module 1

WATERWATCH AUSTRALIA NATIONAL TECHNICAL MANUAL

Background

Module 1 – Background

Waterwatch Australia National Technical Manual
by the Waterwatch Australia Steering Committee

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Preface

The *Waterwatch Australia National Technical Manual* was prepared by the Waterwatch Australia Steering Committee to provide guidance and technical support to the Waterwatch community monitoring network throughout Australia. The content has been gathered from a range of publications, including the existing State Waterwatch Technical Manuals. The guidelines and information reproduced in this Manual have been agreed by the members of the committee based on their knowledge and experience in coordinating community monitoring programs in Australia with advice from the scientific community.

The Manual has been published as a series of modules. Each module is a stand-alone document addressing an important aspect of community waterway monitoring. The following modules are available in the Manual:

1. Background (this module)
2. Getting Started: the team, monitoring plan and site
3. Biological Parameters
4. Physical and Chemical Parameters
5. Data ... Information ... Action!
6. Waterwatch and Schools
7. Estuarine Monitoring
8. Groundwater Monitoring

Contents

Introduction

Clean fresh water is one of our most valuable assets. It is essential for sustaining aquatic environments, agriculture and human health. The effect of our activities on the waters in all parts of Australia should be of major concern to us all.

This section introduces Waterwatch and explains how you can get involved in helping to monitor and care for our waterways.

What is Waterwatch?

Waterwatch Australia is an initiative to help us understand, monitor, care for and sustainably manage our most precious natural asset – water. It is a community water monitoring network that is all about understanding and keeping an eye on your local water body – it could be a creek, pond, lake, dam, wetland, lagoon or estuary.

Community water monitoring occurs in every State and Territory. Waterwatch supports a wide range of communities to monitor the health of waterways; to undertake and participate in outreach activities, including environmental education, conferences and workshops; and, action projects to protect, rehabilitate or restore the health of our waterways.

Since it began, Waterwatch has formed partnerships with the community, government and industry to begin to sustainably address many of the issues that affect water quality and the health of our waterways. Waterwatch is now recognised as one of Australia's most successful environmental initiatives.

The catchcry of Waterwatch is *communities caring for catchments*, as the involvement of local people is an essential aspect of environmental management. Estimates indicate that regular monitoring occurs at nearly 7000 sites nationally.

Management of Waterwatch Australia

Waterwatch operates as a network of committed people working towards the communities goals and vision. Representatives from all States and Territories provide advice and direction to national coordination on a regular basis. This advice assists in determining the national priorities of community water monitoring and increasing national consistency in monitoring, education and delivery.

Onground Coordinators

Across Australia, regional and local coordinators are employed to support the community to understand, protect and restore waterway and catchment health. Coordinators play a vital role to support the community in monitoring and awareness raising activities through:

- development,
- learning,
- fostering ownership,
- facilitating community involvement in catchment management, and
- training.

Through this training and support, people involved in Waterwatch are better able to understand and interpret the results of their monitoring, and design projects to tackle problems they encounter. All the groups and individuals within a catchment are linked through local and regional coordination ensuring that all data collected is interpreted in the context of the whole catchment.

Waterwatch funding

The Commonwealth provides support via the Natural Heritage Trust for community involvement in water education, monitoring, protection and restoration activities. Contact your regional natural resource/catchment management authority to find out how you can access support to understand, monitor and improve waterway health in your local area.

Who can get involved in Waterwatch?

You! – and anybody else who cares about the local environment.

The Waterwatch network is made up of individuals, community groups and school groups who regularly check their local waterways, undertake actions to help maintain good water quality, and help raise community awareness about water.

Forming groups and partnerships

There are different kinds of groups who have an interest in the condition of waterways. Potential partners include schools, Landcare or conservation groups, community groups, service clubs, industry, local businesses, state government agencies, catchment boards and local government.

You may belong to a school and be interested in using a local stream for study or be a member of a local community group concerned about issues in a sub-catchment. Often schools form partnerships with local governments to benefit from linking areas of study to real local and regional issues. Students find it valuable for action–research projects in studies of society and environment, science, health and physical education, technology and the arts. Teachers find Waterwatch valuable in the study of biology, environmental science, chemistry, environmental studies, agricultural studies, science and geography.

Your group may be isolated or be part of a larger catchment or regional Waterwatch network with a well developed structure and plan of action.

For some groups, the principal focus is education and awareness, while others may concentrate on gathering data about the condition of the waterway. Other groups may undertake direct remedial action to fix a known problem: for example, some Waterwatch groups carry out community-based conservation activities such as fencing areas of riverbanks, removing litter from waterways, eradicating weeds and invasive species, and reducing the use of pesticides and other pollutants.

Through a team approach, community members can gain access to the expertise and resources of local authorities concerned with water issues. Conversely, local authorities can benefit from your monitoring and from the greater understanding spread through the community.

Who should use this manual?

The *Waterwatch Australia National Technical Manual* is designed for Waterwatch coordinators, environmental staff, teachers and experienced Waterwatchers to help them support students and the community to undertake waterway health. The manual provides information to help you understand more about the health of Australia's waterways, and the tools to monitor their condition in order to protect and restore them for all.

How this manual will help

There are many reasons why individuals and groups are concerned about their waterways. This manual has been designed to meet these varying needs.

The *Waterwatch Australia National Technical Manual* gives you the tools to progress from concern about the condition of the waterway to acting on issues in a cooperative, informed and effective manner. The broad steps include:

- recognising that there is an issue affecting aquatic health;
- forming a group, either on a small sub-catchment or extending to a number of groups over the whole catchment;
- gathering information either through surveys or monitoring to answer key questions posed by the issue and raise awareness; and
- acting on findings and recommendations, in collaboration with others.

We can come to know our waterways and appreciate them through a variety of monitoring and survey methods. Different methods are suited to different groups with different goals and resources. Methods range from descriptive, for example, presence or absence; to those which involve precise quantitative measurements. The level of confidence you can place in the accuracy of data collected varies according to the methods you use. After reading *Module 2 Getting Started: the team, monitoring plan and site*, you will be able to decide which monitoring methods will produce the data quality you want.

The manual also gives guidelines on how to plan your monitoring for best results. The plan can be simple or complex but in either case, you will reach your goals more effectively by planning. The monitoring plan (discussed in detail in Module 2) is built around eleven questions:

Q1 Why are you monitoring?

Q2 Who will use your data?

Q3 How will the data be used?

Q4 What will you monitor?

Q5 What data quality do you want?

Q6 What methods will you use?

Q7 Where will you monitor?

Q8 When and how often will you monitor?

Q9 Who will be involved and how?

Q10 How will the data be managed and reported?

Q11 How will you ensure your data are credible?

By following the guidelines in this manual you will be able to effectively work towards healthy waterways for all.

Compiling your waterway profile

Compiling a profile of your waterway is generally a one-time 'detective' investigation. It will yield valuable information about the cultural and natural history of the waterway and the uses of the land surrounding it. This profile will be helpful in:

- explaining to new members of your group the purpose of monitoring and surveys;
- building a sense of importance of the stream and its role in the catchment; and
- identifying land uses with a potential to affect the health of the waterway.

Your Waterwatch group might choose to monitor these areas and activities more intensively in the future.

It is best to compile your profile of the waterway in the early stages of your Waterwatch activities. Use the information you uncover to help choose your goals, develop your monitoring plan and plan future activities (see Module 2).

The investigation can be done at any time of year and can take as little or as much time as you wish to devote to it.

Your profile might concentrate on the main concerns of Waterwatch group members or it might include all issues. In any case, rely on the interests of your group to establish what you want to know about your waterway.

Information to include in your profile

The types of information you need to collect, as part of the profile of your waterway, include geographical data, environmental uses of the water in your catchment, the value your community places on that waterway and the threats to that waterway. As a minimum, you should find out and record the size of the stream, its catchment boundaries, water uses, dischargers and the general land use in the area.

Geography and background information

- Where does the stream begin and end?
- What is its length?
- Where does it flow?
- What is the local topography?
- Where are the catchment boundaries?
- Where are the towns?
- What is the size of the population in the catchment?

Environmental values (uses)

- How is the land used in the catchment?
- What are the current uses of the waterway (such as fishing, swimming, drinking water supply, stock drinking, irrigation, industry, scenic value, protection of aquatic ecosystems)?
- What and where are the historical land uses such as old tip sites and mine tailings dumps?
- Have there been historical land use changes in the catchment?

Values

- What does the community value about the waterway?

Threats

- What industries, sewage treatment plants, farms, stormwater pipes, urban areas and others discharge to the waterway?
- What is currently being done to improve waterway health?

Other information

- Who is responsible for regulating water quality and quantity, riparian vegetation and any water diversions in your catchment?
- Do any monitoring programs already exist? If so, what is being measured, how often and for what purpose?
- Is enough information currently available to provide a baseline to compare future changes in, e.g. riparian vegetation, water quality, stream flow, hydrology, condition of the stream bed and banks, or aquatic life?

Any or all of this information will be valuable and you might also uncover other useful information in the process.

Sources of information

It is important to find out what is known about your waterway and if there are any projects already underway. This information may save you effort and money, help you identify good sites to study, and allow your activities to fit into the overall efforts to work towards healthy waterways in the catchment.

By dividing research tasks between members, you will quickly gain a rich picture of the waterway which will answer many questions of value to your group. Keep a written account (profile) of information for use by the group and for members who might join the group at a later date. Maps, photographs and other information on previous monitoring studies in the catchment will be of particular value to your group over time. The types of information you will need to include in your profile and the possible or typical places to seek out such information are provided in Table 1.1.

Table 1.1: Types and sources of information

Type of information	Possible source
Location of drains and pipes, including stormwater outlets, entering or discharging into your waterway	Drainage maps at the local council or water authorities, local residents
Extent of vegetation cover	Aerial photographs at the local council or with the local historical society, museum, library newspaper archive
Urban and industrial development (such as industries, sewage treatment plants, farms)	Aerial photographs and drainage maps at the local council or with the local historical society, museum, library newspaper archive, telephone book
Geographic 'shape' of your catchment	Contour or topographic maps at the local council or Commonwealth agencies (Geoscience Australia or Australian Surveying and Land Information Group)
History of the waterway, including past land uses, such as old rubbish dumps which can leach pollutants for years after closure	Local council and/or local residents, historical society, museum, library and newspaper archive – look for historical photos of the area and stories about fishing contests, fish kills, spills, floods and other major events affecting the waterway and its catchment
When residential developments were built	Council or town planning offices, library and newspaper archive, local residents
When streams were channelled or diverted	Council or town planning offices, library and newspaper archive, local residents
When highways and bridges were built	Commonwealth or State Departments of Transport, library and newspaper archive, local residents

History of your waterway

A very good way to learn about your river is to ask older people in the community to tell their stories of the river. Doing oral histories is a particularly good activity for local school students and builds a sense of connection with the past, and stewardship for the land and its water.

People who fished or swam in streams in their youth have probably witnessed how the stream has changed. They might remember industries or land use activities of the past, such as mines or farms, that could have affected the stream. They might have tales to tell about fish they once caught or floods that led to channelisation. Questions to ask include:

- How has the stream changed?
- What stories can they tell about the stream?
- What stories did their grandparents tell about the stream?

For many people, particularly the young, the waterway has always been as we see it now. It often comes as a surprise to learn that you could once see the stream bottom at the local swimming hole, or that the river used to flow by a different channel to the sea. Stories of the past can inspire the community to imagine what the river could be like again.

Mapping your catchment

A catchment base map is a convenient and useful way of recording the information you collect. It can include land uses and potential monitoring sites and show a variety of factors that could influence the health of your catchment.

Topographic maps are a useful starting point. They are available from camping shops, Government bookshops and information shops as well as some newsagents and tourist bureaux. There are many different scales of topographic maps. The two most commonly used are:

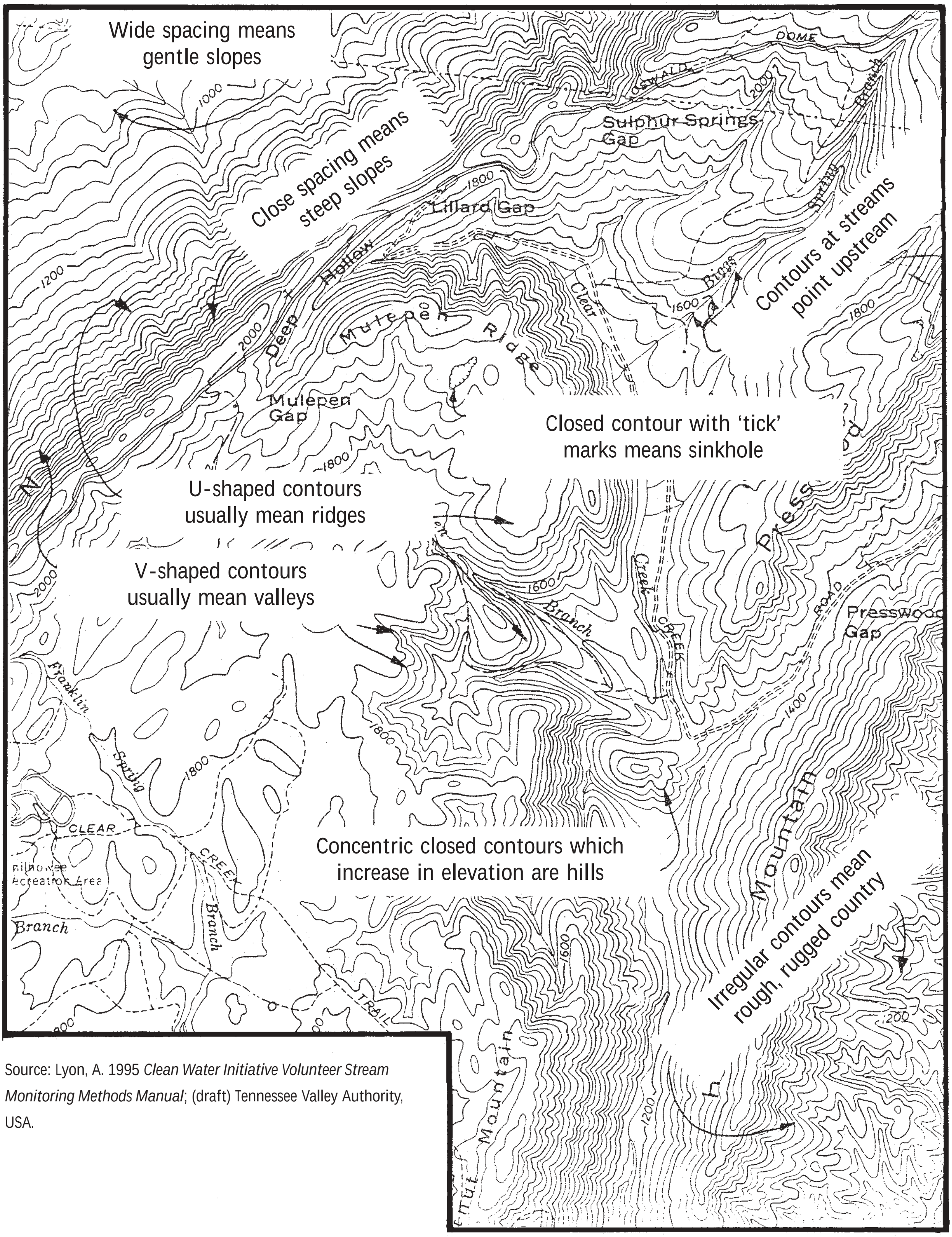
- 1:25 000 with a 4cm grid, i.e. 4cm = 1000m; and
- 1:100 000 with a 1cm grid, i.e. 1cm = 1000m.

Each map has its scale printed in the margin. Whatever scale it is, one grid square will represent 1km by 1km. Thus, a 1:100 000 map shows a larger area, but with less detail, than does a 1:25 000 map.

Your local water authority, council, national parks or forestry office may generate a map from a GIS (Geographical Information System) computer database. Many GIS systems can add extra information to topographic maps such as different land uses, industrial, urban and commercial areas, mining sites, stormwater drainage, sewerage systems, sewage treatment plants, roads, railways, powerlines, parkland, golf courses and rubbish sites. The information available depends on what is in the database.

You should learn the basics of how to read a contour or topographic map. Figure 1.1 shows some basic terminology and how to translate it on a contour map.

Figure 1.1: Contour basics



Source: Lyon, A. 1995 *Clean Water Initiative Volunteer Stream Monitoring Methods Manual*; (draft) Tennessee Valley Authority, USA.

Making your catchment base map

The steps you need to take to create a catchment-specific base map are:

1. Obtain a topographic map of the catchment. You may need to cut and paste several maps together to show the whole length of your stream.
2. Overlay your base map with a clear plastic sheet. Work up the stream tracing its course and the tributaries or drains that join it.
3. Use your contour map to find the boundary of the catchment. The catchment boundary will be a line joining ridges of higher ground above the smallest streams which drain into your river or stream. Mark the boundary onto the map overlay.
4. To work out the surface area of your catchment, count the number of one kilometre squares enclosed by the catchment boundary.

Adding information to the catchment map

You now have a base map on which you can record things that may influence the health of your waterway. See LAND USES box for some of the major land uses within a catchment.

Using the notes gathered (discussed above) and your own general knowledge of the local area, build up a comprehensive picture by marking the location of all land uses that may have an influence on waterway health.

You could hold public meetings or workshops to give members of your community an opportunity to view the information collected and help you identify river uses, special attributes and problems. Make sure you explain your group's ideas at these workshops. Assemble topographic maps, or some other clear base maps, that cover your catchment. Invite participants to identify and locate stream use areas, special attributes and problem areas using labelled or colour-coded Post-it® notes. You can learn a surprising amount about your catchment through this exercise.

Such meetings provide a way for people to share their interests and thoughts and a way for all viewpoints to be heard. This respectful sharing of viewpoints and interests is the cornerstone to building a cooperative effort to work towards healthy waterways.

You can check the information recorded on your base map when you walk and/or drive the stream during the on-ground catchment survey (see *Module 2 Getting Started: the team, monitoring plan and site*). The next step is monitoring.

What is monitoring?

Monitoring is an essential part of Waterwatch. Monitoring means checking the condition of waterways; it is a way of gathering information about the health of waterways. It involves surveying aquatic life and vegetation surrounding the water body, and collecting, processing and analysing samples of water. This information is used to tell a story about changes to the health of the waterway.

Common indicators of aquatic health include the condition of the habitat, bacteria levels, nutrient concentrations, aquatic invertebrates, turbidity, and dissolved oxygen.

Monitoring can be as simple as a visual survey of your waterway or as complex as collecting and analysing numerous water samples to a high level of accuracy and precision. How and what you monitor depends on the issues affecting your water body and the purpose for gathering information about its health.

Land uses

- Aquaculture in estuaries
- Construction activities
- Croplands and pastures
- Dams
- Draining wetlands
- Fertilisers
- Forest practices
- Golf courses
- Livestock operations
- Mining operations
- On-site sewerage disposal systems
- Pesticides (biocides)
- Septic systems
- Urbanisation and stormwater

(see Land uses and their impacts on page 27 for details)

Why monitor waterways?

Water quality and the ecology of waterbodies are both influenced greatly by what is happening on the land. You may, through monitoring, be able to identify particular land uses that are affecting or likely to affect water health and flows in your area.

Monitoring is important for a variety of reasons. For instance:

- It is a way to know how healthy our waterways are.
- It helps us understand the impacts of our activities – good or bad (see LAND USES box on the previous page).
- It is an essential tool for making good management decisions and evaluating the effects of these decisions.
- It promotes community stewardship of the environment and involvement in actions to improve and protect the condition of our waterways.

Getting to know your catchment

A water catchment is an area or basin of land bounded by ridges, hills or mountains from which all surface run-off water drains to a river, stream, lake, wetland or estuary.

What happens in a catchment?

When it rains, water drains to the lowest point on the land, forming small creeks that feed into larger streams and rivers as they run downhill. In this way water can drain into a river from an area that is often many square kilometres in area. Natural features, such as ridges, hills or mountains form the boundaries of a catchment. From these high points, all water flows down to the lowest point (like water in a bathtub flowing to the plug hole). In the case of a natural catchment, the low point could be a wetland, lake, junction with a river, or river mouth where it enters the sea.

Catchments vary in size and makeup. Large ones are bordered by mountain ranges and include hundreds of small sub-catchments. Each sub-catchment may itself be bordered by low hills and ridges and drained by smaller creeks or gullies. What happens in all of these smaller catchments and streams will affect the wellbeing of the main river. So, water quality at one spot along the river will be influenced by what has happened upstream and will itself affect water quality downstream.

Advantages of using the catchment idea

We all live in catchments. Catchments are ideal units to work with when looking at land use and management issues because many things are linked by water, and what happens in one part of a catchment is likely to affect other parts. For example, a soil erosion problem on a farm near the top of a catchment may contribute to silting of creeks and rivers lower down. Monitoring the water will reveal a composite picture of all the environmental processes taking place in the catchment.

Another advantage in using the catchment idea is that we can select an area (sub-catchment, catchment or region) of a size that suits the issues and interests of each group. If the issue faced by the community is a major one, such as diffuse pollution along a large river, land use in a catchment covering thousands of square kilometres may need to be examined by a coalition of Waterwatch groups.

On the other hand, if a small group wants to do something about a local problem, it may be best to work within a smaller sub-catchment area. For example, a school may be interested in a sub-catchment that covers the school grounds to help explain the principles of ecosystems. A farmer may be interested in revegetating the stream banks and monitoring the improving condition of the water leaving their property in a small sub-catchment. Efforts at the sub-catchment scale contribute to improving the larger catchment area.

Where does water go?

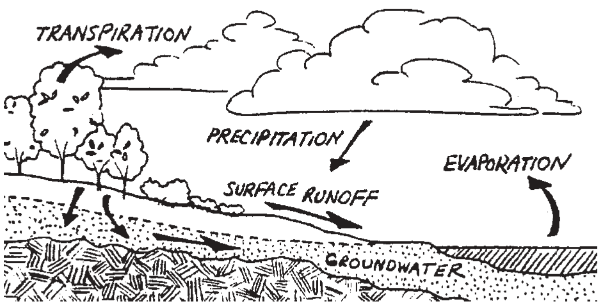
To understand how waterways get polluted, we have to understand how water moves through the environment. This is called the water cycle (see Figure 1.2).

Rivers and streams receive water in four ways:

- Surface flow or run-off water is that which does not soak into the ground but runs across the surface into waterways.
- Through flow is water that has been absorbed into the top soil that then moves downhill to a creek through the unsaturated zone.
- Baseflow is water that has sunk deep into the soil and met the groundwater which seeps into a creek. It sustains the creek long after rain has stopped falling.
- Direct input is rain falling into the water body.

The water cycle is completed by evaporation from water bodies and evapo-transpiration from plants, and condensation and rainfall.

Figure 1.2: The water cycle



Source: Mayio, A. 1995 *Volunteer Stream Monitoring: A Methods Manual*; (draft) US Environmental Protection Agency.

Does it matter which pathway water follows to the stream?

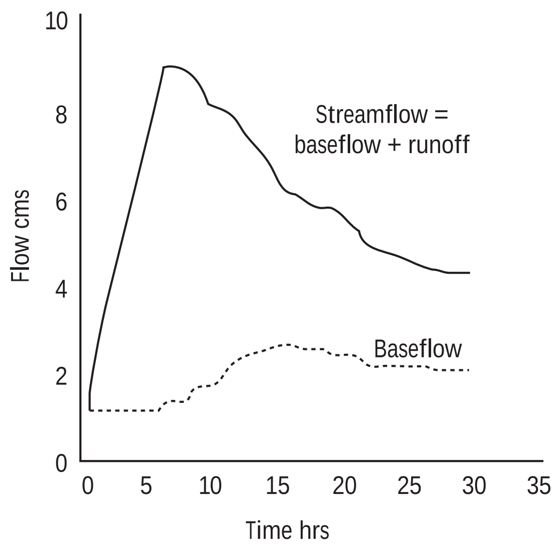
Yes it does! Water which falls from the clouds is usually fairly pure but the water quality of run-off and baseflow can be very different.

The baseflow, which comes from groundwater, is full of dissolved minerals, and is described as being 'hard'. Soap will not easily lather in hard water. Turbidity, suspended solids and nutrient levels are normally low. However, materials that have been trapped or stored underground can leach out into the groundwater that makes up the baseflow. These could be either natural, such as iron from iron-rich sediments, or man-made, such as petroleum products from leaking underground tanks.

Run-off water picks up few dissolved minerals during flow over the soil and is often described as 'soft'. However, run-off can pick up a variety of contaminants while flowing across the ground surface. These include leaves, animal waste, detergent, fertiliser and soil, which make the water turbid and increases nutrient levels. In addition, run-off over pavement in urban areas will pick up oil, various chemicals and litter.

In floods the proportion of run-off water in the stream increases and the quality of water may worsen. It is very helpful to know how the flow (volume per time) of your stream has changed in order to interpret your water quality data (see Figure 1.3).

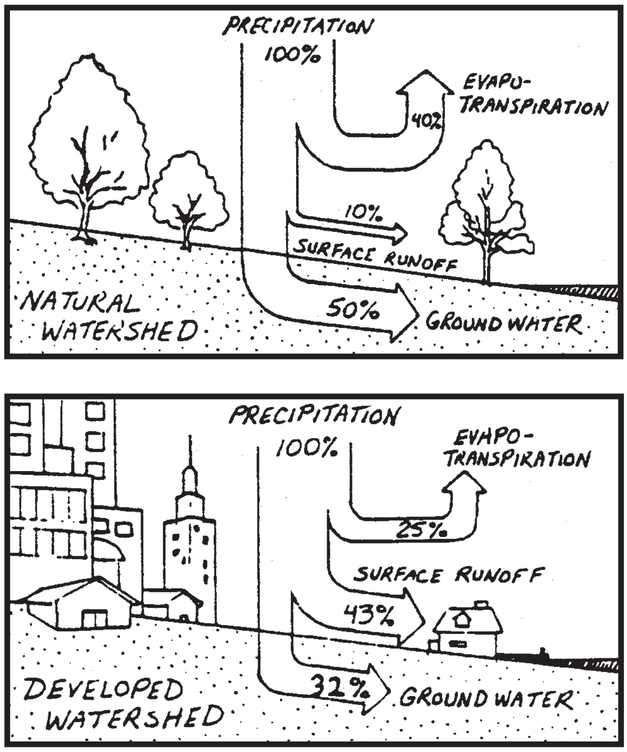
Figure 1.3: Increase in stream flow after rain at 0 hours



Tennessee Valley Authority 1992, Teacher-student Water Quality Monitoring Network; *Fall Workshop – Teacher Guide*.

Whether or not water from rain falling in your catchment flows across the surface or soaks into the soil depends on many factors including slope, amount of rainfall and most importantly, ground cover. During heavy rain or storms, run-off water rapidly increases the level and flow of rivers. In some streams, flow may increase quickly because of hard man-made surfaces such as roads, footpaths and parking areas. Clearing of land to make way for cities and towns or for farming increases run-off into waterways (see Figure 1.4).

Figure 1.4: Effect of cities on the pathway of water from rain to rivers



Source: Mayio, A. 1995 *Volunteer Stream Monitoring: A Methods Manual*; (draft) US Environmental Protection Agency.

In some catchments, stream flow may take a long time to respond to rainfall. In forested country, run-off is slowed by vegetation and water soaks into the ground. In relatively flat country, water also infiltrates the ground. Eventually however, all rain will make its way through the catchment and become stream flow. Baseflow maintains the low flow in waterways in the dry season long after there has been rain in the catchment. In these areas, stream flow will rise slowly, but also fall slowly.

Knowing the pattern of stream flow in a catchment is important in interpreting water quality data, because run-off and baseflow come from different sources with different levels of water quality.

How does water quality naturally change along a stream?

Some characteristics of a stream, such as water temperature, flow rate, water depth, stream bed and food sources, will naturally change as it flows from headwaters to a lake, wetland or the sea (see Table 1.2 on page 13).

Before interpreting your monitoring results, it is helpful to know what natural changes take place along the watercourse. Once you have listed these natural changes, you can then better identify human-caused changes to the stream.

Upper catchment

In the upper areas of the catchment, such as in mountain regions or foothills, streams are often fast-flowing. This means the stream has the energy to erode its bed and bank, and carry large amounts of rock and gravel downstream.

Vegetation has a greater influence on both the ecology and physical environment of small streams in the upper catchment than in larger streams. Headwaters in forested areas are often shaded from the sun's warming rays by overhanging tree branches. These streams are often fed by groundwater that seeps to the surface at a constant cool temperature. This stream environment shows only small daily or seasonal changes in water temperature. Aquatic insects adapted for cooler water may be found here, for example the stonefly larva.

Headwater streams in non-forested areas, or streams fed largely by run-off from the land, tend to show greater changes in water temperature both during the day and from season to season. Here, sunlight and air temperature have a greater impact on water temperature.

The type of stream bottom or substrate – boulders, cobbles, gravel, sand or silt – is determined in part by the speed of the current and by bedrock. Boulders, cobbles and bedrock are characteristic of fast-flowing streams and offer many living places for aquatic macro-invertebrates.

The headwaters of a river system are very important to the health of the entire river. Overhanging vegetation in forested areas provides much of the food required by stream organisms in the form of leaves, fruits, seeds, twigs and bark. Some of this material is fine, but most is coarse. Some macro-invertebrates collect this material, while others shred it. Both collector and shredder macro-invertebrates are common in forested streams.

In headwater streams that are not shaded by stream-bank vegetation, attached algae and rooted aquatic plants produce most of the available food.

Middle catchment

In the middle part of the catchment, the land is generally flatter and the stream flows more slowly. Usually there is a combination of erosion on the outside edge of bends (meanders) where the water flow is more rapid, and setting of sediment (deposition) on the inside of bends where the water flow is slower. During large floods, water spills out over banks onto the flood plain and deposits a layer of sediment.

Often, in these middle reaches, the stream bank and its trees no longer shade all of the water surface. Here the sun is able to warm the water through the day, particularly where the current slows to form pools. Water temperature tends to drop at night as the accumulated heat is given off to the cold air. Daily and seasonal changes in water temperature tend to be greatest here.

Attached algae become more abundant and grazer (plant eating) and collector macro-invertebrates dominate this section of the stream. Organisms like mayfly nymphs shear off pieces of algae growing on rocks. Collectors feed upon fine material (shredder faeces and small plant fragments) transported from upstream and from local vegetation.

Lower catchment

As the river widens and gathers more flow, it often becomes deeper and more turbid. Close to the sea or a large lake, it travels very slowly and deposits the large quantities of sediment it has been carrying from further upstream.

Here, vegetation has little effect on the physical shape of the channel. Aquatic plants with roots may grow in the turbid water along the shoreline and algae may grow in the shallows attached to stones or other objects. Collector macro-invertebrates are common in this stretch of the stream, filtering out minute food particles suspended in the water and gathering fine particles that have settled to the river bottom.

Dissolved oxygen levels are often reduced in the lower catchment. In slow moving areas the stream bottom becomes silty from a continuous supply of fine sediment from upstream. There is less mixing between the water and atmospheric oxygen with the result that oxygen levels are not replenished quickly in sediments. The breakdown of organic matter by bacteria further decreases dissolved oxygen levels in sediments. Organisms that tolerate lower oxygen levels are more common in this section of the river.

Table 1.2: Typical changes in physical characteristics, food production and macro-invertebrates of a river from the upper to lower catchment

	Upper catchment	Middle catchment	Lower catchment
Physical characteristics			
Altitude	High	Decreasing	Low
Slope	Steep	Generally decreases	Flat
Velocity	Fast	Generally decreases	Slow
Depth	Shallow	Deeper	Deepest
Width	Narrow	Generally increases	Wide
Bottom	Rocky stream-bed	All types	Gravel, sand, silt or mud
Turbidity	Clear water	Generally increases	More turbid
Percentage shading	High	Generally decreases	Low
Temperature	Cold	Increasing	Warmer, possible stratification (layering)
Dissolved oxygen	High	Generally decreases	Lower
Nutrients	Low	Generally increases	Higher
Food production			
Plant growth	Minor	Attached algae and large rooted plants	Free floating algae and large plants at margins of river
Food source for macro-invertebrates	Mainly coarse pieces of streamside vegetation (dead leaves)	Increasing proportion of fine particles	Mainly fine particles
Macro-invertebrates			
Feeding types	Shredders and collectors dominate	Grazers and collectors dominate	Filtering collectors dominate
Body shapes	Adapted to fast moving water e.g. streamlined body shape	Wide variety of body shapes	Adapted to slow moving water e.g. burrowers
Abundance	Low	Generally higher	Generally lower
Diversity	Low	Generally higher	Generally lower

How does water flow affect water quality?

Flow rate affects water temperature, dissolved oxygen, turbidity and pollution levels.

Stream flow is altered by weirs and dams. These man-made obstructions reduce the flow of water downstream and even out the natural high and low flows to which many ecosystems, especially wetlands, have adapted.

Low stream flows

Under low-flow conditions (baseflow) water entering the watercourse is largely groundwater from sub-surface seepage. The visible presence of orange iron stains may be evidence of this. During low flows the waterway can become semi-stagnant resulting in:

- reduced flushing of pollutants;
- increased algal growth;
- low dissolved oxygen levels, particularly at night;
- increased salinity where this is a problem; and
- larger temperature variations which increases stress on living things.

Moderate stream flows

The best water quality usually occurs under moderate flow conditions where there is sufficient flow to ensure:

- dilution and flushing of pollutants;
- limits to the build up of algae; and
- good oxygenation of the water.

High stream flows

During and immediately after heavy rainfall, water flows over the surface of the ground, picking up pollutants, which results in:

- increased sediment load (i.e. increased turbidity); and
- increased nitrate and phosphate levels.

Estuaries

Tidal movements almost totally dominate flow patterns in estuaries. Except in times of flooding, water in estuaries moves in and out with the tide. This affects:

- movement of litter and sediment; and
- movement of discharge from stormwater pipes and sewerage systems.

It is usual practice to test water quality on an ebb tide (outgoing).

How does pollution affect streams?

Water in a stream is always moving and mixing. Pollutants that enter the stream travel some distance before they become well mixed. At the discharge site and immediately downstream, water quality might be very poor but stream water quality may recover as pollutants are diluted with more water. Unfortunately, most streams are often affected by more than one source of pollution.

Point source and diffuse pollution

Pollution is broadly divided into two kinds depending on the source. Point source pollution comes from a clearly identifiable source, such as a pipe, which discharges material directly into the waterway. Typical sources of such pollution include factories, wastewater treatment plants, and illegal pipes direct from homes and boats.

The source of diffuse pollution (non point source) is more difficult to identify because it originates over a broad area from a variety of causes. Examples include:

- sediment from housing developments, timber harvesting, and mining;
- fertilisers and pesticides from croplands, forests, homes, local parks and golf courses;
- bacteria from leaking sewer lines, animal wastes from livestock, wildlife and domestic animals;
- bacteria and leachate from leaking landfills, open dumps and litter;
- oil, grease, heavy metals and toxic compounds from urban streets and parking areas;
- accidental chemical spills; and
- atmospheric fallout from cars, buses, planes, factories, power plants and wood burning stoves.

Solving point source and diffuse pollution problems

If the problem is caused by a point source, such as a pipe discharge into a lake, it can easily be identified and tested. Permits for discharging directly into waterways are required by law. If monitoring indicates a problem, a government agency can be asked to take action. These kinds of problems can be solved with engineering solutions.

If the cause is diffuse pollution it is more difficult to solve, where identifying the sources is a challenge. Because diffuse pollution originates over a large area, it is necessary to monitor many sites to actually find the main source or sources of the problem. Surveying land use, stream hydrology and riparian vegetation can help determine the causes. Fixing diffuse pollution will require you to work with many different land managers.

What are wetlands?

Wetlands are areas featuring permanent or temporary shallow open water. They include billabongs, marshes, swamps, lakes, mud flats and mangrove forests. A wetland is virtually any land which is regularly or occasionally covered with water that is still or flowing, fresh, brackish, or saline, including areas of sea water which does not exceed a depth of six metres at low tide.

Wetlands usually occur next to creeks and rivers, near the coast and even in arid desert areas. They can range in size from a small swamp to a vast shallow lake.

There are many types of wetlands. Those that contain water all year round are called permanent wetlands and those that only fill seasonally are called temporary wetlands. Another type, ephemeral wetlands, only occasionally contain water after heavy rains or during floods. This may occur very infrequently, perhaps once every ten or more years.

The quality of water in wetlands will vary depending on the location. The salinity (how salty or fresh the water is) determines the type of plants and animals present.

Some wetlands are valued landscapes because of their scenic beauty and popularity as recreational sites. However, their attractive appearance can sometimes lead to problems through overuse, for example, trampling, noise, pollution, bank erosion, and over-fishing.

Why are wetlands important?

Wetlands are among the world's most diverse and productive environments providing essential habitats for many species of plants and animals. Many wetlands are also essential for supporting human populations and their continuing loss or deterioration is a major global concern.

Wetlands are important for a number of reasons:

- They are breeding grounds for many animals especially fish and waterbirds. In Australia, the billion dollar commercial and recreational fishing industries depend on the health of wetland areas.
- They are vital habitats for the survival of many species, some of which are in danger of extinction, for example, the Western Swamp Tortoise, the Orange-bellied Parrot, the White-bellied Frog and the Honey Blue-eye Fish.
- They support wildlife which can help control insect pests on farms.
- They are natural firebreaks.
- They are important drought refuges for wildlife.
- They provide places for a range of recreational activities such as swimming, fishing and boating.
- They help purify water by acting like kidneys along waterways, filtering sediments, nutrients and other pollutants from the water.

Water which moves down creeks and rivers can pick up all sorts of silt, rubbish and contaminants, particularly in stormwater runoff from city and suburban areas. When this water enters a wetland it slows down and its contents settle. Pollutants are naturally filtered and much of the washed-down material can be used as nutrients by wetland plants, which in turn nourish birds, fish and other animals. Bacteria and viruses carried in the water are killed by exposure to plenty of sunlight as the water is spread over a large surface area. Some are also eaten by microscopic water life.

This filtered water can now gently flow out of the wetlands into a river system or out to sea. It is cleaner and healthier, protecting the health of plants, fish and other animals it meets downstream.

How can you tell if a wetland is healthy?

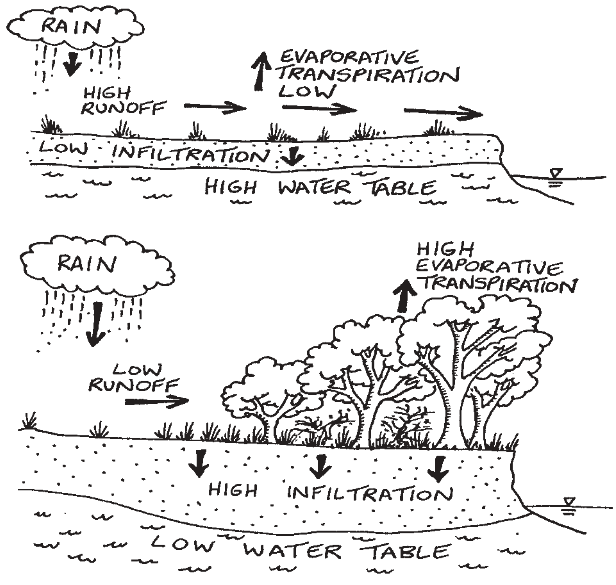
The vegetation growing in and around a healthy wetland will show no signs of stress. Healthy wetlands will often be surrounded by diverse and abundant communities of native plants, with few weeds. The area of vegetation surrounding a stream or wetland is sometimes called the buffer zone because the vegetation 'buffers' the stream or wetland and its animal communities from the adverse effects of land management activities within the catchment (see Figure 1.5 on page 16).

The buffer zone does this by:

- reducing water runoff from surrounding land into the stream or wetland;
- reducing the amount of sediments, contaminants and nutrients in this runoff;
- preventing invasion by exotic plants, such as willows;
- protecting fauna from disturbance; and
- providing wildlife corridors.

Inadequate buffer zones are one of the causes of degradation of wetlands and waterways.

Figure 1.5: Ways in which a riparian buffer can intercept runoff



Munks, S. 1996 *A Guide to Riparian Vegetation and its Management*; Department of Primary Industry and Fisheries, Tasmania.

Water quality will also give a good indication of wetland health. Poor water quality in the wetland might arise from the poor quality of inflows or from local contamination. Some wetlands along the Murray River, for example, have been badly affected by salinity. Often this will be obvious, as the soil will have traces of salt on the surface and some of the surrounding plants may be stressed or dead. Specialised types of plants that thrive on salty soil may be found here instead of the original plants.

One of the best ways to tell if a wetland is healthy is to take a sample of water and check for the presence of macro-invertebrates. If healthy, you can expect to find a diverse and abundant macro-invertebrate population. Conversely, expect low diversity and variable abundance in less healthy wetlands.

Changes to wetlands

In some natural wetlands the plant and animal communities have adapted to a cycle of drought and flood. There is a natural succession of plants as the environment changes. Flooding is often a trigger for many animals, such as fish and birds, to breed, and for growth and flowering of many plants.

These natural changes are disrupted by such events as permanent flooding or draining a wetland for agriculture. In the Murray–Darling Basin, many wetlands have been partly or completely drained, while those wetlands adjacent to weirs on the Murray River are now permanently flooded.

As well as this, introduced pest species, such as, carp, mosquito fish and willows, can dramatically alter wetlands.

What is an estuary?

Estuaries contain a wide variety of habitats where fresh and salt water meet and mix in a continually changing environment.

Fresh water does not readily mix with salt water. Fresh water flowing from upstream is relatively light and rides over the more dense salt water from the ocean. This difference in density causes layering or stratification of the water, which in turn affects water quality and currents in the estuary. If tidal flow is very strong, the fresh and salt water layers may completely mix.

Unlike the one-way flow of rivers, water in estuaries often cycles backwards and forwards before finally leaving. Water-borne pollutants and sediment may remain in the estuary for a long time and harm plants and animals. This is particularly so in estuaries that are large but have a narrow opening to the ocean.

Why are estuaries important?

Estuaries support multi-million dollar fisheries and recreational activities throughout Australia. Sea grass beds in estuaries provide nursery grounds for fish, habitat for wildlife, nutrient uptake, shoreline protection, oxygen supply, recreation and ecotourism.

Changes to estuaries

Estuaries receive human sewage, farm runoff, industrial wastes and other contaminants. Toxic substances affect the health of fish, wildlife and humans; bacterial contamination threatens recreational users and shell fish farms; and nutrients trigger algal blooms. Algal blooms have caused destruction of sea grass beds and in turn the loss of habitat for prawns, and food for fish and dugong. The apparent silting up of some estuaries is due to an increase in the fine particle loads in rivers caused by changed land use such as sand mining or clearing vegetation for farms, industry and urban settlement. High turbidity readings are particularly evident after heavy rainfall and particulates in the river water tend to clump together (floc) and settle out upon meeting the brackish and salt water in an estuary.

Measuring estuarine health

Although estuaries are complex systems with many habitats, plants and animals, and physical and chemical conditions, a few indicators are suitable for measuring environmental health. These include:

- dissolved oxygen levels which controls the presence or absence of estuarine species and can vary with depth if the water is stratified;

- nutrients – nitrogen and phosphorus are critical for survival of aquatic biota, however, an over abundance can trigger uncontrolled growth of algae;
- submerged aquatic plants provide shelter, habitat, food and oxygen and are indicators of estuarine health; and
- bacteria – faecal bacteria indicate the possible presence of disease organisms such as dysentery, typhoid or hepatitis which threaten recreational users or consumers of contaminated shellfish.

What is groundwater?

Groundwater is any water that is stored below the plant root zone; it is more commonly thought of as water which occupies openings, cavities and spaces in layers of rocks well beneath the surface of the earth. Where saturated rocks are permeable enough to transmit significant amounts of groundwater, they are called aquifers.

The source of most groundwater is rainfall and surface water which filters through the soil profile down into the aquifers. Groundwater varies considerably in quality, from pure water with little dissolved matter (in some cases better quality than most rivers and streams) to highly mineralised waters, sometimes more saline than sea water. Salinity is a measure of the amount of different inorganic chemical compounds (salts) which are dissolved in water (see Module 4).

Why is groundwater important?

About 97 per cent of the world's fresh water is stored under the ground in aquifers. The economy of many parts of Australia relies in part on the availability of groundwater supplies for:

- town water supplies;
- animal grazing;
- crop irrigation; and
- mining and industry.

Groundwater, however, is not just important for supply purposes. It plays a vital role in the water cycle. It may take a long time (possibly thousands or millions of years) but water which filters underground can flow out into rivers and eventually find its way back to the ocean.

Groundwater flows from the soil profile into rivers. It can sustain water flow long after rains have ceased in a catchment. Groundwater can, therefore, have a major impact on the volume and quality of surface water supplies. If groundwater quality and flow deteriorates, so too can the lakes and rivers connected with it.

Like surface water, groundwater quality can change over time. Changes in quality generally take place slowly and can be due to natural causes, such as fluctuating storage levels in aquifers arising from changes in rainfall. However, they can also be due to human actions such as:

- Clearing the land of trees and native vegetation can lead to more water filtering into the ground and less evapo-transpiration from trees. The result is rising groundwater levels which can transport salts to the soil surface and discharge salts into streams.
- Excessive pumping of groundwater for irrigation, where groundwater levels rise to, or near the land surface, evaporation can concentrate salts in the soils, making them unproductive. Shallow groundwater levels can also cause waterlogging and reduce the productivity of the land.
- Contamination from polluted surface waters, where partially saline groundwater is used for irrigating crops, it is possible that increased salinity in underlying aquifers will occur. This can cause the migration of natural salt accumulations into otherwise salt-free areas.
- Direct contamination from pollutants stored underground, for example, septic tank effluent, can lead to increases in nitrate in underlying aquifers.

Groundwater pollution

Groundwater pollution is very serious due to the great difficulty and costs involved in cleaning up polluted aquifers. Because of the relatively slow rates of groundwater flow in aquifers, it may take many years before contamination from a distant source reaches water supply bores.

Important things to remember

Before you begin waterwatching consider safety, courtesy, environmental and legal matters.

Safety considerations

Clothing and protection

- Wear proper clothing and footwear, including long pants, long socks, long-sleeved shirt, sturdy waterproof shoes with a good grip, a hat and latex rubber gloves. Warm clothing and a raincoat are essential in cold and wet weather. Wear a hat and use sun screen in sunny weather. Take a towel to dry your hands.
- If your site is in a heavily vegetated area, wear bright, easily visible clothing.
- Wear life jackets when sampling from boats or in other dangerous situations.

Medical

- Know any important medical conditions of group members, for example, allergies to bee stings.
- Take a fully stocked first aid kit with you when venturing into the field for surveys or samples.
- Do not sample if you have broken skin (cuts etc.). Use latex rubber gloves or get someone else to do the sampling.
- Take care when handling chemicals. Always use safety gloves and glasses and avoid contact with skin, eyes, nose and mouth.
- Carry drinking water with you. Do not drink from the water you are surveying or testing as it may be polluted. In particular, when sampling in urban areas, do not put your hands near your mouth, or eat or drink while testing the water.

Avoiding potential problems at the site

- When selecting a site for monitoring or surveying, choose one that has safe and easy access to the streambank or wetland and the water. You need only gain access to one bank and simply observe the other when conducting the surveys. Check that the stream bank is stable and not too slippery. Do not choose a monitoring site in a place that is prone to floods without warning.
- Let someone else know how long you intend being out and where you will be sampling.
- Never survey alone. Work with at least two other people. If one of you is injured, one person can go for help and one can stay with the injured person.
- Carry coins for a phone in case you need to make an emergency call. Make sure you know where the nearest phone is located, or carry a fully charged mobile phone (you may not have service, however, if you are in a remote area).
- Do not enter the water to take samples if it is more than knee deep. Sampling can generally be done from the water's edge, except for macro-invertebrates which need to be sampled in shallow riffles, less than knee deep. When entering these shallow waters, make sure you wear gum boots with a good grip. Do not enter barefoot as cuts are common and you could easily lose your foothold.
- Be careful of hidden objects, holes, snakes, prickly vegetation etc. when walking to the waterway or along the bank. Always watch where you are going and never put your hands or feet in places where you cannot see.
- Know how to clean up chemical spills and be familiar with the Material Safety Data Sheets that are provided with chemical reagents.
- Do not allow children to sample without adult supervision.

Waterwatch group leaders and coordinators are responsible for passing on safety procedures and must instil an ethic of due diligence and care into all participants in the project. Teachers must check Education Department safety and excursion guidelines.

Waterwatch groups must ensure students and young people involved in Waterwatch are well supervised. They must be properly advised about all likely risks and be adequately instructed about how to carry out the tasks.

Courtesy considerations

- If you must cross private property to reach your survey site, first seek the property owner's permission.
- If you need to cross farm fences, crawl through or under them. Do not stand on the wire, as this may damage the fence.
- Leave all gates as you found them.

Environmental considerations

- Look at and photograph animals and plants but do not harm them.
- Take away more litter than you brought in.
- Avoid muddying the waters, leave clear water where possible.
- Collect chemical waste water generated from monitoring in a waste liquid bottle and solid waste in a plastic bag.
- Sample macro-invertebrates at a site no more than three or four times per year.

Appendixes

These appendixes consist of key terms you will need to understand as well as a list of land uses and their impacts on the environment. Both appendixes are arranged in alphabetical order.

Key terms

Accuracy – measure of how close repeated measurements are to the accepted or true value. Accuracy can be measured as a standard deviation.

Acid – a substance that releases hydrogen (H^+) ions in solution. Acid solutions have a pH value less than 7 units.

Aerobic – living or occurring in the presence of oxygen; organisms and processes that require free oxygen.

Algae – unicellular, multicellular, or colonial aquatic photosynthetic plants which do not have true roots, stems, or leaves.

Algal bloom – extensive growth of algae in or on a body of water; blooms may occur from excess nutrients in waterbodies, or from particular climatic conditions.

Ammonia (NH_3) – colourless gas consisting of nitrogen and hydrogen atoms which is very soluble in water. Ammonium (NH_4^+) is the ionic form of ammonia.

Anaerobic – living or occurring without oxygen.

Anoxic – conditions where oxygen is absent.

Aquatic – living in or on water.

Aquatic vegetation – includes emergent, submergent and floating plants. *Emergent plants* include those species with true stems, roots and leaves, and most of their vegetative parts above the water. *Submergent plants* include similar species to emergent plants except that they are completely immersed in the water. *Floating plants* are those species which are not fixed in place but are carried by the water.

Aquifer – any rock or soil layer capable of storing water and which allows water to pass through.

Arable – land suitable for the economic production of crops, usually involving regular cultivation.

Autoclave – an apparatus used to sterilise objects by means of steam under pressure.

Autotroph – any organism able to use inorganic substances, e.g. carbon dioxide, to make their own chemical compounds using either sunlight (photosynthesis) or chemical energy (chemosynthesis).

Bacteria – single-celled microscopic organisms which break down organic material.

Bank – sloping ground bordering a river, stream or lake.

Baseflow – water that has sunk deep into the soil and met the groundwater which seeps into a creek.

Basin – area of land drained by a river and its tributaries.

Bedload – the sediment that moves by sliding or rolling along the bed of a channel due to the action of the water.

Benthic – plants or animals living in or on the bottom of a water body.

Best Management Practices (BMPs) – any engineered structure or management activity or combination that eliminates or reduces the adverse effects of pollutants.

Biochemical Oxygen Demand (BOD) – the amount of dissolved oxygen required for aerobic organisms to break down organic matter in a volume of water. BOD is an estimate of organic loads in water samples.

Biodegradable – compounds and materials capable of being decomposed by micro-organisms.

Biomass – the amount of living material existing at a given instant of time in a specified area or unit volume.

Bore – a deep hole that reaches an underground water source and through which water rises due to hydrostatic pressure.

Brackish – water that contains dissolved salts in the range 800 to 50 000µS/cm (500 to 30 000mg/L), which is less than sea water (58 000µS/cm or 35 000mg/L).

Buffer zone – an area of vegetation surrounding a water body which protects it from the effects of human activity by minimising runoff and erosion.

Buffering capacity – the ability of a solution to resist a change in pH when an acidic solution is added.

Calibration blank – deionised water processed as a sample. It is the first sample analysed and used to set the meter to zero.

Calibration standard – solutions of known concentration used to calibrate a meter before running a test.

Carnivore – an animal that feeds on other animals.

Carrying capacity – the maximum number of animals that can be supported by an ecosystem without the ecosystem suffering deterioration.

Catchment – an area or basin of land bounded by natural features of hills or mountains from which all run-off water drains to a river, stream, lake, wetland or estuary. Also known as a watershed (American).

Channelisation – process of altering the channel of a watercourse by deepening, straightening, or lining the bed with cement or other materials to direct the flow of water or prevent flooding.

Chlorination – the addition of chlorine to wastewater or drinking water to disinfect the water.

Chlorophyll – the green pigment in plants that enables them to use the energy of the sun for photosynthesis.

Coarse particulate organic matter (CPOM) – food particles e.g. leaf fragments greater than 1mm in size.

Coliform bacteria – bacteria found in the intestines of warm blooded animals that help digestion. They are used to indicate faecal contamination in water quality analysis.

Combined Sewer Overflow (CSO) – sewer systems in which sanitary waste and stormwater are combined in heavy rains; common in older cities. Discharge from CSO is usually untreated and flows directly to streams.

Community – the assemblage of plant and animal populations inhabiting a given area.

Completeness – a measure of the amount of valid data actually obtained compared to the amount expected to be obtained; usually expressed as a percentage.

Confluence – place where a tributary joins a river.

Contour bank – a constructed earth bank which follows the contour of the land and is used to direct water flow over the land to prevent erosion and drainage problems.

Culvert – a covered channel or large pipe that diverts the natural flow of water.

Decomposition – breakdown of organic materials by micro-organisms.

Deionized water – water that has had all the ions (atoms and molecules) other than hydrogen and oxygen, removed. Sometimes called distilled water.

Designated uses – a formal list of desirable uses that a waterbody should support such as fishing, swimming and aquatic life.

Detection limit – the lowest concentration of a parameter that a given method or piece of equipment can reliably determine and report as greater than zero.

Detritus – small pieces of dead and decomposing plant and animal material.

Diffuse-source pollution – contaminants that have originated from a widespread area or from various dispersed locations, such as roads, shopping centres and agricultural activity. Also known as non-point source pollution.

Discharge – release of liquid into a water body such as treated waste water from industrial plants, power plants and wastewater treatment plants; also refers to volume of run-off which enters water bodies.

Discharge zone – an area where the groundwater moves upward and escapes through natural springs, evaporation, transpiration and surface drainage.

Dissolved Oxygen (DO) – oxygen gas (O_2) dissolved in water.

Distilled water – water that has most of its impurities removed. Also known as deionised water.

Drift – the down-stream, free-floating movement of, normally benthic, animals in a flowing river or stream.

E. coli *(Escherichia coli)* – a species of bacteria belonging to the faecal coliform group which is found in the intestines of warm blooded animals in large numbers. The presence of E. coli in water is considered to be evidence of fresh faecal contamination.

Ecosystem – a community of living organisms and their non-living (abiotic) environment functioning as one system e.g. a pond ecosystem.

Edge water – is an area near the bank with slow or little current compared with the main flow. Vegetation may be overhanging and surface-dwelling insects can be present in well sheltered edge waters.

Effluent – waste material, such as sewage, discharged into the environment.

Electrode – an electric conductor through which current flows.

Emergent plants – plants rooted underwater but with their tops extending above the water.

Endemic – plants or animals peculiar to a particular geographical area.

Ephemeral stream – one that only flows for a short time, e.g. after rain.

Erosion – the wearing away of the earth's surface by running water, wind, ice or other geologic agent or process, including weathering, dissolution, abrasion and corrosion.

Estuary – a body of water adjacent to the sea, typically at the mouth of a river, in which the tide ebbs and flows. At its mouth it meets the ocean but its upstream limit is marked by the extent of tides.

Eutrophication – enrichment of a waterbody by nutrients (mostly nitrates and phosphates) from erosion and run-off from the surrounding land. This process is natural but can be accelerated by human activities, e.g. sewage disposal and fertiliser run-off.

Evaporation – the process by which water changes its physical state from a liquid to a gas.

Evapo-transpiration – the process of living plants transforming water into vapour that is released into the atmosphere.

Exotic species – an introduced non native species, e.g. weeds, feral animals.

Faecal – relating to animal or human excrement.

Fauna – animal life.

Fertilizer – any substance, natural or manufactured, added to the soil to supply nutrients for plant growth.

Field blank – deionised water treated as a sample; also known as a trip blank.

Field replicates sample – a duplicate sample that is collected at the same time and place. It is used to measure precision of sampling and analysis.

Filamentous – plant body of some types of algae, made up of thread-like rows of similar cells.

Filter feeder – animal that filters microscopic organisms from water.

Fine Particulate Organic Matter (FPOM) – consists of fine food particles less than 1mm in diameter.

First flush – initial flow of storm water run-off that often contains high concentrations of contaminants that have built up during the previous dry period.

Fish kill – the sudden death of fish; usually due to the introduction of pollutants and/or the reduction of dissolved oxygen concentrations in a water body.

Flagellum/flagella – a whip-like structure present in motile algae, which serves as an organ of propulsion.

Flocculant (floc) – mass of particles that form into clumps as a result of a chemical reaction.

Flood plain – a relatively level part of the valley that is covered by water during a major flood. It is formed from deposits laid down from previous flooding.

Flora – plant life.

Fluvial – belonging to or produced by a river.

Food chain – a 'chain' of organisms, through which energy is transferred. Each organism in the chain feeds on and obtains energy from the one preceding it, and in turn is eaten by and provides energy for the one following it, e.g. plant to herbivore to carnivore.

Genera (genus) – group of closely related organisms. Only the species group contain more similar organisms.

Glide/pool – section of the stream with low velocity and with little or no turbulence on the surface of the water.

Grazer/scraper – animals that consume algae and associated material attached to the surface of submerged plants or rocks.

Groundwater – water that infiltrates into the earth and is stored in the rock and soil below the earth's surface.

Habitat – preferred place or home for each species of plant and animal to live and reproduce.

Headwaters – upper tributaries of a stream.

Heavy metals – a metal whose specific gravity is approximately 5.0 or higher e.g. copper, cadmium, zinc, nickel, mercury and chromium. They are present in industrial, municipal and urban run-off.

Herbicide – a chemical substance used for killing plants, usually weeds.

Herbivore – an animal that feeds solely on plants.

Hydrograph – a graph showing the seasonal variation in the level, velocity or discharge of a body of water.

Hydrology – applied science concerned with the water cycle which includes precipitation, run-off or infiltration, storage and evaporation.

Impact site – a site located immediately downstream of a pollution source where the pollutant is completely mixed with the water.

Impervious surface – a surface that resists the penetration of water, e.g. asphalt roads.

Impoundment – body of water contained by a barrier such as a dam.

Infiltration – the movement of water through the pores of soil or other porous medium.

In-stream cover – the amount of living space or hard substrate available for aquatic life. In-stream cover includes aquatic plants, snags, logs, rocks, branches and islands. Many insects begin their life underwater and need to attach themselves to a firm surface. Fish and other aquatic organisms require in-stream cover where they can feed, and shelter from predators and the current. These sites also help them establish territories, reproduce and provide markers that help in navigation. Aquatic plants provide food and oxygen for fish and other creatures in the stream. Islands and protruding snags provide roosting and preening sites for birds; concrete lined channels or drainage lines provide almost no in-stream cover that is necessary for the survival of aquatic life.

Integrated catchment management (total catchment management) – management of land, water and other biophysical resources and activities on a catchment basis.

Invertebrates – organisms without a backbone.

Ions – electrically charged molecules formed by the loss or gain of an electron.

Land use – purpose for which land is used; activities that take place on land such as construction, farming or tree clearing.

Larva (plural: larvae) – developmental stage of an insect in which it proceeds from an egg to larva to pupa to adult.

Leachate – water carrying impurities which has percolated through contaminated soil, e.g. from a rubbish tip or mine site.

Leaching – the process in which water percolating through the earth dissolves many substances and then carries them away in solution or suspension.

Limiting factor – a factor such as temperature, light, water or a chemical that limits the existence, growth, abundance, distribution or presence of an organism.

Load – volume or mass of a substance transported by a river, which is derived from multiplying the concentration by the flow rate over a specific period of time.

Macro-invertebrate – animal lacking a backbone and visible to the unaided eye, e.g. crayfish.

Macrophytes – large aquatic plants that can be seen with the unaided eye.

Mangroves – a swamp forest in tidal, saline or brackish water which grows along the shore of estuaries.

Meanders – bends in the course of a river which continually curve from side to side in wide loops.

Metabolic rate – the rate at which an organism uses energy to sustain essential life processes such as respiration, growth and reproduction.

Metamorphosis – period of transformation from a larva to adult.

Micro-organisms – single celled microbes (plants, fungi, animals, viruses) that are invisible to the unaided eye.

mL – millilitre: one thousandth of a litre.

ML – megalitre – one million litres (approximately the quantity contained in one Olympic-sized swimming pool).

Motile – capable of motion, particularly locomotion in some algae through the beating of flagella.

Mystery (unknown) samples – solutions made up by a quality control lab. The concentrations of particular indicators are unknown to samplers.

Nitrate (NO_3) – main source of nitrogen for plants; fertiliser consisting of sodium nitrate or potassium nitrate is an agricultural and urban pollutant.

Nitrogen (N) – one of the major nutrients required for the growth of plants, it is usually present as organic nitrogen, ammonia, nitrate and forms of nitrite. Excess nitrogen can cause accelerated eutrophication in water bodies.

Non-point source pollution (NPS) – a source of pollution that cannot be pinpointed as it comes from many individual places. Also called diffuse-source pollution.

Nutrient – an element or compound such as nitrogen, phosphorus or potassium that is necessary for plant growth.

Nymph – young, sexually immature stage of certain insects which is usually similar to the adult in form and where partial metamorphosis is undertaken, i.e. egg-nymph-adult.

Oligotrophic – water which is relatively low in nutrients.

Omnivore – an animal that eats both animals and plants.

Organic compounds – molecules that typically contain atoms of carbon and hydrogen. Oxygen and nitrogen may also be present.

Organism – any living individual plant or animal.

Outfall – pipe through which industrial facilities and wastewater treatment plants discharge their effluent (wastewater) into a water body.

Overclearing – the removal of trees and shrubs, particularly from steep areas which results in accelerated erosion by wind and water and can lead to salinity problems.

Overgrazing – continued grazing of pasture or rangeland at a level that permanently and adversely affects vegetation and leads to land degradation.

Overstorey – woody plants greater than 5m tall, usually with a single stem, e.g. eucalypt trees.

Parameter – a component of the environment or water that is being measured, e.g. temperature or nitrogen.

Parasitic – living off another organism (host).

Parts per million (ppm) – the number of parts by weight of a substance per million parts of liquid.

Pathogen – disease-causing organism such as bacteria, virus or fungi.

Pathogenic – capable of causing disease.

Peak flow – maximum flow of a waterway.

Percolation – downward movement through the subsurface soil layers to groundwater.

Periphyton – plants and animals that are attached to submerged objects such as rocks, macrophytes and tree debris; often microscopic.

Permeability – ease with which water flows through soil or rock.

Pesticide – any chemical or biological agent that kills plant or animal pests. Herbicides, insecticides, fungicides and rodenticides are all types of pesticides.

pH – a measure of the concentration of hydrogen ions in a solution. The pH scale ranges from 0 to 14.

Phosphorus (P) – a non-metallic element that is an important nutrient for all organisms. A deficiency is considered a major 'growth-limiting factor'. It is a common ingredient in fertilisers and cleaning agents. The Australian environment is adapted to very low levels of P in soils and water.

Photosynthesis – process that occurs in the cells of green plants where solar energy is used to combine water and carbon dioxide to produce a simple sugar such as glucose. As a result of the process, plants release oxygen.

Phytoplankton – small animals and plants which float or drift in a water body.

Pipette – eye dropper-like instrument that can measure very small amounts of liquid.

Point source pollution – pollution that can be traced to a single point such as a pipe or culvert which discharges industrial or wastewater treatment plant effluent.

Pollutant – any substance which causes pollution.

Pollution – any harmful or undesirable change in the physical, chemical or biological quality of air, water or soil as a result of the release of chemicals, radioactivity, heat or large amounts of organic matter.

Pools – distinct habitats within a stream where velocity is low and depth greater. The bottom sediments are usually soft. Pools are important habitats for fish.

Potable – suitable for drinking.

Precision – the degree of agreement among repeated measurements of the same characteristic on the same sample, or separate samples, collected as close as possible in time and space. It tells you how consistent and reproducible your field and lab methods are to each other.

Predator – an animal that kills and eats other animals.

Pristine – an environment which remains untouched and undeveloped.

Productivity – production of organic material.

Protocol – defined procedure.

Pupae – developmental stage of an insect between larva and adult.

Quality assurance (QA) – a broad plan for maintaining quality in all aspects of the program, e.g. training, keeping written records, quality control and reporting.

Quality control (QC) – those activities you do to ensure accuracy and precision of your monitoring/surveys. A QC program aims to ensure that the data are good enough for their intended use.

Reagent – substance or chemical for use in a chemical reaction.

Recharge zone – area of land where surface water from rain, irrigation or streams moves downward and infiltrates an aquifer.

Recovery site – a site located well downstream of a suspected pollution source which is monitored to see how far the pollution impact extends.

Reference collection – a standard set of plants or animals that is used to verify identification, e.g. macro-invertebrates.

Reference site – a site located immediately upstream of the potential pollution source and is unaffected by the pollution source.

Regulated river – a river in which structures have been built to control or divert the flow of water.

Relative percent difference – compares how close the result from a water sample is to the true result. Expressed as either a positive difference (the sample result is higher than the true value) or a negative difference (the sample result is lower than the true value).

Relative standard deviation – standard deviation expressed as a percentage.

Representativeness – the extent to which collected data actually represent the conditions you are monitoring. It is most affected by site location.

Respiration – a process in which animals and plants absorb and use oxygen from the surroundings and give off carbon dioxide.

Riffles – occur where rocks and debris in the stream create shallow areas over which the water rushes quickly to form a rapid. Because of the variety of rock sizes in the stream bed, riffles provide many different habitats for macro-invertebrates (water bugs) as well as richly oxygenated water.

Riparian zone – transition habitat between water and land. The riparian zone occurs between a normal river level and the edge of the flood plain and can vary from 5m to 100m or so wide and forms a transition between the watercourse and the land.

Riparian vegetation – vegetation found on the banks of a river or stream that is directly influenced by the presence of water. A healthy stream system generally has a healthy riparian zone. Damage occurs when riparian vegetation is cleared for roads, parking areas, buildings, fields, lawns, agriculture, timber harvesting, quarries, etc. Many streams in urban settings have almost no riparian vegetation.

Riprap – rock used on an embankment to protect the bank against erosion.

Run (glide) – a fast flowing area of a stream where shallow to deeper water flows gently and smoothly over boulders, rocks and gravel where the water's surface is not broken, that is, there is little or no turbulence at the surface.

Run-off – portion of rainfall, melted snow or irrigation water, that flows across the land's surface instead of soaking into the ground. Run-off may pick up and carry a variety of pollutants.

Salinisation – a process in which the concentration of salts in the root zone of the soil increases. This is often caused by the capillary rise of saline moisture from a shallow water table.

Salinity – concentration of salts, measured in milligrams per litre (mg/L) or microsiemens per centimetre µS/cm).

Salts – compounds that dissociate in water to yield a positively charged ion and a negatively charged acid radical ion.

Saturation – a point at which a solution contains enough of a dissolved solid, liquid or gas so that no more will dissolve into the solution at a given temperature and pressure.

Scavenger – animal that feeds on dead organic material.

Sediment – insoluble material suspended in the water that consists mainly of particles derived from rocks, soil and organic materials. It is a major non-point source pollutant to which other pollutants may attach.

Sedimentation – the transport and deposition of sediment particles by flowing water or wind.

Seepage – the process by which water percolates downwards and/or laterally through the soil, often emerging at ground level lower down a slope.

Sensitivity – related to detection limits, it refers to the capability of a method or instrument to discriminate between two samples that have very similar concentrations.

Sewage – domestic or commercial wastewater that contains human waste.

Sewerage system – a complete and contained pipe system that facilitates the collection, transportation, treatment and discharge of wastewater (sewage).

Shock-loading – the sudden introduction of pollution to a water body that severely impacts on aquatic life.

Silt – fine particles of mud or clay in a water body.

Siltation – the deposition of silt carried by flowing water.

Soil degradation – decline in soil quality, commonly caused through its improper use by humans. Examples are loss of organic matter, decline in soil fertility, decline in structural condition, erosion, adverse changes in salinity, acidity or alkalinity and the effects of toxic chemicals, pollutants or excessive flooding.

Soil salinity – characteristic of soils relating to their content of water-soluble salts; such salts predominantly involve sodium chloride, but sulphates, carbonates and magnesium salts may occur. High salinity adversely affects the growth of plants and therefore increases erosion hazard.

Soluble – dissolves in a solution, usually water.

Split sample – one sample that is divided equally into two sub-samples. Split samples are used to measure precision.

Standard deviation – a statistical measure used to compare how closely three or more results are clustered around the average value. It is expressed as a ± from the average value.

Storm flow – that portion of rain that leaves a drainage area in a comparatively short time; also called excess rainfall or surface run-off.

Stratification – formation of layers where different conditions such as temperature, light, nutrients, prevail in a body of water, e.g. thermal stratification.

Stream reach – a length of stream that has relatively similar features, e.g. numerous riffles.

Streambank – zone forming the margin of a stream channel which results from erosion and deposition of the stream; streambanks are identified right bank or left bank looking downstream.

Submergent plants – plants that live and grow fully submerged underwater.

Substrate – material forming the bottom of waterways. It includes:

- sand/silt/clay (less than 1mm); clay has a sticky cohesive feeling; sand is made of tiny gritty particles like sugar.
- gravel (1–20mm), a gravel bottom is made up of small stones about the size of your fingernail.
- cobbles (2–30cm), most rocks on this stream bottom vary from the size of a marble to a basketball.
- bedrock/boulders (more than 30cm), boulders are larger than a basketball and the bedrock is solid.

Surface run-off – water originating from rain or snow that flows across land surfaces instead of soaking in.

Suspended sediment – the sediment that is being transported by water or air while held in suspension.

Taxon (taxa) – any named group of organisms; level of classification within a scientific system that categorises living organisms based on their physical characteristics.

Taxonomic key – reference guide used to identify organisms.

Through flow – flow of water through the ground. Water which has been absorbed into the top soil then moves downhill to a water body.

Titration – addition of small, precise quantities of a reagent to a sample until the sample reaches a certain endpoint, which is usually indicated by a colour change.

Tolerance – the degree to which an organism is able to endure normally unfavourable environmental conditions.

Topographic map – a map that shows the surface features of a region.

Topography – the representation of surface features of a region on maps or charts.

Total dissolved salts – dissolved salts in water.

Toxic – being harmful, destructive or deadly to humans, animals or plants.

Toxic chemicals – any chemical that causes death or harm to humans, animals or plants.

Trace metals – naturally occurring metals found in minute quantities in the environment.

Transpiration – the process by which water taken up by plants from the soil, is evaporated from tiny pores on the leaf surfaces to the atmosphere.

Tributary – a smaller stream that flows into a larger one.

Turbidity – the cloudy or muddy appearance of a naturally clear liquid caused by the suspension of particulate matter.

Understorey – the zone consisting of shrubs, herbs and grasses growing underneath trees. Understorey shrubs are woody plants less than 5m tall, frequently with many stems near the base.

Unknown (mystery) samples – solutions made up by a quality control lab. The concentrations of particular indicators are unknown to samplers.

Verge – the area commencing at the top of the bank and extending from the bank to the next major vegetation or land use change.

Water cycle – movement of water from the atmosphere to the earth and back to the atmosphere through precipitation, run-off, infiltration, percolation, storage, evaporation and transpiration.

Water logged – the condition of a soil saturated with water and lacking most or all of the soil air. The condition may be caused by excessive rainfall, poor soil drainage or excessive irrigation.

Water pollution – any human-caused contamination of water that reduces its usefulness to humans and other organisms in nature.

Water quality criteria – maximum concentrations of pollutants that are acceptable if waters are to meet water quality standards.

Water table – upper surface of the zone of groundwater saturation.

Watercourse – channel, having a defined bed and banks which surface water flows on a permanent or intermittent basis under natural conditions, e.g. creeks, springs, streams and rivers.

Watershed – a dividing ridge between two catchments. Also a North American term for catchment.

Wetland – areas featuring permanent or temporary shallow open water. Land which is regularly or occasionally covered with water that is still or flowing, fresh, brackish, or salt, including areas of marine water which does not exceed a depth of 6m at low tide. Includes billabongs, marshes, swamps, lakes, mud flats and mangrove forests.

Woody debris – stems, branches or roots of dead or living trees that have fallen into the stream. It helps to form important fish habitats, such as pools, and provides hiding places.

Zone of saturation – the underground area above an impermeable layer where water fills all open spaces between rock, sand and soil particles.

Land uses and their impacts

Aquaculture in estuaries. Estuaries are often the site of aquaculture industries. Estuaries are also important nursery grounds for many species of fish. Water quality in estuaries is affected by human activities upstream and the amount of tidal flushing as well as effluent from aquaculture.

Construction activities can harm nearby waters in three ways. The first occurs when natural land cover is disturbed during excavation and grading operations. Soil stripped of its protective vegetation can be easily washed into nearby surface waters. Second, stormwater run-off often carries material used on the site, such as oil, grease, paints, glues, preservatives, acids, cleaning solutions and solvents, into nearby lakes or streams. Third, badly designed and managed projects can accelerate run-off and cause erosion.

Croplands and pastures. Run-off from croplands and pastures may carry chemicals, sediments, nutrients, bacteria and organic material into nearby lakes and streams. Nitrates and pesticides can seep from agricultural lands and contaminate underlying groundwater supplies. Sediment is often the main pollutant entering waters in these areas. Cropland and pasture erosion is the most significant source of sediment. Good water quality and soil erosion management practices by individual land managers are the key to stopping valuable soil loss. This also protects water quality by preventing movement of sediment and other pollutants from croplands to waters.

Dams along a watercourse may change the water conditions, not merely during and immediately after their construction, but through their existence. Upstream, the raised water level behind the dam wall increases stream width and depth and this will affect erosion, sediment load and water temperature. Downstream the dam will suppress the natural fluctuations in the flow. The need to produce electricity at certain times will lead to large and/or repeated releases of stored water, or even cause the stream to dry up, if all the inflow is retained. These changes affect the stream characteristics, especially water temperature, when discharges are drawn from the relatively deep and cold water in the storage. As many large dams are in unpolluted remote areas, the changes in water flow may harm relatively sensitive ecosystems.

Draining wetlands. Wetlands are complex natural systems that provide an important habitat for many species and act to filter water and remove many pollutants. Draining of wetlands can result in release of acid drainage from acid-sulfate soils.

Fertilisers. Nitrogen, phosphorus and potassium are the three primary nutrients applied to crops, gardens and lawns as fertilisers. Phosphorus entering water bodies in run-off from over-fertilised areas can cause heavy algal blooms and excessive weed growth, making waters unsuitable for drinking, swimming, waterskiing and other uses. The presence of nitrates in rural well water presents a risk to infants who may develop methaemoglobinaemia (blue-baby syndrome). Studies have indicated that nitrogen in fertilisers and manures are probable sources of elevated nitrate concentrations in rural groundwater supplies.

Forest practices. Waters in forested areas are usually of high quality, so pollution, if it does occur, is likely to harm a valuable and relatively sensitive ecosystem. Forestry activities that can transfer pollutants or sediments from land to water are:

- construction of roads,
- clearing of land for fire breaks,
- stacking and loading operations during harvest,
- mechanical site preparation,
- controlled burning for site preparation, and
- application of pesticides and herbicides.

Golf courses are great places for recreation but to keep them in peak condition the grounds person may use lots of fertilisers and pesticides. The water hazards and the creeks that flow through golf courses can be affected by these activities. It is also possible that the groundwater in the area may be affected.

Livestock operations. Animal feedlots are pens and buildings used to confine animals for feeding, breeding, raising, or holding purposes. They include open ranges used for feeding and raising animals and/or poultry, but do not include pastures. Poor feedlot management can allow stormwater run-off to carry pollutants from accumulating manure into surface and groundwaters. Feedlots can create significant pollution problems. Pollutants include nutrients, organic materials and bacteria that may affect humans and animals. High nitrate levels in the groundwater have been associated with improper storage of animal manure.

Mining operations can cause dramatic changes in surrounding catchments. Lakes, streams and groundwater can be polluted by sediments, tailings, dust, chemicals and wastes from open pit, strip and underground mines.

On-site sewage disposal systems. Many homes are not connected to municipal wastewater treatment systems and rely on septic tanks and trenches for sewage treatment. If they are well designed, installed and maintained, septic systems will safely treat wastewater for 20 to 50 years. Improper design, installation or operation of septic systems or holding tanks can lead to pollution of ground or surface waters by bacteria, nutrients and household toxic chemicals.

Pesticides (biocides) are used to control undesirable plants or animals. They include herbicides, insecticides and fungicides. Pesticides are used on agricultural lands, on urban lawns and gardens, as well as in lakes to control some weeds, and in forest management.

Septic systems use natural decomposition to treat wastes. Holding tanks do not *treat* wastes, but simply contain them on-site. Septic systems and holding tanks must be periodically pumped out or cleaned. Care must be taken in the disposal of materials removed when cleaning. Solids cleaned out of septic systems can be land-spread since they are partially treated, but continuous spreading on a single site should be avoided. Wastes removed from holding tanks need additional treatment as they have usually undergone little decomposition.

Urbanisation and stormwater. The urbanisation of land concentrates people, and therefore the pollutants that result from their lifestyles, in areas that are largely covered with non-absorbing surfaces such as buildings, driveways, roads, footpaths and parking lots. This combination of people, pollutants and pavement produces 'urban run-off' that may carry a greater pollutant load than municipal sewage. The amount of pollutants carried in urban run-off is influenced by:

- traffic density,
- littering,
- fertiliser and pesticide use,
- construction site practices,
- animal wastes,
- soil characteristics,
- the topography of the area,
- percentage of impervious surfaces,
- air pollution levels, and
- the amount of rain.

Pollutants transported in urban stormwater systems to nearby waters include:

- nutrients,
- bacteria,
- litter,
- soil,
- toxic chemicals, and
- organic (oxygen-consuming) materials.