggested enhancing recreational fishing/picnic facilities, including barbecue facilities where possible, along both sides of the breakwater. They were also, however, interested in the possibility of declaring all areas as a Fisheries Reserve in consort with a larger reserve area for Ross River.

(c) Townsville Port Authority (TPA)

The TPA owns several areas of land on the banks of the creek (Figure 15), much of which is leased, and has jurisdiction over the creek waters up to highest astronomical tide level. It is responsible for maintenance of the creek boat ramps and leasing of moorings in the creek to private and commercial operators. As a visible user of the creek, the TPA often finds itself the target of concern about pollution in the creek. It therefore requested that the scoping study include a study of the stormwater runoff and the heavy metal contamination of the creek bed. The TPA foresees no opportunity for recreation in the harbour area, but feels that there may be opportunities further upstream.

(d) Pure Pleasure Cruises

Pure Pleasure has two motor vessels operating out of Ross Creek, departing from the Wonderland Complex in Flinders Street East. The company experiences no major problems or conflicts with other uses, but raised two points. The first is that Wednesday night yacht racing is sometimes a problem in that competitors have had some near misses with Pure Pleasure's high speed catamarans (which are required to give way). The second point relates to pollution. They believe that generally the water "pollution problem has improved over the years with many of our staff noticing the return of many species of fish life". However, they also note that after big tides or rain, "large quantities of rubbish have been washed downstream and this is not aesthetically pleasing for the many tourists and locals that stand looking in disgust at one of Townsville's great assets". It is believed that the source of this problem is upstream from the city "where Council needs to clean up on a regular basis".

(e) North Queensland Conservation Council (NQCC)

The submission from the NQCC relates solely to pollution of the creek from contaminated land and is discussed in Sections 5.4.2 and 5.4.3.

(f) Townsville Canoe Club

The Townsville Canoe Club use the creek several times a year for evening group paddles. They do not foresee any changes to their level of use. They are concerned about litter in the creek which can cause problems for paddlers, and request that pollution, in particular oil and litter, be cleaned up. The railway sheds were mentioned as in need of "cleaning up". Some members of the club also expressed concern about the adverse effects caused by the use antifouling products on the creek.

(g) Queensland Rail

The submission from Queensland Rail detailed present and future landuse, as described in Section 2.7.3, and pollution issues which are discussed in Section 5.4.3.

(h) The Maritime Museum of Townsville

The Museum does not currently use the creek but has plans to construct mooring facilities for historic vessels. The Townsville City Council have advised the Museum that access to the creek by the public is to be maintained.

The Administrator of the Museum advises that "the practice of vandals throwing objects at the boats moored adjacent to the creek takes place", and "the removal of stone pitching to be thrown into the creek". He also feels that the practice of handline fishing along the creek banks has a detrimental effect on the creek banks. Pollution in the form of plastic has been noticed in the creek and it is noted that the creek has been used by "park people" as a toilet.

3.3 Community Ideas for Improvement and Future Use of Ross Creek

3.3.1 Representations from Individual Users

Ross Creek users have provided a long list of suggestions for improving the creek (Table 3.3). The most often mentioned need for improvement relates to rubbish and pollution. It is felt that rubbish is a particular problem after high tides and rain, when litter from the banks and stormwater drains is washed into the creek. Some users advocate stricter enforcement of penalties while others stress the need for more regular clean-ups by authorities.

Next most frequently mentioned is the need for improved amenities such as bike ways and pedestrian paths to facilitate greater access to the creek. Several respondents mentioned the desirability of keeping these separate for safety reasons. The provision of barbecues, swings, seats, and toilets is also mentioned a way to make the creek a more enjoyable place to visit. Provision of shade was the fourth most mentioned response to the question on improvements to the creek.

There is concern about the use of parks such as Hanran and Central Parks by "vagrants", "thugs", "derelicts", "drunken Aborigines" and "park dwellers". Respondents complained of being verbally and physically harassed (having objects thrown at them) and were concerned about the amount of rubbish left in the parks which often ended up in the creek. Respondents made suggestions such as the permanent relocation of park dwellers and the absolute enforcement of no alcohol and no-camping policies.

A number of submissions were made about the importance of maintaining and protecting the mangroves and fish, revegetating the banks with native trees and leaving the area as a natural environmental attraction. Comments were made about the creek being a "haven for wildlife" and the increase in bird species since the planting of trees in the vicinity of Queens Road. One submission called for the total protection of all fauna and flora and for the area to be declared a wildlife sanctuary. Several submissions requested that the creek be re-stocked with fish.

3.3.2 Representations from Non-users

A substantial proportion (41%) of respondents to the telephone survey had no suggestions about how the creek could be improved. Part of the reason for this is attributed to the fact that they had no prior warning of the subject and may have found it difficult to comment on an issue they had not previously thought about. Some residents simply replied that they knew nothing about it or were not interested. The full list of the types of suggestions is shown in Table 3.4.

The responses were similar to those of the creek users. Most often mentioned was "to clean it up", followed by landscaping the banks and greater provision of amenities such as parks including barbecue areas. Provision of footpaths and bikeways was also mentioned by a number of people, and there were equal numbers in favour of leaving the creek in its natural state and protecting the mangroves, and for dredging the mudflats and erecting rock walls.

3.3.3 Representations from Groups and Organisations

An important issue when considering future uses of Ross Creek is its capacity for use. Both the Regional Harbour Master and the Townsville Port Authority could only foresee opportunities for recreation upstream.

In relation to aesthetic improvements to the creek, Pure Pleasure Cruises suggested that the "simple answer to this question" is less concrete and more greenery. They refer to the presence of dirt car parks along the creek which would be more usefully converted to either parkland or used for some commercial enterprise. Pure Pleasure Cruises do not see any increase in recreational usage along the creek until such time as the general appearance is improved. They foresee the use of the creek for Sunday walks and increases in fishing and boating activities following on from the improvement of its general appearance.

The extensive changes planned to the creek if the railway yards are relocated to Stuart have been discussed in the previous section.

3.4 Summary

The random telephone survey suggests that Ross Creek is currently used by 12% of the Townsville population and that 38%, and possibly a further 17% would use it in the future if it was developed to increase its recreational appeal. The 77 submissions received from individuals who use the creek indicate a high degree of concern for the future of the creek and its environs. Information from the random survey suggests that the development of the creek as a recreational area would receive support throughout the community, not just from those areas nearest to the creek.

Respondents have provided detailed information about their current use of the creek, the problems they experience and ideas for its future development. The creek is used most extensively as a location for business, to live near, and for recreational activity such as fishing, bait collecting, walking, observing nature, boating, and for family enjoyment. A large proportion of creek users expressed interest in the conservation and development of the creek (48% and 39% respectively).

The overall message received from the Townsville community in relation to the future of Ross Creek can be summarised as follows:

1. clean up and control pollution (litter and chemical);
2. provide amenities such as parks with barbecues, play equipment, tables and chairs, board walks, interpretive facilities, and toilets;
3. provide bike ways and walking tracks around the perimeter of the creek;
4. plant trees to provide shade and landscape the creek banks;
5. remove drunks and vagrants from the parks;

6. retain and protect the mangroves and the wildlife, revegetate the banks with native vegetation, and retain the natural appeal of the creek; and,
7. improve facilities at boat ramps for fishers and boat users.

Table 3.1 A Summary of the Points People Enjoyed about Ross Creek (Users from Non-random and Random Surveys)

Points Most Liked about Ross Creek	No. of Times Mentioned
Its visual appeal	38
Recreation	37
Living near a marine/natural environment	35
Observing nature	24
The enhancement it provides for my business	14
A safe harbour for my boat	13
Fishing	3
Walking; walking with my pets; relaxation, eating at the creek side restaurants; a safe place to launch a boat	2
It provides a change of environment from the city area; its uniqueness re: our domestic situation; its potential to appreciate my real estate; watching people walk and exercise their dogs; the therapeutic effect of water; attractiveness of boats in the creek; lights reflecting on the water in the city; the mangroves; the attractive buildings like River Quays	1

Table 3.2 A Summary of Points People Dislike about Ross Creek (Users from Non-random and Random Surveys)

Points Disliked about Ross Creek	No. of Times Mentioned
Rubbish	75
Water pollution	45
Lack of amenities (particularly in the area of boat ramps)	34
Mosquitoes	25
Lack of shade	23
Conflict with other users (concern about aborigines hassling for cigarettes and other things); drunk aborigines; park dwellers; people drinking; undesirable persons; verbal abuse from park dwellers and the occasional thrown stubby bottle; the park people fighting, drinking and cursing make dining at cafe undesirable for family; drunk park dwellers; amateur anglers who keep all the fish they catch regardless of size or species (mainly Asians); conflict with aboriginals in parks eg. objects thrown; discourage people camping in Parks and along the museum area in Palmer St.; indigenous occupation of several Parks does not allow use by others due to violent verbal and physical attacks; drunks around Flinders St. and the Casino in early hours of the morning (when it is best for fishing); drunken abuse from park dwellers close to the city; people camping and drinking and leaving their rubbish behind; noise from model boats; model boat people have cleared mangrove areas; have been verbally abused by other users in the Lowths Bridge area; Hanran Park can't be used by white population because of racist behaviour by aboriginal users; and, traffic a big problem if Entertainment Centre being used	22
Lack of walking paths/bicycle paths	20
Lack of facilities to educate people about the natural processes and functions of the creek ecosystem	15
Lack of access as blocked by industry/car parking	12
Concern about safety	4
Not enough light on south side of creek near boat moorings in Palmer St.; Harbour Board attitude to fishing	2
People walking unleashed dogs that disturb nesting birds and leave deposits near home; sandflies; the smell at low tide; the state of some boats moored in the creek; degradation of creek banks; loss of mangroves; noise from trail bikes and fuel driven model boats; motor bikes and cars that abuse the area supposed to be a park; live aboard boaties that use the toilet while in the creek; bank opposite Fisherman's Wharf is untidy and unattractive; look of the creek banks when the tide is out; worry that the creek no longer flushes - all the debris and rubbish accumulates; park surfaces around the creek in Hermit Park/Railway Estate area are rough and hard to walk on; and, concern about safety	1

Table 3.3 A Summary of Suggestions for Improvements to Ross Creek (Users from Non-random and Random Surveys)

Suggestions for Improvement	No. of Times Mentioned
Clean it up; have regular cleanups; stricter controls such as enforced penalties for littering and industrial pollution; prevent sewage overflows; put 10 or 20 cent deposits on cans and bottles; promote awareness of litter; stop pollution from bulk carriers; pressure appropriate authorities for better control of boat and industrial pollution	39
Improve amenities eg. bike/walking paths from Harbour to Queens Rd. (one suggestion to Ross Dam); boardwalks; bridges; family areas with barbecues and swings; seats; toilets; educational information; gentle landscaping, including barbecues and walking tracks	26
Remove vagrants that squat around the banks; remove hobos and other derelicts; police no camping rule; relocate aboriginal residents; discourage vagrants and thugs; enforce no alcohol policy; the drunken aborigines; get rid of drunken park dwellers; relocate park dwellers; no alcohol and park dwellers; remove indigenous population; get rid of drinking parties; remove aborigines; re-establish bridge dwellers; remove bridge people to allow family access to park; removal of park people from family access areas; clean up parks	17
Plant more trees for shade; revegetate creek banks; improve soil in parks and encourage tree growth	12
Retain mangroves and natural vegetation; plant native vegetation buffer; definitely no removal of mangroves; do not develop area near Hermit Park as it is a haven for wildlife; leave area as a natural attraction; maximise health of mangroves; protect mangroves from vandals	11
Improve facilities at boat ramps including provision of toilets, water, and facilities for fish cleaning, rubbish collection, boat wash down and car parking	9
Erect signs advising fish types and legal sizes	5
Pressure Harbour Board to allow more access to fishing in the creek and to control pollution	4
Lots of tree planting in the Hermit Park/Railway Estate area; turn old dump into botanical garden of dryland species; complete Bicentennial Park with swimming areas, shade and barbecues; mow grass in parks near Hermit Park and Railway Estate more frequently; dredge from the Causeway to George Roberts Bridge and develop as a recreational waterway; develop area between creek and the Civic Theatre as a recreational park with water sports - same for Causeway at Queens Rd.	3
Develop/improve vacant land on Flinders St. East and car parks on south bank; improve water flow under Boundary St. to upper reaches to improve fish stocking, flushing; connect creek to Ross River to improve flushing and fish stocks; enforce no alcohol policy; don't stifle development by adopting Better Cities plan with draconian height restrictions and plot ratios; and, improve look of Victoria Bridge with plants/hanging baskets	2
Stop abuse of park areas by cars and motorbikes; develop both sides of creek into marina style floating berths to attract more visitors; erect stone walls the full length of the creek; fill creek bottom between park and old bridge with sand to negate methane problem and create a saltwater swimming hole; allow no high rise alongside creek; spray for mosquitoes; make it safer to use parks along the creek; control heavy vehicle use; preserve creek as a total sanctuary i.e. no fishing; improve parking, developments must be sympathetic to the environment; provide security for boat ramp carpark; provide a small boat ferry service up and down the creek between Fisherman's Wharf and the Casino; floodlighting the city area to reflect off the creek; dredge banks so that mud banks aren't exposed when the tide is out; from a tourist point of view behaviour of the aborigines is a problem, have witnessed them hassling others and have been hassled myself; children's playground in Dean Park area; landscape the banks to a similar level to around the Entertainment Centre; amenities such as toilets, especially on south bank in Palmer St. area; teach foreigners English; have more boats moored near Fisherman's Wharf; establish sound planning foundations for city to the breakwater; become working partners with the TPA; become crime conscious; establish a pond in the park near high school for use by model boats; ensure health of fish and more fish; try and make appealing to the eye; enable/encourage the public to use it more and they may become more interested in keeping it pollution free; tidy up creek bank on Palmer St.; provide a safe viewing rail around creek; redevelop similar to Brisbane's South Bank; and, remove stray cats	1

Table 3.4 Suggested Changes to Improve Ross Creek (Non-users from Telephone Survey)

Suggested Change to Ross Creek	No. of Times Mentioned
No change	36
Clean it up	16
Landscape the banks	12
Provide more parks, barbecue areas and areas for families similar to Rowes Bay, Pallarenda and Ross River	10
Provide bike paths and footpaths; dredge the mudflats, don't like the look of the mud, erect stone walls; leave it natural, leave the mangroves	6
Don't like the board walk - need more parks, grass, trees and maybe a pool like the South Bank in Brisbane	4
Solve 'aboriginal problem' - they are an eyesore, leave rubbish and hassle for cigarettes or ask you to "go away from our place"	3
Pond upper reaches of creek to eliminate tides, salt water and 'rust', allow water sports in ponded areas	2
Improve access for fishing; take down Victoria Bridge - it's an eyesore; dress up Ogden St. carpark; plant more trees and improve landscaping in upper reaches of creek; use it as a dump, fill it in and eliminate both mosquitoes and 'the darkies'; improve safety of Queens Rd. by installing safety rails	1

4. BIODIVERSITY OF ROSS CREEK

There is a paucity of information available on floral and faunal diversity in Ross Creek, past and present, with the exception of vegetation and fish community diversity. Information on existing biodiversity has been gathered primarily from users, as documented in the public surveys (Section 5.8) and various scientific sources.

4.1 Vegetation Diversity

4.1.1 Historical Changes to Vegetation in Ross Creek

From the 1941 aerial photographs it is clear that much of the environment around Ross Creek from Victoria Bridge upstream had remained in an original state whilst downstream there was comprehensive change. The mangroves had been cleared, with the exception of a few small remnant patches, and the creek banks were concreted or reinforced with rock walls.

The immediate creek environment had never supported woodland nor any large trees as the Ross Creek area was originally part of a large coastal mangrove inlet. The only possible exceptions would have been the small hills of Magazine Island and Flagstaff Hill which were at the mouth of the creek but were quarried for the breakwaters and walls of the creek (Figure 14). The other exception would have been the slopes of Castle Hill.

Mangroves, salt-marsh vegetation, and some grasses were the original component of the Ross Creek vegetation. From 1941 to the 1980's, most of this vegetation disappeared due to the intense "land-reclamation" for the rail yards and city dumps upstream from Victoria Bridge (Figures 3 and 4). Very little original mangrove environment remains except for a small strip of vegetation in front of the south bank maintenance yards. This is the most significant remnant of the original creek vegetation. Other small patches of mangroves did survive the intense land use around the creek and became important in providing the source of regeneration of fringing mangrove stands along the creek today. Patches of particular note are around the mouth of Woolcock Street Canal, the small island next to Boundary Street upstream, the ponded area between Queens Road causeway and the old Sandy Crossing causeway, and at the north-eastern side of the large ponded area.

Figures 16, 17 and 18 taken from the 1971, 1976, and 1989 aerial photographs, show the major changes to the creek and its environment, especially around the mid-1970's. In 1976, the creek's surroundings were filled and grassed, or left bare, with fringe mangroves dotted along its edge (Plate 2). However, once the disturbance around the creek had ceased, mangroves and some salt-marsh vegetation became re-established to the point where most of the creek banks are now well vegetated. The rock walls of the northern rail yards and the hard dirt banks of the Bicentennial Park pond are the main exceptions (Figure 18).

4.1.2 Current vegetation assemblages

A survey of all the vegetation of the Ross Creek environment was undertaken for the purposes of this study. Eight species of mangrove, four salt-marsh species, three main exotic grasses, and three dominant woody weeds were identified. No species of macro-algae were noted although undescribed micro-algae are evident along most of the creek margins and the Lakes Development. Fouling algae such as *Ceramium* spp. and *Padina* spp. have been observed on the waterline of floating pontoons in the harbour (Zann 1975).

Figure 14 Townsville in 1885 showing Magazine Island and Flagstaff Hill

Figure 15 Townsville Port Authority land next to Ross Creek

Figure 16 Ross Creek in 1971: Mangrove distribution

Figure 17 Ross Creek in 1976: Mangrove distribution

Figure 18 Ross Creek in 1989: Mangrove distribution

(a) Non-estuarine vegetation

As Ross Creek was originally in the middle of a large mangrove tidal flat there was very little non-estuarine vegetation. However, with the extensive land reclamation around the creek, many exotic species of vegetation have been introduced.

Grasses are predominant especially Guinea Grass (*Panicum maximum*), Rhodes Grass (*Chloris gayana*), and Red Natal Grass (*Melinis repens*). Most of the grassed areas are on old landfill sites which are largely kept mown. Only on the dump hill at Bicentennial Park and around the Maintenance Yard rail lines is the grass unkempt. Rhodes Grass covers much of the hill while Guinea Grass dominates most other open grassed areas.

Woody weeds are found scattered around the creek margins and have established strongly in unkempt grass areas and along the mangrove perimeters. Of particular concern are the legumes *Leucaena leucocephala*, *Parkinsonia aculata*, and *Macroptilium lathyroides* (Phasey Bean).

Other trees that are found around the creek are principally a result of deliberate planting such as in established parks, streets and large open grass areas. These include a variety of exotic species such as *Terminalia* spp., Rain Tree, *Albizia* sp., mango and native eucalypts, melaleucas, she-oaks, and fig trees.

(b) Estuarine vegetation

Mangroves are by far the dominant type of vegetation found around Ross Creek. They occur mostly in fringe stands of some 4-5m wide covering either the small inlets or the inter-tidal zone along the creek banks (Plate 5). Other significant stands of mangroves occur around tidally inundated areas or mudflats.

There are eight species of mangroves found along the creek. The most abundant is *Avicennia marina* which provides a continuous canopy for the mangrove environment. *A. marina* is a pioneer species establishing along the full length of the creek following land reclamation. The other species of mangroves growing amongst the *A. marina* are *Aegialitis annulata, Bruguiera gymnorhiza, Lumnitzera racemosa, Osbornia octodonta, Ceriops tagal, Rhizophora stylosa,* and *Xylocarpus granatum*.

Salt-marsh vegetation has colonised the tidal flats behind mangrove stands or in areas where the mangroves have not established (Plate 14). Although there are sporadic and small colonies of salt-marsh vegetation the majority occur in a few large tidal flat and salt pan areas. The dominant species is the Saltwater Couch (*Sporobolus virginicus*) with *Sued australis* (Seablite), *Halosarcia* sp. (Samphire), *Sarcocornia australis* (Chicken Claws), and *Sesuvium portulacastrum* (Sea Purslane).

Campbell (1977) surveyed the mangrove vegetation of Ross River estuary identifying seven species. Of these, only *Exceorcaria agallocha* was not found in this scoping study. Ross Creek has two species not found by Campbell, *Lumnitzera racemosa* and *Xylocarpus granatum*, which probably occur outside his sampling sites. Campbell also found the same four salt-marsh species occurring upriver from Rooneys Bridge.

4.1.3 Vegetation of the Land Use Zones

(a) Area 1 (Figure 19)

There is very little mangrove vegetation in this area. The most significant stands are on the mudflats at the western end of Hanran and Central Parks (Plate 11). There are scatterings of mangroves (*A. marina*) around the southern side of George Roberts Bridge and at the junction of Ross and Archer Streets. There is no salt-marsh vegetation and very few exotic grass and woody

weeds are present. Woody weeds are becoming established in neglected areas along the rock walls and open spaces such as at the junction of Sir Leslie Thiess Drive and Entertainment Drive.

Trees in Hanran and Central Parks, Fishermans Wharf, and Lennon Drive include Terminalias, figs, melaleucas and palms. Landscaped street areas such as the River Quays development (Plate 7) include many palms and melaleucas around the Ferry Terminus on Breakwater Road.

(b) Area 2 (Figure 20)

This area contains the most significant stand of mangroves and salt-marsh vegetation of the creek. All species of mangroves and salt-marsh vegetation of the creek can be found on the south bank at the railways maintenance yards areas (Plate 15). This is an original stand of estuarine vegetation and the mangrove stand has in fact increased its distribution at the expense of the salt-marsh vegetation. Pure stands of Saltwater Couch are a major feature and there are also fine examples of salt pans and associated vegetation.

The mangroves are present in patches along the rock walls of the northern rail yards and only occur in thin fringes where the banks are steep from Boundary Street to the maintenance rail yards on the south bank. There are larger stands of mangroves around the eastern side of Woolcock Street Canal.

Some large trees can be found scattered around Reid Park and the Woolcock Street Canal parks. A group of mango trees at the junction of the northern and southern lines belonged to the original homes that were once on the eastern banks of Monkey Island channel. The Woolcock Street Canal parks have a number of medium sized Rain Trees and the creek side of Civic Theatre has a stand of medium to large eucalypts with a scattering of melaleucas.

Clump planting as a visual buffer for the Civic Theatre from the rail yards consists mainly of 4-5m eucalypts with a mixture of other native trees such as melaleucas and she-oaks. Clump planting has commenced in the eastern Woolcock Street Canal Parks.

Exotic grasses, particularly Guinea Grass, dominate the open space areas which are mostly kept cut except around the rail lines and close to the edges of the mangroves. Woody weeds are quite common in this area along the rock walls, across the edges of land fill, and along the edges of the mangrove stands. Of note are *Leucaena leucocephala* and *Parkinsonia aculata* which are prevalent in the park east of the canal.

(c) Area 3 (Figure 21)

This area has good examples of fringe mangroves (Plate 5). Only in the ponded area have the mangroves failed to establish fully. The creek banks are not as steep as found in Area 2 and there is far less tidal fluctuation which makes them very suitable for a healthy mangrove establishment. Some larger stands of mangroves occur on and around the mudflats and old creek islands such as that next to Queens Street causeway. Small patches of salt-marsh vegetation occur at the Summerfield Road inlet and on the eastern side of the Sandy Crossing causeway.

Only a few large Rain Trees and Albizias are scattered around the open areas. Clump and strip planting of native trees have been undertaken in Bicentennial Park and on the Philp Street side of the creek (Plate 13). Woody weeds, mostly *Macroptilium lathyroides*, have established among the Rhodes Grass on Bicentennial Park hill. Uncut Guinea Grass hugs the edges of the mangrove stands especially between Queens Road and Boundary Street.

Figure 19 Ross Creek vegetation - Area 1

Figure 20 Ross Creek vegetation - Area 2

Figure 21 Ross Creek vegetation - Area 3

4.2 Faunal Diversity in Ross Creek

With the exception of birds, faunal diversity in Ross Creek and its surrounds is based on a review of relevant literature and reported sightings from the community surveys. Field observations were utilised for assessing bird diversity and comparing observations and reported species lists.

4.2.1 Marine life

(a) Fish

Information available on fish diversity in Ross Creek is provided from scientific studies (e.g. Arthington *et al*. 1984, Milward and Webb 1990) as well as public-user sources.

Milward and Webb (1990) conducted a study to determine the extent of the introduced tilapia species *Oreochromis mossambicus* in the Townsville region. Their study included Woolcock Street Canal and Curralea Lake and listed the fish species observed in upper Ross Creek and the lake during March to September 1989. The lists illustrate the diversity evident in the relatively small creek catchment (Tables 4.1 and 4.2). The public survey in Section 3 of this report gathered information about the type of fish caught in Ross Creek (Tables 4.3 and 4.4).

A precursor to the work by Milward and Webb was a study by Arthington *et al*. (1984) examining tilapia occurrences and distribution in Queensland. It was noted that as early as 1980 there were self-maintaining populations in Ross Creek and Woolcock Street Canal. The species is prohibited in Australia and considered a threat to naturally occurring species because of competitive advantage due to its rapid growth rates and feeding habits. Although tilapia is still evident in Ross Creek and its associated waterways (including the harbour) general fish diversity is high, including piscivorous fish species (such as barramundi which may prey upon tilapia), which could reflect the open tidal system of Ross Creek and the canal. The reduced tidal flushing of Curralea Lake is expected to favour tilapia settlement as diversity is not as high as in the canal and creek.

(b) Marine invertebrates

There is little available information describing the diversity of marine invertebrates in Ross Creek. Several studies were brought to the authors' attention which could not be retrieved within the time-frame of the study. The late Professor Ron Kenny (formerly of the Zoology Department, James Cook University) carried out ecological studies of various limpet species in the Townsville region (which included the harbour and lower reaches of Ross Creek). He also reported on the outcome of a major fire at the Sugar Terminal in the harbour around 1966 which documented a species list of marine organisms killed as a result of the fire.

Zann (1975) reported on the biology of marine fouling organisms in the Townsville region focusing on Ross Creek and Ross River. This work followed on from previous fouling studies carried out in Ross Creek by Straughan (1968, 1972 and 1973). Successional lists of invertebrate colonisation were reported on a number of substrates, including wooden and concrete installations. *In-situ* plates were utilised to monitor surface film settlement over a thirty day period at a site located adjacent to the old Pump House Station in the harbour facility. The resultant species list is shown in Table 4.5. Zann also reported on changes with depth in fouling species' distribution on wooden and concrete installations within the harbour (see also Table 4.6). The wooden structures were heavily bored by crustaceans and molluscs but the colonising fouling organisms were very similar to those found on the concrete structures.

Several post-graduate research projects at James Cook University have focussed on estuarine animals in the Townsville area. However, only a few have utilised Ross Creek (and then mainly only harbour sites are incorporated) with most of the emphasis placed on Ross River, Ross River Estuary and Cleveland Bay. It is possible that much of the fauna recorded in nearby estuaries also

occurs in Ross Creek. Some of the studies relevant to species composition are Grigg (1972 - distribution of marine and freshwater copepods, Cleveland Bay and Ross River), Draper (1975 - barnacles, Ross River Estuary), Campbell (1977 - sesarmid crab distribution, Ross River estuary), Warburton (1978 - *Uca* species (fiddler crabs), Ross River Estuary), Hoedt (1984 - anchovy biology, Cleveland Bay), Mueller (1986 - biology of the Pacific Blue-Eye, Ross Creek and Three-Mile Creek), Yap (1990 - Sciaenidae biology, Cleveland Bay), Cabanban (1991 -Leiognathidae dynamics, Cleveland Bay) and Jackson (1991 - distribution of squid in Townsville waters, included sites in the harbour).

(c) Public Comment

Twenty-five survey respondents collect bait in the creek at a number of locations from Hermit Park to the sandbar in the harbour. Varieties caught include mullet, herring, prawn, yabby and hairtail in winter, and mullet, herring and prawn in summer. The main method used for catching bait was by cast net. Table 4.3 lists the relevant details collected in the survey.

Thirty-seven of the respondents to the Ross Creek survey fish regularly in the creek and provided information about species, location and abundance. This information is summarised in Tables 4.4. The areas where most fish are caught are from the harbour to Lowths Bridge. In winter, the most frequently caught species are trevally, whiting, hairtail, mangrove jack (also known as red bream), cod, bream and barramundi. In the summer, barramundi, mangrove jack, trevally, and cod are the most frequently caught fish, followed by queenfish, bream, and flathead. The average number of fish caught in an hour is one, and on average seven out of ten fish are thrown back because they are under size.

4.2.3 Other Vertebrates

Little information exists on the occurrence of terrestrial wildlife in and around Ross Creek. Water rats are common and a crocodile sighting under the Magnetic Island ferry terminal was reported to the City Council at the end of 1993 (D. O'Sullivan pers. comm).

(a) Birds

The creek supports numerous species of birds. Like the vegetation of the creek there are those species that belong principally to the estuarine environment or water birds, and those of the non-estuarine environment or land birds. The water birds of Ross Creek included: the surface feeders (gulls and terns); swimming birds (cormorants, pelicans); large wading birds (egrets, herons, curlews, ibises); and small wading birds (plovers). The land birds of the creek included: grass birds (quails, wrens, larks, willie-wagtail, finches); aerial feeders (swallows, bee-eaters); birds of prey (kites); small bush birds (flycatchers, fantail, triller, honey-eaters, warblers, silvereye); and medium-sized bush birds (kingfishers, cuckoo-shrikes, friarbirds, drongoes, pigeons, doves, cockatoos, lorikeets, parrots).

From the public survey and general observation during the study, some 50 species of birds have been identified. These are listed in Table 4.7. The majority of swimmers and surface feeders are found in the non-ponded areas of the creek. The wading birds inhabit the mudflats. The small and medium-sized bush birds can be found in stands of mangroves but are far more numerous in clump plantings of native trees.

(b) Public Comment

Survey respondents mentioned siting a total of 46 species of birds in the vicinity of Ross Creek. The most frequently mentioned sitings were egrets, ibis, cormorants, plovers, herons, seagulls, magpie-larks, myna birds, terns, pelicans and bee-eaters. Some specific species observed were a White-browed Crake, Buff-banded Rail, Eastern Reef Egret, Mangrove Gerrygone, Jabiru,

Crested Hawk, Brahminy Kite, Whistling Kite and Black Kite. Other animals observed around the creek included rabbits, rats, flying foxes, cats, possums, lizards, snakes, crabs and butterflies. A list is also included in Table 4.7.

One respondent mentioned that the variety of birds had increased since trees have been planted near Queens Road, and another reported that plovers' nests and young have been destroyed by grass slashing. Mention was also made of wild cats breeding near the Sheraton Casino and Entertainment Centre, and of the large number of rats in the rock walls of the breakwater in the harbour.

4.3 Comparable Estuaries

There are a number of estuaries in the Townsville region that could be used for a comparison of biological diversity with Ross Creek. However, effective comparisons can only be made once the full extent of terrestrial and marine diversity has been determined for Ross Creek.

Ross River estuary provides an adequate waterway for ecological comparison, due to its close proximity, and having experienced much less development, especially urbanisation. Ross River also experiences flood mitigation via three weirs and the lower reaches of the river are inundated by freshwater flows in times of extreme and consistent rain events. It might be expected that Ross River would exhibit a greater native floral and faunal diversity than Ross Creek due to a greater degree of impact to the Ross Creek system. Upstream of the city this appears to be the case for floral species diversity due to the pockets of naturally occurring mangrove and salt marsh vegetation and areas of introduced floral assemblages. The commercial and urban development downstream of Ross Creek seriously disadvantages ecological development due to pollution loading and changes to creek bank structure (in some cases removing tidal banks and replacing with concrete walls). It is expected that the differences noted in species lists between Ross Creek and Ross River are a direct result of urban development.

Other possible estuarine waterways which may be used for biological and ecological comparison are the lower reaches and estuarine areas of Three Mile Creek and the Alice/Black River systems. Research studies have been carried out which list floral and faunal species (Beumer 1971 and Penridge 1971 - Three-Mile Creek; Beumer 1976 - Alice/Black River) which may be used as a basis of comparison with Ross Creek.

4.4 Conservation

The Townsville City Council's *Living Today for Tomorrow* is an environmental conservation strategy for Townsville and takes into account the environmental issues for all aspects of the city and surrounds (Townsville City Council 1993c). Strategies are included for the marine and terrestrial flora and fauna and there are recommendations which apply to the protection of natural heritage of Ross Creek.

Some of the recommendations of the Queensland Department of Environment and Heritage's *Coastal Protection Bill* may apply to Ross Creek. The areas adjacent to the creek may contain some properties that are covered in the Townsville City Council's *Urban Conservation Strategy*.

4.5 Summary

Ross Creek provides an interesting focus for wildlife in Townsville. While it may not have high conservation value on a regional scale, the close proximity of the creek and its wildlife to the inner city area make it an important local biological resource, especially for recreation and aesthetic purposes.

Table 4.1 Fish species collected in upper Ross Creek between March and September 1989 (Milward and Webb 1990, revised list Webb pers. comm.)

Scientific Name	Common Name
Acanthopagrus australis	Silver Bream
Ambassis vachelli	Perchlet
Ambassis sp.	Perch
Chanos chanos	Milkfish
Chirocentrus dorab	Wolf Herring
Gambusia holbrooki	Mosquitofish
Gerres macrocanthus	Silver Biddy
Rediogobius bikolanus	Speckled goby
Gobiid spp. (5)	Goby
Hemiramphus sp.	Garfish
Lates calcarifer	Barramundi
Leiognathus equulus	Black-tipped Ponyfish
Lutjanus argentimaculatus	Mangrove Jack
Mugil cephalus	Mullet
Nematolosa erebi	Bony Bream
Scatophagus argus	Spotted Butterfish
Selenotoca multifasciata	Striped Butterfish
Sillago sp.	Whiting
Terapon jarbua	Crescent Perch
Platycephalus fuscus	Flathead

Table 4.2 Fish species collected in Curralea Lake between March and September 1989 (Milward and Webb 1990, revised list Webb pers. comm.)

Scientific Name	Common Name
Hypseleotris compressa	Empire Gudgeon
Sphyraena barracuda	Barracuda
Arothron sp.	Toadfish
Chanos chanos	Milkfish
Gerres macrocanthus	Silver Biddy
Platycephalus fuscus	Northern Dusky Flathead
Platycephalus indicus	Bar-tailed Flathead
Lates calcarifer	Barramundi
Chirocentrus dorab	Wolf Herring
Rediogobius bikolanus	Speckled Goby
Gobiid spp.	Goby
Leiognathus equulus	Black-tipped Ponyfish
Mugil cephalus	Mullet
Nematolosa erebi	Bony Bream
Nematolosa come	-
Scatophagus argus	Spotted Butterfish
Scomberoides tala	Queenfish
Selenotoca multifasciata	Striped Butterfish
Anguilla reinhardti	Eel
Leiopotherapon unicolor	Spangled Perch
Megalops cyprinoides	Tarpon

Table 4.3 Bait Collection[1] in Ross Creek from Responses to the Users Survey (number of times mentioned)

	WINTER				SUMMER			
Location	**Mullet**	**Herring**	**Prawn**	**Yabby**	**Hairtail**	**Mullet**	**Herring**	**Prawn**
Hermit Park/Railway Estate	4	5	7	-	2	6	6	5
Ross Creek (entire)	5	4	3	1	-	6	4	6
Boat Ramps	2	2	-	-	-	3	1	2
Behind Railway Station	2	2	1	-	-	2	2	2
Slipways	-	-	-	-	-	-	-	1
Between Railway yards and Telecom	1	1	-	-	-	1	1	-
Sandbar in Harbour	1	-	1	-	-	1	-	1

[1] - Methods used for bait collection:

1. cast net (mentioned 15 times)
2. drag net (mentioned 1 time)
3. lures (mentioned 1 time for hairtail)
4. yabby pump (mentioned 1 time)

Table 4.4 A Summary of Recreational Fishing in Ross Creek from Non-random and Random Surveys (number of times mentioned)

Location	Crab	Barramundi	Mangrove Jack	Trevally	Cod	Queen-fish	Flathead	Whiting	Grunter	Black Salmon	Mackeral	Hairtail	Bream	Tarpon	Tilapia	Teraglin	Gold Bream
WINTER																	
Harbour	-	1	-	5	1	-	-	3	2	-	1	-	1	1	1	1	-
Lowths Bridge/Harbour	-	1	3	-	4	-	-	-	-	-	-	4	2	-	-	-	-
Slipways	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Hermit Park/Railway Estate	-	1	1	1	-	-	-	-	-	-	-	-	2	-	1	-	1
Various	-	1	1	-	-	-	-	1	1	-	-	1	2	-	-	-	-
Between Telecom and Rail Yards	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
RE/HP/Harbour	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-
SUMMER																	
Harbour	1	10	7	7	6	2	1	-	-	1	-	-	-	-	-	-	-
Lowths Bridge/Harbour	-	3	3	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Slipways	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-
Hermit Park/Railway Estate	1	1	1	1	-	-	2	-	2	-	-	-	-	-	-	-	-
Various	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Between Telecom and Rail Yards	-	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-
RE/HP/Harbour	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.5 Species Colonisation and Succession of *In-Situ* Plates by Marine Fouling Organisms in Townsville Harbour over a Thirty Day Period (taken from Zann 1975)

1.	Bacteria settlement heay, consisting of mainly gram-negative rods, 5% gram-positive reflecting terretrial discharge (most marine bacteria are gram negative).
2.	Diatom settlement - *Nitzchia* spp. make up 90% of diatom assemblage. In particular, *N. closterium, N. logissima, N. grevillei*, and species of *Navicula, Achnanthes, Melosira, Astroniella* and *Bacilleria* common for the first two weeks.
3.	*Podophyra fixa*, a suctorian, present, *Vorticella* sp., noted and the hydrozoans *Obelia bicuspidata, O. nodosa* (not common) and *Campanularia* sp. present. It is suggested that the high concentration of diatoms on the plates prevented settlement and growth of the hydrozoans).
4.	*Balanus amphritite* - barnacles settled after ten days
5.	After thirty days, the above and serpulids *Polatoleios krauseii, Hydroides basispinosus, H. multispinosa, Mercierella enigmatica* and *Spirorbis* sp.: sebellids; the barnacle *Balanus amphritite*; oysters *Ostrea* sp. and *Cassostrea echinata*; mussels *Mytilus* sp. and ascidians noted.

Table 4.6 Occurence of Marine Fouling Organisms in Relation to Depth on Wooden and Concrete Installations in Townsville Harbour (taken from Zann 1975)

High Water	Barnacle *Chthamalus malayensis* dominates high water level.
Mean Water	Merging to Oysters *Crassostrea echinata* and *C. amasa*.
Below Mean Water	Barnacles *Balanus ammphritite* and *B. variegatus*, and serpulids *Hydroides* spp. and *Pomatoleios krauseii*.
Below Mean Low Water Spring	Ascidians, Sponges and some corals *Favites* sp. and *Porites* sp. noted.
Algae	Algae uncommon but *Ceramium* spp. and *Padina* spp. present at the waterline of floating pontoons.
Wooden Pylons	Heavily bored by crustaceans, *Limnoria* sp. and *Sphaeroma* sp. above the mean water level, and teredinid bivalves *Lyrodus* spp. and *Teredo* spp. below the mean water level.

Table 4.7 A Summary of Wildlife Observed In and Around Ross Creek (Users from Non-random and Random Surveys)

Type of Wildlife Observed	No. of Times Mentioned
BIRDS	
Ibis	13
Egret, plover	12
Magpie-lark	8
Cormorant, heron	7
Seagull, myna bird	6
Tern, honeyeater, pelican, rainbow bee-eater	4
Red-tailed black cockatoo, kingfisher, brahminy kite, darter	3
Black kite, kite, brolga, curlew, kookaburra, whistling kite, sea eagle	2
White Cockatoo, scrub hen, crow, white-browed crake, flycatcher, silvereye, dove, bush canary, buff-banded rail, duck, crane, Eastern Reef egret, mangrove gerrygone, cormorant chicks, egret chicks, jabiru, peaceful dove, crested hawk, Blue Mountain parrot, bustard, wren, sand piper, wood swallows	1
OTHER ANIMALS	
cats	6
crabs	5
rats, snakes, lizards	3
dogs, python, butterflies, possums, rabbits, white-tailed water rat, flying fox	1

5. POLLUTION LOADING IN ROSS CREEK

The present character, form, and constitution of Ross Creek is greatly affected by land reclamation, waste disposal and pollution. The intense industrial activity around the middle and outer reaches of the creek, discharges from the central business district and wider suburbia, continuous boating use around the inner city, and the filling of estuarine inlets, tidal flats, and mangrove stands with industrial and domestic waste, make Ross Creek a sad example of neglect and indifferent exploitation of its ecological, aesthetic, and recreational function and potential.

5.1 Ross Creek Catchment

Ross Creek provides for the discharge of the majority of the Townsville urban stormwater drainage and therefore represents a critical component of Townsville's drainage system. The Ross Creek catchment covers an area of approximately 2,500 hectares. Storm-water runoff during the wet season flows through a network of stormwater pipes, drains and channels which empty into the Woolcock Street Canal or directly into Ross Creek. The Woolcock Street Canal services the bulk of the catchment area (about 2,000 hectares) and discharges into Ross Creek via flood control gates at the junction of Charters Towers Road and Boundary Street (Figure 22).

The canal catchment drains mainly residential areas, including a number of major commercial centres, small-shopping centres, service facilities, and light industry. The catchment can be divided into three sub-catchments (Figures 23 and 24).

Sub-catchment 1	drains the north-western area and empties into the two sediment basins (Curralea Lake and the Lakes Stage II) in the suburb of Currajong along Woolcock Street. These basins or lakes reduce flow velocities, and trap sediments and pollutants. The outlet of the lakes is at the source of Woolcock Street Canal at the intersection of Kings Road and Woolcock Street.
Sub-catchment 2	drains the south/south-western section of the catchment. Runoff flows mostly into grassed open channels which empty through a concrete channel into the canal opposite the Townsville Showgrounds.
Sub-catchment 3	is the smallest of the three, which drains the north/north-eastern section of the catchment. Unlike the other two sub-catchments, it has no single drainage outlet point but consists of a number of individual stormwater pipes which drain directly into the main canal.

There are no networks of pipes, drains, or channels directly around Ross Creek and therefore, no major drainage outlet points. Consequently all drainage around the creek is from numerous individual stormwater pipes that drain small sections of industrial, commercial and residential land (Figure 25).

5.2 Drainage and Pollution

Ross Creek is heavily influenced by climatic, tidal and urban inputs (including industrial and harbour activity - dredging and vessel movement) which affect the water quality and ecology of the system. Stormwater runoff often carries contaminants such as sewerage, animal wastes, oils, household litter, chemical residues, vegetative matter and soils. These pollutants are mainly carried through the stormwater pipes but some may flow directly overland into the creek during heavy storms. As Townsville experiences significant rains only during the summer months,

pollutants which have collected in gully traps or drains over the dry months are mostly flushed into the creek in major single events.

Figure 22 Woolcock Canal Catchment drainage

In effect, the stormwater pipes and drainage systems in Townsville function only during the wet season. Exceptions to this are the inputs into the system through water wastage, commercial/industrial runoff, or accident. Water wastage may be from residential areas, parks and gardens, or commercial use. Such inflow is not significant enough to flush litter into the creek but may carry liquid wastes. Commercial/industrial inputs consist of deliberate or accidental discharge into the stormwater drainage system. There is direct discharge into the creek via stormwater or special purpose pipes on a continuous basis from the major industries such as the rail yards (Figure 25) and the harbour (Figure 26). Accidental spillage into the drainage system may be due to instances such as traffic accidents or a sewerage overflow if there is a systems failure. The Townsville City Council has a number of sewerage overflow points into the stormwater drainage system for times of emergency when a sewerage pumping station fails (Figures 23 and 25).

5.3 Water Quality

There is little long-term monitoring data available for water quality of Ross Creek but data for short term studies are available, especially in recent years. The water quality is expected to be extremely variable due to the level of stormwater runoff which drains from a catchment dominated by urbanised land use (residential, commercial and industrial). Added to this, the creek provides moorings for pleasure and fishing vessels and hosts a major harbour and attendant industrial infrastructure. First flush events are expected to produce the most deleterious water quality in the creek with respect to hydrocarbon and bacteriological pollution, and nutrient loading.

Some of the earliest water quality work in Ross Creek was conducted by Dr. John Collins and undergraduate students from James Cook University. In 1976 and 1977 they collected hydrographic data on several occasions a year from sites which extended from Townsville Harbour to Bay Rock, north of Magnetic Island. From 1978 to 1987 the focus of the study changed to describe the hydrographic features of Ross River, at sites selected from the base of Aplin's Weir to the mouth of the river. The initial Ross River study included several sites in Ross Creek. In additional to the hydrographic data, nitrate, phosphate and chlorophyll data were collected. No scientific publication has been produced from this work but the data have been retained for later evaluation. The range of water quality parameters considered in this study was insufficient to allow a detailed assessment of the health of ecosystems in Ross Creek.

The Queensland Department of Environment and Heritage (QDEH) has monitored water quality in Ross Creek since early 1979. The early data consisted primarily of dissolved oxygen measurements with the occasional examination of pH, colour, turbidity, suspended solids and Biochemical Oxygen Demand (BOD). In addition to this program, QDEH published the results of a monitoring program which conducted regular sampling over a four year period (Jan 1988 to Dec 1991) in 23 water bodies in Queensland to assess the quality of waters in the State (QDEH 1993). Sites within the Ross River system included: seven sites along the river from the mouth to 9km up stream; six sites in Ross Creek from the centre of the harbour to 4.5km from the mouth; and four sites within the Lakes Development Stage I (Curralea Lake). These sites were sampled on a maximum of 15 occasions (between 15-02-88 and 27-08-90) and it is unknown if the sampling was undertaken on a particular point of the tidal cycle. The parameters monitored were general physico-chemical measurements (pH, dissolved oxygen, temperature, turbidity and light penetration (via secchi disc depth), suspended solids and nitrogen (total, ammoniacal, organic and oxidised fractions) and phosphorus (total and dissolved reactive fractions). Analyses of samples from the Curralea Lake sites included an assessment of total organic carbon. The Ross River sites were studied for all the above parameters with the addition of the bacterium, *Escherichia coli*. The scope of the QDEH study was extended to include trace metal surveys of waters and sediments, biochemical oxygen demand, total dissolved ions, hydrocarbons, oil and grease in waters and sediment, fluoride and sediment fractions of nitrogen and phosphorus in southern Queensland catchments.

Figure 23 Ross Creek Catchment: stormwater drainage and sewerage overflows

Figure 24 Woolcock Channel Section of Ross Creek Catchment: modified stormwater drainage

Figure 25 Ross Creek stormwater drainage and sewerage overflows

Figure 26 Townsville Port stormwater drainage

The Townsville City Council monitors water quality parameters for Local Government Public Health Guideline requirements, in and around the Woolcock Street lakes, investigating the effects of inputs via the stormwater drainage outlets into the two lakes, Woolcock Street Canal and Ross Creek (the Lakes Stage II were completed in early 1994 and as yet residential and commercial development has not started). Samples have been taken since January 1988 on a weekly basis for pH, conductivity, turbidity, chlorophyll a/phaeophytin, algal biomass and bacteriological examinations. The sites selected in the study rarely, if ever, meet Local Government Public Health Guidelines, particularly for bacteriological parameters in the Woolcock Street Lakes deeming them unfit for public use (recreation/body contact).

An examination of the water quality parameters for Ross Creek in the above-mentioned studies shows that for the majority of parameters tested, environmental guidelines for marine ecosystems (ANZECC 1992) are achieved. To date, no study in Ross Creek has been carried out during a wet season to determine the changes to observed baseline concentrations of nutrients and other physico-chemical parameters with increased stormwater inflow, or over tidal cycles to determine the amount of natural variation in water quality due to tidal movement.

5.4 Sources of Contaminant Loading

The parameters investigated in the monitoring programs in Section 5.3 do not adequately address the full range of potential contaminants that can occur in the Ross Creek waterway. The urban stormwater runoff and the industry-based inputs to Ross Creek have the potential to produce a variety of organic and metal-based pollutants. These may exist in the water column for a short time but are more likely to be found in the sediment. Several environmental studies of Ross Creek have found high levels of metal and organic pollutants in the sediments which do not comply with various environmental guideline levels.

5.4.1 Urban stormwater runoff

During September 1989 and March 1990, the ACTFR conducted water quality investigations at Curralea Lake for the Townsville City Council and found that for the parameters tested (clarity, dissolved oxygen, salinity and bacteriological analyses), the quality over the four sampling periods was generally acceptable for recreational use (Volker *et al*. 1990). Storm flow generated from heavy rains in March 1990 resulted in very high bacteriological levels in the lake and it is possible that this was related to a sewerage pump station overflow. The report found that highly polluted inflow was expected under certain conditions and that a reduction in the reported pollution in the lake would require rapid turnover with tidal waters in Woolcock Street Canal. As mentioned in Section 5.3, the Townsville City Council has monitored bacteriological levels in the Woolcock Street Lakes and Canal since 1988 and found the values frequently exceeding Local Government Public Health Guidelines. Stormwater overflow will result in flushes of polluted water into Ross Creek which will cause a potential risk to public health around the causeway canal outlet. Lakes Stage II is more of a public concern as it links directly to the canal. The two lakes include residential developments on the lake margins and are ornamental in design, but it should be remembered that the lakes are designed for flood mitigation (i.e. urban stormwater control) and as such are a potential risk to human health and a source of contaminants to Ross Creek.

5.4.2 Land reclamation

Almost all the land around Ross Creek from Bicentennial Park to Dean Park has been reclaimed using industrial waste, domestic and commercial garbage, and imported soils (Figure 5). The land reclamation along the banks of Ross Creek since 1935, utilising mullock from the Charters Towers goldmines to the dump fills of the 1940's to the late 1980's, present potential contaminant sources from leachate to Ross Creek. A submission by the North Queensland Conservation Council to the National Toxic Network Information System on Ross Creek and its environs (Knight 1994)

commented on the contamination of land reclamation sites over mangrove fringes on Ross Creek by mullock and rubbish fill material, as well as the subsequent use of the reclaimed land by Queensland Rail (southern rail yards). Knight (1994) also added that the contamination of reclaimed land was high, and the resulting contamination to the Ross Creek waterway was additional to that from urban runoff (high bacteriological and petroleum hydrocarbons contamination) and the associated harbour facilities (petroleum hydrocarbons and tributyltin contamination).

5.4.3 Townsville Railway Yards

The railway yards potentially present a major problem as they are still in use and are a possible source of contamination by trace metals and organic pollutants. The majority of runoff and seepage from the northern rail yards and maintenance yards will end up in Ross Creek. *In-situ* soil contamination by cyanide, trace metals (lead, zinc, arsenic, chromium), petroleum hydrocarbon products (diesel wastes, oil, etc.) and organics (biocides such as diuron, bromacil, dieldrin, etc.) has been recognised by Queensland Rail on the sites. The NQCC report (Knight 1994) comments on trace metal contamination in the yards and the burying of chemical storage drums. This is documented in the Townsville Railway Landuse Study (Ove Arup and Partners 1993) which also lists the minor and major chemical spills in the yards, and the site's potential for chemical leaching and seepage into Ross Creek.

5.4.4 Mooring of Marine Vessels

There is little available information regarding discharges from vessels into Ross Creek (i.e. sewerage or oil/fuel spillage). Discharge into Ross Creek by pleasure craft or vessels using the Townsville Harbour is prohibited. The Townsville Port Authority (TPA) maintains a sewerage treatment plant near the reclamation area which takes raw sewerage from berthed vessels. The TPA is also the first response authority for oil and diesel spills within the harbour and Ross Creek, and has an Oil Spill Contingency Plan in place should such an event occur.

Accidents such as fuel spillage (from vessels in general or from the bulk fuel loading berth) could very rapidly destroy flora and fauna in the creek. This could happen over a period of minutes to hours, depending on the extent of the spill. In many cases contaminant concentrations in the water column would disappear very quickly and there would be little chance of detection. This is a common problem in water quality monitoring programs in most developed areas, particularly harbours. Biological monitoring could be used to detect the effects of such episodic events.

A study in 1991 by the Queensland Department of Primary Industries - Fisheries (Witney 1991) investigated the occurrence of tributyltin (TBT) in water, sediment and oyster tissue in certain Queensland waterways. TBT and its by-products are associated with TBT-antifouling paint which was commonly used prior to legislation restricting its use in Queensland, although as discussed in Section 3.2.4, there is concern that Royal Australian Navy and overseas commercial shipping may still use TBT-antifouling paints. TBT was used as an anti-fouling agent as it was more toxic to fouling organisms than copper-based products and also appeared to provide the greatest separation between target (fouling organisms) and mammalian toxicity. Environmental effects of TBT on molluscs result in shell deformities in oysters and sex changes in species of marine snails (Witney 1991, Mitchell 1989). Larval stages of a wide variety of marine organisms are also susceptible to TBT and associated compounds indicating that polluted areas may experience long term changes in community structure. The environmental levels of TBT in the water and sediment in Ross Creek in January 1988 and March 1989 (downstream of the small craft moorings near the Motorboat Club (Plate 16)) were extremely high in comparison with those recorded anywhere else in the state, indicating the poor level of flushing in Ross Creek and the high level of harbour vessel activity. Other sites selected in Cleveland Bay reported values comparable to the rest of the state indicating TBT contamination is restricted to the Ross Creek waterway.

5.5 Sediment

Sediment samples have been collected by QDEH on several occasions at locations along Ross Creek (-0.3, 0.8, 1.6, 2.4, 3.5 and 4.5 average middle thread distance (AMTD) - 2.4 and 3.5 represent the rail yard locations). In 1981 results for mercury, lead, copper, chromium, zinc, nickel, cadmium and arsenic indicated that lead, copper and zinc were higher than ambient concentrations for standard shale (Forstner and Whittman, 1981) which is used to compare metals levels in sediments as there is little existing information regarding guideline metal concentrations for "pristine" tropical estuarine systems. Zinc concentrations are high throughout Ross Creek and nickel is high within the harbour. Sources of trace metal contamination are difficult to identify because of the lack of sufficient information but it is likely that the harbour and the railways are responsible for a significant proportion of the trace metal loadings to Ross Creek. Levels of associated organo-pollutants have not been addressed by QDEH in any report to date.

Gibbs (1993) reported on the bio-availability of cadmium, cobalt, copper, iron, manganese, nickel, lead, tin, selenium and zinc in sediment samples from sites in Townsville Harbour and in Ross Creek. It was reported that the capacity of cadmium, lead and zinc to become available under certain conditions (e.g. channel dredging) could pose a problem as the harbour is located within the Great Barrier Reef area. The reported concentrations obtained for the Townsville Harbour were very high and thought to be associated with the large volume of ore and ore-products imported and exported from the harbour. The levels, however, were lower than those obtained in Ross Creek, particularly in the muds located off a ship repair facility which carries out sandblasting, cleaning and repainting of boats.

Data made available from the Townsville Port Authority for the long term dredge spoil disposal study in September 1993, supported the values obtained by Gibbs (1993). There is no indication, however, if the values obtained by the TPA are total metals or the bio-available metals fraction. Values obtained around the shipping repair facility are much lower than those from Gibbs (1993) but of the same order as those reported at other sites in Ross Creek. Copper, lead and zinc levels were particularly high in Ross Creek. In addition to the metals study, total petroleum hydrocarbons, oil, grease, and tributyltin (mono- and di-) concentrations in sediment were investigated and found to be significantly higher than concentrations reported in Ross River. Some of the triplicate sediment samples for each parameter were below the detection limit indicating the apparent localisation of contamination within the creek.

A study by Smith *et al*. (1985) found that the high usage of Townsville harbour provided a source of polycyclic aromatic hydrocarbon contamination in the sediment which was localised to the harbour vicinity. Contamination was restricted to the surface sediments suggesting that the sediment had not been agitated in recent times. Levels observed in Townsville Harbour were similar to Gladstone Harbour and coastal sediments in similar locations around the world.

5.6 Refuse and Litter

A survey of the visual pollution of Ross Creek was undertaken for this report. It was found that most of the banks of Ross Creek, particularly upstream from Lowths Bridge, are characterised by some form of surface litter. Some of this litter has been deliberately deposited over the banks of the creek by those who see the creek as a convenient dumping ground. Other litter, mostly plastics, paper, bottles etc., has either reached the creek via the stormwater drains and overland flow, or as wind transported material from nearby streets (Plate 18).

There were three major types of refuse identified during the survey - commercial, domestic and garden waste. Commercial wastes included refuse such as building rubble (concrete, asphalt, steel, wood), steel and concrete pipes, tyres, metal tins and drums. Domestic waste included plastics (bottles, bags, wrappings, sheets, toys), glass bottles, styrofoam boxes and cups, paper (sheets,

cartons, wrappings), and rubber (bike tubes, balls). Garden waste included branches, palm fronds, leaves, weeds, and lawn clippings.

5.7 Visual Pollution of the Land Use Zones

(a) Area 1 (Figure 27)

This area is the least visually polluted of the three areas. There is some heavy commercial rubbish associated with boat building and repair industries, mostly in the form of rubble. Light commercial waste has been dumped around the few remaining mangroves on the small mudflats on the corner of Ross and Archer Streets. There is also light domestic waste that is visible among the mangroves along Tomlins Street and Hanran Park.

On the whole the city area has avoided the accumulation of wastes, most probably because of its high public profile and tidal movement. Most industries and businesses have been careful in keeping their surrounds neat and tidy. Domestic waste is not a major problem because there are no significant stands of mangroves to trap floating debris, and rubbish entering the creek downstream from Lowths Bridge either sinks in the deeper areas of the creek or is transported back up the creek by fluctuating tidal cycles and/or strong north-easterly winds.

(b) Area 2 (Figure 28)

This stretch of the creek is heavily polluted. A legacy of the railways has been the total neglect and abuse of the banks of Ross Creek. The banks and associated tidal flats of the creek, adjacent to the rail yards, are used as dumping grounds and are heavily polluted with an assortment of discarded materials. Concrete rubble, railway sleepers, timber, metal drums, machine parts, and much more have been dumped on the rock walls of the creek at the northern yards (Plate 12). The southern yards, as part of their land reclamation process, have masses of railway sleepers, rail lines, concrete rubble, iron roofing, tyres, machine parts, rocks, etc., deposited along the edges of the little remaining salt-marsh vegetation (Plate 19).

There is some domestic waste scattered amongst the mangrove stands. One area which is particularly polluted is around a major pipe outlet at the Woolcock Street Canal park toward the rail yards. Garden waste has been deposited over the creek bank opposite the Civic Theatre, its origin most likely from the maintenance of the theatre's gardens.

Zone 3 (Figure 29)

This area is visually polluted with domestic rubbish prevalent in nearly all of the mangrove stands. Domestic waste is particularly profuse around the mangrove inlet of Summerfield Street (Plate _). These types of deposits are usually closely associated with major stormwater pipe outlets. One of the reasons for domestic rubbish being such a problem along this stretch of creek could be the poor tidal flushing in this region of the creek (unlike downstream from Boundary Street which is free flowing).

There are significant areas littered by commercial waste, probably originating from building projects that have used the creek as a convenient dumping ground. Concrete and asphalt deposits are common, along with some scattered timber and steel. The Townsville City Council yards at First Avenue are used for a storage site for large piles of soil and woodchips. Of lesser visual impact are the piles of soil deposited next to the creek at the Model Engineers Fun Park. Sporadic dumping of garden waste has occurred in this area, in particular next to the Model Engineers Fun Park. This most likely originates from the maintenance of the Park.

Of some concern is the surface rubbish found on and around the Bicentennial Park hill. Both domestic and commercial refuse have never been adequately covered during or after the dump

operation, or surface erosion has exposed the refuse. This rubbish is not only visible in isolated patches but is widespread across and around the hill.

Figure 27 Polluted areas around Ross Creek - Area 1

Figure 28 Polluted areas around Ross Creek - Area 2

Figure 29 Polluted areas around Ross Creek - Area 3

5.8 Public Concern

Seventy-five per cent of the respondents to the public survey were concerned about pollution in Ross Creek, particularly visual pollution. The most often mentioned types of pollution were litter, rubbish, domestic waste, plastics, polystyrene, bottles, cans and surface slicks of oils and fuels. A full list is shown in Table 25.

5.9 Summary

Ross Creek is greatly affected by pollution which can be linked to a number of urban and commercial factors. Its catchment drains residential and commercial land and the original morphology of the creek has been altered by land reclamation to satisfy town planning needs. While the creek is most commonly used as a commercial avenue, via daily harbour and tourism activity, management considerations need to include its additional use as an aesthetic and recreational feature of Townsville, and its ecological value, to ensure that pollution loading to the waterways and sediment is closely monitored and kept to a minimum, with contingency plans in place to allow for prompt remediation in case of severe pollution by solid and liquid wastes.

6. CONSIDERATIONS FOR FUTURE MANAGEMENT OF ROSS CREEK

6.1 Land Use Considerations

6.1.1 Zoning for Land Use

All the existing land uses around the central business district and the port area have developed as a result of the zoning remaining since the initial 1867 planning scheme. The existing land use zones are appropriate for present and future land use adjacent to the creek and there is no apparent reason why any change of category is needed. However, some inconsistencies and/or developments exist that will require attention.

Sub-divided allotments are still demarcated along Central Park in the Planning Scheme Maps (Figure 11) but under the South Townsville Special Development zone plans this area will remain for Open Space. Land use change will occur upstream from Lowths Bridge and will require re-classification of land use zoning. The northern and southern rail yards are to be re-developed into medium density housing and commercial use in the future. Such land, which is now zoned Special Purpose (being State Government land) will need to be rezoned according to the development needs as well as the recreational use and protection of Ross Creek. Reid Park is designated Open Space and includes the Civic Theatre development. Similar types of development are likely in the future. This land may need more precise planning scheme zones for the use of the park and the requirements of the creek in the future (Figure 12).

Land use from Boundary Street to Queens Road has been zoned Sport and Recreation. This is satisfactory for present land-use around the Brodie Street area but is unlikely to be appropriate for the other open space areas. For example, the Model Engineers Fun Park should be classified differently and the remaining park areas zoned according to the creek's use and development. Housing allotments and roads are still designated on the Planning Scheme Zoning Maps for all the Sport and Recreation area (Figure 13). These are not appropriate for present and expected future land-use.

From Queens Road to Bicentennial Park the park area is zoned Open Space. This is an appropriate categorisation as it is unlikely to be used for any purpose other than aesthetics and recreation. Again there are housing allotments and roads designations marked on the Planning Scheme maps (Figure 13). These are unlikely to be developed with the "roads" likely to be closed and the allotments amalgamated.

6.1.2 Improving the Recreational Values

The Townsville City Council has acknowledged passive and active recreational needs of the community by developing a Culture and Leisure Policy to guide planning for recreation. The objectives of this policy are to develop a well balanced spectrum of opportunities to meet present and future community needs and to ensure facilities are used efficiently, not wasted nor degraded. These objectives have not yet been applied to the Ross Creek area in any major way.

The present recreational use of Ross Creek represents only a fraction of the potential for the area. As is evident from the community surveys undertaken, there is a considerable latent demand for recreational use of the creek. Most of these demands are already documented in the Ross River Recreation Masterplan (Section 2.8.4) which had undertaken a similar survey. The Townsville Streetscape Strategy recommendations (Section 2.8.3) for the role of open space, passive and active recreation, and enhancing accessibility of the city for pedestrians and cyclists, are also similar to the issues mentioned in this report. Although the Streetscape Strategy applies to the city centre, its recommendations are relevant to the whole area of the creek.

The community surveys undertaken for this report found a number of recreational interests and needs:

- construction of cycle/pedestrian paths along and around the creek, and facilitation of access to the creek;
- improvement in the amenities of the creek by provision of barbecues, playgrounds, seats and tables, and toilets;
- provision of more shade in the way of trees or shelters;
- resolution of the recreational limitations caused by the presence of, and hindrance by, the Aboriginal park people; and,
- improvement of boat ramp facilities for anglers and boat users, such as bins, toilets and lighting.

Future opportunities exist for the implementation of:

- a comprehensive cycle/pedestrian system around the creek that could link with a network of cycleways, such as a Ross River track or Woolcock Canal track;
- a program to facilitate present and future needs of the Aboriginal park people;
- boardwalks around the city area which would provide an attractive and efficient way to facilitate pedestrian movement; and,
- non-motorised water sports, such as canoe or paddleboat hire, from Boundary Street to Bicentennial Park.

6.1.3 Improving the Aesthetic Values

Aesthetic development of Ross Creek is an integral part of overall recreational, conservation, and water quality planning. Development in these areas should positively enhance the aesthetic qualities of the creek. Recreation, conservation, and water quality issues are discussed in Sections 6.1.2, 6.2.2 and 6.3 respectively.

Upstream from Lowths Bridge the recreational, conservation, and water quality considerations cover all aesthetic concerns except for the rail yards. The re-development plans for the northern rail yards and the maintenance yards have incorporated landscaping, vegetation buffers, parks, boardwalks, etc. which attempt to integrate the creek's potential into the new development. Option B of the Railway Plans (Section 2.7.3) would be the most compatible to the creek's aesthetic, recreational, and ecological requirements. However, any proposed changes to, or interference with, the creek's structure for aesthetic purposes should come under the guidelines of a comprehensive management strategy for Ross Creek.

Downstream from Lowths Bridge the aesthetics of the creek area are very important as they contribute substantially to the character of the city centre. The city centre is a waterside community with Ross Creek providing a natural and aesthetic asset that has been largely neglected and under utilised. Some developments have tried to complement the creek's surrounds, such as Fishermans Wharf, the Maritime Museum building, and the landscaping of River Quays Development. Other areas could be greatly enhanced by landscaping and beautification programs (Plate 20).

Suggestions for the comprehensive aesthetic improvements can be found in the Ross River Recreational Masterplan (Section 2.8.4) and the Townsville Streetscape Strategy (Section 2.8.3). These reports are complemented by the TCC's Development Control Plans. These plans provide firm guidelines for the type of development that is appropriate for the creek environs. The Townsville Streetscape Strategy provides the best comprehensive guide for a full range of appropriate development possibilities for present and future aesthetic enhancement of the creek and should be referred to in conjunction with the recommendations of this report.

Five of the Streetscape's strategies relevant to Ross Creek are highlighted below:

1. Enhance the permeability and accessibility of the city by pedestrians and cyclists (Streetscape Strategy 5, p53 and Figure 25).
2. Initiate a city greening program which creates a green, shady and lush image for the city centre (Streetscape Strategy 6, p55 and Figures 10, 26 and 28).
3. Provide new facilities in the city aimed at encouraging visitors and providing visitor comfort (Streetscape Strategy 7, p63 and Figure 30).
4. Reclaim the banks of Ross Creek for uses which positively enhance the attractiveness and enjoyment of the city, and work towards the accessibility of linear access routes to both banks (Streetscape Strategy 9, p72).
5. Maintain urban quality (Streetscape Strategy 12, p77).

6.1.4 Improving the educational value

Ross Creek environs are a resource that can offer many educational opportunities for all age groups. For primary and high schools there are existing natural features that can be utilised for school education and recreation. The location of Ross Creek to a number of primary and high schools makes the creek an ideal and easily accessible educational resource.

Areas of potential value as an environmental education resource could include:

- the mangroves and salt-marsh vegetation on the south bank at the maintenance rail yards (once relocation and re-development have occurred, access and relative safety would make this area ideal for education purposes;
- the south and north banks immediately upstream from Boundary Street;
- the "island" downstream from Queens Road, in and around the small ponded area between Queens Road and Sandy Crossing; and,
- rehabilitated mangrove, salt marsh and terrestrial vegetation areas.

6.1.5 Lessening the Impact from Creek Users

Pedestrian access to the creek can wear tracks on the banks which scar and become vulnerable to erosion. While it is important that the public have access to the creek for net and rod fishing, canoeing, model boat use, bird-watching, photography etc., it is equally important that entry points into the creek are managed to minimise impact on the environment.

Vehicle access around the creek has caused permanent tracks and erosion surfaces. Bicentennial Park hill has a network of eroded tracks over the whole area and vehicles have damaged new clump planting areas destroying some tree seedlings. Access needs to be carefully controlled for specific purposes such as park maintenance and parking facilities.

6.1.6 Developing Park Potential

(a) The Ponded Areas

There are very few areas around the city centre that have the potential to be developed into a high quality park of reasonable dimensions. Bicentennial Park and its pond is one such area. With ample open space, a 18m high hill, and large ponds (Plate 17), this area has the potential to be developed into an aesthetically rich and recreationally diverse park. Upgrading and expansion of the ponded areas should be the central to any development of the park.

There are two ponds which are dissected by the old Sandy Crossing causeway and a bare dirt "island" on which a major power pole is sited. Vehicle access on to the causeway and dirt banks is

from the Sooning Street/Queens Road intersection and is often used by anglers, or those who simply park their car and rest. The causeway is also used as an important thoroughfare for pedestrians and cyclists, particularly school children.

The causeway is constructed of masoned rock on both sides with rock fill and concrete surfacing. This surfacing has deteriorated due to general wear and tear and the frequent tidal runoff that flows over the top once a tide height of 3.1m is reached. Erosion from high tide runoff has also occurred around the edges of the causeway, among mudflats and exposed dirt banks.

The two ponds are connected by a 60cm diameter concrete pipe which is partly blocked by rocks. This pipe is not adequate for good tidal flow and flushing for the large pond. By contrast the small pond is connected to the downstream region by two 120cm concrete pipes and enjoys good tidal flow and flushing. Flow is not only restricted into the large pond by the size of the culvert but also by two old steel pipes which run directly parallel to the causeway on the large pond side. These pipes (water supply 22.5cm and sewerage 45cm) severely restrict flow under about 3m tidal height. The sewerage pipe is now redundant being replaced by a new system that is approximately a metre underground from the existing pipe.

The mangrove stands around the small pond and its "island" are well established as are the stands next to First Avenue and at the end of the large pond. There is also some salt-marsh vegetation on the causeway "island". Mangrove establishment has not occurred in some areas around the large pond due to grassed public access points and the degraded dirt bank areas.

The management considerations for this area should include:

- the upgrading and expansion of the ponded area to facilitate recreational use such as canoeing and fishing, and provide sufficient and regular flushing from tidal flows;
- the linking of ponds to Ross River via an underground pipe to simulate the original tidal flow regime;
- the upgrading and incorporation of good pedestrian and cycle access, especially along the causeway;
- the rehabilitation and revegetation of degraded areas; and,
- the restriction of vehicular access.

6.2 Biodiversity Considerations

6.2.1Suggestions for maintaining and enhancing biodiversity in Ross Creek

Recommendations of the Federal Ecological Sustainable Development Working Group (Commonwealth of Australia 1991) emphasise that the maintenance of ecological systems and protection of biodiversity is a major component of ecologically sustainable development. To ensure such an aim, the regeneration of renewable resources and the absorption of society's wastes and by-products is essential.

Within an urban context this requires a strategy of protecting and enhancing existing animal and plant communities and limiting the impact of intense land-use on the surrounding environment. The Townsville City Council has already gone some way in recognising these aims by producing an Environmental Conservation Strategy for Townsville (Townsville City Council 1993c) which is based on the general principles of ecological sustainable development.

This strategy formulates a framework of broad recommendations for the city and its environs in which various aspects of conservation and land use management are addressed. Existing initiatives in areas such as biodiversity conservation, remnant vegetation and wildlife management, water pollution and waste management, are highlighted and related to target areas of concern. Although

Ross Creek is not specifically mentioned in the document, guidelines and examples of council initiatives relate to the main issues that affect the creek. For the issue of biodiversity the council recognises ".... the importance of conserving biodiversity to maintain a healthy supply of economic and ecological resources to current and future generations..." (Townsville City Council 1993c, p13.).

6.2.2 Managing vegetation

The preservation and establishment of estuarine and non-estuarine vegetation is vital to the on-going ecological and structural functioning of the creek. Of note along Ross Creek are the mangrove systems. Marine life is very dependent on the mangrove systems for a safe habitat, nursery and breeding grounds, and food sources. Birds can be abundant in the mangroves, using them for nesting sites, perching, and feeding. Many feed off the insects that live amongst the mangroves or forage for nectar and pollen when the mangroves are in flower. Bird life is enhanced by the establishment of non-estuarine vegetation, especially Australian native species.

(a) Estuarine Vegetation

Most mangrove and salt-marsh vegetation is a vital ecological and structural component of the creek ecosystem. Although there is not a wide distribution of species, the overall biodiversity is a significant representation of the regional estuarine vegetation. Such biodiversity has an important role in the Ross Creek ecosystem and has interest for the general public being easily accessible for educative and aesthetic reasons.

There are two important areas of estuarine vegetation for management:

1. The fringe mangrove vegetation upstream from the rail yards to Bicentennial Park (Plates 5 and 6). These stands have taken 20 years for mature re-establishment, mainly by the pioneering species *Avicennia marina*, since the destruction of the creek surrounds in the 1960's and 1970's. Other species, such as *Rhizophora stylosa,* are more prevalent in the few remnant areas that escaped land reclamation such as around the mouth of Woolcock Canal, and the old "island" that is bisected by Queens Road (Figures 20 and 21).

2. The large and original stand of mangroves and salt-marsh vegetation (~4.5ha) on the south bank of the creek adjacent to the Maintenance Rail Yards (Plates 14 and 15). This system has the full variety of all estuarine vegetation found in Ross Creek and contains most estuarine vegetation found along Ross River. It is a highly significant area for its biodiversity, educative and aesthetic values and is potentially very accessible to the community (Figure 20).

   This area is threatened by continuous land reclamation by Queensland Rail (approximately ¾ hectare has been "reclaimed" recently) and, once the railways relocate by the new development options encouraging major structural changes within, and around, the current mangrove system.

(b) Mangrove Rehabilitation and Establishment

The areas of mangroves which occur on steep banks and undergo full tidal fluctuation often experience serious bank erosion and destabilisation. An area of particular note is sections along the south bank from Boundary Street to the edge of the maintenance rail yards. This area requires a mangrove and bank rehabilitation strategy as there are likely to be several detrimental consequences in the near future. The first is the loss of the vegetation and soil from the vulnerable areas particularly in times of heavy rain and stormwater runoff. Such bank erosion would cause ugly scars on the creek edge, contribute to further bank erosion, and possibly expose and release the rubbish deposited in the Reid Park dump. The second consequence involves the release of

considerable amounts of sediment into the creek which may not flush into Cleveland Bay but accumulate in strategic boating areas causing inconvenience to the creek users and great cost to the council in dredging blocked channel areas.

Some areas around the city centre could establish mangrove communities for the purposes of improving some unsightly mudflat areas and softening the harsh and unattractive concrete and rock walls that line the creek. Such areas could include the boat ramps between the Maritime Museum and Archer Street, from the River Quays development to Victoria Bridge, along the concrete walls of Hanran and Central Parks, and the new development to take place at the northern rail yards. Establishment could also be encouraged around areas in the upper stretches of the creek especially where there are poor or negligible mangrove stands. Of particular note are the areas around Boundary Street causeway and the Bicentennial Park ponds. Establishment and rehabilitation of salt-marsh vegetation should be undertaken around the Sandy Creek crossing "island".

One area where change of the natural vegetation should take place is the open drain/inlet area at the end of Summerfield Street (Figure 21). The top end of the inlet is mostly salt pan with a small patch of mangroves on the branch behind the Summerfield Street houses. These mangroves grow in a dank and smelly pool and the area is used as a dumping ground for garden waste. Local residents regard this area as a sand-fly breeding ground and mosquito habitat. Mangrove species have tried to establish along the salt-pan areas but are cleared regularly by the local residents.

(c) Non-Estuarine Vegetation

The non-estuarine vegetation is made up of mostly introduced exotics and clump planting of native species. Such plantings are attractive, stabilise the surrounds, and provide a good habitat for many bird species (Plate 13). However, the creek as a whole from Lowths Bridge to Ross River needs a more comprehensive planting strategy if the resource potential of the creek is to be fully enhanced. Such a strategy could include aesthetic, recreational, educational, biodiversity, and structural components to suit the existing and future land-uses around the creek, and be might aim to encourage high quality inner city living.

(d) Exotic Weed Control

Exotic weeds have become established around the creek and are likely to become a major problem as they continue to spread around the creek environment. The exotic grasses are mostly kept mown and may be easily shaded out once trees are established. However, the strip of Guinea Grass left along the edges of the mangroves after cutting infringes on the natural vegetation and is unsightly, a fire hazard, and has negative environmental impact. Woody weeds such as *Leucaena leucocephala* and *Parkinsonia aculata* are also a significant problem around and along the edges of the creek. These plants are well adapted to this environment and will spread rapidly to an extent that will be costly and difficult to control.

6.2.3 Managing Fauna Biodiversity

(a) Birds

The bird fauna is an important component of the Ross Creek environment and its enjoyment. A rich bird life with a compatible habitat central to the city can reduce insect pests, control pathogens, ameliorate vegetation diversity, greatly enhance the inner city aesthetics and foster a general quality of living that is needed in heavily developed urban areas. Numbers of birds and bird species are likely to increase if the diversity of vegetation is enhanced. Much of the bird fauna around Ross Creek is dependent on the mangrove ecosystem. Preservation of this habitat ensures continued health to the rich variety of fauna found, and which could be found, along the creek. Mudflats (discussed below) are also very important habitats for wading birds.

(b) Marine Fauna

The importance of maintaining the current diversity of marine fauna should be recognised in Ross Creek and its associated waterways. Provision for the maintenance and enhancement of mudflats and estuarine vegetation, especially mangroves, will ensure habitats exist for fish and marine invertebrates. Reducing and containing pollution, particularly in the lower reaches of Ross Creek, will lessen impacts on fish and benthic communities.

(c) Mudflats

The mudflats along the creek are an integral part of the estuarine system and require protection as a significant wildlife habitat. These mudflats are important feeding sites for populations of wading birds such as egrets, ibises, plovers and curlews, which forage for the marine organisms that inhabit the mudflats (Plate 11). Swimming and diving birds, such as cormorants, terns and seagulls, also scavenge around the mudflats or use them as resting places between feeding periods. The mudflats also provide a habitat for numerous species of marine invertebrates that burrow into the mud such as oligochaete worms, crustaceans, molluscs etc. Many bait fishermen find the greatest proportion of bait around the edges of mudflats.

6.3 Pollution Considerations

The Townsville City Council's Environmental Conservation Strategy recognises the need to anticipate and prevent solid waste and water pollution, and encourage an urban life-style that reduces pollutant production.

Various objectives must be set within a total management plan for Ross Creek to reduce the impact of liquid and solid waste pollution. Environmental value and status of the creek has been established by this study which allow these objectives to be determined. One of the most significant objectives is achieving ecosystem protection guidelines for water quality. This will work towards sustaining biodiversity and maintain the aesthetic appeal of the creek. Provision of an unpolluted and unlittered habitat will ensure clear feeding areas for marine life and birds.

Water quality guidelines for recreational use and the protection of ecosystems (marine) have recently been compiled by the Australia and New Zealand Environment and Conservation Council and the Australian Water Resources Council as part of a jointly developed National Water Quality Management Strategy. The maximum allowable levels of various pollutants to protect the above-mentioned environmental values are listed in ANZECC (1992 - see Table 2.1, p2.3).

Many organic pollutants, which occur in urban stormwater runoff and industrial pollutants, have no recommended guideline value as yet. For the protection of Ross Creek, however, detectable quantities of organic contaminants should be treated as significant, the source located and remediation exercised.

Many pollutants (trace metals and organics) accumulate in the tissues of aquatic organisms, especially sedentary species. The inclusion of such animals in a monitoring program, particularly in the environs of the harbour, would greatly enhance the scope of such a program detailing the presence and/or extent of trace pollution in Ross Creek. *Telescopium telescopium* is a mollusc present in Ross Creek which could be used for this purpose.

Sediment quality is also an important management issue as a majority of the chemical pollutants only remain within the water column for a short period of time before falling to the sediment. The sediment-bound pollutants may not affect the water column and remain inert until disturbances such as dredging occur. Monitoring pollutant loads within the sediment is recommended, and in the interim, management (TPA, QDEH etc.) should aim to reduce the inputs of pollutants via

drainage and spillage to the sediment.

Solid waste, particularly in the form of commercial and domestic litter, needs to be controlled and managed in a way to prevent the fouling of the waterways and creek banks as is evident today. There is an immediate need for a major clean up of all the current accumulated litter around the creek. This type of pollution was a major "dislike" listed by the creek users surveyed.

For the control of solid waste entering Ross Creek, future management needs to consider means by which litter can be trapped during storm surges, and the regular maintenance and cleaning of these traps. Prevention of illegal dumping also needs to be strictly enforced.

7. BIBLIOGRAPHY

Arthington, A.H., McKay, R.J., Russell, D.J. and D.A. Milton (1984) Occurrence of the introduced cichlid *Oreochromis mossambicus* (Peters) in Queensland. *Australian Journal of Marine Freshwater Research* **35**: 267-272.

Australian and New Zealand Environment and Conservation Council (ANZECC) (1992) *Australian water quality guidelines for fresh and marine waters*, Australian and New Zealand Environment and Conservation Council, Melbourne.

Beumer, J. (1971) *A Preliminary Investigation of the Trophic Ecology of Four Fishes from a North Queensland Mangrove Swamp*. B.Sc. Hons. Thesis, James Cook University of North Queensland, Queensland.

Beumer, J. (1976) *The Fishes of a Tropical River with Emphasis on the Spangled Perch,* Therapon unicolor*, Gunther, 1859, and the East Queensland Rainbow Fish,* Nomatocentris splendida*, Peters, 1866*. Ph.D. Thesis, James Cook University of North Queensland, Queensland.

Cabanban, A.S. (1991) *The Dynamics of Leiognathidae in a Tropical Demersal Ichthyofaunal Community*. Ph.D. Thesis, James Cook University of North Queensland, Queensland.

Campbell, G. (1977) *A Comparative Study of the Distribution, Physiology, Morphology and Behaviour of five Sesarminae species occurring along the Ross River Estuary, Townsville*. M.Sc. Thesis, James Cook University of North Queensland, Queensland.

Commonwealth of Australia (1991) Ecologically Sustainable Development Working Groups - Final Report - Agriculture, Canberra.

Draper, M.R. (1975) *Environmental Influences on the Life Cycles of Barnacles in Ross River Estuary*. Ph.D. Thesis, James Cook University of North Queensland, Queensland.

Forstner, U. and G.T.W. Whittman (1981) *Metal Pollution in the Aquatic Environment* (2nd ed.) Springer Verlag, Berlin.

Gibbs, R.J. (1993) Metals of the bottom muds in Townsville Harbour, Australia. *Environmental Pollution* **81**: 297-300.

Gillespie, Peddle and Thorp Pty. Ltd. (1993) *Draft Townsville City Centre Streetscape Strategy.* Prepared for the Townsville City Council, Brisbane, Queensland.

Grigg, H. (1972) *The Taxonomy and Distribution of Pseudodiaptomus (Copepoda, Calanoida) in the Townsville Region, 1972*. M.Sc. Thesis, James Cook University of North Queensland, Queensland.

Hoedt, F.E. (1984) *Aspects of the Biology of Anchovies (Pisces: Engnulidae) from the Waters of Cleveland Bay, Townsville*. B.Sc. Hons. Thesis, James Cook University of North Queensland, Queensland.

Jackson, G.D. (1991) *Age, Growth and Population Dynamics of Tropical Squid and Sepoid Populations in Waters off Townsville, North Queensland, Australia*. Ph.D. Thesis, James Cook University of North Queensland, Queensland.

Knight, J. (1994) *Ross Creek and Environs (Townsville City), North Queensland*. A submission to the National Toxic Network Information System, Canberra.

Milward, N.E. and A.C. Webb (1990) *The Status of the Introduced Tilapia Species* Oreochromis

mossambicus *in the Townsville Region: Distribution, Feeding and Reproduction*. A report to the Townsville City Council, Zoology Department, James Cook University of North Queensland, Queensland.

Mitchell, R.L. (1989) *Aspects of the Biology of Intertidal Mud Snails of the Genus Nassarius (Family Nassariidae, Order Neogastropoda)*. B.Sc. Hons. Thesis, James Cook University of North Queensland, Queensland.

Mueller, C. (1986) *Biology of the Pacific Blue-Eye,* Psuedomugil signifer*, Knur (Teleosteii, Melanotaeniidae) from Fresh and Saltwater Habitats in North Queensland*. B.Sc. Hons. Thesis, James Cook University of North Queensland, Queensland.

Ove Arup and Partners (1993) *Townsville Railway Land Use Study*. Prepared for the Department of Transport, Queensland Rail and Townsville City Council, Townsville, Queensland.

Penridge, L.K. (1971) *A Study of the Fish Community of a North Queensland Mangrove Swamp*. B.Sc. Hons. Thesis, James Cook University of North Queensland, Queensland.

Queensland Department of Environment and Heritage (1993) *Water Quality Data Report, Queensland January 1988 to December 1991*. Environment Data Report No. 4. Queensland Department of Environment and Heritage, Brisbane, Queensland.

Ross River Aquatic Park Development Committee (1986) *Ross River Recreation Master Plan* Prepared by Landplan Studio Pty. Ltd., Townsville, Queensland.

Smith, J.D., Hauser, J.Y. and J. Bagg (1985) Polycyclic aromatic hydrocarbons in sediments of the Great Barrier Reef region, Australia. *Marine Pollution Bulletin* **16(3)**: 110-114.

Straughan, D. (1968) Ecological aspects of serpulid fouling. *Australian Natural History* **68**: 59-64.

Straughan, D. (1972) The influence of seasonal rainfall and water temperature on the population of *Mercierella enigmatica* Fauvel (Annelida : Polychaeta) in the Ross River Estuary, North Queensland. *Journal of Experimental Marine Biology and Ecology* **9**: 165-172.

Straughan, D. (1973) Control of marine fouling in a water cooling system in tropical Australia. In: *Proceedings of the 3rd International Congress on Marine Fouling*, R.F Acker (Ed.), October 2-6, 1972, Gaithersburg, Maryland, USA. pp. 880-897.

Taylor, H.J. (1980) *The History of Townsville Harbour (1864-1979)*. Prepared for the Townsville Harbour Board, Brisbane, Boolarong Publications, Queensland.

Townsville City Council (1993a) *Draft City of Townsville Planning Scheme: Development Control Plan No. 1,* Townsville City Council, Townsville, Queensland.

Townsville City Council (1993b) *Development Control Plan No. 4, South Townsville Inner City Village*, Townsville City Council, Townsville, Queensland.

Townsville City Council (1993c) *Living Today for Tomorrow: an environmental conservation strategy for Townsville*. Townsville City Council, Townsville, Queensland, 56pp.

Townsville Port Authority (1994) *Draft Port Plan*. Townsville Port Authority, Townsville, Queensland, 39pp.

Volker, R.E., Brodie, J.E. and R.M. Larsen (1990) Keyatta Park Ornamental Lakes Water Quality

Investigation. *Australian Centre for Tropical Freshwater Research Technical Report No. 90/07*, ACTFR, James Cook University of North Queensland, Queensland.

Warbuton, N.J. (1978) *Field Observations on Behavioural Isolation in the* Uca *species of Ross River Estuary*. B.Sc. Hons. Thesis, James Cook University of North Queensland, Queensland.

Witney, E. (1991) TBT in antifouling paints - a Queensland perspective. *Queensland Department of Primary Industry Information Series*, Queensland Department of Primary Industry, Brisbane, Queensland, 57pp.

Yap, M.R.S. (1990) *The Biology of Sciaenidae in Cleveland Bay, North Queensland*. M.Sc. Thesis, James Cook University of North Queensland, Queensland.

Zann, L. (1975) *The Biology of the Marine Fouling of Tropical North Queensland*. A Report to the Department of Defence, James Cook University of North Queensland, Queensland.

8. APPENDICES

APPENDIX A

THE ADVERTISEMENT FOR PUBLIC SUBMISSIONS PUBLISHED IN THE TOWNSVILLE BULLETIN, FEBRUARY 5, 1994, P.8.

APPENDIX B

LETTERS AND QUESTIONNAIRES DISTRIBUTED TO KNOWN AND POTENTIAL USERS OF ROSS CREEK AND RESIDENTS WHOSE HOMES BACKED ONTO THE CREEK

APPENDIX C

QUESTIONNAIRE USED IN THE RANDOM TELEPHONE SURVEY TO 100 PERSONS IN TOWNSVILLE

APPENDIX D

PLATES