HAURAKI
DISTRICT COUNCIL

Water Quality Parameters

Chemical and Physical Factors Influencing
Water Quality in Rivers and Streams

This booklet has been compiled from information supplied by Wai Care. http://waicare.org.nz

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River Water Quality Parameters

In this booklet you will find all the supporting information you need to understand:

a) the importance of the water quality parameters you are measuring;
b) what activities causes them to change;
c) what effects these changes will have in stream life;
d) what solutions are available to avoid or remedy problems; and
e) what range of values would you expect to find in Auckland streams.

You can use this booklet to help select appropriate parameters to define what is influencing the water quality of your chosen catchment.

Contents

Water Temperature

Many of the physical, chemical and biological characteristics of streams are directly affected by water temperature. It is a very important parameter in terms of stream health and it is simple to measure. Unfortunately the interpretation of water temperature results is not so simple because temperature influences many different properties of water.

Several things influence the rise and fall of water temperature in a stream but the most important being, the season, time of day and the weather. A wide range of temperatures can occur along the length of a stream especially in the summer months due to factors such as : water depth, water colour, amount of shading vegetation and flows.

Many native stream inhabitants can only tolerate a narrow range of temperatures and they are particularly sensitive to high temperatures.

As temperature can vary substantially throughout the day it is important to sample at the same time each day so that you are comparing like data.

Causes of Temperature Variation

Stream water heating often causes environmental damage over time. Many problems associated with stream water temperature are caused or worsened by human land uses and activities, such as:

- Warm runoff from hard (impervious) urban surfaces such as roadways, footpaths, car parks, concrete yards and rooftops, can substantially affect the temperature of the receiving water. Extreme temperature pulses from these surfaces can occur during summer rain showers. Piped systems then transfer this heated runoff directly to waterways with potentially lethal results;

- Clearing of overhanging riparian vegetation allows the sun to shine directly onto the water. Heating is more noticeable in smaller waterways, of which Auckland has many;

- Sediment and other suspended materials absorb heat from the sun. Sediment can also decrease the depth of channels, increasing the surface to depth ratio and contributing further to the problem;

- The shading provided by stream banks is often removed by stream channel works (straightening, widening, concrete channels etc);

- Industrial or commercial premises may have cooling processes which generate heated or chilled wastewater which cannot be discharged without approval from the Regional Council;

- In residential areas heated swimming pools or spa pools may have overflows or filter discharges to stormwater systems.

- Dams and ponds increase the surface area of un-shaded waterways and storage time of water within the system. Both factors contribute to increased water temperatures.

The Effects

- Warmer water cannot hold as much oxygen as cooler water. Biodegradable waste matter in a water body will compound the problems as bacteria breaking down the waste use up oxygen as part of this process.

- Increases in water temperature will increase the energy consumption by stream life. Increased activity results in greater oxygen use by fish, aquatic insects and bacteria.

- Water temperatures enable these plants to grow more vigorously and may lead to algal blooms, which can lead to a number of undesirable effects.

- Warmer temperatures can stress aquatic organisms and they then become more vulnerable to other stresses. Fish and some stream insects are particularly susceptible to rapid temperature changes and can suffer internal damage.

- Most species have different temperature tolerances at different life stages, for example generally larval stages can tolerate a narrower range of temperatures than adults.

- If the overall temperature range of a stream changes, so does the numbers and variety of organisms in the community. For example stonefly larvae, which are an indicator of good water quality, drop markedly in numbers as soon as maximum water temperatures exceed 19^{o}C. Temperatures between 21^{o}C to 24^{o}C are lethal to many sensitive aquatic invertebrates.

- A short period of high temperatures each year can make the stream unsuitable for sensitive organisms by wiping out breeding populations, even though the rest of the year the temperature is tolerable.

The Solutions

- Restoring shade on stream banks by riparian vegetation planting will reduce maximum water temperatures in streams. Encouraging grass, ferns and sedges to grow may provide enough shading for small, narrow (less than 1 metre wide) streams. In wider streams tall trees are necessary. Tree spacing and density will affect how much shade is provided by riparian vegetation.

Note: Although it is possible to restore shade at a site, the temperature benefits may not be realised for some distance downstream, as the cooling effect takes some time to occur. Typically around 200-400 metres of shaded stream is required to achieve “normal” temperatures.

- Avoid activities that increase the cloudiness of water by sediment or waste discharges. For example rainfall followed by surface runoff and/or erosion contribute to elevated turbidity in summer. Discoloured waters absorb more heat from the sun.

- Ensure that water from swimming or spa pools are directed to the sewer, or ensure that they cool sufficiently prior to release. In any event backwash water must go to the sewer as it contains high levels of other contaminants such as chlorine and organic material.

- The warmth of urban runoff may be reduced by retaining the water in places where there is overhanging vegetation to shade the water. The stormwater runoff from large commercial areas can be reduced by painting roof surfaces in light reflective colours (white is best) and by shading areas such as car parks.

Expected Temperature Ranges

Water temperature data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. Regardless of land use however, waterways that have substantial areas of riparian vegetation have significantly lower water temperatures. Differences are more pronounced during the summer than during the winter months as expected. Temperature ranges for some land use types are shown in the table below (all units are degrees Celsius).

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	6.0	13.7	20.0	Cascades
Exotic Forestry	6.0	13.0	20.0	Mahurangi River
Agriculture	7.4	16.0	22.0	Hoteo River
Urbanising	7.0	14.5	21.0	Oteha Stream
Urbanised	10.2	17.5	26.0	Puhinui River

The Resource Management Act (1991) limits acceptable temperature increases due to wastewater discharges, after reasonable mixing in receiving waters, to less than 3^{o}C. Any such discharges require a resource consent from the Regional Council.

Water clarity

The quality of our water contributes greatly to our economy, particularly through tourism. Water clarity is specifically mentioned in the RMA because it affects the recreational enjoyment of water and how people perceive it.

Water clarity is an indirect measurement of the amount of suspended solids in water. In New Zealand it is the preferred method for assessing water turbidity or ‘murkiness’. In other words, high water clarity means low turbidity and vice versa.

As runoff occurs within a catchment, tiny particles of clays, silts or organic material are washed into waterways. Depending on water velocity these tiny particles can be supported in the water column and are termed suspended solids. The faster the water is flowing the better it’s ability to keep soilds in suspension.

Many Auckland waterways have a low level of fine suspended ‘colloidal’ material even during low flow situations. This opalescent or ‘slightly milky’ appearance is a consequence of the predominantly clay soils in the Region. Our urban streams are mostly small with short flow paths and muddy rather than stony embankments and bases. In slow-flowing lowland streams, high levels of turbidity may persist for long periods. This is due to the low rate of flushing and the fact that very fine particles are held in suspension almost indefinitely.

Measuring the murkiness of a stream under a variety of flow conditions is one way of measuring catchment condition.

The Causes of Reduced Water Clarity

There are many possible sources of reduced water clarity. Stormwater runoff from urban areas may carry heavy sediment loads where they drain areas of soil that has been disturbed due to earthworks from subdivision or redevelopment. Increases in impervious area due to urbanisation results in greatly accelerated runoff during rainfall events. Higher stream flows lead to greater water velocity leading to stream bed and bank erosion.

Wastewater discharges from residential and industrial processes have the potential to adversely effect water clarity, regardless of flow condition. Contaminants such as paint, concrete cutting wastes and equipment washwater are all potential negative influences on water clarity.

Microscopic algae also can contribute to turbidity when too much nutrient and sunlight increase their numbers (this is a minor contributor to most Auckland waterways due to their short length and therefore the time it takes to get from the top to the sea).

The Effects

Suspended materials or reduced water clarity can ruin habitat for aquatic life. The suspended material restricts light passing through the water column. Reduced light can limit plant growth that in turn affects aquatic life relying on the plants for food. Higher levels of sediment can lead to habitat destruction or direct effects on the stream life themselves, as follows:

- Where there is less light penetrating the water, there will be less photosynthesis and this can reduce the level of oxygen in the water;

- The water becomes warmer because suspended materials absorb heat from the sun. This also decreases the amount of oxygen present in the water (cold water can hold more oxygen). Shaded waterways will be less affected.

- Sediments settling out of the water column may cover bottom dwelling creatures or the places where they live. The gill structures of many aquatic creatures are easily clogged by sediments, reducing their ability to take up oxygen.

- Poor water clarity has direct effects on fish and birds that rely on their sense of vision to find and catch their prey.

- Turbid waters may indicate the presence of contaminants, such as paint, in solution or adsorbed into sediment particles. These contaminants may result in directly (acutely) toxic effects on aquatic life or build up over time and result in longer term (chronic) toxicity.

The Solutions

Reduction or loss of water clarity can be minimised by:

- Retaining or improving vegetation along stream banks for stabilisation.

- Providing water velocity dissipation structures where stormwater pipes enter natural streams to prevent scouring. Stream bed or bank armouring in the form of rock baskets (gabions) can also be used to ensure that flow velocity within the stream does not worsen existing instability problems.

- Slowing stormwater runoff from urbanised areas by using ‘natural’ systems such as grassed swales (drainage channels) rather than concrete lined channels. Flows within waterways can be managed by using ponds and/or wetland systems.

- Controlling stormwater runoff from areas of land disturbances using sediment control devices such as silt fences, sediment traps, rock filters, etc.

- Avoiding the discharge of pollutants into waterways from poor ‘housekeeping’ practices regarding material spillage and wastewater disposal.

Expected Levels of Water Clarity/Turbidity

To understand the water clarity results you obtain you need to get information on the natural levels in your area at various times of the year. Natural variations within an area may be related to soil types and events such as flood flows. Interpretation of variation and baseline levels should take into account, not only the natural features of the area but also information about local land use practices and riparian management. You need a sound knowledge of your Wai Care catchment before you can decide what might be causing elevated turbidity.

Water clarity data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. Water clarity (turbidity) ranges for the various land use types are shown in the table below, all units are nephelometric turbidity units (NTU) Booklet 3 ‘The Field Manual’ explains how to convert the water clarity tube readings that you will be collecting into NTU’s for comparison with this data. As described for water temperature, turbidity levels in catchments with substantial areas of riparian vegetation were significantly lower than those without.

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	1.2	2.3	44.0	Cascades
Exotic Forestry	5.1	11.5	49.1	Mahurangi River
Agriculture	6.5	13.0	54.0	Hoteo River
Urbanising	3.1	30.5	545	Oteha Stream
Urbanised	3.8	11.9	85.0	Puhinui River

The appearance of water usually determines how people perceive its acceptability for various uses.

Nitrogen

Nitrogen is a mineral nutrient, essential to all forms of life. It is found in proteins, including enzymes, DNA and many other building blocks of life itself. Aquatic organisms can use both dissolved and some particulate forms of nitrogen. As with most essential chemicals the delicate balance if an Ecosystem can be upset when nitrogen levels become too high.

Nitrogen occurs naturally in surface waters even in pristine native bush catchments albeit at low concentrations. Under these circumstances nitrogen is washed into streams from the soil and from the decay of organic material such as leaves etc. In natural waters nitrogen can be dissolved in solution, attached to sediment particles or algae or in gaseous form.

Nitrogen may be present in the inorganic form of nitrate (NO_3), nitrite (NO_2) and ammonia (NH_3 and NH_4); or in combined forms such as proteins and humic acids.
In low oxygen, slightly acidic, environments such as swamps, high nitrate levels are generally converted back to ammonia with the release of nitrogen gas.

The Causes of High Nitrogen

High concentrations of nitrogen in water bodies are almost always the result of human activities.

- Overuse of fertiliser on lawns, gardens and playing fields can result in high nitrate levels in groundwater. This groundwater then seeps into streams taking the nitrate with it.

- Broken or overflowing sewage systems are a potential source of high nitrogen in urbanised catchments. Depending on how well oxygenated the water is and the flow rate, the nitrogen may be present as NO_3, NO_2 or NH_3/NH_4.

- Decaying organic matter, including vegetation such as grass clippings, can produce nitrogen rich leachate, particularly when stockpiled in large quantities.

- Some industrial/commercial wastes and/or contaminated stormwater runoff, such as food production residues/wastes, can contain high nitrogen levels.

- Vehicle exhaust emissions are high in nitrous oxide. Therefore main vehicle thoroughfares may have stormwater with elevated nitrogen due to particles settling out from the air.

The Effects

Nitrate (NO_3)is the most chemically stable form of nitrogen and is the most common in well oxygenated streams. It is readily taken up by aquatic plants. Regardless of the land use type nitrogen levels will show a seasonal pattern with elevated levels in winter, when leaching from the soil is greatest, and lower levels in summer.

Excess nitrate can result in algal blooms in larger water bodies and proliferation of aquatic weeds (often termed macrophytes). When these plants breathe at night, oxygen is removed from the water reducing the ability of other life to survive. During the day these plants pump oxygen into the water as they photosynthesise resulting in super-oxygenated water (greater than 110% saturation). Photosynthesis also results in a shift in the carbonate /bicarbonate balance of the water toward a more alkaline pH (up to 9 in summer). When these plants die they rot and this process uses up oxygen. This oxygen demand may restrict the invertebrate species that can inhabit a waterway to those tolerant of low oxygen levels.

Nitrite (NO_2) is a relatively unstable intermediate in the conversion between nitrate and ammonia. NO_2 usually occurs at very low levels in well oxygenated waters but levels can increase after discharges of ammonia rich wastewater such as domestic sewage. NO_2 can be used as a rough indicator of proximity to a pollution source.

Ammonia is produced by decay of organic material and in well oxygenated waters converts to NO_3 (through NO_2). This conversion process uses up oxygen leaving less in the waterway to sustain aquatic life. Ammonia also exerts a toxic effect on aquatic life with chronic impacts being experienced by sensitive aquatic life at levels around 0.77 mgN/l.

The Solutions

- Manage application of nitrogenous fertilisers to avoid heavy applications particularly in late autumn and winter. By using split dosing (a little bit often) losses due to leaching will be greatly reduced.

- Enhance wetlands and riparian vegetation to ensure maximum nitrogen uptake by plants. Most nitrate moving in groundwater through riparian margins and wetlands is removed by denitrification. This is a microbial process that results in nitrate being converted to gaseous nitrogen.

- Report misconnected, leaking or overflowing discharges of sewage to the appropriate service provider so they can be remedied. Ensure that stormwater runoff from roofs or hardstand areas are not diverted to the sewer and thereby help reduce overflows.

- Report discharges of waste or contaminated stormwater to the relevant pollution control authority so that the industry concerned can be educated as to appropriate housekeeping and disposal practices.

- Avoid placement of vegetation stockpiles (compost stacks) in close proximity to waterways of stormwater systems.

Expected Nitrogen Ranges

Nitrogen data (NO_3 and NO_2) collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. Nitrogen ranges for the various land use types are shown in the table below, all units are milligrams per litre (mg/l). These units are directly comparable to parts per million (ppm) or grams per cubic metre (g/m3).

Nitrate (NO_3)

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	<0.01	0.02	0.12	Cascades
Exotic Forestry	0.01	0.27	1.33	Mahurangi River
Agriculture	0.01	0.49	1.12	Hoteo River
Urbanising	0.10	0.53	1.80	Oteha Stream
Urbanised	0.02	1.80	2.82	Puhinui River

Nitrite (NO2)

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	<0.001	0.0	0.	Cascades
Exotic Forestry	<0.002	0.003	0.009	Mahurangi River
Agriculture	0.0	0		Hoteo River
Urbanising	0.003	0.013	0.180	Oteha Stream
Urbanised	<0.001	0.014	0.117	Puhinui River

Phosphorus

Phosphorus is a nutrient that occurs naturally at low concentrations even in pristine catchments. In such situations the phosphorus is sourced from the weathering of rocks and decay of vegetation or other organic matter. Phosphorus occurs in natural waters in either dissolved or particulate form.

Dissolved phosphorus may occur as simple inorganic ‘soluble reactive phosphorus’ (SRP) or in more complex forms such as organic phosphates excreted by organisms. Particulate phosphorus includes that bound to clay particles suspended in the water column or deposited on a stream bed, precipitates and phosphates occurring in living and dead organisms, such as algae and plant matter.

The Causes of High Phosphorus

Increases in phosphorus levels in streams are most often caused by human activities.

- Most of the phosphorus in soils is bound to soil particles or is part of soil organic matter. Stream banks that are not stabilised by planting or engineering measures are prone to erosion due to increased stream velocities in urbanised areas. Surface runoff may also contribute soil particles into waterways during rainfall events, particularly from areas of disturbed soil from subdivision.

- Discharges of sewage from overloaded or failed sewerage infrastructure.

- Unauthorised discharges of industrial/commercial wastewater and contaminated stormwater from poor yard housekeeping practices.

- Detergent discharges from domestic or commercial sources associated with cleaning of vehicles, equipment or products.

- Urban stormwater runoff containing fertilisers, animal wastes (e.g. dog poo) and plant material.

Under certain conditions high levels of phosphorus in water may result from re-suspension of bottom sediments which have accumulated over many years.

The Effects

Phosphorus is an essential element of life; it is a nutrient required for plant growth and is a part of many of the molecules responsible for life processes in plant and animal cells.

In most stream waters phosphorus availability limits plant growth because it is present in very low concentrations. This is because it is strongly adsorbed onto organic matter and soil particles. Algae and larger aquatic plants rapidly take up any remaining ‘free’ phosphorus, in the form of inorganic phosphates.

When phosphorus levels exceed what is needed for normal plant growth a process called eutrophication takes place. This nutrient-rich water stimulates plant growth, resulting in problem conditions such as algal blooms and excessive weed growth. When these plants die oxygen is used in the decay process, and the resulting lack of oxygen in the stream water may become a limiting factor for aquatic life. Excessive weed growth is often responsible for localised flooding due to blockage of the stormwater drainage network.

The Solutions

- Runoff from urban and rural areas contains phosphorus bound to soil particles. Avoiding or reducing runoff by planting riparian vegetation , minimising soil disturbance, and incorporating engineering solutions to reduce water velocity will all reduce phosphorus inputs. Riparian strips and silt traps and wetlands are the last line of defence and their long term effectiveness is limited by how much sediment they can store. Eventually the accumulated sediment must be removed to maintain their effectiveness.

- In urbanised areas domestic sewage is a major potential source of phosphorus. Domestic sewage contains around 20-30 mgP/l. Report sewage discharges to the appropriate service provider as soon a possible so the problem can be isolated and remedied. Ensure that roof and yard stormwater do not enter the sewer as this contributes to infrastructure overflows during rainfall events.

- There is a global trend toward phosphorus free products on the domestic market. You can switch to using these products as part of your commitment to the overall philosophy of Wai Care.

- Industrial/commercial products, such as detergent, toothpaste and washing powder, contain phosphates. Commercial premises where these products are manufactured, stored or distributed have the potential to discharge phosphate rich wastewater and/or contaminated stormwater through poor house keeping practices.

- Vehicle and equipment washing using detergents is a major source of phosphate discharge to streams in urbanised areas. Vehicles should be taken to a wash facility (car wash) connected to the sanitary sewer, or washed on a grassy area so detergent and other contaminants can soak in. Equipment or products should only be washed in purpose built wash areas connected to the sanitary sewer.

Expected Phosphorus Ranges

In freshwater ecosystems too much phosphorus, rather than nitrogen, is often the catalyst for problems such as algal growths and aquatic weed proliferation.

Total phosphorus levels as low as 0.01 mgP/l have been reported to result in nuisance water plant and algal growth.

The ANZECC (1992) guidelines recommend the following ranges for total phosphorus in different water bodies to prevent eutrophication:

Rivers and streams	0.010 - 0.1	mgP/l
Lakes and reservoirs	0.005 - 0.05	mgP/l
Estuarine waters	0.005 - 0.15	mgP/l
Coastal waters	0.001 - 0.01	mgP/l

Wai Care is proposing that you test for soluble phosphorus only because a chemical digestion involving ‘aggressive’ chemicals is required before total phosphorus can be assessed.

Soluble phosphorus data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. Phosphorus ranges for the various land use types are shown in the table below, all units are milligrams per litre (mg/l).

Soluble Phosphorus

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	<0.01	0.02	0.04	Cascades
Exotic Forestry	<0.01	0.01	0.06	Mahurangi River
Agriculture	<0.01	0.02	0.13	Hoteo River
Urbanising	<0.01	0.02	0.14	Oteha Stream
Urbanised	<0.01	0.02	0.16	Puhinui River

Dissolved oxygen

Dissolved oxygen (DO) is a measure of the quantity of oxygen gas present in water. DO is vital to aquatic organisms such as plants, micro-organisms (bacteria), invertebrates (animals without backbones such as insects, worms and snails) and fish which need to breathe just as we do.

Another useful measure of water oxygen levels often used by water quality managers is dissolved oxygen saturation, which is the relative percentage of oxygen present in a water sample compared to full saturation. This measure takes into account other influences on water oxygen carrying capacity such as temperature and salinity.

It can tell us at a glance if there is a negative influence on dissolved oxygen levels such as pollution. Sewage effluent, decaying aquatic vegetation, contaminated stormwater discharges and wastewater from human activities all reduce DO levels as they are decomposed by micro-organisms.

DO levels in natural waters depend on four main factors:

∉ **How quickly oxygen is transferred into the water from the air**

The rate of oxygen transfer depends on how saturated the water is already and the area of exposed surface. Any agitation of the water as it passes over rocks or drop structures greatly enhances this process. Shallow fast flowing streams generally have higher DO than deeper slow flowing ones.

∉ **How quickly oxygen is used up by organisms in the water**

All aquatic organisms use up oxygen from the water as they breathe. If large amounts of biodegradable material enter the waterway oxygen will be consumed by the breakdown process. This is caused by an increase in the numbers and activity of the bacterial involved in the breakdown process.

∉ **Photosynthesis of plants and algae**

Aquatic plants and algae release large amounts of oxygen into stream water during daylight hours as a by product of photosynthesis. They consume oxygen from the water during the hours of darkness. Peak DO levels occur in early afternoon and minimum levels just before sunrise.

∉ **Flow variations**

Under very low flow conditions stream DO levels may be reduced, particularly if surface agitation is reduced or the water temperature increases (cold water holds more oxygen). Flood events may increase DO levels but once the flood recedes the breakdown of organic material left by the flood can depress oxygen levels for days or even weeks.

The Causes of DO Change

The input of any degradable matter to a waterway will result in the consumption of oxygen. Despite individual sources contributing only small amounts the cumulative impact of many small amounts can cause a major impact. Small, slow flowing lowland streams, which are common in the urbanised part of the Region, are particularly susceptible in summer low flow situations where little if any dilution is available for wastewater.

Point sources include: failing sewerage pipes and pumps, blockages or system overflows; unauthorised wastewater discharges from industries (e.g. food processing); and discharges from residential activities (e.g. pool filter backwash water or vehicle washing).

Non-point sources include urban stormwater runoff which may contain organic material from a variety of sources. In particular stormwater from industrial yard and processing areas with poor housekeeping practices can contain biodegradable contaminants. Runoff from urbanised areas includes wastes from vehicles, animal wastes (particularly dogs) and garden wastes.

Leaves and other organic materials from garden maintenance may be important where they are stockpiled close enough for leachate produced by rotting to enter a stream. Spraying aquatic or stream bank weeds by Councils or individuals can also add to decaying matter in streams.

The Effects

Waterways that have adequate levels of DO can usually sustain a robust and diverse aquatic community. Reductions in DO even for short periods may result in sensitive species, such as mayfly, stonefly and caddisfly larvae, being absent or only in small numbers in the stream community. As DO levels decrease so do the number of species tolerant of such conditions increase. There are a number of nuisance algae, microorganisms, and insect larvae (e.g. chironomid midges or ‘blood worms’) which can tolerate or even thrive in low DO environments.

The Solutions

Point source discharges from industry and urban areas have improved considerably in recent years with systems or practices that avoid or at least minimise organic material contamination of waterways.

- With few exceptions industrial processes are required to discharge into the municipal sewage treatment system in the Auckland Metropolitan Area. Incidences of organic pollution are mostly due to accidents such as operator error or failure of the supporting sewer infrastructure.

- Problems with sewage system infrastructure increase with system age and network providers invest substantial resources to ensure that pipes are renewed and connections checked. Pipe networks are sized to accommodate increased flows during wet weather conditions. Regular surveys are undertaken to ensure that clean stormwater runoff does not enter systems through misconnections. Debris, such as sediment and litter, entering the drainage network can result in overflows at low points in the system. Councils have a regular cleaning schedule for trouble spots to try and ensure that problems are avoided.

- Disposal of organic materials through regular refuse collection services (such as garden waste composting companies or at authorised refuse disposal facilities will reduce the potential for leachate to be generated.

Non-point sources or organic pollution are more difficult to control however the following methods will help.

- Screening or treatment of stormwater runoff to remove organic material.
- Shading of waterways with riparian vegetation reduces weed growth within and beside the channel reducing the need for spraying or removal.
- Avoid practices which result in wastes entering stormwater systems, such as leaving animal faeces on footpaths.

Expected Dissolved Oxygen Ranges

The ANZECC guidelines (1992) recommend that for the protection of freshwater and marine ecosystems DO levels should not fall below 80-90% saturation. Results of more than 110% saturation indicate that algae or weed photosynthetic activity is producing large amounts of DO.

DO levels below about 40% will not support most aquatic life. At least 60% is required to sustain fish populations. The DO level required to sustain sensitive species is around 80-90%.

A DO test tells us precisely how much oxygen is present in the water but it does not indicate how much oxygen the water is capable of holding at that temperature. The percentage saturation is a much better measure of how much oxygen is available to aquatic organisms.

DO data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types.

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	7.6	10.3	12.1	Cascades
Exotic Forestry	6.9	9.7	11.2	Mahurangi River
Agriculture	6.2	8.9	11.0	Hoteo River
Urbanising	3.9	8.0	10.4	Oteha Stream
Urbanised	4.0	8.3	10.1	Puhinui River

The corresponding DO saturation values are shown in the table below.

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	77	98	103	Cascades
Exotic Forestry	74	93	98	Mahurangi River
Agriculture	52	82	93	Hoteo River
Urbanising	51	80	93	Oteha Stream
Urbanised	45	86	96	Puhinui River

It is note worthy that even our ‘control’ site experienced DO saturation below the level at which ANZECC guidelines suggest adverse impacts might be expected to occur.

pH

The pH of a stream is a measure of how acidic or alkaline (basic) the water is on a scale of 0 to 14. Pure distilled water is neutral with a pH of 7. pH measurements below 7 indicate that the solution is acidic containing more H^+ ions than OH^- ions. Measurements above 7 indicate that the reverse situation exists making the water alkaline. It is important to remember that for every one unit change on the pH scale, there is approximately a ten-fold in how acidic or alkaline the sample is.

The usual pH range for freshwater aquatic systems is 6 to 9 with most waterways around 7. Saline waters which have a pH of around 8, require a large amount of acidic or alkaline material to change their pH much.. Toxic effects on biota are rarely due to high or low pH but most biota are sensitive to rapid changes even though they may be within accepted ranges.

- **The geology and soils of the catchment largely determine the pH of stream waters under base flow conditions.**

The pH of freshwaters is generally between 6 to9, although wide variations exist due to catchment geology. Water from areas with limestone deposits can have relatively high pH. In contrast streams originating from geothermal areas can be acidic due to sulphurous contaminants. Streams draining large wetland areas may also be acidic due to the presence of acids from the breakdown of organic matter (humic acids).

- **Photosynthesis by aquatic plants and algae can cause significant variations in pH.**

During the day dissolved carbon dioxide (which is one of the causes of acidity in stream water) is taken up by plants, making the water more alkaline. pH values are usually highest (least acidic) at mid-afternoon.

Measurement of pH tells us a lot about the natural condition of a water body as well as indicating whether it is being polluted.

The Causes of pH Changes

- Excessive growth of algae and in-stream aquatic plants can lead to elevated pH at certain times of the day. These fluctuations can be quite large and can reduce the number of species to those tolerant of such changes.

- Industrial wastewater or contaminated stormwater can cause significant changes to either acidic or alkaline conditions. For example concrete batching plants produce high pH stormwater runoff due to the lime used in cement.

- Exhaust emissions, containing both nitrogen oxides and sulphur dioxide, can be extreme near high use roads and motorways. When it rains these gases with water to form nitric and sulphuric acid (acid rain). This runoff may contribute to pH changes in streams depending on the dilution available from other sources.

The Effects

Animals and plants in streams are adapted to certain ranges of pH. Even under natural conditions, the animal and plant communities of streams tending toward acidity contain many different species to those with more alkaline waters. Sudden changes in pH or excursions outside of ‘normal’ pH ranges will kill sensitive aquatic life.

pH changes can also affect aquatic communities by changing other aspects of water chemistry. For example water containing ammonia becomes more toxic as pH moves into the alkaline range. Similarly acidic water can mobilise contaminants such as trace metals (zinc, copper, lead, etc) attached onto sediments, which can ultimately result in toxic effects on stream life.

The Solutions

- Road runoff and stormwater from industrial sites may be neutralised by passing through stormwater treatment devices such as grass swales (drains) or wetlands.

- Industrial sites must take appropriate measures to ensure that process wastes are not flushed into the stormwater system but are discharged into the sanitary sewer for appropriate treatment. Good yard housekeeping practices will help ensure that stormwater does not become contaminated by spilled materials.

- Nutrient input into streams must be minimised to ensure that algae and aquatic plants have a reduced influence on stream pH. Many strategies are described in the sections on nitrogen and phosphorus.

Expected pH Ranges

The ANZECC (1992) guidelines for natural waters recommend 6.5 to 9.0 as the optimal range for freshwater aquatic ecosystem protection. Other sources such as the USEPA recommend 6.0 to 9.0 and this is the range generally used within the Auckland Region by water quality managers.

pH data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. pH ranges for various land use types are shown in the table below, values are pH units.

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	7.0	7.8	8.3	Cascades

Exotic Forestry	6.9	7.4	7.8	Mahurangi River
Agriculture	7.0	7.4	8.0	Hoteo River
Urbanising	6.9	7.3	8.2	Oteha Stream
Urbanised	6.9	7.5	8.2	Puhinui River

The higher values found at the Council’s control site are likely to be influenced by geological sources.

Biochemical Oxygen Demand (BOD)

BOD is a measure of the amount of oxygen used up by biological and chemical processes in a sample of stream water over a 5-day. Oxygen in the water is consumed by process such as: the break down (rotting) of organic material; oxygen use by bacterial activity; and chemical reactions as chemicals are converted to more stable forms (e.g. the conversion of ammonia to nitrate).

BOD is calculated by measuring the oxygen level of the water on collection and then 5 days later after storage in the dark (to stop photosynthetic activity) at a constant temperature (usually 20^{o}C). The difference between the two values is the demand or consumption of oxygen by chemical and biological processes.

The **causes, effects and solutions** for elevated BOD are the same as those referenced for DO.

BOD data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. Points of note are that even our 'control' site registered some oxygen demanding substances and that urbanised streams contain some level of oxygen demanding substances more than 50% of the time.

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	<2	<2	2.1	Cascades
Exotic Forestry	<2	<2	2.3	Mahurangi River
Agriculture	<2	<2	5.7	Hoteo River
Urbanising	<2	<2	3.5	Oteha Stream
Urbanised	<2	2.1	15	Puhinui River

Microbiological Indicators

Microbiological indicator organisms are typically used in water quality monitoring to provide a measure of faecal contamination and therefore the sanitary quality of the waterway. Water contaminated by human or animal excreta may contain a diverse range of pathogenic (disease causing) microorganisms such as viruses, bacteria and protozoa. These organisms may pose a health and ecological hazard in streams.

The detection of specific pathogens is usually complex, expensive and time consuming, and often not practical. In routine monitoring for microbiological quality it is necessary to use quick and simple tests for the presence of indicator organisms. An effective indicator organism for detecting faecal contamination of water should;

- Always be present when faecal pathogens are present
- Be present in faeces in large numbers so that the organism can be detected after considerable dilution
- Be relatively quick and easy to detect
- Survive in water at least as long as pathogens

Although no single indicator fulfills all the required conditions the coliform group is generally accepted as the most suitable set of organisms to indicate faecal contamination. The coliform group comprises *E. coli*, other faecal coliforms and related Enterobacteriaceae. They are the most sensitive but least specific of the indicator group for faecal contamination. Water contaminated with faeces will always contain coliforms, but because some coliforms also occur naturally in soil and vegetation, coliforms may sometimes be present in water when no faecal contamination has occurred.

E. coli is the most specific indicator of faecal contamination generally available as it is nearly always present in the gut of humans and animals in high numbers..
The current NZ Ministry for the Environment Guidelines suggest using *E. Coli* for fresh water. *Enterococci* are the indicator organism recommended for testing bathing water quality. The chances of *E.coli* multiplying in unpolluted water are very small and the number of organisms in water can be interpreted quantitatively.

Causes of high bacteriological counts

The results of coliform tests are often highly variable and do not necessarily indicate the degree of faecal contamination present in a waterway. This is because members of the coliform group are also found naturally, in decaying vegetation and soils, and may elevate levels in water. Some coliform bacteria are capable of multiplying in water to high numbers when enriched with organic wastes from places such as pulp and paper mills and vegetable processing plants. However the coliform test may provide useful information on the level and nature of contamination when used in association with the *E. coli* test.

Sources of faecal contamination in stream waters include;

- Waste water treatment plants
- On site septic systems
- Domestic and wild animal manure
- Stormwater runoff

There can be huge differences in results both over time, in wet and dry conditions and at different locations. You will need to look carefully at the impacts around the site, stormwater and sewer pipes and other influences such as birds or other animals to determine the likely origin of the problem.

The Effects

The same materials result in elevated levels of faecal bacteria in streams can;

- present a health risk and cause disease
- cause cloudy water (refer to water clarity)
- emit unpleasant odors
- increase oxygen demand (refer to dissolved oxygen and BOD)

The solutions

- Regular maintenance and checks of sewage system infrastructure;
- Repair sewers and wastewater storage
- Ensure sewer seals are watertight to prevent stormwater entering system and that they are adequate to cope with increased flows during heavy rainfall;
- Ensure that wastewater systems are planned and managed to cater for population growth by building adequate pipes and pumping stations;
- Develop long term wastewater improvements to achieve greatest environmental benefits;
- Dispose all animal excreta to prevent it from entering streams or stormwater drains;

Expected levels of bacteria

The NZ Ministry for the Environment has set guidelines for *E. Coli,* but these are untested in the New Zealand environment.

Bacteriological data collected from Auckland streams as part of baseline monitoring programmes shows considerable differences between land use types. Tables of both ‘Total’ and ‘Faecal’ coliforms have been included.

Points of note are:

- even our ‘control’ site registered elevated levels of total and faecal coliforms on some occasions;
- urbanised streams contain by far the highest levels of bacterial indicator organisms, probably due to sewage system failure during storm events;
- the minimum total coliform values are predominantly faecal coliforms;

- the maximum total coliforms have a lower proportion of faecal coliforms (although the numbers are still enormous).

Total Coliforms

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	2	120	5,000	Cascades
Exotic Forestry	23	255	17,000	Mahurangi River
Agriculture	23	420	38,000	Hoteo River
Urbanising	220	2,300	90,000	Oteha Stream
Urbanised	490	5,000	240,000	Puhinui River

Faecal Coliforms

Land Use	Minimum	Median	Maximum	Site Location
Native Bush Stream	1	70	3,300	Cascades
Exotic Forestry	17	140	3,300	Mahurangi River
Agriculture	17	140	22,000	Hoteo River
Urbanising	50	500	35,000	Oteha Stream
Urbanised	110	800	54,000	Puhinui River

Flow rate of streams

The flow rate of your stream will have a strong influence on all of the water quality parameters you routinely measure. In particular water velocity determines how much waste material can remain suspended in the water. The range of flows experienced at a site will be an important factor in determining which particular plants and animals will find suitable habitats in a stream reach. In the Auckland Region low flow conditions in particular dictate whether higher aquatic life such as fish can be supported or not. Further information is contained in Booklet 4 'Tests surveys and assessments' in the Biological and Habitat Assessment Sections.

Rainfall intensity and duration are key determinants on how often and how large flood events are. Large-scale catchment features such as geology, soil type, slope, degree of vegetative cover and percentage of hard surfaces are other important contributors.

The Causes of Flow Variation

- The type and extent of vegetative cover in the catchment can alter runoff into waterways. Vegetation reduces the impact of raindrops on soil. As some of the water soaks in there is a reduction in the amount and speed of water entering the adjacent stream or channel. Wetlands and riparian vegetative strips are vital in interrupting overland flows (runoff) and can help smooth out peak flows to more closely resemble the natural state.

- Changing a stream channel by straightening, concrete lining or piping will increase the speed which water moves through leading to scouring and erosion. Damage to stream banks and aquatic systems often depend on how much the channel has been changed.

- Stormwater runoff from hard (impervious) surfaces such as roads, paving, industrial yards, car parks and roofs can lead to extremes in flow variation.

The Effects

Higher flows than normal will disrupt community structure by flushing away algae and stream plants and increasing sediment levels due to stream bed scouring or bank collapse. Lower than normal flows can lead to increased temperatures, lower oxygen levels, less dilution for other waste inputs and increased algae and plant growth.

In urbanised catchments coverage of high percentages of ground surface means less water can soak into the ground to replenish the groundwater system (called aquifers). Normally this groundwater discharges slowly into streams providing the base flows in periods of no rain. Cutting off this supply results in less recharge and lower summer flows.

Ideally you should avoid conducting your tests when extreme conditions are occurring, particularly flood flows. Apart from introducing an unnecessary risk of harm to the sampling team, test results will give extreme results for most parameters. Any differences in flow rate should be taken into account when interpreting your results.

The Solutions

It is unlikely that changing land management practices will reduce the total flow in streams appreciably, however it is practical to reduce flow velocities (and therefore erosive power) during floods and sustain base flows.

- Increase the roughness of the channel above the low flow level (i.e. up the stream/river bank) and on the flood plain. Plantings in these areas will increase drag and slow water down.

- Change surface runoff speed with strategically placed riparian plantings. Dense ground cover such as grasses and sedges are most effective for slowing overland flow.

- Maintain and where possible enhance existing stands of bush and establish new stands where practical.

- Avoid changing the path of waterways to increase flow/drainage rate and put back meanders where channel straightening has already happened.

- Direct flows through grassed areas or other absorbent systems

- Retain or re-establish riparian vegetation or wetland areas or install stormwater treatment devices such as ponds. Runoff retained in ponds or wetlands is slowly released after the flood peak has passed.

Use soak holes or baffles to reduce the energy and speed of stormwater runoff.

Macroinvertebrates

Macroinvertebrates are animals that do not have backbones, but are visible to the naked eye. **In this section, and in booklet 3, we have used the terms macroinvertebrates and "bugs" interchangeably.**

In streams, many "bugs" live on the stream bottom or on other substrates. These bottom dwellers are referred to as benthic macroinvertebrates. Many of these "bugs" are insects, but there are many other groups that may also be represented such as crustaceans, snails and worms.

Stream bugs can be separated out into groups based on their feeding habits as follows:

- **Shredders** are mainly large insect larvae that chew up dead leaves. As a group they are relatively uncommon in our streams;
- **Browsers** consume fine particulate matter, algae and associated bacteria, fungi and slime, which are the main components of biological films on the surfaces of stones and plants. They are by far the largest and most diverse feeding group;
- **Collectors** depend on fine particles of organic matter. Tend to be more abundant in the lower catchment;
- **Filtering collectors** are adapted for capturing these particles from flowing water, using a range of devices, including snares, nets, brushes and filtering hairs.
- **Gathering collectors** gather small sediment deposits from the stream bottom or others substrates.
- **Predators** feed on other macroinvertebrates.

Stream "bugs" and the structure of their communities, are commonly used in biological surveys as indicators because they provide important clues about general health of a stream, specifically:

- They are sensitive to chemical and physical changes to their environment;
- A range of sensitivity/tolerance levels (coded green for low tolerance, yellow for moderate tolerance and red for high tolerance in Wai Care) can be given to the many different types of "bugs". The presence, absence or relatively high numbers of the different types can then be used as an indicator of stream health;
- They move very little, making them vulnerable to stream pollution. Being still also makes them suitable for assessing effects on specific sites by comparing upstream with downstream;
- They are relatively easy to collect and identify;
- As they are prolific breeders they can recolonise waterways rapidly once pollution problems have been remedied.

Macroinvertebrate communities reflect the presence of most environmental stresses through changes in number and diversity (community composition), and many provide general indications about types of pollution. Chemical testing may be used to confirm the presence and particular type of pollutant/s, although this may be unsuccessful if pollution is intermittent. The information you gain from chemical testing may also be limited by the range of tests you do. For example, a phosphate and nitrate test will not reveal anything about the level of dissolved oxygen in your stream.

Biological surveys using only macroinvertebrates have some drawbacks -

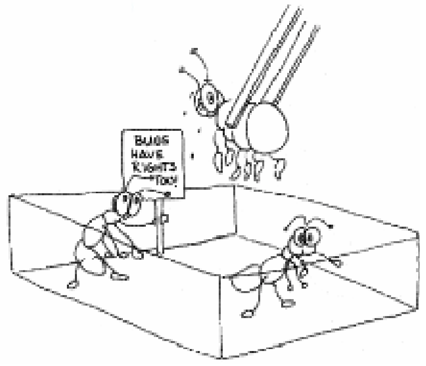
- They do not respond directly to all effects such as herbicide.
- They can not be used to identify a particular pollutant. Species which may be sensitive to one pollutant may tolerate another.
- Macroinvertebrates may be missing due to other factors than just water quality, e.g. habitat damage or recent flooding.
- Macroinvertebrates often show a very patchy distribution and large numbers of samples are needed to be accurate.
- Numbers may vary seasonally as insects hatch and emerge from the stream.
- The need for the samplers to have skills in classifying “bugs”.

How to use biological surveys to determine stream health

At the simplest level, gauge the overall health of the stream by seeing what is present or absent. This is known as a **qualitative** method, because you don’t consider the number of “bugs”.

To detect more subtle effects on the stream, more precise sampling and detailed sorting is required. You have been provided with taxonomic keys and photos to help you identify “bugs” and you will have to become familiar with the tiny body parts you use to identify the different types of “bugs”. While most of the “bugs” can be identified in the field and released back to the stream, this **quantitative** method may require taking “mystery bugs” back to the lab for identification. Removing bugs should be kept to an absolute minimum.

“Put me back, I’m too young to be a statistic.”



The causes of change to macroinvertebrate communities

Various environmental pressures may be acting within a catchment to influence the stream life within your waterway. In the short-term it may be difficult to sort out the natural variation of your stream from human impacts. Knowing what you could expect to find under natural conditions together with a well designed monitoring programme will help you to sort out the most probable causes of change.

If your biological survey indicates that your stream is degraded you should be able to attribute the imbalance to one or more of the following factors:

- **Water quality**: the chemical makeup of the stream water due to natural influences, such as geology, or human impacts.

- **Energy sources**: the source of nutrients for the stream’s food chain. These sources may be natural, such as decaying leaves and woody debris, or from human sources, such as sewage and fertiliser.
- **Biological interactions**: the links between the species in the food chain – the ‘who-eats-who’ of the waterway. Living things in a stream rely upon others for food. When one or more species disappears there is a domino effect as other species move where there is food or die.
- **Flow regime**: variations in flow regime have an impact on the stream life directly (washed away by floods, or conversely the stream drying up) or indirectly (e.g., erosion). These effects a magnified by man-made changes.
- **Habitat Structures**: the types and amounts of natural features that provide instream habitat (woody debris, pools, undercut banks) and riparian vegetation for adult invertebrates (life cycle functions) and cover for fish.

Macroinvertebrate tolerance to pollution

Biologists have determined the pollution tolerance of many common macroinvertebrates. The bug box simplifies these down into three broad categories that are colour coded (green, yellow and red). Common stormwater pollutants such as suspended solids, nutrients and organic waste deplete dissolved oxygen and take their toll on “sensitive” macroinvertebrates such as mayflies, stoneflies and some caddisflies. These conditions may also favour algal growth. Pollution tolerant types such as midges, sandfly larvae and aquatic worms are able to thrive in these conditions. General ‘rules-of-thumb’ are shown in the table below.

Observation	**Analysis**
High diversity, lots of stoneflies, mayflies and caddisflies	No problem, good water quality
Moderate diversity, few if any stoneflies, fewer mayflies (present but not common) and an abundance of caddisflies.	Mild enrichment present, moderate algal growth possibly the result of lower overhead canopy and increased nutrients.
Low diversity, high density, lots of scrapers and collectors	Organic pollution (nutrient enrichment) or sedimentation; lots of algal growth resulting from nutrient enrichment
Only 1 or 2 taxa, high number of collectors	Severe organic pollution or sedimentation
Low diversity, low density, or no “bugs”, but the stream appears clean	Toxic pollution (e.g., chlorine, acids, heavy metals, oils, pesticides), or naturally unproductive due to limited light or nutrients

Of course the life of “bugs” are never this simple. Within any particular group there variations in pollution tolerance and some of these differences are identified on the lid of the “bug box”. More detailed information about pollution tolerance of macroinvertebrates can be obtained from your Wai Care co-ordinator.

The effects of change

Any reduction in the diversity and abundance of macroinvertebrates has consequences for the stream ecosystem. These organisms play an important role in the web of relationships that maintain a stable stream community, including functions such as nutrient cycling and controlling excess growth of algae, and many are at the top of the menu for fish and eels. A diverse community will exist where the combination of biological, chemical and physical factors are capable of supporting it and, given such conditions, a community is more likely to ‘bounce’ back more quickly if there are intermittent stresses such as water contamination. Streams that receive a constant barraged of pollution, such as wastewater or sediment, or other physical impacts, become dominated by pollution tolerant macroinvertebrates.

The solutions

Using a holistic approach to monitoring you will have a more comprehensive view of your stream, and thus be able to find solutions that treat the causes, rather than the symptoms, of your stream’s problems. For example, artificially introducing fish into a stream system to bolster the population will not be effective if the population decline is caused by a lack of sufficient food supply. Perhaps the aquatic insect populations are depleted because of a loss of streamside vegetation and increased sedimentation from unstable banks. In this case, restoring the vegetation and controlling the sediment problem are the better solutions than restocking the stream with more hungry fish.

“Taking Action” (booklet 8) and “Clean Up Your Act” (booklet 7) offer some practical solutions for common waterway problems.

Habitat

The diversity and abundance of stream life is limited by the quality of the physical habitat. Both instream and riparian habitat influence the structure and function of the aquatic community, setting the basic template within which biological communities develop.

The presence of a degraded habitat may make it more difficult for you to determine the effects of pollution on the stream. Biological communities will be responding to two different sets of stresses and it is essential in these situations that you use a reference site. See Booklet 1 ‘Starter Pack’ for more information about selecting sites.

The causes of change

When you begin to survey your stream it will soon become apparent that streams change in character along their length. Many of the changes can be related to the gradient of the stream, which is usually a function of its position within a catchment. Natural gradual changes are usually overwhelmed in urban areas by the range of modifications that result from human activities and the effects these have on stream life will depend on the nature and extent of these changes.

Major causes of degradation of stream habitat include:

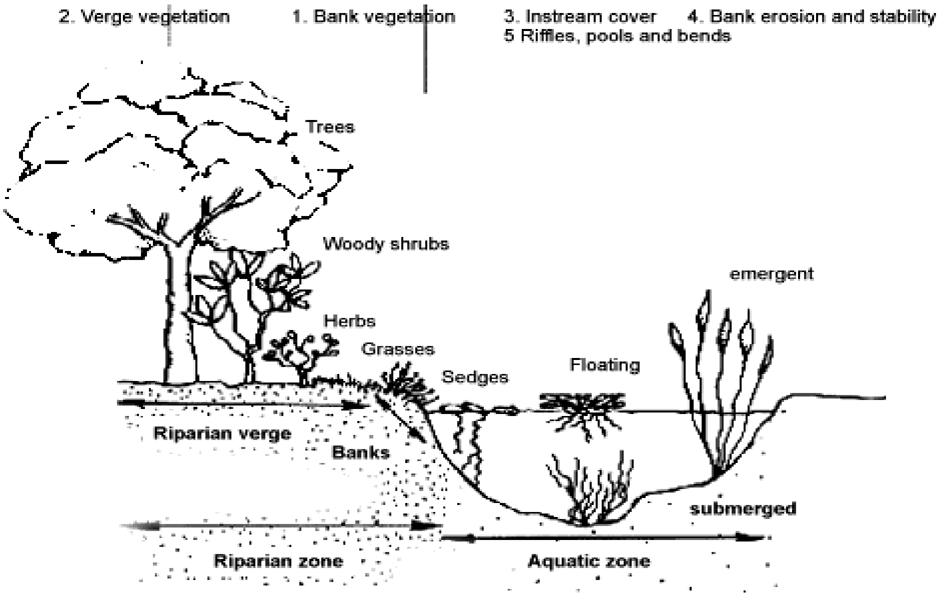
- clearing of vegetation along the stream bank and immediately adjacent land for urban or commercial development.
- channel engineering works including removal of trees likely to cause snags, construction of embankments or channelisation, widen streams and reduce habitat for aquatic organisms.
- changes from the natural water flow and volume in a stream (through inputs from stormwater pipes and drains, irrigation, dams or weirs).
- diffuse and point source pollution.
- roads and recreational activity.
- aquatic and terrestrial weed infestation
- riparian plant growth management with herbicides or mowing.
- In rural areas access of stock to stream bank can lead to:
    - soil compaction and increased erosion along stream bank and wetland fringes;
    - alteration of the composition of stream-side vegetation through reduction of plant cover and regeneration;
    - increases in organic matter content of waterways from stock manure;
    - increased erosion due to pugging and vegetation removal.

The Effects

The riparian zone can provide protection against many of potential impacts from adjacent land use and also contribute to a range of instream habitat qualities:

- Vegetated areas store more water during rainfall events. This water will drain to the stream over time, reducing peak flow and supplementing low flows.
- Vegetation beside the stream is able to strip some nutrients and capture some of the sediment from the surface runoff. The ability of the riparian zone to “filter” runoff is dependent on the type and width of the vegetative barrier.
- Trees provide overhead shade canopy that keeps stream temperatures cooler. On small streams, even shorter vegetation gives valuable shade.
- Logs, root overhang, low-hanging branches and other streamside vegetation that hangs over the water provide protective cover for fish.
- Trees contribute large woody debris to the stream that can be colonised by the stream “bugs”. This is can be a highly productive habitat in a muddy-bottom stream, and it is often the most abundant type of habitat.
- Branches and logs also helps trap and retain leaves and twigs in the stream so that it can be used by “bugs”.
- Larger forms of debris affect the flow of the water and provide greater habitat diversity. They also provide breeding places for stream life, and can be used by fish to establish territories.
- Vegetation provides a source of food for aquatic organisms by dropping leaf and other plant material into stream. Terrestrial insects falling into the stream from the riparian zone is an important source of food for native fish.
- Plant roots stabilise the stream bank. One study found that bank sediment which was made up of 16-18% roots, with a 50mm deep root mat on the bank surface, had 20,000 times more resistance against erosion than comparable bank sediments without bank vegetation. Deep root systems offer more bank protection than shallow root systems.
- Riparian vegetation is important to the completion of the life cycles of some aquatic insects. After emergence the adults of some taxa feed on riparian plants. In some instances, egg numbers vary with amount of available food.
- Where riparian vegetation remains in tact the microclimate is cooler, more humid and sheltered.

riparian zone | stream habitat |



Cross section of stream habitat zones

The solutions

As development increases urbanised catchments become less hospitable for stream life. Protecting riparian areas from degradation is the best way of preserving stream quality, but this is rarely an option – the damage has usually been done.

Through Wai Care water monitoring and assessments you will be able to define the nature and scope of the problem/s relating to habitat, and then develop a practical strategy to solve it. The diagram below outlines some of the options you can consider for the management of your riparian area. A whole catchment approach may be required to define and solve problems that relate to habitat quality. Planning the restoration of a riparian buffer zone is covered in booklet 8, “Taking Action”.

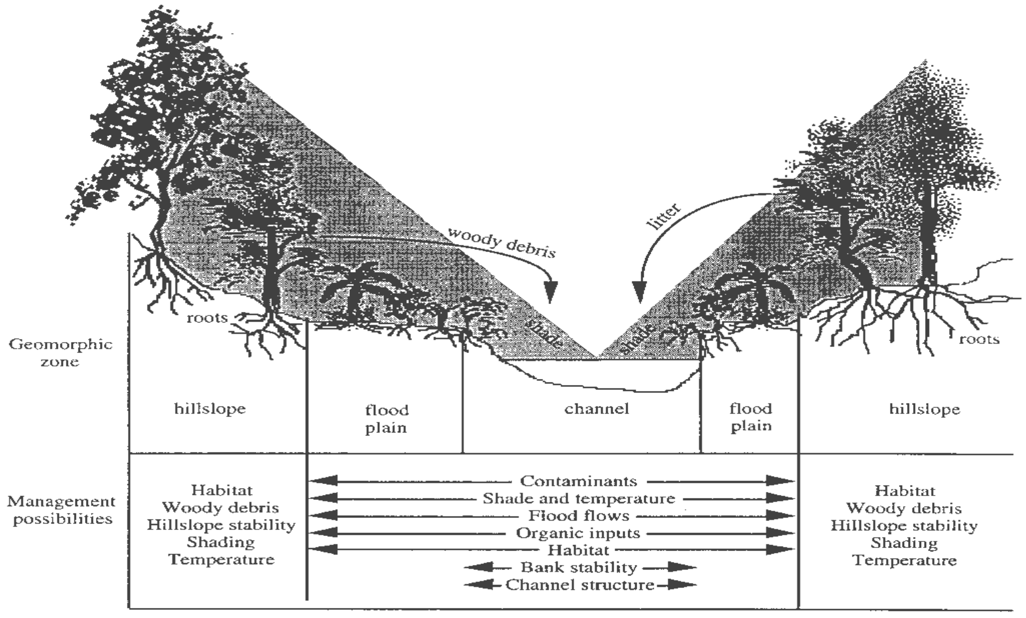


Figure 2 Conceptual diagram of a stream and its riparian area showing geomorphic zones and management possibilities.

Glossary

acidic	Having a pH of less than 7 (fully described in pH section of Booklet 6).
aerobic	Having oxygen.
algae	Simple aquatic plants of one or many cells that need sunlight to live.
algal bloom	Excessive growth of algae due to nutrient levels and other physical and chemical conditions.
alkaline	Having a pH of greater than 7 (fully described in pH section of Booklet 6).
ammonia	Compound of nitrogen toxic to stream life at high concentrations (fully described in nitrate section of Booklet 6).
anaerobic	Living or occurring without oxygen (also called anoxic).
aquatic	In water.
aquifer	A layer of soil or rock which water can pass through or be retained in.
assemblage	A number of species together in one area or habitat.
audit	A record of all the information relating to a place or system.
base flow	Low flow in a stream usually sourced from ground-water discharge.
baseline study	Data collected to document existing conditions.
bed sediment	The material on the bottom of a waterway.
benthic	Living in or on the bottom of a waterway.
bioaccumulation	The build-up of a chemical in body tissues.
bioavailability	How readily a chemical is taken up by living organisms either through the skin or via food.
Biochemical Oxygen demand (BOD)	The amount of oxygen used up from a water sample by bacterial and chemical activity as organic materials break down (fully described in Booklet 6.
biodegradeable	Compounds or materials that can be broken down by micro-organisms.
bioindicators	Organisms that are used to detect changes in the stream environment.
biota	The animals, plants, and bacteria that live in a particular location.
buffer strip	A vegetative barrier between a waterway and surrounding land uses such as agriculture or urban development.
canopy angle	A measure of the openness of a stream to sunlight.
carcinogenic	Potentially capable of causing cancer.
catchment	The area of land from which rainfall drains into a single low point.
chemical oxygen demand (COD)	The amount of oxygen used up from a water sample by organic and inorganic chemicals as they break down.
channelisation	Stream modification to provide more uniform flow.
chlorinated solvent	A volatile organic compound containing chlorine.
chlorophyll	The green pigment in plants that allows them to use the energy of the sun in photosynthesis.
climate	General weather conditions of a region.
colloidal	Fine suspended particles that don’t settle out and are not easily filtered.
colorimetry	Measuring the concentration of a chemical by comparison with colours of standard solutions of known concentration.
combined sewer	A wastewater collection system where domestic and industrial wastewater is combined with stormwater in a single pipe.
community	In ecology, the species that interact in a common area.
concentration	The amount of a substance present in a given volume of stream water. Usually expressed as milligrams per liter for water samples.
confluence	The flowing together of two or more streams; the place where a tributary joins the main stream.
contaminant	See Pollutant.

contamination	Reduction of water quality compared to natural conditions due to human activity.
covariates	Measures that change over time; as a result of, caused by or in conjunction with other measures you are interested in.
culvert	A covered drain or channel that takes a watercourse under something.
cumulative effects	The combined environmental impacts that build-up over time.
cyanobacteria	Photosynthetic bacteria; often referred to as blue-green algae.
data	Numerical values or measures of any kind.
decomposition	The breakdown of organic materials by bacteria into more stable forms (rotting).
denitrification	Reduction of nitrate to nitrite or ammonia by bacterial action.
deposition	The settling out of particles from the water column.
detection limit	The concentration below which a particular analytical method becomes difficult to determin with certainty.
detritovores	Organisms that feed on detritus (usually not bacteria and fungi).
detritus	Fresh to partly decomposed organic matter.
dilute	Make less concentrated.
discharge	To emit or come out, usually relates to fluid flows expressed as volume per unit of time.
disposal	Methods by which unwanted materials are relocated, contained, treated, or processed.
dissolved oxygen (DO)	The amount of oxygen present in a water sample (fully described in the DO section of Booklet 6).
dissolved solids	Amount of minerals, such as salt, that are dissolved in water, that is used as an indicator of salinity or hardness.
E.coli	A specific type of bacteria (fully described in the microbiological Indicator section of Booklet 6).
ecoregion	An area of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.
ecosystem	The interacting populations of plants, animals, and microorganisms occupying an area, plus their physical environment.
eddy	A current which flows differently to the main current of the stream.
effluent	Liquid flowing out (usually relates to wastewater).
ephemeral stream	A part of a stream that does not flow all year round.
EPT richness index	A measure of macroinvertebrate community health (fully described in the macroinvertebrate section of Booklet 6).
erosion	Natural wearing away of rock or soil by physical, chemical, or biological forces.
estuary	A coastal body of water, typically at the mouth of a river, which is open to the sea and allows fresh water from inland to mix with sea water.
eutrophic	A nutrient-enriched, highly productive body of water.
eutrophication	A process by which a water body becomes rich in dissolved nutrients and the other physical changes which promote excessive plant growth.
exotic species	Introduced , non-native species.
faecal coliform	A specific type of bacteria (fully described in the microbiological Indicator section of Booklet 6).
fauna	The animal life inhabiting a particular area
fertiliser	Any natural or artificial substance which is added to soil to supply nutrients for plant growth.
flood plain	The relatively level area of land bordering a stream channel and inundated during moderate to severe floods.
flora	The plant life inhabiting a particular area or environment.
gauging station	A particular site on a stream where flow data is systematically obtained.

geographic information system (GIS)	Computer programs that link mapping information, such as roads, town boundaries, water bodies, with other relevant information about a particular location.
groundwater	Water that exists beneath the land surface.
habitat	The part of the physical environment where plants and animals live.
hazardous waste	Any solid, liquid, or gaseous substance which, because of its nature, is classified under the Hazardous Substances and New Organisms Bill (HSNO). These substances are generally subject to special handling, transport, storage, and disposal requirements.
headwater	The source and upper part of a stream.
heavy metals	Elements that can contaminate water and sediment and cause damage to some forms of life in high concentrations.
herbicide	A chemical substance used for killing plants.
hydrograph	Graph showing variation of streamflow over time.
impact analysis	Monitoring activities that aim to determine adverse effects of a particular activity on a waterway.
imperviousness	The degree to which a surface sheds water (e.g. concrete is high).
invertebrate	Creature without a backbone.
land use	The activities (e.g. residential) which land is developed and used for.
leaching	The movement of chemicals into solution from soil or rock to ground water.
limiting nutrient	The plant nutrient present in lowest concentration relative to need.
macroinvertebrate	Invertebrates visible to the naked eye.
macrophyte	A large aquatic plant either free-floating or attached to a surface.
mass load	The volume or mass of a substance; derived by multiplying the concentration by the flow rate over a specific period of time.
meander	A curve in the course of a river that swings from side to side.
metabolism	The chemical changes in living systems by which energy is provided for vital processes and activities and new material is assimilated.
Milligrams per litre	A unit expressing the concentration of chemical constituents in solution as weight (milligrams) per unit volume (liter) of water, written as mg/l.
mineralisation	The conversion of humus and soil organic matter into inorganic substances by microbial breakdown.
mitigation	Actions aimed at reducing the effects of a particular land use or activity.
monitor	To systematically measure conditions in order to track changes.
nitrate	A compound of nitrogen (fully described in the nitrogen section of Booklet 6).
nitrification	The oxidation of ammonia to nitrate and nitrite by bacterial action.
nitrogen	An element that is essential to all plants and animals.
Non-point source	Coming from a diffuse or widespread source.
nutrients	Chemicals that are needed by plants and animals for growth (e.g., nitrogen, phosphorus).
outfall	The formed point or structure where a discharge occurs.
overland flow	Surface runoff flowing over land toward a channel.
parameter	Any variable that can be measured, e.g. nitrate.
particulate matter	Very small, separate particles of matter.
parts per million	A unit of measurement of the number of parts of a substance in a million parts of another substance (e.g. 10 ppm nitrate in water means 10 parts of nitrate in a million parts of water).
perennial	A waterway that flows throughout the year.
periphyton	Organisms that grow on underwater surfaces, including algae, bacteria, fungi, protozoa.
pesticides	Chemicals used for the control of undesirable forms of life (e.g. insects).
pH	A measure of the acidity or alkalinity of a solution (fully described in the pH section of Booklet 6).

phosphorus	A trace element essential to plants (fully described in the phosphorus section of Booklet 6).
point source	A source at a discrete location such as a discharge pipe.
pollutant	Any substance that degrades water quality to make it less suitable for any purpose (e.g. supporting aquatic life, drink water supply).
pristine	An environment that remains in its natural state.
protozoan	Single-celled animal-like micro-organisms.
quality assurance	Evaluation of data collection and analysis techniques to ensure correct proceedures were followed.
reagent	A substance used in a chemical reaction.
reference site	A site which has the best possible conditions.
restoration	The renewing or repairing of a natural system so that its functions and qualities are made as good as they can be.
riffle	A shallow part of the stream where water flows swiftly over completely or partially submerged obstructions to produce a broken surface.
riparian	Areas of vegetation adjacent to rivers and streams.
riparian zone	Pertaining to or located on the bank of a body of water, especially a stream.
runoff	Water that is not absorbed by soil and drains off the land as surface flow.
salinity	The amount of dissolved salts in water, generally expressed in parts per thousand (ppt).
sediment	Particles of sand, clay, silt, and plant or animal matter carried in water.
sewage	Household and commercial wastewater that contains human waste.
sewage fungus	A white or cream colored, furry looking, growth formed by a combination of bacteria, algae and fungi, which grows in water that is organically enriched (e.g. sewage or leachate).
siltation	The deposition or accumulation of fine soil particles (mud).
sinuosity	A measure of how twisty and complex (meandering) a stream path is.
solution (solute/solvent)	Formed when a chemical is dissolved in a liquid. The solute is the chemical that dissolves and the liquid it dissolves into is the solvent.
source control	A practice, method, or technology used to reduce pollution from a source (e.g. proactive industrial site auditing).
species	Populations of organisms that may interbreed and produce fertile offspring having similar structure, habits, and functions.
species diversity	An ecological concept that incorporates both the number of species in a particular sampling area and the evenness with which individuals are distributed among the various species.
species (taxa) richness	The number of species (taxa) present in a defined area or sampling unit.
stormwater drain	A system of gutters, pipes, or ditches used to carry stormwater to a waterway.
stormwater	Rainwater that runs off the land, usually paved or compacted surfaces in urban or suburban areas.
stream	An intermittently or permanently flowing body of water in a defined channel. The terms ,'river' and ,'stream' are often used interchangeably, depending on the size of the water body and where it is.
stream health	Refers to the condition of the whole waterway. Monitoring stream health involves looking at not only water quality but also the physical features of the stream and the plants and animals that live there.
stream order	A numerical system of stream size classification starting from 1st order which have no tributaries and flow year round. Stream order only increases when two streams with the same classification join (e.g. two 2nd order streams join to make a 3rd order.
stream reach	Fully defined in Booklet 2.
substrate	The material underlying a stream (also called bed or bottom).

suspended solids	Organic and inorganic particles, such as sand, clay, and mud, that stay in the water column.
sustainable use	Use of a resource while conserving an ecological balance and avoiding depletion.
taxon (plural taxa)	A classifcation level for grouping related organisms.
taxa richness	Fully described in Booklet 3.
tolerant species	Those species that are adaptable to compromised environments.
toxic chemical	A substance or mixture that is directly or indirectly harmful to life.
trend analysis	Comparing recently collected data with past or baseline data to detect changes in stream condition.
tributary	A stream or river that flows into a larger stream or river.
turbidity	A measure of water clarity (fully described in the turbidity section of Booklet 6).
variable	Something that you can measure to describe a waterway (e.g. flow, pH).
water quality guidelines	Set levels of water quality which, if exceeded, may limit what the water can be used for (e.g. drinking water, protection of aquatic life).
water table	The depth or level below which the ground is saturated with water.
wetlands	Ecosystems whose soil is saturated for long periods seasonally or continuously, including marshes, swamps, and ephemeral ponds.