module 3

WATERWATCH AUSTRALIA NATIONAL TECHNICAL MANUAL

Biological Parameters

Module 3 – Biological Parameters

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
2. Getting Started: the team, monitoring plan and site
3 Biological Parameters
4. Physical and Chemical Parameters
5. Data … Information … Action!
6. Groundwater Monitoring
7. Estuarine Monitoring

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Introduction

Module 3 Biological Parameters concentrates on macro-invertebrate (water bugs) monitoring and also includes an introduction to undertaking habitat surveys. Module 3 is designed to raise awareness of waterway health amongst school groups and to help community groups effectively use macro-invertebrates to assess the health of their waterways.

Within Australia there is a huge diversity of animals that live together in our waterways. They include frogs, platypus, fish, birds and macro-invertebrates. Of all the animals however, it is the macro-invertebrate group that appears to be the most useful indicator of waterway health.

What is a macro-invertebrate?

A macro-invertebrate is an animal without a backbone. They are a diverse group of animals. Most freshwater macro-invertebrates are very small but many can still be seen with the naked eye.

There are many kinds of macro-invertebrates in our waterways. They include worms, snails, mites, bugs, beetles, dragonflies and freshwater crayfish. A group of different macro-invertebrates living together in the same aquatic habitat is called a 'biological community'. Biological communities inhabit all types of waters from rushing mountain streams with rocky bottoms, to sluggish meandering rivers with sandy or muddy bottoms, to heavily vegetated ponds and farm dams. Some common examples of macro-invertebrates are illustrated in Figure 1.

Macro-invertebrates have proved to be a useful indicator of the 'state of health' or condition of a waterway and are now the basis of rapid biological assessment techniques used across the whole country. Therefore, if your Waterwatch group wants to assess the health of your local waterbody, it would be sensible to measure the 'water bug' populations.

To assess the condition of the waterbody it is also important to survey its physical and chemical characteristics, see Module 4 Physical and Chemical Parameters. It is also a good idea to do a habitat survey at your site to note of any possible changes in the surrounding environment that may have affected the health of your waterway. All these surveys put together will show you what sort of habitat the waterbody and its surroundings offer to fauna.

Macro-inverterbate types and classification

As for other animals and plants, the classification system for macro-invertebrates is hierarchical. Within the animal kingdom, macro-invertebrates belong to various phyla. Each phylum comprises several classes, each class comprises several orders, and so on down to genus and species. As an example, here is the classification of a common freshwater shrimp.

Kingdom	Animalia
Phylum (plural phyla)	Arthropoda
Class	Crustacea
Order	Decapoda
Family	Atyidae
Genus (plural genera)	*Paratya*
Species	*australiensis*

By convention, genus and species names are written in italics and the species name is entirely in lower case.

Where do macro-invertebrates live?

Understanding about macro-invertebrates will help you assess the health of your waterway. Knowing where macro-invertebrates live, why they live where they do and how they have adapted to live where they live will help you understand your local waterway (see Table 1).

Your waterway will probably have several different habitats suitable for macro-invertebrates. Macro-invertebrates are found in still water and flowing waters.

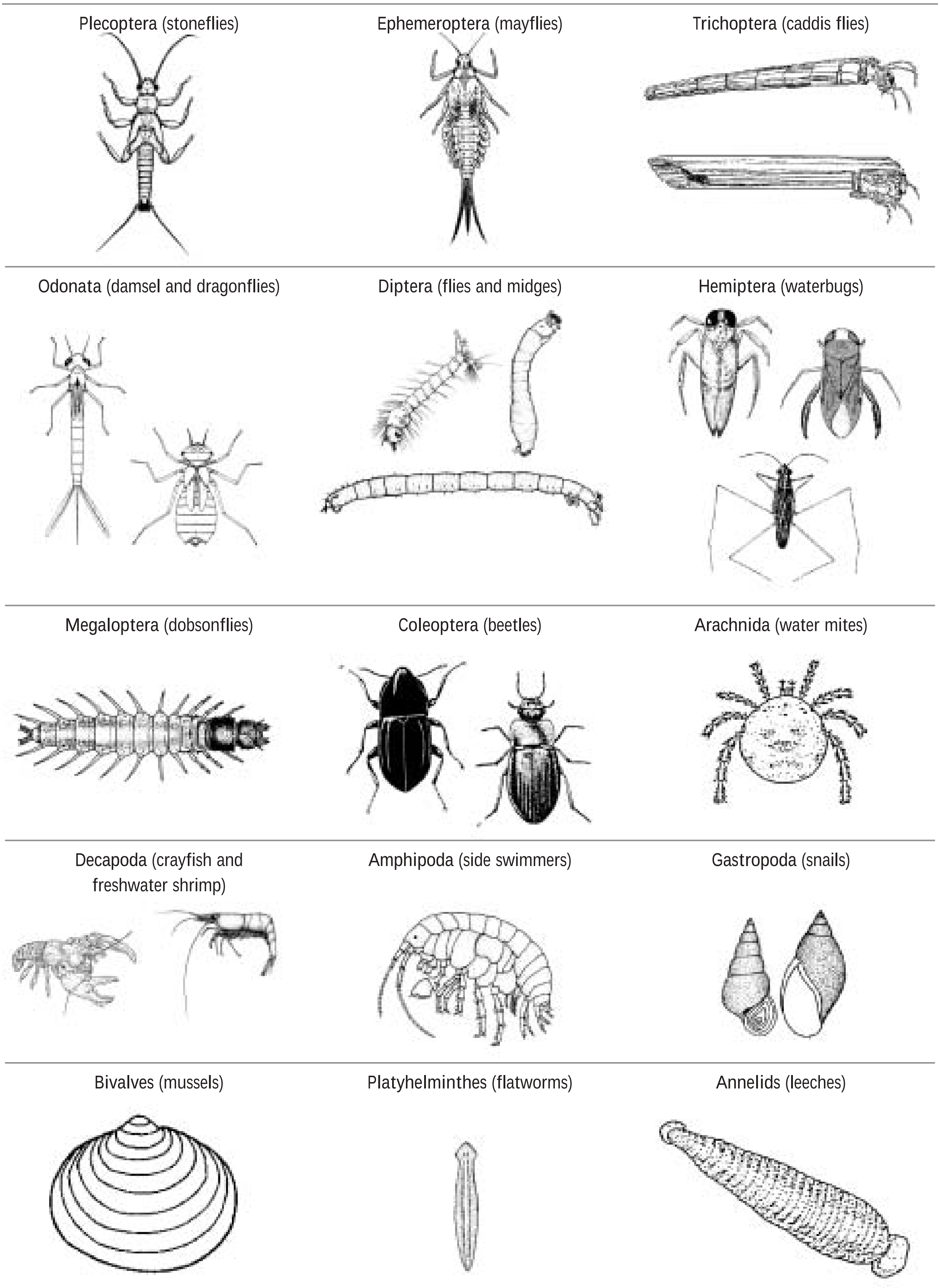
We can broadly categorise aquatic habitats as moving water (rivers, creeks and streams) or still water (wetlands, backwaters, lakes and pools). Moving water can contain four different habitats – riffles, runs, pools and edgewater (see Figure 2).

Riffles are shallow rocky sections of streams with fast flowing turbulent water. The rocks provide a variety of living places and a large surface area onto which macro-invertebrates can attach. Food is continually swept along in the current from upstream. Since riffles provide a variety of living places, current conditions and food, they often support a diversity of macro-invertebrates.

Table 1: Habitats of macro-invertebrates

Freshwater habitats	Macro-invertebrates that may be living there
Edgewater includes overhanging vegetation from banks	Fast-moving bugs and beetles, freshwater shrimp
Bottom – mud, sand, silt, gravel, rocks	Worms, fly larvae, bivalve mussels
Aquatic plants – plants under the surface as well as those growing through the water and floating	Gripping insects, caddis flies, damselflies, shrimp, snails
Flowing water – riffles, pools and runs	Gripping insects, caddis flies, beetle larvae that have burrowed into logs and under rocks, mayflies and stoneflies

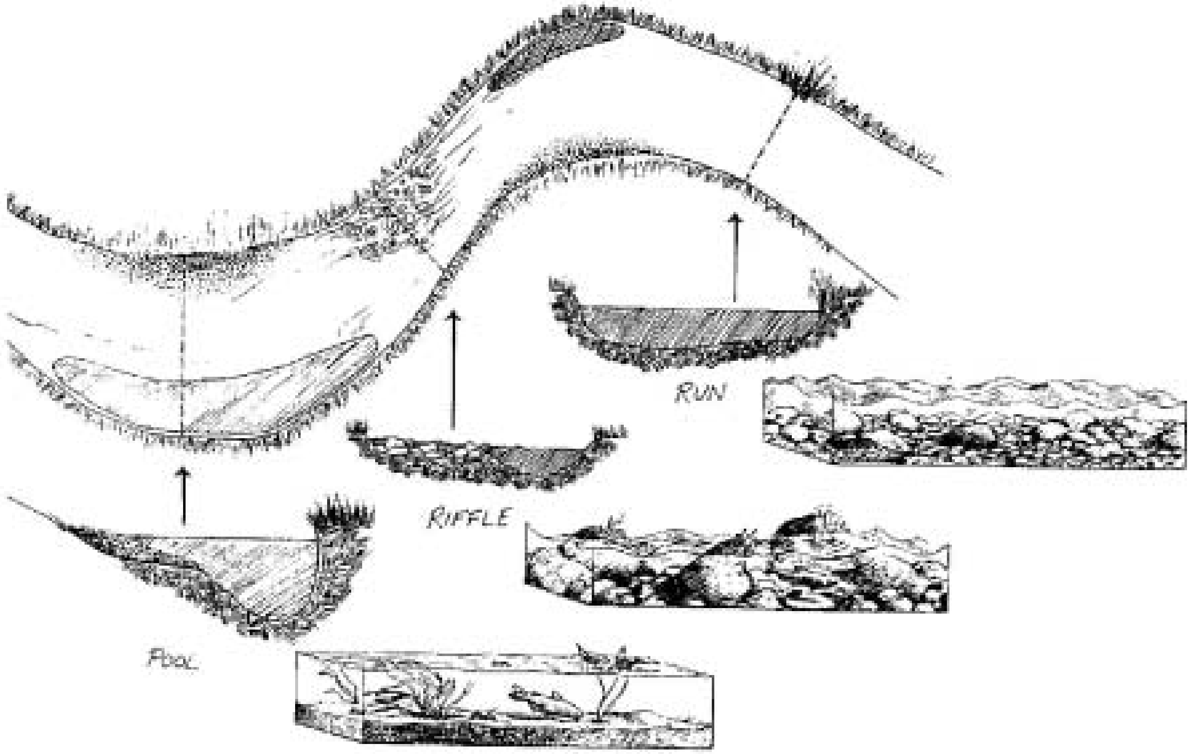
Figure 1: Examples of common macro-invertebrates



Note: organisms are not to scale or actual size.

Source: South Australia Snapshot 97 Critter Catalogue

Figure 2: Plan view and cross-sections of a pool, riffle and run – varying flows and depths create a variety of habitats for macro-invertebrates



Source: TVA Clean Water Initiative, 1995

Runs are generally deep and slow and the water surface is smooth. Smaller particles, like sand and gravel, tend to settle on the bottom. This limits the variety of living places for macro-invertebrates. In addition, occasional floods will wash sand and gravel and any macro-invertebrates downstream. Food is suspended in the water, deposited on the bottom or may grow in the stream bed. Since the physical habitat is not as stable as riffles, there are fewer and less of a variety of macro-invertebrates living in runs.

Pools usually have sandy or muddy bottoms with fewer types of macro-invertebrates present than in riffles. The habitat is less suitable so macro-invertebrates will attach to plant stems, roots, logs and other submerged objects.

Edgewater habitats may have emergent plants, sheltered overhangs with suspended root mats and leaf packs in quiet back eddies. The composition of macro-invertebrates will tend to differ from that in riffles. Animals survive best in places that provide protection, camouflage and food sources.

Special adaptations

Animals living in fast-moving water must be able to 'hang on' and, at the same time, catch their food. You can often find examples of adaptations in your sample. Some special adaptations include streamlined bodies, suction parts, special hooks and fine filters.

In contrast, animals living in still or slow-moving water don't have to hang on and food is not brought to them in the current. Slow moving waters tend to house macro-inveterbates that are a wider range of sizes and shapes and are more mobile.

Characteristics of the aquatic environment that affect macro-invertebrates

The physical, chemical and biological characteristics of a river vary from its headwaters to the lowlands and these in turn influence the composition of macro-invertebrate communities downstream. Methods of assessing the physical habitat are described in Module 1 Background. Methods describing how to measure physical and chemical qualities of water which affect macro-invertebrates are described in Module 4 Physical and Chemical Parameters. Some important features of the waterway that affect macro-invertebrates are listed below.

Physical characteristics that affect macro-invertebrates

- Riffle, edgewater and pool habitats vary in physical conditions which influence the type of macro-invertebrate communities that live there.
- Current velocity refers to how fast the water is moving. Riffles with current velocities of about 0.5 metres per second support the most diverse communities. Occasional

floods may disturb your site and flush away some macro-invertebrates and plants downstream.

- Bottom composition – the river bottom is made up of different materials but cobbles (rocks of marble to basketball size) provide the best habitat for macro-invertebrates.
- Flow (discharge) – the amount of water in the channel determines how much of the river bed is exposed to air. When the river is drying up, animals will concentrate into remaining water holes. Some macro-invertebrates are better at coping with these conditions than others, so the composition of the community changes.
- Depth and water clarity of the stream affect whether light can penetrate through the water column to the bottom and allow plants to grow. Plants provide shelter and food for macro-invertebrates.
- Shading provided by trees and other vegetation helps moderate extremes of water temperature in summer. Stream-side vegetation provides food (leaves, branches, bark) for aquatic animals. The growth rate of aquatic plants in heavily shaded streams tends to be slower.
- Temperature – small creeks in the upper end of the catchment are typically colder than those downstream. Some macro-invertebrates cannot tolerate warm water or wide variations in water temperature. In addition, as water warms, the level of dissolved oxygen falls and eventually stresses aquatic animals.

Aquatic chemistry and its effects on macro-invertebrates

The water in your catchment is a complex mixture of chemicals. The stream is affected by the composition of rain water, the geology of the catchment itself (such as limestone), animals in the water and by human activities. The most important chemical characteristics that affect macro-invertebrates are:

- pH. Acidity of the water is measured on a scale of zero to 14 pH units. Extreme pH conditions – less than 5 and more than 9 pH units – can be toxic to aquatic life.
- Dissolved oxygen. Macro-invertebrates and other aquatic animals take up oxygen that is dissolved in water. In still or slow flowing waterways with a high density of aquatic animals and plants, biological activity can lower dissolved oxygen to dangerous levels (less than 5milligrams per litre). Dissolved oxygen is added to water by plant photosynthesis during the day time and by water mixing with air as it flows over rocks.
- Nutrients (phosphate and nitrate) are essential for life. Lakes, ponds and slow moving streams tend to trap nutrients and silt. If nutrient levels are low, the water is usually clear and the number of macro-invertebrates is low. Increasing concentrations lead to more plant growth and more abundant grazing macro-invertebrates.

Biological characteristics that affect macro-invertebrates

The river is a living community of plants and animals which is dependent on getting food, oxygen and sunlight. The pattern of activity varies with the seasons. Macro-invertebrates are affected by:

- the amount of available food. Food comes from small aquatic organisms, algae, streamside vegetation and decaying food particles travelling from upstream. Some macro-invertebrates feed mainly on leaves and other food that drops into the stream from overhead vegetation; others eat algae. The amount of algal growth is affected by sunlight and nutrients. As the vegetation cover hanging over the stream opens up from the headwaters downstream, the type of food available changes and with it the composition of the macro-invertebrate community.
- the seasons. Macro-invertebrates hatching in summer will mature from egg to adult and will be larger and easier to find in the spring sample.

Human-caused changes in macro-invertebrate numbers and diversity

In order to survive, macro-invertebrates need specific ranges of environmental conditions, such as temperature, oxygen levels, pH and salinity. Changes in the water quality can therefore affect macro-invertebrates by decreasing variety (numbers of different types of macro-invertebrates), and leave only those species tolerant of poor water quality. In general, diverse communities tend to be more stable than less-diverse ones, and it is generally assumed that high levels of variety are desirable for a healthy community.

Pollution, while it can reduce the variety of species in the community, may lead to a greater number of those species that survive polluted conditions. These species usually increase in number because of the lack of other species, some of which compete with them for food and some of which feed on them.

Human activities in a catchment or within the stream itself can significantly alter the characteristics of macro-invertebrate communities and therefore affect animals higher in the food chain. Changes in sediment load, clearance of stream form, and increases in nutrient and effluent input all affect community structure.

Suspended solids can reduce light penetration and therefore limit photosynthesis, with consequences for macro-invertebrate diversity and numbers. Sediment deposited on the stream bed can smother bottom-dwelling communities and alter habitat by filling in holes and depressions.

Riparian vegetation supplies food in the form of organic material (leaves, bark, etc.). Removal of this food source will not only affect macro-invertebrates that feed on it, but also increase the amount of light reaching parts of the stream that the overhanging vegetation previously shaded. Loss of shade may result in an increase in algal production – conditions that will favour selected macro-invertebrates. Increased solar radiation may also raise surface water temperatures, further affecting the number and diversity of macro-invertebrates.

Removal of snags (woody debris) and the formation of channels will alter macro-invertebrate diversity significantly, by reducing the variety of habitat available for colonisation. Removal of snags is particularly important in sandy reaches of a stream, where they may be the only habitat for colonisation. It can also affect macro-invertebrate communities by destabilising the river bed.

Barriers, such as dams, can alter the natural flow, temperature and water chemistry through controlled releases from the cold bottom layer of the dam, disrupting the various life stages of many stream macro-invertebrates. They also obstruct the animals' drift or movement down the stream.

Increases in nutrients from catchment run-off (through erosion, salinity, sedimentation etc.) increase the potential for algal productivity. The macro-invertebrate community will respond to the changes in food supply and an increase in grazing macro-invertebrates will occur.

Sewage and industrial effluent contains many components, including toxic substances, such as heavy metals and pesticides, that can kill macro-invertebrates. As well, heated water reduces dissolved oxygen levels and disrupts macro-invertebrate metabolism which can also kill them. Severe organic pollution causes depletion of oxygen in the water and invertebrates are largely eliminated except for species such as tubificids (worms) and chironomids (midge larvae), which can tolerate low levels of oxygen. With less sever organic pollution, diversity is reduced but the abundance of tolerant species increases. The effect of pollution by toxic substances, like heavy metals, differs somewhat as different species have different tolerance ranges. However, as with organic pollution, the result is a reduction is species diversity and a change in the relative abundance of tolerant organisms.

What can macro-invertebrate communities indicate about the health of your waterway?

Monitoring, via sampling and identification, will reveal information about the macro-invertebrate community in your waterbody and will help you tell its story. When you sample you are collecting information on the community's abundance, diversity, composition and pollution tolerance.

Abundance refers to the number of macro-invertebrates present. Large numbers of macro-invertebrates tend to be found in water enriched with nutrients. Small numbers may indicate erosion, toxic pollution or scouring by floodwaters.

Diversity refers to the number of different types of macro-invertebrate present. Healthy streams usually have a greater diversity than degraded streams, although the diversity in headwaters can be naturally low due to a lack of different types of food. Communities with many different species appear to be more stable and healthy than less diverse ones.

Composition refers to the proportion of different types of animals living together. A sample from healthy streams tends to contain a good number of mayflies, stoneflies and caddis flies. If the sample contains a lot of worms and midge larvae (chironomids), the stream is probably degraded.

Pollution tolerance refers to the tolerance of animals to organic pollution from sewage, industrial effluent and heated water. For example, most stonefly families are intolerant of pollution whilst worms are quite tolerant. Pollution tolerant animals do occur in natural streams where there is low dissolved oxygen, for example, in small clumps of leaves buried in sediment.

How does pollution affect macro-invertebrates?

Macro-invertebrates are sensitive to a range of pollutants and changes to habitat.

Organic pollutants come from sewage treatment plants, animal manure, and food processing industries. Organic wastes generally:

- increase abundance of collector animals that either filter the water for food or gather dead and decaying plant matter
- lower dissolved oxygen
- increase nutrient levels and promote rapid plant growth.

Increase in abundance. The initial release of organic pollutants in small amounts may cause an increase in abundance of all macro-invertebrates. However, as the amount of organic waste increases further, those macro-invertebrates that are best adapted to it will become more and more abundant. Poorly decomposed sewage or animal manure from upstream will be deposited on the bottom of the stream favouring gathering collectors, such as caddis flies. Fine particles of organic waste suspended in the water, such as well decomposed sewage, manure or processed coarser material from upstream, favour filtering collectors, such as black fly larvae. The abundance of animals in each feeding group at a site can suggest the type of pollution impact.

Lower dissolved oxygen. Heavy organic pollution will reduce macro-invertebrate diversity. Decay of dead plants and organic waste may lower dissolved oxygen to critical levels reducing the number of sensitive macro-invertebrates. For example, some families of stonefly larvae are very sensitive to pollution and cannot survive if dissolved oxygen falls below a certain level. They disappear first. Mayflies are a little more tolerant but are next to disappear as oxygen continues to fall. If dissolved oxygen levels become very low, only very tolerant animals, such as tubifex worms and chironomid larvae, will survive. If your sample contains many tubifex worms and chironomid larvae but little else, it indicates that the site is degraded by severe organic pollution.

Growth of aquatic plants. Excess nutrients can come from organic wastes, fertilisers and detergents, animal manure and erosion. In many streams, phosphorus appears to be in shortest supply, so small amounts of phosphorus added to waterways can produce a sudden growth of aquatic plants. Under favourable conditions, such as little wind and current, blue-green algae may bloom and produce toxins that can kill stock and harm humans.

Toxic pollution can come from various sources such as tip sites, industries and mines, and includes acids, solvents, petroleum compounds, pesticides, herbicides and heavy metals, such as cadmium, lead and zinc. These pollutants poison or harm living things. They can often be traced to point sources, such as discharge pipes. Most macro-invertebrates are killed by the comparatively high concentration of toxic substances found around discharging pipes. Both low abundance and low diversity of macro-invertebrates suggest toxic pollution of the waterway.

Sometimes a toxic pollutant may act in a selective way, especially if present in only low concentrations.For example, an insecticide washed into a stream from a diffuse source, such as intensive horticulture,may only kill the most sensitive invertebrates, while numbers of other types of invertebrates may not change. Macro-invertebrates from the mayfly and stonefly groups are usually the most sensitive to toxic pollutants. Caddis flies are normally considered moderately sensitive, while certain types of worms and chironomids are known to be the most tolerant.

Conditions gradually improve downstream from the pollution source as the toxins are diluted by tributary streams and groundwater. The variety of aquatic invertebrates gradually increases and eventually the clean water aquatic invertebrates reappear.

Physical changes to the waterway include construction works, removal of woody debris and streamside vegetation, erosion and straightening of the natural stream meanders. These changes reduce the variety of aquatic habitats available for different kinds of macro-invertebrates. Water bodies that are only slightly degraded may have lower numbers of sensitive groups like stoneflies. In waterways that lack a variety of habitats for animals, for example, concrete-lined channels, the abundance and diversity of invertebrates will be very low.

Urban areas. Physical degradation of aquatic ecosystems is particularly common in urban areas. Waterways are often realigned and channelled to stop them from meandering. They may be lined with concrete or even diverted underground in pipes. Concrete channels do not provide adequate shelter from predators or floods. Other streams may be left to follow their natural course but their riparian vegetation is often removed and replaced with grass or pavement.

Erosion. Clearing away stream-side vegetation, carrying out earth-works and removing gravel from the stream bed cause an increase in erosion and suspended solids in the waterway. In rural areas, stock grazing around waterways destroys riparian vegetation, causes banks to slump and increases erosion. This blocks light from reaching aquatic plants, reducing growth and resulting in fewer macro-invertebrates in the stream. In addition, sediment deposited on the stream bed can fill in deep holes, smother bottom dwelling plants and fill in gaps between rocks that are normally occupied by macro-invertebrates. Deep holes in the stream bed are the preferred habitat of some native fish, providing cold water refuges from the summer heat.

Overhanging stream-side vegetation. Removal of this food source (branches, fruit, leaves and bark) will not only reduce the population of shredder macro-invertebrates that feed on it, but also increase the amount of light reaching the stream. Loss of shade may result in algal growth, a condition which will favour grazer macro-invertebrates. So, as shredders decrease, grazers become more common. More sunlight will also raise surface water temperatures and lower dissolved oxygen levels, again harming sensitive macro-invertebrates.

Large woody debris (snags, logs and branches). Removal of large woody debris will significantly reduce the variety of living places available for macro-invertebrates. In large rivers, large woody debris is often removed to ensure safe boat travel. Woody debris is particularly important in sandy reaches of the stream where it may be the only suitable habitat available. De-snagging can also destabilise the river-bed and further reduce the variety of habitats available to macro-invertebrates.

Flow regulation and water extraction

Dams and weirs can change the natural seasonal flow pattern of rivers. They can also reduce the size and frequency of floods. Flow in some rivers is greatly reduced by the amount of water taken for irrigation. These changes can lead to increases in salinity and disruption of the reproductive cycles and growth of fish, macro-invertebrates and plants.

Not only do dams alter the natural flow pattern, but the water released from the bottom of a dam may also harm macro-invertebrates downstream. Water in a deep dam tends to form layers with a relatively warmer layer floating on top of a colder, denser bottom layer. The temperature difference can be quite marked, for example, 3–4°C. In addition, oxygen levels in the bottom layer can fall to zero due to bacterial decomposition and isolation from the atmosphere. Dissolved oxygen levels quickly return to normal when the discharge water in the river mixes with the air at the end of the discharge pipe. However, fish have be known to die beyond the end of the discharge pipe when there are large releases of water. Dams also block drift or movement of animals downstream to new habitats.

Introduction of exotic (feral) organisms

A large number of exotic organisms have been introduced into Australia and they have a major impact on our natural aquatic systems. For example, willow trees change aquatic habitats by blocking sunlight, altering the water chemistry and choking streams and rivers with mats of fine roots. European carp stir up the sediment in water bodies, uprooting plants and making the water murky. Brown and rainbow trout are voracious predators, eating large numbers of native fish and macro-invertebrates, including aquatic snails.

Exotics plants and animals change the abundance and diversity of aquatic invertebrates by predation, competition and habitat change. They can even cause the localised extinction of native organisms, however the exact impact of any exotic is hard to predict.

Monitoring macro-invertebrates

Broadly speaking, Waterwatch groups monitor macro-invertebrates for one of two reasons – awareness raising for education outcomes or waterway assessment monitoring and action. You need to decide why you are monitoring. You can do this by developing a Monitoring Plan (see Module 2, or for a summary, Table 2 in this Module). The Monitoring Plan should be developed in consultation with your local Waterwatch Coordinator.

Macro-invertebrate monitoring can tell you about the impact of human activities and how well your community is looking after the waterway. Monitoring can also raise awareness of life in the waterway and promote a sense of stewardship towards the health of the aquatic environment.

Macro-invertebrate monitoring includes:

1. planning what to do, for example, deciding how, where and when you are going to collect and analyse macro-invertebrate samples
2. collecting (and possibly preserving) the organisms
3. sorting and identifying macro-invertebrates in the sample either in the field or the lab
4. developing findings, conclusions and recommendations.

Macro-invertebrates can be monitored in all types of waters but the focus of this manual is on flowing waters. Different procedures for monitoring macro-invertebrates under wide-ranging conditions from shallow streams with rocky bottoms to large deep rivers with sandy or muddy bottoms are described.

Strengths and limitations of macro-invertebrate monitoring

Macro-invertebrates are good indicators of water quality as they:

- are affected by physical, chemical and biological conditions of the waterway
- are a critical part of the aquatic food web – feeding on plants and being eaten by predators
- can't easily escape pollution and therefore show the effects of pollution events, intermittent pollution or chronic long-term changes to the waterway
- are abundant, easily sampled and identified.

Macro-invertebrates can be used to monitor changes in streams from headwaters to lowlands, and above and below pollution sites. They reflect changes and problems in the river. For example, stonefly larvae are unlikely to be found if dissolved oxygen has fallen to low levels, turbidity is high, toxic pollutants have contaminated the river, or temperatures are elevated. Be aware however, of the limitations of macro-invertebrate sampling. For example, the absence of stoneflies indicates there has been an impact on the stream, but it does not tell us exactly what caused the impact.

You should combine macro-invertebrate monitoring with an assessment of the catchment (see Module 1) and the physical and chemical conditions (see Module 4) to provide further clues about the causes of changes in the waterway. Assessing the habitat will help you decide if differences in macro-invertebrate samples from one site to another are due to different habitat conditions or some other cause. To be certain that habitat is not causing differences in your macro-invertebrate samples, always compare data from the same habitats.

There are advantages in combining different monitoring methods. Macro-invertebrates provide a short- to medium-term record of the pollution history of the site. Chemical testing on the other hand, only provides a snapshot of specific pollutants trapped in your water sample. Some macro-invertebrates have a life span of up to four years. This, together with their relative lack of mobility, can make them useful indicators of intermittent pollution. For example, a 'slug' of toxic waste released into a stream after an accident may have an impact on diversity and abundance, an effect that remains evident for several months. By contrast, chemical and physical testing at the site may fail to detect pollutant because it has moved downstream.

How can you use information from macro-invertebrate monitoring?

Sampling for macro-invertebrates can be used for:

- educating and raising awareness. Monitoring macro-invertebrates is an excellent activity for learning about waterways and promoting stewardship of the environment.
- providing baseline data about the state of the catchment. Baseline monitoring will develop a picture of stream health over the whole catchment and show changes from headwaters to the mouth. By comparing results with those from reference (least disturbed) sites, you will be able to rank all sites from best to worst and effectively plan for their improvement.
- identifying the impact of pollution and pollution control activities. Changes in macro-invertebrate abundance and diversity can show the impact of point source or diffuse pollution on the waterway. When pollution control activities occur, for example, fencing to keep cows away from a stream, monitoring should show when the stream has recovered.
- determining whether waterways can continue to sustain certain uses that have been identified by the community as important. Waterways have many uses, from providing drinking water to maintaining the integrity of aquatic ecosystems. Australian states and territories are beginning to formally identify uses or values placed on waterways by the human community and the minimum water quality standards required to sustain those uses. Macro-invertebrate monitoring can provide information that indicates the condition of aquatic ecosystems and whether those uses can be sustained.
- identifying water quality trends. Macro-invertebrate testing results from a site can be used to identify worsening or improving conditions over time.

What is the best habitat to sample?

Two habitat types have been identified as providing good macro-invertebrate sites for sampling: riffles and edgewaters. Each habitat is home to a distinct group of macro-invertebrates.

Riffles have the most diverse habitats for macro-invertebrates, and are the most desirable collecting places. Under good conditions, they contain organisms that vary from tolerant to very sensitive. By comparing riffle samples from one site to the next, the impact of human activities will become obvious.

For example, macro-invertebrate diversity found in a riffle upstream of a sewage treatment plant will probably be greater than that in a riffle downstream.

Sometimes there are no riffles where you would like them. If this is the case, choose an edgewater habitat and sample organisms living in and around vegetation on the edges of water bodies. Muddy bottom water bodies usually have fewer types of macro-invertebrates because the habitat is less suitable. The same type of habitat must be selected at different sites if you want to meaningfully compare results.

What methods and equipment can be used?

To get a representative collection of macro-invertebrates in your waterway, there are two methods available:

- kick sampling using nets
- sweep sampling using nets.

Nets for kick sampling of macro-invertebrates in riffles is recommended where possible or sweep sampling for edgewaters if no riffles occur at the site of interest.

Nets

For groups mainly interested in awareness and education, the type of net is not critical. It can even be a kitchen sieve or be made, at home, from a nylon stocking attached to a coat hanger and broom handle (see Figure 3). Alternatively, you may choose to simply pick waterbugs from rocks or leaf packs collected from the stream (see Waterbug awareness, below).

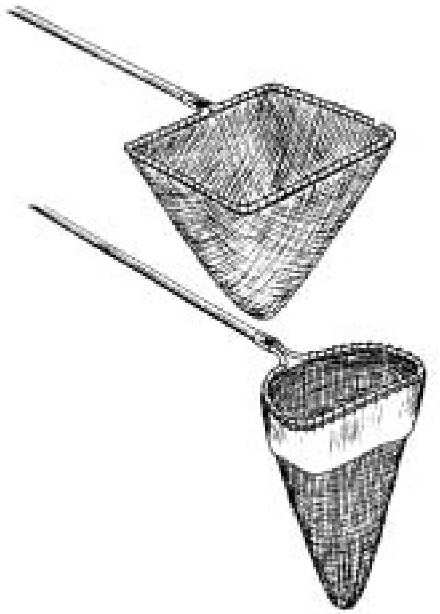
For kick and sweep sampling a long-handled net is best. It should have a triangular or a D-frame with a 0.25 millimetre or 0.3 millimetre nylon mesh size. This mesh catches smaller waterbugs like midges but does not quickly plug up with sediment. A handle that extends to about 2 metres is useful.

Kick sampling method for riffles

The best riffle habitats for kick sampling:

- are well scoured, mainly cobbles (rocks of tennis ball to soccer ball size, 6–25 centimetres) with some gravel (4–16 millimetre) bottoms
- have a current velocity of 0.1 to 0.5 metres per second – fast water but not fast enough to knock you over
- have a depth of 10 centimetres to 50 centimetres – about knee deep.

Figure 3: Sampling nets



Source: TVA Clean Water Initiative, 1995

Method. Wearing rubber boots, stand in knee deep water facing downstream. Hold the net in front of you with the opening facing upstream. Disturb the rocks underfoot by vigorously shuffling and kicking. The current will sweep dislodged macro-invertebrates into the net. Move slowly upstream while you do this to sample a 10m length of the stream bed.

Sweep sampling method for edgewater habitats

The best edgewater habitats for sweep sampling:

- have a good stable bank
- are well vegetated (instream and overhanging) with good habitat for macro-invertebrates to live in
- is representative of the waterway.

Method. Vigorously sweep your net against aquatic plants, roots, logs and the substratum at the water's edge to dislodge any attached animals. Use upward scooping movements to sweep any dislodged animals into your net. Sample a 10 metre length of water's edge.

Where is the best place to locate monitoring sites?

The type of monitoring site you select will depend on a number of factors such as why you are monitoring and what you are wanting to find out about your waterway.

The following sections provide you with some helpful guidance when selecting your monitoring sites.

Locating sites for baseline monitoring

Riffle sites are best for sampling, so locate and add these to your catchment map. Riffle sites for river baseline monitoring should represent the full range of conditions in the catchment. Sites should be chosen from:

- natural or least disturbed areas in the catchment (reference sites)
- streams of different sizes or with different catchment areas
- areas near the headwaters and lowlands in the catchment
- areas of differing land uses, for example, urban, agriculture, forestry
- waterways receiving point source discharges, for example, wastewater treatment facilities, drains
- rivers receiving diffuse pollution, for example, irrigated land, logging areas, land treated with pesticides or fertilisers.

Results from reference sites located in the natural or least disturbed areas of your catchment can be compared with results from other sites. Reference sites need not be on your river, but the habitat should be similar. Consult an experienced aquatic biologist who is familiar with the characteristics of rivers in your area.

Locating sites for pollution impact monitoring

First, you need to locate and map all the suspected sources of pollution affecting your river. Then identify riffles at sites above and below the suspected source of pollution – these are the reference, impact and recovery sites (see Figure 4).

- Reference site. This site is located immediately upstream of the suspected pollution source. You will compare the macro-invertebrate community at this site with downstream communities to look for differences that might be caused by the pollutant.
- Impact site. One site should be located immediately downstream of the suspected pollution source where the pollutant is completely mixed with the river water, say 100 metres downstream. The macro-invertebrate community here will show the full impact of the pollution.
- Recovery site. This site is located further downstream where the river has at least partially recovered from the impact. You will compare the macro-invertebrate community at this site to the community at the reference site to measure how well it has recovered.

Locating sites for whole-catchment impact

To locate sites for whole-catchment impact you need to pair up an impacted catchment with a relatively natural catchment (paired catchments). For example, a small sub-catchment may be entirely converted to forest harvesting but a nearby sub-catchment is untouched. The catchments should be similar in every way except the impact being measured. To show the extent of catchment impact, sample at four sites – a reference or control site, an integrator site, an impact site and a recovery site(see Figure 5).

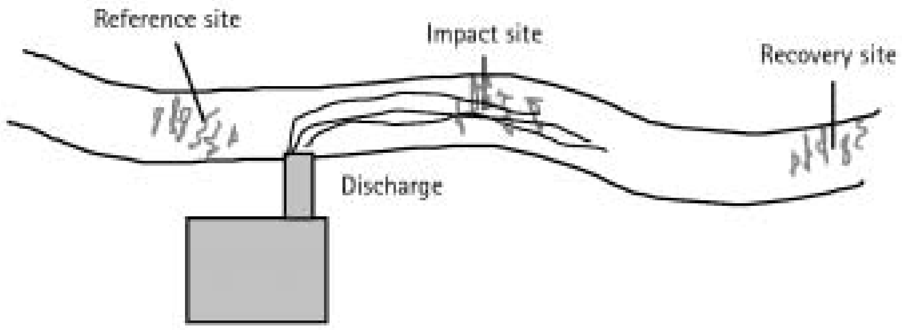
- A reference or control site on the unimpacted tributary immediately upstream of where it joins the main flow (confluence) provides a basis of comparison.
- An integrator site in the impacted tributary immediately upstream of the confluence indicates the integrated impact from all the individual impacts in the whole sub-catchment.
- An impact site will show the effect of the impacted stream on the stream draining from the relatively natural sub-catchment.
- A recovery site indicates the extent of recovery.

When should you sample?

Ideally, macro-invertebrate sampling should occur twice a year, with recommended times being spring and autumn. Spring samples will have larger specimens of insects that were hatched last summer, making them easier to identify. Autumn samples will show the effects of lower flows and higher temperatures, when pollution inputs may have a greater impact.

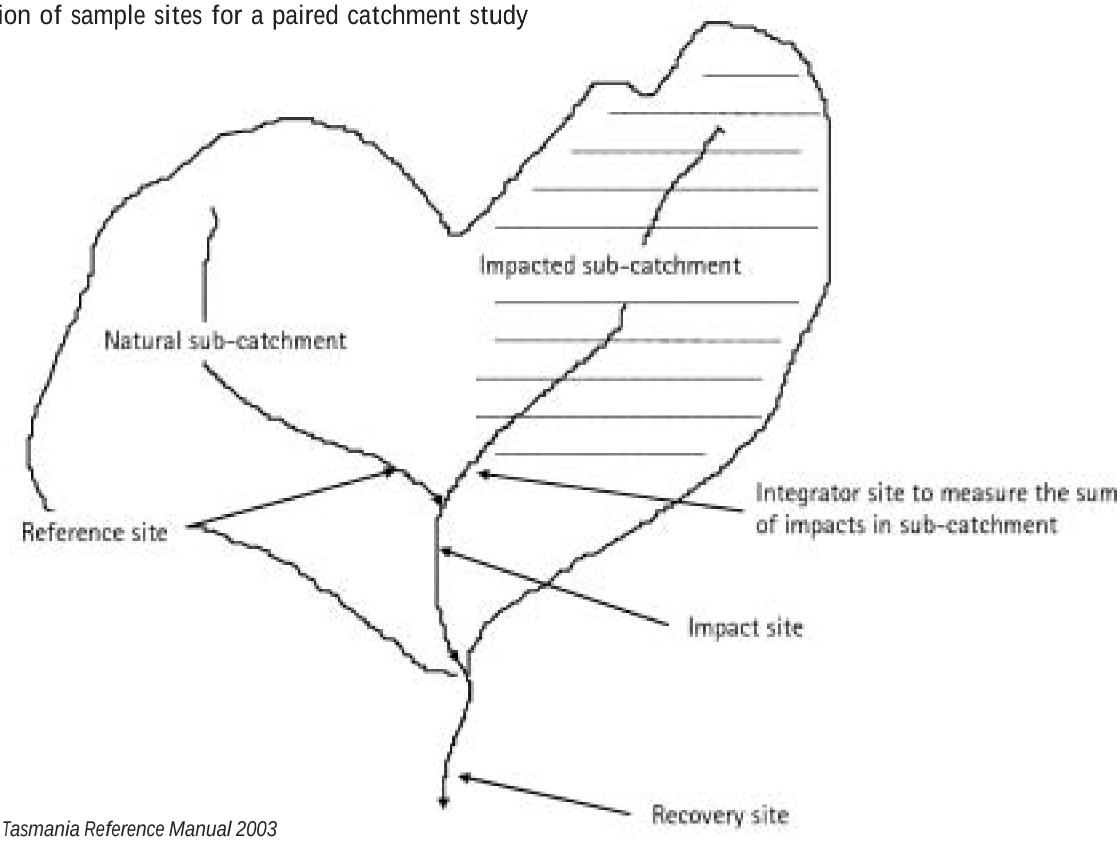
Sampling should occur no more than four times a year to minimise the physical damage to a site.

Figure 4: Ideal location of riffle sampling sites for macro-invertebrate sampling to measure pollution impacts



Redrawn from Dates, G & Byrne, J, 1996

Figure 5: Location of sample sites for a paired catchment study



Source: *Waterwatch Tasmania Reference Manual 2003*

What factors affect your choice of monitoring methods?

The general approach taken to monitoring macro-invertebrates depends on your goals, skills of group members and resources available (see Table 2). In particular, two important considerations will influence your choice of monitoring method:

- the level of skills of group members to identify macro-invertebrates
- ability of the method to detect differences in samples from site to site caused by human impact.

Level of identification

The main choice you will need to make depends on the level to which you want to identify the animal – broad groups with similar overall body shape, or order or family. This, in turn, depends on the identification skills of group members.

- Identification of overall body shape. Identifying gross body shape can be done by anyone with little training (Waterbug Awareness Method).
- Identification to major group level (phylum, class order), for example, stoneflies (Order: Plecoptera). Identifying most macro-invertebrates to order level can be easily done by a trained non-biologist. It involves using diagrams included with this manual that show obvious body features (see Part B Macro-invertebrate Descriptions). Identification is fairly simple. Results are interpreted using the SIGNAL 2 score for major groups (order, class and phyla).
- Identification to family level, for example, families within Plecoptera such as Eustheniidae and Gripopterygidae). Identifying families involves patience, knowledge of some fairly subtle differences in body characteristics, a low power (x20) binocular microscope, and support from a trained coordinator or aquatic biologist to check the identification. The SIGNAL 2 score for families is used to interpret the results of sampling.
- for an even more accredited method you can use the AusRIVAS method in your State/Territory. Visit the following websites for further details http://ausrivas.canberra.edu.au or www.deh.gov.au/water/rivers/nrhp/monitoring.html#ausrivas. This method is not covered in this module.

Ability of the method to detect differences in macro-invertebrates between sites

Identification of macro-invertebrates according to overall body shape will only give an indication of the most heavily polluted sites. Identification of macro-invertebrates to SIGNAL 2 major group level will give more resolution but family level identification (SIGNAL 2 family) is the most sensitive method.

Table 2: Monitoring plan and macro-invertebrate sampling methods

Questions to be considered	Waterbug awareness	Macro-invertebrate rating	Macro-invertebrate intensive sampling (to be developed for community use)
Why are you monitoring?	To educate/raise awareness To identify grossly polluted spots	To educate/raise awareness To identify the impact of pollution and pollution control activities and report to land managers to determine the general condition of the site	To educate/raise awareness To identify the impact of pollution and pollution control activities To determine the precise severity of pollution problems and rank sites on the waterway To identify whether waterways are meeting standards to support designated uses To identify water quality trends To select sites for remedial action To support government agency monitoring efforts
Who will use the data?	Teachers, students, group members	Teachers, students, the general public, land owners, natural resource managers, catchment and rivercare groups	Teachers, students, the general public, land owners, natural resource managers, catchment and rivercare groups
How will the data be used?	To educate and raise awareness of students and group members To plan future monitoring efforts	To screen potential problem areas for possible future intensive studies To identify areas for possible corrective actions by local and state agencies	To help government agencies make management decisions about waterways To help develop catchment management plans For state of environment reporting For selection of sites for remedial action
What will you monitor?	Presence of macro-invertebrates by gross body shape	Abundance and diversity of macro-invertebrates to order level (and some families)	Abundance and diversity of macro-invertebrates to family level
What data quality do you need?	As identification is based on gross body shape, data only provide very general indications – the activity of collecting data is more important than results	The data are capable of indicating the general condition of the site on a four-point scale (excellent, good, fair or poor)	Quality controlled sampling and analysis ensures a high level of confidence in numerical data for decision-making purposes

Questions to be considered	Waterbug awareness	Macro-invertebrate rating	Macro-invertebrate intensive sampling (to be developed for community use)
What methods and equipment are used?	Pick macro-invertebrates from rocks, leaf packs or from net samples. Equipment includes: • sampling nets or kitchen sieve • shallow white tray or bucket • ice cube tray or ice-cream or yoghurt containers • plastic pipettes • small paintbrush • tweezers • plastic spoons	Standard sampling methods are used at all sites. Field identification of macro-invertebrates. Equipment includes: • sampling nets (or artificial substrates) • shallow white tray • ice cube trays • plastic pipettes • small paintbrush • forceps • plastic spoons	Standard sampling methods are used at all sites. Sampling and preservation of fauna in alcohol for laboratory identification to family level Equipment includes laboratory and preserving equipment in addition to sampling and sorting implements
Where will you monitor?	As determined by your goals, e.g. to educate students, sites must be accessible, safe and close to the school.	Choose sites as required by the question you want to answer, e.g. if point source pollution impact is being assessed, riffles at reference, impact and recovery sites bracketing the impact are best.	Choose sites as required by the question you want to answer, e.g. baseline monitoring sites will be located in representative areas of the catchment.
When and how often will you monitor?	Timing depends on the education or awareness needs of the group, e.g. field days, school projects, on-ground catchment survey. It is not designed as a regular monitoring tool	Twice yearly in autumn and spring – maximum is four times a year (once per season) to avoid depleting populations	Twice yearly in autumn and spring – maximum is four times a year (once per season) to avoid depleting populations
Who will be involved and how?	Suitable for all – new groups, schools etc. Demonstration by Waterwatch coordinator.	Best suited for trained community members, secondary students and older. Training by Waterwatch co-ordinator.	Suitable for experienced groups willing to undertake rigorous training needed and work under direction of freshwater ecologists
How will the data be managed and presented?	Not essential to record data but generally helpful in preparing reports for presentations to sponsors, the community and officials	Keep complete and accurate records of result sheets. Interpretation of results should be done in conjunction with habitat assessment and water quality results – site ratings can be indicated on your catchment map using different colours	Sites are compared with reference conditions to estimate level of impact – site ratings can be indicated on your catchment map using different colours
How will you ensure your data are credible?	No training is needed but is strongly recommended. Data are not used for decision making by others	Field training by Waterwatch coordinators ensures comparability and accurate identification Replicate samples by sampling teams provide a check on representativeness As well as using diagrams with this manual, a comparison of macro-invertebrates with a verified reference collection is highly desirable for accuracy	Formal field and laboratory training with freshwater ecologists 10% of macro-invertebrate samples to be preserved for identification to the same taxonomic level by an freshwater ecologist External field duplicate samples taken by ecologist to ensure data confidence

Note: To choose which method best meets your needs, find the closest match between your monitoring plan and the suggested answers for each sampling method.

The sensitivity of the method refers to its ability to detect differences in the macro-invertebrate community from site to site. Sometimes these differences are subtle. For example, your sample may contain a number of mayflies belonging to the order Ephemeroptera, which is composed of nine families in Australia (Hawking & Smith 1997, Colour Guide to Invertebrates of Australian Inland Waters). Most mayfly families are sensitive to pollution, although a few families are fairly tolerant. You will need to identify which families make up your sample to be sure about the 'message' mayflies convey about your site.

For monitoring the impacts on waterways, it might be useful to think of identification to SIGNAL 2 major group level as a first step. This level will be sensitive to moderate to heavy pollution. If the pollution is more subtle, and you suspect there is a problem that does not show up from identifying to order level, you might want to go further and identify families.

Checklist for Macro-invertebrate Sampling

- Sample an alcove and a riffle if both are present
- If possible choose areas with good macro-invertebrate habitat – stones, logs, vegetation
- Take each sample thoroughly – at least 3 minutes and 10 metres of stream within a 100m length of stream
- Be sure to disturb the bed material
- Spread the samples out well in big trays so small invertebrates that hide and don't move can be seen
- Aim to pick at least 100 macro-invertebrates per sampling area, and preferably 150–200 – try to find as many types as possible
- Keep invertebrates from each sampling area separate

Waterbug awareness

The procedures described in this section are a general guide for finding and identifying waterbugs by their body shape. The bugs may tell an interesting story about the waterway. Waterbug Awareness is not designed for groups wishing to undertake regular monitoring, but is useful for one-off events, such as catchment surveys, community field days, school projects or Waterwatch Snapshots events.

The result sheet required for Waterbug Awareness Monitoring is available in Appendix 1 of this module.

Choosing your sites

Your choice of site will be determined more by convenience and ease of access than by any other factors, for example, close to school. You can choose to sample from a riffle (shallow broken water with rocks of about tennis ball to soccer ball size), edgewater (close to banks), or amongst water plants in pools. At your site, there are likely to be many small animals which are not easily seen. Waterbugs can be found attached to rocks and plants, and hiding in leaf packs.

Equipment

When preparing to go to the site you will need to assemble general and specific equipment for the test method to be used (see Table 3).

Table 3: Field trip check list

Tick off the equipment that you need to take on your visit to the test site. Put another line (making a cross) when you are packing up to return (i.e. ✓✗).

Date							
General equipment							
Waterwatch Manuals							
Data result sheets							
Pens, pencils, note paper							
Marker pen (waterproof) / pencil							
Clean water							
Paper towel							
Rubbish bag							
First aid kit							
Sun cream and hat							
Camera and film							
Drinking water and food							
Gum boots / walking boots / raincoat							
Specific waterbug awareness equipment							
Kitchen sieve or net.							
White bucket or flat tray for holding samples during sorting.							
Four white containers, e.g. ice cream containers.							
Sorting implements to pick bugs from plants and rocks:							
tweezers (forceps);							
plastic spoon for large bugs (with 2-3 very small holes);							
plastic squeeze pipette for small bugs (about 5mm diameter);							
fine paint brush for lifting small bugs (small artist type).							
Emergency phone number							

Sampling method

Step 1 Choose your site(s). If you have a choice of sampling areas a riffle is best, otherwise sampling an edgewater, pool, or aquatic plant habitat is quite satisfactory.

Step 2 Sample one of the following areas at your site with the method described.

Riffles	Rock rubbing method. At your riffle site, randomly choose several rocks of about hand size. Place the rocks in your bucket or tray, add stream water and with your hands gently brush off anything which could be living. Kick method. Wearing gum boots, stand in the stream and kick the rocks to dislodge animals. Hold the net downstream to catch them.
Leaf packs in edgewaters or pools	Remove several handfuls of submerged leaves that have collected on the bottom and place them in the tray. Remove leaves one at a time and look closely for the presence of animals. Use tweezers, spoon or small paint brush to carefully remove anything that looks like an animal into the bucket or tray.
Aquatic plants in edgewaters or pools	Using a sieve or net, sweep backwards and forwards through any aquatic plants near the water's edge to trap animals attached to the plants or swimming in the water. Do not collect too much material in your net. Empty the contents of the sieve or net into your bucket or tray.

Step 3 Label each white ice cream container with a name, that is, 'worm-like', 'animals with shells', 'crayfish-like' and 'insect-like'. Add stream water to the containers (about 1 centimetre deep).

Step 4 Sort through your sample. Use a pipette, spoon or brush to transfer your waterbugs to the labelled containers for a closer look. Often the waterbugs are moving, so they are easy to find. Sort the bugs so similar looking bugs are all placed in the same container.

Note: There are four easily recognised types of waterbug (see Table 4). Identify each type of waterbug by their general features and from the drawings in Figure 6 - Waterbug identification guide. Or for more detailed identification keys see the section *Identifying macro-invertebrates – further resources* in this module (pg 24).

Table 4: Types of waterbugs and tolerance to pollution

Animal body shape	Tolerance to pollution
Worm-like animals, e.g. worms and leeches. They stick to rocks or sticks, or crawl slowly.	They are generally tolerant of pollution.
Shelled animals, e.g. snails and mussels.	They vary from tolerant to intolerant of pollution.
Crayfish like animals.	These are generally intolerant of pollution.
Insect-like animals. They include a wide range of animals that have distinct heads, legs, bodies and tails. They come in many sizes and shapes and often move quickly.	They are generally intolerant of pollution.

Step 5 On the Waterbug Awareness Result Sheet (Appendix 1), indicate which method of sampling (Step 2) you used and tick the box that best shows the number of waterbugs in each container (none, occasional or plentiful).

Step 6 Return all the waterbugs, leaf matter and rocks to your waterway. Wash your hands to remove parasites. Before you leave the site, make sure you have:

- cleaned all your equipment
- collected all rubbish
- checked all equipment in your kit
- noted any equipment that is broken or lost and needs to be replaced
- recorded all the results.

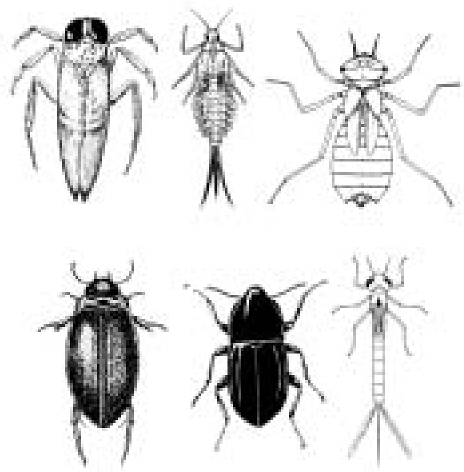
Step 7 (optional)

You may choose to pass your result sheet onto your Waterwatch Coordinator. If so, please complete the first part – Background information. Your coordinator can help you to fill in this information.

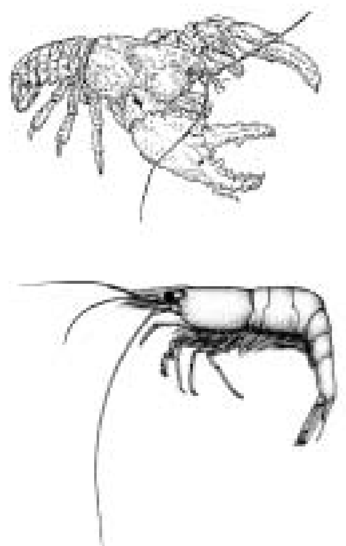
Figure 6: Waterbug identification guide and tolerance to pollution

Worm-like animals
(generally tolerant)

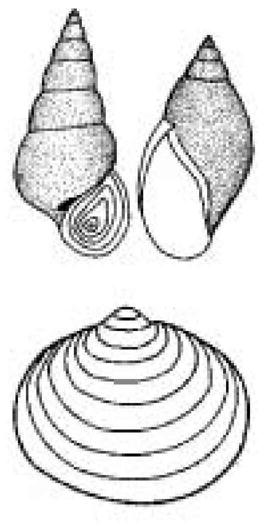
Insect-like animals
(generally tolerant)



Crayfish-like animals
(generally intolerant)



Animals with shells
(vary from tolerant to intolerant)



What do the waterbugs in your sample mean?

The variety and number of waterbugs in your sample give you a sense of the health of the stream (see Table 5). Some waterbugs cope well with pollution or changes in their habitat, whilst others are very sensitive and die.

Table 5: Interpreting your results

If you find:	It suggests:
Only one or two kinds of animals, e.g. worm-like animals, but many of them.	Severe organic pollution.
A variety of animals, but only a few of each kind and the stream appears clean.	Stream has undergone flooding (scouring) or the sample was taken during high flows from an area that dry a few days before.
No animals.	Toxic pollution.

To more accurately measure the condition of the waterway, you will need to use the SIGNAL 2 score described later in the Module.

Using macro-invertebrates to understand the health of the habitat

Understanding the health of the habitat involves following standardised sampling and sorting procedures and identification to the level of order or family. This method produces data of known quality and can be used to assess the condition of sites in the waterway.

The SIGNAL 2 score provides an indication of things that might be affecting waterbugs at a site, such as water quality or habitat. SIGNAL stands for 'Stream Invertebrate Grade Number – Average Level'. Each type of macro-invertebrate has a grade number from 1 to 10, based on its sensitivity to organic pollution. A low-grade number means the waterbug is more tolerant of water pollution. More sensitive waterbugs have high grade numbers. The grade numbers for groups containing phyla, classes and orders can be used but the most accurate SIGNAL scores for a site are obtained by using grade numbers of families.

SIGNAL 2 scores are based on the number of different types of water bugs in the sample. The procedure described here does not use relative abundance but weighting of abundance is possible.

Templates for result sheets required for monitoring macro-invertebrates to understand river health can be found in Appendix 1 of this module (major groups and family level).

Some material in this section has been sourced from *SIGNAL 2 Manual*, Bruce Chessman, 2003 (www.deh.gov.au/water/rivers/nrhp/signal/index.html).

Overview of procedure

Before rushing out to sample macro-invetebrates, it is important to decide on the objectives of your monitoring program (see Module 2 on how to develop a monitoring plan).

It is also a good idea to undertake a site description assessment to document any changes at your site over time to aid you in interpreting your results (a site description record sheet is available in Appendix 1).

1. Decide whether you will identify waterbugs to family level or major group level (order, class and phylum).
2. Assemble collection equipment and other supplies.
3. Follow directions to the first site and find your riffle or edgewater location. It is a good idea to note down or even better draw the location of your site and monitoring location .
4. Fill in the first page of the Macro-invertebrate Record Sheet(s).
5. Use the kick sampling or sweep sampling technique to collect macro-invertebrates. Take each sample thoroughly (at least 3 minutes and 10 metres of stream for kick or sweep sampling). Be sure to disturb the stream bed.
6. Sort your sample on site. Aim to pick at least 100 animals, preferably 150 to 200. Try to find as many different types as possible.
7. Record the number of macro-invertebrates you found at your site in the Macroinvertebrate result sheet.
8. Calculate the sum of the individual grade numbers for the water bugs in your sample.
9. Divide the sum by the number of different groups (families or order class phyla) you collected. This is the SIGNAL 2 score for your site.
10. Return material to the stream and clean up your site before leaving. Wash your hands to remove parasites when you finish.

Always keep the riffle and edgewater samples separate from one another and in particular only compare samples that have been collected in the same manner. Sampling must not be done when the stream is swollen or turbid due to recent rains. Refer to the notes on safety in Modules 1 and 4.

Equipment

The general equipment you will need for both the kick sampling and sweep sampling techniques includes:

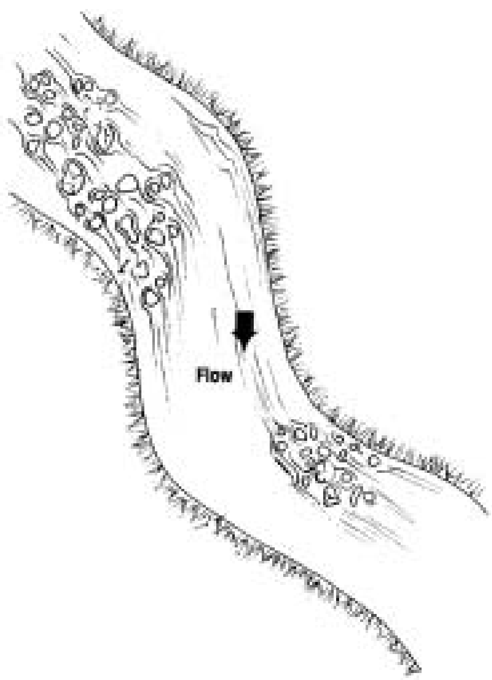
- long handled sampling net (triangular or D-frame, 0.25–0.3 millimetre mesh)
- large flat white plastic tray for holding samples during sorting
- white ice cube trays for sorting macro-invertebrates
- latex rubber gloves for use at sites known to be polluted
- rubber boots (gum boots) or waders
- sorting implements, such as:
  - tweezers (forceps)
  - plastic spoons for moving large bugs (drill 2–3 very small holes to drain water)
  - pipettes for moving small bugs (about 5 millimetre diameter with rubber squeeze bulb)
  - small artist-type paint brushes for lifting small bugs
- set of small jars or vials (filled with 90% ethyl alcohol) for collecting macro-invertebrates for identification checks by an aquatic ecologist and/or building a reference collection
- magnifying glass or binocular microscope (x10 or x20) to help with identification.

Steps for kick sampling riffles

Kick sampling in riffles is the recommended technique as it is used by professional aquatic ecologists, and riffles contain the greatest diversity of macro-invertebrates.

1. At your site, select a shallow fast-moving area of broken water (riffle) with a depth of 10–50 centimetres and rocks of tennis ball to soccer ball size.
2. Approach your riffle from downstream to avoid disrupting the macro-invertebrates before you are ready to collect. You should start at the bottom and work 10 metres upstream.

Figure 7: Kick sampling riffle sites



Source: TVA Clean Water Initiative, 1995

3. Position yourself at the downstream end of the riffle. Face downstream and hold the net in front of you with the opening facing upstream so dislodged macro-invertebrates are carried into it by the current. Be sure the net fits tightly against the stream bed.
4. Disturb the stream bed with your feet. Use your feet to dig well into the stones and turn them over. Continue this process while working upstream over a distance of 10 metres in both the fastest and slowest parts of the riffle. Rub at least two stones by hand to dislodge organisms. If you turn over any large stones, please turn them back again after sampling.
5. Use a forward scooping motion to lift the net from the water to stop waterbugs escaping. Your net should be free of mud but you may have to flush the net with water to remove mud before sorting.
6. Gently empty contents of the net into about 2 centimetres of water in a large flat white tray for sorting.
7. Rinse the net so all the animals and debris are removed before taking another sample.

Steps for sweep sampling edgewaters

This technique samples the organisms living in edgewaters of waterways where riffles are unavailable. The best edgewater sites have overhanging or emergent vegetation, undercut banks or root mats that provide suitable living places for macro-invertebrates.

1. Use your net to make short upward sweeping movements from about 1 metre out from the bank to the bank edge, disturbing aquatic vegetation if present to dislodge macro-invertebrates.
2. You should move steadily upstream over a total length of 10 metres.
3. You will need to stop regularly to flush mud out of your net. The sample should be free of mud before sorting.
4. Gently empty the contents of the net into about 2 centimetres of water in a white tray for sorting. Keep the sample separate from riffle samples.
5. Rinse the net so all the animals and debris are removed before taking another sample.

Sorting your samples

Do not mix samples from different habitats, for example, from riffles, edgewaters, or artificial substrates. Each habitat supports a distinct community of macro-invertebrates.

Sort your samples at the site. However, if you have to leave the site before sorting due to lack of time, bad weather or other constraints, take your samples back to your work-base. You can do this by placing your samples into garbage bags with water, loosely tying off the top and placing the bags into large plastic buckets. Remove most of the air from the bags to prevent buffeting during the trip back. If it is a hot day or a long drive, use battery powered aerators to maintain dissolved oxygen levels. Return all organisms to the waterway after noting them on your Record Sheet.

To ensure that an adequate number of macro-invertebrates are collected from the sample, you should aim to transfer around 100 to 200 waterbugs from the sorting tray to ice-cube trays. This generally takes one person between 30 minutes and an hour depending on their experience and the site.

1. Spread the sample out over the bottom of a white tray. Spend a little time watching the macro-invertebrates. See how they move and look at the different shapes and colours (the colours change when they are preserved).
2. Add about 1 centimetre of water to the wells in your ice cube tray. Pick through your sample in the sorting tray. Use a pipette, tweezers, spoon or brush to transfer your macro-invertebrates to the wells in the ice cube tray. Place animals belonging to the same group in the same well of your ice cube tray.
3. For the first 10–20 minutes, transfer any animal that you see from the sorting tray into the ice cube trays. For the last 10–20 minutes, look particularly for animals that are uncommon. Fast moving macro-invertebrates will be obvious but some will only start to move after 10 minutes or so. If after 30 minutes you find an invertebrate you haven't seen before, sort for another 10 minutes until you find no new taxa.
4. There are many key guides available to identify your macro-invertebrates, see the following section for a list of further resources. A x10 magnifying glass or low power binocular microscope is useful for looking closely at the animals.

Figure 8: Sorting your sample

Source: Kruger, T and Lubczenko, V, 1994

5. Count the number of each type of animal in each well of the ice cube trays. You can record your results on either the result sheet for SIGNAL 2 for major groups or SIGNAL 2 for families. If you find a macro-invertebrate you cannot identify, record this on your result sheet, giving a brief description of what you found. Consult your Waterwatch Coordinator or macro-invertebrate guides listed in the following section..
6. When you have finished, return the animals to the water, as close as possible to the collection site.

Identifiying macro-invertebrates – further resources

You can identify macro-invertebrates either by comparing collected specimens with illustrations of the various groups, or by using identification keys.

Identification keys generally consist of a series of paired descriptions of particular bodily features. Each pair, called a couplet, is numbered. You begin with the first couplet and select the description that best fits the specimen you are 'keying'. The chosen alternative will direct you to another numbered couplet. Continue this process until you have eliminated enough wrong alternatives to positively identify the specimen.

Some Waterwatch manuals contain keys or pictorial guides to macro-invertebrates which are a good start. If you are wanting more detailed information there is a range of books, compact discs and websites which are very useful (see *Further resources* on page 44 for a list).

Setting up a reference collection

It is a very good idea to build a reference collection of aquatic invertebrates. Place up to three or four of each kind in a glass jar or vial. The sample glass jars or vials should be filled with 90 per cent ethanol and sealed to prevent the alcohol from evaporating. You can use methylated spirits if you cannot get ethanol. Add a label that records the type of macro-invertebrate, date and place of collection. You should check these samples every few months and top up the alcohol if necessary. You may need to get permission from your state government agency to sample and preserve macro-invertebrates.

By building a reference collection you will come to know the macro-invertebrates much better and it will make it easier for others to identify their samples. You should get your reference collection checked by an aquatic ecologist. Future Waterwatchers and experts can look at your reference collections and see what kinds of animals lived at your sites in the past.

What are your quality control measures?

Quality control includes the steps you take to make sure your data are accurate and precise. The main quality control challenge is to make sure the sample collected is representative of the macro-invertebrate community living at the site and animals are correctly identified.

Internal quality control checks

The following internal quality control checks are recommended.

- Repair any holes in your net before further sampling.
- Use wide trays so you can see animals that do not move.
- Collect at least 100 animals, preferably 150 to 200, to increase your chances of finding as many different types as possible.
- Collect field replicate samples at 10 per cent of sites to make sure your method and identification is satisfactory. School groups can be divided into several sampling teams to collect replicate samples.
- Use your reference collection to compare with the unknown animals from your river samples to help you identify them.
- Make sure the same habitats are sampled.

External quality control checks

The following external quality control checks are recommended.

- Compare your sample data with that collected by a professional aquatic biologist at the same site, within a day of your group (external field replicate).
- Check the identification of 10 per cent of the macro-invertebrates sampled with an aquatic ecologist.

SIGNAL stands for 'Stream Invertebrate Grade Number – Average Level.' It is a simple scoring system for macro-invertebrate (water bug) samples from Australian rivers.

A SIGNAL score gives an indication of water quality in the river from which the sample was collected. Rivers with high SIGNAL scores are likely to have low levels of salinity, turbidity and nutrients such as nitrogen and phosphorus. They are also likely to be high in dissolved oxygen.

When considered together with macro-invertebrate richness (the number of types of macro-invertebrates), SIGNAL can provide indications of the types of pollution and other physical and chemical factors that are affecting the macro-invertebrate community.

What is SIGNAL 2

This section provides a brief overview of using, calculating and interpreting your SIGNAL 2 scores. This section has been sourced from *SIGNAL 2 Manual*, Bruce Chessman (2003). For the complete manual list of SIGNAL scores visit www.deh.gov.au/water/rivers/nrhp/signal/index.html

The original version of SIGNAL required all macro-invertebrates to be identified to the taxonomic (classification) level of family. This is the level most agency biologists routinely used. Although species-level identification provides more information, especially on conservation values, it is a specialised and laborious task. Community groups, such as those in the national Waterwatch program, often cannot take identification to family level due to lack of access to the necessary equipment or resources. Typically, these groups identify to the taxonomic levels of order, class and phylum, depending on the type of macro-invertebrate.

SIGNAL 2 has versions to suit both family and order-class-phylum identification.

Templates for result sheets for both levels of SIGNAL 2 can be found in Appendix 1 of this module.

Calculating SIGNAL 2 Score

Once you have identified all the specimens, to either the family or the order–class–phylum level, you can calculate the SIGNAL 2 score.

Each type of macro-invertebrate has a 'grade number' between 1 and 10. A low grade number means the macro-invertebrate is tolerant of a range of environmental conditions, including common forms of water pollution. A high number means the macro-invertebrate is sensitive to most forms of pollution. The higher the number, the greater the average sensitivity.

Generally, you should not mix grades for the family and order–class–phylum levels of identification in the same calculation. However, in family-level studies, a few groups that are more difficult to take to family level are often left at order–class–phylum level, for example, mites (Acarina) and segmented worms (Oligochaeta). In these cases, you can use the order–class–phylum grades in the family-level calculation. However, you must do this consistently if valid comparisons are to be made between SIGNAL 2 scores for different samples.

You can calculate SIGNAL 2 scores with or without abundance weighting. If no weighting is used, the SIGNAL score is the average of the grade numbers for those macro-invertebrate types collected.

If you want to use abundance weighting, you should derive a weight factor for each type of macro-invertebrate.

Various weighting schemes exist. Speak to your local Waterwatch coordinator on advice about how to do this or if this already exists for your State/Territory or region.

These calculations proceed by the following steps.

1. Make a list of the macro-invertebrate types found in the sample at either the family or the order–class–phylum level, depending on how far the identification is taken.
2. Enter the relevant grade number alongside each type of macro-invertebrate in the list. If a type has been recorded that has no grade number assigned, delete it from the list. This will rarely happen.
3. Enter the number of specimens of each macro-invertebrate type collected (abundance) alongside the grade number.
4. Use the weight table to determine the weight factor for each type of macro-invertebrate, according to the number of specimens collected. Tabulate the weight factors next to the abundance values.
5. Multiply the grade number for each macro-invertebrate type by the corresponding weight factor and tabulate the results.
6. Add the weight factors for all macro-invertebrate types.
7. Add the products of grade numbers and weight factors.
8. Divide the second of these totals by the first to produce the abundance-weighted SIGNAL 2 score.

Interpreting your results with SIGNAL 2

Table 6 provides a broad guide for interpreting the health of the site according to the SIGNAL 2 score of the site.

Table 6: Guide to interpreting the SIGNAL 2 scores

SIGNAL 2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution
Less than 4	Severe pollution

(Source: Gooderum J and Tsyrlin E, 2002)

Quadrant diagram for SIGNAL 2

For a more accurate interpretation of your results you should use the bi-plot and quadrant diagram method detailed in the *SIGNAL 2 Manual*. The quadrant diagram allows for variances in geographic regions to be factored into your interpretation. Your local Waterwatch coordinator can assist you in setting up the quadrant diagram and interpreting your results.

Relating macro-invertebrate results to other information

It is always important to remember that SIGNAL 2 scores and biplots are a simple, rapid assessment and not a comprehensive assessment of a stream or even of its macroinvertebrates. The biplot provides an indication of things that may be affecting the macroinvertebrates at the site, such as water and habitat quality.

Linking SIGNAL 2 assessments to other types of information will increase the weight of evidence and lead to more confident conclusions. Such information might include water quality test results, physical habitat assessments and assessments of other life forms, such as vegetation. Waterwatch manuals provide methods and guidance on how to undertake these types of assessments.

It is also important to understand what may be influencing the stream: the land use in its catchment, the human activities that may be affecting it, and the infrastructure present, such as dams, drains and wastewater discharge points. It is difficult to interpret results from a single site in isolation.

Animals that live in and around waterbodies occupy niches in or on vegetation, banks, rocks, submerged logs and the stream bottom. These are all examples of different habitats. The condition of various habitats is a good indication of the quality or health of the freshwater environment.

Habitat assessment

This section describes how you can rate the health of the habitat on a scale of excellent, good, fair or poor. The rating:

- assesses the health of the site for freshwater organisms and its value for human uses
- allows you to monitor the condition of the site over time
- allows you to compare one site with another
- identifies areas that need restoring or protecting.

All the result and record sheets required to undertake a Habitat Assessment can be found at Appendix 1 of this module.

Riparian vegetation

Plants growing along the edge of the waterbody are called riparian vegetation. Riparian vegetation includes native and introduced species that ideally form a broad band (the riparian zone) along the edge of a waterbody. For an estuary, the riparian zone starts from the highest high tide mark. Riparian vegetation protects the waterbody from agriculture and other human activities near the stream.

Natural riparian vegetation is a valuable source of food and shelter, for animals on the land as well as for freshwater organisms. Leaf litter, insects and fallen branches from overhanging native trees give year-round food, habitats and shelter for native fish and invertebrates and, in northern parts of Australia, for turtles (see Figures 9.1 and 9.2).

Riparian vegetation shades the stream and the banks, making the water in small waterways as much as 10ºC cooler than the water in equivalent unshaded streams. Temperatures that are higher than expected for the season can be lethal to many freshwater plants and animals.

The roots of suitable species of riparian vegetation bind the soil of the banks, holding it together against erosion by the water. Aboveground plant parts interrupt any overland movement of water, sediment, nutrients, pesticides and herbicides into the water.

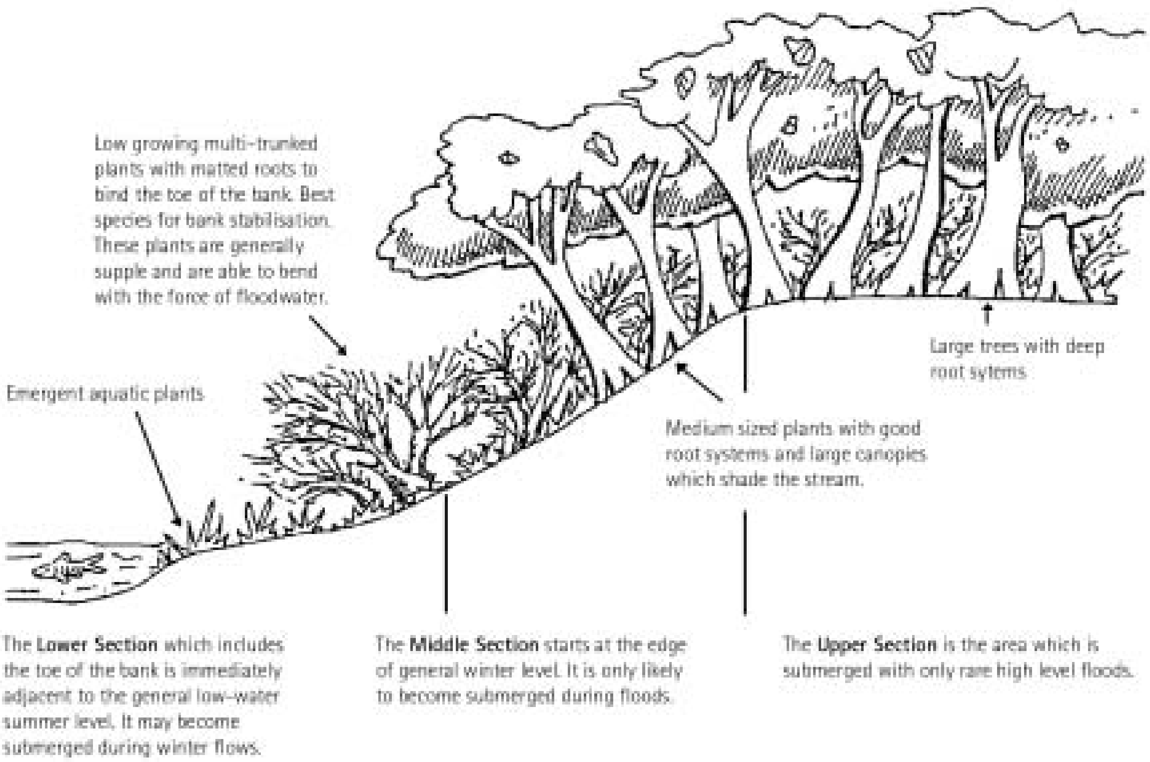
In contrast, where there is either little riparian vegetation or only introduced riparian plants, especially those that lose their leaves in winter such as willows, the waterbody may be deficient in good food supplies, or in snags and other underwater habitats; it may be contaminated by pesticides and sediment, or be subject to wide temperature variations.

Physical shape of the waterbody

Streams often have pools and riffles and runs, and this variety of habitats is able to support a variety of fauna species. A riffle is a section of a river or stream where shallow water flows over rocks in rapid turbulent flow. Riffles are important for aerating the water (adding air and therefore oxygen) and for providing a habitat for many macro-invertebrates. Large slow-flowing rivers may not have riffles but may have quiet pools, which suit fish more than macro-invertebrates. Lakes can have beaches and inlets that are shallow and stony, as well as deep areas.

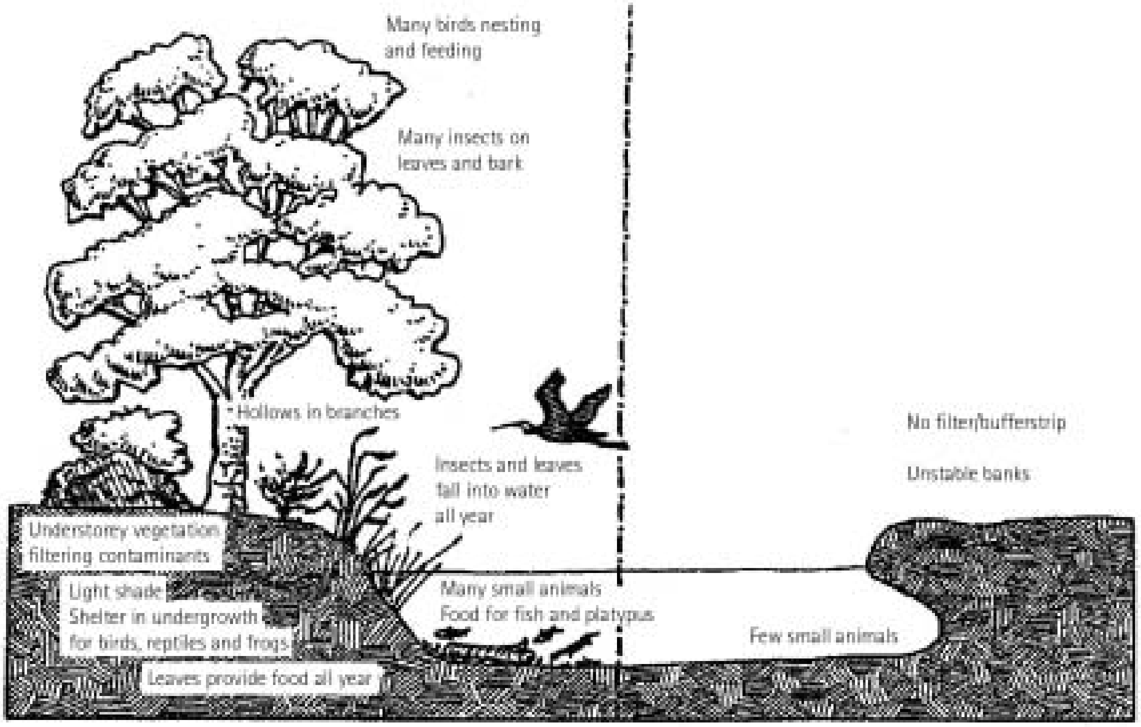
When waterbodies have been affected by human activities they may be deeper, or shallower, or straighter, or less braided than unaffected waters. Although shape variations like these occur naturally between waterbodies, they can also be a result of gravel extraction, sedimentation, channel straightening and other river engineering works.

Figure 9.1: The riparian environment



Source: Munks S, 1996

Figure 9.2: Comparison of a native and willow-lined bank



Source: Munks S. 1996

Surveying the habitats of your waterway

Your group's approach to habitat surveys will depend on its goals and the resources available. Site descriptions and habitat surveys are excellent tools to use when setting priorities for your Waterwatch group. They help the group understand the relationships between the land uses on the surrounding land, and possible causes of problems in the waterbody.

Habitat rating

A 'habitat rating' is different from a 'site description'. Rating involves giving each habitat feature a score that represents its quality or condition. Scores are added together to form a rating for the whole site (see Habitat Rating Sheets (Awareness and River Health Assessment in this module). Once completed, ratings make it possible to compare sites from different parts of the catchment. Habitat ratings can be recorded in the Waterwatch Australia Database for community water monitoring data and information(see Module 5). Sites rated as healthy or good can be useful for reference or as sources of information about vegetation types.

The condition of the habitat influences the physical and chemical quality of the water and the kinds and numbers of macro-invertebrates that live at a site. The assessment of habitat quality at the sample sites is essential to interpreting the test results. Habitat surveys and ratings can help your group determine if poor water quality is caused by a loss of riparian vegetation and by eroding waterbody banks or by stresses elsewhere in the catchment.

- Returning to the same site and checking for the same things, say once a year, will allow you to identify long-term changes in habitat quality. Photographs taken from the same place every year would be a useful addition to your assessment of the waterway.

Rating the health of your waterbody's habitats

To assess the health of the habitat around the stream you are monitoring, you will need to consider five features:

- quality of verge vegetation;
- quality of bank vegetation;
- extent of in-stream cover;
- degree of bank erosion and stability; and
- variety of riffles, pools and bends.

Bank vegetation refers to trees, shrubs, grasses, etc. actually growing on the bank. This vegetation provides food and shelter for aquatic animals in the form of fallen leaves, twigs and branches, etc.

Verge vegetation is considered to be stream side vegetation up to 40m from the bank of wide rivers or 10-20m from the bank of small streams. The verge vegetation can be quite extensive but many streams in urban areas have almost no verge vegetation at all. The condition and type of vegetation around a water body gives a good indication of the quality of the aquatic environment. It helps to explain physical and chemical changes and the macro-invertebrates found in the water.

In-stream cover refers to the diversity of living places available to aquatic life and includes aquatic vegetation, woody debris, snags, fallen trees, logs and rocks. Streams with a rich diversity of in-stream cover allow fish and macro-invertebrates to shelter from the current, feed and reproduce. Aquatic plants supply food and oxygen, and protruding snags form roosting and preening sites for birds.

Bank erosion and stability. Streams naturally erode, usually on the bends of meanders. However, changes in adjacent land use can cause a stream to become unstable, resulting in continuous erosion along its channel. Such changes include increased run-off from impervious surfaces and piped tributaries, stock access, or direct interference such as straightening or channelling the stream. If it has been stabilised with concrete banks, the stream will be stable but should not be ranked highly as it is not ecologically healthy.

Riffles, pools and bends. The variety of habitats found in riffles, pools and bends helps to support a variety of living things. Before you consider assessing this part of the habitat, make sure that riffles, pools and bends are a natural part of the catchment being studied. For example, large slow flowing rivers may not have riffles but the bends provide different habitats because the cutting action of water at bends provides deeper areas.

How to carry out the survey

1. Survey both sides of the stream for approximately 100m and extending out from the water by 40mfor a medium/ large size waterway or 10-20m for a small stream.
2. For each feature in Table 7 Habitat Descriptions and Ratings, select a category (excellent, good, fair or poor) that is most like your habitat. If the description in the table does not match, try another category.
3. Record the score for each feature on the Stream Habitat Rating Sheet.
4. For an overall assessment of the site, add up the scores to obtain a total. Refer to Tables 7 and 8 for an interpretation of your assessment. Bank and verge vegetation and in-stream cover are more important in determining the health of the habitat than either bank erosion and stability or riffles, pools and bends.

Quality control

The main quality contol challenge for the Habitat Rating is to ensure consistent evaluation of features of the habitat. The easiest way to accomplish this is to have one team whose job is to carry out the habitat assessment throughout the catchment. From time to time the evaluation of habitats by field teams should be compared with that of your *Waterwatch* coordinator.

While this allows valid comparisons to be made within your catchment or region, it does not guarantee valid comparisons across regions or the state because of subtle differences in human perception.

Habitat awareness survey

Table 7: Rating the habitat

Features of the habitat	Excellent	Good	Fair	Poor
Riparian habitat (Examine habitat over a length of 100 m and 40 m back from the water of a medium size waterway or less for a small stream)	8 Mainly undisturbed native plants on both sides of waterbody to 40 m from water. Introduced species are present at very low levels or completely absent.	6 Native vegetation on both sides of waterbody in generally good condition. Some intrusion of introduced species. Riparian zone less than 40 m but still wide.	4 Mixture of native and exotic species on both banks, OR one side may be cleared and the other side undisturbed native plants OR narrow corridor of native plants on both sides. Other impacts may be present e.g. fire, stock grazing in riparian zone	2 Any native vegetation present is severely modified on both sides by grazing or human access, OR cleared land both sides (eg agriculture, housing) OR species present are virtually all exotics (willow, pines, introduced grass etc).
In-stream cover (aquatic plants, snags, logs, bank overhangs and overhanging vegetation)	8 High cover on banks. Abundant in-stream, and overhanging vegetation. Abundant snags and logs or boulders. Bank overhangs present.	6 Good cover on the banks, moderate areas of in-stream and overhanging vegetation. Some snags, logs or boulders.	4 Some cover. Some areas of in-stream or overhanging vegetation. Invasion of bank vegetation by terrestrial grasses. Few snags, logs or boulders.	2 Little or no cover. No overhanging vegetation or in-stream plants. The stream is largely cleared with few or no snags or logs. Any boulders present are submerged. Site may have rock or concrete lining.
Bank erosion & stability (roots, bare soil, slumping, erosion, fall-ins, cracking of bank)	4 Stable. No erosion or deposition evident. No slumping of banks. Lower banks completely covered with root mat, grasses, reeds or shrubs.	3 Very occasional and very localised erosion. Little slumping or undercutting of bank. No significant damage to bank. Good vegetation cover.	2 Some erosion evident but localised. No continuous damage to bank structure. Moderate vegetation cover.	1 Extensive areas of erosion. Unstable, extensive areas of bare ground, bank failure such as cracks and fall-ins. Little vegetation cover. Despite stability of concrete channels they score only 1. Areas of bank works score 1 because of instability.
Riffles, pools & bends (Before you consider assessing this part of the habitat, make sure that riffles, pools and bends are a natural part of the catchment being studied. If not, then ignore this part)	4 Wide variety of habitats. Riffles and pools of varying depths present. Bends present.	3 Good variety of habitat e.g. riffles and pools, or bends and pools. Variations in depth of riffles and pools.	2 Some variety of habitats, e.g. occasional riffle or bend. Some variation in depth.	1 Uniform, or only slight variety of habitat. All riffles or pools with uniform or only slight variation in depth e.g. channelled stream.

Interpreting your Results

Table 8: Interpreting your habitat assessment results

Habitat Rating	Overall Condition of the Habitat	Colour Code for Map
Excellent 18–20	Site in natural or virtually natural condition; excellent habitat condition.	Blue
Good 13–17	Some alterations from natural state; good habitat conditions.	Green
Fair 8–12	Significant alterations from the natural but still offering moderate habitat; stable.	Yellow
Poor 5–7	Significant alterations from the natural state to very degraded. May have moderate to severe erosion or sedimentation problems.	Red

Appendix 1

Record sheets

This section includes the record sheets you will need to record your data. Make sufficient copies of each. The forms are:

- Site description record sheets
- Waterbug awareness result sheet
- Macro-invertebrate monitoring record sheets
- SIGNAL 2 score (major groups) result sheet
- SIGNAL 2 score (families) result sheet
- Habitat rating record sheet

Site description record sheets

Complete a site description record sheet for each one of your sites. Each time you visit your site, take a copy of the site description record sheet completed on the last visit to look for any changes. A site is a 100m length of the waterway.
Face downstream when describing the left and right banks.

Background information

Date: __________ Time: __________ Name of Group: ____________________

Name of investigators: ____________________

Name of water body: ____________________

Site code: ☐☐☐☐☐☐ Map Name: ____________________

Easting (6 figs): ☐☐☐☐☐☐ Northing (7 figs): ☐☐☐☐☐☐☐

Type of water body (tick a box):

☐ Pond/wetland ☐ Lake/dam ☐ Bore / piezometer ☐ Drain ☐ Estuary

☐ Creek/stream ☐ River ☐ Irrigation channel ☐ Spring ☐ Inlet / bay

Position in the catchment: ☐ Upper ☐ Middle ☐ Lower

Site name: ____________________

Land title numbers of adjacent properties: ____________________

Estimated elevation: __________ Name of suburb, nearest town or settlement: ____________________

Brief description of access to site: ____________________

Comments: ____________________

____

Describe the weather both now and in the past 24 hours (tick a box):

	Clear/sunny	Overcast	Showers	Rain (steady)	Rain (heavy)
Weather now	☐	☐	☐	☐	☐
Past 24 hours	☐	☐	☐	☐	☐

General Features of your Site

Bird's eye view of the site

Sketch a bird's eye view (a view looking down from above) of your stream site, showing curves in the stream, adjacent land on both sides, etc. Mark areas of vegetation, eroded banks, fences, roads, drains, etc. Try to draw about 100 metres of stream length. Remember, it is only a rough sketch. Label the sketch. Mark and number any photo sites and draw an arrow to show the direction from which each photograph was taken. Show the direction of stream flow and the scale of your sketch.

Describe the location of photo sites

____

____

1. Landscape features surrounding the site

____

____

2. Stream channel and banks

a) Average width of wetted part of stream ________ (metres)

b) Average width of channel, e.g. to base of roots of woody plants ________ (metres)

c) Average depth of riffles at the site ________ (metres)

d) Dominant size of bed material (boulder, cobble, gravel, sand or silt) ______________________________

e) Evidence of erosion (head cuts, undercutting banks, incised bed) ______________________________

	Left bank	Right bank
f) Average height of the banks		
g) Levee banks present or absent		
h) Typical bank slope over 100m of stream (vertical or undercut, gradual or little slope, variable, artificial banks)		
i) Soil type and erosion potential		

3. Description of the water

a) Appearance of water – clear, oily sheen, foamy, frothy, milky, muddy, coloured brown, green, reddish or other - describe

____

b) Smell of water - none, sewage, fish, chlorine, rotten eggs, other - describe ______________________________

c) Average water velocity ☐ high ☐ medium ☐ low

4. Plant material in the water (tick the best description)

a) Presence of logs greater than 10cm in diameter in the water ☐ None ☐ Occasional ☐ Plentiful

b) Large aquatic plants ☐ Present/absent ☐ Attached ☐ Free floating

c) Algae in the waterway

i) Algae growing on submerged stones, twigs, etc ☐ None ☐ Occasional ☐ Plentiful ☐ Colour (green or brown)

ii) String-like algae (filamentous) ☐ None ☐ Occasional ☐ Plentiful ☐ Colour (green or brown)

iii) Detached "clumps" or "mats" of floating algae ☐ None ☐ Occasional ☐ Plentiful ☐ Colour (green or brown)

5. Riparian vegetation

	Left bank	Right bank
a) Average width of stream side vegetation		
b) Length of riverbank with vegetation overhanging the water		
c) Total length of riverbank with willow infestation		
d) Total length of each bank lined with native vegetation		

6. Evidence of animals and birds

Birds (describe/name) ______________________________

Animals (describe/name) ______________________________

7. General conditions affecting the stream

Note: the general conditions around the site that might be affecting your stream.

These conditions may include dead trees, degraded vegetation on bank, banks collapsed, eroded, stock erosion paths, mud in or entering stream, litter, rubbish in or next to stream, actively discharging pipes, other pipes, drains entering, dams, weirs across stream.

____

____

____

____

____

____

8. Land uses near the site

The way the land is used and managed can have a severe effect on the health of the waterway. Look at the surrounding land uses for a distance of up to 400m away from the site. Add comments if a land use or management practice appears to be causing problems.

	Land use area as a percentage of total	Comments
Agriculture	☐ %	______________
Built environment	☐ %	______________
Construction	☐ %	______________
Recreation	☐ %	______________
Bush, forests, nature reserves	☐ %	______________
Other land uses	☐ %	______________

9. Significant changes to the site since your last visit

Compare conditions at the site with those recorded on your site description record sheets from the last visit.

____

____

____

10. Ideas for action

While describing the site, you may think of some actions that could be taken to improve the habitat in and around your stream. Write them down here for reference.

____

____

11. Pipe and drain inventory

Record observations on each pipe and drainage ditch found on the banks or in the stream. Photocopy additional sheets sufficient for each pipe or drain that you are likely to find. Pipes or drains can be abandoned or active.

a) This information applies to a: ☐ Pipe ☐ Drain ☐ Other (name)

b) Location of pipe/drain ☐ In-stream ☐ In bank ☐ Near stream

Describe location for purpose of adding to your base map ______________________________

____

____

c) Type of pipe and diameter

	Diameter (m)		Diameter (m)
☐ Industrial outfall	☐	☐ Agricultural field drain	☐
☐ Sewage treatment plant outfall	☐	☐ Settlement pond drain	☐
☐ Storm drain	☐	☐ Parking area drain	☐
☐ Combined sewer overflow	☐	☐ Bridge culvert	☐
☐ Other (name)	☐	☐ Unknown	☐

d) Discharge flow

Rate of flow	☐ None	☐ Trickle	☐ Heavy	☐ Intermittent	☐ Steady
Appearance	☐ Clear	☐ Foamy	☐ Turbid	☐ Oily sheen	☐ Coloured (name)
Odour	☐ None	☐ Sewage	☐ Fishy	☐ Chemical	☐ Chlorine

Other observations ______________________________

e) Condition of the stream bank below the pipe or drain

☐ No problem evident ☐ Sewage litter, e.g. toilet paper ☐ Rubbish, e.g. cans, paper ☐ Eroded ☐ Lots of algae

f) Additional comments

Use this space to expand on or explain information provided above. For example, you may want to add notes on the condition of the stream below the discharge.

____

____

____

Waterbug awareness result sheet

Photocopy the results sheet each time you collect data.

Background information

Date: __________ Time: __________ Name of Group: ______________________________

Name of investigators: ______________________________

Name of water body: ______________________________

Site code: ☐☐☐☐☐☐ Map Name: ______________________________

Easting (6 figs): ☐☐☐☐☐☐ Northing (7 figs): ☐☐☐☐☐☐☐

Type of water body (tick a box):

☐ Pond/wetland ☐ Lake/dam ☐ Bore / piezometer ☐ Drain ☐ Estuary

☐ Creek/stream ☐ River ☐ Irrigation channel ☐ Spring ☐ Inlet / bay

Position in the catchment: ☐ Upper ☐ Middle ☐ Lower

Estimated elevation: __________ Name of suburb, nearest town or settlement: ______________________________

Brief description of site: ______________________________

Comments: ______________________________

____

Results

1. Which type of waterbug collection method did you use?

☐ Riffles - rock rubbing method or ☐ kick method

☐ Edgewater, riffle or pool — leaf packs sorting method

☐ Aquatic plants — sieve or net sampling method

2. Tick the box (none, occasional, or plentiful) that best shows the number of each type of waterbug found.

Waterbugs	None	Occasional	Plentiful
Worm-like (Generally tolerant)	☐	☐	☐
Animals with shells (Vary from tolerant to intolerant.)	☐	☐	☐
Crayfish-like (Generally intolerant)	☐	☐	☐
Insect-like (Generally intolerant)	☐	☐	☐
Other types (describe)	☐	☐	☐

Macro-invertebrate monitoring record sheet

Photocopy the results sheet each time you collect data.

Background information

Date: __________ Time: __________ Name of Group: ______________________________

Name of investigators: ______________________________

Name of water body: ______________________________

Site code: ☐☐☐☐☐☐ Map Name: ______________________________

Easting (6 figs): ☐☐☐☐☐☐ Northing (7 figs): ☐☐☐☐☐☐☐

Type of water body (tick a box):

☐ Pond/wetland ☐ Lake/dam ☐ Bore / piezometer ☐ Drain ☐ Estuary

☐ Creek/stream ☐ River ☐ Irrigation channel ☐ Spring ☐ Inlet / bay

Position in the catchment: ☐ Upper ☐ Middle ☐ Lower

Estimated elevation: __________ Name of suburb, nearest town or settlement: ______________________________

Brief description of site: ______________________________

Comments: ______________________________

____

Describe the weather both now and in the past 24 hours (tick a box):

	Clear/sunny	Overcast	Showers	Rain (steady)	Rain (heavy)
Weather now	☐	☐	☐	☐	☐
Past 24 hours	☐	☐	☐	☐	☐

Collection method

Sample type

☐ Kick sample ☐ Sweep sample ☐ Riffles ☐ Edgewater ☐ Replicate sample collected

SIGNAL 2 score (major groups) result sheet

Record the type and numbers of macro-invertebrates of each group (without weighting). Also record the weighting factor if you are using that method. Make extra copies of this record sheet as required.

Macro-invertebrate Major group (order, class and phyla)	Common name	SIGNAL 2 sensitivity grade	Number of specimens	Weight factor	Grade x weight factor
	Total				

SIGNAL scores without weighting =

$$\frac{\text{sum of grade numbers}}{\text{number of different groups found in sample}}$$

SIGNAL scores with weighting =

$$\frac{\text{total of grade x weight factor}}{\text{total of weight factor}}$$

Refer to your Quadrant Diagram for further interpretation.

SIGNAL 2 score (families) result sheet

Record the type and numbers of macro-invertebrates of each group (without weighting). Also record the weighting factor if you are using that method. Make extra copies of this record sheet as required.

Macro-invertebrate Major group (order, class and phyla)	Common name	SIGNAL 2 sensitivity grade	Number of specimens	Weight factor	Grade x weight factor
	Total				

SIGNAL scores without weighting = $\frac{\text{sum of grade numbers}}{\text{number of different groups found in sample}}$

SIGNAL scores with weighting = $\frac{\text{total of grade x weight factor}}{\text{total of weight factor}}$

Refer to your Quadrant Diagram for further interpretation.

Habitat rating record sheet

Photocopy the results sheet each time you collect data.

Background information

Date: __________ Time: __________ Name of Group: ______________________________

Name of investigators: ______________________________

Name of water body: ______________________________

Site code: ☐☐☐☐☐☐ Map Name: ______________________________

Easting (6 figs): ☐☐☐☐☐☐ Northing (7 figs): ☐☐☐☐☐☐☐

Type of water body (tick a box):

☐ Pond/wetland ☐ Lake/dam ☐ Bore/piezometer ☐ Drain ☐ Estuary

☐ Creek/stream ☐ River ☐ Irrigation channel ☐ Spring ☐ Inlet/bay

Position in the catchment: ☐ Upper ☐ Middle ☐ Lower

Estimated elevation: __________ Name of suburb, nearest town or settlement: ______________________________

Brief description of site: ______________________________

Comments: ______________________________

____

Describe the weather both now and in the past 24 hours (tick a box):

	Clear/sunny	Overcast	Showers	Rain (steady)	Rain (heavy)
Weather now	☐	☐	☐	☐	☐
Past 24 hours	☐	☐	☐	☐	☐

Habitat Rating

Rating the habitat. Circle your rating score for each part of the habitat below:

Habitat rating	Bank vegetation	Verge vegetation	In-stream cover	Erosion & stability	Pools, riffles and bends
Excellent	4	4	4	4	4
Good	3	3	3	3	3
Fair	2	2	2	2	2
Poor	1	1	1	1	1

If you wish to get a general rating for the site then add up all the numbers you circled for a total score. The minimum total is 5 and maximum 20.

Total score:	Stream Habitat Rating:

Habitat rating		Overall condition of the habitat	Colour code for map
Excellent	18–20	Site in natural or virtually natural condition; excellent habitat condition.	Blue
Good	13–17	Some alteration from natural state; good habitat conditions.	Green
Fair	8–12	Significant alterations from the natural state but still offering moderate habitat; stable.	Yellow
Poor	5–7	Significant alterations from the natural state to very degraded. May have moderate to severe erosion or sedimentation problems.	Red

Further resources

To identify your animals to family level, refer to one or more of the following guides.

- Chessman B. 2001, *SIGNAL 2, A Scoring System for Macro-invertebrates (Waterbugs) in Australian Rivers, User Manual*. Version 2, 2001. This draft has been developed for Waterwatch Australia for community groups.
- CSIRO, 1991, *The Insects of Australia*, second edition, Melbourne University Press, Carlton. This book gives keys to the identification of all families of insects, both aquatic and terrestrial, known to occur in Australia and provides information on insect anatomy, systematics and biogeography.
- Davis J. and Christidis, F. 1997, *A Guide to Wetland Invertebrates of Southwestern Australia*, Western Australian Museum.
- Gooderum J. and Tsyrlin E. 2002 The Waterbug Book, A Guide to the Freshwater Macro-invertebrates of Temperate Australia. CSIRO Publishing, Collingwood Vic. An excellent and essential reference for identification of waterbugs to family level.
- Harvey, M. S. and Yen, A. L. 1989, *Worms to Wasps, An illustrated Guide to Australia's Terrestrial Invertebrates*, Oxford University Press, Melbourne. This book has a useful introduction to terrestrial invertebrates and also describes aquatic groups.
- Hawking, J.H. and Smith F.J., 1997, *Colour Guide to Invertebrates of Australian Inland Waters*, Cooperative Research Centre for Freshwater Ecology, Identification Guide No 8, Albury. This provides valuable ready reckoner with 200 colour photographs of many common invertebrates.
- Hawking, J.H. 1994, *A Preliminary Guide to Keys and Zoological Information to Identify Invertebrates From Australian Freshwaters*, Co-operative Research Centre for Freshwater Ecology. This provides a comprehensive list of keys and other information.
- Ingram B. A. , Hawking, J. H. and Shiel R.J. 1997 *Aquatic Life in Freshwater Ponds*, Co-operative Research Centre for Freshwater Ecology, Albury.
- Miller R., 1983, *Freshwater Invertebrates*, Gould League of Victoria. This is a helpful beginners guide to identification.
- Williams, W.D. 1980, *Australian Freshwater Life*, Macmillan, Melbourne. This book provides comprehensive information on common Australian invertebrates in inland waters.
- Zborowski, P. and Storey, R. 1995, *A Field Guide to Insects in Australia*, Reed Books Chatswood, NSW. This text gives a useful introduction to insect orders and many families, and includes many groups which occur in aquatic environments.

Websites

www.clw.csiro.au/ColourBugGuide

www. waterwatch.org.au
(this site also has links to State Waterwatch websites)