SECTION 3.0. MOVING WATERS: BROOKS, STREAMS AND RIVERS

THIS SECTION CONTAINS:

- How a stream works
- Information on stream channels
- Habitat in a stream
- Insects in and around streams
- A quiz to test your knowledge

3.1. How a Stream Works

The basic structure of a stream influences its health and ability to provide habitat. Stream structure is a balance of its soils, water table levels, and land elevations, creating a habitat that is unique with each stream. Understanding this balance is important: enhancement of habitat often corrects problems that occur when people tamper with its balance.

The structure of a stream is defined by:
• Water flow features (the stream's pools, riffles or other specialized sections)
• Channel (the stream's width and shape)

Let's look at each one of these so we understand what they mean.

Water flow Features

The flow of a stream can be broken down into four main areas

• Riffles

• Pools

• Runs

• Flats

3.1.1 Watercourse Features

Riffles
These are the swift, shallow portions of streams or rivers where the water surface is broken. Often rocks protrude through the water surface. The stream bottom is usually gravel and rock. Riffles are important areas for two major reasons. Most of the food supply for salmon or trout is produced on them and young salmon will establish feeding territories here during the summer. Salmon that are laying eggs (**spawning**) select areas where water is seeping through the gravel. These areas are usually found at the tail of a pool or at the head of a riffle.

Runs
These are swift, deep portions of streams or rivers. Although water flow in a run may be as swift as in a riffle, the water is deeper. Runs can range in depths (depending on stream size) from 20 cm to 2 meters (8 in. to 6.6 ft.) deep. The stream bottom is usually rock and boulder.

Pools
These are slow, deep portions of rivers and streams (in proportion to the watercourse’s size). Pools can be of various depths, but are the deepest areas of a stream. The bottom can be gravel, rock, boulder, silt or log-strewn. Pools provide living areas for a variety of fish. These slow, deep areas are a refuge in the winter for many species of fish, and provide ideal cover for some of the largest trout. Pools are critical habitat for salmon during low flow periods in the summer and winter, for the migration of adults as holding and resting areas, for spawning adults holding areas and as winter habitat for pre-smolts. During normal flows

pools are dominated by trout, and the size of the pool and available instream cover, are the major determining factors on how many, and how large a trout, can live there. The largest numbers of speckled and brown trout are found in pools.

Flats
These are the shallow, slow portions of streams, usually located at a point where the watercourse widens. A flat can be as shallow as a riffle, but is much slower-moving.

Natural streams are seldom straight. Streams curve around in a winding pattern or ***meander.***

These meanders are formed by the way the water flows.

The pattern in which these four features occur depends on the soil-type, vegetation, slope, and amount of water flow. In most normal streams there is a sequence of shallow to deep water over a section of river. Scientists call this the **riffle:pool ratio**. In your watercourse project you may need to balance the riffle:pool ratio. Habitat biologists can help you determine whether this is necessary and if so, how to do it.

A healthy river will have a mixture of the four physical features. The manner in which they are mixed is unique for each stream, creating its individual character and appeal.

3.1.2 Typical Stream Channel Patterns

Gravity, friction, and depth of flow are the three main forces that create stream channels.

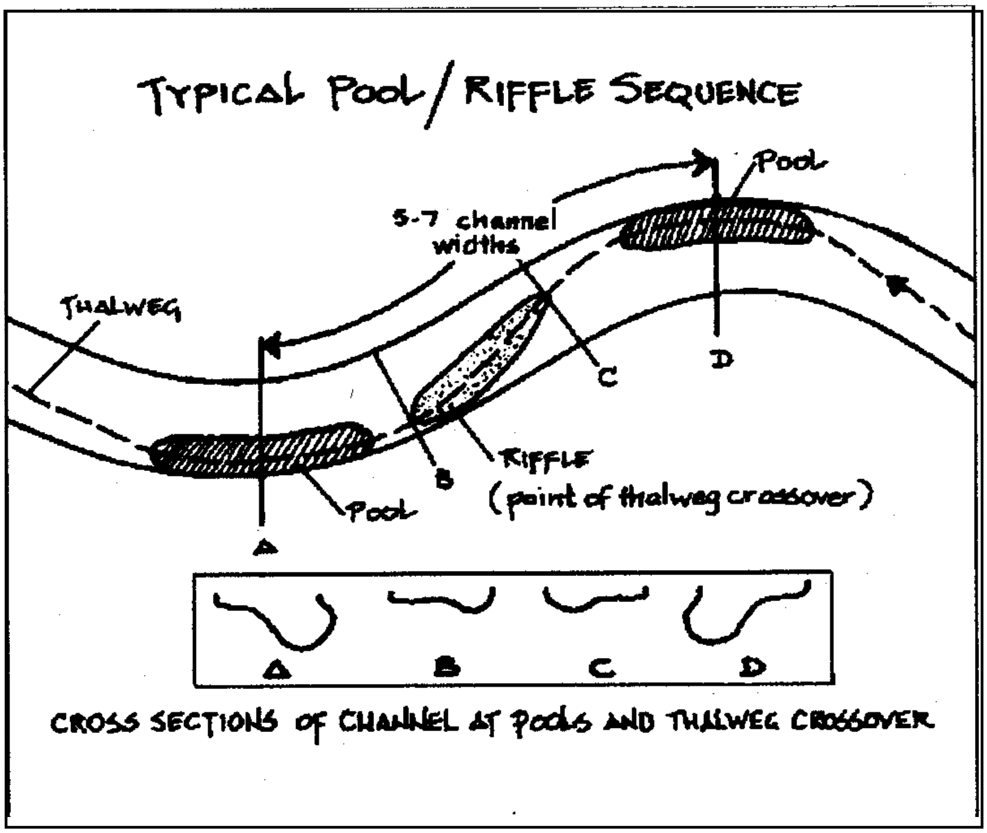
A healthy stream channel adjusts to change naturally without changing its basic shape and form.

- Gravity causes water to move downstream and gives it speed, while friction between water and the streambed and banks creates a turbulence that slows down the flow.

- Friction increases in a stream when water flows over large materials such as rocks, boulders and debris. The size and amount of material determines the stream's "roughness".

- The speed of the water flow depends not only on slope and roughness of the streambed, but also "on the depth of flow". As the water level rises, the friction on the bottom and sides has less and less influence on the speed of the flow. Basically what happens is that water is now flowing over water and a stream is said to be "streaming". At this point, the internal strength of the water keeps it from pulling apart and causes it to slosh from side to side that slows the stream down. You can observe this effect by watching water run down a chute or a trough.

A combination of the forces described above create the physical features of a stream (riffles, pools, flats, and runs), and the shape of the channel.
The illustration below shows a typical pool/riffle sequence.



When the water is streaming, on the outside of a bend, the water is actually higher on the outside than inside of the turn. The water falls with gravity, under the main flow, to dig a pool. The heaviest material is dropped first, then gravel to build the head of a riffle, then silt and sand are deposited on the inside of the bend. Essentially at this point, the flow of the water is sorting the bottom material by size.

In shallow areas along the banks that go dry in low flow, vegetation, such as reeds, grasses, and willows, begin to grow. These plants also influence stream structure by slowing down the flow of high water running through them and by collecting debris, silt, and sand which build up the banks at these points, narrowing the stream. The roots stabilize the banks so as the water goes around a bend it digs down and under, creating deeper pools and undercut banks.

Logs falling in the stream often catch at the end of a riffle or the beginning of a pool because the flow of the water is slower here. These logs alter the stream bottom by giving the gravels of the riffle and run a firm base to pile up on, keeping it out of the pool. The small head difference across the log further aids in deepening the pools. Logs and other large debris (called **large organic debris or LOD**) are essential in streams to create good pools, habitat diversity, and cover for fish.

Logs in the streams rot very slowly because they are always wet. Hardwoods withstand the impact of sand and gravels and are most commonly found as natural digger logs. Softwoods usually "pulp" quickly and are gone in a couple of years. Therefore, hardwood debris is very important in streams.

Three general terms are used to define the basic types of stream channels:

Straight: Applies to sections or **reaches** of rivers that are relatively straight over a long distance. Such reaches are generally unstable. Even though the channel is straight, the water still bounces back and forth as it travels down the channel.

If the stream is flowing over a mix of sand, gravel, or cobble (glacial till), it will form a nicely shaped channel.

The pools occur at intervals in the river, spaced 5 to 7 times the width of the river channel.

Over other kinds of stream bottoms, such as sand or boulders, the pattern is not as clear.

Braided: Applies to sections that have poorly defined, unstable and steep banks, and shallow watercourse with many channels around small islands. Too much sediment coming from tributaries or the crumbling, eroded banks often create the islands.

Meandering: Applies to sections with a single channel that has many bends, or "meanders", giving an "S" shaped pattern.

A stream will always attempt to maintain its meander shape and pattern. This curving pattern is formed by the water flood flows, and is the pattern which is in balance with the substrate and banks to form a stable stream. Even when a stream channel appears straight, the line of its deepest point **(thalweg**) meanders back and forth across the channel in a predictable pattern.

You may wonder what the meandering of a stream has to do with adopting it. It is important to stress at this point that you will be working with a natural system that has its own natural patterns. In the Adopt-A-Stream program we are trying to work with a natural system and help it repair itself. If you don't understand the "natural flow" of the stream you are working on, you might end up working against nature, instead of with it.

When obstructions in a stream cause it to depart from the normal meander shape, the stream will always tend to try to get back to its natural meandering.

Here are some general principles that will help you understand a stream's meandering:

- The width of the stream and the length of the curves or meanders are closely related. If you imagine that a meander is a piece of string that you can straighten out, the length of the curve would be about 5-7 times larger than the width of the stream.
- When unstable stream banks become reinforced with rocks or plants the stream will tend to deepen and become more stable. At any given time streams are carrying all kinds of different materials such as particles of earth, plants, and debris. The way these materials are moved around and dropped off at various points affects a stream's shape and structure.

When you look at a stream you probably think of the water as flowing in one direction. Actually, as water moves downstream it is also moving back and forth across the channel. This back and forth movement causes materials (like silt and sand) to be deposited or dropped at the inside of a curve, which creates a point bar. Floating debris builds up on the outside of the curve. For example, if a log or boulder were put on the inside bank of a curve, the structure would become buried. In your stream there may be need to help nature by strategically placing something that will improve fish habitat. This is covered in later sections of the manual and a habitat professional will help you decide on these locations.

The physical structure of a stream and the quality of the water flowing in it creates a habitat or home to many forms of life. A naturally shaped stream gives more useful living space. Making a stream straighter can dramatically alter the amount of useful habitat for fish and other wildlife.

3.2. Stream Habitat

Streams, of course, are habitats to many other forms of life other than fish. Plants, small

Here are some important things that influence the habitat potential of a stream.

- **Cover for fish (in the stream) called in-stream cover**
- **The stability of the banks**
- **The amount of shade provided to the stream**
- **The slope of the stream**
- **The chemistry of the water and the nature of the water table in the soil**
- **The temperature of the water**
- **The number of insects (food)**

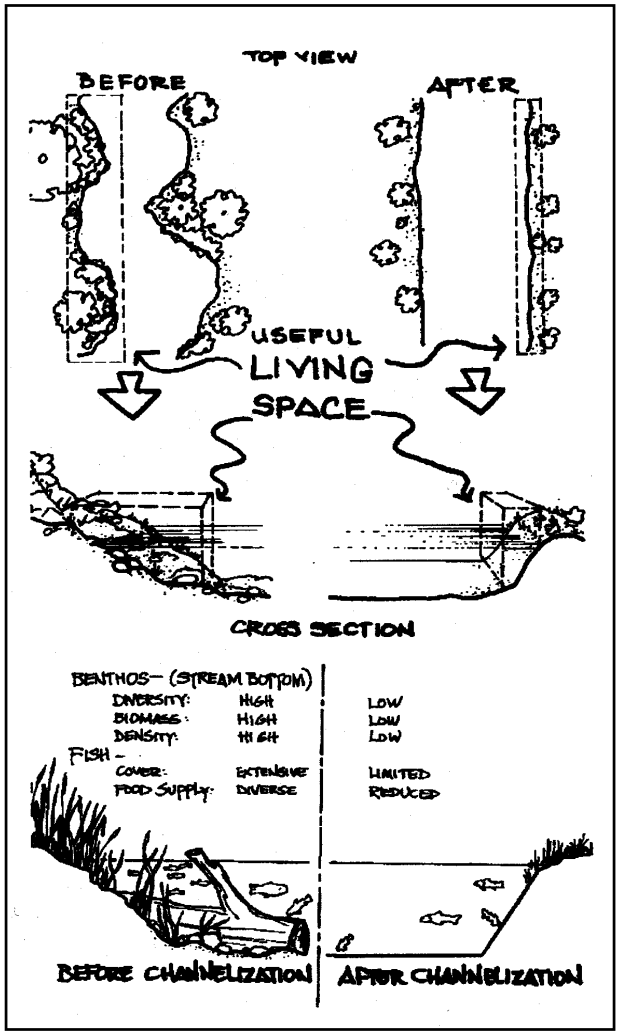
insects and invertebrates, and small mammals live and use the water. The areas around streams, called **riparian habitat,** are very important to a whole host of plants and animals.

In the section called **Facts on Fish** we will discuss what kind of stream habitat a fish requires. Birds and animals congregate around streams. One reason this occurs is that all animals need a source of water. Many animals either eat the fish or insects or the plants growing in and around streams. The areas along streams are also commonly used for travel, nesting, and shelter. If you walk along the sheltered edge of a stream in winter you will see many animal tracks and deer beds in the snow.

Adopting a stream means you are also adopting the watershed around the stream, all the animals that use the stream, and its riparian zone.
In addition to improving fish habitat you may want to consider putting up nest boxes for birds (see Section **Where to Go For Help**). Local naturalists, birding clubs, or the regional biologist from the Department of Natural Resources may have other ideas on how to improve the area around the stream. The habitat potential of a stream is created by many different factors.

3.2.1 In-stream Cover

In-stream cover is generally provided in five ways:



- **Undercut Banks**: where water has eroded away the material under a stream bank. The upper portion has not slipped into the water because the root systems of trees, shrubs, and other vegetation have held the soil.

- **Rocks, stones and boulders** found in streams provide protection from predators, weather, and other factors. The size of a rock, its shape and location, all have an influence on what uses it for cover. Irregular rocks and boulders as well as slab-sided boulders with no sand or silt under them, provide the best cover for juvenile fish.

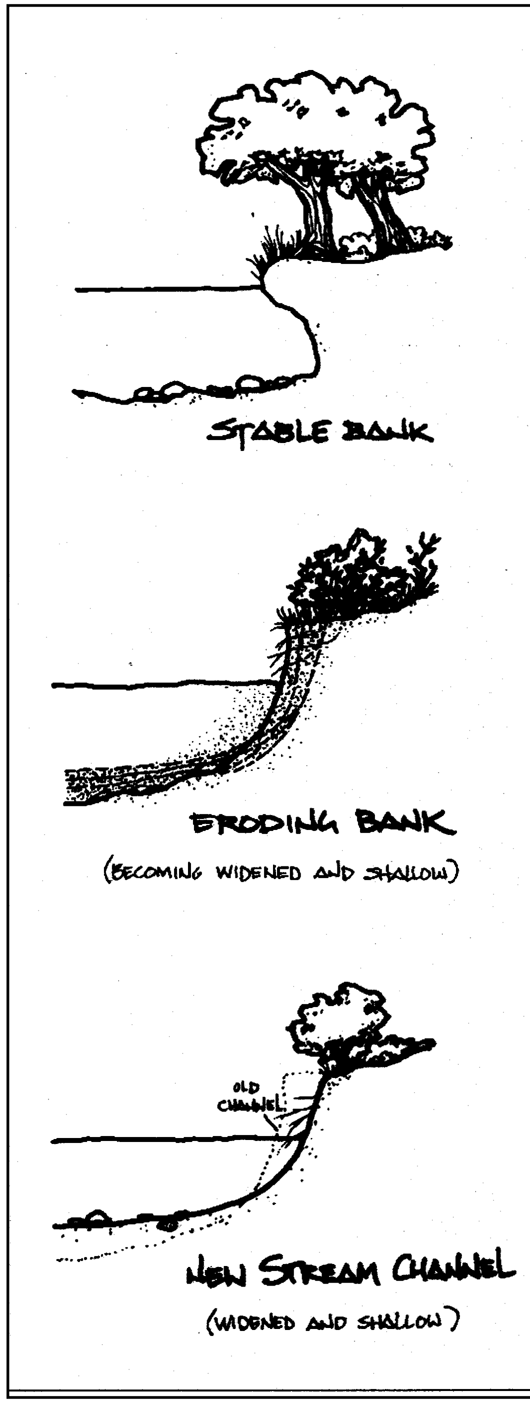
- **Logs and trees**. These are essential in streams to assist in developing pools, cleaning the bottom, and stabilizing the stream. The proper amount of large material can make the difference between poor and excellent fish habitat in many streams. Logs and stumps also provide overhead cover as an escape from predators or fast flowing water. However, too much of a good thing can be bad. Log jams, which cause water to be diverted over the stream banks, can cause severe erosion and may have to be removed.

- **Low overhanging grasses and bushes** also provide overhead cover under which fish can hide. This is particularly important for trout.

- **Water depth, water colour, and surface turbulence** also act to hide fish from land predators. The broken water surface of riffles hides young salmon and the deep water of pools hides trout. The quality of a pool is determined by depth and how much of the bottom is hidden by the cover features listed above.

3.2.2 Bank Stability

Although erosion is a natural and dynamic process, human activities often change the stability of a stream bank, causing increased erosion. The stability of a bank gives an indication of how much erosion is taking place. Excessive erosion produces silting and encourages the stream to widen and become shallow. Banks that are actively eroding will eventually cause a decrease in the abundance of fish and invertebrates, such as insects. Stable banks have little or no erosion, are not slumping, and usually have growths of grasses, shrubs and trees. In some instances, they have been stabilized previously by artificial means. The impact on the stream of stable and eroding banks is illustrated.



3.2.3 Stream Canopy (Shading)

Shading affects life within the stream because many fish are sensitive to high temperatures. Shade keeps the air and water cool. The amount of shade depends on how many plants and trees are growing near the stream, the height of the trees, and the direction the stream is flowing (the direction is important because of where the sun is in relation to the trees. For example, a stream flowing in a north-south direction may have different amounts of sun than a stream flowing in an east-west direction. Trees overhanging the stream also provide nutrients (in the form of old fallen leaves) and food (insects dropping into the stream).

3.2.4 Stream Gradient or Slope

Stream gradient is the actual visual angle of descent or slope of the stream. Slope affects the speed of the water flow and how much of the stream will be pool or riffle. This directly affects the balance between salmon and trout and other species. For example, salmon prefer a 75:25 riffle - pool ratio while trout prefer a 50:50 ratio of pool to riffle.

3.2.5 Stream Chemistry

Nova Scotia's streams have poor levels of nutrients and minerals. This is expressed as **low conductivity**. To help compensate for this, leaves and litter that come from plants along the watercourse are very important, accounting for up to 90% of the food in a stream. Leaves from deciduous trees and bushes are the best.

Most stream life quickly dies if the pH falls below 4.7.

Vinegar has a pH of 3.0.

The chemistry of fresh water is not nearly as complex as that of salt water. However, some basic chemicals in fresh water should be mentioned. The amount of dissolved oxygen gas is a vital requirement for fish and insects living in water. Twenty percent of the earth's atmosphere is oxygen. Land animals use lungs to bring oxygen into their bodies. Many insects, amphibian tadpoles, and all fish use gills to perform the same function. The gills absorb oxygen from the water and release waste gases back to the water, but oxygen levels in the water are only 6 to 12 parts per million, far less than the air. This means the oxygen levels in water can be easily depleted. Oxygen dissolves in water depending on water temperature. The colder the water the more oxygen it can hold.

Acidity is another important component of stream chemistry. The amount of acid in the water is measured on a 14-point scale called the pH scale. Liquids like lemon juice, vinegar and battery acid are all considered "acidic" with a pH ranging from 0 - 7. Substances like baking soda, milk of magnesia, ammonia, and lye are all alkaline with a pH ranging from 7 -14. A pH of exactly 7 is neutral (milk is an example of a neutral substance).

During stream surveys you will be asked to take water samples to test for pH. The alkalinity of a water sample refers to its ability to counter the effects of acid. Alkalinity is mainly determined by the kind of rock base that forms the streambed and the watershed.

Water also contains minerals such as calcium and magnesium, which determines how “hard or soft” the water is. Other nutrients found in the stream include phosphorus and nitrogen. Usually when stream samples are taken, the water is also examined for toxic amounts of copper, mercury, and other metals.

3.2.6 Stream Temperature

Stream temperature is controlled by the shape of the channel, shade, the air temperature, the surrounding soil, the speed of the water flow, and the water volume. If the channel is narrow and deep (with good pool development), it has a large volume of water to heat up and cool down in comparison to the water surface, so temperatures do not change much over the day. If the channel is wide and shallow it will heat and cool quickly, following the air temperature.

Everyone knows it is cooler in the shade because there is little or no direct sun. The amount of shade along a stream affects the amount of direct sun that reaches the water. Direct sun heats the dark coloured, unshaded stream bottom, raising water temperatures. The shallower the water, the more effect it has. Shallow streams have water temperatures that follow the air temperature throughout the day. This is because there is a relatively large surface in contact with the air and a small volume of water.

Springs in the riparian area are important moderators of temperature because groundwater temperature is usually cool and stable. Water also seeps in and out of the stream and these seeps can have an important influence on temperature. If an area is cleared of vegetation (e.g. clear-cut, farm field, or parking lot), the seeps heat up in the sun. The cooler groundwater becomes hot.

In the winter the temperature situation is reversed. Shade actually warms the stream temperature by moderating cold winds and frigid temperatures. The vegetation also keeps frost from getting into the ground so that springs and seeps keep running longer in the winter and the stream bottom resists freezing. A healthy stream keeps an open passage under the snow and ice during low flow periods in winter. This insulating layer provides over-winter water for fish, prevents freezing of eggs, and keeps ice formations to a minimum. Since there is less ice, there is also less ice damage to the stream during the thaw or spring break-up.

> A healthy stream can maintain temperatures within ideal ranges for fish throughout their growing season.

Streams fed by lakes are warmer because of the heating effect of the sun on the open water. If the stream channel is well developed and shaded, the water temperature will drop to tolerable levels within a kilometer downstream of the lake.

Tributaries that come into the stream, of course, can affect the water quality and habitat. Try to identify where and what kind of water is entering the stream you are studying.

3.3. Stream Production

Habitat biologists use the word **production** when they talk about streams because they think about the habitat in a stream as a kind of factory where fish can be produced. So when they talk about the biological production they generally mean how many fish can be found or "produced" in streams.

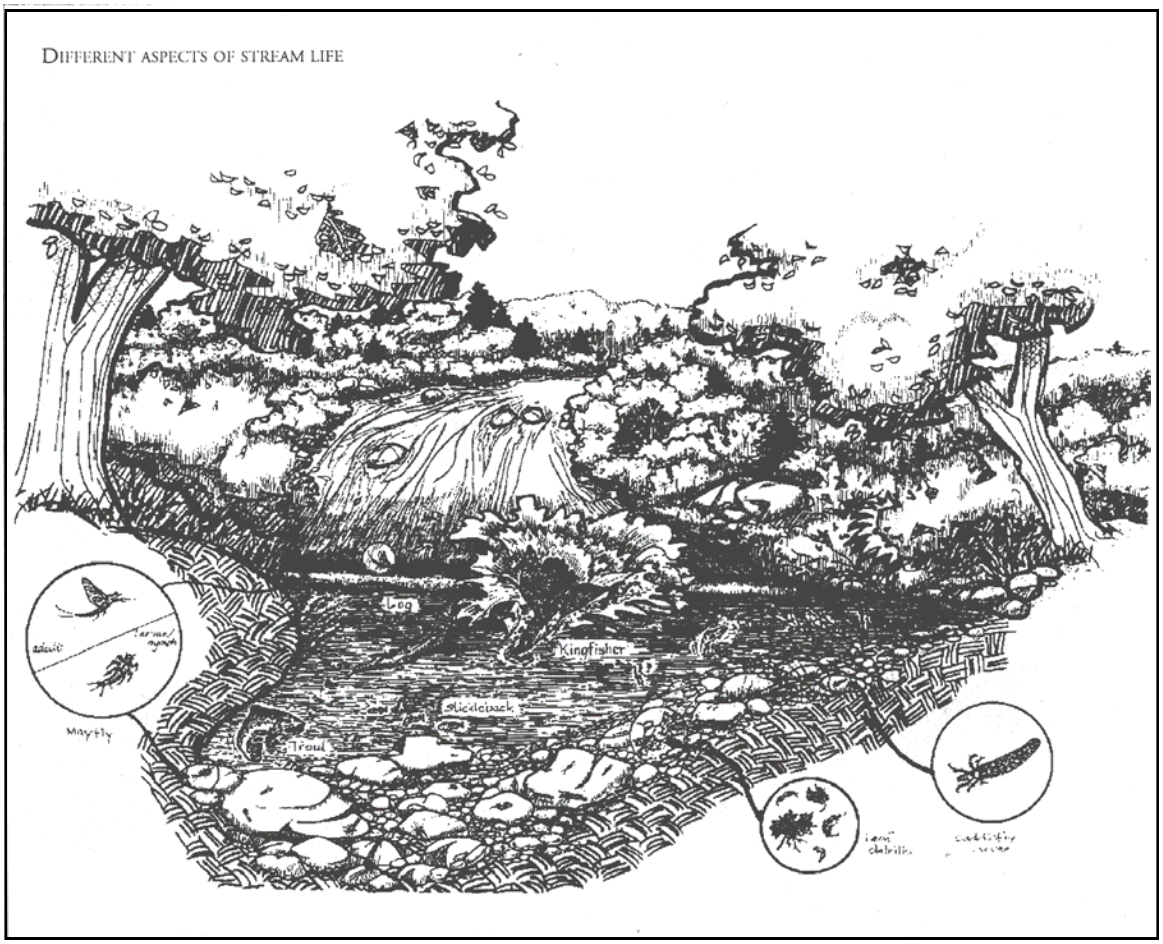
How well a stream "produces" is a combination of many factors. When we try to improve or enhance habitat, as in the Adopt-a-Stream program, we are also trying to improve stream production.

The vegetation growing alongside the stream has a strong influence on productivity because the habitat provided in a stream is tightly linked to its surroundings. Small streams in forested regions receive much of their materials from the surrounding forest ecosystem. Needle and leaf debris, twigs and branches are the main sources of nutrients to feed plants and animals in the stream.

There are two important food chains related to streams. The first (sometimes called the Internal Pathway or autochthonous) is based on what is produced in the stream through algae on the rocks and wood in the stream via photosynthesis. The required inputs to make this work are the "correct" mix of chemicals, nutrients and sunlight. It is this layer of algae on the rocks that often makes the stream slippery for wading anglers. However, in most shaded, woodland streams the amount of sunlight reaching the stream is small and limits algal production. Typically, the most stable streams have the best development of algae, since the suspended sediments in freshets scour the stream bottoms and remove algae growths in less stable watercourses. Algal growth is used in either its live or decomposed state by invertebrates (usually immature insects) which in turn are preyed upon by other species. These insects are the basic food for fish. Because of their low organic retention and their greater light interception, larger streams depend primarily on in-stream production of this alga as a food source.

The second important food chain (sometimes called the External Pathway or allochthonous) is based on what is produced in the forests and is dependent on plant material from streamside vegetation entering the stream. There is actually a steady drop of plant material from land into the stream throughout the year, but the vast majority falls in the autumn when large amounts of leaves, small twigs, etc., become incorporated in the stream bottom. There the material begins the relatively slow process of decomposition through the action of fungi and bacteria. This material is colonized by microbes and is then consumed by stream invertebrates (mainly insects), which are in turn prey for carnivorous invertebrates and fish.

This illustration is one example of some of the different aspects of stream life



3.4. Insects and Their Life History

Because of the importance of food for fish it is important for you to understand a little about insects and how they live. Looking for insects is one of things you will be looking for when you survey your watercourse. As food for so many fish and other animals, the presence or absence of insects are important indicators of stream health.

Many insects use the water for the early stages of their lives. Winged adults can often be seen flying above or resting on the stream vegetation and water, but it is beneath the surface of the water, among the rocks and stones, that the real abundance of insects occurs in immature forms.

The adult female of aquatic insects lays her eggs in or on the water. Then the insect life-cycle follows one of the two patterns:

1. In forms with simple life-cycles, eggs hatch into "nymphs". These can be somewhat like adults except they lack wings.

2. In forms with complex life cycles, the eggs hatch into "larvae", a grub-like form of life. After a period of feeding, a mature larvae develops into a pupa (a resting stage during which the adult structures, most noticeably the wing pads on the back of the thorax, develop).

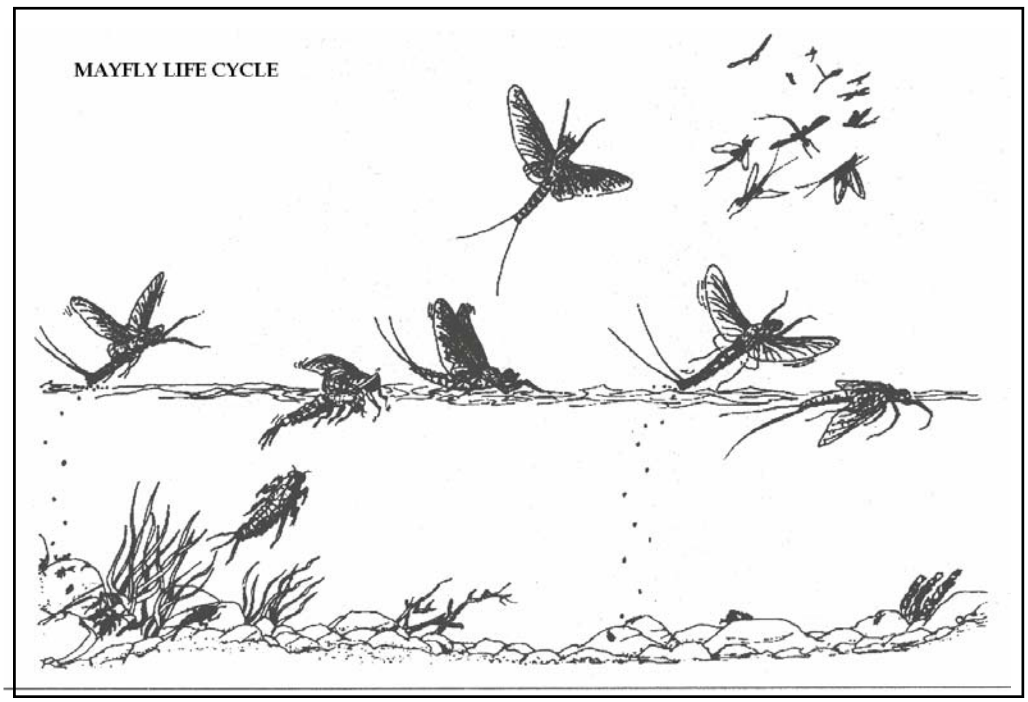
Both larvae and nymphs are voracious feeders. Some clamber about the bottom of the stream browsing on plant material, some prey on other animals, and others remain fixed in one place getting their food from water by means of intricate filtering mechanisms. Growth is by molting, a shedding of the body-covering to allow for enlargement. As maturity approaches, the pupa or mature nymph ascends to the water surface or walks ashore to allow the adult to emerge. During this phase it becomes very vulnerable to foraging fish. After emergence, the adult rests for a time to allow its wings to harden before flying off. Mating on the water takes place in the adult phase, completing the cycle.

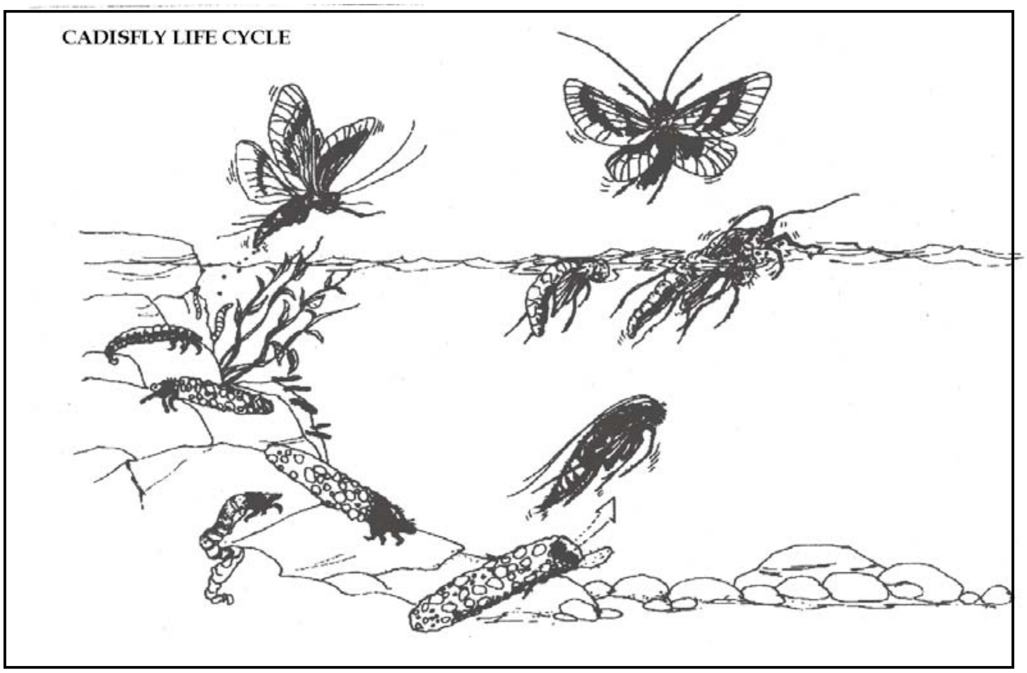
Immature stages of aquatic insects occur on or under the water, but only the true bugs (Hemiptera) and the beetles (Coleoptera) have aquatic adults. In the other major groups of aquatic insects, the adults live on land, usually remaining close to the stream. They can often be seen in mating swarms or laying eggs on the water surface. The adult stage is mainly a reproductive phase; many adults are short-lived and most do not feed.

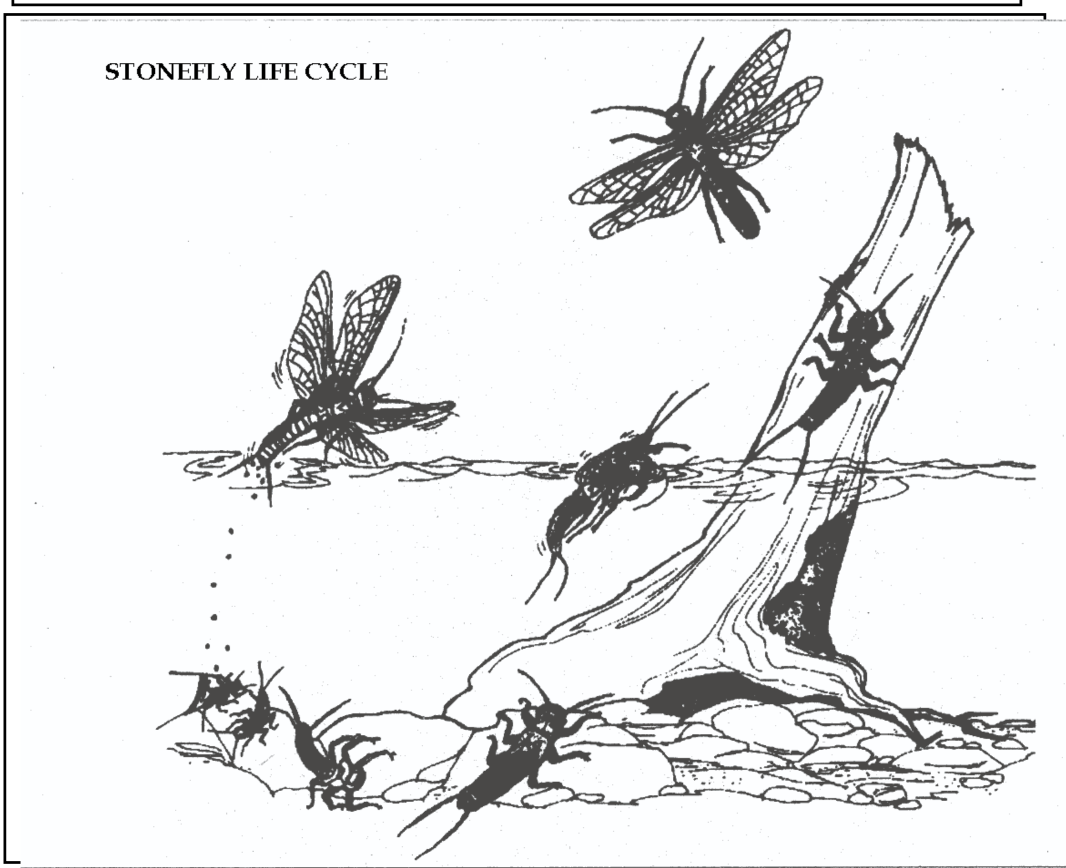
Important examples of aquatic insects with simple life cycles are stoneflies (Plecoptera) and mayflies (Ephemeroptera). Complex life cycle types include the true flies (Diptera) and Caddis flies (Trichoptera).

Aquatic insects occur in all bodies of fresh water, from stagnant pools to the largest lakes, from the smallest trickle to the fastest rivers. A typical stream suitable for trout and salmon is roughly composed of two alternating and contrasting habitats: the riffle and the pool (described earlier). Riffles, where the water is shallow and fast, contain gravel with a lot of oxygen. This gravel offers favourable spaces for many animals, and it is here that most of the stream insects occur. Diatoms (minute green plant cells), a principal food of herbivorous larvae and nymphs, grow on the tops of stones in these rapid sections. Fast currents also carry minute particles of food to insects such as black fly larvae and the net-spinning caddis, which feed by filtering mechanisms.

The following three illustrations show the life cycles of the caddis fly, mayfly, and the stonefly.




CADISFLY LIFE CYCLE


STONEFLY LIFE CYCLE

TEST YOUR KNOWLEDGE!
HOW WELL HAVE YOU READ THIS SECTION?

TRUE AND FALSE QUIZ

1. The structure of a stream is defined by its water flow features and its channel.		
2. A flat is shallow, slow portion of the stream.		
3. Pools should be spaced in a stream every 50 metres.		
4. The distance between the pools depends on the width of the stream.		
5. Natural streams should not meander.		
6. Good habitat for fish includes nice, sunny, open banks where the water can heat up.		
7. Important sources of food for life in Nova Scotia's streams are the leaves that fall into the water.		
8. Most stream life dies if the pH falls below 4.7.		
9. Insects are the most important source of food for smaller fish.		
10. A nymph is an adult insect.		

ANSWERS CAN BE FOUND AT THE END OF THIS MANUAL