Swan River Education Kit

Working Scientifically in the Swan River Environment

A teaching approach for Science

acknowledgements

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Project Coordinators	*Susan Worley (Ribbons of Blue)* *Kathleen Broderick (Water and Rivers Commission)* *Melinda Wild (Water and Rivers Commission)*
Writers	*Susan Worley (Ribbons of Blue)* *Dianne Guy (contract writer)*
Editors	*Allan Watson (Perth Editorial Service)* *Karen Majer (Water and Rivers Commission)* *Barb Horan (contract editor)*
Graphic Design	*Genevieve Duvergé (Duvergé Design)*
Illustrators	*Ricky Arnold (Ricky Arnold & Associates)* *Ian Dickinson (Dickinson Art)*
Water Quality Data disc	*Pip Wittenoom (Ribbons of Blue)*
Cartography	*Brett Harrison (Banksia Environmental Mapping)*
Production Coordinator	*Melinda Wild (Water and Rivers Commission)*

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The Swan River Education Kit

The Swan River Education Kit, an initiative of the Water and Rivers Commission and the Swan River Trust, is a broad-based education program with curriculum support materials, developed for use by schools in the Swan River catchment.

The kit aims to encourage a knowledge of the river and provides a meaningful context in which students can develop skills of investigation and attitudes of environmental responsibility.

This resource has been developed for teachers of the Science, and Society and Environment learning areas. It aims to enrich teaching and study in these learning areas by providing a range of themes and ideas for studies of the Swan River that can be easily integrated into the school curriculum.

The kit was developed in the belief that direct experience of the river environment is essential for students to develop a close association with it and an environmentally responsible attitude. These materials have been written on the assumption that the teacher will provide students with the opportunity to visit a river site on at least one occasion to gain practical 'hands-on' experience.

An integrated, whole-school approach to a study of the Swan River environment could be developed within the context of the Curriculum Framework.

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Contents of the Swan River Education Kit

The Swan River Education Kit consists of:

WORKING SCIENTIFICALLY IN THE SWAN RIVER ENVIRONMENT

Activities for studies of the physical and biological environment of the river in the Science learning area.

A SENSE OF PLACE IN THE SWAN RIVER ENVIRONMENT

Activities for studies of the Swan-Avon catchment in the Society and Environment learning area.

EXCURSIONS IN THE SWAN RIVER ENVIRONMENT

Fieldwork excursions and activities with worksheets and resource information. The excursions support some activities suggested in the Society and Environment, and Science booklets.

SUPPORT MATERIALS

- Brochures
- Water facts
- Video
- Posters
- Water Quality Data disc
- Swan-Canning River and Estuarine System Map

River Communities

River Communities – Resource Sheets

Resources

Appendices

These teaching ideas and support materials are designed to assist teachers to develop understandings, values and skills as they relate to the Swan River and its catchment in particular, and to rivers and their catchments in general

Rationale and aims

The Swan River system is the recreational and scenic heart of Perth, and a very important part of Western Australia's natural and cultural heritage. As a natural wonder, it provides a great diversity of landscapes, flora and fauna. The river system is a magnet for the people of Perth and its visitors, and a valuable resource for a lifestyle that people greatly value.

The Swan River is under environmental pressure. The population of Perth is growing, and the activities of people in both urban and rural subcatchments are contributing to problems of waterway pollution and other forms of degradation. Everyone in the catchment needs to be aware of these issues; since we all live in a catchment, we are all responsible for catchment health.

One way to address issues relating to the Swan River is through education, and the river is an excellent medium for environmental education. A visit to a river site will encourage students to develop an increased awareness of the importance of the river to people, and of the incompatibility of some forms of human activity with river health. It is hoped that this awareness will result in students wanting to contribute to the formulation of landcare and rivercare strategies.

An environmental encounter with the river provides interesting and worthwhile experiences for students of Science. The river is a particularly good setting to focus on the processes of Science and its modes of investigation, to foster the development of scientific concepts, principles and attitudes related to a study of natural systems, and to promote an interest in the application of science to environmental problems.

This booklet aims to assist students to develop:

- an understanding of physical, chemical and biological concepts as they relate to the health of the Swan River, and the ways in which they can be measured and investigated
- an understanding of the river system as an ecological unit consisting of interdependent living and non-living components
- an understanding of various pressures such as pollution and other forms of degradation that affect the river system
- skills of scientific investigation
- a sense of belonging to, and enjoying, the river environment
- environmentally responsible values and behaviours, and a commitment to helping maintain and improve the health of the river and its ecosystems

Links to Science learning area outcomes

This booklet assists teachers to address the major curriculum outcomes of the Science learning area as described by the Curriculum Framework. A teaching program using some of the suggested ideas and activities will foster in students:

- an improved understanding and appreciation of the systems and processes that support life
- a willingness to take a responsible role in using Science and its applications in the world
- the development of a personal perspective about their role in helping to care for the environment

Scientific investigations at the Swan River will encourage in students questions and reflective and critical thinking about the river, and the impact of our activities on it. Students will develop confidence in applying scientific understandings, processes, skills and values to river-related issues and develop attitudes and behaviours consistent with the values associated with ecological sustainability.

The Working Scientifically outcomes underpin the suggested teaching approach. Many of the conceptual outcomes of Science can be developed using the river as a focus, as the following table indicates. Student achievement of outcomes will be dependent on the opportunities presented to them to develop and demonstrate appropriate skills and understandings.

Curriculum connections

RIVER ENVIRONMENT FOCUS	OUTCOME
Investigating water quality and the effects of pollution and seasonal changes.	Natural and Processed Materials
Relationships between the physical environment and the living communities it supports. *Relationships between processes of river degradation and wise use of water and other resources.*	Earth and Beyond
Plants and animals and their role in river communities. *Interdependence of river communities.* *Relationship between living things and their non-living environment.*	Life and Living
Energy flow and cycling of matter within an ecosystem.	Energy and Change
Observation, investigating, evaluation, communication.	Working Scientifically

These materials have been developed to promote principles of education associated with the Science learning area that are embedded in good teaching practice. These include:

- the use of students' prior knowledge and interest as starting-points for learning
- development of a positive attitude towards the environment
- promotion of student-centred inquiry learning and action research methodology
- the use of strategies to promote literacy
- commitment to cooperative learning
- commitment to active citizenship

Structural overview

There are two main themes developed in this booklet:

- **Water Quality Investigations**
- **River Communities**

The table below outlines the subject material of each theme, grouped into three main activity sections: ***Preliminary activities, On-site activities*** and ***Follow-up activities.***

WATER QUALITY INVESTIGATIONS	RIVER COMMUNITIES
page 7 - page 40	page 41 - page 82
preliminary	
River health and pollution • Plan a water quality investigation • Pollution • Estuarine environment • Management options	River environment • Ecology • Biology • Pollution
on-site	
Site familiarisation • Conduct a water quality investigation • Pollution • Estuarine environment • Solutions and management	River environment • Ecology • Biology • Management for the future
follow-up	
Water quality investigation • Pollution • Managing pollution	River environment • Ecology • Management for the future

Scientific investigations at the Swan River will encourage in students questions and reflective and critical thinking about the river, and the impact of our activities on it.

Themes

Water Quality Investigations

This theme contains activities with a focus on the Swan River environment and the development of science investigation skills. These are essentially physics and chemistry-related activities. Concepts developed within this theme are river health and pollution, water quality investigations, the estuarine environment and river management options.

River Communities

This theme contains activities with a focus on biological concepts as they relate to the river. Concepts such as estuarine and freshwater ecology, plants and animals, and ecosystem management are explored.

Activities

Activities within each theme have been grouped into:

- **Preliminary activities** to motivate students, elicit prior knowledge, encourage questions and facilitate planning of investigations.
- **On-site activities** to encourage development of skills of observation, investigation and teamwork at the river site. See suggestions for suitable sites on the *Swan-Canning River and Estuarine System Map.*
- **Follow-up activities** to encourage interpretation and evaluation of findings, consolidation of knowledge and action.

Activities are written as **broad suggestions** for the teacher. Many are quite open-ended to allow teachers to make modifications to suit their students. **Resource Sheets** accompany some activities, and are found at the back of each theme. They comprise information sheets on various topics, maps, diagrams and tables. There is **variety** in the type of activities suggested, the amount of time recommended to complete them and the level of understanding and skills required as background by students. Some activities refer to strategies contained in other teachers' manuals, such as Ribbons of Blue.

Suggestions for using this resource

Rather than offering a step-by-step program of lessons, this resource encourages teachers to choose activities to develop a teaching program that will suit the interests and needs of students. There is no prescribed way in which to use the activities. A minimalist approach might see you dip your toe in the shallow end or you could wade in at the deep end to become fully immersed!

When developing a balanced program you could select activities from one or both themes in this booklet according to:

- Science learning area **outcomes** you want to develop
- the **riverside site(s)** you want to visit
- any **cross-curricular links** you wish to establish
- the **concepts** within a theme that you wish to focus on and follow through
- **focus questions** suggested in this booklet or devised by you or your students
- particular **excursions** in the booklet *Excursions in the Swan River Environment*

Student achievement of outcomes will be dependent on the opportunities presented to them to develop and demonstrate appropriate skills and understandings.

Planning sheet

Teacher | Class | Site location

date(s) of site visit(s)

Chosen themes and topics

Link to Science outcomes

Key task and focus questions

Activities chosen, sequence and timing, and assessment details

Preliminary activities

Site visit activities

Follow-up activities

Assessment opportunities

Working Scientifically in the Swan River Environment

Water Quality Investigations

Students are encouraged to work scientifically to plan an investigation of one or more aspects of water quality, conduct their investigation, process their data and evaluate their findings. They then use their results, further investigations and information gathering as a basis for suggesting future management actions.

Teachers may find value in using one or more focus tasks to draw together desired outcomes.

Water Quality Investigations

This section of the booklet contains a range of teaching ideas designed to develop students' understandings of the non-living characteristics that determine the water condition of the Swan-Canning river system, and the related concept of water quality and river health.

This section examines the following ideas:

- Water quality can be measured by a mosaic of physical, chemical and biological techniques.
- Water quality investigation involves posing a question or identifying a problem, designing a study, collecting data, analysing and interpreting data, modifying the investigation, drawing conclusions and offering solutions to problems.
- Pollutants are detrimental to water quality, and to aquatic and human life.
- Land-use activities in catchments are sources of pollutants in waterways.
- The hydrology of the Swan estuary imposes unique environmental conditions which influence its biology and potential to become polluted.
- All members of society share the responsibility for protecting water quality.

Focus questions

- *What is a 'healthy' river?*
- *What do I want to know about the river?*
- *How can I measure water quality?*
- *What is pollution and how does it affect river health?*
- *What management strategies can be implemented to protect the river environment?*

The growth of urban and semi-rural populations and an increase in activities along the Swan-Canning River system has resulted in a number of existing and potential water quality problems. Community awareness will help to protect the river.

River health and pollution

REFERENCE CHECKLIST

- Resource Sheet 1, *H_2ONLY*
- Resource Sheet 2, *Comparison between a healthy and an unhealthy river*

OTHER RESOURCES

- Excursion 12, *Rating river health,* in the booklet *Excursions in the Swan River Environment*
- *Don't Let your River go down the Drain* (poster)

To explore existing knowledge about the substances that enter rivers via drains, students could:

- Refer to a picture of a drain emptying into the river and convey what they think the message is. Discuss their interpretations. See Resource Sheet 1, *H_2ONLY* or the poster *Don't Let your River go down the Drain.*
- Brainstorm a list of the sorts of things that might go into rivers via drains. Construct a summary table to show the likely effects of each of these things on waterways, and suggest alternative forms of disposal.
- Find out about the ways in which people use rivers as drains. Suggest why people use rivers in this way.
- Decide who is, or should be, responsible for preventing rivers from being used as drains.

To explore what they know and feel about the health of the Swan River and its tributaries, students could:

- Recount their personal experiences related to river health.
- Discuss impressions they have gained about river health through the media.
- Skim relevant media articles and discuss their main ideas.
- Consider how accurately the health of a river could be judged, by using powers of observation only.
- List things that could be observed at the river that might be clues to the state of its health. Sort the clues into categories, rate them in order of perceived importance and construct a 'healthiness' scale that could be used to judge the river site to be visited. Complete Excursion 12, *Rating river health,* in the booklet *Excursions in the Swan River Environment.*
- Identify, compare and discuss the indicators of river health. See Resource Sheet 2, *Comparison between a healthy and an unhealthy river.*

River health and pollution (contd)

To consider types of pollutants and whether they can be measured, students could:

- After some discussion, make an individual (and then whole-class) definition of the term 'pollutant'. See Resource Sheet 3, *Waterways pollution.*
- Decide which of the substances on their list of things that enter the river via drains would be classed as potential pollutants.
- Identify which of these potential pollutants could be measured. If pollutants are measurable it is possible to objectively establish levels of pollution. Changes in temperature, acidity, amount of sediment, quantity and types of litter (including leaf litter), salinity, the presence of petrol and oils from road surfaces, and the concentration of chemicals (including fertiliser and pesticides) carried into the river by surface runoff, via groundwater or through drains can all be measured.

To improve knowledge about pollution in other river systems, students could:

- Identify and locate on maps the major world and Australian rivers.
- Recall prior knowledge about water quality problems associated with any of the rivers located, e.g. the Nile, the Ganges, the Murray-Darling.
- Brainstorm reasons to explain why water pollution is so much more of a problem now than it was in the past.
- Imagine a time when there was little, if any, pollution of waterways. Suggest what could have been done back then to make a difference now. (If students rely only on regulatory solutions, ask them to think about alternatives.)
- Begin a media file on global, Australian and local water quality issues.

REFERENCE CHECKLIST

Resource Sheet 3, *Waterways pollution*

Plan a water quality investigation

OTHER RESOURCES

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Ribbons of Blue primary or secondary school manual

Step 1: To consider the value of testing aspects of water quality, and the parameters that can be investigated, and to develop skills required for investigations, students could:

- Consider how measuring the physical and chemical characteristics of water can increase our understanding of the aquatic environment.
- Test samples of water that look the same but have different pH values, salinity levels or temperatures, e.g. tap water, pool water, pond water and other water sources around the school could be compared. First, make predictions about the pH values, salinity levels and temperature of the samples. Then conduct the tests. Display the results graphically. Offer explanations of results. (Ribbons of Blue can provide assistance with water testing demonstrations.)
- Discover how graphs of water quality data help to make measurements meaningful. Refer to the Ribbons of Blue primary school manual, *Classroom Activities: Interpretation of Results.*
- Prepare for some practical aspects of fieldwork by making a list of skills needed to accurately test water at the river site. Consider the various problems of collecting water, e.g. how to collect water from the middle of the stream and from halfway between the surface and the bottom. Invent appropriate water sampling equipment. Refer to the Ribbons of Blue primary school manual, *Field Work: Sampling.*

Step 2: To consider the parameters to be tested at their site and ensure that they practise using equipment and assessing the significance of their results, students could:

Note: Refer to the Ribbons of Blue primary or secondary school manual for background information on each of the following parameters, and on the use of equipment.

Temperature

- Revise the skill of using the thermometer. Conduct investigations around the school to discover the 'normal' temperature for pond water, water in fish tanks, tap water, water in drains or that in compensation basins. Predict the temperature of river water at the site to be visited.

Plan a water quality investigation (contd)

Acidity

- Introduce or review the concept of pH as a measure of acidity. Measure the pH of tap water and various other liquids in order to familiarise students with pH values. Measure the pH of substances that might enter drains and eventually the river, e.g. petrol, oil, detergents and fertilisers. Practise measuring pH with indicators, pH strips, pool test kits or pH meters.

Salinity

- Use a conductivity meter to compare the salinity of tap water, distilled water and sea water. Make a scale or chart that will be used to show the site's water salinity result relative to these. Demonstrate how salt affects the reading on the conductivity meter by slowly adding spoonsful of salt to tap water, stirring and remeasuring. Repeat this process until the saltiness of the sea water sample is reached. Graph conductivity readings against the number of spoons (or mass) of salt. Calculate the mass of salt contained in a litre of sea water. (If a conductivity meter is not readily available, refer to *Making an EC Meter* in the Landcare in your Hands manual.)
- Research the concept of dryland salinity caused by rising saline groundwater. Look at a map of tributary rivers leading into the Swan and predict whether they would be salty. Justify predictions. Refer to the Ribbons of Blue primary school manual, *Classroom Activities: Salt,* and the Landcare in your Hands manual.

Turbidity

- Discuss the possible causes of murky water. Consider how turbidity reduces light penetration, and how this affects aquatic life. Refer to Water facts 6, *Algal Blooms,* and the video *Algal Blooms and Nutrients.*

  ***Note:** Causes of turbidity include the presence of sediment, algae and natural tannins. Turbidity results in increased deposition on the bottom, and consequently affects bottom-dwelling organisms.*

- Invent ways to measure turbidity. Possibilities include using a light penetration device or a filtrate scale based on discolouration of filter paper, or measuring the mass of suspended solid after filtering a water sample. (Ribbons of Blue suggest using a turbidity tube – a simple light penetration device.)

OTHER RESOURCES

- Ribbons of Blue primary school manual
- Landcare in your Hands manual
- Water facts 6, *Algal Blooms*
- *Algal Blooms and Nutrients* (video)

Plan a water quality investigation (contd)

REFERENCE CHECKLIST

Resource Sheet 4, *Nutrient enrichment in the Swan River system*

OTHER RESOURCES

Ribbons of Blue primary and secondary school manuals

Nutrients

- Recall any prior knowledge of the sources of nutrients in the river. Decide how nutrients might move into waterways. Practise testing phosphate and nitrate concentrations in water using a Palintest Kit or other colorimeter or spectrophotometer.
- To show how fertilisers and sewage cause algal blooms, complete the activities *Watching Eutrophication* (Ribbons of Blue primary school manual) and *Sewage Pollution is a Serious Problem* (Ribbons of Blue secondary school manual). See Resource Sheet 4, *Nutrient enrichment in the Swan River system*. Refer also to the Ribbons of Blue primary school manual, *Classroom Activities: Fertilisers*.

Dissolved oxygen

- Use reference materials (or specimens) to study the gills of macroinvertebrates and fish. Compare oxygen availability for land animals and aquatic animals. Water has about 9 mg/L dissolved oxygen compared to about 350 mg/L of oxygen in air.
- Investigate the factors that affect the amount of oxygen that dissolves in water.
- Revise the concepts of photosynthesis and respiration and the way in which these processes are related to levels of dissolved oxygen.
- Investigate ways to measure the amount of dissolved oxygen in water. Practise measuring, using a dissolved oxygen test kit.

Step 3: To decide what aspects of the aquatic environment will form the basis for their investigation and then prepare for their investigation, students could:

- After discussing aspects of the site to be visited, decide what water quality parameters could be investigated at the site.

Note: Water quality investigations could focus around the detection of pollutants, sources, impacts and solutions. The nature of the site chosen will influence the students' decisions. An estuarine investigation might centre on the influence of tides and freshwater flow on the physical environment. However, an investigation of a tributary or drain might focus on the effects of dryland or urban salinity.

- Generate questions that will form the basis of their on-site investigations.
- Form a group with students who have similar ideas for an investigation. Plan the investigation and determine what else needs to be known before work can begin.

Plan a water quality investigation (contd)

Step 4: To finalise details of the planned on-site investigation, students could:

- clarify the question(s) to be investigated
- write up the methods they will use
- draw up tables for recording their results
- list their equipment needs and arrange access to these
- allocate responsibilities to group members
- determine how their investigation fits with those of other groups
- review water-sampling techniques
- calibrate equipment and clarify safety procedures

Step 5: Students could now give some consideration to the end-point of their investigation. They might, through discussion, generate an idea for a key task and a method of presenting and communicating the results of their water quality investigation. Some examples are:

- Invent and build improved water-testing equipment with a view to either demonstrating its use to a group of students or writing a set of instructions to accompany the equipment.
- Design a series of posters or riverside signs, or a TV commercial, drawing the community's attention to pollution problems in river environments. Plan to send these to appropriate organisations for comment.
- Write a brief report for the local council, the Water and Rivers Commission or the school newsletter detailing the water quality investigation project and the results determined.

Note: Students may develop other ideas after considering solutions and management options.

Pollution

For water quality investigations that focus on sources of pollutants, students could:

- Complete the activities *What Causes our Water to become Polluted?* and *What Types of Substances are Pollutants?* Refer to the Ribbons of Blue primary school manual, *Water Catchments: Pollution.*
- Construct and display a concept map that shows sources of pollutants.
- View the video *Algal Blooms and Nutrients.*
- Find out where rubbish tips used to be situated around the banks of the river. Discuss how pollutants get into the river in groundwater, and the types of land uses that could pollute groundwater. Refer to Water facts 10, *Groundwater Pollution.*

For water quality investigations that are to focus on the impact of pollutants on water quality, students could:

- Refer back to the pollutants listed as a result of the introductory discussion on drains, and begin research to find out more about the impact of each pollutant on water quality.
- Find out about the effects of pollutants on waterways. Refer to the Ribbons of Blue primary school manual, *Classroom Activities: Pollution – What are some of the Pollutants in our Waterways?* For more information see Resource Sheet 3, *Waterways pollution* and Water facts 3, *River and Estuary Pollution.*
- Determine how to tell when a pollutant reaches serious levels. Use measures such as sensory impact, threshold limits for each type of pollutant or a quantitative impact on fauna to reach consensus on tolerable levels of pollution for each potential pollutant. Use these ideas to design a monitoring scale.
- Develop ideas about acceptable standards for each pollutant. Refer to the Ribbons of Blue primary school manual, *Interpretation of Results.*

REFERENCE CHECKLIST

- Resource Sheet 3, *Waterways pollution*

OTHER RESOURCES

- Ribbons of Blue primary school manual
- Water facts 3, *River and Estuary Pollution*
- Water facts 10, *Groundwater Pollution*
- *Algal Blooms and Nutrients* (video)

Pollution (contd)

To consider land-use activities in the catchment as a source of pollutants, students could:

- Consider the meanings of the terms 'catchment' and 'subcatchment'. Refer to Resource Sheet 5, *Catchments* and the Landcare in your Hands manual.
- Brainstorm a list of all the types of land-use activities in the catchment of the Swan-Canning river system.
- Investigate sources of pollutants by finding out more about the types of land-use activities in the catchment.
- Discuss factors other than chemical pollutants that affect water quality, e.g. processes that remove vegetation, allow water to overheat, change water flow regimes or destabilise the banks.
- Construct a table that relates land uses to their potential pollutants. See Resource Sheet 3, *Waterways pollution*, or Water facts 3, *River and Estuary Pollution*.

REFERENCE CHECKLIST

- Resource Sheet 3, *Waterways pollution*
- Resource Sheet 5, *Catchments*

OTHER RESOURCES

- Water facts 3, *River and Estuary Pollution*
- Landcare in your Hands manual

Estuarine environment

To develop understanding of the estuary as a constantly changing environment, students could:

- Recall and discuss what they know about the effect of tides in the Swan River estuary. See Resource Sheet 6, *Seasonal changes in the water of the Swan River estuary.*
- Consider how tidal movements would influence the measurable characteristics of the water (temperature, salinity and dissolved oxygen).
- Make predictions about the salinity of the estuary at different times of year and consider the impact of seasonal changes in salinity on estuarine fauna.

  ***Note:** In summer salt water can extend as far upstream as Ellen Brook on the Swan River and Kent Street Weir on the Canning River, whereas in winter the surface water of the estuary can be fresh as far down as Blackwall Reach.*

- Collect information about estuaries from various sources. Consider how the estuarine nature of the Swan River influences its pollution potential.

REFERENCE CHECKLIST

- Resource Sheet 6, *Seasonal changes in the water of the Swan River estuary*

Management options

To consider water quality problems and find out about possible solutions, students could:

- Reflect on what could be done to address the problem of waterway pollution. Brainstorm possible solutions. Generate focus questions about solutions.
- Find a solution that each of these groups might suggest: people in the community, schools, scientists, local business, big business, local government, the State Government, the Federal Government. Find out what is being done by some of these groups to address water quality problems.
- Contact the Swan Catchment Centre, a local council or local newspaper to find out whether there are community groups working on rivercare in the local area. Refer also to the Swan River Trust *Rivercare Directory.* Invite a guest speaker.
- Add potential solutions to the 'sources of pollution' concept map.
- Talk to another student group interested in water quality, perhaps via the Internet. See Appendix 1, *Watery web sites.*

To develop a deeper understanding of a particular management issue, students could:

- Conduct a community awareness campaign aimed at helping to prevent water pollution in the Swan River system.
- Develop a water pollution prevention strategy for the local community. Present it to the community through the community newspaper.
- Write a cartoon strip, comic book or children's story book based on the adventures of the 'River Police' whose aim is to ensure the protection of the river environment.

REFERENCE CHECKLIST

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Appendix 1,
Watery web sites

OTHER RESOURCES

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Swan River Trust
Rivercare Directory

Site familiarisation

To reflect on the features and values associated with a river site, students could:

- Describe the site first from an everyday perspective, noting aspects such as its natural and cultural features, interest value, recreational value, aesthetic value and health status.
- Describe the site from a scientific perspective, noting characteristics of the non-living environment (water and riverine landforms, e.g. the banks and the floodplain) and characteristics of the living environment (vegetation and animals).
- Consider how various people might perceive the environment, e.g. a land developer, a retired person, a sailboard rider.
- Consider what perspective might give the site the greatest value.
- Write a personal perspective of the site and make a judgement of its value.
- Consider how the environmental health of the site might be judged by observations alone. Apply the pollution scale that was created in the preliminary stage. Alternatively, complete Excursion 12, *Rating river health,* in the booklet *Excursions in the Swan River Environment.*

- Conduct a site survey to collect details of the characteristics of the site. Refer to the Ribbons of Blue primary school manual, *Fieldwork: Rating your Waterway – Site Rating.*
- View the site as a subcatchment, (i.e. identify where the water comes from and where it flows to).
- Map the site to show its water features such as the river, drains (open and closed), tributaries, natural wetlands and constructed pools. Show the direction of flow of water and the high water line.

OTHER RESOURCES

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Excursion 12, *Rating river health,* in the booklet *Excursions in the Swan River Environment*

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Ribbons of Blue primary school manual

Conduct a water quality investigation

To conduct the investigations that were planned in the preliminary stage, students could:

- Look at the site in the context of the planned investigation and consider its suitability. Modify plans if necessary. Select the best water-sampling locations. Try out the sampling devices.
- Conduct the investigation.

If no detailed investigation was planned in the preliminary stage, students could try some simple investigations to introduce them to aspects of water quality testing. For example, students could:

- Test river water for various parameters, and compare the results with those of the pre-visit tests that were conducted on tap water and sea water.
- Test for differences in temperature, salinity, turbidity and pH of: deep and shallow water; water near the river bank and near the centre of flow; water near a sandy bank, a hard bank and/or a vegetated bank. Students should ask questions and make predictions before testing.
- Devise a plan for a water quality investigation that will compare the inflow water from a drain or tributary with the water of the main river. Select the best sampling sites; decide what will be tested, the sampling technique to be used and how often the testing needs to be done. Ideally students should test the river water for various parameters over a period of time (e.g. allow for four site visits a year) and relate any changes to seasonal effects.
- Imagine they are river doctors who visit the river to give it a health check. Visible water quality problems represent the symptoms of ill health and the water tests represent a medical examination to find clues about the cause of any problems. Assess the general health of the 'patient' and conclude by prescribing appropriate treatment.

Pollution

To explore the area to identify potential sources of pollutants, students could:

- Identify and sketch a map of the different types of land uses that occur alongside the river and colour-code the map according to the severity of their potential impact on the river.
- Identify any drains in the area and locate them on a sketch map. Try to determine their sources. Open drains will be quite visible, but closed drains may be noticeable only at the point of entry into the river.
- Look for and note the effects of substances entering the river via drains. For instance, notice any conspicuous sediment deposits, stains or slicks on the water, nasty smells or dead vegetation.
- Look for evidence of the impact of humans at the site. Complete Excursion 3, *Effects of human activities at the river,* and Excursion 6, *Alien plant game,* in the booklet *Excursions in the Swan River Environment.*
- Examine any material that has washed up on the banks. Decide on its probable source and write a story about how it might have arrived at the site.

OTHER RESOURCES

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Excursion 3, *Effects of human activities at the river,* in the booklet *Excursions in the Swan River Environment*

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Excursion 6, *Alien plant game,* in the booklet *Excursions in the Swan River Environment*

Estuarine environment

To improve their understanding of aspects of the estuarine environment, students could:

- Draw a sketch map that shows the position of the estuary relative to the river and the ocean. See related activities in the booklet, *A Sense of Place in the Swan River Environment.*
- Observe the direction of tidal movement and measure its rate of flow. To measure the tide, attach a 1-m rule to a stake and plant the stake in the water. Record the height of the tide every 15 minutes, or measure the total change in the tide during the time of the site visit. (Place most of the rule above water level if the tide is rising, and below it if the tide is falling.)
- Design an instrument to measure the rate of flow of water at different depths. Students could build the instrument later and then test it out on a subsequent visit.
- Measure the water's salinity, dissolved oxygen and temperature at different depths. Then graph the data by placing depth on the vertical axis, and using horizontal scales for dissolved oxygen, salinity and temperature. Interpret the graphs. See Resource Sheet 7, *Dissolved oxygen profile.*
- Conduct a transect of the fringing vegetation and note vegetation transition zones in relation to water level (high and low tide).
- Identify and name the various habitat zones.
- Collect samples from the bottom, spread them in white science trays, and observe and identify any living things.
- Collect zooplankton and algae for microscope studies. Refer to the *River Communities* theme in this booklet, Water facts 6, *Algal Blooms,* and the video *Algal Blooms and Nutrients.*

REFERENCE CHECKLIST

Resource Sheet 7, *Dissolved oxygen profile*

OTHER RESOURCES

A Sense of Place in the Swan River Environment

Water facts 6, *Algal Blooms*

Algal Blooms and Nutrients (video)

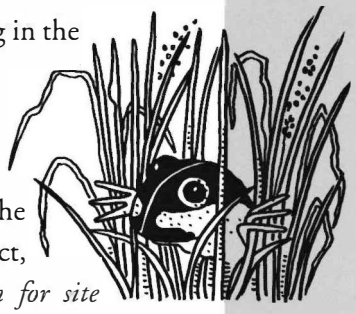
Solutions and management

To encourage students to care for the riverine environment in order to ensure its future health, students could:

- Design signs that might be placed at the entry and exit points of drains to increase public awareness about where the drains come from, where they go to and what is in them.
- Write a radio commercial designed to discourage people from emptying inappropriate material into drains.
- Design a stencil that could be painted on a concrete section of a drain or kerb to increase the community's awareness of where urban stormwater drains lead to. (Stencils should be simple statements or illustrations, like the Swan River Trust's 'Drains to the River' and 'Clean Water Only'.)
- Study aspects of the fringing vegetation that contribute to its effect as a buffer. Suggest how it might help to control water quality.

***Note:** Reeds and sedges at the water's edge help to control water quality. They act as nutrient filters and as barriers to pollutants moving through groundwater.*

- Look for evidence of revegetation activities that might be occurring in the area.
- Contact a local rivercare group to see if the class can help in any revegetation activities.
- Consider whether the river site, a stream or drain in or near the school grounds could offer opportunities for a revegetation project, and make an action plan. Complete Excursion 7, *Action plan for site revegetation,* in the booklet *Excursions in the Swan River Environment.*
- Identify what appears to be the main environmental problem at the site. Design site modifications that will help to solve the problem in some way, e.g. to increase the oxygenation of a stream, create more stream habitat or reduce sedimentation.



OTHER RESOURCES

Excursion 7, *Action plan for site revegetation,* in the booklet *Excursions in the Swan River Environment*

'Drains to the River' and *'Clean Water Only'* (Swan River Trust stencils)

Water quality investigation

To encourage follow-up of on-site investigation, students could:

- Graph and display data collected during the site visit, interpret the graphs and offer explanations for the results.
- If necessary, improve or redesign the investigation. Include modifications to sampling equipment and methods, and changes to testing procedures.
- Write a report of the investigation.

To extend the scope of the investigation(s), students could:

- Set up a computer database to manage the monitoring results.
- Research the tolerable range of values for each of the parameters tested.
- Compare their results to existing data. Use the data disc *Water Quality Data* and Appendix 2, *Water quality data disc explanatory notes*, as a basis for data analysis and interpretation exercises. See also Resource Sheet 8, *Water quality data – analysis and interpretation.*
- Invent tools to improve monitoring, e.g. find better ways to collect water from different depths, to measure the rate of flow of water at different depths, to measure light penetration through a sample or to concentrate samples of algae or zooplankton. Refer to Water facts 6, *Algal Blooms*, and the video, *Algal Blooms and Nutrients.*
- Using the data disk, graph changes in dissolved oxygen and salinity against depth for different river sites at different times of year. Predict the consequences of these changes for fauna and river health in general. Refer also to the *Swan-Canning River and Estuarine System Map* for location of sites.
- View their water quality investigation as a starting-point only, and design and plan a longer term water monitoring study.
- Prepare a report for local government based on the data gathered.

Note: The local government body is likely to be very interested in the findings of any investigation, particularly those conducted over a longer period of time, and may also be interested in entering into a joint venture to monitor water quality over a longer period.

- Develop the investigation as a project for entry into a competition such as the Science Talent Quest, Earthworm Awards, Shell or BHP Science Awards, or Ribbons of Blue Awards. For more information on competitions contact the Science Teachers' Association of Western Australia.

REFERENCE CHECKLIST

Resource Sheet 8, *Water quality data – analysis and interpretation*

Appendix 2, *Water quality data disc explanatory notes*

OTHER RESOURCES

Water Quality Data (data disc)

Water facts 6, *Algal Blooms*

Algal Blooms and Nutrients (video)

Swan-Canning River and Estuarine System Map (poster)

follow-up

Water quality investigation (contd)

- Join a community water monitoring program if one exists in the subcatchment. Refer to the Swan River Trust *Rivercare Directory* for the names of support groups in the Swan-Canning region.
- Encourage mathematicians to manipulate their data. Work out how to use the results of their nutrient testing to determine the total annual load of phosphate that enters the estuary from the subcatchment. Work out how to measure the total mass of sediment entering the estuary from a particular drain.
- Collect reports of current research into aspects of water quality in the Swan estuary. List a number of research, projects and find out the main focus of scientific research. Students can imagine they are members of an assessment panel which allocates funds for research, and rank the research projects listed in order of perceived importance, allocate funding accordingly and justify their decisions. (The *Swan-Canning Cleanup Program Action Plan*, published by the Swan River Trust, is an excellent source of information.)
- Share the results of their investigation with students doing similar studies in another part of the State. (Ribbons of Blue can put students in touch through the Internet.)

OTHER RESOURCES

Swan River Trust
Rivercare Directory

Swan-Canning Cleanup Program Action Plan

follow-up

Pollution

To improve their understanding of the impacts of pollutants by further investigating the link between water conditions and aquatic life, students could:

- Set up controlled experiments to investigate the growth of duckweed in response to the addition of various nutrient combinations. Duckweed is found in many of the nutrient-enriched freshwater streams and drains during summer. Refer to the Year 11 Web of Life manual for details of experiments.
- Set up controlled experiments to investigate the effects of salt water on plant growth. Test plants that are affected by dryland salinity, such as wheat, oats, clover, lupins, peas and canola.
- Continue (and conclude) research on the effects of particular pollutants on water quality and the plant and animal life that the water supports.
- Organise a student forum at which results of research on water quality issues can be presented.
- Sketch a graph to show algal biomass, nutrient concentration and dissolved oxygen levels against time in a eutrophic system. Explain the shape of the graph.
- Find out more about the toxic blue-green blooms sometimes associated with eutrophication. Resource material on eutrophication in the Peel-Harvey estuary is available from the Water and Rivers Commission and the Department of Environmental Protection. Refer to Water facts 6, *Algal Blooms*, and the video *Algal Blooms and Nutrients.*
- Research the effects of eutrophication on a river system, and draw a flow chart to illustrate the causes and effects of eutrophication. Refer to the *Swan-Canning Cleanup Program Action Plan.*
- Find a local example of an aquatic weed (e.g. in the Canning River). Suggest how it might have got into the river. Discuss how water quality affects the growth of aquatic weeds.
- Research the effects of salinity in a catchment (for example the Avon catchment). Map the extent of clearing. Discuss how changes in salinity in the Avon River could affect the Swan River.

OTHER RESOURCES

- Web of Life manual
- Water facts 6, *Algal Blooms*
- *Algal Blooms and Nutrients* (video)
- *Swan-Canning Cleanup Program Action Plan*

follow-up

Managing pollution

To improve their understanding of ways of preventing pollution entering rivers and consider what can be done to ensure healthy waterways for the future, students could:

- Conduct a community survey to identify the pollutants that enter stormwater drains and groundwater in the local area. Then design a community awareness campaign aimed at helping to prevent waterway pollution.
- Prepare and give a talk to a local community service organisation aimed at increasing awareness of the potential effect of various activities in the local area on river water. Suggest strategies to reduce this impact.
- Prepare an environmental impact assessment of any proposed new housing and commercial development in the catchment area. Consider potential water quality problems. Advise the developer of strategies to prevent pollution. Students could also interview people to determine their awareness of, and their degree of concern for, the potential impact of the development on water quality.
- Develop understandings about Integrated Catchment Management. (Visit the Swan Catchment Centre to gather information.)
- Write a comic strip based on the activities of the 'River Police' (people or riverine animals) on their quest for river protection.
- Create a TV advertisement to raise awareness of how people's activities can affect river health and what they can do about it.
- Design a newspaper spreadsheet that contains articles of information giving people an understanding of the state of the Swan River environment. Information could take the form of interviews, reports, historical research, cartoons and stories about positive action.
- Prepare a poster or photo display for the local library or shopping centre that raises community awareness about river health and promotes the idea that people share responsibility for the health of the river system. Devise a code of conduct to accompany the display.
- Design a display for the school fete, conduct a special event on World Environment Day (5 June), or become involved in a fund-raising event to support positive local action aimed at preserving the health of the river. Arrange a radio interview to publicise your class action.

follow-up

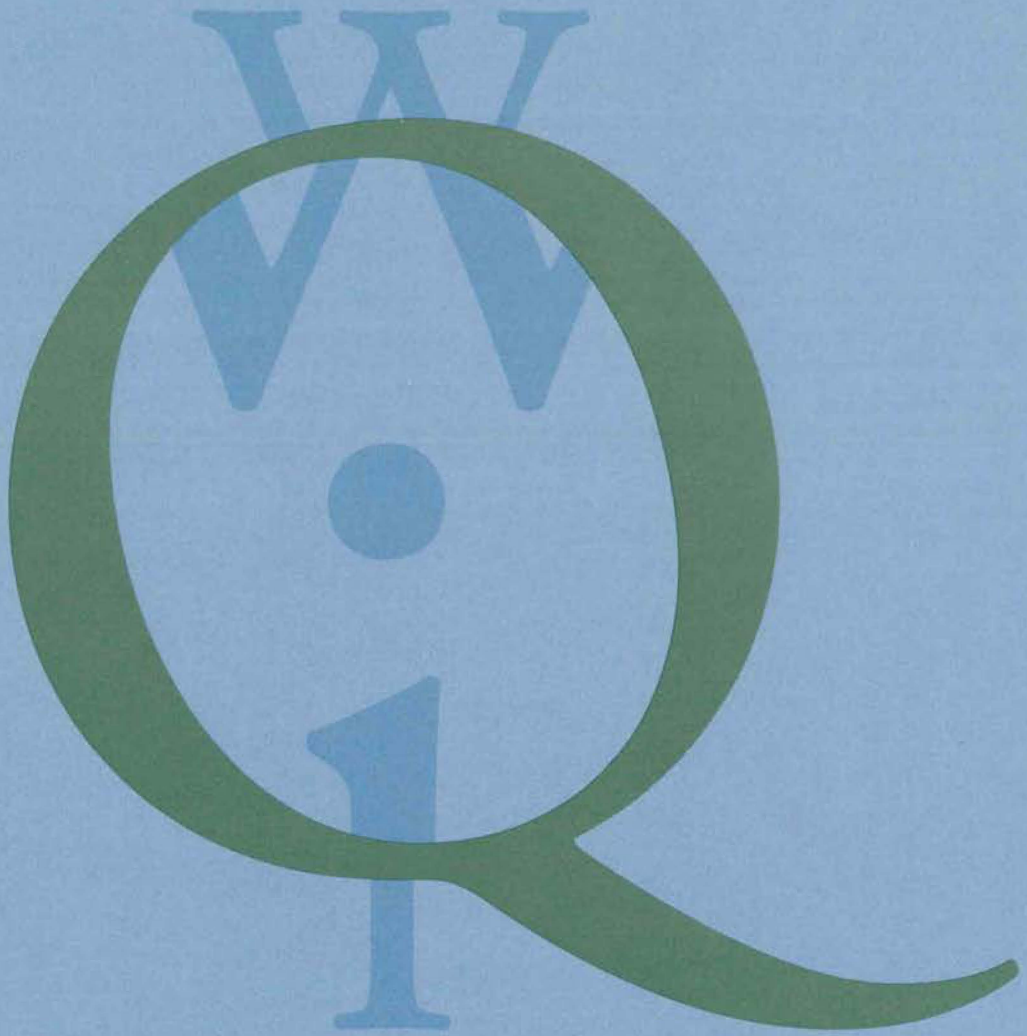
Managing pollution (contd)

- Organise a scientific forum on the future of the river based on current research and management practices. Groups of students could represent different research interests, different management practices and different visions for the future.
- Present a media file about the Swan River to the school library.
- Design and display a series of posters featuring the river doctor and his treatments for the river's ailments.
- Consider future waterways problems that might arise as Perth's population grows. Discuss steps that might be taken to create the ideal of a perfectly healthy catchment. Show these on a timeline.
- Survey nurseries, local councils and local gardeners to find out about the phosphate and nitrate content of different fertilisers used and the quantity of fertilisers recommended for use. Then prepare guidelines for gardeners to advise on appropriate levels of fertiliser use.

follow-up

Water Quality Investigations

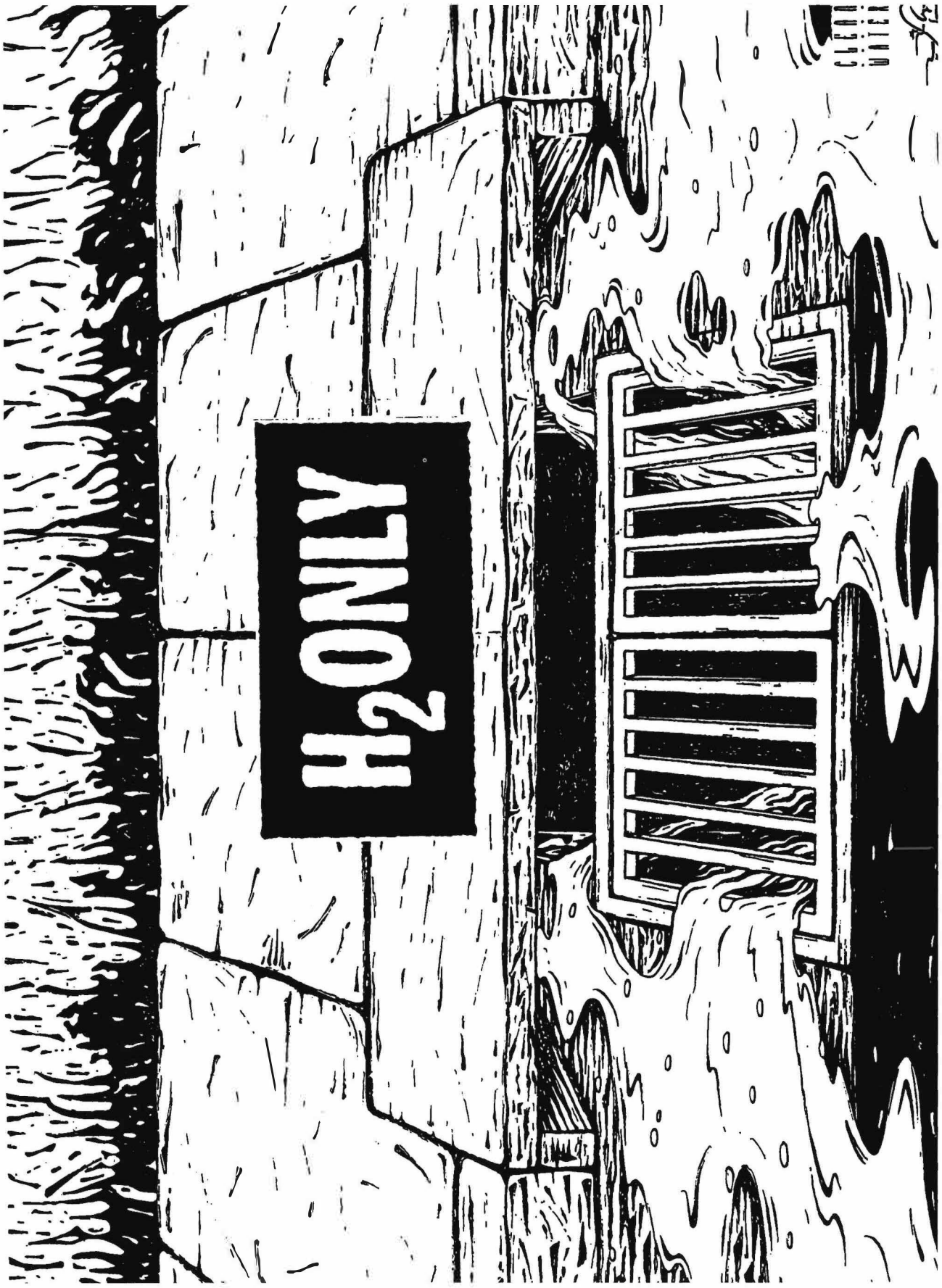
Resource Sheets



Working Scientifically in the Swan River Environment

H_2ONLY

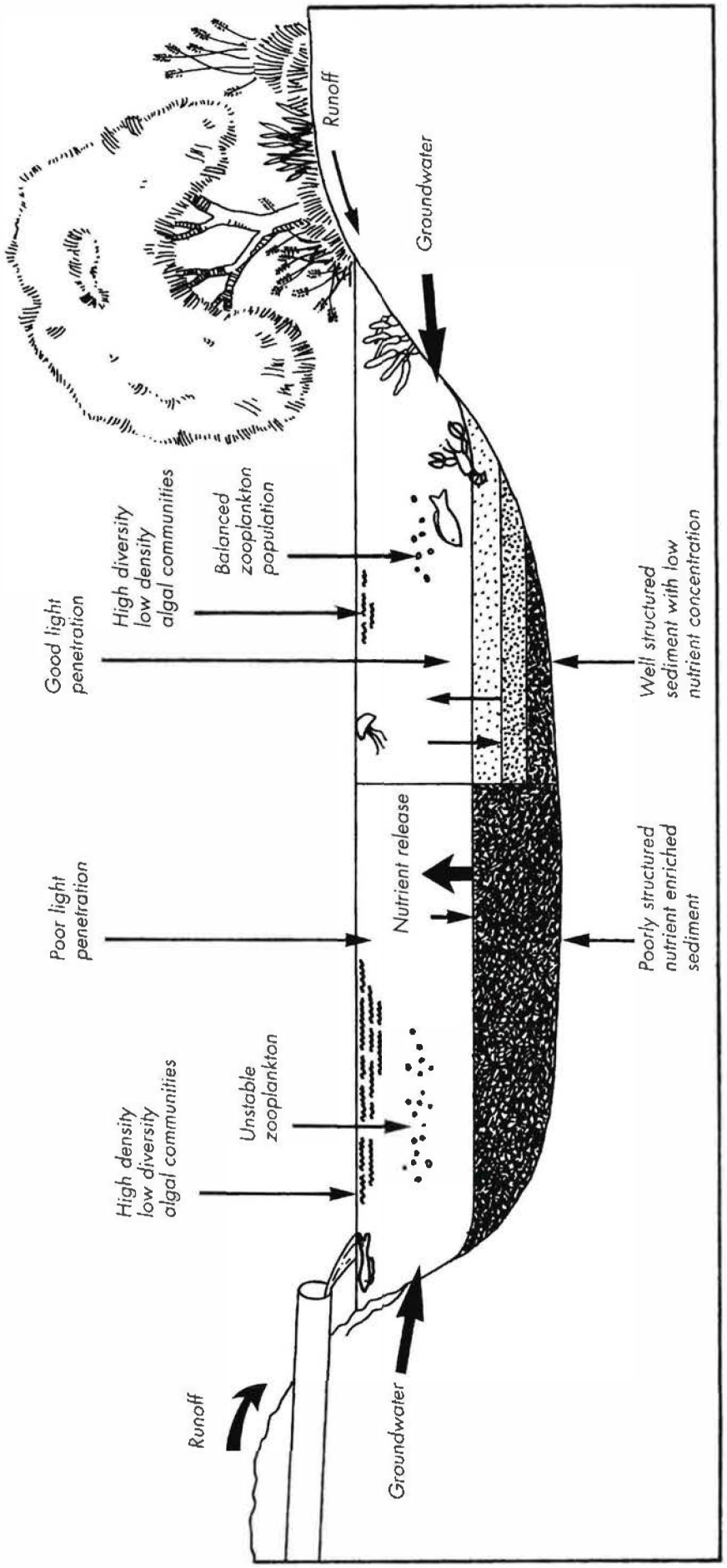
1 resource sheet



2 resource sheet

Working Scientifically in the Swan River Environment

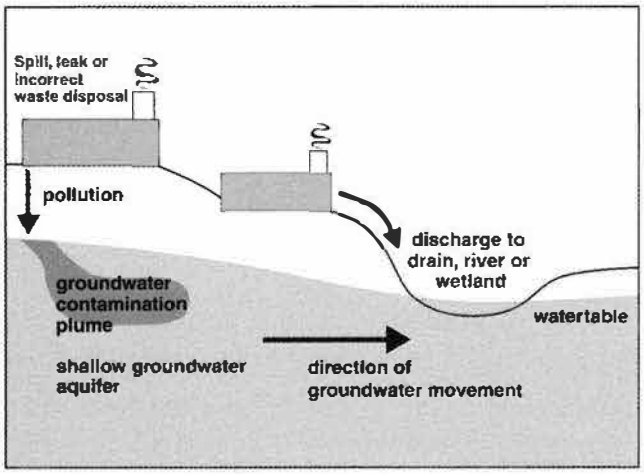
Comparison between a healthy and an unhealthy river



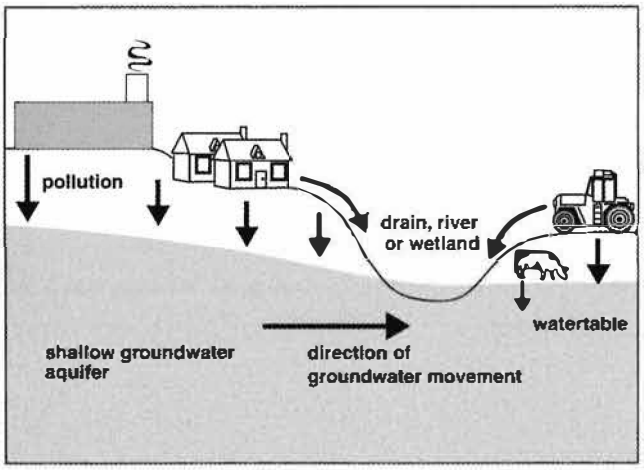
Waterways pollution

Water quality problems occur in the Swan-Canning estuarine system and its tributaries (streams and drains). A waterways pollutant is any substance that is added to water in large enough quantities to cause problems for birds, aquatic plants, animals and people. Increased population and urban development, and greater use of the river for recreation, sporting, fishing and other activities, has resulted in increased discharge of water to the Swan River system and increased the risk of contamination.

Pollutants come from a number of different **sources** in urban and rural areas. Some come from a particular activity occurring at a particular location (point source pollution). However, most pollution comes from a wider or more diffuse area (non-point pollution). Pollutants can be carried into streams from normal drainage (runoff) from the land or from industrial and stormwater drains. They can be leached through the soil to the groundwater, which moves underground and then into the river.



Point source pollution



Diffuse sources of pollution
(Water facts 10, *Groundwater Pollution*)

Domestic/suburban pollutants include detergents, oils, chemicals (e.g. chemicals in solvents, cleaners, paints), fertilisers, pesticides, herbicides, bacteria and nutrients from septic tanks, litter (e.g. plastics, cigarette butts, metal, polystyrene, cardboard), domestic animal wastes, grass clippings and other garden rubbish (e.g. plant cuttings and seeds) and building materials (e.g. sand and cement).

Industrial pollutants include wastewater from factories and workshops (e.g. from washing down machinery). It also includes hot water.

Agricultural pollutants include commercial fertilisers (phosphates and nitrates) and pesticides (insecticides, herbicides and fungicides) that are used in rural areas. Animal wastes (e.g. droppings) come from paddocks, dairies, horse stables and animal yards. High levels of nutrients in the form of nitrogen and phosphorus from fertilisers and wastewater may cause accumulation of nutrients and excessive growth of algae in wetlands and waterways. This is known as eutrophication. The death and decay of algae can produce stagnant (low oxygen) conditions which can cause fish kills. Some algal blooms are toxic. Problem algal blooms occur mainly in late spring and summer when water levels are low, the water is warm and nutrient concentrations are high.

Salt can be a pollutant. Rising stream salinity results from people clearing vegetation in agricultural areas. In particular it is caused by the clearing of deep-rooted native vegetation (which uses much of the water in the watertable, keeping the salt down), and replacing it with shallow-rooted crops and pastures that use less water. The watertable rises, bringing salts to the surface. Salty water can find its way into waterways and cause massive ecological and economic problems.

Water from across the catchment eventually finds its way into the estuary. This means that pollutants from all land uses in the catchment can also end up in the estuary.

Excess turbidity (muddiness) can also be a pollutant. It may be caused by a variety of activities that lead to erosion of the catchment and of river banks (e.g. clearing the vegetation of the river bank and allowing unrestricted access of cattle and sheep). Excess turbidity reduces the amount of light that can penetrate the water, which may limit the growth of algae and other aquatic plants including seagrasses. In extreme cases fine particles may also coat and choke the gills of fish. Sediments can be carried down the river and accumulate in river pools or in the estuary, and can eventually fill and destroy pools.

Pollutants can have direct and indirect effects on river health. Petroleum products and toxic chemicals directly affect aquatic life. Domestic and animal wastes can contribute to the build-up of excess nutrients, algal blooms and blooms of toxic blue-greens, causing the death of wildlife and threatening human health. Bacteria and viruses can be a public health concern.

Aquatic weeds can grow and deprive the waterways of oxygen, particularly when they die. Sunlight can't get through and the water stagnates and smells. Weeds can affect birds and other wildlife.

Some pesticides do not break down rapidly in the environment. Once ingested, aquatic organisms cannot eliminate them from their systems, so these substances are incorporated into all feeding levels in the food web.

Nutrient enrichment in the Swan River system

Nutrients are chemicals that are essential for plant and animal growth and wellbeing. They are important in the aquatic ecosystem because the rate of nutrient supply determines the rate of primary production (production of plant material) if light and temperature are also favourable for growth.

Plants and some animals obtain nutrients from mineral solutions in their environments. Some animals obtain them from eating plants, and some eat other animals. This creates a complex food web. Nutrients are returned to soil and water through the processes of decay, and become available to other plants and animals in a continuous 'recycling' process.

Excessive amounts of certain nutrients, such as nitrogen and phosphorus, in a wetland or waterway can be harmful. In a natural system, nutrients are constantly cycled and the process of build-up of nutrients coming in from the catchment is slow. However, human use of the catchment means that more nutrients are being added to it by artificial means (e.g. fertilising paddocks and gardens). Human land-use activities in the subcatchments of the Swan-Avon river system increase the 'export' of nutrients to rivers and streams, therefore increasing their nutrient load. This process of nutrient enrichment is called **eutrophication**. The most important nutrients contributing to the eutrophication of the Swan River estuary are **nitrogen and phosphorus**. They enter the river (in soluble form as organic matter, or attached to sediment particles) directly, in runoff, or via groundwater.

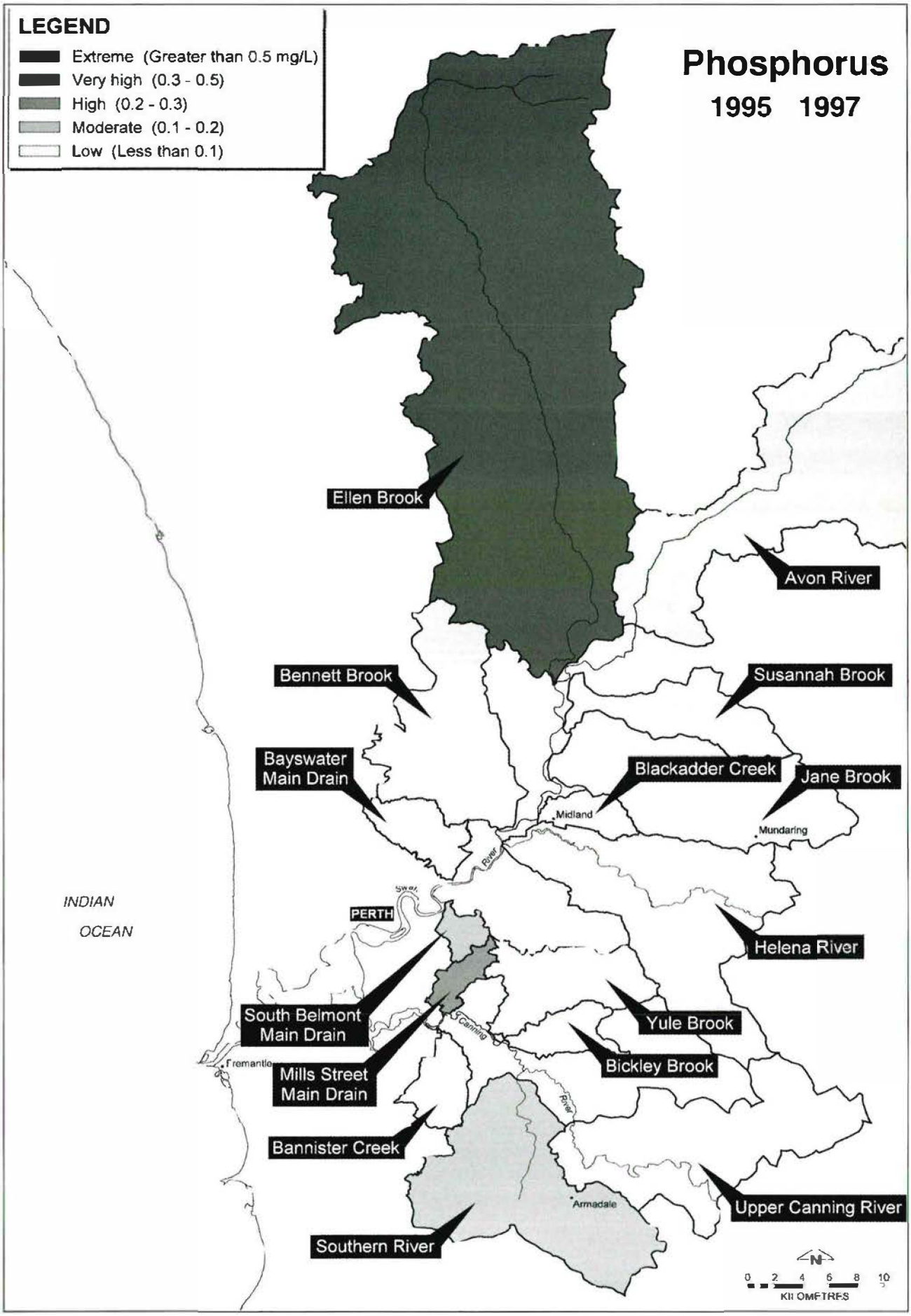
Eutrophication disrupts the ecology of the aquatic ecosystem, causing a change in species composition, so that the natural community of plants and animals may come to be replaced by less diverse groups. Nutrient enrichment also results in **algal blooms**, especially in spring and summer. The Swan River has experienced a high number of algal blooms over recent years.

Excessive growth of algae and other plants can reduce light penetration, and some blooms are toxic. When an algal bloom dies, the process of rotting can use up all the oxygen in the water. Oxygen depletion in bottom waters can cause the death of worms, crabs and other invertebrates, and severe oxygen depletion can result in fish deaths. For humans, the slimy scum of algal blooms and offensive smell of rotting algae are a nuisance and a potential cause of health problems.

Excess nutrients come from widespread sources in urban and agricultural areas in the Swan-Avon catchment. Sources of nitrogen and phosphorus include excess from commercial fertilisers applied to crops and pastures, effluent from animal feedlots and intensive animal industries (e.g. piggeries) and grazing areas, and wastes from agricultural industries (e.g. food-processing factories). In urban areas phosphates are concentrated in detergents, wastes from sewerage systems and industries, and runoff from lawns and gardens. Organic material, including the leaf litter from introduced deciduous trees, also adds nutrients to the waterbody.

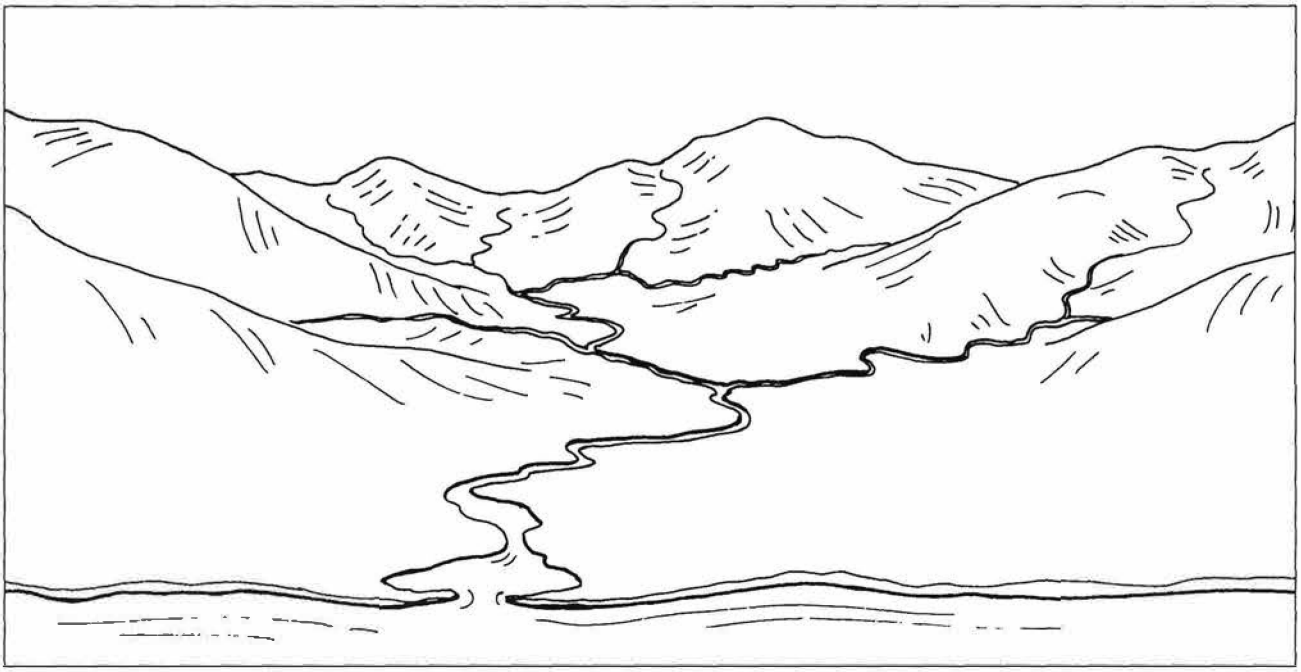
The amount of nutrients exported from the various subcatchments depends on factors like the type of land use in the catchment (residential, industrial, agricultural, horticultural), the size of the catchment and extent of clearing (which affect streamflow volumes), the soil type (which affects the ability to hold nutrients) and water flows, including drainage in the catchment. Ellen Brook, the Mills Street Main Drain and the Southern River subcatchment contribute significant phosphorus and nitrogen loads to the Swan River system.

Efforts to manage nutrient enrichment include promoting research into algal blooms, investigating ways of reducing nutrient build-up in rivers, exploring techniques such as oxygenation to make river conditions less suitable for algal blooms, implementing Best Management Practices, and education for urban and rural landholders to work together to tackle the problem at its source.



Classification of subcatchments of the Swan-Canning system based on total phosphorus concentrations between 1995 and 1997. Subcatchments of the Swan-Canning system have been classified according to total phosphorus concentrations measured in their freshwater streams and drains between 1995 and 1997. Concentrations of total phosphorus are measured in milligrams per litre (mg/L) and median concentrations have been used to classify subcatchments. Although algal blooms in the upper Swan are considered nitrogen 'limited', simultaneous reductions in both total nitrogen and phosphorus are required to ensure better water quality.

Catchments



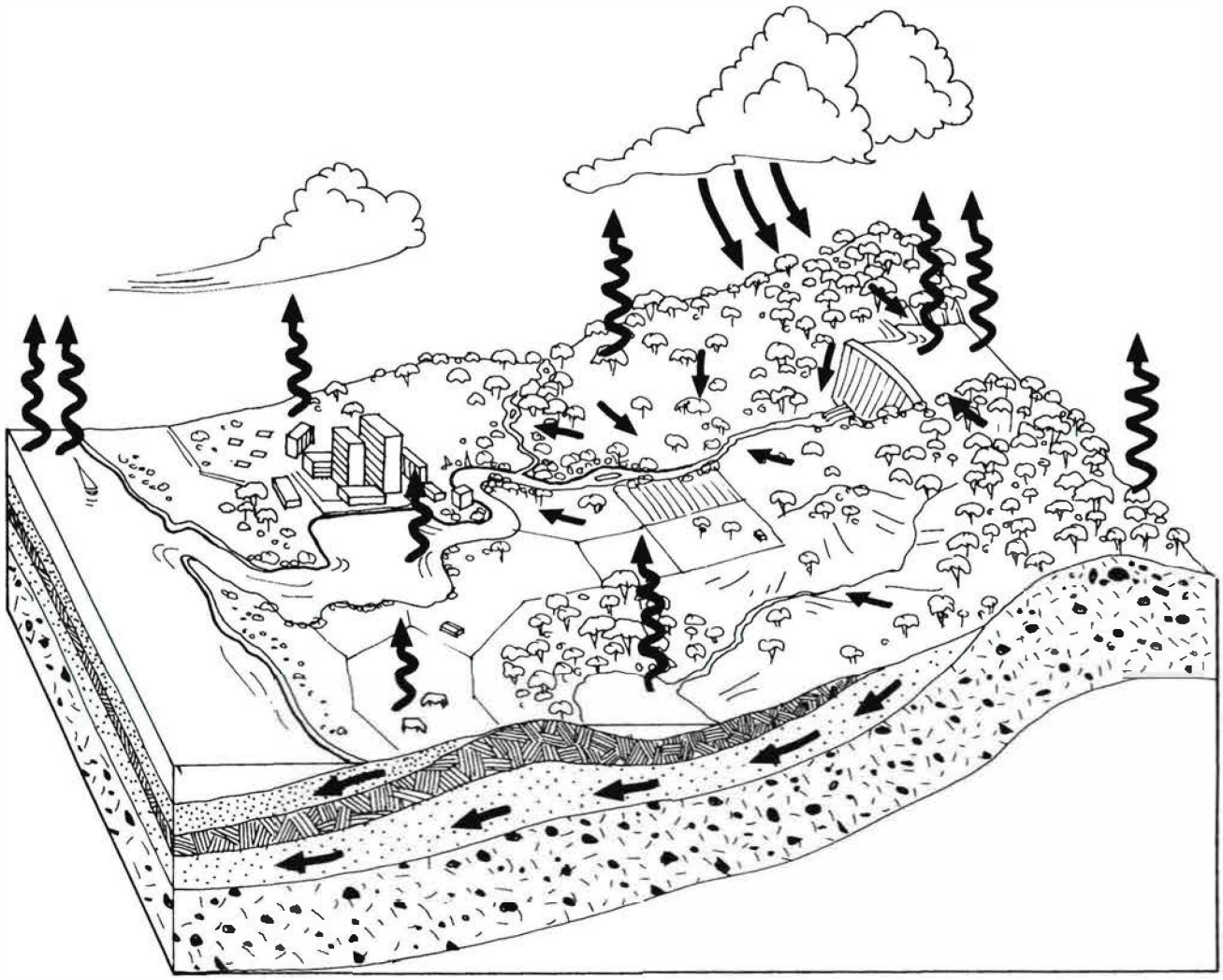
A catchment is the area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater. The water flows to a common low point. (Think of water falling on a roof – the catchment – and flowing to the top of a downpipe, or water in a bathtub flowing down to the plughole.) In a natural catchment the low point might be low-lying land, a lake, river or stream, a wetland or the mouth of a river where it enters the sea. The high points might be the tops of steep slopes where the water starts to flow.

Catchments vary in size. Large catchments are usually bordered by mountain ranges or hills, and they contain the major drainage networks of creeks (tributary streams) and rivers. These large catchment areas are made up of many smaller subcatchments, which may be bordered by low hills/ridges, and they may be drained by only small streams. A local catchment might simply consist of all the land that drains down towards a spot on the river.

The water cycle

Water links everything in a catchment. The water cycle is the never-ending movement of water through the atmosphere, waterbodies (oceans, lakes, rivers), land, soil and living things. The water changes state as it goes, from water vapour to liquid water and even, in some instances, to a solid form (ice and snow).

The water cycle begins when the sun's energy causes water to evaporate from the sea, other waterbodies, land and vegetation, through the process of evaporation. Plants return water to the atmosphere by transpiration, and animals and humans by respiration and sweating. The invisible water vapour in the atmosphere then forms water droplets by the process of condensation. We see this as clouds. These may join and fall as precipitation (rain, hail, snow) onto the land or waterbodies. Most precipitation soaks into the soil by the process of infiltration. Some is evaporated from the surface soil, and some of it soaks deeper into the **groundwater**. The top of the saturated soil is the **watertable**. Groundwater moves slowly toward rivers, wetlands or the sea. Water that does not soak underground runs off over the land.



Water cycle

The water that flows over the surface in a catchment area, including its streams, is called **runoff**. Runoff collects in wetlands or compensating basins, or is carried away by the network of drains, streams and rivers to estuaries and the sea.

A catchment's resources

Catchments contain a range of natural resources – water, natural vegetation, soil, minerals, air and wildlife. As we all live, work and play in a catchment, we all use its resources in a number of ways. Within large catchments there are different types of land-use activities such as various forms of agriculture (crop growing or raising animals) and urban land uses (towns and cities which contain residences and gardens, places for recreation, transport links, offices, shops, warehouses and factories). Mining and forestry also occur in catchments.

Problems and management

Today, because our population is growing and our use of technology is increasing we are putting pressure on our catchments and creating environmental problems such as soil erosion and water pollution. This is destroying the very resources that we depend on and upsetting the natural balance of our environment. Whatever problems we create in one part of a catchment can affect the quality of land and water elsewhere within it.

Various organisations and people in the community are taking action to improve the health of our catchments, working on landcare and watercare programs in local subcatchments and in catchments covering thousands of square kilometres. Those people working to improve conditions in the smaller catchments are helping to improve the large catchment area and the river.

Since we all live in a catchment, we should all work to improve the conditions of the catchment.

Seasonal changes in the water of the Swan River estuary

In an estuary, fresh water comes from the streams that flow into it from the catchment and meets sea water, which enters as tides. Estuaries undergo constant daily and seasonal changes. There are changes in the volume and quality of water flowing into the estuary; salinity, temperature and oxygen levels change through the year.

The Swan River estuary is subjected to changes in freshwater flow and salinity. Because of the winter rainfall/summer drought climatic pattern in the south-west of Western Australia, the Swan River flows only in winter. This causes great differences in the salinity of the estuary between summer and winter. In winter salinity tends to be much lower because fresh water is flowing into the estuary. This flow is strong enough to prevent sea water moving far into the estuary on the incoming tide, so the upper estuary is fresh throughout winter.

In early spring, rainfall decreases and the freshwater flow is reduced. Sea water is then moved into the estuary through tides. Because the density of salty sea water is much greater than that of fresh water, the bodies of water do not mix readily, but tend to remain separate. The sea water moves upstream beneath the still-flowing lighter fresh water like a wedge. This process, which results in the layering of fresh water over sea water, creates a 'salt wedge'.

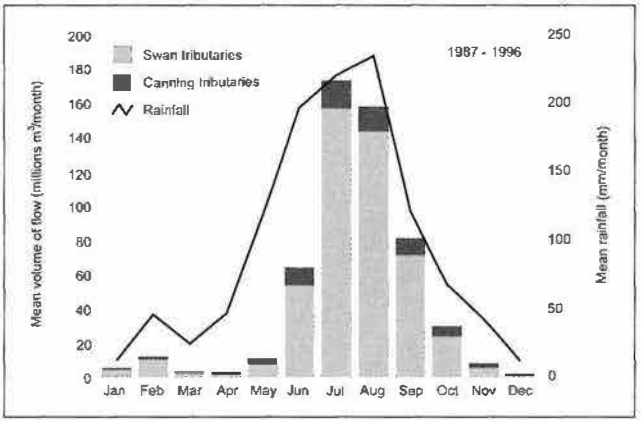
The two bodies of water are gradually mixed by the force of the wind in the open waters of the estuary, and the salinity of surface water increases. As weather conditions become even drier and there is no effective river runoff, this mixed water progresses further upstream. By the end of summer, the whole estuary normally has a salinity level similar to that of the sea.

The estuary's salt wedge can result in deeper bottom waters constituting a separate layer to the better oxygenated surface water. Very little oxygen can diffuse from the air through the surface layer of water and into the deeper waters.

These deeper waters may then become deoxygenated (depleted of oxygen). This is known as anoxia. Millions of invertebrates that live in the mud and sand on the estuary floor are unable to escape and sometimes die as a result of the lack of oxygen.

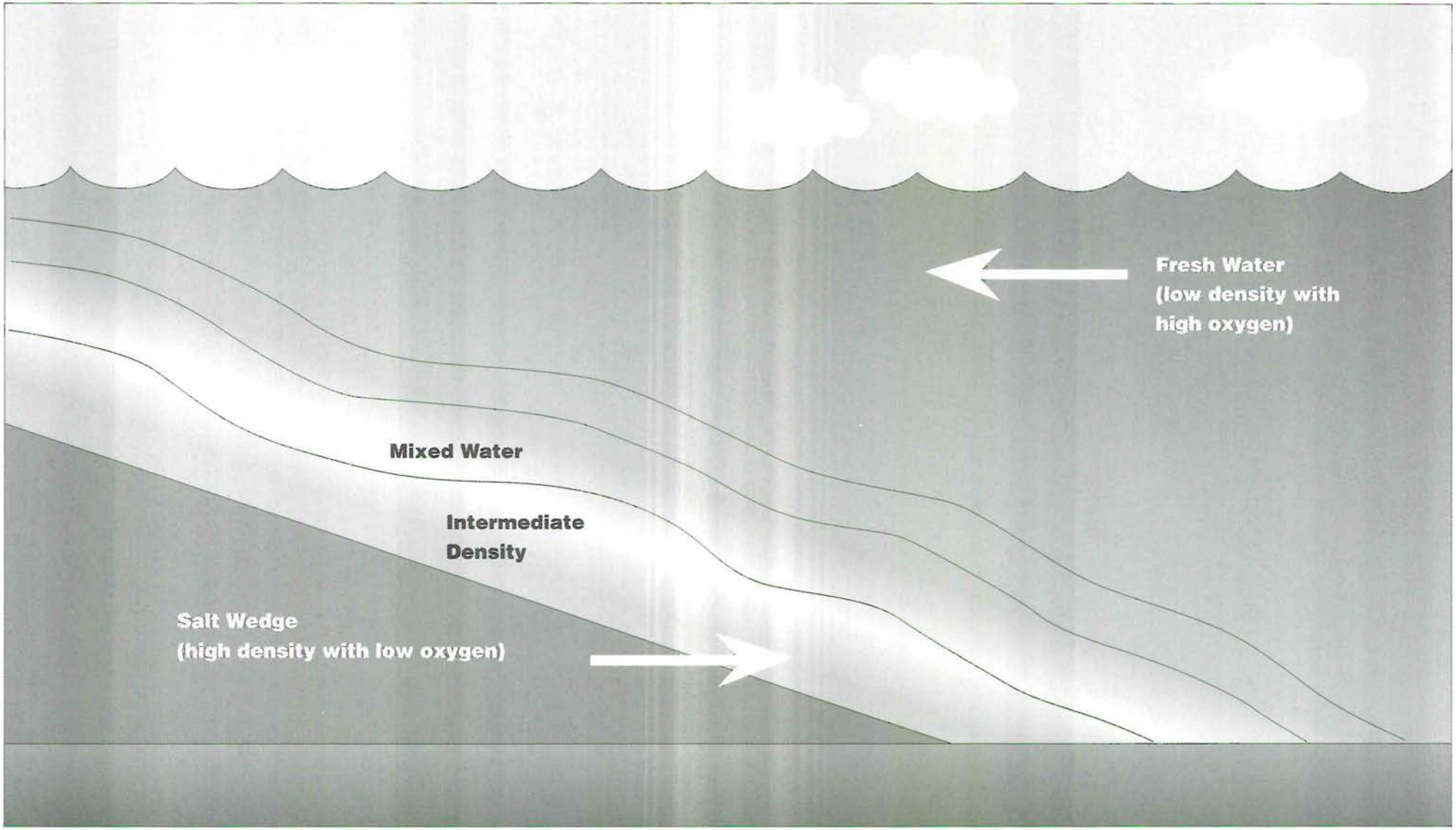
Changing weather conditions affect the estuary's hydrological status. For example, winter storms increase water levels as more sea water enters the estuary. In calmer weather, water levels decrease as water moves out.

Water temperatures in the estuary change seasonally, and vary from place to place along the estuary and with the depth of the water. Other factors affecting temperatures are the inflowing water, atmospheric temperatures and the degree of mixing of waters. Temperatures range in winter from about 13 degrees to 16 degrees and in summer from 23 degrees to 26 degrees.



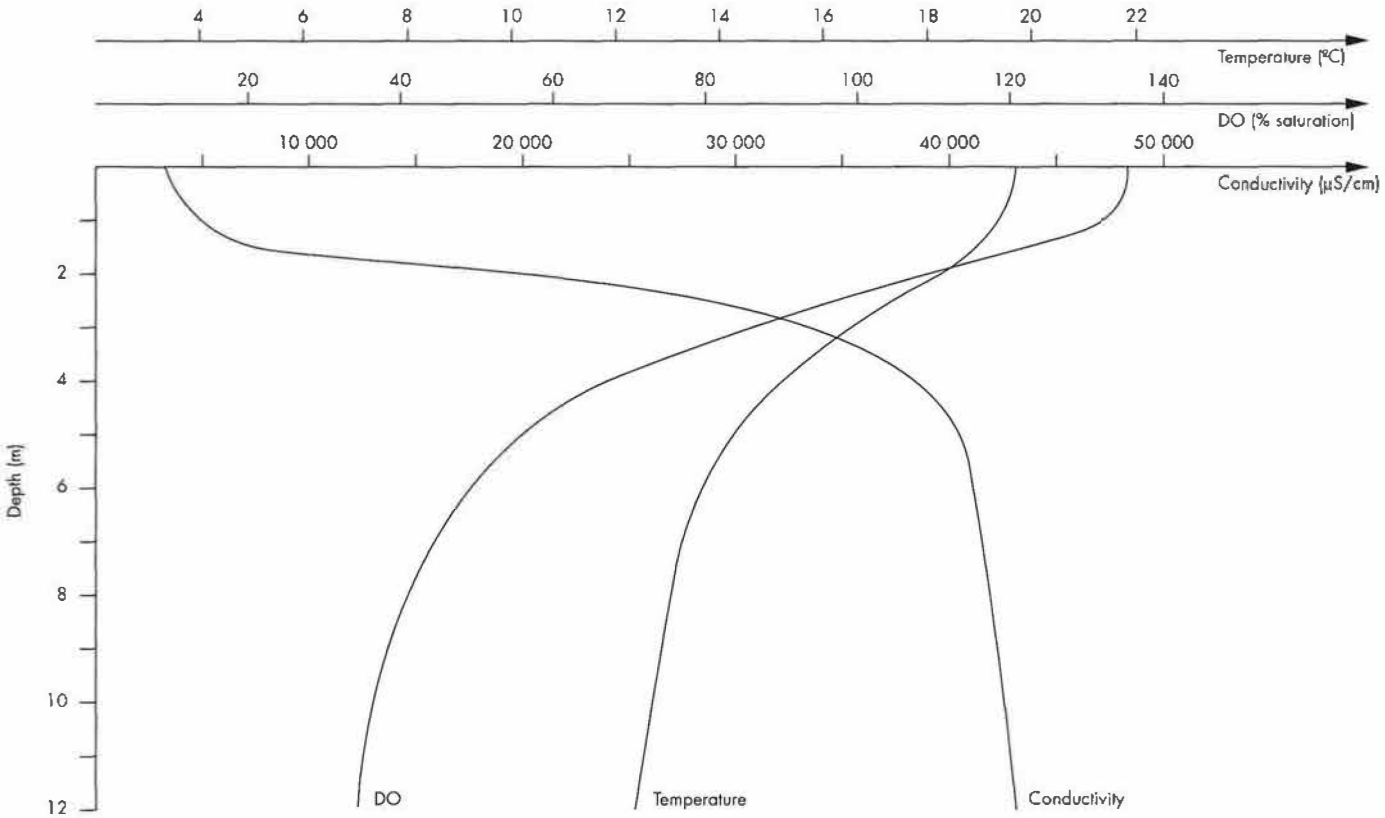
Mean volume of flow and rainfall for the Swan-Canning system (1987-96)

This figure shows average rainfall and river flows into the Swan-Canning system, indicating peak occurrences during the winter and early spring. The flow from the Swan River is approximately 15 times greater than that from the Canning.



Salt wedge diagram showing the movement and gradual mixing that occurs as the salt wedge moves up the river.

Dissolved oxygen profile



The following graph shows Spring data collected from a site near Blackwall Reach in the Swan-Canning estuary. The site is 12 metres deep and readings for temperature, dissolved oxygen (DO) and salinity (conductivity) have been made at 0.5 m intervals.

As depth increases, both temperature and dissolved oxygen levels decrease while conductivity increases. This indicates a layer of fresh water overlying the saltier ocean water (the salt wedge). The fresh water is warmer and higher in dissolved oxygen. The dissolved oxygen levels at the surface are supersaturated, probably caused by an algal bloom. At depth the salt water is low in dissloved oxygen, suggesting little mixing with the surface water.

To construct a water quality profile for your own site you don't need to take readings every 0.5 m – often a sample at the surface, middle and bottom of the water column will provide enough data to see how the parameters change with depth.

Water quality data – analysis and interpretation

This resource sheet provides information about some approaches to graphing water quality monitoring data, and some guidance on interpreting the graphs. These simple data analysis and interpretation activities will help students to make meaning of their results. They will also provide a basis for further work – for environmental action, problem-solving and scientific research. Obviously the usefulness of the graphing and interpretation exercises depends on the quality of the data.

Graphing results

1. Spatial comparisons

- *Graph the results for each parameter against distance along the river.*
- *Compare different sites according to any of the parameters.*

Compare data collected from different locations on the same day. This is useful for looking at variations in a particular parameter along one waterway, or for comparing the same parameters on two or more waterways. For example, comparing turbidity or salinity between the upper and lower catchment, or comparing phosphate levels in a rural stream with those in a forest stream. Line or bar graphs can be used to show results.

2. Comparisons between variables

- *Look for relationships between different parameters.*
- *Collect other data and see if they correlate with physical/chemical data.*

Plot data for variables that may have a relationship on the one graph. For example, plot dissolved oxygen and total abundance of macroinvertebrates, or temperature and total abundance of macroinvertebrates. To put both sets of data on one graph you need two vertical scales, one for % DO sat (the amount of oxygen dissolved in the water expressed as a percentage of saturation) and one for abundance of macroinvertebrates, or one for temperature and one for abundance of macroinvertebrates. The sites are placed on the horizontal scale. Complete the bars.

You could record information about streamline vegetation quality or catchment land use, and display this graphically against one or more of the physical/chemical/biological measurements. For example, measure the width of streamside vegetation and plot it against phosphate concentration.

3. Temporal comparisons

- *Graph last year's data for each measurement at each monitoring site visited and use it to compare with this year's results.*
- *Look for seasonal patterns.*

To compare data for two or more different years, use one graph with time in months on the horizontal axis and the parameter under study on the vertical scale, and plot the points using different colours to distinguish years. Another method is to construct a time series graph showing any parameter plotted against time over several years. For example, plot the salinity results for one site over the last five years. Place salinity on the vertical scale and months or seasons for the five years sequentially on the horizontal scale. Note that with this sort of graph you continue to record, year after year.

Another type of temporal graph is called a seasonality graph. To graph seasonality you place the months or seasons for only a year on the horizontal scale. You might also plot five year's results as superimposed points so that you end up with a scatter graph. From this you can speculate about seasonal patterns.

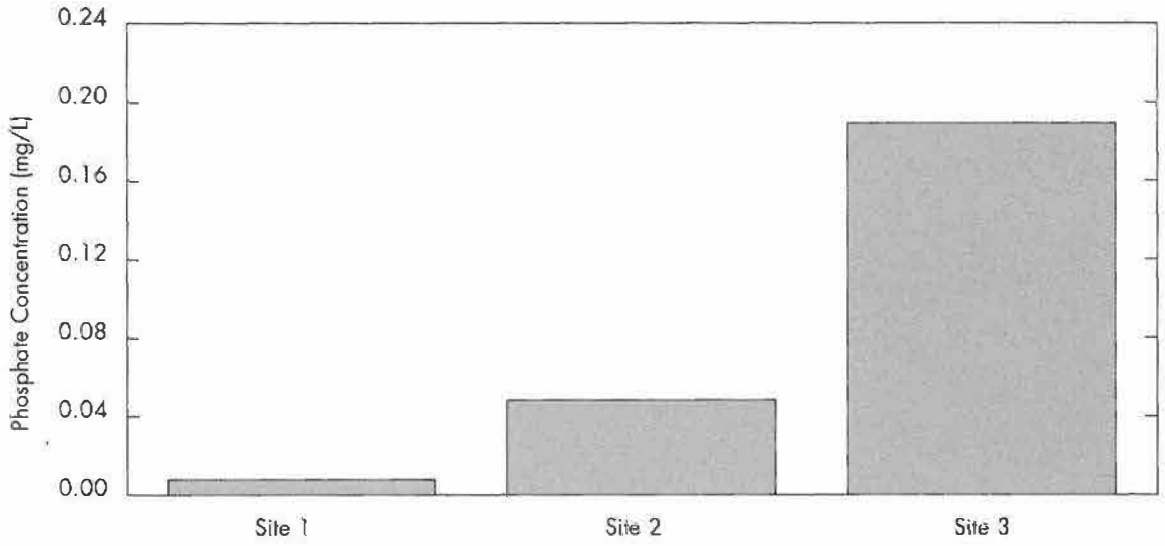
Interpretation of the data

Make meaning of the graphs by looking for trends and trying to derive explanations. For example, measurements of one parameter can be compared to measurements of another, or measurements can be compared to qualitative things like type of site, quality of vegetation surrounding land-use or historical information.

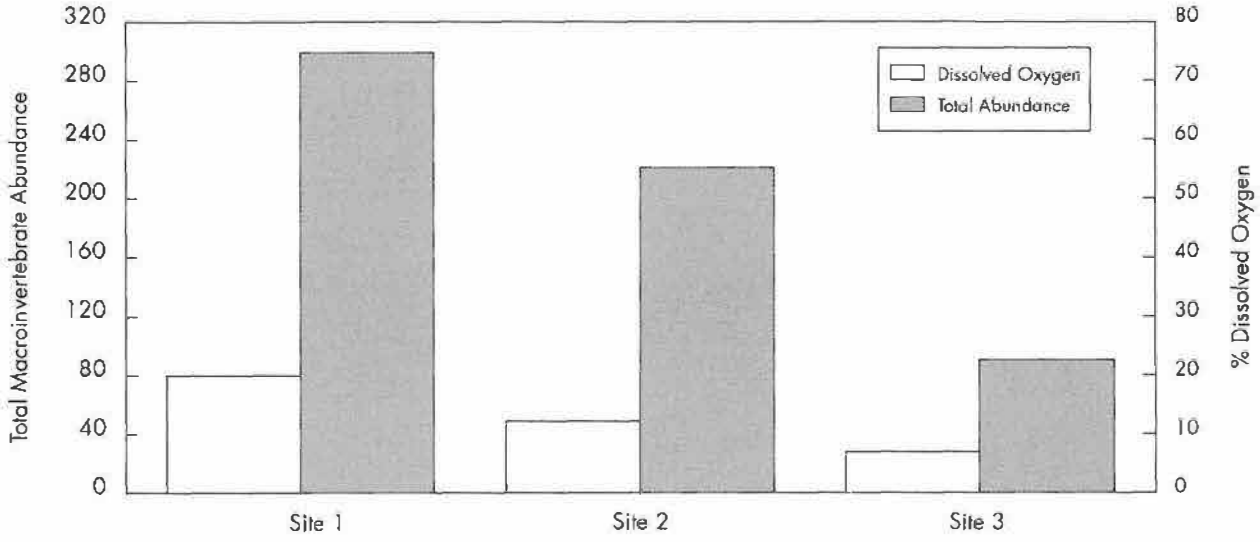
Make simple written or oral reports to try out explanations. Make generalisations or predictions, and devise new investigations based on the interpretations.

Note: It is a good idea to keep a file of all water quality monitoring results, graphs and interpretation activities so that these can be used by other teachers from year to year.

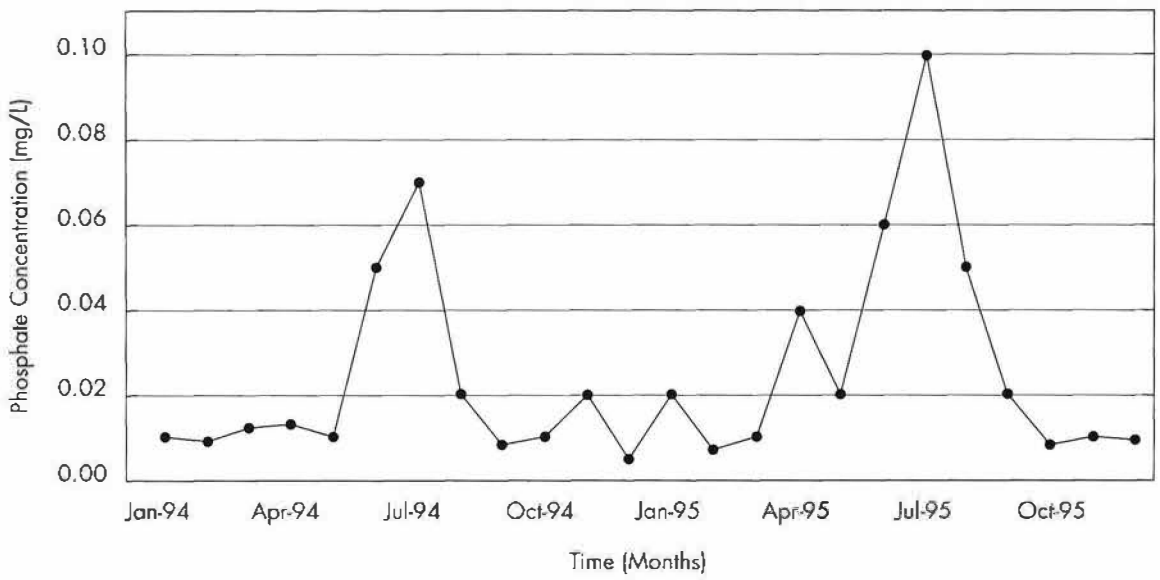
1. Spatial comparisons



2. Comparisons between variables



3. Temporal comparisons



Working Scientifically in the Swan River Environment

River Communities

Students are encouraged to investigate the plants and animals of the ecosystem and their relationship with the ever-changing environment and with each other. They can also examine the negative impact of human intervention on the ecosystems, suggest solutions to problems and begin to contribute to management options that ensure the future health of the ecosystem.

River Communities

This section contains activities designed to develop students' understandings of ecological and biological concepts as they apply to either an estuarine or a freshwater river site in the Swan River system.

This section examines the following ideas:

- The Swan River environment is a complex ecological system, with interdependent living and non-living components.
- The Swan River environment has distinctive estuarine and freshwater ecosystems.
- The Swan River system is subject to both human-induced and natural changes.
- All members of society can share in the responsibility for preserving and maintaining the Swan River ecosystem.

Focus questions

- *What lives in the river?*
- *How are the plants and animals that live in the river interdependent?*
- *How do living things cope with physical and chemical changes in the river?*
- *How do humans interact with these ecosystems?*

The estuarine and freshwater environments of the Swan River system are productive places that support an array of living things that interact with their living and non-living environments.

River environment

To expand on knowledge of the Swan River environment, students could:

REFERENCE CHECKLIST

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Resource Sheet 6, *Seasonal changes in the water of the Swan River estuary*

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Resource Sheet 9, *The Swan-Avon catchment*

- Recall knowledge of river and estuarine environments in general, and of the Swan River estuary in particular.
- Consider the meaning of the terms 'river', 'stream', 'estuary' and 'ocean'. Make a map or drawing that shows the relationships that exist between them.
- On an outline map of the Swan-Avon catchment, identify tributary streams, rivers, the estuary and the ocean. See Resource Sheet 9, *The Swan-Avon catchment.*
- Consider the influence and extent of salt, and fresh water incursions from season to season. See Resource Sheet 6, *Seasonal changes in the water of the Swan River estuary.*

  Note: In summer, tidal water extends as far up as Ellen Brook in the Swan River catchment and the Kent Street Weir in the Canning River catchment, because the tributaries (e.g. Helena River, Susannah Brook) are not flowing. However, in winter fresh water flows into the system, and surface fresh water extends down the river as far as Blackwall Reach.

- Locate the proposed river study site on a map. Determine whether it is a stream, river or estuarine site, or a drain.

To reflect on their understanding of the health of the Swan River system and suggest ways in which river health might be investigated, students could:

- Discuss the health of a nearby part of the river system, perhaps by using pictures or posters of river scenes to help formulate ideas. Compile a list of the characteristics of a healthy river.

  Note: When judging river health consider water clarity, lack of visible pollution, the presence of animals and natural or wetland vegetation, and the occurrence of recreational activities like swimming or fishing.

- Discuss the chemical and biological characteristics of the environment that could be measured in order to assess the health status of a river system.
- List questions about the condition of the Swan River system. Sort questions into categories – those questions that have an answer that can be agreed on, those for which there are different answers, and others for which as yet there is no answer. As a basis for further work, select the questions that are most appropriate for an ecological investigation.

Ecology

To develop an understanding of ecological concepts as they relate to river communities (e.g. adaptations of organisms to the environment, habitats and food relationships), students could:

- Generate a list of key words or terms that relate to river ecology, e.g. 'ecosystem', 'food web', 'adaptation', 'habitat'. Use posters, newspaper articles, stories (and prior knowledge) as prompts. Develop a deeper understanding of these key concepts through small group discussion.
- Classify the chosen study site as either freshwater or estuarine in nature.

For studies at an estuarine site

- Predict how the estuary would change at different times of the year in terms of dissolved oxygen, salinity and temperature. See Resource Sheet 6, *Seasonal changes in the water of the Swan River estuary.*
- Sketch graphs of the predicted changes in these factors as a function of depth and distance from the mouth of the estuary.
- Predict the consequences of seasonal changes for estuarine life. See Resource Sheet 10, *Adaptations for life in an estuary.*
- Construct a table comparing the conditions of the estuary to those of the streams that lead into it.
- Select the estuarine cross-section diagram and then make a list of animals that might be found in that environment. Draw these creatures in the appropriate habitats on the cross-section. See Resource Sheet 11, *Estuarine cross-section,* and Resource Sheet 12, *Estuarine habitats.*
- Propose and draw a food chain or food web diagram for this environment.
- Explain what the food web diagram suggests about interrelationships between the estuarine organisms.

For studies at a freshwater site

- Select the freshwater cross-section diagram and then make a list of animals that might be found in that environment. Draw these creatures in the appropriate habitats on the cross-section. See Resource Sheet 13, *Freshwater stream cross-section.*
- Draw a food chain or food web diagram for this environment.
- Explain what the food web diagram suggests about interrelationships among the freshwater organisms.

REFERENCE CHECKLIST

- Resource Sheet 6, *Seasonal changes in the water of the Swan River estuary*
- Resource Sheet 10, *Adaptations for life in an estuary*
- Resource Sheet 11, *Estuarine cross-section*
- Resource Sheet 12, *Estuarine habitats*
- Resource Sheet 13, *Freshwater stream cross-section*

Biology

To become familiar with how organisms live, their adaptations to their environment and the interrelationships that exist between organisms, students could:

REFERENCE CHECKLIST

- Resource Sheet 14, *Fringing vegetation of the Swan-Canning river system*
- Resource Sheet 15, The *problem with aquatic and foreshore weeds*

OTHER RESOURCES

- Excursion 6, *Alien plant game,* in the booklet *Excursions in the Swan River Environment*
- Ribbons of Blue primary school manual
- RGC Wetlands teachers' manual *From Sand to Ducks*
- *Controlling weeds in waterways and wetlands* (pamphlet)
- *Living with Streams* (video)
- *Frog Symphony Unit*

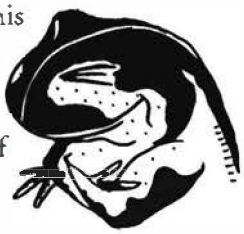
Focus on vegetation

- Predict the types of vegetation that might be seen at the river. Discuss expected differences between wetland and dryland vegeration, and riverine and estuarine vegetation. See Resource Sheet 14, *Fringing vegetation of the Swan-Canning river system.*
- Identify the ecological functions of natural vegetation in a riverine environment. Information contained in the video *Living with Streams* provides a good starting point.
- Contrast the roles of native vegetation and introduced plants in an ecological system.
- Decide how to judge if a plant is a weed. Make a list of the common characteristics of weeds and then write a definition of a weed. Complete Excursion 6, *Alien plant game,* in the booklet *Excursions in the Swan River Environment* or refer to the pamphlet *Controlling weeds in waterways and wetlands.* Also see Resource Sheet 15, *The Problem with aquatic and foreshore weeds.*
- Suggest why introduced species are unable to fill the ecological roles of native plants.

Note: At the estuarine site, vegetation, birds and other fauna (habitats, adaptations and interrelationships) might be investigated. At the freshwater site, vegetation, frogs and macroinvertebrates (habitats, life cycles and human impact) might be investigated.

Focus on frogs

- Using prior knowledge and information in reference materials, make a concept map to illustrate knowledge about frogs. Refer to the RGC Wetlands teachers' manual *From Sand to Ducks* for the worksheet *Finding Out About Frogs.*
- Suggest reasons why, frogs are in decline globally. Refer to articles in natural history journals to see the reasons scientists give for this phenomenon.
- Develop questions that could form the basis of a fieldwork frog investigation. Plan the investigations. Refer to the Ribbons of Blue primary school manual, *Field Biology: Frogwatch* and the *Frog Symphony Unit.*



Biology (contd)

Focus on macroinvertebrates

- Find out what insects spend part of their life cycle in water and compare their larval and adult forms. Illustrate life cycles either from prior knowledge or from information contained in reference materials. See Resource Sheet 16, *Estuarine invertebrates.*
- Find out what other animals can be categorised as macroinvertebrates.
- Select the freshwater cross-section diagram and then make a list of all macroinvertebrates that might be found in that environment. Draw these 'macros' in the appropriate habitats on the cross-section. See Resource Sheet 13, *Freshwater stream cross-section.* Refer also to Water facts 2, *Macroinvertebrates and Water Quality.*
- Consider how the presence of different aquatic macroinvertebrates is related to the quality of the freshwater streams they inhabit.

  Note: Aquatic macroinvertebrates reflect the water quality and seasonal conditions of freshwater streams they inhabit.

- Suggest ways in which macroinvertebrates and other aquatic organisms might be affected by pollutants such as chemicals, hot water, sediment, excess nutrients and salt.
- Suggest which parts of the river system would offer macroinvertebrates the best protection from pollution.
- Discuss ways of collecting macroinvertebrates. Decide what to wear when sampling, and invent sampling equipment. Discuss the ethics of collecting small organisms, and create a set of guidelines to minimise the possible harmful effects of the study. Refer to Water facts 2, *Macroinvertebrates and Water Quality,* for information about different macroinvertebrates and how to collect them.

Focus on birds

- Suggest what sorts of birds might be seen at the river. Choose one or two birds and find out more about them. Concentrate on the ways in which they are suited to a riverine life.
- Suggest why each of these birds uses the waterway. Find out what they eat, how they get food and how their feathers, legs, feet and bills are adapted for an aquatic life.
- Suggest the various types of bird habitats that might be found at the river. See Resource Sheet 17, *Birds of the Swan River system.*
- Practise doing quick drawings of birds to facilitate accurate identification. Become familiar with field reference books.

REFERENCE CHECKLIST

- Resource Sheet 13, *Freshwater stream cross-section*
- Resource Sheet 16, Estuarine invertebrates
- Resource Sheet 17, Birds of the Swan River system

OTHER RESOURCES

- Water facts 2, *Macroinvertebrates and Water Quality*

Pollution

To consider how human activities have had an impact on the river, and the role of research and management in working to ensure that the integrity of the ecosystem is maintained, students could:

- Recall what they already know about research and management of the Swan River system by constructing an explosion chart to show their scientific knowledge of the river.
- Produce a scrapbook of newspaper and journal articles that relate to river problems and management.
- Draft a flow chart that shows how an algal bloom might occur. Refine the flow chart after consulting reference materials. Refer to Water facts 6, *Algal Blooms*, and the video *Algal Blooms and Nutrients* for more information.
- Make a list of water pollutants that could originate in urban areas, and note where they might come from (e.g. industrial effluent piped into the river, runoff from roads and car parks that enters the river through drains, and ballast water released from boats in the harbour). Refer to Water facts 3, *River and Estuary Pollution*.
- Make a list of water pollutants that could originate in rural areas and note where they might come from (e.g. sediment from the clearing of vegetation, nutrients from fertilisers applied to crops and wastes from intensive livestock industries). Refer to Water facts 3, *River and Estuary Pollution*.
- Discuss the likely effects of the types of pollutants listed. For each type predict the probable degree of impact (high, medium or low) on the riverine ecosystem and justify predictions.

To consider selecting a key task for their ecological investigation and to choose a suitable method of presentation, students could:

- Prepare a paper to be presented at a student forum to deliver findings on the condition of the Swan River and to suggest directions for ongoing research.
- Produce a newspaper supplement (similar to *Earth 2000*) about the river environment. Send it to a newspaper for comment.
- Create a display for the school library, community library, school fete or open day focusing on the future of the health of the Swan River system.
- Design a community questionnaire to find what sort of attitudes people have towards protection of the environment. Provide feedback to participants.

OTHER RESOURCES

- Water facts 3, *River and Estuary Pollution*
- Water facts 6, *Algal Blooms*
- *Algal Blooms and Nutrients* (video)

River environment

To become acquainted with the environment at the site, students could:

- Reflect on their surroundings and record their first impressions.
- Through observation, consider the state of health of the environment. Use a simple health rating system based on criteria such as visible water quality, the presence of vegetation (natural vegetation, weeds, aquatic weeds), animals and litter. Complete Excursion 12, *Rating river health,* in the booklet *Excursions in the Swan River Environment.*
- Locate places where animals could live. Make a sketch map or cross-sectional diagram of the site to show all the different habitats. Show what animals might live in these habitats.
- Assess the quality of the site's habitats. Refer to the Ribbons of Blue secondary school manual, *Field Biology: Habitat Survey.*
- Design a travel poster that advertises the special qualities of the site to a migratory bird, frog, pelican, tiger snake, dolphin or any other animal that might visit it. Alternatively, write a postcard to that animal explaining how perfect the environment is for them either to live in or to visit.
- Compare the environment of two different vegetation communities at the site, e.g. aquatic vegetation and emergent vegetation.

OTHER RESOURCES

•

Excursion 12, *Rating river health,* in the booklet *Excursions in the Swan River Environment*

•

Ribbons of Blue secondary school manual

Ecology

For an investigation at an estuarine river site

To investigate the aquatic life of the estuary, students could:

- Look carefully into the water for visible signs of aquatic life and record what they see. Using a plankton net, make a number of sweeps in the water and collect the plankton for a later microscope study. Use a microscope to identify microalgae. Suggest how and why the populations and distribution of microalgae might change seasonally. For sampling and identification techniques refer to the Ribbons of Blue primary school manual, *Classroom Activities: Fertilisers – Watching Eutrophication*. Refer also to *Water facts 6, Algal Blooms*, and the video *Algal Blooms and Nutrients*.
- Examine the bottom as a potential habitat. Wade out (wearing shoes) to examine it more closely. Determine whether the substrate is muddy, sandy, silty or shelly, and describe any other conditions noticed. Determine whether there is algae, seagrass and detritus present. Scoop up a dish of sediment from the bottom, spread it in a science tray and examine it carefully for the presence of marine worms, molluscs or small crustaceans. See Resource Sheet 18, *Aquatic plants – algae and seagrasses*. Refer also to Water facts 6, *Algal Blooms*, and the video *Algal Blooms and Nutrients*.
- Use a prawning net to collect small fish and crustaceans. Place them in buckets or trays of river water for examination and return them to the river as soon as possible.
- Make a list of other organisms that would live in the river. Discuss what they would eat and what would eat them. Draw diagrams to show these feeding relationships.

- If the site is to be visited again, record salinity levels and relate them to organisms found in the estuary at different times of the year. Refer to the Ribbons of Blue primary school manual for monitoring guidance.

REFERENCE CHECKLIST

Resource Sheet 18, *Aquatic plants – algae and seagrasses*

OTHER RESOURCES

Ribbons of Blue primary school manual

Water facts 6, *Algal Blooms*

Algal Blooms and Nutrients (video)

Ecology (contd)

For an investigation at a freshwater site

To investigate the aquatic life in the stream or drain, students could:

- Collect sediment (if the stream is dry). When back at school, add water and watch to see what emerges over the next few weeks. Refer to the Ribbons of Blue primary school manual, *Classwork Activities: Sediments – What's in those Sediments?*
- Collect and identify macroinvertebrates. For more information refer to Water facts 2, *Macroinvertebrates and Water Quality,* the Ribbons of Blue manual, Herdsman Lake Wildlife Centre identification sheets, and RGC Wetlands teachers' manual, *From Sand to Ducks.*
- Suggest the best habitats for macroinvertebrates at the site, and then collect them to test this prediction. Compare the types of organisms found in leaf litter, amongst fringing vegetation, and on stones or logs.
- Use the pollution index to calculate a generalised rating for the water quality of the stream. Refer to Water facts 2, *Macroinvertebrates and Water Quality.*
- Consider why a greater range of macroinvertebrates tend to be found in healthier water, and why less healthy water has fewer types of macroinvertebrates (but in larger numbers).
- Identify fishes found in the macroinvertebrate net. Determine whether any Gambusia are present. Suggest how this introduced fish competes with tadpoles. Return native freshwater fishes and tadpoles safely to the water, as they are protected species.
- Investigate to see if the site is a suitable place for mosquitoes to breed. Suggest ways in which the site could be managed to reduce the mosquito problem.
- Search for frogs. First, identify any suitable habitat and consider the care that should be taken so as not to alarm or hurt them. (All frogs are protected species.) Try to identify frogs from their calls. Refer to the Ribbons of Blue primary school manual, *Field Biology: Frogwatch,* and the RGC Wetlands teachers' manual, *From Sand to Ducks,* for information about catching and identifying frogs. Refer also to the *Frog Symphony Unit.*
- Design and draw an ideal frog habitat. Plan how to improve the site for frogs.
- Compare the aquatic life in a degraded drain and a natural stream and relate observations to differences in habitats. Refer to Water facts 4, *Living Streams.*

OTHER RESOURCES

- Ribbons of Blue primary school manual
- Water facts 4, *Living Streams*
- Water facts 2, *Macroinvertebrates and Water Quality*
- RGC Wetlands teachers' manual, *From Sand to Ducks*
- Herdsman Lake Wildlife Centre identification sheets
- *Frog Symphony Unit*

Biology

To investigate the living components of the ecosystem, students could:

Focus on vegetation

- Make a map of different types of vegetation at the site by identifying and locating wetland vegetation (e.g. reeds, sedges, paperbarks, flooded gums) and any surrounding dryland vegetation. Show grassed areas, planted trees and areas of weeds on the map. See Resource Sheet 19, *Some native plants of estuaries and saline waterways*, and Resource Sheet 20, *Some native plants of freshwater rivers and creeks.*
- Work out a simple way in which to distinguish dryland vegetation from wetland vegetation.
- Identify some of the different types of vegetation at the site. Refer to the Ribbons of Blue primary school manual, *Field Biology: Eucalypts – Eureka Eucalyptus.*
- Construct a vegetation transect showing the change in the vegetation from the water's edge, across the verge and to the edge of the floodplain. On the transect mark in changes in physical conditions. Relate these to changes in vegetation. Determine the high and low water lines, if possible. Consider how changes in water level might affect vegetation. Refer to the Ribbons of Blue primary school manual, *Field Biology: Communities – Comparing Communities.*
- Rate stream condition in rural and semi-rural areas by assessing the streamline vegetation. Refer to Water facts 4, *Living Streams.* Complete Excursion 13, *Streamline vegetation survey*, in the booklet *Excursions in the Swan River Environment.*
- Distinguish between weeds and indigenous plants. Describe and try to identify any foreshore and aquatic weeds that are found. Write a story to explain how weeds were introduced to the site. Complete Excursion 6, *Alien plant game*, in the booklet *Excursions in the Swan River Environment.*
- Make a collection of weeds for later identification.
- Design a revegetation and weed eradication plan for the site. Complete Excursion 7, *Action plan for site revegetation*, in the booklet *Excursions in the Swan River Environment.*

REFERENCE CHECKLIST

Resource Sheet 19, *Some native plants of estuaries and saline waterways*

Resource Sheet 20, *Some native plants of freshwater rivers and creeks*

OTHER RESOURCES

Ribbons of Blue primary school manual

Excursion 6, *Alien plant game*, in the booklet *Excursions in the Swan River Environment*

Excursion 7, *Action plan for site revegetation*, in the booklet *Excursions in the Swan River Environment*

Excursion 13, *Streamline vegetation survey*, in the booklet *Excursions in the Swan River Environment*

Water facts 4, *Living Streams*

Biology (contd)

Focus on birds

- Carefully observe the activities of one type of bird over a period of time. Record the bird's behaviour. See Resource Sheet 17, *Birds of the Swan River system.*
- Identify, count, draw and describe some birds observed at the site or in nearby wetlands. For help with bird identification see the Herdsman Lake bird identification sheets/bird field guides or the Ribbons of Blue primary school manual, *Field Biology: Birdwatch.*
- Observe bird behaviours. Note whether birds are feeding, nesting or resting. Suggest what the habitat needs are for each type of activity and match birds to their habitat.
- Draw a cross-section of the site. On it, locate birds in their feeding, nesting and resting habitats.
- Observe examples of adaptations of birds to their environment. Look at their feet, beaks and wings. Consider how they swim, dive, fly, take off and land. Consider why several types of birds are able to occupy the same habitat.

REFERENCE CHECKLIST

- Resource Sheet 17, *Birds of the Swan River system*

OTHER RESOURCES

- Ribbons of Blue primary school manual
- Herdsman Lake Wildlife Centre bird identification sheets/bird field guides

Management for the future

To examine ways to minimise the negative impact of human activity on the ecosystem, students could:

- Visualise and describe or draw a fabulous future for the river ecosystem. List action strategies within an agreed time frame that will ensure this future.
- Draft a set of rules for people who fish at the river. Later, students might find out what fishing regulations already apply for recreational fishers. (Contact Fisheries Western Australia for more information.)
- Write questions about some aspect of the future of the river, e.g. scientific research that is needed, how the river environment is managed and who is responsible for looking after it. Select some questions for further investigation.
- Identify the most valuable components of the site by auctioning them to the highest bidder. Complete Excursion 2, *Needs auction*, in the booklet *Excursions in the Swan River Environment*.
- Create a concept map that summarises the site's ecosystem components, aspects of ecology and human impacts.

OTHER RESOURCES

Excursion 2, *Needs auction*, in the booklet *Excursions in the Swan River Environment*

on-site

River environment

To report on their fieldwork studies and present their findings, students could:

- Create a display that relates water quality to aquatic life.
- Enter their work in one of the Science competitions. (Contact the Science Teachers' Association of Western Australia for details.)
- Compare the biological rating of a site as determined by macroinvertebrates or vegetation assessments with the physical and chemical rating as determined by water testing.
- Compare the results of macroinvertebrate, vegetation and water quality investigations for different streams. Make suggestions about how any differences in results might relate to the effects of different land uses in each of the catchments.
- Develop a web site to share findings with other schools. Encourage students in following years to update and add seasonal or year-to-year information to build up a picture of the site.

follow-up

Ecology

For investigations at an estuarine site

To follow up their ecological studies of life in the estuary by researching and experimenting, students could:

- Complete and refine their estuarine cross-section diagram.
- Construct a concept diagram that shows the interrelationships between animals, plants and the non-living environment of the estuary.
- Investigate the collected samples of algae, zooplankton or invertebrates.
- Test the response of estuarine mussels or worms to salinity. Under a stereomicroscope examine a specimen in a sample of the water from which it was collected. Replace the water with slightly more or slightly less saline water and note any behavioural responses of the organism. Identify adaptations that would help the organism to cope with seasonal changes in salinity. Ensure that the organism is returned safely to its environment.
- Experiment to determine the growth response of microalgae to different salinities. Use water of the same salinity, water that is slightly more saline and water that is slightly less saline than that at the collection site. After some days and weeks, make microscopic examinations of the samples to see if salinity has caused changes in the abundance of species of microalgae. Note that all experiments will need some nutrients for continued growth of the algae. Refer to the Ribbons of Blue primary school manual, *Classroom activities: Fertilisers – Watching Eutrophication*, for methods of identifying and counting algae. Refer also to Water facts 6, *Algal Blooms*, and the video *Algal Blooms and Nutrients*.
- Make a herbarium or classroom display of weeds. Develop a poster on weed control.
- Graph salinity and dissolved oxygen against depth at three different sites in the estuary. Interpret the graph to explain changes of salinity and dissolved oxygen with depth. Discuss how these differences could affect aquatic life in the estuary. Use the data disc *Water Quality Data* and Appendix 2, *Water quality data disc explanatory notes*. See also Resource Sheet 8, *Water quality data – analysis and interpretation*.
- Write an information brochure for the general public about the habitats of estuarine birds, or prepare a talk about a particular estuarine organism, focusing on its relationship to its environment and what would need to be done to ensure its conservation.
- Find out what migratory birds visit the Swan River and where they come from. Use a globe or map of the world to mark their journeys.
- Find out about recreational and commerical fisheries in the estuary. Relate different activities (e.g. fishing, prawning) to habitat needs and seasonal movements or life cycles of the animals.

REFERENCE CHECKLIST

Resource Sheet 8, *Water quality data – analysis and interpretation*

Appendix 2, *Water quality data disc explanatory notes*

OTHER RESOURCES

Water Quality Data (data disc)

Ribbons of Blue primary school manual

Water facts 6, *Algal Blooms*

Algal Blooms and Nutrients (video)

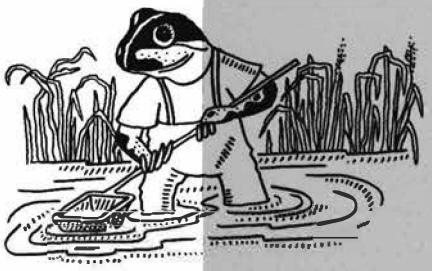
follow-up

Ecology (contd)

For investigations at a freshwater site

To follow up their ecological studies of life in a freshwater stream, students could:

- Conduct further research into a chosen aquatic life form that was found at the site.
- Find out more about the life cycles of macroinvertebrates. Write and illustrate a story about the life cycle of one macroinvertebrate. Plan to read the story to younger students.
- Predict how each type of macroinvertebrate would respond to pollutants which block out light, increase sedimentation or reduce oxygen levels. Predict how events such as clearing vegetation from the banks, removing logs and debris from the streambed, or increasing stormwater runoff into the stream would change water conditions and consequently affect macroinvertebrates.



- Find out more about an aquatic weed found at the site. Write a story about how it got into the river and its impact from the point of view of a fish, a canoeist and a conservationist.
- Make a concept map that summarises the interrelationships among animals, plants and the non-living environment of the stream.
- Write a report about the ecology of the study site. Conclude with recommendations about the best ways to conserve it.
- Develop a plan to restore the site to a living stream. Refer to Water facts 4, *Living Streams.*

OTHER RESOURCES

•

Water facts 4, *Living Streams*

follow-up

Management for the future

To consider the problems that the river environment faces and the role of people in managing and preserving the river system for the future, students could:

- Follow up studies on the vegetation investigation by writing a story to explain how and why the weeds were introduced to the environment and how their spread can be controlled. Refer to the Teacher Resource Sheet that accompanies Excursion 6, *Alien plant game*, in the booklet *Excursions in the Swan River Environment.*
- Find out more about frogs. Design and describe a plan to make the site under investigation a reserve for frogs.
- Find out more about the effects of human-induced change on the environment of the estuary or stream. Consider changes that might occur as a result of: clearing in the catchment; the removal of fringing vegetation; the introduction of weeds; inflow from drains carrying chemicals or hot water; spraying for weeds or insects along the bank; seepage of groundwater carrying nutrients; or overflow from sewage treatment plants. See Resource Sheet 21, *Changes to the Swan River.*
- Construct flow diagrams to show the effects of a particular human-induced change on different components of the estuary or stream. Combine two or more flow diagrams to build up a web of potential effects.
- Decide how much change the ecological system can tolerate before it breaks down. Suggest ways to reduce the impact of various changes.
- Find out why eutrophication is a potential problem in waterways.
- Conduct controlled experiments to investigate eutrophication by adding nutrients to a hay infusion. Refer to the Ribbons of Blue primary school manual, *Classwork: Fertilisers – Watching Eutrophication.*
- List ways to prevent, control or cure eutrophication.
- Find out about what is being done to protect and manage the Swan River ecosystem. See Resource Sheet 22, *Management for the future.* Refer also to the Swan River Trust website (www.wrc.wa.gov.au/srt) and the *Swan-Canning Cleanup Program Action Plan.*
- Write a management plan for the site. Decide who should be part of the management team and suggest a role for each representative.
- Invite a guest speaker from an organisation that works to care for the riverine environment, and prepare questions for the visit.
- Visit the Swan Catchment Centre to find out about catchment and rivercare groups.
- Plan a low budget campaign to attract more people to a rivercare group.
- Contact the WA Museum to find out more about Frogwatch. Join Frogwatch.
- Become involved! Offer to help in some revegetation or cleanup activities that are being undertaken at the river site.
- Design a series of signs or posters that stress the need to manage the river environment for birds.
- Write a talk for recreational fishers about their responsibilities at the river.

REFERENCE CHECKLIST

Resource Sheet 21, *Changes to the Swan River*

Resource Sheet 22, *Management for the future*

OTHER RESOURCES

Excursion 6, *Alien plant game*, in the booklet *Excursions in the Swan River Environment*

Ribbons of Blue primary school manual

Swan River Trust website www.wrc.wa.gov.au/srt

Swan-Canning Cleanup Program Action Plan

River Communities

Resource Sheets

The Swan-Avon catchment

Area

The Avon basin (Avon, Yilgarn and Lockhart catchments) drains an area almost twice the size of Tasmania, covering approximately 12 million hectares.

Population

The area supports approximately 54 000 people.

10 resource sheet

Working Scientifically in the Swan River Environment

Adaptations for life in an estuary

Estuaries are productive environments for aquatic life. They are rich in nutrients compared with rivers and oceans, and they are also good animal refuges, offering protection from storms, competitors and parasites. However, estuaries do experience sudden and often widespread changes in salinity, temperature and dissolved oxygen levels, so aquatic organisms must find ways to cope with these changes.

Salinity

Salinity is perhaps the most important factor affecting aquatic species. Most aquatic animals are adapted to life in sea water. These animals vary in terms of the degree to which they are able to tolerate the lower salinities of the estuary. A smaller number of animals are adapted to life in fresh water, and few of these species tolerate salinities in excess of 2 ppt (parts per thousand). Ocean salinity is 35 ppt.

The salinity level of the estuary varies along its length, with depth and with the seasons. There are extreme changes in salinity from almost freshwater conditions in winter to saline (or almost hypersaline) conditions in summer. This change in salinity causes a change in the concentration of dissolved gases (fresh water contains more oxygen than sea water at the same temperature) and in the density and viscosity of the water.

Adaptations to changing salinities

Estuarine organisms possess adaptations or behaviours that enable them to cope with changing salinities. Few organisms remain in an estuary for the whole of their life cycle. Some fish are truly estuarine, spending their whole lives in the estuary. Some use it as a nursery habitat only and others are marine visitors, coming in when the salinity suits them. Mobile animals like fish and crabs can swim away from unfavourable conditions. Prawns and crabs move out of the estuary in winter when waters are less saline. However, less mobile (sedentary) animals such as barnacles and worms have to either seal themselves inside their shells or adapt to the conditions. Many sedentary animals die when conditions are unfavourable and must recolonise when conditions change. Many algae and seagrasses die off during winter periods when salinity levels become too low.

Some organisms are able to tolerate extreme conditions for a short time only. A sudden change, such as an unusual heavy summer fall of rain which produces a freshwater flow into the estuary, or extreme conditions of salinity, will produce a variety of responses. For example, worms, molluscs and fish produce slime or mucus to cover and protect their sensitive body surfaces. Some polychaete worms and crabs retreat into holes or burrows, plugging them. Other animals withdraw their sensitive body parts, or close their shells.

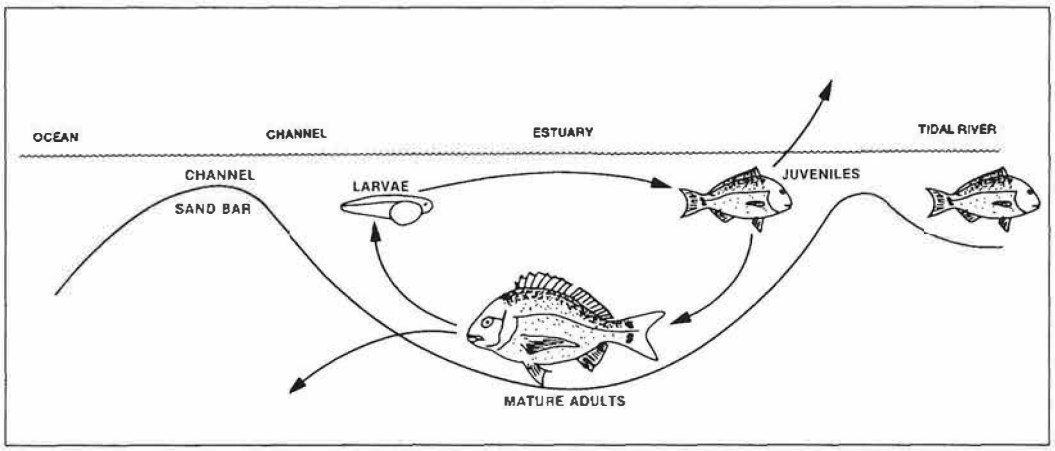
If an organism cannot escape or reduce contact with the water during times of abnormal salinity it must use a physiological response. Many animals are able to reduce the concentration of their internal body cells and fluids (using a process called osmosis) until they are the same as (iso-osmotic with) estuarine water. Alternatively, an animal may modify its metabolic rate or change its patterns of activity.

The physiological response of an animal to salinity changes takes time to complete, so it is often supplemented by a behavioural response that enables it to either delay or moderate exposure to unfavourable conditions, completely avoid them, or slowly adapt their body to the new saline environment. For example, some bivalves close their shell valves when sea water suddenly becomes diluted. After a while they become used to these conditions.

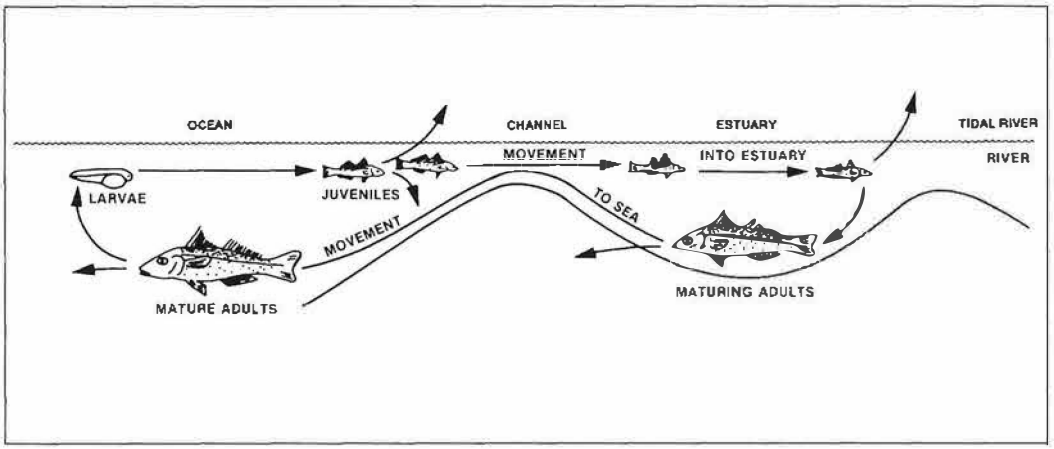
Adaptations to changing temperatures

Temperatures are more variable in the estuary than they are in the ocean. In winter the estuary is colder than the ocean, and in summer it is warmer. Daily temperature fluctuations can also be extreme, especially in the shallows. Also, the solubility of oxygen depends on temperature. (More oxygen dissolves in cold water than in warm water.)

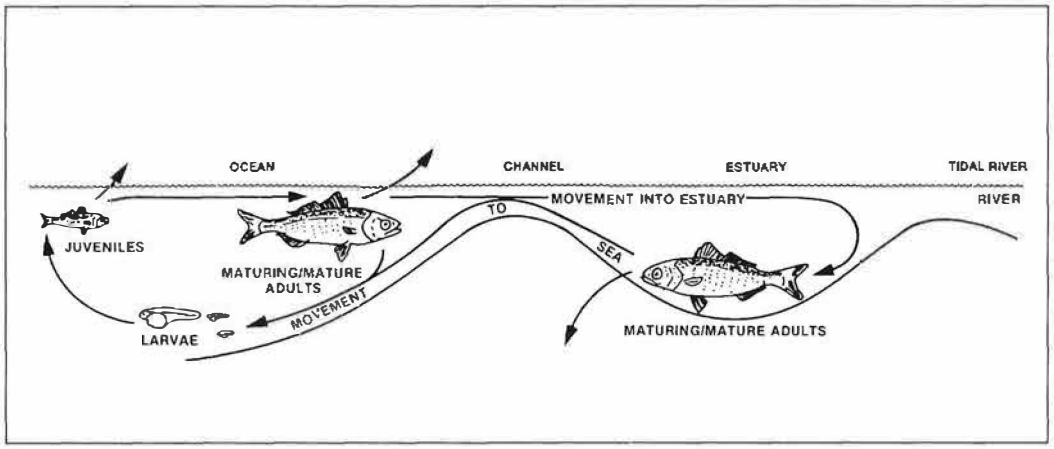
Adverse temperatures may cause responses of avoidance and escape. One of the most common mechanisms that certain organisms use to cope with conditions in the cold winter months is to transform into a resting stage. Another habit is to burrow into the mud or sand on the bottom of the estuary. Fortunately in the Swan-Canning system temperatures are rarely extreme, never reaching freezing in the winter or going above 40° C in the summer.



1. Truly estuarine species



2. Nursery habitat for juveniles



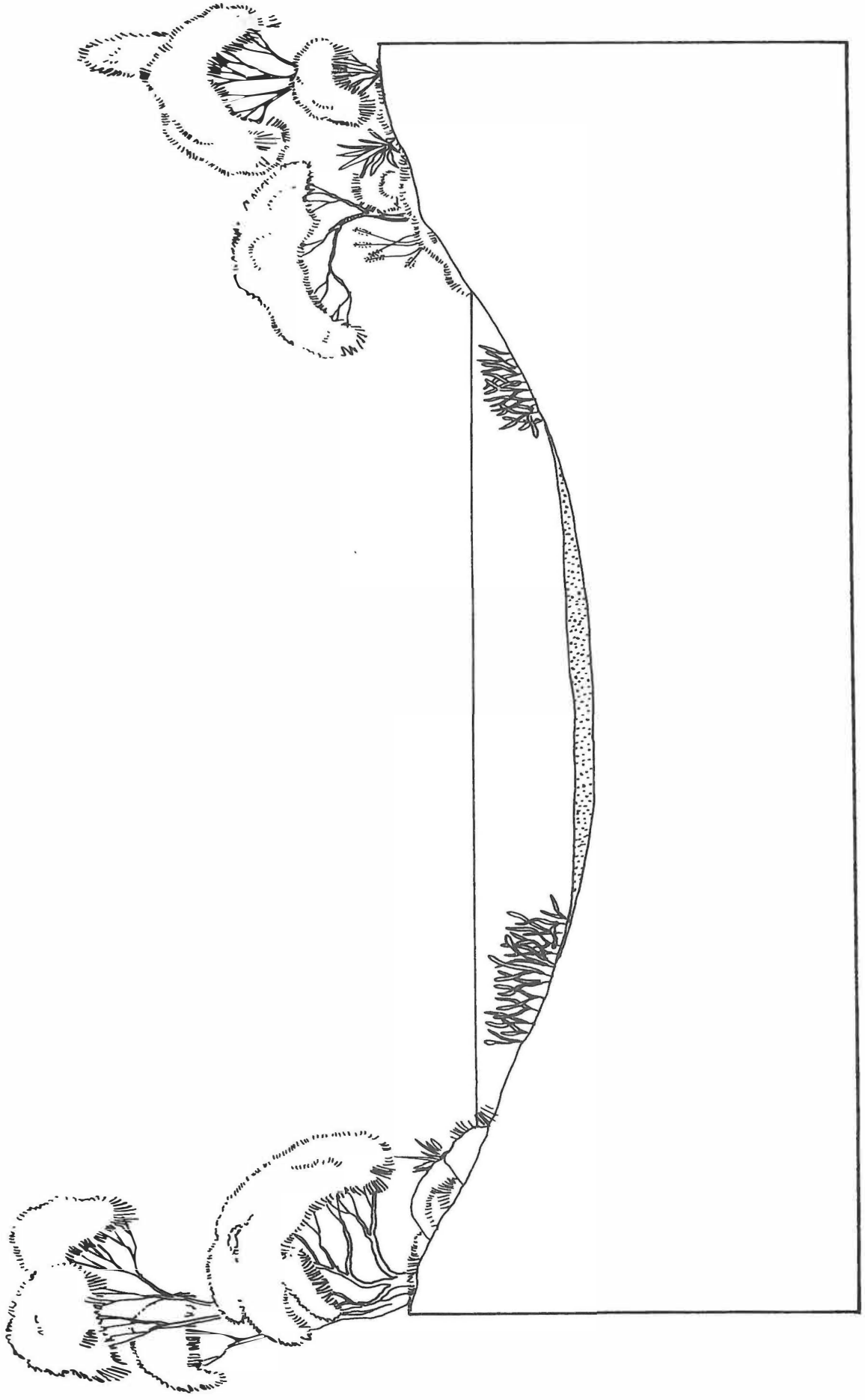
3. Marine visitors

The diagrams above have been adapted from *Peel-harvey Estuary Progress No 3, The Algae and the Fishery* (Department of Conservation and Environment 1983).

11 resource sheet

Working Scientifically in the Swan River Environment

Estuarine cross-section

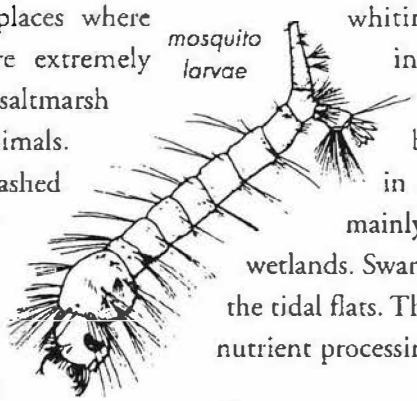


Estuarine habitats

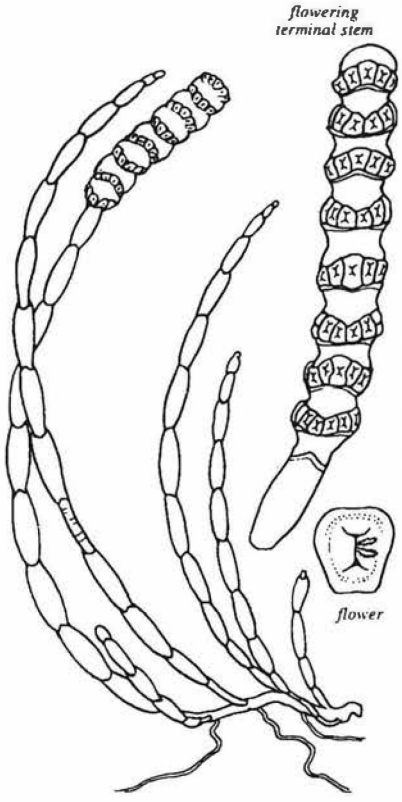
The Swan-Canning estuary, like all other estuaries, has a variety of different habitats. Each habitat varies in terms of its physical and chemical conditions and the way in which organisms use it. All estuarine habitats play an important role in maintaining the estuary as a functioning system. A functioning system is one that efficiently processes and cycles nutrients and energy, and has a healthy diversity for its kind and location. The types of habitats are described below.

Salt marshes and fringing reeds

The low-lying area around the estuary is salt marsh (or samphire marsh). Saltmarsh plants that can tolerate salty conditions and are flushed regularly by tides occupy this habitat. Though they are sometimes viewed simply as swampy, smelly places where mosquitoes breed, salt marshes are extremely productive estuarine habitats. Most saltmarsh plants are not eaten directly by animals. Instead, broken or dead pieces are washed by tides into the estuary, where they are broken down or eaten by detritus-feeding animals. The receding tide also exposes small plants and animals on which the birds feed. Female mosquitoes lay their eggs in the pools of water that are left behind, and the mosquito larvae form an important part of the diet of ducks and other animals. The saltmarsh areas provide valuable cover and nesting areas for waterfowl.



Salt marshes are considered the 'kidneys' of an estuary because they are so important in influencing nutrient inputs and cycling in the system.



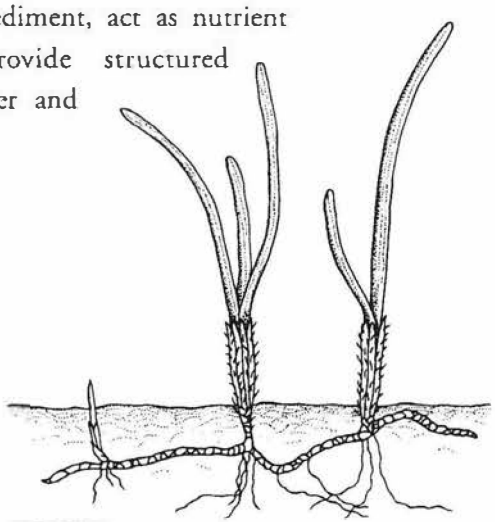
beaded samphire

Sandbanks and mudflats

The estuary's shallow sandbank and mudflat habitats are environments that are exposed during periods of low tide. They provide abundant food for wading birds, including migratory waders. Here, whiting forage for invertebrates that inhabit sandbanks and mudflats during the rising tide. At low tide, birds probe the sand with their beaks in search of food. Invertebrates feed mainly on the detritus produced by coastal wetlands. Swans and ducks use the deeper waters of the tidal flats. This habitat is extremely important for nutrient processing as well.

Seagrass meadows

Seagrass occurs in clear waters up to three metres deep. Small invertebrates live and feed among these grasses. Seagrass meadows provide a nursery habitat for fish and crustaceans that feed either on invertebrates or on the detritus formed from decaying seagrass and algae. They are also important refuges from predators. Seagrass meadows help to bind and oxygenate the sediment, act as nutrient banks and provide structured diversity to water and mud.



seagrass

Open waters

The open waters provide a habitat for the many fish that use the estuary. Pelicans, grebes, darters and cormorants fish these waters, and algae such as *Chaetomorpha* and *Enteromorpha* can be found floating here. Invertebrates are usually less numerous in the sediments of the open waters than they are on the mudflats, sandbanks and fringes of the salt marshes.

Chaetomorpha x 100

Islands

The two islands in the Swan-Canning river system, Ron Courtney Island and Heirisson Island, were artificially created during dredging operations. Birds use these islands as feeding and roosting areas, and in some cases as breeding grounds. The islands are refuges from disturbance by people and dogs.

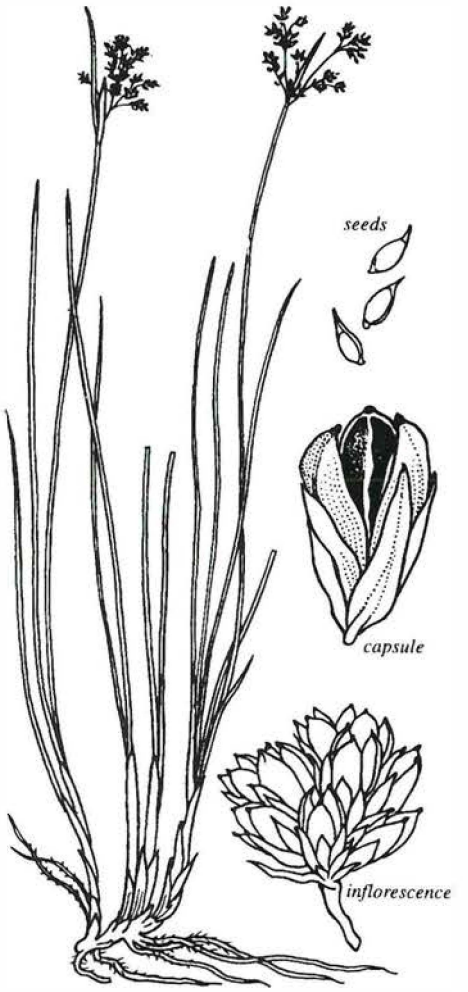
Cleared parkland and pasture

Much of the river foreshore has been cleared of its natural vegetation to provide for pasture and parklands, or filled in to make tip sites, roads and recreational areas. Many of these areas become flooded at times, providing a feeding and roosting ground for ducks and birds such as herons, ibises and stilts. Many insects, frogs and small crustaceans are found amongst the puddles left by the receding floodwater. Well-vegetated foreshores and parklands that have not been over-cleared help to keep erosion under control and filter nutrients out of the water flowing from the land.

Fringing (riparian) vegetation

Fringing vegetation plays an important role in the maintenance of a biologically balanced and healthy waterway. It provides a wide range of functions, which are essential for supporting plant and animal life and for maintaining the quality of the environment. These functions include: sediment, nutrient and pollutant filtering, stabilising banks, and most importantly, provision of food for the whole waterway.

Balanced and healthy waterways are usually characterised by their fringing vegetation. The water in which the plants grow may be fresh, brackish or saline and the particular species determined by the tolerance of the plant to water quality. Sedges, shrubs and trees not only provide a pleasing appearance to a waterway; they are an incredibly rich shelter and breeding habitat for a wide range of organisms.



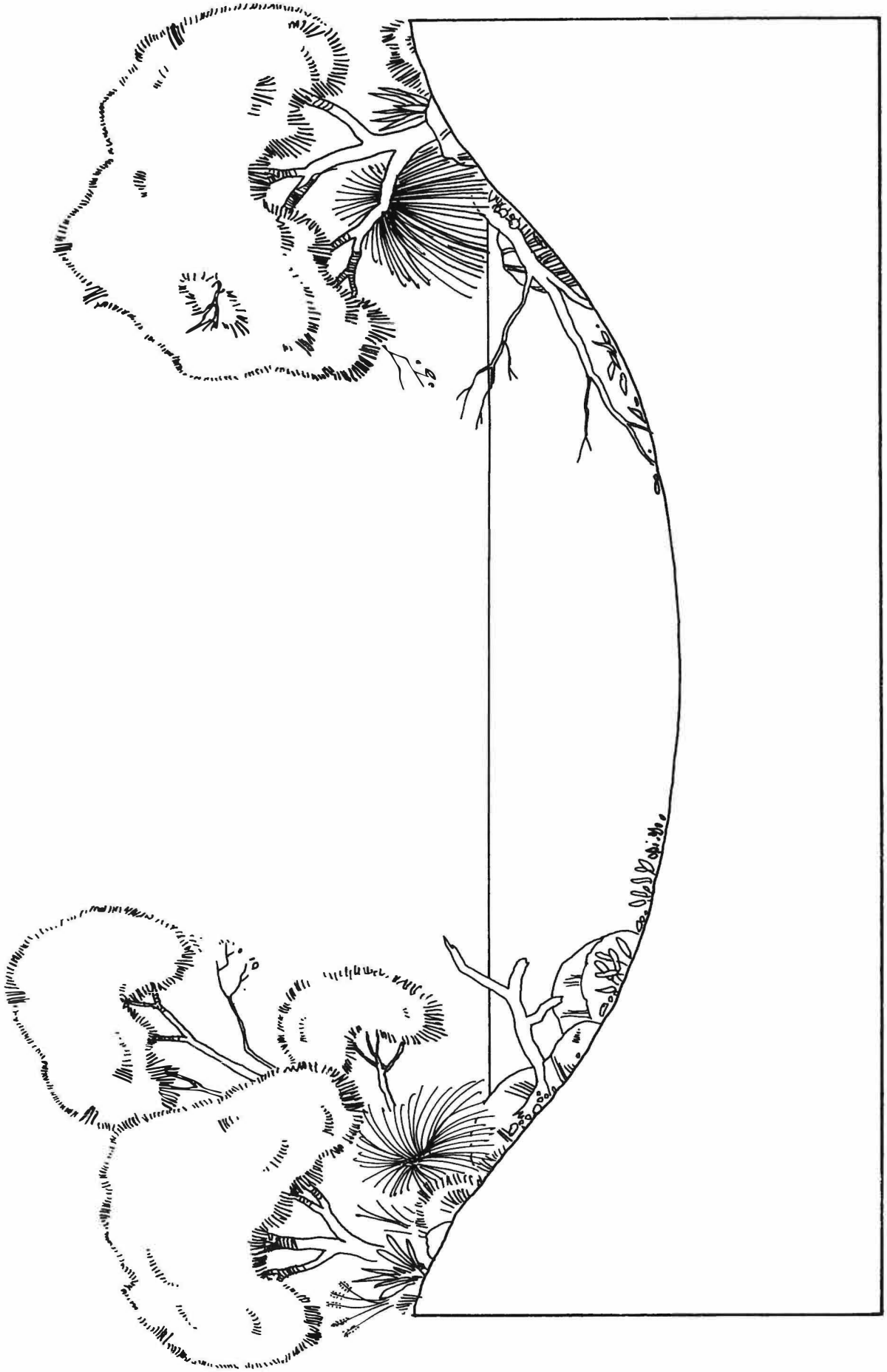
sea rush

See also Resource Sheet 14, *Fringing vegetation of the Swan-Canning river system*. This sheet can be read in conjunction with Resource Sheet 17, *Birds of the Swan River system*.

Working Scientifically in the Swan River Environment

Freshwater stream cross-section

13 resource sheet



14 resource sheet

Working Scientifically in the Swan River Environment

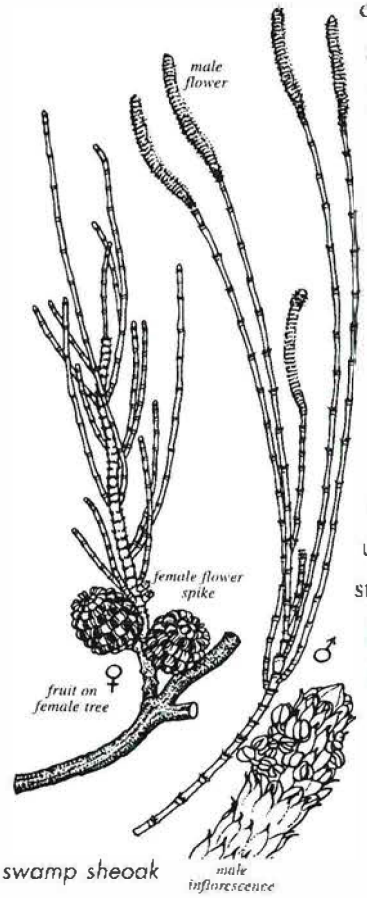
Fringing vegetation of the Swan-Canning river system

The Swan-Canning river system supports a variety of fringing plant types – trees, shrubs, sedges and rushes, samphires, herbs and grasses – and a number of different plant communities. Because the water in which fringing vegetation grows can be saline, brackish or fresh, a number of different types of plant communities are found.

Fringing plant communities exist on the river banks and on the strips of land along the banks. Salt marsh communities of salt-tolerant plants occur in areas subjected to tidal flooding. Upstream on higher land there may be a fringing forest community of salt-tolerant paperbarks and sheoaks. Still further back, in low-lying areas beyond the influence of salt water, freshwater paperbark and flooded gums may be found.

The importance of fringing vegetation

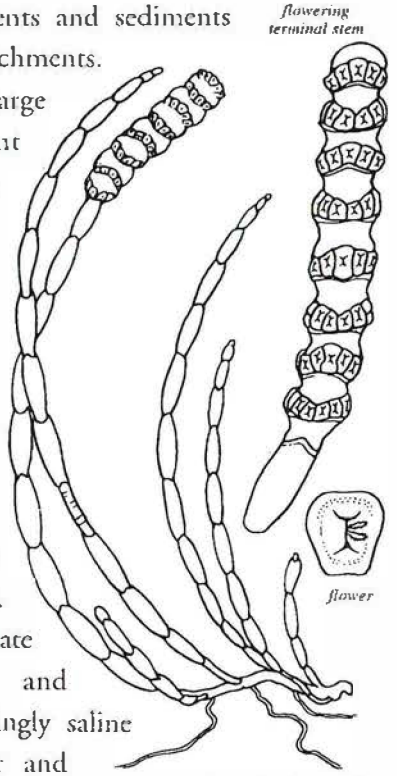
Healthy waterways are usually characterised by their fringing vegetation. All fringing plant communities are important to help maintain an ecologically balanced, healthy river system. The fringing vegetation of the Swan-Canning river system ensures the existence and diversity of animals in the riverine environment as it provides food and shelter for birds, frogs, reptiles, mammals and other animals that live in or around the water. It also helps to filter water that enters the estuary, and to maintain the quality of other surface and ground-waters. Fringing vegetation has some ability to remove pollutants and to take up excess nutrients. It also stabilises and aerates sediments, prevents murkiness caused by floating sediments and prevents erosion of the banks.



swamp sheoak

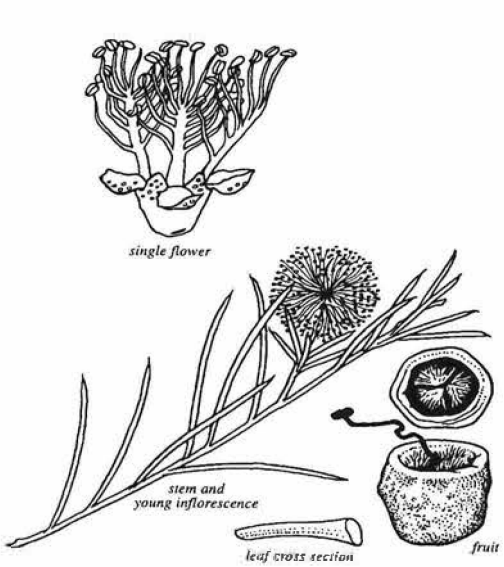
Estuarine plants

The estuary is a very productive environment because it receives nutrients and sediments from the surrounding catchments. There are therefore a large number of native plant species. There is a wide range of habitats because of variations in the degree of inundation and the degree of waterlogging, and changes in nutrient and salinity levels from place to place. Fringing plants are adapted to the estuary's ever-changing environment. Many plants can tolerate seasonal inundation and waterlogging, and increasingly saline conditions over summer and autumn.

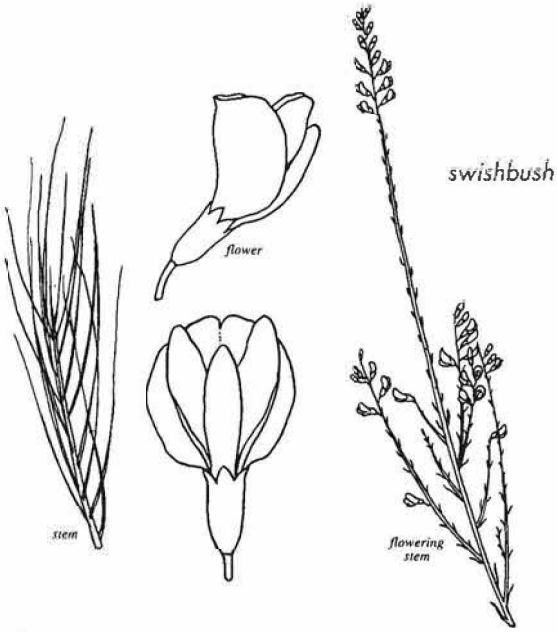


beaded samphire

The most common tree found in estuarine areas is the swamp sheoak. Shrubs include the saltbush, sea heath and slender myopium. There are many types of sedges and rushes that are important for bank stability. A number of samphires, including shrubby samphire and beaded samphire, and herbs such as trailing jointweed, brookweed, creeping brookweed and seablite, also inhabit the riparian zone of estuaries.



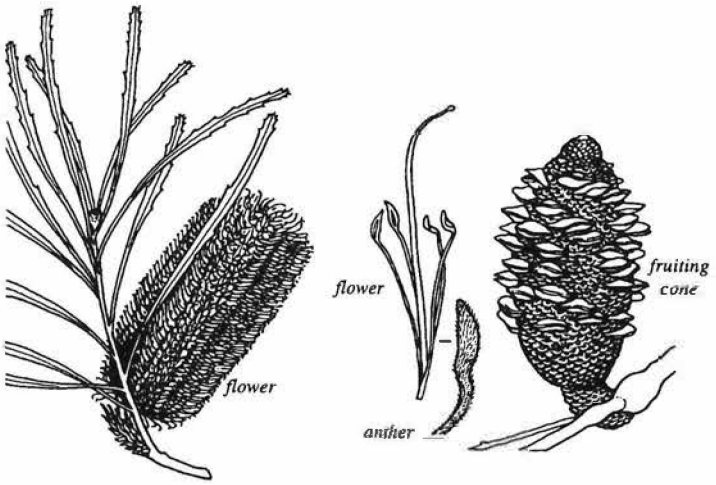
swamp paperbark



Freshwater stream plants

There is a large variety in the type and distribution of plants found near freshwater streams due to different soil types and water depths, the timing and duration of flooding and the length of the dry period.

Some common trees include the peppermint, wattle, swamp banksia, river banksia, flooded gum, modong and swamp paperbark. Some common shrubs include the swamp peppermint, coojong, wonnich, astartea, variable-leafed grevillea, robin redbreast bush, narrow-leafed oxylobium, albizia and swishbush. There are many sedges and rushes found along freshwater streams, and the herb centella and the grass matgrass are also found.



swamp banksia

Refer to Resource Sheet 19, *Some native plants of estuaries and saline waterways*, and Resource Sheet 20, *Some native plants of freshwater rivers and creeks*, for more details on selected plants.

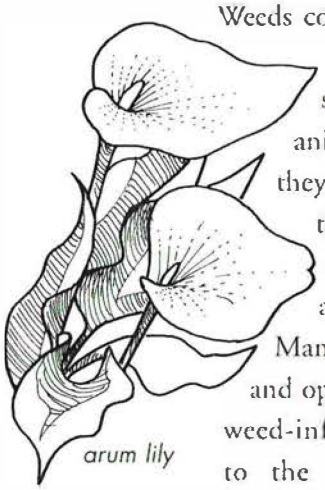
15 resource sheet

Working Scientifically in the Swan River Environment

The problem with aquatic and foreshore weeds

Weeds in the riparian zone and in the water can be a serious problem. A weed is an alien or introduced plant that is invasive.

Weeds compete with local plants for space and light. They usually don't suffer from pests or diseases, and animals may not feed on them, so they spread easily. They can overtake the natural vegetation, reducing the diversity of native species and the value of habitats.



arum lily

Many old creeklines and open drains are weed-infested due to the clearing of natural vegetation, which has allowed rapid weed growth.

Clearing along the river, grazing of river foreshore areas and constant mowing of parklands has meant that natural understorey vegetation was eventually unable to re-establish itself. In the end the native species was replaced by weeds that enjoy disturbance.

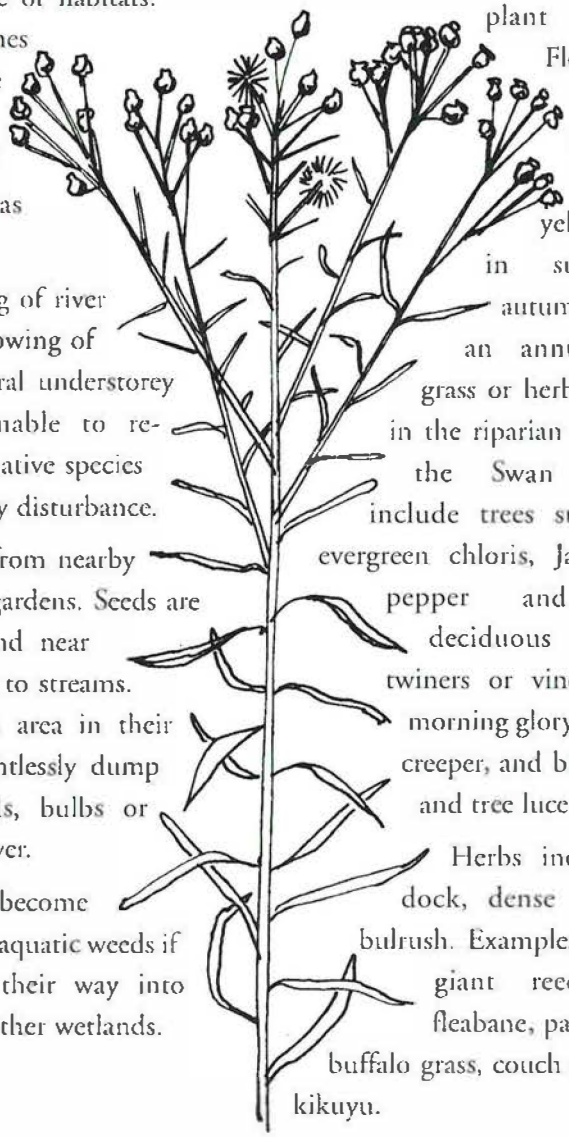
Foreshore weeds mostly come from nearby gardens, farmland and market gardens. Seeds are blown or washed into bushland near streams and into drains leading to streams. Birds can bring them into an area in their droppings. People often thoughtlessly dump garden waste containing seeds, bulbs or cuttings in bushland near the river.

Imported aquarium plants can become dangerous aquatic weeds if they find their way into streams or other wetlands.

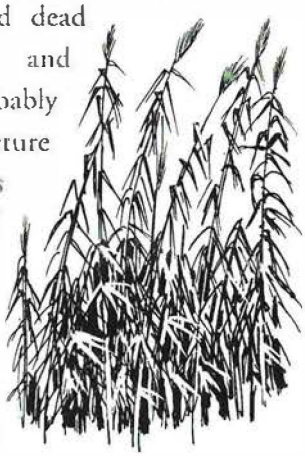
pampas grass

Riparian zone weeds

Weeds in natural bush can be recognised in a number of ways. Their leaves are generally bright green, large, soft or broad, and may drop at one time of the year (meaning the plant is seasonally deciduous). Flowers are usually large and colourful. A plant that looks lush and healthy in winter and spring but yellow and dead in summer and autumn is probably an annual pasture grass or herb. Weeds in the riparian zone of the Swan River include trees such as evergreen chloris, Japanese pepper and the deciduous poplar, twiners or vines such as morning glory and bridal creeper, and bushes such as castor oil bush and tree lucerne.



floxleaf fleabane



giant reed bamboo

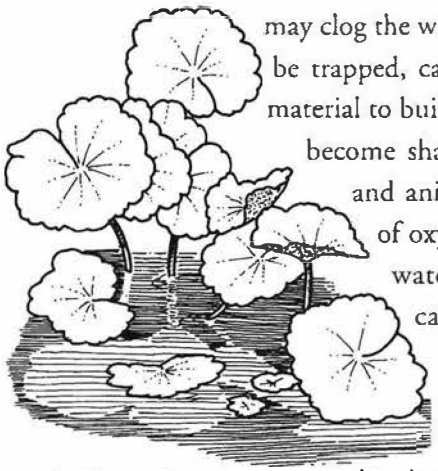
Herbs include watsonia, arum lily, dock, dense flat sedge and bulrush. Examples of grasses are giant reed, flaxleaf fleabane, pampas grass, buffalo grass, couch and kikuyu.

castor oil bush

bridal creeper

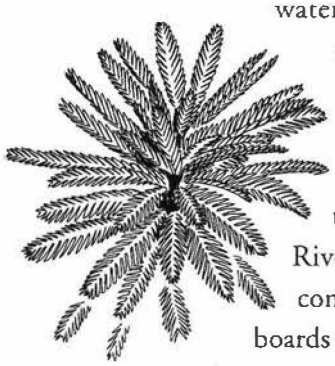
Aquatic weeds

When non-native aquatic plants are introduced to a waterbody they can grow rapidly due to the fresh slow-moving water and plentiful nutrient supply. This can result in a number of problems: weeds may clog the waterway; sediment may be trapped, causing silt and organic material to build up and the water to become shallower; aquatic plants and animals may be deprived of oxygen and light and the water may stagnate, causing the death of aquatic life. Habitats for birds and other animals may also be lost. Recreational areas may be ruined and irrigation pumps may become clogged with plant material.

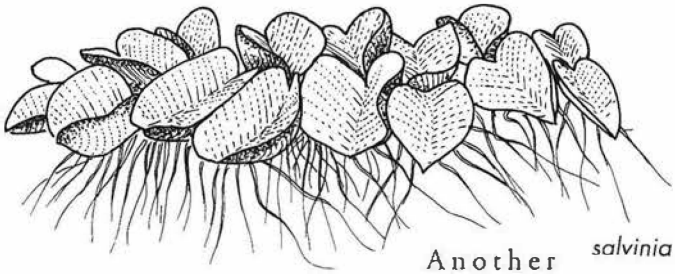


hydrocotyl

Some weeds are fast-growing and free-floating varieties, which have the potential to do great harm to the environment. Examples are salvinia, hydrocotyl, water hyacinth, water lettuce, alligator weed and parrot's feather. Salvinia (a plant often used in fish tanks and garden ponds) has in the past infested upper parts of the Canning River. It cannot tolerate saline conditions, so the removal of the boards at Kent Street Weir to flush it downstream into salty water has proved the most effective means of natural control.

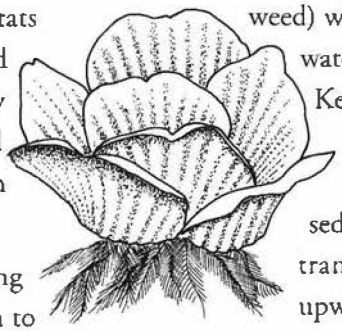


parrot's feather



Another *salvinia* example is *Hydocotyl ranunculoides.* A particularly fast-growing noxious weed, it can form dense, deep floating mats. The noxious weed *Sagittaria graminea,* another fishpond plant, has infested some parts of the river.

Some aquatic weeds are attached to sediment or other substrate. An example is *Vallisneria americana* (ribbon weed) which likes swiftly flowing fresh water and occurs upstream of the Kent Street Weir, particularly in the upper reaches of the Canning. It attaches to the sediment, and its long strap-like translucent green leaves grow upwards to the surface.



water lettuce

Most outbreaks of aquatic weeds have been successfully treated, but controlling outbreaks is expensive and time-consuming. Removal by hand is the most common approach. It is critical that people never empty aquarium plants from fish tanks or backyard ponds into rivers or drains, and use safe aquatic plants such as the fern-like azolla and the waterlily.

alligator weed

water hyacinth

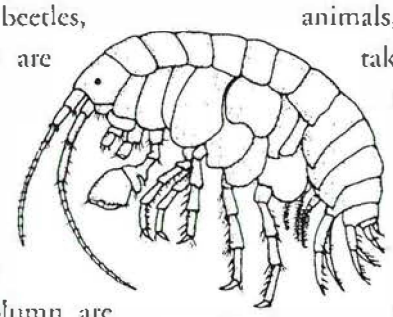
16 resource sheet

Working Scientifically in the Swan River Environment

Estuarine invertebrates

Invertebrates (animals without backbones) are an important part of the estuarine ecosystem since they are the food of most fish and wading birds. The diversity and abundance of invertebrates in a waterway are good indicators of river health because they live in the water for all or most of their lives.

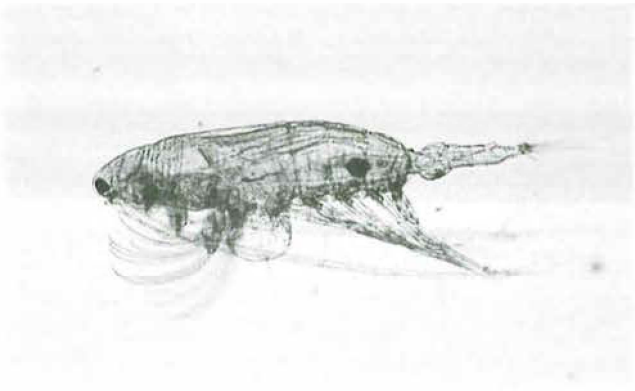
There are many types of aquatic invertebrates. Macroinvertebrates are big enough to be seen. The main groups are worms, snails, crustaceans (e.g. prawns and crabs) and insects (e.g. beetles, bugs and flies). Microinvertebrates are barely visible to the naked eye.



amphipod

Habitats

The habitats of invertebrates vary. Those invertebrates that float, drift or swim weakly along in the water column are known as zooplankton. Some types of invertebrates are found attached to the algae and seagrass of the estuary. Most invertebrates are bottom-dwelling (benthic) organisms, found in the top five centimetres of the sediment. Generally, invertebrates prefer the sandy, shallow, well- aerated conditions that are found in sediments around the estuary foreshore, rather than the fine, oxygen-depleted mud of the deeper waters.



zooplankton

Food

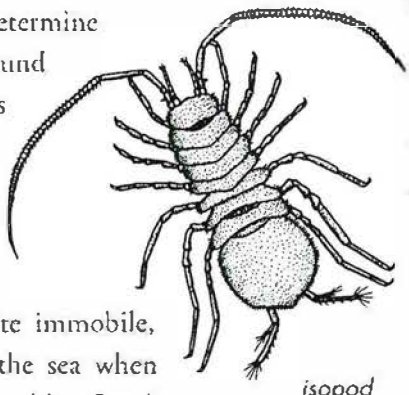
Free-swimming zooplankton generally feed on smaller zooplankton or phytoplankton. Bottom-dwelling invertebrates feed on microscopic food particles found on the surface of the sediment or in the gaps between sand grains, or on the protozoa and bacteria that decompose seagrass and algae.

Sometimes macroinvertebrates are grouped or classified according to how they obtain their food. Predators (e.g. boring snails and crabs) prey on smaller animals, whereas filter feeders (e.g. mussels) take smaller particles of organic matter from the water. Scrapers (e.g. snails) scrape fine algal growth off hard surfaces, whereas collectors (e.g. long-tentacled worms and crabs) take smaller particles of organic matter like dead algae and broken-down plant material from sediment. Shredders (e.g. amphipods) break up larger particles from leaves, bark and other detritus.

Note: Detrius is organic material, including animal waste products and the remains of animals, plants and microorganisms, together with the associated microbial community (bacteria and fungi).

Responses to salinity

The salinity of the water and the nature of the bottom sediments largely determine the types of invertebrates found in the estuary. Most species of invertebrates are marine organisms, so the variety of types of invertebrates decreases upstream.



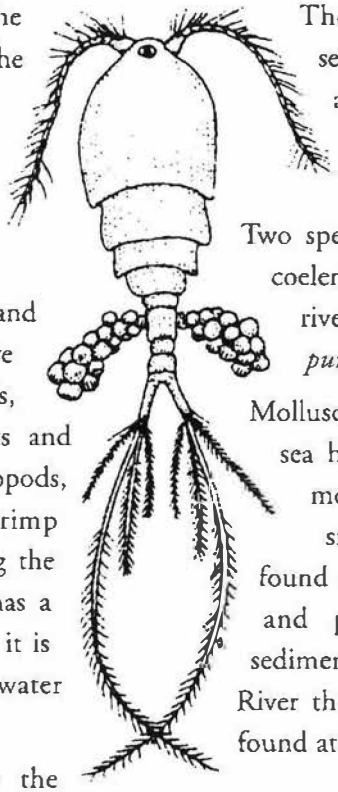
isopod

Most invertebrates are quite immobile, so they cannot retreat to the sea when salinity levels are unfavourable. Species that cannot tolerate the lower salinities during winter die, and new stocks have to be recruited from larvae that come in with the returning seawater in spring and summer.

Only true estuarine species can survive the full range of salinity experienced in the estuary.

Types of aquatic invertebrates

The most obvious invertebrates in the estuary are large crustaceans (e.g. the decapods – king prawns, river prawns and blue manna crabs). Small crustaceans live in the shallows and amongst weeds, feeding on detritus and smaller plants and animals. They include amphipods, isopods, copepods and shrimps. The shrimp *Palaemonetes australis* is common among the weed and seagrass of the shallows. It has a wide tolerance to salinity differences, so it is found in both estuarine and freshwater environments.

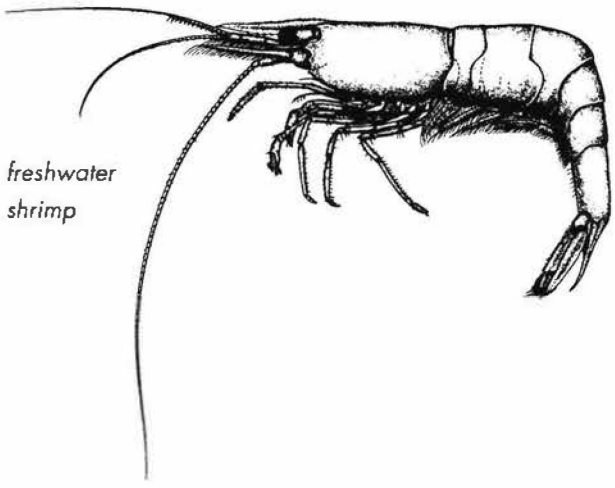


copepod

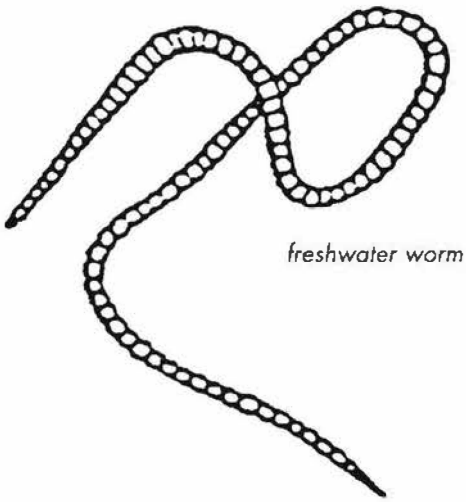
Annelids are mainly represented by the polychaetes, which are segmented marine worms. They can be found buried in the sediments, in burrows or tubes. They appear at night to feed on detritus. Polychaetes give off a phosphorescent glow at breeding time.

Two species of jellyfish, which belong to the coelenterates, are commonly found in the river system: the brown jellyfish *Phyllorhiza punctata* and the transparent *Aurelia.*

Molluscs include snails, periwinkles, abalone, sea hares and bivalves. A common bivalve mollusc is *Mytilus edulis planulatus*, the small black mussel. Bivalve molluscs are found attached to solid objects such as jetties and pylons, or buried slightly in the sediments. In the lower reaches of the Swan River the gastropod snail *Batillaria australis* is found attached to seagrass.



freshwater shrimp



freshwater worm

17 resource sheet

Working Scientifically in the Swan River Environment

Birds of the Swan River system

The Swan River system is an important wetland for many species of birds in the south-west of Western Australia, as it contains a variety of productive habitats. Types of birds at the estuary include waders, waterfowl, reed-dwellers, birds of prey, fish-eaters and divers.

The **larger waders** are long-legged, long-necked birds that feed in deeper water. Examples are herons, egrets and ibis. **Larger wading birds** feed on crustaceans, fish and frogs, and occasionally on reptiles and small birds. Thickets of shrubs and trees in or near swamps are vital roosting and nesting sites for the larger wading birds that feed in the nearby estuary. The most valuable habitats are the freshwater swamps with their live plants, although dead shrubs and trees also provide loafing perches for some herons. Many cleared areas of the foreshore (e.g. parklands and pasture lands) are prone to seasonal flooding, and so provide a feeding and roosting ground for large waders like herons and ibises.

The **small waders** have a variety of body sizes, leg lengths and bill types for hunting different-sized prey in various depths of water. Examples are the plovers, sandpipers and stilts. Some species often travel long distances to the estuary from their breeding grounds in other parts of Australia, though many are migrants from the northern hemisphere. To escape the harsh northern winter they make journeys of up to 9000 kilometres from their breeding grounds in Alaska, Japan, China and Russia. Most arrive around September to feed in the shallows over the summer months. They moult and put on fat to supply the energy needed for the long journey back.

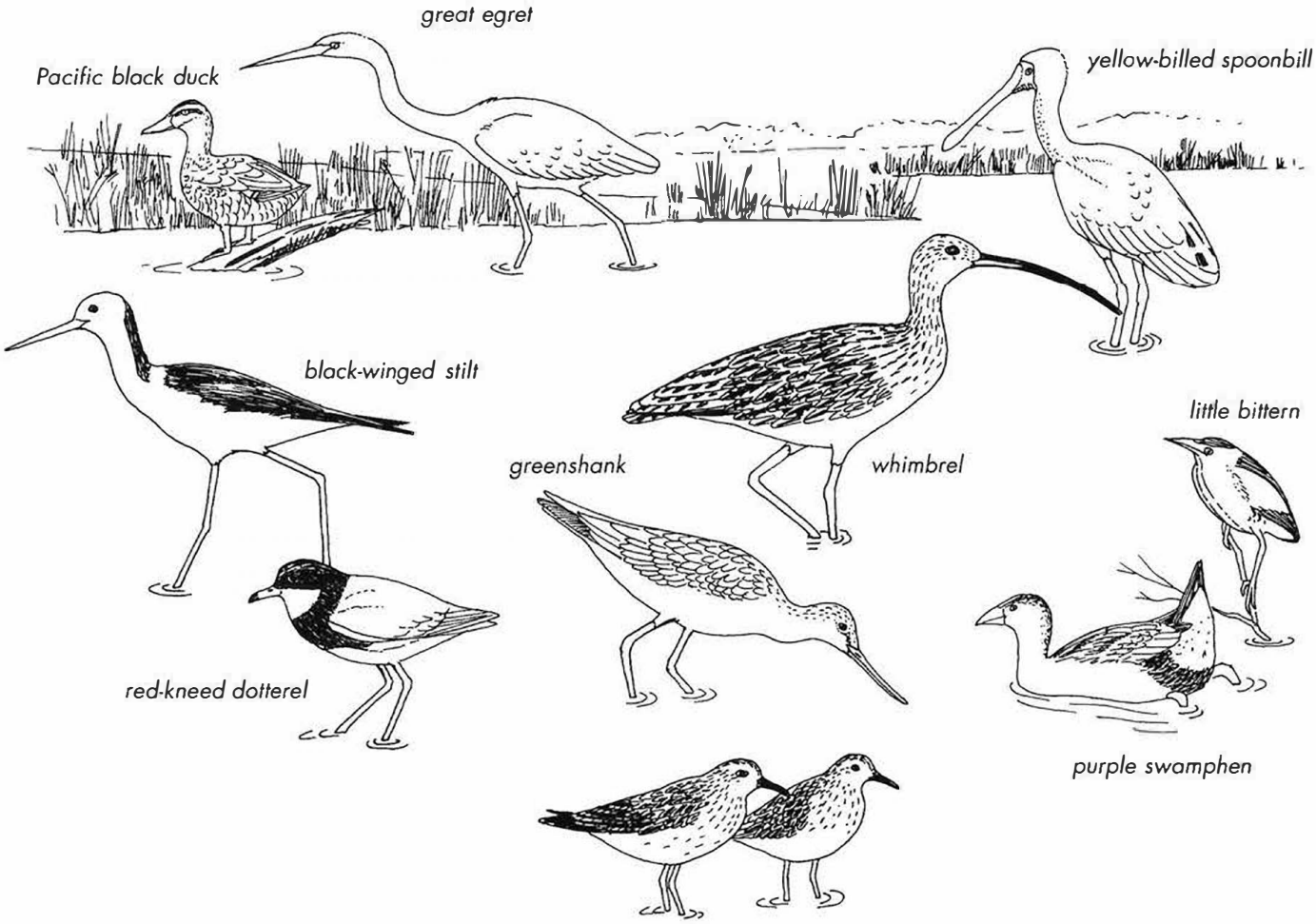
Huge flocks of various sized, long-legged wading birds with bills adapted for obtaining food sieve, scoop, probe and spear for food in the rich feeding areas of the shallow waters, on tidal mudflats and in salt marshes, particularly during periods of low tide. Reeds also attract many wading birds, especially during the winter or when there are high tides. They feed almost exclusively on the invertebrate life (like molluscs, polychaete worms, insect larvae and crustaceans) although they may also eat aquatic plants and insects.

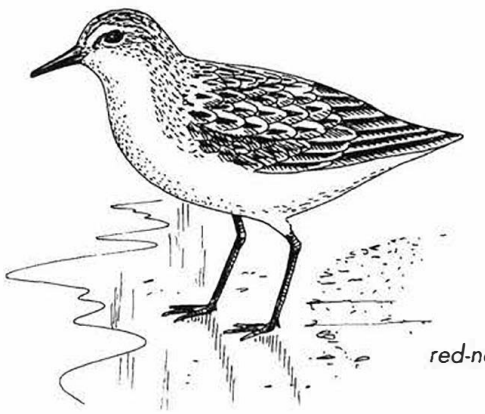
Waterfowl are the geese, swans and ducks. In summer many waterfowl arrive on the estuary from inland wetlands that have dried up. Ducks and swans are basically herbivorous, grazing on the vegetation along the banks and seagrasses in the shallows. They also eat juvenile fish. Some ducks dabble and dredge for a mixture of plants, seeds and small animals. Areas of reeds provide nest sites for waterfowl, as do sandbars and islands.

Reed-dwellers like the rails, crakes and coots can be spotted amongst reeds and bank vegetation, feeding on the stems of young reeds and on frogs and molluscs. These areas of fringing reeds (and areas of salt marsh) provide cover for reed-dwellers. Reed-beds in freshwater swamps are attractive habitats for crakes and rails.

Birds of prey like the sea eagle, osprey and whistling kite feed over the open waters of the estuary. They are skilled hunters, catching fish and ducklings.

Fish-eaters and divers include grebes, pelicans, darters, terns and cormorants. The diving birds use the deeper open waters of the estuary as they dive to catch bottom-dwelling animals or plant material or catch fish that swim close to the surface. Grebes have streamlined bodies and lobed feet that make them very manoeuvrable in the water, so they can chase their prey of fish and invertebrates under the surface. Darters and cormorants do not have water-repellent plumage, so they can swim freely under water to chase their prey without being buoyed up by trapped air. Pelicans, the largest birds on the estuary, cooperate when catching fish by swimming in formation and driving the fish into shallows, where they scoop them out.



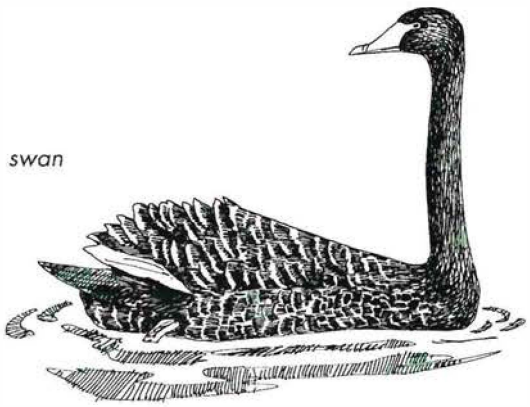


Common waders

grey plover
red-capped plover
ruddy turnstone
whimbrel
common sandpiper
marsh sandpiper
bar-tailed godwit
sharp-tailed sandpiper
curlew
large sand plover
banded stilt
eastern curlew
grey-tailed tattler
greenshank
black-tailed godwit
red knot
red-necked stint
sandpiper

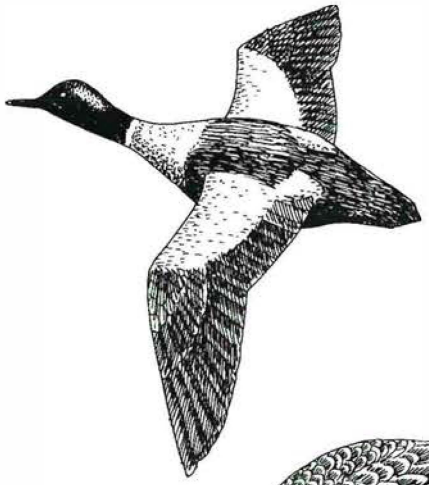
Common larger wading birds

Pacific heron
great egret
rufous night-heron
straw-necked ibis
white-faced heron
little egret
sacred ibis
yellow-billed spoonbill


swan

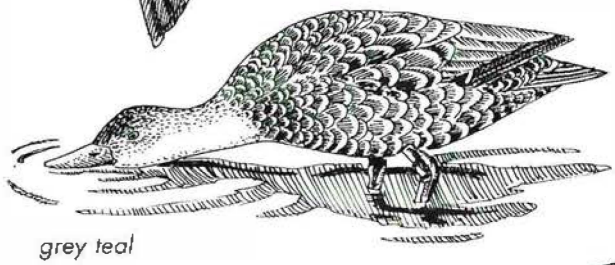
Common waterfowl

black swan
Pacific black duck
Australasian shoveler
maned duck
Australian shelduck
grey teal
hardhead
musk duck


Australian shellduck

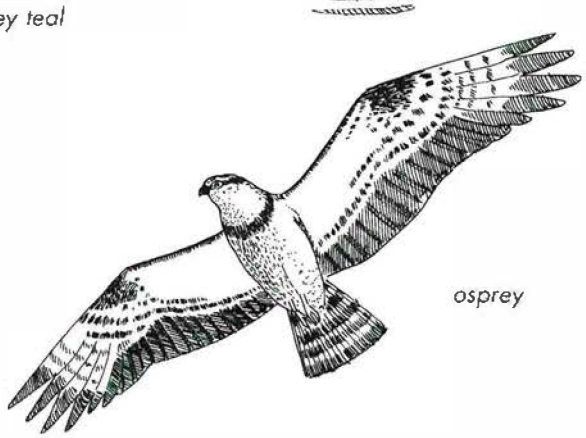
Common reed-dwellers

buff-banded rail
spotless crake
eurasian
Australian crake
purple swamphen
coot


grey teal

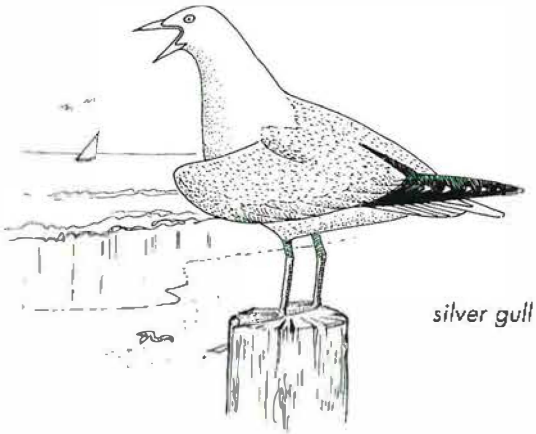
Common birds of prey

osprey
marsh harrier
whistling kite
white-bellied sea eagle


osprey

Common fish-eaters/divers

great crested grebe
Australasian grebe
darter
pied cormorant
silver gull
whiskered tern
white-winged tern
hoary-headed grebe
Australian pelican
great cormorant
little pied cormorant
little black cormorant
fairy tern
crested tern


silver gull

Aquatic plants – algae and seagrasses

Aquatic plants (including algae and seagrasses) live and grow in or on water. These plants are a very productive food source for animals, and they provide a shelter for small animals that are the food source of many juvenile fish. They stabilise sediments and help to keep oxygen and nutrient levels in balance. The presence of a great diversity of algae in a river indicates that it is healthy. The growth of algae is affected by water salinity levels, temperatures, light conditions, available nutrients, water movement and the degree of sedimentation.

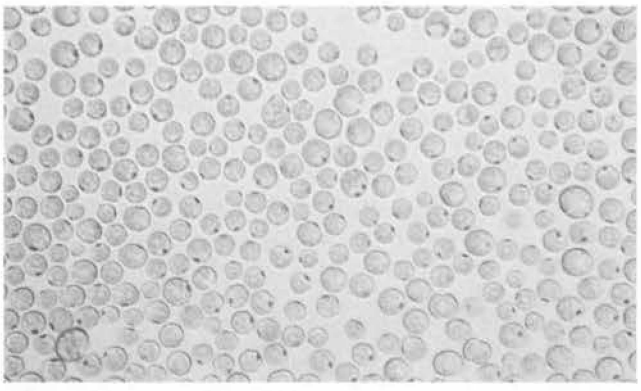
Microscopic algae (microalgae)

There are three main groups of microscopic algae (according to their habitat requirements). Planktonic algae (phytoplankton) float in the water column, taking the nutrients needed for growth from the water. Epiphytic algae attach to other plants. Benthic microalgae are found in sediments.

The most common species of microscopic algae found in the river are diatoms. They are a type of phytoplankton.

Freshwater species of algae are mostly restricted to the upper estuary, but can be found in the lower estuary in winter. Marine species are confined to the lower estuary, except during summer-autumn when they move into the upper estuary as salinities increase.

Spirogyra chlorophyte



Chlamydomonas chlorophyte

When conditions such as salinity, temperature, light and nutrient levels are right, microscopic algae can grow extremely fast to create an algal 'bloom'. The river experiences occasional blooms of microscopic algae such as diatoms, dinoflagellates, chlorophytes and cryptophytes. The blooms can appear as fluffy growths on other macroalgae or as brown, red or green colourations in the water. The chlorophyte *Chlamydomonas* blooms in October from the upper reaches of the Swan to Perth Water. A diatom bloom commonly occurs in the lower reaches around Melville Water in the spring, associated with salt water moving up river. Dinoflagellate blooms occur in late summer and autumn in the middle and upper parts of the upper estuary. A diatom, *Melosira moniliformis*, occurs in this area in spring, appearing as a growth on macroalgae or on rocks or jetty piles. Fortunately, while some varieties of microalgae are toxic, most toxic forms will not survive in the estuary's saline waters.

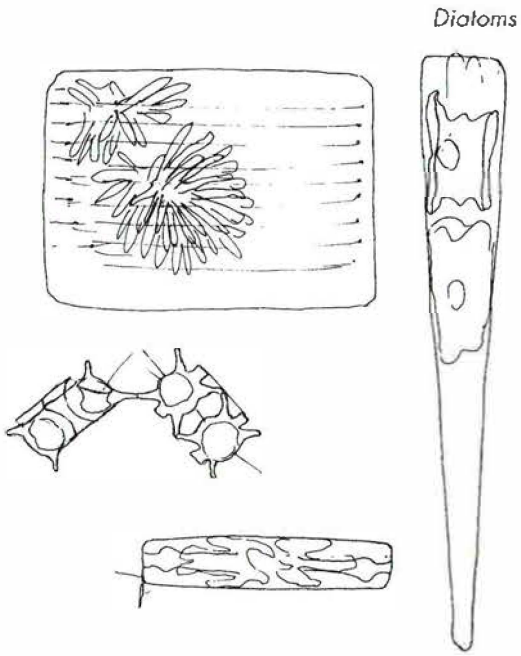
Macroscopic algae (macroalgae)

Over sixty-five species of macroscopic (large) algae have been identified in the Swan River estuary. They either float freely in the water column, grow on other large water plants or are attached to a substrate such as sand, rocks, logs, branches or jetty pylons. Many macroalgae die off in winter due to decreased salinity and increased turbidity. In summer they re-grow from spores. With increasing distance upstream fewer different kinds of macroalgae are found. Many species nearer the estuary mouth are strictly marine in nature. During spring, large accumulations of macroalgae can occur, mainly in the warm shallows of Peppermint Grove and Mosman Bay and along the Canning River foreshores.

Seagrasses

Seagrasses are flowering plants, so they prefer clear water and sand or mud for their root systems. The most common type of seagrass is *Halophila ovalis* (paddle weed), which grows in clear waters up to three metres deep. *Zostera*, another species of seagrass, is restricted to the lower reaches of the Swan River.

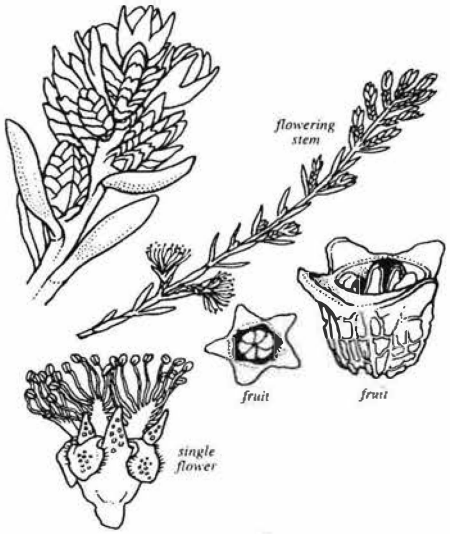
Seagrass roots anchor the sediments, stabilising the floor of the estuary and providing a home for molluscs, worms and other invertebrates. Some burrowing fish like estuarine cobbler excavate burrows for laying eggs and brooding. Some fish species use the seagrass meadows as shelter, and feed on the algae and invertebrates found among the leaves. Some fish lay eggs on them. The decaying leaves of seagrass provide a large amount of organic matter for aquatic animals – they are a major food source for a variety of invertebrates.



Nuisance phytoplankton, blue-greens and plant species	Comments
1. *Heterosigma* phytoplankton fish	Slimy layer – nuisance warnings and potential to kill
2. *Scrippsiella, Gyrodinium* dinoflagellate phytoplankton	Red tide – nuisance warnings, some adhere to the body
3. *Rhizoclonium* macroalgae	Unaesthetic appearance and temporary loss of recreational amenity
4. *Anabaena* blue-green phytoplankton	Blue-green – unsafe for recreation, prevalent in the upper Canning River
5. *Microcystis* blue-green phytoplankton	Blue-green – unsafe for recreation, prevalent in the upper Canning River
6. *Anabaenopsis* blue-green phytoplankton	Blue-green – unsafe for recreation, prevalent in the upper Canning River
7. *Hydrocotyle* plant	Introduced – gazetted noxious plant, occasional outbreaks in the Canning River
8. *Salvinia* plant	Introduced – gazetted noxious fern-like plant, most common in the Canning River

Common nuisance phytoplankton, blue-greens and plant species found in the Swan-Canning system.

Some native plants of estuaries and saline waterways



TREE

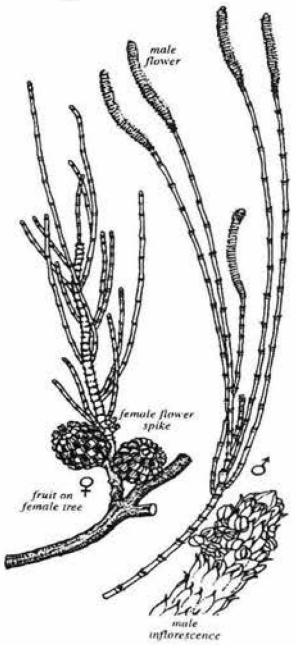
saltwater paperbark (Myrtaceae)
Melaleuca cuticularis

Location

Salty wetlands. Tolerant of waterlogging and salt in water and air.

Description

A small gnarled tree or large shrub up to 7 m with very white papery bark. Leaves are dull, greyish-green and thick. Flowers are white to cream, either single or in small clusters near the end of the stem.



TREE

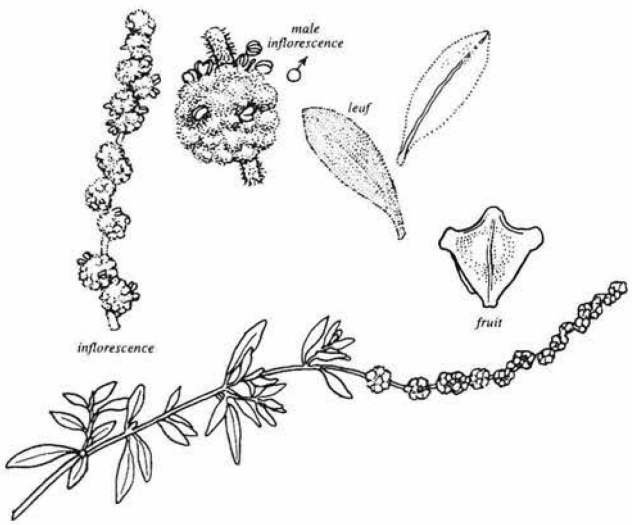
swamp sheoak (Casuarinaceae)
Casuarina obesa

Location

Rivers, estuaries and clay flats on coastal plain.

Description

Grows to 10 m with a 4 m spread. Graceful branches. Separate male and female trees. There are distinctive slender greyish-green needles that function as leaves.



SHRUB

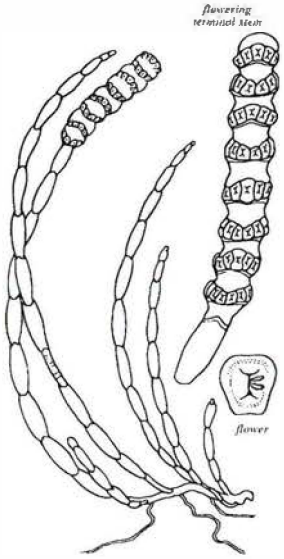
saltbush (Chenopodiaceae)
Atriplex hypoleuca

Location

Wet saline soils on coastal and estuarine fringes.

Description

Sprawls along the ground. Leaves are flat and elliptic, 10-40 mm long.



SAMPHIRE

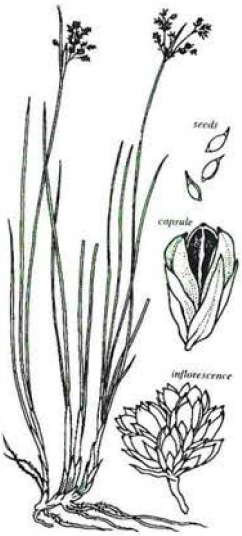
beaded samphire (Chenopodiaceae)
Sarcocornia quinqueflora

Location

Saline flats associated with coastal lakes, estuaries and rivers.

Description

An erect, spreading shrub to 0.5 m, often rooting at the nodes. Succulent stems with segments 5-15 mm long. Leaves are fused together.



SEDGE

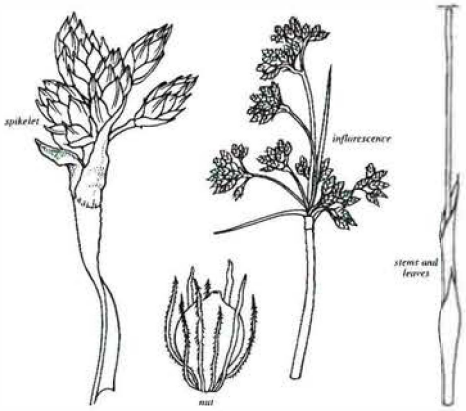
sea rush (Juncaceae)
Juncus kraussii

Location

A widespread wetland sedge which grows in saline and brackish habitats fringing watercourses and lakes.

Description

A tussock-forming plant 0.8-1.5 m high with dark green stems. It forms clumps and sometimes extensive colonies.



RUSH

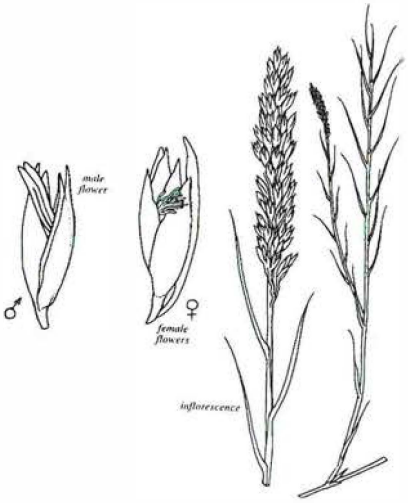
lake club-rush (Cyperaceae)
Schoenoplectus validus

Location

Fresh, brackish or semi-saline waters along margins of rivers and lakes and winter wet depressions.

Description

An erect sedge reaching 3 m. It forms clumps and sometimes extensive colonies.



GRASS

marine couch (Poaceae)
Sporobolus virginicus

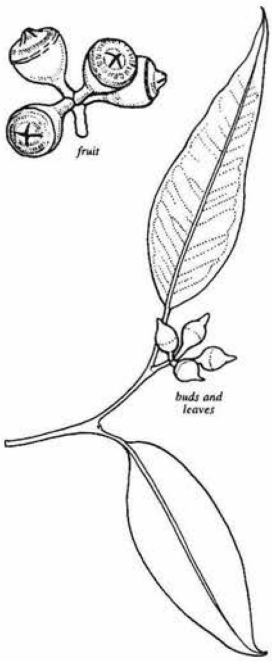
Location

Occurs in salt marshes and close to the coast.

Description

A perennial grass 0.1-0.4 m tall with numerous thick creeping scaly stems.

Some native plants of freshwater rivers and creeks



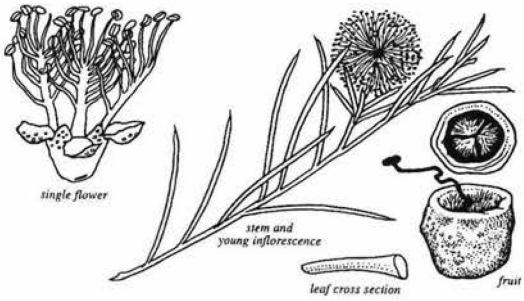
TREE
flooded gum (Myrtaceae)
Eucalyptus rudis

Location

Fringes winter wet watercourses and lakes. Found in waterlogged areas – can tolerate prolonged flooding

Description

Height up to 25 m, spread to 4 m with a rounded crown. The trunk is rough with flaky dark grey bark. Upper branches smooth with cream/pale grey bark. Leaves are dull and grey-green or bluish-green. Flowers are white to cream in clusters of 4-10. Buds with conical caps.



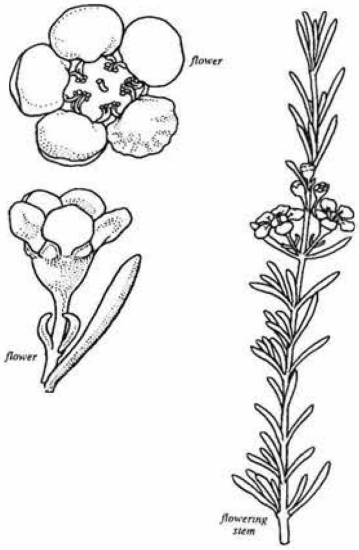
TREE
swamp paperbark (Myrtaceae)
Melaleuca rhaphiophylla

Location

Near watercourses and wetlands at the drier end. Prefers waterlogged sites. Less adapted to saline conditions than the saltwater paperbark.

Description

It grows to 10 m and the bark is greyish-white and papery. The leaves are greenish-grey, narrow and needle-like. The flowers are dense, cream and elongated in clusters (spikes), and it flowers spring-summer.



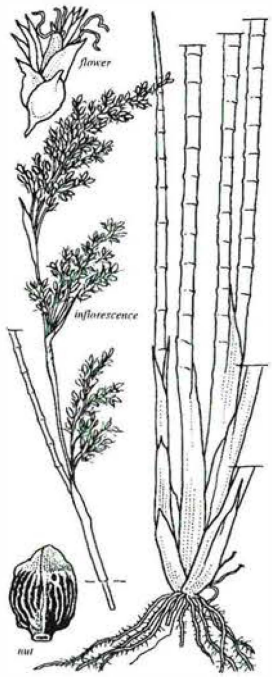
SHRUB
astartea (Myrtaceae)
Astartea fascicularis

Location

Damp, sandy, alkaline soils near watercourses; swamps.

Description

Grows to 2 metres and spreads 1.5 m, slender stem, with branches that weep and leaves in tight opposite clusters. Flowers are white or slightly pink, in groups of 2-4.



SEDGE

jointed twigrush (Cyperaceae)

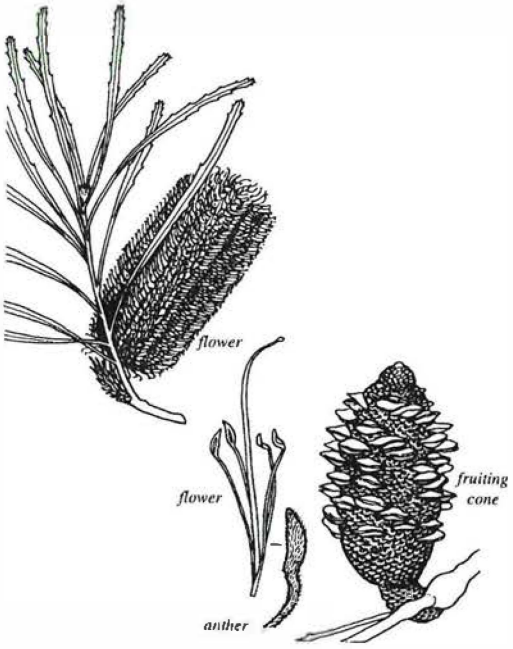
Baumea articulata

Location

Forms extensive colonies in fresh and brackish water along the margins of watercourses. Can cope with deep inundation for long periods.

Description

Spreading sedge to 2.5 m tall. Stems are cylindrical, hollow and 4-13 mm in diameter. Leaves are similar to stems. Fruits are small pale nuts. Spikelets contain 2-5 small flowers.



TREE

swamp banksia (Proteaceae)

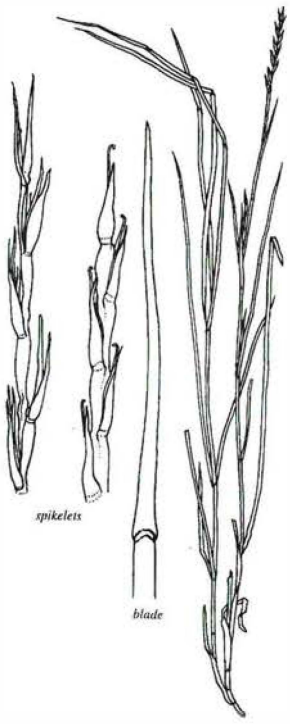
Banksia littoralis

Location

Frequently occurs in swampy areas but is not tolerant of inundation. Prefers areas subject to only short winter waterlogging or very shallow groundwater table.

Description

Grows up to 12 m high, with an irregular, gnarled, thick trunk and a slightly drooping canopy. Narrow, strap-like leaves are 100-230 mm long and 4-10 mm wide. Erect, cylindrical flower cone up to 200 mm long and 60-70 mm wide.



GRASS

matgrass (Poaceae)

Hemarthria uncinata

Location

Damp areas near swamps, estuaries and watercourses.

Description

Rhizome-forming grass to 1 m high. Leaf blades flat or folded, 50-150 mm long. Rim of short hairs at junction of leaf sheath and blade. Flowers narrow and spike-like.

Changes to the Swan River

Declining water quality and destruction of habitats have been the main problems facing the Swan River.

Changes to vegetation

Human activity has caused the removal and degradation of the fringing vegetation on river foreshore areas. Clearing for agriculture has destroyed a great deal. Constant grazing by animals and mowing has meant that the natural understorey vegetation was unable to re-establish, and when bigger trees died there were no young seedlings to replace them. Eventually native species have come to be replaced by weeds. Activities of humans and animals that remove vegetation on the river banks have interfered with the natural processes of erosion and deposition of sediment along the river, resulting in further destruction of fringing vegetation. Changes to drainage patterns have caused more fresh water to enter the salt marshes. This has changed vegetation from salt-tolerant types to freshwater-dependent vegetation, which in turn has affected animals of the salt marshes.

Introduced species

Introduced species of animals, including rabbits, rats, feral cats and foxes, have caused considerable damage to the river ecology. Exotic plants including arum lily, watsonia and blackberry have become a major problem along river banks. Introduced species of aquatic animals (e.g. the koi) and plants (e.g. *Hydrocotyle*) have also disrupted aquatic ecosystems.

Modification of the river

Reclamation (filling in) of parts of the foreshore areas for various reasons (e.g. to provide sanitary landfill sites, eradicate mosquito-breeding areas, provide recreation areas and make more land available for expansion of the city), has meant the loss of vegetation and bird habitats. Removal of the shallows, especially tidal flats, through the process of dredging has reduced the available feeding grounds for birds that rely on aquatic plants, invertebrates and fish found in these areas. Increased turbidity brought about by dredging operations affects birds that fish by sight. The draining of swamps and lakes is another activity that has reduced nesting and feeding areas for waterbirds.

Pollution

The river foreshore has been used as a dumping-ground for refuse in the past. Many tip sites were established to dispose of household, industrial and building material wastes. Litter such as plastics, fishing line and hooks left on the foreshore or in the water can become tangled around birds' legs or be mistaken by birds for food, resulting in a slow painful death. Nutrient loading and eutrophication occur mainly in late summer, when water levels are lowest and nutrient concentrations are high. Algal blooms can cause low-oxygen conditions in the water, leading to fish kills. Widespread clearing of the native vegetation in the catchment has increased salinity: because the plants are no longer there to use the water, the watertable rises and salt ends up in streams. Another problem is the spraying of pesticides to control mosquitoes in salt marshes. This may disrupt and contaminate food chains on which waterbirds depend. Some pesticides kill insect larvae, crustaceans and frogs.

Recreational activities

Recreational activities can have an effect on the environment. Boating activities and people using the foreshore can disturb vegetation and the feeding and breeding of waterbirds. Dogs are also a problem when they chase birds and destroy nests by digging in the sand. Disturbance of migratory waders results in a decrease in their production of fat, reducing the chance of successful migration back to their breeding-grounds in the northern hemisphere. Construction of recreational facilities and other foreshore structures also have an effect on the environment.

Management for the future

It is important for the future of the Swan River that the level of disturbance to habitats and the estuarine environment is minimised. The riparian environment needs to be protected to preserve and enhance habitats, landscapes and river water quality. A large amount of catchment and foreshore restoration needs to be undertaken to help the Swan-Canning system absorb and process nutrients better.

Today, there are many activities being conducted that contribute to improving river health. Some work is carried out by the Swan River Trust, the Water and Rivers Commission, other government agencies and local government, and some by community groups. Even individuals are doing things to make conditions better (e.g. people who own land that fronts onto a river or stream and people who volunteer for cleanup days).

Formation of rivercare groups

Various rivercare groups care for rivers, drains and streams in the catchment. They collect information, identify issues, carry out cleanups, revegetation and weed control, and promote community awareness. Their activities protect the foreshore from erosion, produce a more attractive environment and contribute to the conservation of indigenous species and the maintenance of habitats to support the river's ecosystem. Improving the network of 'living streams' in the catchment will help to improve water quality.

The establishment of reserves

Some areas, like Alfred Cove and Pelican Point (which are parts of Milyu Reserve), have been designated as bird reserves and are frequented by many migratory waders and seabirds. They have been set aside for the protection of birds.

Cleanup programs and rubbish removal

National and local cleanup days remove domestic rubbish, tyres, weeds and other litter from the foreshore. The Swan River Trust regularly cleans the foreshore and removes algae and debris.

Pollution control

Rubbish tips have been cleaned up and are monitored to check for leachates that might find their way into the river. Controls are being put in place to stop the various pollutants, including industrial discharges and sewage overflows, from affecting the river. Local government and industry are working to reduce pollution of drains and the river. Oil and chemical spills are cleaned up quickly to prevent river pollution.

Water quality

Water samples are checked for oxygen levels, salinity, algae and a variety of nutrients, metals and chemicals. This information provides the basis for management decisions. Information from community water quality monitoring programs conducted by schools and community groups has resulted in action plans to improve water quality. Landcare programs in the catchment encourage landholders to improve practices in relation to the application of fertilisers and to take steps to reduce the amount of salt that is reaching the streams.

Revegetation projects and foreshore restoration

Weeds need to be controlled and affected areas rehabilitated so the river ecosystem can be preserved. Many community groups are involved in revegetation programs. Rehabilitation of a weed-infested area involves removing weeds so that the native vegetation is able to regenerate. Revegetation with local native species is needed in some places. Most weeds can be removed mechanically. Any parts of a plant that may cause it to re-invade the weeded area (e.g. seed heads, bulbs, corms) are removed. Sometimes herbicides are applied (carefully and with appropriate advice) to particular plants. In some cases eroded foreshore areas are replenished by adding sand.

Education programs

The community is being informed of potential problems through the media and by the use of Swan River Trust and Water and Rivers Commission advertisements, posters, 'Water facts' sheets and other community information. For example, the pamphlet on weeds, *Controlling weed in waterways and wetlands*, encourages people to reduce weeds by managing their gardens (e.g. composting, using native plants, removing flowerheads before they seed), and never emptying aquarium plants into rivers or drains. Stencils are being painted on stormwater drains (which can transport nutrients, litter and pollutants to rivers), encouraging people to be environmentally responsible.

Rules and regulations

In some cases it is necessary to impose regulations. For example, to protect the breeding stock and to ensure that plenty of young fish are recruited into the estuaries, fish stocks are protected by restricting the legal size for catches, restricting bag limits and reducing the open fishing season. Commercial fishing licences are also limited.

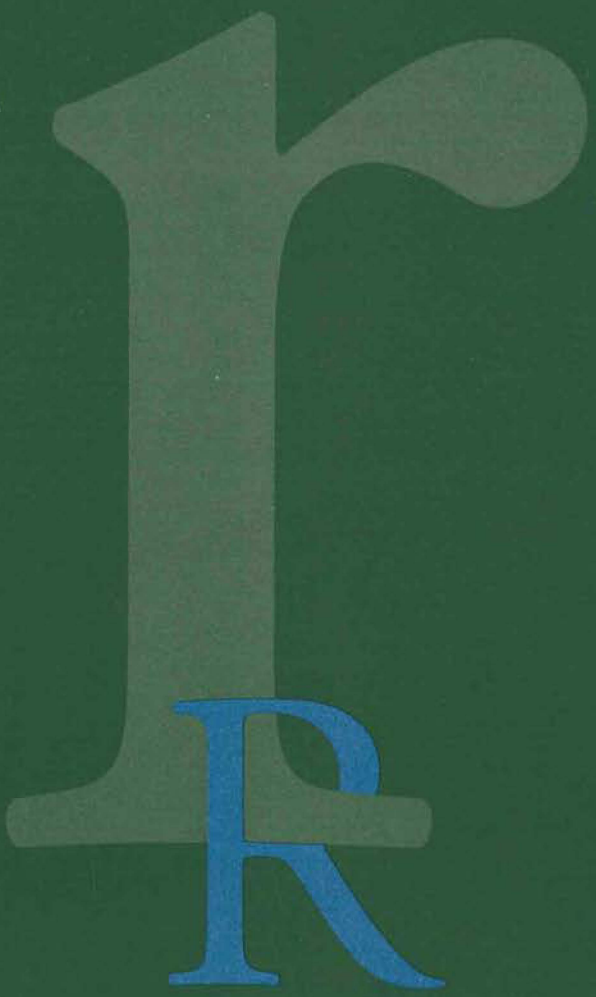
The Swan-Canning Cleanup Program (SCCP)

SCCP is a major program coordinated by the Swan River Trust. It began because of concern about the increasing occurrence of algal blooms in the upper reaches of the Swan and Canning rivers. The program aims to control algal blooms, improve catchment management to reduce the flow of nutrients that feed the algae, and encourage widespread community participation in all stages of the cleanup.

In recent years, the Swan-Canning river system has been showing symptoms of a system under environmental stress. Algal blooms in the Swan and toxic blue-green blooms in the Canning have given rise to community concern about the deteriorating health of the rivers. The level of blooms was unacceptable. Action was needed to protect and restore the river system.

In addition to SCCP, a range of projects are conducted across the areas of catchment management, monitoring, research, community awareness and trials to develop river intervention techniques. These projects have improved understanding of water quality and ways to measure the ecological health of the estuary and rivers. Many of these were carried out in partnership between organisations including the Water and Rivers Commission, Agriculture WA, the Ministry for Planning and local government. The Cleanup Program works in collaboration with national programs, especially the Swan-Avon Integrated Catchment Management program, which is funded through the National Landcare Program (now the Natural Heritage Trust).

Resources



This kit contains the following resources:

Booklets

- *Excursions in the Swan River Environment, Fieldwork and activities to support studies in Science, and Society and Environment,* Water and Rivers Commission/Swan River Trust, 1999
- *Working Scientifically in the Swan River Environment, A teaching approach for Science,* Water and Rivers Commission/Swan River Trust, 1999
- *A Sense of Place in the Swan River Environment, A teaching approach for Society and Environment,* Water and Rivers Commission/Swan River Trust, 1999

Map/Poster

- *Swan-Canning River and Estuarine System Map,* Water and Rivers Commission, 1999

Data disc

- *Water Quality Data, Swan River Estuary and its Catchments,* Ribbons of Blue, 1999

Video

- *Living with Streams,* Water and Rivers Commission/Swan River Trust

Posters

- *H_2Only,* Swan River Trust
- *Don't Let your River go down the Drain,* Swan River Trust

Water facts

- Water facts 1, *Water Words,* Water and Rivers Commission, 1996
- Water facts 2, *Macroinvertebrates and Water Quality,* Water and Rivers Commission, 1996
- Water facts 3, *River and Estuary Pollution,* Water and Rivers Commission, 1997
- Water facts 6, *Algal Blooms,* Water and Rivers Commission, 1998
- Water facts 7, *The Water Cycle,* Water and Rivers Commission, 1998

Brochures

- *A Guide to Our Services,* Water and Rivers Commission, 1999
- *A Guide to Our Services,* Swan River Trust, 1998
- *A Guide to Our Services,* Ribbons of Blue, 1998
- *5 Entertaining and Educational Ways to Find Out More About Our Most Vital Resource: Groundwater, Wetlands, Rivers* (video order form), Water and Rivers Commission, 1996
- *An Educational Video on the Swan and Canning Rivers, New Release: Algal Blooms and Nutrients* (video order form), Water and Rivers Commission, 1998
- WaterTalk, *Wetlands,* Water and Rivers Commission, 1998
- *The Avon Ascent, A self-guided drive tour of the Avon Valley,* Avon River Management Authority, 1995

Other resources available from the Water and Rivers Commission/Ribbons of Blue/Swan River Trust:

Videos

- *Living with Wetlands,* Water and Rivers Commission/Swan River Trust
- *What is Groundwater?,* Water and Rivers Commission
- *Living on Groundwater: Part 1 - Country WA,* Water and Rivers Commission
- *Living on Groundwater: Part 2 - Urban WA,* Water and Rivers Commission
- *Algal Blooms and Nutrients,* Water and Rivers Commission/Swan River Trust

Posters

- *Living streams - I can do that!,* Water and Rivers Commission
- *Clean water - I can do that!,* Water and Rivers Commission
- *Healthy wetlands - I can do that!,* Water and Rivers Commission
- *Catchment friendly gardens - I can do that!,* Water and Rivers Commission

Manuals

- Ribbons of Blue manual: *Environmental Awareness to Action,* A water quality monitoring program for primary school students, Waterways Commission (now Water and Rivers Commission)
- Ribbons of Blue manual: *Environmental Awareness to Action,* A water quality monitoring program for secondary school students, Waterways Commission (now Water and Rivers Commission)

Brochures/Pamphlets

- *Native vegetation of estuaries and saline waterways in south Western Australia,* Water and Rivers Commission/Department of Conservation and Land Management, 1997
- *Native vegetation of freshwater rivers and creeks in south Western Australia,* Water and Rivers Commission/Department of Conservation and Land Management, 1997
- *A wetlands/waterways health check, Rating your local wetland or waterway,* Waterwatch Australia
- *Caring for our waterways: information and advice for people living near rivers, estuaries and harbours,* Water Advice no. 1, Water and Rivers Commission, 1996
- *Growing local plants to protect water resources,* Water Advice no. 6, Water and Rivers Commission, 1998
- Water facts 4, *Living Streams,* Water and Rivers Commission, 1998

Other

- *Riverview* (newsletter), Swan River Trust
- *Rivercare Directory,* Swan River Trust
- *Swan-Canning Cleanup Program Action Plan, An Action Plan to clean up the Swan-Canning Rivers and Estuary,* Swan River Trust, 1999
- *Controlling Weeds in Waterways and Wetlands,* Swan River Trust/Department of Environmental Protection, 1995

- *Drains to the River, Clean Water Only* (stencils), Swan River Trust
- *Western Australian Salinity Action Plan,* Agriculture Western Australia, Department of Conservation and Land Management, Department of Environmental Protection, Water and Rivers Commission, November 1996
- *Western Australian Salinity Action Plan,* Draft update, State Salinity Council, 1998
- *Draft Avon River Management Programme,* Water and Rivers Commission and Avon River Management Authority, 1999
- *Stream Foreshore Assessment in Farming Areas,* Luke Pen, 1995

Note: The *Water facts* and some other useful publications are available on the Water and River Commission website, www.wrc.wa.gov.au. You can also access a complete list of publications and order copies using the publication order form on the website.

Some other useful resources

- Landcare In Your Hands, *Land Conservation Activities for Secondary Science and Social Studies,* Department of Agriculture, 1991
- RGC wetlands teachers' manual *From Sand to Ducks,* RGC Wetlands
- *Web of Life Manual,* Year 11
- *Stepping out Literacy and Learning Strategies,* Education Department of Western Australia, Western Australia 1996
- Catchment Carers' Trail, *Years 5 - 7 Teacher and Student Notes: Notes for a trail as Part of an Upper Primary School Excursion,* Department of Conservation and Land Management and Water Corporation, 1996
- *Family Walks in the Perth Outdoors,* Department of Conservation and Land Management
- *Waterwatch and your Catchment: Involve Me and I'll Understand,* Department of Primary Industries, Queensland, 1995
- *Catchment Care Education Kit,* Department of Primary Industries, Queensland, 1992
- *Frog Symphony Unit,* Environmental Education Unit, Murray Darling Basin Commission, 1998
- Metropolitan Street Directory
- Topographical maps of the Perth region
- Aerial photographs of the Perth region (Department of Land Administration)
- Landscape photographs of the south-west of Western Australia and Swan-Avon catchment (Department of Land Administration)
- Atlas maps

Organisations/Departments/Associations

- APACE
- Avon Network Centre
- Avon River Management Authority (ARMA)
- Australian Association for Environmental Education (AAEE)
- Birds Australia
- Cockburn Wetlands Centre
- Department of Conservation and Land Management (CALM)
- Ecoplan
- Environmental Weeds Action Network
- Fisheries Western Australia
- Frogwatch CSIRO
- Gould League
- Herdsman Lake Wildlife Centre
- Institute for Earth Education
- Men of the Trees
- Peel-Harvey Catchment Support Group
- Perth Zoo Education Centre
- RGC Wetlands
- Ribbons of Blue
- Science Teachers' Association of Western Australia (STAWA)
- Swan Catchment Centre
- Tammin Alcoa Landcare Education Centre
- WA Museum
- WA Naturalists
- Water and Rivers Commission (WRC)
- Water Corporation
- Wildflower Society of WA
- York Tourist Bureau

Catchment groups within the Swan-Canning system

CATCHMENT GROUPS	DATE ESTABLISHED
Bayswater Integrated Catchment Management (BICM)	1991
Swan Working Group (Swan Catchment Council) (coordinating group for the Swan-Avon ICM Program in the Swan-Canning catchment)	1995
Canning Catchment Coordinating Group	1995
Litoria Catchment Care Group	1995
Bennett Brook Catchment Group	1995
Upper Canning/Southern-Wungong Catchment Team	1996
Ellen Brook Integrated Catchment Group	1996
Bannister Creek Catchment Group	1996
Blackadder Woodbridge Catchment Group	1997
Jane Brook Catchment Group	1997
Claisebrook Catchment Group	1997
Belmont Catchment Management Group	1998
Helena River Catchment Group	1998
Gingin Land Conservation District Committee	1984
Wooroloo Brook Land Conservation District Committee	1989
Chittering Land Conservation District Committee	1991
North Swan Land Conservation District Committee	1997

Integrated Catchment Management (ICM)

ICM is the process of coordinated planning, use and management of water, land, vegetation and other natural resources on a river or groundwater catchment basis. It involves the whole community of the catchment including landholders, businesses, residents, local government and state agencies.

Swan Catchment Centre

The Swan Catchment Centre was established in 1995, in response to community requests to provide support to ICM groups. The centre is open to everyone and is a place where you can find information and get advice on environmental issues in the Swan Catchment. It provides a place for the community to work together with Government and Local Government.

Getting in contact

Some catchment groups in the metropolitan region have employed coordinators who are involved in implementing catchment management activities. Catchment groups may be able to assist teachers in implementing some of the activities contained in the education kit. Teachers are encouraged to contact their local catchment group coordinator (or chairperson) if they are interested. Contact details for catchment groups are available from the Swan Catchment Centre on (08) 9221 3840.

Appendices

Appendix 1 - Watery web sites

The following web sites were taken from * *Waterwatch on the web, An internet resource for waterwatchers,* which was produced by Donna Weston, Ribbons of Blue, for the Getting Better at Getting Wet National Waterwatch Conference, July 1998.

* Note: Hard copies of *Waterwatch on the web, An internet resource for waterwatchers* with screen shots of the sites mentioned are available by contacting:

Ribbons of Blue
Level 2, The Hyatt Centre
3 Plain Street
East Perth WA 6004

NB: The information contained in this appendix was current at the time of printing.

Waterwatch sites

Waterwatch groups all over Australia often have links or information on the main Waterwatch site in that State, so try going to the links or contacts page for that State.

Waterwatch Australia ~ http://www.waterwatch.org.au/

Waterwatch Victoria ~ http://www.vic.waterwatch.org.au/

Waterwatch ACT ~ http://www.act.gov.au/environ/waterus.html

Ribbons of Blue WA ~ http://www.wrc.wa.gov.au/ribbons/

Waterwatch web sites in other States are currently under development.

Other sites

These sites are intended to give a sample of water resources on the WWW. They are in alphabetical order; no attempt has been made to rank them. Depending on your situation and what you want to use the information for, you will find your own favourite pages.

Remember, there is no proofreader, referee or censor with a red pen in cyberspace, so don't automatically assume all these pages are 100 per cent accurate.

The Australian Academy of Science – Toxic Algal Blooms

http://www.science.org.au/nova/017/017key.htm

This is actually the front page of a 'folder' of information about toxic algal blooms, with links to a glossary, activities, further reading and related sites. The Nova section of the AAS site is constantly being added to, so make sure you bookmark it and check back occasionally!

The EcoWater Squad

http://www.ecowater.com/

This is a commercial site, with a water education page that offers free material to community and school groups as well as other non-profit organisations (http://www.ecowater.com/education/index.html). The information is largely related to the domestic water supply.

Envirolink Home Page

http://www.envirolink.org/

This is a great-looking site and always has something interesting in the news section.

Environment Australia – Wetlands, Waterways and Waterbirds Unit

http://www.anca.gov.au/environm/wetlands/wwwhp.htm

The WWW Unit is part of the Environment Australia Biodiversity Group, and administers the national Waterwatch program. The page also has a link to the Directory of Important Wetlands in Australia, which is much easier to search than the hard copy!

Exploring the Environment – Watershed blues page

http://davem2.cotf.edu/ete/main.html

'Exploring the Environment (ETE) is a series of interdisciplinary, problem-based learning (PBL) modules for high school students.' The Water Quality module presents students with hypothetical situations in the Wheeling Creek watershed (= catchment) and gives them chemical, physical and biological data for each of six sites as well as aerial photos and background information. This site is a great example of environmental education on the Internet.

Give Water a Hand

http://www.uwex.edu/erc/

'Give Water A Hand' is a national watershed education program designed to involve young people in local environmental service projects. Following steps in the Give Water A Hand Action Guide (which you can download free), your youth group or class plans and completes a community service project to protect and improve water resources.

Global Action Centre – Water – Hot Links

http://www.globalaction.org/hotlinks.asp?SectionId=2

Great Lakes Program – Outreach – Second Biennial Great Lakes Student Summit

http://wings.buffalo.edu/glp/outreach.html

These student summits bring together hundreds of students and their teachers from states and provinces around the Great Lakes basin. Students in grades 5-9 come together to showcase their own research projects, participate in field trips and attend workshops relating to the Great Lakes issues.

The Groundwater Foundation

http://www.groundwater.org/index.htm

This is a very good Internet site on groundwater education. The Foundation began in 1985 and is dedicated to educating the community about groundwater through result-oriented activities and participation. They also have a great online catalog, and the staff are very helpful with overseas orders.

Home*A*Syst

http://www.wisc.edu/homeasyst/

Home*A*Syst supports voluntary action by turning awareness of environmental risks into individual actions to prevent pollution. Their guide to starting and implementing the program at http://www.wisc.edu/homeasyst/guide.html is quite interesting. There are lots of tips about agency, industry and local organisation involvement, and assessing the success of the program.

Institute for Global Communications: Seas & Waters: Internet – Resources Collection

http://www.igc.org/igc/issues/sw/index.html

IGC is an Internet Service Provider (ISP) and is the US member of the Association for Progressive Communications, a global partnership of computer networks that link activists around the world. This page is a collection of water-related links, and a good stepping-stone to other sites.

The Integrated Catchment Management Information and Support System

http://www.icmiss.dlwc.nsw.gov.au/

The ICMISS prototype provides access to maps, graphs, tables, real-time data, text and reports from a variety of GIS, database, text and image sources. The source data are stored at different locations on the Internet and combined by the ICMISS server when requested by users. There's a demonstration and tutorial to guide visitors through the process.

Melbourne Water – Healthy Waterways

http://www.thegreenwebb.net.au/melbwater/

This site is sponsored by Freddo Frog! There are some good activities for kids and links to Streamwatch (Greater Melbourne), as well as details of the Melbourne drain stenciling program.

National Wildlife Federation – Water Quality

http://www.nwf.org/nwf/water/index.html

US-based site covering water resources, water quality, projects and special reports. There's also a link to the Clean Water Act which gives a chilling overview of the level of water pollution in the USA before the Act was introduced.

National Wildlife Federation – Wetlands

http://www.nwf.org/nwf/wetlands/index.html

This is another NWF link covering wetland types, wetland benefits, threats to wetlands, wetland protection and legislative actions, and further links to NWF wetland resources. The resources include some great ideas for wetlands classroom activities.

New Jersey Community Water Watch

http://www.policy.rutgers.edu/CUPR/Community/organizations/WaterWatch.html

The goal of NJ Community Water Watch is to give communities the resources to have a clear and measurable impact on improving water quality and to clean up waterways in urban areas of New Jersey. This is one of the sites that came up when I used the water+quality+monitoring+community string.

OzGREEN

http://www.peg.apc.org/~ozgreen/

This is the Australian site of the Global Rivers Environmental Education Network. They describe GREEN as 'an innovative, action oriented approach to education', based on an interdisciplinary catchment education model. It is a resource to schools and communities that wish to study catchment work to improve their quality of life. They have some interesting resources which can be ordered online at http://www.peg.apc.org/~lennox/resources.html.

The Ramsar Convention on Wetlands

http://iucn.org/themes/ramsar/

The name says it all – this is the official website of the Ramsar Convention on Wetlands.

River Watch Network

http://www.riverwatch.org/

'From the Rio Grande in Texas to the Danube in Hungary, River Watch Network harnesses the power of people and communities to monitor, restore, and protect the world's rivers.' This is a wonderful site. There's a page of success stories that made me want to read about more of them, also resources, services, programs offered and more. If you only get the opportunity to look at a few of the listed web sites here, make sure this is one of them.

Science Education Associations Home Page

http://science.cc.uwf.edu/

A comprehensive list of links to science education sites around the world. These sites have largely been set up by science teachers' organisations, and this site's stated aim is to promote 'scholarly communication within the global learning community'. Good for international people contacts.

South East Water Limited

http://www.sewl.com.au/education/educationindex.html

The SEWL Water College has been designed for teachers planning a unit of work on water. It features a mix of some very lateral water education ideas, and over 100 good, solid, hands-on activities, structured in an Inquiry Approach Style and linked to the Curriculum and Standards Framework. You'll need to have Adobe Acrobat Reader installed on your computer to view and download the online resources, but it looks well worth it, although time-consuming.

Urbana Middle School – Water Quality and Societies

http://www.ncsa.uiuc.edu/Edu/RSE/RSEgreen/homepage.html

Groundwater is a priceless natural resource that provides 96 per cent of the world's fresh water supply, yet the processes used to study and manage the quality of groundwater resources are often neglected in resource education. The educational activities included in this unit are designed to help middle school students understand the importance of groundwater management, as well as specific facts and principles of groundwater.

US Environmental Protection Agency – Office of Water

http://www.epa.gov/ow/

This is a content-rich site covering topics such as water legislation (US), publications, training and conferences, databases and software, a community page and kids pages, as well as a comprehensive page of links. The Nonpoint Source Kids page at http://www.epa.gov/OWOW/NPS/kids has a terrific water quality and environment game – Splash! – that you can download and try out.

University of Nebraska – College of Agricultural Sciences and Natural Resources – Soil and Water Related Links

http://ianrwww.unl.edu/ianr/casnr/swrc/links.htm

Another collection of links to largely US sites.

University of Nebraska-Lincoln – Water Centre

http://ianrwww.unl.edu/ianr/waterctr/wchome.html

Did you know that there is the same amount of water on Earth today as there was when the Earth was formed? The water from your kitchen tap could contain molecules that dinosaurs drank! This is a great browsing site for water facts and trivia, even though it is a largely academic site.

Water Information Coordination Program

http://water.usgs.gov/public/wicp/

'The purposes of the program are to ensure the availability of water information required for effective decision making for natural resources management and environmental protection and to do it cost effectively.' The WICP acknowledges the role of local agencies and community and non-government bodies in water quality monitoring. This is a good site, especially if you're interested in the direction of water quality monitoring on a large-scale NRM context.

Water and Rivers Commission

http://www.wrc.wa.gov.au

The WRC is the lead agency for Ribbons of Blue/Waterwatch WA. There are links to their services, available publications, water definitions and information for schools. It's a very good site, and I can (almost) guarantee that any feedback will be replied to.

WetNet – The Wetlands Network Homepage

http://www.wetlands.ca/

There are links here to an extensive wetlands resource centre, virtual tours of two Canadian wetlands, and information about upcoming conferences and other events. As it's a Canadian based site, most information is north American.

Appendix 2 – Water quality data disc explanatory notes

The data disk contains actual data collected from the Swan and Canning rivers and their tributaries, stored in a Microsoft Excel version 5.0 workbook.

There are two main spreadsheets:

1) Estuary data – this spreadsheet contains data collected by the Water and Rivers Commission from four points along the Swan River.
2) Community catchment data – this spreadsheet contains data collected by three schools actively involved in the Ribbons of Blue program from different areas in the catchment.

You will find data for a range of parameters, which are explained briefly in the table overleaf.

Please refer to the Swan-Canning River and Estuarine System Map for the sites included on the data disc.

Note: when printing the catchment data spreadsheet off the data disc adjust the scaling to 94% in the page setup.

Table 1: Description of parameters

PARAMETER	DESCRIPTION	UNITS OF MEASUREMENT
NO_3-N	the concentration of nitrogen in the form of nitrate	mg/L (milligrams/litre)
NO_3	the concentration of nitrate	mg/L (milligrams/litre)
TN	the concentration of all the nitrogen in the water, both organic and readily available forms	mg/L (milligrams/litre)
FRP phosphates	the concentration of filterable, reactive phosphorus in the water (i.e. free in the water, not bound to particulates)	mg/L (milligrams/litre)
TP	the concentration of all the phosphorus in the water, both organic and readily available forms	mg/L (milligrams/litre)
pH	a measure of the acidity or alkalinity of the water	pH units
Turbidity	a measure of water clarity	NTU (Nephalometric Turbidity Units)
Secchi depth	a measure of water clarity / light penetration	m (metres)
% DO sat	the amount of oxygen dissolved in the water, expressed as a percentage of saturation (= 100%)	% sat (percentage saturation)
DO (mg/L)	the amount of oxygen dissolved in the water, expressed as a concentration	mg/L (milligrams/litre)
Salinity	the concentration of salts (mainly sodium chloride) in the water	ppt (parts per thousand)
Conductivity	a measure of dissolved salts in the water	µs/cm (microsiemens per centimetre
Temperature	a measure of how hot or cold the water is	°C (degrees Celsius)

Estuary data

The estuary data were collected from the Swan River at Blackwall Reach, the Narrows Bridge, Maylands jetty and Success Hill (refer to the Swan-Canning River and Estuarine System Locality Map for these sites). Water samples for eachsite were collected from three depths:

- just below the water surface (0 m)
- one metre from the surface (1 m)
- just above the sediments, at the bottom of the water column (e.g. 5 m, 14 m, depending on the depth of the water)

There are some features of the data that you should be aware of prior to analysing or graphing it:

- Some data are missing for each site, but you can still graph or analyse the results to get an idea of the patterns and trends over time - you just need to change the period of time you conduct the analysis over.
- Some nutrient data will be recorded as a 'less than' value (<), which may occur because the value is lower than the equipment can detect. In order to analyse the results, you will need to convert the 'less than' value to an actual value. The standard way of doing this is to change the number to half the 'less than' value. For example, <0.01 will become 0.005, <10 will become 5. These halved numbers are referred to as *censored* data.
- The depth for a site will change according to the time of year and the tides.
- Secchi depths are measured only once at each site. They are stored in the spreadsheet under the surface water results for convenience – it does not relate to the depth at which other samples are collected.

Community catchment data

The catchment data were collected by three schools at sites along Ellen Brook, the lower Canning River and Southern River. Site details are listed on the spreadsheets next to the results, and the Swan-Canning River and Estuarine System Locality Map shows the locations for each. All samples are surface water samples collected over differing time periods.

There are some features of the data that you should be aware of prior to analysing or graphing it:

- Some data are missing for each site, but you can still graph or analyse the results to get an idea of the patterns and trends over time – you just need to change the period of time you conduct the analysis over.
- Not all parameters are measured, which is a function of a school's individual interests and equipment availability.
- Some of the turbidity data will be recorded as a 'less than' value (<), which may occur when water in the turbidity tube falls between two numbers. In order to analyse the results, you will need to convert the 'less than' value to an actual value. The method for doing this differs to the one for nutrients. In this case, simply remove the 'less than' sign from in front of the number. For example, a result falling between 30 and 40 NTU will usually be recorded as <40 NTU and when analysing you convert it to 40 NTU.

Table 2: Site information for sites included on the data disk

SUBCATCHMENT	SITE NAME	DATA COLLECTED BY	MAP NO.	EASTING	NORTHING	SITE TYPE
Ellen Brook	All Saints	La Salle College	2134-III-NW	405650	6481650	River
Ellen Brook	Critical Gauge	La Salle College	2134-III-NW	407500	6486600	River
Ellen Brook	Muchea	La Salle College	2034-I-NE	403825	6505700	River
Ellen Brook	Rutland Rd	La Salle College	2134-IV-SW	405950	6497990	River
Ellen Brook	Reserve	La Salle College	2134-IV-SW	408800	6486900	River
Ellen Brook	Warren Road	La Salle College	2134-IV-SW	406550	6493250	River
Lower Canning River	Aquinas Foreshore	Aquinas College	2033-I-NE	393800	6456450	Estuary
Lower Canning River	Marker Buoy	Aquinas College	2033-I-NW	393000	6455600	Estuary
Lower Canning River	Mt Henry Point	Aquinas College	2033-I-NW	391900	6455400	Estuary
Lower Canning River	Salters Point	Aquinas College	2033-I-NW	393500	6455500	Estuary
Southern River	Palamino Reserve	Gosnells Senior High	2033-I SE	403625	6444375	River
Southern River	Downstream of Forestdale Drain	Gosnells Senior High	2033-I NE	403575	6447550	River
Southern River	Southern River Rd Bridge	Gosnells Senior High	2033-I NE	403037	6448725	River
Southern River	Downstream of Corfield Drain	Gosnells Senior High	2033-I NE	403500	6450324	River
Swan-Canning Estuary	Blackwall Reach	SRT / WRC*	2033-I-NW	385040	6456658	Estuary
Swan-Canning Estuary	Narrows Bridge	SRT / WRC*	2034-II-SW	391039	6462854	Estuary
Swan-Canning Estuary	Maylands	SRT / WRC*	2034-II-SE	396692	6465550	Estuary
Swan-Canning Estuary	Success Hill, Guildford	SRT / WRC*	2034-II-SE	401479	6470192	Estuary

* Swan River Trust/Water and Rivers Commission

Estuary data (Note: this is a print-out of the data disc)

SITE	DATE	TIME	DEPTH (metres)	N03-N (mg/L)	TN (mg/L)	FRP (mg/L)	TP (mg/L)	%DO (% sat)	DO (mg/L)	SALINITY (ppt)	CONDUCTIVITY (µs/cm)	TEMP (deg C)	pH (units)	TURB (NTU)	SECCHI (m)
Blackwall Reach	11-Jan-95	8:20	0	0.080	0.380	0.030	0.040		6.40	34.0		24.30			2.7
Blackwall Reach	11-Jan-95	8:20	1	0.020	0.270	0.020	0.040		6.60	35.3		24.50			
Blackwall Reach	11-Jan-95	8:20	13	0.010	0.280	0.020	0.040		6.20	35.7		24.70			
Blackwall Reach	11-Apr-95	9:20	0	0.030	0.170	0.030	0.030		6.33	37.3		21.20			4.3
Blackwall Reach	11-Apr-95	9:20	1	0.030	0.190	0.030	0.030		6.20	37.4		21.20			
Blackwall Reach	11-Apr-95	9:20	13	<0.020	0.190	0.040	0.040		7.34	37.8		21.10			
Blackwall Reach	18-Jul-95	9:45	0	0.610	1.900	0.040	0.090	66.6	6.66	6.3		13.45			0.5
Blackwall Reach	18-Jul-95	9:45	1	0.530	1.600	0.024	0.090	65.0	6.51	6.3		13.44			
Blackwall Reach	18-Jul-95	9:45	13.5	0.071	0.450	0.043	0.040	42.3	3.39	32.5		16.33			
Blackwall Reach	10-Oct-95	9:00	0	0.028	0.310	<0.003	0.030	82.7	6.77	21.0	33500	18.69			2.1
Blackwall Reach	10-Oct-95	9:00	1	<0.005	0.470	<0.003	0.040	81.6	6.65	21.8	34700	18.76			
Blackwall Reach	10-Oct-95	9:00	14.5	<0.005	0.190	<0.003	0.010	76.9	5.87	32.6	49700	18.75			
Blackwall Reach	9-Jan-96	9:30	0	0.031	0.261	0.011	0.040	94.3	6.55	30.0	46200	24.51	8.00	0.0	3.2
Blackwall Reach	9-Jan-96	9:30	1	<0.005	0.190	0.015	0.030	92.2	6.28	33.8	51300	24.35	8.01	12.7	
Blackwall Reach	9-Jan-96	9:30	15	<0.005	0.090	0.008	0.020	80.6	5.41	37.2	56000	24.04	8.02	15.2	
Blackwall Reach	9-Apr-96	8:40	0	0.008	0.078	0.012	0.020	92.3	6.63	38.1	57100	20.12	8.37	1.2	
Blackwall Reach	9-Apr-96	8:40	1	0.008	0.098	0.012	0.020	90.1	6.47	38.1	57200	20.11	8.38	2.0	
Blackwall Reach	9-Apr-96	8:40	14	0.007	0.127	0.012	0.020	86.9	6.27	37.4	56200	20.12	8.39	2.5	
Blackwall Reach	9-Jul-96	9:41	0	1.000	2.100	0.027	0.060	95.8	9.11	11.6	19600	14.21	7.58	1.7	
Blackwall Reach	9-Jul-96	9:41	1	1.000	2.100	0.027	0.060	94.2	8.96	11.7	19800	14.20	7.62	1.7	
Blackwall Reach	9-Jul-96	9:48	14	0.083	0.300	0.021	0.020	78.2	6.13	34.3	52000	16.87	7.89	0.6	
Blackwall Reach	15-Oct-96	8:53	0	0.016	0.530	0.013	0.010	90.5	7.87	14.7	24300	17.64	8.40	53.2	3.1
Blackwall Reach	15-Oct-96	8:54	1	0.016	0.530	0.011	0.030	89.1	7.73	14.9	24500	17.65	8.43	0.0	
Blackwall Reach	15-Oct-96	8:59	14	0.020	0.160	0.014	0.020	85.2	6.56	33.4	50800	18.06	8.45	1.5	
Blackwall Reach	7-Jan-97	9:20	0	0.025	0.300	0.017	0.050	91.9	6.38	32.2	49200	23.89	8.41	1.5	4.3
Blackwall Reach	7-Jan-97	9:21	1	0.022	0.300	0.023	0.050	89.7	6.20	33.0	50200	23.86	8.44	2.4	
Blackwall Reach	7-Jan-97	9:33	14	0.005	0.100	0.014	0.020	83.6	5.75	35.8	54000	23.21	8.49	34.1	
Blackwall Reach	14-Apr-97	8:39	0	<0.005	0.330	0.008	0.020	108.2	7.92	32.1	49	21.02	8.25	4.7	3.0
Blackwall Reach	14-Apr-97	8:43	1	<0.005	0.320	0.007	0.020	108.5	7.94	32.3	49	21.03	8.26	4.7	
Blackwall Reach	14-Apr-97	9:06	16	0.016	0.180	0.021	0.020	64.7	4.67	35.1	53	20.88	8.01	5.0	
Blackwall Reach	14-Jul-97	9:06	0	0.087	0.300	0.005	0.020	96.5	8.72	27.6	43	12.80	7.86	5.5	4.2
Blackwall Reach	14-Jul-97	9:07	1	0.011	0.240	0.004	0.020	95.8	8.61	28.0	43	12.95	7.94	4.6	
Blackwall Reach	14-Jul-97	9:20	15	0.019	0.150	0.008	0.010	86.3	6.99	33.5	51	16.41	8.01	4.9	
Blackwall Reach	13-Oct-97	13:30	0					110.3	9.38	14.2	23600	19.49	7.99	7.7	2.5
Blackwall Reach	13-Oct-97	13:31	1					109.7	8.81	23.9	37600	19.46	8.01	9.4	

Estuary data (contd)

SITE	DATE	TIME	DEPTH (metres)	N03-N (mg/L)	TN (mg/L)	FRP (mg/L)	TP (mg/L)	%DO (% sat)	DO (mg/L)	SALINITY (ppt)	CONDUCTIVITY (µs/cm)	TEMP (deg C)	pH (units)	TURB (NTU)	SECCHI (m)
Blackwall Reach	13-Oct-97	13:39	14					66.6	5.14	34.4	52200	18.30	7.95	11.0	
Maylands	11-Jan-95	11:10	0	0.040	0.810	0.040	0.160		9.00	22.5		28.50			0.9
Maylands	11-Jan-95	11:10	1	0.100	0.880	0.050	0.160		7.70	22.5		26.40			
Maylands	11-Jan-95	11:10	3.5	0.010	0.760	0.070	0.150		3.40	25.0		26.10			
Maylands	11-Apr-95	12:30	0	<0.020	0.880	0.060	0.060		14.44	31.3		23.00			1.8
Maylands	11-Apr-95	12:30	1	<0.020	0.420	0.050	0.050		14.00	31.5		22.50			
Maylands	11-Apr-95	12:30	3	0.050	0.320	0.070	0.070		9.42	35.1		21.00			
Maylands	18-Jul-95	13:20	0	0.720	2.000	0.061	0.150	77.9	8.08	2.8	5160	12.83			0.4
Maylands	18-Jul-95	13:20	1	0.290	1.000	0.050	0.100	75.3	7.81	2.8	5140	12.82			
Maylands	18-Jul-95	13:20	3.5	0.690	2.100	0.062	0.160	73.7	7.64	2.8	5130	12.84			
Maylands	10-Oct-95	12:30	0	0.140	0.950	0.019	0.070	72.1	6.40	3.1	5680	20.14			1.1
Maylands	10-Oct-95	12:30	1	0.150	1.100	0.020	0.060	69.6	6.18	3.8	6800	19.90			
Maylands	10-Oct-95	12:30	3.5	0.150	0.970	0.023	0.090	63.4	5.70	3.8	6790	19.35			
Maylands	9-Jan-96	10:55	0	<0.005	0.520	0.009	0.070	84.9	5.86	18.7	30200	28.60	7.59	24.0	0.8
Maylands	9-Jan-96	10:55	1	0.011	0.691	0.042	0.080	66.6	4.64	19.3	31100	27.91	7.51	26.0	
Maylands	9-Jan-96	10:55	3	<0.005	0.360	0.043	0.060	33.8	2.32	22.9	36300	27.55	7.34	38.4	
Maylands	9-Apr-96	11:05	0	0.025	0.605	0.064	0.110	95.0	6.98	32.1	49100	20.85	8.13	0.0	
Maylands	9-Apr-96	11:05	1	0.033	0.663	0.082	0.150	92.2	6.76	32.5	49600	20.84	8.12	0.0	
Maylands	9-Apr-96	11:05	3.5	0.034	0.574	0.084	0.130	75.5	5.49	33.4	50800	20.98	8.04	4.0	
Maylands	9-Jul-96	11:28	0	0.820	1.800	0.050	0.060	85.7	8.69	3.1	5700	13.74	7.45	20.3	
Maylands	9-Jul-96	11:29	1	1.000	2.400	0.042	0.100	83.8	8.51	3.2	5780	13.70	7.41	20.2	
Maylands	9-Jul-96	11:31	3.5	1.000	2.400	0.056	0.100	82.7	8.39	3.2	5790	13.70	7.37	21.0	
Maylands	15-Oct-96	11:17	0	0.190	0.980	0.028	0.070	85.7	7.63	2.2	4110	20.30	8.23	0.0	0.7
Maylands	15-Oct-96	11:17	1	0.190	0.970	0.029	0.070	79.4	7.24	2.3	4160	19.15	8.18	0.4	
Maylands	15-Oct-96	11:19	3.41	0.190	0.990	0.029	0.060	75.6	6.93	2.3	4180	18.83	8.09	15.7	
Maylands	7-Jan-97	11:44	0	0.006	0.630	0.031	0.080	91.5	6.60	14.9	24500	27.39	8.28	15.3	1.1
Maylands	7-Jan-97	11:45	1	0.008	0.900	0.041	0.120	89.9	6.49	15.7	25800	27.09	8.26	11.6	
Maylands	7-Jan-97	11:49	3.22	<0.005	0.800	0.078	0.170	43.3	3.05	20.5	32900	26.80	8.07	20.7	
Maylands	14-Apr-97	12:09	0	0.530	2.300	0.019	0.140	131.2	10.41	14.1	23	22.45	8.16	0.1	1.0
Maylands	14-Apr-97	12:11	1	0.420	1.500	0.012	0.060	73.3	5.76	17.4	28	21.92	7.92	7.6	
Maylands	14-Apr-97	12:16	3.5	0.071	0.850	0.080	0.090	1.5	0.11	28.1	44	21.87	7.43	7.0	
Maylands	14-Jul-97	11:02	0	0.150	0.790	0.023	0.050	82.8	8.86	6.2	11	11.23	7.70	8.4	1.2
Maylands	14-Jul-97	11:03	1	0.150	0.800	0.023	0.050	79.9	8.58	6.5	11	11.00	7.64	9.7	
Maylands	14-Jul-97	11:08	3.5	<0.005	0.450	0.099	0.280	1.5	0.13	23.3	37	15.77	7.19	14.1	
Maylands	13-Oct-97	8:56	0	0.110	0.750	0.021	0.060	70.3	6.47	1.1	2020	19.67	7.67	3.7	0.6

Estuary data (contd)

SITE	DATE	TIME	DEPTH (metres)	N03-N (mg/L)	TN (mg/L)	FRP (mg/L)	TP (mg/L)	%DO (% sat)	DO (mg/L)	SALINITY (ppt)	CONDUCTIVITY (µs/cm)	TEMP (deg C)	pH (units)	TURB (NTU)	SECCHI (m)
Maylands	13-Oct-97	8:57	1	0.110	0.730	0.022	0.060	70.1	6.45	1.1	2040	19.69	7.60	25.7	
Maylands	13-Oct-97	9:01	3.38	0.091	0.880	0.023	0.070	28.9	2.64	2.0	3690	19.58	7.29	43.0	
Narrows Bridge	11-Jan-95	9:35	0	0.010	0.400	0.050	0.080		6.10	33.9		24.70			1.4
Narrows Bridge	11-Jan-95	9:35	0.5	0.010	0.420	0.050	0.080		6.10	34.1		24.50			
Narrows Bridge	11-Jan-95	9:35	4.5	0.010	0.360	0.040	0.080		5.80	34.6		24.30			
Narrows Bridge	11-Apr-95	8:20	0	0.030	0.380	0.050	0.060		5.90	37.3		20.40			2.1
Narrows Bridge	11-Apr-95	8:20	1	0.030	0.380	0.050	0.050		5.90	37.4		20.50			
Narrows Bridge	11-Apr-95	8:20	4.5	0.030	0.400	0.050	0.070		5.22	37.9		20.40			
Narrows Bridge	18-Jul-95	8:40	0	0.670	2.000	0.057	0.140	74.7	7.74	2.8	5040	12.86			0.4
Narrows Bridge	18-Jul-95	8:40	1	0.670	2.000	0.036	0.140	71.9	7.46	2.8	5060	12.84			
Narrows Bridge	18-Jul-95	8:40	5	0.250	1.100	0.064	0.080	11.9	1.02	25.2	39400	15.31			
Narrows Bridge	10-Oct-95	8:05	0	<0.005	0.420	<0.003	0.040	106.6	10.85	0.0	70	14.54			1.0
Narrows Bridge	10-Oct-95	8:05	1	<0.005	0.770	<0.003	0.060	87.9	7.65	10.2	17400	18.94			
Narrows Bridge	10-Oct-95	8:05	4.5	<0.005	0.160	0.059	0.100	0.0	0.00	30.2	46500	17.70			
Narrows Bridge	9-Jan-96	8:50	0	<0.005	0.190	0.021	0.040	84.9	5.90	27.4	42500	25.36	7.80	18.1	1.5
Narrows Bridge	9-Jan-96	8:50	1	<0.005	0.410	0.021	0.060	82.1	5.56	31.9	48700	25.38	7.77	18.6	
Narrows Bridge	9-Jan-96	8:50	5	<0.005	0.230	0.030	0.040	80.6	5.40	33.0	50200	25.51	7.83	21.9	
Narrows Bridge	9-Apr-96	7:55	0	<0.005	0.290	0.031	0.070	92.1	6.64	38.3	57400	19.89	8.10	3.7	
Narrows Bridge	9-Apr-96	7:55	1	<0.005	0.250	0.031	0.060	89.1	6.42	38.4	57500	19.88	8.12	5.3	
Narrows Bridge	9-Apr-96	7:55	5	<0.005	0.280	0.032	0.080	83.2	5.99	38.6	57800	19.81	8.15	5.1	
Narrows Bridge	9-Jul-96	8:10	0	1.400	2.800	0.053	0.100	81.5	8.12	4.9	8740	14.05	7.50	9.9	
Narrows Bridge	9-Jul-96	8:11	1	1.200	2.600	0.056	0.080	82.1	8.18	5.0	8810	14.04	7.46	16.7	
Narrows Bridge	9-Jul-96	8:14	5.5	0.220	0.800	0.048	0.060	23.4	1.94	29.8	45900	15.44	7.23	5.4	
Narrows Bridge	15-Oct-96	7:58	0	0.140	0.940	0.021	0.060	89.1	8.06	5.0	8970	18.60	8.17	11.2	0.8
Narrows Bridge	15-Oct-96	7:59	1	0.140	0.920	0.021	0.070	87.1	7.88	5.1	9020	18.62	8.22	10.1	
Narrows Bridge	15-Oct-96	8:02	4.75	0.150	0.490	0.041	0.100	6.2	0.49	29.0	44800	17.69	7.81	8.4	
Narrows Bridge	7-Jan-97	8:00	0	<0.005	0.400	0.039	0.050	81.7	5.75	29.1	45000	24.10	8.31	8.8	1.4
Narrows Bridge	7-Jan-97	8:04	1	<0.005	0.300	0.040	0.060	80.8	5.69	29.1	45000	24.10	8.32	9.0	
Narrows Bridge	7-Jan-97	8:13	4.1	<0.005	0.300	0.041	0.060	43.7	3.01	33.9	51400	23.71	8.25	8.5	
Narrows Bridge	14-Apr-97	10:23	0	0.086	1.400	0.005	0.080	133.6	10.18	25.4	40	21.03	8.35	20.4	1.0
Narrows Bridge	14-Apr-97	10:25	1	0.040	1.100	0.005	0.090	101.1	7.41	30.2	47	21.55	8.24	8.7	
Narrows Bridge	14-Apr-97	10:32	5	<0.005	0.460	0.009	0.080	22.0	1.58	34.9	53	21.20	7.72	47.0	
Narrows Bridge	14-Jul-97	8:09	0	0.076	0.530	0.015	0.030	85.8	8.81	13.8	23	10.91	7.37	7.0	1.6
Narrows Bridge	14-Jul-97	8:13	1	0.025	0.450	0.019	0.040	81.9	8.14	15.6	26	11.85	7.51	7.3	
Narrows Bridge	14-Jul-97	8:20	4.5	0.016	0.330	0.022	0.040	30.0	2.55	29.1	45	15.23	7.55	13.0	

Estuary data (contd)

SITE	DATE	TIME	DEPTH (metres)	N03-N (mg/L)	TN (mg/L)	FRP (mg/L)	TP (mg/L)	%DO (% sat)	DO (mg/L)	SALINITY (ppt)	CONDUCTIVITY (µs/cm)	TEMP (deg C)	pH (units)	TURB (NTU)	SECCHI (m)
Narrows Bridge	13-Oct-97	11:52	0	0.006	0.490	0.006	0.030	110.3	9.84	3.9	7070	20.30	8.11	8.4	1.2
Narrows Bridge	13-Oct-97	11:54	1	0.006	0.470	0.004	0.030	109.6	9.58	7.2	12550	20.30	8.13	15.4	
Narrows Bridge	13-Oct-97	12:00	4.8	0.091	0.330	0.031	0.060	18.1	1.43	31.5	48200	17.99	7.57	20.1	
Success Hill	11-Jan-95	13:00	0	0.010	0.860	0.040	0.140		8.50	14.5		29.40			0.7
Success Hill	11-Jan-95	13:00	1	0.020	0.900	0.040	0.260		5.10	15.0		27.60			
Success Hill	11-Jan-95	13:00	5	0.010	1.200	0.070	0.140		1.70	18.0		27.70			
Success Hill	11-Apr-95	14:00	0	<0.020	0.880	0.030	0.090		17.80	26.3		24.00			1.0
Success Hill	11-Apr-95	14:00	1	<0.020	0.790	0.040	0.080		9.90	28.9		21.90			
Success Hill	11-Apr-95	14:00	6	0.020	0.750	0.080	0.140		7.37	31.2		21.00			
Success Hill	18-Jul-95	14:35	0	0.600	1.600	0.064	0.150	79.5	8.26	3.0	5420	12.71			0.2
Success Hill	18-Jul-95	14:35	1	0.400	1.200	0.033	0.140	78.2	8.12	3.0	5420	12.72			
Success Hill	18-Jul-95	14:35	5	0.440	1.300	0.050	0.130	76.3	7.93	3.0	5430	12.72			
Success Hill	10-Oct-95	13:30	0	<0.005	0.650	<0.003	0.040	68.8	6.20	4.3	7730	19.00			1.1
Success Hill	10-Oct-95	13:30	1	0.075	0.380	0.011	0.030	66.8	6.04	4.3	7760	18.88			
Success Hill	10-Oct-95	13:30	4	0.076	0.490	0.012	0.040	64.2	5.83	4.3	7780	18.62			
Success Hill	9-Jan-96	12:20	0	<0.005	0.490	0.007	0.070	85.4	6.11	10.4	17600	29.36	7.38	27.2	1.2
Success Hill	9-Jan-96	12:20	1	<0.005	0.420	0.007	0.020	69.6	5.03	11.0	18600	28.59	7.27	17.6	
Success Hill	9-Jan-96	12:20	3.5	<0.005	0.480	0.009	0.050	41.0	2.88	14.8	24400	28.96	7.14	29.0	
Success Hill	9-Apr-96	12:35	0	<0.005	1.100	0.052	0.160	146.6	11.05	25.6	40100	21.58	8.37	49.3	
Success Hill	9-Apr-96	12:35	1	<0.005	0.790	0.050	0.130	96.8	7.30	26.9	41900	21.10	8.15	43.1	
Success Hill	9-Apr-96	12:35	4	<0.005	0.570	0.058	0.090	52.3	3.92	28.1	43500	21.12	7.84	11.4	
Success Hill	9-Jul-96	13:06	0	0.950	2.400	0.097	0.130	87.6	8.86	3.1	5620	13.89	7.50	16.7	
Success Hill	9-Jul-96	13:07	1	0.520	2.000	0.052	0.130	86.4	8.74	3.1	5640	13.89	7.46	18.2	
Success Hill	9-Jul-96	13:08	3.42	0.800	2.100	0.070	0.110	85.1	8.60	3.1	5640	13.88	7.40	22.5	
Success Hill	15-Oct-96	13:05	0	0.110	0.740	0.019	0.050	90.0	7.93	2.7	4830	20.69	8.24	0.0	1.1
Success Hill	15-Oct-96	13:06	1	0.076	0.740	0.020	0.040	86.1	7.62	2.7	4860	20.47	8.19	0.0	
Success Hill	15-Oct-96	13:07	3	0.069	0.710	0.020	0.040	80.2	7.40	2.8	5150	18.38	8.13	7.7	
Success Hill	7-Jan-97	14:01	0	<0.005	0.900	0.010	0.070	106.5	7.76	7.0	12300	29.53	8.27	11.9	0.9
Success Hill	7-Jan-97	14:02	1	<0.005	0.800	0.014	0.060	102.1	7.59	8.0	13770	28.06	8.24	12.7	
Success Hill	7-Jan-97	14:05	3.5	<0.005	0.800	0.016	0.090	37.1	2.75	9.7	16500	27.62	7.88	19.9	
Success Hill	14-Apr-97	14:11	0	0.770	2.300	0.040	0.050	57.8	4.66	7.6	13	23.69	7.68	3.1	1.5
Success Hill	14-Apr-97	14:13	1	0.660	2.200	0.048	0.070	65.7	5.45	9.8	17	21.44	7.59	5.9	
Success Hill	14-Apr-97	14:17	5	0.097	1.400	0.180	0.270	1.6	0.12	23.1	37	21.75	7.32	11.8	
Success Hill	14-Jul-97	12:41	0	0.130	0.800	0.024	0.030	88.6	9.55	6.2	11	10.87	7.76	11.1	0.9
Success Hill	14-Jul-97	12:43	1	0.120	0.750	0.019	0.040	87.8	9.47	6.2	11	10.88	7.75	11.6	

Estuary data (contd)

SITE	DATE	TIME	DEPTH (metres)	N03-N (mg/L)	TN (mg/L)	FRP (mg/L)	TP (mg/L)	%DO (% sat)	DO (mg/L)	SALINITY (ppt)	CONDUCTIVITY (µs/cm)	TEMP (deg C)	pH (units)	TURB (NTU)	SECCHI (m)
Success Hill	14-Jul-97	12:51	5.5	0.120	0.790	0.020	0.030	88.2	9.52	6.4	11	10.78	7.75	11.8	
Success Hill	13-Oct-97	10:17	0	0.160	0.660	0.015	0.030	79.7	7.35	2.2	4010	19.19	7.57	5.0	1.0
Success Hill	13-Oct-97	10:17	1	0.150	0.680	0.016	0.030	77.8	7.21	2.4	4420	18.89	7.48	16.8	
Success Hill	13-Oct-97	10:22	5.31	0.110	0.800	0.018	0.050	76.4	7.07	2.9	5250	18.78	7.36	20.2	

Catchment data (Note: this is a print-out of the data disc)

SUBCATCHMENT	SITE NAME	SAMPLE DATE	TIME	TEMPERATURE (degrees C)	CONDUCTIVITY (µs/cm)	pH	TURBIDITY (NTU)	SECCHI DEPTH (m)	NITRATE (mg/L)	PHOSPHATE (mg/L)	TOTAL PHOSPHORUS (mg/L)
Ellen Brook	All Saints	10-Jun-92	13:00	14.0	1502	7.35				0.810	
Ellen Brook	Critical Gauge	10-Jun-92	13:25	14.0	1449	7.43				0.670	
Ellen Brook	Muchea	10-Jun-92	7:45	15.9	1362	7.37				0.940	
Ellen Brook	Rutland Rd	10-Jun-92	14:20	15.3	1694	7.84				0.680	
Ellen Brook	Reserve	10-Jun-92	13:40	13.8	1496	7.51				0.750	
Ellen Brook	Warren Road	10-Jun-92	14:00	14.4	2020	7.48				0.440	
Ellen Brook	All Saints	13-Aug-92	17:20	17.0	996	7.37				2.130	
Ellen Brook	Critical Gauge	13-Aug-92	17:00	16.9	1066	7.69				2.060	
Ellen Brook	Muchea	13-Aug-92	13:55	17.1	1212	7.54				2.000	
Ellen Brook	Rutland Rd	13-Aug-92	14:20	17.3	1227	7.58				1.880	
Ellen Brook	Reserve	13-Aug-92	15:05	15.7	1077	7.63				2.060	
Ellen Brook	Warren Road	13-Aug-92	14:40	16.5	1164	7.55				1.940	
Ellen Brook	All Saints	21-Jun-93	09:00	13.1	1725	7.24				0.750	
Ellen Brook	Critical Gauge	21-Jun-93	09:30	13.1	1773	7.02				0.380	
Ellen Brook	Muchea	21-Jun-93	14:00	13.7	1611	7.03				0.610	
Ellen Brook	Rutland Rd	21-Jun-93	12:30	15.1	1840	7.53				0.720	
Ellen Brook	Reserve	21-Jun-93	10:00	13.2	1781	7.10				0.910	
Ellen Brook	Warren Road	21-Jun-93	11:00	14.1	2030	6.80				0.640	
Ellen Brook	All Saints	4-Aug-93	14:30	7.5	997	7.53					
Ellen Brook	Critical Gauge	4-Aug-93	14:45	7.5	946	7.52					
Ellen Brook	Muchea	4-Aug-93	14:50	7.5	1096	7.38					
Ellen Brook	Rutland Rd	4-Aug-93	15:00	7.5	1112	7.39					
Ellen Brook	Reserve	4-Aug-93	14:55	7.5	956	7.50					
Ellen Brook	Warren Road	4-Aug-93	15:05	7.5	1023	7.43					
Ellen Brook	All Saints	16-Nov-93	10:00	13.8	1313	7.07				0.700	
Ellen Brook	Critical Gauge	16-Nov-93	10:05	13.8	1370	7.12				0.610	
Ellen Brook	Muchea	16-Nov-93	10:25	13.8	1320	6.91				0.750	
Ellen Brook	Rutland Rd	16-Nov-93	10:20	13.8	1882	7.00				0.510	
Ellen Brook	Reserve	16-Nov-93	10:10	13.8	1337	7.03				0.810	
Ellen Brook	Warren Road	16-Nov-93	10:15	13.8	1945	6.99				0.510	
Ellen Brook	All Saints	1-Jun-94	12:32	13.3	1605	6.87			0.352	1.880	
Ellen Brook	Critical Gauge	1-Jun-94	12:15	11.9	1483	6.89			0.259	2.000	
Ellen Brook	Muchea	1-Jun-94	10:30	11.2	1329	6.66				2.000	
Ellen Brook	Rutland Rd	1-Jun-94	10:45	11.4	1779	6.98			0.052	2.060	
Ellen Brook	Reserve	1-Jun-94	12:00	11.8	1532	6.15			0.440	1.340	

Catchment data (contd)

SUBCATCHMENT	SITE NAME	SAMPLE DATE	TIME	TEMPERATURE (degrees C)	CONDUCTIVITY (µs/cm)	pH	TURBIDITY (NTU)	SECCHI DEPTH (m)	NITRATE (mg/L)	PHOSPHATE (mg/L)	TOTAL PHOSPHORUS (mg/L)
Ellen Brook	Warren Road	1-Jun-94	11:00	11.9	1407	6.82				1.500	
Ellen Brook	All Saints	27-Jul-94	13:00	15.5	1150	7.20			0.484	1.580	
Ellen Brook	Critical Gauge	27-Jul-94	13:05	15.4	1040	6.80			0.660	1.880	
Ellen Brook	Muchea	27-Jul-94	13:30	17.3	1205	6.50			0.242	1.500	
Ellen Brook	Rutland Rd	27-Jul-94	13:15	15.7	1133	6.90			0.528	1.720	
Ellen Brook	Reserve	27-Jul-94	13:10	16.0	1128	6.90			0.616	1.770	
Ellen Brook	Warren Road	27-Jul-94	13:20	16.7	1212	6.70			0.484	1.770	
Ellen Brook	All Saints	21-Jun-95	12:00		1585	6.96			0.816	0.080	
Ellen Brook	Critical Gauge	21-Jun-95	11:30		1555	7.20			0.810	1.440	
Ellen Brook	Muchea	21-Jun-95	09:00		1618	6.92			0.352	1.160	
Ellen Brook	Rutland Rd	21-Jun-95	09:30		1777	7.09			0.668	1.340	
Ellen Brook	Reserve	21-Jun-95	11:00		1605	6.91			0.668	1.260	
Ellen Brook	Warren Road	21-Jun-95	10:00		1705	6.98			0.704	1.160	
Ellen Brook	All Saints	17-Aug-95			1045	7.16				1.820	
Ellen Brook	Critical Gauge	17-Aug-95			1007	7.22				1.620	
Ellen Brook	Muchea	17-Aug-95			1128	7.20				2.600	
Ellen Brook	Rutland Rd	17-Aug-95			1069	7.07				1.780	
Ellen Brook	Reserve	17-Aug-95			1006	7.25				1.620	
Ellen Brook	Warren Road	17-Aug-95			1095	7.32				2.000	
Ellen Brook	All Saints	9-Nov-95	16:00	20.1	1250	7.70			1.496	1.030	
Ellen Brook	Critical Gauge	9-Nov-95		19.0	760	7.70			0.827	1.030	
Ellen Brook	Reserve	9-Nov-95		17.2	701	7.70				0.940	
Ellen Brook	Warren Road	9-Nov-95		22.0	581	7.80			0.123	0.720	
Canning River	Aquinas Foreshore	18-Jun-92	14:30	18.0	7710	7.15		4.9		0.200	
Canning River	Marker Buoy	18-Jun-92	14:10	17.0	6950	7.25		4.15		0.320	
Canning River	Mt Henry Point	18-Jun-92	14:00	18.0	8120	7.20		5.15		0.320	
Canning River	Salters Point	18-Jun-92	14:20	18.0	6200	7.22		4.3		0.280	
Canning River	Aquinas Foreshore	14-Aug-92	14:30	17.9	1792	7.53		0.41		1.000	
Canning River	Marker Buoy	14-Aug-92	14:10	17.4	1692	7.51		0.47		0.540	
Canning River	Mt Henry Point	14-Aug-92	14:00	17.8	1851	7.52		0.4		3.050	
Canning River	Salters Point	14-Aug-92	14:20	17.6	1762	7.52		0.42		0.560	
Canning River	Aquinas Foreshore	17-Jun-93	13:00		15200	7.80					
Canning River	Marker Buoy	17-Jun-93	13:15	15.8	36600	7.70		3			
Canning River	Mt Henry Point	17-Jun-93	13:30		15800	7.60					
Canning River	Salters Point	17-Jun-93	13:45		27300	7.60					

Catchment data (contd)

SUBCATCHMENT	SITE NAME	SAMPLE DATE	TIME	TEMPERATURE (degrees C)	CONDUCTIVITY (µs/cm)	pH	TURBIDITY (NTU)	SECCHI DEPTH (m)	NITRATE (mg/L)	PHOSPHATE (mg/L)	TOTAL PHOSPHORUS (mg/L)
Canning River	Aquinas Foreshore	12-Aug-93	14:00	16.8	1832	7.21					
Canning River	Marker Buoy	12-Aug-93	14:10	17.1	1038	7.15		0.47			
Canning River	Mt Henry Point	12-Aug-93	14:20	18.4	1863	7.01		0.53			
Canning River	Salters Point	12-Aug-93	14:30	17.8	1748	7.40		0.43			
Canning River	Aquinas Foreshore	17-Jun-94	14:15	17.1	26000	8.10					
Canning River	Marker Buoy	17-Jun-94	14:45	17.0	17000	7.90		0.86			
Canning River	Mt Henry Point	17-Jun-94	14:30	16.8	20000	7.90		1.05			
Canning River	Salters Point	17-Jun-94	14:50	17.4	27000	8.10					
Canning River	Aquinas Foreshore	16-Aug-94	07:40					0.59			
Canning River	Marker Buoy	16-Aug-94	07:35	13.7	6400	7.25		0.35			
Canning River	Mt Henry Point	16-Aug-94	07:20	13.1	6300	7.27		0.56			
Canning River	Salters Point	16-Aug-94	07:30	14.0	6500	7.04					
Canning River	Aquinas Foreshore	23-Jun-95	13:45	15.5		7.89		1.9			
Canning River	Marker Buoy	23-Jun-95	13:35	15.5		7.77		1.4			
Canning River	Mt Henry Point	23-Jun-95	13:30	15.5		7.87		2.22			
Canning River	Salters Point	23-Jun-95	13:40	15.5		7.87					
Canning River	Aquinas Foreshore	28-Jun-96	14:30	14.4	8280	7.50	<10				
Canning River	Marker Buoy	28-Jun-96	14:20	14.0	8270	7.40	10				
Canning River	Mt Henry Point	28-Jun-96	14:00	13.9	8640	7.50	15				
Canning River	Salters Point	28-Jun-96	14:30	14.3	8520	7.70	<10				
Canning River	Aquinas Foreshore	23-Aug-96	15:30	15.8		7.70	<10				
Canning River	Marker Buoy	23-Aug-96	15:00	15.7	2160	7.60	<15			0.940	
Canning River	Mt Henry Point	23-Aug-96	14:45	15.6	2200	7.50					
Canning River	Salters Point	23-Aug-96	15:15	16.1	2920	7.80	<20				
Canning River	Aquinas Foreshore	19-Jun-97	12:30	16.3	22400	7.90	<10			0.440	
Canning River	Marker Buoy	19-Jun-97	12:40	15.9	23900	7.80	<10			0.280	
Canning River	Mt Henry Point	19-Jun-97	12:35	14.5	22100	8.10	<10			0.180	
Canning River	Salters Point	19-Jun-97	12:45	14.7	23100	7.70	<10			0.100	
Southern River	Palamino Reserve	23-Mar-94	14:10	28.5	624	9.89			0.158		
Southern River	Downstream of Forestdale Drain	23-Mar-94	13:35	25.5	786	7.74					
Southern River	Downstream of Corfield Drain	23-Mar-94	12:15	23.3	1055	7.29					
Southern River	Palamino Reserve	1-Apr-94	14:30	24.0	594	6.55	60		2.640		
Southern River	Downstream of Forestdale Drain	1-Apr-94	13:50	24.0	597	8.07	<25		1.980		
Southern River	Southern River Rd Bridge	1-Apr-94	13:20	26.9	903	6.73	<25		0.139		
Southern River	Downstream of Corfield Drain	1-Apr-94	12:15	24.8	969	6.90	<25		0.189		

Catchment data (contd)

SUBCATCHMENT	SITE NAME	SAMPLE DATE	TIME	TEMPERATURE (degrees C)	CONDUCTIVITY (µs/cm)	pH	TURBIDITY (NTU)	SECCHI DEPTH (m)	NITRATE (mg/L)	PHOSPHATE (mg/L)	TOTAL PHOSPHORUS (mg/L)
Southern River	Palamino Reserve	1-May-94	12:30	17.8	486	7.29	80		0.572		1.540
Southern River	Downstream of Forestdale Drain	1-May-94	11:45	15.4	476	6.67	30				0.380
Southern River	Southern River Rd Bridge	1-May-94	11:24	15.7	729	6.74	<25				
Southern River	Downstream of Corfield Drain	1-May-94	10:15	16.5	804	6.63	<25		1.056		
Southern River	Palamino Reserve	8-Jun-94	14:20	15.0		6.19	80		3.520		1.380
Southern River	Downstream of Forestdale Drain	8-Jun-94	13:20	14.4		6.39	64		0.414		0.840
Southern River	Southern River Rd Bridge	8-Jun-94	12:35	15.0		6.41	35		0.790		1.340
Southern River	Downstream of Corfield Drain	8-Jun-94	11:40	17.5		6.39	32		0.660		1.090
Southern River	Palamino Reserve	3-Aug-94	13:55	19.7	506	7.10	<25		1.452		0.460
Southern River	Downstream of Forestdale Drain	3-Aug-94	13:10	14.6		6.80	<25		1.628		0.400
Southern River	Southern River Rd Bridge	3-Aug-94	12:30	14.8	599	6.91	<25		0.352		0.540
Southern River	Downstream of Corfield Drain	3-Aug-94	11:45	14.8	633	6.97	<25		0.242		0.580
Southern River	Downstream of Forestdale Drain	31-Aug-94	14:05	14.6	210	6.21	40		0.374		0.780
Southern River	Southern River Rd Bridge	31-Aug-94	12:55	14.5	319	6.74	37		0.299		0.580
Southern River	Downstream of Corfield Drain	31-Aug-94	11:55	14.6	407	6.79	60		0.189		1.030
Southern River	Palamino Reserve	21-Sep-94	14:00	21.5	520	7.10	25		4.400		1.530
Southern River	Downstream of Forestdale Drain	21-Sep-94	13:00	21.0	860	6.42	32		1.403		0.640
Southern River	Southern River Rd Bridge	21-Sep-94	12:15	19.5	656	6.73	<25		0.484		0.280
Southern River	Downstream of Corfield Drain	21-Sep-94	11:35	19.4	684	6.54	<25		0.748		0.560
Southern River	Palamino Reserve	18-Oct-94	14:25	23.5	485	8.83	<25		4.180		1.120
Southern River	Downstream of Forestdale Drain	18-Oct-94	13:10	19.2	534	7.34	<25		0.792		0.940
Southern River	Southern River Rd Bridge	18-Oct-94	12:45	19.3	659	7.04	<25		0.210		0.180
Southern River	Downstream of Corfield Drain	18-Oct-94	11:45	19.0	677	7.13	30		0.242		0.610
Southern River	Palamino Reserve	16-Nov-94	13:40	32.0	633	9.20	25		0.660		0.040
Southern River	Downstream of Forestdale Drain	16-Nov-94	13:15	24.4	719	8.82	<25		0.968		0.700
Southern River	Southern River Rd Bridge	16-Nov-94	11:35	23.3	916	6.98	<25		0.277		0.940
Southern River	Downstream of Corfield Drain	16-Nov-94	11:04	23.7	856	7.16	<25		0.392		1.260
Southern River	Palamino Reserve	14-Dec-94	11:55	26.1	969	8.07	40		3.600		
Southern River	Downstream of Forestdale Drain	14-Dec-94	11:10	21.7	855	7.69	<25				0.040
Southern River	Palamino Reserve	20-Feb-95	13:50	35.4	650		80		4.180		4.000
Southern River	Southern River Rd Bridge	20-Feb-95	12:10	27.2	90	6.93	<25		0.053		2.400
Southern River	Downstream of Corfield Drain	20-Feb-95	11:16	26.0	1080	6.68	<25		0.572		2.060
Southern River	Palamino Reserve	20-Mar-95	13:50	30.8	650	7.53	40		3.520		2.580
Southern River	Southern River Rd Bridge	20-Mar-95	12:30	23.8	1070	7.01	<25		0.013		2.680
Southern River	Downstream of Corfield Drain	20-Mar-95	11:58	23.1	1070	6.53	<25		0.013		1.060

Catchment data (contd)

SUBCATCHMENT	SITE NAME	SAMPLE DATE	TIME	TEMPERATURE (degrees C)	CONDUCTIVITY (µs/cm)	pH	TURBIDITY (NTU)	SECCHI DEPTH (m)	NITRATE (mg/L)	PHOSPHATE (mg/L)	TOTAL PHOSPHORUS (mg/L)
Southern River	Palamino Reserve	10-Apr-95	13:26	27.0	510	6.41	<25		1.320		2.790
Southern River	Downstream of Forestdale Drain	10-Apr-95	12:55	23.2	600	6.34	25		0.440		
Southern River	Southern River Rd Bridge	10-Apr-95	12:05	20.3	760	6.35	<25		0.748		3.200
Southern River	Downstream of Corfield Drain	10-Apr-95	11:40	20.4	930	6.48	<25		0.334		2.680
Southern River	Palamino Reserve	14-May-95	13:40	18.2	530	6.21	<25		0.924		1.540
Southern River	Downstream of Forestdale Drain	15-May-95	13:02	14.8	630	6.56	<25		4.180		2.920
Southern River	Southern River Rd Bridge	15-May-95	12:02	15.7	590	6.51	<25		0.616		2.580
Southern River	Downstream of Corfield Drain	15-May-95	11:33	15.7	720	6.18	<25		1.364		2.680
Southern River	Palamino Reserve	10-Aug-95	14:11	16.2	460	7.00			1.540		4.000
Southern River	Downstream of Forestdale Drain	10-Aug-95	12:55	15.0	470	7.10	<25		0.396		1.340
Southern River	Southern River Rd Bridge	10-Aug-95	11:05	14.1	460	7.18	<25		0.334		1.760
Southern River	Palamino Reserve	7-Sep-95	13:50	17.8	340		35		0.079		0.750
Southern River	Downstream of Forestdale Drain	7-Sep-95	12:20	21.3	280	6.05	<25		1.320		0.720
Southern River	Southern River Rd Bridge	7-Sep-95	10:57	16.0	300	6.18	60		0.792		1.060
Southern River	Palamino Reserve	28-Sep-95	14:00	18.8	500	8.78	<25		2.552		0.440
Southern River	Downstream of Forestdale Drain	28-Sep-95	13:10	17.6	150	7.74	<25		0.748		0.460
Southern River	Southern River Rd Bridge	28-Sep-95	11:05	17.3	660	7.42	<25		0.392		0.750
Southern River	Palamino Reserve	23-Oct-95	13:30	23.2	500	8.32	<25		0.968		1.340
Southern River	Downstream of Forestdale Drain	23-Oct-95	12:30	19.1	590	8.49	<25		0.748		0.750
Southern River	Southern River Rd Bridge	23-Oct-95	11:05	17.0	640	7.85	<25		0.414		1.060
Southern River	Southern River Rd Bridge	14-Dec-95	10:30	21.4	925	7.11	30		0.189		0.220

SWAN RIVER TRUST

Level 3, Hyatt Centre
87 Adelaide Terrace
East Perth WA 6004
Telephone: (08) 9278 0400
Facsimile: (08) 9278 0401
http://www.wrc.wa.gov.au/srt

WATER AND RIVERS COMMISSION

Level 2, Hyatt Centre
3 Plain Street
East Perth WA 6004
Telephone: (08) 9278 0300
Facsimile: (08) 9278 0301
http://www.wrc.wa.gov.au

RIBBONS OF BLUE

Level 2, Hyatt Centre
3 Plain Street
East Perth WA 6004
Telephone: (08) 9278 0300
Facsimile: (08) 9278 0301
http://www.wrc.wa.gov.au/ribbons

Natural Heritage Trust