9. Explanations of categories and scores

THE "MONITORING" part of this stream health monitoring and assessment kit consists of collecting a standard set of information at a stream. The set includes observations on recent flow and farm conditions, some water quality measurements (water velocity, pH, conductivity, temperature, clarity) and some habitat observations (stream bed composition, deposits, bank vegetation). There are also observations on invertebrates and periphyton (algae) in the stream. You gather this information at regular intervals (for example, every 3 months).

Following the instructions in **Unit 7. Assessing the health of your stream**, you can use the combined scores of the water quality, habitat and biological results to get an overall picture of the condition of a stream. By monitoring regularly you can use the information to see whether the stream is changing over time, and the direction of that change. As mentioned in **Unit 7**, you may also need to look in detail at each measurement to find clues about why your stream is changing.

On the following pages, we go through the monitoring form in detail and look at what the answers to each question tell us about the health of a stream. We then consider some broader influences on stream health. Refer to **Unit 10. Farm practices and stream health** for the background to *Stream monitoring form B. Recent farm conditions and activities*.

RECENT FLOW CONDITIONS

9.1 Recent flow conditions

IT IS STRESSED throughout this manual that stream flows have a major influence on stream life. Therefore, ideally, stream monitoring should be carried out only following periods of stable flow. Because rainfall, and hence flows, vary so much throughout New Zealand, this will not always be possible. The following outlines how different flow conditions may affect stream life and your monitoring results.

Stable flows

Category: 5

Stable flows

Stable flows are necessary for biological communities to develop that reflect stream water quality and habitat conditions. You can proceed with monitoring without concern for the effects of flow disturbances.

Brief flooding

Category: 4

Brief flooding

Brief flooding will only have minor effects such as removing some loosely attached mats of filamentous periphyton. Invertebrates are generally resistant to such events. However, if the brief flood was quite intense (e.g., water depth more than doubled) then the event will have had a more significant effect and you should probably register the event in category 3.

Several brief floods

Category: 3

Several brief floods

Several brief floods can cause repeated damage to biological communities by washing away weakly attached periphyton, macrophytes and invertebrates. If you proceed with the stream health evaluation be cautious that the biological scores will not truly reflect the condition of the stream. You will probably have a value that indicates better conditions than would normally be shown.

Prolonged flooding

Category: 2

Prolonged flooding

Prolonged flooding can cause severe destruction of the streambed communities. If this has occurred then your invertebrate and periphyton results will not reflect the normal state of the stream habitat or water quality. **Your biological results should not be used to evaluate stream health.** It will normally take between 3 and 6 weeks for communities to recover. Time for recovery will vary depending on the season (water temperatures and light) and how severe the floods have been. Recovery from severe floods takes longer.

Prolonged low flows

Category: 1

Prolonged low flows

Prolonged low flows, and associated severe reductions in water depths and velocity, and excessive heating of the water (e.g., to more than 22 °C) can result in the destruction of many invertebrates. Green filamentous periphyton tend to proliferate in such situations and accentuate the problems caused by poor flow conditions. Such situations can be induced in some streams by excessive abstraction (e.g., for irrigation).

HABITAT QUALITY

Water velocity

9.2 Habitat indicators of stream health

Water velocity

Water velocity depends mostly on the slope of the stream, though in streams in rolling to hilly catchments that have the pool–riffle–run structure (see pages **9.28–9.29** for an explanation) there will be variations in flow velocity over a short distance. Selecting a “run” area as a monitoring site helps to ensure that the velocity is easy to measure (no obstructions or very slow-moving areas).

The water velocity measured from the rate of movement of a floating object is only a rough indication because water moves at different speeds at different depths and distances from the stream edge. In a shallow stream the measurement is an approximation of maximum water velocity, because water speed is greatest where friction is least – at the surface near the centre of the channel. Near the bed, water movement is slower because of friction between the water and the substrate. Obstructions in the stream (e.g., logs, debris, silted-up areas) also slow down the flow.

Water velocity represents one of the most important environmental factors affecting the biota of streams. On one hand, water delivers food materials and oxygen and removes waste materials; on the other hand, flow is a direct force on organisms. Both invertebrates and plants have evolved ways to withstand high flows and to take advantage of the associated high oxygen content and nutrient supply. These include taking refuge in the slower moving areas, for example, beneath or behind large stones on the stream bed, or within the leaves and stems of water plants. This means that even faster flowing waters can support diverse and healthy communities of invertebrates and periphyton.

Very slow flows represent the most unfavourable conditions for stream life. Under these conditions the oxygen supply is restricted and there is potential for wide variations in both pH and temperature (see sections below) which can be harmful to aquatic invertebrates.

Water velocity is a local factor that generally cannot be altered, though very slow flows may be a result of an obstruction or damming downstream of the site. Seasonal growth of water plants may affect water velocity. If flow velocity differs markedly from one monitoring to the next, then some activity upstream or downstream could be causing the change.

Less than 0.1 m/sec
Rating: very poor
Score: 1

Less than 0.1 metres/second

The stream is very sluggish and invertebrates that require rapidly flowing, clean, waters such as mayflies and stoneflies will probably not be present. The bed is likely to be fairly silty and could well have profuse aquatic plant growth. Mats of long filamentous algae can grow from stable attachment points and snails, midges and worms probably dominate the invertebrate community.

This could be a natural condition for your stream, and in this case it is especially important that the stream is protected from other sources of degradation.

0.1 to 0.29 m/sec
Rating: good
Score: 8

0.1 to 0.29 metres/second

This is a low to moderate velocity and capable of supporting a range of both pollution-tolerant and pollution-sensitive invertebrates.

0.3 to 0.69 m/sec
Rating: very good
Score: 10

0.3 to 0.69 metres/second

This is the range of moderate stream velocities, which is ideal for healthy invertebrate and periphyton communities, though the exact components of the community will also depend on other factors, particularly stream substrate.

0.7 to 0.99 m/sec
Rating: very poor
Score: 5

0.7 to 0.99 metres/second

This range represents moderate to high stream velocities that are likely to preclude some invertebrates such as snails and some caddis larvae from living in the stream. In high-velocity streams in mountain areas (i.e., areas with little or no agricultural activity) mayflies and stoneflies should dominate and the bed should be composed of gravels and cobbles. However, when these velocities occur in low-altitude streams flowing across agricultural land, it generally means that they are flowing in erosion gullies where the stream bed is mixed material and sediment movement is high. Such an environment is not good for the development of diverse, healthy stream-bed communities of either periphyton or invertebrates.

1 m/sec or more
Rating: poor
Score: 3

1 metre/second or more

Stream velocities are high. In mountain streams, this will result in a bed dominated by cobbles, usually with only thin mats/films of periphyton and invertebrates dominated by mayflies/stoneflies and some caddis. Midges can also grow in the crevices between (and underneath) the stones. However, such streams are unlikely to be on agricultural land, and velocities of over 1 metre per second on farm properties usually indicate flow in severe erosion gullies with associated silt movement and unstable bed material.

Water pH

Water pH

pH is a measure of the concentration of hydrogen ions in the water, and hence the strength of acid present. The pH scale ranges from 1 to 14, with pH 7 indicating neutral conditions. Under 7 is acid and over 7 is alkaline. With increasingly acid waters, numbers of species and individuals of aquatic organisms decrease. For example, some species avoid egg-laying in low pH conditions.

Rainwater is normally slightly acidic because it contains dissolved CO_2 from the air. A small proportion of the gas dissolved in pure water forms carbonic acid (H_2CO_3). Stream water usually contains bicarbonate and carbonates and the carbonic acid itself can dissolve carbonate rocks to form carbonates; all this tends to neutralise the acid so that natural waters do not usually experience wide fluctuations in pH.

Industrial activity in northern Europe has lead to the formation of strong acids (sulphuric and nitric acids) in the atmosphere and this has contributed to a lowering of pH in surface waters of the Northern Hemisphere. Such effects are not common in New Zealand. However, many streams have naturally low pH due to high concentrations of *humic* substances – the products of vegetation decay which are picked up as water percolates through the ground before reaching a stream. In brown-water streams draining swampy areas pH measures of 5 or less are quite common.

It is important to realise that pH is not an absolute measurement in streams. As explained, pH levels depend on the amount of dissolved CO_2 in water. Many lowland streams support rich growths of water plants, including algae, the respiration of which releases CO_2 into the water. Photosynthesis, on the other hand, takes up CO_2. Maximum uptake at around the middle of the day can deplete CO_2 sufficiently to cause pH to rise significantly. For monitoring farm streams it is suggested that the pH measurement is always taken at around the same time of day to give a more accurate picture of fluctuations over time.

pH 5 or less
Rating: poor
Score: -5

pH: 5 or less

pH is very low. This could be due to the waters draining a swamp or some pollution discharge/seepage (e.g., from cleaning agents). This level of acidity can result in reduced numbers of species and individuals of invertebrates. There is evidence that naturally acid waters are less harmful than those acidified by atmospheric pollutants. One suggested reason is that non-natural acid waters take up metals and retain them in solution more readily and it is the metals that are detrimental to stream life (see Allan, 1995, p. 40–41, for examples).

pH 5.5 - 6
Rating: fair
Score: 5

pH: 5.5 to 6

pH in the 5.5 to 6 range is moderately low and would normally signify an influence of waters draining swampy areas. A pH in this range is not normally detrimental to stream life. However, in farm streams not connected to swampy areas, the acidity is probably a result of non-natural inputs and there is potential for deterioration if no action is taken to trace the source.

pH 6.5 - 7.5
Rating: excellent
Score: 10

pH: 6.5 to 7.5

The pH range around neutral is good for stream life.

pH 8 - 9
Rating: fair
Score: 5

pH: 8 to 9

pH in the 8 to 9 range is moderately high and usually signifies intense photosynthetic activity by periphyton and macrophytes. This can be checked by taking another recording the following morning before 8 a.m. If the pH has dropped back to 7.5 to 8.0, then the high daytime reading is probably a result of aquatic plant growth.

pH 9.5 or more
Rating: poor
Score: -5

pH 9.5 or more

A pH of greater than 9 is high and usually signifies intense photosynthetic activity by periphyton and macrophytes. This can be checked by taking another recording the following morning before 8 a.m. If the pH has dropped back to 7.5 to 8.0, then the high daytime reading is a result of aquatic plant growth.

Water temperature

Water temperature

Stream temperature is important because every species has a preferred temperature range. The range varies considerably from species to species. Sometimes, a temperature *change* is important, for example, as a trigger for egg hatching in some mayflies. Many organisms are unable to survive in temperatures above about 30 °C (except for some adapted to life in hot springs). At the other end of the scale, temperatures below freezing point constitute a very harsh environment because of the effects of ice.

A single temperature measurement is not particularly informative, but a series over time will provide a rough picture of the temperature regime in a stream. The longer the series and the closer together the measurements, the more informative the series will be.

Temperature depends largely on time of year and weather conditions. Stream type also plays a part. For example, lowland streams tend to experience quite stable temperatures (i.e., closely following average air temperatures). Shading along streams reduces the occurrence of extremely high water temperatures.

Water temperature fluctuates on a daily basis and for this reason it is suggested that measurements are always conducted at the same time of day.

Less than 5
Rating: fair
Score: 5

Less than 5 °C

Values below 5 ºC are low and indicative of winter conditions in southern regions. Invertebrate and periphyton growth would be slow in such waters. Some species may be excluded.

5 to 9.9
Rating: good
Score: 8

5 to 9.9 °C

Values of 5 to 10 °C are moderate to low and indicative of winter conditions. Most invertebrates and periphyton can survive well in these temperatures.

10 to 14.9
Rating: excellent
Score: 10

10 to 14.9 °C

Values of 10 to 15 °C are very suitable for most invertebrates and periphyton.

15 to 19.9
Rating: good
Score: 5

15 to 19.9 °C

Temperatures of 15 to 20 °C will start to be stressful for some invertebrates (e.g., stoneflies).

20 to 24.9
Rating: fair
Score: 5

20 to 24.9 °C

Temperatures of 20 to 25 °C are moderately high. Some invertebrates, such as some mayflies, stoneflies, and some fish, such as trout, are unlikely to survive such conditions for prolonged periods (e.g., several weeks).

25 to 29.9
Rating: poor
Score: 0

25 to 29.9 °C

Temperatures between 25 and 30 °C are likely to be stressful to fish, stoneflies, mayflies and some caddis flies. Such high temperatures may be a result of lack of shading and very sluggish flows.

30°C or more
Rating: poor
Score: -5

30 °C or more

Temperatures over 30 °C are likely to be very stressful to most stream life and result in their death. Again, such high temperatures may be a result of lack of shading and very sluggish flows. However, stream temperatures will rarely get to these levels.

Water conductivity

Water conductivity

Conductivity is a measure of the total ionic strength of the water and is widely used in water quality studies as a quick field indication of the level of enrichment (i.e., nutrient content) of the water. It is measured in microSiemens per centimetre (μS/cm). The method has limitations. In particular, areas that receive geothermal inputs or are subject to tidal influence will show higher readings because of the presence of non-nutrient ions (for example, the sodium ions in seawater). For most farm streams a conductivity reading should give a reasonable indication of nutrient levels.

All stream waters contain some nutrients as a result of natural conditions and processes. The underlying rock type determines the “base” level of nutrients in streams (see pages **9.25–9.27**). Runoff and seepage are natural processes which add extra nutrients. In agricultural areas these inputs may increase because of both non-point-sources, such as gradual runoff from cultivated land, and direct inputs from stock faeces and urine.

Nutrient level is important in stream health because, under suitable conditions, excessive amounts encourage proliferations of algal growth which can in turn lead to wide daily fluctuations in both pH and dissolved oxygen levels which are known to be harmful to fish. Thick growths also exclude certain invertebrate species (e.g., mayfly larvae), and there is an overall degradation of waterways in both biology and appearance. In larger streams and rivers, periodic high flows can flush out algal growth. However, in small farm streams, the degradation may be less easy to reverse.

Note that after prolonged or heavy rain, the conductivity of stream water may be elevated due to increased runoff.

Under 50
Rating: excellent
Score: 20

Less than 50 μS/cm

Very low concentrations of dissolved ions. Nutrient enrichment is highly unlikely unless there is a specific waste-water discharge. Usually expect only thin films of periphyton.

50 to 149
Rating: good
Score: 16

50 to 149 μS/cm

Low concentrations of dissolved ions. Nutrient enrichment is unlikely unless there is a specific wastewater discharge. Usually expect only thin films or mats of periphyton.

150 to 249
Rating: fair
Score: 10

150 to 249 μS/cm

Slightly enriched waters. Thick mats of slime and some green filamentous periphyton growths may occur in summer if the stream bed is cobbly and water velocities are 0.31 to 0.7 m/s during summer low flows.

250 to 399
Rating: poor
Score: 6

250 to 399 μS/cm

Moderately enriched waters. Thick mats of slime and green filamentous periphyton growths may occur on any stable objects in the stream during summer low flows.

400 or more
Rating: very poor
Score: 1

400 μS/cm or more

Enriched waters. Extensive mats of green filamentous periphyton should be expected in low velocity areas (under 0.3 m/s), particularly in summer. Your stream may be draining a catchment with a siltstone/sandstone geology. In some areas, conductivity can be very much higher than this (e.g., up to 700 or 800 μS/cm).

Water clarity

Water clarity

The clarity of stream water has a powerful influence on people's perception of stream health: clear water is generally assumed to be clean.

Clarity is also an important feature of the habitat for stream life because it affects the amount of light that gets through to the stream bottom. Plants (in this case, periphyton – algae) need light for photosynthesis, and hence growth. If algal growth is strongly inhibited by low water clarity, and if the problem persists for long enough, there may be flow-on effects. For example, invertebrates that consume algae may die out.

Water clarity generally reflects the amount of fine suspended sediment in the water. The size of the sediment load depends on underlying rock type and the amount of erosion or stream-bed disturbance going on upstream. On farms, a range of activities may contribute: cultivation too close to the stream edge; stock in the stream; bank collapse. Recent rainfall may cause sediment input to increase. In slow-flowing streams, sediment may settle out onto the stream bed, with the potential effect of smothering invertebrate and periphyton habitat.

The apparatus provided with this kit ("clarity tube") is based on a scientific method of measuring water clarity called the black disk method (Davies-Colley 1988). The clarity tube has been designed for use on farm streams that are fairly turbid (see Kilroy & Biggs 2002). The following is a commentary on the range of readings that may be obtained.

Clear to bottom
Rating: excellent
Score: 10

Clear to bottom

For a farm stream this represents nice, clear water! Note that the New Zealand clarity standard for recreational use of fresh water (e.g., swimming) (MfE 1994) is a conventional black disk measurement of 1.6 metres. This is equivalent to a clarity tube reading of about 85 cm (see the SHMAK information sheet "Measuring Water Clarity: Tube, Disk and Turbidity" in **Unit 15. Educational and training material**).

70 to 99 cm
Rating: good
Score: 8

70 to 99 cm

Slightly turbid. This may inhibit plant growth and the suspended solids could settle on the stream bed.

55 to 69 cm
Rating: fair
Score: 5

55 to 69 cm

Moderately turbid water. It will be difficult to see the bottom in pools and at this level is probably starting to affect stream life, both through light restriction for photosynthesis and through settlement of sediment on the stream bottom. A review of what is happening upstream is needed.

35 to 54 cm
Rating; poor
Score: 5

35 to 54 cm

This very turbid water is likely to silt up the stream bed and be detrimental to most stream life. Again a review of what is happening upstream is needed. This clarity will almost certainly be caused by some fairly obvious disturbance.

Less than 35 cm
Rating: very poor
Score: 1

Less than 35 cm

This extremely turbid water will result in a silty stream bed and will be detrimental to most stream life. An immediate review of what is happening upstream is needed. This clarity will almost certainly be caused by an obvious disturbance.

Composition of the stream bed

Composition of the stream bed

A range of materials can make up the stream bed, from solid bedrock through to fine silt.

Bed material type has a major influence on the type of organisms found in a stream and this is reflected in the scores assigned to the different materials. To obtain an overall score for a given stream site, the monitoring system requires an estimate of the coverage of each different category.

Bed composition may not change greatly between monitoring occasions. Indeed, in healthy streams any changes will be minor. However, because of the potential for siltation, or clearing out of silt, on farm streams, it is useful to record the bed composition after any changes in the stream environment due to major natural events (e.g., floods) or changes in land-use practices.

Bedrock
Rating: poor
Score: -10

Bedrock

Bedrock – a solid rock surface – may occur in streams on upland farms. The rock tends to be smoothed from the action of water flowing over it. There are few crevices within which insects and native fish can live and/or hide, so bedrock is not a very good habitat for stream communities. Snails can often be seen crawling over the surface of bedrock areas grazing the attached periphyton. Aquatic mosses can grow well on bedrock and if these are extensive then they can provide some areas of good habitat for insects.

Boulders
Rating: good
Score: 10

Boulders

Boulders are defined as rocks that are more than 25 cm across (i.e., breadth rather than length – they will not fit through a square aperture with 25 cm sides.) Because of their size they tend to be very stable and have moderate amounts of space around their bases within which insects and native fish can live.

Large cobbles
Rating: excellent
Score: 20

Large cobbles

Large cobbles are 12–25 cm across (i.e., they fit through a square with 25 cm sides, but not through a 12 cm square). They are fairly stable and have extensive crevices between adjacent stones within which insects and native fish can live. Stream beds composed mainly of large cobbles can form excellent habitat for stream life as long as the gaps between the stones are not filled with silt.

Small cobbles
Rating: good
Score: 10

Small cobbles

Small cobbles (6–12 cm across) tend to be reasonably stable and have extensive crevices between adjacent stones within which insects and native fish can live. Stream beds composed mainly of large cobbles tend to be good habitat for stream life providing the gaps between the stones are not filled with silt.

Gravels
Rating: fair
Score: 0

Gravels

Gravels (up to 6 cm across) tend to be stable during average flows. Because of their size, they pack together with very small spaces in between. These spaces could form reasonable habitat for invertebrates. However, again because of their small size, gravels move quite easily if water flows increase. This movement tends to be detrimental to the stream life, by scouring off any periphyton growth and attached invertebrates and exposing invertebrate refugia (or hiding places).

Sand
Rating: poor
Score: -10

Sand

Sand is usually quite mobile and thus represents a poor habitat for most stream life. However, some worms and insect larvae borrow into sands and live below its surface. In stable spring-water streams, periphyton may grow on the sand surface.

Mud/silt
Rating: very poor
Score: -20

Mud/silt

Mud and silts tend to be very mobile and thus represents a poor habitat for most stream life. However, some worms and insect larvae borrow into sands and live below its surface. Mud and silt can also become stagnant and the resulting low levels of oxygen near the surface of the mud and liberation of sulphides can be very detrimental to stream life.

Man-made
Rating: very poor
Score: -20

Man-made

Most man-made bed materials, such as concrete, tend to be poor habitat for stream life, except in situations where other stable habitat may be missing (e.g., shopping trolleys in urban streams can be good habitat for fish and invertebrates).

Woody debris and water plants
Rating: fair
Score: 0

Woody debris

Woody debris is often utilised by stream insects as habitat, and is particularly important in soft-bottomed streams, where it may be the only ‘stable’ habitat feature available. Removal of woody debris can be detrimental to stream communities in such streams.

Water plants (rooted in the stream bed)

Water plants usually grow in streams with silt or sand beds. They provide an extra layer of habitat above the bed. Many aquatic plants such as water cress (emergent plant) and oxygen weed (submerged plant) are used by snails, worms and caddisfly larvae as habitat. However, some aquatic plants can reduce stream health by choking waterways and inducing harsh instream conditions.

Score summary for stream bed composition

Understanding your stream bed scores: summary

Score: -20 to -10

Much of the stream bed is silt, sand or artificial surfaces. The former two are unstable and all three are poor habitat for most invertebrates and periphyton.

Score: -10 to 0

Bedrock does not have many crevices for invertebrates to hide in so is not very good habitat. Snails can occupy the surfaces. Sand tends to be very mobile and poor habitat also. Gravels, woody debris and water plants can provide limited habitat for invertebrates, but are generally poorly colonised by periphyton.

Score: 0 to 10

Moderately high proportions of cobbles provide good invertebrate and periphyton habitat.

Score: 10 to 20

Large proportions of the bed composed of cobbles provides really good habitat for invertebrates and periphyton.

Deposits

Deposits

Deposits (fine, loose, usually pale brown "flocculent" [almost floating]) material covering or partly covering the stream substrate) can form a temporary covering on the stream and generally indicate that some recent event has caused excess suspended sediment to settle out. This can happen when extra silt has entered the stream, or when the water flow has slowed down to below "normal". Streams with sand or silt beds may also have additional deposits and these are identified from material settling out on leaves of water plants near the banks. Deposits are not always easy to identify, especially on streams that already have silt or sand-covered beds.

Little/none
Rating: excellent
Score: 10

Little or none noticed

Clean gravel/cobble/boulder/bedrock surfaces are good for stream life.

Fine cover
Rating: good
Score: 5

Fine cover (less than 1 mm thick) of silt mainly in edge areas

Limited amounts of fine deposits in edge areas should not inhibit invertebrates greatly. If composed of organic detritus, these deposits may provide food for some invertebrate groups.

Moderate cover
Rating: fair
Score: 0

Moderate cover (up to 3 mm thick) in edge areas and elsewhere

A moderate amount of streambed siltation. This can inhibit the development of healthy invertebrate communities.

Moderate to thick
Rating: poor
Score: -5

Moderate to thick layer (3 mm thick or more), patchy, most of bed

A moderate to high degree of streambed siltation. This is likely to reduce the quality of the habitat for streambed life.

Thick
Rating: very poor
Score: -10

Thick (over about 5 mm thick) on most horizontal surfaces

A severe amount of streambed siltation. This will eliminate some invertebrate species (e.g., some caddis larvae) that are sensitive to silt and reduce the diversity of periphyton communities.

Bank vegetation

Bank vegetation

The vegetation growing on the banks of a stream forms an important part of the stream habitat. Taller plants provide shade and important habitat for adult insects. Shade helps to reduce temperature extremes, especially in slow-flowing streams. On small streams, even short vegetation gives valuable shade. All substantial vegetation (i.e., not crops or close-cropped grass) protects the stream from exposure to sunshine and winds. Root systems help to stabilise the stream bank and prevent erosion, especially if vegetation grows right down to the water's edge. Inputs such as leaf fall add organic matter to the system and are an important food for some invertebrates. Vegetation growing immediately next to the water provides shelter for fish. Bank vegetation as a whole acts as a filter for runoff from the surrounding land, removing nutrients and thereby partly "purifying" the water before it enters the stream. A diverse, native vegetation is most desirable.

Native trees
Rating: excellent
Score: 10

Native trees

Native trees and shrubs (and also non-coniferous introduced evergreens) form excellent stream bank vegetation, providing large shaded areas which reduce the potential for increased water temperatures and the problems this may cause (e.g., blooms of algae). They are good filterers of pollutants in runoff. Leaves fall into the stream all the year round and are a steady source of nutrients, and food for invertebrates

Wetland vegetation
Rating: excellent
Score: 10

Wetland vegetation

Marginal wetlands are extremely good for filtering out pollution from the land such as silt and nutrients, particularly when stock are denied access to these sensitive areas. Wetland vegetation is often recommended as suitable for riparian planting (see Collier *et al.* 1995) and the restoration and protection of natural wetlands is encouraged. Waters flowing from wetlands are often "tea-stained" from the tannins released from decomposing vegetation. There is usually very little pollution from nutrients and silt in such streams.

Tall tussock grassland
Rating: good
Score: 8

Tall tussock grassland (not improved)

Large tussock bushes overhanging streams provide excellent shade, some bank stability, and help to filter out pollutants in runoff.

Introduced trees (willow, poplar)
Rating: good
Score: 8

Introduced trees (willow, poplar)

Poplars and, particularly, willows provide excellent shading for streams, helping to maintain lower stream water temperatures during summer and the reduction in light helps prevent periphyton blooms. Willows have often been used very effectively to help stabilise stream banks, but are aggressive colonisers and may outcompete native wetland and forest vegetation (see Howard-Williams and Pickmere 1994). Introduced trees are often deciduous, releasing large amounts of leaf fall into the stream over a short period in autumn. Submerged willow roots provide excellent habitat for eels and other native fish, but may fill-up streambed interstices and reduce the available habitat for invertebrates

Other introduced trees
Rating: fair
Score: 5

Other introduced trees (conifers)

Conifers provide the same shade, stabilisation and nutrient filtering benefits as the native and deciduous introduced trees. However, their leaves contain resins and generally decompose less quickly within the stream.

Scrub
Rating: fair
Score: 5

Scrub

"Scrub" refers to weedy species (e.g., gorse, broom) and regrowth. This can provide reasonable shade for very small streams, thereby helping prevent high water temperatures and periphyton blooms. On wider waterways scrub is less effective as shade; also scrub tends to be in areas that may be experiencing increased erosion as the stream channels go through the transition from one vegetation phase to another (e.g. pasture reverting to native forest).

Short tussock
Rating: poor
Score: 3

Short tussock grassland, improved

Short tussock mixed with pasture grasses provides little shade and reduced filtering capacity compared to tall tussock.

Rock, gravels
Rating: fair
Score: 5

Rock, gravels

Rock and gravelly banks are of little value to stream ecosystems, except where this is a natural feature of the stream type (e.g. braided rivers). They do not have negative impacts, but neither do they benefit the stream by providing shade or filtering runoff from surrounding lands. Such banks may be more easily eroded during floods than tree-lined banks. Overall their influence is “neutral”.

Pasture grasses and weeds
Rating: poor
Score: -10

Pasture grasses and weeds

Short vegetation does not benefit the stream either by providing shade or by filtering runoff from the surrounding area. Such banks are also more easily eroded during floods than banks lined with trees or mixed tall vegetation.

Bare ground, roads, buildings
Rating: poor
Score: -10

Bare ground, roads, buildings

Bare ground or built-over areas near or adjacent to a stream edge help to increase direct runoff into a stream. Unsealed roads or open areas may be a source of silt that could find its way into the stream. Sealed roads or other areas with vehicles are liable to contain pollutants.

Score summary for bank vegetation

Understanding your bank vegetation scores: summary

Score: 8 to 10

Trees provide shade for the stream bed which helps reduce daily fluctuations in water temperature and reduces light penetration to the stream bed if the channel is narrow enough. This can reduce the potential for blooms of filamentous algae and maintain better water temperatures for invertebrates and fish. Tall tussock plants have a similar benefit in narrow streams and, together with wetland vegetation, can also act as a good filter for land runoff.

Score: 5 to 8

Trees and scrub provide shade for the stream bed which helps reduce daily fluctuations in water temperature and reduces light penetration to the stream bed if the channel is narrow enough (5–6 metres). This can reduce the potential for blooms of filamentous algae and maintain better water temperatures for invertebrates and fish. Tall tussock plants have a similar benefit in narrower streams and, together with wetland vegetation, can also act as a good filter for land runoff. Trees and tussock are better for this (and more permanent) than scrub.

Score: 0 to 5

The lack of tall vegetation on the stream banks is potentially a limiting factor for healthy stream communities.

Score: -10 to 0

Pasture, bare ground, roads and buildings right to the stream edge at the site will reduce the quality of the habitat for instream life. Filamentous algal blooms could occur periodically and invertebrate communities may not be very diverse.

9.3 Stream-bed life as indicators of stream health

THE PLANTS and animals that live on the beds of streams can provide a very good indication of overall stream health. This is because many organisms have preferences for certain ranges of conditions.

Stream-bed organisms making up a community are an "integration" of the physical and chemical state of the stream over, say, a week or two. This contrasts with direct measurement of chemical composition of the water. The latter provides only a brief "snapshot" of stream quality. For this reason, biological monitoring has become very widespread in scientific monitoring programmes both in New Zealand and overseas.

The biological monitoring system in SHMAK is based on methods currently in use in New Zealand.

STREAM BED LIFE

Invertebrates

Invertebrates

Invertebrates, literally, are "animals without backbones". They include, for example, the *arthropods* [animals with jointed legs and exo-skeletons (outside skeletons), e.g., insects, crustaceans, spiders]; *molluscs* [animals with shells, e.g., snails, bivalves (mussels)]; and a variety of different worm-like creatures. Of those insects that inhabit streams, many are the juvenile (or larval) forms.

Most invertebrates are quite small; indeed many are practically invisible to the naked eye. For the stream-bed survey, we concentrate on the "macro-invertebrates", which are clearly visible to the naked eye. Use of a hand lens which magnifies just two to three times makes examination of invertebrates much easier.

Rather than try to identify all invertebrates found on the stream bed, we have selected a set of 17 types or *taxa*. Together these can give us a good idea of stream health for the following reasons.

- Each type (or *taxon*) is tolerant of a different range of physical and chemical stream conditions. A score has been assigned to each taxon according to where the tolerance range lies in the spectrum from a really healthy stream to a very degraded one. The scores range from 1 to 10 and most are based on the Macroinvertebrate Community Index (MCI) which was originally worked out for invertebrates in the Taranaki region (Stark 1985).
- They are relatively easy to recognise by non-experts with a little training.
- They are easy to collect.
- Invertebrates in general are good "integrators" of stream condition at a particular site because most do not move around very much in the stream. The community is therefore susceptible to the effects of localised pollution and disturbances.
- The 17 categories alone should give a good idea of stream condition and there is no need to take any other invertebrate types into account.

Notes follow on each of the 17 "indicator" taxa (types).

Worms (thin brown/red)

Score: 1

Description on form: **Worms (thin brown/red)**

Scientific name(s): Oligochaetes, various species

Range of sizes: 2–6 cm long, about 1-3 mm diameter

Features to look for: Range of features from thread-like worms, white, red or brownish in colour to more traditional 'earthworm' like features

Where: Often in mud or silt in degraded lowland streams; sometimes in great numbers. Can be found in small numbers in most stream types. Don't confuse them with "bloodworms" (chironomid larvae) which are shorter, brighter red and with a distinct head and eyespots

Flatworms, leeches

Score: 3

Description on form: **Flatworms**

Scientific name(s): Platyhelminthes

Range of sizes: up to 1 cm

Features to look for: Small, brownish, undefined shape; they move with a creeping motion (see photo).

Where: Better known as internal parasites, the Platyhelminthes also have freshwater species. Flatworms are fairly tolerant but occasionally turn up in quite clean waters as well. High mountain streams often have good numbers of flatworms.

Freshwater crustaceans

Score: 5

Description on form: **Freshwater crustaceans (amphipods, water fleas)**

Scientific name(s): Crustacean orders Amphipoda and Cladocera

Range of sizes: 1–10 mm long

Features to look for: Amphipods are up to 10 mm long, but are usually a lot smaller, and look like tiny shrimps,. Colouration ranges from very dark to very pale. Water fleas are tiny, grey-brown flea-shaped creatures; very active and often in great numbers. The legs are clearly visible (especially if you use a hand lens to look at them.)

Where: At the margins of slow-flowing streams, particularly amongst submerged weed beds.

Small bivalves

Score: 3

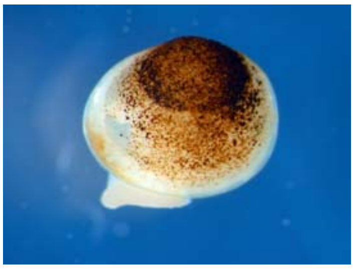
Description on form: **Small bivalves**

Scientific name(s): for example, *Pisidium* sp.

Range of sizes: 2–4 mm wide

Features to look for: Tiny, grey-brown or whitish double shells, like miniature mussels or clams.

Where: At the margins of silty, slow-flowing streams.



Snails, rounded

Score: 3

Description on form: **Snails, rounded**

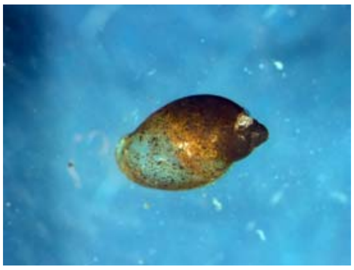
Scientific name(s): *Physa* and others

Common name(s): Water snails

Range of sizes: Usually 4–6 mm across

Features to look for: Again clearly snail-like; colour from light beige to darker brown, with markings. The shell is quite rounded with the top of the spiral a small peak. You'll sometimes see clear, jelly-like blobs of snail eggs in the same areas.

Where: Mainly found in enriched (degraded?) water, on upper and undersides of stones. *Physa* is an introduced snail capable of living in stagnant conditions because it can 'breathe' air, unlike many other snails that rely on dissolved oxygen.



Snails, pointed end

Score: 4

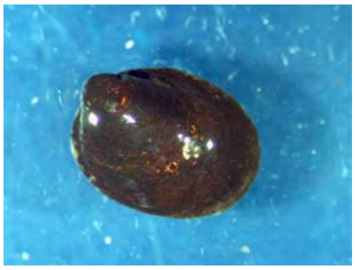
Description on form: **Snails (pointed end)**
Scientific name(s): *Potamopyrgus*
Common name(s): Water snails
Range of sizes: Typically 1–4 mm across
Features to look for: Obviously snail-like, but tiny and often almost black; sometimes lighter brown. The top of the spiral is pointed.

Where: Found in range of stream types, usually most abundant where the water is quite enriched. Often on the undersides of stones, also on water plants and among algae. *Potamopyrgus* is sometimes extremely abundant.

Limpet-like molluscs

Score: 7

Description on form: **Limpet-like molluscs**
Scientific name(s): *Latia* sp. (pictured); *Ferrissia* spp.
Range of sizes: 2–8 mm wide
Features to look for: Dark coloured shells adhering to rocks. When empty, the shells appear a lighter russet-brown colour. Often very abundant. Where: *Latia* is restricted to the North Island, whereas *Ferrissia* can be found on both main islands. *Latia* prefers larger stones in relatively stable streams. *Ferrissia* is often abundant on aquatic plants.



"Axehead" caddis larvae

Score: 3

Description on form: **"Axehead" caddis larvae**
Scientific name(s): *Oxyethira albiceps* (1); *Paroxyethira* sp. (2)
Range of sizes: Up to 3 mm long
Features to look for: A tiny cased caddis larva with a wedge-shaped case, something like an axehead (sometimes also called purse-cased caddis). The pupae are a similar shape and are firmly attached to rocks

Where: Axehead caddis larvae are found attached to stones or other substrate in streams with slow-flowing, relatively enriched water; or among periphyton growth, which they feed on. Because of its tolerance to enriched waters, *Oxyethira* is in a category separate from other caddisfly larvae.


1


2

Midge larvae

Score: 2

Description on form: **Midge larvae**
Scientific name(s): Chironomidae (family)
Range of sizes: 2–5 mm long, very slender
Features to look for: Tiny, white, brownish, bright red or transparent wriggling worm-like larvae. Have a distinct head and eyespots. Body diameter more or less uniform. Red chironomids ("bloodworms") can be distinguished from worms by their movement, their brighter red colour, and their legs.

Where: Often in large numbers on the tops of rocks Associated with algal mates, but are also often abundant on submerged plants and in silt/mud on the streambed. Not always noticeable straight away: but scrape off the algae you should see them move using a looping motion. Red chironomids ("bloodworms") occur in silt.

Damselfly larvae

Score: 4

Description on form: **Damselfly larvae**
Scientific name(s): Odonata (Zygoptera) (e.g., *Xanthocnemis*),
Range of sizes: 1-2 cm long
Features to look for: Sandy-coloured, delicate larvae, with leaf-like gills that look like tails. Unlike the mayflies (which also have three tail filaments) damselfly larvae do not have gills along the sides of the body.

Where: In slow-flowing streams, often associated with aquatic plants.

Cranefly larvae

Score: 5

Description on form: **Cranefly larvae**

Scientific name(s): e.g., *Aphrophila* sp.

Range of sizes: up to 2.5 cm

Features to look for: Cranefly larvae are fat grayish-brown or light green grubs. The head is retracted into the body so is not obvious. The body is segmented and may have "false legs" that look like ridges visible on the body between each segment

Where: Cranefly larvae are moderately tolerant and are found in stony streams of varying quality.

"Axehead" caddis larvae

Score: 3

Description on form: **Beetle larvae and adults**

Scientific name(s): e.g., Elmidae

Common name: Riffle beetles

Range of sizes: Adults 2-3 mm long , larvae up to 7 mm long

Features to look for: Small black beetles present only in summer. The larvae look a bit like some chironomids; but they look "striped", have well-defined jointed legs, and have a more crawling type of movement (as opposed to the wriggling of chironomids).

Where: Adults clinging to the underside of rocks in faster-flowing water; larvae on top of stones, often abundant in runs in gravel bed streams

Caddisfly larvae

(several types in this category)

Score: 6

Description on form: **Caddisfly larvae (rough, stony cases; free-living)**

Scientific name(s): Trichoptera (family); various taxa

Range of sizes: Up to 2 cm long.

Features to look for: Many caddis larvae build cases in which they live, made of small stones, sand grains, even twigs and pieces of leaf. Some move around taking their cases with them. Others are free living, but may build "houses" of small stones to which they can retreat. The next three descriptions illustrate common types of caddisfly larvae. For SHMAK, they are all counted in a single category of invertebrate.

Where: These types of caddis are found in a range of water and stream types in moderate-to-fast flowing water, amongst or on stony substrates. Several species are also found in lowland, soft-bottomed streams, and often form one of the more sensitive groups in these habitats

Common name: Common stony-cased caddis
Scientific name: e.g., *Pycnocentria* sp. (pictured)
Range of sizes: <10 mm (length of case)
Features to look for: A caddis which moves around carrying its case. The case is a slightly curved cylinder tapering towards one end. It is made of tiny stones or particles of sand and is dull brown in colour. Very common in stony streams in a range of water types.

Common name: Free-living caddis larvae (stony houses)
Scientific name(s): e.g., *Aoteapsyche* sp.
Range of sizes: Up to 2 cm long
Features to look for: A free-living caddis which builds itself a stony retreat for pupation. You'll notice the stone "houses". The larva itself has a brown head, brown plates on the upper side behind the head and short legs. The rest of the body is fat, light brown and grub-like, with gill-tufts on its underside.

Common name: Green caddis (another free-living caddis larva)

Scientific name(s): e.g., *Hydrobiosis* sp.

Range of sizes: Up to 2 cm long

Features to look for: A free-living, predatory caddis larva which builds a stony house only when it is about to pupate (transform into an adult). Dark, flattened, head; pincer-like front legs; slender, bright green, grub-like body. Often very aggressive when captured. There are also brown-coloured taxa (as pictured).

Smooth-cased caddis larvae

Score: 9

Common name: **Smooth-cased caddisfly larvae**

Scientific name(s): *Olinga feredayi, Beraeoptera*

Range of sizes: Up to 10 mm long (with case)

Features to look for: *Olinga and Beraeoptera are* smooth-cased caddis. The case is a distinctive chestnutcolour, without stones/sticks or other material stuck to it. It is usually not as common as the stony-cased caddis.

Where: Mostly in clean streams, under stones. Smooth-cased caddis are treated as a separate category because of its preference for cool, clean, stony streams.

Spiral caddis

Score: 10

Common name: **Spiral caddis**

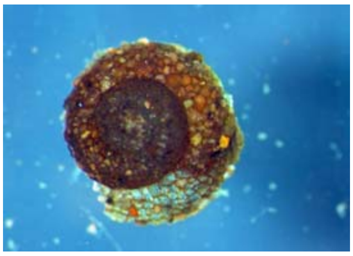
Scientific name(s): *Helicopsyche* sp.

Range of sizes: Up to 3 mm across (with case)

Features to look for: A cased caddis with a flattened spiral house made of sand grains and fine grit; light brown in colour. Can be very common.

Don't confuse these with snails! Look for the gritty appearance of the case, compared with the smooth shell of snails.

Where: These caddisfly larvae occur only in really clean streams, hence their high score. Again they are treated in a separate category.



Mayfly larvae

Score: 9

Description on form: **Mayfly larvae**

Scientific name(s): e.g. *Deleatidium* sp.

Range of sizes: Body up to 2 cm long

Features to look for: Mayflies make quick, distinctive movements – they seem to undulate side-to-side. Even very tiny ones can be picked out from this. They have three long tail filaments and well-developed legs.

Where: Almost always found on the underside of stones, in clean water. In the North Island mayflies are also found associated with submerged aquatic plants in cool, clean streams. Mayflies are an important part of fish diets in some streams because they drift in the currents where trout can easily prey on them. (Fly fishermen try and imitate these mayflies.)

Stonefly larvae

Score: 10

Description on form: **Stonefly larvae**

Scientific name(s): e.g. *Stenoperla, Austroperla (pictured)*

Range of sizes: Up to 2.5 cm long

Features to look for: Stonefly larvae have two "tail filaments" and long antennae. The legs are prominent and stick out like elbows. *S. prasina* has a distinctive green body, with an orange underside. Austroperla has three thin gill filaments coming out from between its two more robust tail filaments.

Where: Stonefly larvae are found in cool, clean, stony streams.

Sandfly larvae

Don't score these!

Not an "indicator", but worth mentioning: Sandfly larvae

Scientific name(s): *Austrosimulium* sp.

Range of sizes: 2–5 mm long

Features to look for: These are small larvae, fatter than chironomids, with a characteristic bottle-shaped base; attached to rocks. You may also see pupae (resting stage) of sandflies: about 2–3 mm across, shield-shaped, with a pair of protrusions at the top. Of course the adults need no introduction to most outdoors lovers in New Zealand.

Where: You are bound to come across these at some stage. They have not been included in this assessment because these rather tolerant insect larvae are widespread in many streams, from pristine forest streams to impacted lowland waterways. Therefore they are not particularly good "indicators".

Invertebrate score summary

Understanding your invertebrate scores: summary

Score: 0 to 1.9

The invertebrates at this site are only (or mainly) robust types. This would usually indicate polluted waters, particularly if water clarity is low and conductivity is high. If the stream bed is composed of gravels or cobbles, then the presence only of organisms that have scores of 0 to 2 usually indicates very degraded water quality.

Score: 2 to 3.9

The invertebrates at this site are robust or moderately robust types. This could indicate polluted waters if the stream bed is composed of gravels or cobbles. However, if the stream bed is naturally composed of sand/silt, slow flowing waters (e.g. < 0.1 m/s velocity) and/or large submerged plants then this is the natural habitat for many of these organisms and the degree of water quality degradation should also be inferred from water clarity, conductivity and pH.

Score: 4 to 5.9

Most invertebrates at this site are fairly robust types. These could indicate slightly to moderately polluted waters if the stream bed is composed of gravels or cobbles. However, if the stream bed is naturally composed of sand/silt or bedrock, the flow is naturally slow (e.g., velocities of less than 0.1 m/s) and there are large submerged plants then this is the natural habitat for many of these organisms and the degree of water pollution may be low. The water clarity results will provide a useful assessment of degradation from suspended silts, etc. and the conductivity results will assist with determining the degree of enrichment.

Score: 6 to 7.9

Most invertebrates at this site are not robust to degraded water quality and therefore suggest that you have a moderately healthy stream.

Score: 8 to 10

The invertebrates at your site are all sensitive to degraded water quality so this suggests that your stream is healthy. If only mayflies are found in your samples it may also indicate an unstable gravel bottom and/or that a flood has occurred recently. (Many gravel bed rivers of the South Island are dominated by the mayfly *Deleatidium*).

Periphyton

Periphyton

Periphyton is the slimy stuff you see growing on stream-bed rocks and stones, or sometimes as a film or filaments on a stable sandy bottom. It ranges in colour and form from bright green "clouds" of filaments to thin yellowish-brown slimy films to shiny black or brown-whitish "mats". Literally periphyton means "around plants", implying that it grows closely attached to a substrate. The term covers mostly algae, though small amounts of bacteria and fungi may be included in the slime. This community is a very important component of the stream ecosystem as it is more or less the bottom of the food chain. A range of invertebrates "graze" periphyton as their main food source.

Like macroinvertebrates, the periphyton community is a very useful indicator of the overall condition of a stream.

- Periphyton does not move around at all, therefore it is a good integrator and indicator of local pollution and disturbance, even when the pollution can no longer be detected in the water by most chemical analyses.
- Periphyton is easy to collect and relatively easy to assign to indicator categories.

A rough quantitative measure has been included in the list of periphyton indicator types, viz., a thin film; a medium mat; a thick mat; short filaments; long filaments. The thickness/length of periphyton growth depends on several factors:

- the amount of nutrients in the water (enrichment);
- the length of time the periphyton has been growing (since the last flood washed away growth);
- the amount of invertebrate grazing.

Studies have shown that the most important of these factors is the length of time since the last flood. This highlights the importance of not assessing periphyton growth immediately following a flood (say, within 2 to 6 weeks, depending on location in New Zealand) or after a very long period of low flows (say, more than 12 weeks). In the former case, much of the periphyton crop will have been washed away; in the latter, growth may well be thick and patchy because low, slow flows have allowed more growth to accumulate than usual. In both these cases, periphyton growth is not "typical".

Periphyton usually consists of a diverse mixture of algae. Experienced biologists may be able to identify some filamentous species from their macroscopic appearance, but normally a microscope is needed for identification. In general colour and texture provide some clues to the algal groups present. For example, a thin green film is likely to comprise some kind of colonial green alga. Brown films and mats of all thicknesses are almost always mainly diatoms – single-celled algae characterised by their silica "skeletons" (the feature usually used in species identification) and yellow-brown pigments (hence the brown colour). Patchy brownish blobs may be red algae. Green tufts and strands are filamentous green algae. Brown trailing filaments may indicate some filamentous forms of diatom, or they may be another algal group, the yellow-green algae. Sometimes, green algae look brown if they become coated with diatoms growing on the outer cell wall as epiphytes. Medium or thick dark shiny mats (listed as "black") are usually blue-green (i.e., cyanobacterial) filaments.

The indicator groups listed on the periphyton monitoring form cover most categories of periphyton normally found in New Zealand streams. Scores are assigned according to the conditions in which each category is usually found growing dominating the cover of stream beds.

No periphyton

(no score)

No periphyton

Sometimes streams have no visible periphyton growth. Stones do not feel at all slimy or slippery to touch and no colour comes out with firm brushing with a toothbrush. There are two main reasons for this. First, invertebrates may be grazing the algae as fast as it is growing. Second, a recent high flow could have scoured away all growth. No periphyton survey is possible. For the second case, it is likely that there will be few invertebrates present too, and it may be better to postpone the monitoring. (See pages **9.1–9.2** for notes about the effects of high flows on stream ecosystems.)

Thin mat/film (less than 0.5 mm thick)

Thin green film

Score: 7

Green:
A very thin green film indicates growth of encrusting single-celled green algae, which indicate slightly enriched conditions.

Thin light brown film

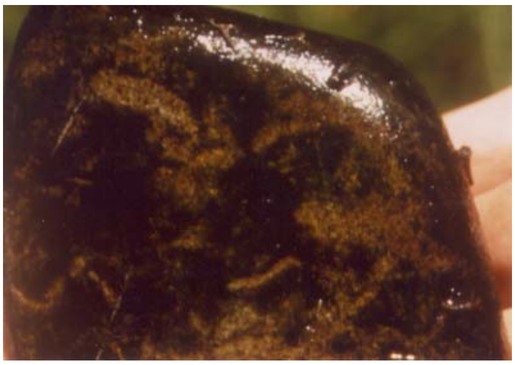
Score: 10

Light brown:
A thin yellowish-brown or reddish-brown sheen on rocks almost always consists of diatoms. These are single-celled algae which have silicon (glass) cell-walls, and brownish cell pigments. In clean water with low nutrient concentrations, the layer will remain thin, particularly since invertebrates will graze on it.

Thin black/ dark brown film

Score: 10

Black/dark brown:
Very dark thin coatings on stones usually contain some blue-green algae as well as diatoms. In clean waters, the layer will often remain thin.

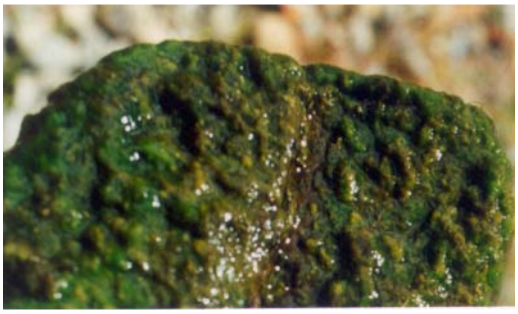


Medium mat or film (0.5 to 3 mm thick)

Medium green mat

Score: 5

Green:
Thicker encrusting green algae indicate prolonged moderate to high nutrient conditions. A mixture of very short filamentous and other algae can have the appearance of a mat.



Medium light brown mat

Score: 7

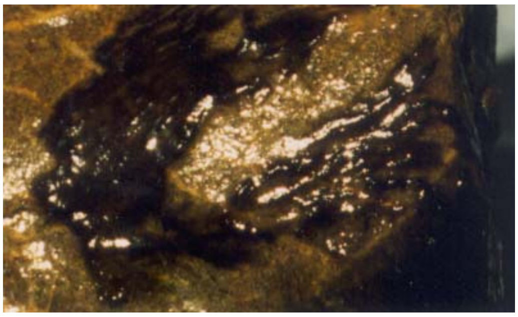
Light brown:
Thicker mats of diatoms will develop in slow-flowing waters with moderate enrichment.

Medium black/dark brown mat

Score: 9

Black/dark brown:

In slow-flowing water, moderately thick patches of blue-green algae can develop, even if the water is extremely clean.

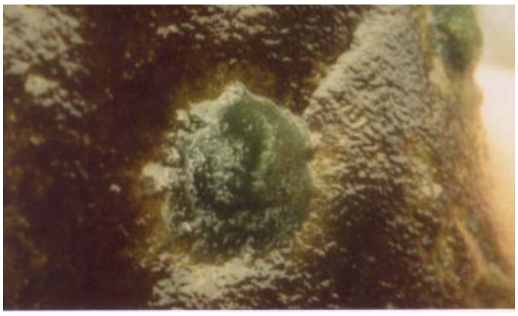


Thick mat (over 3 mm thick)

Thick green mat

Score: 4

Green:
Heavy growth of green algae is normally formed from the filamentous types. The thick mats of coarse green algae shown are *Vaucheria,* which develops in sluggish flows and often fairly enriched nutrient concentrations.

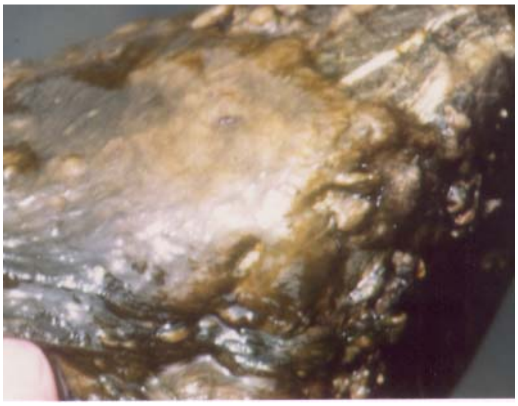


Thick light brown mat

Score: 4

Light brown:

Thick, slimy (or "jelly-like") masses of diatoms will form on the tops of rocks after prolonged sluggish flows and moderate to high nutrient concentrations. The diatoms are usually types that have stalks to attach them to the stones. These growths may appear more whitish than brown under certain conditions (particularly after long periods of stable flow).

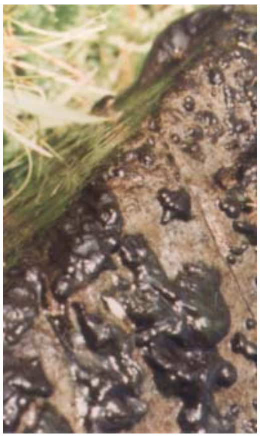


Thick black/dark brown mat

Score: 7

Black/dark brown:

These are predominantly blue-green algae. Thick growths can occur even in quite low-conductivity water. The "solid" brownish growths that grow in low nutrient concentrations during long stable periods are blue green algae (*Nostoc*). The latter is very common in Otago.



Filaments, short (less than 2 cm long)

Short green filaments

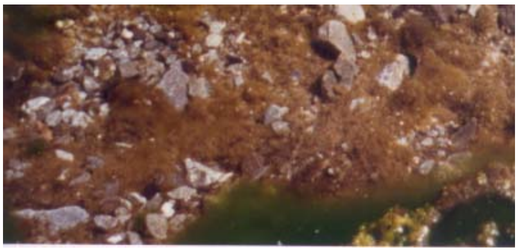
Score: 5

Green:
Filamentous green algae normally grow best in moderate to high conductivity, slow-flowing water. Patches of short filaments often occur amongst moderately thick diatom growth.

Short brown/red filaments

Score: 5

Brown/reddish:
Some kinds of diatoms grow in filaments if the flow is slow enough.



Filaments, long (more than 2 cm long)

Long green filaments

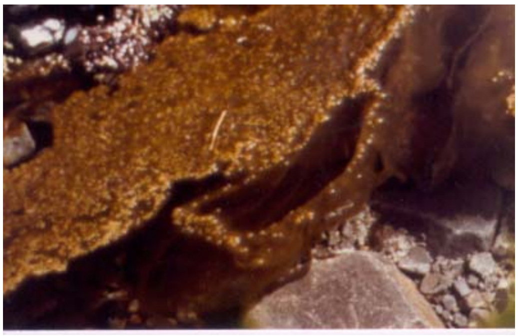
Score: 1

Green:
Long green filaments almost always indicate high-nutrient conditions and prolonged slow flows. In extreme cases, the filaments can cover the entire stream bed. Such heavy grows have detrimental effects on the stream for other stream life For example, wide daily swings in pH may result (see pages **9.4–9.5**).

Long brown/red filaments

Score: 4

Brown/reddish:
Again, long brown filaments consist of diatoms. Coarse, dull-brown filaments could also be green algae covered with a thin growth of small, attached diatoms.



Periphyton score summary

Understanding your periphyton scores: summary

Score: 0 to 1.9

There are mainly long filamentous green algae at the site indicating that there is moderate to high enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond or could occur naturally in streams that have a high proportion of mudstone/siltstone or recent volcanic rocks (central North Island) in their catchments.

Score: 2 to 3.9

These communities suggest a moderate level of enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond or could occur naturally in streams that have a high proportion of mudstone/siltstone or recent volcanic rocks (central North Island) in their catchments.

Score: 4 to 5.9

These communities suggest slight enrichment from phosphorus and/or nitrogen. Such enrichment could be from enriched seepage, a discharge from a treatment pond or could occur naturally in streams that have a high proportion of mudstone/siltstone, recent volcanic rocks (central North Island), limestone or marble in their catchments. Clean stones can result from recent abrasion by flood flows or intense grazing by invertebrates/insects that live in the gravels.

Score: 6 to 7.9

These communities are generally composed of species that are able to grow under moderate to low nutrient conditions. These communities also usually grow back first after a flood has removed previous growths, but may be out-grown by filamentous algae if nutrient levels are sufficiently high.

Score: 8 to 10

These communities usually signify low concentrations of nutrients and/or intensive grazing by invertebrates/insects that live among the gravels.

9.4 Natural catchment influences

EVERY STREAM has its own natural features and these have a big influence on stream life whether or nor not there are any impacts from agriculture. The factors that affect stream ecosystems on a broad scale include rainfall patterns, underlying geology, topography (or slope) and overall catchment land use.

Rainfall – its total amount, distribution and intensity – is probably the single most important influence on stream life. Rainfall ultimately determines how much water will flow in a stream, even if the stream is sourced from groundwater. The distribution of rainfall over the year, in combination with catchment topography, determines the frequency of flooding and of low flows, both of which have major impacts on stream communities. Rainfall also plays a part in determining how vulnerable streams are to influences from the catchment. For example, on the west coast of the South Island, relatively evenly distributed high annual rainfall leads to continual flushing out of stream systems, which, as a result, can be quite "forgiving" in terms of responding to the effects of activities in the catchment. In other places, low summer rainfall results in an annual high risk of low flows, but intermittent intense falls in winter lead to floods. Within a region, then, rainfall is one of the main factors that determine the characteristics of a "healthy" stream. In this monitoring and assessment system, the result of the assessment will reflect stream health regardless of the effect of rainfall.

The other important broad-scale features are fixed over time.

Geology

Geology

The underlying geology of an area determines the natural levels of dissolved and suspended material in the area's streams and rivers. Different rock types have different compositions, and dissolve and erode at different rates. The rock type also determines what sort of material makes up the stream bed – for example: smooth, rounded cobbles; fine gravels; irregular rocks – and this in turn influences the types of plants and animals which live there.

There are three main categories of rock type, based on mode of formation.

1. Sedimentary rocks result from the deposition and consolidation of particles eroded from existing rocks. Different sources of material and deposition conditions result in different types such as mudstone, sandstone, siltstone, limestone and greywacke.
2. Igneous rock forms when molten rock from deep within the Earth's crust cools after being forced through existing rocks or after being extruded onto the surface. The rocks in this group differ according to where and how they were extruded and how quickly they cooled. Granite, for example, intruded deep below the ground surface and cooled slowly. It is coarse-grained and acidic (rich in silica). Conversely, igneous rocks were extruded onto the land or beneath the sea and cooled quickly forming fine-grained rocks. These include ignimbrite and pumice, acid rocks, which are porous because of the gaseous and explosive nature of the molten rock. Andesite and basalt are more alkaline.

3. Metamorphic rocks derive from either sedimentary or igneous rocks and are formed by re-crystallisation under very high temperatures or pressures or both. Different types form under different conditions and parent rock. Examples are marble and schist.

The main categories found in New Zealand are listed below together with a commentary on their likely influence on the streams that flow over them.

Schist

Rating: very good

Score: 10

Schist

Schist (found mainly in Otago and parts of Westland and Marlborough) provides an extremely good rock type for stream life, both underlying the catchment and as a sediment type on the stream bed. This rock is very low in plant nutrients and so seepage and groundwater entering streams in such catchments will not be high in nutrients providing that the seepage is not enriched from farming activities. This rock also breaks up into quite flattened stones and cobbles that contain numerous small crevices which periphyton and small invertebrates can use as refugia – "hiding places" which conceal small organisms from predators and hide them from the effects of floods. These rocks tend to stack on the stream bed forming lots of gaps for invertebrates and fish to live in.

Basalts, andesites

Rating: good

Score: 8

Basalts, andesites

Basalts are found in parts of the eastern South Island (notably Banks Peninsula) and in the Auckland area. Andesites are found on Mt Taranaki and the central volcanic area of the North Island south of Lake Taupo. Basalts and andesites provide a moderately good rock type for stream life, both underlying the catchment and as a sediment type on the stream bed. Basalts are generally low in plant nutrients, but andesites can be quite high in nutrients. Thus, seepage and ground waters in catchments dominated by these rocks can vary from unenriched to moderately enriched. These rocks are very resistant to breakage and tend to form rounded, stream bed particles which are moderately good habitat for invertebrates and fish.

Greywacke

Rating: good

Score: 8

Greywacke

Greywacke is a hard sedimentary rock commonly found in Canterbury, Marlborough, parts of Nelson and southern North Island/Hawkes Bay. The alluvial plains of Canterbury and Hawkes Bay comprise mostly greywacke. This is a good rock type for stream life, both underlying the catchment and as a sediment type on the stream bed. This rock is very low in plant nutrients and so seepage and groundwater entering streams in such catchments are also naturally nutrient-poor. Greywacke breaks up into rounded or flattened stones and cobbles which stack on the stream bed forming lots of gaps for invertebrates and fish to live in.

Marble

Rating: good

Score: 5

Marble

Marble is particularly common in the Nelson region. Natural enrichment occurs from this metamorphic rock type, but only to a moderate level which can stimulate growth of periphyton and invertebrate communities. The stream bed material formed by marble tends to be very stable and quite rounded, which is good for the development of a diverse streambed life.

Granites

Rating: fair

Score: 5

Granites

Granites (including grano-diorites) are most common in parts of Fiordland, Westland and Nelson. They are low in nutrients. However, they tend to break up and form bed sediments of rounded cobbles and abundant sand. The sand tends to fill the gaps between cobbles, reducing the living spaces for stream life. The sands are also very abrasive on communities living on the surface of the cobbles that project a small amount above the stream bed.

Limestone

Rating: poor

Score: 3

Limestone

Limestone is most commonly found as a parent rock in belts on the eastern side of the Southern Alps in the South Island, parts of Westland, Hawkes Bay and southern Waikato/King Country. Limestone tends to have moderate levels of nutrients and, as a result, streams draining limestone areas often have seasonally high amounts/blooms of filamentous periphyton on stable sediments, regardless of landuse. This rock tends to exist as sheets of bedrock in streams. It is prone to erode into small soft stones or to break down to silts readily, neither of which provides good habitat for stream life.

Volcanic ash, ignimbrite

Rating: poor

Score: 3

Volcanic ash, ignimbrite

Volcanic ash and ignimbrite is most common in the central North Island and Bay of Plenty. These rocks tend to have moderate to high levels of nutrients and streams draining such areas often have seasonally high blooms of filamentous periphyton on stable sediments, regardless of land use. Ash breaks down to fine sands and ignimbrite tends to erode into small soft stones, or to break down to sand readily which does not provide good habitat for a diverse range of stream life. However, streams dominated by this substratum often have beds of large aquatic plants along the margins of the streams which provide good habitat for invertebrates and fish (particularly eels).

Mudstones, siltstones

Rating: very poor

Score: 1

Mudstones, siltstones

Mudstones and siltstones are found in small deposits around much of New Zealand, and larger areas are found in the Rangitikei/Wanganui and Hawkes Bay/Gisborne regions. These rocks tend to be high in plant nutrients and streams draining such catchments often have blooms of filamentous green algae, regardless of landuse. This soft rock tends to exist as sheets of bedrock in streams and also to erode into small soft stones or to break down to silts readily which does not provide good habitat for stream life.

Note: areas covered by alluvium/river gravels

In some plains regions of New Zealand (such as Hawkes Bay, Taranaki, Canterbury and Southland) the underlying rock is obscured by thick deposits of alluvium or river gravels. Much of this material originated from moraines deposited by glaciers or erosion of mountain lands in relatively recent geological times. For the purposes of this kit, the underlying geology for streams in these areas is taken to be the rock type making up the alluvium. Thus, streams rising from or flowing over the Canterbury and Southland Plains would have an underlying geology of greywacke.

Topography

Topography

Another natural characteristic that has a major influence on the physical attributes of stream ecosystems is topography, which is considered here as catchment gradient or steepness. The steepness of a catchment affects the speed and amount of runoff following rainfall. The steeper the land, the greater is the likelihood that eroded soils will enter the stream, especially if there is relatively little forest or if there have been recent disturbances in the catchment, for example, forest clearance.

The slope of the stream itself helps to determine water velocity. Moderate velocities are important for maintaining oxygen levels in the water and a gravel or cobble substrate. Higher velocities mean more erosion of the stream bed and a higher capacity for carrying sediment.

The erosive action of river water depends also on the frequency of flooding and this is a function of the amount and distribution (in time) of rainfall and the water-holding capacity of the catchment. Rock type and vegetative cover affect the latter. If the flow is fast enough, stream water picks up eroded rock particles and organic material. These suspended sediments are deposited on the stream bed when water velocity decreases.

Steep (slopes more than 20°)

Rating: fair

Score: 5

Steep (slopes of more than 20°)

Steep slopes tend to have very rapid runoff, which can result in rapid floods and considerable disturbance of the stream bed. However, streams draining such areas also tend to be steep and have large, boulder-cobble, bed sediments which are very stable. Catchments as steep as this tend not to be developed for farming and can be reasonably stable.

Hilly (slopes of 10–20°)

Rating: fair-poor

Score: 3

Hilly (slopes of 10–20°)

Hilly slopes can have quite rapid runoff. If hilly catchments are used for extensive grazing or forestry there is potential for erosion, which could result in silting up of areas of the stream bed from time to time. Such unstable silt-covered areas are not good habitat for stream invertebrates and algae.

Rolling (slopes of 3–10°)

Rating: Good

Score: 8

Rolling (slopes of 3–10°)

Streams draining areas of “rolling” or gentle slopes tend to have a high diversity of channel structures that enhance the biological diversity of the system. The diversity arises from the formation of a succession known as the run–riffle–pool sequence. This is an alternation between deep, slow-moving water (pools) and shallow, faster flowing areas (riffles). Between these extremes, there may be stretches of water of moderate depth and speed (runs).

Riffles tend to have gravel/cobble substrates and the water flow may be broken where rocks break the water surface. These areas are formed by the deposition of gravel on alternate sides of the stream. Pools form from the depressions just upstream of riffle areas and have smaller substrate material. The development of the run–riffle–pool sequence therefore also depends on the presence of a range of substrate sizes in the stream.

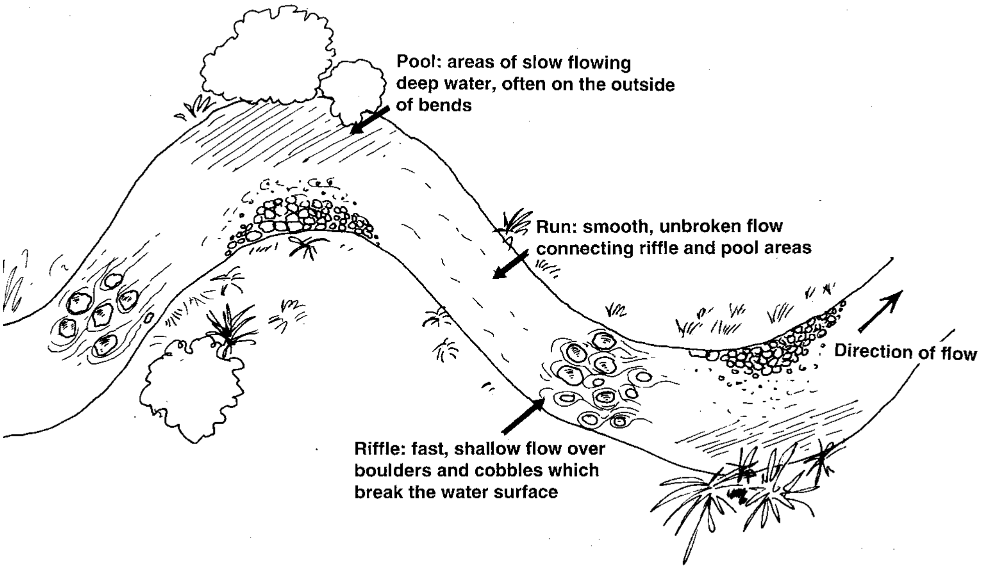


Diagram illustrating the run–riffle–pool sequence in a stream

Flat (slopes less than 3°)

Rating: poor

Score: 1

Flat (slopes of less than 3°)

Streams draining flat areas tend to be sluggish and have beds that are composed of sands and silts, which are not very high quality habitats for many stream organisms.

Topography and water source

The source of stream water is interlinked with topography.

For example, in mountainous areas, stream flows may originate from direct runoff following rainfall, from snowmelt, from high-altitude lake storage or from a combination of these. Such streams are unlikely to flow through agricultural areas and therefore are usually beyond the scope of this kit.

In hilly to steep catchments at lower altitudes, the water source is mostly a mixture of direct runoff, spring-fed from underground storage or lake-fed. The proportions of each are not really an issue for stream health: more important are the slope of the catchment and the frequency of flooding.

In rolling to flat lowland areas, streams which are spring-fed or wetland-fed generally have steady flows and water which is largely free of sediment, both of which are considered to be desirable for stream health.

Geology and topography are not considered directly in this stream health monitoring and assessment system. However, their overall influence is taken into account in the assessment of stream bed composition which is largely a product of these features.

Land use

9.5 Broad-scale land use effects

AN IMPORTANT potential influence on stream health is overall catchment land use. Land use, be it natural vegetation or some form of agriculture, tends to be fixed for long periods. Change is likely to happen slowly and it is unlikely that a single farmer could either instigate or influence a major land use change.

The proportions of different land-use types in a stream catchment may influence the habitat quality of the stream. The main issues are the potential for each land use to introduce non-point source pollution to waterways (including sediments) and the potential for direct damage to the stream bed or banks from machinery and stock.

A score is assigned to each land use so that you can see if there are likely to be any negative effects of landuse practices on your streams and any significant changes over time. The scores reflect the potential for each land use to cause damage to the stream ecosystem.

Crops

Rating: very poor

Score: -10

Crops (including horticulture)

Development of land for cropping usually results in increased amounts of silt and plant nutrients reaching streams. This may be particularly severe if cultivation is right to the edge of (or across) open drainage channels.

Intensive grazing

Rating: very poor

Score: -10

Intensive grazing (over 15 stock units/ha)

Intensive grazing refers mainly to lowland dairy units, beef cattle ventures and deer and pig farms. Irrigation may be a regular practice. Associated fertiliser application and stock trampling usually results in increased amounts of silt and plant nutrients reaching streams. The most severe effects occur when stock have unlimited access to the stream as their only drinking water supply. Stock rotations are unlikely to be long enough to allow stream ecosystems to recover. Deer, in particular, tend to wallow in the water and can cause severe bank damage and build-up of silt in streams. The effects may be obvious a considerable distance downstream.

Medium grazing

Rating: poor

Score: 3

Medium grazing (4–14 stock units/ha)

Medium grazing applies mainly to beef and deer units in areas where irrigation is not usually practised. Again, grazing and stock trampling can lead to increased amounts of silt and plant nutrients reaching streams with deer, again, liable to cause the most severe damage. Smaller stock numbers and perhaps greater rotation times will tend to concentrate damage into certain areas.

Extensive grazing

Rating: fair

Score: 5

Extensive grazing (less than 4 stock units/ha)

Extensive grazing, particularly by sheep (e.g., dryland farming in high country areas) tends to have only moderate to low impacts on stream ecosystems. It is possible that wild animals such as rabbits and goats may add to the effects.

Production forest/wood-lot

Rating: poor

Score: 3

Production forest/woodlot

Production forests are mostly fast-growing conifers. They affect stream health mainly during the planting/establishment phase and during felling. At planting, land clearance can cause increases in silt inputs to the stream. It may also lead to an increase in stream flow, particularly during high flows, when vegetation (and therefore the capacity for transpiration in the catchment) is removed. As the forest grows, usually the overall effect is to reduce stream flows from their pre-plantation levels. At felling, land clearance can lead to more “peaky” stream flows and bank/hillside destabilisation after tree felling. During tree growth, management practices such as pruning can impact on the stream by introducing large amounts of organic matter over a short time.

Exotic forest (non-production)

Rating: good

Score: 8

Exotic forest (non-production)

Exotic forests tend to reduce the amount of water in streams during summer because of their very high rates of evapotranspiration. Also, because many of the non-production species are deciduous, they are responsible for a concentrated input of organic material into streams over a short time in autumn if they are close to streams. In other respects, their overall impacts on stream ecosystems are similar to those of native forests.

Native forest (non-production)

Rating: excellent

Score: 10

Native forest (non-production)

Native forest is an excellent land use in areas surrounding streams. Since most natives are evergreen, leaf litter inputs to streams will occur steadily all year round. Like exotic trees, they provide shade for the stream, thereby reducing the potential for increased water temperatures and blooms of algae.

Conservation grasslands/ tussock

Rating: good

Score: 8

Conservation grassland/tussock lands

Tall tussock grasslands generally occur in relatively high-altitude areas (over 500 metres above sea level) that are unlikely to be intensively developed. Tussock vegetation is an effective filter of nutrients from runoff. Lack of animals (both stock and feral) in these catchments enhances the potential for high water and habitat quality.

Wetlands

Rating: excellent

Score: 10

Wetlands

Wetlands are a natural part of stream environments. At least 90% of New Zealand’s wetlands have been lost by land drainage for agriculture. The remaining areas are highly valued natural ecosystems containing a range of native plant species. Streams flowing from wetlands are often “tea stained” from the tannins liberated from decomposing vegetation. However, there is usually very little pollution from nutrients and silt in such streams.

Scrub

Rating: fair

Score: 5

Scrub

Scrub – which refers to weedy growth on neglected land, including gorse, etc. and regrowth – is reasonably favourable as catchment vegetation in terms of stream health. It is relatively undisturbed, though there may be some stock present.

Buildings, yards, etc.

Rating: very poor

Score: -10

Buildings, yards, mining, quarries

Runoff from these areas when it is raining is usually contaminated with high levels of pollutants (particularly silt). Mines and quarries usually have drains containing silty water. Depending on the type of mine, there may also be high levels of heavy metals. Stormwater drains beside roads may pick up a variety of unpleasant substances including oil and petrol and heavy metals, all of which can be actively detrimental to stream life.