LESCHENAULT INLET MANAGEMENT AUTHORITY

REPORT TO THE COMMUNITY 1995

WATERWAYS COMMISSION

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1995

Waterways Commission
216 St Georges Terrace
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Report No 56,
June, 1995

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LESCHENAULT INLET MANAGEMENT AUTHORITY

The membership of the Leschenault Inlet Management Authority during the 1994/95 year consisted of the following people:

Sir Donald Eckersley, OBE	Community Member	Chairman
Mr Roger Glover	Community Member	Deputy Chairman
Cr Michael Bennett	Shire of Dardanup	
Cr Graham Bricknell	City of Bunbury	
Mr Derrick Brown	Community Member	
Mr Geoff de Chaneet	Department of Agriculture	
Mr John Evans	Community Member	
Mr Domenic Figliomeni	Bunbury Port Authority	
Dr Ray George	Community Member	
Mr Jim Muir	Community Member	
Cr Kevin Ryan	Shire of Dardanup	
Cr Maidee Smith	Shire of Harvey	
Mr Don Spriggins	Department of Conservation and Land Management	

FOREWORD

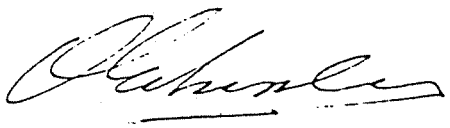
This is the first *Report to the Community* from the Leschenault Inlet Management Authority (LIMA), and follows on from the information leaflet series on Status of Leschenault Waterways which has been produced in previous years. It is our intent to prepare a similar report to the community each year.

This Report explains all the work and operations of the Waterways Commission LIMA in the Bunbury region over the last 12 to 18 months. The report also includes descriptions of publications and general reports prepared by the Commission on waterways management and environmental studies which are available to the public through the LIMA office. You are encouraged to review these reports, which are available free of cost from the LIMA office.

There is a reasonable level of technical detail in parts of this report, and LIMA would like feedback on how this is received by the community. We would like to hear from you about your reaction to the detail and content of the report, so it can be improved for next year.

For the last 17 years, LIMA has worked with the local community to improve water quality and provide facilities for the community to use and enjoy the local waterways. The current review of the water industry by the State Government includes changing the way waterways are managed by integrating the overall management of water resources and waterways into one statewide organisation. The final picture of how this department will operate is not clear at this time, however we are confident that local community involvement in waterways management will be retained in the form of LIMA.

There is much more work to do before we can say that all water quality issues are under control. I trust that this report clearly illustrates LIMA's contribution to the protection of the Leschenault waterways, and that with the continued support of the community we will progress the protection of the waterways in the future.



Sir Donald Eckersley, OBE

Chairman
Leschenault Inlet Management Authority

THE YEAR'S HIGHLIGHTS

- Completion of the report on annual nutrient loads to the Leschenault Estuary
- Completion of the report on macrophyte abundance and distribution in Leschenault Estuary
- Completion of a study on foreshores on the Collie and Brunswick rivers identifying waterway and community recreational values of these foreshores
- Release of the Cathedral Avenue Planning Study identifying planning issues for the Cathedral Avenue estuary flats, and incorporation of the planning strategy into the Shire of Harvey District Planning Scheme No1
- Commencement of a comprehensive water quality monitoring program for the estuary and rivers
- Completion of the management plan for Lot 131 Clifton Park, and formation of a community management committee for the Lot 131 reserve on the Collie River foreshore
- Release for public comment of the draft foreshore management plan for the Collie River foreshore at Eaton
- Consultation with the community on the proposal to increase the management area for LIMA to coincide with the catchment area of the estuary, up to the Wellington Dam on the Collie River
- Assisting the Shire of Donnybrook/Balingup with river improvement works in the Preston River within the Donnybrook townsite
- Construction of river foreshore boardwalks and viewing platform on the Collie River
- Provision of 32,000 tree seedlings to farmers and community groups in the catchment
- Support for other waterways within the South West region

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1. MANAGING THE WATERWAYS

1.1 Summary

The Leschenault Estuary has enjoyed generally good water quality in the last year, mostly as a result of the marine water flushing provided through the Cut. Recent monitoring has shown however, that this water quality may be short lived, and in the longer term the Leschenault Estuary and its associated rivers may suffer increased algal blooms similar to the Swan/Canning system and the Peel/Harvey Estuary.

LIMA has commenced a water quality monitoring programme to determine the current state of health of local waterways, their ability to support basic ecosystem functions, and to establish trends in water quality over time.

Scientific reports have been produced by the Waterways Commission on the annual nutrient loads to the Leschenault Estuary and the macrophyte abundance and distribution in the Estuary, to promote understanding of waterways processes.

Recently LIMA have been able to monitor general water quality conditions through the services of an Environmental Officer. Result indicate that more research is needed to fully understand the processes which bring sediments, nutrients and organic material into the estuary and rivers. The nutrient studies carried out from 1984 to 1992 have provided estimates of 610 tonnes of nitrogen and 51 tonnes of phosphorous entering the waterways each year. Currently there is no knowledge of what happens to these nutrients or where they go. Research into the final destination of nutrients and sediments out of the catchment is required, to provide LIMA with information on measures needed to maintain good water quality conditions in the estuary and rivers.

LIMA is working closely with the Leschenault Catchment Coordinating Group to promote catchment management principles in land use, and raise the catchment community's awareness of the relationship between activity on the land and the resulting water quality in nearby rivers and estuary.

LIMA has expanded its influence over the last ten years, to be more involved with planning and development matters around waterways. The growth in residential and industrial land use in this region has brought intense pressures on local waterways. LIMA has influenced this growth by providing recommendations to planning and decision making authorities on planning and development referrals, and by assisting local government authorities with the preparation of management plans for foreshore areas.

Management plans for the Collie River foreshore at Clifton Park and Eaton have been prepared and endorsed by the community, and LIMA is currently preparing management plans for the Collie River islands, the northern estuary foreshore, and the Collie River foreshore at Millar's Ford, Burekup.

LIMA has constructed boardwalks and viewing platforms along the Collie River foreshore at Clifton Park and Eaton to improve public access to the river, and increase the community enjoyment of the foreshores. Our field activities have included cleaning rubbish and debris from rivers and estuary foreshores, cleaning algae accumulations from small boat access channels, maintaining retaining walls, boardwalks and jetties for public access, and providing and maintaining signs and barrier fencing to protect sensitive waterway and foreshore areas.

1.2 The background to LIMA

This section provides a short description of how waterways management issues and community direction has helped LIMA to evolve, and to be doing the things it does.

The Leschenault Estuary, Inlet and associated rivers provide a major recreational focus for the population of the Bunbury region. The waterways are an important part of the eco-system for many plants and animals, and have significant conservation value.

Some of the important studies which have influenced the development of LIMA include the original fact finding study and Management Programme prepared in 1979. These studies identified significant pressures on the waterways, including riverbank erosion, recreational usage of the estuary and foreshores, development of land adjacent to waterways, nutrient input into waterways leading to algal growth problems, and the need to provide for public access to waterways.

The Management Programme was revised in 1992 to focus more closely on matters affecting waterways, and a comprehensive list of recommendations were prepared addressing issues relating to landuse and waterway planning, conservation and environmental protection, recreation and tourism, public education, navigation and boat safety, fishery management, liaison and coordination with other agencies and local government, and management structure and responsibilities.

Studies carried out during the 1980's have shown that there is significant nutrient input into Leschenault waterways each year. In addition, the growth of the Preston River delta over the last 20 years indicates that sedimentation within the estuary and rivers is an issue which requires investigation and understanding.

The issues facing waterways management in the 1990's still relate to preserving good water quality, carrying out investigations and research to fully understand waterways processes, managing people use of waterways, and controlling development pressures so that public access, recreational values and eco-system functions are maintained.

1.3 LIMA's early history

Coordinated management of Leschenault waterways started in April 1965 with the establishment of the Bunbury and Districts Water Advisory Committee formed by local authorities to address issues relating to waterways. The Committee was non-statutory and relied on a cooperative approach from three local authorities, the Town of Bunbury, the Shire of Harvey and the Shire of Dardanup. By June that year it was felt that the current title of the committee was not indicative of its objectives and functions and it was decided that the committee thereafter be known as the Leschenault Estuary Conservation Committee.

At the first meeting it was agreed that membership of the committee should be comprised of one representative each from the three local government authorities, the Town Planning Commission, the Public Works Department, two engineers representing the Town of Bunbury and the Shire of Harvey, a health inspector from the Town of Bunbury and representatives from the Bunbury Harbour Board and Bunbury Chamber of Commerce. A representative from the Swan River Conservation Board was nominated as Chairman. Representatives from other bodies were to be coopted as appropriate to attend the monthly meetings.

The issues addressed by the Committee included dredging of boat channels within the estuary; foreshore improvements; erosion control; algal blooms and water quality monitoring; and the impact of subdivision and other development on the estuary and rivers.

The Leschenault Inlet Management Authority (LIMA) was established in 1977 using the provisions of the Waterways Conservation Act 1976. The creation of the Waterways Commission, Swan River Management Authority, Peel Inlet Management Authority and LIMA was a result of increasing community concern for the health of certain rivers and estuaries, and the recognition of the need for statutory control over certain activities which effected waterways. The primary role of the Waterways Commission and management authorities was to conserve and enhance the waterways and associated foreshores.

The first meeting of this group was held in April 1977 and chaired by Donald Eckersley who has been the Chairman of the Authority since that time. The Authority became fully operational in November 1977 after the proclamation of the management area.

1.4 LIMA's mission statement and key goals

1.4.1 Mission statement

The Leschenault Inlet Management Authority conserves and enhances the waterways in their management area as healthy systems in order to facilitate their sustainable uses, for the benefit of the community and the environment.

1.4.2 Key goals

Goal 1 Established measures of water quality (relating to algae, chemicals, salinity, nutrients, pH and oxygen levels) show acceptable changes relative to an established standard of acceptability.

Goal 2 More people take an interest in the health of the waterways and they are more aware of the needs and policies related to waterways.

Goal 3 More people use the waterways for passive recreation and in a responsible manner (in areas and in ways which do not degrade the environment).

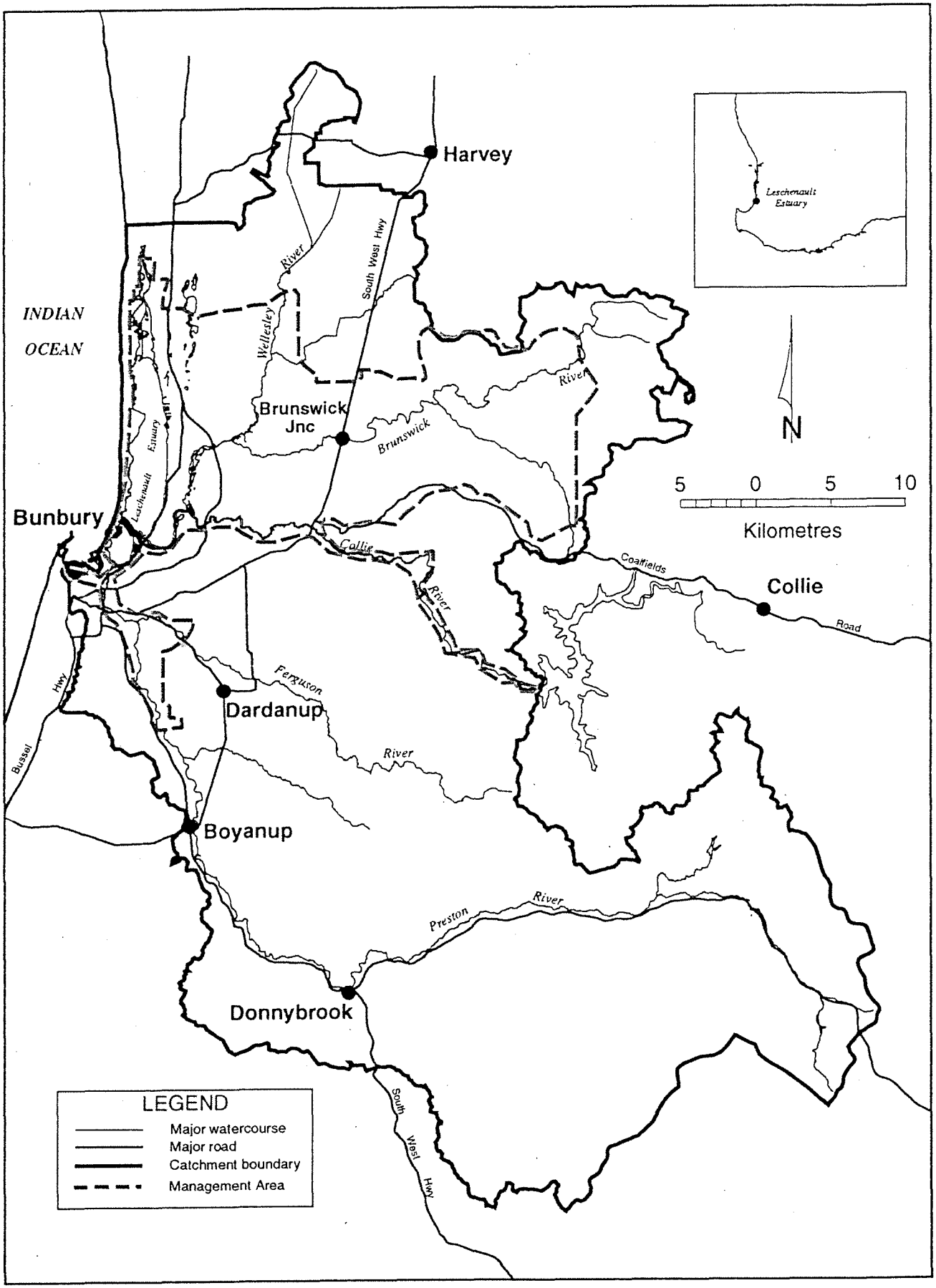
Goal 4 Instances of, and public complaints about, wildlife showing chemical or other contamination or injury from human activity have declined.

1.5 Management boundary review

During 1994, LIMA reviewed the management area boundary to determine whether the existing boundary was the most appropriate from a waterways management perspective. The latest waterways management authorities to be established in Albany, Denmark and Northam were created with waterways catchment boundaries for the management area. There is a strong link between land use activities and the health of the catchment, and the resulting health of waterways which drain the catchment area and receive surface and ground water flows.

LIMA consulted with effected local authorities, Land Conservation District Committees (LCDCs) and government agencies in the coastal plain catchment of the estuary with regard to changing the management area boundary to coincide with the catchment boundary for the Leschenault Estuary and Inlet.

FIGURE 1: Existing and proposed management area boundaries



LIMA resolved that the boundary would be limited on the Collie River to the Wellington Dam, because the dam acted as a sink and trap for nutrients, sediments and other polluting materials. This decision was also partly due to the need for comprehensive community consultation in the catchment area above the Wellington Dam if the management area was to include this catchment, and that most of the land use activities which impact on water quality in the estuary and coastal plain section of the Collie River occurs downstream of the Dam. Figure 1 shows the existing and proposed management boundaries.

All parties contacted agreed that the catchment boundary would be an appropriate management area boundary for LIMA, with the exception of the City of Bunbury. Discussions are still taking place with the City of Bunbury on this issue.

The Environmental Protection Authority is currently considering the request from the Waterways Commission to amend the management area boundary to coincide with the catchment area for the Leschenault Estuary and Inlet, up to the Wellington Dam on the Collie River. The EPA has expressed support in principle for waterways management areas to coincide with waterways catchment areas. A decision is expected during 1995.

2. STATE OF THE LESCHENAULT WATERWAYS

The Leschenault Estuary and Inlet are of significant environmental and economic value to the south west of Western Australia. The waterway and its surrounds are the hub of recreational activity in the Leschenault region. It has safe protected waters most of which are freely navigable by small pleasure craft. Much of its popularity is due to its quality as a recreational fishing and crabbing area.

The Estuary contains a diversity of ecologically important habitats including seagrass beds, tidal mud, sand flats, salt marshes, fringing sedge lands, heathlands and *Melaleuca* forest vegetation, along with their associated biodiversity. The Inlet also contains small remnant stands of the grey mangrove, *Avicennia marina*. The areas of aquatic vegetation and mangroves are nursery areas for fish and invertebrates, many of which are important to the recreational fishing industry. The Leschenault Estuary continues to be a healthy, biological productive waterway with relatively low algal growth.

2.1 General water quality

Water quality monitoring during 1993-94 was undertaken in the Collie River, however there was no water sampling carried out in the Estuary, Inlet or other river systems. Overall, general impressions indicated that water quality was good. The short monitoring programme carried out in the estuarine reaches of the Collie River showed some of the physio-chemical and biological signs of enrichment with excessive loads of nutrients. Between April and May 1994 phytoplankton blooms of *Cryptomonas sp* and *Heterosigma akashiwo* occurred in the Collie River near its confluence with the Brunswick River.

Routine water quality monitoring of the estuarine and catchment sections of the Estuary and Inlet, Collie, Preston, Ferguson, Brunswick and Wellesley Rivers began in November 1994 and has continued into 1995. Water quality in the catchment and estuarine reaches is generally good.

The Collie River has been stratified for much of the year, with layers of fresh water near the surface and more saline water on the bottom, with little exchange of oxygen between the layers. Oxygen levels in the Collie were very low to negligible in the bottom layer of water near the substrate. This can cause nutrients to be released from the sediments into the bottom layer of the water column.

Three temperature inversions have been recorded in the estuarine reaches of the Collie River. These inversions have direct implications for phytoplankton blooms, as the inversions release nutrients from the bottom layer to the surface layer and increases nutrient availability for phytoplankton. Weekly phytoplankton sampling in the estuarine sections of the Leschenault catchment began in March 1995. Results indicate that the Brunswick River is more eutrophic (higher nutrient levels) than the Collie River, the Preston River, the Leschenault Estuary and Inlet respectively. Small to medium phytoplankton blooms have been recorded in the Brunswick River, Collie River and Estuary in April 1995. The estuarine sections of the Brunswick and Collie Rivers are dominated by Cryptomonads and diatoms, while the Estuary is dominated by the marine/estuarine diatom *Rhizosolenia setigera.*

2.2 Algae bloom and seagrass conditions

2.2.1 Seagrass and macroalgae

The growth of seagrass and large algae (macroalgae) in Leschenault estuary varies from year to year but is not showing any long-term trend. Seagrasses make up to 10-40% of the large plants in the estuary. Seagrass beds play an important role in providing animal habitats and stabilising the sediments. The dominant seagrass in the estuary is *Halophila ovalis* (paddleweed). An epiphytic green algae has been observed growing on the paddleweed and at present no adverse effects have been noted.

A mix of green, red and brown species of macroalgae grow in the Leschenault Estuary with an annual "crop" from 600 to 2,200 tonnes (dry weight). This diverse population of macroalgae is a sign of a healthy estuary and nuisance species such as *Cladophora* and *Enteromorpha*, which are currently causing problems in Peel-Harvey Estuary and the Albany Harbours, are at low levels.

The macroalgae *Rhizoclonium*, which bloomed and spread over an extensive area in Vittoria Bay in the Leschenault Estuary in 1990, did not bloom during the 1993 -1995 period. However, *Rhizoclonium* was noted to be increasing in the Inlet from November 1994 and an increase in nutrient levels entering the Inlet is believed to be responsible.

The green algae *Caulerpa geminarta* has been spreading throughout the Estuary over the last couple of years and the reason for this increased distribution is unknown.

2.2.2 Phytoplankton

Phytoplankton are small, often microscopic single celled plants which float or drift in the water. They feed on nutrients from the water and a dense growth or 'bloom' can turn the water green or brown. Leschenault Estuary is moderately rich in nutrients and some minor phytoplankton blooms have been observed in recent years.

In May 1993 a *Cryptomonas* algal bloom occurred in the lower reaches of the Collie River and the same species bloomed again in April 1994. A bloom consisting of *Heterosigma* and Diatoms occurred in March 1994. In the 1994-1995 season small blooms under 18,000 cells per ml occurred in the Collie River during April and May 1995. Blooms peaking up to

30,000 cells per ml were recorded in the Brunswick River in April 1995 while a peak of up to 58,000 cells per ml was recorded in the northern end of the Estuary. As in other years, the bloom took oxygen from the water when it died and decayed, causing low dissolved oxygen concentrations at the bottom of the river.

The *Cryptomonas* bloom in April 1994 was the largest ever recorded in the Collie River for that species. In January 1994 Dodson Road wetlands recorded a blue-green algal bloom consisting of *Anabaena sp* and *Oscillaria sp*. This wetland regularly blooms in the warmer months of the year due to a combination of excessive nutrients, dry winters, and a still water body.

The greatest concentrations of phytoplankton are found in the lower to middle reaches of the estuarine section of the Collie and Brunswick Rivers and in the northern part of the Estuary. At the peak of plant growth, up to 170,000 plant cells per millilitre of water have been measured in the Leschenault Estuary. This is cause for concern, however the blooms are modest when compared to densities in excess of one million cells per millilitre commonly found in the Peel-Harvey Estuary and the Swan-Canning Rivers.

In the middle and lower estuary, the phytoplankton is less numerous and is made up of a diverse group of plant species adapted to the more marine conditions.

2.3 Nutrients

The plant nutrients nitrogen and phosphorus run into the estuary from the agricultural and urban catchment and are of concern because at high levels they can feed excessive growth of algae in the waterways. Nutrient loads to the Leschenault Estuary have been monitored and show considerable variability from year to year because of seasonal differences in rainfall and streamflow. On average, around 51 tonnes of phosphorus and more than 610 tonnes of nitrogen enter the estuary each year from surface run-off from the rural catchment. It is not possible to comment on annual trends because of seasonal variability. Compared with the rural catchment, nutrient loads to the Estuary from the Bunbury urban area are considered insignificant.

Groundwater contributes very small amount of nutrients to the estuary compared with surface run off. A Geological Survey study has estimated that only 1.6 tonnes of nitrogen enter the estuary annually from groundwater on the eastern shoreline of the Estuary near Australind.

2.4 Environmental pollution

2.4.1 Heavy metals

Greenpeace alleged in March 1995 that water flowing into the Wellington Dam from the Collie River contained heavy metal and other dangerous substances. Western Collieries have been discharging water from its mine into the south branch of the Collie River near Cardiff for several decades. Results of the water tests collected from the River by Greenpeace indicate that several metals are above the acceptable limits for drinking water, and the pH of 3.5 would have adverse effects on aquatic vertebrates and invertebrates within the south branch of the Collie River.

It is believed that the Wellington Dam acts as a sink allowing contaminants to settle and sink to the bottom sediments. The Water Authority of Western Australia (WAWA) have commented that there has been no indication of heavy metals from the Collie River effecting

water quality in the Wellington Dam. Both WAWA and the Department of Environmental Protection (DEP) consider that the discharge of water does not present any immediate environmental or health concern.

The south branch of the Collie River and Wellington Dam is outside LIMA's management area, however LIMA has been sampling for heavy metals in the catchment areas of the Collie, Brunswick, Wellesley, Ferguson and Preston Rivers. To date, all results show negligible levels of heavy metals, and further monitoring will take place on a quarterly basis.

2.4.2 Giant marine fanworm - *Sabella* cf. *spallanzanii*

The CSIRO Centre for Research on Introduced Pests have completed a preliminary study of the introduced giant fanworm, *Sabella* cf *spallanzanii*, in several port areas of WA, including Cockburn Sound, Fremantle, Bunbury and Albany. A report on the fanworm is expected to be available from the CSIRO, Fisheries Division during the second half of 1995.

In early September 1994, about 30 hectares of unusual fanworms were found thriving in the shallow Southern Flats area of Cockburn Sound. The find attracted considerable attention as the species, believed to be a native of the Mediterranean, had not been previously recorded in WA. It appears to be the same species which was discovered during the mid 1980's in Port Phillip Bay, Victoria. There, the species is regarded as a pest since colonies have invaded scallop beds and now threaten the local scallop and longline fisheries.

CSIRO received a reported sighting of the giant fanworm in Bunbury in January 1995 and on investigation abundant worms were found in and around the power station water-intake enclosure. Other colonies, sometimes dense, were also found in other areas of the harbour, and also in the Leschenault Inlet.

There is strong evidence that the WA fanworms are the same as the pest fanworms in Port Phillip Bay, although this needs to be confirmed.

Little is known about the fanworm's biology, behaviour, or any likely impact it may have on West Australian native fauna, fisheries or marine environment in general. The Victorian experience however, clearly defines the species as an introduced pest and indicates that it would be unwise to ignore its presence in Western Australia. A detailed survey is needed, along with further scientific research into the species biology, to understand the full implications of the fanworm's presence in our waters.

2.5 The fishery

The numbers of crabs and fish frequenting the Leschenault Estuary varies from year to year depending upon climatic and environmental conditions. The 1992-1993 crab season was poor with some good catches noted later in the season during March and April. The crab season improved slightly in 1993-1994 and was excellent in 1994-1995 with good catches all season for both professional and amateur fishers.

The numbers and variety of species of fish within the Estuary between 1992 and 1995 were generally average with catches of leatherjackets, tailor, herring, mullet and average to poor catches of King George whiting and yellow fin whiting. The table below is a breakdown of commercial fish catches for the Leschenault Estuary. For more information on fish numbers please contact the Fisheries Department.

TABLE 1: Commercial fish catches in the Leschenault Estuary

Whole Weight in Kilograms

	92/93	93/94	94/95
Black bream	0	0	Results for this
Bony herring	8,782	1,999	year are estimated
Cobbler	761	406	to be similar to
Crabs	6,114	1,277	the 93/94 season.
Garfish	58	215	
Herring	1,728	845	
Sea mullet	26,059	20,363	
Yellow eyed mullet	41,196	47,055	
Tailor	534	113	
King George whiting	6,133	5,300	
Western sand whiting	6,648	6,637	
Total	98,013	84,210	

3. WATERWAYS PROTECTION AND ENHANCEMENT

OBJECTIVE: To protect waterways from the effects of human and other activity and provide facilities for public use.

The Waterways Protection and Enhancement programme ensures the Estuary and rivers are clean and free from hazards and pollution, rehabilitates the waterways environment and, in partnership with local government, provides facilities for community use of the waterways within the management areas. This work is often carried out in partnership with the local community, and is in response to needs and problems identified by the community, local government and LIMA.

Activities of LIMA include:

- **Waterways cleaning** which involves removing unwanted algae, rubbish and debris as well as responding to pollution incidents.
- **Protection and rehabilitation** which involves works to revegetate and stabilise waterways and to protect the foreshores from erosion.
- **Provision of facilities** which involved providing and maintaining recreational facilities (in conjunction with local government) for the public's use and enjoyment of waterways.

Actual works carried out during 1994 and 1995 include:

3.1 Waterways Cleaning

Estuary foreshores were cleaned of rubbish and small boat access channels were cleaned of algae accumulations.

3.2 Foreshore protection and rehabilitation

Under LIMA supervision a team of Year 12 students used salvaged timber from the old pipeline trestle to retain a 30 metre section of badly eroding sandbank on the Collie River foreshore at the Elbow in Australind.

Paperbarks and sheoaks were planted along the Collie River foreshore.

Landcare District Committees and community groups in the Leschenault catchment planted 20,000 trees during winter 1993, and a further 30,000 trees during winter 1994.

During 1994, the LIMA nursery produced and provided 32,000 seedlings free of charge to farmers and community groups within the catchment. The 1995 program involves about 35,000 seedlings for nursery production, to be planted in the catchment by farmers and community groups.

Community service workers spent 1242 hours working for LIMA during 1994 - preparing the nursery, planting trees, and cleaning up rubbish as well as maintaining the estuary and river foreshores and structures.

LIMA is sponsoring two field hands on a Jobskills funded traineeship this year to assist with nursery production and to maintain estuary and river foreshores.

Signs have been maintained on the estuary foreshore, with signs denoting boat channels and limits of recommended boat access in the estuary replaced and renewed.

LIMA organised tree plantings on the Cathedral Avenue foreshore, and maintained revegetation works on the estuary foreshore and Collie River foreshore by controlling weed and grass growth with slashing and mowing, and chemical spraying.

Staff carried out weed eradication works on river foreshores during the year, targeting blackberry and pampas grass along the Brunswick and Collie River foreshores. Much more work needs to be done to control these species.

LIMA staff maintained vehicles, boats and equipment, and commenced construction of a steel pontoon barge for work on the Estuary and in rivers. The barge is expected to be completed during August 1995.

3.3 Provision and maintenance of facilities

The provision of facilities by LIMA is generally in accordance with a foreshore management plan, prepared for a particular river or estuary foreshore and involving local community and local authority involvement.

LIMA has been successful in gaining Landcare and Environment Action Programme (LEAP) funding for several construction projects during 1994. With sponsorship of the project shared between LIMA and the local authority on each occasion, major projects have been carried out with only small funding contributions from each party.

LIMA and Waterways Commission staff prepared engineering design details for boardwalks, river access sites and river crossings on the Collie River foreshore at Eaton, on the Preston River foreshore in Donnybrook, and within the mangrove colony on the Leschenault Inlet foreshore.

3.3.1 Lot 131 Clifton Park - Collie River

Work has started on facilities and rehabilitation recommended in the management plan for Lot 131 Clifton Park. Worsley Alumina funded construction of a boardwalk across a large open drain and the local community helped plant more than 3,400 trees in degraded areas on the foreshore.

3.3.2 Eaton foreshore reserve - Collie River

In a joint project with the Shire of Dardanup, a 60 metre timber boardwalk has been constructed across a backwater of the Collie River at Eaton. A timber viewing platform has been constructed on a high vantage point above the Collie River adjacent to the boardwalk, and both structures have been integrated into the Shire's river foreshore walk trail. The construction of the structures was carried out using Landcare and Environment Action Programme funding, Westrek organisation and supervision, Shire of Dardanup funding and materials, and Waterways Commission funding, materials and project management.

Waterways Commission (WWC) staff prepared engineering design details for two small timber walkways across wetland areas on the Eaton foreshore near the Eaton Scout camp. These structures, when built, will include materials salvaged from the pipeline trestle removed from the Leschenault Estuary in 1992.

3.3.3 Leschenault Estuary foreshore

LIMA has maintained barrier fencing, the Estuary boardwalk and jetty and other public recreational facilities along the Estuary foreshore. Some facilities suffered damage through vandalism and required repair. Bins, seats and barbeques on the Estuary foreshore required maintenance and repair. This work is normally shared with the local authority, except where the facilities are the sole responsibility of the Waterways Commission.

3.3.4 Leschenault Inlet mangrove colony

Waterways Commission engineering staff assisted the South West Development Commission with the preparation of design details for a timber boardwalk to be built through the mangrove colony in the Leschenault Inlet.

3.3.5 Preston River Donnybrook

LIMA staff attended Donnybrook River Improvement Program committee meetings to help determine the needs of the local community. Waterways Commission engineering staff assisted the Shire of Donnybrook/Balingup with the preparation of design details for a river crossing, a gully crossing, riverbank erosion control works and a river access site within the townsite of Donnybrook. This work involved surveying sections of the river, and meeting with Donnybrook residents to determine river access requirements.

4. ENVIRONMENTAL INVESTIGATIONS

OBJECTIVE: To understand waterways and establish standards to maintain their environmental quality.

The wide range of uses to which waterways and their catchments are subjected and the pressures of increasing population and development inevitably cause degradation. To enable the waterways environment to be protected from the harmful effects of human activity and to retain their natural features wherever possible, we must study and record the elements of that environment. We must understand the normal functioning of the waterways, monitor changes and assess these against some base standards, to ensure that the waterways are safe and clean.

Major initiatives in 1994-95 have been to review and design:

- Estuarine and catchment water quality monitoring;
- Nutrient audit report on nutrient loads and trends, and a
- Macrophyte study on abundance and distribution.

These initiatives provide managers with the means to identify trends from catchments to estuaries and prepare the basis for assessing the success of current and future management measures.

4.1 Water quality monitoring program

4.1.1 The aims of monitoring

The purpose of any water quality monitoring program is to provide information to managers of waterways on ecosystem 'health'. On-going monitoring programs are designed primarily to show changes in the health of an eco-system over time. Because of the open-ended temporal dimension of a routine monitoring program it is fundamentally different from other types of environmental research which are normally of relatively short duration, normally three to five years at most.

In WA, eutrophication has been identified as the greatest threat to the health of aquatic ecosystems. The routine water quality monitoring program has been designed primarily to monitor changes in the trophic status of the Leschenault aquatic systems. The target ecosystems are the Leschenault Estuary and the river systems of the area.

4.1.2 Measures of ecosystem health

The eutrophication of aquatic systems is caused by their enrichment with plant nutrients, mainly nitrogen and phosphorus. Therefore, an obvious chemical measure of the health of the Leschenault aquatic systems is the amount of these substances in the water. Knowledge of changes in the concentration of nutrients over time is important information, especially in terms of catchment management, however, chemical monitoring programs have limitations as indicators of ecosystem condition. For example, nutrient cycling within aquatic systems is a complex process with numerous pathways, temporary storage and permanent sinks, thus, making the interpretation of data difficult. This is compounded by the fact that large time lags often exist before stress symptoms are manifest.

4.1.3 Primary production

Most of the problems associated with eutrophication are essentially biological in nature. The functional group most affected by nutrient enrichment are the primary producers. For example, severely eutrophic waters are often dominated completely by phytoplankton in the warm months. The phytoplankton are a difficult group to use as health indicators because their identification, and quantification of patchiness or spatial variation, is technically difficult. Fortunately, a good indicator of phytoplankton abundance is chlorophyll-a concentration, which is one of the photosynthetic compounds. The measurement of chlorophyll-a in water is a relatively straight-forward procedure. When nutrient availability is not limiting, temperature often controls total phytoplankton abundance and the timing of severe blooms.

4.1.4 Secondary production

Data on the types of phytoplankton present and their abundance is important for the assessment of trophic state, but it is only part of the picture. As aquatic systems become more eutrophic there are also changes in the nature of secondary productivity in the ecosystems. A good measure of secondary productivity is the presence and relative abundance of aquatic macro-invertebrate species. Information on invertebrate communities is especially valuable because they tend to be more permanent inhabitants of ecosystems and are therefore better indicators of progressive change in the health of aquatic systems than are fluctuating phytoplankton populations. Healthy ecosystems usually support a wider variety of invertebrate species. Invertebrate communities in eutrophic systems generally become simplified and contain fewer species than communities in healthy ecosystems. Some species of macro-invertebrates are sensitive to toxicants and die when exposed, thus ecosystem change may indicate the presence of pollutants other than nutrients.

4.1.5 Dissolved oxygen

The stimulation of biological productivity results in other changes in aquatic systems. The concentration of oxygen in the water near the sediments can become very low in eutrophic conditions. The mechanisms of oxygen loss includes physical, chemical and biological interactions. For example density stratification established by pronounced temperature and salinity differentials may favour the development of anoxia in bottom waters. While the average level of dissolved oxygen in enriched waters may not change significantly as eutrophication proceeds, the range or variability in the concentration of oxygen is larger in eutrophic systems (Deeley pers comm). Low oxygen concentration in water can also influence the availability of nutrients for phytoplankton growth. The regular measurement of temperature, salinity and oxygen are easy to undertake, inexpensive and can be an informative means of monitoring the overall state of aquatic systems (Derrington 1994).

4.1.6 Design of the monitoring system

The monitoring program of sampling is comprised of two integrated parts. One program is designed to regularly assess the health of the catchment's five major freshwater systems - the Wellesley, Brunswick, Collie, Ferguson and Preston Rivers. The other monitoring program will target the Estuary itself as well as the estuarine reaches of the major tributary inflows.

4.1.7 Design constraints

The major constraint in the design of the monitoring program was the limited resources available. The program needed to be small enough to be managed by one person. It could not result in an excessive amount of data which would require large amounts of time to process, analyse and draft reports. This severely reduced the number of sites selected, the frequency of sampling and the number of variables that could be measured.

4.1.8 Monitoring network in the estuarine areas

Figure 1 shows that the monitoring network in the estuary consists of a total of nine sampling sites. In the Estuary itself there are three sites located at the northern and southern ends of the Estuary basin. This provides a reasonable assessment of spatial differences within the Estuary. One site has been located in the Inlet, because it is prone to phytoplankton problems in the summer months.

There are a further five sampling sites in the estuarine reaches of the major tributary inflows to the estuary. This area of the Collie River has probably the worst water quality in the region. There have been regular severe phytoplankton blooms and monitoring to date has shown the area just below the confluence with the Brunswick River to be very low in oxygen (Waterways Commission Annual Report 1994, Derrington 1994). This has been attributed to high loads of nutrients from the northern part of the catchment (Donohue and Deeley 1994).

The quality of water in the estuarine reaches of the Brunswick and Collie Rivers above the confluence with the Brunswick, is unknown. Sampling sites have therefore been located in each these areas. The sampling site in the estuarine reaches of the Preston River provides for the comparison of water quality in each of the estuarine areas.

4.1.9 Monitoring network in the rivers

Water quality monitoring in the catchment of the Estuary is based on five sampling sites, one on each of the Wellesley, Collie, Ferguson, Preston and Brunswick Rivers. Additional sites will be added as monitoring progresses.

4.1.10 Sampling frequency and variables to be measured

The variables being measured are listed in Table 2, along with details of sampling frequency. As the table shows the frequency of sampling varies depending on the system being monitored and the variables measured.

FIGURE 2: Water quality monitoring program sampling sites

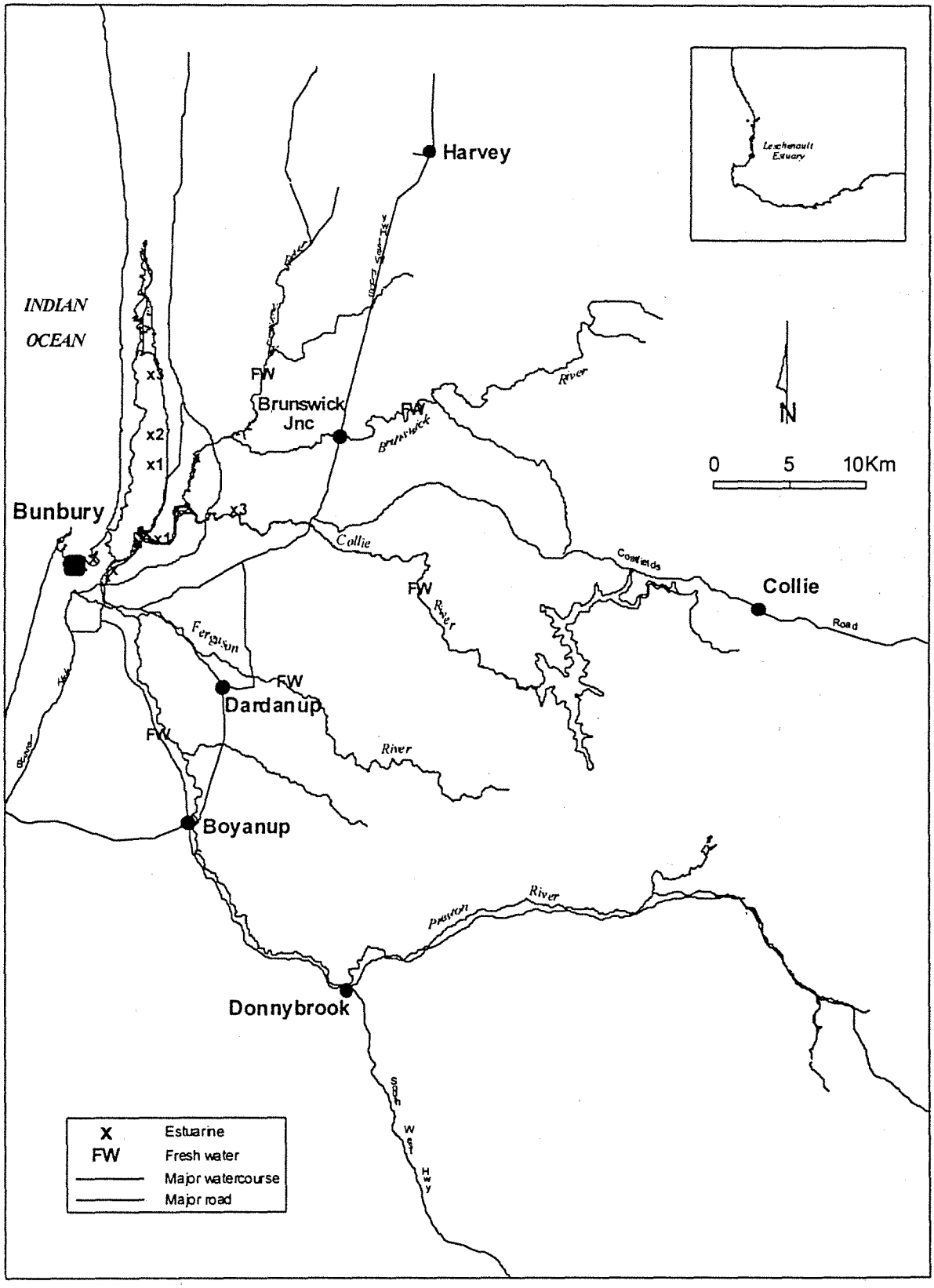


TABLE 2: List of variables to be measured and the sampling frequency for each variable.

Variable	Estuarine /River	Where measured (Field/	Sampling Frequency (Weekly/Monthly/ Quarterly)		Sampling Methods		Reason for inclusion
		Base/Lab)	Estuarine	River	Estuarine	River	
Dissolved Oxygen	E / R	F	W	M	surface 1m bottom	below surface	Standard; requirement for aquatic life; rapid indicator of organic pollution and trophic state
Salinity	E / R	F	W	M	surface 1m bottom	below surface	Indicates stratification, tidal influence and ground water
pH	E / R	F	W	M	surface 1m bottom	below surface	pH out side of 6 - 8 indicates pollution
Temperature	E / R	F	W	M	surface 1m bottom	below surface	Standard; DO interpretation; mixing; aquatic life protection and salt wedge
Secchi depth	E	F	W		secchi disk		standard; indicator of suspended material; clarity and public perception
TN, TP	E / R	L	M	M	1m or if stratified surface & bottom	between surface & 1m	Nutrient status; indicator of eutrophication
Flow strata (high, medium, low)	R	F		M		visual flow gauge	Interpretation of flow-dependent data
Tide (flow, ebb, still)	E	F	W		visual tide chart		Interpretation of data
Chlorophyll-a	E / R	L	W	M (initial)	integrated sample	integrated or surface	standard; indicator of phytoplankton density; trophic state; comparison with other systems in WA
Phytoplankton	E / R	B	M	M (initial)	integrated sample	integrated or surface	Species present; interpretation of Cl-a
Macro-invertebrates	E / R	F / B	M	M	core sample	dip net sample	indicator of water quality; WQ changes and pollution; secondary productivity

4.2 Water quality monitoring in the Leschenault catchment

4.2.1 Estuarine

The Estuary and the Inlet are both clean and well flushed. The Inlet has seen an increase in *Rhizoclonium* (green algae) since November 1994. This algae is visible at low tide and is smothering seagrass and mangrove seedlings in the area. An increase in nutrients is probably responsible for this increased growth. The Estuary is in good condition. The northern end of the Estuary becomes hypersaline in the warmer months, as this section is not well flushed and water evaporates, concentrating salts in the water body. This condition is a natural event and is reversed when winter rains dilute the salinity levels.

The estuarine sections of the Preston and Brunswick Rivers are clean and have shown only moderate signs of poor water quality over the last year. Again this year the Collie has been stratified for most of the dry season causing anaerobic conditions in the bottom layers of the water body. Stratification occurs when saltier denser water from the Estuary pushes itself underneath the brackish surface water. These two water types do not mix because of differences in the densities and oxygen levels in the water column. The Collie River this year has under gone three temperature inversions releasing hydrogen sulphite (H_2S) from the benthic sediments, along with benthic organic material/nutrients, benthic diatoms and dinoflagellates.

The Collie River has recorded low levels of oxygen at the bottom of the water column as well as warmer water. A combination of these two conditions causes the colder, aerated, fresher water on the top to become heavier than the bottom layer of water which is saltier and warmer, thus the water body "turns over" releasing benthic material to the surface. When this occurs, nutrients from the bottom become available to phytoplankton, and increased growth of phytoplankton then leads to a bloom.

Explanations for temperature inversions in the Collie are a combination of two points:

- Warmer water on the bottom of the Collie is that water moving up the salt wedge from the Estuary, while the water at the surface is colder as it comes from up stream. Since the salt and brackish waters don't mix, the temperature remains true to its original source.
- The surface water is colder as it reflects the changes in the air ambient temperature. When night falls the air temperature falls cooling the surface water, the surface water is then slowly reheated during the day. The bottom layer of water is not influenced by air temperature differences, thus it remains constant.

Hence during the night and early morning surface waters become denser than the bottom layer of water. When other factors such as depletion of oxygen in the bottom water layer occurs, the warmer, anaerobic bottom layer becomes lighter than the aerated, colder, surface water and the system turns over.

Oxygen depletion in a water body is undesirable as higher animals require oxygen and die in anaerobic conditions. Due to these inversions in the Collie River fish would have moved either up or down stream to more aerobic conditions. Furthermore, in sections of the Collie River where there has been little or no oxygen, invertebrates would either perish or move to more suitable conditions depending on their mobility.

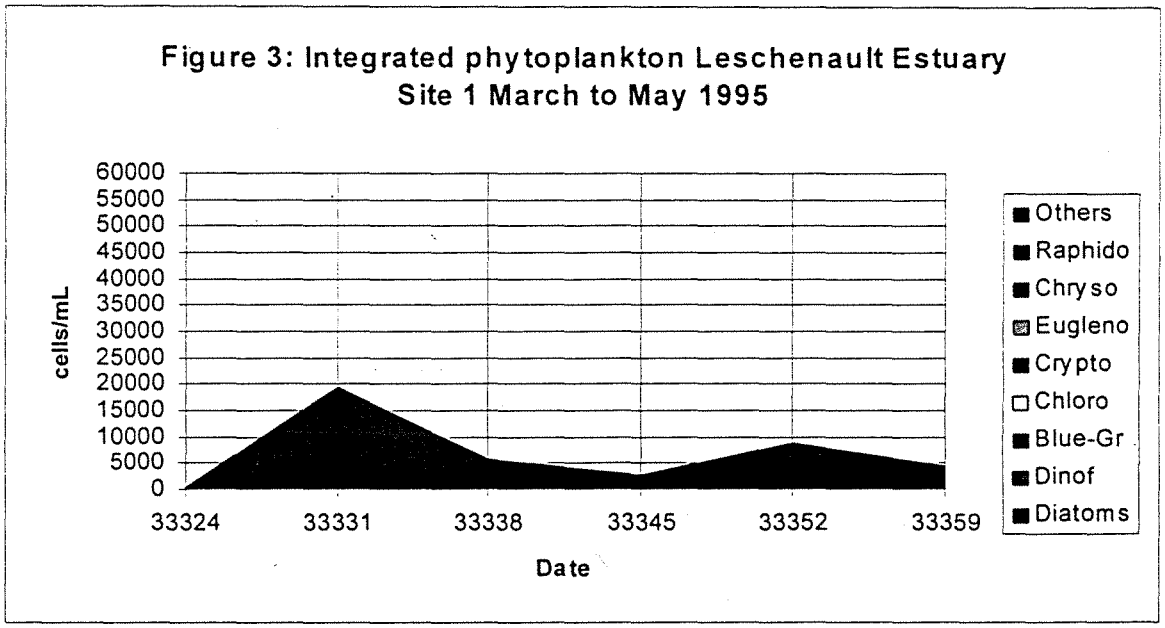
4.2.1.1 Phytoplankton

Weekly phytoplankton samples were taken in the estuarine sections of the Leschenault catchment from March 1995. A summary of a report completed by Waterways Commission staff follows.

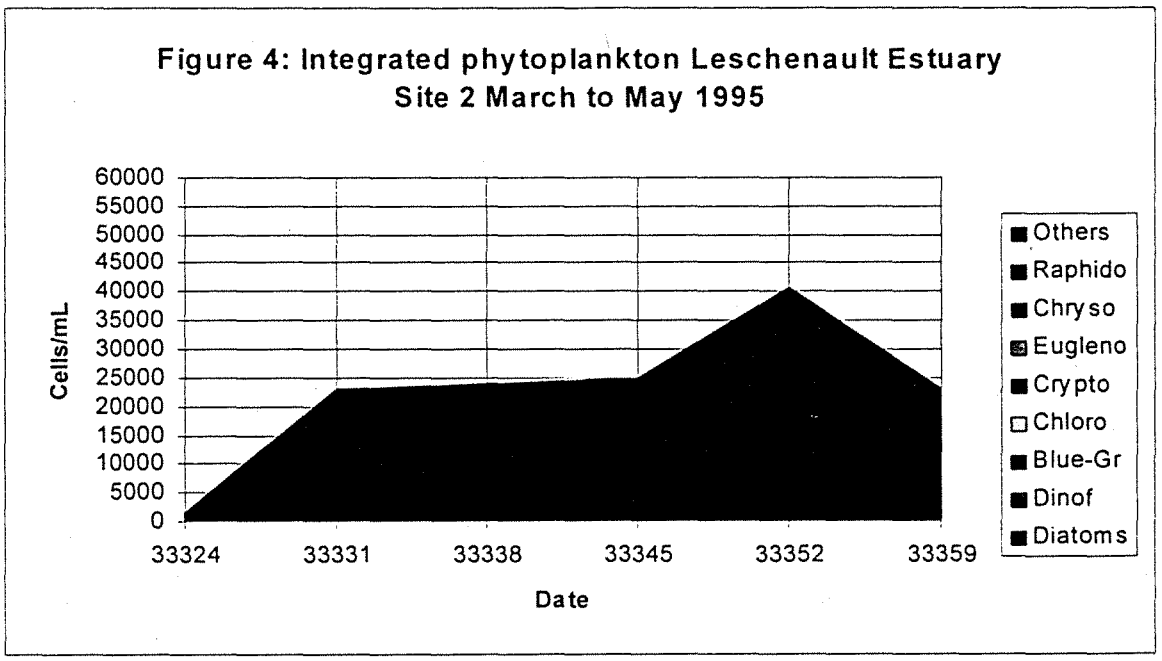
The table below compares the date codes on the following graphs to the dates on which the samples were taken.

Date Code	Date
33324	28 March 1995
33331	04 April 1995
33338	11 April 1995

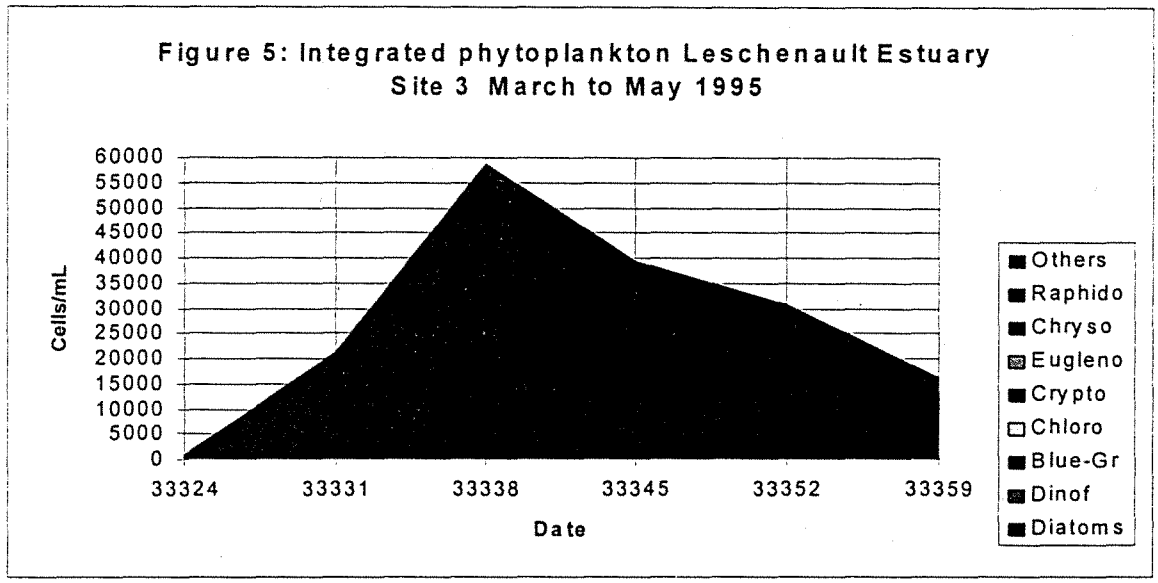
Date Code	Date
33345	18 April 1995
33352	24 April 1995
33359	02 May 1995



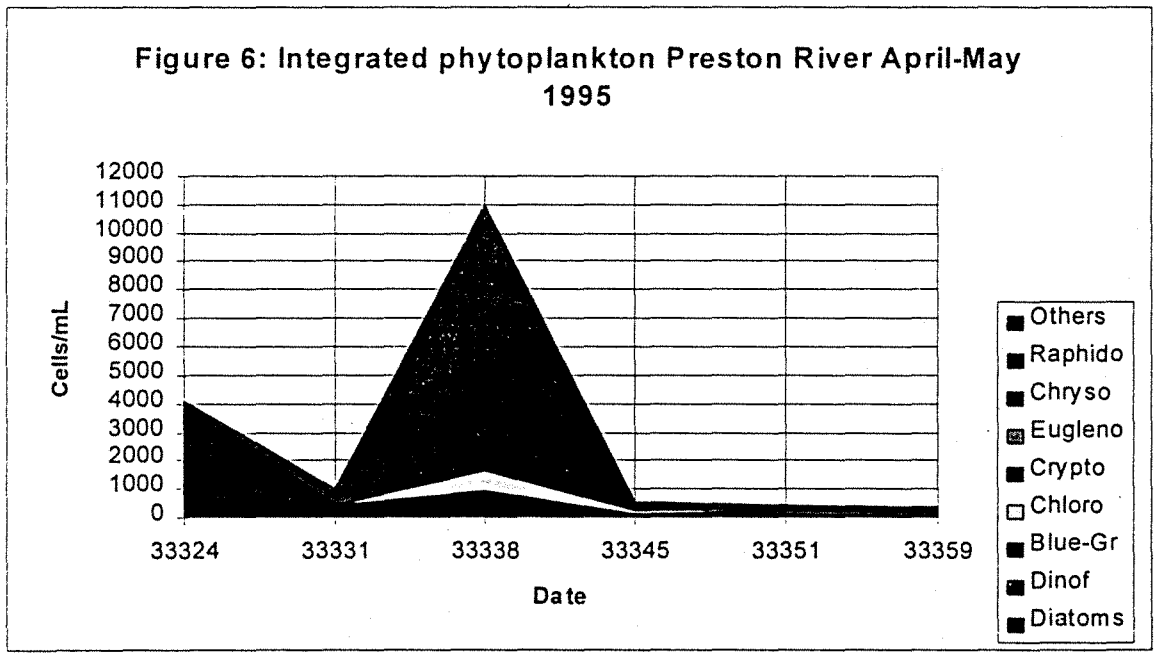
Estuary - During the sampling period the estuarine phytoplankton was dominated by diatoms. The dominant species was the marine/estuarine *Rhizosolenia setigera.* Cell density peaked at 58,000 cells/ml on 11 April 1995 at Site 3, followed by Site 2 with 40,000 cells/ml on 24 April 1995. Site 1 was consistently lower than the other sites due to the tidal influence of the 'Cut'. This species has been associated with fish gill damage, as it has fine long spines at both ends. The magnitudes of integrated phytoplankton densities of the diatom cells present at Sites 1-3 indicate a moderate bloom was in progress in April 1995. Figures 3, 4 and 5 illustrate the cell densities and composition of phytoplankton during the sampling period.



Inlet - During the sampling period phytoplankton in the Inlet was dominated by diatoms. The dominant species were the marine/estuarine species *Nitzschia, Chaeloceros, Skeletonema* and small centric diatoms of *Thalassiosira.* By 2 May 1995, there was an increase of Cryptomonads and Chlorophyte species. The phytoplankton species in the Inlet was generally low to moderate at less than 5,000 cells/ml, however, the phytoplankton densities were considered high for an open ocean water body.

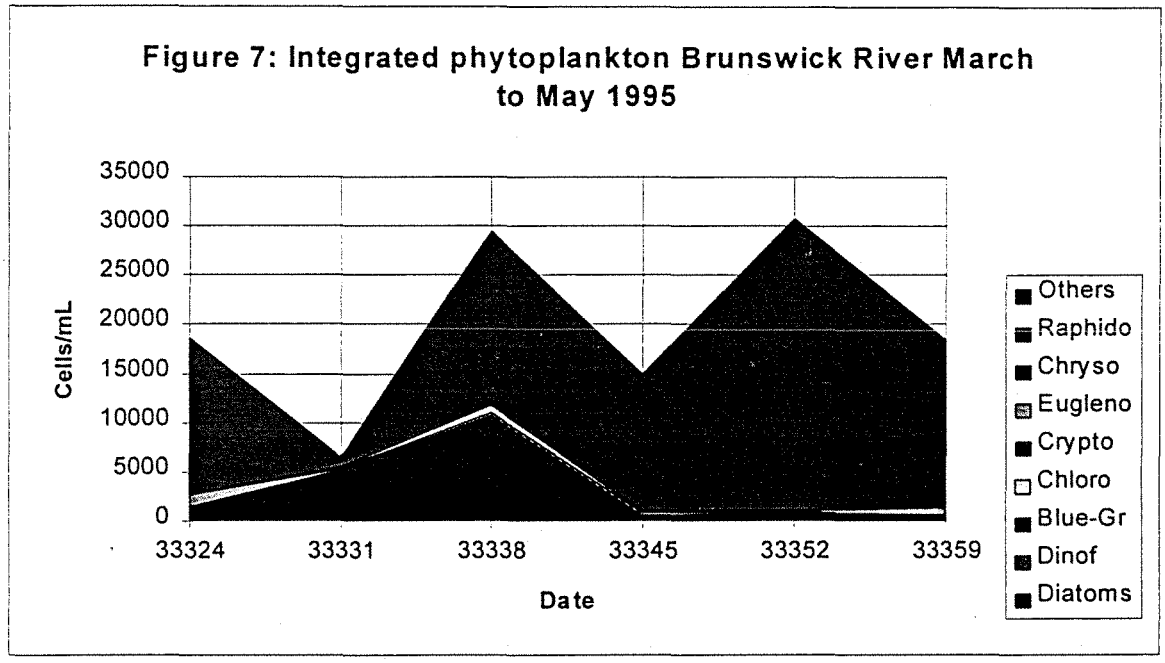


Preston River - At the beginning of sampling, cell densities were moderate at 4,000 cells/ml and were dominated by diatoms. The highest cell density was recorded on 11 April 1995 at 11,000 cells/ml and was dominated by Cryptophytes. The phytoplankton density then fell below 1,000 cells/ml and remained low.

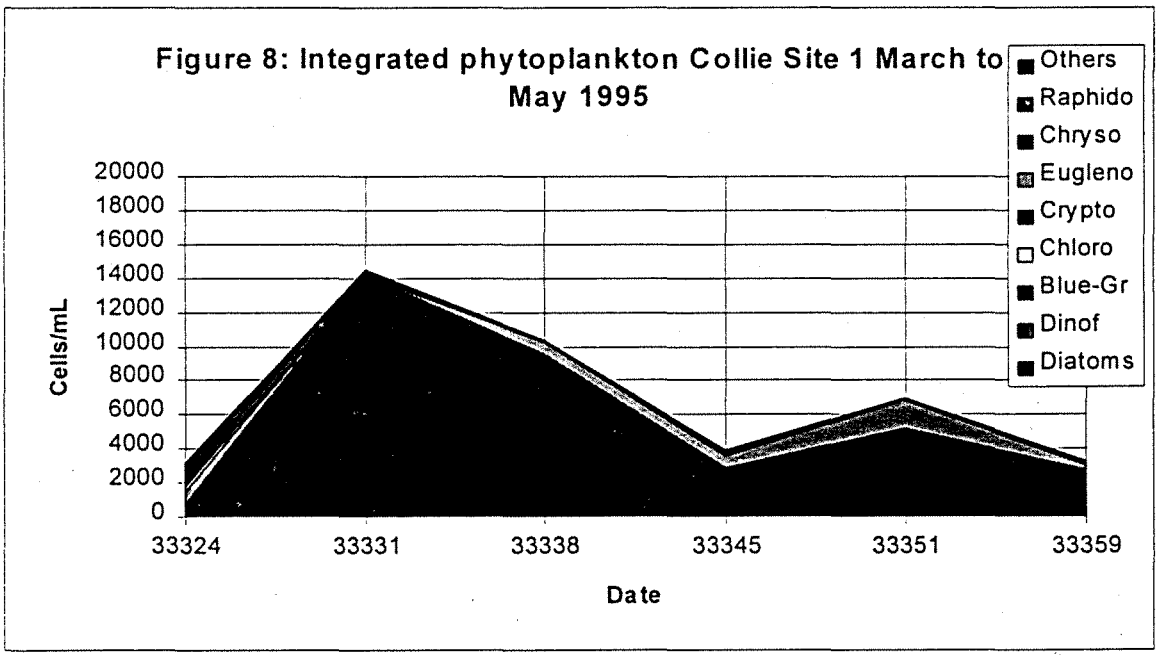


Some of the harmful Raphidophytes (*Heterosigma*) which can affect trapped fish were present in low densities. The above data indicates that the river is in good condition with a low phytoplankton biomass. Figure 5 illustrates the phytoplankton density and composition over the sampling period.

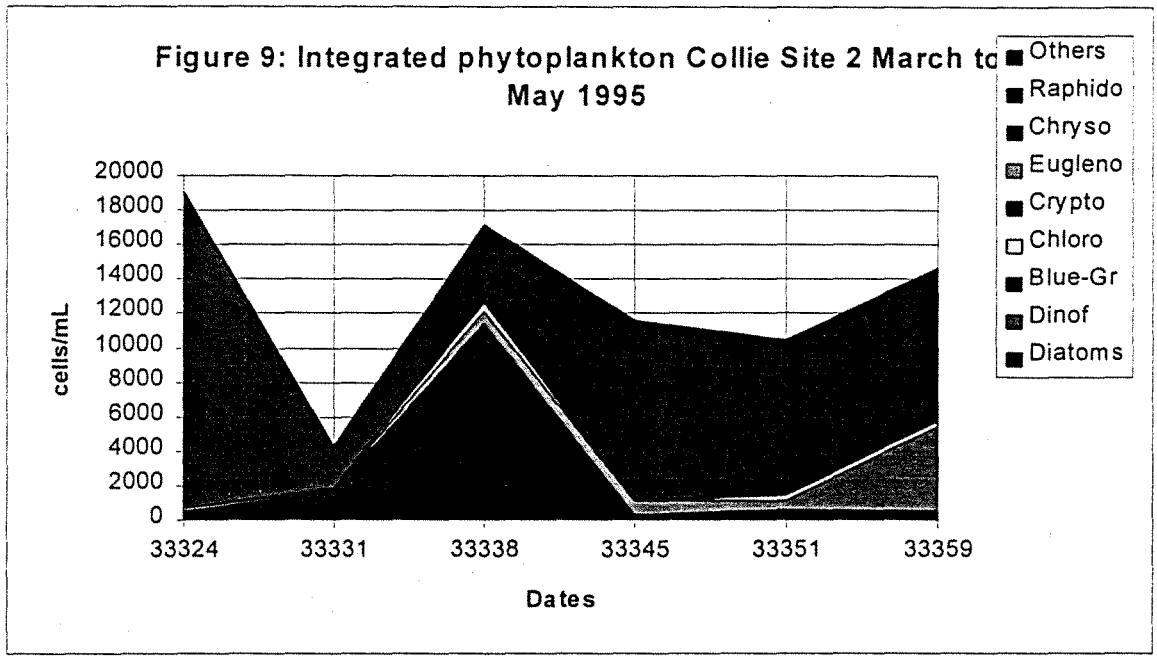
Brunswick River - At the beginning of the sampling period, the cell densities were high at 18,600 cells/ml and were dominated by Cryptomonads. Cell densities peaked twice at 30 000 cells/ml on 11 and 25 April 1995 and were dominated by Cryptophytes, *Nitzchia* and centric diatoms. The data collected indicates that high phytoplankton densities dominate the river. Figure 6 illustrates the phytoplankton density and composition over the sampling period.

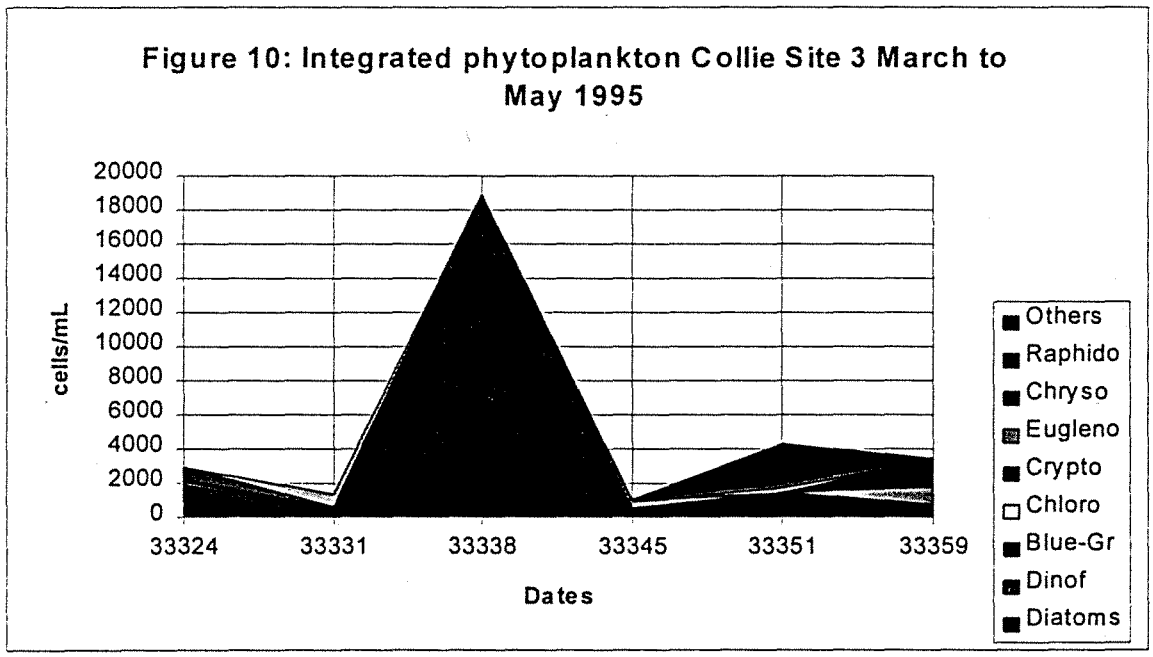


Collie River - The highest integrated cell densities over the sampling period were at sites 2 and 3 where densities exceeded 18,000 cells/ml on 28 March and 11 April respectively. Collie River sites 1 and 3 were dominated by diatoms while site 2 was dominated by diatoms on 11 April 1995 and for the remaining period by Cryptomonads. Some of the potentially harmful Raphidophytes (*Heterosigma*) were present at site 1 in low densities. The size and integrated densities of the cells present at sites 1-3 indicate that site 2 was most eutrophic, followed by site 1 and site 3. Figures 8, 9 and 10 illustrate the phytoplankton density and composition over the sampling period.



Results to date indicate that the Brunswick River was more eutrophic and more affected by diatom and phytoplankton blooms than the Collie River, Preston River, Estuary and Inlet respectively, over the sampling period.





4.2.2 Catchment

The catchment area consists of five rivers, the Wellesley, Brunswick, Collie, Ferguson and Preston. The water quality in the catchment is good as all rivers are relatively clean and flowing all year round. The major concerns in the catchment are increases in the salinity of the Wellesley and Ferguson Rivers in the dry season when irrigation commences and nutrients and sediments entering waterways from the catchment area. Biological sampling in catchment rivers started in March 1995. Table 3 shows a list of fish and invertebrates species collected to date. It is estimated that at least two to three years of data needs to collected before the data can been used to detect incidents of pollution and decrease in water quality.

TABLE 3. Invertebrates and fish presence in the Leschenault Catchment at each site.

	Wellesley	Brunswick	Collie	Ferguson	Preston
Fish -					
Pygmy perch	*			*	
Gambusia	*		*	*	
Decapoda -					
Shrimp	*	*	*	*	*
Marron/Gilgie		*	*		*
Acarina - Mites			*		
Amphipoda - Sand hoppers			*	*	*
Diptera - Flies	*	*		*	*
Coleoptera - Beetles	*	*	*	*	
Hemiptera - Bugs				*	
Ephemeroptera - May Flies	*	*	*	*	*
Tricoptera - Caddis Flies	*	*	*	*	*
Odonata - Dragon Flies		*	*	*	
Oligochaeta - Worms	*				
Gastropoda - Snails		*			

Key :- * indicates presence

4.3 Nutrient monitoring

Recognition that problems of eutrophication in the Peel-Harvey and Vasse Wonnerup Estuaries were linked to nutrients coming from the coastal plain, prompted the Waterways Commission to begin monitoring in the Leschenault catchment. The result of this monitoring was a report entitled *Estimated Annual loads of Nutrients to the Leschenault Estuary, 1984 - 1992*, a summary of this report follows. Copies can be obtained from the LIMA office.

4.3.1 Summary - *Estimated Annual Loads of Nutrients to the Leschenault Estuary, 1984 - 1992*

The excessive input of plant nutrients has been identified as the greatest threat to the health of estuarine ecosystems in the south west of Western Australia. The process of enrichment of aquatic ecosystems with nutrients, called eutrophication, is normally a slow process that occurs naturally as waterbodies age. Human activity in catchments can increase the export of nutrients to rivers and streams and accelerate the rate of eutrophication of receiving waterbodies. Nitrogen and phosphorus have been shown to be the most important nutrients in natural waters.

The photosynthetic algae and plants, seaweeds, seagrasses and microscopic planktonic algae, are the groups most obviously affected by a change in nutrient status. For example, an increase in the biomass and a change in species composition of macroalgae communities is a common response to nutrient enrichment. Frequent seasonal blooms of phytoplankton are another common response to enrichment in rivers, lakes and estuaries.

The natural drainage network of the Leschenault catchment comprises five main drainage systems: the Wellesley, Brunswick, Collie, Preston and Ferguson river systems. The drainage systems converge on the coastal plain and only the Preston and Collie Rivers discharge directly into the Leschenault Estuary. In 1984, monitoring commenced in four of the major tributaries to the Estuary. Every year between 1984 and 1993, weekly grab samples were collected from sites on the Brunswick, Collie, Ferguson and Preston Rivers during the winter wet period. Monitoring of the Wellesley River, a large tributary of the Brunswick River, began during the winter of 1990. Each sample was analysed for ammonium-nitrogen, nitrite-nitrogen, total nitrogen, filterable reactive phosphorus and total phosphorus.

The primary aims of the nutrient monitoring program were to :

- estimate the total external load of nutrients to the Leschenault Estuary;
- identify the major contributing catchments to the total annual load;
- identify trends, if any, in the levels of nutrients in the monitored streams.

It was estimated that in the period 1984 to 1992 an average of 624×10^6 m^3 of fresh water was discharged to the Leschenault Estuary by the Collie and Preston Rivers per year. The estimates of total discharge to the estuary varied between years from a minimum of 248×10^6 m^3 in 1987 to a maximum of 957×10^6 m^3 in 1991. About 40% of inflows originated from the Brunswick River catchment. The gauging between 1990 and 1992 showed that about 10% of flow comes from the catchment of the Wellesley River and about 30% from the Brunswick River arm of the system. The catchment of the Collie River supplied about 35% of the total inputs, the Ferguson River catchment about 4% and the Preston River catchment about 20%.

The estimates of total external loading of the estuary with phosphorus averaged 51 tonnes per year in the monitoring period. External loading estimates varied between a minimum of 28 tonnes in 1986 and a maximum of 94 tonnes in 1988. Of the total external phosphorus load, nearly 70% was contributed by the Brunswick River. It was estimated that in the period 1990 to 1992, the Wellesley and Brunswick River arms of the catchment each contributed about 35% of the total external loading to the Estuary. In the monitoring period the Collie River supplied an average of about 10% of the external load phosphorus to the Estuary, the Ferguson River contributed 5% and the Preston River 15%.

The estimates of annual external loading of the estuary with nitrogen averaged 610 tonnes per year. External nitrogen loading varied between a minimum of 215 tonnes in 1987 and a maximum of 1090 tonnes in 1991. Of the total external load, nearly 46% was contributed by the Brunswick River. In the period 1990 to 1992, the Wellesley River contributed 17% of the external load to the Estuary and the Brunswick River supplied 25%. The Collie River contributed an average of about 20% of the external load of nitrogen to the Estuary, the Ferguson River about 6% and the Preston River about 30%.

Generally, the levels of nutrients in streams of the Leschenault Estuary catchment were low when compared to other monitored catchments in the south west of WA. Of the five monitored streams, the Wellesley River contained the highest concentrations of both phosphorus and nitrogen and the Collie River contained the lowest.

The monitoring indicated that the Wellesley, Ferguson and Preston Rivers contained moderately high concentrations of nitrogen. The higher levels of phosphorus in the Wellesley River were related to differences in the intensity and nature of land uses in the

catchment. It has a larger area cleared of native vegetation, a high density of surface drainage and a large area of irrigated land. These factors, combined with the catchment's poor soils, could have resulted in the higher levels of nutrients in the surface drainage of the Wellesley River catchment. This Authority is now aware that there is evidence of enrichment with phosphorus in the system, especially in the Wellesley River.

4.4 Macrophyte abundance and distribution study

The Waterways Commission consulted the Marine and Freshwater Research Laboratory at Murdoch University to conduct a study on macrophyte abundance and distribution in the Leschenault Estuary. Thirty two sites were sampled up to twice a year between November 1984 and April 1993. A summary of this report follows and copies of the report with full details can be obtained from the LIMA office.

4.4.1 Summary - *Macrophyte Abundance and Distribution Report*

The aquatic flora found in Leschenault Estuary is similar to that found in other southern estuaries, except that the Leschenault Estuary has a relatively high diversity of red algae, and *Hormophsa triquetra*, the dominant brown algae which is not common in other southern estuaries.

Total plant biomass in Leschenault Estuary was generally 3000 - 5000 tonnes dry weight, with the maximum biomass generally occurring in spring. There were large differences in the biomass of seagrass and macroalgae between individual surveys, but if seasonal patterns are taken into account seagrass biomass and total macroalgal biomass appear to be relatively stable.

Macroalgae biomass was unusually high in spring 1990, but this was not coincident with high estimated nutrient input to the Estuary. Water clarity may be a more important factor given the limited tissue nutrient data available which implies that nutrients are not limiting. It should be emphasised that nutrient inputs from the Parkfield Drain could be more critical than total nutrient input to the Estuary.

On the basis of the surveys conducted to date plant biomass per unit area in Leschenault Estuary was similar to that found in the Peel-Harvey Estuary. The major differences between Leschenault Estuary and the Peel-Harvey Estuary is the relative proportions of total biomass accounted for by seagrass, brown algae and green algae. Macrophyte biomass in the Peel - Harvey Estuary is dominated by green algae, whereas in the Leschenault Estuary seagrass and brown algae are the dominant species present.

The well flushed and essentially marine nature of the southern section of the Leschenault Estuary has resulted in a relatively low macrophyte biomass that is dominated by seagrasses. The northern section of the Estuary appears to be poorly flushed, and has a relatively high plant biomass dominated by brown and green algae. Rooted (*Halophila sp.*) and attached (*Hormophysa sp.*) macrophytes dominate plant biomass and the proliferation of the free floating green algae that causes fouling problems in the Peel-Harvey System has not occurred.

Despite the high biomass present in the northern section of the Estuary it appears to be in a relatively healthy state under the present nutrient loading regime and hydrodynamic conditions.

TABLE 4. Aquatic angiosperms and macrophytes observed in Leschenault Estuary and their presence in other south west Western Australian estuaries.

	Leschenault Inlet	Peel-Harvey*[1] Estuaries	Wilson Inlet*[2]	Oyster Harbour*[3]
AQUATIC ANGIOSPERMS				
Halophila ovalis	*	*		*
Ruppia megacarpa	*	*	*	
Heterozostera tasmanica	*			*
Zostera muelleri	*	*		
MACROALGAE				
CHLOROPHYTA (Green)				
Chaetamorpha linum	*	*	*	*
Lamprothamnium papulosum	*	*	*	
Enteromorpha sp	*	*	*	*
Cladophora sp	*	*	*	*
Caulerpa spp	*	*		*
PHAEOPHYTA (Brown)				
Hormophysa triquetra	*			
Dictyota paniculata	*		*	*
RHODOPHYTA (Red)				
Gracilaria sp	*	*	*	*
Chondria sp	*	*	*	*
Laurencia sp	*	*		*
Spyridia filamentosa	*			*
Ceranium sp	*	*	*	*
Hypnea episcopalis	*			

*1 Lukatelich (unpublished)
*2 Lukatelich *et al*, 1984
*3 Bastyan (unpublished)

Tidal exchange and the silting of rivers probably result in a degree of 'buffering' against the effects of nutrient inputs from the associated catchments. However as the degree of buffering is unknown, nutrient inputs should still be minimised, whilst an increase in nutrient loading to the northern section of the Estuary, which is far less well flushed, has the potential to result in the proliferation of nuisance green algae.

4.5 Research plans

LIMA is in the process of developing a number of research plans that will be completed by staff or contracted out to environmental consultants as sufficient resources become available. LIMA prioritised proposals for research and selected two projects for inclusion in the 1995/96 draft budget. These two research plans are as follows:

4.5.1 Leschenault Estuary nutrient flux and cut dynamics

Project Description - Design and implement a monitoring program to determine the impacts of nutrients, (particularly nitrogen and phosphorus) of various forms entering the Leschenault Estuary. It involves measuring how much of the nutrient load is flushed out to the ocean; how much is left accumulating in the Estuary; estuarine flushing; sinks of nutrients; residency time for nutrients in the Estuary and the role and importance of nutrients in the estuarine sediments.

Seasonal flushing and mixing of tidal salt and fresh water in the Estuary are the only sources of estuarine to ocean (and vice versa) exchange of nutrients, therefore cut dynamics or estuary flushing should be linked in with this research project. The research project will then incorporate monitoring the tidal influences in the Estuary and rivers and mapping its seasonal progression and regression.

Objective - To estimate nutrient loads and to determine factors affecting water quality and to report against water quality guidelines.

4.5.2 Mangrove growth trends and status

Project Description - To determine the factors affecting the health of the grey mangrove (*Avicennia marina*) colony in Leschenault Inlet and Estuary. This requires the physical and chemical analysis of:

- tidal water and groundwater primarily to discover if the mangroves are inundated with salt or fresh water, or a combination of both. Mangrove colonies require inundation with both fresh and salt water and exposure to just one type of water will result in detrimental effects to the colony.
- levels of nutrients entering the mangrove tidal flats, as excessive nutrients have adverse effects on the mangrove communities.

An invertebrate and vertebrate survey will be carried out. Mangroves are part of an ecosystem, particularly a food chain, and therefore if one section of the chain is disturbed this is reflected in the rest of the ecosystem. Monitoring of other plants and animals to determine the health of the mangroves, is required.

Past and present growth trends need to be addressed to indicate the health of the colony. Mapping of the mangroves before and after the 'Cut' and the 'Plug' were built needs to be completed, to determine whether the mangroves have increased, decreased or stayed the same. Furthermore, a sapling and seedling survey of the mangroves needs to be completed as this will indicate whether the mangroves are regenerating. This assessment will help determine the growth trends of the mangroves, and provide base line information for reference for future developments that may influence the mangroves.

Objective - To protect environmentally significant remnant vegetation.

Other research plans that LIMA will develop within the next few years are as follows:

4.5.3 Water quality and catchment audit

Project Description - Develop with the Department of Agriculture, CALM and Leschenault Catchment Coordinating Group (LCCG) a monitoring program to assess water quality and nutrient levels in the catchment. Further information explaining the water quality program will be released once the above departments have discussed this proposal.

Objective - Develop an integrated water quality catchment program and to assess nutrient loads affecting the water quality of the catchment.

4.5.4 Preston river erosion study and foreshore assessment

Project Description - Carry out a river foreshore assessment of the Preston River to identify and map fringing vegetation. This will involve surveying and identifying fringing vegetation communities, identifying areas of erosion, identifying boundaries for the waterways Protection Precinct and recommend on rehabilitation requirements. This information will be used to make erosion control, foreshore rehabilitation and stabilisation plans for sections of the river between Bunbury and Boyanup.

Objective - To stabilise and rehabilitate the Preston River foreshore between Bunbury and Boyanup.

4.5.5 Seagrass and algae biomass and distribution

Project Description - To determine the distribution of seagrass and macroalgae within the Leschenault Estuary. This requires identification of algal species and mapping them using aerial photographs, ground truthing and surveying. To determine biomass of seagrass and macroalgae, cropping sites will be selected and dry weights taken similar to the study completed in the Leschenault Estuary in 1993 by the Marine and Freshwater Research Centre at Murdoch University.

Objective - To identify any changes in distribution of seagrass and macroalgae in the Estuary for future management planning.

4.5.6 Ecosystem requirements for rivers

Project Description - To determine the amount of water required by a river to sustain fringing vegetation, invertebrates and vertebrates. The Water Authority of WA are currently devising ecosystem models that will determine this, with research on the North and South Dandalup River systems.

Objective - To determine the amount of water a river ecosystem requires to be able to manage the ecosystem and determine how much water from a river can be used for other purposes.

4.5.7 Preston River sedimentation study - Stage 1 and 2

Project Description - Stage 1 - Compile existing data and information on sedimentation within the Preston River and within the Leschenault Estuary as a result of sediment transport from the Preston River. Design a monitoring program to establish sediment transport and deposition levels within the main sections of the Preston River and the Leschenault Estuary. To determine methodology and prepare procedures for monitoring silt loads and sedimentation in the Preston River to be funded by a second stage project in the next budget.

Project Description - Stage 2 - Implement stage 1 monitoring programs.

Objective - To determine impacts on water depth and exchange efficiency and identify possible long term changes in estuarine structure and distribution of fringing vegetation.

4.5.8 Management of the oxbows from the Preston River

Project Description - To determine the condition and significance of the oxbow wetlands of the Preston River. To gauge the role of the wetland oxbows to bird, invertebrate and other life. To determine the factors affecting the health and sustainability of these wetlands and to determine management guidelines for their conservation.

Objective - To develop management guidelines and an information base on environmentally significant wetlands.

4.6 Pollution control

Pollution control activities involve licensing and monitoring industrial waste water discharges to the waterways, investigating and dealing with pollution complaints, managing and preventing accident spills polluting the waterways and providing support and advice to industries and the public on preventing pollution of the waterways.

The Waterways Commission uses delegated powers under the Environmental Protection Act 1986. Staff maintain surveillance to detect pollution including toxins and wastes and respond quickly to polluting activities. The Commission, with the support of other government agencies, industry and the public, has identified and controlled various point sources of pollution discharging into the waterways.

The Commission takes action to reduce the amount of pollutants from industrial discharges through licensing and monitoring. Controlling these sources is important because wastewaters can be collected and treated to remove pollutants prior to discharge. The Commission has the close cooperation of industry to improve and manage wastewater quality. The main emphasis is on nutrient reduction.

LIMA administers three industrial licences to discharge treated wastewater into the Leschenault Estuary, Collie and Preston Rivers (Table 1).

Site inspections are conducted to ensure compliance with licence conditions. All industries complied with all licence conditions in the 1993-1995 period. LIMA staff have met with officers from the Department of Environmental Protection and the Water Authority about industries out side its management area that may have potential impact on the estuary. Proposals to improve their waste treatment facilities are currently being reviewed by the Department of Environmental Protection.

There have been two separate incidents of pollution affecting the waterways in the Leschenault region during 1995. The first occurred on 14 January 1995 when a car collided with the Meadow Lea wastewater pipeline on Estuary Drive on the Preston River bridge. The pipeline was promptly repaired and is to be relocated underneath the bridge away from traffic. It is estimated that three cubic metres of wastewater was released into the Preston River. It appears that this once off accident had no effect on the river as this section of river is tidally influenced and the spillage was rapidly diluted.

The second incident occurred on the night of 16 April 1995, when an incident at the Masters Dairy in Boyanup resulted in wastewater being discharged directly into the Preston River. The wastewater consisted of water, milk and detergent and an estimated 5-15,000 litres was

released into the Preston River. It appears that the pump on the irrigation line had failed causing overfilling of the irrigation effluent holding tank. The Dairy will fit another alarm which will work independently of other alarms and will be linked directly to the factory and to the boiler house, and an extra 50 000 litres of storage will be installed for rapid manual use. This section of the Preston River was still flowing and the wastewater was immediately diluted away from the source. However, there were reports of marron climbing up the river banks and dead fish, due to the initial impact of the pollutant

TABLE 5. Licensed industrial waste discharges to the Leschenault Estuary.

Industry	**Nature of wastewater discharge**	**Licence compliance**
Western Power - Bunbury Power Station	Cooling waters and fly ash slurry	100%
Meadow Lea Foods	Cooling waters and condensates	100%
SCM Chemical Ltd Australind	Titanium dioxide wastes	100%

5. PLANNING

5.1 Planning referrals

Since January 1994, the Authority has received fifty seven referrals from planning bodies including the WA Planning Commission and local government authorities (both within and outside LIMA's management area). The referrals included applications for subdivision, amalgamation and strata titles and town planning scheme amendments.

The outcomes of planning advice provided to the decision making bodies is included in the table below.

TABLE 6: Outcomes of planning decisions made by the Leschenault Inlet Management Authority - January 1994 to June 1995

Approved with all LIMA conditions	20
Approved with partial LIMA conditions	4
Approved not including LIMA conditions	0
Refused taking account LIMA concerns	1
Refused for other reasons	1
Decision unknown*	23
Advice only provided	4
Yet to be considered by LIMA	4
TOTAL	57

*Outcome has been deferred, still to be determined or not communicated to the Authority.

Each of these referrals is considered by the Authority and a response prepared detailing conditions LIMA would like to see placed on the application. Such conditions include connection to reticulated sewerage, ceding of foreshore reserves and control of stormwater runoff. Advice only is provided if the application lies outside the management area.

5.2 Development applications

Development applications are those applications or issues referred to the Authority for consideration and comment or advice but which are not specifically planning referrals.

Examples of these are applications for works in or alongside waterways, and use of the inlet and estuary for windsurfing, rowing and dragon boating events, and requirements of the Waterways Conservation Act and Regulations. Developments assessed by the Department of Environmental Protection under the Environmental Protection Act 1986 are also referred to the Authority for comment.

TABLE 7: Outcomes of decisions made and advice provided by the Leschenault Inlet Management Authority - January 1994 - June 1995

Approved with all LIMA conditions	17
Approved with partial LIMA conditions	0
Approved not including LIMA conditions	1
Refused taking account LIMA concerns	2
Refused for other reasons	0
Decision unknown*	25
Advice only provided	17
Project did not proceed	1
Yet to be considered by LIMA	4
TOTAL	**67**

*Outcome has been deferred, still to be determined or not communicated to the Authority.

5.3 Management planning

Foreshore management plans are a means of guiding future use and development of foreshore areas and outline management strategies to enhance these areas.

The Leschenault Inlet Management Authority is responsible for ensuring the waterways and associated foreshores in the region are adequately protected and maintained and as a result are committed to the preparation of management plans to achieve this end. Management plans are normally prepared in partnership with the local authority, and also local community groups where they exist.

Over the last two years LIMA staff have been involved in the development of the following management plans and guidelines, several of which are still in preparation:

- Lot 131 Clifton Park Management Plan
- Eaton Foreshore Draft Management Plan
- Northern Leschenault Estuary Foreshore Draft Management Plan
- Millars' Ford Draft Management Plan
- Collie River Islands Draft Management Guidelines
- Donnybrook River Improvement Program

Copies of all these plans are (or will be on completion) available from the LIMA office.

5.3.1 Lot 131 Clifton Park Management Plan

Lot 131, located alongside the Collie River at Clifton Park has been subject to a number of development proposals over many years. In order to maintain and enhance the conservation and recreation values for the community and the environment, Lot 131 was purchased by the State Government in 1992.

A working group chaired by Sir Donald Eckersley, OBE was established in March 1993 to prepare a management plan to present background information and recommendations for management and use of the area to the community. Membership of the working group was drawn from the then South West Development Authority, the Shire of Harvey, the Department of Conservation and Land Management, LIMA and members of the Clifton Park community.

The Lot 131 Clifton Park Draft Management Plan was presented to the community at a public meeting held in November 1993. A public workshop was held two weeks later to further explain the plan and to provide guidance on how to make a submission.

Following a two month submission period during which eight submissions were received the final document was prepared incorporating comments and advice from the community.

The final Lot 131 Clifton Park Management Plan was launched at a symbolic handover ceremony at which Sir Donald Eckersley, Chairman of the South West Development Commission handed over management of the area now known as Clifton Community Reserve jointly to the Shire of Harvey and the Leschenault Inlet Management Authority.

In line with recommendation 4 of the management plan, a community management committee has been established comprising five representatives from the Australind and Clifton Park community and one representative each from the Shire of Harvey and Leschenault Inlet Management Authority. Several meetings of this committee have been held and a works plan for the next twelve months has been developed.

The working group will reassess the implementation schedule outlined in the management plan at their next meeting. The schedule will be amended where and if required and will be presented to the Shire of Harvey and LIMA for approval.

5.3.2 Eaton Foreshore Draft Management Plan

The Eaton foreshore contains a mix of most used river foreshore and some of the least used and isolated foreshore in the Bunbury region. The recreation areas adjacent to the Collie River are a regional attraction and in constant demand by the public.

The Eaton Foreshore Draft Management Plan was prepared by a working group convened jointly by the Shire of Dardanup and LIMA in February 1993 as a means of promoting a better understanding of the area and to provide a formal agreement between all the parties involved on how the area is to be used and managed. Membership of the working group comprised representatives of the Shire of Dardanup, LIMA and the Eaton community.

The draft plan, which was released at a public meeting held in Eaton on Monday 20 March 1995, aims to develop the recreational and conservation opportunities of the Eaton foreshore area and to protect fringing vegetation and riverbank and foreshore stability.

The plan was open for public submissions until the end of April 1995. Four submissions were received. These submissions will be considered in the preparation of the final plan which is expected to be released in June or July 1995.

5.3.3 Northern Leschenault Estuary Foreshore Draft Management Plan

A working group was established in February 1995 to develop a management plan for the Leschenault Estuary foreshore from the beginning of Cathedral Avenue in the south to Buffalo Road in the north. The foreshore along the estuary in this region is degraded due to grazing in the past and increasing human activity. The management plan aims to rehabilitate the area and provide appropriate and controlled public access to the estuary and foreshore.

Representatives from the Shire of Harvey, LIMA and the Australind community have met on several occasions to prepare draft recommendations for management to achieve the above aims.

Several estuary access sites will be developed while at the same time ensuring minimal disturbance to the estuary foreshore. Several areas will be developed for public recreation and a walktrail along the foreshore has been proposed. There are currently a number of fences and other relics of the farming activity remaining on the site. Many of the fences will be removed, and some will be retained to define access arrangements to the foreshore.

It is hoped that a draft document will be prepared prior to the end of June 1995 and launched in June or July.

5.3.4 Millar's Ford Draft Management Plan

The Millar's Ford area has been subject to considerable controversy over several years. As a result, the Shire of Dardanup, the Shire of Harvey and LIMA have combined to prepare a management plan to ensure adequate levels of public access to the foreshore reserve and that the foreshores are managed appropriately.

A working group comprising representatives from LIMA, the Shires and local residents was convened in February 1995. Several meetings, including a site inspection, have been held to commence the process of developing draft recommendations for management.

It is suggested that the area immediately downstream of the Collie River bridge should be developed as a canoe launching area and that there should be suitable areas for vehicle parking and turn around space on both sides of the river.

It is likely that a draft document will be released for public comment during August/September of this year.

5.3.5 Collie River Islands Draft Management Guidelines

The Collie River Islands - Bar, Alexander and Snake, make up some of the least used and isolated river foreshore in the region. With access only by boat, few people have visited the islands and there is little understanding of their conservation and ecosystem values. The purpose of the management guidelines is to identify the environmental values of the islands, and integrate this with the recreational and amenity requirements of the community.

The management guidelines are being prepared by a working group convened in February 1995 and made of up representatives from the City of Bunbury, the Shire of Dardanup, the Shire of Harvey, LIMA, the Clifton Park and Eaton communities and the private landowner.

A number of issues including appropriate levels of access to each of the islands, litter and vandalism and fire management will be considered.

The Collie River Islands Draft Management Guidelines will be released for public comment during June 1995. A six week submission period will allow members of the public to comment on any aspect of the guidelines and to suggest other issues that should be addressed by the final document.

5.3.6 Donnybrook River Improvement Program

The Donnybrook River Improvement Program (DRIP) committee was established by the Shire of Donnybrook-Balingup to look at means of improving the riverine environment of the Preston River through the Donnybrook townsite.

The Leschenault Inlet Management Authority and the Waterways Commission have been assisting in the preparation of a management plan for this area. LIMA staff have been attending the group's monthly committee meeting on regular basis throughout 1995 and have met with committee representatives on a number of other occasions.

Assistance has also been provided in the preparation of engineering drawings for several river crossings, erosion control works and a canoe launching facility to be constructed by the group in the future.

5.4. PLANNING STUDIES

5.4.1 Cathedral Avenue Planning Study

The Cathedral Avenue Planning Study (CAPS) was prepared by Waterways Commission in conjunction with the Shire of Harvey Draft District Planning Scheme No. 1, to identify issues in the Cathedral Avenue area adjacent to the Leschenault Estuary, and to make recommendations for planning and managing land use.

The main issues addressed in the study were lot sizes and appropriate land uses. After 3 months public comment period, the Shire of Harvey has adopted the preferred arrangement for lot sizes, and land use, with minor changes, and has incorporated these into the District Planning Scheme No 1 forwarded to the Ministry for Planning for endorsement by the Minister.

5.4.2 Warren Blackwood Regional Planning Study

LIMA and Waterways Commission staff have assisted the Ministry for Planning with this study, to provide advice on planning for waterways management and protection across the Blackwood and other river areas covered by this study.

5.5 MANAGEMENT PROGRAMME

In 1983 the Authority released the first Leschenault Inlet Management Programme. More recently, the Leschenault Waterways Management Programme was finalised in January 1992 (Waterways Commission Report No26) as a result of the Leschenault Inlet Management Programme Review carried out in 1990.

The management programme addresses a variety of issues including catchment management, urban expansion, water quality and recreational use. It is the aim of the programme "to fulfil the demands for use and development in so far as they are consistent with the conservation and enhancement of a functional healthy estuarine environment for the enjoyment of present and future generations" (Leschenault Waterways Management Programme 1992).

It is proposed in Recommendation 154 that the programme will be reviewed in 1999. The review will identify which objectives and recommendations have been achieved and any reasons for facets of the programme not being implemented. An updated programme will be prepared as a result. A preliminary audit of recommendations will commence during 1995/6.

5.6 POLICY DEVELOPMENT

Waterways conservation policies provide developers, the community and local and state government agencies with a clear understanding of the position taken by the Waterways Commission and its waterways management Authorities.

The Waterways Commission and Swan River Trust has recently formed a Policy Reference Group, to review policy and policy development across the state to ensure consistency in the way policies are developed and implemented.

This working group, with representation from each of the Waterways Commission regional offices and divisions, was given the task of preparing a policy development protocol and waterways conservation policies which are consistent across the organisation but still relevant to each of the local management authorities

6. COMMUNITY AWARENESS AND INVOLVEMENT

The Community Awareness and Involvement (CA&I) sub-programme was created in 1993 with information, education and community involvement as its priority.

Objective: The objectives of the CA&I sub-programme are to increase public awareness and provide information, to provide advice to community and catchment groups and encourage community involvement, and to educate and involve schoolchildren and the community in waterways conservation.

6.1 Ribbons of Blue

The Ribbons of Blue (RoB) Program was launched in the Leschenault catchment in June 1993, and in 1994 completed its first full year of operations. RoB is an education program which involves school students in hands on monitoring and assessment of local waterways, encourages them to relate their findings to the total health of the environment and leads to the development of action plans to maintain or improve the environmental values of those waterways.

Funding for Leschenault RoB program in 1994 was achieved through a grant from the Federal Waterwatch program, and matching funds from SCM Chemicals, Westralian Sands, Shire of Harvey, Shire of Dardanup, South West Development Commission, Wellesley LCDC and the Waterways Commission. The funds enabled a part time coordinator to be employed to promote and service the program in schools throughout the catchment.

Fifteen schools were involved in RoB activities during 1994, and so far in 1995, 9 schools have started the program including Australind Primary School which has 2 classes involved.

St Mary's Catholic Primary School in Donnybrook studied the Noneycup Creek which flows past their school, monitoring water quality and including a survey of aquatic life in the creek. The students also completed a revegetation project in the creek, weeding out introduced flora

and replanting native species. The work of the students was recorded in poster form and was awarded first prize in its category in a statewide RoB competition.

Other schools having similar success with the program were Dardanup Primary School which carried out a farm water survey at the head of the Crooked Brook, Donnybrook Primary School studied Mill Brook catchment, and Australind, Boyanup and Brunswick Primary Schools have all undertaken river study excursions. Burekup Primary School extended its monitoring activities with a Arbor Day tree planting activity which was well supported by the local community.

6.2 Community support and involvement

Waterways Commission and LIMA staff provide support to community groups within the limits of staff resources, and try to involve communities in activities that improve waterways values. Staff have attended meetings to provide waterways management advice to the Leschenault Catchment Coordinating Group (LCCG), Blackwood Catchment Coordinating Group (BCCG), Geographe Bay Advisory Committee (GBAC), Hardy Inlet Advisory Committee (HIAC), Wellington Forest Advisory Committee (WFAC), and several Land Conservation District Committees across the region.

Tree planting activities have been organised involving local communities for the Leschenault Estuary foreshore and the Collie River foreshore. LIMA assisted the Capel LCDC with trees for a community tree planting activity in the Capel River catchment.

6.3 Community education

6.3.1 Leschenault Waterways Discovery Centre

The concept of an eco-museum arose from discussions aimed originally at establishing a more conventional museum of the South West. After many years this was modified and the then South West Development Authority developed the concept of the South West Eco-Museum. Because of the wide range of eco-systems throughout the south west region, the best way to interpret all of these was to divide the museum into a number of modules, each strategically located to interpret the close surroundings. Funding was provided to the SWDA to develop the concept and invitations were issued to put forward proposals for funding.

In June 1993, the Shire of Harvey requested the involvement of LIMA in a proposed South West Eco-Museum Project module. Shortly after a submission was prepared and submitted to the SWDA for funding to develop architectural and landscape design plans for a facility to be constructed on the foreshore of the Leschenault Estuary. The initial objectives of the proposed project were as follows:

- to inform the local community and visitors of the nature and function of an estuarine system and catchment processes;
- to present visitor information which will add to the level of experience they obtain from visiting and discovering things about the area;
- to inform people how they can interact with the environment in a safe and low impact way.

This initial funding submission was successful and consultants Michael Tooby and Associates were engaged to prepare a design concept for the eco-museum module.

The concept developed by the consultant comprised four levels of interpretation:

- the main facility located on the estuary foreshore which would tell the whole story of the Leschenault waterways and their catchments;
- information shelters where visitors stopped for a picnic or to camp would have at least twenty minutes to study a significant part of the story;
- display boards located in roadside parking bays or information bays with a small amount of information requiring approximately five minutes study.
- roadside signs at river crossings for example which would identify features of the environment as being part of the Leschenault waterways system.

A public meeting was held to present Mr Tooby's design concept which was widely accepted by those present.

The concept is a large and ambitious one and the working group has reluctantly chosen to develop it in a number of stages. Further funding has been received from the South West Development Commission for the development of a preliminary information building to be located on the estuary foreshore opposite SCM Chemicals. LIMA and the Shire of Harvey have previously developed this as a public recreation site and see it as an appropriate location for an interpretative facility.

Plans are currently being developed for a gazebo style structure which would house information boards and displays while also providing additional BBQ and picnic facilities for the area. A toilet block will also be constructed. Funds for this development are available and it is hoped that the facility will be constructed during the second half of 1995.

Sources of funding will continue to be investigated and it is hoped that the main facility can be commenced within the next few years.

In order that such a facility be successful public support is particularly important. It is likely that a "Friends of the Estuary" type group will be established to develop this support.

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APPENDIX 1 - REPORTS AND PUBLICATIONS

Waterways Guidelines

Guidelines for determining a waterways protection precinct. Waterways Commission Guidelines No. 3, 1994.

Guidelines for the preparation of foreshore management plans in waterways management areas - a guide for proponents. Waterways Commission Guidelines No. 5, 1994.

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