The **Stewardship** Series

The Streamkeepers Handbook

Canada

Province of
British Columbia

A Practical Guide To Stream And Wetland Care

The Streamkeepers Handbook

A practical guide To stream and wetland care

Fisheries and Oceans	Pêches et Océans

Fraser River Action Plan	Plan d'action du Fraser

Environment Canada	Environnement Canada

Ministry of Environment, Lands and Parks

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The Streamkeepers Handbook:

a Practical Guide to Stream and Wetland Care

Community Involvement Division
Salmonid Enhancement Program
Department of Fisheries and Oceans
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V6B 5G3

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FOREWORD

Welcome to the Streamkeepers Program! This program provides guidance for people who wish to help protect and restore local waterways in British Columbia. Support for this program is supplied by the Department of Fisheries and Oceans (DFO) Salmonid Enhancement Program (SEP). SEP's Community Involvement staff are the initial contacts for people interested in the program. Other government agencies and private organizations are involved as well. Projects are organized in modules, permitting easy updating of information and adding of new projects. We encourage you to share your suggestions for future development of this program.

The Streamkeepers Program is modeled after stream stewardship programs in the United States. We are grateful to the Oregon Department of Fish and Wildlife for permission to use material and graphics from Stream Scene: Watersheds, Wildlife and People, to the Izaak Walton League Save Our Streams program, and to the Adopt-A-Stream Foundation of Everett, Washington for permission to use their material. Alaska Water Watch and a number of county agencies in Washington State also provided useful information.

INTRODUCTION

British Columbia's streams, lakes, and wetlands are valuable natural resources. Stream corridors are particularly important. They support more species of plants and animals than any other habitats and provide important refuges and migration routes for birds and wildlife. Streams also are essential for maintaining our renowned salmon and trout runs.

Streams respond rapidly to the pressures of residential and industrial activity in surrounding drainage areas or watersheds. Streams are good indicators of watershed health. Since we all live within a watershed, be it coastal rain forest or interior dry land, we all share the responsibility of maintaining the quality of the natural resources within them.

The Fraser River basin is an example of a very large watershed. It drains one-quarter of the land area and is home to two-thirds of the province's population. This basin supports the largest salmon runs in the world. The Fraser River is our largest and most valuable river, but its condition has deteriorated steadily over the years. The task of cleaning up such a large river may seem formidable. However, we can start by taking care of the small watersheds that feed it.

Pressures from development will continue to increase as our population expands in many areas of the province. Habitat will continue to be lost when we do not appreciate fully the value of our aquatic resources. Plant and animal populations which depend on undisturbed land will be threatened. In some locations, their numbers may fall to dangerously low levels.

The growing number of volunteers committed to working to protect and restore aquatic habitats in our province will find support and information in the Streamkeepers Program.

ORGANIZATION OF THE HANDBOOK

The Handbook is organized into five sections:

Section 1 Introduces you to the Streamkeepers Program and provides information on how you can get involved.

Section 2 Provides a summary of avilable projects.

Section 3 Contains basic information on watersheds, the water cycle, and stream ecology.

Section 4 Is a guide to the agencies responsible for managing various watershed resources.

Section 5 Contains the appendices: references and resources, a list of Community Advisors offices, glossary, and useful household tips for keeping our streams clean.

SECTION I
About The Streamkeepers Program

Introduction

The Streamkeepers Program has been developed in response to the concerns of the many volunteers working on stream enhancement projects. In spite of volunteer efforts and government regulations, development pressures from our expanding population continue to threaten our aquatic habitats. Everyone, from residents to land developers, foresters, and farmers, needs to become aware of how important good watershed practices are to the long term protection of our environment.

Objectives of the Streamkeepers Program

- to provide volunteers with the training and support required to protect and restore local aquatic habitats
- to educate the public about the importance of watershed resources
- to encourage communication and cooperation in watershed management

Becoming Involved

The Streamkeepers Handbook describes several projects, ranging from simple to complex. Some take half a day, others several days a year. Your first step is to contact the nearest Department of Fisheries and Oceans Community Advisor. In areas far from a Community Advisor's office, Water Management, Fisheries, or Habitat Protection staff at the nearest Ministry of Water, Land and Air Protection, Lands, and Parks office may provide assistance.

Your Role

As a volunteer, you can share the responsibility for protecting aquatic habitats in your community. Some projects require formal approval or technical training, but many can be started right away. Always remember to ask for the permission of landowners when you wish to work on privately owned land.

The information you collect will help you assess the health of your local streams and watershed and detect long-term changes. You will learn to recognize habitat problems and help design and undertake restoration projects in local streams and wetlands. You may need to work with local government, private companies, or residents to ensure that land use does not threaten local waterways. The data you collect also will be useful to government agencies, who do not have the resources to survey and monitor every stream.

You can help increase awareness of watershed issues in your community and involve other people in your projects. Long term improvements in watershed health will be achieved only with community understanding and support. You may wish to start your own Streamkeepers Group. The Fraser Basin Management Program has developed a guide to establishing community stewardship groups (Anon., 1995). This guide provides information about community resources, funding sources, and organizing techniques. You also may wish to consider these five steps of stream adoption developed in Washington State:

Forming a Streamkeepers Group

(source: Adopt-A-Stream Foundation, Everett, Washington).

1. *Investigate:*
Find out historical and current information about your stream.
2. *Establish a streamkeepers group:*
Involve the people who share the watershed.
3. *Establish short and long-term goals:*
Decide how you want your stream to look in the future.
4. *Create an action plan:*
Design and schedule activities to reach your goals.
5. *Become a streamkeeper:*
Get your feet wet and continue to monitor your stream's health.

Community Advisor's Role

DFO Community Advisors provide technical assistance to volunteer groups working on stream enhancement projects. There are Community Advisors in fifteen locations in the province. Appendix 2 lists their addresses and telephone numbers. Community Advisors will help you get started on Streamkeepers projects and put you in contact with other resources and active Streamkeepers in your watershed. Community Advisors can provide you with assistance in many areas:

- connecting you with a supply of project modules
- supplying current information about your watershed
- helping secure project approval
- advising you about training courses
- providing technical assistance
- referring you to other agencies, technical experts, and Streamkeepers groups in your area
- helping communicate information between Streamkeepers groups and various agencies

Streamkeepers Training

Capilano College (continuing education program) offers the three credit college course at many locations in the province, wherever there are at least ten interested people. This course has a 22 hour classroom component and a 36 hour stream survey practicum. Students do the practicum on their own and submit the work for credit. For information, contact Capilano College.

The Pacific Streamkeepers Federation offers a similar course, but without college accreditation. They also offer mini-courses on individual modules. For information, contact the Pacific Streamkeepers Federation at the number listed.

CAPILANO COLLEGE
Fisheries Science Department,
PO Box 1609,
Sechelt, B.C.,
V0N 3A0
Telephone:
1-604-987-1535
Fax:
1-604-885-9350
E-mail:
dave_bates@sunshine.net

Pacific Streamkeepers Federation

The Pacific Streamkeepers Federation (PSKF) has been incorporated as a nonprofit society. It provides support for more than 150 volunteer groups in B.C. and the Yukon. The aims of the Federation are:

- to provide for exchange of information among streamkeeper groups
- to provide a coordinated voice for streamkeeper concerns
- to facilitate education and training of volunteers
- to support streamkeeper and enhancement groups
- to help form new stream stewardship groups
- to foster cooperation among the various stakeholders in a watershed
- to promote the management of aquatic resources at the local level

The Federation handles sales of the Streamkeepers Hand- book and Modules. It has produced a directory of streamkeeper groups. It also has an on-line forum for exchange of information and ideas.

PACIFIC STREAMKEEPERS FEDERATION
720 Orwell Street,
North Vancouver, B.C.,
V7J 2G3
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1-604-986-5059
Toll Free:
1-800-723-7753
E-mail:
pskf@direct.ca
On-Line
http://www.pskf.ca/

The Streamkeepers Database

There is little information available on small streams, lakes, and wetlands, so any data you collect is valuable. Many people will find it useful, including members of your own group, other Streamkeepers groups interested in similar projects, and government agencies. People can monitor changes in the health of our watersheds and assess the effectiveness of restoration and protection projects. Data sheets for summarizing your information are provided with project modules.

The Streamkeepers Program has begun to develop a database to store the information you collect and provide easy access by interested groups. You can mail or fax the data sheets to the Database. In time,

STREAMKEEPERS DATABASE
Department of
Fisheries and Oceans
Suite 400,
555 W. Hastings St.,
Vancouver, B.C.,
V6B 5G3
Fax:
1-604-666-0292

people with computers and modems will be able to send or retrieve information from the database by e-mail.

Reliability of the results is an important aspect of data collection. Often this is called QA/QC or Quality Assurance/ Quality Control. For Streamkeepers, this means that other people should be able to recognize and find the location of your stream and any sampling sites. Data sheets often ask for references to NTS map numbers, measured distances, and watershed codes, to provide this geographic information. You should use standard methods, as outlined in the modules.

The procedures described in the project modules rely on many simplifications and generalizations that may not be applicable in all situations. The following steps provide quality control guidelines to help you investigate unexpected results:

Quality Control Steps

(source: Adopt-a-Stream Foundation, Everett, Washington)

1. Repeat the test or measurement, taking care to follow procedures correctly.
2. Make certain your testing equipment is clean and in good working order.
3. Remember that parameters vary throughout the year, and sometimes daily. Make sure you conduct your test or measurement at the same time of day (or year) as previous tests you want to compare it to.
4. Compare your results with previous data you have collected on the stream. Remember to check studies conducted by others, also. See if your measurement is within previously measured variation.
5. Look at other parameters. Do they seem abnormal, as well? Can you make any correlations?

As you compare your results with those from other sites in the area, you can recognize typical conditions. If the results still seem unusual, talk to your Community Advisor or someone at an appropriate government agency before jumping to conclusions. Some apparent problems result from natural occurrences. When the whole province is considered, characteristics of undisturbed habitats are quite variable. What is normal in one part of the province may be rare in another.

Streamkeepers Equipment Kits

Some equipment used in aquatic surveys is expensive or must be ordered from specialty stores. The Streamkeepers Program has assembled equipment kits at several locations in the province. These kits contain benthic invertebrate samplers, water quality test kits, and surveying supplies. Contact your Community Advisor to find out if an equipment kit is available for loan in your area.

SECTION II

Project Modules for Streams

Introduction

This section summarizes Streamkeepers project modules. The level of commitment required, the best time of year to do the project, and training or formal approval requirements are described. Each module describes the project in detail, and provides the following information:

how the project benefits the watershed
approvals or training required
volunteer effort required
time of year and work conditions
safety concerns
materials and equipment
project procedure
collecting, reporting, and evaluating data
identification guides and other resources

Project Timing

Surveys of physical and chemical characteristics are best done during times of very high and very low stream flows. Habitat problems are most likely to be found at these times. The low flow period in late summer usually occurs in August and September, when high temperatures and long spells of dry weather combine to reduce water levels. Water quality and flow problems often show up during this period. The high flow period, or freshet, occurs during heavy autumn and winter rains in coastal areas and during the spring snow melt in inland and northern areas. Damage from flooding, erosion, and sedimentation usually shows up during high flow. Plant and animal surveys are best done during spring, summer, or fall, when organisms are abundant and easily sampled. Restoration projects are best done during the summer low flow period. Often, restoration projects require some alteration of the stream channel or banks. Environmental damage can result if they are done at the wrong time of year.

INTEREST	MODULE
Get to know your watershed	1
Establish stations to assess or monitor your stream.	2
Assess the health of your stream or set up long term monitoring	2, 3, 4, 11, 12, 13
Report illegal activities on your stream	9
Improve community awareness and respect for local streams	10
Restore habitat in your stream	5, 6, 7, 8, 14

MODULE 1 Introductory Stream Habitat Survey

Collecting available watershed information and surveying your stream provides a useful starting project for a Streamkeepers group. You will collect maps, historical information, and current data, then walk your stream to identify and map undocumented conditions. As you become familiar with your stream, you can select the best locations for reference sites or sampling stations. Some of the more detailed surveys described in other modules will be done at these locations.

The mapping process helps you relate land and water use with stream health in your watershed. You will be able to identify habitats in need of protection or restoration. Documenting habitat problems, such as erosion, insufficient stream bank vegetation, pollution sources, or stream barriers, helps you choose appropriate restoration projects.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
No	recommended	2 days or more	2 or more	High flow and low flow seasons

MODULE 2 Advanced Stream Habitat Survey

This module provides instructions for establishing a permanent reference site and conducting a detailed habitat assessment. You will establish a benchmark, do cross-sectional and longitudinal surveys, and measure water discharge of the stream. You will then examine or measure the individual parts of the stream channel and bank that comprise the habitat. These include streambed material, embeddedness of the substrate, instream cover, percent pool habitat, off-channel habitat, bank stability, stream bank vegetation, overhead canopy, and riparian zone. The final step will be to combine these observations into an assessment that ranks the habitat at that location as good, acceptable, marginal, or poor.

These reference sites are the locations used for habitat assessments and surveys described in other modules. The sites also may be used for long-term monitoring programs.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
No	recommended	½ day per site	2 or more	Late summer early fall

MODULE 3 Water Quality Survey

Water quality measurements provide basic information about your stream. Measuring a few important stream characteristics in selected locations, at critical times of the year, can help you detect watershed problems.

You will be given detailed instructions for measuring turbidity, dissolved oxygen, pH, and temperature using simple equipment. You will sample at least twice a year, when stream flow is very high and very low, and more often if you can.

Human activities in your watershed alter water quality and stream flow. Often, natural vegetation is removed and urban development covers the soil with impermeable surfaces. When this happens, runoff from precipitation flows directly into streams rather than being absorbed by the soil and then slowly released. Flood, drought, sedimentation, contaminant addition, and fluctuations in water temperature often result.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
No	**recommended**	**2 days to ongoing**	**2 or more**	**High flow and low flow seasons**

MODULE 4 Stream Invertebrate Survey

You will be given instructions for sampling, counting, and identifying benthic invertebrates. These are small, spineless animals such as insect larvae, worms, snails, clams, and crustaceans that live in or on the stream bottom.

Invertebrates play an important role in the aquatic food chain. They eat algae, leaves, or organic debris and are food for fish, birds, amphibians, reptiles, and other insects in the stream ecosystem. The various kinds of invertebrates you find in your stream tell a lot about the health of your watershed. Some invertebrates tolerate organic pollution, and their abundance may suggest water quality problems. Others require good water quality, so their presence suggests a healthy stream.

This survey is thorough enough to detect moderate to severe stream degradation and is relatively quick, easy, and inexpensive.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
No	**recommended**	**2 days to ongoing**	**2 or more**	**Early spring early fall**

MODULE 5 Storm Drain Marking

Storm drain marking involves painting a yellow fish symbol beside roadside storm drains to remind people that water entering these drains flows into a nearby creek.

You will be provided with carts containing all the necessary materials. While marking drains, you also will distribute brochures that explain the significance of the yellow fish and provide household tips for stream care.

Storm drains collect runoff from roads and parking lots and empty into the nearest stream. People sometimes dump toxic household wastes, such as paint and pesticides, down storm drains and these compounds flow into a nearby stream. Storm drain marking projects help educate people about the harmful consequences of their actions, while providing alternate suggestions.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
No	Not necessary	½ day to ongoing	2 to many	Spring through fall

MODULE 6 Stream Cleanup

Cleaning up a stream is a rewarding activity for any group and often is the first step in a stream restoration project. A very small group can spend just a short time cleaning up a local stream bank, or a large group can take on a major project.

When you undertake a large-scale cleanup, you want to be sure you do more good than harm. The stream cleanup module provides guidelines on personal safety, time of year, permission required, and project organization. It also tells you which materials to remove and which to leave in the stream.

Streamside areas often are used to dump unwanted household and commercial garbage. Garbage attracts more garbage. Unless this cycle is broken, habitat damage may occur and recreational value of the area will be lost.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
yes	Not necessary	30 minutes to ongoing	2 to many	Summer: instream All year: streambanks

MODULE 7 Streamside Planting

Planting streamside vegetation is a valuable restoration project. This module provides information about the role of streamside vegetation and how to propagate, plant, and maintain native species along stream banks. Species suitable for both mild coastal climates and more harsh climates in the interior are described.

Riparian vegetation is critical in maintaining healthy aquatic ecosystems, particularly in small streams. The riparian zone provides food for aquatic and terrestrial organisms, stabilizes banks, regulates stream flow and water temperatures, and traps sediment and contaminants from upland sources. Wooded streamside areas provide nesting sites for birds and travel corridors for wildlife.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
yes	recommended	A few days	4 or more	Throughout the year

MODULE 8 Streamside Fencing

Vegetation and banks are damaged when domestic animals are allowed unrestricted access to streams. When grazing removes stream bank vegetation, water temperatures rise, contaminants flow unchecked into streams, and stream health deteriorates. Also, animals often wear down banks, causing erosion and sedimentation. Animal wastes contaminate the water with organic and inorganic nutrients, bacteria and viruses.

Fencing streams in agricultural areas solves many of these problems. It also helps protect vegetation that has been planted in an attempt to restore habitat. The streamside fencing module provides information on approaching landowners, designing fences, and incorporating cattle watering areas.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
yes	Not necessary	several days	2 or more	Spring through fall

MODULE 9 Observe Record Report

This module provides information about using the Observe Record Report system (ORR). You may witness habitat destruction or other environmental violations. This module provides guidelines on assessing each situation and taking appropriate action.

Minor situations often are handled effectively through education. However, gather evidence discretely and do not intervene in more serious situations. You do not wish to become involved in a potentially dangerous situation. The ORR system provides steps to gather evidence safely and tells you who to call in various emergency and non-emergency situations.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
no	Not necessary	½ day to ongoing	2 per team	Any time

MODULE 10 Community Awareness

This module offers a variety of approaches to heightening community awareness of the value of your stream. These methods include:

installing road signs at stream crossings

developing and distributing information brochures or newsletters

organizing community meetings

organizing public displays

accessing the media effectively

making media productions

You can clean up streams, monitor their condition, and undertake enhancement projects, but you must have the support of your community to ensure the long-term health of your watershed.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
no	Not necessary	A few days per project	2 to 4 to organize, more to implement	Any time

MODULE 11 Juvenile Fish Trapping and Identification

This module shows you how to select sampling locations and trap juvenile fish in your stream, using Gee traps. These live-traps are baited and placed in the stream for several hours or overnight. A key is provided to help you identify salmonids and other kinds of fish likely to enter these traps.

Trapping provides information about fish species native to your stream, where they live, and their relative abundance.

The kinds of fish you find will tell you about the quality of the stream habitat. Salmonids are considered indicators of a healthy watershed because they require good water quality and habitat. Documenting their presence helps identify and protect good quality streams and watersheds. Their absence may indicate the need for restoration projects.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
yes	**recommended**	**½ day or more**	**2 or more**	**Spring through fall**

MODULE 12 Salmonid Spawner Survey

This module describes how to count spawning salmonids on a stream. Survey teams walk the length of the stream, using the same procedures Fisheries Officers use to count spawners. This process is repeated a few times during the spawning season and total spawning populations are estimated from the counts. A key is included to help you identify fish species.

Spawner surveys provide information about the status of breeding populations. These fish must survive various fisheries, as well as environmental hazards, to return to their spawning grounds. Monitoring the abundance of spawning populations is essential to maintaining future generations of fish.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
no	**Not necessary**	**1 day or more**	**2 or more**	**Year round**

MODULE 13 Creel Survey

A statistically reliable method of sampling the angling effort on a stream is described in this module. You will count the number of anglers, fish caught, and hours fished at each fishing spot on your stream. Surveying a stream during all the daylight hours is extremely labour-intensive. This module describes a survey design that samples during one-sixth of the available potential fishing time. Data then are expanded to estimate total angling effort and catch.

Creel survey data can be used to provide information about the impact of angling on a particular fish population. Fisheries managers can use the data to provide estimates of population abundance when there are no other estimates available. They also use the information to set appropriate fishing regulations.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
yes	Not necessary	A few weeks or more	2 or more	Year round

MODULE 14 An Introductory Handbook for Instream Habitat Restoration Projects

The Streamkeepers assessment and monitoring activities help you get to know your stream very well. Over time, you may discover opportunities to restore habitat within the channel. However, this type of work involves a high risk of failure, potential stream channel damage, and possible personal liability. Such projects should be attempted only with professional guidance.

You will be introduced to techniques for restoring spawning and rearing habitat and migration access. Techniques include bank stabilization, fish passage improvement, and placement of boulder clusters, weirs, large woody debris, and spawning gravel.

This module focuses on assessing the suitability of your stream for these types of projects. It also provides guidance for selecting appropriate installation sites and structure designs.

Project approval required	Training	Time Commitment (per year)	Number of people	Time of year
yes	recommended	1 week or more	2 or more	summer

SECTION III

The Wetlandkeepers Handbook

Wetlands play an essential role in the well-being of our environment. For centuries, people have lived beside them, taken advantage of their many resources, and developed a rich folklore about them. Today, most of us know little about wetlands and often regard them as wastelands, of little value in their undrained state. Environment Canada and the B.C. Wildlife Federation have developed the following training modules to enhance public awareness of the value of wetlands and encourage participation in wetland monitoring. Modeled after the Streamkeepers Program, each module provides information on a specific monitoring or restoration activity.

Wetlandkeeepers is designed for community groups interested in conserving a local wetland. For more information on the handbook and program activities, contact:

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1420 Falls Street,
Nelson, B.C., V1L 1J4
e-mail: tsouth@netidea.com

telephone: 1-250-354-1088
fax: 1-250-354-1033
web site: www.siass.com/wetk.htm

1. Introduction

Module 1 Introducing Wetlands and the Wetlandkeepers Program

This module introduces the functions and values of wetlands and the philosophy behind the program. It also discusses land ownership, safety practices, and equipment.

2. Wetland Assessment and Monitoring

Module 2.1 The Initial Wetland Assessment

The first step in understanding your wetland is to assess its characteristics. Start by examining air photos and topographical maps of the wetland and surrounding area. Then study the vegetation and soils at the site to determine the class or type of wetland. You will produce a detailed map to document your results and use in subsequent surveying and monitoring activities.

Module 2.2 Conducting a Survey of Wetland Plants

You learn how to identify plants and estimate the proportion of area each species occupies. This information helps you monitor changes in species composition, review your data, and find causes for the changes. It builds on data collected in Module 2.1 and provides baseline data for long-term monitoring and restoration activities.

Module 2.3 Conducting a Wetland Bird Survey

This module shows you how to design, conduct, and evaluate a bird survey. Bird surveys provide useful information about wetland health and help you document the value of a particular wetland. You can use these data in public education programs and as part of an application for funds to conserve the wetland.

3. Wetland Restoration Planning

Module 3.1 The Law Relating to Wetlands

This module briefly reviews federal, provincial and municipal laws useful in protecting wetlands. It also discusses conservation covenants and other options for protecting privately owned lands. If you want to protect a public wetland legally, find out which laws apply, then check that they are being followed. If you suspect violations, enlist the aid of the government in enforcing the laws. You also may decide to explore legal options with a non-government organization.

Module 3.2 Developing and Implementing a Public Education Program

Public education programs at a wetland site are important in garnering public support for wetland conservation. This module discusses forming a community based steering committee, designing and promoting a program, maintaining a motivated volunteer force, and preparing a site.

4. Restoration Activities

Module 4.1 Wetland Cleanup

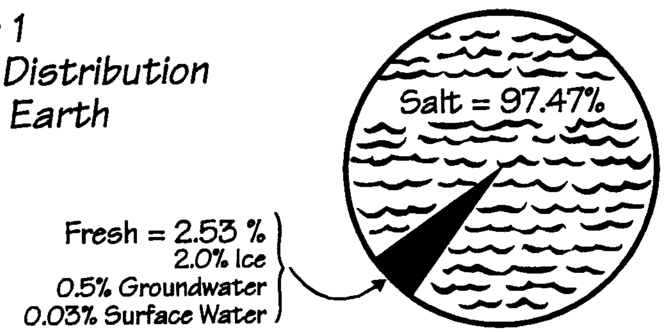
Industrial activity and unplanned urban development continue to damage and destroy wetlands. Logging and other industrial debris destroys plants. Removing the debris exposes the land and allows plants to grow again. This module provides information on cleanup methods, obtaining permits, finding funds, motivating volunteers, and disposing of debris.

SECTION IV

Watershed Ecology

Water covers three-quarters of the Earth's surface. However, only 2.5% is fresh water, and 0.03% surface water that people can use (Figure 1). Fresh water is an essential resource for all living things.

Figure: 1
Water Distribution on the Earth

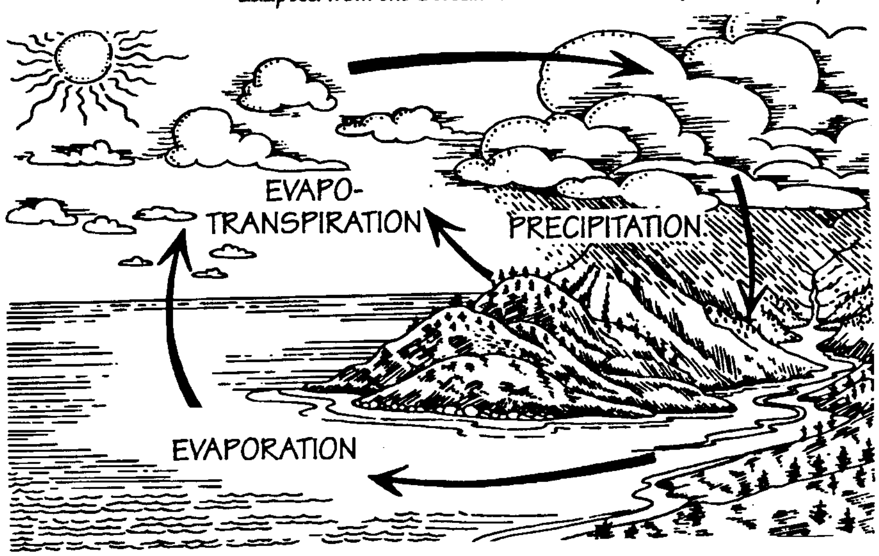


The Water Cycle

Water moves continuously from the air to the land and back again through the water cycle. Energy from the sun drives this cycle (Figure 2). Precipitation falls to earth, drains into streams, lakes, and rivers, and then enters the ocean. Water evaporates back into the air from the water and land. Plants add water vapour to the air through evapotranspiration. Water falls again as precipitation. In fact, water is cycled through the atmosphere every nine to twelve days! Human activities can disrupt this cycle of water transport and purification.

Figure 2 Water Cycle

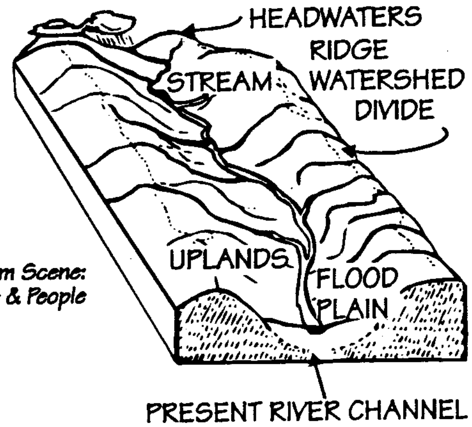
adapted from the Stream Scene: Watersheds, Wildlife & People



Watersheds

A watershed drains water into a stream, which drains into a larger stream, lake, or ocean (Figure 3). The boundaries of a watershed are the highest elevations of surrounding hills and ridges. Surface water occupies only a small portion of the total watershed area; most of the area is land.

Figure 3
The Watershed

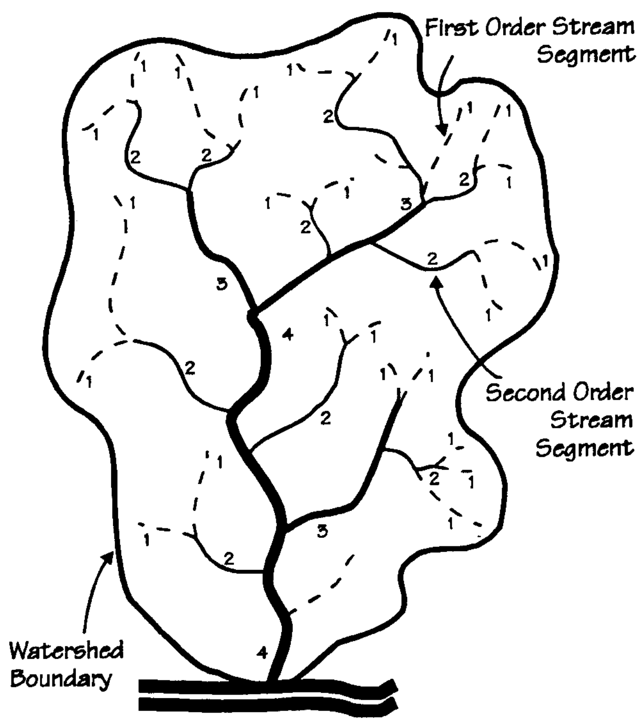


adapted from the Stream Scene: Watersheds, Wildlife & People

One method of describing the network of streams in a watershed is shown in Figure 4. First order streams are the headwater creeks with no tributaries. Second order streams form when two first order streams merge, and so on. Rivers often are sixth order or greater.

Figure 4
Stream Order

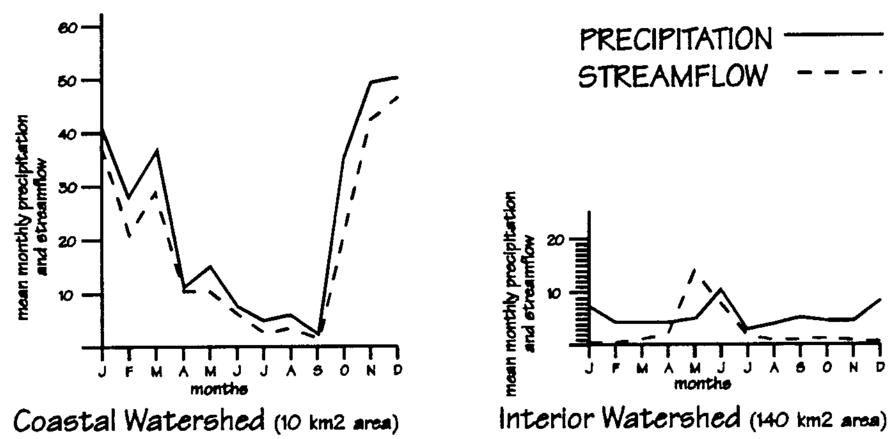
adapted from A Handbook for Fish Habitat Protection on Forest Lands in British Columbia



Streams are perennial (flow year round), intermittent (flow for less than half the year), or ephemeral (flow only during times of heavy rainfall). Ephemeral and intermittent streams provide seasonal habitat for fish and other wildlife, and areas of refuge during high flow in main channels.

Climate, topography, soil, and vegetation control the volume and rate of water flow through a watershed. Climate is the predominant factor that controls seasonal patterns and quantities of water flow in a watershed. The relationship between precipitation and stream flow in coastal and interior watersheds is very different (Figure 5). On the coast, stream flow increases dramatically after rainstorms. In the interior, winter precipitation is stored as snow, and stream flow is greatest when the snow melts during the spring. Generally, more precipitation falls in coastal watersheds, so more water is cycled through them than through interior watersheds.

Figure 5 Annual Streamflow Patterns



Watershed topography affects stream flow. Surrounding mountains modify climate, affecting amounts and types of precipitation in a watershed. Steep sided watersheds have more rapid runoff, greater erosion, and wider fluctuations in flow than watersheds with more gentle slopes. Orientation to the sun and prevailing winds also influences runoff patterns.

Soil structure and depth affect rates of runoff. Deep, porous soils absorb runoff well and release it slowly. Compacted or shallow soils absorb much less water, so rapid runoff and erosion are more likely to occur. Soils also influence basic water chemistry. Streams that pass through coastal forest soils have very different nutrient concentrations, pH levels, dissolved minerals, and natural turbidity than those flowing through arid mineral soils.

Vegetative cover greatly affects the volume and rate of water flow through a watershed. In a forested watershed, evapotranspiration returns great quantities of water to the air. When plant cover is removed, water flows more directly into streams. Vegetation enhances the soil's ability to absorb water by providing spongy humus and root systems that make the soil more porous. The forest canopy helps to break the force of falling raindrops and reduce the rate of snow melt. Removing watershed vegetation can result in major changes to both volume and rate of runoff.

The Stream in its Natural State

It is common to view streams only from the perspective of human use. However, streams unaltered by human activity have natural cycles and complex food webs.

In an undisturbed watershed, runoff is absorbed by plants and soil. Water is stored in the ground, lakes and ponds, then released slowly, even during dry spells. Stream flows fluctuate, but there are few extremes of flood and drought. Impurities and sediment are absorbed by the soil, purifying water before it enters streams.

Natural vegetation stabilizes stream banks. Plants provide shade, food (leaves, twigs, fallen insects), and cover for many animals. Logs fall into streams and provide diverse habitat. This large woody debris also dissipates a stream's erosive energy.

Sunlight filters through trees. Algae grow on streambeds. Bacteria and fungi partially decompose leaf litter and other organic matter. In streams, some invertebrates eat plant material, breaking it down into organic material for other species. Small predators, such as fish, birds, amphibians, and aquatic insects, feed on these invertebrates. Otters, mink, and large birds feed on the smaller predators.

Downstream of shaded headwater areas, streams widen and open to more sunlight. Species adapted to these changed conditions replace some upstream species. Further downstream, species suited to growth in major rivers become common.

Human activities can upset stream ecosystems. Some organisms can adapt, but others perish. Species tolerant of poor conditions tend to replace those that require good water quality.

Salmonid Ecology

Salmonids are good indicators of stream and watershed health. They are relatively easy to see, are adapted to particular habitats, and are important links in aquatic and terrestrial food webs. Salmonids need very high quality water to thrive.

Salmonids in British Columbia waters include:

salmon - chinook, coho, sockeye, chum, pink

trout - steelhead, rainbow, cutthroat, brown

char - dolly varden, lake trout, brook trout

grayling

whitefish

Sculpins, sticklebacks, squawfish, dace, shiners, sturgeon, and lampreys are some other kinds of fish found in British Columbia streams and rivers.

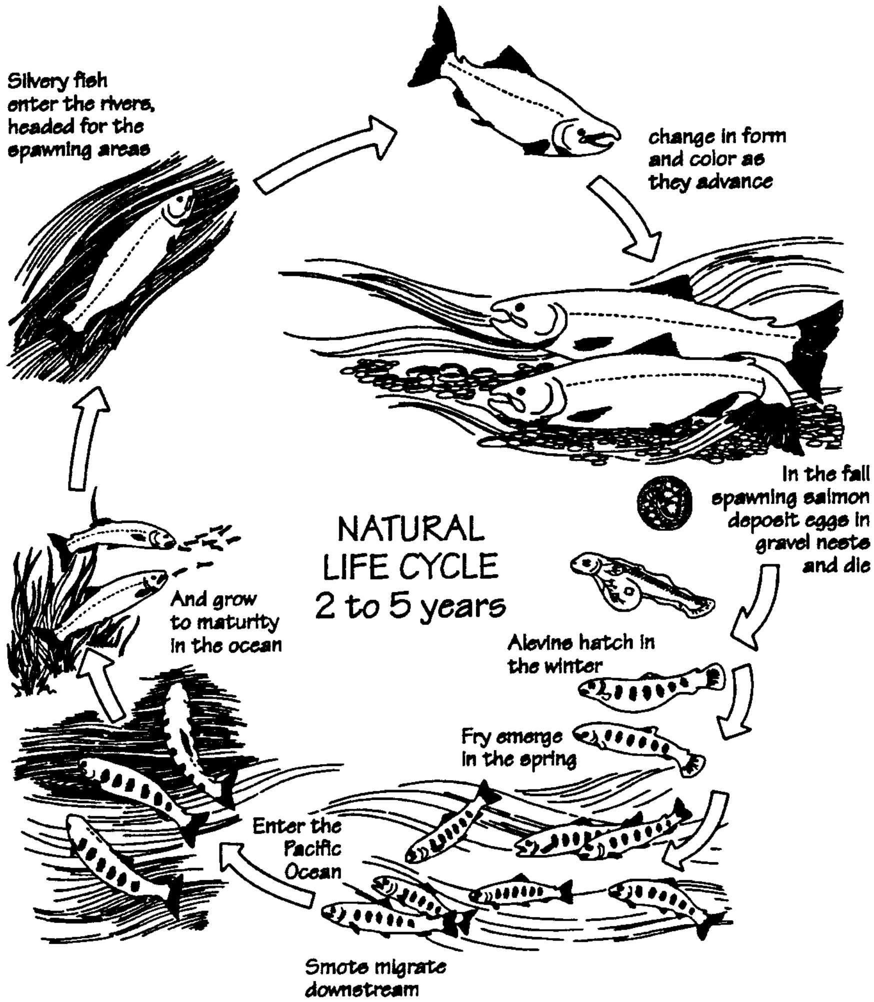
Salmon and some trout and char species spend part of their life in the ocean, but return to their natal stream or lake to spawn. The early phase of their life cycle is spent in streams and rivers.

A generalized salmon life cycle is shown in Figure 6. Each species has its own timetable for adult migration, spawning, egg development, juvenile rearing, and migration to the sea. This helps partition the environment, so that species that would otherwise have to compete for similar food and space resources can survive.

Salmonids require cool, well-oxygenated water, clean gravel, abundant cover, shade, and adequate stream flow. After spawning, the eggs and alevins (larvae) spend from two to nine months in the gravel, depending on the species and location. Eggs and alevins need clean water to supply oxygen and remove wastes, and die if gravel becomes clogged with sediment.

Fry require a good supply of aquatic insects, cool water temperatures, and good cover from predators. Removing streamside vegetation affects these types of stream habitat and food supply. Mortality rates can be high for smolts migrating to the sea if they face physical barriers, pollution problems, and lack of cover for protection from predators. When adults return to their streams to spawn, they need good water quality, adequate stream flow and clean gravel for spawning.

Projects to enhance fish habitat should meet the needs of specific streams and the species found there. In some streams, increasing spawning habitat is beneficial. In others, creating additional rearing habitat is more important. For streams suffering from pollution, improving water quality is an essential first step before considering any other enhancement options.



LENGTH OF LIFE CYCLE VARIES WITH SPECIES AND CONDITIONS

Human Impacts On Stream Ecosystems

Human activities often affect water quality negatively. Nonetheless, these impacts can be minimized by adopting management practices that protect aquatic environments. The reference section of this handbook lists several publications that provide habitat protection guidelines for several industries and activities. Some potentially disruptive human activities are described below.

Logging removes large amounts of plant cover, increasing the amount of runoff and sediment to streams. Although current regulations are designed to control logging activities in watersheds, logging has caused major problems in the past.

Agricultural activity often extends to stream banks. Removal of streamside vegetation causes water temperatures to increase during summer. When livestock have direct access to streams, erosion and runoff problems result. Also, runoff from agricultural land may contain fertilizers, manure, and pesticides.

Surface mining strips off surface soil and rock layers. Waste material is eroded and carried into streams. Tailings runoff can contain toxic materials from mineral processing.

Urban development involves clearing land, replacing natural landscapes with buildings, roads, parking lots, and storm drain systems. Runoff increases and groundwater storage decreases, resulting in wide fluctuations in stream flow. Also, urban runoff may contain toxic substances.

Point source pollution comes from specific locations, such as industrial or sewage outfalls. Although effluents can seriously degrade water quality, they are relatively easy to locate and control through legislation.

Non-point source pollution is diffuse and very hard to control, but is the major cause of degraded water quality in many communities. Pollutants come from various land uses throughout a watershed. Common pollutants include heavy metals and hydrocarbons from road runoff, contaminants from household compounds, sediment, and animal wastes.

Acid rain is not yet a serious problem in British Columbia. However, as air pollution from automobiles and industries increases, acid rain may become more common.

Dams, dikes, levees and engineered stream channels can seriously affect stream flow patterns, channel morphology, and water quality.

Minimizing Human Impacts

Maintaining healthy, productive watersheds is possible. We can begin by adopting land use practices that reduce disruption of the environment. Regulations already exist to govern point source pollutants and reduce the negative impacts of large scale developments. Non-point sources of pollution are more difficult to identify and control but must be dealt with to improve the conditions in many watersheds.

We as individuals must each start accepting responsibility for our own land use practices, whether we live on a farm or a city lot. Some useful hints are provided in Appendix 4: Home Tips for Clean Streams.

SECTION V
Streamkeepers and Government

Many government agencies are responsible for regulating land and water use. One of their aims is to reduce harmful impacts on the environment. You can ensure that your concerns are addressed by participating in resource decisions in your community. It helps to have a basic understanding of:

- the government agencies involved
- how decisions are made in your community
- where and how you can participate in the decision-making process
- information needed when you have concerns about your watershed
- how to best express your concerns

Who Manages Our Land?

More than 90% of British Columbia's 93 million hectares are classified as provincial Crown land. Land and water use on this land is regulated by provincial agencies. Much of the remaining 10% is privately owned and within municipal boundaries. Some landowners believe they have the right to develop their land any way they wish. However, municipalities can enact bylaws to regulate development. These bylaws can ensure the protection of a community's environmental assets.

How Decisions Are Made

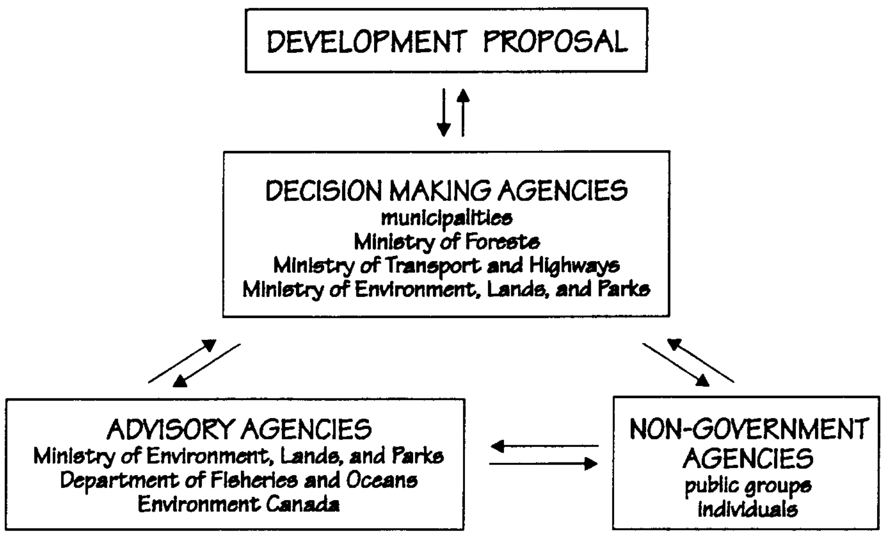
Canada's Constitution gives authority to the provinces for land and water management. Provincial and municipal agencies regulate the use of these resources. Federal agencies provide guidelines to ensure that developments comply with federal environmental protection laws. Table 1 lists the different agencies responsible for managing natural resources. The referral process shown in Figure 7 ensures that the concerns of the various agencies are considered in each development proposal.

TABLE 1
Watershed Activities and Responsible Government Agencies

Activity	Local Government	Provincial Government Ministry	Federal Government Department
Fisheries Management		WLAP Fisheries Branch (freshwater fish)	Fisheries & Oceans (marine and anadromous fish)
Wildlife Management		WLAP (Wildlife)	Environment (Conservation)
Forestry (timber harvest)	Planning (urban)	Forests (Crown land)	
Gravel Pits, Mines	Engineering & Operations	Energy, Mines & Petroleum	Energy, Mines, & Resources
Land Development	Planning	WLAP (Lands, Environmental Assessment)	
Roads	Engineering & Operations	Transport & Highways	
Agriculture		Agriculture, Fisheries & Food	Agriculture
Aquaculture		Agriculture, Fisheries & Food	Fisheries & Oceans
Environmental Emergencies, Spills	Fire Dept.	WLAP (ORR, Conservation Officers)	Environment (Protection), Fisheries & Oceans (Fisheries Officers)
Enforcement of Environmental Laws	Bylaw enforcement	WLAP (Conservation Officers)	Environment (Protection), Fisheries & Oceans (Fisheries Officers)
Sewage Disposal	Engineering & Operations	WLAP (Waste Management)	Environment (Protection)
Waste Disposal, Waste Discharge To Water	Engineering & Operations	WLAP (Waste Management)	Environment (Protection)
Flood Control	Engineering & Operations	WLAP (Water Management)	Environment (Conservation)
Water Use, Supply, Drinking Water	Public Health	WLAP (Water Management) Health	
Streamside Zoning and Adjacent Land Use	Planning	Forests (Crown land)	Fisheries & Oceans
Water Quality	Engineering & Operations	WLAP (Waste Management, Water Management)	Fisheries & Oceans, Environment

CHECK THE BLUE PAGES OF YOUR TELEPHONE BOOK FOR LOCAL NUMBERS

Figure 7 An Example of the Referral System



The federal Fisheries Act is one of the most powerful pieces of legislation designed to protect aquatic habitats. Section 35 of the Act prohibits any work or undertaking that may result in the harmful alteration, disruption, or destruction of fish habitat. Section 36 prohibits the deposition of deleterious substances into waters frequented by fish. However, the Act does not state how land and water should be used, and often can be applied only after habitat damage has occurred. The Act has limited power to prevent poor land and water use practices.

Environmental agencies have developed site-specific guidelines for avoiding habitat damage. These guidelines are more detailed than the broad provisions of the Fisheries Act. However, these guidelines are only recommendations and do not have the force of law behind them.

Some Acts and Guidelines to Protect Aquatic Habitats

- Fisheries Act
- Water Act
- Land Development Guidelines
- Stream Stewardship: A Guide for Planners and Developers
- British Columbia Coastal Fisheries/Forestry Guidelines
- Forest Renewal Act
- Forest Practices Code

Some municipalities have adopted as law the habitat protection guidelines provided by federal and provincial agencies. We all have the greatest opportunity to influence land use decisions at the local level.

How and Where You Can Participate

Officials are elected to govern and make decisions according to our needs and desires. Local, provincial, and federal governments rely more on public participation now than in the past. However, we need to make our opinions known, if we want our elected representatives to make wise land use decisions.

There are many opportunities to participate in local land use planning. The publication, Stream Stewardship: A Guide for Planners and Developers, provides information about how municipal land use decisions are made. Municipal Official Community Plans (OCPs) are reviewed about every five to seven years. Zoning applications must be publicized. Town Hall meetings and local environmental advisory councils invite public participation. Municipal planning staff and elected officials may respond to the concerns of Streamkeepers groups if they are brought to their attention.

All levels of government hold public meetings to survey public opinion on environmental issues. At these forums, you can present information your Streamkeepers group has collected about your watershed.

Information Needed

Several Streamkeepers project modules provide information about collecting data on stream conditions. Your data will help show your concerns are valid when you approach government agencies about protecting or improving habitats.

Effective Communication

Public education and cooperation with government agencies will help change attitudes toward aquatic habitats. An enthusiastic, well-informed spokesperson in your group can best get your message across. You may wish to consider public meetings and other ways of raising awareness.

APPENDIX 1: REFERENCES AND RESOURCES

Adopt-A-Stream Foundation. 1994. *Streamkeepers' Field Guide: Watershed Inventory and Stream Monitoring Methods. Available from:*

Adopt-A-Stream Foundation,
P.O. Box 5558,
Everett, Washington, 98206

Alaska Dept. Environmental Conservation. 1993. *Alaska Water Watch, Partners in Environmental Stewardship.* Handbooks available include:

Water Quality Sampling - Streams
Alaska Stream Survey
Stream Macroinvertebrates

Available from:

Alaska Department of Environmental Conservation,
Division of Environmental Quality,
Water Quality Management Section,
410 Willoughby Ave.,
Juneau, Alaska, 99801-1795

Anon. 1993. *British Columbia Coastal Fisheries/Forestry Guidelines.* Third Edition. a joint publication of B. C. Ministry of Forests, Ministry of Environment, Lands, & Parks, Department of Fisheries and Oceans, and Council of Forest Industries. Crown Publications Inc., Victoria, B.C.

Anon 1994. *Stream Stewardship, a Guide for Planners and Developers.* Co-published by Dept. Of Fisheries and Oceans, Ministry of Water, Land and Air Protection, and Ministry of Municipal Affairs. 48 pp.

Anon 1995. *Community Stewardship: A Guide to Establishing your Own Group.* Co-published by Fraser Basin Management Program, Dept. Of Fisheries and Oceans, Environment Canada, and the Watershed Stewardship Working Group of Forest Renewal B.C.

Bologna, D. M. 1994. *How to Save a River: A Handbook for Citizen Action.* Island Press, Washington, D. C. 266 pp.

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Friends of Environmental Education Society of Alberta. 1990. *Adopt-A-Stream*. Available from:

FEESA,
320-9939 Jasper Ave.,
Edmonton, AB.,
T5J 2X5

Hoenig, E. and J. Carr. 1990. *Stream Team: A Volunteers Handbook.* (Olympia, Lacey, Tumwater, and Thurston County).
Available from:

City of Olympia, Public Works Dept.,
Water Resources Program,
P.O. Box 1967,
Olympia, Washington, 98507-1967

Hubbard-Gray, S. and S. Tilander. 1989. *Stream Team Guidebook.* City of Bellevue Storm and Surface Water Utility. Bellevue, Washington.

Mitchell, M.K. and W.B. Stapp. 1991. *Field Manual for Water Quality Monitoring; An Environmental Education Program for Schools.* Available from:

W.B. Stapp,
2050 Delaware Ave.,
Ann Arbour, Michigan, 48103

McClarin, M. And K. Fulton. 1995. *Water Stewardship: A Guide for Teachers, Students, and Community Groups.* Ministry of Water, Land and Air Protection, Victoria, 194 pp.

Oregon Dept. Fish and Wildlife. 1990. The Stream Scene: Watershed, Wildlife and People. Available from:

Oregon Dept. Fish and Wildlife,
P.O Box 59,
Portland Oregon, 97207

Resource Inventory Committee, B.C. Several publications are available or in press. Some of them discuss biodiversity and provide identification keys for many groups of terrestrial and aquatic species. Others describe survey techniques. Some titles are available in 1995 and others will be published in 1996. They are available from:

Resource Inventory Committee
840 Cormorant St.,
Victoria, B.C.
(telephone: 1-250-920-0661)

AQUATIC ECOSYSTEMS:
Aquatic Habitat Classification System for B.C.
Collecting and Preserving Aquatic Plants
Field Key to Freshwater Fishes of B.C.
Fish Collection, Preservation, Measurement and Enumeration Manual
Guide for Selection of Standard Methods for Quantifying Sportsfish Habitat Capability and Sustainability in Streams and Lakes in B.C.
Identification Keys to the Aquatic Plants of B.C.
Lake Survey Procedures Manual
Physical/Hydrological Classification of Watersheds
Reconnaissance Stream Inventory Manual
Review of Habitat Capacity for Spawning Salmon and Rearing

ELEMENTS OF BIODIVERSITY
A Key to Small Mammals in B.C.
Amphibians in B.C.
Bats
Beaver and Muskrat
Bitterns and Rails
Capturing and Handling Protocol
Fast-streamed Amphibians (Tailed Frogs and Giant Pacific Salamanders
Forest and Grassland Songbirds
Freshwater - Colonial Nesters
Fungi
Geese, Ducks, and Sandhill Cranes (Waterfowl)
Hares and Cottontails
Large Mammals: Aerial Inventory Methods
Large Territorial Carnivores (Bears, Wolves, and Cougars)
Lizards and Skinks
Medium Territorial Carnivores
Moles and Pocket Gophers
Nighthawks and Poorwills
Pikas and Sciurids (Squirrels)
Pond-dwelling Herpetiles, Amphibians, and Painted Turtles
Raptors
Riverine Birds (Dippers and Harlequins)
River Otter and Mink
Slow-stream Amphibians (Northwest and Long-toed Salamander)
Small Mammals
Small Mustelids
Small Territorial Carnivores
Snakes
Swallows and Swifts
Terrestrial Amphibians
Terrestrial Arthropods
Ungulates: Ground-based Census Method
Upland Gamebirds
Vascular and Non-vascular Plants
Woodpeckers and Sapsuckers
Woodrat, Porcupine and Mountain Beaver

ECOLOGY
Ecoregion Mapping and Methodology
Range Interpretations
From Ecosystem Mapping
Soil Inventory Methods for B.C.
Terrestrial Ecosystems Mapping Methodology for B.C.
Terrestrial Vertebrate Capability And Sustainability Mapping Methodology

GROUNDWATER
Groundwater Mapping and Assessment in B.C.

VEGETATION
Procedures and Standards for Vegetation Classification
Procedures and Standards for Vegetation Sampling
Proposed Land Cover Classification Scheme

S.E.P. Community Projects Directory. Salmonid Enhancement Program, Department of Fisheries and Oceans, Vancouver, B.C. (published annually).

T. Buck Suzuki Environmental Foundation. 1994. *Resource Manual for Salmon Habitat Protection Activities.* Vancouver, B.C. 160 pp.

Toews, D. A. A. and M. J. Brownlee. 1981. *A Handbook for Fish Habitat Protection on Forest Lands in British Columbia.* Department of Fisheries and Oceans, Vancouver, B.C.

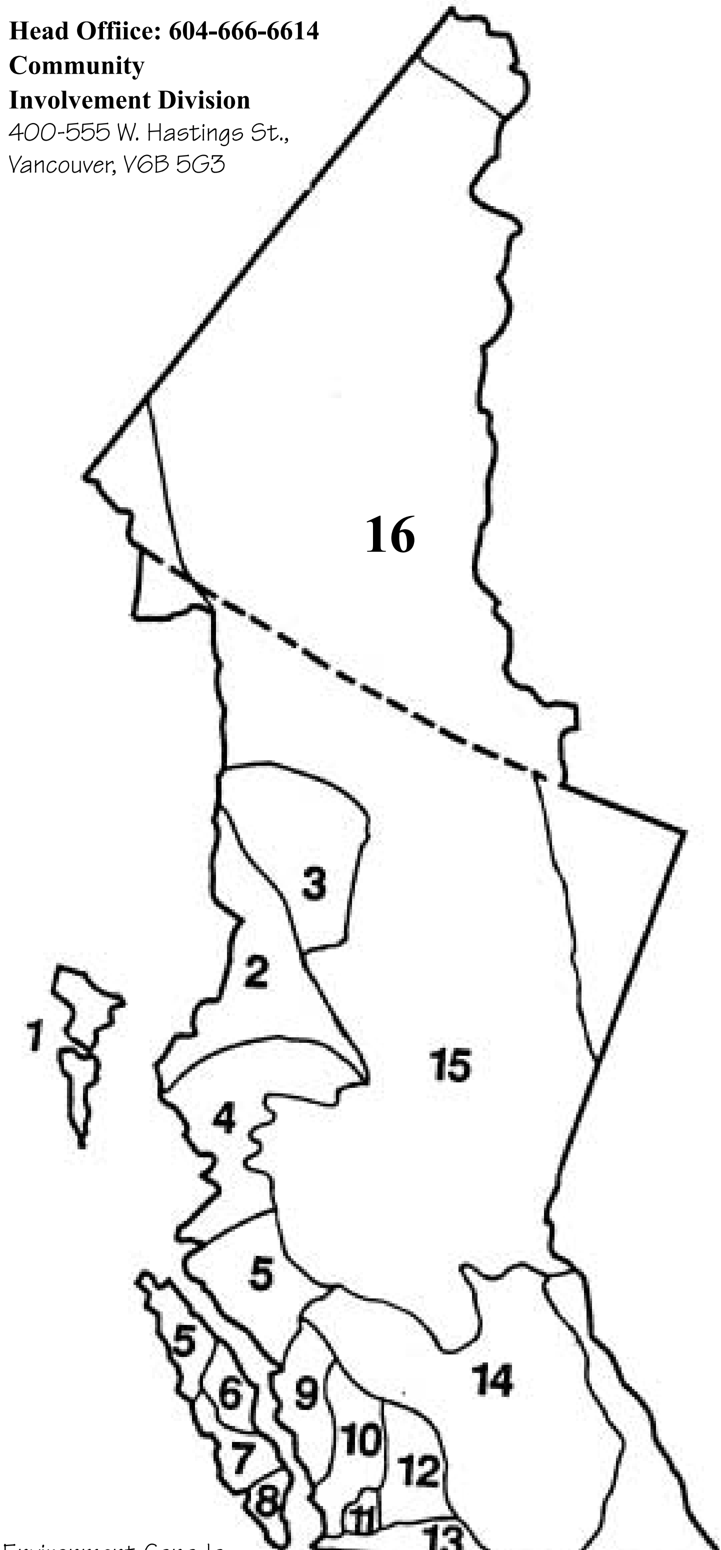
U.S. Environmental Protection Agency. 1992. *Streamwalk Manual.* Available from:
Water Division,
EPA Region 10,
1200 Sixth Ave.,
Seattle, Washington, 98101

Yates, S. 1988. *Adopting a Stream, a Northwest Handbook.* University of Washington Press, Seattle, Washington.

Yates, S. 1989. *Adopting a Wetland, a Northwest Guide.* Snohomish County Planning and Community Development.

APPENDIX 2: Salmonid Enhancement Program Community Advisors

Head Offiice: 604-666-6614
Community
Involvement Division
400-555 W. Hastings St.,
Vancouver, V6B 5G3



Environment Canada
Emergency Reports, Oil & Chemical Spills.............1-800-663-3456
ORR Ministry of Environment, Lands, & Parks.....1-800-663-9453
ORR Department of Fisheries and Oceans 1-800-465-4336

MAP AREA		TELEPHONE
1	**Queen Charlotte Islands** Box 208, Queen Charlotte City, V0T 1S0	**250-559-0039**
2	**Northern Interior and Northern Coast** 100-3219 Eby St., Terrace, V8G 4R3	**250-615-5353**
3	**Smithers and Area** Box 578,. Smithers, V0J 2N0	**250-847-5298**
4	**Central Coast** Box 340, Hagensborg, V0T 1H0	**250-982-2663**
5	**Northern Vancouver Island** Box 10, Port Hardy, V0N 2P0	**250-949-1558**
6a	**Vancouver Island, Cambell River** Quinsam Hatchery 4217 Argonaut Road, Campbell River, BC V9H 1B3	**250-287-9564**
6b	**Central Vancouver Island, East** 148 Port Augusta St., Comox, V9N 7Z4	**250-339-0431**
6c	**Central Vancouver Island, West** 3225 Stephenson Pt. Rd., Nanaimo, V9T 1K3	**250-245-7780**
7	**Robertson Creek Hatchery** Box 1100, Port Alberni, V9Y 7L9	**604-724-6521**
8	**Lower Vancouver Island** Box 241-5653 Club Road, Duncan V9L 3X3	**250-746-5137**
9	**Sunshine Coast, Howe Sound** Box 10, Madiera Park, V0N 2H0	**604-883-2613**
10	**West Vancouver, Howe Sound** P.O. Box 2360 1120 Hunter Place Squamish, B.C. V0N 3G0	**604-892-6395**
11	**Burrard Inlet, Indian Arm** Unit 3, 100 Annacis Parkway, Delta V3M 6A2	**604-666-0743**
12	**North of the Fraser to Boston Bar** Unit 3, 100 Annacis Parkway, Delta V3M 6A2	**604-666-2870**
13	**South of the Fraser to Boston Bar** Unit 3, 100 Annacis Parkway, Delta V3M 6A2	**604-666-0742**
13b	**Eastern Fraser Valley Mission/Abbotsford** 201-32335 Fletcher Avenue, Mission, V2V 4N3	**604-814-1076**
14	**Central Interior, South** 1278 Dalhousie Dr., Kamloops, V2C 6G3	**250-851-4954**
15	**Central Interior, Prince George** **Central Interior, Williams Lake** 3690 Massey Drive, Prince George, V2N 2S8	**250-561-5533** **250-398-6544**
16	**Yukon** 100-419 Range Road, Whitehorse, Yukon	**867-393-6721**

APPENDIX 3. GLOSSARY

acid: substance with pH less than 7.0; acidity is caused by high concentrations of hydrogen ions

acid rain: rainwater carrying acidic atmospheric pollutants (nitrous or sulfuric oxides)

alevin: newly hatched fish with yolk sac attached, larva

alkaline: substance with pH greater than 7.0; alkalinity is caused by high concentrations of hydroxyl ions; basic

anadromous fish: fish that migrate from salt water to fresh water for spawning

aquatic: refers to water

aquatic insect: insect species whose larval stages live in water

basic: alkaline

benthic: refers to the bottom of a body of water

benthic macroinvertebrates: spineless animals that inhabit the bottom of streams and lakes; visible to the eye; aquatic worms, snails, clams, immature stages of aquatic insects

biochemical oxygen demand (BOD): the amount of oxygen used up in biological decomposition and chemical oxidation of sediment, water, or effluent

boulders: rocks larger than 30 cm (12 inches) in diameter

canopy: upper layer formed by trees

carrying capacity: number of organisms a habitat can support throughout a year without damaging organisms or habitat

coarse particulate organic matter (CPOM): leaf and fine woody debris >1 mm in diameter

cobble: rock from 7 to 30 cm (3 to 12 inches) in diameter; rubble

collectors: aquatic invertebrates that feed on fine material

community: the plants and animals that interact in a habitat; the community of people who influence a habitat

coniferous: cone-bearing trees with needles

consumers: organisms that depend on other organisms for their food

cover: vegetation or other features that provide shelter for wildlife

deciduous: trees that shed their leaves in fall

decomposition: breakdown of organic materials

deposition: depositing of material by a stream, generally at points of reduced stream flow

discharge: the amount of water flowing past a given point on a stream; measured in cubic feet or cubic metres per second

dissolved oxygen: oxygen dissolved in water; the amount depends on water temperature, plant photosynthesis, plant and animal respiration, and physical aeration

dissolved solids: solid (generally inorganic) material in solution

diversity: number of species in a particular community or habitat

drainage basin: watershed

ecosystem: the organisms, physical environment, and climate in a given area

effluent: waste liquid from a house, industry, sewage treatment plant, etc.

engulfers: predators that eat their prey whole

ephemeral streams: ones that flow only during and shortly after extreme rainfall or snowmelt

erosion: movement of soil by water and wind

evaporation: conversion of water from liquid to vapour

evapotranspiration: water lost from plants through evaporation and photosynthesis

filtering collectors: aquatic invertebrates that feed by filtering small organic particles from the water

fine particulate organic matter (FPOM): organic material <1 mm in diameter

first-order stream: stream with no tributaries

fish ladder: a stepped fishway with water flowing over it

flood: stream flow greater than the channel can contain

floodplain: area along a stream or river subject to flooding; often the location of human development

freshet: a sharp rise in discharge or a flood event associated with rainfall or snow melt

fry: recently emerged fish, after the yolk sac has been absorbed

functional feeding groups: classification of aquatic invertebrates by their feeding method

gathering collectors: aquatic invertebrates that feed on particles on the bottom of a stream

gradient: degree of slope, or steepness of a geographic feature

gravel: rock 0.5 to 7 cm (0.2 to 3 inches) in diameter

ground water: water that sinks into the soil and collects over impermeable rock; it then flows laterally toward a stream, lake or ocean.

habitat: an area that provides food, water, and shelter for an organism

headwaters: unbranched tributaries of a stream

herbaceous: plants with soft rather than woody stems

humus: decayed organic matter in or on the soil

infiltration: drainage of water through soil

intermittent stream : one that does not flow year-round

invertebrate: an animal without a back bone

ion: an electrically charged atom or molecule

larva: immature stage in a life cycle between egg and adult

limiting factors: conditions that establish a population or range of a species

mg/l: milligrams of a substance per litter of water, parts per million (ppm)

midreaches: streams carrying the water from several tributaries

milt: sperm-filled milky substance released by male fish to fertilize eggs

monitor: track a characteristic over time, using uniform methods to evaluate change

non-point source pollution: pollutants that enter waterways from broad land areas as a result of the way the land is used (e.g. sedimentation, runoff)

nymph: immature form of insects such as stoneflies and mayflies that do not pupate

perennial streams: ones that flow throughout the year

periphyton: algae growing on surfaces in a stream, lake, or ocean

pH: measure of the hydrogen ion activity; measures the acidity or alkalinity of a solution: the pH scale ranges from 1 (strong acid) to 14 (strong base), with 7.0 as neutral

piercers: predators that feed by sucking fluids out of their prey

plankton: microscopic plants and animals suspended in the water

point source pollution: air or water pollutants entering the environment from a specific source

pool: deeper and slower flowing water in a stream or river

population: group of individuals of a specific kind, in a given area, at a given time

ppm: parts per million or milligrams per litre (mg/l)

precipitation: rain, snow, hail, or sleet falling to the ground

predator: an animal that hunts and kills other animals for food

primary production: organic material produced by plants from inorganic material and sunlight

producers: plants that manufacture food from inorganic nutrients

pupa: stage of a life cycle between larva and adult

reach: a stream section with fairly homogenous characteristics

rearing habitat: places in a stream that provide food, resting places, and shelter for young fish

redd: a nest in the streambed in which salmon and trout lay their eggs; the eggs incubate, then hatch in the gravel

riffle: relatively fast flowing, shallow water in a stream

riparian area: the border of the stream above its banks; wet soil areas influenced by the water of a stream, lake, or wetland

riparian area of influence: transition area between riparian area and upland vegetation

riprap: rock covering used to protect stream banks from erosion

river continuum: a conceptual model explaining changes in composition of aquatic invertebrate communities in streams and rivers

run: a part of the stream with smooth, slow to moderate flow, deeper than a riffle

salmonid: a fish of the Salmonidae family (salmon, trout, char)

scrapers: aquatic invertebrates that feed by scraping the surface of rocks for algae

secondary production: material that is transformed by consumers (eaten or decomposed)

shredders: aquatic invertebrates that feed on leaves or twigs that fall into a stream

silt: tiny, fine particles suspended in or deposited by water

siltation: the process of becoming clogged by fine sediments

smolt: a juvenile anadromous fish that has undergone physical changes to prepare for life in saltwater

spawning: laying and fertilizing eggs

spawning habitat: parts of a stream or lake that provide suitable areas for fish to spawn; usually gravel beds

streambed: part of the stream over which water moves; substrate

stream order: a system used to classify (and analyze) streams

stream flow: volume of water carried by a stream

substrate: inorganic material that forms the streambed

suspended sediments: particles carried in water without being dissolved

terrestrial: living on land

turbidity: degree to which light penetration is blocked because water is cloudy; measure of sediment suspended in water

water table: upper level at which the soil is saturated with water

watershed: all the land area that drains into a particular body of water

wildlife: any animal that is not tamed or domesticated

APPENDIX 4. HOME TIPS FOR CLEAN STREAMS

RECIPES FOR CLEANER WATER: Outdoor Alternatives

Information supplied by the King County Surface Water Management and Washington State Department of Ecology.

Pesticides

For ants:
Kill ants in the house with soapy water. Sprinkle boric acid on trails and where ants are found in nooks and crannies. Keep boric acid out of the reach of children and pets.

For caterpillars:
Apply Bacillus thuringensis (Bt) bacteria to them during warm weather when they are small, or gently sponge or mist/spray leaves with soapy water.

For insects on plants:
Spray infested leaves with a solution of 10 ml liquid soap in 1 litre (2.5 teaspoons in 1 quart) of water. After a few minutes rinse off with water.
Soak a large handful of pipe or cigarette tobacco in 5 litres (1 gallon) of water for 24 hours. Dilute with water to the color of weak tea and apply with spray bottle. Use caution when handling.

Fertilizers
Ingredients for organic fertilizers:
- cottonseed meal: ....supplies nitrogen
- bone meal: ....supplies calcium, phosphorus
- dolomite: ....supplies potassium, calcium
- greensand: ....supplies potassium
- blood meal: ....potent source of nitrogen
- fish meal: ......supplies nitrogen, trace minerals
- kelp meal: ..supplies trace minerals, potassium
- chicken/steer manure/guano:

  supplies nitrogen, organic matter

Paint Strippers
Use safe commercial strippers with a "Caution" advisory on the label. Some old paints contain lead. Use precautions against breathing dust and dispose of paint scrapings in the trash.

Automotive Antifreeze
Buy propylene glycol-based antifreeze, it is significantly less toxic than ethylene glycol-based.

Degreaser (Automotive)
Use a water-based cleaner such as Simple Green, or citrus-based products with "Non-toxic", "Biodegradable", and "Non-flammable" on the label.
For grease spots on the garage floor, sprinkle kitty litter or cornmeal on the spot; sweep up after several hours and dispose in the garbage.

Car Cleaner and Polish

For car wash:
Use 30 ml (2 tablespoons) mild dish detergent or 250 ml (1 cup) soap flakes in 9 litres (2 gallons) of warm water.

For cleaning chrome:
Apply a paste of baking soda and water to the chrome with a sponge; let it set for a few minutes, then rinse and wipe dry with a soft cloth. Rub chrome with newspaper to make it shine brightly.

Glass Cleaner
- 250 ml vinegar (1 cup)
- 2 litres warm water (2 quarts)

Do not use this as a windshield wiper solution as it may damage the pump; use plain water for this purpose.

RECIPES FOR CLEANER WATER: Indoor Alternatives

All-purpose Household Cleanser
Recipe #1
- 1 litre warm water (1 quart)
- 5 ml liquid soap (1 teaspoon)
- 5 ml borax (1 teaspoon)
- 15 ml vinegar or lemon juice (1 tablespoon)

Recipe #2
- 2 litre water (2 quarts)
- 125 ml household ammonia (half cup)
- 125 ml white vinegar (half cup)
- 50 ml baking soda (quarter cup)

These cleansers will work on anything from countertops and wall to floors and carpets.

Furniture Polish
- 0.5 litre mineral oil (2 cups) with
- a few drops lemon juice

Degreaser (kitchen)
- 30 ml TSP (2 tablespoons)
- 4.5 litres hot water (1 gallon)

Or use nonchlorinated scouring powder (e.g. Bon Ami) with an abrasive scouring pad or fine steel wool.

Degreaser (kitchen)
30 ml TSP (2 Tablespoons)
4.5 litres hot water (1 gallon)

Or use nonchlorinated scouring powder (e.g. Bon Ami) with an abrasive scouring pad or fine steel wool.

Drain Cleaner

Pour 125 ml of baking soda (half cup), then 125 ml vinegar (half cup) down the drain, cover and let sit for 15 minutes, then rinse with 2 litres (2 quarts) boiling water. For a bad clog, remove the trap and clean out the obstruction with a plunger or a plumber's snake. Treating drains once a week with the recipe above prevents problems and keeps your drains smelling fresh.

Disinfectant/Mildew Cleaner
125 ml borax (half cup)
5 litres hot water (1 gallon)

To inhibit mold and mildew, do not rinse off borax solution.

Oven Cleaner
30 ml borax, baking soda or TSP (2 tbsps)
5 litres hot water (1 gallon)

Wear gloves and scrub with very fine steel wool (0000). For baked on spots, try scrubbing with pumice (available at hardware stores). As a last resort, use an aerosol cleaner that says, "No caustic fumes".

Laundry Bleach

125 ml of borax (half cup) per load of laundry will whiten and remove spots. If you must use a bleach, use an oxygen bleach like sodium perborate instead of chlorine bleach.

Laundry Detergent

Use soap flakes with 125 ml added borax (half cup).

Spot Removers

All-purpose:
125 ml borax (quarter cup)
1 litre cold water (2 cups)
Soak the stain before washing as usual.

Blood: Before rinsing with water, pour 3% hydrogen peroxide directly on the stain, then wash as usual.

Ink: Apply a paste of lemon juice and cream of tartar; allow it to dry, then wash as usual.

Household Products Hazardous to Stream Life:

Information supplied by the B.C. Ministry of Environment, Lands and Parks

Automotive Products
Motor oil
Antifreeze
Brake fluid
Carburetor cleaner
Gasoline
Gasoline additives
Transmission fluid
Degreasers
Sealers

Paint and Solvents
Paints
Rustproof coating
Shellacs
Paint thinners
Lacquers
Paint and varnish strippers
Varnishes
Enamels

Recreational Products
Swimming pool contents (chlorine)
Outboard motor products (gas, oil, etc.)

Pesticides
Disinfectants (bathroom, kitchen, etc.)
Insecticides (garden products, flea collars, etc.)
Fungicides (mold and mildew control)
Herbicides (weed killers)
Molluscides (slug baits)
Wood preservatives (creosote, pentachlorophenal)

Cleaning Products
Detergents
Drain and toilet cleaners
Rug and upholstery cleaners
Leather preservers
Dry cleaning agents
Car wash detergent
Shoe polish.

From Home Tips for Clean Streams, Fisheries and Oceans Canada, Habitat Management

Lawn and Garden Tips

Pesticides and weed killers create problems when they enter lake and streams. Some chemicals may stay active for a long time and accumulate in the environment. Others can kill desirable insects, animals and plants as well as pests. Fertilizers, chemical and organic, can cause excess weed and algae growth when they enter water reducing available oxygen for other forms of aquatic life. This excess growth not only looks and smells bad, but it can eliminate fish populations. Following these tips will not only be good for the environment, it's good for your pocketbook, too!

Encourage bug-eating birds & friendly insects

Attract birds with tree cover, food during the winter, and protection from cats. Spiders, ladybugs and lacewings all eat pest insects. Recognize and respect these useful insects.

Care for your plants

Healthy plants, properly cared for, are more resistant to pests and require fewer chemical "medicines".

Read and follow pesticide and herbicide directions

Applying more chemicals than directed may do more harm than good. Never spray near ditches, lakes, or streams. Spray on windless days when it is not too hot. Avoid spraying before or during rain.

Time chemical applications properly

Spray only when you will actually see the pest or disease and then spray only when the chemical will be most effective.

Water your treated lawn or garden carefully

Sprinkling too heavily will wash chemicals off and into drain tiles that lead to ditches and storm sewers, and eventually to aquatic environments.

Dispose of lawn and garden chemicals carefully

Follow instructions on the container. Never dump chemicals into ditches, down drains, into the gutter or near water. They can interfere with the workings of sewer treatment plants and septic tanks, or cause fish kills. If you have unused pesticides, please contact the nearest B.C. Ministry of Water, Land and Air Protection office (Waste Management Branch) for instructions on proper disposal.

Sidewalk and Drive Tips

Streets and driveways are sources of water pollution. Oil leaks from cars can contribute large volumes of oil pollutants. Antifreeze is highly toxic. Contaminants from car exhausts can wash off roads and into streams.

Recycle your used crankcase oil

Take it to the nearest gas station that has recycling capabilities. Companies pick up the used oil from these stations and recycle it as motor oil and home fuel oil.

Fix that leaky crankcase or transmission

If repair is not possible, put a tray under the car and recycle the oil that is collected.

Sweep your walks and driveways

Hosing and rainfall wash litter and dirt from the sidewalks and driveways into your streams; sweeping them is better.

Keep your exhaust clean

Tune-ups and anti-pollution devices reduce the fallout from your exhaust which is picked up by runoff on streets and parking lots.

De-ice with sand and cinders

Runoff carries salt and chemical de-icers into streams and rivers. Grit is safer, but remember to sweep it up before the next rainstorm or it may clog drains.

Keep suds out of gutters

Use low-phosphate soaps when you wash your car. Do not dump leftover detergents or cleaning compounds into local waterways or storm drains. Dry car wash products are available now.

Watch your construction projects

When pouring concrete, keep wet concrete away from fish bearing waters. It is very toxic.

Tips for Controlling Animal Wastes

Keep your animal wastes at home

No one appreciates other people's animal wastes in their yards, parks or streams. Wastes left on sidewalks or in gutters are flushed directly into your streams and lakes by runoff. Before having a large concentration of animals on your property, ensure that you have developed a program to keep their wastes out of nearby streams.

Lot Coverage Tips

Building homes, roads and commercial properties removes vegetation and results in extensive paved areas. The average city lot has 50 to 75 percent of its surface covered. The trend towards townhouse and condominium developments results in even greater lot coverage and less vegetation. Sealing the ground with concrete and asphalt is the major cause of increased amounts and greater force of runoff. As more land is paved, less rain can infiltrate the soil to recharge groundwater supplies. Infiltration through the ground cleans water and provides underground water to keep streams flowing during the summer. The result of increased paving is often increased flow in the summer

Plant another tree

Trees and shrubs capture and hold a lot of rain before it reaches the ground. Their roots hold water in the ground. Whenever possible, keep existing trees and bushes growing and try to plant more.

Recharge groundwater supplies

Redirect your roof down spouts away from the drain tiles, street and storm sewers, French drains (gravel-filled trenches), abandoned septic drain fields and cisterns all hold and slowly release water to the ground. Check with your local municipality.

Avoid landscaping plastic

Large plastic sheets used to prevent erosion and weed growth create as much runoff as paved streets. Landscape cloth is a good alternative that allows water to penetrate to the soil. Use burlap on hillsides and perforated plastic sheets on level areas to let water penetrate.

Limit use of bark mulch

Bark mulch creates toxic leachate that may enter water courses. Limit use of bark mulch to areas that do not drain directly into storm sewers or open water.

Avoid paving your lot

Leave as much of your lot as you can in grass and trees. Consider using the new porous asphalt or paving bricks for your driveway. Water seeps through them.

Tips for your Swimming Pool

Keep chlorine and other chemicals out of ditches and streams

Swimming pool chemicals are toxic to fish and animals. Pools should not be drained or vacuumed into water courses or storm drains. Direct the water into the ground or a domestic sewer to prevent direct entry into fish bearing streams.

Tips for Streamsiders

A lot depends on you. Unwise and careless use of stream banks and stream beds can lower water quality to the point where fish dies and the stream becomes an eyesore, not an asset.

Keep your stream shaded

Trees, bushes and grasses on the banks will shade the water, keeping it cool for fish in the summer, prevent streambank erosion and collapse and provide wildlife habitat and a food source for fish. Streambank vegetation also provides cover and shelters from predators. Leaves that fall into the stream break down over time and become an important part of the food chain.

Educate your children

Streams are valuable. Don't let children dam them, disturb the bottom mud or gravel, collapse the banks, destroy vegetation or harass fish and wildlife.

Keep livestock away from streams and marshes

Animal wastes degrade water quality and their hooves can cause banks to collapse, which leads to heavy siltation and can block water flows.

Keep litter out of streams

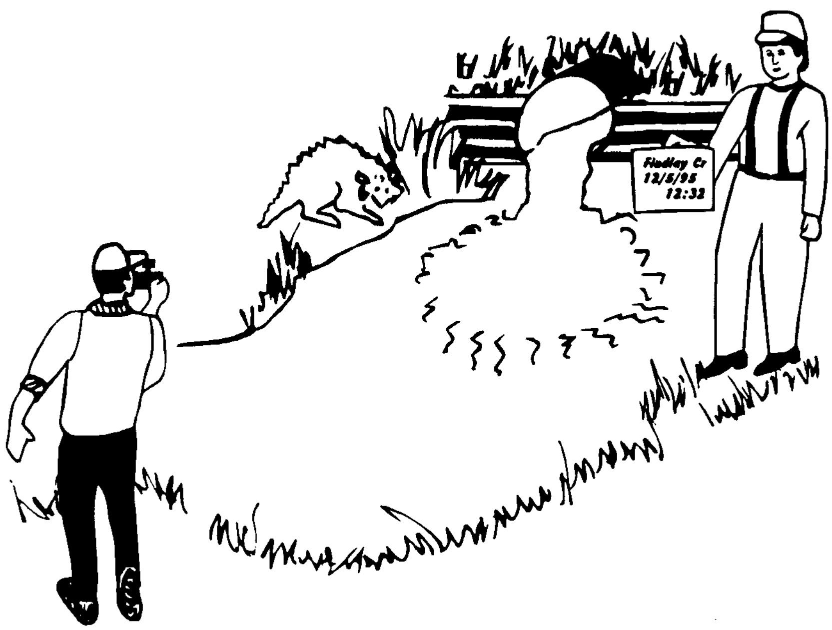
This includes tree branches, grass clippings, old appliances, and trash. Large objects can block the flow of water and fish and may destroy fish eggs. Organic matter will rot and reduce the amount of dissolved oxygen in the water. The oxygen is needed by fish and it helps keep the water smelling fresh.

Don't over-beautify

Despite good intentions, changes you make to your stream may destroy spawning beds and fish eggs or block fish migrations. Do not build ponds or dams without guidance and approval from Fisheries and Oceans Canada and the B.C. Ministry of Environment, Lands and Parks

STREAMKEEPERS

Module 1
Introductory Stream Habitat Survey



Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
No	recommended	2 days or more	2 or more	High flow and low flow seasons

Fisheries and Oceans
Pêches et Océans
Canada

MODULE 1

Introductory Stream Habitat Survey

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Gary Taccogna (Community Involvement Program, Department of Fisheries and Oceans) and Mel Kotyk (Environmental Protection Officer, District of North Vancouver) compiled the information for this module. The Langley Environmental Partners Society has field-tested this module extensively and provided considerable input into the revisions.

Project Activity and Purpose

You will collect information about your stream using available watershed maps and data from various sources. Then you will walk the stream to look for important unmapped features such as small tributaries and wetlands, habitat problems, and opportunities for habitat improvement. This introductory survey will help you focus your conservation and rehabilitation efforts. It also will help you decide where to establish monitoring sites for the more detailed assessments described in other modules.

Introduction

Stream ecosystems are complex interactions among plants, animals, and their physical environment. Human activities in watersheds make these systems even more complex. This module provides a starting point for studying your stream. It tells you how to find existing information, identify watershed boundaries, and then work on site to identify and map problem areas in your stream. Land and water use activities upstream and on surrounding slopes provide clues about problems you may discover in your stream.

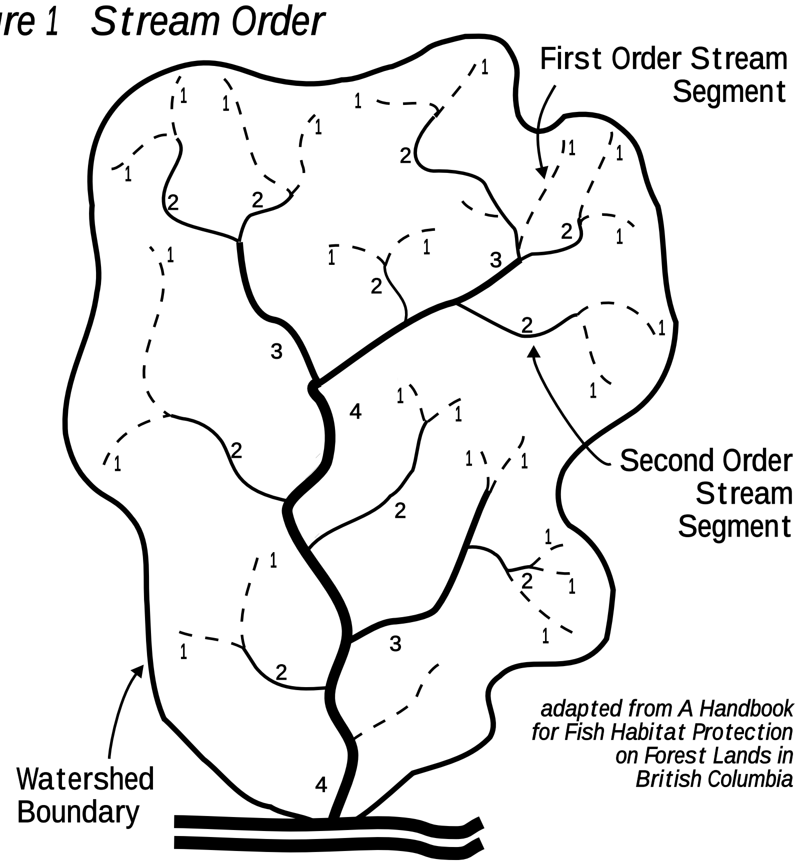
Maps and existing data provide useful background information. Information about many streams in the province is available in the Stream Inventory Summary System (SISS) database. The Department of Fisheries and Oceans (DFO) and Ministry of Environment, Lands, and Parks (WLAP) have data on physical characteristics and fish productivity in the SISS database.

A watershed consists of a network of tributaries or stream segments that feed into a main channel. Surveying an entire watershed may seem like an enormous task. One good way to organize information about a watershed is to break it into smaller stream segments. Your group can survey and monitor one segment in your watershed, and other groups can survey other segments.

One way to divide a watershed into smaller stream segments is to use the stream order system (Figure 1). Headwater tributaries are first order stream segments. When two segments of the same order merge, they form a higher order stream. Two first order streams merge into a second order stream segment; two second order streams merge into a third order stream segment, and so on. Large rivers often are sixth order or higher.

The order number for the main stream is related to the number and size of segments in the watershed. Natural geological processes and human disturbances such as construction of drainage canals and

Figure 1 Stream Order



channelization of large streams will alter the relationships between different segments.

Different segments of a stream and different streams can be compared using the stream order system. Stream order influences the physical and biological characteristics of a stream segment. For example, first order segments often are small and well-shaded, whereas downstream segments are larger, slower- flowing, and more exposed to the sun. Different species of plants and animals thrive in each of these environments.

Project Guidance and Approval

You need no formal project approval. Contact your Community Advisor, before you start the survey, for information on streams already surveyed. He or she can tell you how to gather existing data and share results with other interested groups and agencies. A Streamkeepers certification course offers training for this module.

Level of Effort

At least two people are required for a stream survey. One person monitors locations and takes measurements and the other records the information. It can take half a day to survey one stream segment and weeks to survey an entire watershed. If you decide to use several teams, make sure they are trained to use consistent methods.

Time of Year and Working Conditions

You can collect data at any time of year. However, the field survey is best done twice a year: during the high flow period (winter in coastal areas, spring freshet in interior areas) and during the late summer low flow period. Habitat problems are easiest to detect at these times of year.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property. Beware of domestic animals and wildlife.

Warn everyone, especially children, about urban hazards such as syringes, needles, broken glass, and condoms. Remove them with tongs and place them in a special hazardous materials bucket, or flag them with bright tape. Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials. Contact emergency response agencies or municipal crews to remove these materials.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear highly visible clothing. Wear waders with felts when walking in the stream.

Materials and Equipment

2 copies of a 1:20,000 scale TRIM map (topographic)
1 copy of a 1:50,000 scale NTS map (topographic)

pencils	paper
clipboard	data sheet
first aid kit	hip chain
thermometer	waders or boots

tape measure (black numbers on yellow) for turbidity
camera (35 mm with wide angle lens is best)
wading staff (marked in cm)
map wheel or non-stretch string

optional:
compass
binoculars

Procedure - Before You Go to the Field

Step 1. REVIEW EXISTING DATA

Information about your stream or watershed may be available from various sources. Contact your Community Advisor or local DFO or WLAP office for access to the Stream Inventory Summary System (SISS) database. It contains detailed information about larger streams in the province, but often has little or no information about smaller streams and tributaries. The database describes stream names, locations, watershed codes, physical characteristics (gradient, flow), and fish productivity (species, escapement, life history timing, potential production). It also provides information on physical and water quality problems, obstructions to fish migration, enhancement or management activities, land use, water use, and previous studies.

Contact Water Survey of Canada (Environment Canada) for the water quality and stream flow data they have collected at established sampling stations on streams in the province. Municipal or regional district offices may have data on local streams. Long-term residents are good sources of historical information. Also check the Streamkeepers Database for data collected by other Streamkeeper groups in your area. The current address is in the Handbook.

Step 2. OBTAIN MAPS AND AERIAL PHOTOGRAPHS

Maps are useful for planning the survey and recording any new information you collect. Use a large scale topographic map, such as a 1:20,000 scale Terrain Resource Information Management (TRIM) map. Appendix 1 contains information on ordering the right TRIM map for your stream. Order two copies to use as working and good copies. If you are working on a large stream, order all the TRIM maps that cover the watershed. Also, order a 1:50,000 National Topographic Series (NTS) map to provide a bigger perspective of the land around the watershed. NTS maps are available at most map stores.

Aerial photos are taken at altitudes ranging from very low level (<1:11,000 scale) to high level (1:90,000 scale). When you order TRIM maps, you can order a set of aerial photos as well. The Stream Inventory Manual (Anon., 1994) provides advice on how to interpret aerial photos.

Step 3. ESTABLISH WATERSHED BOUNDARIES, WATERSHED CODES, AND STREAM ORDERS

Map the **watershed boundaries** using a 1:20,000 TRIM map and the following procedure taken from the Streamkeepers Field Guide (Adopt-a-Stream, 1994):

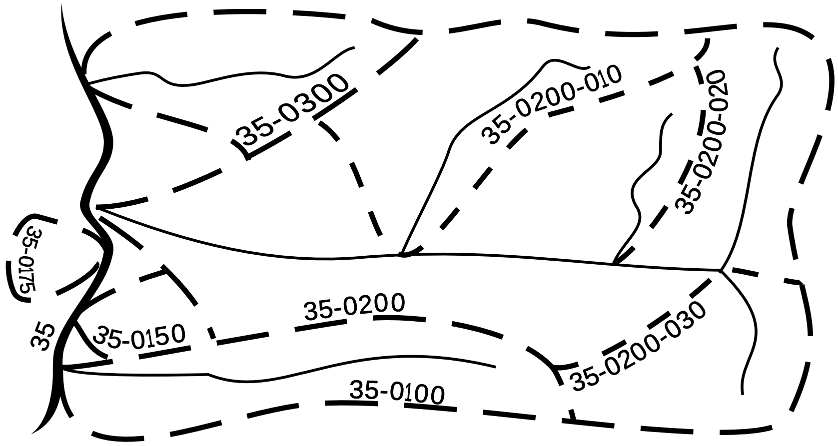
1. Locate the outlet point of your watershed. It will be the lowest elevation in your watershed and in most cases will be the mouth of your stream.
2. Trace the stream from its mouth to its tributaries. Using a pencil, make marks along the stream and its tributaries every inch (2.5 cm) or so, dividing them into one inch (2.5 cm) sections.
3. At each mark, draw a line perpendicular to the stream or tributary, running out in both directions.
4. Follow each line out from the stream or tributary until you reach a maximum elevation. Mark all these high elevation points with an "X."
5. Locate the beginning of each tributary, or the place where the stream's water originates. Extend a line out from each of these locations, in the direction opposite to the flow of water. Follow these lines until you reach a maximum elevation. Mark the high points with an "X."
6. Connect all the high points with a line following the highest elevations. The result of "connecting the dots" will be the boundaries of your watershed. Double check your boundaries to ensure accuracy, and then mark the boundaries with a pen or magic marker.

You can add other information to the map about land and water use in the watershed. If there is too much information to show on one map, use several maps or acetate overlays to present data separately on forestry activities, urban development zones, agricultural land, and so on. If you discover a problem during your stream survey, this information may help you find the cause.

Often, two streams in the province have the same name. The **watershed code** system was developed to avoid confusion. Watershed codes have been assigned for most streams and tributaries large enough to appear on a 1:50,000 NTS map. Codes are listed in the SISS catalogue, available at DFO offices, and the Watershed Code Dictionary, available at WLAP offices. Record the codes on the TRIM map next to your study stream and its tributaries and on the Data Sheet, Stream Location and Conditions Section. Other people will find the code useful when trying to locate your stream. If you do not find your stream in the SISS database, assign watershed codes following the procedure outlined in Appendix 2.

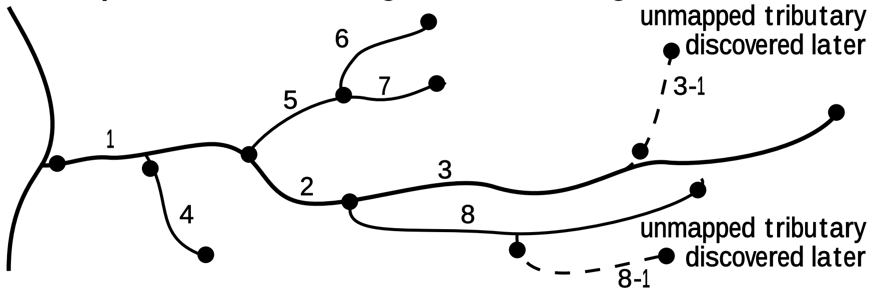
Figure 2
Watershed Code Example

source: Shera and Grant 1980



When you consider the stream network in terms of **stream order**, you can easily divide the stream into **segments** for further study (Figures 1 and 3). Use a 1:20,000 scale map to work out stream order. Map scale affects the ordering of the stream network, since the number of identifiable small tributaries changes with the map scale used. Colour code all the stream segments on your map. Use one colour for all first order segments, another for all second order segments, and so on. You can number these segments, to help you keep track of them and organize your data. Since there is no conventional system for keeping track of stream segments, we suggest the method shown in Figure 3. Number the mainstem segments first, from the mouth of the stream to its headwaters, then number the tributaries. Use the additional system (e.g., 3-1,8-1) when you add newly discovered tributaries to your map.

Figure 3
Example of Numbering Stream Segments



Procedure - Field Survey

Start your stream survey at the mouth of the stream, or the lower end of the segment you plan to survey. Survey each stream segment separately and use a new Stream Location and Conditions Data Sheet for each segment. Take along the field copy of the 1:20,000 TRIM map.

Step 4. COMPLETE THE STREAM LOCATION AND CONDITIONS DATA SHEET, THEN WALK THE STREAM

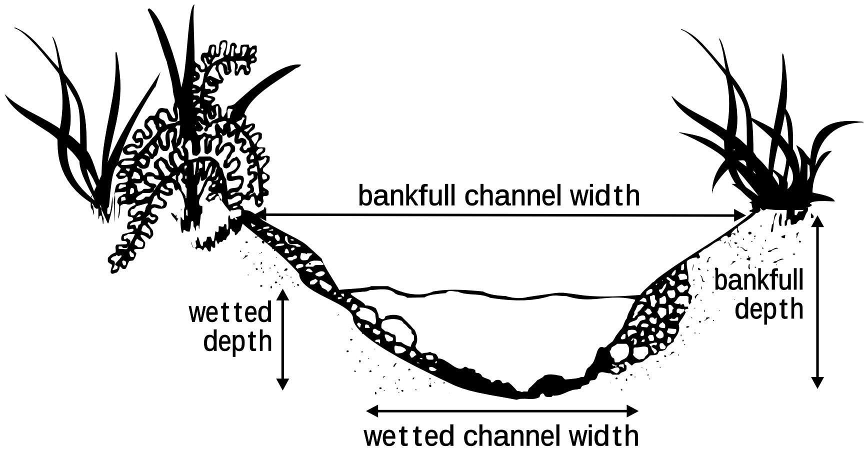
Before starting your walk, fill in the data sheet with the stream name, town, watershed code, stream segment number, stream length surveyed, people involved, and date. Record the relevant map sheet number, map type (e.g., TRIM), and map scale for the survey start and end points. Note the weather and stream conditions. You can use this information later when you interpret the results.

Clearly describe the downstream start point and upstream end point of the stream segment. Give precise directions to these points so that someone else can find them. Provide distances from known landmarks on the stream, such as bridge crossings. If you cannot survey the entire segment in one day, establish another start and end point within the segment.

Measure the channel dimensions at a riffle that typifies the average dimensions. The bankfull channel is the active stream channel, formed during annual floods (Figure 4). Its width and depth reflect the total discharge or volume of water during annual flood events. A change in the bankfull channel dimensions may be a warning sign of changing runoff patterns in the watershed. You may see permanent reminders left by receding flood waters. These mark the boundaries of the bankfull channel. Sometimes the boundaries are hard to find. Look for:

- the edge of the active stream channel and the beginning of the flood plain
- the start of well-established perennial vegetation such as trees, shrubs, and ferns
- a change in the bank slope from vertical to more horizontal
- a change in bank material from coarse gravel to fine sand or soil
- the highest stain lines (these mark the height of frequent inundation and are formed by sediment or lichen).

Figure 4
Bankfull and Wetted Channel Dimensions



Stretch a measuring tape across the channel at the top of the bankfull channel, making sure it is level and perpendicular to the stream flow. Measure the bankfull channel width, then the wetted channel width. Measure bankfull and wetted depth in the deepest part of the channel. Record the information on the Stream Location and Conditions data sheet. Measure air and water temperatures. Leave the thermometer for at least two minutes before taking the reading.

Measure water turbidity in a deep pool. Use a standard household tape measure (black numbers on yellow) and lower the tape into the water until you cannot see the number "one" at the end of the tape. Subtract 1 from the number showing at the water surface. Record this turbidity reading on the data sheet. If the water is clear to the bottom of the pool, record turbidity as "greater than ... depth."

As you walk upstream, use a **hip chain** to measure the exact location of stream features upstream of the stream segment start point. A hip chain is worn at the waist and is a plastic or leather case containing biodegradable thread. It measures long distances by feeding the thread through a calibrated counter. Attach the string to an object at the start point. Set the counter to zero and start walking. To get the most accurate measurement, walk the bank parallel to the centre-line of the stream. Avoid crossing from one bank to the other. When you wish to record the location of a particular feature, such as an outfall pipe, read the distance traveled off the counter. Attach the string again and reset the counter at landmarks along the stream, such as bridge crossings and tributary confluences. This helps avoid compounding small errors when measuring long distances.

Confirm the location of any details already included on the TRIM map. Look for features that are not on the map, including:

- unmapped tributaries, wetlands, swamps, backwaters
- intermittent channels, ditches
- unmapped landmarks, such as hydro or pipeline crossings
- stream banks with little or no native vegetation
- artificially stabilized stream banks (e.g., large rocks, timber, concrete)
- areas used for garbage disposal
- areas where livestock can enter the stream
- pipe outfalls
- barriers to fish migration
- eroding stream banks, collapsing banks, active slide areas
- water intake pipes and diversions (screens need openings less than 2.5 mm to be effective fish barriers)
- active discharges of pollutants

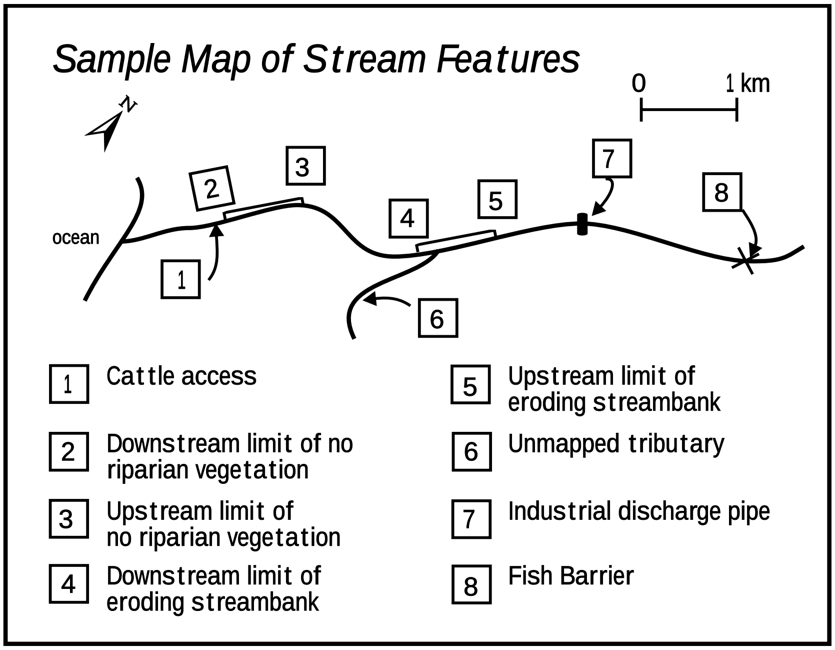
Describe any pollution or habitat problems in detail. Mention the extent, severity and source of discharges, the type and size of physical barriers, and details of bank degradation. Step 5 describes how to record this information. Appendix 3 describes these problems and their impacts more fully and tells you what type of information to collect for each type of feature.

Step 5. COMPLETE THE FIELD DATA SHEET

To save work and keep your data sheets complete, record the general survey information at the top of the Stream Reconnaissance Field Data Sheet, then make photocopies. Use a fresh copy for each feature. As well as the field data sheet, there is a Stream Feature Checklist, to help you briefly describe the feature.

Assign a unique number to each feature you observe, starting with the most downstream feature (Figure 5). Use these numbers to label a feature, locate it on the map, then later retrieve the appropriate data sheet. Record the feature number and a brief description on the field data sheet. Record the location of the feature as metres upstream from the segment start point. If the feature extends along the length of a stream, record the location of the downstream end of the feature. Also, record the appropriate measurements as described in Appendix 3. Note the predominant land use on both sides of the stream near the feature. Add any comments on observable water quality problems, and recommended actions.

Photograph the feature with someone standing in the photo to provide scale. Include in the foreground a piece of paper showing stream name, feature, date, and location. Record the photo frame number on the field data sheet.



Step 6. TRANSCRIBE FIELD DATA AND ASSESS STREAM CONDITIONS

At home, copy the stream feature numbers from the field data sheets onto your good copy of the TRIM map. Use a map wheel or nonstretch string to transfer distances onto the map.

You, or other Streamkeeper groups in your watershed, can conduct long-term monitoring programs or carry out more detailed assessments of stream health at particular locations or reference sites. The completed introductory survey will give you a good idea of where to establish these sites. Modules 2, 3, and 4 describe in detail the procedures used to survey and assess habitat, water quality, and benthic invertebrates.

Collecting, Reporting and Evaluating Information

Send the data to the Streamkeepers Database. Streamkeepers throughout the province can share the data you provide. The map, data sheets, and notes on habitat problems establish a good record of the watershed. You can use this information to identify specific habitat problems and potential restoration projects. Presenting the data at local land use hearings may help protect sensitive stream environments from future development.

Survey data will help you interpret the results collected in other project modules. For example, water quality testing may show high turbidity and water temperatures at a reference site. Perhaps you can relate these findings to a section of eroding stream bank mapped in your introductory stream survey.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations, and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

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Water Division, EPA Region 10
1200 Sixth Avenue
Seattle, WA 98101

APPENDIX 1 Ordering TRIM Maps

APPENDIX 2 Watershed Code System

APPENDIX 3 Identifying and Descibing Unmapped Features

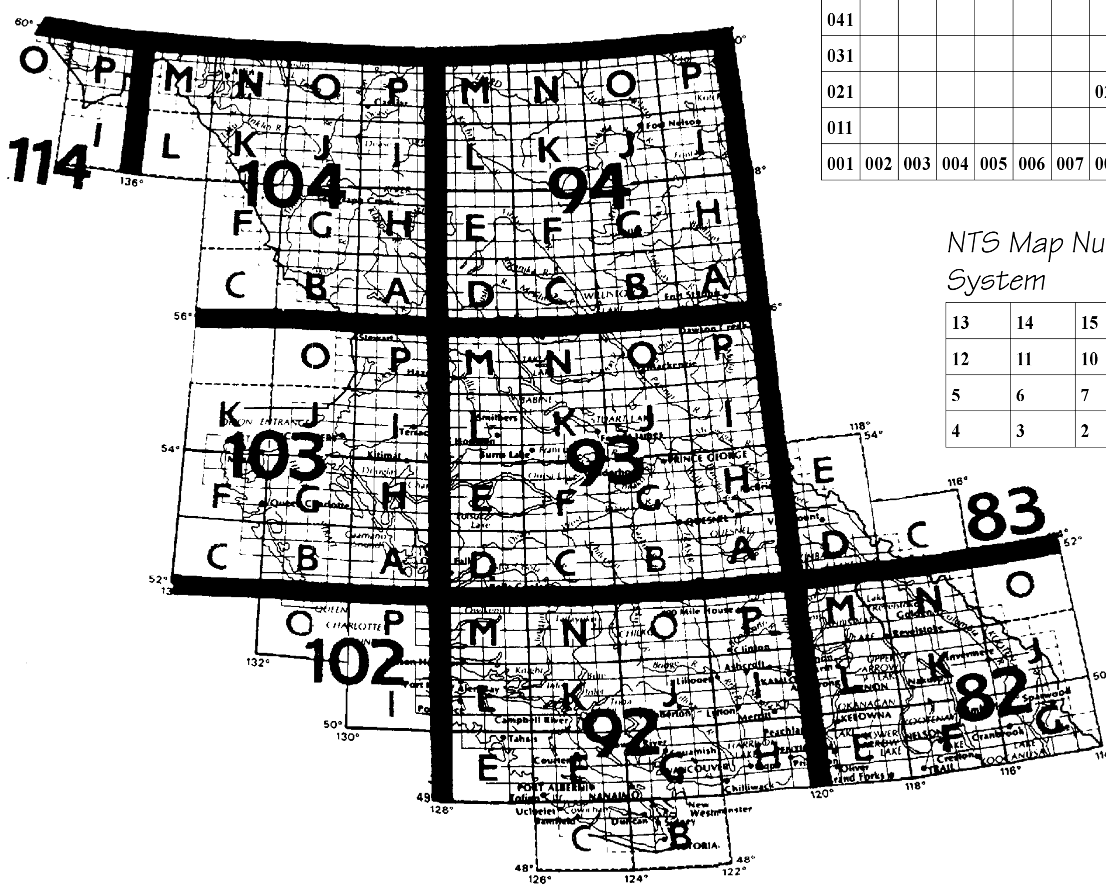
APPENDIX 1 Ordering TRIM Maps

Order a 1:50,000 National Topographic Series (NTS) map. Figure 6 is an index to these maps. Find the index number and letter corresponding to your area of interest. Each lettered box is divided into 16 smaller boxes representing the 1:50,000 scale maps available for that area. For example, if you are interested in the 1:50,000 NTS map for a stream in Prince George, you would order map number 93 G/15.

The same numbering system is used when ordering 1:20,000 scale Terrain Resource Inventory Maps (TRIM maps), but each lettered box is divided into 100 smaller boxes rather than 16. Figure 6 shows an example from area 82 F, in southeastern British Columbia. If you have difficulty determining which small box your stream is in, you can order a 17" by 22" index map for the letter block area. These provide much more detail about the terrain covered by each of the 100 smaller boxes within the letter box.

TRIM Maps are available from your local Government Agent. Call 1-800-663-7867 to find one in your area.

Figure 6 NTS Map



TRIM Map Numbering System

091	092	093	094	095	096	097	098	099	100
081									090
071									080
061									070
051									060
041									050
031									040
021							028		030
011									020
001	002	003	004	005	006	007	008	009	010

NTS Map Numbering System

13	14	15	16
12	11	10	9
5	6	7	8
4	3	2	1

APPENDIX 2 Watershed Code System

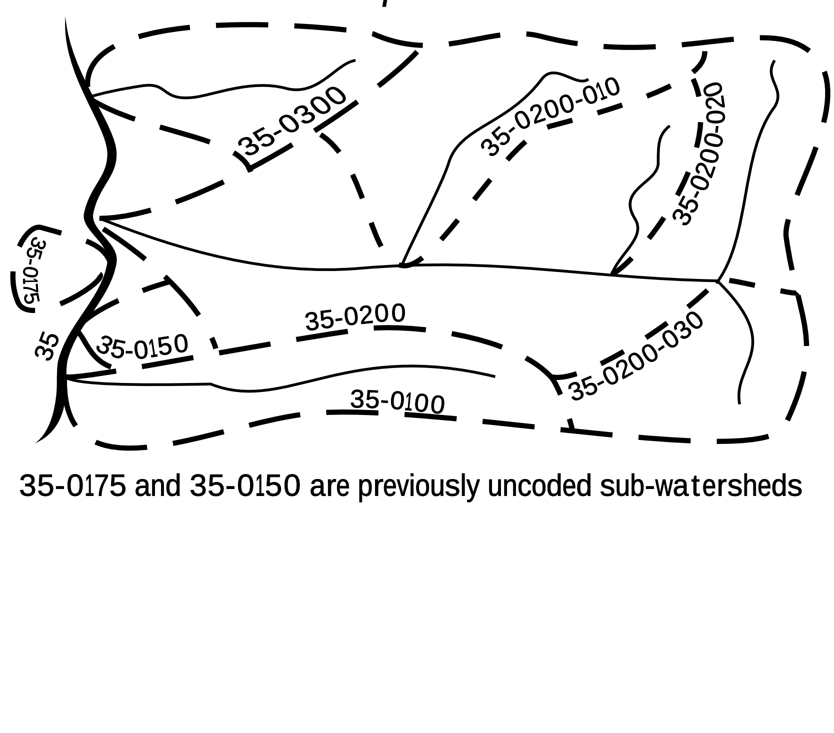
Often, two streams in the province have the same name. The provincial government developed the watershed code system to avoid confusion. Most streams large enough to appear on a 1:50,000 scale NTS map have been assigned watershed codes. The Stream Inventory Summary System (SISS) database and the Watershed Code Dictionary, available at DFO and WLAP offices, list watershed codes. Use the following procedure to assign a code if your stream does not have one.

The coding system uses a hierarchical approach to numbering large watersheds, sub-watersheds, and smaller tributary watersheds. Figure 7 shows the numbering system as it applies to hypothetical river 35, a major watershed. Sub-watersheds and tributaries are numbered sequentially in an upstream direction from the mouth of the main river.

Most watersheds have been assigned a 21-digit number, which is broken down into two, four, and three digit groups (Figure 7). The example is for major watershed 34, the Lower Kootenay River. Within the stream network, each group of digits refers to a successively smaller tributary watershed. An uncoded watershed lies within an already coded, larger watershed. You need to find out where it lies within the coding hierarchy before you can assign it a code. Uncoded watersheds are assigned codes by altering the underlined zeros in the example shown in Figure 8.

Figure 7
Watershed Code Example

source: Shera and Grant 1980



35-0175 and 35-0150 are previously uncoded sub-watersheds

Figure 8

The general format is

__ ____ ___ ___ ___ ___ ___

34	Lower Kootenay River
34-0700	Slocan River
34-0700-110	Little Slocan River
34-0700-110-030	Koch Creek
34-0700-110-030-040	Grissley Creek
34-0700-110-030-040-020	Greasybill Creek
34-0700-110-030-040-020-010	North Greasybill Creek

34 The two digit group designates a major watershed. All major watersheds in the province have an assigned code. Your stream flows within one of these watersheds.

0700 The four digit group refers to sub-watersheds. The largest sub-watersheds are assigned a number between 0100 and 9900, by 100's. For example, Figure 7 shows sub-watershed 35-0200 upstream of 35-0100 and downstream of 35-0300. All three tributaries enter watershed 35 directly. The number assigned does not reflect stream discharge or watershed size.

Between these sub-watersheds, up to 99 lesser sub-watersheds can be added, using the underlined positions of the four digit group shown in Figure 8. These numbers apply to other tributaries that enter the main river directly. Their assigned number reflects geographic and numerical location in relation to already numbered sub-watersheds. In Figure 7, sub-watershed 35-0150 enters watershed 35 about half way between sub-watersheds 35-0100 and 35-0200. Sub-watershed 35-0175 enters watershed 35 about three-quarters of the distance between sub-watersheds 35-0100 and 35-0200.

110 The first three digit group refers to a minor watershed within the sub-watershed. Again, up to 99 of the largest minor watersheds are assigned a number between 010 and 990, by 10's. In Figure 7, minor watershed 35-0200-020 enters sub-watershed 35-0200 upstream of 35-0200-010 and downstream of 35-0200-030.

Between each numbered minor watershed, there is room to add up to nine lesser minor watersheds. The underlined position shown in Figure 8 for the first three digit group is used. As with sub-watersheds, the last digit reflects relative position.

Within each minor watershed, up to four more levels of lesser watersheds within watersheds can be coded using three digit groups. The numbering system follows the same procedure used for minor and sub-watersheds. For example, 34-0700-110-030-040-020-010 refers to North Greasybill Creek, a very small intermittent tributary of Greasybill Creek.

When you walk the stream, you may find many features not previously recorded. This Appendix describes how to identify and map these features and impacts.

APPENDIX 3 *(revised March 2000)* Module 1

Identifying and Describing Features

Note whether feature is on the left or right bank (facing *downstream*)

Stream Feature Description Checklist

BANK EROSION
slumping bank, undercut, upslope slide, other
Measure length, height and slope.

GARBAGE
commercial/industrial source, residential/recreational source, other
Measure length, type and quantity.

SIDE CHANNEL
dry channel, flowing channel, other
Measure length, depth and width of wetted area. Take temperature readings.

LACK OF RIPARIAN VEGETATION
human induced, natural phenomenon, other
Measure length, width and slope.

WETLAND
bogs, marshes, swamp, pond, other
Measure length, depth and width. Take temperature readings.

WATER BODY
Tributary, wetland, ditch, other
Measure bankfull and wetted channel widths and depths, (Optional: compass bearing 10m upstream of confluence, and 25m or at major bends. Measure gradient.)
In water body - take temperature readings 2m upstream of confluence.
In main stem - take temperature readings 2m upstream and 2m downstream of confluence.

ENHANCEMENT
log/rock weir, fishway
Measure length and width, and height of structure to fish access, plunge pool depth.

ENHANCEMENT (con't)
riparian planting, woody debris placement, spawning gravel placement
Measure length and width
incubation box/hatchery
Measure length, width and height
constructed pond/side channel
Measure length, width and depth. Take temperature.
boulder cluster
Measure length and width and approximate size of boulders.

ARTIFICIAL MODIFICATION
dam
Measure length, width and height of structure, and depth of plunge pool.
dredging, channelization, retaining wall, instream crossing, fence
Measure length and width.
bridge
Measure length and width, height from substrate to bridge deck, depth of water.
culvert
Measure height/width or diameter - height from substrate to bottom of structure - if flowing, temperature in flow. In main stem - 2m upstream and 2m downstream.
rip-rap
Measure length, width, slope and approximate size of material.
other
Measure length, width and height

APPENDIX 3 *(revised March 2000)* Module 1

OBSTRUCTION

culvert

Measure height/width or diameter - height from substrate to bottom of structure, depth of water at base - if flowing, temperature in flow. In main stem - 2m upstream and 2m downstream.

log jam

Measure length, width and vertical height from substrate to top of jam.

dam

Measure length, width and vertical height from substrate to top, depth of water at base.

beaver dam

Measure length, width and vertical height from substrate to top, depth of water at base.

falls, cascade,canyon

Measure length, width and vertical height and slope, depth of water at base.

fence

Measure length, vertical height, height from substrate to bottom of fence, depth of water at base.

bridge

Measure length and width, height from substrate to bridge deck, depth of water.

DISCHARGE PIPE

septic effluent

Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water.
DO NOT TOUCH!

industrial outfall

Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water.
DO NOT TOUCH!

DISCHARGE PIPE (con't)

tile drain

Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water. If discharging, take temperature in flow, then in main stem, 2m upstream and 2m downstream.

storm drain

Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water. If discharging, take temperature in flow, then in main stem, 2m upstream and 2m downstream.

trench

Measure length/height/width.

If discharging, take temperature in flow, then in main stem, 2m upstream and 2m downstream.

LIVESTOCK ACCESS

streamside grazing

livestock crossing

Measure affected length and width of stream.

WATER WITHDRAWAL

screened intake

Measure length and width of intake and mesh size.

unscreened intake

Measure length and width of intake

When you walk the stream, you may find features not previously recorded. This Appendix describes how to identify and map these features.

Bank Erosion

Background: Eroded areas of the stream look raw. The soil has slipped down the bank, and either entered or threatens to enter the stream channel. Erosion occurs at several kinds of places, such as undercut banks (the current erodes the soil below the original top of the bank), slumping banks (the bank slumps into the stream), or oxbows (a stream bends sharply and current flows straight ahead into the bend).

Action: Measure the length, height and slope of affected stream bank. Note whether erosion affects the left or right bank (facing downstream). Describe the nature of the erosion (undercut or slumping bank, oxbow, etc.) in the comment section of the data sheet.

Garbage

Background: Consider the severity of the damage before identifying garbage as a feature. Only those areas that require a cleanup crew are considered a feature. Remove only human-made material. Leave all natural material in the stream.

Action: Describe the type, quantity, and location of garbage. Measure the length of bank affected and whether the left or right bank (facing downstream) is involved. Look for evidence of the source of the garbage, such as names and addresses on stationary or other items.

Side Channel

Background: Pay special attention to side channels, since they often are not mapped. They provide important fish and wildlife habitat, such as refuge during floods. A side channel is a lateral channel, with the flow running roughly parallel to the main channel. Water enters from the main channel, either seasonally or year-round. The substrate usually is much finer than in the main channel.

Action: Note the location, length, depth, and width of the side channel. Measure length and width of the side channel, and note whether it lies on the left or right bank (facing downstream). Also, note whether the side channel contains water now.

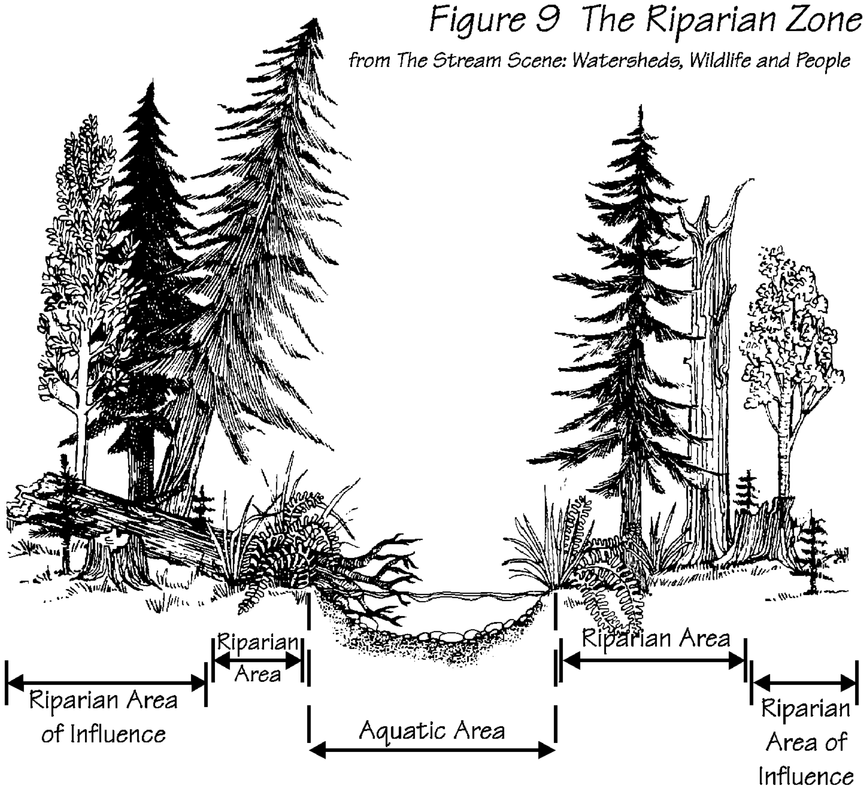
Lack of Riparian Vegetation

Background: Riparian vegetation is the natural ground cover, shrub layer, and tree canopy along the stream bank. Healthy streams have a variety of native species of shrubs and trees (Figure 9).

Action: Measure the length and width of affected stream bank lacking vegetation or landscaped with introduced species or lawns. Measure the slope of the bank lacking riparian vegetation, if appropriate. Note whether the left or right bank (facing downstream) is affected.

Figure 9 The Riparian Zone

from The Stream Scene: Watersheds, Wildlife and People



Wetland

Background: Wetlands are areas inundated with water for part or all of the year. They provide essential habitat for fish and wildlife and moderate the effects of extreme flood or drought conditions. Wetlands may be swamps (contain live or dead trees), bogs (contain mainly Sphagnum moss), ponds (have open areas of water), or marshes (contain mainly emergent vegetation such as reeds, rushes, cattails, and sedges).

Action: Identify the type of wetland. Note the approximate length, width, and depth of the wetland if the map does not show them. Note whether there is a seasonal or year-round connection between the wetland and the stream. Describe any encroachments (harmful disturbances) on the wetland.

Unmapped Waterbody

Background: Some tributaries, wetlands, and ditches may not have been mapped previously. These features are very important to include in the stream survey. You also can use this feature designation if the existing map shows only part of the tributary.

Action: Record the location of the tributary confluence with the mainstem, using the hip chain measurement. Measure both the mainstem and tributary water temperatures a few metres upstream of the confluence.

Optional Action for Unmapped Tributaries: Measure the bankfull and present channel width and depth of the tributary. Take a compass bearing. Have someone stand in the middle of the tributary 10 m upstream and take the bearing from the confluence point to him or her. If the person is out of sight at 10 m, take the reading where he or she disappears. Take a compass bearing every 25 m, or at major bends in the tributary. Measure stream gradient at the same places using a hand level or clinometer (see Module 2, page 14). Include a sketch of the unmapped tributary on the field map.

Action for Unmapped Wetlands: Identify the type of wetland. Accurately measure dimensions and depth of the wetlands. Note whether there is a seasonal or year-round connection between the wetland and the stream. Describe any encroachments (harmful disturbances) to the wetland.

Enhancement

Background: There may be projects along the stream designed to enhance fish resources and habitats. These include added large woody debris, incubation boxes or hatcheries, constructed side channels or ponds, log or rock weirs, riparian plantings, added spawning gravel, fishways, and added clusters of boulders.

Action: Record the type and approximate dimensions of the enhancement work.

Artificial Modification

Background: There may be dams, dredged areas, bridges, channelized areas (linear ditches or streams), culverts, rip rap, retaining walls, instream crossings and other artificial modifications on the stream.

Action: Record the type and dimensions of the modification. Record whether the right or left bank (facing downstream) is affected, where appropriate.

Obstruction

Background: There may be an obstruction on the stream that prevents fish passage for part or all of the year. Fish usually can pass over low falls and inclines up to 1 m high if there is a well-situated plunge pool at the base. The height of the jump should be less than 1.25 times the depth of the plunge pool, to allow fish passage. Other obstructions include culverts, log jams, dams, beaver dams, falls, fences, and bridges. Describe other kinds of obstructions in the comment section of the data sheet.

Action: Identify the type of obstruction. Measure its length, width, height, and slope (Figure 10). Measure the depth of the plunge pool at its base. Note whether the obstruction prevents fish passage under only certain conditions or year-round.

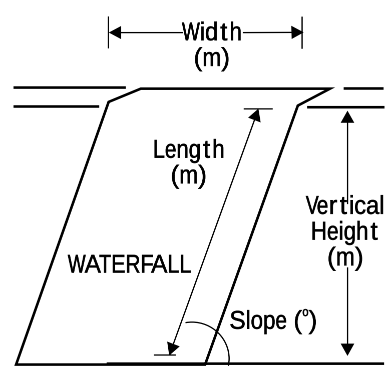


Figure 10
Estimating the Size of a Fish Barrier

Discharge pipe

Background: Pollution and sediment can enter the stream from definite or point sources. You may find septic effluent leaking out of a pipe from a septic tank system (it usually has an unpleasant odour). In agricultural areas you may find tile drainage (used to improve drainage on fields), or trenches (used to divert water or livestock manure to ditches and streams). In urban areas you may find storm drain outlets that direct storm water runoff to a stream. Industrial outfalls or pipes may drain effluent from an industrial site.

Action: Record dimensions of the pipe or trench and its elevation above the stream bed. Describe the pollutant smell, colour, appearance (oily film, sudsy, etc.) if the pipe is discharging actively. DO NOT TOUCH IT!!! Describe whether the pipe is on the left or right bank (facing downstream).

Livestock Access

Background: Livestock that have access to the stream can cause bank erosion, damage fish habitat, and contaminate the water. The most common situations are where livestock graze along unfenced parts of the stream and where livestock cross the stream at a trail crossing or watering ramp.

Action: Measure the affected length and width of the stream, and note whether the left or right bank (facing downstream) is affected. Estimate the number and type of livestock with access to the area.

Water Withdrawal

Background: There may be an intake pipe or diversion ditch that draws water from the stream for agricultural, industrial, or domestic purposes. The pipe or ditch may be screened or unscreened. Screened pipes with openings larger than 2.5 mm and unscreened pipes allow juvenile fish to pass through, resulting in fish mortalities.

Action: Record the dimensions of the intake structure, pipe, or diversion ditch. If possible, find out where the water goes (e.g., to irrigate a nearby field). Note whether the pipe is screened or unscreened. Measure the size of any mesh. Record whether the left or right bank (facing downstream) is affected.

send the data to: Streamkeepers Database, Department of Fisheries and Oceans,
Suite 400, 555 W. Hastings Street, Station 321, Vancouver, B.C. V6B 5G3
or fax to (604) 666-0292

Stream Location and Conditions

(use a new data sheet for each stream section surveyed) **Module 1**

Stream Name/Nearest Town:		Date:
		Watershed code
Organization Name:		
Contact Name:		Phone #
Crew Names:		Stream Segment #
		Stream Section #
		Length Surveyed

Survey Start Point (when applicable)

Mapsheet number_______________ Type________________ Scale__________________
Start Point Location (distance from known stream landmark, directions to start)
Time:______ Weather ʻ clear ʻ shower (1-2.5 cm in 24 hr) ʻ snow ʻ overcast ʻ storm (>2.5 cm in 24 hr) ʻ rain on snow
Water turbidity (cm visibility) _________________________ Temperature ^{o}C (leave thermometer 2 min.) air ___________ water _______________
Measurements taken every _____ m
Bankfull Channel width __________(m) Average depth _____________(m)
Wetted Channel width __________(m) Average depth _____________(m)

Survey End Point (when applicable)

Mapsheet number_______________ Type________________ Scale__________________
End Point Location (distance from known stream landmark)
Time:______ Weather ʻ clear ʻ shower (1-2.5 cm in 24 hr) ʻ snow ʻ overcast ʻ storm (>2.5 cm in 24 hr) ʻ rain on snow
Water turbidity (cm visibility) _________________________ Temperature ^{o}C (leave thermometer 2 min.) air ___________ water _______________
Measurements taken every _____ m
Bankfull Channel width __________(m) Average depth _____________(m)
Wetted Channel width __________(m) Average depth _____________(m)

(Start Point) First and Last Measurements taken 0.1 m from streambank edge (End Point)

Left Bank								**Right Bank**
Wetted Depth								Wetted Depth
Bankfull Depth								Bankfull Depth

Left Bank								**Right Bank**
Wetted Depth								Wetted Depth
Bankfull Depth								Bankfull Depth

Take measurements every 0.5m in streams less than 5m wide, every 1m in streams 5 to 15m

Page ___ of ___

send the data to the Streamkeepers Database

Stream Reconnaissance Field Data Sheet

. . . Additional Feature Information **Module 1**

Stream Name/Nearest Town:	Date
	Watershed code
Organization Name:	
Contact Name:	Phone #
Stream Segment #	
Stream Section #	

Feature Information

Feature #	Photo #	*m* upstream of last feature	Feature Description and Size (see App. 3)	Stream-bank (L or R)	Adjacent Land Use *	Actions/Comments/ Water Quality Concerns

* *Adjacent Land Use Codes:* **U***ndisturbed,* **A***griculture,* **F***orestry,* **R***esidential,* **P***arks,* **C***ommercial,* **I***ndustrial*

Note whether feature is on the left or right bank (facing *downstream*)

Page ____ of ____

Stream Reconnaissance Field Data Sheet

Feature Information con't **Module 1**

Feature #	Photo #	*m* upstream of last feature	Feature Description and Size (see App. 3)	Stream-bank (L or R)	Adjacent Land Use *	Actions/Comments/ Water Quality Concerns

* *Adjacent Land Use Codes:* **U***ndisturbed,* **A***griculture,* **F***orestry,* **R***esidential,* **P***arks,* **C***ommercial,* **I***ndustrial*

General comments on this section of the stream

Page ____ of ____

APPENDIX 3 *(revised)* Module 1

Identifying and Describing Features

Note whether feature is on the left or right bank (facing *downstream*)

Stream Feature Description Checklist

BANK EROSION

slumping bank, undercut, upslope slide, other

- Measure length, height and slope.

GARBAGE

commercial/industrial source, residential/recreational source, other

- Measure length, type and quantity.

SIDE CHANNEL

dry channel, flowing channel, other

- Measure length, depth and width of wetted area. Take temperature readings.

LACK OF RIPARIAN VEGETATION

human induced, natural phenomenon, other

- Measure length, width and slope.

WETLAND

bogs, marshes, swamp, pond, other

- Measure length, depth and width. Take temperature readings.

WATER BODY

Tributary, wetland, ditch, other

- Measure bankfull and wetted channel widths and depths, (Optional: compass bearing 10m upstream of confluence, and 25m or at major bends. Measure gradient.)
- In water body - take temperature readings 2m upstream of confluence.
- In main stem - take temperature readings 2m upstream and 2m downstream of confluence.

ENHANCEMENT

log/rock weir, fishway

- Measure length and width, and height of structure to fish access, plunge pool depth.

ENHANCEMENT (con't)

riparian planting, woody debris placement, spawning gravel placement

- Measure length and width

incubation box/hatchery

- Measure length, width and height

constructed pond/side channel

- Measure length, width and depth. Take temperature.

boulder cluster

- Measure length and width and approximate size of boulders.

ARTIFICIAL MODIFICATION

dam

- Measure length, width and height of structure, and depth of plunge pool.

dredging, channelization, retaining wall, instream crossing, fence

- Measure length and width.

bridge

- Measure length and width, height from substrate to bridge deck, depth of water.

culvert

- Measure height/width or diameter - height from substrate to bottom of structure - if flowing, temperature in flow. In main stem - 2m upstream and 2m downstream.

rip-rap

- Measure length, width, slope and approximate size of material.

other

- Measure length, width and height

APPENDIX 3 *(revised)*

Module 1

OBSTRUCTION

culvert

- Measure height/width or diameter - height from substrate to bottom of structure, depth of water at base - if flowing, temperature in flow. In main stem - 2m upstream and 2m downstream.

log jam

- Measure length, width and vertical height from substrate to top of jam.

dam

- Measure length, width and vertical height from substrate to top, depth of water at base.

beaver dam

- Measure length, width and vertical height from substrate to top, depth of water at base.

falls, cascade,canyon

- Measure length, width and vertical height and slope, depth of water at base.

fence

- Measure length, vertical height, height from substrate to bottom of fence, depth of water at base.

bridge

- Measure length and width, height from substrate to bridge deck, depth of water.

DISCHARGE PIPE

septic effluent

- Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water.
- DO NOT TOUCH!

industrial outfall

- Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water.
- DO NOT TOUCH!

DISCHARGE PIPE (con't)

tile drain

- Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water. If discharging, take temperature in flow, then in main stem, 2m upstream and 2m downstream.

storm drain

- Measure height/width/diameter. Height from substrate to bottom of pipe, depth of water. If discharging, take temperature in flow, then in main stem, 2m upstream and 2m downstream.

trench

- Measure length/height/width.
- If discharging, take temperature in flow, then in main stem, 2m upstream and 2m downstream.

LIVESTOCK ACCESS

streamside grazing

livestock crossing

- Measure affected length and width of stream.

WATER WITHDRAWAL

screened intake

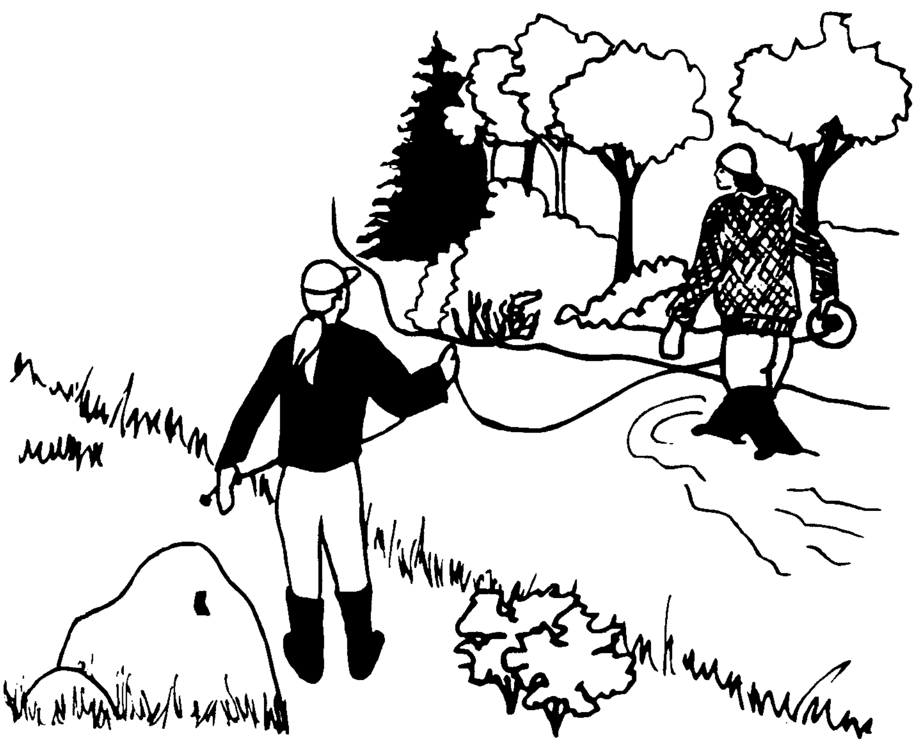
- Measure length and width of intake and mesh size.

unscreened intake

- Measure length and width of intake.

STREAMKEEPERS

Module 2
Advanced Stream Habitat Survey



Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	recommended	half day per site	2 or more	late summer, early fall

Fisheries and Oceans   Pêches et Océans

Canada

MODULE 2
Advanced Stream Habitat Survey

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Gary Taccogna (Community Involvement Program, Department of Fisheries and Oceans) compiled the information for this module.

Project Activity and Purpose

This advanced survey adds details about stream conditions and habitat to information already collected in the Introductory Survey (Module 1). You will choose one or more reference sites on your stream. At each site you will establish a benchmark, conduct cross-sectional and longitudinal surveys, measure stream discharge, and assess habitat quality.

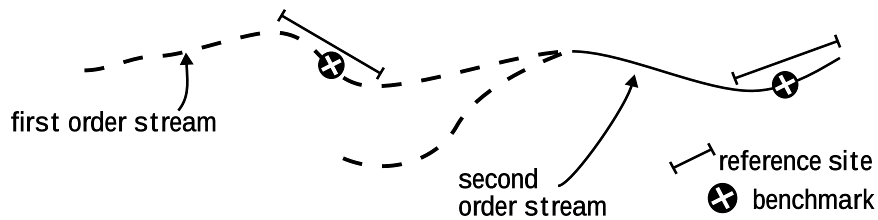
You can use this data to detect changes in stream conditions over the long term or to document the impacts of a suspected habitat problem. In the first case, you will return to a site periodically to document changes in stream conditions over many years. In the second, you will survey sites upstream and downstream of an impact, usually on the same day. If you rehabilitate an area, you will want to survey it in subsequent years to assess the effectiveness of your improvements.

Introduction

The survey methods show you how to collect consistent data so you can compare sites or streams with confidence, even when different people or organizations have collected the information. Your first step is to decide whether you wish to monitor long-term changes or document impacts of habitat problems.

The second step is to define your study area or areas. Select a short section of stream (a reference site) that represents habitat in that stretch of stream (stream segment). Identify the reference site with a benchmark, a metal tag that enables you or others to find the exact location again. Figure 1 shows a reference site and benchmark on first and second order segments of a stream.

Figure 1
Reference Site and
Benchmark on Stream Segments



You can establish several reference sites on a stream, each representing particular types of habitat and stream conditions in the watershed. Consider ease of access when you select the reference site(s). If you are interested in a second order stream, for example, you can establish sites on the first order headwater segments as well as on the second order segment. If you wish to measure the impact of a problem you can collect data at reference sites upstream (control site), in the vicinity (impact site) of the problem, and perhaps further downstream (recovery site). Do all the surveys on the same day. If this is not practical, survey over a few days, as long as stream flow conditions remain constant.

Once you have established a reference site, you can collect detailed information about the physical habitat (this module), water quality (Module 3), benthic invertebrates (Module 4), or fish (Module 11).

Monitoring many sites can be time consuming for one group, but a network of groups in one watershed can share the work. Each group can be responsible for one or two sites. If more than one group is involved, make sure everyone uses consistent methods and timing. The data need to be reliable and comparable to be useful.

Many methods described here were developed for use on streams. They may not work as easily for large or deep rivers. Ask your Community Advisor for advice if you need to modify the methods.

Project Guidance and Approval

You need no formal approval, but you should advise your Community Advisor. He or she can help coordinate equipment, training, and site selection. The methods used are technical in nature. They may seem complicated at first, but are not difficult to learn. A Streamkeepers certification course is available.

Level of Effort

The first time you survey a reference site you may take at least half a day on a small stream, and longer on a larger stream. Subsequent surveys of the same site take less time because you have marked the benchmark already. You can modify the procedure by simply establishing a benchmark and compiling a photographic record of the site. This takes much less time, but still provides useful information about habitat quality.

Time of Year And Working Conditions

Conduct the advanced survey during late summer or early autumn, if possible. Stream flows are lower at these times, making it easier to work in the stream channel. It also is a good time of year to assess vegetation on the banks. If you repeat the survey annually, return at the same time of year, when flow and weather conditions are similar.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property. Beware of domestic animals and wildlife.

Warn everyone, especially children, about urban hazards such as syringes, needles, broken glass, and condoms.Remove them with tongs and place them in a special hazardous materials bucket, or flag them with bright tape. Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials.

Contact emergency response agencies or municipal crews to remove these materials.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear highly visible clothing. Wear waders with felts when walking in the stream.

Materials And Equipment

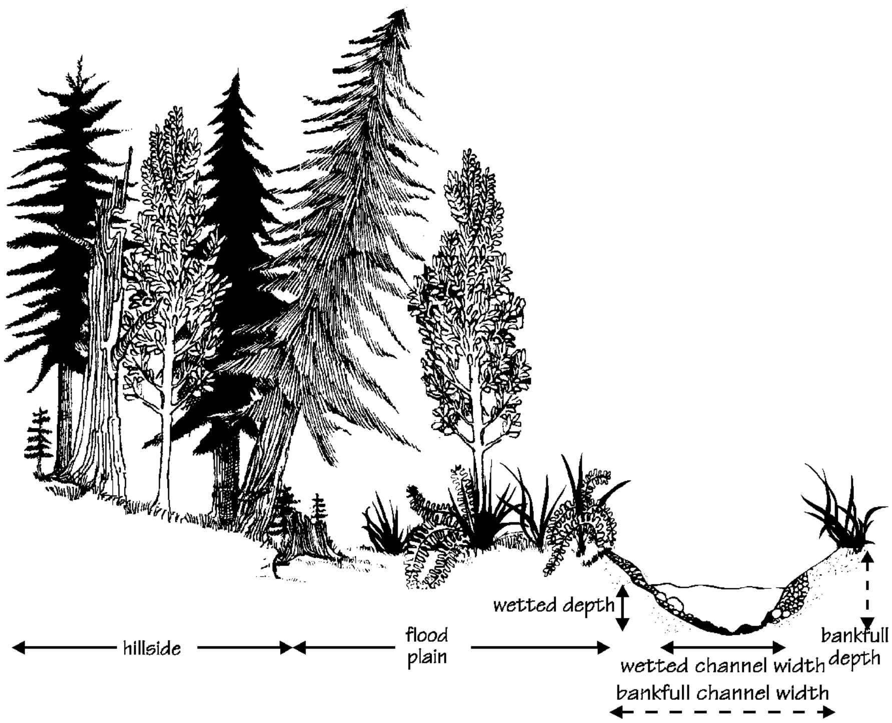
clinometer
survey staff
flagging tape
hip chain
data sheets
felt pen, pencils
hammer
rebar rods (60 cm or longer)
stopwatch
metre stick
fibreglass tape measure
metric ruler
thermometer
clipboard and paper
calculator
nails, rock nails
orange
first aid kit
metal tags (buy from survey equipment supplier
camera, extra rolls of film (35 mm camera with 28 to 35 mm wide angle lens and polarizing filter is best)
stepladder (optional - for taking stream channel photos)

Procedure

Step 1. ESTABLISH A BENCHMARK

Once you select a location for a reference site, establish a benchmark so the site can be found for future surveys. A benchmark is a tagged feature on the stream bank that permanently identifies the reference site. It should be near the midpoint of the length of stream you will survey. The reference site is a length of stream at least twelve times the bankfull channel width. The bankfull channel is the active stream channel to the edge of well-established perennial vegetation (Figure 2). For example, if the bankfull channel width is 2.5 m, the boundaries of the site are about 15 m upstream and 15 m downstream of the benchmark.

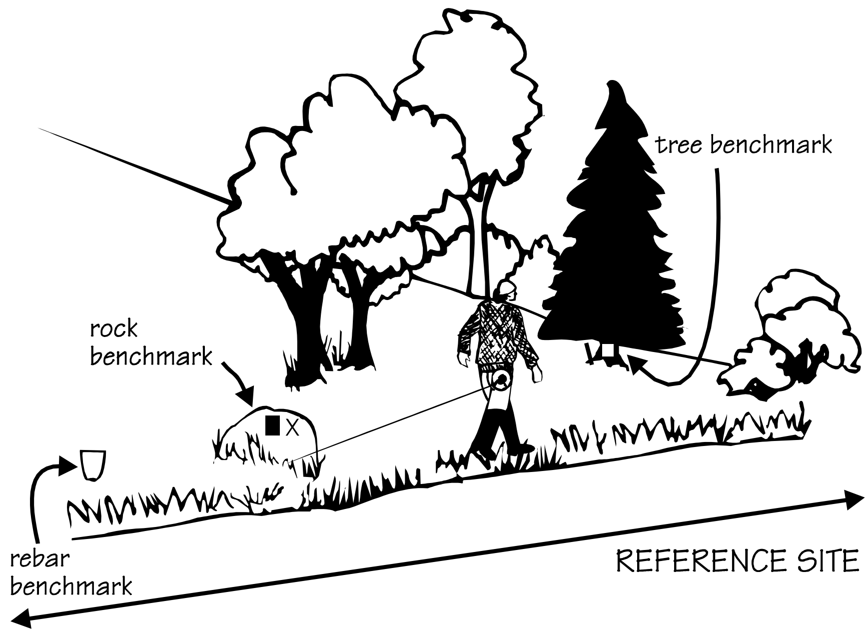
Figure 2
Cross Section of a Stream



Measure the bankfull channel width at a few places in the reference site. Locate the benchmark at a place where the bankfull channel width and general stream conditions appear typical of average conditions for the site. Choose the location for the benchmark carefully; you will make several measurements there. Select a straight length of stream with a single channel, where you can see clear indications of the boundaries of the bankfull channel. The site you choose on the stream should not have a braided channel, multiple channels, large boulders, large logs, or engineered structures that alter the form of the channel at the benchmark. You will measure stream discharge at the benchmark, so choose a riffle area with a relatively smooth stream bottom and uniform depth.

Permanently mark the benchmark using one of the following methods (Figure 3). Nail a metal survey tag into a healthy, firmly-rooted tree of at least 30 cm diameter, preferably a conifer such as cedar, Douglas fir, or pine. Pound a steel rebar rod into the ground and attach a metal tag. Affix a metal tag to a large boulder or bedrock canyon wall using masonry or rock nails.

Figure 3
Examples of Benchmark Locations



Fill in the Locations and Conditions section of the data sheet. Include accurate directions to the stream area and benchmark.

Locate the marker on the bank where it will not be washed away, but will be visible from the channel. Unfortunately, obvious markers may be vandalized. Attach a second marker on the opposite side of the channel, so there is an additional benchmark in case the first one is lost. Attach the second marker directly across the channel from the first, at the same elevation. This way, you can use the two markers as the endpoints for the cross-section survey.

Record the location of the benchmark on the Field Data Sheet, Step 1.

Step 2. CONDUCT A CROSS-SECTIONAL SURVEY

In this step, measure the bankfull and wetted width and depth of the stream channel, as shown in Figure 2. The channel is formed at the bankfull stage, during annual floods. Although you should never measure a stream at the flooding stage, you may observe permanent reminders left by receding flood waters. These mark the boundaries of the bankfull channel. Sometimes the indicators are hard to find. Look for:

the edge of the active stream channel and the beginning of the flood plain

the start of well-established perennial vegetation such as trees, shrubs, and ferns

a change in the bank slope from vertical to more horizontal

a change in bank material from coarse gravel to fine sand or soil

the highest stain lines (these mark the lines of frequent inundation and are formed by sediment or lichen).

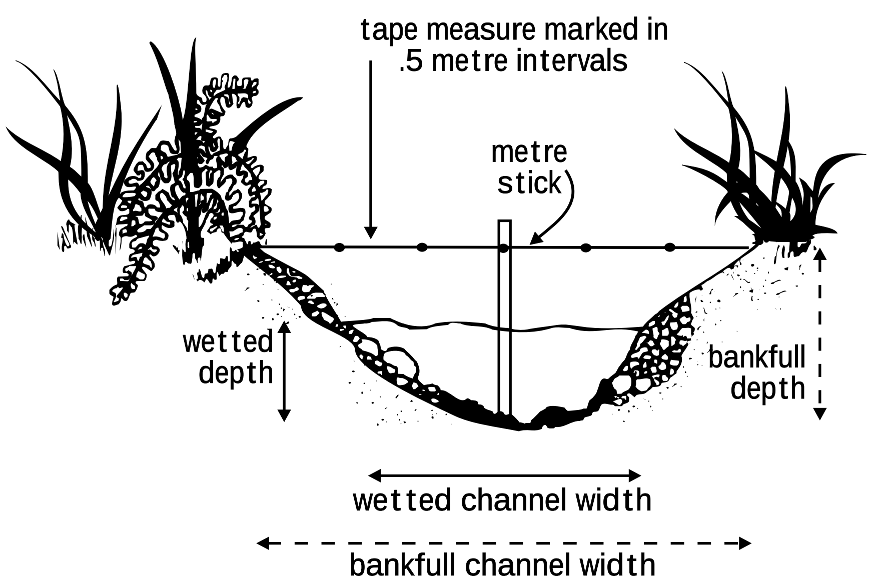
The bankfull channel width and depth reflect the total discharge or volume of water during annual flood events. A change in the bankfull channel dimensions may be a warning sign that natural runoff patterns are changing in the watershed.

Do the cross-sectional survey using the permanent benchmarks as endpoints. If this is not possible, use the same criteria as in Step 1 to choose a cross-sectional survey site.

Stretch a measuring tape between the two markers, so it is at the same elevation as the top of the bankfull channel. Make sure the tape is level and is perpendicular to the stream flow. Measure the bankfull width. Measure the bankfull depth, the depth from the tape measure to the bottom, to either dry land or stream bottom (Figure 4). Measure the depth at regular intervals across the stream (every 0.5 m in streams less than 5 m wide, every 1 m in streams 5 to 15 m wide, and every 2 m in streams 15 to 25 m wide). Also, take initial and final measurements 0.1 m away from each endpoint.

Record all the information on the Field Data Sheet, Step 2. Calculate the average depth to the nearest 0.1 m.

Figure 4
Bankfull and Wetted Channel Measurements



While you still have the tape in place, measure and record the width of the wetted channel. Measure the wetted depth at the same places you measured bankfull depth, except, of course, where there is no water. You will use this information to calculate stream flow and discharge in Step 3. On the Field Data Sheet, draw a sketch of the stream channel cross-section showing the bankfull channel and the wetted channel depths and widths.

Photos

Take three photos while the tape is in place. A wide angle lens is very useful. Record the film type, lens focal length, and camera type in your field notes. You can reduce glare from the water surface by taking the photos with the camera pointed down at the water surface or by using a polarizing filter. A stepladder is helpful, as long as you do not have to carry it far. Have someone stand in the photos holding a paper or small chalkboard stating the name of the creek, date, site number, and orientation in relation to stream flow. Take photos looking upstream and downstream of the cross-section, with the tape measure in place. Also, take a photo of the cross-sectional view along the tape, with the benchmark in the background.

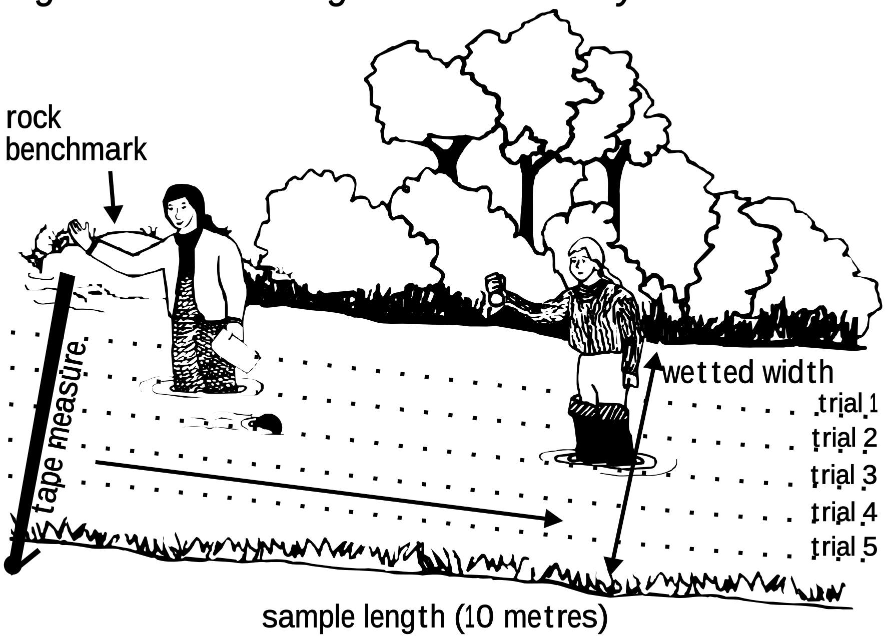
Step 3. MEASURE STREAM DISCHARGE

Stream discharge is calculated by multiplying stream velocity by wetted channel cross-sectional area. Measure velocity in a riffle area, preferably where you did the cross-section profile, because you already have the measurements of the wetted channel profile. If you must choose a new location, measure the depths and widths as for Step 2, wetted channel dimensions. Record the cross-sectional area information on the Field Data Sheet, Step 3.

Calculate the stream cross-sectional area (m2) from your plot of wetted channel dimensions. Multiply width by average depth and enter the value for total cross-sectional area on the Data Sheet, Step 3.

Visually divide the stream width into five sections: one midstream, two near shore, and two half way to the middle (Figure 5). Have someone stand 10 m downstream of you. Stand midstream and drop an orange or tennis ball into the water beside you. Use a stopwatch to record the time it takes the orange to float 10 m downstream. Repeat the process in the other four sections of the stream. Record the individual times for the five trials and calculate the average. Divide the distance (10 m) by the average time in seconds, to get the average stream velocity in m/sec. Record the result on the Field Data Sheet, Step 3.

Figure 5 Measuring Stream Velocity



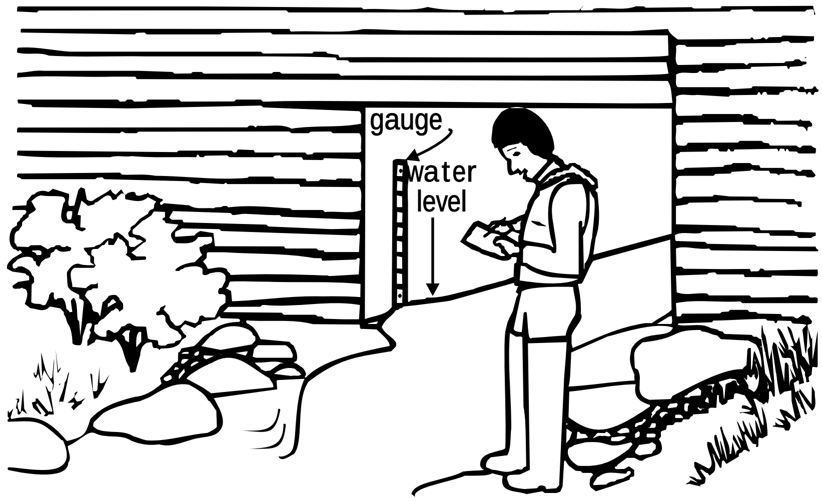
To calculate total stream discharge in m3/sec, multiply the average water velocity (m/sec) by cross-sectional area (m2) and by a correction factor of 0.8. This factor converts your velocity measurement from surface velocity to average velocity. Water flows faster at the surface than deeper in the water column. Average velocity occurs just below the mid-depth. Record the stream discharge on the Field Data Sheet, Step 3.

average velocity (m/sec)	X	cross-sectional area (m2)	X 0.8	=	discharge (m3/sec)

Staff gauge

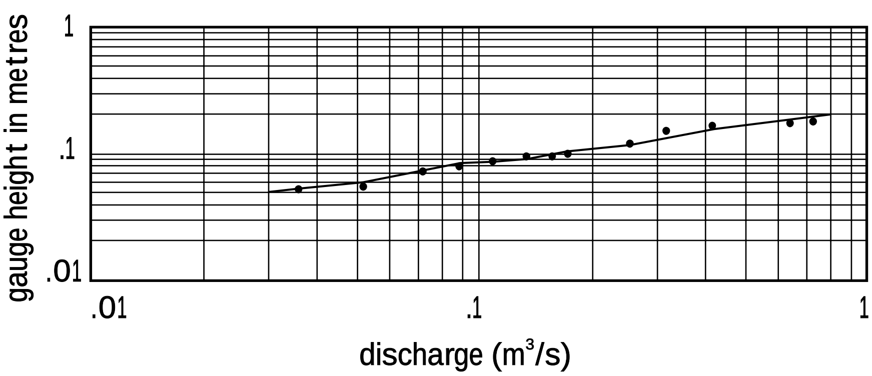
There may be a staff gauge already installed somewhere on the stream, or you may wish to install one at a culvert or bridge abutment if you plan to monitor stream discharge frequently. The staff gauge is a painted scale (marked in metres and centimetres) used to show the water depth (Figure 6). An engineered area of the stream, such as a bridge crossing, box culvert or flood control area, may have a gauge. Gauge readings and stream discharge rates are measured over a wide range of stream flows, then plotted on logarithmic graph paper to produce a rating curve (Figure 6). Once the rating curve has been determined, you can read the staff gauge height, then estimate the stream discharge from the rating curve.

Figure 6 Staff Gauge at a Box Culvert



Staff Gauge:
Example of Rating Curve on Logarithmic Paper

from Stream Channel Reference Sites: An Illustrated Guide to Field Technique



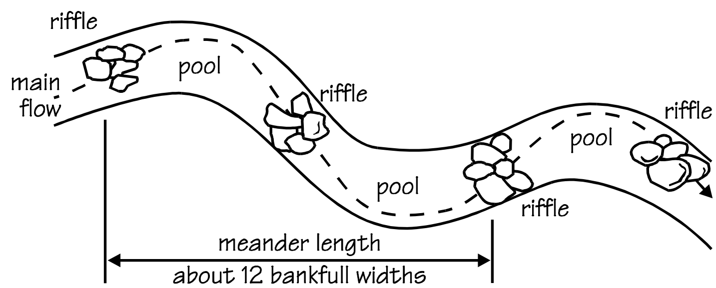
Step 4. LONGITUDINAL SURVEY

In this step you collect information about habitat quality over the entire length of the reference site. The length of the reference site should be at least twelve times the bankfull channel width. On average, a pool-riffle sequence is repeated every six times the bankfull width and a full S-shaped meander is repeated every twelve times the bankfull width (Figure 7a).The benchmark should be near the midpoint of the longitudinal survey.

There are two parts to the longitudinal survey. In the first, you define upstream and down- stream boundaries of the site and divide the site into distinct habitat units. Each stream consists of a repeating pattern of pool and riffle habitat units. Pools have deeper water, lower velocity and water surface gradient, and little or no surface turbulence. Riffles have shallower water, higher velocity and water surface gradient, and some surface turbulence.

In the second part of your survey, you measure or observe nine important habitat characteristics over the length of the reference site. You will use this information in Step 5 to rate the habitat quality at the reference site.

Figure 7a
The Natural Meander Pattern of a Stream
adapted from Stream Analysis and Fish Habitat Design, 1994



STEP 4.1. Mark the Upstream and Downstream Boundaries, Define Habitat Units

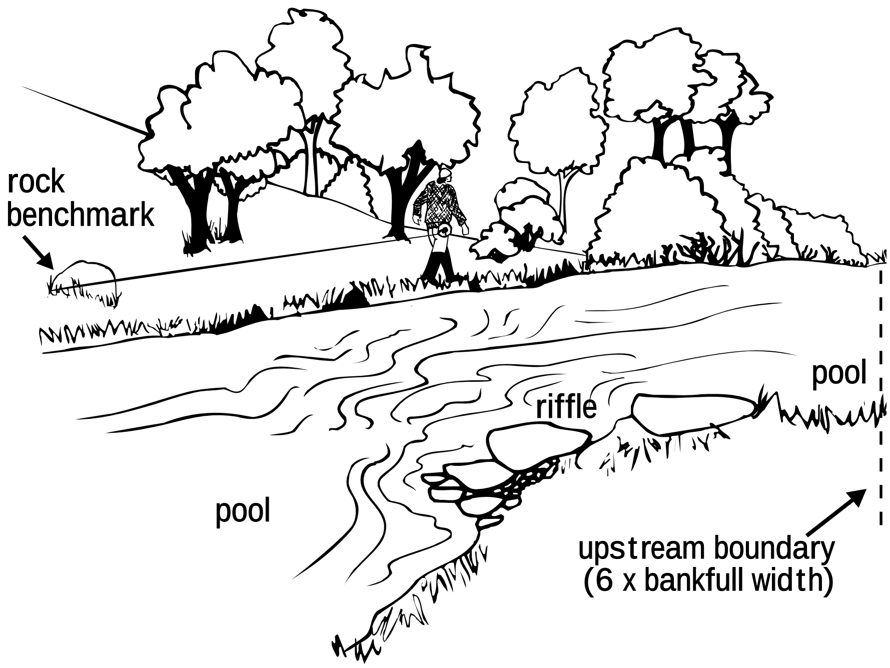
Using a hipchain, walk downstream from the benchmark a distance of about six times the bankfull channel width. Mark the downstream end of the closest pool or riffle habitat unit with a piece of flagging tape. Make sure you can see the marker from mid-channel.

Start walking upstream. Mark the upstream end of the last habitat unit with flagging tape. This mark also is the down- stream end of the next habitat unit. Continue upstream, marking the boundaries of the alternating pool and riffle habitats. Stop when you reach a distance of about six times the bankfull width upstream of the benchmark (Figure 7b).

On the Field Data Sheet, Step 4.1, record the total distances to the upstream and downstream boundaries of the reference site, relative to the benchmark. Record the distance to the boundary of each habitat unit.

Facing downstream, take photos of each habitat unit, starting at the upstream end of the reference site. Take photos from a high point to reduce glare from the water surface, using a polarizing filter or a stepladder if you brought one. Include in the first photo a piece of paper or chalkboard noting location, date, habitat unit type, distance upstream of the benchmark, and camera frame number. Include in each photo the upstream habitat unit marker in the foreground, and the

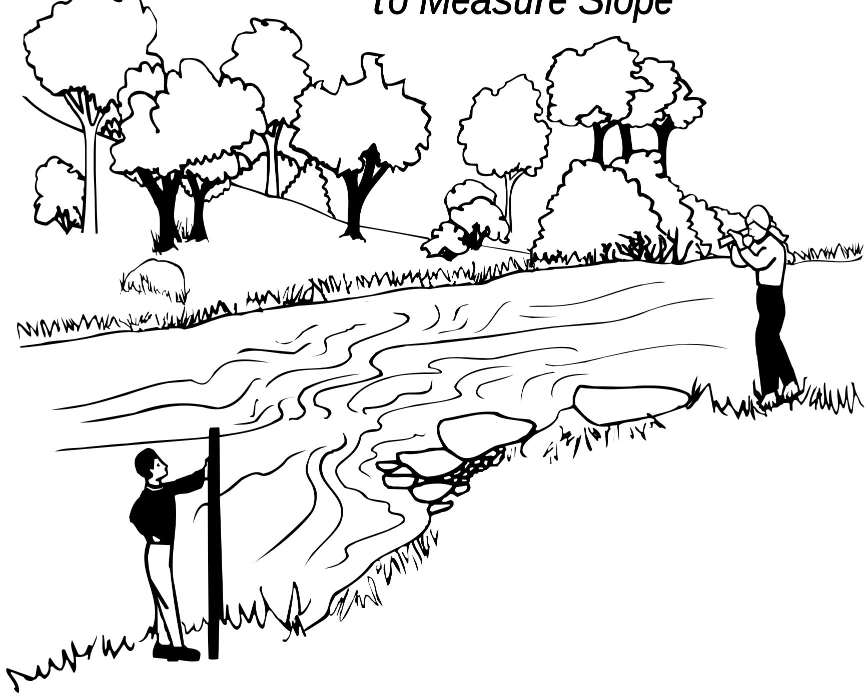
Figure 7b
Alternating Pool and Riffle Habitats in the Reference Site



downstream marker with someone standing beside it for scale. Take two photos if the habitat unit is too long to fit into one photo.

You need to know the stream slope to do the stream habitat assessment in Step 5. Measure the slope or drop in elevation for each habitat unit when you photograph it. Use a clinometer and a survey staff to record the elevation drop at the water surface between the upstream and downstream markers of each habitat unit (Figure 8). You can use a two to three metre long stick and flagging tape as a survey staff. Stand beside the upright staff, with your boot beside the base of the staff. Tie a piece of flagging tape at your eye level. Send your partner to the downstream end of the habitat unit with the staff. Get your partner to position the staff with its base at the same elevation as the water surface. Stand at the upstream marker with your feet at the same elevation as the water surface. Hold the clinometer in front of one eye so you can see the scale through the optics. Use your other eye to aim the clinometer at the staff downstream. Line up the hairline on the clinometer scale with the flagging tape on the staff. Read the percent slope from the clinometer scale (Figure 9). Ignore the scale that gives the reading in degrees. Record the slope in percent on the Field Data Sheet, Step 4.1.

Figure 8
Positions While Using the Clinometer to Measure Slope



STEP 4.2 Measure or Observe Habitat Characteristics

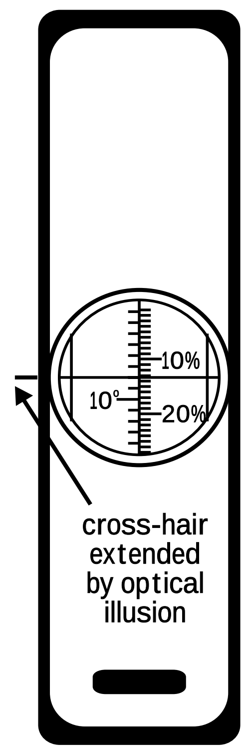
The nine characteristics listed below help describe the quality of stream habitat and capacity for biological productivity. Your measurements or observations should reflect average stream conditions over the entire length of the reference site. The characteristics are considered primary, secondary, or tertiary, based on their significance to habitat quality. Composition of streambed material, embeddedness of substrate, and instream cover are most important in defining habitat quality and types of plant and animal life in the stream. Characteristics of secondary importance include the percent pool habitat, off-channel habitat, and bank stability. Tertiary characteristics include stream bank vegetation, amount of overhead canopy, and size of riparian zone.

PRIMARY CHARACTERISTICS

4.2.1 Streambed Material

Different kinds of streambed material influence plant and animal life in a stream. Substrate sizes range from "fines" like silt, sand, and clay, to large boulders and bedrock (Table 2). Although variety in substrate size is desirable, a streambed comprised primarily of fine sediment is less stable than one comprised primarily of boulder, cobble, and gravel. Large substrates also provide better quality fish and aquatic invertebrate habitat.

Figure 9
Clinometer Scale



Select a representative pool and riffle unit within the reference site. Measure twenty-five particles in each habitat unit using the following procedure:

a) Toss a pebble along the stream bank and begin a transect where the pebble comes to rest. Take one step from the bank into the stream. Without looking at the stream bottom, reach down to the toe of your boot and pick up the first particle touched by the tip of your finger.

b) Measure the length, width, and depth of the particle in cm, using a ruler or metre stick (Figure 10). Call out the three dimensions to the person recording data, who can record it on a piece of paper. Work out the average diameter of the particle by adding the three numbers and dividing by three. For large boulders embedded in the stream, measure the shorter of the two exposed dimensions and record that as the average particle diameter.

Figure 10
Example of Average Size Measurement

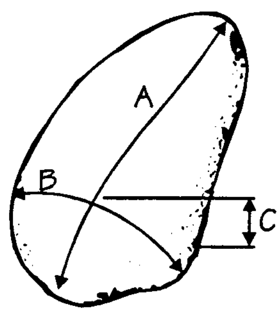


Table 2
Size Categories of Streambed Material

bedrock	solid slab of rock
boulder	>25 cm diameter
cobble	5 - 25 cm diameter
gravel	0.2 - 5 cm diameter
fines	<0.2 cm diameter

c) Take another step across the channel in the direction of the opposite bank and repeat the process. If you reach the opposite bank before you have measured twenty-five particles, toss a pebble along the bank again and begin another transect across the channel.

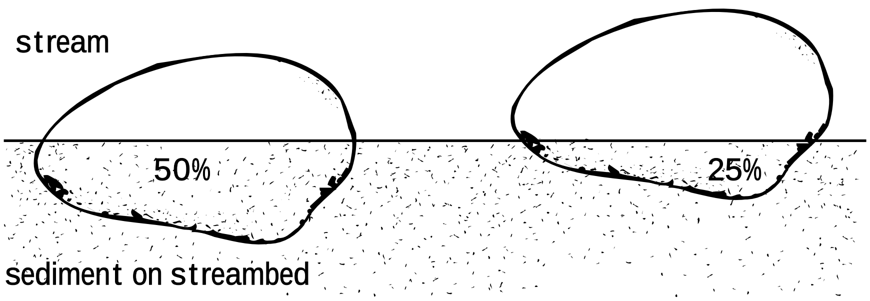
d) Repeat the process in the other habitat unit. Combine the results from the pool and riffle samples. Count the number of particles from your sample that fall into each substrate class listed in Table 1. Convert the data to percentages and record the results for each substrate class in the Field Data Sheet, Step 4.2.1.

4.2.2. Embeddedness

Fine sediments often bury, or embed, some gravel and cobble substrate. Fines accumulate naturally in pools, where gradient and water velocity are reduced. In undisturbed streams, fines do not accumulate significantly in riffles, so large amounts of fines on riffle substrates may indicate erosion problems in the watershed. Embedded riffle substrates provide less desirable habitat for invertebrates, and reduce habitat quality, stream productivity, and fish spawning habitat.

Wade into the middle of a riffle in the reference site. Pick up several pieces of gravel and cobble. Estimate the percentage of rock surface area buried in fines (Figure 11). Often a stain line indicates the level of burial. Repeat this in a few locations in the riffle and record the estimated percent embeddedness on the Field Data Sheet, Step 4.2.2.

Figure 11
Estimating Embeddedness of Gravel and Cobble



4.2.3. Instream Cover

Stable logs, stumps and undercut banks with large protruding root masses provide important habitat for fish and other animals. They provide shelter, cover from predators, and refuge during floods and droughts.

Walk the entire length of the reference site. Count the number of pieces of large woody debris (LWD) at least 1 m long and 0.1 m in diameter that seem unlikely to wash away. Check both stream banks and count the number of stable undercut banks with roots protruding into the channel.

Record the number of pieces of LWD on the Field Data Sheet, Step 4.2.3. Divide the number of pieces of LWD by the length of the survey site expressed in channel widths (the length of the reference site divided by the bankfull channel width, usually about 12). Record this value as well. Repeat the procedure for rooted cutbanks.

SECONDARY CHARACTERISTICS

4.2.4. Percent Pool Habitat

Percent pool habitat refers to the proportion of pool habitat at your reference site. Pools are areas of low energy and riffles are areas of high energy. Pool and riffle habitats alternate in stream channels. Both habitat types are important to stream organisms. Pools provide a refuge in flood conditions and may be the only habitat available during drought conditions. Many factors influence the relative abundance of pools and riffles.

Calculate the total length of pool habitat from the measurements obtained in Part 4.1. Record this value on the Field Data Sheet, Step 4.2.4. Divide the total length of pool habitat by the total length of the reference site. Multiply by 100 to obtain the percent pool habitat. Record the percent on the Field Data Sheet, Step 4.2.4.

Calculate the average slope for the entire reference site from the slope data collected in Step 4.1. This is the average of the individual values. Record the average percent slope on the Field Data Sheet, Step 4.2.4.

4.2.5. Off-channel Habitat

Side channels, ponds, wetlands, and secondary overflow channels next to the main channel provide off-channel habitat. These areas are isolated and protected from main channel floods. They may join the main stream channel occasionally or throughout the year. Off-channel habitat provides seasonal breeding and rearing areas and protection from flood flows for many animal species. Some are easy to see and others are less obvious.

Carefully search both banks of the reference site for small channels that lead away from the main stream. Record the number of side channels and backwater ponds on the Field Data Sheet, Step 4.2.5. Describe their approximate size, shape, and potential as a refuge from floods. Decide whether they are seasonal or year-round. Take photos if you wish.

4.2.6. Bank Stability

This refers to bank areas between the annual high water and low water marks. Examine the banks for signs of existing or potential sloughing to assess bank stability. Streams with unstable banks often have unstable stream beds and poor instream habitat as well. Steep banks and banks with damaged or no vegetation often are unstable. Soil can slide into the channel from unstable areas further up the bank. Artificially stabilized stream banks indicate erosion problems.

Count the number of places on both banks where you see active erosion (sloughing soil, raw appearance), artificial bank stabilization, or signs of landslides into the channel. Use a hip chain or measuring tape to measure the length of stream bank affected by each impact.

Record the individual and total values on the Field Data Sheet, Step 4.2.6.

TERTIARY CHARACTERISTICS

4.2.7. Bank Vegetation

Perennial vegetation at the edge of the bankfull channel includes trees, shrubs, and grasses. Stream bank vegetation contributes to a healthy stream habitat. It binds the soil with root networks, moderates temperature fluctuations, absorbs pollutants from runoff, and provides a source of food and large woody debris. Removing bank vegetation degrades stream habitat significantly.

Measure the lengths of stream bank where there is no vegetation at the edge of the bankfull channel, using a hip chain. Record the values for both the left and right banks on the Field Data Sheet, Step 4.2.7.

4.2.8. Overhead Canopy

Tree and shrub branches overhanging the stream form an overhead canopy. This canopy provides food, shade, and cover for animals in the stream below. The extent of the canopy is estimated as a percentage of bankfull channel area. For example, when the branches on opposite banks meet or overlap at the centre of the channel, 100% cover occurs.

You can estimate overhead cover from a recent large-scale aerial photograph. If you have no aerial photo, use a tape to measure the average distance that branches extend over the top of the stream at your reference site. Take measurements from the right and left banks at a few locations. Calculate the average value for left and right banks, add them, and divide by the bankfull channel width. Multiply this value by 100 and record this percent value on the Field Data Sheet, Step 4.2.8.

4.2.9. Riparian Zone

The riparian zone is the vegetated area between the stream bank and the upland slope at the edge of the flood plain. Stream bank vegetation needs to be wide enough to provide a buffer from land use impacts near the stream. A good quality buffer zone has several species of coniferous and deciduous trees and shrubs. It is wide enough to protect the entire flood plain up to the base of adjacent slopes.

Note the relative abundance of coniferous and deciduous trees, shrubs, and grasses in the riparian zone on the Field Data Sheet, Step 4.2.9. You can estimate the width of the riparian buffer zone from a recent aerial photograph. See Module 1 for more information about aerial photos. If you do not have an aerial photo, find a high point overlooking the reference site. Estimate the average width of the riparian zone, in terms of the number of bankfull channel widths. Record the value on the Field Data Sheet, Step 4.2.9. For example, if the buffer zone on both sides of the stream is about twice as wide as the average bankfull channel width, record two channel widths on the form.

Step 5. CONDUCT A HABITAT ASSESSMENT

The final step in the advanced survey is to rate habitat quality at the reference site. Base these scores on average conditions over the length of the reference site. The habitat assessment is adapted from methods used by the U.S. Environmental Protection Agency (Plafkin, 1989), Washington State Department of Natural Resources (Anonymous, 1993), and the University of Idaho Water Resource Institute (Rabe, 1992).

The scores for the nine characteristics described in Step 4.2 are weighted to reflect their significance to the biological productivity of the stream. Primary characteristics (1-3), related to streambed composition and instream cover, are ranked between 0 and 20 points. Secondary characteristics (4-6), related to channel structure and stability, are ranked between 0 and 15 points. Tertiary characteristics (7-9), related to streamside vegetation, are ranked between 0 and 10 points.

Assign a score for each of the nine characteristics surveyed in Step 4.2 using the scoring table in the Interpretation Sheet, Step 5. Add the values to get the total score for your reference site.

Collecting, Reporting, and Evaluating Information

Send copies of the data to the Streamkeepers Database. The current address is in the Handbook. If the total score for your reference site is in the marginal or poor category, check the individual scores to identify particular problems at the site. This will help you choose a focus for your initial restoration efforts. You may wish to confirm poor results by doing water quality or stream invertebrate surveys at the site (Modules 3 and 4).

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

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Rabe, F.W. 1992. *Streamwalk II: Learning How to Monitor our Streams.* Idaho Water Resources Research Institute, Univ. of Idaho. 61 pp.

Schuett-Hames, D., A. Pleus, L. Bullchild, and S. Hall. 1994. *Timber-Fish-Wildlife Ambient Monitoring Program Manual.* Northwest Indian Fisheries Commission, Washington State.

send the data to: Streamkeepers Database, Department of Fisheries and Oceans,
Suite 400, 555 W. Hastings Street, Station 321, Vancouver, B.C. V6B 5G3
or fax to (604) 666-0292

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2**

Stream Name/Nearest Town:		Date
		Watershed code
Organization Name:		
Contact Name:		Phone #
Crew Names:		Stream Segment #
		Stream Section #
		Length Surveyed

Upstream End Point

Mapsheet number_______________ Type________________ Scale__________________
Location (distance from known stream landmark, directions to benchmark)
Time:______ Weather ‘ clear ‘ shower (1-2.5 cm in 24 hr) ‘ snow ‘ overcast ‘ storm (<2.5 cm in 24 hr) ‘ rain on snow
Water turbidity (cm visibility) _________________________ Temperature °C (leave thermometer 2 min.) air ___________ water _______________
Measurements taken every _____ m
Bankfull Channel width __________(m) Average depth _____________(m)
Wetted Channel width __________(m) Average depth _____________(m)

Downstream End Point

Mapsheet number_______________ Type________________ Scale__________________
Location (distance from known stream landmark, directions to benchmark)
Time:______ Weather ‘ clear ‘ shower (1-2.5 cm in 24 hr) ‘ snow ‘ overcast ‘ storm (<2.5 cm in 24 hr) ‘ rain on snow
Water turbidity (cm visibility) _________________________ Temperature °C (leave thermometer 2 min.) air ___________ water _______________
Measurements taken every _____ m
Bankfull Channel width __________(m) Average depth _____________(m)
Wetted Channel width __________(m) Average depth _____________(m)

(Upstream) First and Last Measurements taken .1 m from streambank edge (Downstream)

Left Bank								**Right Bank**
Wetted Depth								Wetted Depth
Bankfull Depth								Bankfull Depth

Left Bank								**Right Bank**
Wetted Depth								Wetted Depth
Bankfull Depth								Bankfull Depth

Take measurements every 0.5m in streams less than 5m wide, every 1m in streams 5 to 15m

Page ___ of ___

send this data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2**

Stream Name	Date	
Organization Name	Stream Segment #	Section #
	Map Sheet #	

STEP 1. BENCHMARK LOCATION

Directions to benchmark

STEP 2. CROSS-SECTIONAL SURVEY

Location relative to benchmark	Photos taken: (yes or no)
Bankfull channel width (m)	Average bankfull depth (m)
Wetted channel width (m)	Average wetted depth (m)

Measurements taken every _____ metres
Cross-sectional plot

Left Bank									**Right Bank**
Wetted Depth									Wetted Depth
Bankfull Depth									Bankfull Depth

STEP 3. STREAM DISCHARGE

Cross-sectional area of wetted stream (m^2) __________ x ____________ = ___________(m^2)
wetted width **average wetted depth**

Average Time (sec)
[_____ + _____ + _____ + _____ + _____] = ______ ÷ 5 = ______________
trial 1 **trial 2** **trial 3** **trial 4** **trial 5** **total trials** **Average Time (sec)**

Average Velocity (m/sec) _________ ÷ ______________ = ______________________
length (m) **average time (sec)** **Average Velocity (m/sec)**

Average Stream Discharge (m^3/sec) ____________ x _____________ x ___0.8___ = __________
cross sectional area (m^2) **average velocity (m/sec)** **correction factor** **Discharge (m^3/sec)**

send the data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2**

Stream Name	Date
Organization Name	Stream Seg # Section# Map Sheet #

STEP 4.1 LONGITUDINAL SURVEY, MEASUREMENTS

	Photos (yes, no)
Length of survey site (minimum 12 times the bankfull width) Minimum _____ (m) Actual______(m)	
Upstream survey boundary (m upstream of benchmark) Minimum _____ (m) Actual _____ (m)	
Downstream boundary (m downstream of benchmark) Minimum _____ (m) Actual _____ (m)	

* distance **upstream** (Up) of benchmark

habitat unit type (pool or riffle)	bottom of habitat unit*	top of habitat unit*	length of habitat unit (m)	% slope	Photo Frame #
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			

* distance **downstream** (Dn) of benchmark in metres

habitat unit type (pool or riffle)	top of habitat unit*	bottom of habitat unit*	length of habitat unit (m)	% slope	Photo Frame #
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			

send the data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2: (con't)**

Stream Name	Date
Stream segment and section #'s	

STEP 4.2 LONGITUDINAL SURVEY, HABITAT QUALITY

1. Streambed material Collect 25 samples 1 8 15 22 2 9 16 23 3 10 17 24 4 11 18 25 5 12 19 6 13 20 7 14 21	% fines (<0-2cm) - ladybug size and smaller % gravel(0.2-5 cm) - ladybug to tennis ball % cobble (5·25cm) - tennis ball to basketball % boulder (>25cm) – bigger then a basketball with definable edges % bedrock - slab of rock	*Fines* = ______% *Gravel* = ______% ***Cobble*** = ______% ***Boulder*** = ______% *Bedrock* = ______% ***Cobble + Boulder*** *Total* = ______%
2. % embeddedness - cover of gravel and cobble by fine sediment		_________%
3. Instream cover LWD ____________________________ Rooted cutbank	______ # pieces LWD + ______ # rooted cutbanks = ______ ÷ ______ = __________ total cover (length of reference site ÷bankfull width) instream cover	
4. Percent pool habitat survey site slope total length of reference site (m)	total length of pools (m) % pool habitat	
5. Off channel habitat (if present, describe habitat type, size, and whether it is seasonal or year-round)	description	PRESENT ABSENT
6. Bank stability (left or right bank facing downstream) # active bank erosion bank stabilization # slides reaching the channel	*# of sites and length of bank affected (m)* LEFT BANK RIGHT BANK _________ _________ _________ _________ _________ _________	
7. Length of bank with no vegetation (m)	LEFT BANK _____________	RIGHT BANK ___________
8. Overhead canopy	% bankfull channel covered by overhanging branches	
9. Riparian zone type and amount of vegetation	# of channel widths coniferous trees deciduous trees shrubs grasses	______________________ none ❑ few ❑ many ❑ none ❑ few ❑ many ❑ none ❑ few ❑ many ❑ none ❑ few ❑ many ❑
Adjacent land use and impacts		

send the data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet
(use a new data sheet for each reference site surveyed) **Module 2 (con't)**

Stream Name	Date
Stream segment and section #'s	

STEP 5 HABITAT ASSESSMENT ***(the score in bold, estimate a value within the range listed)***

Characteristic	Results	Good	Acceptable	Marginal	Poor	Score
1: Streambed material: **% boulder and cobble**		**15 - 20** 50%	**10 - 15** 30-50%	**5 - 10** 10-30%	**0 - 5** <10%	
2: Embeddedness:		**15 - 20** 25–0%	**10 - 15** 50-25%	**5 - 10** 75-50%	**0 - 5** >75%	
3: Instream cover:		**15 - 20** >3	**10 - 15** 2 to 3	**5 - 10** 1 to 2	**0 - 5** <1	
4: % Pool Habitat **<2% stream slope** **2-5% stream slope** **>5% stream slope**		**11 - 15** >60% pool >50% pool >40% pool	**7 - 11** 50-60% 40-50% 30-40%	**3 - 7** 40-50% 30-40% 20-30%	**0 - 3** <40% <30% <20%	
5: Off-channel habitat: ponds, side channels with protection from flood flows		**11 - 15** year round, good protection	**7 - 11** seasonal, good protection	**3 - 7** seasonal, minimal protection	**0 - 3** little or none, no protection	
6: Bank stability **stability**		**11 - 15** stable	**7 - 11** moderately stable	**3 - 7** moderately unstable	**0 - 3** unstable	
evidence of erosion or bank failure ***(see note 1)***		none	some	some	lots	
7. Bank vegetation: % stream bank covered by vegetation		**8 - 10** >90%	**5 - 8** 70-90%	**2 - 5** 50-70%	**0 - 2** and <50%	
8. Overhead canopy: % bankfull channel overhung by trees and shrubs		**8 - 10** >30%	**5 - 8** 20-30%	**2 - 5** 10-20%	**0 - 2** 0-10%	
9. Riparian zone: **# bankfull channels wide**		**8 - 10** 2 or more	**5 - 8** 1 to 2	**2 - 5** <1	**0 - 2** 0	
trees and shrubs		abundant on whole floodplain	good species mix	common, few species	sparse or absent	
TOTAL SCORE		**102 - 135**	**66 - 102**	**30 - 66**	**0 - 30**	

Note 1: The evidence of erosion or bank failure changes from **Good** (intact banks) to **Acceptable** (healed or banks stabilized) to **Marginal** (active erosion or extensive bank stabilization) to **Poor** (many actively eroding areas or upslope slides reaching channel).

STREAMKEEPERS

Module 3
Water Quality Survey

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	recommended	2 days to ongoing	2 or more	Low flow high flow

Fisheries and Oceans Pêches et Océans

Canada

MODULE 3:
Water Quality Survey

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide you with more information.

Acknowledgements

Kim Fulton provided the information for this module. He is a Water Stewardship Coordinator and a teacher in Armstrong. John Fyke, a high school teacher in Vernon, condensed and field tested the procedures.

Project Activity and Purpose

This module provides instructions on measuring dissolved oxygen, pH, temperature, and turbidity using commercially available kits and simple equipment. The data are incorporated into a water quality index. You will sample water at several locations during at least two seasons of the year.

Information about water quality helps you identify and evaluate problem areas in your watershed. If you decide to develop a restoration project, water quality monitoring will help you evaluate the effectiveness of your effort. Water quality monitoring is useful with many other Streamkeepers projects, as well.

Introduction

Water quality surveys provide information about the chemical composition of water. The background water chemistry determines the kinds of plants and animals that can live there. Water quality changes reflect watershed changes. This type of monitoring is not designed to detect transient problems like toxic chemical spills. You would measure these only if you happened to be sampling at the time of a spill. The Observe Record Report Module (Module 9) provides advice on collecting samples from a toxic spill.

Urban, agricultural, resource, and industrial developments often remove natural vegetation along streams and in other areas of a watershed. When buildings and paved surfaces replace natural vegetation, there is less ground surface available to absorb precipitation. Sediment, nutrients, and contaminants wash into streams, and degrade water quality. Water temperature and flow fluctuate more widely and composition of the stream bed changes. Some species of plants and animals die because they cannot adapt to these changes. Pollution-tolerant species become established.

Community and high school groups have used water quality surveys to detect and address major problems. This module adapts sampling methods developed by Mitchell and Stapp (1994) for the

Rouge River in Detroit, Michigan. By the 1980's, the Rouge River had suffered from years of abuse. Once, it even caught on fire! Students at Detroit high schools analyzed stream water for dissolved oxygen, temperature, pH, turbidity, fecal coliform, nitrate, phosphate, biological oxygen demand, and total solids. They studied local community attitudes and used computers to transfer information among schools. They identified problems with raw sewage, industrial outfalls, poor land management, and erosion. These students learned to contact the appropriate agencies, use the media to raise community awareness about problems and solutions, and organize community projects. The Rouge River is dramatically cleaner now.

Measuring a few key characteristics at critical times of year can help you identify problems in the watershed and select appropriate restoration projects. Long-term monitoring helps detect changes in watersheds before severe damage has occurred.

Project Guidance and Approval

You need no formal approval. A Streamkeeper certification course offers training for this module. Contact your Community Advisor for advice about equipment and similar projects in your watershed. This is a good project to coordinate with other groups in the same watershed. You may wish to share information with other groups or government agencies.

Level Of Effort

Groups of two to four people can sample one location. Divide larger groups and send smaller groups to various locations. The project works well with high school or adult groups. Water quality measurements take about one hour per site.

Time of Year and Working Conditions

Take samples during at least two seasons of the year. Sample in late summer, when stream flow is very low during an extended hot, dry spell. Also, sample when flows are high during the peak runoff period. For coastal streams, this is some time between November and February, during the extended period of heavy rainfall. For inland streams, this is between May and July, during the freshet that accompanies snow melt. Sample more often if you have the resources (every two to four months). If you suspect that turbidity may be a problem after heavy rainfall, sample before, during, and after a storm.

Stream conditions may be cold and wet, with fast flows or potentially contaminated water. Some procedures involve caustic chemicals.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Supervise children in and around streams. Carry emergency phone numbers for police, poison control centre, and ambulance.

Do not attempt to wade fast water or water higher than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Warn everyone, especially children, about urban hazards such as syringes, needles, broken glass, and condoms. Remove them with tongs and place them in a special hazardous materials bucket.

Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials. Contact emergency response agencies or municipal crews for removal.

Get permission to cross or use private property.

Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria and parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in remote areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear waders or boots with felts. Wear a personal floatation device (PFD) when working on large streams.

HANDLING CHEMICALS

Keep all chemicals away from young children. Avoid contact with skin, eyes, nose, and mouth. Read the label on each container before use, especially any precautionary notes or first aid information. In case of an accident or suspected poisoning, call the Poison Control Centre immediately. Be prepared to provide the name of the chemical in question.

Wear goggles. Use test tube caps or stoppers, not your fingers, to cover test tubes during shaking or mixing. Close all containers tightly immediately after use. Do not interchange caps from different containers.

Thoroughly rinse test tubes before and after each test. Deposit all solid and liquid chemical waste into separate labeled, covered containers. Dispose of them safely at home.

Materials And Equipment

cost: about $100 to $200. (Ask the Community Advisor about sources of equipment, such as sharing among groups or borrowing from schools)

boots or waders
data sheets
pencils
eyewash bottle
goggles
rubber gloves
pH kit (Hach no. 1470-00), wide range pH paper, or pocket pH meter
dissolved oxygen kit (Hach no. 1469-00)
thermometer (0.5oC divisions)
2 covered containers for dry and liquid chemical waste
clean 20 litre bucket for wash and rinse water
paper towels or dry cloths for cleaning glassware
turbidity kit (La Motte model TTM no. 7519), turbidity meter, or tape measure(carpenter's measure, black lettering on yellow background) and large bucket or garbage pail

See Module 9 (Observe Record Report) for equipment used to collect samples from a toxic spill.

Background Information

A) TEMPERATURE

Temperature is very important to aquatic life. Most aquatic organisms are cold blooded, so their body temperatures are the same as the water temperature. Table 1 describes the kinds of stream life at various temperatures. Water temperature increases when the sun shines directly on a stream. Shading from trees, water surface area and volume, turbidity, stream bed colour, and orientation to the sun all affect the amount of sunlight absorbed by water.

TABLE 1
Optimal Stream Life At Various Temperatures

TEMPERATURE RANGE	TYPES OF STREAM LIFE
20 - 25^o C (warm)	lots of plant life; high fish disease risk; warm water fish (bass, carp, crappie, catfish, bluegill); caddisflies, dragonflies
13 - 20^o C (cool)	plant life; moderate fish disease risk; trout, salmon, sculpins; stoneflies, mayflies, caddisflies, water beetles, water striders
5 - 13^o C (cold)	plant life; low fish disease risk;trout, salmon, sculpins; stoneflies,mayflies, caddisflies

Warm water contains less oxygen than cold water. When the water temperature increases, the concentration of dissolved oxygen decreases. As the temperature rises, animals use oxygen at a faster rate - the metabolic rate doubles with each 10o C increase. Plants grow faster and produce more oxygen. However, their decomposition consumes more oxygen. As the water temperature increases, animals become stressed and are more likely to succumb to contaminants, parasites, and disease. Organisms die when they cannot adapt to the new conditions.

Shading helps keep summer water temperatures low. Shaded streams are cooler than unshaded streams. In late summer, the water temperature increases between early morning and late afternoon. In unshaded streams, the daily increase can be as great as 10oC. Water loses heat very slowly even when it flows into shaded areas.

Removal of streamside vegetation is a major cause of temperature problems in British Columbia streams. Logging, agriculture, dyking, and urban development often remove streamside vegetation. This adds sediment to the stream from erosion. Besides causing other water quality problems, sediment absorbs heat from the sunlight thereby raising water temperature. Planting streamside vegetation helps correct the problem.

Water withdrawal for irrigation purposes often reduces stream flow during the summer, when flows are already at minimum levels. Low water flows contribute to problems with daily temperature fluctuation because there is less water to buffer the impact of high temperatures.

Thermal pollution from industrial sources also causes increased water temperatures. In addition discharges of water used as coolant may contain toxic antifouling agents or chlorine from municipal water sources.

B) DISSOLVED OXYGEN

Oxygen is essential for aquatic life as well as terrestrial animals. The amount of oxygen dissolved in water affects the number and kind of animals found there. Healthy streams are saturated with oxygen (90 to 110% saturation) during most of the year.

There are several causes of reduced dissolved oxygen levels in streams. Problems most often occur during the summer low flow period. Warm water holds less oxygen than cold water and shallow water heats up more quickly than deep water. Slow flowing water has little surface turbulence, so little oxygen mixes into the water. Organic wastes such as sewage and agricultural runoff consume oxygen as they decompose. Fertilizers from gardens and farmlands provide nutrients for algae and initially, the algae grow quickly and add oxygen to the water. However, later they decompose and consume oxygen.

During the summer low flow period, dissolved oxygen concentrations often fluctuate during the day. When water temperature increases during the day, the oxygen level decreases by late afternoon. Algal photosynthesis during blooms can increase the oxygen level during the day. Animal and plant respiration can depress the oxygen level during the night.

Planting stream bank vegetation helps to increase oxygen levels in streams. Foliage provides shade and roots absorb nutrients. Controlling sources of sewage, manure, and fertilizers also helps. Fencing keeps livestock away from streams. Building structures in streams helps to aerate the water.

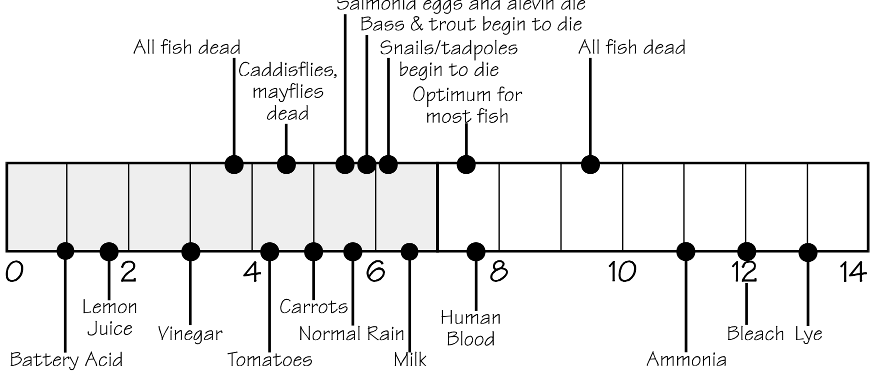
C) pH

The pH scale measures the relative acidity or alkalinity of any substance. The scale ranges from very strong acid, at pH 0, to very strong base, at pH 14 (Figure 1). Pure water has a neutral pH of 7, with an equal concentration of H+ (hydrogen) and OH- (hydroxyl) ions. Acidic water has a high concentration of hydrogen ions and a low concentration of hydroxyl ions. The reverse occurs in alkaline water. The scale is logarithmic, so a one unit difference in pH reflects a tenfold change in acid or alkaline concentration. For example, vinegar (pH 3) is ten thousand times more acidic than distilled water (pH 7).

Most aquatic organisms are sensitive to small pH changes and prefer a pH of 6.0 to 8.5. Waters with a pH beyond this range usually do not have enough species to maintain a food web. There are some specially adapted communities that inhabit water outside this pH range. They inhabit naturally acidic streams that drain hot springs or have high levels of tannic acid, or very productive alkaline lakes and streams.

Stream pH level depends on the geology of the surrounding area, and usually falls between 6.5 and 8.0. Streams that drain soils with high mineral content usually are alkaline, whereas streams that drain coniferous forests usually are acidic. Algal photosynthesis during a bloom can cause increased pH.

Figure 1 pH Scale



Air pollution from automobile and industrial emissions creates "acid rain" when nitrous oxide and sulphur dioxide dissolve in rainwater. Rain is normally acidic (pH 5.0 to 5.6), because water absorbs carbon dioxide from the air and transforms it into a weak acid. Heavy rainfall, snow melt, and road runoff can affect pH.

D) TURBIDITY

Turbidity is a measurement of the cloudiness caused by sediment, microscopic organisms, and pollutants. These suspended particles restrict light penetration in the water, which in turn affects algal growth and oxygen production. Sediment can clog gills or other breathing structures of fish and benthic invertebrates. When sediment settles to the stream bottom, it can smother fish eggs and ruins habitat used by fish and aquatic insects.

Some waters are naturally turbid and their communities have adapted to these conditions. Turbidity is high in streams that drain glaciers and streams in geologically young areas.

Turbidity normally increases during and after rain storms or rapid snow melt. Severe problems with turbidity occur in areas where urban development, logging, and agriculture have disturbed the watershed and caused erosion. You can assess the extent of the problem by comparing turbidity before, during, and after times of heavy runoff. You also can compare turbidity upstream and downstream of suspected point sources of pollution.

E) WATER QUALITY INDEX

You can use a simplified water quality index to compare results from different streams or from different sites on the same stream. This water quality index combines results from temperature, pH, dissolved oxygen, and turbidity tests. The original American index also considers levels of coliform, biological oxygen demand, total solids, phosphate and nitrate.

General Procedure

You may have established reference sites already while surveying the stream (Modules 1 and 2). Sample the water at the reference sites. You may be interested in sampling other locations as well. If you wish to investigate a specific pollution problem, sample immediately upstream and downstream of the problem, and, if possible, further downstream in a recovery area. If you wish to compare results from year to year, make sure to keep the location, time of day, and weather and stream conditions consistent. Record the stream location and condition information on the Data Sheet.

Never sample water you have walked through and disturbed. Start at the site furthest downstream and work your way upstream. Sample the water upstream of where you walk. Collect a large 20 litre bucket of water to use for cleaning the bottles.

Take temperature, dissolved oxygen, and pH samples in shallow fast-moving water midway across the stream, so you have well-mixed water samples. This is not safe during the peak flow period, so take samples from a riffle area while standing on a stable stream bank.

Take water from below the surface. Collect water for dissolved oxygen and pH tests in the small bottles included in the kits. Rinse the sample bottles with stream water, then collect the samples. Follow the instructions in the kits. Do the test immediately after you take a sample. Do the calculations when you have finished all the tests.

After the test, clean the bottle using water from the bucket. Discard the first rinse water in the liquid waste container. Put all dry chemical and packaging waste in the dry waste container.

Take a turbidity measurement at midstream if you are using a turbidity meter. Move to a deep, slow-moving pool if you are using a tape measure.

Water Quality Procedure

A) TEMPERATURE

Take temperature readings twice a day if you suspect problems with daily temperature fluctuations. Measure as early in the morning and late in the afternoon as possible. If you suspect thermal pollution, take temperature readings upstream and downstream of the source within a very short time span.

Lower the thermometer 10 cm below the water surface and keep it submerged for two minutes. Read the temperature while the thermometer is still in the water. Record the temperature readings on the Field Data Sheet, Part A. Calculate temperature differences for times of day or sites and record the changes on the Interpretation Sheet, Part E.

B) DISSOLVED OXYGEN

Take the dissolved oxygen sample in late afternoon, when you are measuring temperature. The oxygen level generally is at its lowest for the day then. Follow the instructions and safety procedures included in the Hach kit. Collect the water samples carefully, so you do not introduce air from agitation or bubbling.

The test results are in parts per million (ppm) or milligrams per litre (mg/l). Use the temperature and oxygen concentration data to calculate percent saturation using Figure 2. Use a ruler to join up the oxygen and temperature readings. Read the percent saturation value where the ruler crosses the middle line. Record the concentration and percent saturation on the Field Data Sheet, Part B.

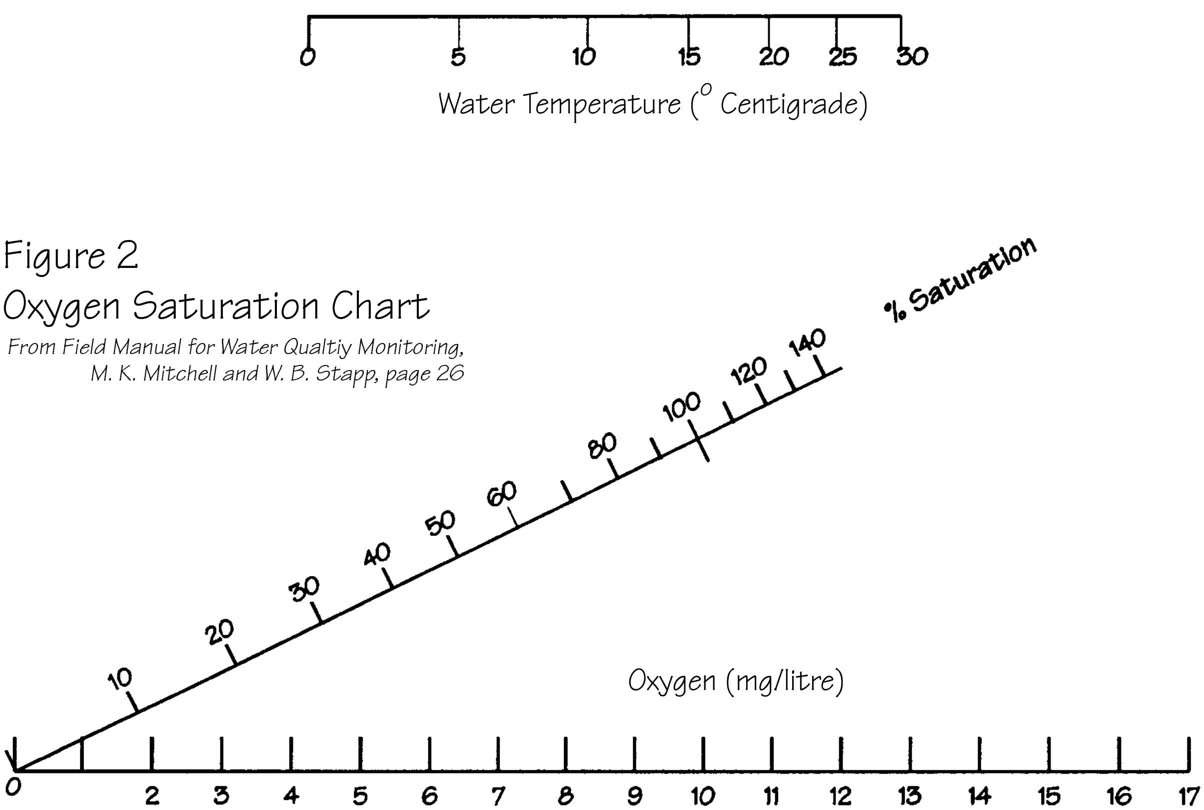


Figure 2
Oxygen Saturation Chart
From Field Manual for Water Qualtiy Monitoring, M. K. Mitchell and W. B. Stapp, page 26

C) pH

Measure pH in late afternoon, when you are measuring the temperature. Follow the directions included with the Hach pH kit. If you are using pH paper instead of the Hach kit, dip the paper in the stream water, then match the colour to the chart included with the paper. Repeat the test to check for reliability. If you use a pocket pH meter, make sure you calibrate it properly. Record the result on the Field Data Sheet, Part C.

D) TURBIDITY

Measure turbidity at peak flood time during the high flow period, when water clarity is likely to be poorest. Knowing normal background turbidity levels is important for comparison. Measure turbidity at other times during the season, when turbidity is not a problem. During low flow periods, measure turbidity when you are taking a late afternoon temperature reading.

Measure turbidity at midstream if you are using a turbidity meter. Follow the instructions on the La Motte turbidity kit. The results are in Jackson Turbidity Units (JTU's). Other types of turbidity meters give results in nephelometric turbidity units (NTU's). NTU and JTU units are interchangeable.

You can use a tape measure to measure turbidity. Do the measurement in a deep, quiet area, but be careful not to stir up sediment. In very shallow water, collect water and do the procedure in a bucket or garbage can. For consistency, use a tape with black numbers on a yellow background. Focus on the number one near the end of the tape and lower it until you cannot see the number. Read the depth at the water surface and subtract one to get the true depth visibility.

Record turbidity readings on the Field Data Sheet, Part D.

E) Q-VALUES AND WATER QUALITY INDEX

Record the results on the Interpretation Sheet, Part E. There are charts of Q-values versus results for the four parameters. Find the Q-value by reading up from your observed result to the point where it meets the curved line, then read across to the Q-value on the left-hand side. Record the Q-value in the table beside the corresponding result. Multiply the Q-value by the weighting factor for each characteristic. Add the results for all four values to get the Total Water Quality Index for the site.

Collecting, Reporting, and Evaluating Information

Compare the water quality rating for your sites with the Table on the Interpretation Sheet. Rate water quality as good, acceptable, marginal, or poor. Keep accurate records of your data. Share information with other groups working in the watershed. Send copies of all three data sheets for each site to the Streamkeepers Database. The current address is listed in the Handbook.

Before you react strongly to evidence of poor water quality, remember that your survey uses simplified versions of scientific methods and equipment. Although the results of your tests usually are reliable, there are exceptions to any rule. Sometimes stream conditions appear abnormal, but are in fact natural in a particular area. Make sure you have reliable background data to compare with data from problem sites. If the calculated Q-value is less than 50 for any parameter, it may be cause for concern. Data from habitat and invertebrate surveys (Modules 2 and 4) may provide support for the conclusions you have reached from your water quality surveys. Be prepared to contact an agency with the appropriate expertise, for assistance.

You can monitor water quality over many years. Once you have collected baseline data, you will find improvement or deterioration in water quality at specific locations. The water quality results allow you to identify problems, choose suitable rehabilitation projects, and evaluate the success of those projects.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact radio stations, television stations, and newspapers. Module 10 contains specific information about increasing community awareness and working with the media.

References And Resources

Adopt-A-Stream Video. Available from the Community Advisor.

Friends of Environmental Education Society of Alberta. 1990. *Adopt-A-Stream*. Order from:

FEESA,
#320 - 9939 Jasper Ave.,
Edmonton Alta,
T5J 2X5
(phone 403-421-1497)

Oregon Dept. Fish and Wildlife. 1990. *The Stream Scene: Watersheds, Wildlife and People.* Order from:

Oregon Dept. Fish and Wildlife,
Office of Public Affairs,
P.O. Box 59,
Portland, Oregon, 97207
(phone 503-229-5400 Ext 432)

Mitchell, M. K. and W. B. Stapp. 1994. *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools.* Order from:

W. B. Stapp,
2050 Delaware Ave.,
Ann Arbor, Michigan, 48103

Yates, S. A. 1991. *Adopting a Stream: A Northwest Handbook*. University of Washington Press, Seattle, WA.

send the data to: Streamkeepers Database, Department of Fisheries and Oceans, Suite 400, 555 W. Hastings Street, Station 321, Vancouver, B.C. V6B 5G3 fax to (604) 666-0292

Stream Location and Conditions

(use a new data sheet for each stream segment surveyed) **Module 3**
(see Module 1 for additional information)

Stream Name/Nearest Town	Date
	Watershed code
Organization Name	Stream Segment #
	Stream Section #
Contact Name	Phone #

Survey Location

Mapsheet number	Type	Scale
Location (distance from known stream landmark)		
Time:______ Weather	‘ clear ‘ shower (1-2.5 cm in 24 hr) ‘ snow ‘ overcast ‘ storm (<2.5 cm in 24 hr) ‘ rain on snow	
Water turbidity (cm visibility)	Temperature ^{o}C (leave thermometer 2 min.) air __________ water ______________	
Bankfull Channel width __________(m)	depth _____________(m)	
Wetted Channel width __________(m)	depth _____________(m)	

First and Last Measurements taken .1 m from streambank edge

Left Bank									**Right Bank**
Wetted Depth									Wetted Depth
Bankfull Depth									Bankfull Depth

Take measurements every 0.5m in streams less than 5m. wide, every 1m in streams 5 to 15m.

send this data to the Streamkeepers Database

Water Quality Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 3**

Stream Name	Date
Organization Name	Stream Segment # Section # Map Sheet #

A) Temperature: Keep thermometer in water 2 min. and take the reading while it is still in the water

Use this section if you are concerned about daily temperature changes.

Time of day	air (^{0}C)	water (^{0}C)
_____a.m.		
_____p.m.		
Difference in water temp.		

Use this section if you are concerned about temperature differences between sites.

Site	air (^{0}C)	water (^{0}C)
upstream		
downstream		
difference in water temp.		

B) Dissolved oxygen: Take samples with a Hach kit when you take the late afternoon temperature reading. Determine % saturation from figure 2

Concentration (mg/l)	
% saturation	
Equipment (if not Hach kit)	

C) pH: Take samples when you take the late afternoon reading.

pH reading	
equipment	

D) Turbidity: Measure turbidity in a deep quiet area. Be careful not to disturb sediment. Use a turbidity meter or tape measure.

Turbidity (JTU, NTU, or cm)	
Background turbidity (if known)	
Turbidity increase over background	
equipment	

send the data to the Streamkeepers Database

Water Quality Survey Interpretation Sheet

Module 3

(use a new interpretation sheet for each site)

Stream Name	**Date**
Organization Name	**Stream Segment #**
	Map Sheet #

Q-VALUES*:* Calculate Q-values using these charts. Find the water quality result on the horizontal axis, follow up to the curve, then read the Q-value off the vertical axis. Q-values less than 50 may be cause for concern and merit further investigation.

E) Water quality index:

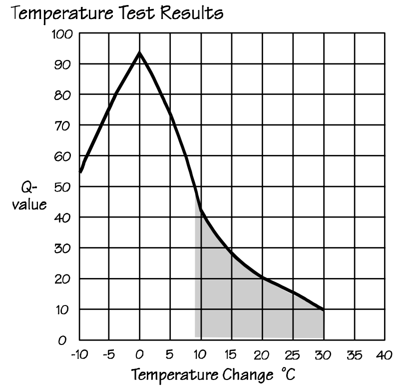
Fill in the table below with data and Q-values. Multiply the Q-value by the weighting factor to get the partial index value for each characteristic. Add up all four values to get the Water Quality Index. Rate water quality at your site using the chart at the bottom.

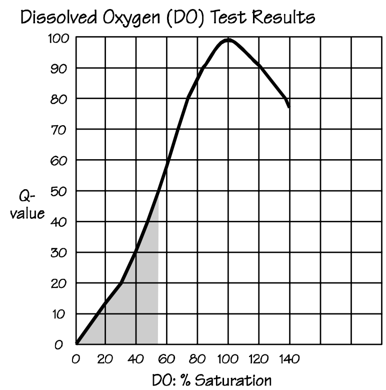
Chemical Test	Result	Q-value	Weighting Factor	Index Value
temperature change			x 0.10 =	
oxygen saturation			x 0.17 =	
pH (units)			x 0.11 =	
Turbidity (JTU, NTU, or cm ✪)				
Total = Water Quality Index				

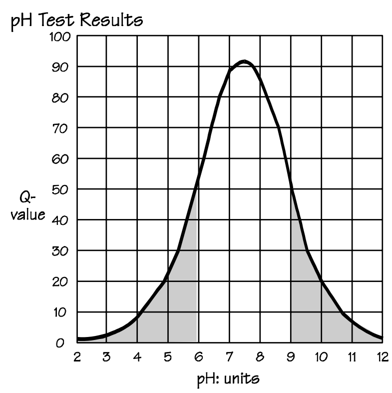
✪ amount above background, if available

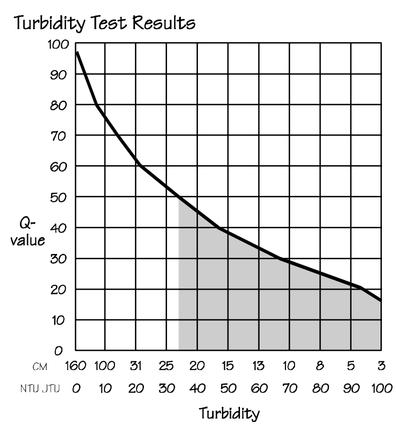
Water Quality Chart	
Good	**0-45**
Acceptable	**30-40**
Marginal	**20-30**
Poor	**<20**

= Q-value less than 50









adapted from Mitchell and Stapp, 1991

Figure 1 pH Scale

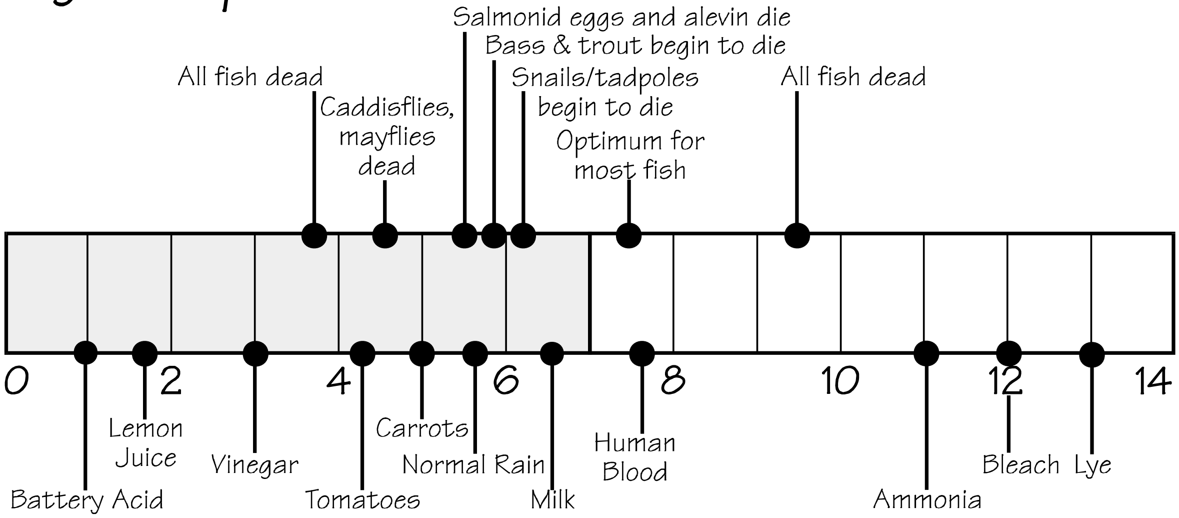
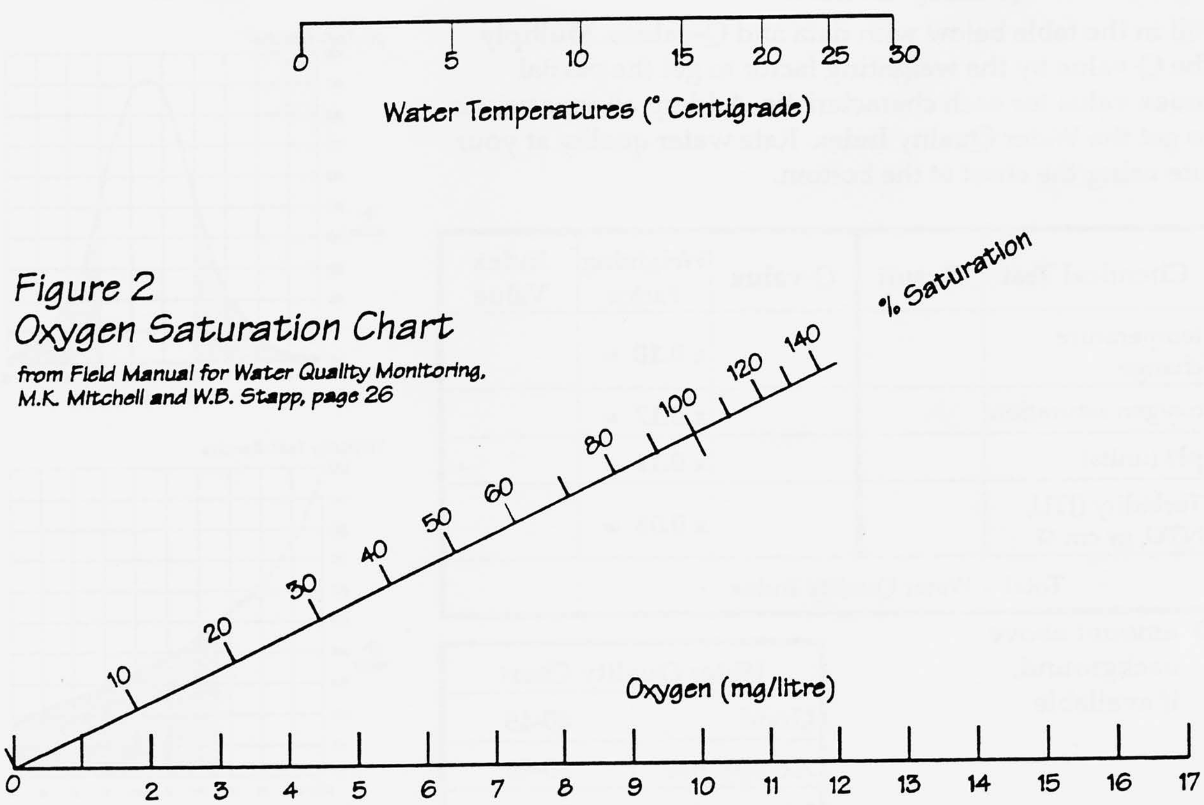


Figure 2
Oxygen Saturation Chart

from Field Manual for Water Quality Monitoring, M.K. Mitchell and W.B. Stapp, page 26



STREAMKEEPERS

Module 4
Stream Invertebrate Survey

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	recommended	2 days to ongoing	2 or more	Early spring early fall

Fisheries and Oceans Pêches et Océans

Canada

MODULE 4:

Stream Invertebrate Survey

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage"hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Michele Nielsen of the Comox Project Watershed Society and Catherine Cardinal, education coordinator for the Salmonid Enhancement Program provided material for this module. Material originated with several projects, including the Adopt-A-Stream Foundation (Everett, Washington), Alaska Water Watch (Alaska), and Save our Streams (Maryland).

Project Activity and Purpose

You will select one or more sampling locations in a stream, and collect invertebrates from the stream bottom. On shore, you will sort, identify, and count the invertebrates, then return them to the stream. The data you collect will help you assess the health of your stream, changes over time, and impacts of pollution.

Introduction

Pick up a rock from a stream and turn it over. Those wiggly critters you see are benthic macroinvertebrates - bottom dwelling, spineless creatures that are small but visible to the naked eye. Most of them are insects at immature stages of development, but worms, snails, and clams also can be found. The kinds and numbers of invertebrates give a good indication of stream health.

Some species of invertebrates require very good water quality, whereas others tolerate a wide range of environmental conditions. Although invertebrates can move about in the stream and drift downstream, they do not move as quickly as fish to avoid adverse conditions. Deteriorating water quality and pollutants usually kill the less tolerant species and encourage other more tolerant ones. You can compare invertebrate populations in different parts of your stream or in different streams in the area. These comparisons will help you to decide whether a stream is healthy or has chronic or periodic water quality problems.

Samples taken in one location, over time, provide information about changes in stream health, seasonal changes, and normal annual variation. Samples taken at several locations provide information about specific problems in a particular watershed.

Project Guidance And Approval

You require no formal approval or permit. Check with your Community Advisor for current information about your stream. Ask for permission to cross or use private property. A Streamkeepers certification course offers training for the module.

Avoid spawning fish and spawning habitat (redds) when sampling. Salmonid eggs will not survive if you disturb them. Because of the wide variety of species of salmonids, eggs can be present any time of year.

Level Of Effort

The survey takes from one half to one whole day, depending on the number of stations. Take samples at least twice a year. You need two people to sample in the stream. Others can stay on shore to sort, identify, and count invertebrates. You will need at least two hours to collect and process the samples at each site. Instructions for an alternate quick and simple method are included in the procedure.

Time of Year and Working Conditions

Early spring (when water temperature is less than 7oC) and fall (before heavy rainfall) are the best times of year to sample. Many invertebrates are large and easy to identify then. Do not sample the stream during or soon after a flood, because conditions may be dangerous and many organisms will have been washed away.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Choose easily accessible, safe sites. Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Warn everyone, especially children, about urban hazards such as syringes, needles, broken glass, and condoms.Remove them with tongs and place them in a special hazardous materials bucket, or flag them with bright tape. Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials. Contact emergency response agencies or municipal crews to remove these materials.

Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear waders with felts when walking in the stream. Wear highly visible clothing.

Materials And Equipment

Surber sampler or 30 cm wide D net (363 micron mesh size)

waders or high boots
scrub brush or nail brush
white 20 litre bucket
ice cube trays (at least 2)
eye droppers or pipettes
laminated field key
pencils
hand lens or magnifying glass
thermometer
insulated rubber gloves
shallow white tray
plastic spoons
gridded pan (optional)
data sheets
blunt tweezers
first aid kit

optional for preserving samples: (seldom recommended)

99% isopropyl alcohol
bottles, labels

optional for a very quick survey:

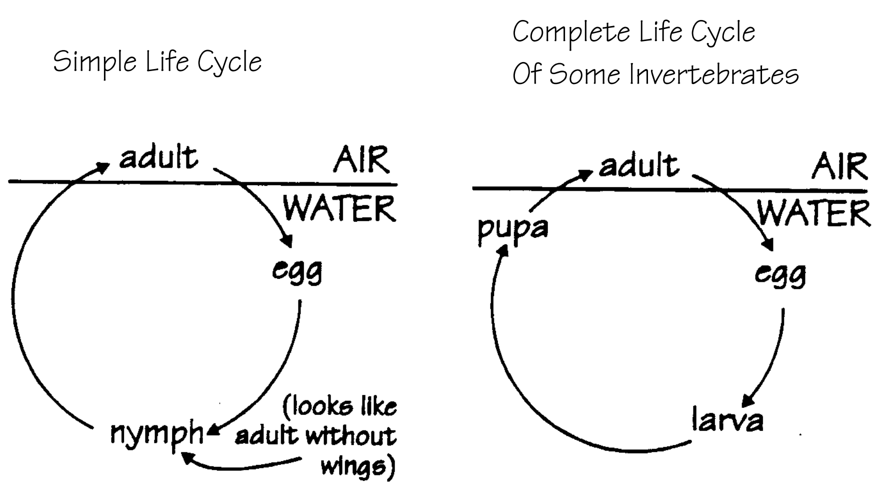
small bucket
laminated field key
scrub brush or nail brush
paper, pencils

Background Information

LIFE CYCLES

Life spans of invertebrates range from days to years, depending on the species. Worms, snails, and clams spend their lives in water. Adult aquatic insects live very briefly in the air, mate, and then lay eggs in the water. Most of their life is spent in the water, in the larval stage. Some insect species pass through true larval and pupal stages before they emerge as adults (Figure 1). Other species grow through a series of nymph stages that resemble wingless adults, then emerge as adults.

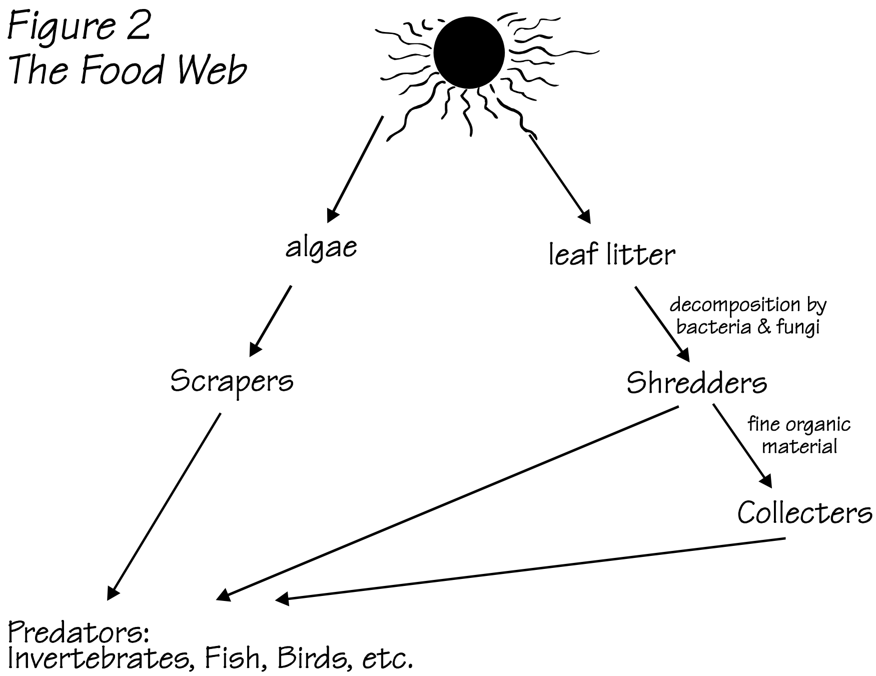
Figure 1 Life Cycle of Aquatic Insects



FOOD WEB

Figure 2 illustrates how food energy in streams is converted. The sun provides energy for plant growth in and around streams. Bacteria and fungi feed on dead plant material. Many herbivorous invertebrate species feed on the algae, bacteria, fungi, and partially decomposed leaves. These invertebrates provide food for predators such as other invertebrates, juvenile and adult fish, reptiles, amphibians, and birds. Aquatic insect larvae and adults are the main food source for many fish, including salmonids. The pathway shown on the right in Figure 2 is most common in headwater streams and the pathway shown on the left is most common in larger streams and rivers.

Figure 2
The Food Web



THE STREAM CONTINUUM

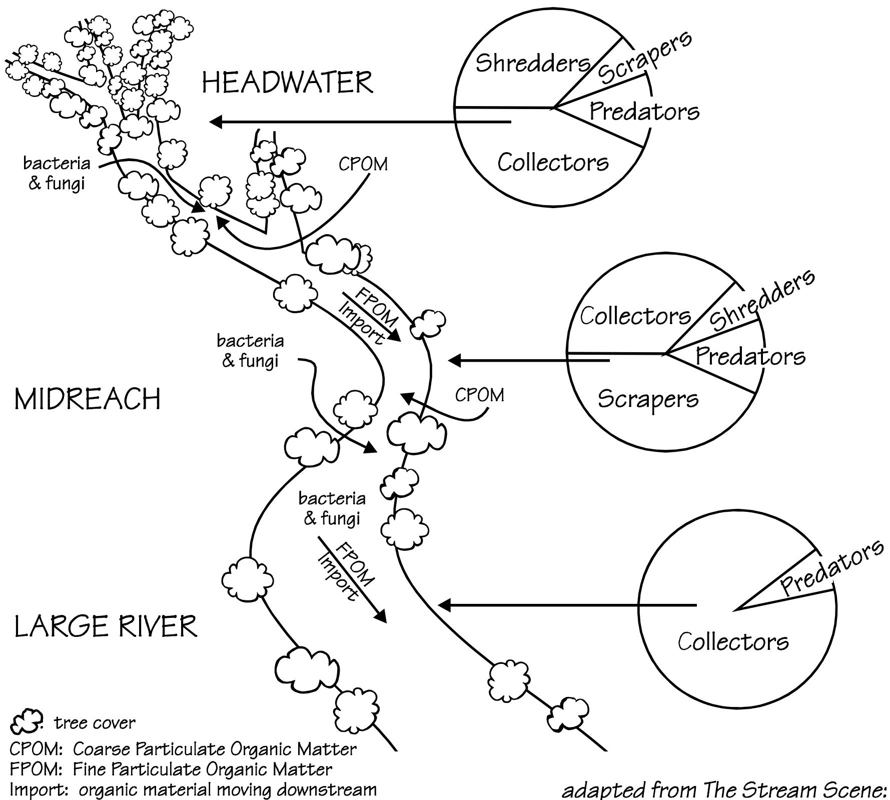
Gradient, stream flow, bottom composition, and streamside vegetation change as streams flow from headwaters, through mid-reaches, into large rivers. These changes in habitat affect plant and animal species in streams, and changes in these species in turn alter the types of food available within the food web.

Invertebrates are classified as shredders, collectors, scrapers, or predators, depending on how they feed. Table 1 describes food, habitat, and some examples of each feeding type. The table is simplified, in that there are thousands of species of invertebrates. Feeding types are not consistent, even within families or genera. However, recognizing the major feeding types in a sample provides useful information about the stream. A good diversity of species and feeding types suggests a healthy stream.

TABLE 1
Feeding Types, Food Sources and Habitats of Stream Invertebrates

FOOD SOURCE	PREFERRED HABITAT	EXAMPLES
SHREDDERS		
leaves, needles, twigs which have had some bacterial decomposition (coarse particulate organic material, CPOM)	shaded headwaters, variety of streamside vegetation indicate good water quality	some stonefly nymphs, some caddisfly larvae
COLLECTORS		
fine particulate organic material from upstream (FPOM ,<1 mm size, e.g. faecal pellets, algae, bacteria, animal and plant fragments)	most abundant in mid-reaches, also in headwater areas; species such as worms are common in large rivers mayflies and caddisflies indicate good water quality; some midges and worms tolerate a wide range of conditions, including organic pollution	FILTERERS :blackfly larvae, clams, some caddisfly larvae <u>or</u> GATHERERS: some mayfly nymphs, midge larvae, some caddisfly larvae, worms
SCRAPERS		
graze on algae, bacteria, and fungi on stream bottom	areas favourable to algal growth: less shaded midreaches, headwater areas during spring and autumn when leaves are off trees	some mayfly nymphs, some caddisfly larvae, snails, water penny
PREDATORS		
small insects	anywhere there is prey	cranefly larvae, some caddisfly larvae; some stonefly nymphs, dragonfly and damselfly nymphs; crayfish, leeches

Figure 3:
Changes in the Aquatic Invertebrate Community as a Stream Widens



adapted from The Stream Scene: Watersheds, Wildlife and People, Oregon dept. of Fish & Wildlife

Figure 3 shows the "stream continuum" model. Dr. K. W. Cummins developed this model to predict changes that occur naturally in the invertebrate community. As with any model, there are exceptions. Generally, water volume and amounts of particulate matter, nutrients, and dissolved substances increase as a stream flows downstream. Gradient and substrate size decrease downstream, as does the importance of streamside vegetation as food. The highest species diversity occurs in the mid-reaches, where there are many food sources and habitat types.

POLLUTION TOLERANCE

Invertebrate communities provide an accurate reflection of stream health because individual species are suited to particular environmental conditions. Invertebrates die or flourish in response to changing water quality conditions. Many insect species require good water quality, especially the larvae of caddisflies, mayflies, and stoneflies. These species require clear, clean, well-oxygenated water, as do salmon and trout. Other insect larvae and aquatic worms tolerate a wider range of environmental conditions. Appendix 1 describes the pollution tolerance of many common types of invertebrates.

Shortcut Sampling Procedure

This alternate method is useful if you are interested in a quick look at invertebrates in a stream. However, many organisms, including those that live deeper in the stream bed are overlooked. Choose a shallow riffle area with moderately fast flow and stones about 5 to 25 cm in diameter. Pick up several rocks and brush or rub the surfaces into a small bucket of water. Pick up the invertebrates carefully with a spoon or eye dropper and examine them. Use the Identification Chart in Appendix 1 to identify them and sort them into pollution tolerance categories. Return the invertebrates, unharmed, to the stream. If most organisms you examine are pollution intolerant, your site probably is healthy. If there are very few pollution intolerant organisms, your site probably has some problems. The complete sampling procedure described below is better for answering these questions.

Complete Sampling Procedure

SELECT THE SAMPLING STATION(S)

Sample invertebrates at any reference sites you have established in Module 2, the Advanced Habitat Survey. If you have not established reference sites already, consider the purpose of your study when you choose sampling locations. For example, establish two or more stations to study the impact of a suspected pollution problem. Sample at an upstream control site, a site within the impact area, and further downstream, if possible, to check for recovery. When you sample more than one station on a stream, start downstream and work your way upstream. If you are interested in a general survey or long term monitoring, you will want to establish a reference site (Module 2).

Consider safety, stream conditions, and location of fish spawning habitat when you choose the sampling location. Do not sample near bridges, obstructions, or artificially modified areas, unless you are interested in these areas specifically. Avoid salmonid redds, which are elliptical depressions of newly cleaned gravel.

Sample a shallow riffle area with moderately fast flow and cobble substrate (rocks 5 to 25 cm in diameter). Choose an area typical of the riffles in this part of the stream. You will take three 30 cm by 30 cm (1 ft2) samples at each sampling station.

Describe your site on the Locations and Conditions section of the Data Sheet. Include stream name, date, station location, air and water temperatures, and recent weather conditions.

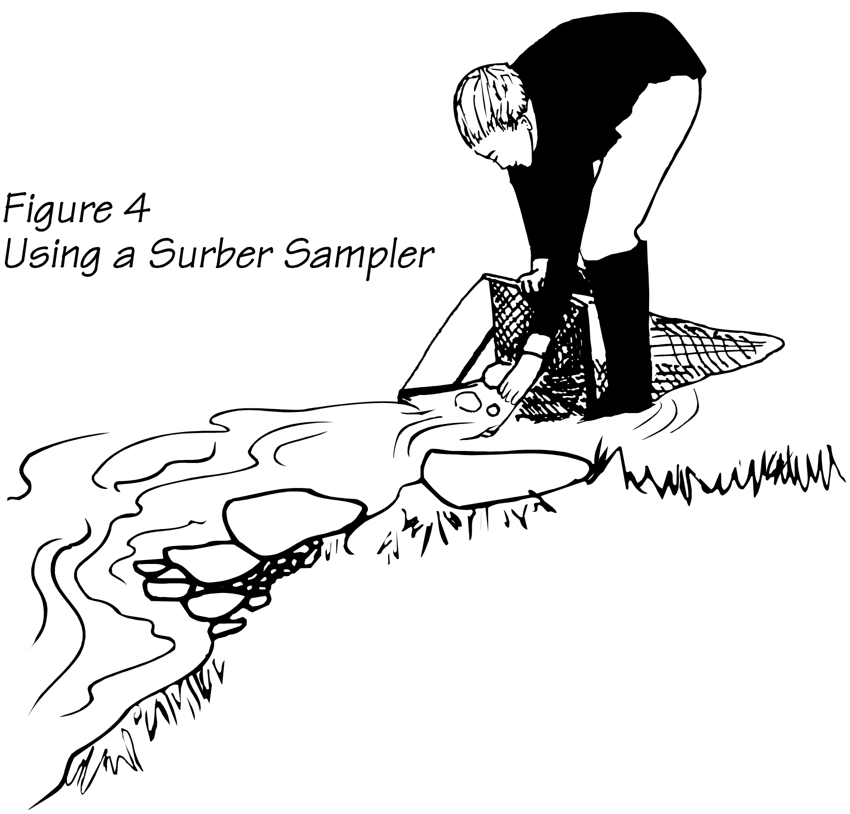
COLLECT THE SAMPLES

Approach the first sampling area from downstream. Do not disturb the sampling area by walking in it or upstream of it. Place the Surber sampler or D-net on the downstream edge of the sample area, so the opening faces into the flow. Push the frame a little way into the stream substrate. If you use a D-net you will need to measure the sampling area. The D-net is 30 cm wide (1 foot), so you can use it to measure the four sides of a 30 cm by 30 cm sampling area. Use large boulders to mark the corners of the square. The Surber sampler encloses an area 30 cm x 30 cm or 1 ft2 in size. Figure 4 shows a surber sampler.

Brush all stones and debris 5 cm or larger within the sampling area. Pick up a stone, hold it under water in front of the net and rub it gently with a brush or your hands. The loosened invertebrates will be swept into the net. Place the cleaned rocks outside the sampling area. Starting at the upstream end, gently agitate the streambed to a depth of 2 to 5 cm to loosen any remaining invertebrates.

Take the net to stream bank and turn it inside out in a bucket, half full of cool stream water. Transfer the invertebrates and debris into the bucket by carefully rinsing or shaking the net, then scraping it with a plastic spoon. Gently pick off organisms that cling to the net. Handle them carefully to avoid injuring them and keep them in the shade. Make sure the entire sample is in the bucket. Check larger pieces of debris in the bucket for bugs, then discard the debris.

Figure 4
Using a Surber Sampler



Take two more samples and combine them with the first one. Analyse and report the results for the three combined samples. Invertebrates are not distributed evenly in streams, so, even at one station, you can expect to find some samples with very few invertebrates and others with many.

IDENTIFY AND COUNT THE INVERTEBRATES

Sort the sample:

Pour some invertebrates from the bucket into a shallow white tray of water. Fill the compartments of two ice cube trays with stream water. Handle the invertebrates gently with tweezers, spoons, or eye droppers. Many will be active. Sort them into separate compartments of the ice cube trays based on obvious differences in appearance. Continue sorting until there are no invertebrates left in the bucket.

Identify the invertebrates:

Use the Invertebrate Field Identification Chart in Appendix 1 to identify the organisms. Appendix 2 contains a key to invertebrates, for those people who are familiar with keys. Figure 5 illustrates the terms for various parts of their bodies. The chart identifies major taxa or groups (classes, orders, families), not species. There are thousands of species and most are difficult to identify. Taxon (plural taxa) is a general term referring to identifiable groups like species, genera, families, orders, or classes. Two different looking organisms usually are different taxa, although sometimes they are two life stages (e.g., larva, pupa) of the same species.

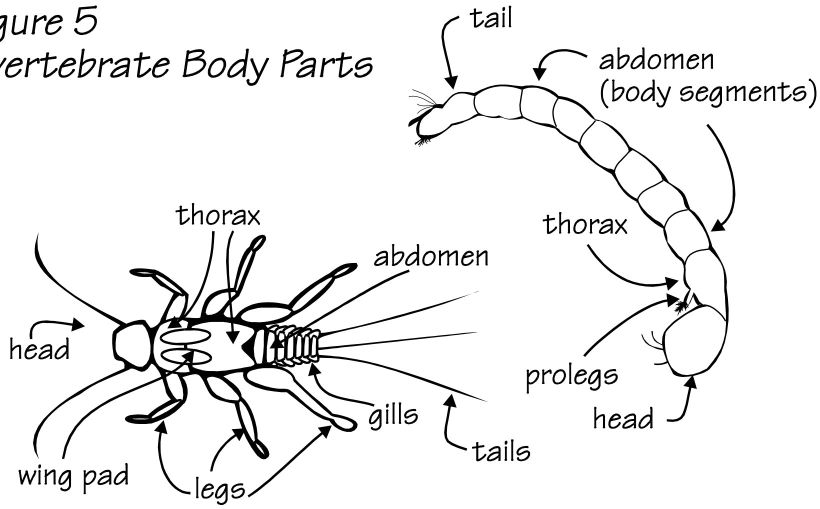
Within each broad taxonomic group, distinguish as many kinds of organisms as possible, based on appearance. For example, there may be a few obvious types of caddisflies in a sample. You do not need to name them, just recognize them as different. Use a hand lens (10X magnification) or magnifying glass to examine small organisms.

Count the invertebrates:

Record the numbers counted (Column B) and the number of identifiable taxa (Column C) for each broad taxonomic group on the Invertebrate Survey Field Data Sheet. Record the total number and calculate the density (number per m2) in Part A of the Interpretation Sheet. Record the most abundant or predominant taxon in Part B. Return the organisms to the area of the stream you sampled. Occasionally, you may want to preserve a sample for future analysis or teaching, but we usually do not recommend it. To prepare a sample, remove as much water as possible and add concentrated isopropyl or ethyl alcohol to make a 70% solution of alcohol in water. Transfer the sample to a labeled bottle.

You can use a tray marked with a grid on it if you find high

Figure 5
Invertebrate Body Parts



numbers of one type of organism in the sample. First, remove all the different looking invertebrates, then spread the remaining ones on the gridded tray. Examine a few grid squares and count the average number of individuals per square. Multiply the average number per square by the total number of squares on the tray to get the total number.

ASSESS THE WATER QUALITY

Pollution Tolerance Index:

The Identification Chart and Field Data Sheet (Column A) categorize the broad taxonomic groups according to their tolerance of organic pollution. Category 1 includes pollution sensitive species found only in high quality water. Category 2 includes species that tolerate some pollution and are found in high or fair quality water. Category 3 includes pollution tolerant species that are found in a wide range of conditions. Find the number of broad taxonomic groups in Column D in each Pollution Tolerance Category. Record the numbers in Part C of the Interpretation Sheet. Calculate the water quality rating using the formula provided in that section.

EPT Index:

Members of the insect groups Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, caddisflies, or EPT) often are grouped together because they all require clean water. Calculate the total number of EPT taxa (from column C, Field Data Sheet) and record the total as the EPT index in Part C of the Interpretation Sheet. Use caution to interpret your results, since results can be biased: experienced workers can distinguish more taxa than inexperienced ones.

EPT To Total Ratio:

This is the total number of EPT organisms counted (column B, Field Data Sheet), divided by the total number of all invertebrates counted. Write the value in Part C of the Interpretation Sheet.

Assess Diversity:

Streams with good habitat and water quality have high diversity (many taxa). Low diversity (very few taxa) in a stream may suggest water quality or habitat problems. However, there are exceptions, such as pristine alpine streams with very few species and low food supply. Record the total number of taxa (bottom of Column C, Field Data Sheet) in Part D of the Interpretation Sheet.

Predominant Taxon Ratio:

The predominant taxon is the group with the highest number of organisms. Divide the number of organisms in the predominant taxon by the total number counted (Column B of the Field Data Sheet). Record this value in Part D of the Interpretation Sheet.

Assess the Site:

Assign a score of 1 (poor) to 4 (good) to each water quality and diversity index or ratio, using Part E of the Interpretation Sheet. Add the numbers and calculate the average. This average gives a general rating of stream health at the site, from 1 (poor) to 4 (good). Sometimes individual indices or ratios may suggest contradictory stream conditions. The general site rating helps even out such results. For example, both species presence and water quality measurements may show good water quality conditions, while species diversity may be low because of physical problems.

Collecting, Reporting, and Evaluating Information

Send copies of your results to the Streamkeepers Database. The current address is in the Handbook.

Invertebrate surveys detect moderate to severe degradation of stream habitat. Table 2 lists common responses to pollution. For example, organic pollution usually results in low numbers of pollution-sensitive organisms and high numbers of a few species of pollution-tolerant species.

Information collected from several locations in the area provides baseline data that can help you identify habitat concerns and choose appropriate restoration projects. When you survey the same stations over several years, you can recognize changes in water quality. If the results of your invertebrate survey are inconclusive or suggest poor conditions, you may wish to examine habitat (Module 2) and water quality (Module 3) to find answers to the problem.

Before you react strongly to evidence of poor water quality, remember that your survey uses simplified versions of scientific techniques. Although the results of your tests usually are reliable, there are exceptions to any rule. Sometimes stream conditions appear abnormal, but are natural in a particular area. Make sure you have reliable background data to compare with data from problem sites.

TABLE 2
Correlating Invertebrate Data with Sources of Pollution.

WARNING SIGN	PROBLEM
high diversity, lots of pollution sensitive invertebrates	no problem, good water quality
low diversity, high numbers, lots of scrapers and collectors	organic enrichment/pollution or lots of algal growth resulting from nutrient enrichment
high diversity and low numbers; or no insects, but the stream appears clean	toxic pollution (e.g. chlorine, acids, heavy metals, pesticides, oil) or another severe problem of unknown origin
reduced numbers of all types of invertebrates	physical problem (e.g., downstream of dam, sediment from erosion) or sometimes streams are unproductive for natural reasons (glacier-fed streams, spring-fed streams)

References And Useful Resources

Adopt-A-Stream Foundation. 1991. *Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods, Macroinvertebrate Survey.* Everett, WA

Friends of Environmental Education Society of Alberta. 1990. *Adopt-A-Stream Aquatic Invertebrates: Identification Key to River Invertebrates.* Edmonton, AB.

Kellogg, L.L. 1992. *Save Our Streams: Monitoring Guide to Aquatic Macroinvertebrates.* Izaak Walton League of America, Arlington, VA.

Merritt, R.W. and K.W. Cummins (editors). 1984. *An Introduction to the Aquatic Insects of North America*. Kendall/Hunt, Inc., Dubuque, Iowa. 722 pp.

Oregon Department of Fish and Wildlife. 1990. *The Stream Scene: Watershed, Wildlife and People*. Portland, OR

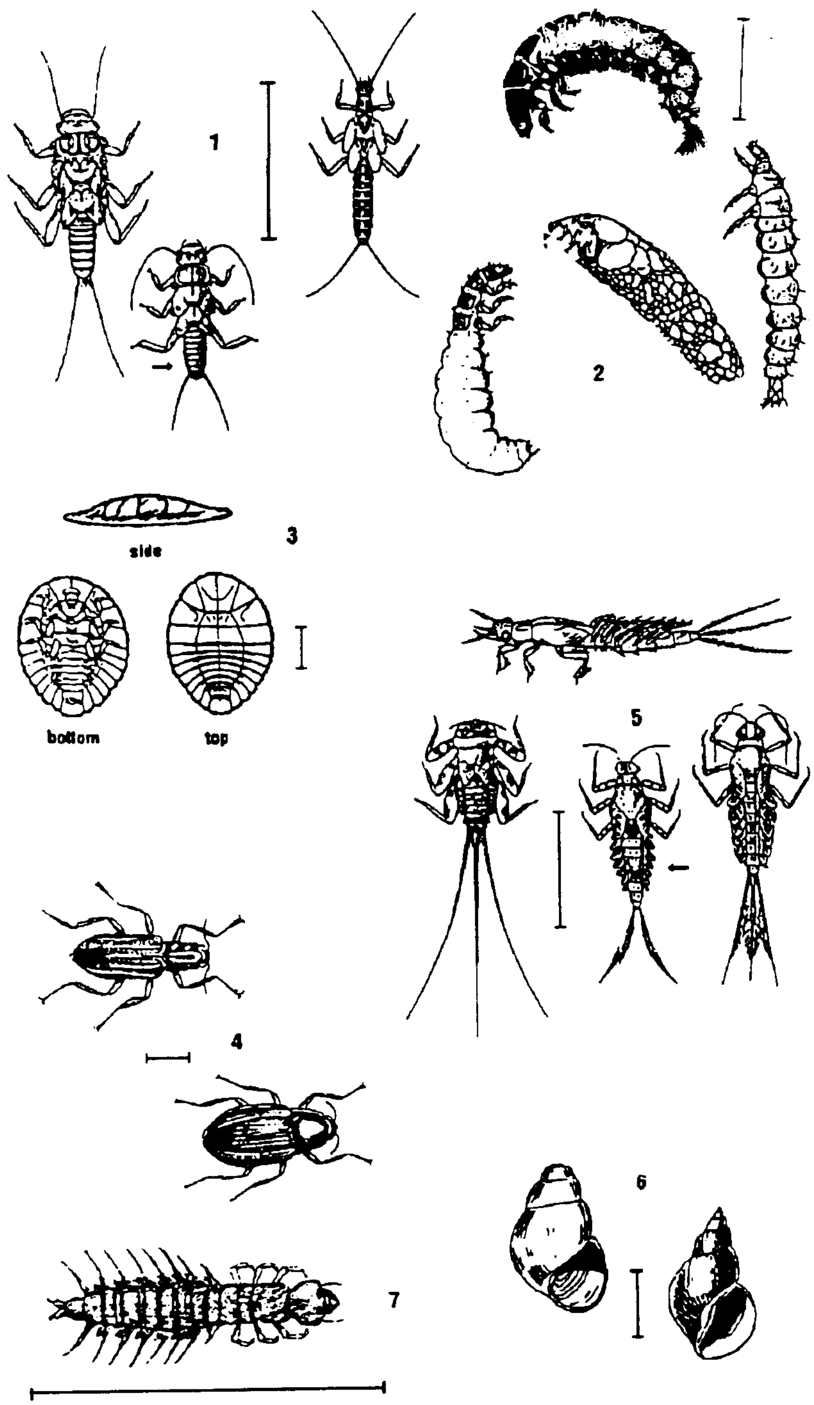
Appendices

Appendix 1: Invertebrate Field Identification and Pollution Tolerance

Appendix 2: Key to Invertebrate Groups

Appendix 1
Field Identification and Pollution Tolerance Chart

adapted from Save our Streams, Izaak Walton League of America



1 Stonefly:
Order Plecoptera
1/2" - 1 1/2", 6 legs with hooded tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (see arrow)

2 Caddisfly:
Order Trichoptera
up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on lower half.

3 Water Penny:
Order Coleoptera
1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs on the other side. Immature beetle.

4 Riffle Beetle:
Order Coleoptera
1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 Mayfly:
Order Ephemeroptera
1/4 - 1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow) 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 Gilled Snail:
Class Gastropoda
Shell opening covered by thin plate called operculum. Shell usually opens on right.

7 Dobsonfly (Helgrammite):
Family Corydalidae
3/4 - 4”, dark coloured, 6 legs, large pinching jaws, 8 pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails and 2 pairs of hooks at back end.

BAR INDICATES RELATIVE SIZE

Category One Taxa

Pollution sensitive organisms found in good quality water

Appendix 1
Field Identification and Pollution Tolerance Chart, *(continued)*

8 Crayfish: Order Decapoda
Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 Sowbug: Order Isopoda
1/4 - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

10 Scud: Order Amphipoda
1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 Alderfly larva: Family Sialidae
1" long, looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 Fishfly larva: Family Corydalidae
Up to 1 1/2", looks like small hellgrammite but often a lighter reddish-tan colour, or with yellowish streaks. No gill tufts underneath.

13 Damselfly: Suborder Zygoptera
1/2 - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body (see arrow).

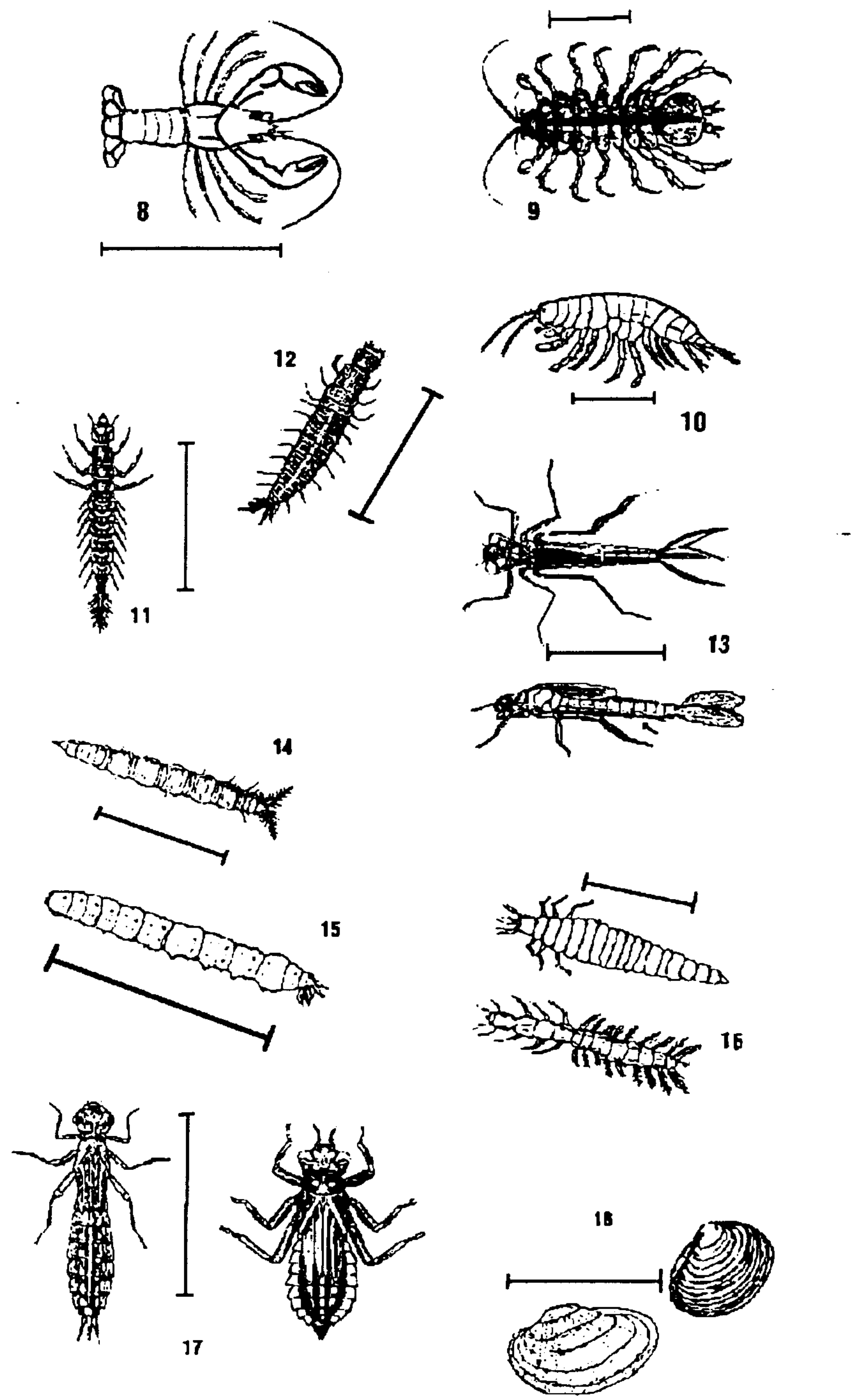
14 Watersnipe Fly Larva: Family Athercidae (Atherix)
1/4 - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 Crane Fly: Suborder Nematocera
1/3 - 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger like lobes at back end.

16 Beetle Larva: Order Coleoptera
1/4 - 1", light-coloured, 6 legs on upper half of body, feelers, antennae.

17 Dragon Fly: Suborder Anisoptera
1/2 - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 Clam: Class Bivalvia

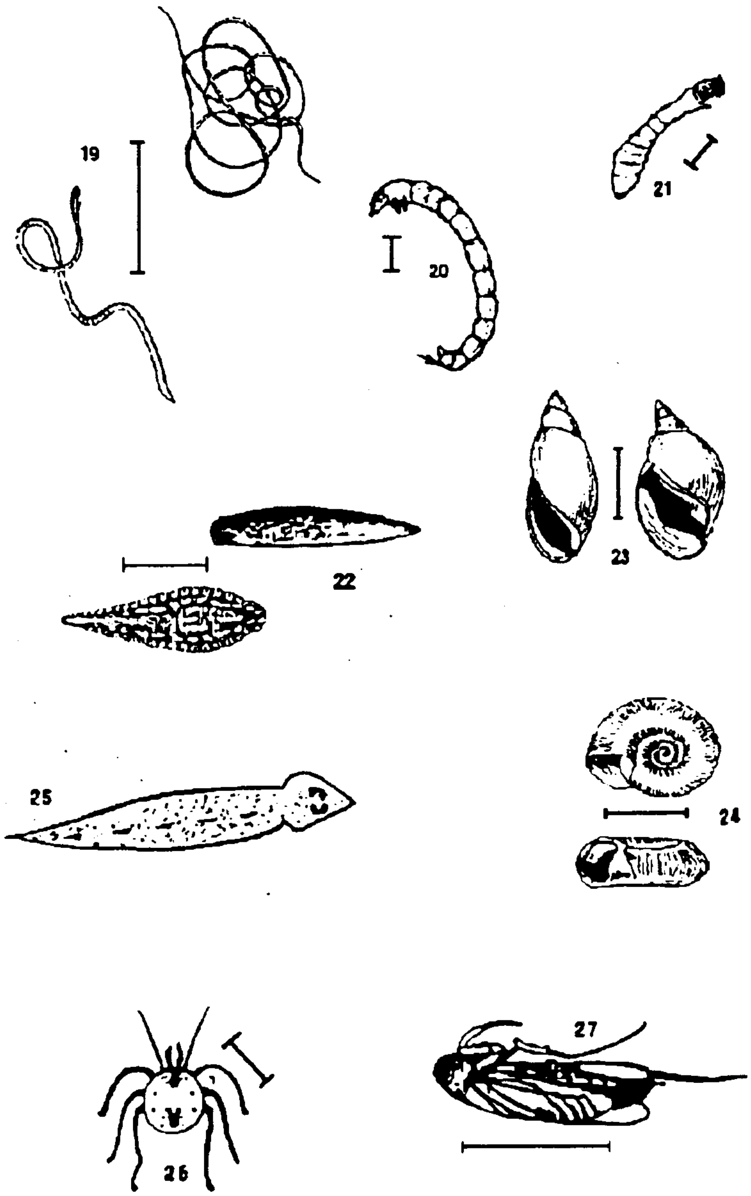


BAR INDICATES RELATIVE SIZE

Category Two Taxa

Somewhat pollution tolerant organisms can be in good or fair quality water

Appendix 1
Field Identification and Pollution Tolerance Chart, *(continued)*



19 Aquatic Worm:
Class Oligochaeta
1/4 - 2", can be very tiny, thin worm-like body.

20 Midge Fly Larva:
Suborder Nematocera
Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 Blackfly Larva:
Family Simulidae.
Up to 1/4", one end of body wider. Black head, suction pad on end.

22 Leech:
Order Hirudinea
1/4 - 2", brown, slimy body, ends with suction pads.

23 Pouch Snail and Pond Snails: Class Gastropoda
No operculum. Breathe air. Shell usually opens on left.

24 Other Snails:
Class Gastropoda
No operculum. Breathe air. Snail shell coils in one plane.

25 Planarian:
Class Turbellaria
Flattened, unsegmented worm-like body, may have distinct eyespots, gliding movement.

26 Water Mite:
Order Hydracarina
Looks like spider, may be very tiny, has 8 legs.

27 True Bug Adult:
Order Hemiptera
Has short legs, swims or dives quickly.

Category Three Taxa

Pollution tolerant organisms can be in any quality of water

BAR INDICATES RELATIVE SIZE

Appendix 2: Key To Invertebrate Groups

This key was adapted from the Adopt-A-Stream Program, Everett, Washington

1a Segmented legs..go to 2

1b no segmented legs.....................................go to 14

2a 6 legs..go to 3

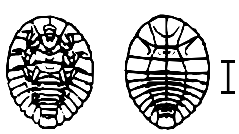
2b more than 6 legs.......................................go to 23

3a no wings, or wings not fully developed and do not cover abdomen completely on back side ....go to 4

3b wings cover abdomen; beetle-like body ....go to 26

4a body longer than it is wide ....go to 5

4b body oval and flat; head and legs totally concealed beneath.........................WATER PENNY ....(Order Coleoptera, Family Psephenidae)
scraper

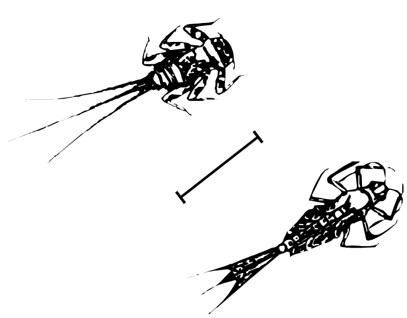


waterpenny

5a 2 or 3 distinct hairlike tails, not hooked, may be fringed with hairs.................................go to 6

5b not as above...go to 7

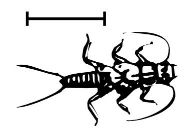
6a 2-3 tails; plate or hairlike gills along sides of abdomen....................................MAYFLY NYMPH ....(Order Ephemeroptera)
flattened - scraper
torpedo-shaped; hairs on front legs - filtering collector
torpedo-shaped; no hairs on front legs - gathering collector



mayfly larva (collectors - filtering or gathering)

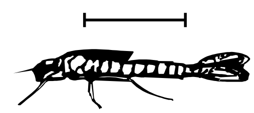
BAR INDICATES RELATIVE SIZE

6b 2 tails; may have hairy gills under thorax.......... ....STONEFLY NYMPH ....(Order Plecoptera)
dark and uniformly coloured, sluggish - shredder
brightly coloured or mottled, very active - predator



stonefly

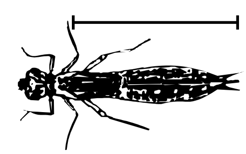
7a 3 oar-shaped tails; no gills along abdomen ....DAMSELFLY NYMPH ....(Order Odonata, Suborder Zygoptera)
predator



damselfly larva

7b not as above...go to 8

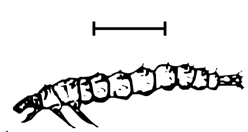
8a fat abdomen; large eyes, mask-like lower lip ....DRAGONFLY NYMPH ....(Order Odonata, Suborder Anisoptera)
predator



dragonfly larva

8b not as above...go to 9

9a may be hiding in a case made of gravel or plant parts; abdomen ends in pair of prolegs which may be hidden by hairs, each has single hook on end, sometimes fused together ....CADDISFLY LARVA ....(Order Trichoptera)
free living, head narrower than thorax - predator



caddisfly larva - predator

net spinning; if separated from net, will appear free-living, but head as wide as thorax - filtering collector

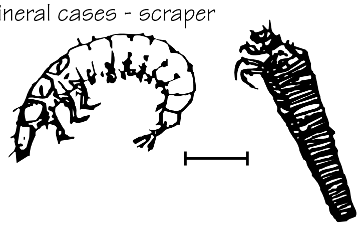
case organic (leaf, stick, etc.) and square, no bark or flat pieces included - filtering collector

case organic, long, slender, tapered - gathering collector

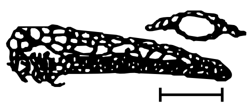
case mineral (sand or gravel); long, slender, tapered or oval and flattened - gathering collector

all other organic cases - shredder

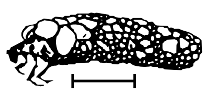
all other mineral cases - scraper



caddisfly larva (filtering collector)



caddisfly larva (gathering collector)

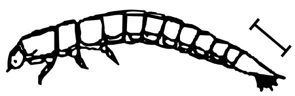


caddisfly larva (scraper)

9b not as above..go to 10

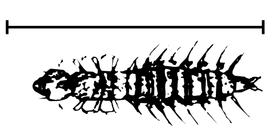
10a well developed lateral filaments extend from abdominal segments..................................go to 11

10b no lateral filaments along abdomen; body is hardened and stiff; lip of abdomen has ventral operculum with hooks and filaments ....RIFFLE BEETLE LARVA ....(Order Coleoptera, Family Elmidae)
gathering collector



riffle beetle larva

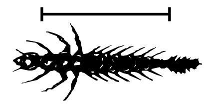
11a fluffy or branched gill tufts under abdomen ...........HELLGRAMMITE or DOBSONFLY LARVA ....(Order Megaloptera, Family Corydalidae)
predator



dobsonfly larva

11b not as above..go to 12

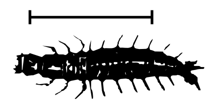
12a abdomen ends in single, unforked, long hair-like tail................................ALDERFLY LARVA ....(Order Megaloptera, Family Sialidae)
predator



alderfly larva

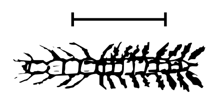
12b not as above..go to 13

13a abdomen ends in a pair of prolegs, each with 2 hooks...FISHFLY LARVA ....(Order Megaloptera, Family Corydalidae)
predator



fishfly larva

13b not as above.............AQUATIC BEETLE LARVA ....(order Coleoptera)
predator

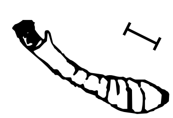


aquatic beetle larva

14a (from 1b), distinct head, body <1.2 cm long ....go to 15

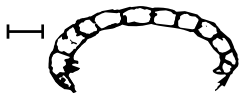
14b no distinct head...................................go to 16

15a body widens at bottom end, may be attached to substrate, dark head ....BLACKFLY LARVA ....(Order Diptera, Family Simuliidae)
filtering collector



blackfly larva

15b both ends of body about the same width; tiny pair of prolegs under head and at tip of abdomen..MIDGE LARVA ....(Order Diptera, Family Chironomidae)
gathering collector

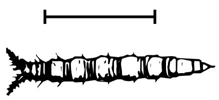


midge larva

16a caterpillar-like body.................................go to 17

16b body not caterpillar-like........................go to 18

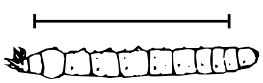
17a two feathered "horns" at back end, caterpillar like legs . WATERSNIPE FLY LARVA ....(Order Diptera, Family Athericidae)
predator



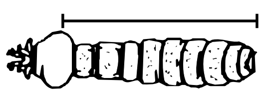
watersnipefly larva

17b may be up to 10 cm long; fleshy, finger-like extensions from one end ....CRANEFLY LARVA ....(Order Diptera, Family Tipulidae)
well developed extensions, last segment not swollen - shredder

poorly developed extensions or last segment swollen - predator



cranefly larva (shredder)



cranefly larva (predator)

18a body without hard shell...........................go to 19

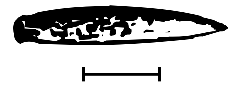
18b body with hard shell.................................go to 21

19a flattened, unsegmented worm-like body; may have distinct eyespots, gliding movement ....PLANARIAN ....(Class Turbellaria)
parasite or predator

planarian

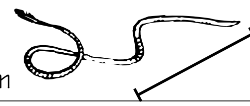
19b segmented body......................................go to 20

20a flattened body with suckers at each end ....LEECH ....(Class Hirudinea)
parasite or predator



leech

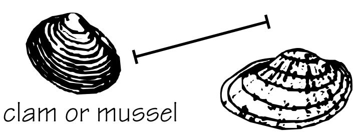
20b long earthworm or threadlike body ....AQUATIC WORM ....(Class Oligochaeta)
gathering collector



aquatic worm

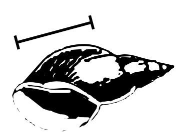
21a snail like..go to 22

21b body enclosed in two hinged shells ....FRESHWATER CLAM OR MUSSEL ....(Class Bivalvia)
filtering collector



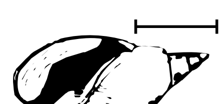
freshwater clam or mussel

22a has plate-like cover over opening; when spire is pointed up and opening faces you, opening usually is on right...........................GILLED SNAIL ....(Class Gastropoda)
scraper



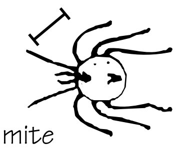
gilled snail

22b no plate-like cover over opening; when spire is pointed up and opening faces you, opening usually is on left ....PULMONATE or LUNGED SNAIL ....(Class Gastropoda)
scraper



pulmonate or lunged snail

23a (from 2b), looks like spider, may be very tiny, has 8 legs..WATER MITE
................(Class Arachnida, Order Hydracarina)
predator

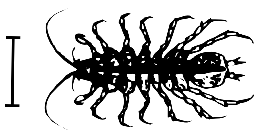


water mite

23b not as above..go to 24

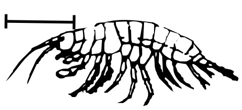
24a lobster or shrimp-like.............................go to 25

24b armadillo-shaped body, wider than high; crawls slowly on bottom
....AQUATIC SOWBUG
...............(Subphylum Crustacea, Order Isopoda)
shredder



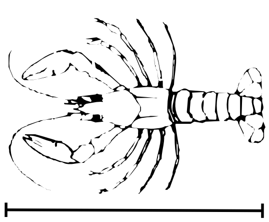
aquatic sowbug

25a looks like tiny shrimp; swims quickly on its side...SCUD
........(Subphylum Crustacea, Order Amphipoda)
shredder



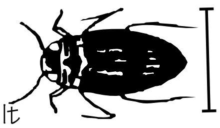
scud

25b looks like small lobster; 2 large front claws (10 legs total)..CRAYFISH
...........(Subphylum Crustacea, Order Decapoda)
predator



crayfish

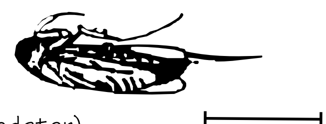
26a (from 3b), short legs, swims or dives quickly
....BEETLE ADULT
....(Order Coleoptera)
predator



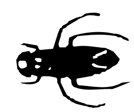
beetle adult

26b not as above...go to 27

27a longer legs, swims quickly
....TRUE BUG ADULT
....(Order Hemiptera)
swims on back - predator
swims on front, oar-like legs - shredder

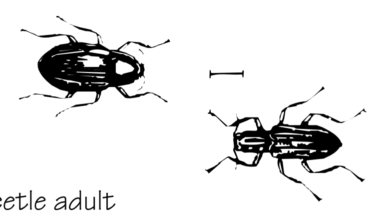


true bug adult (predator)



true bug adult (shredder)

27b beetle-like, crawls slowly on bottom..................
....RIFFLE BEETLE ADULT
....(Order Coleoptera)
scraper



riffle beetle adult

send the data to: Streamkeepers Database, Department of Fisheries and Oceans,
Suite 400, 555 *W. Hastings Street, Station 321, Vancouver, B.C. V6B* 5G3
fax to (604) 666-0292

Stream Location and Conditions

(use a new data sheet for each stream segment surveyed) **Module 4**

Stream Name/Nearest Town	Date
	Watershed code
Organization Name	Stream Segment #
	Stream Section #
Contact Name	Phone #

Survey Location

Mapsheet number	Type	Scale
Location (distance from known stream landmark)		
Time:______ Weather ‘ clear ‘ shower (1-2.5 cm in 24 hr) ‘ snow ‘ overcast ‘ storm (<2.5 cm in 24 hr) ‘ rain on snow		
Water turbidity (cm visibility)	Temperature ^{o}C (leave thermometer 2 min.) air __________ water _______________	
Bankfull Channel width __________(m) depth _____________(m) Wetted Channel width __________(m) depth _____________(m)		

First and Last Measurements taken .1 m from streambank edge

Left Bank									**Right Bank**
Wetted Depth									Wetted Depth
Bankfull Depth									Bankfull Depth

Take measurements every 0.5m in streams less than 5m. wide, every 1m in streams 5 to 15m.

send the data to: Streamkeepers Database

Invertebrate Survey Field Data Sheet

(use a new data sheet for each stream section surveyed) **Module 4**

Stream Name	Date
Stream Segment # Stream Section #	Sampling location
sampler used, mesh size, total area sampled	# of 30cm x 30cm samples

COLUMN A Pollution Tolerance	**COLUMN B Number Counted**	**COLUMN C Number of Taxa**	**COLUMN D Common Name**
CATEGORY 1 **(pollution intolerant)**			Caddisfly Larva (**EPT**)
			Dobsonfly (hellgrammite)
			Gilled Snail
			Mayfly Nymph (**EPT**)
			Riffle Beetle
			Stonefly Nymph (**EPT**)
			Water Penny
Sub-total			
CATEGORY 2 **(somewhat tolerant of pollution)**			Alderfly Larva
			Aquatic Beetle
			Aquatic Sowbug
			Clam, Mussel
			Cranefly Larva
			Crayfish
			Damselfly Larva
			Dragonfly Larva
			Fishfly Larva
			Scud
			Watersnipe Larva
Sub-total			
CATEGORY 3 **(pollution tolerant)**			Aquatic Worm
			Blackfly Larva
			Leech
			Midge Larva (chironomid)
			Planarian
			Pouch and Pond Snails
			True Bug Adult
			Water Mite
Sub-total			
TOTAL			

send the data to: Streamkeepers Database

Invertebrate Survey Interpretation Sheet

(use a new data sheet for each stream section surveyed) **Module 4**

Stream Name	Date
Stream Segment # Stream Section #	Sampling location
sampler used, mesh size, total area sampled	# of 30cm x 30cm samples

A) ABUNDANCE AND DENSITY

ABUNDANCE: total number of organisms from **Column B** =

DENSITY: invertebrate density per square meter

(total # counted) ÷ (# of 30cm x 30cm samples x.09m^2) =

__________ ÷ (__________) = _______

B) PREDOMINANT TAXON

C) WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: use the **total number of broad** taxonomic groups found in each tolerance category, from Field Data Sheet (**Column D**)

POLLUTION TOLERANT INDEX			
Good	**Acceptable**	**Marginal**	**Poor**
>22	22-17	16-11	<11

3 x (# of category 1)
+ 2 x (# of category 2)
+ (# of category 3) =

EPT INDEX: total number of **EPT** taxa from **Column C**, Field Data Sheet

EPT INDEX			
Good	**Acceptable**	**Marginal**	**Poor**
>8	5-8	2-5	0-1

EPT are stonefly, caddisfly and mayfly =

EPT TO TOTAL RATIO: total number of **EPT** organisms from **Column B**, Field Data Sheet divided by the total number of organisms

EPT TO TOTAL RATIO			
Good	**Acceptable**	**Marginal**	**Poor**
0.75 - 1.00	0.5 - 0.75	0.25 - 0.50	0 - 0.25

of **EPT** _______ ÷ total =

send the data to: Streamkeepers Database

Invertebrate Survey Interpretation Sheet

(use a new data sheet for each stream section surveyed) **Module 4**

Stream Name	Date
Stream segment # Stream section #	sampling location
sampler used, mesh size, total area sampled	# of 30cm x 30cm samples

D) DIVERSITY ASSESSMENT

TOTAL NUMBER OF TAXA: from **Column C**, Field Data Sheet

PREDOMINANT TAXON RATIO: divide the **number** of invertebrate in the **predominant taxon** by the **total number of invertebrates** counted:

__________ ÷ ________ = ______

predominant total

PREDOMINANT TAXON RATIO			
Good	**Acceptable**	**Marginal**	**Poor**
0 - 0.40	0.40 - 0.60	0.60 - 0.80	0.80 - 1.0

E) SITE ASSESSMENT RATING:

Assign a rating between 1 and 4 to each index or ratio, then average the results to produce a general site assessment.

SITE ASSESSMENT RATING			
Good	**Acceptable**	**Marginal**	**Poor**
4	3	2	1

SITE ASSESSMENT RATING	
Index or Ratio	**Rating**
Pollution Tolerance Index	
EPT Index	
EPT to Total Ratio	
Predominant Taxon Ratio	
Total	
Average	

General Comments -
Unknown Bugs

see page 13 and 14 of Module 4 for further information

STREAMKEEPERS

Module 5
Storm Drain Marking

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	Not necessary	½ day to ongoing	2 or many	Spring through fall

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MODULE 5:

Storm Drain Marking

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

The Salmonid Enhancement Program of the Department of Fisheries and Oceans, B. C. Ministry of Environment, Lands and Parks, and the B. C. Conservation Foundation jointly developed the Storm Drain Marking Program.

Project Activity and Purpose

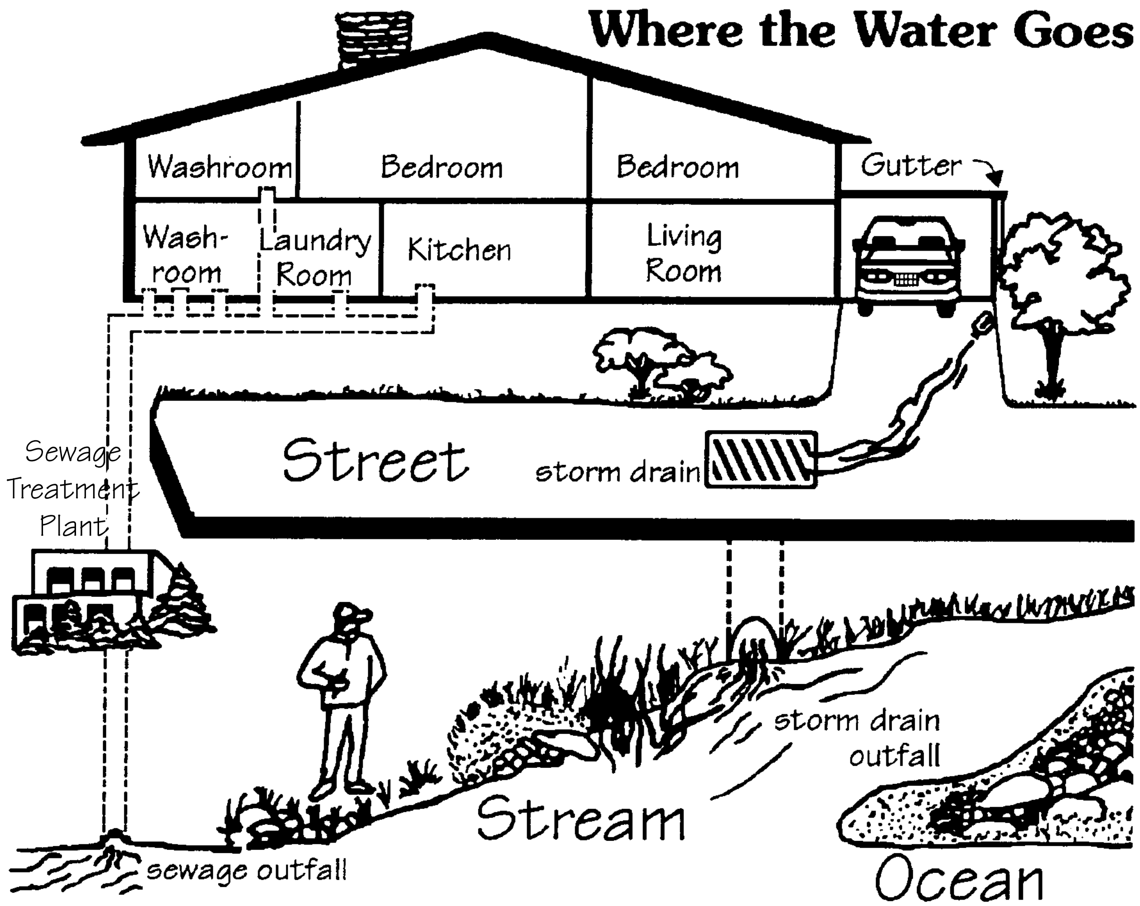
You will paint yellow fish symbols on the road beside storm drains and deliver pamphlets to residents and businesses along your route. These pamphlets remind people that storm drains empty into a fish-bearing creek nearby. They also provide lists of safe waste disposal methods and environmentally friendly household compounds.

Supervised groups of school children, Girl Guides, and Boy Scouts often mark storm drains in residential areas, but anyone can take on this project. Only adults should mark storm drains in commercial or industrial areas because traffic conditions are more hazardous. You may need additional permission from property owners.

Introduction

In urban areas, storm drains along paved streets and parking lots collect rain and snowmelt water. Paved surfaces prevent rainfall from filtering through the soil naturally, so water runs off quickly into storm drains. The runoff picks up contaminants along the way. Floods and droughts are frequent in watersheds where buildings and paved surfaces cover much of the land.

Storm drains empty into an underground collection system that discharges untreated water into a nearby stream. Runoff does not go into the domestic sewage system. People who do not realize this often dump oil, swimming pool water, and toxic household or industrial compounds into storm drains. Road runoff contains sediment, animal waste, oil, and particles from car exhaust. All these substances flow into the nearest stream and harm fish, wildlife, and plants.



Storm drain marking is an excellent way to raise community awareness about stream health. It involves children, leaves a semi-permanent reminder on the street, and distributes information in neighbourhoods close to streams. However, there are some disadvantages to using paint. Paint may be spilled accidentally into the drain. Over time, the paint chips off the road and flows into the storm drain, adding to pollutants already present. One alternative is to attach metal plates with a warning message onto the drains. However, municipal staff would need to do the work, rather than volunteers.

Plans for new urban developments in some municipalities require that storm runoff flow into wetland retention ponds. The ponds are planted with wetland plant species that remove toxins from the water. The ponds also help moderate flood and drought conditions in the receiving stream. You may wish to check on the stormwater collection system proposed for new developments in your area. References for design of stormwater treatment systems are provided at the end of the module.

There are few storm drains in rural areas. However, domestic and agricultural pollution in drainage ditches can be a major threat to stream health. A solution developed in the Maple Ridge - Pitt Meadows area is to build "fish sticks" and erect them along the ditches. Wooden fish cutouts, painted yellow and mounted on sticks, are being placed along banks by local Boy Scout troops.

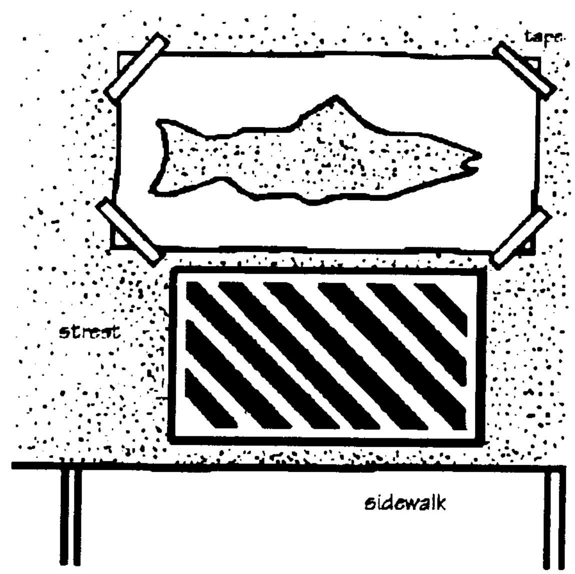
Project Guidance and Approval

Many municipalities in British Columbia have approved storm drain marking programs for volunteers. You need little or no training. The Community Advisor will refer you to a volunteer coordinator. In areas new to the program, the Community Advisor may help set up the program. Always remember to obtain permission before painting drains on private property.

Level of Effort

You will be given a cart containing everything you need. You can adapt the project easily to a small group (minimum two) interested in a single outing or a large group interested in a long term commitment. Groups of two to six children, supervised by one adult, work well with each cart.

You can mark ten to fifteen storm drains in an hour when the drains are close together. You may choose to set either a time limit or a specific area as your goal. On well-used roads, you may need to repaint drains after three to five years.



Time of Year and Working Conditions

You can mark drains during spring, summer, and fall on any dry day. The road must be dry for the paint to stick well. Very hot and cold temperatures interfere with paint drying.

Safety

Traffic is the greatest hazard for anyone working at the roadside. Adults should supervise children and caution them about road safety. Wear the traffic safety vests provided in the kit and assign a traffic lookout. Leave dogs and very small children at home.

Be careful with the paint. It is lead-free, but try not to spill any, especially near a storm drain. Supervise children and follow the instructions in the cart. Wear grubby clothes and the rubber gloves provided. If you are sensitive to the smell of paint, you can deliver pamphlets or watch for traffic, instead.

Let someone know where you are going and when you will return. Carry emergency phone numbers for police and ambulance, respect private property, and beware of dogs.

Materials and Equipment

Everything you need is supplied by the volunteer coordinator. The kit usually contains fast-drying latex paint.

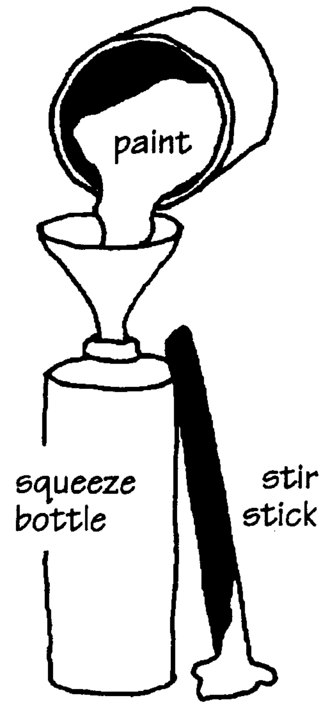
Procedure

The following instructions for storm drain marking are repeated from the manual prepared by the Department of Fisheries and Oceans, B. C. Ministry of Environment, Lands and Parks, and the B. C. Conservation Foundation. The volunteer coordinator may have municipal sewer and drainage maps. The maps are useful in relating the storm drains to a particular stream or watershed.

PREPARATION

Read all the instructions and become familiar with the equipment in the cart. Give each child one or more of these simple tasks:

Suggested Tasks:
Traffic Watchdog
Record Keeper
Whisk Broom Sweeper
Brochure Deliverer
Stencil Positioner
Cleaner-upper
Eye Artist
Painter



Cart Contents:
1 tin yellow paint
1 fish template
5– 3cm paint brushes
waiver claim form
1 funnel
1 stir stick
1 x-acto knife
1 pair tweezers
2 rolls masking tape
1 whisk broom
5 pairs rubber gloves
10 garbage bags
3 safety vests
fish-eye stickers
record forms
information brochures
3 – 500ml squeeze bottles for paint

Return the cart cleaner than it was when you got it. A squeeze bottle of paint is enough for about 20 drains. Usually, there are four or five houses between storm drains.

Organizing Teams:

Make up teams of four to six people. For safety resins, each team should work on one side of the street and not cross over, so send two teams out together. A buddy system of two older children and two younger children plus an adult is an ideal group.

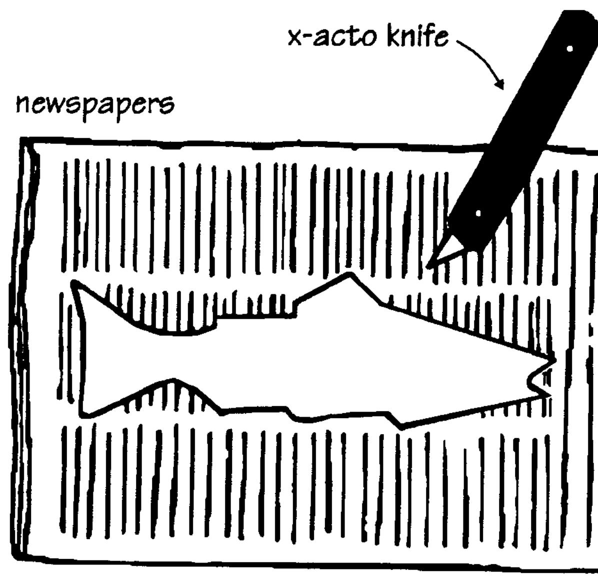
Set up mini-kits using the supplies in the cart, along with tin cans, shampoo or ketchup bottles, and extra brushes from home.

A mini–kit should contain:
1 roll masking tape
1 ice cream bucket/small box
1 paint squeeze bottle
1 paint brush
1 page of fish eye stickers
1 pair of tweezers
1 plastic garbage bag
1 – 2 pairs rubber gloves
1 safety vest, fluorescent hat or t-shirt
1 shopping bag of brochures ready for home delivery
1 shopping bag with 20 precut stencils
Record forms

HOW TO MARK A STORM DRAIN

Before you Start:

1. Complete the waiver claim form.
2. Prepare stencils with x-acto knife and several layers of newspaper. Use metal template as a cutting guide only.
3. Prepare handouts by stuffing brochures into available bags.
4. Explain procedures and assign jobs to participants.
5. Fill squeeze bottles with yellow latex paint (use stir stick and funnel provided).

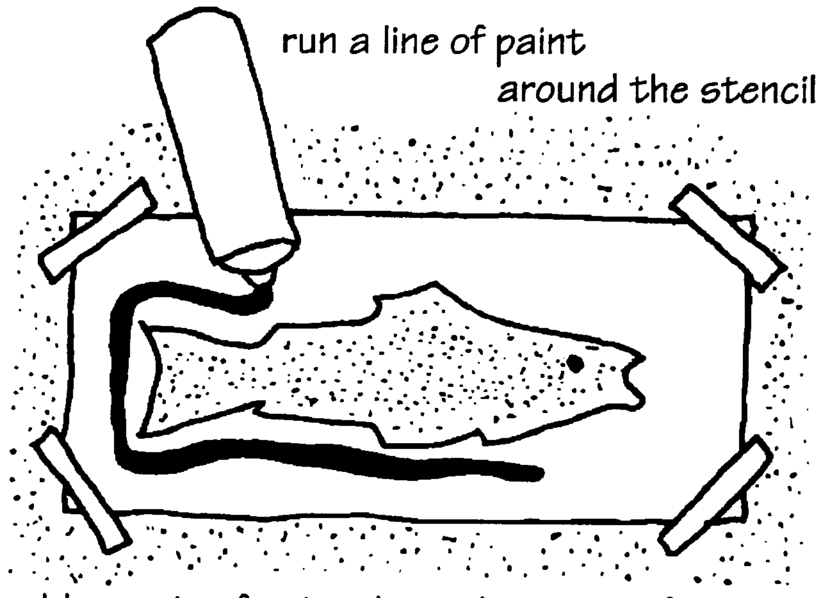


Prepare the Drain:

1. Wear safety vest and gloves while painting drains. Post a watchdog to watch for cars.
2. Use whisk broom to sweep dust, gravel and dirt from the pavement.
3. Position stencil on the road (not the sidewalk) about 5 to 10 cm above the storm drain. The fish should look right side up when viewed from the sidewalk.
4. Fasten each corner of the newspaper template in position with masking tape.
5. Position the dot sticker for the eye within the fish outline.

Paint the Drain:

1. Use squeeze bottle to squeeze paint on the newspaper template 1 cm from the edge, following the outline of the fish symbol. Add more paint in the centre of the fish if needed.
2. Brush toward the centre of the fish. Add more paint from squeeze bottle as required. Continue brushing until the road surface within the outline of the fish is completely and evenly painted.
3. The paint dries in approximately 10 to 15 minutes.



Clean-Up:

1. Remove eye sticker with tweezers and discard in a garbage bag.
2. Carefully remove the newspaper template and tape from the road surface and reuse to mark other drains. Carefully discard in garbage bag.
3. When you are finished for the day, clean the brushes with soap and water. Dispose of wash water in the sink. Leave the cart and equipment clean and tidy.

Deliver Brochure Information:

1. Deliver the brochures to each house on the street where storm drains have been marked. Hang the bags on doorknobs or place in mailboxes. Do not knock on doors.

Record Marking Information:

1. Complete record form with number of drains.
2. Indicate on the map streets where you have marked drains.

Collecting, Reporting and Evaluating Information

The volunteer coordinator keeps a master database, to keep up to date on areas that need painting or repainting. You may wish to survey people in the area after you finish the project, to find out whether attitudes and behaviour have changed. Children and adults who help mark storm drains also become good teachers. If records are kept about stream problems related to storm drains, you can compare data on the frequency of problems before and after the project.

Send a copy of the Summary Sheet to the Streamkeepers Database. The current address is in the Handbook.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings.

References

B.C. Ministry of Environment, Lands, and Parks. 1992. *Urban Runoff Quality Control Guidelines for the Province of British Columbia.* B.C. Ministry of Environment, Lands, and Parks, Victoria, BC. (call 1-250-387-9985 for a copy).

Schueler, T. R. 1992. *Design of Stormwater Wetland Systems*. Metropolitan Washington Council of Governments, Washington, DC. (call 1-202-962-3256 for a copy).

Chilabeck, B. 1992. *Land Development Guidelines for the Protection of Aquatic Habitat*. Joint publication of Deptartment of Fisheries and Oceans and Ministry of Environment. Lands and Parks. 128pp.

send the data to the Streamkeepers Database

MODULE 5:
STORM DRAIN MARKING SUMMARY SHEET
(see Module 1 for additional information)

Stream Name	**Date**
Organization name and municipality	**Crew size**
Contact name	**Phone#**

Details of drain marking	
number of drains marked	
number of volunteers involved	
number of hours spent	
names of streets marked	
How long does the paint last?	

STREAMKEEPERS

Module 6
Stream Cleanup

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
yes	Not necessary	30 minutes to ongoing	2 to many	Summer: instream All year: streambanks

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MODULE 6:
Stream Cleanup

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgements

The staff of the Community Involvement Program and the Adopt-A-Stream Foundation, Everett, Washington provided the information for this section.

Project Activity and Purpose

You will check a length of a stream for the extent of the garbage problem, then organize a cleanup project along the stream bed and banks. This involves mobilizing a work crew and organizing the collection and disposal of garbage.

You can damage stream habitat by removing all large material from the stream. Logs and stumps provide cover for fish, dissipate stream energy, and trap sediment. REMOVE ONLY HUMAN PRODUCED MATERIAL AND DO NOT DISTURB NATURAL MATERIAL.

Introduction

Cleaning up a stream or wetland area is a simple but very satisfying project. Many of us know a lovely spot along a stream. Then, one day, someone dumps a load of garbage there, and before it can be removed, someone else adds more. Sadly, garbage attracts more garbage. This can lead to poor water quality and loss of habitat for fish and wildlife. When you clean up a stream, you set a good example for others and help to halt the cycle of deterioration.

Project Guidance and Approval

You will need no prior approval to clean up stream banks at any time of year. If you wish to clean up a stream channel, you should contact the Department of Fisheries and Oceans. DFO guidelines usually restrict instream work between mid-September and mid-July to protect incubating fish eggs you may get permission to work in the stream during the spring or fall if you can show that you will not cause siltation or disturb spawning areas.

Contact your Community Advisor for advice on locations and necessary approvals. He or she can advise you about dealing with special situations, such as removing large, deeply embedded material from streambeds. You may need to contact your municipality, Department of Fisheries and Oceans (Habitat Management) or the Ministry of Water, Land, Air and Parks. Consult landowners if you plan to cross or use private property. You may wish to arrange with your municipality to have a dumpster available or some other method of garbage removal.

Level of Effort

Adapt the cleanup to your needs and resources. You may simply wish to take a few children and garbage bags out for a stroll along the banks of your local creek. Alternatively, you may wish to organize a major project to drag oil cans, household appliances, shopping carts, and other garbage out of streams.

Working Conditions and Time of Year

You can clean up stream banks throughout the year. Instream cleanups usually are done during the summer, when stream flows are low and environmental impacts are low. Be prepared to get dirty, muddy, and wet. Access may be difficult and you may have to scramble through underbrush. You should be in good shape for all this physical labour. Know your limitations.

Safety

PERSONAL SAFETY

Concern for your personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance. Supervise children closely around any body of water.

Do not attempt to wade in fast flowing water or water higher than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be very dangerous.

Lift using you knees, not your back. Get help carrying heavy objects. Workers Compensation does not cover you!

Warn everyone, especially children, about urban hazards such as syringes, needles, broken glass, and condoms. Remove them with tongs and place them in a special hazardous materials bucket, or flag them with red tape.

Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials. Contact emergency response agencies or municipal crews for advice on removal of the materials.

Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water.

EQUIPMENT

Always carry a first aid kit. When working in isolated areas, bring a survival kit containing at least a lighter, fire starter, candle, and flares. Carry a cell phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear waders with felts when walking in the stream. The water may be fast flowing and the bottom may be slippery. Wear a personal flotation device (PFD) when working in large streams.

Materials and Equipment

Work gloves	rubber gloves
Bright flagging tape	plastic garbage bags
Rope	shovel
Pry bar	camera
First aid kit	wheel barrows
Hazardous material buckets	waders or boots

Dumpster (for large projects) or pickup trucks

Winch or come-along (optional) and choker

Procedure for Large Cleanup Projects

BEFORE YOU GET YOUR FEET WET

1. Survey the area you intend to clean up. Take photos. Contact your municipality if you want suggestions on locations to clean up.
2. Make sure you have enough people for the area you want to cover. Have one or two planning meetings with a small group and plan to get more volunteers for the day of the cleanup.
3. List tasks (approvals, garbage disposal, etc.) and applicable dates; assign volunteers to take on the tasks.
4. Call the volunteers to confirm their assignments.
5. Well before the cleanup day, obtain permission from property owners and appropriate agencies. Arrange for garbage bags, cans, and a dumpster at the site. Ask people to bring trucks and wheelbarrows.
6. Advertise the cleanup in your community - ask for more help.

7. Ensure that you have permission from property owners to store any garbage temporarily.
8. Arrange for garbage removal and the means to get it there. Volunteers with pickup trucks work well. Arrange with your municipality for a free dumpster, if possible, or for no dump fees, since you are performing a community service.

ON THE CLEANUP DAY

1. Leave logs, other natural material, and overhanging vegetation in the stream. **THEY PROVIDE IMPORTANT AQUATIC HABITAT**. Remove only manmade material from the stream. Seek advice before removing deeply embedded material from the stream bottom.
2. Establish a "staging area" with first aid supplies, refreshments and restroom facilities. Always station someone there.
3. Have volunteers sign in when they arrive and sign out when they leave. Get names and addresses.
4. Make everyone aware of safety concerns.
5. Make a map of where people will be working and keep track of everyone involved in the cleanup. Have only a few people in the stream, and have the rest haul away garbage.
6. Make the event as festive as possible. Provide refreshments.
7. If you find evidence of the source of the garbage, keep it and report it to the authorities.

Collecting, Reporting and Evaluating Information

Take photographs of the stream before and after the cleanup. Record the amount and types of debris collected and take photographs of the pile of garbage. Send thank-you notes to the volunteers. Keep a short report on the project. If you do the cleanup again next year, you can compare the results.

Advise the Community Advisor and your municipality of the results of the cleanup. Send a copy of the Stream Cleanup Summary Sheet to the Streamkeepers Database. The current address is in the Handbook.

You may wish to set up a "Garbage Watch" program. This will help to discourage illegal dumping of garbage. Consider posting signs where roads cross the stream (Module 11) to inform the public about sensitive stream habitat.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing awareness and working with the media.

Resources

Adopt-A-Stream Foundation. *Stream Cleanup Tips*. Everett, Washington.

Send the data to the Streamkeepers Database

MODULE 6:
STREAM CLEANUP SUMMARY SHEET

(See module 1 for additional information)

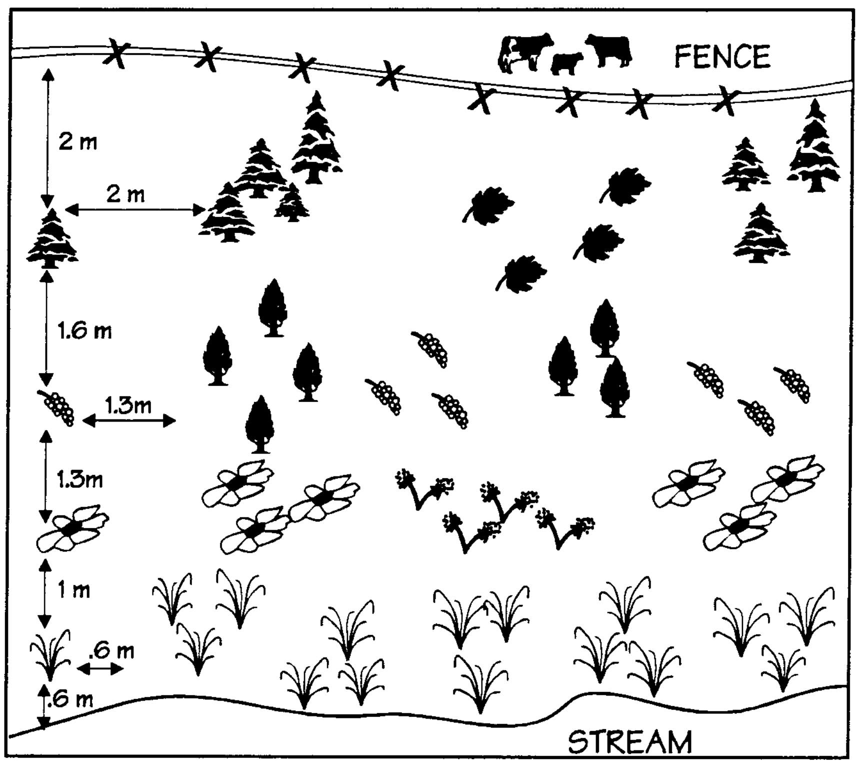
Stream Name	**Date**
Organization Name	**Crew size**
Contact Name	**Phone #**
Municipality	

Upstream limit of work (directions, distance to known landmarks)
Downstream limit of work (directions, distance to known landmarks)

Details of stream cleanup	
Length of stream cleaned up (m):	
Volume of garbage removed	
Types of garbage found	

STREAMKEEPERS

Module 7
Streamside Planting



Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
yes	recommended	A few days	4 or more	Throughout the year

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MODULE 7: *Streamside Planting*

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgements

Kim Fulton provided the materials for this section. He is a Water Stewardship Coordinator and a teacher in Armstrong. Dr. Michael Carlson and staff of Kalamalka Forestry Research Center, Vernon, provided technical advice and practical assistance.

Project Activity And Purpose

You will restore a stream bank by planting suitable native species to replace native vegetation that has been removed. The project involves obtaining plant stock, planting, and caring for the plants. Over time, the plants will grow and restore the riparian zone of the stream.

Introduction

Trees, shrubs, herbs, grasses, and primitive plants such as mosses and lichen form riparian or streamside vegetation. These plants tolerate occasional flooding. The riparian zone includes the immediate bank of the valley bottom or flood plain. The riparian area of influence may also include the adjacent lower slopes (Figure 1). Stream size and valley topography help define the width of the riparian zone.

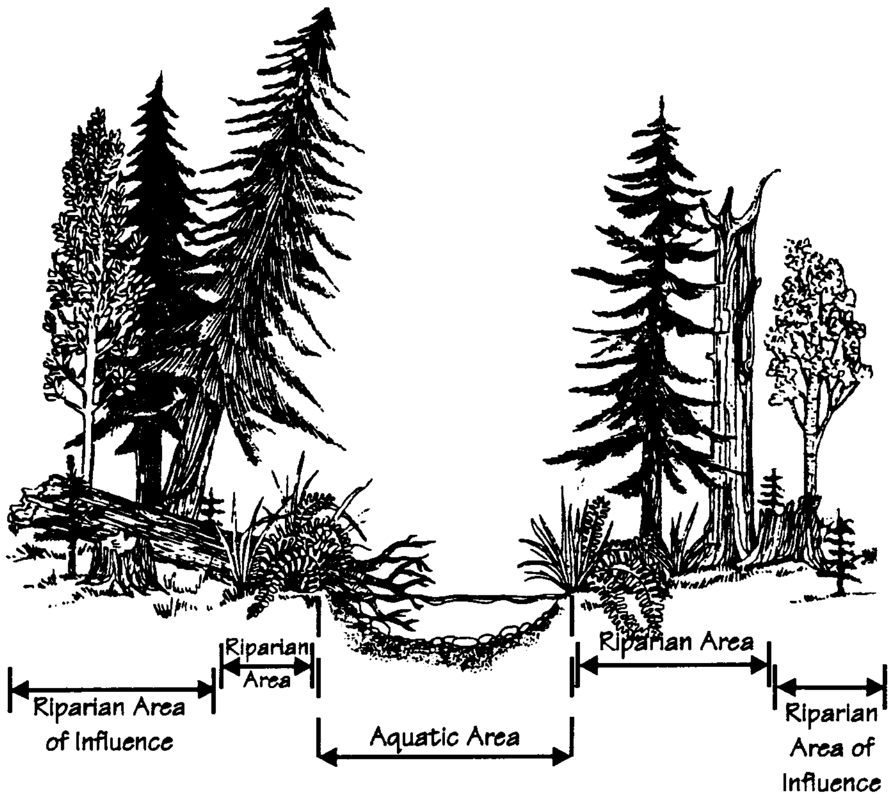
Riparian vegetation is a very important part of a stream ecosystem. Plants stabilize stream banks, reduce erosion, and provide protective cover for fish. Trees provide shade, which helps control water temperatures. Logs fall into the stream, where they create diverse habitat and help dissipate erosion energy. Leaf litter provides an important source of food for stream organisms. Plants trap sediment and filter out pollutants before they reach the stream. They help the soil absorb precipitation and release it slowly during dry spells. The riparian area provides habitat and travel routes for birds and wildlife.

Urban development, logging, and agriculture have reduced or destroyed the riparian vegetation of many streams and rivers.

Fortunately, streamside planting is an inexpensive, effective restoration project. Case studies in Iowa and Ontario show that

Figure 1 Riparian habitat

From The Stream Scene: Watersheds, Wildlife, and People.



cottonwood and willow planted on stream banks in agricultural areas reduce pollution in streams. Fertilizers stimulate tree growth rather than algal growth in these streams. The streams recovered within three years.

Project Guidance And Approval

Consult your Community Advisor about streamside planting. He or she can advise you on suitable locations, site preparation, and any necessary approvals. A Streamkeepers certification course offers training for this module. You need the permission of any landowner before you start work. You may wish to present your project at a local council meeting to help gain support.

In areas where livestock have access to streams, you should fence the planting area to protect it. Module 8 provides instructions on fencing. Stabilize any actively eroding stream banks before you start planting. Planting the banks will eventually helps stabilize eroding banks, but meanwhile, erosion may wash out the plants before they can become established.

Level Of Effort

Your project requires some planning and organizing, but it need not be time consuming. It may take as little as two months from the time you start planning until planting is complete. It will take longer if you need to stabilize banks or install fences. You should plan on three years of maintenance and follow up.

This is a good annual project for clubs and school groups working alone or together. For example, a club can collect seedlings or cuttings, then work with a school group to plant them.

Table 1 outlines the procedures, time of year, and commitment. Growing conditions vary throughout the province, so the table contains broad recommendations. You can start much earlier in the year in mild coastal areas than in cold interior and northern areas.

Table 1
Procedures, Time of Year,
and Commitment for Streamside Planting

JOB	TIME OF YEAR	TIME	# PEOPLE
planning, approval, ordering any purchased plants	winter	1 day	1 or 2
take dormant cuttings	Jan. to Feb.	half day	4 or 5
establish cuttings	Feb. to May	half day	2
plant the site	Feb. to June	depends on the site size	up to 10
weed and water	July to Sept.	variable	up to 10

Time of Year and Working Conditions

The best time to collect cuttings is during the cool dormancy period in late winter or early spring. Plant the cuttings or seedlings immediately or later in the spring. Maintain the site during summer and early fall.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property. Beware of domestic animals and wildlife.

Warn everyone, especially children, about urban hazards such as syringes, needles, broken glass, and condoms. Remove them with tongs and place them in a special hazardous materials bucket. Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials. Contact emergency response agencies or municipal crews to remove these materials.

Be aware of people around you when using shovels and other tools. Watch for tools left on the ground.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear highly visible clothing. Wear waders with felts when walking in the stream.

Materials and Equipment

Each method of obtaining plants and each phase of the project requires a different list of supplies (Table 2). The project materials may total about $100.00 for a small project.

Purchased plants grow very reliably, but can be expensive. Native species are available at some nurseries. If you purchase seedlings, make sure they are native species adapted to your climate. Sometimes government programs or private companies supply funds or plants. Growing plants from seed is inexpensive, but requires a greenhouse and two years of growing time.

Table 2
List of supplies required for obtaining plants and planting them

TAKING CUTTINGS for storage or immediate planting: general: field guide to trees and shrubs, clippers, elastic bands for bundling for immediate planting: burlap sacks, buckets, planting dibble, predator guards for storage: plastic bags, twist ties, freezer or fridge
STARTING SEEDLINGS FROM CUTTINGS, before planting out: potting soil, planting containers (6-15 styroblocks, milk cartons, peat pots, recycled pots), spring weather or greenhouse, rooting hormones for species other than willow and poplaf
PURCHASING SEEDLINGS: money ($5 to $10 per plant), supplier, scientific names of native plants
STARTING SEEDS: potting soil, planting containers (6-15 styroblocks, milk cartons, peat pots, recycled pots), seeds from the wild or from supplier, greenhouse, fertilizer
SALVAGING NATIVE PLANTS: square-ended shovel, clippers, wheelbarrow, burlap, twine, capillary bed or similar facility if storing plants
PLANTING SEEDLINGS: first aid kit, sturdy footwear, shovels, wheelbarrow (optional), landscape cloth (optional), stakes, several colours of flagging tape, predator guards (mouse guards, 1/8" wire mesh, or aluminum foil), watering cans or buckets, mulch, truck or trailer
SITE MAINTENANCE watering cans, “Weedeater” or lawn trimmers, manure (optional)

Background Information

Stream banks need a good diversity of plant species to provide a variety of foods, cover types, and habitats for aquatic organisms, birds and wildlife. Both deciduous and coniferous species are important. Deciduous trees like black cottonwood grow rapidly and begin to enhance a stream quickly. Coniferous trees like red cedar grow more slowly, but will enhance a stream long after you and the cottonwoods have disappeared. A mixture of coniferous and deciduous plants ensures a year-round supply of leaf litter for a diverse community of aquatic insects.

Native species common on British Columbia stream banks are listed in Appendix 1, along with habitat requirements and propagation methods. Some species require special methods or extra care for successful propagation.

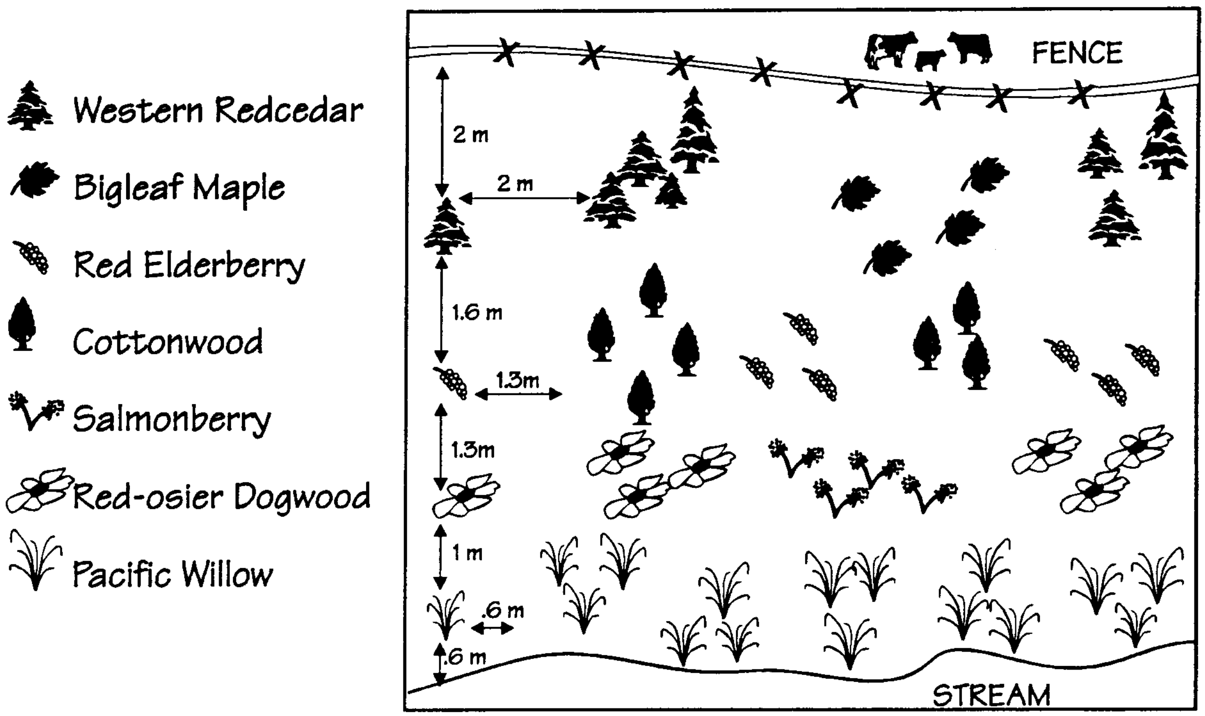
Each species has a definite preference for either wetland or upland conditions (Figure 2). The system shown in Table 3 is one way of classifying plants according to their suitability as stream bank species. Choose some species for close to the stream (WET, FACW, FAC) and some for further away (FAC, FACU, UPL). For example, willows prefer wetter sites, whereas Douglas firs prefer drier soil.

Table 3
Classification of suitable streamside plant species
(source: Cowardin et al., 1979)

WET	obligate wetland: almost always occurs in wetlands
FACW	facultative wetland: usually in wetlands, occasionally in non-wetlands
FAC	facultative: equally likely to occur in wetlands or non-wetlands
FACU	facultative upland: usually occurs in non-wetlands
UPL	obligate upland: almost always found in non-wetlands

Planting projects usually include willow and cottonwood. These species are common along streams throughout the province. They are very easy to propagate from cuttings and grow very quickly. You also can plant seedlings of other species. Nature will introduce new species over time, especially herbaceous plants, mosses, and other simple plants. You may need to control the growth of species such as blackberry and hard hack that can be invasive to the point of taking over.

Figure 2 Sample Planting Plan



Work out a planting plan on paper ahead of time. This will make the actual planting easier, because you will know how many of each species you need and where to plant them. Consider the habitat requirements of the plants when you work out spacing and arrangement. Figure 2 shows a sample planting plan. The spacing in this sample is to be used as a general guide only.

Your planting project should mimic natural growth along the stream. For example, many species grow in clumps. Copy the species and natural spacing patterns that you see at an undisturbed site, or ask a naturalist or landscaper for advice.

Procedure

The procedure involves four steps:

Step 1. Planning the Project
Step 2. Obtaining Plant Stock
Step 3. Planting Your Site
Step 4. Follow-up Care

Step 1. PLANNING THE PROJECT

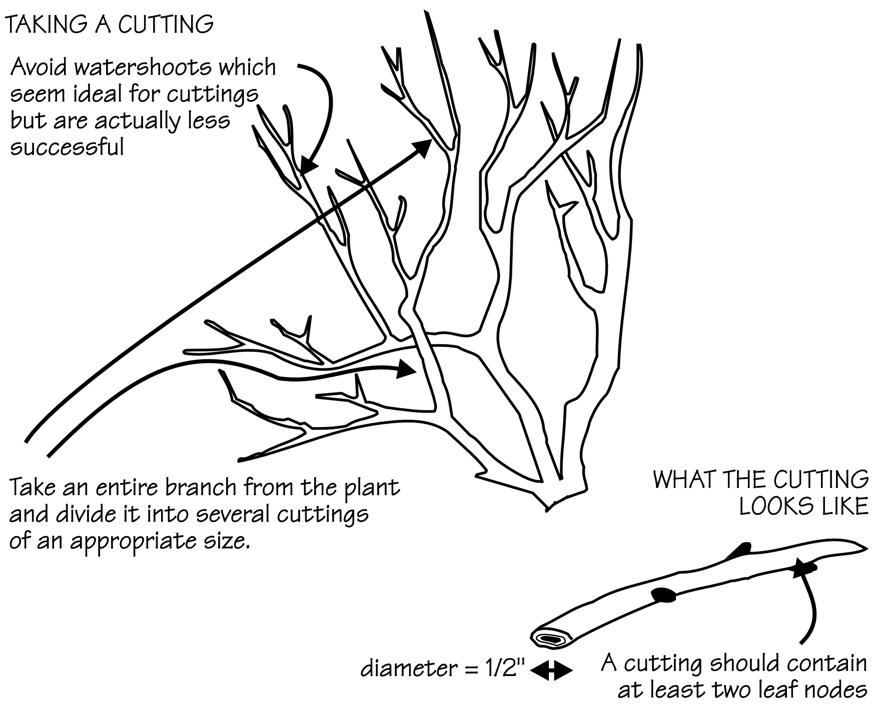
Select the area you wish to rehabilitate. Obtain any necessary approvals at least two months before you plan to plant. You will know good locations already if you have done the Introductory Stream Habitat Survey (Module 1).

Plant any steep, bare slopes with a grass seed mixture designed to control erosion. Check with a local nursery, municipal engineering department, or the Ministry of Transport and Highways for recommendations. Arrange to fence the stream bank before you start planting if livestock have access to the stream. See Module 8 for instructions.

Examine undisturbed areas of the stream or other streams nearby. Choose tree and shrub species that grow well in the area. Appendix 1 and the references listed at the end of this module provide guides to native species. Make a planting plan for your site.

Figure 3
Taking a Cutting, What the Cutting Looks Like

from the King County Deparment of Public Works



Some species are hard to identify without their leaves. Willows, for example, are the only plants with both single bud scales and alternate buds (Figure 3). You may wish to identify and tag suitable plants during summer or autumn, and return to take cuttings in the winter.

Step 2. OBTAINING PLANT STOCK

a) Propagating Cuttings:

Cottonwood (Populus trichocarpa) and willow (Salix spp.) are the easiest to propagate from cuttings. Use native species such as the Pacific willow (Salix lasiandra) or pussy willow (Salix spp.), not the introduced weeping willow. You may find it frustrating to start other species from cuttings, and probably need to follow special instructions for individual species. The success rate for cuttings of other species can be less than 50%. Gardening books such as Kruckeberg (1982) and Spurr (1980) provide information on propagating plants. These other species are worth trying because they create more species diversity on the stream bank. Appendix 1 includes propagation methods for many native species.

Collect cuttings from several trees over a wide area and take 5% or less of the stock (1 in 20). This keeps you from depopulating natural areas and ensures genetic variability in the plant material. Pruning also improves the vigour of the parent plants.

You can take softwood cuttings from spring through early fall, when plants are not dormant. This method works well for several species, but is beyond the scope of this module. Consult a reference such as Spurr (1980) for instructions for specific plant species.

Take hardwood cuttings while the plants are fully dormant, in January and February. Choose normal, healthy growth from young trees or shrubs. Cuttings from weak thin shoots, abnormally thick shoots, or older plants do not root well. Cut the previous season's growth with sharp pruning shears (Figure 3). The previous year's growth is the area above the terminal bud scar, the circular scar all around the branch. Select branches about 1 cm in diameter and cut the bottoms at a 45-degree angle, just below a leaf node or bud.

Trim off the tops of the cuttings at a slight angle. Cuttings should be 20 to 40 cm long (8 to 16 inches), with at least two or three healthy buds. Bundle them in groups of twenty-five, with an elastic band near the bottom, so you can recognize the bottoms at planting time. When you are working at temperatures above freezing, keep the cuttings moist by placing them in a wet burlap sack as you collect them. This is not practical or necessary in subzero weather.

Method 1 - Planting cuttings right away: In milder parts of the province, you can plant the cuttings immediately. Store them, right side up, in a 22 litre bucket one-third full of water, for up to 48 hours. Take the cuttings to the site in the bucket. Plant the cuttings following Step 3 and pour the water from the bucket over them.; it contains natural rooting hormones that have leached out of the plants.

Method 2 - Storing, then propagating the cuttings: Where the climate is harsh, store the bundled cuttings in plastic bags. Squeeze out the excess air and seal the bags. Store them in a freezer or fridge until you are ready to root them. When the ground thaws, you can plant them directly in the soil, or start them in a greenhouse or cold frame. In mild coastal climates, you can store the cuttings by burying them in frost-free soil in your back yard until you are ready to plant them. Root the cuttings in pots or in styroblocks with 45 cavities (called 6-15's in nurseries). Fill the cavities with damp potting soil. Push the cuttings to the base of the cavities, then pull them up 1 to 2 cm so you do not expose the bottoms to air. Bury half or more of each cutting, leaving one bud above and one or more below soil level. Water the cuttings well, then put the blocks into a sunny area of a garden or cold frame. Keep them moist. When leaves and good root system have developed, in two to three months, cuttings are ready to transplant to the stream bank.

b) Planting Seeds:

You can grow many species from seed collected in the wild or purchased from suppliers. However, this takes up to two years and requires a green house in most parts of the province.

Collect seeds from plants near your proposed site that are adapted to local conditions. Take 5% or less (1 in 20) of the native stock, so you do not disrupt the area. If you order seeds from a supplier, use the scientific names to ensure you get native species. Some seeds require special conditions before germination. Kruckeberg (1982) provides information on growing native species from seed.

c) Purchasing Plants:

Make sure you buy native species adapted to local conditions. Buy two-year-old acclimated plants, so you can plant them outside immediately. Acclimate greenhouse plants before you plant them.

You can use one-year-old plants where the climate is mild. Where the climate is harsher, grow one-year-old plants for another year before planting them. Sometimes you can find inexpensive conservation-grade plants.

d) Transplanting or Salvaging Native Plants:

Consider salvaging native plants from an area threatened by land development. Obtain permission from the owners and remove only those plants threatened by bulldozers. Dig up plants on a wet cloudy day during the dormant season, when the ground is not frozen.

Use a very sharp flat-blade spade to dig out the root ball in a 30 cm (1 foot) radius around the plant stem. Wrap the root ball in burlap and tie it around the stem. Store the plants with their rootballs in moist sawdust or mulch to protect them from harsh weather. You can store them this way for several months. The King County guide to native plant propagation describes how to build a capillary bed, which is an easily constructed holding facility for salvaged plants. Volunteer groups in a few locations in the province have built capillary beds. Ask your Community Advisor if there is this type of facility near you.

Please do not transplant native plants from areas that are not slated for development. You may accidentally depopulate an area, transplant at the wrong time of year, or even disturb an endangered species. If you still choose to transplant, take 5% or less (1 in 20) of the plants of that species, leave lots of seed at the site, and be sure to remove them at the right time of year.

Step 3. PLANTING YOUR SITE

Work on a cloudy or damp day to avoid drying out roots and killing the plants. On a rainy day, you do not need to water the plants! Explain procedures well to volunteers before you start. You can colour code the plan, stakes, and plants using a different colour of flagging tape and label for each species.

Choose the location for each plant very carefully. Make sure you can dig the soil at the site. Arrange stakes on the site according to the planting plan. You may need to bring extra soil if the banks have rip rap. Avoid sites that have permanent standing ground water within a few inches of the soil surface. Many riparian plants survive temporary flooding, but permanent water will drown the roots. Willow is the one exception - it prefers wet soil conditions so is planted closest to the stream.

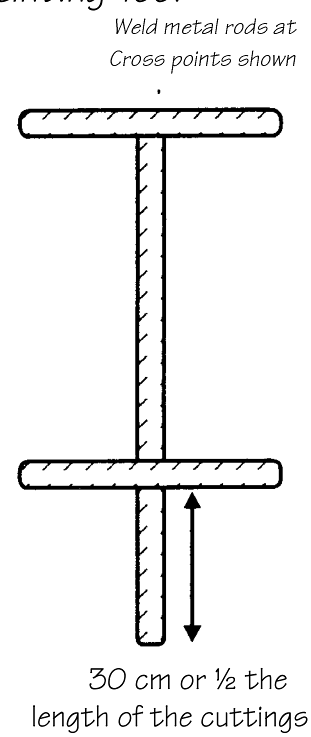
Method 1 - Planting unrooted cuttings immediately

Use this method for willow and cottonwood cuttings. Clear away weeds and grass from an area 1 metre in diameter. Use a dibble, a simple planting tool. (Figure 4) Push it into the ground, at least half as deep as the length of the cutting. Drop the cutting into the base of the hole and push it down a little. Leave one healthy bud above the soil surface to sprout leaves. The buds below the surface will sprout roots. Tamp the cutting in place by pushing the tool into the ground 5 cm away, then pressing toward the cutting. This fills air pockets and surrounds the cutting with damp soil. Water the cutting with the reserved water in the bucket. Place a rodent guard around the stem of each plant and press it into the soil. Use a commercially available mouse guard or aluminum foil. A sturdy wire mesh guard will deter beavers. You may wish to place a piece of landscape cloth around the cutting to inhibit weed growth.

Method 2 - Transplanting rooted cuttings or seedlings

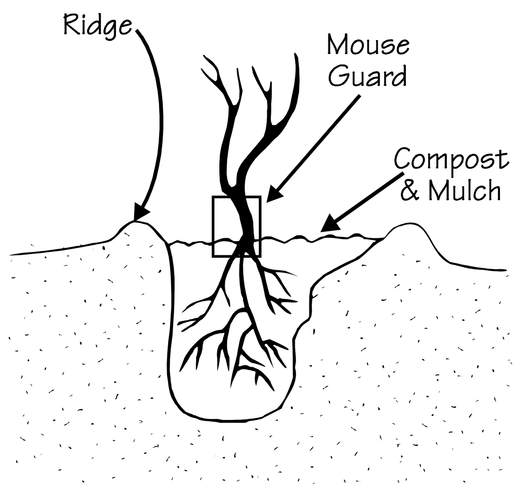
Use this method for any plants growing in styroblocks or pots. Clear away weeds and grass from an area 1 metre in diameter. Dig a hole about half again as large as the diameter, and deeper than the rootball of the plant. Dig up the soil at the bottom of the hole. Hold the seedling over the hole and "tease" the rootball gently with your fingers so that some soil falls into the hole. Place the plant in the hole so that the top of the rootball is just below ground level. Pack the soil firmly

Figure 4
Dibble
Planting Tool



around the plant, covering all roots. Build a ridge of soil around the plant, 0.5 m in diameter and 10 to 15 cm high, to collect moisture (Figure 5). On slopes, build a berm or short wall of soil on the downhill side.

Figure 5
A Rooted, Planted Cutting



You may wish to place a piece of landscape cloth around the plant to inhibit weed growth. You can add a scoop of composted mulch on top of the cloth to hold in moisture. This is optional but beneficial. Water the plant well with 8 to 12 litres of water, unless it is raining. Mark the plant with a stake, so no one tramples it and you can find it easily later.

Step 4. FOLLOW UP CARE

Check your site every week or two from July to September, or until the first heavy rains of autumn. Water the plants well and remove competing weeds and grasses until the plants become well established. Check the mouse guards periodically. You may need to plant again if only a few seedlings survive. Plan on routine summer maintenance for the next two to three years.

Collecting, Reporting, and Evaluating Information

Complete the Streamside Planting Summary Sheet and send it to the Streamkeepers Database. The current address is in the Handbook.

Take photographs or videos before and after planting, and in successive years. Keep a record of your site plan, and make notes on the success of different species. You can evaluate your project further. For example, you can monitor improvements in water quality (Module 3), aquatic invertebrates (Module 4), and fish (Module 11) by sampling before you start the project and in successive years.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

References and Useful Resources

Adopt-A-Stream Video (available from Community Advisors)

Cowardin, L.M., V. Carter, F.H. Golet and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish & Wildlife Publication FWS/OBS-79/31. Washington, DC.

Cowlitz Conservation District. *Streamside Planting Guide for Western Washington.* Cowlitz County Soil and Water Conservation District, Kelso, WA.

Guard, J. 1995, in press. *Wetland Plants of Oregon, Washington, and Southern British Columbia.* Lone Pine Publishing, Vancouver, BC.

Johnson, A.W. and J.M. Stypula (editors). 1993. *Guidelines for Bank Stabilization Projects in the Riverine Environments of King County.* King County Dept. of Public Works, Surface Water Management Division, Seattle, WA.

King County Department of Public Works - Surface Water Management Division. *Northwest Native Plants Identification and Propagation for Revegetation and Restoration Projects*. Available from:
King County Surface Water Management Division,
700 Fifth Ave., Suite 2200
Seattle, WA 98104

Kruckeberg, A.R. 1982. *Gardening with Native Plants of the Pacific Northwest: An Illustrated Guide.* Univ. Washington Press, Seattle, WA.

Lyons, C.P. 1952. *Trees, Shrubs, and Flowers to Know in British Columbia.* J.M. Dent and Sons (Canada) Ltd., Vancouver, B.C., currently reprinted by Lone Pine Publishing.

MacKinnon, A., J. Pojar, and R. Coupe. 1992. *Plants of Northern British Columbia.* Lone Pine Publishing, Vancouver, BC. 352 pp.

Parish, R., D. Lloyd, and R. Coupe. 1995, in press. *Plants of Southern British Columbia.* Lone Pine Publishing, Vancouver, BC.

Pojar, J. and A. MacKinnon. 1994. *Plants of Coastal British Columbia.* Lone Pine Publishing, Vancouver BC, 527 pp.

Spurr, J. (editor) 1980. *Cuttings Through the Year.* Univ. Washington Arboretum, Seattle, WA.

Thurston Conservation District. *A Guide to Stream Corridor Revegetation in Thurston County.* Thurston Conservation District, Dobbs Creek Model Farm, Olympia, WA.

U.S. Army Corps of Engineers, Seattle District. 1993. Wetland Plants of the Pacific Northwest. Available from:
Government Bookstore,
1305 SW First Ave.,
Portland OR. 97201-5801

Appendix

Appendix 1: Native Species Suitable for Riparian Vegetation Projects

Appendix 1: Native Species Suitable For Riparian Revegetation Projects

(the information for this table was compiled from C.P. Lyons, Thurston Conservation District manual, King County manual)

Codes:

COASTAL/ INLAND	SUN/ SHADE	WETLAND/ UPLAND
c = coastal	s/ = sun	upl = obligate upland
i = inland	/s = shade	facu = upland/some wetland
	ps = part shade	fac = upland + wetland
		facw = wetland/some upland
		wet = obligate wetlands

PROPAGATION METHODS

Willow and poplar cuttings and two year old seedlings of many species are the easiest to propagate. Establishing cuttings of other species and starting plants from seed can be difficult. Seek advice from an experienced gardener and consult gardening books by Kruckeberg and Spurr.

Common Name (scientific name)	Coastal/ Inland	Sun/ Shade	Wetland/ Upland	Propagation method
TALL CONIFEROUS TREES				
Douglas fir (Pseudotsuga menziesii)	c/i	s/ps	upl	seed, transplant
Sitka spruce (Picea sitchensis)	c	s/s	fac	seed, transplant
Western Hemlock (Tsuga heterophylla)	c/i	/s	facu	transplant, seed
Western Red Cedar (Thuja plicata)	c/i	/s	fac	transplant, seed
TALL DECIDUOUS TREES (>50 Feet)				
Big Leaf Maple (Acer macrophyllum)	c/i	s/ps	facu	seed ,transplant
Black Cottonwood (Populus trichocarpa	c/i	s/	fac	cutting, seed, transplant
)Quaking Aspen (Populus tremuloides)	i	s/	facw	seed, sucker
Red Alder (Alnus rubra)	c	s/s	fac	seed, cutting, sucker,
SHORT DECIDUOUS TREES (15 - 60 Feet)				
Bitter Cherry (Prunus emarginata)	c	S/ps	facu	seed, transplant
Black Hawthorn (Crataegus douglasii)	c/i	s	fac	seed,transplant
Cascara (Rhamnus purshiana)	c	s/s	fac	cutting, seed, transplant
Crabapple (Pacific) (Malus diversifolia)	i	s/	fac	seed
Mountain Alder (Alnus tenuifolia)		s/	facw	seed,transplant
Oso Berry or Indian Plum (Osmaronia cerasiformis)	c	s/s	upl	transplant,seed, cutting
Red Elderberry (Sambucus racemosa v. arborescens)	c	s/ps	facu	cutting, seed
Vine Maple (Acer circinatum)	c	/s	facu	seed, transplant
Water or Black Birch (Betula occidentalis)	c/i	s/s	wet	seed, transplant
White or Paper Birch (Betula papyrifera)	c/i	s/	facu	seed, transplant
Willows: Pacific (Salix lasiandra), Sitka (S. sitchensis) Scouler's (S. scouleriana), Sitka (S. sitchensis)(many called pussy willow)	c/i	s/	facw/wet	cuttings

Common Name (Scientific Name)	Coastal/ Inland	Sun/ Shade	Wetland /Upland	Propagation method
SHRUBS (2 - 15 FEET)				
Blueberry, Huckleberry (*Vaccinium spp.*)	c/i	s/s	upl	seed, cutting, sucker
Douglas, Rocky Mtn maple (*Acer glabrum*)	c/i	/s	facu	seed, transplant
Gooseberries (*Ribes spp*)	c/i	s	fac	seed, cutting, layer
Hudson Bay currant (*Ribes spp.*)	i	s	fac	seed, cutting, layer
Mock Orange (*Philadelphus gordonianus, P. lewisii*)	c	s/s	fac	cutting, layer
Ninebark (*Physocarpus capitatus*)	c	s/s	fac	cutting
Nootka or Wild Rose (*Rosa spp, R. nutkana*)	c/i	s/ps	fac	cutting, sucker, seed
Red Osier Dogwood (*Cornus stolonifera*)	c/i	s/s	facw	cutting, seed layer
Salal (*Gaultheria shallon*)	c	s/	upl	transplant, seed
Salmonberry (*Rubus spectabilis*)	c	s/s	fac	cutting, transplant
Service or Saskatoonberry (*Amelanchier spp.*)	c/i	s/	facu	sucker, seed
Sitka Alder (*Alnus sinuata*)	c/i	s/s	facw	seed, cutting, sucker
Snowberry (*Symphoricarpos albus*)	c/i	s/s	facu	cutting, transplant
Snowbrush (*Ceanothus velutinus*)	i	s/	upl	cutting, transplant
Spiraea or Hardhack (*Spiraea douglasii*)	c/i	s/s	facw	sucker, cutting
Tall Oregon Grape(*Berberis aquifolium*)	c/i	s/s	upl	cutting, layer
Thimbleberry (*Rubus parviflorus*)	c/i	/s	facu	cutting, transplant
Twinberry (black) (*Lonicera involucrata*)	c/i	/s	fac	cutting, seeds
Twinberry (red) (*Lonicera utahensis*)	i	/s	facu	cutting, seeds

Soil moisture characteristics and site conditions to consider when choosing plant species:

These recommendations are taken from Johnson and Stypula, 1993.

Very Droughty Soils: Use UPL and FACU species. These conditions may be expected in porous or well-drained (sandy) soils or high on the bank, especially on south or west facing banks with little shade.

Droughty Soils: Use mostly UPL and FACU species; FAC species may be used occasionally if site conditions are somewhat moist. These soils occur in areas similar to very droughty soil, but where moisture retention is better (e.g. less sandy soils, shade, and north or east facing banks).

Moderate Soils: Use FACU, FAC, and FACW species. They are loamy soils with some clay, on level areas to steep slopes. They may be shallow soils over hardpan, or areas where seeps are common. Plant selection should consider microclimatic conditions, including seeps, slope, aspect, etc. Steeper slopes, for example, will be drier than level soils because of water run off.

Wet Soils: Use mostly FAC and FACW species; WET species can be used in particularly wet areas as long as the soil is not compacted... (usually) these soils consist of nearly level silt loams. They retain water rather than allowing it to run off after rain, and are moist to wet for most or all of the year. Because these areas have minimal slope and typically slow-moving streams, erosion is seldom a problem.

Very Wet Soils: Use FACW and WET species. These soils may be found along meandering rivers and streams with low banks. There is typically a high water table that allows the development of organic soils (peat and mucks). They are not well suited to large woody vegetation, as trees tend to blow over. Dense thickets of shrubs and small trees are common. Because these areas have minimal slope and typically slow-moving streams, erosion is seldom a problem.

send the data to: *Streamkeepers Database, Department of Fisheries and Oceans,*
Suite 400, 555 W. Hastings Street, Station 321, Vancouver, B.C. V6B 5G3
or fax to (604) 666-0292

Streamside Planting Summary Sheet

(use a new data sheet for each site planted)

Module 7

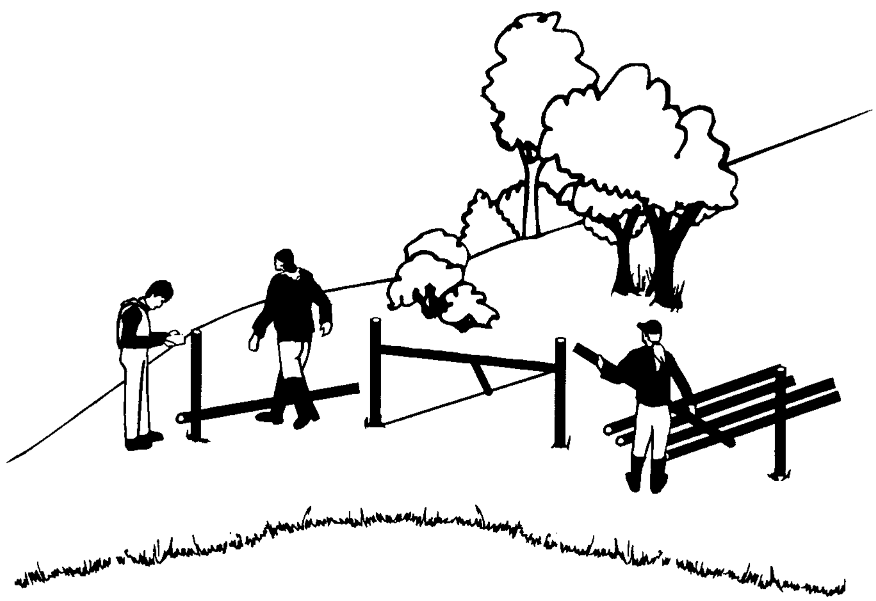
Stream Name/Nearest Town	**Date**
	Watershed code
Organization name	**Stream Segment #**
Contact name	**Crew size**
	Phone #

Upstream limit of work (directions, distance to known landmark)
Downstream limit of work (directions, distance to known landmark)

Details of streamside planting
Source of stock (cuttings, nuresery seedlings, seed, salvaged plants)
Species planted and number of each species
Additional comments (why the planting was done, etc.)

STREAMKEEPERS

Module 8
Streamside Fencing



Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	Not necessary	several days	2 or more	spring through fall

Fisheries and Oceans Pêches et Océans

Canada

MODULE 8

Streamside Fencing

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Bryan Allen, Community Advisor with the Department of Fisheries and Oceans, and Karen Munro organized the material for this module. Lance Brown of the Ministry of Agriculture, Fisheries and Food, in Kamloops, provided advice on current fencing practices. Dr. D.A. Quinton, Agricultural Research Station, Kamloops, gave permission to use information from his Agriculture Canada publication Wire Fences for Livestock Management.

Project Activity and Purpose

This module provides guidance for constructing wire fences to control livestock access to riparian areas along streams, ponds and wetlands. Instructions for building both barbed wire and smooth wire fences are provided. Woven wire and electrical fences are described, but only briefly. Streamside fencing protects existing riparian vegetation, and allows regeneration of heavily grazed areas.

Introduction

Streamside or riparian areas are important parts of a stream ecosystem. The root systems of plants stabilize banks, help control erosion, and absorb contaminants that otherwise would enter the stream. Trees and shrubs provide shade, cover and food for many land and water-dwelling organisms. This vegetation and water are very attractive to livestock as well as wildlife. Protecting the aquatic and band areas is essential to maintaining a healthy stream ecosystem.

Livestock can damage the riparian zone and stream quality when they have uncontrolled access to the stream. Livestock reduce or eliminate stream bank vegetation by grazing and trampling it. They damage streambeds and banks when they walk into streams to drink. Over time, this causes streams to change shape: bottoms become muddier, channels widen, and pools fill in. Erosion and lack of shade cause increased turbidity, increased water temperatures, and decreased dissolved oxygen levels. Nutrient concentrations increase due to the addition of animal wastes and these nutrient loads lead to algal and bacterial blooms. When blooms decompose, this increases the biological oxygen demand. Water contaminated by manure also contains disease-causing organisms.

Restricting livestock access to streams provides benefits to landowners as well. Soil erosion is reduced greatly. Animals provided with clean water are healthier and gain weight more quickly than those provided with unpalatable waste-contaminated water. Animals also pass on bacteria and viruses in waste-contaminated water. Mastitis, a disease likely to infect dairy cows living in wet, muddy environments, is one example. Fencing also helps prevent accident. Many farm animals are injured or killed very year when stream banks collapse under them or they slip on slippery stream banks.

Most opportunities for fencing occur on privately owned land, where you must have the approval and cooperation of the landowner. You may find it helpful to have someone who knows the owner, such as a local Provincial District Agriculturist, introduce you group and explain the benefits of a fencing project. You will find property owners more cooperative if you can provide details of costs and financial arrangements ahead of time. Before starting the work, you and the landowner should agree on ownership of the fence and routine maintenance. You may decide to arrange a formal contractual agreement. Explain to the landowner the importance of not disturbing the fenced streamside vegetation. Ask the owner when and where to start the work. You may need to wait for mares to finish foaling, or animals to move to another pasture.

Landowners may have genuine concerns about the impact of fencing on their property. They may worry about the competence of the fence builders and, therefore, the quality of the finished fence. After all, their livestock are at risk from a poorly built fence. You may wish to let them supervise the work, or offer other assurances of fence quality. Your group may wish to arrange for liability insurance, to reduce landowner responsibility for volunteers working on their property. Landowners will cant continued access to water for their livestock, so you can incorporate troughs of inset watering areas in the fence design. They may be concerned about growth of undesirable plants behind the fence. A volunteer group usually restores the stream banks by planting native species (Module 7) in association with the fencing project. Planting stream banks involves a commitment to weeding and maintaining the site, which inhibits growth of undesirable plants. It also provides an opportunity to discuss with the landowner the most suitable species to plant. Fore example, cottonwood is commonly used for bank restoration. However, some farmers consider it a nuisance species, because seedlings sprout up everywhere.

Consider the type and size of livestock involved when you design the fence. There are several styles of wire fences, each suitable for particular animals. Smooth wire fences are used for many animals. Barbed wire fences are acceptable for thick skinned cattle. Wooden post-and-rail fences are used for horses on many properties. Woven or page wire fences will control smaller animals like foals, calves, and sheep. Electric fences require a power source and frequent maintenance, but a practical and inexpensive in many situations.

This module describes general recommendations for building fences on stream banks. D.A.Winton's publication, Wire Fences for Livestock Management, provides site-specific details, equipment lists, and techniques. This publication is available from Agriculture Canada offices. The provincial Ministry of Agriculture, Fisheries, and Food also has publications and fact sheets that describe fencing techniques and adaptations for streamside areas.

Project Guidance and Approval

If your project is on private land, discuss details of maintenance with the landowner, and agree on the responsible party. On Crown Land, you may need a letter of permission from a provincial agency such as the Ministry of Forests or the Ministry of Environment, Lands, and Parks (MOELP). Any instream work, such as building fences across streams or inset watering ramps, requires MOELP approval.

The fence you build should comply with acceptable agricultural designs. Fence designs are specific to the site, the type of animal, and local customs. Find someone in your community with fencing experience to advise you on details. You also may contact your local B.C. Ministry of Agriculture, Fisheries, and Food office for advice. Consult your telephone directory or call Enquiry B.C. (1-800-663-7867) for information about the nearest provincial agriculture office.

Level of Effort

Fencing is a very costly project for a volunteer group. Materials alone can cost $1000 or more per kilometre. You may need to scale down your project and consider fencing only the areas with most sensitive stream habitat first. Check the Community Stewardship guide (Anon., 1995) or your DFO Community Advisor for funding suggestions. Fencing suppliers may give you a discount if you tell them materials are to be used for a public service project.

Fencing requires significant physical effort. Although two experienced farm workers with the proper equipment can do the job, you probably will need four volunteers to do the same work.

Time of Year and Working Conditions

In many parts of the province, fences are built from spring through fall. Digging may be a problem when the ground is frozen or wet. Be very careful handling wire in very cold weather. Stream protection guidelines require that stream crossings and inset watering areas be built during the summer, when work is least likely to disturb salmonids.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency telephone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property.

Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

SAFETY PRECAUTIONS FOR FENCING

Use protective full-length clothing, gloves, and eye or face guards when working with chemically treated posts. Some people have allergic reactions to these chemicals.

Wear tough clothing to protect you from wire ends or barbs: long pants, heavy work boots, and snug fitting heavy duty gauntlet-type leather gloves. Wear a hard hat and ear protection when operating a mechanical post pounder. Use driving caps on posts to prevent splintering. Wear eye protection when cutting or tensioning wire and when driving nails or staples. Always use proper shields on power equipment. Carry nails, staples, and tools in a nail apron or tool bag.

Keep the work area free from debris. Pick up all pieces of wire, cut posts, nails, staples, etc., to protect equipment, livestock, and people.

Materials and Equipment

Quinton (1990) describes some materials and equipment used to build barbed and smooth wire fences. Always use good quality, corrosion-resistant materials.

materials:

wooden posts treated with chromated copper arsenate to CSA standard 080, 244 cm (8 feet) long, of the appropriate diameter; fence line posts are one size smaller than ends, brace and corner posts

protective clothing, gloves, eye or face shields

staples

wire

droppers or stays

specialized tools:

hand swager (tool to crimp ends of compression sleeves)

wire benders or small vise-grip pliers

wire pullers or tensioning device

post-hole auger

two-person post pounder

tension meters

fencing pliers

playout device for wire

common tools:

notched marking stick

claw hammer

25-cm (10 inch) crescent wrench

saw

18-m chain or tape

plumb bob

12.7mm (1/2 inch) electric drill

hand brace and 9.5 x 200 mm bit (0.4 x 8-inch bit)

Types of Fences

High-tensile smooth wire fences use 12-1/2 gauge, Class 3 galvanized steel wire. Smooth wire has several advantages over barbed wire. It is less expensive, easier to string out and tighten, requires no pretensioning, and has greater tensile strength. Smooth wire fences are safer for livestock and wildlife because there are no barbs to damage their hides. These fences tolerate greater shock loads than barbed wire fences because the wire is not stapled tightly to the posts.

Barbed wire is made from two-stranded low-tensile wire, and the barbs are considered a deterrent to animals. Many landowners still prefer barbed wire, despite the advantages of smooth wire. Two-stranded barbed wire needs to be pretensioned before being tied off.

Woven wire or page wire is used to confine small animals like sheep, calves, and foals. It is expensive, so it is used sparingly. Also, animals can become tangled in the wire. Page wire comes in rolls of various length, height, and wire spacing.

Electric fences often are used when temporary fencing is required. They are easy to install and practical, but require a reliable power source. Electric fences also are used for permanent fencing, but they require frequent maintenance, and have a potential liability factor associated with their use.

Wooden post-and-rail fences are used on many properties to fence horses. These fences are two to three times more expensive to build than wire fences.

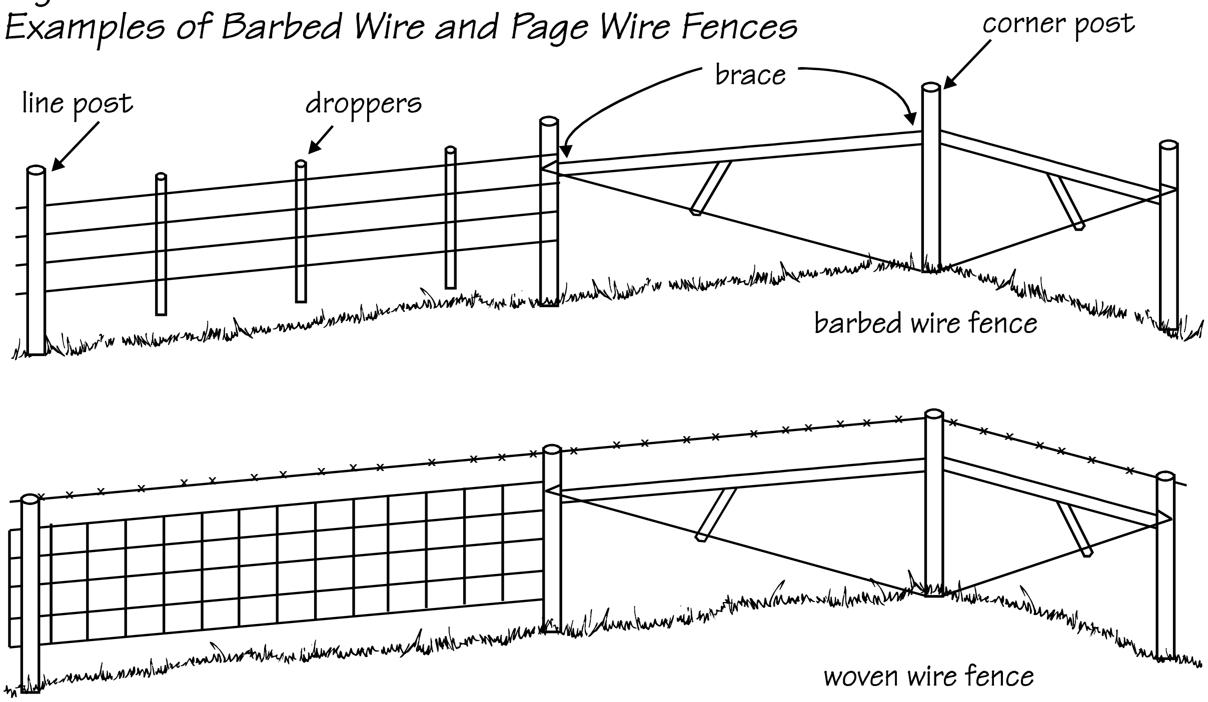
Procedure

Many details of your fencing project are best worked out according to the particular site chosen, so only federal guidelines are given here. Get advice from an experiences fence builder in your area and talk to staff at the local provincial or federal agriculture office. Quinton (1990) is a reference currently available for fence building instruction.

CHOOSE THE MOST EFFECTIVE FENCE TYPE AND PLAN THE FENCE

Build the fence to comply with acceptable agricultural designs and allow for crossing and watering points. Make your fence-line as straight and level as possible, to simplify construction and reduce your costs. Clear away as little vegetation as possible. You will need to accommodate dips and rises in the ground. Figure 1 shows examples of barbed wire and page wire fences.

Figure 1
Examples of Barbed Wire and Page Wire Fences



Set the fence back from the stream bank to allow free growth of streamside vegetation and some natural alteration of the channel. If the bank is actively sloughing, set the fence well back. Channel erosion may wash out your fence before the roots of new vegetation can become established enough to stabilize banks.

Barbed or smooth wire fences with four to six strands of wire are adequate to protect the riparian zone of most streams. The number of stands used depends on the expected livestock pressure on the fence. Livestock pressure refers to the chance of animals encountering and pushing on the fence. For instance, fenced range land is considered a low pressure situation, whereas a holding pen is a high pressure situation. Streamside fences on range land may be in a high pressure situation, because animals are attracted to stream areas, especially when the land has a low slope. An extra strand should be added in areas most likely to endure high livestock pressure. The additional cost of one extra wire strand is small. Sometimes, you may need a more specialized type of fence. For example, you may need woven wire or many strands of smooth wire to keep out sheep and young animals.

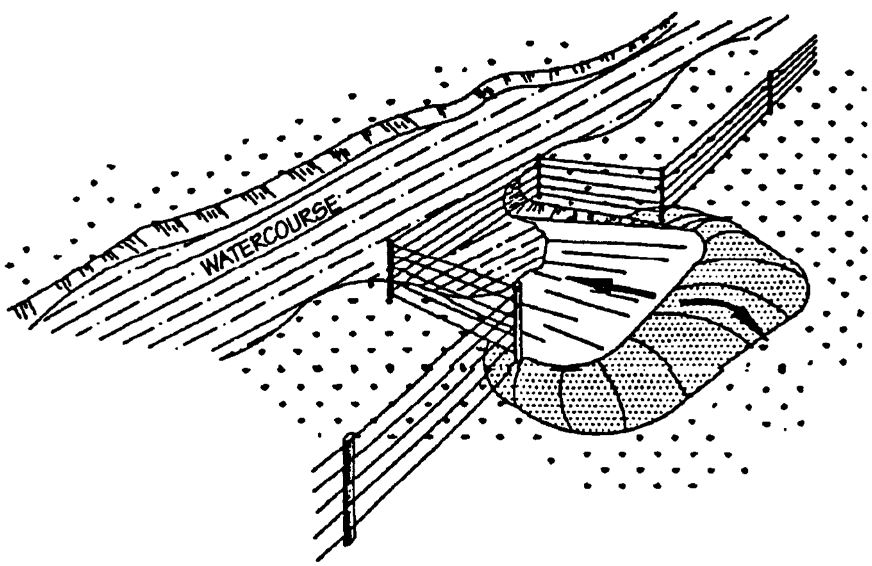
Measure the distance you plan to fence and make a sketch of the area. Work out the supplies needed and costs involved. Posts can be spaced every 5 to 12 m (5 to 13 yards), depending on the terrain.

DESIGN WATERING AND STREAM CROSSING POINTS

Assess the need for water access. You do not need to provide direct access when animals have other watering areas. You may wish to consider installing a pump and trough system as an alternative to providing access to the stream. Any instream watering points should keep livestock out of the fenced off areas to reduce sedimentation in the stream. Figure 2 is a design for a ramp inset watering area described by Brown (1994). The floor of the ramp should be constructed of clean material, such as poured slatted concrete, clean gravel over "GeoGrid" fabric, or precast concrete pads. Design the ramp with a gradient less than 10:1 to provide acceptable footing for livestock. Wherever possible, install the ramp in a straight, wide section of the stream where banks are stable and with a gentle slope.

Figure 2
A Ramp Inset Watering Area

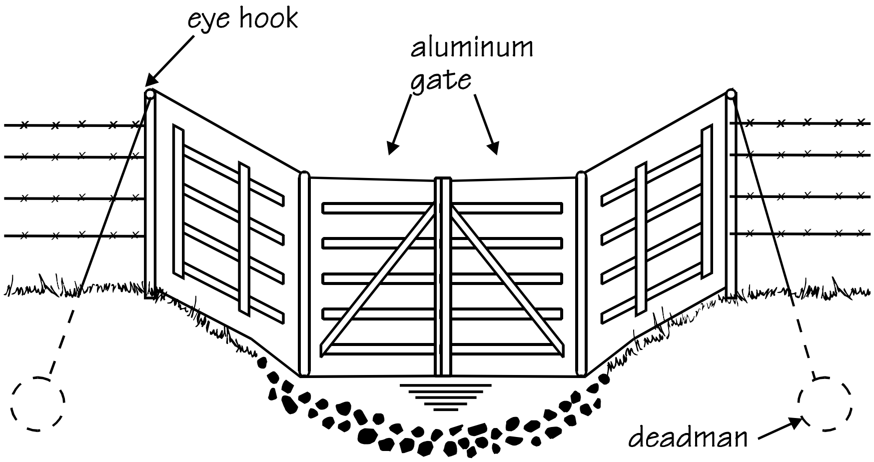
source: Brown, 1994



If you build a fence across the stream, make sure the lowest fence wire will be above the high water mark. You may wish to consider using an adjustable swing gate if the fence crosses a stream that has great fluctuations in water levels. This way, you can open the gate to let flood water and debris pass at high flows, but restrict livestock access to the stream at low flows. Figure 3 illustrates this type of gate at a livestock crossing, but a similar design is used on streams.

Figure 3
An Adjustable Swing Gate at a Livestock Crossing

source: Adams & Whyte, 1990



CONSTRUCT THE FENCE

Step 1. Prepare the fence line

Use survey stakes to mark the ends of the fence line. Push sighting poles into the ground just beyond the survey stakes.

You will use these sighting poles to make sure the fence line is straight. Level the ground along the fence line to remove high spots that could catch the bottom wire and low spots that could leave a large gap under the bottom wire.

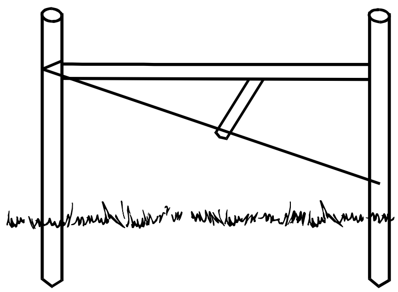
Step 2. Set end, corner, and gate posts

These posts usually are one size larger than posts used in the fence-line. Their location and placement are the most important factors in building a successful fence. These posts mark the beginning and end of each section of fence. Fence wire is attached and tightened at the posts. Auger pilot holes first, to help set the posts at the correct lean, then pound in the posts using a post pounder. Pound standard 244 cm (8 feet) posts 122 cm (4 feet) deep. If soil is loose or boggy, you will need to strengthen posts with deadman anchors. These prevent posts from twisting or pulling out. Typically, a deadman anchor consists of a large piece of wood buried in a trench near the post, and attached to it with cable or heavy wire. Sometimes deadman anchors are used instead of braces. Figure 1 shows the position of a deadman at a gate post.

Step 3. String guide wire

Guide wire is strung from one end post to the other, at the desired height of the bottom wire. When properly strung, the guide wire ensures a straight fence, with all wires parallel to the soil surface. Attach the guide wire to the first end post, then string it along the livestock side of the fence, not the stream side.

Figure 4
A Single Span Horizontal Brace Assembly



This way, pressure from livestock will push the wire against the posts, not away from them. The livestock side will receive the most pressure from animals. At the other end post, tighten the guide wire using wire pullers and temporarily attach it to the post, using a crimped sleeve or Wire vise.

Step 4. Construct brace assemblies

Brace assemblies are the anchors fro the fence wire, so they must be as strong as possible. They are built at corners and ends of fences, at gates, and within the fence line whenever the slope changes significantly. Within the fence line, braces usually are spaced less than 400 metres (435 years) apart.

Braces are built using 244 cm long (8 feet) fence posts that are one size bigger than line posts. The diagonal "twitch" wire is made with two complete wraps of smooth wire, to prevent brace failure. Figure 4 shows an example of a single span horizontal rail brace assembly. Other types, such as double braces, are used in fences exposed to great stress, suing more than six wires, or built in loose or boggy soil.

Step 5. Set fence line posts

Line posts are regular fence posts set along the line of the fence, and are one size smaller than the bracing and end posts. Line posts maintain proper wire spacing, absorb some wire weight, prevent overturning, and add visibility to the fence. These posts can be set a maximum of 12 m (13 yards) apart. Pound in each post with the post pounder to a depth of at least 76 cm (2.5 feet). Make sure they are perpendicular to the fence wires and the ground.

Step 6. String line wire

Wire is supplied on a drum, so make a support for it that allows the wire to play out smoothly. Be careful when handling both barbed wire and high-tensile smooth wire. Wire, especially smooth wire, can recoil when cut. When you cut the wire, make sure the far end is attached to something and step on the wire near where you plan to cut it. Secure any cut ends or push them well into the soil.

You will need to string barbed wire one line at a time, to prevent tangling. Before it is stapled, barbed wire must be pretensioned to "set" the two strands and barbs. Smooth wire does not require pretensioning and all the wires can be strung at the same time. Always string the wire on the livestock side of the fence, except at the corners, where you should always put the wire on the outside of the turn. This makes a stronger fence, because the staples do not pull out when animals press against the fence. Attach the wires at the end posts, position them loosely on the line posts, and tension the wire.

Step 7. Staple wires in place and apply tension

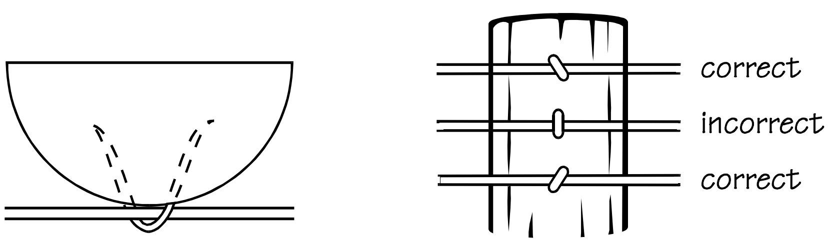
You can staple smooth wire to the line posts as you string it out. The staples should be loose enough to maintain even wire tension along the fence. This way, the wire can respond freely to pressure from animals leaning on the fence. You can apply tension to the wires after stapling, since smooth wire has no barbs and can move freely through the staples.

The staples must be inserted properly so they do not pull out (Figure 5). Staples are rotated away from the flat surface to increase resistance to being pulled out. Drive them in slightly off the vertical grain of the wood. If they are driven in vertically, the wood may split along the grain.

Barbed wire must be pretensioned to set the two strands and barbs. This involves applying 275 kg (600 lb) tension, then relaxing it to the 114 kg (250 lb) operating tension. Do this for each fence strand individually after it has been strung out and before it is stapled. Staple the wire using the same method as for smooth wire.

Figure 5
Correct Staple Placement

source: Quinton, 1990 *source: Adams and Whyte, 1990*



staple ends in the wood vertical placement on a post

Various in-line tension springs and wire strainers are used. The final tension applied is 114 kg (250 lb) at temperatures of 10 to 20oC. After tensioning, you will need to adjust fence tension occasionally: after a freeze/thaw cycle, when trees fall on the wire, etc. Tension can be set easily on smooth wire fences using the in-line tension devices. Adjusting tension on barbed wire fences is more difficult, since it usually involves pulling out the staples on the line posts first.

Step 8. Install droppers

Droppers act as wire spaces, help distribute the load on the fence, and add visibility and stability. They are made of metal or wood and are snapped, stapled, or wired firmly on the fence wire. Place the droppers up to 3 m (10 feet) apart, depending on the estimated livestock pressure on the fence.

Step 9. Incorporate gates where needed

You may need to install gates to provide access to certain areas. Each gate should be hinged and at least as high as the fence. Gates can be purchased or built from wire, steel pipe, and pivots.

FENCE MAINTENANCE

Fences built to agricultural standards usually require very little maintenance. Occasionally, you may need to tighten slack wires or remove any trees that have fallen across the fence. Also, remove any debris that has accumulated, especially at watering points and livestock crossings. Over time, you will need to replace any sections of fence that are undercut by the stream or loosened by frost heaving or flooding.

Collecting, Reporting, and Evaluation Information

Send a copy of the Stream Fencing Summary Sheet to the Streamkeepers Database. The current address is listed in the Handbook. When your fence is finished, follow up with the maintenance plans agreed upon between the landowner and your group.

Some benefits of fencing are apparent soon after a fence is built, especially if stream bank planting is done at the same time. Water quality may improve first, because fencing deters erosion and animal waste additions. However, it takes a long time for stream banks to recover completely. It may take a few years to restore water temperatures and fish habitat. Water quality, benthic invertebrate, and juvenile fish surveys (Modules 3, 4, and 11) are the monitoring techniques most likely to provide evidence of improvements on the stream. You may wish to conduct these surveys when you install the fence and again in subsequent years to monitor improvements in water quality and stream habitat.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

References

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send the data to the Streamkeepers Database

MODULE 8: STREAM FENCING SUMMARY SHEET

(See Module 1 for additional information)

Stream Name/Nearest Town	**Date**
Organization name and municipality	**Crew size**
Contact name	**Phone #**

Upstream boundary of work (directions, distance to known landmark)
Downstream boundary of work (directions, distance to known landmark)

How long is the fence?
what type of fence is it?
Comments

STREAMKEEPERS

Module 9
Observe Record Report

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	Not necessary	½ day to ongoing	2 per team	Any time

Fisheries and Oceans Pêches et Océans

Canada

MODULE 9:
Observe Record Report (ORR)

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgements

Pete Caverhill (B. C. Ministry of Environment, Lands, and Parks) and Joe Kambeitz of the DFO Community Involvement Program provided material for this module. The B.C. Wildlife Federation, Department of Fisheries and Oceans, and B.C. Ministry of Environment, Lands, and Parks established the Observe Record Report program several years ago.

Project Activity And Purpose

This module provides guidelines to identify and report unlawful activities that affect fish, wildlife, and aquatic habitat. Your accurate reports will enable enforcement agencies to investigate serious violations. Ultimately, this will help to prevent the loss of habitat and wildlife. Report more serious violations immediately using the hotline telephone numbers. Report non-emergency situations directly to agencies listed in Appendix 1.

Introduction

You may come across people destroying habitat or violating fisheries and wildlife regulations. Sometimes you may find only the consequences. The Observe Record Report or ORR program provides a system for reporting evidence to the authorities.

When people disobey the regulations and guidelines that protect our waterways, they do so out of either ignorance or defiance. Enforcement authorities cannot be everywhere, so many situations go unreported until extensive damage has occurred. ORR provides a means for you to report violations and act as extra eyes for enforcement agencies.

Project Guidance And Approval

You need no formal approval. However, you do need a good understanding of the regulations, guidelines, and local bylaws so you can recognize an offence and assess its seriousness. Your Community Advisor or the agencies listed in Appendix 1 can provide information and copies of regulations. You also need a tactful and informative manner when you deal with members of the public. Avoid anyone who is committing a criminal act. Even trained and armed Fisheries or Conservation Officers approach these situations with caution. Also, remember that you have no right to trespass on private property or confiscate property.

Level Of Effort

You can use ORR if you come across a problem while participating in another Streamkeeper activity, or you may wish to organize formal patrols. You need no formal training and you can commit as much time as you want. If you are asked to be a witness in court proceedings, please consider it seriously. Although it requires extra time and effort, it is a necessary part of our justice system.

Safety

PERSONAL SAFETY

Concern for personal safety is most important. Do not approach anyone who appears to be committing a criminal offence. You may wish to provide information to people who do not seem to know they are harming the environment. Leave if the individuals become agitated.

Work in pairs, never alone. You are gathering evidence, and corroboration with a partner is useful. Let someone know where you are going and when you will return. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water higher than your knees. Watch out for slippery stream beds, undercut banks, waterfalls and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts or wounds to stream water. Know the symptoms and treatment for hypothermia.

Avoid foul smelling areas, spills of unknown substances, or containers of hazardous or unidentified materials. Contact emergency response agencies or municipal crews for advice on removal of these materials.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear waders with felts when walking in the stream. Wear rain gear or highly visible clothing. Wear a personal flotation device (PFD) when working in larger streams.

Time Of Year And Working Conditions

You can watch for violations at any time of year. Weekends and evenings are prime times for illegal activities, because offenders think no one is on duty.

Materials And Equipment

pencil, pens, notebooks
watch
ORR report form (Appendix 2)
list of emergency numbers (Appendix 1)
camera (date monitor -optional)
sampling equipment for toxic spill or fish kill (new ziploc
bags, new glass sample bottles, surgical
gloves, permanent marker)

These items are optional but useful:
video camera (attached to you with a sturdy strap)
binoculars
cellular phone or CB radio
tape recorder
flagging tape

Procedure

The most important step is to assess the seriousness of the offence and decide whether to report it. Report only the serious problems. No enforcement agency has the resources to respond to every incident. For example, toxic spills, fish kills, or dying fish are emergencies you should report immediately. On the other hand, heavy siltation from runoff may occur normally or because of unacceptable land use practices. It is unlikely to be an immediate threat to aquatic life, so you can take time to investigate further before contacting the authorities.

You can resolve minor problems, such as a neighbour dumping oil into a storm drain, by politely providing information. However, you need to handle more serious problems very carefully, to protect yourself. The person or persons involved may know they are doing something illegal and may be prepared to respond aggressively. In any situation, you should collect evidence from a safe distance, then decide whether to report the incident immediately.

The story at the end of this section illustrates the importance of remaining calm and making detailed observations. Appendix 1 lists some typical environmental violations and emergency situations, along with telephone numbers of appropriate agencies.

Follow the procedure outlined here if you decide to report a serious offence. Often, enforcement staff arrive too late to witness the violation, so your detailed evidence will be valuable.

OBSERVE

Make accurate and detailed observations. They should answer the five W's: WHO, WHAT, WHEN, WHERE and WHY. For example, if you find dead fish in the river, note the species, number, location, time, and condition of the fish. Try to find out the cause of the kill. If you see a bulldozer in a stream, note the make, colour, and any identifying marks. Confirm details with your partner.

RECORD

Record your detailed observations using notes, tape recordings, video recordings, and/or photographs. Include the date, time, and specific location. Describe any vehicles, including license numbers, the physical appearance of the offenders, and details of the offence.

You may want to take legal samples as evidence. Water samples for suspended solids or turbidity analyses are safe to handle, as are most fish samples taken to detect cause of death. Never handle materials that can pose a hazard to human health. Ask your Community Advisor for help with sample bottles and procedures.

Take photos while you are still some distance away, and more as you approach. If you wait until you reach the location, you can miss the opportunity for both distance and close-up shots. Take photographs discreetly, so you do not alarm the violator.

DO NOT APPROACH ANYONE IF YOU THINK THERE IS EVEN A REMOTE CHANCE OF AGGRESSION! Report the situation to the authorities.

REPORT

Call the ORR Hotline (DFO or WLAP number) or the local police department immediately, if you feel the situation is an emergency. Warn them about any hazardous substances. Send a permanent record to the authorities. It may be an ORR reporting card (see APPENDIX 2) or a longer written report, complete with photographs. The length of your report will be based on the seriousness of the violation and the amount of evidence.

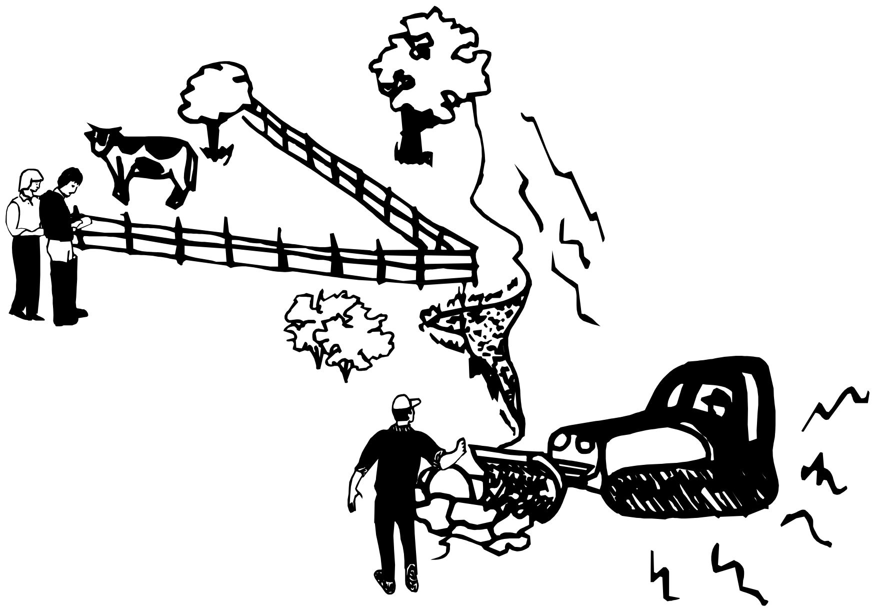
Handling A Situation Effectively And Safely

This story illustrates the importance of arriving prepared, remaining calm and polite, making and recording detailed observations, and reporting the incident.

Muddy water has flowed in a nearby stream for the past three weekends in November. This morning, a neighbour telephoned at 9:00 a.m. to report the same thing. You call your partner and agree to meet at the stream at 10:00 a.m. You pack your camera, sample bottles, note pad, binoculars, and boots.

You take a water sample as you walk upstream and label it with date, time, and location. You plan to take another sample upstream of the disturbance. As you round a curve, you see a large orange bulldozer in the creek, with one man operating the machine and another yelling directions from the bank. Trees are down across the stream, a stretch of the bank is bare, and soil is sloughing into the water. You snap some photos and confer with your partner. You estimate the extent of bank damage, count the number of felled trees, and make notes.

You observe the workers through binoculars. One man is about 5’8", 45 to 50 years old, 190 lbs., with receding dark hair and a heavy mustache. The other is very tall and thin, about 6’4", 38 to 42 years old, with blond hair.



As you leave, you notice a lowbed trailer and truck parked near a house. You walk up the road and note the house address and the make and licence number of the truck. You take a long distance photo of the bulldozer in action and sample the water upstream of the disturbance. When you return to your car, you and your partner go over the details, make written notes, and record the time.

You call the 24-hour hotline immediately. You will call the appropriate agency later, during regular office hours, to check on progress. Send them a written report. Your photos, water samples, descriptions of people, and estimate of the number of trees cut form the basis for a strong report. Although you can send a report without these details, detailed evidence will help the agency investigate the situation and may be needed for a successful conviction.

Collecting, Reporting And Evaluating Information

Keep copies of your reports, even if they are not used in the formal ORR system. For example, you may wish to keep a list of people who dump harmful substances in the storm drain even after you have advised them against it.

Follow through on your reports. Note the name of the person to whom you make your report. Call back a few days later to check on progress. If no one pursued your report, ask why. Perhaps you need to improve your techniques or reports, or send the information to other staff or agencies. Often government agencies are inundated with cases and cannot investigate every report.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 11 contains specific information about increasing community awareness and working with the media.

APPENDIX 1:
Environmental Emergency Response and Violation Contact Numbers

APPENDIX 2:
Sample of the Observe, Record and Report Card, available from B.C. Water Land and Air Protection.

Appendix 1: Environmental Emergency Response and Violation Contact Numbers

SITUATION	WHO TO CALL	PHONE #
EMERGENCY		
fishing violations: illegal gear, overlimit, or fishing in closed areas	ORR (DFO Hotline) (salmon/marine species) ORR (WLAP Hotline) (freshwater species)	1-800-465-4336 1-800-663-9453
wildlife kills, illegal hunting	ORR (WLAP Hotline)	1-800-663-9453
hazardous chemical or oil spills; hazardous discharges to storm drains; fish kills; dumping hazardous materials in streams	Environment Canada ORR (DFO Hotline) ORR (WLAP Hotline)	1-800-663-3456 1-800-465-4336 1-800-663-9453
sewer overflows	municipal engineering department	check blue pages of your phone directory
extreme erosion, sedimentation, flooding	Provincial Emergency Response operator	1-800-663-3456
forest fires		Zenith 5555
NON-EMERGENCY		
dirty or turbid water, minor erosion and sedimentation; dumping garbage in or near water	urban: municipal engineering department rural: local DFO or WLAP office	check blue pages of your phone directory
requests for information	Environment Canada Information	1-604-664-9100

WLAP: Ministry of Water, Land, Air Protection

DFO: Department of Fisheries and Oceans

Appendix 2: Sample of the Observe Record Report Card

WE REQUEST YOUR HELP TO:

- Enforce Fish and Wildlife Laws
- Report Pollution and Littering

Everyone who uses or enjoys the outdoors has a responsibility to protect and maintain it.

Fish and Wildlife law violations, pollution and littering hurt all of us and cost everyone a lot of money. You can help prevent these acts and bring violators to justice by serving as an accurate witness.

Do not confront a suspected violator — you as a citizen cannot make an arrest or collect evidence. Use this card to record important facts — then notify the nearest office of the following:

- Department of Fisheries and Oceans
- B.C. Environment
- R.C.M.P. Detachment

Or telephone the toll-free-number **1-800-663-WILD (9453)** where your complaint will be registered and directed to the right action centre.

* * *

RECORD IMPORTANT INFORMATION

VIOLATION WITNESSED:

DATE ____________ TIME ____________ pm am

VEHICLE, VESSEL OR AIRCRAFT DESCRIPTION:

LICENSE NO. ____________ PROV. or STATE ____________

MAKE ____________ MODEL ____________

COLOUR ____________

UNUSUAL MARKS ____________

DETAILS OF VIOLATION:

LOCATION ____________

SPECIES TAKEN ____________

HOW TAKEN ____________

LOCATION OF CARCASS (if applicable) ____________

POLLUTION OR LITTERING ____________

OTHER ____________

DESCRIPTION OF VIOLATOR:

NAME (if known) ____________

SEX ____________ AGE ____________

HEIGHT ____________ WEIGHT ____________ EYES ____________

HAIR ____________ BEARD/MOUSTACHE ____________

PHYSICAL MARKS OR SCARS ____________

CLOTHING (hat, coat, etc.) ____________

PECULIARITIES ____________

OTHER EVIDENCE (type of gun, etc.) ____________

REMARKS: ____________

WITNESS(ES): Name ____________ Address ____________ Telephone ____________

PLEASE ACT IMMEDIATELY

With timely, accurate information, an apprehension and conviction can often be obtained without it being necessary for you to appear as a witness.

If you are willing to appear and testify in court, please complete below.

NAME ____________

ADDRESS ____________

CITY ____________ PROV. ____________

PHONE ____________ POSTAL CODE ____________

Immediately take this card to one of the agencies listed inside, or mail to one of the following:

Dept. of Fisheries & Oceans General Investigation Unit 555 West Hastings Street Vancouver, B.C. V6B 5G3	B.C. Environment Conservation Officer Service Parliament Buildings Victoria, B.C. V8V 1X5

* * *

This program is sponsored jointly by the Department of Fisheries & Oceans (Canada) and B.C. Environment in cooperation with the B.C. Wildlife Federation and the people of British Columbia.

ENV112148.791

Observe Record and Report

BC Environment

STREAMKEEPERS

Module 10
Community Awareness

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	Not necessary	A few days per project	2 to 4 to organize More to implement	Any time

Fisheries and Oceans / Pêches et Océans

Canada

MODULE 10:
Community Awareness

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Mark Johnson (Community Advisor with the Department of Fisheries and Oceans) and Karen Munro provided information for this module.

Project Activity And Purpose

This module describes six projects that help you express concerns and provide information about watershed and stream health to other members of your community:

1. Road Signs
2. Brochures and Newsletters
3. Community Meetings
4. Public Displays
5. News Media
6. Media Productions

Consider your goals when you choose a project. Some community awareness projects inform a wide audience. Others target specific groups.

Introduction

Each of us has an obligation to help take care of our own environment. Community awareness projects remind people that aquatic habitats are important. When residents of a community are given enough information, they often support decisions about land use that protect the environment. Community awareness projects let people know how commonplace activities can damage aquatic habitats. Some projects provide information about environmentally friendly practices and products that help protect these natural resources.

Many common urban activities affect our streams. Property development, driving, car washing, and garden pesticide usually add sediment and contaminants to streams through runoff. The impact can be severe when an entire watershed is considered. There are few or no regulations for these non-point sources of pollution. Collectively, these activities often cause more damage than major developments. Various government agencies try to limit damage to the environment by regulating major urban, industrial, agricultural, forestry, and mining developments.

Public awareness projects can help heighten interest in current development proposals, land use decisions, and other activities that affect watersheds. Informed citizens are more likely to support your efforts and become involved in the local decision making process. Sometimes you may find yourself dealing with difficult issues, but you will draw more support for your cause if you can maintain a positive attitude.

Established groups with well-defined goals and objectives can organize these projects most successfully. Such groups also have important contacts and resources within the community. There are several references at the end of this module that can guide you in organizing a Streamkeepers group.

Project Guidance And Approval

Contact your local Community Advisor for guidance and information before starting a major project. He or she can provide resources and contacts with government agencies or other groups already involved in watershed protection.

1. ROAD SIGNS

You can place signs at stream crossings. A simple sign that includes the stream name, a fish symbol, and a short conservation message is best the signs draw attention to the streams as people pass. This is especially useful on a small or culverted stream, where there is no bridge to remind us of the stream visually. Many people do not realize that small headwater creeks are easily damaged yet provide important fish and wildlife habitats.

PROJECT GUIDANCE AND APPROVAL

Contact your municipality and the B.C. Ministry of Transportation Highways (MOTH) for approval and cooperation. Get permission from landowners, such as other agencies, private property owners, or First Nations Councils. Check for local guidelines on sign design and placement. These often differ from one jurisdiction to another.

LEVEL OF EFFORT

One or two people can organize project funding, agency assistance, and approval. You will need a larger crew if you wish to make and install the signs yourselves. You may need to plan for maintaining the signs after they are installed. Contacting the agencies and arranging for material and labour may involve two to three days of phone calls and letter writing. It may take up to two or three months to reach the stage of installing signs.

TIME OF YEAR AND WORKING CONDITIONS

You can build and install signs any time of year, depending on the weather. Be prepared to time your project to fit into the schedule of the Municipal Engineering Department or MOTH. You will probably rely on their resources and assistance.

SAFETY

Staff form the municipality or MOTH may install the signs. If your group installs or maintains the signs, make everyone aware of traffic safety. Park safely and wear traffic safety vests.

MATERIALS AND EQUIPMENT

60cm by 90cm, 30mm thick aluminum sign blank

Fish decal	maps
Painted lettering	premixed concrete (20 kg)
Wheel barrow	water bucket
2.2m of 4" x 4" treated post	shovel

Cost: up to $100 per sign

PROCEDURE

Locate and map suitable sign locations. You may wish to start with the most crucial habitat areas or those that seem to suffer from regular abuse. Consider trails, foot bridges, culverts, and bridges.

Decide how many signs you need. Plan to spread the work and expense over a few years if the project involves many signs.

Choose the size, text, colours, and materials for the sign. You may need to consider design guidelines provided for the jurisdiction where you are working. The Fraser River Action Plan has developed guidelines for consistent recognition of particular habitats. They suggest keeping the message simple and graphic:

- use green lettering and border on a white background
- use the yellow stylized salmon figure commonly used to represent salmonids
- use another colour and fish shape to represent other fish (for example, a blue stickleback), if there are on salmonids in the stream
- use a red fish if you want to emphasize an endangered species (for example, a red Salish Sucker)
- include a brief pictorial reference to habitat restoration or enhancement activities on the stream
- use a special symbol to denote environmentally sensitive areas

In many areas employees of the municipality or MOTH install signs. Decide who will be responsible for maintaining the signs before starting the project.

COLLECTING, REPORTING AND EVALUATING INFORMATION

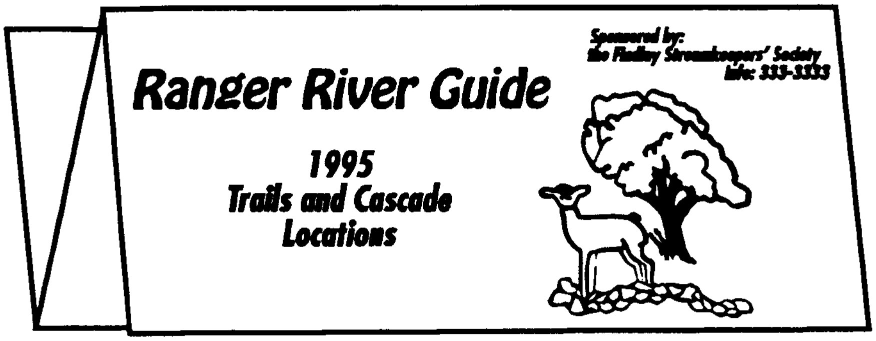
Keep an updated map of sign locations and future sites. Keep records of correspondence, approvals, costs, number of signs, and sign design. Send the Community Awareness Project Summary Sheet to the Streamkeepers Database. The current address is in the Handbook.

You can evaluate the success of your project by doing a stream cleanup before you install your signs and again some time later. Compare the different amounts of garbage collected each time.

2. BROCHURES AND NEWSLETTERS

You may wish to produce a brochure about your watershed or stream. A map of your area showing streams, roads, trails, and fish and wildlife distribution will interest the people in your community. Alternatively, you may wish to submit an article to a newsletter or even start your own.

Decide how to distribute the brochure or newsletter. Select a theme, collect the information, and design your brochure. Include a contact number for interested readers. Some brochures about watersheds and their resources may be available. Consult your Community Advisor.



PROJECT GUIDANCE AND APPROVAL

You need no formal approval. Various agencies may share experience and information, or even provide financial support.

LEVEL OF EFFORT

It may take as much as ten days to research and prepare the material, get printing estimates, and arrange for distribution.

TIME OF YEAR AND WORK CONDITIONS

The brochure or newsletter can be prepared any time, but avoid distributing it during holiday seasons when it is less likely to get the attention it deserves.

SAFETY

If you are delivering brochures in person, respect private property, leave dogs at home, supervise children, and watch for traffic.

MATERIALS AND EQUIPMENT

message and information

camera ready copy prepared to printers' specifications

cost: $500 to $2,000 for printing 1,000 to 10,000 copies

PROCEDURE

Choose the message, intended audience, number of copies, and the distribution method. Research and collect all the information, and be sure to check everything carefully. Organize your material.

You should include a title, the purpose of your brochure, objectives and goals of your group and name and phone number of a contact person. You may also want to include a watershed map, comments on the current state of the watershed, and a list of affiliated organizations.

Design an attractive brochure. You may wish to seek guidance from a professional desktop publisher. Always get someone else to proofread it. Get quotes from at least three printers. Use recycled paper and plan to print an initial run of 1,000 to 10,000 copies. Distribute the brochures through the mail, door to door, or in a "help yourself" rack.

COLLECTING, REPORTING, AND EVALUATING INFORMATION

Keep track of the costs, time involved, resources used, number of copies made, and distribution method. Record all responses to the brochure. You may want to conduct a poll of common environmental practices before you distribute the brochure, and again a year later, to evaluate the effectiveness of your campaign. If your brochure has a clear message, you will be able to evaluate its effectiveness more easily. Share this information with the Community Advisor. Send a copy of the Community Awareness Project Summary Sheet to the Streamkeepers Database. The Current address is in the Handbook

3. COMMUNITY MEETINGS

Public hearings, municipal council meetings, and service club meetings provide good opportunities to discuss local watershed issues. You and you group may want to attend, or present a brief at a meeting. You may want to organize a public meeting to raise your own concerns, inform people, and listen to community concerns about local issues. This is an excellent way to find active supporters and choose community based projects.

PROJECT GUIDANCE AND APPROVAL

You need no formal approval to organize a public meeting. Your Community Advisor has experience dealing with the public and can provide some guidance. You may wish to consult a professional about organizing the meeting.

LEVEL OF EFFORT

Meetings require preparation and organization. You need to develop and research items for the agenda, produce the notice, arrange a location, hold the meeting, and distribute minutes. All this may take five or six days.

TIME OF YEAR AND WORK CONDITIONS

Schedule your meeting for a weekday evening. Avoid statutory holidays, July and August, and major sporting and cultural events. Select a convenient location.

SAFETY

Community meetings can get quite heated. Watch what you say. You may get quoted!

MATERIALS AND EQUIPMENT

Meeting notice
Meeting room
Refreshments
Chairperson, preferably experienced
Cost: up to $700
stationary
audiovisual equipment
minutes

PROCEDURE

Discuss the project with your group and the Community Advisor. Decide on a target audience and write down clear goals and objectives for the meeting. Arrange a meeting place, date, and time. Several references in this module provide suggestions for organizing meetings.

Prepare a notice that includes title, place, time, kind of meeting (information, training, problem solving), agenda, and contact person for further information. Distribute it by mail, fax, electronic mail, or community bulletin boards. Arrange for free announcements in the newspaper, on the radio, or on television.

Prepare your meeting place. Organize audiovisual equipment, seating, and refreshments.

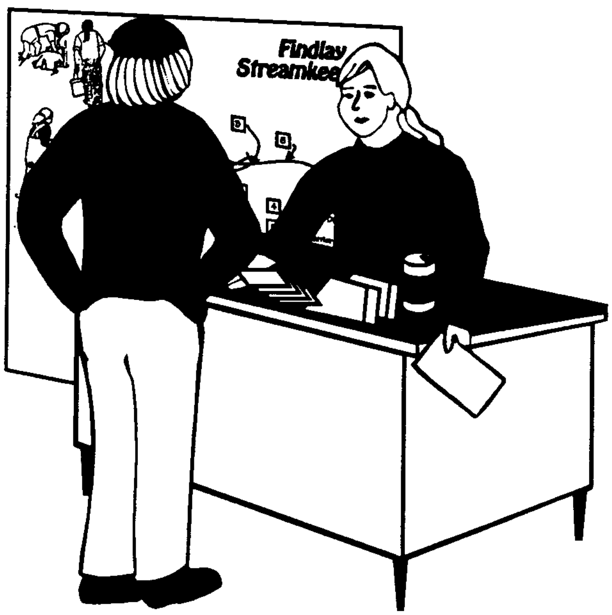
Decide whether to make decisions by consensus or majority vote. Outline the basic ground rules and objectives of the meeting. Keep to the agenda and keep the meeting on time. Assign someone to record action points, deadlines, and relevant information. At the end, summarize action points and plans, inform everyone of any future meetings. Thank all the participants. Clean up the room.

Distribute minutes to all the participants. Confirm details with people who volunteered to take on specific tasks.

COLLECTING, REPORTING, AND EVALUATING INFORMATION

Send copies of the meeting and minutes to the Community Advisor. Inform potentially affected businesses, government agencies, and citizens of any proposed actions that arise from the meeting.

4. PUBLIC DISPLAYS



You can organize material about your project and present it to the public in a display at a shopping mall, open house, or community festival.

PROJECT GUIDANCE AND APPROVAL

Approach event organizers or shopping mall administrators.

LEVEL OF EFFORT

This is an inexpensive and effective way to reach people and find new volunteers. You may need two to four days to collect photos, make posters, and arrange interesting display items. Arrange for a volunteer to stay at the display to provide information.

TIME OF YEAR AND WORK CONDITIONS

You can do this project any time of year. Tie it in with one of your other projects or a community event. Shopping malls have more time available at some times of year than others.

SAFETY

Be careful lifting heavy displays.

MATERIALS AND EQUIPMENT

Poster material
Photos
Display items (equipment, waders, aquarium, etc.)
Tables, chairs, room dividers or display boards
Cost: $100 to $500 (more if the display is done by a professional)

PROCEDURE

Make arrangements with event organizers or shopping mall administrators well advance. Prepare an information sheet about the project that includes phone contacts. Organize materials for your display.

Set up and take down the display at hours convenient to the organizers. Have enthusiastic, well informed members of your group at the display. The display is only a prop to get people talking with your group. Put out a sign-up sheet for names and phone numbers of people interested in further information, or becoming volunteers.

COLLECTING, REPORTING, AND EVALUATING INFORMATION

Discuss the public response to the display with your group members. You may find new volunteers through your efforts.

5. NEWS MEDIA

Newspaper, radio and television coverage of your project gets your message to a larger audience and invites public recognition for your volunteers. Your work may educate or inspire others and you may gain new volunteers.

Reporters want a good story to interest their audience. Their job is not to provide you with free publicity. You need to interest a reporter in your project. Stress the newsworthy and interesting angles and the significance of your project to the community. Try to find a human interest angle or surprise element, such as the successful rehabilitation of an area, or the volunteers work of children. Your story should be positive and can tie in with other current issues or events. Provide a written summary or press release about your project to the reporter to avoid being misquoted.

PROJECT GUIDANCE AND APPROVAL

You need no approval.

LEVEL OF EFFORT

You may need time, effort and persistence to interest reporters in your story.

TIME OF YEAR AND WORK CONDITIONS

You can do this kind of work any time of year.

SAFETY

No particular safety guidelines apply, except to watch what you say. You can avoid misquotes by providing a written report to the reporter.

MATERIALS AND EQUIPMENT

Press release with details of the project

Typewriter or computer.

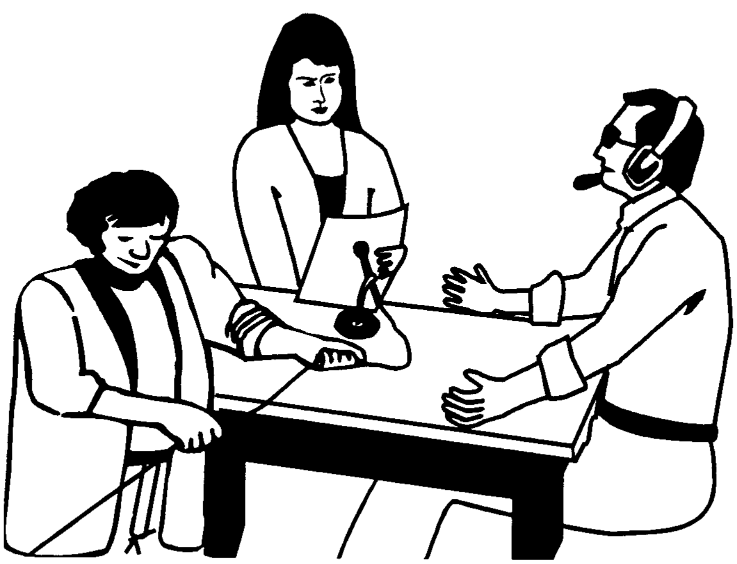
PROCEDURE

Get to know the local environmental and be aware of deadlines and schedules in the media.

Newspapers: news papers often have limited staff available. Give lots of advance notice to advertise an event or arrange coverage of a cleanup or other activity. Remind them a few days before the event. Send a clipping and thank you note after the story is published. If necessary, correct any mistakes politely.

Press releases: a press release is a simple, accurate one page summary of your project. It tells who, what, when, where, why, how. Include project background, importance of the project, and contact people. A press release is useful for many projects, and busy reporters appreciate the concise information. Make sure someone proofreads it first. Hand deliver, fax, or mail the press release.

Public service announcements: local media sometimes provide space or time for free public service announcements from registered nonprofit organizations. They may prepare one for you or ask you to supply it. A college communications class or advertising agency may be willing to provide free assistance.



Letters to the editor: this section of a newspaper provides a forum for opinions and information. It requires only a well-written letter.

Interviews: choose a strong spokesperson from your group who enjoys dealing with the media, is enthusiastic, and is well informed. Be prepared with interesting quotes and a short summary. If you cannot answer a question, be honest about it and offer to get back to the reporter with the information later.

COLLECTING, REPORTING AND EVALUATING INFORMATION

You may wish to survey community attitudes before and after a media campaign. Keep a record of responses from the public and save copies of all clippings for future reference.

6. MEDIA PRODUCTIONS

Your group can produce a slide show or short video about your project. Offer to show it to schools, clubs, parent councils, municipal committees, or engineering departments.

PROJECT GUIDANCE AND APPROVAL

You do not need approval, but you may wish to consult your Community Advisor or other groups for successful ideas.

LEVEL OF EFFORT

The project involves some time and effort. You probably can get some advice or assistance from the communications department of a community college or a community television station.

TIME OF YEAR AND WORK CONDITIONS

You can do this project any time of year.

SAFETY

No particular safety guidelines apply.

MATERIALS AND EQUIPMENT

summary sheet	camera
Film or video tape	script
Cost: as little as $25	

PROCEDURE

Consider your intended audience. Choose a theme and strong images that relate to your topic. Organize your material and edit it well. Keep your presentation to twenty minutes of less. Most audiences have short attention spans. You may want to provide a short written summary. Be prepared to answer questions.

COLLECTING, REPORTING AND EVALUATING INFORMATION

Listen for responses to your presentation.

General References and Resources

Anon. 1995. *Community Stewardship: A Guide to Establishing Your Own Community Group.* Copublished by Fraser Basin Management Program, Department of Fisheries and Oceans, Canadian Wildlife Service and Watershed Working Group of Forest Renewal B.C., Canada.

BC Media Guide. 1990. Available free from the BC Government Communications Office (1-604-387-1337)

Bolling, D. M. 1994. *How to Save a River: A Handbook for Citizen Action.* Island Press, Washington, DC. 268 pp.

British Columbia Environmental Network Guide. *Grassroots Organizing: Getting Serious About Survival.* BCEN, Vancouver BC. Call 1-604-879-2279 for a copy.

Gross and Zimmerman. 1991. *Interpreter's Handbook Series.* VW-SP Foundation Press, Inc. Univ. Wisconsin, Stevens Point, WI. -Full ref from Mark Johnson

Fletcher, T. and J. Rockler. 1990. *Getting Publicity: A Do It Yourself Guide for Small Businesses and Non-profit Groups.* Self Council Press, Vancouver, BC. 144 pp.

Yates, S. 1988. *Adopting a Stream, A Northwest Handbook*, University of Washington Press, Seattle, Wa.

Check with the library for references on public speaking and running meetings.

send the data to the Streamkeepers Database

MODULE 10:
COMMUNITY AWARENESS PROJECTS SUMMARY SHEET

(see Module 1 for additional information)

Stream Name	**Date**
Watershed code	**NTS Map#**
Organization name	**Crew size**
Contact name	**Phone#**

Stream Sign Information	
sign message	
number of signs installed	
Locations	

Brochure and Newsletter Information	
basic message	
number of copies made	
distribution methods	
distribution area	

STREAMKEEPERS

Module 11
Juvenile Fish Trapping and Identification

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
Yes	recommended	A half day or more	Two or more	Spring through fall

Fisheries and Oceans Pêches et Océans

Canada

MODULE 11

Juvenile Fish Trapping and Identification

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage “hands on” environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Brenda Donas and Barry Peters (Community Advisors with the Department of Fisheries and Oceans) and Dave Bates (Instructor, Capilano College) supplied the information for this module.

Project Activity and Purpose

You will learn how to collect and identify juvenile fish using a Gee minnow trap. Many surveys are designed to study salmonid populations, but other species are found in the traps as well. The most common reason for collecting juvenile fish is to find out which species are present, where they live, and how many there are.

There are several methods of collecting fish, and each is chosen for a specific purpose. This module describes how to use a Gee minnow trap. Other methods, such as beach seining, electrofishing, snorkeling, and various fences and traps, also are used to trap fish.

Introduction

Gee traps are manufactured commercially in the United States. They were designed to collect bait fish. You can modify the wire mesh cylinders easily or even make them at home. A Gee trap captures juvenile fish less than 200 mm long. It also selects for specific habitat preference, behaviour, and species, so it does not provide a reliable estimate of total fish numbers. Data from Gee traps are best used to show population trends over time and the presence or absence of individual species.

Many fish species inhabit British Columbia streams and lakes. McPhail and Carveth (1995) describe the species and their distribution in the major drainage systems of the province. The list of families shown in Table 1 is drawn from their work. Figure 1 shows the zoogeographic regions of the province referred to in Table 1. Details of salmonid distribution and ecology are well known, because these species are so important to the B. C. economy. In comparison, little is known about many non-salmonid species. Some require the same environmental conditions as salmonids, while others require different conditions or tolerate a wider range of conditions. You may find dace, sculpins, sticklebacks, suckers, minnows, and other fish in the traps.

Table 1
Distribution of Families of Freshwater Fish in the Eight Zoogeographical Regions of B.C.

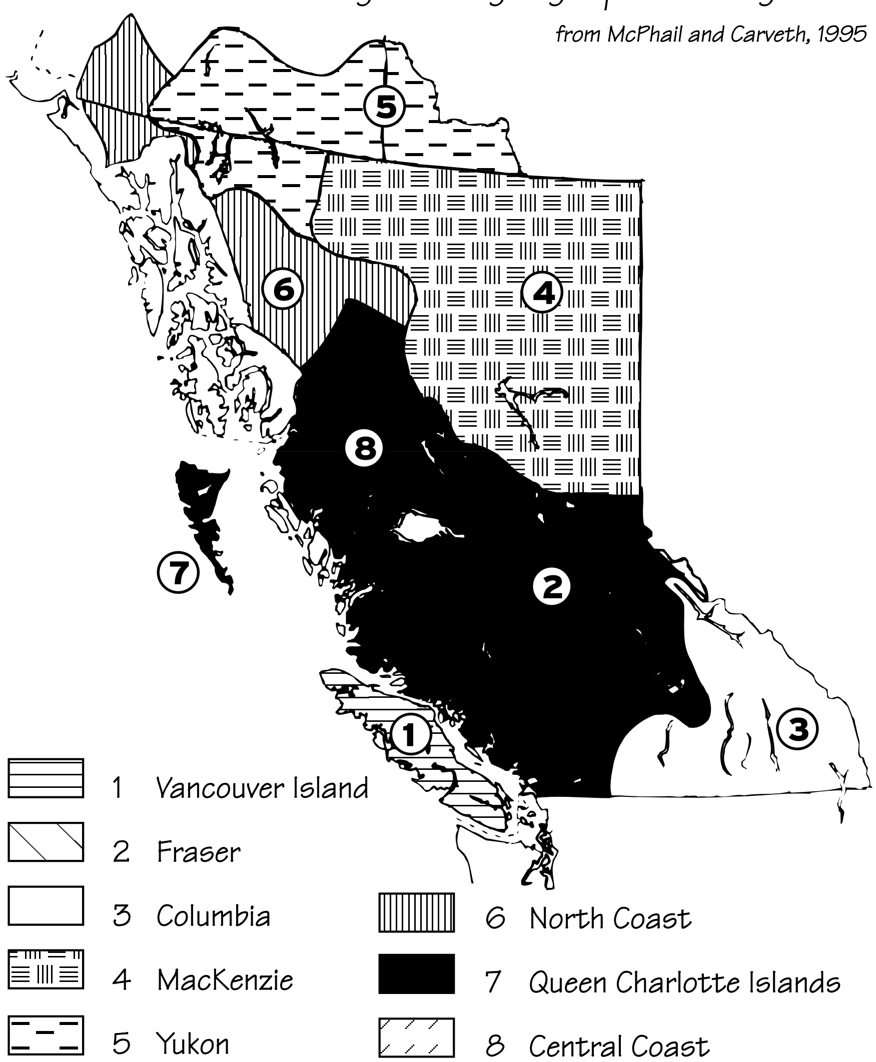
FAMILY	Van-couver Island	Fraser	Columbia	Mac-kenzie	Yukon	North Coast	Qn Char-lotte	Central Coast
Lamprey	X	X				X	X	X
Sturgeon	X	X	X			X		X
Herring	X	X				X	X	X
Minnow		X	X	X	X	X		X
Sucker		X	X	X	X	X		X
Catfish	X	X	X					
Smelt	X	X				X	X	X
Salmonid (salmon, trout, char)	X	X	X	X	X	X	X	X
Salmonid (whitefish)		X	X	X	X	X		X
Salmonid (graylings)			X	X	X	X		
Cod		X	X	X	X	X		X
Stickleback	X	X		X		X	X	X
Sculpin	X	X	X		X	X	X	X
Sunfish, Bass	X	X	X					
Flounder	X	X				X	X	
Perch			X					
Goldeneye				X				
Pike				X	X			
Trout-Perch				X				

Salmon, trout, char, whitefish, and grayling all belong to the salmonid family. They are considered good indicators of a healthy watershed because they require good water quality and habitat. Salmonids are among the first fish to relocate or disappear when an aquatic habitat starts to deteriorate. Documenting their presence helps identify and protect good quality streams and watersheds. Detecting their absence may identify the need for habitat improvement projects.

Salmonid life cycles can be described in general terms, but the details and timing of the stages vary with each species. Even within one species, behaviour can vary from stream to stream. Childerhose and Trim (1979) and Groot and Margolis (1991) describe salmonid biology in detail. Between July and February, pacific salmon return from the ocean to their natal streams to spawn. The eggs hatch into alevins and incubate in the gravel. They emerge as fry, rear for a period

Figure 1
British Columbia's Eight Zoogeographical Regions

from McPhail and Carveth, 1995



ranging from days to years, then migrate to the ocean. Trout spawn during winter or spring, eggs incubate through the spring, and fry emerge in early to midsummer. The life cycle timing of char is similar to salmon. Both trout and char have sea-run races that spend part of their life cycle in the ocean, like salmon.

Your trapping effort will be most successful when you understand the life cycle of the various species. For some species, early spring is best, and for others, any time between spring and fall is fine. The ideal period may be very short for a particular species. If you set the traps too early in the season, some species may still be in the gravel. If you set them too late, many fish will have migrated out of the stream. Chum and pink salmon migrate to the ocean almost immediately after emerging from the gravel and sockeye migrate to a lake. Usually, these species are not sampled using Gee traps, but can be assessed using an adult spawner survey (Module 12). Coho, chinook, steelhead, sea-run trout, and char can spend a year or more in the stream. During spring, both newly emerged fry and older juveniles of these species can be trapped. You will find older juveniles easier to identify than small fry.

Besides providing general information about fish distribution, trapping can answer many other questions. It can show the locations of good fish-rearing habitat, which helps convince planners and others about the importance of a particular water body. It also can provide information about individual species or populations, and whether there are barriers to their migration. Coho and other species are elusive during the spawning stage, so finding juvenile stages in traps confirms the presence of these species. Trapping also helps assess growth, distribution, and survival of hatchery fry-stocking projects.

Project Guidance and Approval

Fry trapping should be done with the guidance of a fisheries biologist. Contact your Community Advisor, or a biologist at DFO or MOELP to discuss the purpose of your proposed project. If your proposal is accepted, you will receive a Scientific Collection Permit. Notify local Fisheries and Conservation Officers before starting to trap. Take a copy of the Scientific Collection Permit with you into the field. Return all juvenile fish to the stream unharmed after you have finished sampling. A Streamkeepers certification course offers training in juvenile trapping.

Level of Effort

The traps usually are set overnight, but in special circumstances they can be set for a shorter period. The effort required varies from a few hours to a day, depending on the number of sites and their locations. It takes a few minutes to half an hour to process the fish in each trap, depending on trap contents and the extent of the information being collected. A large group of people with several traps and locations can survey a much larger part of a watershed.

Time of Year and Working Conditions

Although you can trap fish year round, spring through fall is the best period. Avoid trapping during freezing or extremely warm weather, when fish are easily stressed, injured, or killed. Also, avoid trapping when a stream is in flood. Few fish will enter the traps anyway and stream conditions during floods are not safe for people, either.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property. Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear highly visible clothing. Wear waders with felts when walking in the stream.

Materials and Equipment

waders or boots
3 buckets
thermometer
metric ruler
flagging tape
data sheets
key to identify fish
marking pen
glass jar or other viewing container
magnifying glass (optional)
Gee minnow traps
aquarium dipnets
bait for traps
Alka-Seltzer (anesthetic)
twine
waterproof paper
pencil
first aid kit

Procedure

Check the Stream Inventory Summary System (SISS) for details of salmonid species present in your stream, their life cycles, and their distribution. Your Community Advisor can help you find the information. In many cases, the SISS database contains no information about small streams.

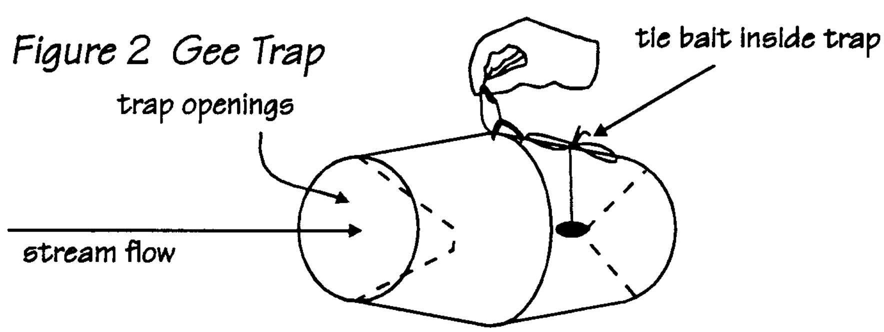
If you plan to study the fish community over a long period, your trapping procedures should be identical from year to year. Make sure that time of year, number of traps, trap locations, bait, soak time, and stream conditions are consistent each year. Record this information on the Field Data Sheet.

THE TRAP

The Gee trap separates into two pieces to allow you to add bait and remove fish easily (Figure 2). You can adjust the trap to catch certain sizes of fish, by covering the trap with fiberglass fly screen to retain small fry, or by enlarging the opening to catch larger fish.

Fresh salmon roe is the best bait. Tie a piece of roe the size of a ping pong ball in a piece of nylon stocking. Suspend it from the top of the trap in front of an opening. If you throw it on the trap floor, fish will pick at it from the outside, but may not enter the trap. Substitute fish-flavoured dry cat food or a punctured tin of wet cat food if you have no roe.

Figure 2 Gee Trap

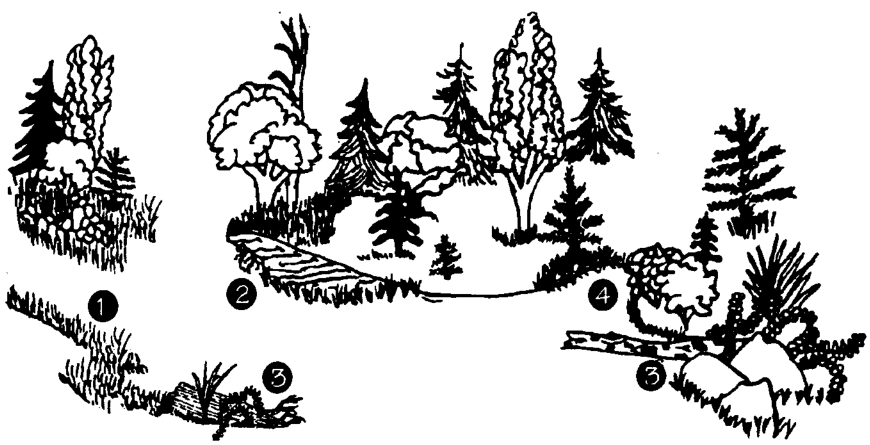


Step 1. Choose a Site and Set the Trap

Fish trapping usually is part of a larger watershed survey. If the introductory and advanced stream habitat surveys (Modules 1 and 2) have been done, set the traps at reference sites established during these surveys.

Set at least two traps at every suitable location in a reference site. If there are only one or two suitable locations, use more than two traps at each location. Set the traps in slow-moving water near instream cover (Figure 3). Cover is anything that provides a hiding place for fish, such as undercut banks, large stumps, logs, protected pools, and back eddies. Sloughs and side-channels also are good places to set traps. The water should be deep, so the trap can be fully submerged.

Figure 3
Examples of Good Locations to Set a Gee Trap



❶ side channel ❷ cutbank ❸ large woody debris
❹ side pool with overhanging vegetation

Generally, you should not place traps in fast flowing water, because fish will become exhausted swimming against the current and fish that are pinned against the sides of traps can die. You can set a trap in fast-flowing water for a few hours if you are interested in that particular habitat and check the trap every two hours. Never leave a trap in fast water overnight.

Set traps lengthwise in the current. Attach a piece of twine to the eye of the clip holding the two halves of the trap together and tie the other end to a tree. Mark the tree with a piece of flagging tape labeled with the trap number. Write down the trap number and location, so you can find it again. Traps that are abandoned or lost in streams become fish killers.

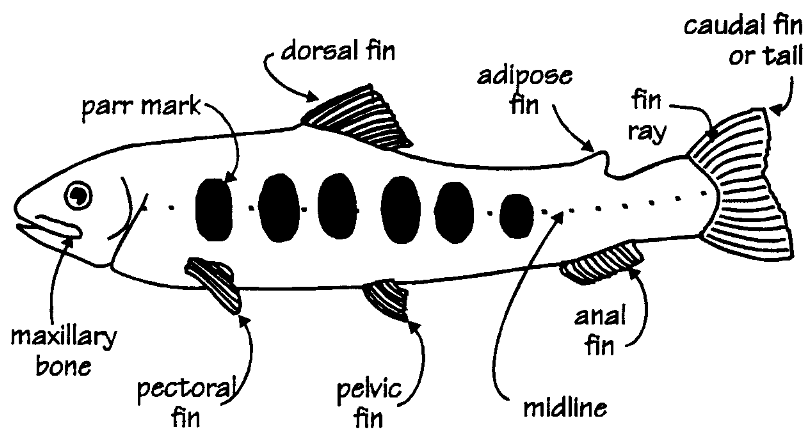
To catch the most fish, set your traps before dusk, and pick them up in the morning, leaving the traps in the stream for about twelve hours. This period is the "soak time." You can use a shorter soak time from late spring to early fall, when water is warmer and fish are more active. Even two hours can be long enough to check for the presence of fish. Never leave a trap in the water for more than twenty-four hours.

Step 2. Identify the Fish

Empty the trap by taking it apart and gently pouring the fish into a bucket of water. Keep the bucket cool and in the shade. Handle the fish very gently and keep them out of water as little as possible. Remove the salmonid species first and identify them using the key in Appendix 1. Catch one fish at a time with a dip net, place it in a glass jar or other clear viewing container, and identify it. Repeat this procedure for non-salmonid species, using the key in Appendix 2. This key identifies all the families of fish in the province. If you wish to identify them to the species level, use the keys in McPhail and Carveth (1995). Record the numbers on the Field Data Sheet. Use a separate data sheet for each sampling site.

Figure 4 shows the features used to identify juvenile salmonids. Juvenile salmonids can be difficult to identify to species, especially at the emergent fry and smolt stages, but with practice you will be able to identify them quickly.

Figure 4
Identification Features for Juvenile Salmonids



If you are interested in fish size, measure length from the nose tip to the tail fork and record the length in millimetres. Use Alka-Seltzer to anaesthetize the fish first. It produces dissolved carbon dioxide. Use one or two tablets for every four litres of water. Since the ideal concentration varies with temperature and water chemistry, experiment to find the right concentration. Dissolve one tablet in four litres of stream water and add one fish to test the strength of the anesthetic. The fish should become disoriented and start to roll over within one or two minutes. If it does not, gradually increase the concentration of Alka-Seltzer. After you find a good concentration, add a few more fish to the bucket. Work quickly and anaesthetize only a few fish at a time. Prolonged exposure to CO2 will suffocate them. When you have finished with a fish, let it recuperate in a bucket of fresh water. Return all fish to the location where you trapped them.

Step 3. Complete the Data Sheets

Fill in the details on the Stream Locations and Conditions Data Sheet. Record the exact survey location, weather, water temperature, turbidity, and percent bankfull. Measure turbidity in a deep pool area, using the tape measure. Turbidity is the maximum depth in centimetres that you see the "one" at the end of the tape. Estimate the percent bankfull: the amount of water compared with the bankfull channel size. The boundaries of the bankfull channel are defined by the edge of perennial vegetation growth. Record the fish species on the Field Data Sheet, along with other data such as length measurements. If a trap catches nothing be sure to record that result as well.

Collecting, Reporting and Evaluating Information

Always keep neat, organized records of your field activities. Send copies of the data to the Streamkeepers Database. The current address is in the Handbook. Also send copies to your Community Advisor and/or the fisheries biologist who has assisted you.

Fish distribution can be patchy. It is common to find lots of fish in one trap and few or none in others at the same site. If you set many traps but catch no fish, investigate the situation further. Fish may be absent from the samples for many reasons. Many species migrate to seasonal rearing or overwintering habitat, so they may inhabit an area for only part of the year. There may be water quality or habitat problems, a barrier to spawner migration, or no returning spawners due to over-fishing. A transient chemical spill in the past may have eliminated fish. Natural recolonization of such areas takes many years, or may never occur. You can find out if the stream is suitable for recolonization or has water quality or habitat problems by conducting the surveys described in Modules 1 through 4.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

References

Childerhose, R.J., and M. Trim. 1979. Pacific Salmon. Douglas and McIntyre, Vancouver, BC. 158 pp.

Conlin, K. and B. D. Tutty. 1979. Juvenile Salmonid Field Trapping Manual. Fish. & Marine Serv. Man. Rep. 1530; 136 pp.

Groot, C. and L. Margolis (editors). 1991. Pacific Salmon Life Histories. Univ. British Columbia Press, Vancouver, BC.

McPhail, J. D. and R. Carveth. 1995. Field Key to Freshwater Fishes of British Columbia. Prepared for Aquatic Inventory Task Force of the Resource Inventory Committee, Victoria, BC. 233 pp.

APPENDIX 1:

Key to Identifying Juvenile Salmonids

(from McPhail and Carveth 1995)

APPENDIX 2: Pictorial Key to the Families of Freshwater Fishes

(from McPhail and Carveth, 1995)

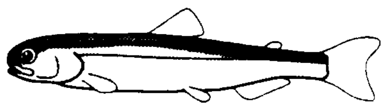
Appendix 1

from McPhail and Carveth 1995

Key to Juvenile Salmon, Trout and Char

Family Salmonidae (subfamily salmoninae)

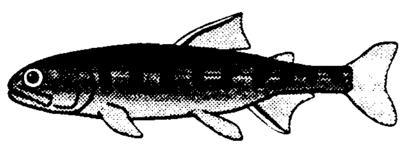
1 (10) Anal fin base longer than dorsal fin base; in profile, outer margin of anal fin slants backwards; no distinct dark spots on dorsal fin 2



2 (3) Sides silvery; no parr marks; back iridescent greenish-blue; small fish (usually less than 50 mm in fresh water)
.......PINK SALMON (Oncorhynchus gorbuscha)

3 (2) Parr marks on flanks 4

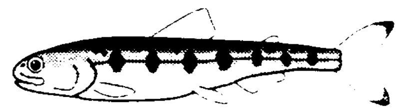
4 (7) Parr marks in the form of deep bars, the largest marks deeper than the vertical eye diameter 5



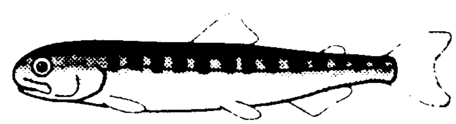
5 (6) Adipose fin uniformly pigmented; parr marks variable but the spaces between parr marks usually wider than the marks themselves; anal fin not sickle shaped, white leading edge contrasting sharply with adjoining dark pigment
COHO SALMON (Oncorhynchus kisutch

6 (5) Adipose fin with a clear unpigmented "window"; space between parr marks usually wider than the marks themselves, fin not sickle-shaped, white leading edge of anal fin not contrasting conspicuously with dark pigment CHINOOK SALMON
. . . . (Oncorhynchus tshawytsch)

7 (4) Parr marks small, oval shaped, none much higher than the vertical diameter of the eye 8



8 (9) Size in fresh water to over 100 m;, parr marks roughly divided in half by mid line, combined width of parr marks much less than half the combined width of intervening light areas; no greenish iridescence on sides below mid line
. . . . SOCKEYE SALMON/KOKANEE (Oncorhynchus nerka)



9 (8) Size in fresh water less than 500 mm; parr marks faint or absent below mid line; combined width of parr marks more than half the combined width of the intervening light areas
. . . . CHUM SALMON (Oncorhynchus keta)

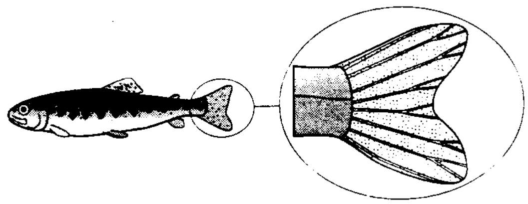
10 (1) Dorsal fin equal to, or longer than anal fin base, in profile, hind margin of anal fin vertical
. . . . 11

11 (17) Numerous distinct dark spots on dorsal fin; in very small specimens only the first dorsal ray may be black 12

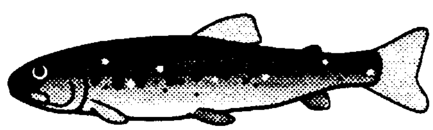
12 (15) Coloured spots (red to yellow) along mid line or between parr marks; combined width of parr marks along mid-line about equal to or greater than the combined width of intervening light areas 13

13 (14) Parr marks usually 8 or 9, the widest about width of eye; no dark spots other than parr marks below midline; adipose fin dusky
. . . . BROOK TROUT (Salvelinus tontinalis)

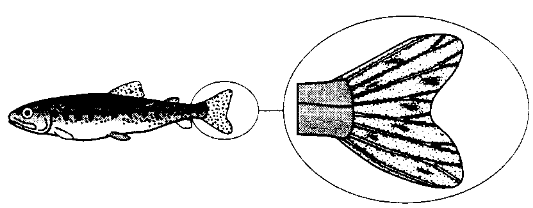
14 (13) No coloured (red to yellow) spots; width of dark areas along mid-line less than width of lighter areas
. 15



15 (16) Few or no spots on tail, on fish less than 50 mm the melanophores are evenly dispersed over the entire tail; hind margin of upper jaw does not reach hind margin of eye; no red or yellow marks under lower jaw
. . . . . RAINBOW TROUT (Oncorhynchus mykiss)

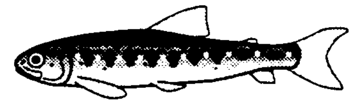


16 (17) About 11 (10-12) parr marks, none as wide as eye diameter; small black scattered spots in addition to parr marks
. . . . BROWN TROUT (Salmo trutta)



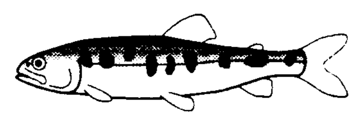
17 (15) Usually black spots on tail, on fish less than 50 mm, melanophores are concentrated between the rays, often forming streaks (precursors of spots); hind margin of upper jaw usually reaches to or past hind margin of eye; often red or yellow marks under lower jaw . CUTTHROAT TROUT (Oncorhynchus clarki)

18 (11) Dorsal fin without numerous dark spots; in very small specimens the first dorsal ray may be dusky but not black. 18



19 (18) Black spots on back and sides; 8-10 regularly shaped parr marks; width of dark areas on mid-line about equal to a width of light areas; a single red dot between each parr mark
. . . . ATLANTIC SALMON (Salmo salar)

20 (11) No black spots on back and sides, parr marks are irregular blotches; width of dark areas on mid-line greater than width of light areas; parr marks not separated any single red dots 21



21 (22) Parr marks along mid-line are vertical bars with width of dark areas equal to or less than width of light areas; dorsal fin starts about middle of body (excluding tail)
. . . . LAKE TROUT (Salvelinus namaycush)

22 (21) Parr marks are irregular blotches; with of dark areas on mid line greater than width of light areas; dorsal fin starts in front of middle of body (excluding tail)
. . . . DOLLY VARDEN & BULL TROUT
. . . (Salvelinus malma or Salvelinus confluentus

** The young of these species can not be reliably identified except biochemically.

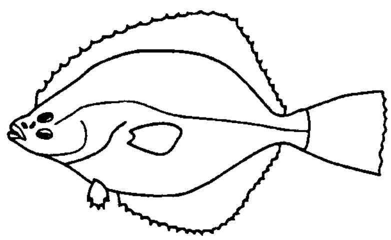
Appendix 2

from McPhail and Carveth 1995

Key to Families of Fish

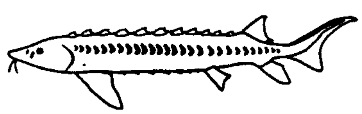
1 (2) Paired fins absent (no pectoral or pelvic fins); mouth in the form of a sucking disk; seven external gill openings . . . . LAMPREYS (Petromyzontidae)

2 (1) Paired fins present; mouth with normal jaws; a single external gill slit. 3



3 (4) Body flat; eyes on same side of head . . . . FLOUNDERS (Pleuronectidae)

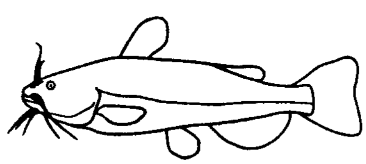
4 (3) Body normal; eyes normal, one on each side of head 5



5 (6) Tail heterocercal (upper lobe much longer than lower lobe); scales in the form of bony scutes arranged in widely separated rows on back and sides . . . . .STURGEONS (Acipenseridae)

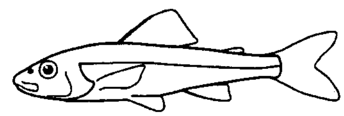
6 (7) Tail not heterocercal; scales either normal or absent. 7

7 (18) Adipose fin present 8



8 (9) Body without scales; 4 pairs of long barbels around mouth . . . . CATFISH (Ictaluridae)

9 (8) Body with scales; no barbels around mouth 10



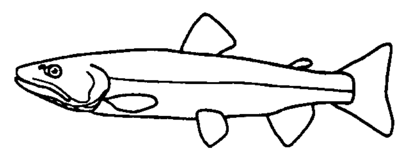
10 (11) Tips of pectoral fins extend well past origin of pelvic fins. . . . . TROUT-PERCHES (Percopsidae)

11 (10) Tips of pectoral fins do not reach origin of pelvic fins 12

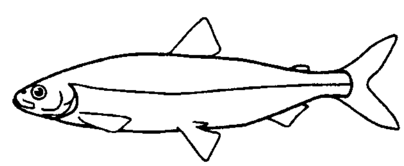
12 (17) Axillary process (small, fleshy spear-like tab at base of pelvic fin) present 13

13 (14) Dorsal fin base large, dorsal origin in front of posterior tips of pectoral fins . . . . GRAYLINGS . . . .(Salmonidae; Subfamily Thymallinae)

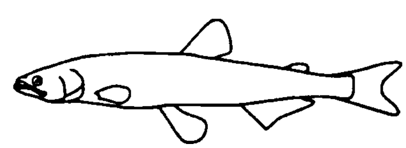
14 (13) Dorsal fin base small, dorsal origin is well behind posterior tips of pectoral fins. 15



15 (16) Scales small, difficult to count with naked eye; well developed teeth in jaws .SALMON, TROUT, CHARS . . . . (Salmonidae; Subfamily Salmoninae)



16 (15) Scales large, could be counted with naked eye; teeth in jaws absent or very weakly developed . . . . .WHITEFISH . . . . (Salmonidae; Subfamily Coregoninae)



17 (12) No axillary process at base of pelvic fins . . . . SMELTS (Osmeridae)

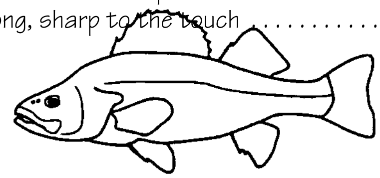
18 (7) Adipose fin absent 19

19 (20) Separate spines (usually 3 or more in front of soft dorsal fin) . . STICKLEBACKS (Gasterosteidae)

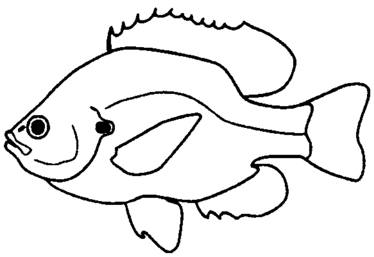
20 (19) Spines in dorsal fin not separate but interconnected by a continuous membrane. 21

21 (26) Two or more spines (may be soft spines clearly visible in dorsal fin) 22

22 (25) Body covered with ctenoid (rough to the touch) scales; 2 or more spines in anal fin; dorsal spines strong, sharp to the touch 23

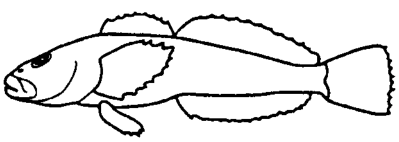


23 (24) Two dorsal fins (spinous and soft dorsals separated at their base) . . . . . PERCHES (Percidae)



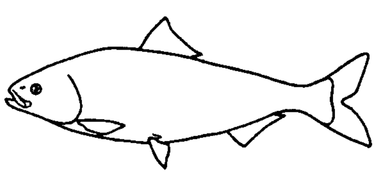
24 (23) One dorsal fin (it may be indented); anal fin with 3 to 9 spine

lae)



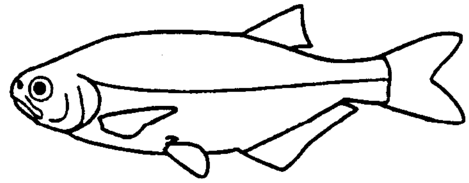
25 (22) Body without scales (small prickles may be present); no spines in anal fin; dorsal spines weak, soft to the touch . . . . SCULPINS (Cottidae)

26 (21) No spines in dorsal fin (except for 1 in the carp) 27



27 (28) Scales on the belly in the form of a sharp saw-like keel . . . . HERRINGS, SHAD (Clupeidae)

29



29 (30) Anal fin base more than twice as long as dorsal fin base . . . . GOLDEYE (Hiodontidae)

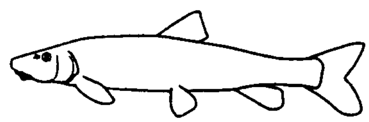
30 (29) Anal fin base less than twice as long as dorsal fin base 31

31 (32) Teeth in jaws 34

32 (33) Dorsal and anal fin bases long (at least half the length of the body); single barbel at tip of chin . . . . .CODS (Gadidae)

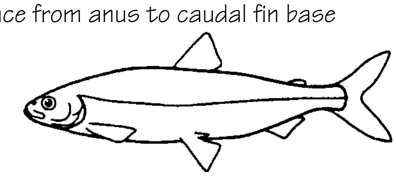
33 (32) Dorsal and anal fin bases short (much less than half the body length): snout shaped like a duck's bill . . . . PIKES (Esocidae)

34 35



35 (36) Mouth turned down; lips thick, covered in tiny papillae; distance from snout to anus over 2.5 times distance from anus to caudal fin base

iidae)



36 (35) Mouth usually not turned down; lips thin, without tiny papillae; distance from snout to anus less than 2.5 times distance from anus to caudal fin base . . . . MINNOWS (Cyprinidae)

send the data to the Streamkeepers Database

STREAM LOCATION AND CONDITIONS

(use a new data sheet for each stream segment surveyed)
(see Module 1 for additional information)

Stream Name	**Date**
Watershed code	**NTS Map#**
Organization name	**Crew size**
Contact name	**Phone#**

Recent weather conditions	**Water turbidity (cm)**
Water temperature (^{o}C) ***(Leave thermometer in water 2 min.)***	**Air temperature (^{o}C)**
Stream condition (% bankfull)	**Photos taken: (yes or no)**

Upstream boundary (directions, distance to known landmark)
Downstream boundary (directions, distance to known landmark)
IF YOU ARE SAMPLING A SPECIFIC POINT ON THE STREAM, RECORD: **Specific location of sampling station (directions, distance to known landmark):**

send the data to the Streamkeepers Database

MODULE 11:
JUVENILE FISH TRAPPING FIELD DATA SHEET

Stream name	Date

COMMENTS

Trap # / bait used	Location	Time set	Time re-trieved	species	Length (mm)

STREAMKEEPERS

Module 12
Salmonid Spawner Survey

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
no	Not necessary	1 day or more	2 or more	Spring through fall

Fisheries and Oceans   Pêches et Océans

Canada

MODULE 12

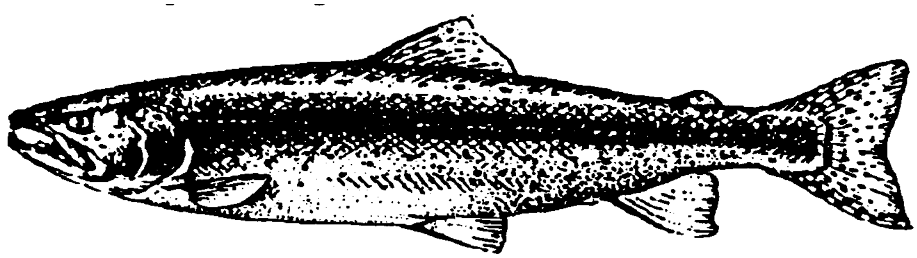
Salmonid Spawner Survey

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgments

Sandie MacLaurin, Community Advisor with the Department of Fisheries and Oceans, organized the material for this module. DFO fisheries officers and contract field staff on the central coast provided information, as well. Material was taken from training guides developed for the Aboriginal Fisheries Division Guardian Training Program and the Community Economic Development Program.

Steelhead Trout



Project Activity and Purpose

You will count adult salmon, trout, or char that have returned to your stream to spawn. This involves walking the banks of a stream several times during the spawning season, counting the fish, and observing their condition. This kind of survey is known as a foot survey. You will complete a data sheet each time you do a survey. At the end of the season, you will use all the results to estimate the size of the spawning population. You can compare these numbers with data from previous years or with fisheries management targets.

Fisheries officers prepare annual reports of salmon streams, known as BC 16 reports, from the survey data. These reports are used to assess trends in fish populations. Volunteer groups carrying out enhancement or habitat improvement projects can use spawner survey results to assess the success of their projects.

Introduction

Spawner surveys provide information about the number of adult salmonids that reach the spawning grounds, and the proportion that spawn successfully. Fisheries managers use the term escapement to describe the number of fish that escape the various fisheries.

The size of harvests taken by various fisheries is the major factor affecting the number of fish that return to spawn. Habitat damage also reduces fish numbers. Enhancement or habitat improvement projects can help more fish reach the spawning grounds. Information about stream habitat, such as obstructions, changes in stream beds, pollution, and other potential problems are recorded as part of the survey. All these factors interact to affect the escapement in a single year, or over many years. The results of previous surveys can help you recognize trends in relative abundance of various fish populations. For some streams, records go back many years.

Counting spawning fish is easier in some streams than others. Some species, like coho, are elusive and very difficult to count. Fisheries biologists sometimes use an easily surveyed stream as an indicator or "index" stream for a general area, when other streams are too difficult to survey.

There are times during the spawning season when stream conditions will not be suitable for a survey. Often, there are high flows or floods during the spawning season. Walking the banks then can be dangerous, and fish are hard to see when water clarity is poor. However, high water flows trigger most species to begin migrating to spawning grounds. For many salmon runs, the best time to do the first count is right after the first freshet, as water levels begin to drop and visibility improves.

The timing of salmonid migration and spawning depends on the species, the run, and the geographic location of the stream (north, south, inland, coastal). Adults may migrate to the spawning grounds weeks or months before they begin to spawn. Spawners of various species can be found in streams throughout the year. The period of peak spawning usually occurs during the times listed in Table 1, but there are exceptions.

An enhancement project can be assessed using a spawner survey. Hatchery staff usually mark a proportion of the fry they release. When fish return to spawn, dead spawners can be recovered, data recorded from the marked ones, and data used to estimate survival rates for the various groups. Shaw (1994) describes the sampling techniques.

Table 1 **Timing of the Spawning Period for Salmonid Species**	
SPECIES	**SPAWNING PERIOD**
pink salmon	August through September
chum salmon	EARLY RUN: late July through late September LATE RUN: late September through November
chinook salmon	EARLY RUN: July through August or early September LATE RUN: mid-September through mid-November
coho salmon	EARLY RUN: late August through December LATE RUN: January through February
sockeye salmon	August through October
kokanee	September through November
cutthroat trout	December through June
steelhead trout	March through May
rainbow trout	April through June
dolly varden/ bull trout	September through November

The foot survey described in this module involves counting fish in defined sections of a stream. This method is simple, does not take much time, and works well on small to mid-sized streams with good water visibility. This method has some limitations and shortcomings, but used consistently, you can compare results from year to year. There are other methods more suitable for other situations.

Project Guidance and Approval

You need no project approval for a spawner survey, unless you plan to collect samples or tags. However, you should contact local property owners if you need to cross their property to get to your stream. Contact your local Community Advisor, Department of Fisheries and Oceans office, or Ministry of Environment, Lands, and Parks office before starting a survey. Staff from these agencies can tell you about previous spawner studies on the stream, methods used, and results obtained. They can tell you whether or not a foot survey is suitable for your stream, review the technique and data forms with you, and advise you on recovering tags from marked fish. They also can provide practical information about timing, access points, danger areas, and maps.

Level of Effort

Two people can walk the banks of a stream once during the spawning season and obtain useful information. However, for a complete spawner survey, you should walk the entire stream every five to twenty days during the spawning season. You may wish to divide a long stream into manageable sections, with several teams of two sharing the work. If so, make sure you coordinate the survey so that everyone goes out simultaneously. This way, you can compare data and add results to get a stream total. The time involved can range from two hours to an entire day, depending on the length of stream surveyed and the stamina of the volunteers.

Time of Year and Working Conditions

Do a foot survey when fish return to the stream to spawn. Check Table 1 for the general time of year to expect them in your stream. You may be surveying in the middle of winter, or the in heat of the summer, depending on the fish stock.

Do not do a spawner survey during high water or floods. Travel along stream banks can be extremely dangerous at those times. In addition, heavy silt loads during floods reduce water visibility, making fish difficult to see. The survey involves walking long distances along the stream banks and some wading across streams. There may be bears or other potentially dangerous wildlife on the stream.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property. Beware of domestic animals and wildlife.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, flares, compass and a portable radio telephone or cellular phone. You may wish to bring a whistle to call for help if you are injured.

CLOTHING

Dress for the weather and stream conditions. Wear highly visible clothing. Wear a personal flotation device (PFD) when working near larger streams.

WILDLIFE AWARENESS AND SAFETY

Bears, wolves, and other predators may be common and bold around streams during the spawning season. Reduce your chances of encounter by making lots of noise, so animals will avoid you. Keep food in airtight containers and leave no food scraps behind. Walk downwind, if possible, so that bears can smell you and leave the area. Avoid confined areas such as overgrown side channels when you see tracks and other signs of wildlife use. Take bear spray for additional protection.

Materials and Equipment

waterproof paper	notebook or clipboard
data sheets	polarized sunglasses
waders or boots	pencils
thermometer	map
tally counters	safety equipment
bear spray	compass

machete or sawduik brushing device (for bushwhacking)
measuring tape (yellow with black numbers, for turbidity measurements)

optional:

rubber gloves	camera
wading stick	knife

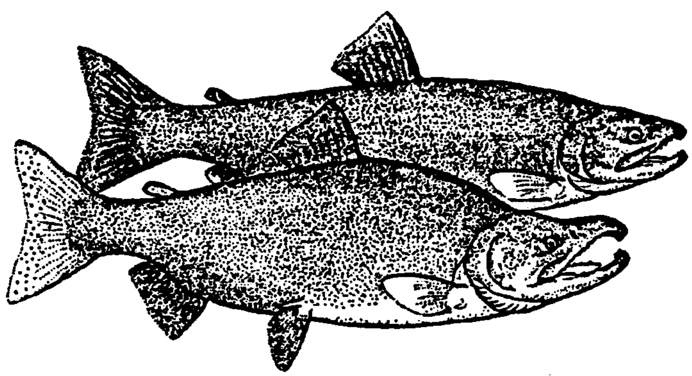
Background Information

In large watersheds, people often focus on specific streams or segments of streams where they can count spawners accurately and consistently from year to year. Some spawning areas are not accessible, so you may be limited to counting fish in key holding areas of a stream.

THE SET INTERVAL SURVEY METHOD

The foot survey described in this module is based on the set interval method. Spawning grounds are surveyed several times during the spawning season. The frequency with which you survey should coincide with the residency time of the spawners. Residency time or turnover rate is the time it takes for one group of fish to spawn and die before the next group starts to spawn. This time varies from five to twenty days and depends on location, species, run type (summer, fall), and stream conditions. Counts of live and dead fish are combined to produce an estimate of total numbers for the season.

Sometimes fish start migrating earlier or later than expected and part of a run may be missed. If the residency or turnover time is different from expected, the interval used between survey dates may be too great. Sometimes the count includes fish that are not spawning in the area, but are migrating through. All these factors affect the accuracy of the count, and should be considered when designing a survey.



Sockeye
Salmon

OTHER METHODS

Spawner numbers can be estimated using other methods described by Cousens et al. (1982) and summarized here. Many are variations on the set interval method. Some yield more accurate results than others and some provide only an estimate of relative abundance. The method used is based on stream size, access, size of spawning areas, fish species, amounts of data needed, previous method used, and human resources available.

The **single count survey** is a count of live fish during the spawning period before any fish die, or a count of live plus dead fish at or just after the peak of spawning activity. The **adjusted frequent survey** is an intensive survey of spawning areas to count live and dead fish during the peak of the season, sometimes daily. The **factor five method** involves surveying shallow riffle spawning areas several times to count live fish, then using a formula to estimate numbers from counts, turnover rate, and number of survey days. With **strip surveys**, spawners are counted in one metre wide strips in a spawning area and results are extrapolated for other spawning areas. The **dead pitch or carcass count** involves removing and counting all dead fish within reach of the shore, every three days or less.

FACTORS TO CONSIDER WHEN PLANNING THE SURVEY

Weather

Plan to do the survey on a bright day when water clarity is good. Fish are very difficult to see on rainy days. Although you need good visibility, you do not want glare off the water or the sun in your eyes, so consider which side of the stream is best for reducing glare

Time of day

Midday usually is the best time of day to see and count fish because the sun is directly overhead and not shining in your eyes. Time of day can affect fish distribution. Sometimes fish spawn at night or in the early morning, and stay in deeper pools during the day. You also may need to time the survey to avoid contact with potentially dangerous wildlife. Ask local fisheries or conservation staff about safe times of day in your area.

Potentially large number of fish

If you expect many spawners, make the survey sections small enough to allow accurate counts in a reasonable amount of time. Use hand-held tally counters to record fish numbers

More than one salmonid species in the stream

The spawning periods of two or more species may overlap. Use the key in Appendix 1 to distinguish the species. Have each person count only one species, and keep the counts separate.

Choosing to do the survey walking upstream or downstream

Decide the direction based on access, terrain, potential wildlife encounters, and angle of the sun. Do not try to survey with the sun in your eyes. If you have a choice, walk upstream. Spooked fish generally turn around and swim downstream, so you will be less likely to count them twice.

Procedure

1. COLLECT AND REVIEW EXISTING DATA

Obtain a large scale topographic map (1:20,000 TRIM map) from Maps BC (387-1441, Victoria). You may wish to use aerial photographs, also available at Maps BC, to locate important features such as canyons, waterfalls, and access points. These maps also are used in Module 1, Introductory Stream Habitat Survey.

Contact your Community Advisor or local DFO office for information about salmon species listed in the Stream Inventory Summary System (SISS) database. Contact the local WLAP office for information about other species. Look at the historic spawner records and stream reports for information about typical run timing, spawner abundance, and previous survey methods used.

2. ESTABLISH SURVEY AREAS OR SECTIONS

Make an extra copy of the TRIM map and any working sketches from previous spawner surveys. Update the map with information on vehicle access points, changes in stream channel, and other useful information from the SISS database.

Divide the system into workable survey sections and mark them on the map. Consider the terrain, physical abilities of the volunteers, and time commitment when you set up the survey sections. Some sections of your stream may be difficult to survey. Make the sections short if you expect lots of spawners. Reasonable access by vehicle or short hike is important. Use landmarks such as bridges, roads, and barriers as the start and finish points of a section whenever possible.

3. DEVELOP A COORDINATED PLAN AND TRAIN THE SURVEYORS

The details of your plan depend on the size of the survey, the number of teams, and the number of survey days. Always send two people to survey a section. Decide how often to survey using information from previous surveys.

Arrange transportation to and from the survey locations. Set up a central first aid and emergency response location. Ensure that everyone is familiar with emergency procedures, methods, and survey locations. Also make sure they know how to read the maps and sketches and how to record data. Arrange to collect the completed forms and go over the results with team members.

Make up a simple schedule, like that in Table 2. Keep this schedule as part of your survey records. Prepare a large map for the coordinator, showing all the survey sections and team members.

Table 2 **Spawner Survey Schedule**		
Date, Time	**Stream Section**	**Team members**

4. DO THE SURVEY

a) At the start

Record information at the stream using waterproof paper, then transfer it to the Field Data Sheet when you have finished the day's survey. Record exact survey location, weather, water temperature, turbidity, percent bankfull, and fish countability. Measure turbidity in a deep pool area, using the tape measure. Turbidity is the maximum depth in centimetres that you see the "one" at the end of the tape. Estimate the percent bankfull: the amount of water compared with the bankfull channel size. The boundaries of the bankfull channel are defined by the edge of perennial vegetation growth. Fish countability is affected by weather conditions (wind or rain disturbs the water surface), turbidity (generally or locally, from a turbid tributary), and water colour. When these conditions are poor, they reduce your ability to see and count fish.

Walk the stream bank and look for fish. Do not walk in the water to count, because that will disturb spawning fish and their habitat. Both members of a team should count spawners and compare results. If there are two or more species present, have each person count a different species. Use the Appendix key to identify the species, if necessary.

Confirm with your partner where to stop first to compare numbers. Natural features such as changes from riffle to pool, or bends in the stream are good places to stop. Stop frequently to make sketches and enter data. This helps reduce inconsistencies in the count. Record the convenient stopping places so you can use them again in your next survey of that section.

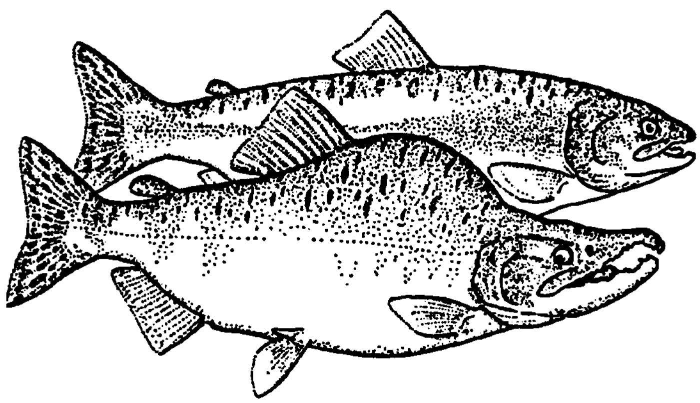
b) Finding fish

Consider fish behaviour when you look for fish. Some species lie in shallow riffles and are easy to see. Others, like coho, hide in deep pools or under cutbanks and logs, and can be very difficult to find.

Sometimes fish congregate at the confluence of a tributary, so check those locations carefully. If fish are difficult to see, toss a rock or poke a stick into an area, then watch for movement. Polarized sunglasses reduce glare and make it easier to see into the water. Some determined surveyors use a snorkel and mask so they can look into pools from an overhang or pool edge.

c) Counting fish

Count both live and dead fish during the first survey. In later surveys, count live fish and estimate the percent that have arrived since the last survey. New fish are in much better shape, appear cleaner, and do not have white blotches and scars.



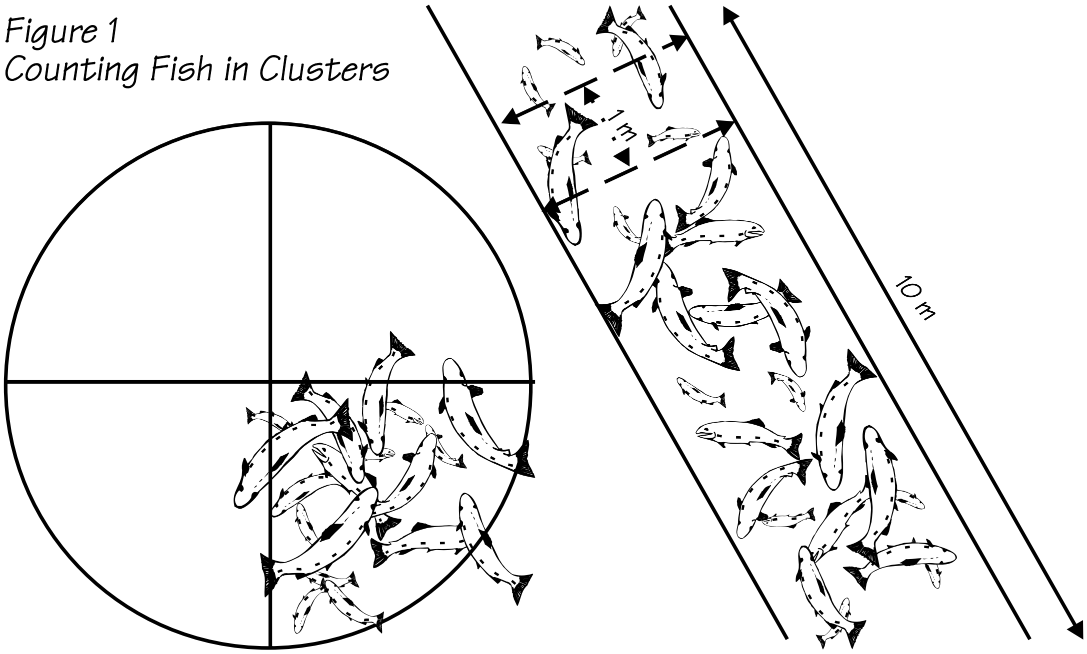
Pink Salmon

You will have little difficulty counting fish when numbers are low or when they are evenly spread out. However, when fish are clustered or densely packed, you will need to count them in groups. For example, one click of the tally counter may represent one hundred fish. Decide early in the survey whether to count in ones, tens, hundreds, or more, based on the abundance and density of the fish.

Fish can be distributed evenly or in clusters. When fish are distributed evenly throughout a riffle, for example, divide the riffle into imaginary strips and calculate the average number of fish in a strip. Then extrapolate the number per strip into a count for the whole riffle. When fish are clustered, you can imagine the cluster as a square or circle. Count the number of fish in a part of the cluster (one quarter, one eighth, etc.), and extrapolate to a total number (Figure 1).

Counting fish in large deep pools where fish are many layers deep can be difficult. Toss in a stone to get the fish to move around. Divide the pool into imaginary divisions, consider the depth of fish, and extrapolate the results. If it seems impossible to estimate numbers, compare the size of this pool to a smaller pool where you have counted fish already, and adjust the numbers upward.

Figure 1
Counting Fish in Clusters



d) Collecting data from tag studies

You may be able to help recover data if tagging studies have been done for fish in your stream. Contact your Community Advisor or local DFO or WLAP office for guidance.

e) Recording the data

Write the spawner counts on waterproof paper while you are in the field. Later, fill out the Field Data Sheet, using a separate data sheet for each survey section and for each species. Add data for that survey section as the spawning season progresses. Include general stream conditions for each date. Save any sketches and notes you make during the surveys.

Record the total number of live and dead fish observed for each species counted during the first survey. Enter the sum of these two figures in the "new total to date (TTD)" space on the Field Data Sheet.

The number of pre-spawning deaths can be counted. This number is important, because in some years conditions may be poor (e.g., low water, high temperatures) and pre-spawning mortality may be significant. The dead fish often appear fresh, unscarred, and with a full belly. The body cavities of females contain many eggs, and males have intact sperm sacs.

Estimate the percentage of fish that are actively spawning. These fish will be paired up, sitting over or near redds, or found in shallow riffle areas. Their tails often appear ragged. Fish milling around in deep pools are usually not actively spawning.

Count only the live fish in the second and subsequent surveys. Record the total number of live fish and use your own judgment to estimate the percent new fish since you last walked the stream. Record the number of new fish on the spawning grounds. New fish look fresher and lack the white blotchy scars of older spawners. For example, if you count 1000 live fish in the second survey and estimate that 30% of them are new, the number of new fish is 300. Add the number of new fish to the previous TTD to get the new TTD estimate. Data from the surveys might look like this:

SPECIES: Chum	**first survey**	**second survey**	**third survey**	**fourth survey**	**fifth survey**
# live fish	860	1000	400		
# dead fish	10	n/a	n/a		
% new	n/a	30%	10%		
# new fish	n/a	300	40		
previous TTD	n/a	870	1170		
new TTD	870	1170	1210		
# pre-spawning mortalities					
% active spawners	75%	100%	100%		

After the final survey, summarize the results of all the spawner surveys on the Summary Data Sheet. Use a separate summary sheet for each species. Include a sketch of the spawner distribution on the back of the summary sheet. If you surveyed the whole stream, you can add all the results from individual sections to get the total spawner population for the stream. If you surveyed only some parts of the stream, there is no reliable way to extrapolate these results to the whole stream. Make sure you indicate on the Summary Data Sheet whether you surveyed the entire stream or only a portion of it. If you surveyed only a portion, clearly identify the location of the start and end points.

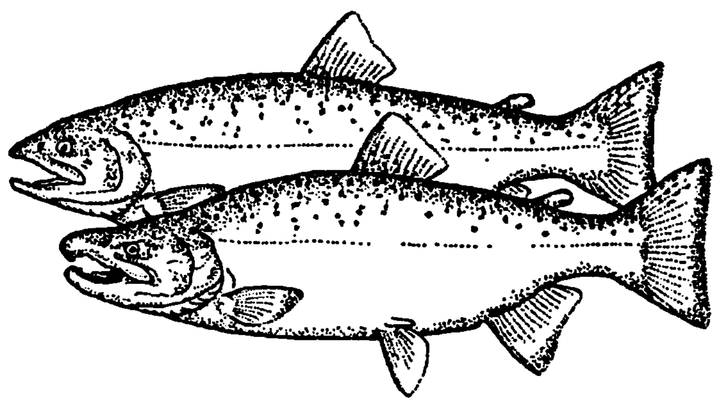
Collecting, Evaluating, and Reporting Information

Send copies of your completed field and summary data sheets to the Streamkeepers database. The current address is in the Handbook. Also, send copies to any fisheries staff who helped you with the project. They can help you prepare a BC 16 report, the Annual Report of Salmon Streams, or use your data to prepare the report themselves. Compare your survey data with historical spawner counts to assess the health of the population. If you have been involved in a stream enhancement project, you can use the data to learn how the population has responded to your enhancement efforts.

Public Relations

You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

Coho Salmon



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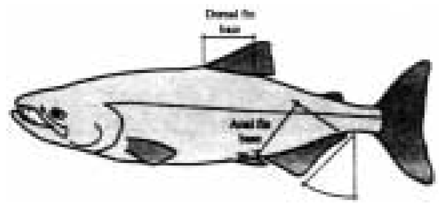
APPENDIX 1. Key to Adult Salmonids

(source: McPhail and Carveth, 1995)

Appendix 1
Key to Adult Salmon, Trout and Char

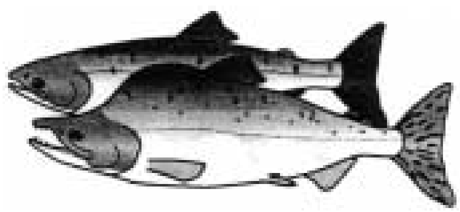
(from McPhail and Carveth, 1995)

Family Salmonidae (subfamily Salmoninae)



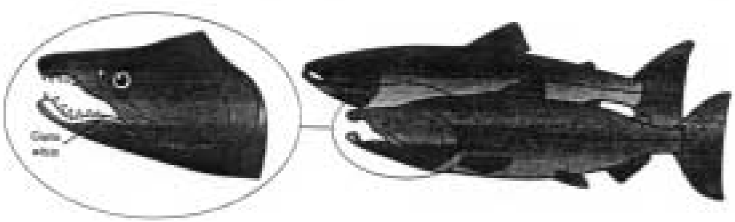
1 (10) Anal fin base longer than dorsal fin base; in profile, hind margin of anal fin slants backwards (not vertical). 2

2 (7) Distinct spots on tail 3

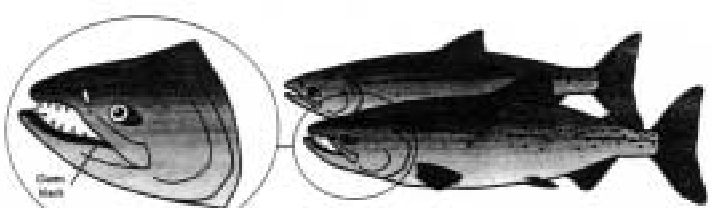


3 (4) Tail spots oblong (not round) . . . . PINK SALMON (Oncorhynchus gorbuscha)

4 (3) Tail spots round (not oblong) 5

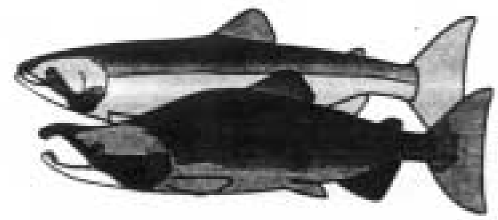


5 (6) Tail spotted on upper half; gums at base of teeth in lower jaw white. . . . . COHO SALMON (Oncorhynchus kisutch

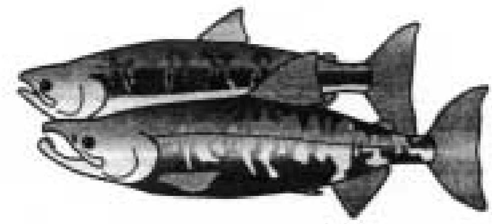


6 (5) Tail spotted on both upper and lower halves; gums at base of teeth in lower jaw black. . . . . CHINOOK SALMON (Oncorhynchus tshawytsch)

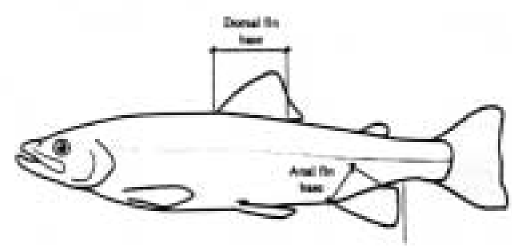
7 (2) No spots on tail, but occasionally some fine speckles 8



8 (9) Adults occur in fresh water both as migratory spawners (Sockeye) and as residents (Kokanee); flanks are uniformly coloured (silver in non-breeding Kokanee, usually red in breeding Sockeye and Kokanee). . . . . SOCKEYE SALMON/KOKANEE . . . . (Oncorhynchus nerka)

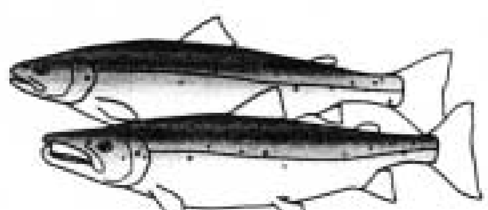


9 (8) Adults in freshwater only as spawners; flanks in males pale with irregular red and black blotches, females with a purplish lateral strip. . . . . CHUM SALMON (Oncorhynchus keta)



10 (1) Base of dorsal fin equal to, or longer than, anal fin base; in profile, hind margin of anal fin is vertical (no backward slant). 11

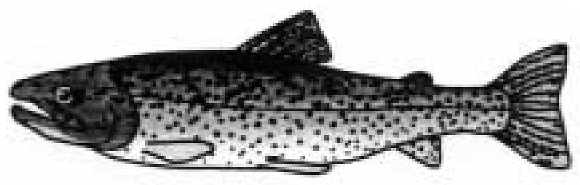
11 (18) Background colour on flanks light (silver or golden) with dark spots 12



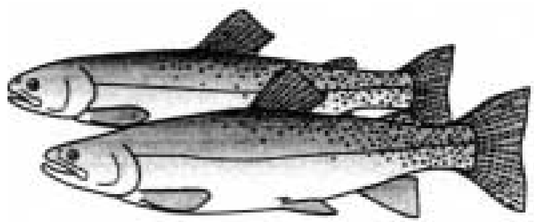
12 (13) Relatively few spots on flanks, mostly above lateral line, some spots x-shaped; caudal fin usually without spots; spawning males with conspicuously hooked lower jaw . ATLANTIC SALMON (Salmo salar)

13 (12) Spots on back and sides more numerous; none x-shaped; caudal fin usually heavily spotted. 14

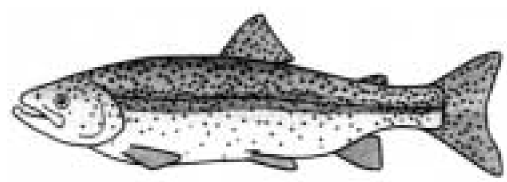
14 (17) Red or orange slash under lower jaw; upper jaw extends back past hind margin of eye; tail usually yellowish with black spots 15



15 (16) Anterior flanks heavily spotted above and below lateral line, anal fin usually with spots . . . . COASTAL CUTTHROAT TROUT . . . . (Oncorhynchus clarki clarki)

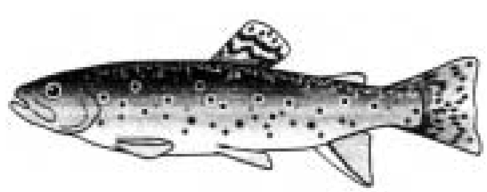


16 (15) Anterior flanks lightly spotted (mostly above lateral line), anal fin usually without spots . . . . WESTSLOPE CUTTHROAT TROUT . . . . (Oncorhynchus clarki lewisi)



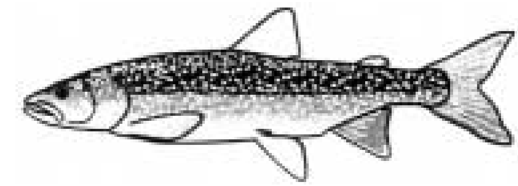
17 (14) No red or orange slash under lower jaw; except in spawning males upper jaw does not extend back beyond hind margin of eye; sides usually silver with a pink hue extending along midline; tail dusky with dark spots. . . . . RAINBOW TROUT (Oncorhynchus mykiss)

18 (11) background colour on sides dark with light or coloured spots 19



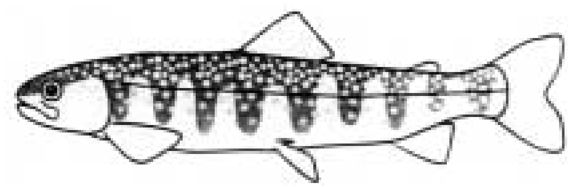
19 (20) Dorsal fin yellowish, with bold black streaks; red spots on flanks surrounded by blue haloes . . . . BROOK TROUT (Salvelinus fontinalis)

20 (19) Dorsal fin dusky and without bold black marks; spots on sides not surrounded by light haloes. . . . 21

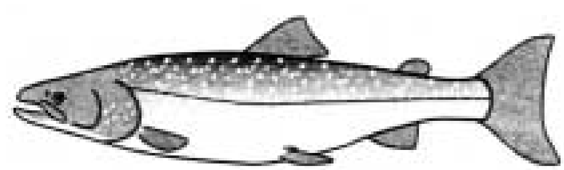


21 (22) Tail deeply forked, light coloured spots on both halves of tail; head and body covered in light irregular spots . . . . LAKE TROUT (Salvelinus namaycush)

22 (21) Tail not deeply forked; spots if present only on upper half of tail 23

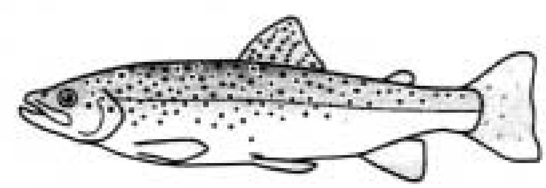


23 (24) When viewed from the side snout is blunt; upper jaw short (barely reaches hind margin of eye) . . . . DOLLY VARDEN (Salvelinus malma)*



24 (23) When viewed from the side snout is more pointed; upper jaw long (reaches well past hind margin of eye) BULL TROUT (Salvelinus confluentus)*

25 (26) Background colour on back and flanks light (silver or golden) with dark spots 26



26 (25) Spots on flanks mostly dark surrounded by conspicuous light haloes; some spots along side are red . . . . BROWN TROUT (Salmo trutta)

** This species pair is difficult to distinguish unless you have both in hand.*

send the data to the Streamkeepers Database

MODULE 12:
SPAWNER SURVEY FIELD DATA SHEET

(use a new data sheet for each survey section and species)

Stream Name		**Date**
Watershed code		**NTS Map#**
Organization name		**Crew size**
Contact name		**Phone#**
Upstream boundary of survey (directions, distance to known landmark)		
Downstream boundary of survey (directions, distance to known landmark)		
Survey method used		

SPECIES ____________________	**GENERAL STREAM CONDITIONS**				
date					
weather					
water temperature (^{0}C)					
% bankfull					
water turbidity (cm)					
***fish countability**					
	SPAWNER INFORMATION				
# of live fish					
# of dead fish		**n/a**	**n/a**	**n/a**	**n/a**
% new fish	**n/a**				
# of new fish	**n/a**				
# prespawning deaths					
% active spawners					
****previous TTD**	**n/a**				
****new TTD**					

*** fish countability = nil, poor, fair, good, or excellent ** TTD = Total To Date**

send the data to the Streamkeepers Database

MODULE 12:
SPAWNER SURVEY SUMMARY DATA SHEET

(use a separate summary sheet for each species)

Stream Name	**Date**
Watershed code	**NTS Map#**
Survey method used	**Organization name**
Contact name	**Phone#**
If this estimate is not for the whole stream, define the section surveyed	

SPECIES			
***total number of spawners**		**# of survey dates**	
spawning start date		**spawning end date**	
spawning peak period			
fish distribution			
number of prespawning deaths, cause of death			
****habitat problems**			
COMMENTS			
make a sketch of fish distribution and spawning areas on the back of the data sheet			

***(add all the TTD numbers from the last survey date for each survey section)**

**** HABITAT PROBLEMS: obstructions (type, severity, location, recommended action, silting, erosion, pollution)**

STREAMKEEPERS

Module 13
Creel Surveys

Project Approval Required	Training	Time Commitment (per year)	Number Of People	Time of Year
yes	Not necessary	A few weeks or more	2 or more	Year round

Fisheries and Oceans   Pêches et Océans

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MODULE 13

Creel Survey

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage "hands on" environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Acknowledgements

Mike O'Neill (manager of the Toboggan Creek Hatchery, Smithers) and Brenda Donas (Community Advisor, Department of Fisheries and Oceans) provided the information for this module.

Project Activity and Purpose

In this module you will conduct a creel survey to estimate the number of anglers on a stream and the number of fish caught. You will visit the stream regularly during the fishing season and collect information about anglers' catch and fishing effort. By accurately sampling during part of the available angling time, you can estimate total angling effort and catch. A reliable survey should account for at least one-sixth of the catch and effort at each fishing spot on a stream. You can design the survey to recover data from tagged fish, find out whether anglers are local or visiting, or provide answers to other questions.

Data from creel surveys help fisheries managers manage fish stocks effectively. Data provides information about the impact of angling on a particular fish population and is used to assess the health of the population if there are no other stock assessment data available.

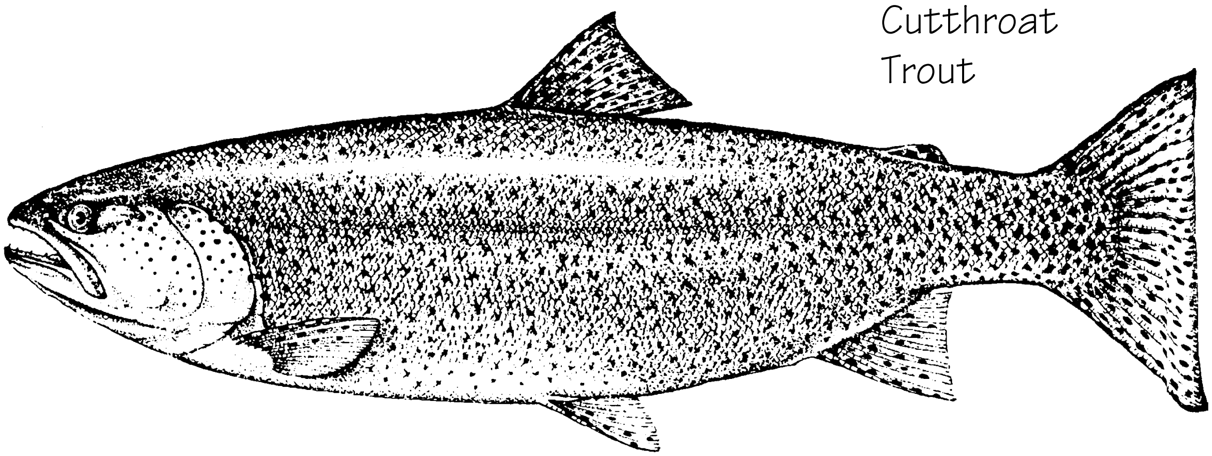
Introduction

Information about angling effort and success is important in understanding the health of a stream's fishery and in designing effective fishing regulations. Fishery management strategies are aimed at keeping streams filled to capacity with native breeding stocks and allowing anglers to take fish that are surplus to breeding requirements. If hatchery-reared fish supplement the stock, managers may wish to use a creel survey to recover valuable tag data.

Angling is a growing recreational activity throughout British Columbia. Fish stocks in streams as well as oceans are facing increasing pressures. Overfishing can reduce the number of potential spawners to a level so low that the population is in danger of collapsing. Fish stocks take many years to recover from such a decline. Some stocks have become extinct.

Complete knowledge of angling effort and harvest on every stream is ideal, but too costly to consider. The creel survey was developed to study angling effort in a statistically reliable way. It uses consistent methods, so you can compare results from year to year and, sometimes, from stream to stream.

Once you have established the timing and frequency of your survey, you can choose the kinds of observations you wish to make or the questions you wish to ask. Catch success is calculated from the number of hours fished and the number of fish caught. You may wish



to collect tags, or find out the sex, length, and age of the fish. You also may wish to know whether the anglers are local or from out of town. Such information can demonstrate the importance of the stream to the local economy, and local businesses will find the information useful.

To obtain statistically reliable results, you will need to survey all potential angling locations on a stream. If you spend four hours every other day at each fishing location, you will have surveyed one-sixth of the potential fishing hours, assuming twelve hours of daylight.

Several practical matters affect the time commitment and the accuracy of your results. The first is the length of the fishing season. Obviously, a stream with a one-month fishery requires fewer survey days than a stream with a three-month fishery.

The second practical matter is the size of the stream and distribution of fishing spots. Short streams with a few well-known fishing spots are easy to survey. Long streams with many angling locations are much more difficult to survey. A survey of a large area requires more volunteers and more coordination.

The third matter to consider is access to your stream. On most streams, there are vehicle access points where anglers park then walk to fishing spots. These locations are convenient for anglers and surveyors alike. Your task is more complicated when anglers travel by boat or hike long distances to fishing locations.

Creel surveys usually are not done every year on the same stream. Trends in fish populations can be followed adequately by repeating surveys every three to five years.

Project Guidance and Approval

You need approval from your Community Advisor or the local office of the Ministry of Water, Land and Air Protection (WLAP). You also should notify DFO and WLAP enforcement officers and biologists of your survey plans. They may be able to help you design your survey or may even wish to include a few questions of their own.

Level of Effort

A creel survey requires a considerable time commitment. The sport fishing season for your stream may be several weeks or months long. You probably will wish to organize and train several volunteers. Each fishing location is surveyed for at least one-sixth of the total daylight hours, so a creel survey during the long summer days can be a big job.

Time of Year and Working Conditions

Creel surveys are done during the fishing season. If the season is long, make sure you survey at least during the peak fishing weeks. A shortened survey still provides useful information about trends. Depending on fish stock, you may be working in the middle of winter or the heat of summer. You will need to be in good physical condition if your survey involves much hiking. There may be bears or other potentially dangerous wildlife in the area of your the stream.

Safety

PERSONAL SAFETY

Concern for personal safety is essential when working outdoors. Always tell someone where you are going and when you will return. Work in pairs, never alone. Carry emergency phone numbers for police and ambulance.

Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Log jams can be unstable, so take care to walk around them.

Get permission to cross or use private property. Beware of domestic animals and wildlife. Bears may be common and bold during the fishing season.

HEALTH

Do not drink stream water. Although it may look pristine, it can harbour bacteria or parasites that will make you sick. Do not expose cuts and wounds to stream water. Know the symptoms and treatment for hypothermia.

EQUIPMENT

Carry a first aid kit. When working in isolated areas, carry a survival kit containing at least a lighter, fire starter, candle, and flares. Take a cellular phone if you have one.

CLOTHING

Dress for the weather and stream conditions. Wear highly visible clothing. Wear waders with felts when walking in the stream.

WARNING

Do not confront anyone you suspect may be violating fishing or other regulations. Follow the Observe Record Report procedure described in Module 9.

Materials and Equipment

waders, or boots
first aid kit
waterproof paper
pencils
rain pants and coats
knife
data sheets

If collecting tags or physical data:

ziploc bags
Tweezers
tape measure
tag labels
scale books

For surveys on long rivers, consider adding:
boats and fuel life jackets
rope radio (for remote locations)
bear spray extra food and clothing

Procedure

Step 1. DESIGN THE SURVEY FORM

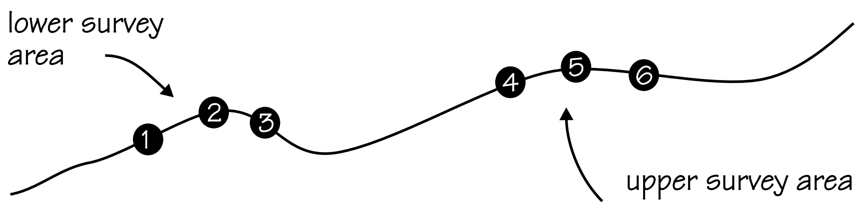
Select the information you wish to collect. At the very least, you will wish to record the number of anglers, the amount of time each angler spends fishing, the number of fish caught during the survey period, and the species caught. When you combine data from the whole survey period, you will be able to calculate total angler effort and catch success, or catch per unit effort. The Field Data Sheet provides space for these basic data. You may wish to add additional questions, such as where the anglers reside or how often they fish. If you are collecting physical data from fish that have been caught and killed, local fisheries staff will provide you with the appropriate data sheets and equipment.

Step 2. WORK OUT A SURVEY DESIGN AND SCHEDULE

If your stream is long, with many fishing spots, you will need to work out a schedule of volunteers to survey all locations throughout the season. You will need to design your survey according to number of sites, length of fishing season, and number of volunteers available. To be statistically reliable, someone should survey each site for at least one-sixth of the available angling time. This can be done by sampling each site every other day for one-third of the available daylight hours. When there are twelve hours of daylight, you can divide the day into three four-hour shifts (7 to 11 a.m., 11 a.m. to 3 p.m., and 3 to 7 p.m.). During the summer or winter, change the lengths and times of the shifts according to the total hours of daylight.

The following example is for a fall coho fishery on a hypothetical stream. The fishery occurs for sixty days during September and October. The lower 3 km of the stream is open to angling, and contains six good angling spots. Divide the stream into upper and lower survey areas, with three survey sites in each area (Figure 1). Because the sites are close together on this hypothetical stream, you may decide that one person can cover three sites in the upper or lower survey areas in one shift.

Figure 1
Angling Sites (1-6) on a Hypothetical Stream



For a 60-day fishery, each area is surveyed on thirty dates. You may choose to survey the upper area on even dates and the lower area on odd dates. Make sure you assign morning, afternoon, and evening shifts randomly but equally in both the upper and lower survey areas. This type of experimental design is called random stratified sampling.

To assign shift times randomly, prepare thirty pieces of paper. These represent the thirty days at the lower survey area. On ten pieces, write the morning shift time, on another ten write the afternoon time, and on the last ten write the evening time. Throw the pieces into a hat and mix them. Pull out one piece and write the shift time on the first odd day on the calendar (September 1). Continue drawing papers and writing times on the odd dates to the end of October. When you are done, put the pieces of paper back in the hat and repeat the procedure for the even dates for the upper site.

You will need seven volunteers to cover the week. Perhaps each person will volunteer to do one four-hour shift each week. When fishing spots are more spread out, you will need one volunteer at each spot.

Step 3. DURING EACH SURVEY PERIOD

Using waterproof paper, record the number of anglers you observe during each shift. Record how much time each angler spends fishing and the number of each species caught in that period. Appendix 1 is a key to adult salmonid identification. Do not include fish caught before or after the survey period. Interview anglers for any information you cannot get by observation.

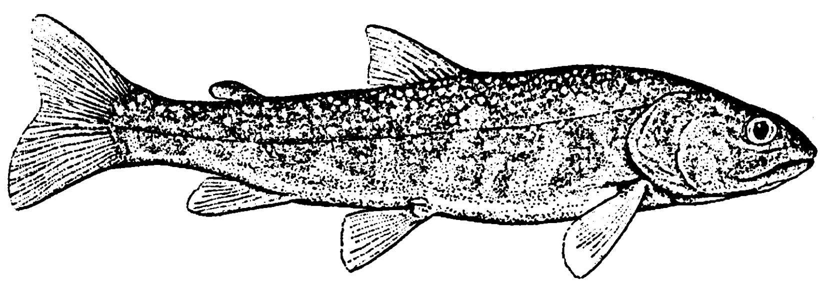
Keep the data for each angler separate and transfer it to the Creel Survey Site Data Sheet at the end of the day. Use a separate data sheet for each site. Here is an example of a field data sheet partly completed for the hypothetical coho survey.

Angler #	Hours fished	Number Caught Per Species (See code below)							Marked Fish
				co					Species mark
1	3			0					co/ADIPOSE
2	4			2					
3	1			0					
......									
TOTALS	8			2					+

species code: co = coho, st = steelhead

Also, complete the Conditions and Locations Data Sheet. These conditions will change during the survey period, so use new sheet for each date. Record the exact survey location, weather, water temperature, turbidity, and percent bankfull. Measure turbidity in a deep pool area, using the tape measure. Turbidity is the maximum depth in centimetres that you see the "one" at the end of the tape. Estimate the percent bankfull: the amount of water compared with the bankfull channel size. The boundaries of the bankfull channel are defined by the edge of perennial vegetation growth.

Dolly Varden Char



Collecting, Reporting, and Evaluating Information

As the survey progresses through the weeks, combine the data for all survey locations on the Summary Sheet. At the end, total the number of anglers, hours fished, and number of fish caught. In the example, these totals represent one-sixth of the total effort and catch possible, so use an expansion factor of six to get the total effort and catch. If you surveyed during more or less than one-sixth of the available time, use the appropriate expansion factor. Find the catch rate by dividing the total number of fish caught by the total number of angler hours. This also is known as catch per unit effort. A sample completed Summary Sheet is included below.

Date	# Anglers Ob-served	Total Hours Fished	Total Catch (#) And Catch Rate (#/hr) By Species (see codes on field sheet)									
			co									
			#	#/hr	#	#/hr	#	#/hr	#	#/hr	#	#/hr
Sept. 15/95	50	150	75	0.5								
Sept. 17/95	25	75	15	0.2								
....												
Sept. 30/95	15	30	3	0.1								
total number	900	6000	3000	.05								
expanded total	4, 800	36, 000	18, 000	0.5								

expansion factor	6

You can compare estimates obtained from this creel survey with those from previous creel surveys, as long as the same methods were used. The total number of fish caught, hours fished, and catch rates will give some insight into whether the level and quality of angling have changed since the last survey. This data also provides an indication of the total harvest in the fishery and is useful in assessing stock abundance.

Send a copy of your Creel Survey Summary Sheet to the Streamkeepers Database, the Community Advisor, and local fisheries staff who worked with you on the project. The current address of the Streamkeepers Database is listed in the Handbook. A statistically reliable creel survey provides useful data for fisheries managers. They will find it useful for making decisions about management strategies affecting your stream.

Public Relations

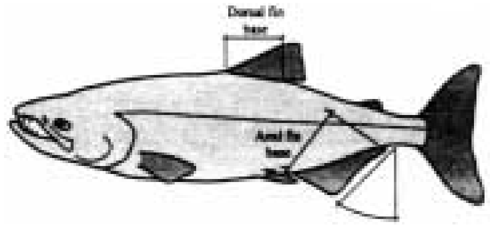
You can clean up streams, monitor their condition, and undertake enhancement projects, but you need the support of your community for these projects to succeed. Talk about your project with others whenever and wherever you can, including at schools and public meetings. Place signs at visible projects. Contact newspapers, radio stations and television stations. Module 10 contains specific information about increasing community awareness and working with the media.

(from McPhail and Carveth, 1995)

Appendix 1

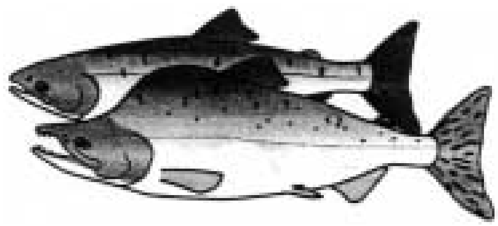
Key to Adult Salmon, Trout and Char

Family Salmonidae (subfamily Salmoninae)



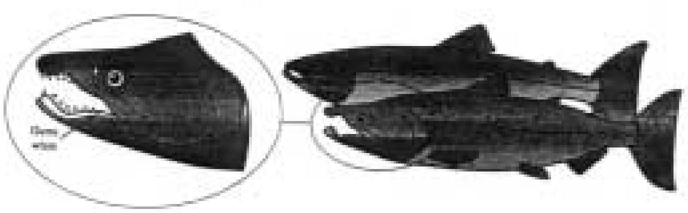
1 (10) Anal fin base longer than dorsal fin base; In profile, hind margin of anal fin slants backwards (not vertical) 2

2 (7) Distinct spots on tail 3

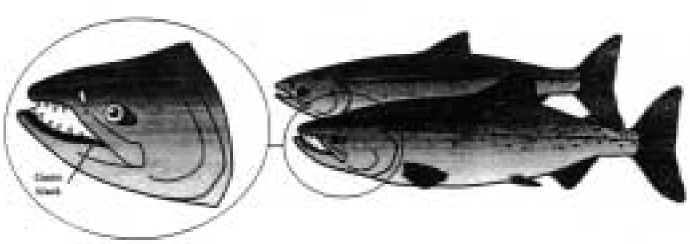


3 (4) Tail spots oblong (not round)
. . PINK SALMON (Oncorhynchus gorbuscha)

4 (3) Tail spots round (not oblong) 5



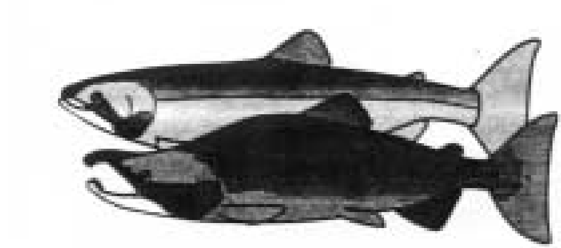
5 (6) Tail spotted on upper half; gums at base of teeth in lower jaw white.
. . . . COHO SALMON (Oncorhynchus kisutch



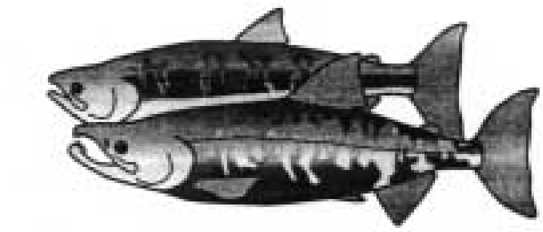
6 (5) Tail spotted on both upper and lower halves; gums at base of teeth in lower jaw black.

. . CHINOOK SALMON (Oncorhynchus tshawytsch)

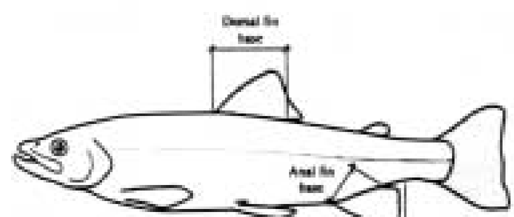
7 (2) No spots on tail, but occasionally some fine speckles . . 8



8 (9) Adults occur in fresh water both as migratory spawners (Sockeye) and as residents (Kokanee); flanks are uniformly coloured (silver in non-breeding Kokanee, usually red in breeding Sockeye and Kokanee) . . . . . . SOCKEYE SALMON/KOKANEE
. . . . (Oncorhynchus nerka)

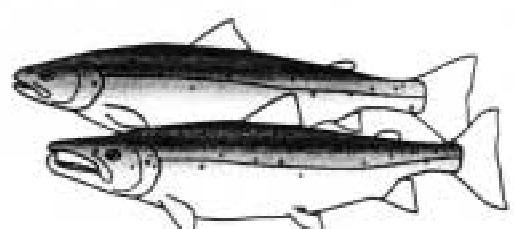


9 (8) Adults in freshwater only as spawners; flanks in males pale with irregular red and black blotches, females with a purplish lateral strip.
. . . . CHUM SALMON (Oncorhynchus keta)



10 (1) Base of dorsal fin equal to, or longer than, anal fin base; in profile, hind margin of anal fin is vertical (no backward slant). 11

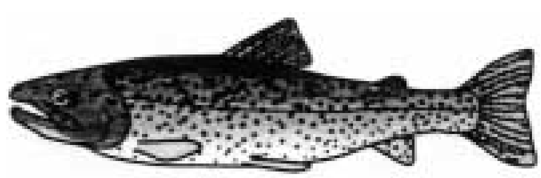
11 (18) Background colour on flanks light (silver or golden) with dark spots 12



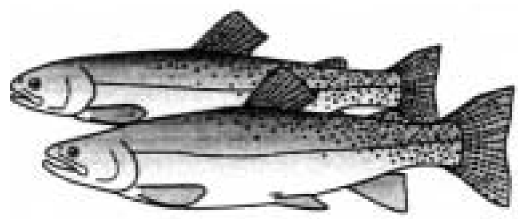
12 (13) Relatively few spots on flanks, mostly above lateral line, some spots x-shaped; caudal fin usually without spots; spawning males with conspicuously hooked lower jaw
. . . . ATLANTIC SALMON (Salmo salar)

13 (12) Spots on back and sides more numerous; none x-shaped; caudal fin usually heavily spotted . . 14

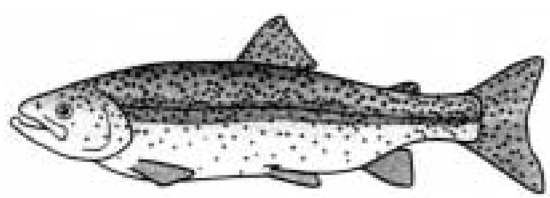
14 (17) Red or orange slash under lower jaw; upper jaw extends back past hind margin of eye; tail usually yellowish with black spots 15



15 (16) Anterior flanks heavily spotted above and below lateral line, anal fin usually with spots
. . . . COASTAL CUTTHROAT TROUT
. . . . (Oncorhynchus clarki clarki)

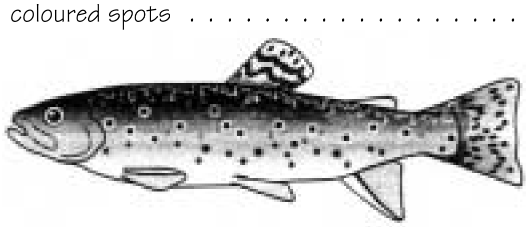


16 (15) Anterior flanks lightly spotted (mostly above lateral line), anal fin usually without spots
. . . . WESTSLOPE CUTTHROAT TROUT
. . . . (Oncorhynchus clarki lewisi)



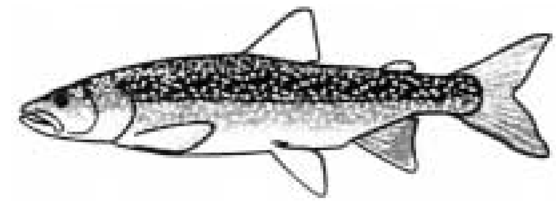
17 (14) No red or orange slash under lower jaw; except in spawning males upper jaw does not extend back beyond hind margin of eye; sides usually silver with a pink hue extending along midline; tail dusky with dark spots . . . . RAINBOW TROUT
. . . . (Oncorhynchus mykiss)

18 (11) background colour on sides dark with light or coloured spots 19



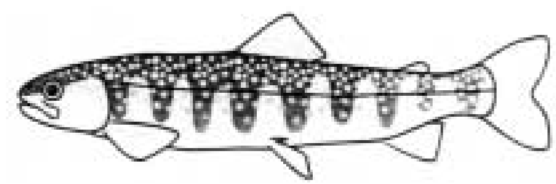
19 (20) Dorsal fin yellowish, with bold black streaks; red spots on flanks surrounded by blue haloes
. . . . BROOK TROUT (Salvelinus fontinalis)

20 (19) Dorsal fin dusky and without bold black marks; spots on sides not surrounded by light haloes 21

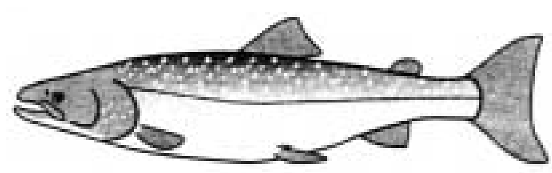


21 (22) Tail deeply forked, light coloured spots on both halves of tail; head and body covered in light irregular spots . . . LAKE TROUT (Salvelinus namaycush)

22 (21) Tail not deeply forked; spots if present only on upper half of tail. 23

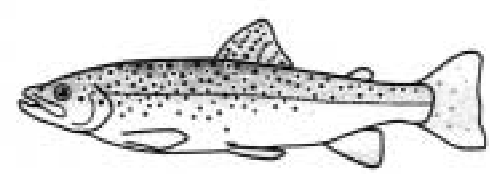


23 (24) When viewed from the side snout is blunt; upper jaw short (barely reaches hind margin of eye)
. . . . DOLLY VARDEN (Salvelinus malma)*



24 (23) When viewed from the side snout is more pointed; upper jaw long (reaches well past hind margin of eye). . . . BULL TROUT (Salvelinus confluentus)*

25 (26) Background colour on back and flanks light (silver or golden) with dark spots 26



26 (25) Spots on flanks mostly dark surrounded by conspicuous light haloes; some spots along side are red . . . . BROWN TROUT (Salmo trutta)

* This species pair is difficult to distinguish unless you have both in hand.

send the data to Streamkeepers Database

Stream Location and Conditions

(use a new data sheet for each stream segment surveyed)
(see Module 1 for additional information)

Stream Name/Nearest Town	**Date**
Watershed code	**NTS Map#**
Stream segnment order	**Length surveyed**
Organization Name	**Crew size**
Contact Name	**Phone #**

Recent weather conditions:	**Water turbidity (cm)**
Water temperature (^{0}C) ***(Leave thermometer in water 2 min)***	**Air temperature (^{0}C)**
Stream condition (%bankfull)	**Photos taken: (yes or no)**

Upstream boundary of survey (directions, distance to known landmark)
Downstream boundary of survey (directions, distance to known landmark)
IF YOU ARE SAMPLING A SPECIFIC POINT ON THE STREAM, RECORD: **Specific location of sampling station (directions, disatnce to known landmark)**

send the data to Streamkeepers Database

MODULE 13:
CREEL SURVEY SITE FIELD DATA SHEET

(use a new data sheet for each stream segment surveyed)

Stream Name	**Date**
Survey Sites(s)	
Survey Shift	**Surveyor**

Angler #	**Hours Fished**	**# Caught Per Species (See code below)**						**Marked Fish**
								species/mark

SPECIES CODES **co = coho** **ch = chinook** **so = sockeye**
pk = pink **cm = chum** **st = steelhead** **rn = rainbow**
dv = dolly varden

MODULE 13: CREEL SURVEY SUMMARY SHEET

Stream Name	**Survey Period**
Stream segment location	

Date	**# Anglers Ob-served**	**Total hours fished**	**Total Catch (#) And Catch (#/hr) By Species (See codes on field sheet)**									
			#	**#/hr**	**#**	**#/hr**	**#**	**#/hr**	**#**	**#/hr**	**#**	**#/hr**
Total number												
Expanded total												

Expansion factor used	

STREAMKEEPERS

Module 14 An Introductory Handbook for Instream Habitat Restoration Projects

Project Approval Required	Training	Time Commitment (per year)	Number of People	Time of Year
yes	recommended	1 week to ongoing	2 or more	Mostly summer low flow

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Canada

Table of Contents

MODULE 14
An Introductory Handbook for Instream Habitat Restoration Projects

Welcome to the Streamkeepers Program! The Department of Fisheries and Oceans Community Involvement Program provides these Streamkeepers training modules. These modules encourage “hands on” environmental activities in watersheds in British Columbia. Volunteer groups, schools, and individuals are using this material to monitor and restore local waterways. Your local Fisheries and Oceans Community Advisor can provide more information.

Introduction

Earlier Streamkeepers training modules provided information on assessing watershed and stream health and on restoring stream banks through planting and fencing. Module 14 is a handbook designed to prepare you for the next level of restoration work, resolving problems within the stream itself. This module does not provide step-by-step instructions because most projects need to be designed specifically for a site. Instead, it introduces you to the complexities of stream behaviour, describes the steps in planning a habitat restoration project, and outlines several publications that do provide detailed instructions. Professional biologists and engineers usually do the work of restoring degraded stream channels. Since these projects have significant impact on stream habitat, they require government approval. Volunteer groups also can undertake restoration projects, but they need to be well prepared for the work and should seek advice from professionals.

Repairing stream damage caused by human disturbance can be a difficult task. A stream is a complex system that strives to stay in equilibrium. Some attempts to repair damage can lead to even greater damage if the project and its results are not well thought out. The structure may wash out, cause property damage or rapid erosion, or alter the stream channel. Instream work must be done at a time of year least likely to harm fish and other aquatic organisms. Groups that undertake a restoration project can be liable for damage caused to adjacent properties if various government agencies have not reviewed and approved the project.

As with any problem, you will develop a better long-term solution by considering the underlying cause of the problem rather than by treating an isolated symptom. This handbook is designed to help you identify and resolve problems resulting from human disturbance in the watershed. You will not attempt to improve on nature. Any disturbance of watershed land affects the stream. In some parts of the province, logging, mining, or agriculture have a great impact on the land base and stream health. Although urbanization affects less of the land base in the province, it causes a great deal of damage in concentrated areas. Channelization and altered flow patterns have affected most urban streams.

A major focus of this handbook is predicting whether a restoration project is likely to succeed at a particular location. This helps you avoid wasting time, money, and effort on a project that could get washed out or cause further damage. In some cases, it is better to do no work within the channel because of an unstable stream or surrounding terrain.

This handbook introduces you to stream hydraulics, which helps you understand the forces at work in a stream and predict the outcome of restoration work. It shows you how to bring together the information you collected in earlier modules and assess the severity of habitat problems (Steps 1 and 2). There are several criteria to help you evaluate the site, the potential project, and the probable outcome. After considering these criteria, you will be able to decide whether or not to proceed. The handbook then helps you choose a suitable project for your stream (Step 3), develop a proposal (Step 4), implement the project (Step 5), and evaluate and maintain the site (Step 6). You can take some steps on your own. For example, you can assess the condition of the stream, identify problem areas, and decide whether your site is suitable for a restoration project. However, you should seek expert advice in designing the project, obtaining approvals, and constructing the project.

In many parts of the province, your DFO Community Advisor (CA) will be your first contact. Depending on resources in your community, you may get help from the provincial Ministry of Water, Land and Air Protection (WLAP) or federal fisheries biologists and engineers, or from staff in the recently developed WLAP Urban Salmon Habitat and Watershed Restoration Programs. Staff or graduate students at local colleges and universities also are useful resources. You may want to call on these people to help you develop your project. They are used to dealing with technical matters and the approvals process. Their level of involvement with the project will vary, depending on the experience and resources in your group.

Modules 1 and 2 describe reconnaissance and habitat assessment procedures. Complete these activities for your stream or stream segment before you consider any habitat improvement projects. You also should do Modules 3, 4, 11 and 12, the biological and water quality assessments.

Principles

The following material is adapted from Trout Unlimited's Saving a Stream. It summarizes the principles that apply in developing any habitat restoration project.

"Cardinal Rules" of Stream Restoration

adapted from Saving a Stream (Trout Unlimited)

Look at the big picture. Focus on the riparian zone and watershed too, not just the stream.

Learn from nature. Try to duplicate conditions in healthy, productive sections of a stream when designing a project.

Focus on the limiting factors at work in your stream. Address the most important factors. Focus on the causes, not just the symptoms.

Each stream is like an individual - treat it that way! Consider the physical, hydraulic, and biological characteristics specific to your stream.

Work with, not against, the natural capacity of streams and watersheds to restore their own health. Changing land use practices in the watershed may be enough to improve stream conditions.

Involve a wide variety of experts, including professionals and local landowners familiar with the watershed.

Strive for natural appearance.

Stream Hydrology

The information in this section is provided to help you understand the forces that create and maintain streams. It will help you distinguish between natural processes in a stream and problems caused by human interference. It also will help you understand why some locations are better for a restoration project than others. Streams contain and channel much energy. Any materials or structures you place in a stream are liable to be eroded, moved, and deposited downstream.

Human activities have affected most streams in B.C. to some extent. This discussion begins with the concept of undisturbed streams and moves on to those affected by humans.

The Dynamic Forces of a Stream

Flowing water is a powerful force. It carves out a channel, moves materials downstream, and sometimes changes course unexpectedly. The stream system is in equilibrium. If one part is altered, the stream will work to regain equilibrium by altering another part.

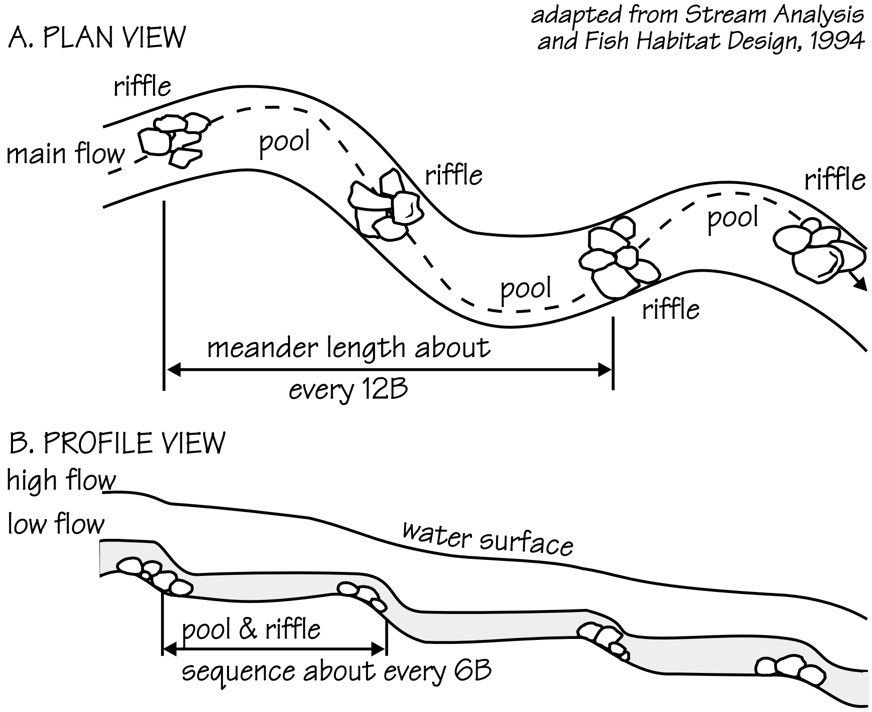
Several complex factors shape the stream channel. The most important factors are **hydraulic force** (flowing water) and debris load (e.g., rocks, wood, ice carried in the water). Flowing water moves in a three-dimensional wave pattern. It makes the current snake horizontally from one side of the flood plain to the other and, simultaneously, undulate vertically from the top of the water column to the bottom. The sinuous meander pattern is repeated regularly, on average every twelve times the channel width (Figure 1a). Also, the vertical wave pattern creates a sequence of pools and riffles (Figure 1b), repeated about every six times the channel width. Human intervention, such as channelization, or natural features, such as bedrock outcroppings and large woody debris, can disrupt the three-dimensional flow pattern.

This flow pattern causes scouring of both the stream bed and the banks. Consequently, the stream moves a great deal of material downstream. The lighter, smaller sediment moves downstream faster than larger, heavier material. Material carried by a stream is called alluvium. Stream channels formed in this way are called **alluvial**.

Over time, the stream moves back and forth across the flood plain. Although the boundaries change, features such as depth, width, and general shape of the channel remain constant. This holds true even in different parts of the world, among rivers with similar size and climate.

The hydraulic force of a stream is controlled by the size of the watershed and climatic conditions. These characteristics establish the volume of runoff flowing into a stream during flood peaks, which in turn determine stream width and depth. The peak floods that shape the stream channel are called **bank- full** floods and occur, on average, every two out of three years.

Figure 1
Average Meander, Pool and Riffle Spacing Expressed in Bankfull Channel Widths (B)



The debris load of an alluvial stream comes from the surrounding land. The size of particles moved along by the stream depends on underlying geology of the area, the volume of water, and gradient of the stream bed. With material moving downstream continuously, only the larger materials tend to remain at a given point. The stream bed usually consists of large boulders and cobbles in the steep upper reaches, cobbles and gravel in the moderately-sloping middle sections, and gravel, sand, and silt in the low-gradient lower reaches.

Most British Columbia streams, particularly those along the coast, are alluvial. Their beds, banks, and flood plains shift and their boundaries change readily. Since water deposited the material, water can move it again.

Tractive Force

The stability or mobility of stream bed materials is controlled by stream gradient (slope) and water discharge. Water flowing over the stream bed exerts a tractive force, measured in kilograms per square metre (kg/m2) of stream bed. The tractive force calculation incorporates both slope and water discharge and is useful for estimating stability of the bottom substrate.

CALCULATING TRACTIVE FORCE:

tractive force = 1000 X water depth X slope

where:

tractive force = force of water over the stream bed area(kg/m2)

1000 = specific weight of water (1000 kg/m3)

depth = water depth (m) (step 2, Module 2)

slope = stream slope (no units) (step 4.1, Module 2)

EXAMPLE

average bankfull channel depth = 0.6 m

(water depth during flood)

slope = 0.03 or 3%

(3 m elevation drop over

100 m stream length)

Field studies have shown that, at a given flow, the tractive force (in kg/m2) exerted on the stream bed has the same numerical value as the smallest diameter of stable material (in cm). Smaller materials are mobile at that flow. This relationship works for loose rock greater than one centimetre in diameter. However, more force (greater water depth and/or greater gradient) is required to move packed and silted gravel.

As shown in the example above, you can use the tractive force calculation, along with stream bed composition data, to assess stream bed stability during flood conditions. Measuring the bankfull channel depth (Module 2, pages 8 and 9) during low flows helps you estimate water depth during a large flood.

At this site, stream bed substrates greater than 18 cm in diameter are stable during bankfull flood and those less than 18 cm are mobile. You can estimate stream bed stability during flood flows by comparing this number to the stream bed composition data, also collected during the Module 2 survey. For example, if only 30% of the stream bed particles are larger than 18 cm, then 70% move during flood flows.

Thus, since most of the stream bed moves during bankfull floods, you probably will run into problems maintaining an instream structure at this location.

You also can use the tractive force calculation to choose the appropriate size of materials for a restoration project involving gravel or boulder placement (example on page 23). In practice, engineers often incorporate a safety factor when designing projects. They may suggest using materials 1.5 times greater than the calculated value. In the above example, only material greater than 18 cm in diameter will be stable during a bankfull flood. Although you could place boulder clusters at this site, you could not place spawning gravel here and expect it to last for long. You might consider adding a weir to retain the gravel. However, it is easier to find a more suitable location, where the channel is flatter, shallower, and has lower tractive force. For example, you could add spawning gravel in an area where the bankfull depth is 0.4 m and the slope is 1%. Here, the tractive force is 4 kg/m2 and the minimum diameter of stable substrate is 4 cm.

The Effect of Human Disturbance on Stream Dynamics

Gradual bank erosion is a natural process that benefits stream life. It creates habitat diversity by creating pools, undercut banks, back eddies, and sloughs. It exposes tree roots and provides new sources of gravel. These features give character to the stream and provide complex habitat for the various stages in the life cycles of fish and other stream organisms.

However, human activities in the watershed often accelerate the erosion process by affecting the two basic processes that form the stream channel: hydraulic force and debris load. Many habitat problems you will discover in your stream surveys result from poorly planned activities. Removing natural vegetation, channelizing streams, impounding water, or paving and building up areas change the pattern of water flow in the watershed. They also change the rate of erosion on the surrounding land. Streams in urban areas often suffer severe habitat degradation because the land base is highly developed and streams have been modified and channelized to protect private property.

When sediment input or water flow changes, a stream adjusts its shape to compensate. Several kinds of human activities create similar symptoms in the stream channel. Adding a habitat restoration structure is an attempt to treat these symptoms. However, an effective long-term solution must address the cause of the problem.

Increased discharge results from any land use that reduces the amount of natural vegetation, especially paving of urban areas and logging. Increased discharge leads to increased water depth and velocity, creating increased energy that dissipates by eroding stream beds and banks. This increases the debris load of the stream. The channel adjusts by becoming wider and sometimes deeper. Gravels wash away, leaving only cobbles and boulders in steeper sections and fine sediment in lower gradient sections near the mouth of the stream.

Decreased discharge comes from diverting tributaries and other sources of runoff, or from withdrawing water for irrigation, industrial, and domestic uses. The shallower water depth and slower velocity mean the stream has less energy available to erode the banks and move stream bed materials. The stream may become narrower and shallower. Usually, fine materials accumulate and compact the stream bed.

Increased debris load comes from activities that accelerate soil erosion, such as agriculture, logging, and urban development. The stream has enough energy to carry a certain amount of sediment. When that amount is exceeded, the extra is deposited on the bottom. This sediment fills pools, silts the gravel, changes the gradient, and usually raises the level of the stream bed. The stream tries to maintain its original channel size, so it erodes the stream banks to make a wider channel.

Decreased debris load comes from damming, dredging, culverting, and channelizing streams. These activities diminish the sources of new material available to replenish what the stream has washed downstream. The stream channel often deepens and narrows. Gravel bars may disappear and only larger material or bedrock remains as the gravel migrates downstream.

Channelization affects the shape of the stream directly, and often has the same effect as increased discharge. Straightening a stream and eliminating its meanders creates a higher gradient over a much shorter distance. Often such activities include protecting the banks with rip-rap or concrete, which can create a narrower channel and lead to deeper water during floods. Higher water velocities result from such activities.

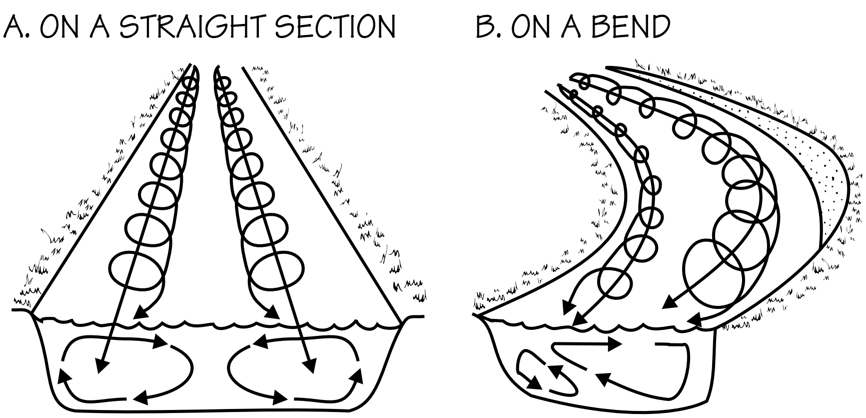
Hydraulic Impacts of Habitat Restoration Projects

Most habitat restoration projects involve placing a structure in the stream to create either pool habitat (by scouring) or gravel bar riffle habitat (by depositing). Many of these structures cause both scour and deposition. Predicting the impact of adding a structure to a stream is an imprecise science, developed more through observation than theoretical application. With experience, the results are becoming more predictable.

Unobstructed water moves in a double spiral pattern, as shown in Figure 2a. The water moves clockwise on one side of the channel and counterclockwise on the other side. In a straight section, the two spirals are equal in size, and the main flow (thalweg) follows the middle of the stream.

Figure 2
Screw-like Spiral Pattern of Stream Flow

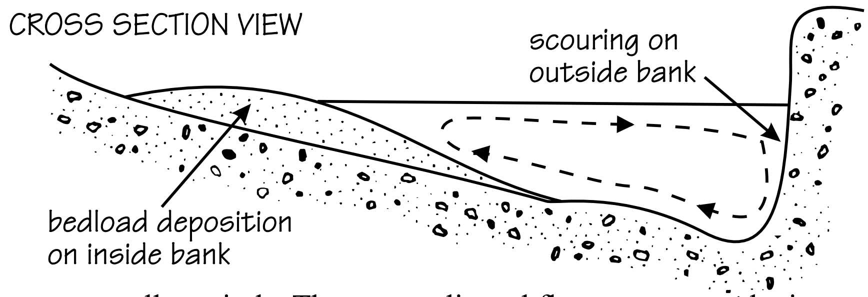
adapted from A Training in Stream Rehabilitation, 1988



A bend in the stream disrupts the equilibrium between these two spirals and alters the direction of rotation. The spiral at the outside of the curve becomes bigger and the one on the inside becomes smaller (Figure 2b). The thalweg follows the predominant spiral, so it shifts to the outside of the curve. Continual scouring produces deeper water on the outside of the bend and continual deposition forms a point bar on the inside of the bend (Figure 3).

Natural obstructions and restoration structures disrupt the pattern of spiral flow. The effect of this disruption is relatively easy to predict when a simple habitat structure is placed at an ideal stream location. When more than one structure is added, or where the location is less than ideal (Table 1, page 22), the spiral flow pattern is broken into

Figure 3
Scour and Deposition Patterns on a Stream Bend



many smaller spirals. These complicated flow patterns make it more difficult to predict the amount and location of scour and deposition.

Three situations can cause scouring:

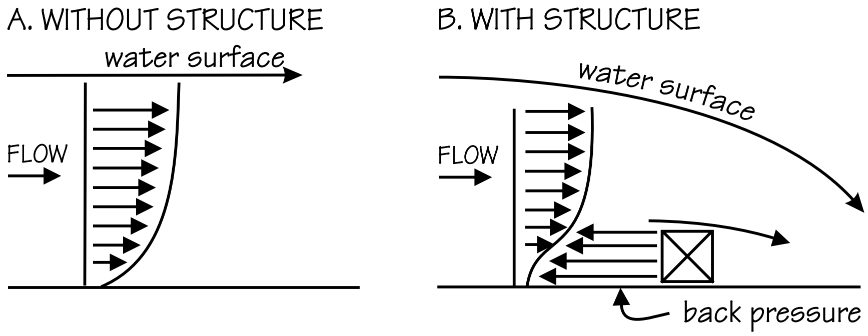
- on the outside bend of a meander
- where water falls over a structure
- where water velocity increases (e.g., at a constriction or where the gradient becomes steeper)

Some habitat structures create all three types of scour, whereas others create mainly one type.

Similarly, three situations can cause deposition of material:

- on the inside bend of a meander
- in a quiet area created by back-pressure upstream of an instream structure (Figure 4)
- where water velocity slows (e.g., eddies, wider areas of the channel, lower gradient sections)

Figure 4
Velocity Profile in a Stream
A. Without a Structure and B. With a Structure



adapted from A Training in Stream Rehabilitation, 1988

The following general hydraulic principles apply when you design a structure to create scour and deposition areas.

Bankfull Depth

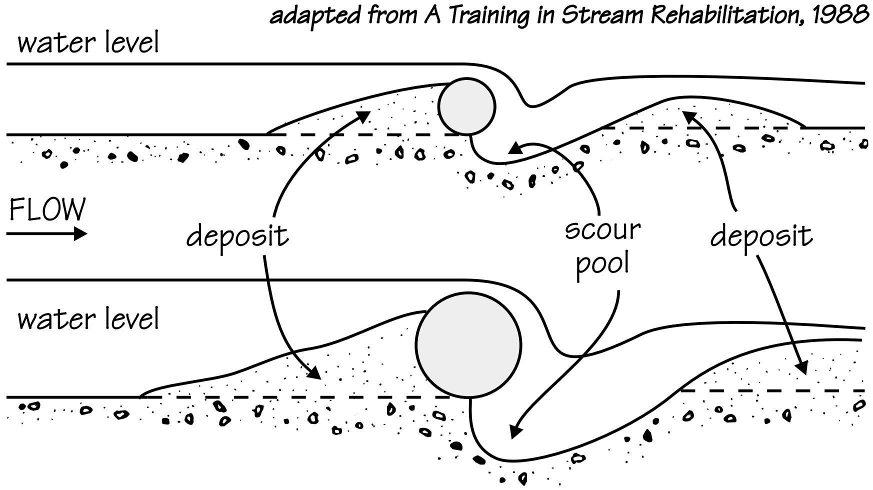
Bankfull channel depth determines water depth, which in turn determines the depth of scour around an obstruction. Experience has shown that the maximum scour depth created around a structure is slightly greater than bankfull depth.

Structure Height

The height of a structure also influences the amount of scour. Generally, higher structures create deeper plunge pools (Figure 5). Observations have shown that the depth of the scour is at least as great as the structure height. Depth of scour is limited by the available stream energy, which depends on bankfull channel depth, as discussed above. Experience also has shown that higher structures deposit more and deeper bedload both upstream and downstream of the structure than do lower structures.

Figure 5
The Effect of Structure Height on Scour and Deposition Zones

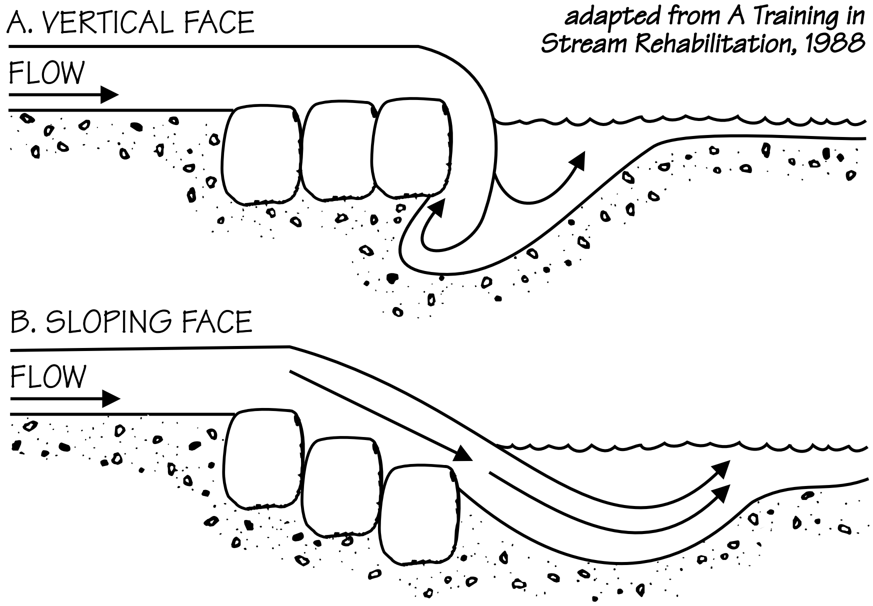
adapted from A Training in Stream Rehabilitation, 1988



Angle of Downstream Face of the Structure

This angle affects the stability of the structure by determining where the force of the stream is directed onto the stream bed. A vertical face creates scour at the base of the structure, undercutting it and ultimately causing it to slip into the newly created scour pool (Figure 6a). A sloped face directs the water away from the base, which causes both scour and deposition further downstream (Figure 6b).

Figure 6
The Effect of A. Vertical Versus
B. Sloping Structure Face on Scour Location



Orientation of the Structure

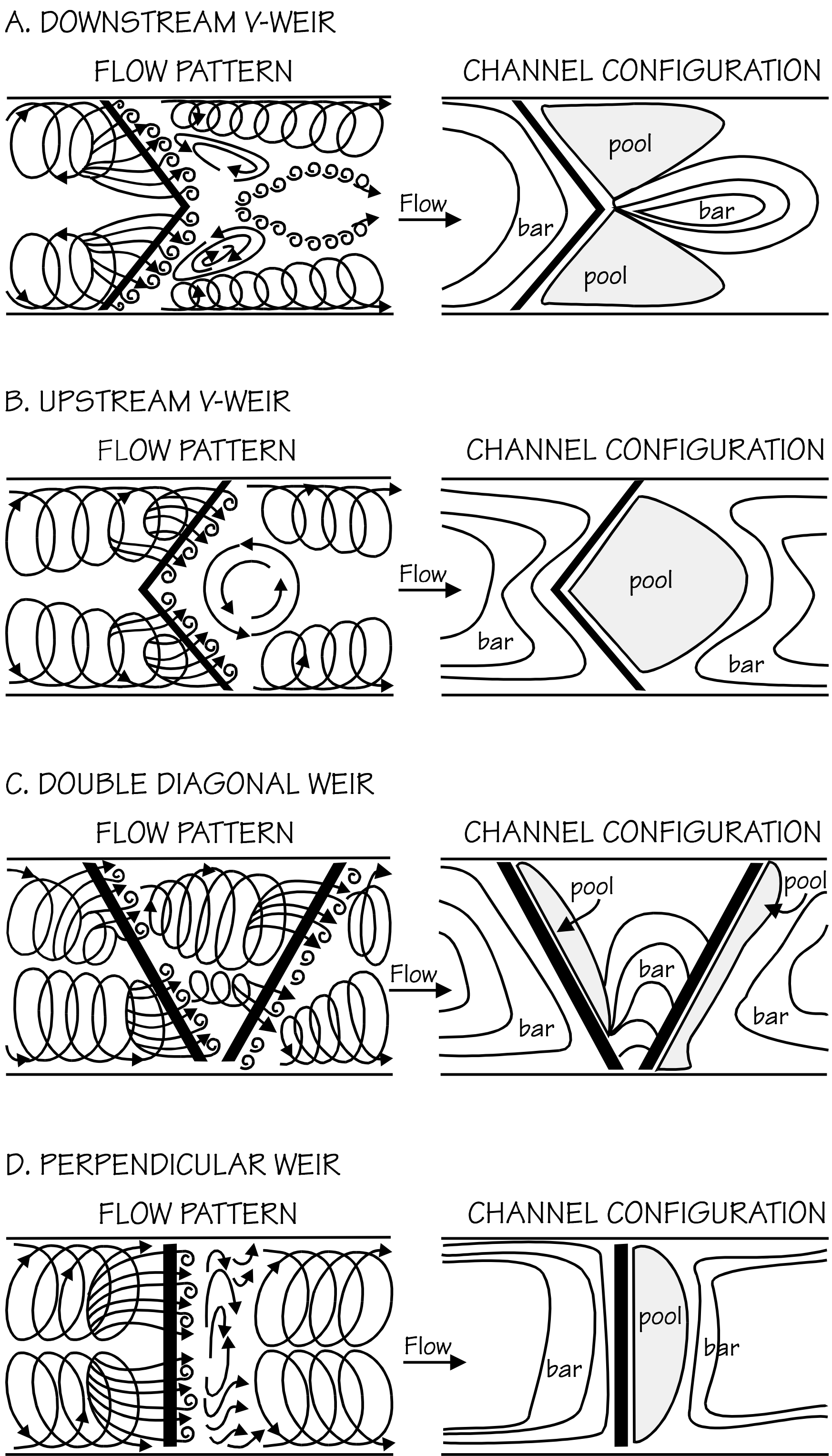
Water passing over a structure moves downstream in a direction perpendicular to the angle of the structure. Figure 7 shows how various instream structures affect stream flow and the patterns of scour and deposition. These patterns were observed following installation of the structures. The size of the spiral pattern in each sketch shows the amount of scour possible.

The patterns occur repeatedly, but with considerable variability among structures. For example, a V-shaped weir with its apex pointing downstream directs the flow toward both banks (Figure 7a). Scour pools develop at the banks and material deposits in the quiet midstream area. A V-shaped weir with its apex pointing upstream directs flow toward the centre of the channel, constricting the channel and creating deeper scour there (Figure 7b). However, at high flow some upstream V-weirs may split the flow and direct it towards the banks. Straight structures that span the stream can be oriented to spread out the flow, rather than constrict it. A long structure (two to three times the stream width) placed diagonally in the stream spreads the flow, decreases the water velocity and energy, and deposits material upstream and downstream of the structure (Figure 7c).

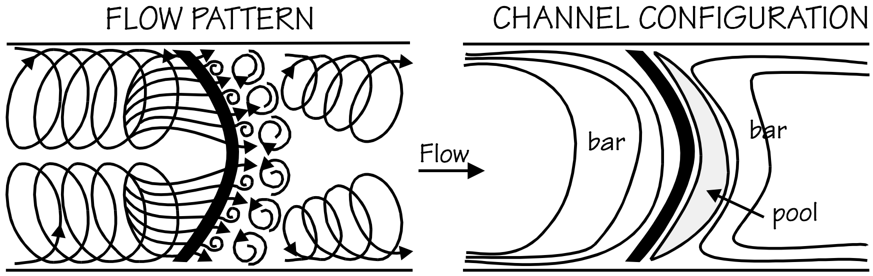
Several illustrations show full-spanning structures. However other structures, such as boulder groupings, wing deflectors, and other

Figure 7
The Effect of Structure Orientation on Flow, Deposition and Scour

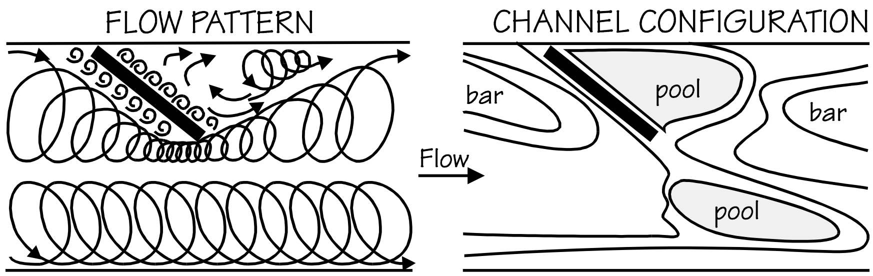
adapted from A Training in Stream Rehabilitation, 1988



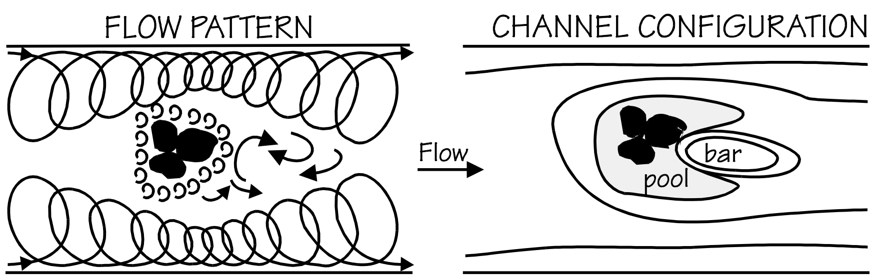
E. U-SHAPED WEIR



F. WING DEFLECTOR



G. BOULDER CLUSTER



Several illustrations show full-spanning structures. However other structures, such as boulder groupings, wing deflectors, and other clusters can provide the same effects but cost less to install and require less maintenance than full- spanning structures.

Safety

All the concerns for personal safety outlined in previous modules are essential when doing stream restoration work. Follow the safety recommendations listed in Modules 1 and 2 when doing watershed and site reconnaissance for a restoration project. Do not attempt to wade fast water or water deeper than your knees. Watch out for slippery stream beds, undercut banks, waterfalls, and fast flowing areas. Be especially careful working around log jams.

In addition, there are special safety concerns to consider when restoring stream habitat. These usually involve construction techniques, so similar safety recommendations apply. Some are outlined in the references for individual techniques or in the Workers Compensation guidelines. Often you will be working right in the stream, around heavy machinery, lifting heavy materials, or using hand tools. There are real dangers involved in this work. Your group may want to buy insurance to cover personal injury.

First Aid

On a project involving more than a few people and heavy machinery, someone at the site should have first aid training. You may want to send a member of the group to Swift Water Rescue Training. Have an evacuation plan in case of a medical emergency. If you will be working right in the water, wear a personal flotation device and proper thermal protection. Send only experienced river swimmers into the water when you work on a large stream. Install a safety line diagonally across the stream downstream of the site, in case someone is swept away. Have a rescue throw bag, first aid kit, survival kit, and cellular telephone at the site. Also, have warm blankets and extra clothes in case someone gets wet or develops hypothermia.

Most instream projects are done during the summer, when the risk of heat exhaustion, heat stroke, or dehydration are greatest. To prevent these conditions, have plenty of fluids available. An active person should drink at least 1.5 litres (50 ounces) of water every eight hours, regardless of air temperature. Plan rest breaks at appropriate intervals.

Safety Around Heavy Equipment and on the Stream

At the start of the day, stress the importance of following all safety guidelines. On a project involving several people, assign someone the job of watching for unsafe practices and correcting them (e.g., tools left lying around, shovels and rakes pointing upward, someone not wearing safety equipment). This is a good job for a less active person.

Although using common sense may seem obvious, it cannot be stressed enough. Wear all the safety equipment recommended for the job (e.g., safety goggles, steel toed boots, waders with felts, hard hats, heavy work gloves, ear plugs).

Stay well back from any heavy equipment. If you cannot see the eyes of the operator, he or she cannot see you. Recognize the limitations and capabilities of each volunteer (for example, some people are more agile than others). Be aware of your surroundings and the possible dangers. Do not use any equipment with which you are unfamiliar.

Step 1: Watershed Reconnaissance

Module 1, Introductory Stream Habitat Survey, tells you how to do an initial reconnaissance of the watershed. When you are done, you will have a map, photographs, and field notes documenting the location and severity of habitat problems along the stream. This information helps you rank habitat problems and select the most important ones to deal with first. For example, without this information you might add spawning gravel and later discover that sediment from an upstream bank failure silts up the gravel. Perhaps spawners cannot pass upstream through a culvert to reach the spawning ground you have created for them.

You also will collect information about land and water use in the surrounding watershed. This information provides clues about the cause of stream channel problems. You may find that resolving a particular land or water use problem in the water- shed provides greater benefits to the stream than does an instream project.

When you select an improvement project, consider why the area does not have desirable habitat now. For example, some stream reaches would benefit from adding large woody debris (LWD). Before you begin, look for reasons why there is little LWD in the stream now. Are there large coniferous trees on the bank that provide a source of LWD? Has urbanization in the watershed resulted in larger floods that wash it out? The best long-term solution where there is little or no stream bank vegetation is to restore that vegetation. Since trees and shrubs take a long time to mature and contribute debris, you also can provide immediate benefits by securing LWD in the stream channel. If there is enough stream bank vegetation, but large floods wash out the LWD, the best long-term solution is to solve the land-use problems that cause the flooding. In this case, you will want to work with your local government to create environmental protection bylaws. For example, some municipalities restrict the total land area that can be covered with impermeable surfaces such as pavement and rooftops. Stormwater detention facilities can be incorporated into new or existing developments to reduce flooding.

Step 2: Site Assessment

Module 2, Advanced Stream Habitat Survey, helps you assess stream conditions at your proposed project site. You rate the quality of nine important physical characteristics of the stream environment. Completing Module 2 is very important for several reasons. The observations you make during this survey allow you to:

- assess habitat quality, identify physical problems, and determine the extent of damage at a particular site,
- assess stream bed stability and decide whether the site is suitable for an instream project, and
- calculate the size of material needed at the site to withstand flood flows.

You should complete Modules 3, 4, 11 and 12, the water quality and biological surveys. These data provide a good picture of stream health and will help you assess the severity of the habitat problems. You also can use these data to evaluate improvements after you finish the project.

Once you have narrowed down your list of habitat problems, you need to consider the suitability of the site(s) for stream channel modification. The technical resource people can be very helpful at this stage. Table 1 lists twelve important criteria you should use to evaluate your site. The most important criterion relate to the potential erosive force of the stream at your proposed site and the resulting stability of the stream bed. The tractive force calculation described on page 10 provides this information. Besides helping you assess stream bed stability and hydraulic force, the calculation helps you select the appropriate size of gravel or boulders needed for the project.

A paradox of instream restoration work is that the sections of the stream that could benefit most from structural enhance- ment are so steeply sloped and unstable that structures often get washed out. Low gradient areas are well suited to such work, but often they do not need these improvements.

TABLE 1. Site Assessment Criteria	
1.	*Evaluate the potential of the project to jeopardize public safety or damage private property.*
2.	*Evaluate the potential impacts of the project on other wildlife species in and around the stream. Some species, like the Nooksack dace and Pacific giant salamander, have a limited distribution range, are rare, and may be threatened with extinction.*
3.	*Check that there are no other problems, such as poor water quality or quantity, that could offset the benefits of structural enhancement. You should have discovered these problems in earlier stream surveys.*
4.	*Calculate tractive force at bankfull flood. This provides information on the stream forces at work during flood conditions, stream bed stability under these conditions, and the size of gravel or boulders neededfor an instream project.*
5.	*Consider access to the site and availability of local materials. These are important considerations if you need to bring in equipment or move logs, stumps, or boulders to the site.*
6.	*Locate the project where the stream slope is less than 3%. High gradient areas have high tractive force, so many projects wash out.*
7.	*Choose an area where stream banks are relatively low and the channel is at least the average width. During floods, the increased stream energy will dissipate on adjacent flood plains rather than within the stream channel.*
8.	*Locate the structure where stream banks are stable and have well-developed vegetation.*
9.	*Where possible, place structures in a straight section of stream rather than on a bend. Bank stabilization is an exception, since erosion often occurs on a bend. Avoid highly braided channels that are shifting actively across the valley floor.*
10.	*In high energy stream segments, select a site with room for a few structures. Upstream structures provide velocity breaks for adjacent downstream structures, and add to the effectiveness of the work. This is not as important in low energy segments, such as below a lake outlet.*
11.	*Consider the effect of nearby large natural or artificial structures on stream flow and current patterns. They may affect or be affected by your structure. Also, consider where the structure would come to rest should it be washed out. For example, it might lodge in a culvert and cause flooding.*
12.	*Study the existing stable natural channel features. These features have endured through time and provide clues about successful designs and materials you can copy in your project.*

EXAMPLE:
Assessing a Site for Spawning Gravel Enhancement

After completing steps 1 and 2, you may decide that the stream would benefit from adding spawning gravel. You should consider the following questions first.

Does the amount of spawning habitat limit fish production?

Factors other than spawning habitat may limit fish production. For example, coho, trout, and char seldom are limited by spawning area. Before you conclude that increasing the amount of gravel will increase the number of fish, check for other factors. These include rearing habitat, holding pools, over-wintering habitat, water quality or quantity problems, and predators.

Is this a suitable spawning area for the species concerned?

Find out where fish spawn now and the size and depth of spawning gravel in those areas. Check with DFO, WLAP, and the Streamkeepers Database to see if data have been collected on the number, species, and preferred location of returning spawners. Unfortunately, there is little or no information available for many small streams. Usually, it is easier to replace or add gravel to existing spawning areas than to create spawning areas where fish have not spawned in the past. Spawning preferences differ among species and populations of sal- monids. For example, some coho and steelhead spawn as far upstream as possible, whereas some chum spawn very close to the estuary. The physical characteristics that affect the quality of spawning areas are location within the watershed, gradient, substrate stability, gravel depth, size and quality, water depth, and water velocity. Water quality, instream cover, and stream bank vegetation also are important.

Why does the site lack good spawning habitat?

The most common causes of insufficient spawning gravel in urban streams are channelization and increased flood flows. Perhaps stream flow is too fast in this area to allow gravel to settle. If the stream has too little energy, gravel may not migrate downstream to this location and any gravel placed here will become covered in fine sediment. There may be no source of gravel upstream if the banks have been engineered to prevent erosion. A lake or dam may form a barrier to downstream migration of gravel.

Will added gravel stay in the stream?

Some parts of your stream are more suitable than others. Consider gradient when choosing a location. It should be steep enough to prevent siltation, but not so steep that the gravel would wash out. The tractive force calculation allows you to estimate the size of stable substrate for a given location. Gravel catchment devices such as rock weirs can be used to help retain spawning gravel, especially in higher gradient sections.

The example of adding spawning gravel to the stream (page 23) shows you how to apply steps 1 and 2 to planning a restoration project. You may discover a need for additional spawning gravel in the stream but wonder if you have chosen a good location to place new gravel.

Step 3: Project Selection

Table 2 correlates typical habitat problems found during watershed surveys with the appropriate restoration techniques. It is cross-linked to Table 3, which lists the references that describe the techniques in detail. The reference section at the end of the module provides an annotated bibliography to these references.

Appendix 1 provides a brief description of these techniques, where to use them, and their advantages and disadvantages. It does not include detailed instructions since the techniques must be adapted specifically to the site. Your technical resource people can help you select an appropriate project.

Figure 8 shows a sample site plan that includes several stream restoration structures used in series.

Figure 8
Example of a Series of Restoration Structures

adapted from A Training in Stream Rehabilitation, 1988

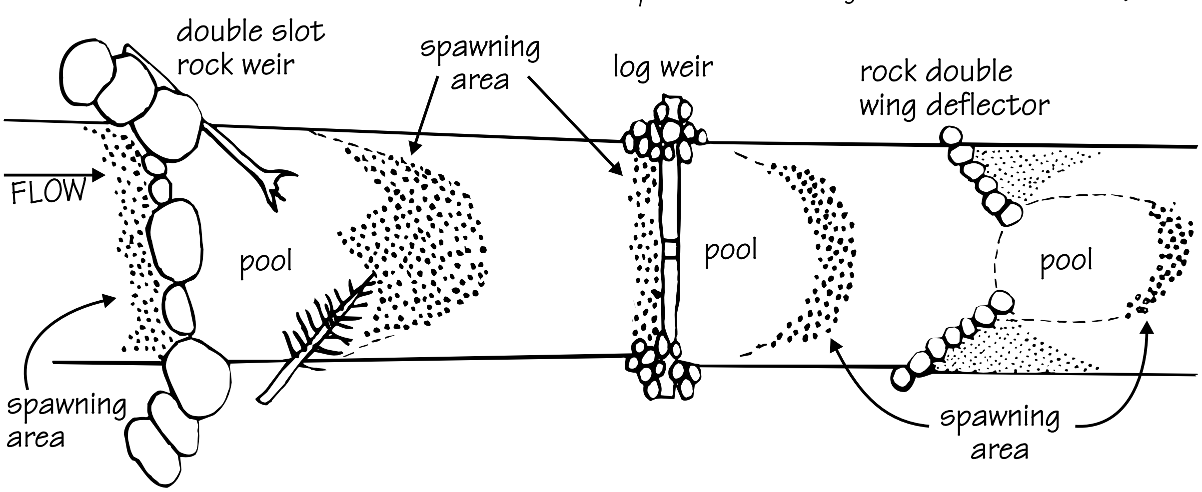


Table 2
Habitat Restoration Techniques

Problem / Action	Streamside Planting	Streamside Fencing	Rock Rip-Rap	Spiles and Wattles	Tree Revetment	Log Crib/ Log Bank Cover	Culvert Passage	Fishway	Beaver Dam Management	Log Jam Management	Fish Screens	Water Quality Assessment	Stream Invertebrate Survey	Rock/Log Weir	Wing Deflector	Boulder Placement	Gravel Catchment/ Placement	Large Woody Debris Placement	Off-channel Habitat Development	Flow Augmentation	Storm Drain Marking	Community Awareness	Observe, Record and Report	Stormwater Detention
Lack of Riparian Vegetation	◆	◆	◆	◆	◆																			
Livestock Access	◆	◆																						
Streambank Erosion	◆	◆	◆	◆	◆	◆									◆									
Impassable Culvert							◆																	
Impassable Dam/Falls								◆																
Impassable Beaver Dam									◆															
Impassable Log/Debris Jam										◆														
Unscreened Water Intake/Diversion											◆													
Stormwater/ Discharge Pipes												◆	◆								◆	◆	◆	◆
Poor Streambed Material	◆	◆												◆	◆	◆	◆		◆					
Lack of Instream Cover	◆	◆	◆	◆	◆	◆								◆	◆	◆		◆	◆					
Inadequate Stream Flow Seasonally	◆	◆							◆			◆	◆						◆	◆				
Lack of Pool Habitat	◆	◆													◆				◆					
Lack of Off-Channel Habitat																			◆					
Illegal Activity Observed																							◆	

Table 3
Habitat Restoration Publications

Restoration Method / References	Fish Habitat Enhancement: A Manual for Freshwater, Estuarine, and Marine Habitats	The Streamkeepers Handbook: A Practical Guide to Stream and Wetland Care	A Training in Stream Rehabilitation, Emphasizing Project Design, Construction and Evaluation	Stream Analysis and Fish Habitat Design: A Field Manual	Guidelines for Bank Stabilization Projects in the Riverine Environments of King County	Freshwater Intake End-of-Pipe Fish Screen Guideline	A Guide to Selection & Propagation of Some Native Woody Species for Land Rehabilitation in B.C.	Culvert Guidelines: Recommendations for the Design and Installation of Culverts in B.C.	Fish Habitat Rehabilitation Interim Procedures for the Watershed Restoration Program	Urban Runoff Quality Control Guidelines for B.C.	Land Development Guidelines for the Protection of Aquatic Habitat	Design for Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetlands
Streamside Planting	◆	◆			◆		◆		◆			
Streamside Fencing	◆	◆										
Rock Rip-Rap	◆		◆		◆				◆			
Spiles and Wattles	◆				◆				◆			
Tree Revetment			◆		◆				◆			
Log Crib / Log Bank Cover	◆		◆		◆				◆			
Culvert Passage	◆							◆			◆	
Fishway	◆		◆						◆			
Beaver Dam Management	◆								◆			
Log Jam Management	◆								◆			
Fish Screens	◆					◆						
Rock / Log Weirs	◆		◆	◆					◆			
Wing Deflectors	◆		◆		◆				◆			
Boulder Placement	◆		◆	◆	◆				◆			
Gravel Catchment / Placement	◆		◆	◆					◆			
Large Woody Debris Placement	◆		◆	◆	◆				◆			
Off-channel Habitat Development	◆		◆						◆			
Flow Augmentation	◆			◆					◆			
Storm Drain Marking		◆										
Stormwater Detention										◆	◆	◆

Step 4: Project Planning and Approvals

You will work closely with the technical resource people on the planning and approvals process. They can help you assemble the necessary information and cut through the red tape. This step may take much longer than the instream work, so you should start planning well in advance (e.g., in the autumn for a project the next summer).

With few exceptions, instream work must be done within the **"fisheries window",** to reduce the impact of the work on the stream and its inhabitants. This period varies a little around the province, depending on climatic conditions and species of fish in the stream, but generally is between July 15 and September 15. Check with the local DFO or WLAP office for the timing of the fisheries window in your region.

You need project approval from relevant government agencies and written permission from property owners before you start any instream work. Consult with property owners in the initial planning stage. The Water Management Branch of WLAP issues the permits for instream work. A form entitled Environmental Review: Notification for Proposed Works and Changes In and About a Stream under the Section 7 Regulation of the Water Act must be completed and submitted to WLAP. Appendix 2 contains a copy of this form. WLAP will send you the form and a Section 7 User's Guide on request. The agency circulates the application to other interested government offices through the "referral system." Staff at DFO, and the provincial Fish and Wildlife Branch comment on the application and influence WLAP in their decision to approve or reject the application.

It is important to submit all the requested information in the permit application. A well-prepared application contributes greatly to a successful project and increases your chances of quick approval. The information you prepare for the application also can be used when applying for project funding. The following information will form important elements of your proposal:

- location of work (name of stream, specific location of work, street address and legal description of property)
- complete description of proposed work (the specific project, dimensions of the work, and methods to be used)
- site plan, area map, engineering drawings (should be easy to interpret and show clearly the details of the project)
- tenure of land (name of registered owner or lessee, letter of permission from the owner; if on Crown land, include the tenure document)

Consider access for heavy equipment and delivery of material. Plan to use as much local material (boulders, large woody debris, etc.) as possible, but consider carefully the impact of moving or removing material. Arrange as many free sources of materials, equipment, skilled operators, and professional assistance as possible. Ask local businesses to donate, or sell at a discount, materials for the project. Get several quotes.

Step 5: Project Implementation

Now you are ready for the field work! Your technical advisor may supervise the instream work. There are several ways your group can keep the work day running smoothly. A well run and enjoyable day will encourage the volunteers to return for future projects.

Check that all approvals, materials, tools, and equipment are ready. Arrange for duplicates of essential equipment in case of breakdowns. Arrange first aid, a first aid attendant, refreshments, and sanitary facilities. Recruit volunteer labour, especially people with specific skills. Although you want to have more than the minimum number needed, you do not want too many people. Work can be frustrating when too many people mill around with nothing to do or get in each other's way. Make sure the volunteers know what to bring (e.g., work gloves, work boots, waders, personal safety gear, lunch, a change of clothes in case they get wet).

Start the day with a brief orientation, including safety information and assigned tasks. Provide refreshments, a shady rest area and, perhaps, lunch. Take lots of photographs before, during and after construction. A close up of each person at work makes a great thank-you card. End the day with a thorough site cleanup.

Step 6: Evaluation and Maintenance

Most of the projects listed in Appendix 1 require some ongoing maintenance. Usually, the need for maintenance increases with the complexity of the structure. Make sure that everyone involved in the project agrees on who is responsible for maintenance.

You should monitor a variety of stream conditions before and after the project, using Modules 2 (Advanced Stream Habitat Survey), 3 (Water Quality Survey), 4 (Stream Invertebrate Survey), 11 (Juvenile Fish Trapping and Identification) and 12 (Spawner Survey). These data will help you evaluate the success of the project, the health of the stream and subsequent problems in the watershed. Documenting the improvements in stream conditions will help you gain public support for these types of projects. Also, if you conclude that your project is not as successful as you had hoped, you have a chance to make improvements.

Arrange for recognition of the project itself and the efforts of the volunteers. You have made a major commitment of volunteer time and funds. Depending on the size of the project, consider sending letters of appreciation to volunteers and contributors, arranging a barbecue, writing a report for your group, or arranging media coverage.

You and your group will be well aware of the benefits of your project but you need the support of your community for enhancement projects to succeed. Talk about your project with others whenever and wherever you can, including at school and public meetings. Placing an information sign at the enhancement project is especially appropriate. Module 10 contains specific information about increasing community awareness and working with the media.

References Listed in Table 2

This annotated bibliography contains brief comments on the references commonly used in British Columbia for habitat restoration projects. However, it is not a complete list of resource materials. Your Community Advisor can help you locate these references.

Fish Habitat Enhancement: A Manual for Freshwater, Estuarine, and Marine Habitats
Adams, M.A. and I.W. Whyte. 1990. Department of Fisheries and Oceans, DFO/4474. 330 pp.

to get a copy, telephone (604) 666-6614

This manual describes many techniques used to restore stream habitat in B.C. There is a very brief introduction to ecosystem functions, life histories of some aquatic species, and project planning. For each technique it provides background information, advice on appropriate stream conditions, design and installation guidelines, photographs, drawings, maintenance requirements, factors influencing cost, advantages, disadvantages, and examples of successful projects.

A Training in Stream Rehabilitation, Emphasizing Project Design, Construction and Evaluation
House, R., J. Anderson, P. Boehne and J. Suther (eds.). 1988. Oregon Chapter American Fisheries Society, Bend, Oregon.

out of print, contact your Community Advisor

This manual presents course materials used by the Oregon Chapter of the American Fisheries Society for a stream rehabilitation course. The 16 sections cover topics ranging from the theoretical to the practical. Topics include stream hydrology, the usefulness of hydraulic principles in predicting the outcome of habitat improvement projects, and design details for several projects. The manual also discusses watershed analysis, limiting factor analysis, project evaluation, and case studies of past failures and successes in both coastal and interior Oregon streams.

Stream Analysis and Fish Habitat Design: A Field Manual
Newbury, R.W. and M.N. Gaboury. 1994. 256 pp.

to get a copy, write Newbury Hydraulics, Box 1173, Gibsons, B.C. V0N 1V0,
or telephone (604) 886-4625

This manual describes in detail the design of full-spanning cobble and boulder weirs. These weirs control gradient and create a natural and stable series of pool and riffle habitats in a stream. The first three chapters present the steps in project design and describe stream analysis and design procedures. The fourth chapter focuses on site design and construction steps and provides case studies of five Manitoba streams. The text describes, in easily understood language, hydraulic principles from the watershed level down to the streambed microhabitat level. It also shows how to calculate total annual flow yields, used for planning water storage projects to augment stream flow.

Guidelines for Bank Stabilization Projects in the Riverine Environments of King County

Johnson, A.W. and J.M. Stypula (eds.). 1993. King County Department of Public Works, Surface Water Management Division, Seattle, Wash.

to get a copy, telephone (206) 296-1951

This practical guide describes how to assess bank erosion problems on large streams, evaluate alternative solutions, design and construct bank stabilization projects. It provides design specifications for several techniques, emphasizing materials that match the natural surroundings. It also discusses planning, on-site construction supervision, and maintenance. The manual applies to many B.C. streams, even though it focuses on stream geology, ecology, erosion, and bank failure processes in Western Washington.

Freshwater Intake End-of-Pipe Fish Screen Guideline

Anonymous. 1995. Department of Fisheries and Oceans, DFO/5080. 27 pp.

to get a copy, telephone (604) 666-6614

This well-illustrated booklet provides information on the size and design of fixed screens. The screens often are placed over intake pipes used to extract water at up to 125 litres per second. The booklet discusses fish screens for permanent and temporary pipes used for irrigation, construction, and small scale municipal and private water supplies.

A Guide to Selection and Propagation of Some Native Woody Species for Land Rehabilitation in British Columbia

Marchant, C. and J. Sherlock. 1984. B.C. Ministry of Forests Research Report RR84007-HQ, Victoria, B.C. 117 pp.

out of print, contact your Community Advisor

This is a good guide for people ready for more advanced streamside planting techniques than those discussed in Module 7 of the Streamkeepers Handbook. The publication provides details on biology, identification, and propagation of 26 coastal and interior B.C. native woody plant species, excluding large conifers. It describes ecological and physical aspects of disturbed land. It also includes criteria used to select species best suited to various soils and climates.

Culvert Guidelines: Recommendations for the Design and Installation of Culverts in British Columbia to Avoid Conflict with Anadromous Fish

Dane, B.G. 1978. Department of Fisheries and Oceans, Technical Report Number 811. 57 pp.

to get a copy, telephone (604) 666-6614

This report provides culvert installation guidelines that allow fish passage with a minimum of stress. It discusses hydraulic criteria and provides examples of culvert designs and auxiliary fish passage structures such as culvert baffles and tailwater control facilities.

Fish Habitat Rehabilitation Interim Procedures for the Watershed Restoration Program
Slaney, P.A. and D. Zaldokas (eds.). (in prep.). B.C. Ministry of Environment, Lands and Parks, Ministry of Forestry, and Department of Fisheries and Oceans.

to get a copy, telephone (604) 222-6761

This guide for the B.C. Watershed Restoration Program describes many techniques used to restore stream habitat in B.C. There are several chapters on design specifications, along with drawings and photos for specific techniques. The manual discusses principles of stream restoration, the approval process in B.C., procedures to assess stream channels and limiting factors, and life histories and habitat requirements of several species of fish. It also provides criteria for evaluating the potential environmental, social and economic benefits of a project.

Urban Runoff Quality Control Guidelines for the Province of British Columbia
Anonymous. 1992. B.C. Ministry of Environment, Lands and Parks, Environmental Protection Division, Victoria, B.C. 132 pp.

to get a copy, telephone (250) 387-9985

This report is for people working with their municipalities to improve the quality of storm water runoff. There are two main sections. Part I introduces the types and concentrations of contaminants typical in urban runoff. It summarizes information on treatment technologies, characteristics and sources of contaminants, operation requirements, maintenance, ecological impacts of treatment systems, and possible future developments. Part II describes in detail the methods municipalities can use to develop a comprehensive program to control urban runoff quality in a watershed.

Land Development Guidelines for the Protection of Aquatic Habitat
Chilibeck, B., G. Chislett and G. Norris. 1992. Department of Fisheries and Oceans and B.C. Ministry of Environment, Lands and Parks. 128 pp.

to get a copy, telephone (604) 666-6614

This book describes the guidelines designed to protect fish populations and their habitat from the damaging effects of land development activities. It describes techniques and materials you should use to reduce negative impacts when working in or around a stream. It also lists appropriate periods for instream work, both generally and for specific regions of B.C.

Design for Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetlands in the Mid-Atlantic Region
Schueler, T.R. 1992. Metropolitan Washington Council of Governments, publication #92710, 134 pp.

to get a copy, telephone (202) 962-3256

The report presents detailed design guidelines for stormwater wetlands. Diagrams, design criteria, and effectiveness in removing pollutants are described for four basic approaches: the shallow marsh, the pond/wetland, the extended detention wetland, and the pocket wetland. The report also discusses the differences in hydrology, morphology, and ecology between stormwater wetlands and undisturbed natural wetlands.

Other Useful References

Saving a Stream, a Practical Guide to Coldwater Habitat Projects
Trout Unlimited (1996). Washington DC. 42 pp.
to get a copy, telephone (703) 284-9424
This recent publication covers much of the information covered in Module 14. It was written for Trout Unlimited volunteers in the United States. Except for regulatory and approval requirements, most of the information can be used in B.C. It describes six major steps in planning and conducting a habitat restoration program: defining the purpose of the program, recruiting partners and resource people, assessing current stream and watershed conditions, planning the project, organizing and conducting the project, and monitoring and maintaining the results.

Videos

Constructing Pools and Riffles (7 min. video)
to get a copy, write Newbury Hydraulics, Box 1173, Gibsons, BC, V0N 1V0,
or telephone (604) 886-4625
This is a good instructional video for those interested in constructing pool and riffle habitat to stop erosion and improve habitat diversity. The video demonstrates how to select appropriate locations for riffle construction and the steps to follow during a site survey. The viewer is taken step by step through the construction phase and the footage clearly illustrates the application of five main design specifications.

Running Water I: Rivers, Erosion and Deposition (30 min. video)
Earth Revealed Series - Program #19, Magic Lantern Communications Ltd., Oakville, Ontario,
to get a copy, telephone (905) 827-1155.
This introductory video discusses erosion, transport and deposition processes in streams and the factors that influence these processes. It discusses ideas such as stream discharge, velocity, bedload transport, suspended loads, energy budgets, formation of cutbanks and gravel bars, meander patterns, and flood plain formation and function. It also discusses the impact of human activities such as damming and dredging on river dynamics.

Appendix 1
COMMON HABITAT RESTORATION TECHNIQUES

Check Table 3 for the references that provide detailed instructions for these projects. This appendix provides a quick overview of the projects, where to use them, and their advantages and disadvantages. Many of the drawings have been adapted from the publications listed in the reference section. **All the techniques except streamside planting and fencing require technical assistance with project design.**

1. STREAMSIDE PLANTING

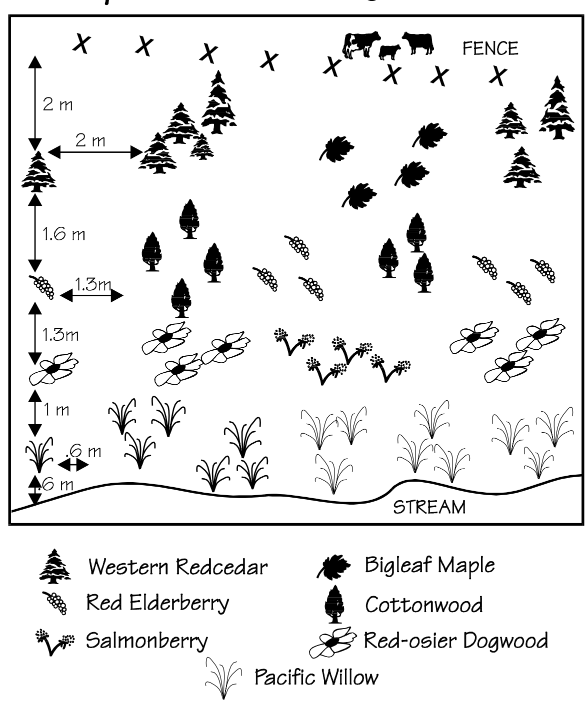
a) **the project:** Module 7 and other references describe streamside planting in detail. You plant cuttings or seedlings of native species along unvegetated or sparsely vegetated stretches of the stream banks. Other stream improvement projects often include planting.

b) **where to use it:** Plant on any streambank that lacks sufficient natural vegetation. Use native species adapted to local climate and soil conditions. You may need to stabilize or grade the banks first if the slope is greater than 2:1.

c) **advantages:** Planting stabilizes the banks and reduces erosion, shades and cools the stream, and reduces the amount of sediment and pollutants entering the stream from runoff. It provides cover for fish, helps moderate stream flows and flood levels, and attracts wildlife and salmonid food species. The project is relatively inexpensive. You can take cuttings from nearby plants adapted to local conditions.

d) **disadvantages:** You may attract unwanted weed species, so you will need to do some maintenance. Some species are hard to propagate, particularly from cuttings.

Example of a Planting Plan



2. STREAMSIDE FENCING

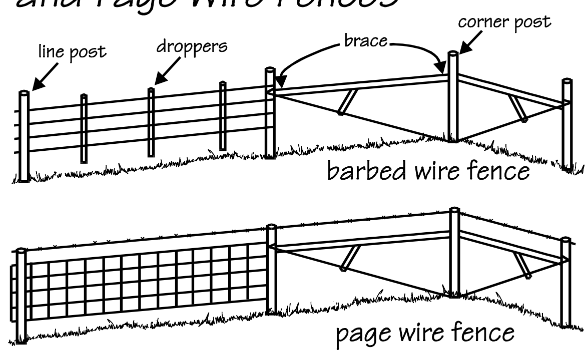
a) **the project:** Module 8 and other references provide instructions on building fences along streams. You build these fences along the stream corridor to protect stream banks, vegetation, and the stream itself. This is a good project to combine with a streamside planting project in agricultural areas, although the stream and banks also will recover slowly if left alone.

b) **where to use it:** Build fences in areas where livestock have unrestricted access to the stream. If you have limited resources, start with productive salmonid habitat such as spawning areas.

c) advantages: Fencing restricts livestock access to the stream, which stops further bank erosion and allows vegetation to grow back. It also improves water quality by reducing inputs of sediment and animal wastes. The advantages described for streamside planting also apply.

d) disadvantages: You must consult with landowners and have their approval. Since many landowners do not want to change old practices, you may need to explain how fencing will benefit them. The project can be expensive, especially for long, meandering streams. You may need to provide alternate water sources for livestock. You need to inspect and maintain fences regularly.

Examples of Barbed Wire and Page Wire Fences



3. ROCK RIP-RAP

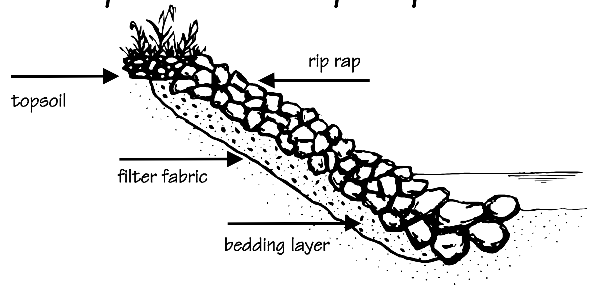
a) the project: You place hard angular rocks (e.g., granite) of various sizes so they lock together along the banks. This protects the banks and stabilizes the soil. You can use rip-rap to prevent other stream improvement structures from being washed away.

b) where to use it: Use this technique in areas where streambanks are eroding and are composed mainly of sand or fine sediments. You can use it in wide channels with low habitat diversity. Rip-rap works best on banks with slope less than 2:1 and on streams with maximum water velocity less than 4.0 m/sec.

c) advantages: Rip-rap is stable at most flow levels, very durable, straight forward to install and easy to maintain, and can improve habitat for fish and other aquatic organisms when installed with that objective in mind.

d) disadvantages: You need to use heavy machinery for most construction phases. Large projects are costly to install. Rip-rap looks unnatural, restricts natural channel movement, and can cause erosion problems upstream or downstream when installed improperly. It is difficult to establish vegetation on rip-rapped banks.

Example of Rock Rip Rap



4. SPILING AND WATTLING

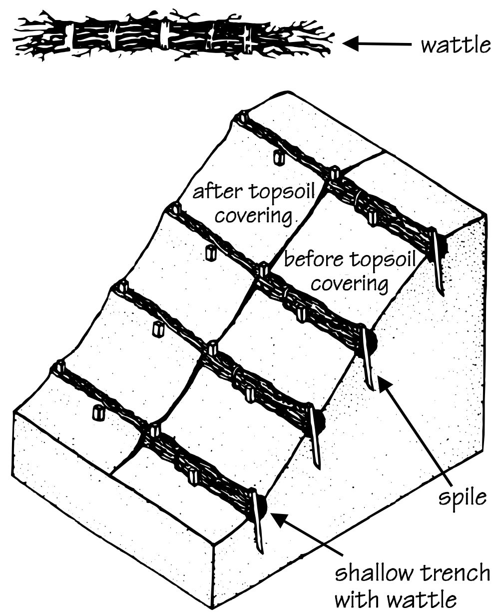
a) **the project:** You can use spiles and wattles to stabilize banks. Wattles made of willow cuttings are woven through spiles, or anchor posts, on the bank. The "wall" of willow cuttings takes root, grows, and stabilizes the bank.

b) **where to use it:** Install spiles and wattles to stabilize eroding stream banks.

c) **advantages.** This is a relatively simple and inexpensive method to stabilize eroding banks. The woven network of stakes and willow whips provides short-term structural stability until the willows develop root networks along the bank.

d) **disadvantages:** You can use spiles and wattles only on stream banks with low and moderate flows. You need to do some follow-up maintenance.

Spiles and Wattles



5. TREE REVETMENTS

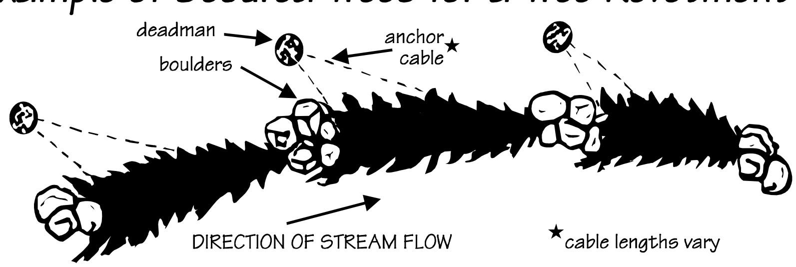
a) **the project:** You groom the stream bank to a slope no greater than 2:1 and cable durable green coniferous trees, such as cedar and pine, to the bank. The tree tops rest in the stream and are anchored in place. The branches dissipate stream energy that otherwise would erode the bank. Sediments settle behind the branches and begin to rebuild the bank. After establishing the revetment, you should plant the banks.

b) **where to use it:** Use revetments to protect rapidly eroding stream banks.

c) **advantages:** Revetments dissipate stream energy at the erosion site without narrowing the stream channel. They create new fish habitat and often attract juvenile fish. They also provide stable areas where new vegetation can become established.

d) **disadvantages:** You need heavy equipment to groom the bank. Further erosion may occur upstream or downstream of the trees. The revetment lasts only five to ten years, so you should ensure that bank vegetation grows back.

Example of Secured Trees for a Tree Revetment



6. LOG CRIBS

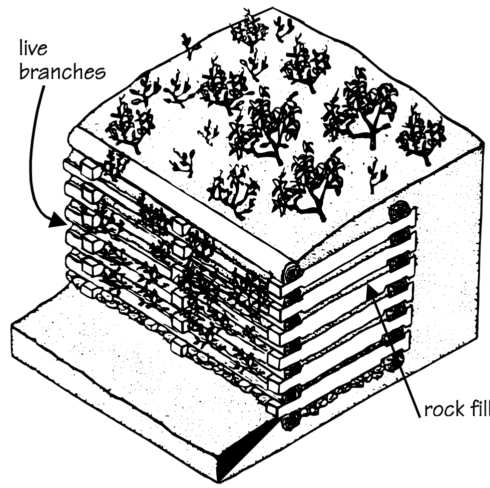
a) **the project:** You add a log wall, crib-style, to protect eroding banks and provide cover for fish. You should plant vegetation on the top of the wall behind the crib and on the vertical surface.

b) **where to use it:** Install log cribs in streams with eroding banks and with low to moderate gradient, flood flows, and banks.

c) **advantages:** Cribs provide excellent protection from bank erosion and require little maintenance. They increase habitat diversity for juvenile fish and decrease sedimentation in the stream.

d) **disadvantages:** They are time consuming, labour intensive, complex and costly to build. They last five or more years, depending on the materials used.

Example of a Log Crib



7. LOG BANK COVER

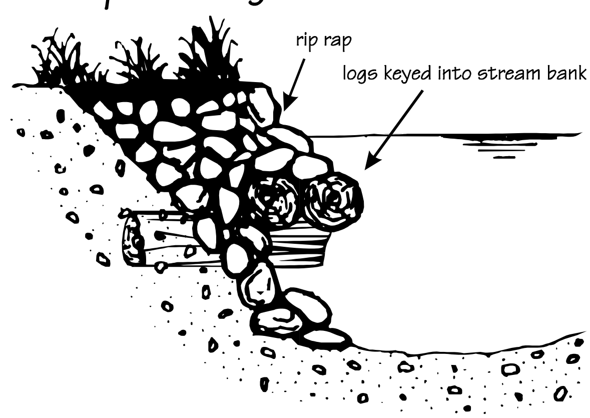
a) **the project:** You build a shelf from lumber or logs, install it along a bank, then cover and plant vegetation on it. This creates an undercut bank effect, which provides cover for juvenile and adult fish.

b) **where to use it:** You can add log bank cover to streams with low to moderate gradient, stable flows, and a relatively stable channel.

c) **advantages:** These structures provide stable overhead cover, and offer some bank protection. They also create pools when areas under the structure are scoured.

d) **disadvantages:** Log bank covers are labour intensive to build and may be costly. They are not durable in large streams.

Example of Log Bank Cover



8. CULVERT PASSAGE

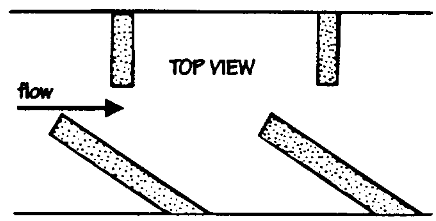
a) the project: Older culverts may have been poorly designed or installed. You can install baffles in culverts where water velocities are too great or depths too shallow to allow for the passage of fish. You can construct outlet pools where there is an impassable drop at the culvert outlet.

b) where to use it: Consider modifying any culvert that delays fish passage for more than three consecutive days during the migration period. These conditions restrict adult fish passage: water velocities greater than 0.9 to 1.2 m/sec (depending on length of culvert); water depth less than 0.23 m in the culvert; a vertical drop of more than 0.31 m at the culvert outlet, and a slope of greater than 0.5 to 1%, depending on culvert length. These conditions hinder juvenile fish passage: water velocities greater than 0.3m/sec; any vertical drop at the outlet, and any slope.

c) advantages: Fish can migrate beyond previously impassable culverts. Baffles and outlet pools usually cost less than replacing the whole culvert.

d) disadvantages: An engineer or technician should design the modification. Often, he or she decides that the culvert is undersized already. Since baffles reduce the flow capacity of the culvert, an engineer may want to replace it with a larger culvert. You need specialized equipment to modify the culvert. You need to clean out trapped debris occasionally.

Example of Culvert Baffles



9. FISHWAY

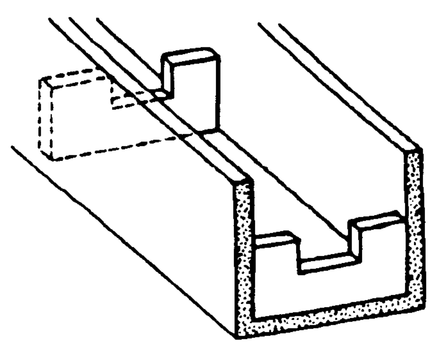
a) the project: You install a fishway to provide passage around natural or artificial barriers to fish migration. Use a pool-and-weir fishway on streams with consistent water levels and a vertical slot fishway on streams with widely fluctuating water levels. Use a denil fishway in a temporary situation or on a steeply sloped passage. A natural looking sequence of pools and riffles also can be constructed to help fish get past a barrier using rock weirs.

b) where to use it: Use fishways to provide passage around artificial barriers such as culverts, dams, and weirs. You may need to consider fisheries management concerns when contemplating a fishway around natural barriers such as chutes and falls. Removing natural barriers and providing access to previously unused habitats may negatively affect the native species upstream.

c) advantages: Fishways allow migration past obstructions and can introduce fish into previously unused areas. You can design a fishway to select certain species.

d) disadvantages: Most fishways involve detailed engineering studies, relatively high costs, and much labour. They also require some maintenance.

A Pool and Weir Fishway



10. BEAVER DAM MANAGEMENT

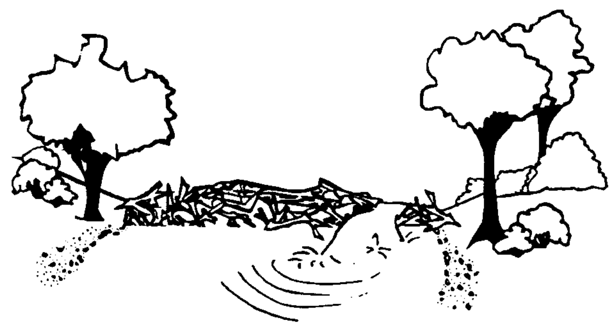
a) **the project:** Most beaver dams are best left in place, since they provide excellent summer and winter rearing habitat for juvenile salmonids. The impounded water behind the dam can augment stream flows during dry periods. You can improve fish passage by opening holes in the dam at critical times. In some areas, fencing the stream bank has kept beavers from returning to rebuild the dam. If you must remove a beaver dam, dismantle it by hand down to the stream bed.

b) **where to use it:** Modify or remove only those dams that prevent fish from reaching spawning or rearing habitat further upstream.

c) **advantages:** A properly managed beaver dam provides fish passage during critical migration periods while maintaining rearing habitat and water storage benefits.

d) **disadvantages:** Beavers often return and repair the dam, so you need to be constantly vigilant to maintain an opening. Removing the dam may reduce rearing habitat, particularly the critical overwintering habitat, or affect the habitat of other species.

Breached Beaver Dam



11. LOG AND DEBRIS JAM MANAGEMENT

a) **the project:** Fisheries staff should assess the net benefit of debris removal and supervise the project. Many jams only appear to be impassable so you should check fish populations above and below the jam to assess the extent of the blockage. Large woody debris provides important fish habitat, so you should remove it only if it forms a migration barrier, flood threat, or erosion problem. Often, you can improve water and fish passage by selectively removing some material using a chain saw, winch, block and tackle, or commercial log yarder.

b) **where to use it:** Remove only those jams that prevent or harmfully delay salmonid migration, cause sedimentation, or erode the banks.

c) **advantages:** Removing a log or debris jam allows access to upstream areas.

d) **disadvantages:** Working in and around a debris jam is dangerous. You may need to salvage the juvenile fish and dewater the site. Removing the blockage may cause more harm than good, by reducing the amount of rearing habitat or instream cover, or by releasing large amounts of sediment.

Jammed Logs

12. FISH SCREENS (WATER INTAKE SCREENS)

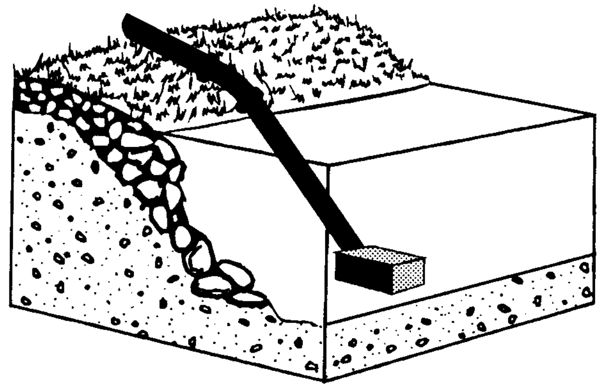
a) **the project:** You cover entrances to water intake pipes or diversion channels with fixed or movable screens. This prevents juvenile fish from being sucked into the water intake.

b) **where to use it:** Screen any water intakes on streams and lakes where water is removed for human consumption, industry, or agriculture. The surface area of the intake screen should be large enough to prevent fish from being sucked up against it.

c) **advantages:** Screening the intakes prevents fish from entering the pipes and dying. You can install a self-cleaning system to reduce maintenance on streams that carry a heavy debris load.

d) **disadvantages:** Engineers and qualified contractors should design and build larger fish screens. Most screens require routine cleaning and main- tenance.

Example of a Screened Intake



13. ROCK OR LOG WEIRS

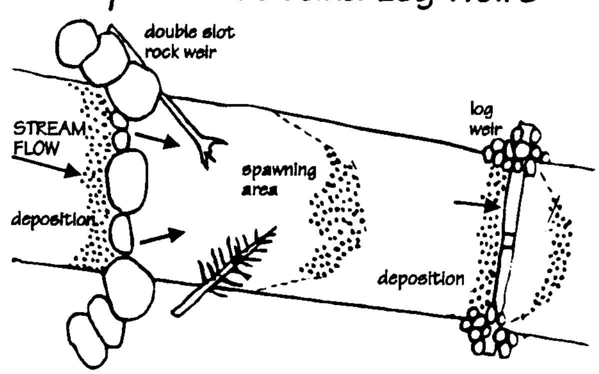
a) **the project:** Rock or log weirs modify stream flow and increase the number of pools in a stream. Pools provide valuable rearing habitat for salmonids. Plunge or scour pools develop downstream of the weir and spawning gravels accumulate upstream of it.

b) **where to use it:** Consider adding weirs to streams with insufficient pool habitat, or to catch and retain spawning gravel. Install them where the stream gradient is 1 to 3%, the banks are low, and the channel is wider than average. They work best on streams less than 10 m wide.

c) **advantages:** Weirs create valuable rearing and spawning habitat and look natural in the stream. The materials are inex- pensive when they are available at the site. Weirs usually need very little maintenance.

d) **disadvantages:** A hydrologist or hydraulic engineer should help design and install the weir. You may cause bank erosion down- stream if you do not protect adjacent stream banks properly.

Example of Rock and Log Weirs



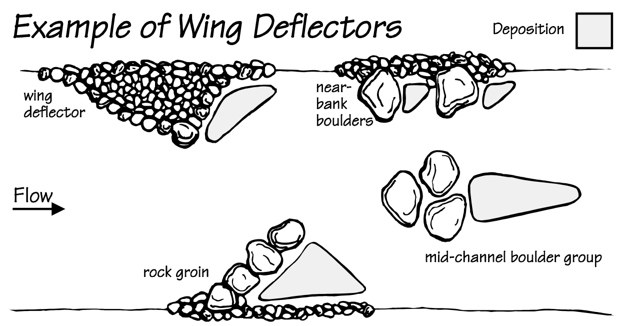
14. WING OR FLOW DEFLECTORS

a) the project: You place rocks along a stream bank or at mid-channel to redirect the flow of water and scour bed material. The stream deposits the material below the deflectors further downstream.

b) where to use it: Install deflectors on streams with low to moderate gradients, in wide, slow, silty areas or areas with eroding banks.

c) advantages: Deflectors can be used to direct flow away from eroding stream banks and improve fish habitat by creating scour pools and cleaning spawning gravel. Adding large woody debris enhances the effectiveness of deflectors in creating fish habitat.

d) disadvantages: Deflectors restrict natural channel movement. Installation can be expensive and require heavy equipment. Poorly constructed deflectors can create erosion problems downstream or on the opposite bank.



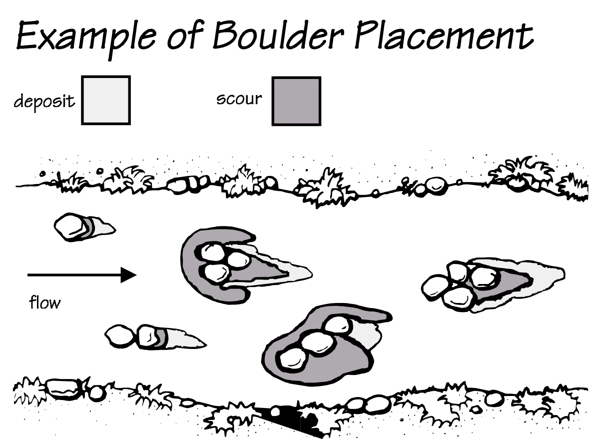
15. BOULDER PLACEMENT

a) the project: Place clusters of large boulders in a stream to increase habitat diversity. Clusters create substantially more fish habitat than do single boulders.There are several cluster designs that achieve various patterns of scour and deposition on the stream bed.

b) where to use it: You can place boulders in streams with a gradient less than 3%, relatively stable banks, and low habitat diversity. Add boulder clusters to the middle or downstream end of a riffle, or the upstream end of a pool or run. Place them in the deepest part of the channel.

c) advantages: Material costs are low and the structure requires very little main- tenance. The added boulders look natural and provide resting areas for fish and cover in the form of turbulent surface layer, scour pools and overhangs.

d) disadvantages: The project is labour intensive and may require machinery. Improperly placed boulders can lead to erosion of unstable banks. Boulders can shift if the stream bed is unstable.



16. GRAVEL CATCHMENT/PLACEMENT

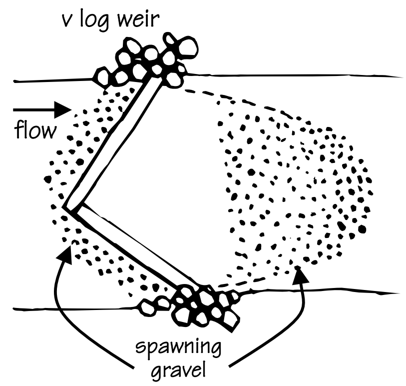
a) **the project:** You place clean river-run gravel into a suitable spawning area of the stream. You also may install a log or boulder weir to hold the gravel in place, or trap gravel moving downstream.

b) **where to use it:** You can add gravel to areas of a stream that have limited spawning habitat and enough rearing habitat to support increased fry production. The technique often is used to enhance pink and chum salmon production. Since juveniles rear in the ocean, the factor limiting production is spawning habitat. Make sure that flood flows are unlikely to wash out the gravel. Choose areas of low to moderate tractive force. Gravel placement is most effective in low gradient areas that lack a natural source of gravel, such as a lake outlet.

c) **advantages:** Adding gravel improves spawning success and increases production of aquatic insects and fish.

d) **disadvantages:** Gravel often gets washed out of flood-prone coastal streams. You may need to add a gravel catchment weir to prevent this.

Example of Gravel Catchment



17. LARGE WOODY DEBRIS (LWD) PLACEMENT

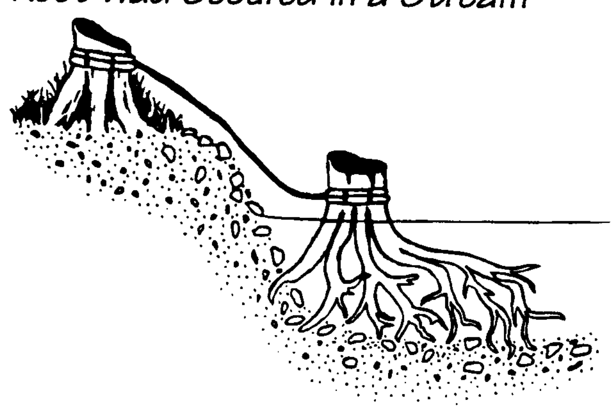
a) **the project:** You anchor root wads, coniferous trees, or logs in pools or along the outside edge of curves in the stream.

b) **where to use it:** Place LWD in streams where there is not enough cover for fish. Use it in moderate and low gradient streams less than 15 m wide, or less than 20 m wide if the stream is lake fed. Place the LWD in relatively deep water.

c) **advantages:** Adding LWD increases the amount of submerged and overhead cover for juvenile and adult fish.

d) **disadvantages:** LWD may catch debris or sediment, which can alter flow or partially dam the stream.

Root Wad Secured in a Stream



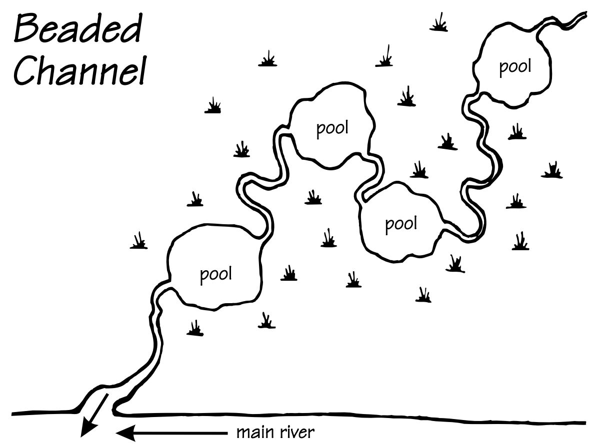
18. OFF-CHANNEL HABITAT DEVELOPMENT

a) the project: You can provide extra fish habitat by constructing side channels, spring or groundwater-fed channels, or overwintering ponds next to the main channel. You also can add channels in areas beyond the current floodplain, such as behind dykes or in old side channels.

b) where to use it: Consider developing off-channel habitat in streams that lack sufficient spawning, rearing, or overwintering habitat. These areas provide a refuge and reduce fish mortality caused by flood or drought in the main stream.

c) advantages: These projects increase salmonid production greatly by creating additional spawning or rearing habitat.

d) disadvantages: Off-channel developments can be expensive to build and require substantial engineering expertise and heavy machinery. Poorly designed systems can run dry in the summer and trap fish. You may need to clear debris from side channels or clean the substrate occasionally with heavy machinery.



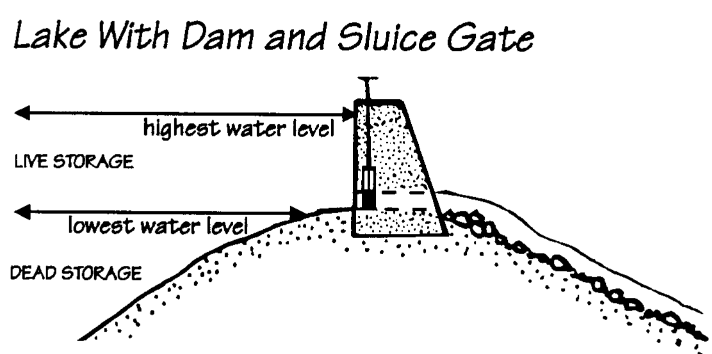
19. FLOW AUGMENTATION

a) the project: You build a flow control structure on a lake to regulate stream flow. The structure stores water during periods of high runoff and releases it during periods of low runoff.

b) where to use it: Consider increasing the water storage capacity on streams where you have evidence that low summer flow significantly limits fish production.

c) advantages: Regulating stream flow avoids severe floods and droughts, which otherwise would decrease survival of fish eggs and juveniles. You can control water temperature by releasing water from specific depths in a lake. Small scale projects are inexpensive.

d) disadvantages: Dams should include a fishway to allow free passage of fish. Fluctuating water levels in the impoundment can affect shoreline areas. Medium and large scale projects can be expensive. Someone needs to monitor flows, adjust flows, and maintain the structure.



20. STORMWATER DETENTION

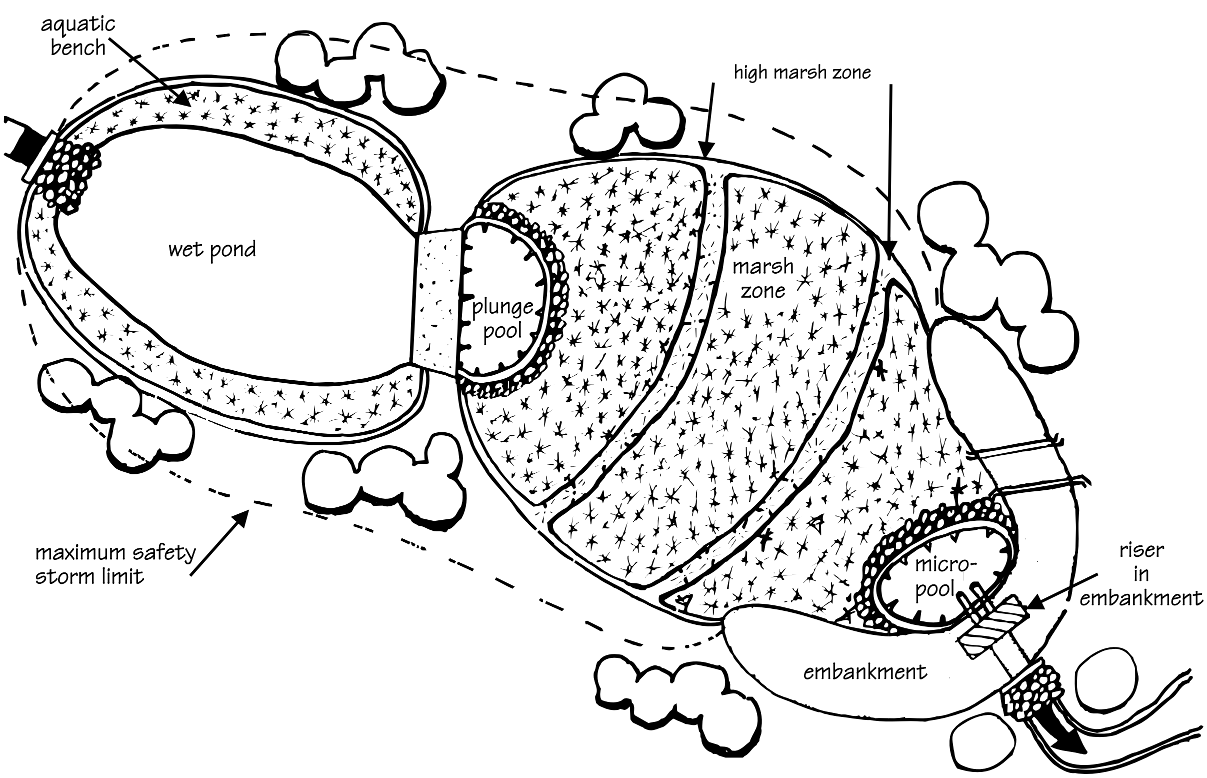
a) **the project:** You can encourage municipal planners and developers to build better systems to treat stormwater runoff in urban areas. Available technologies include in-ground tanks, oil/water separators, infiltration systems, ponds, and wetlands. These systems help detain runoff, provide infiltration and replenish groundwater supplies, and remove some sediment and pollutants in urban runoff. Public education (Module 10) and storm drain marking projects (Module 5) also help improve quality of the stormwater runoff.

b) **where to use it:** Consider installing these systems in urban areas where stormwater is collected and discharged to streams or other water bodies. They intercept runoff from streets, roofs, and parking lots before it enters a body of water.

c) **advantages:** These systems are long lived, adaptable to many locations, and remove pollutants reliably when maintained properly. Systems that include wetlands have the potential to increase wildlife habitat.

d) **disadvantages:** Storm water detention systems should be designed by engineers, can be expensive to install, require relatively large areas of land, and require ongoing maintenance.

Example of a Stormwater Detention Pond Layout



Appendix 2: Application Form

Environmental Review: *Notification for Proposed Works and Changes In and About a Stream under the Section 7 Regulation of the Water Act*

Notification for Proposed Works and Changes In and About a Stream under the Section 7 Regulation of the Water Act

Please refer to the application guidelines when completing this Notification Form

1. **Applicant Name:** ______________________
   Address: ______________________
   City & Province: ______________________
   Postal Code: __________ Telephone: __________

2. **Location of Works:**
   Stream Name: ______________________
   Location on Stream: ______________________
   What stream/river/lake does it flow into? ______________________
   Address, if different from above: ______________________
   Legal description of property: ______________________

3. **Sketch Plan:** attach drawing showing lot boundaries, location of proposed works, stream direction and flow and location of buildings.

4. **Proposed Timing:**
   Start (day/month/year): __________
   Finish (day/month/year): __________

5. **Type of Works (Check (✓) appropriate box):**

- ☐ **Routine maintenance by a public utility**
- ☐ **Pipeline crossing in a naturally dry channel**
- ☐ **Fish habitat restoration or maintenance by government**
- ☐ **Flow or water level measuring device by government**
- ☐ **Existing dike or erosion protection works repair or maintenance**
- ☐ **Stream channel restoration or maintenance by a municipality or the province**
- ☐ **Fish fences or screens, fish or game guards by government**
- ☐ **Clear span bridge**
- ☐ **Pier or wharf**
- ☐ **Ice bridge or winter ford**
- ☐ **Aquatic vegetation control**
- ☐ **Cutting annual vegetation**
- ☐ **Road crossing culvert**
- ☐ **Storm sewer outfalls**

Dimensions of the proposed works: Length: __________ Width: __________ Diameter: __________

6. **Do you own the land on which the works are to be located?** **yes** ____ **no** ____ **(check one)**
   If not, who owns the land?
   Land Ownership: Private: ______ Crown: ______
   Landowner's approval, if different from applicant:
   Landowner's Name: ______________________
   Address: ______________________
   Postal Code: ______________________
   Telephone: ______________________
   Landowner's Signature: ______________________
   (Attach tenure document for Crown land)

7. **Who is doing the work?**
   Contractor: if different from applicant:
   Company Name: ______________________
   Contact Name: ______________________
   Address: ______________________
   Postal Code: ______________________
   Telephone: ______________________

The information on this notification form will be made available to the public under the Freedom of Information legislation, if requested.

8. **Statement of Intent:**
   I declare that the information contained on this form is complete and accurate information. I have read, understood and will meet the requirements to construct works and changes in and about a stream in accordance with Section 7 of the *Water Act* and the Regulation.

   Signed: ______________________ Date: ______________________

Ministry Use Only:

______ :Meets the requirements to proceed under regulation ______ :Approval required

OP15456-1

Notification for Proposed Works and Changes In and About a Stream under the Section 7 Regulation of the Water Act

Application Guidelines

Please fill in all sections of the form, incomplete forms do not constitute a notification and will not be processed.

1. Name and mailing address

Enter your name, mailing address and telephone number.

2. Location of works

- Identify the name of the stream on which you intend to carry out the proposed works.
- Specify where on the stream are the works to take place (e.g. distance from road crossing or confluence with another stream).
- Indicate what stream, river or lake the stream flows into.
- Indicate location of works if different from your mailing address.
- Enter a complete legal description of the property on which the works are to be carried out (e.g. Lot 1 of Section 31, Township 20, Range 12, W6M, Kamloops Division of Yale District, Plan 18411). This information is listed on your annual assessment or land tax notice, or you may obtain it by requesting a copy of your Certificate of Title from the appropriate Land Title Office.

3. Sketch Plan

Attach a drawing which clearly shows:

- the lot boundaries of the property on which the works are to take place
- the location of proposed works
- the stream and direction flow
- the location of house/buildings
- the approximate scale (e.g., 1cm=10m)

A copy of part of a cadastral or topographic map or legal plan, at a reasonable scale, may be used for the drawing.

4. Proposed Timing

Indicate proposed start and finish of the works (day/month/year).

5. Type of Works

Identify the nature of the works by checking one of the boxes. Also, note the dimensions of the works and list length, width and diameter where appropriate.

6. Ownership of the Land

- If you own the land on which the works are to be carried out check "yes" and go to question 7.
- If you are not the owner of the land, indicate whether the land is privately owned or owned by the Crown.
- You must have the landowner's approval. The landowner must enter his/her address, telephone number and postal code and sign. If the land is owned by the Crown, please attach the appropriate tenure document.

7. Who is Doing the Work

If you are not carrying out the work, indicate contractor/company's name, mailing address, postal code and telephone numbers.

8. Statement of Intent

Make sure each section of the form is filled out and that the information is accurate and complete. After having read and understood the conditions outlined in the Section 7 Regulation, and ensured that your project meets all requirements, sign and date the form.

When your form is complete, send it along with the sketch plan to the BC Environment regional office located nearest to the proposed works. This notification form must be completed, by providing the information specified, and must be **received** by a habitat officer in the nearest Ministry of Environment, Lands and Parks office at least 45 days prior to the proposed commencement of the work.