SECTION 2.0. THE WATERSHED

THIS SECTION CONTAINS:

- An introduction to watershed systems
- Facts on water
- Historical uses of our watersheds
- Impacts of human activity in the Watershed
- A quiz to test your knowledge

WATER FACTS

• A healthy human can go without food for a month, but will die in less than a week without fresh water.

• Although we always seem to have an endless supply of water, 97% of the earth's water is seawater.

• If all of the earth's water could fit into a gallon jug, only a tablespoon of it would be fresh or 1 % of the earth's water supply.

• Another 2% of the earth's water is contained in glaciers and ice-caps.

• Two-thirds of the world's freshwater is found beneath the ground.

• In Canada, there's 37 times more groundwater than surface water.

2.1. What is a Watershed?

Everyone in Nova Scotia lives in a watershed. A watershed is an area of land that is drained by a particular river or stream or other body of water. Some people call watersheds river basins. You may not live anywhere near a stream but you most definitely live in a watershed area. For most of us, water is something we take for granted. When we turn on our taps it is there and after we use it, it disappears mysteriously. We swim in it, we drink it, we bathe in it, and cook with it, but rarely do we understand where the water has come from and where it goes. Water is not only useful to us, but also necessary for our survival.

More and more of late we have come to realize that we need to take more care with this precious supply of fresh water. In order to do that we must understand how water systems are interconnected within the watershed system.

Much of the watershed is invisible to you because it lies beneath the earth's surface. The part of a watershed you can see is the land on which snow and rain fall and the places where surface water collects. In the soil and rock, underground water flows through channels following the slope of the ground or bedrock. Sometimes this water comes to the surface in springs and seeps, and bubbles up to become a streambed.

Stream drainage follows the lowest areas of land, so watersheds drain from a high point in the land to a lower point in the land or to the sea. In the Cape Breton Highlands you can stand

on a ridge in the middle of two watersheds - one river on one side drains eventually into the Gulf of St. Lawrence and the river on the other side of the ridge drains into the Bras d'Or Lakes. There are many cases in Nova Scotia where the headwater marshes are shares by two watersheds.

The size of a watershed can vary tremendously depending on the lay of the land and the soil and rock conditions of the area. Sometimes we may be talking about a small watershed area connected by a small stream that flows to the coast. Bigger rivers in our province, like the St. Mary's or Margaree rivers, drain a much larger watershed area. A big watershed area like the St. Mary's is really a collection of smaller systems put together called sub watersheds.

In Nova Scotia there are about 1200 watersheds emptying into salt water. These small watersheds combine together to form 76 major watersheds in our province.

SOME WATERSHED!

Some watersheds in other areas of Canada are huge.

The watershed of the Mackenzie River (Canada's largest river), for example, contains seven provincial and territorial boundaries and involves three provinces, two territories and the federal government in its management. The water collected from this huge area drains into the Beaufort Sea.

Surprising as it may seem, about 60% of Canada's freshwater drains north into the Arctic Ocean and Hudson's Bay.

When the settlers first came to Nova Scotia they relied on the watershed to give them much of what they needed to live. Some First Nations even identified themselves with particular river systems. These peoples understood that networks of brooks, streams, rivers, and lakes were a special sort of community to which they belonged and where all things were interconnected. Today in our modern world we have lost this feeling of interconnectedness. We sometimes forget that something that is done many miles away from us can have a profound effect on the ecology of our area. We think of water as coming from our taps, we don't envision the huge surface and groundwater systems that connect all flowing water together and from where all of our water comes.

As an example, water flows differently over forested land than it does over cleared land and paved roads. Imagine the effect of the paved cities, towns, and highways on the flow of water and imagine what gets washed into the water when it runs over all of our human-made world. We will cover some of the impacts of this later but just as one example, think of the impact of road salt on our water systems. Each winter, tons of salt are put on our highways to help us travel more safely. When the salt melts the snow and ice the briny water flows into our streams and what is left washes in with spring rains. Care is now taken in most areas to keep

the salt out of our wells and town water supplies.

2.2. Water Table Changes

Long ago mature forests covered the watersheds. The story of how forests soak up snowmelt and rainfall can be complicated to explain. Forests catch and use water to live and grow. They also provide uneven ground that slows flows and a climate for soils under them with a shady environment sheltered from prevailing winds all of which encourage the water to soak into the soils rather than run off. For these and other reasons forests tend to retain water in the soil after rainstorms. This sponge-like ability to hold and gradually release water helps to ensure that the roots of trees have adequate water supplies and the streams have a good base flow of water.

Forests harvesting, agriculture, urban and rural development, in short our land use practices change the runoff patterns increasing the quick and erosive surface flows and decreasing how much soak into the ground. This can change low flow summer and winter habitats for fish. Water running off cleared land peaks quickly, disappears downstream, and tends to be warmer. Humans add to this effect by infilling swamps and marshes, digging tile drains into once-moist fields, creating road ditches, and installing storm sewers that "quick-charge" our watercourses. What is the result of all this activity? When it rains, there is an erosive flush of high water over the land and into rivers. Shortly after, water tables quickly lower in the soils and our watercourses wither in dry summer heat.

A stream is only as healthy or clean as the valley through which it flows.
Extensive use of the valley without regard for the stream will quickly spell the end of a cold-water (and sometimes a warm-water) fish community and affect many other forms of life.

The "Global Climate Change Effect" of a warmer climate has resulted in shorter more intense summer rainfall, which combined with our poor land use and physically degraded streams, produces even lower water tables and low stream flows in Nova Scotia. The worst droughts in recorded history have become progressively worse in the 1980's, 1990's and 2000's. Compared to the past, our summer habitats for freshwater fish are warm and drying up and in the frozen winter we have low flows that weaken over-wintering habitats.

2.3. Historical Uses of Our Watersheds

In the first section of this manual we talked about how rivers and streams once had abundant populations of fish. Many rivers in our province can not sustain the numbers of fish they once supported. This is primarily the result of the changes people have made to watershed lands and watercourses.

Nova Scotia was once covered with an ice sheet a mile thick. As it melted about 12,000 years ago, old river valleys were exposed and new ones were created. Plants, animals, and humans began to inhabit the land as the ice retreated. Gravity pulls water down hill to the sea. Gravity is an accelerating force so, if the water is not slowed by the roughness of the bed and banks of the stream, and the water's internal strength, it would flow faster and faster as it went to the sea. Water flowing down a valley develops characteristic turns and bends as the meandering flow of the water slows itself down. These river valleys were, of course, the best places for humans to settle. Land was cleared without regard for the natural processes. Old trees that held banks in place were cut allowing the banks erode and causing the river to become shallower and wider. After about 150 years of intensive land use (land clearing, pulp and log drives, dam construction, gravel removal) watercourses, which once had lots of fish, have been and still are being degraded.

About thirty years ago people began to get worried about all of these changes to our watercourses. In the 1970's, in response to their concerns, many people with good intentions decided to "clean up" our streams. The problem was that they removed everything from the watercourses including logs and dead trees, which were providing important habitat. This is a good example of how work to help a watercourse can backfire! Later in this section we will look in more detail at the impact humans have on watersheds.

2.4. Watershed Planning

Sometimes all that is necessary to limit the effects of humans on the watershed is to do some careful planning and thinking. Projects that are planned improperly can do massive damage to water systems while well-planned activities can be carried out to limit the effect on our water and the life in it. More and more often now, scientists, governments, the public and industries understand the need to manage our watersheds as a whole system.

In the Adopt-A-Stream manual there are sections on different types of watercourses in the watershed. These sections include: Moving Waters (brooks, streams, rivers), Stillwaters (lakes, ponds, wetlands) and Estuaries. Although these systems are separate ecosystems in themselves with different plant and animal species they may all be within one watershed system.

One of the reasons it is so important for you to understand the concept of watershed management is because the success of the work that you do in adopting a particular

watercourse may be very much affected by what someone else is doing or has done, many kilometers upstream or downstream from you. It's pretty easy to see that if someone dropped huge amounts of chemicals in a stream right beside where you are working that many forms of life might be affected. But what if someone drops something into the stream up on that ridge of land at the top of the Highlands where you can't see it? The effect of that action will still be felt many kilometers away. For example, detergent flushed into a river can affect fish 80 kilometers downstream. In some instances many community groups are now looking at watershed management as a way to ensure good water quality and habitat for fish and other animals.

This section of the manual will discuss all the different ways watersheds and their watercourses are affected by the activities of humans.

2.5 Problems Affecting Habitat

It's sometimes harder to see the effect of change in larger streams because of their large volumes of water, but remember that small brooks become streams, and streams eventually become rivers. What happens somewhere else in your watercourse can have a tremendous effect even though it might be difficult for you to "see" the changes.

Additionally it is important to realize that everything done on rivers in Nova Scotia has the potential of affecting our estuaries, coastal waters and wetlands. All of the water systems are connected and interrelated.

Human activities that affect stream habitat include:

- **Contamination from Silt and Sand**
- **Municipal Sewage and Septic Tanks**
- **Forestry Operations**
- **Farming Operations**
- **Contamination from Pesticides, Herbicides, and Road Salt**
- **Urban Sprawl and Industrial Activities**
- **Dams and Diversions**
- **Acid Rain**
- **Water crossings and Road Construction**
- **Invasion of Non-Native Plants**

2.5.1 Contamination from Silt and Sand

Silt and sand from forestry, farming, urban development, and road construction, are very damaging to stream habitat. Remember the farmer at the beginning of this manual?

In later sections you will learn that a healthy stream with good fish habitat will have a gravel and cobble bottom. This bottom must be relatively free from silt and sand. In streams that have formed naturally, silt and sand are deposited outside of the channel or along the edges.

Natural erosion and changes in stream channels can occur only during high flow periods. Generally, the silt and sand are kept out of critical habitats by the flow patterns. Silt is produced when soils are exposed and allowed to erode during poor land use practices. Silt and sand particles, which enter the stream during low flows and in such great amounts that the flows can't move them, end up contaminating habitat.

Silt and sand can be divided into two categories:

Heavy Sand and Small Gravel

Heavy sand and small pieces of gravel are pushed along by the flow, bouncing and rolling over the stream bottom. As they move downstream they fill in all the spaces in the bottom gravel in a process similar to plugging up a sieve or a strainer. Try and imagine pieces of rice filling in the holes in a sieve; the process is quite similar. At first big particles plug up spaces, then smaller and smaller ones complete the smothering, until water can no longer pass through the bottom. The process continues down the stream, filling in more and more habitat and reducing insect production (insects use the spaces between rock for shelter and feeding). These spaces are important for fish as well as insects. The silt fills in over-wintering areas, spawning beds, and escape cover for fish. In severe cases, entire pools will fill in until the next freshet. As the spaces fill in, the channel tends to loose its features, becoming shallower and wider and creating long runs. This is a situation that does not fix itself unless something (like a fallen log) causes the channel to move again.

Fine Silt and Clay

These smaller particles stay suspended (or hanging) in the water. The turbulence or movement of the water and negative electric charges (much like static from a dryer) keep these particles suspended. The result is "cloudy" water that won't settle until it reaches a lake or pond. In fresh water, settling may take many weeks, but the electric charge that keeps the silt suspended is lost as soon as the fresh water contacts salt water. This silt material is very rich in nutrients but because it is carried by water that runs off the land it can also be dangerously rich in heavy metals, pollutants, pesticides, and herbicides.

Cloudy water makes it difficult for fish to see their food. Additionally, insects are displaced from the rocks and float away. Plants in the stream become covered and receive less light so their growth is limited. If the bottom has already been partially plugged by the first injection of silt, this finer silt seals the bottom tight. If it has not been sealed, the fine particles pass through the gravel but can coat eggs and fish gills, weakening respiration. In most cases the first thing to be done is to stop all sources of silt and sand. Rivers do not naturally run muddy after it rains.

2.5.2 Municipal Sewage and Septic Tanks

Approximately 85% of the water in Canada that is drawn for municipal use is returned to its source. Every day millions of gallons of sewage are pumped into our water systems. Some of this is treated and some is not. For many years, people believed that when sewage was pumped back into the water it would become diluted. The problem is that we're dumping increasing amounts of sewage and this sewage contains more and more materials besides human waste. For years people have been dumping detergents, solvents, paints, oil, and other household chemicals down their drains, never thinking about where these chemicals might end up. The federal government reports that one single liter of oil can contaminate up to two

million liters of water.

In some cases, sewage from homes and cottages with old or even no septic systems is draining directly into our watercourses. Standards for constructing septic systems were much less stringent in years past.

Before you point the finger at something or someone else for polluting watercourses, ask yourself where your sewage is going and if it's treated. Also think about what you put down your own household drain.

As you will see later in this section, farmers are now being asked to keep their cows and other animals out of brooks. One farmer was said to remark "what's the problem with one cow in a brook when a whole community is dumping their sewage in?" What has to develop is stewardship on the part of everyone for all watersheds and watercourses.

2.5.3 Forestry Operations

The relationship between forests and water is very complex, depending upon the type of forest, amount of precipitation, geology, slope, water table, and soils. Problems associated with forest cutting include: large-scale clear cutting, cutting to the stream edge, trails and road construction, machines traveling in wet areas, and dumping of slash and debris.

Large-Scale Clear Cutting

Removal of all trees in an area allows heat to penetrate the soil and raise the temperature of the air and groundwater, which in turn can raise stream temperature. In winter, frost can penetrate deeper and freeze seeps and springs, reducing the water flow. Large-scale cutting can also alter seasonal flow patterns and melt snow faster. If roads and trails used for hauling wood intercept the water flow, they can channel muddy water into streams. Increased flooding caused by heavier flows off the land can cause streams to widen and pools to move.

Forests play an important role in regulating stream flows and maintaining water quality. In a natural stream, up to 99% of the nutrients for its aquatic life come from the forest ecosystem.

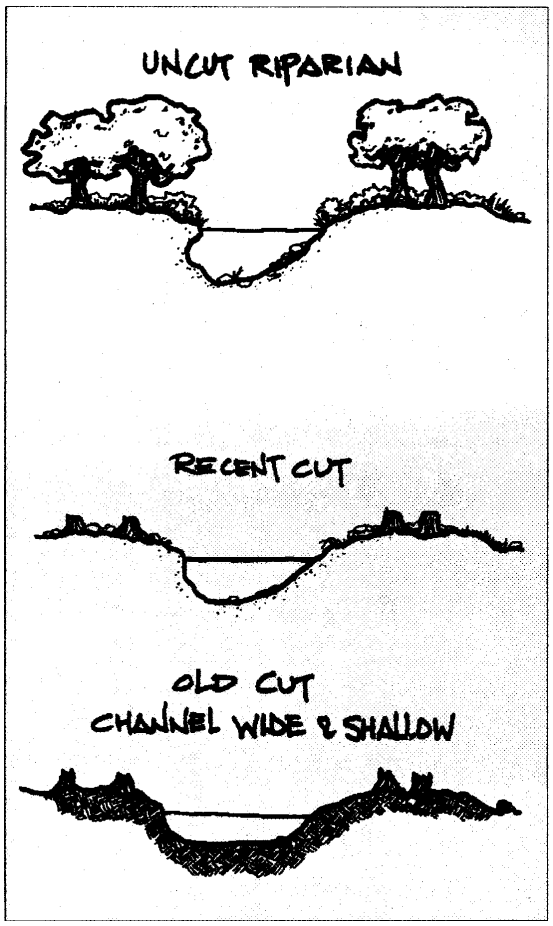
Trees and the plants that grow under them use large amounts of water while their roots stabilize the soil.

Fallen leaves and decayed vegetable matter on the forest floor cushion the impact of rain, cutting down on the amount of water flowing over the land and causing erosion.

The shading effect of forest cover slows snowmelt. This reduces spring flooding.

Cutting to the Stream Edge

Clearing off the vegetation beside the stream can raise water temperature by removing shade. This also reduces the leaf and litter input from the forest into the stream, which is the basis of many aquatic food chains. Banks can also become unstable and erode more easily when all trees are removed. Root systems, particularly deep hardwoods, stabilize banks much like reinforcement steel in concrete walls. There will also usually be fewer land insects, since many depend on trees during part of their life cycle. The illustration shows some of the impacts of cutting wood near a stream channel.



Hauling Trails and Roads

These trails and roads can increase soil erosion and siltation in streams. Culverts can wash out resulting in heavy siltation.

Machine Travel

For many years many Nova Scotians drove forestry equipment right across streams. Now most people are aware of how damaging this can be for fish and stream ecology. The big tires not only damaged the stream bottom but often they would be filled with mud from the machine trail and put silt into the water. Now, responsible operators use permanent or portable crossings to cross wet areas. These wet areas often include water seeping out of the

ground (seepages), which although small, may join into a brook that in turn joins into a bigger stream or river system.

Slash and Tree Tops

Slash or leftover material from forestry operations, such as branches and treetops, are sometimes dropped into a stream. These can wash down, creating dams and obstacles which block fish passage and cause erosion. The increased organic material washing into the stream from the slash left decaying in the clear-cut can overload the stream's natural system and use up too much oxygen in the water.

Forest management directly affects the water cycle and the quality of life in nearby watercourses. The incorrect construction of forest roads, skidder/forwarder trails, bridges, and culverts is covered later in a section on road construction.

Log Drives

Of course, forest operations in the past, particularly log drives, had a tremendous impact on streams. Younger readers may not realize that the rivers of our province were the highways to get logs to the mill or coast. In some cases, horses were used in the stream to pull ploughs right through the water to straighten the rivers to make them better for log driving. The sides of the rivers were shored up with logs and rocks to keep them straight.

Logs were "driven" down the rivers in the spring when waters were high and fast. Many Nova Scotian communities were built around the pulp and lumber mills that these log drives supported.

Wildlife Habitat and Watercourses Protection Regulations

The new Wildlife Habitat and Watercourses Protection Regulations came into effect on January 14, 2002. The regulations make guidelines for forestry operations mandatory on all lands. They provide for the protection of water quality, biodiversity and wildlife habitat. The regulations and more information can be found at http://www.gov.ns.ca/natr/forestry/strategy/wildl_hab.html

Your local Department of Natural Resources can assist woodlot owners in developing methods of cutting and moving wood so that it does not have such an impact on streams.

Alternatives to clearcutting, such as selection or partial cuts, may be feasible on your property.

2.5.4 Farming Operations

Most farms in Nova Scotia were built along the water. The barn was located as close to it as possible to ensure a good water supply. Unfortunately this has resulted in some farm practices that affect watercourses:

In 1900 there was three times as much cleared land as there is today.

Many farmlands are located near watercourses.

Agricultural practices have caused serious changes in stream channel shapes, and added much silt and sand to the water.

- Manure run-off from livestock operations and manure piles near the water
- Removing vegetation along the watercourse
- Poor ploughing practices (e.g. ploughing right to the water, fall ploughing)
- Poor drainage designs (drainage ditches, surface run-off)
- Channelization and dredging of the stream for irrigation and flood control purposes
- Fertilizers and chemicals running off the land into the stream
- Water taken out of the stream for irrigation
- Livestock walking in and crossing streams, trampling and eroding banks

Loss of stream bank vegetation increases erosion and causes more bank material to enter into the stream during snow-melt and heavy rains. These materials take the form of fine particulate silt, fertilizers, manure, pesticides, etc. A greenbelt (an area of uncut vegetation left along a watercourse) will help stop silt run-off as well as keep the stream cooler. Improved, long-term drain designs also decrease the import of soil and associated material. It is in the farmer's best interest to keep manures, fertilizers, and soil materials on fields and out of the water. The illustrations on the next page show two examples of the impact of farming right up to the edge of a watercourse.

Every farming operation with a stream should have a greenbelt along the watercourse.

Stream and river channelization (straightening the way the stream flows) for flood control and drainage takes away habitat necessary for rearing and spawning. Dredging eventually widens

the river channels, decreases the volume of water and loosens soil on the banks, causing increased siltation and higher temperatures. Fertilizer leaking into streams creates nutrient over-enrichment of waters. Fertilizer spillage usually results in too much algae, leading to cloudy water, decreased oxygen, and an overload of nutrients. Pesticides and herbicides used for crop protection may be toxic to fish and wildlife that live in and around the stream. Even organic waste that is dumped into the stream causes problems as it decomposes. A lot of oxygen in the water is taken up to decompose or break down this material.

2.5.5 Pesticides and Herbicides

During the 1950's the forest area near the Northwest Miramichi River in New Brunswick was sprayed with the pesticide DDT in a solution of oil in order to control tree infestations of the spruce budworm. The chemical was sprayed to try to get rid of the budworm, but many other insects, birds (whose reproductive rates were reduced through egg shell-thinning), fish, reptiles, and mammals suffered. Many creatures that survived the initial spraying died at a later time. They had been deprived of a food supply because the vegetation they had eaten had been poisoned as well.
It is known that DDT residue can remain active in soil for years, but its long-term effects remain unclear. DDT use has now been banned but there are many chemicals that we use every day with long-term effects that are unknown.

Forest workers often get blamed for high chemical use, but farmers, manufacturers, dry cleaners, and homeowners are only a few of the other people in our society that also contribute to chemical overloads.

Water quality can also be detrimentally affected by two interrelated pollution problems: enrichment and chemical overloads.

Enrichment simply means fertilizing a stream by means of waste water from local sewage treatment plants, septic systems, barnyard drainage, and fertilizers washed in from farm fields and storm sewers. A normal, healthy stream has clear water washing over clean rubble and rock, occasionally flowing through weed beds of rooted aquatic plants. A stream that has an enrichment problem quickly develops excessive algae on the rocks. These trailing strands tend to choke river channels and create periods of low oxygen.

Pollution, on the other hand, usually refers to the introduction of toxic chemicals, herbicides, pesticides, heavy metals, oil, gasoline, and paints which actually poison the aquatic life of a stream. Chemicals such as Dioxin, DDT, PCB and Mirex, or heavy metals such as cadmium, zinc and lead can poison aquatic life if released in sufficient amounts. Many chemicals enter the water when liquid and solid wastes are poured or dumped directly into watercourses. Effluent sources in Nova Scotia include: coal washing, surface mining, gravel quarries, saw mills, pulp and paper operations, textile and other product manufacturing, petroleum

processing, transportation, and our homes. Radioactive wastes are especially poisonous to all forms of life. Acid rain (discussed later) is one of the most widespread and serious forms of industrial pollution found in the world today.

Chemicals reach watercourses in run-off from the land and through field and sewer drains. These chemicals may come from:

- **Households (what we put down the drain)**
- **Industries**
- **Farm operations**
- **Roadside and railway line spraying**
- **Forestry operations**
- **Road salt**
- **Treated wood for bridges**

Everyone uses chemicals.

When we use a strong chemical to clean a toilet, we often don't think about where that chemical is going.

Eventually, after leaving our septic system or sewage system, it enters a watercourse. The problem with some chemicals is that even small quantities can cause major changes in natural systems.

2.5.6 Urban Sprawl and Industrial Activities

It is hard to assess the damage created by much of our past careless use of natural things, but now we know that the removal of gravel from streambeds for road building has caused serious problems.

When humans invade previously undeveloped land we call it urban sprawl. Traditionally people have tended to settle around watercourses. They use this water in factories, for transportation of goods, and for waste disposal. Often the land around watercourses is also a prime target for recreational development (cottages, camps).

The clearing of watershed lands and the construction of roads, bridges, culverts, pipelines, railways for human use can lead to the destruction of stream beds, removal of streamside vegetation, siltation, damage to banks and interference with current flows, particularly in summer.

Developments and construction can also be destructive to water habitat if rock containing iron

pyrite is exposed. Some gold bearing rocks and slates, especially those from the Halifax Formation, may contain large quantities of pyrite. The sulfides in pyrite produce sulfuric acid when exposed to oxygen and hydrogen in the atmosphere. This sulfuric acid gets washed into brooks, streams and lakes, causing fish kills by lowering the pH to intolerable levels. For example, when the Halifax airport was built the construction exposed shale to the air. When it rained, water ran over the shale and into the rivers lowering pH and killing fish in nearby watercourses.

Although not as common as pyrite contamination, other heavy metals contained in rock (copper, zinc, lead, arsenic) can also poison aquatic life. If you are going to use rock in your project, either as fill or bank stabilization, you should make sure it won't be harmful to plant or aquatic life. Your habitat contact should be able to give you advice.

The infilling of stream-side habitat areas for "land reclamation" purposes to construct cottages, wharves, etc. can result in increased siltation with all of its side-effects, and the blockage of nutrients moving from the land to the stream.

Increases in development around watercourses also leads to an increase in the recreational demands placed on the area. Too much recreational use leads to carelessness and over-use. This, in turn causes problems such as littering, the use of recreational vehicles such as four-wheel drive trucks or all-terrain vehicles in forested areas and through shallow streams, and an increased potential for forest fires. Forest fires result in the destruction of the entire terrestrial ecosystem and increase water run-off, thereby increasing ash and silt loads in rivers.

2.5.7 Dams and Diversions

Flows of rivers and streams are diverted or changed for many reasons: hydroelectric power, irrigation for farms, control of flooding, domestic, and industrial uses. Rerouting or damming watercourses also can cause major habitat changes unless careful provisions are made.

Dams present physical barriers to fish migrating up and down the stream. Unless proper fishways are constructed, fish migrating upstream will be unable to reach spawning areas above the dam. If salmon have begun their migration towards the ocean and have been halted by the dam, the time allotted in their biological clocks for migration and smoltification can run out. The smolts will either wait to migrate another year or not migrate at all, spending their entire lives in fresh water. The increased time spent in lakes increases exposure of salmon and trout to predators and disease organisms.

Fish migrating downstream suffer injury or death passing through turbines, hitting concrete spillways, or slapping against water and rocks in the pool below. Below the dam, the fast, cascading water becomes overfilled with dissolved atmospheric gases. The effects on fish are similar to the "bends" suffered by divers. If fish swim there for a period of time, gas bubbles

form under the skin and throughout their systems and can cause death. Nitrogen bubbles are the principal cause of death.

The Federal Fisheries Act (see the section on Laws and Regulations) says screens must be provided on intakes to prevent mechanical injury to migrating fish and also to provide a means of safe and effective fish passage past the dam or obstruction.

2.5.8 Acid Rain

Acid rain is one of the most serious problems facing many watercourses in Nova Scotia and one of the most difficult to do something about. The greatest portions of poisonous emissions are sulfur dioxide and nitrogen oxides, which react chemically with oxygen and moisture in the atmosphere and soil to become acid, sulfuric and nitric acids. These are carried on the winds for a few or several hundred or thousand kilometers, dropping to earth in dry form or in precipitation (rain, snow, sleet, hail, fog,).

Acid rain starts from gases and fine particles that are put into the air by:

- Oil refineries
- Fossil-fuelled electrical plants
- Smelters
- Domestic and industrial heating
- The exhaust pipes of millions of motor vehicles

About a third of the acid rain in Nova Scotia is produced locally; most of the rest comes from industrial areas of Ontario, other parts of Canada, and the United States. It is believed, although difficult to measure, that at least half of the sulfates falling over eastern Canada come from the United States, particularly from the industrial heartland of the Midwest and the eastern seaboard.

Acid rain can be deadly to terrestrial and aquatic ecosystems. Viewed from a distance, a river or lake may appear crystal clear and healthy in cases of extreme acidification. But looking closer you will find no evidence of any plant or animal life. For most fish, the first effects of acidification can be seen at pH levels below 5.6. These effects become critical if the pH drops below 5.0 or 4.7 in tea coloured waters. As the pH drops, the level of acid goes up.

An increase in acidity also upsets the overall delicate balance of an ecosystem. It affects natural chemical reactions such as the decomposition of organic materials, resulting in changes in the abundance of nutrients available to plants and animals.

Toxic metals such as mercury, aluminum and lead are sometimes contained in acid rain or leached from soils into water by a low pH. These chemicals can poison fish or be absorbed in fish tissues. The fish may survive but the chemicals are passed up the food chain to birds and mammals, especially humans. Frogs, toads and salamanders are also extremely sensitive to increased acidity. Declines in amphibians have also been linked to increased exposure to

ultraviolet light. Depleted ozone layers in our atmosphere will also bring less productivity in our food chains.

Nova Scotia is especially vulnerable to the effects of acid rain because of its geological structure, and its geographical location directly in the path of prevailing summer winds from industrial areas of North America.

If a rough line is drawn from Digby to Canso, most of the rivers south of this line will be affected to some extent by acid precipitation, particularly in the southwest and less so as one moves eastward. Most of this region consists of metamorphic and granitic rocks, shallow soils and many bogs, heaths and lakes with small watersheds. Drainage is poor and the buffering capabilities of this type of geology are low because of a lack of limestone and other natural acid neutralizers. The majority of Nova Scotia's salmonid streams and rivers flow through this region. Nine of the rivers, situated in the southwestern extremity of the province, have a pH level below the critical level of 4.7. Salmonids are no longer reproducing in sections of these rivers. Another thirteen rivers are in extreme danger of losing their runs (pH 5.0 - 4.7) and nine more are approaching the critical stage (pH 5.3 - 5.1).

Two rivers in this region that are exceptions to this generalization are parts of the LaHave River and the Musquodoboit River. They flow through areas of soil types that neutralize the effects of acid precipitation. The least acid-sensitive of Nova Scotia's rivers, due to differences in geological structure, are those that flow into the Bay of Fundy and Northumberland Strait.

Acid rain is a complex problem to solve. Here are some long-range challenges for society as a whole:

- Clean up the source and control emissions through special scrubbers in the smoke stacks of industry
- Reduce individual car use and dependence on fossil fuels
- Control the quality of the fuel burned ("coal-washing", for example, reduces the sulfur content in coal)
- Apply lime to low pH streams. Survival of Atlantic salmon parr has been shown to be improved by the use of limestone "filters" in the acidic water supply of the Biodiversity Facility on the Mersey River in Nova Scotia. However, the effects of this type of buffering are limited; the application of lime to a river or lake must be continual, it’s expensive, and it will not itself bring dead lakes back to life.

2.5.9 Road Construction

Dredging of streambeds to get sand and gravel for road construction was once a serious problem in Nova Scotia.

When gravel was required for road construction it was often removed from the closest streams.

This not only destroyed important spawning and rearing habitat, it also increased siltation and temperatures, eroded banks, and decreased food production in the stream.

As already mentioned, the removal of gravel has damaged many stream habitats. Also the construction of roads can:

- Physically obstruct streams with rocks, large organic debris
- Scour stream beds, destroying spawning and rearing areas
- Decrease bank stability, straighten channels, increase stream gradient, all of which leads to increased erosion
- Obstruct the migration of fish, divert water flow and contribute leaching of wood preservatives into the watercourse when poorly designed bridges and culverts are installed (see the illustration).
- Increase turbidity and sedimentation
- Silt entering the water is a serious problem associated with the construction of many roads and bridges. Silt smothers eggs and other organisms, reduces insect populations, and clog gills of fish.

2.5.10 Invasion of Non-Native Plants

In some parts of Nova Scotia, a plant called Purple Loosestrife is taking over wetland areas. This imported plant, although attractive, is of little or no use to wildlife and tends to choke out more useful native plants. Loosestrife can, in fact, take over an entire wetland area. Its growth should be discouraged in wetlands and in private gardens where seeds may be carried

to nearby wetland areas.

Once established, loosestrife is almost impossible to eradicate. Even a leaf can generate a plant. One mature plant can produce more than 2.5 million seeds each year and it is through seed dispersal that most plants are started. Although the flower is beautiful and colourful (so much so that some people mistakenly plant it in their gardens) it quickly shades out all other plants and forms impenetrable stands where nothing else can grow. It also fills in holes in wetlands making the wetland shallower and dryer. Muskrats lose food, fish lose habitat, birds lose nesting space, shorebirds are crowded off the shore and other birds move away as well.

You can help by digging up and burning any loosestrife you find. Do not leave any root fragments in the ground because the plant will still continue to grow.

Every province in Canada is now infested with loosestrife and it is rapidly becoming a big problem in Nova Scotia.

This chapter has attempted to help you to understand the interconnectedness of water systems around you and the huge impact that humans have on water.

Water is a scarce resource and a valuable one. The Adopt-A-Stream program is aimed at learning about, appreciating, and helping this important resource. By adopting a watercourse in Nova Scotia you will be helping fish, wildlife, and all living things - including yourself!

Remember that the watercourse you adopt is part of watershed - a much bigger water system!

> *The rivers are our brothers. They quench our thirst. They carry our canoes and feed our children. So you must give the rivers the kindness you would give any brother.*
>
> (Chief Seattle, 1852)

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

TRUE AND FALSE QUIZ

	True	False
1. 97% of the earth's water is salt water.		
2. Most of the earth's fresh water lies below the surface of the earth.		
3. In the earlier days before chemicals and technology watercourses were well looked after.		
4. Cleaning all the logs and debris out of a stream is a good idea.		
5. The main source of chemicals in our watercourses comes from forestry operations.		
6. Canada has one of the best records worldwide for its treatment of municipal sewage.		
7. Farmers should plough up to the edge of a stream because the manure from the field will help fish.		
8. Chemicals and detergents coming from our toilets and household drains can seriously pollute water supplies.		
9. Acid rain is one of the serious problems facing watercourses in Nova Scotia.		
10. Purple loosestrife should be dug up and burned if it is found.		

ANSWERS CAN BE FOUND AT THE END OF THIS MANUAL