SECTION 7.0. RESEARCHING AND SURVEYING THE WATERCOURSE

THIS SECTION CONTAINS:

- How to research the history of your watercourse
- Forms for collecting information
- How to survey the watercourse as it is today
- "Think Like a Fish" A Detailed Habitat Assessment
- A quiz to test your knowledge

Scheduling Your Work

Your work is part research and part fieldwork, ideally spread over the entire year. Plan to do the research during the winter months. The initial watercourse field survey should be done in the spring when the water is high. Rehabilitation and enhancement can take place during the summer and fall.

7.1. The Past and Present (Initial Research)

Before you begin rehabilitation you must understand the problems. To properly understand the problems, you should have a good sense of the watercourse's history. Start by finding or making a simple map of the area where you plan to work. Make sure you include smaller streams (**tributaries**) entering the main watercourse. Existing 1:10,000 orthophoto maps of the area can be very useful. (These can be obtained from Service Nova Scotia http://www.gov.ns.ca/snsmr/land/products/geobase.asp **Where to Go For Help**). Be sure to make several copies of your hand-drawn map as it will be used later for different activities. In this exercise you develop different maps showing how the watercourse has changed over time, and how it looks now. To understand the "past" and "present" of your watercourse, you should be able to answer four basic research questions:

1. **What was it like in the past?**

2. **What changed it?**

3. **What is it like now?**

4. **What is changing it now?**

You can answer the first two research questions by:

- Talking to older members of the community, especially fishermen and landowners; this is an exercise in "oral history".

- Searching libraries and archives for photos, books, letters, maps and other printed information.

- Checking relevant government departments for any records or maps they may have that show your watercourse.

7.2. Oral History Research

By talking to older members of the community you can often develop a surprisingly detailed history of your area. **Oral history** is especially important in stream rehabilitation work because often there are no written descriptions of the area. Use the appropriate form on the following pages as a guide for collecting information. Gathering oral history is a great project for schoolchildren or youth groups because it asks them to contact people they already know, such as their grandparents. Oral history is a two-way street: Children usually enjoy this kind of interactive task, while older people like telling stories to the younger generation. You may want to contact a local senior's group and get its members formally involved in the project. In Antigonish, seniors visit the classroom in an innovative program called Grandparents in the Classroom. You could use this concept to enhance your Adopt-A-Stream program.

Interviewing Tips

• Start by telling the older person why you are conducting the interview. Tell them how valuable their role is in the project.

• Using a tape recorder is easier than taking notes. However, some people don't like being tape-recorded; if this is the case, take careful notes. Don't be afraid to go over these notes with the person after the interview. You'll find that people are generally eager to make sure you have "got their words down right".

• Give your subject a copy of the map that shows what the watercourse looks like today. Ask them to take a pencil and show you how it has changed.

• It is not necessary to ask all the questions on the form. They're a guide only. Feel free to be as conversational as possible. Your goal is to discover the questions that trigger the memory of the person who is being interviewed.

• Ask the person if there is anyone else you should talk to who might help you get more information on the past history of the river/stream.

Oral History Form

Streams/Rivers

Name of Interviewer

Name of Person Interviewed

Phone Number

Name of Stream or River

How long have you lived in this community?

Has the width of the stream/river changed? Yes ☐ No ☐

Please describe:

Are the flooding patterns different today from when you were younger? Yes ☐ No ☐

Please describe:

Has any "flood control" work been done on the river? Yes ☐ No ☐
Please describe:

Was the river/stream ever straightened? Yes ☐ No ☐
Where?

Were stones/boulders piled on the banks to keep the bends from changing? Yes ☐ No ☐

Where?

Were there ever any log drives on the river? Yes ☐ No ☐

Were there any factories/industries that polluted the river/stream? Yes ☐ No ☐

Were there any dams on the river/stream? Yes ☐ No ☐

Where?

If so, were there fishways constructed for fish? Yes ☐ No ☐

When were they removed?

Did you ever fish in the stream or remember someone who did? Yes ☐ No ☐

If so, what do you remember about the fish?

What kind?

Their size?

How many?

Where are/were the good fishing places?

Where do the fish spawn?

Where have you seen small fish (fry) in the spring?

Did a commercial or organized fishery exist on the watercourse in the past? Yes ☐ No ☐

Why do you think this stream doesn't have as many fish today?

Did you ever swim in the river? Yes ☐ No ☐

Where were the swimming holes?

Do you know of any feeder streams that aren't there now or are much smaller than they used to be? Yes ☐ No ☐

Are ice jams common in the spring? Yes ☐ No ☐

Have there always been ice jams in the spring? Yes ☐ No ☐

Do you remember things that were dumped into the river that are not dumped now? Yes ☐ No ☐

What other kinds of changes have you seen?

Are there old farm areas that have now grown over? Yes ☐ No ☐

Where were these farms?

How was sewage disposed of in the past?

What do you think could be done to make this stream more like it was when you were younger?

Do you remember anything about birds or animals around or near the water that is different today? Yes ☐ No ☐

Please describe:

Do you have any old photographs of the stream? Yes ☐ No ☐
Comments:

Oral History Form
Wetlands

Name of Interviewer:

Name of Person Interviewed:

Phone Number:

Were wetlands in the area filled in or drained for construction?

Were wetlands drained for agriculture? Yes ☐ No ☐

Were wet or marshy lands in the area ever filled in for farming? Yes ☐ No ☐

Were wet or marshy lands ever filled in to help control flooding? Yes ☐ No ☐

Have wet areas that you remember now gone dry? Yes ☐ No ☐

Were wetlands or meadows harvested for feed? Yes ☐ No ☐

Do you remember places where you saw large flocks of ducks and geese feeding and resting that you don't see now? Yes ☐ No ☐

Oral History Form

Estuaries

Name of Interviewer:

Name of Person Interviewed:

Phone Number:

Name of Stream or River:

How long have you lived in this community?

What changes in land use have you seen around the estuary?

What industries were here in the past that aren't here now? (sawmills, pulp mills, boat building etc.)

Did they put waste into the estuary? Yes ☐ No ☐
What kind?

When did these industries stop?

Were parts of the estuary or salt marsh ever filled in or dyked? Yes ☐ No ☐
When did this happen and what was it for?

Did you dig clams in places where you can't dig them now? Yes ☐ No ☐
Where were these places?

Did you find oysters and mussels in places where you can't get them now? Yes ☐ No ☐

Where?

Did you ever fish in the area? Yes ☐ No ☐

What was the fishing like compared to now?

If there are any causeways, large wharves or constructions near the estuary, find out when they were built and if the person noticed changes after they were built.

Do you remember any differences in the number of birds or animals in or around the estuary? Yes ☐ No ☐

Do you notice any other changes in the area? Yes ☐ No ☐

Comments:

7.3. Researching Written Records

Most of the sources listed in this manual are eager to provide historical information to you or your group. Don't be shy about consulting them.

Checking old newspapers, magazines, books, etc. can bring forward a wealth of information about your watercourse.

This is an ideal research project for junior or senior high school students and fits well with many curriculum areas. Classes may want to work together to produce a "book" on the local history of the watercourse. Talk to teachers about assigning these research projects.

Sources of Information

Information on where and how to contact the organizations listed below is contained in the section **Where to Go For Help**.

- **The local library** might have a "clipping" file that deals with the history of your area. Books on local history might contain valuable information and pictures that will make the past come alive. Ask the librarian for help.
- **Your local newspaper** probably has an "archive" which contains copies of all past issues where you might find more detail on events, such as major construction projects, that have shaped the history of your stream or river. Ask the editor for help.
- **Local natural history or fishing clubs** may have club records that will be of use. This might include statistics on bird counts or number of fish caught. Provincial groups such as the Nova Scotia Salmon Association also may have valuable information.
- **Local or head offices of the Nova Scotia Department of Agriculture and Fisheries and the Department of Fisheries and Oceans Canada** might be able to provide you with scientific information on the stream, including its fish stocks both past and present.
- **The Nova Scotia Government Archives** may contain more information on road-building, log-drives etc.
- **The Nova Scotia Museum** or a local museum/historical site such as Ross Farm or Sherbrooke Village is worth contacting. Many historical sites pride themselves on finding out as much information as they can about local land-use patterns.
- **Superintendents and interpreters at National Parks (Cape Breton Highlands and Kejimkujik) and historical sites** (such as Louisbourg) collect information, photos, and maps of the past.
- **The Nova Scotia Government** has produced a two-volume book called *The Natural*

History of Nova Scotia which may help your general scientific understanding of the area. You can obtain these books at your local library or through the Government Bookstore in Halifax.

- **The Nova Scotia Department of Transportation** may have old road maps of the area. Compare these old maps to current ones to see how road patterns have changed.

- **The Department of Agriculture and the Department of Health** both have an interest in and information on water. Both departments may be able to provide you with useful information.

- **Check with all institutions in your area**. Use your imagination and check with everyone! Military bases, hospitals, industries and other institutions in your area may have records about water that even governments are not aware of. It's quite possible for you to discover resources and information that would be of great use to those who manage our watercourses. You might find valuable information in the most unlikely place.

Remember that gathering all of this written information together has never been done before! This part of the project, combined with the oral history research, can add to the body of scientific knowledge. By carrying out this research, community-based groups have a very important role to play in helping us to understand the watercourses in our province.

7.4. Current Land Use

Once you have collected oral histories and researched written/pictorial records, you should be able to produce a map of what the watercourse was like long ago to compare it to your map of today.

Now, you are ready to add further details to your map of the watercourse, as it exists today. At this point you are asking the final two research questions:

What is it like now?

What is changing now?

These final research questions can be answered by:

- Obtaining physical information (including facts about fish populations) by talking to local people and examining government records.
- Making on-site observations and researching current land-use patterns.
- Doing a survey on the watercourse's physical condition and habitat potential.
- Interviewing people and examining written records. Information on the current condition of the watercourse can be obtained by the same methods you used to discover its history (talking to people and examining recent records).

Don't forget to add all of this information to your map.

7.5. Land-Use Form

The next thing you should do is complete a land-use form. Mark important facts on your map. Sometimes the best way to fill out the land-use form may be to spend a few days driving around your area. If you don't have time, you can divide your area into sections and have helpers do different sections of the map. If you are working on a river, you can "walk" the river (or have helpers walk different sections).

Current Land-Use Form

Some of the questions apply to wetlands, and estuaries, as well as streams and rivers.
Are there ice jams in the spring? Yes ☐ No ☐

Does the river run muddy when it rains? Yes ☐ No ☐

Do you know where the "mud" is coming from? Yes ☐ No ☐

Has anyone recently removed gravel from the river? Yes ☐ No ☐
How many farms are along the watercourse?

Is the land ploughed right up to the water's edge? Yes ☐ No ☐

Do you see farm animals in the water? Yes ☐ No ☐

Are there barns with manure piles near the water? Yes ☐ No ☐
How many forest operations are along the watercourse?

Has the forest been cut right up to the watercourse? Yes ☐ No ☐

Have greenbelts been used? Yes ☐ No ☐
What industries are along the watercourse?

Are these industries putting waste into the river? Yes ☐ No ☐

What is the waste?

What kind of non-industrial development is along the watercourse? (e.g. golf courses, malls, homes, other types of construction)

Is there a landfill site near the river? Yes ☐ No ☐

How many bridges cross the watercourse?

What types of roads cross the watercourse?

How do the roads drain?

Where are the culverts?

How are they built?

What else drains into the watercourse?

What else is dumped into the watercourse? (e.g. snow or garbage)

Where does the local sewage go?

How is the watercourse used for recreation (boating, ice-fishing, swimming etc.)

Make a list of all the things that have changed the watercourse.

7.6. Surveying the Watercourse

The next step is to physically survey your watercourse to get information about fish species, water chemistry, temperature, and other physical features. Generally, you will be looking at the physical shape and condition of the watercourse and its habitat potential. This information can give you clues as to possible problems. It is likely that most of your efforts will concentrate on only one portion of the watercourse. With some instruction a group can easily do a cooperative assessment.

Note: Blank survey forms for each type of watercourse are contained in this section

Some surveys will already be available from the Nova Scotia Department of Agriculture and Fisheries office. Additionally, more detailed water-quality information may be available through the nearest office of the Departments of Environment. There also may be additional information that needs to be collected because of some special feature in your area. Therefore, before you begin any type of survey discuss what needs to be done with the NSSA contact.

When the information is collected and your survey is complete, meet again with your NSSA contact. You will be then be able to cooperatively determine how to improve your watercourse in specific ways.

The reasons for performing a survey are:

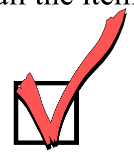
- To help you determine the true nature and extent of **all** the problems in the watercourse. A quick look may suggest one problem (e.g. eroding banks), whereas a more serious problem (e.g. no nursery area for fish) may be missed without an organized investigation.

- To help you gather information that will aid a habitat professional to determine the best ways to resolve any problems.

- To enable you to fully understand how a natural stream functions. This is valuable knowledge in itself for any citizen concerned about environmental issues.

7.7. Materials/Equipment

In order to conduct a survey you need all the items in the following checklist:



______A supply of survey forms
______Your hand-drawn maps of your stream or stream section
______Meter (yard) stick (preferably wooden one-metal ones can be mounted on an old hockey stick. Be warned that the ink on metal rulers can wash off if you have insect repellent on your hands).
______Celsius thermometer
______Water sample bottles *****
______Clip boards
______Pencils
______Orange flagging tape
______Waterproof knapsack
______Hip waders or rubber boots
______Insect repellent
______First aid kit - winter survival kit, if applicable
______Kit for testing pH (if available)

**** Use a clean, well-rinsed plastic bottle that has a secure lid. It should be capable of holding about a half a liter or 2 cups. Put a label on the bottle before you leave for the stream and number the bottles (it's hard to put numbers on wet bottles). If you prefer to number the bottles in the field use masking tape and write numbers on with a pencil or permanent marker. Make arrangements to have the sample tested quickly or the pH can change.

7.8. Survey Procedures

Please see these sections Before You Begin Restoration and Enhancing a Watercourse for important legal, safety, and ecological considerations when you are working on a site.

If you're responsible for a group, have people do the work in pairs. For safety reasons, do not conduct a stream survey alone or during thunder and lightning storms. You should always try to conduct a survey when water levels are as normal as possible. You can start at the mouth of the stream and work upstream until the source is located. However, if the source can easily be identified (e.g. a lake), it may be easier to start there and work downstream.

1. As you walk along the watercourse, stop at the following places:

- **Where another brook or stream** joins the watercourse
- **Where drainpipes** go into the watercourse
- **Where there are bridges/culverts** over the watercourse
- **Where farm animals** use the water
- **Where land has been ploughed or forest cut** right up to the water's edge
- **Where you see a lot of garbage**
- **Any other place** where you suspect there is a "problem"
- **Where your maps** (past and present) indicate potential problem areas

2. On your map, number the places where you stopped. Then write this number on the top of a survey form. **Start a new form for each place you stop.** Master survey forms for the different watercourses are included in the following pages; make numerous copies of the one you need.

3. In stream surveys, mark every pool in the river with a "P" at the appropriate place on your map. Record the maximum depth of each pool using a metre stick. Make an estimate of depth if it is deeper than your measuring stick.

4. At each stop, take a water sample. Make sure the number on the bottle corresponds to the number on the stream survey sheet. Always pre-rinse the bottle with the water you are collecting before you take the sample.

5. Take the temperature of the water. Be sure to hold the thermometer in the water long enough. It takes at least two minutes for the instrument to adjust to the water.

6. Test the pH if you have a testing kit.

7. Answer the remaining questions on the survey form.

Stream Survey Form

Recorder's Name ______________________ Stream Name________________________

Group Name __________________________ Location # on map ____________________

Date__________________________________ County ____________________________

Please describe weather conditions eg. rain, snow or sleet, approximate air temperature, cloudy, sunny, windy?

Stream Section #	Water Bottle #
PH	Water Temperature
Grid Reference (on topographic map) Map #	Stream depth 1. Deepest part of pool 2. Crest of riffle

Why did you stop here?

If there is a drainpipe, where it is coming from?

Is there a water intake? Yes ☐ No ☐

If there is another watercourse, do you know its name?

Do you know the landowner's name?

How much of the following can be seen on the bottom?

% Boulder = the size of a dinner plate or larger (approx.25 cm)

% Cobble = the length of an index finger up to a dinner plate (6.4-25 cm)

% Gravel = the size of a thumbnail up to the size of an index finger (2-6.4 cm)

% Pebble = the size of a baby fingernail up to a thumbnail (0.6 - 2 cm)

% Sand = less than 6 mm

% Silt = less than 1 mm

Pick up a rock - are there insects on it? Yes ☐ No ☐

Look closely - are the insects moving? Yes ☐ No ☐

Count the insects on a softball-sized rock.

Count the casings from caddisflies.

Name the kinds of insects if you know what they are.

Is the rock muddy? Yes ☐ No ☐

Was it set in sand or silt?

How far down (approx.) do you have to go through mud/silt until you reach rock or gravel?

Check what the shoreline or edge of the area is like.
Streamside vegetation? Yes ☐ No ☐

Please indicate the percentage of each type:

%Hardwood trees (deciduous)	%Softwood trees (coniferous)
%Alders	%Shrubs
%Grasses	%Manicured grass
%Farm Field	
%Marsh	%Swamp

Is there human development evident e.g. houses/factories, etc.? What?

Is there any evidence of bank erosion? Yes ☐ No ☐

Please mark these areas on the map using a code in the same way that you mark pools.

Other important physical features to note?

Evidence of wildlife? Name them if you can.

☐ Fish ☐ Birds ☐ Animal tracks

Evidence of farm animals? Yes ☐ No ☐

In the water? Yes ☐ No ☐

On the banks? Yes ☐ No ☐

Evidence of farm drainage? Yes ☐ No ☐

Describe the general water movement:

☐ Shallow and slow ☐ Shallow and fast
☐ Deep and slow ☐Deep and fast

Any obstructions or barriers?

☐ Logs ☐ Trees Other?

Any garbage?

☐ Paper/cardboard ☐ Plastic ☐ Tires ☐ Glass ☐ Metal

Other?

Comments:

Lake/Wetland Survey Form

Recorder's Name ______________________ Stream Name________________________

Group Name __________________________ Location # on map ___________________

Date_________________________________ County ____________________________

Please describe weather conditions eg. rain, snow or sleet, approximate air temperature, cloudy, sunny, windy?

Type of Wetland?

☐ Lake ☐ Pond ☐ Fen ☐ Bog ☐ Swamp ☐ Marsh

Do you know the source of water for the wetland? Yes ☐ No ☐

Please indicate (spring, name of river/stream)

If it is a lake, what is the bottom like?

Draw a sketch and indicate the following:

☐ Silty ☐ Muddy ☐ Rocky ☐ Lots of plants

If it is a lake, take the water temperature near places where water flows into the lake.
Water temperature (location)

Are there any drainpipes coming into the wetland? Yes ☐ No ☐

Do you know where it is coming from? Yes ☐ No ☐
Where?

Do you know the landowners name?

Check what the shoreline or edge of the area is like. Mark these on your sketch.

Streamside vegetation? Yes ☐ No ☐
Please indicate a checkmark in the box(s):

☐	Hardwood trees (deciduous)	☐	Softwood trees (coniferous)
☐	Alders	☐	Shrubs
☐	Grasses	☐	Manicured grass
☐	Farmland	☐	Field
☐	Marsh	☐	Swamp

Human development e.g. houses/factories, etc.? Please name what kind

.

Evidence of bank erosion? Yes ☐ No ☐

Other important physical features to note?

Evidence of wildlife? Name them if you can.

☐ Fish ☐ Birds ☐ Animal tracks

Do you see any evidence of farm animals or farm drainage in the watercourse? Yes ☐ No ☐

Any garbage?

☐ Paper/cardboard ☐ Plastic ☐ Tires ☐ Glass ☐ Metal

Other?

Estuary Survey Form

Recorder's Name ______________________ Stream Name ________________________

Group Name __________________________ Location# on map ____________________

Date_________________________________ County _____________________________

Please describe weather conditions eg. rain, snow or sleet, approximate air temperature, cloudy, sunny, windy?

____Name(s) of river(s) flowing into the estuary?

Saltmarshes present? Yes ☐ No ☐
Kelp beds present? Yes ☐ No ☐
Are there any drainpipes coming into the estuary? Yes ☐ No ☐
Do you know where they are coming from? Yes ☐ No ☐
Where?

Do you know the landowner's name? Yes ☐ No ☐
Are there wharves? Yes ☐ No ☐
Causeways? Yes ☐ No ☐

Check what the shoreline or edge of the area is like.

Shoreline vegetation?
Yes ☐ No ☐

Please indicate a checkmark in the box(s):

☐	Hardwood trees (deciduous)	☐	Softwood trees (coniferous)
☐	Alders	☐	Shrubs
☐	Grasses	☐	Manicured grass
☐	Farmland	☐	Field
☐	Marsh	☐	Swamp

Human development e.g. houses/factories, etc.? Please name what kind.

Evidence of bank erosion? Yes ☐ No ☐

Other important physical features to note?

Evidence of wildlife? Name them if you can
.

☐ Fish ☐ Birds ☐ Animal tracks

Do you see any evidences of farm animals or farm drainage in the watercourse? Yes ☐ No ☐

Any garbage?

☐ Paper/cardboard ☐ Plastic ☐ Tires ☐ Glass ☐ Metal

Other?

7.9. Survey Follow-Up

Once the water collection bottle is dry and you are at home, make sure you label it with the following information:

1. ***Your name***
2. ***Your mailing address***
3. ***Your phone number***
4. ***Watercourse collected from***
5. ***Approximate location on watercourse***
6. ***Date collected***

Contact the NSSA coordinator for directions on where to send the bottle for tests

- You may have to copy the information you have collected onto clean survey forms. Forms used in the field tend to get dirty and wet. Make sure your new copies are neat and legible and that all of the data at the top of the form is entered. Make a clean copy of the map you used with its numbered locations and staple this to your stream sample forms.
- Make sure that you have a recording of the water temperature of the river at the hottest time of the year (you may have to go back).
- Make new clean copies of any maps that have been soiled or damaged. You should now have at least two separate maps (one that tells the history of the watercourse and one that shows its present condition).

MAKE SURE THAT YOU KEEP COPIES OF ALL OF THE INFORMATION YOU COLLECT.

ALL OF THE INFORMATION WILL BE USEFUL FOR REPORTS OR FOR DISCUSSION SESSIONS WITH PROFESSIONALS.

7.10 "Think Like a Fish" to identify limiting factors

There are numerous survey forms and approaches to assessing fish habitats. Generally you can find a form for any given jurisdiction, and in some cases extensive manuals on how to fill them out and computer programs to help analyze the data. Many have been developed to provide information to fisheries stock managers or to provide information for single species fish habitat models. The biggest challenge with any of the forms is how to interpret the data once it is collected. How do you find the aspects of the watercourse, known as variables, that are limiting the productivity of the habitat? Is it necessary to do detailed assessments if one or two of the variables are obviously weak? What protocol do you follow to ensure the data is comparable between assessors, years, other rivers and the habitat models?

Following through the chart below is a strategic planning process, not a linear process where you have to complete the steps in the order presented. You should access the current situation, set your goals and priorities, take action, and monitor successes and then repeat the process until you have restored the productivity of the habitat. You may find that land use in the watershed is so bad that it has to be mitigated before any other action is taken. This is often the case and that is why it is the first thing we look at. However there is little sense in working hard on land use issues if the pH of the water due to acid rain is so low as prevent sustainable fish production. Or you may find that land use is a chronic problem that needs to be addressed in the lower reaches of the watershed but the habitat is fragmented by hanging culverts, or long reaches without pools, and your first priority would be to get the migrating fish up to the good habitat. Each watershed has different needs and priorities; there isn't a step-by-step cookbook approach that fits all situations.

If you live in one of the few un-impacted areas in the Maritimes, it is very important that you organize to protect the ecosystem by maintaining natural ecological processes and preventing impacts from human activities. Monitoring the health of the ecosystem is a good idea to ensure things continue to function well.

To design a monitoring program, you first consider the aspects of the ecosystem that are the most at risk from activities in the watershed or along the coast. Focus on monitoring the changes that would be caused by these activities. For each variable monitored you should determine the range of natural variation and set target limits that the variable should stay within. For example, if you are monitoring water temperature on the river it will fluctuate each hour and over the summer as the air temperature changes. This is natural variability. If a healthy summer temperature is under 20^0C and you're your data shows it is getting warmer each year or exceeding 20^0C, then you need to take action to solve the problem. The 20^0C would be a trigger value that would initiate an action plan. The action plan should be developed at the start of the monitoring program and include all the partners and government agencies who will need to be involved in the solution and their roles.

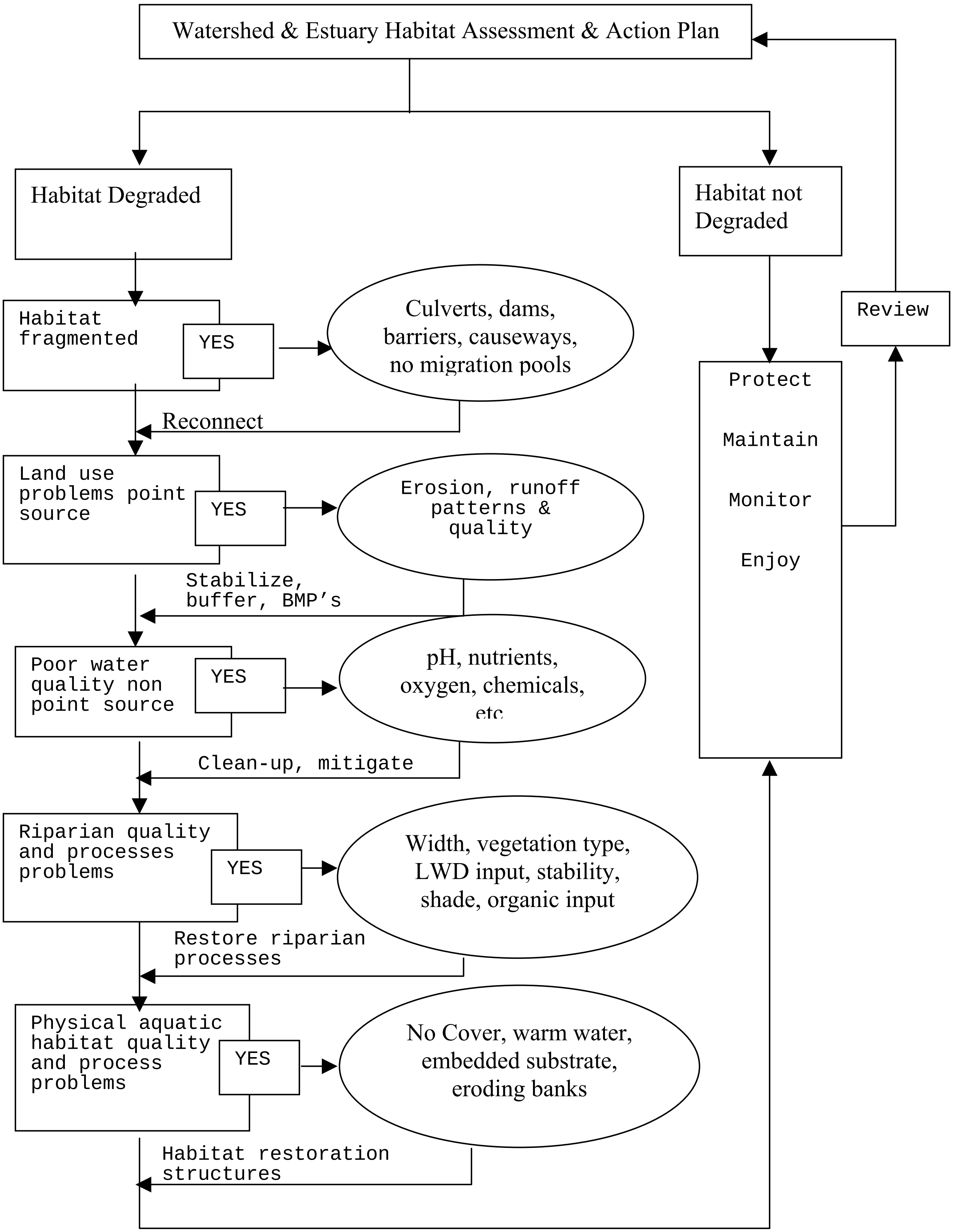
If you are not sure what monitoring to do or there are no imminent threats then a general health-monitoring program should be undertaken. If these variables are within normal ranges, there is little need to worry. However if a variable starts to change or reaches levels for concern you would take action to investigate the cause with further tests.

For freshwater systems, you should monitor for temperature, pH, conductivity, and dissolved oxygen, plus nutrients, metals, hydrocarbons if you suspect these are problems, and a secchi disc or visual assessment for turbidity, plus an annual walk to assess changes in bank erosion and adjacent land use. More detailed monitoring can include programs to monitor invertebrate populations and fish populations and there are protocols available to undertake this level of monitoring.

For estuary systems monitor salinity, temperature and a secchi disc or visual assessment for turbidity, plus an annual walk to assess changes in bank erosion and adjacent land use. If eutrophication is suspected, a chlorophyll *a* test and a macrophytes survey may help confirm it.

Once it is determined that you have degraded habitats, you need to address the cause of the problems first. You cannot make progress in restoring habitats if the activities that destroyed them are continuing. In cases where the problem is bigger than the local watershed, for example acid rain, then it is reasonable to undertake mitigation efforts before the overall problem is solved and cleans itself up. In ether case you should work through the process below to help set out the order in which issues are tackled and to help ensure all the problems are covered.

For assistance with environmental monitoring programs Contact The Community Based Environmental Monitoring Network at St Mary's University.
Dr. C. Conrad, Research Coordinator;
Saint Mary's University, Department of Geography;
Community-Based Environmental Monitoring Network;
923 Robie Street;
Halifax, Nova Scotia;
B3H 3C3
Website:
http://www.envnetwork.smu.ca
Phone #'s:
CBEMN Office: 902-491-6243
CBEMN Office: environmental.network@smu.ca


Watershed & Estuary Habitat Assessment & Action Plan
Habitat Degraded
Habitat not Degraded
Habitat fragmented
YES
Culverts, dams, barriers, causeways, no migration pools
Reconnect
Land use problems point source
YES
Erosion, runoff patterns & quality
Stabilize, buffer, BMP's
Poor water quality non point source
YES
pH, nutrients, oxygen, chemicals, etc
Clean-up, mitigate
Riparian quality and processes problems
YES
Width, vegetation type, LWD input, stability, shade, organic input
Restore riparian processes
Physical aquatic habitat quality and process problems
YES
No Cover, warm water, embedded substrate, eroding banks
Habitat restoration structures
Protect
Maintain
Monitor
Enjoy
Review

Land use erosion and runoff problems

For most non-point or the larger more identifiable sources, there are regulatory processes in place to try to control their impact. These sites are easily identified as muddy runoff from farms and forestry operations, discolored water from pipe outfalls, and large percentage of the watershed area covered by hard impermeable surfaces draining into storm sewers. Not all erosion and runoff cases are covered by permits or regulatory controls during the normal operations. No one applies for cows in the brook or sheet erosion from farm fields or erosion from skidder tails, etc. These have to be dealt with by contact with the landowner and encouraging them to use best management practices.

Water quality

Water quality for fish and wildlife is a major problem in the Maritimes. Large areas are suffering from the impacts of acid rain that has lowered the pH and resulted in a lower productivity of the habitats. Connected with this are increased levels of dissolved metals leached from the soil by the acid. The second most common problem is sand and silt from small but common poor land use activities and bank erosion. The pile of earth on a front lawn, the newly seeded lawn, the new gardens, or the dirt washed off vehicles and equipment get into storm sewers of ditches and into the streams. Thirdly, there are nutrients and chemicals from common activities, fertilizing the lawn, washing the car, pesticides and cleaners, and poorly constructed or poorly maintained septic systems. The rain is capable of washing these chemicals and nutrients into ditches, storm sewers, and watercourses. The numerous small sources add up to big problems.

Fragmentation of habitats

A common problem in rivers and coastal areas is the fragmentation of habitats and the partial and total blockage of migration routes. These include culverts, dams, fishing gear set illegally, causeways, debris, and long reaches without adequate depth or resting pools.

Riparian quality and processes

Adjacent to all water bodies is a strip of vegetation that creates productive and unique wildlife habitats and contributes to the stability, form, and productivity of the aquatic habitats. The width of the area varies depending on the lay of the land and the flood patterns. Experienced foresters and biologists can see the change in the vegetation and define the edge of the riparian zone. For regulatory and guideline purposes distances have been set to define the riparian zone for stream protection. This is not usually adequate for wildlife and care must be used when working with these distances if they are intended to be buffers to prevent damage to streams. Riparian zones have considerable capacity to buffer impacts including removal of sands and silts, remove excessive nutrient loads and many chemicals, and regulate groundwater input to streams. However look closely at these buffer areas to be sure the pollutants are just not channeling through the area or overwhelming the mitigating capacity. Riparian zones (greenbelts) should be left between water and all land use activities.

Physical habitat quality and processes

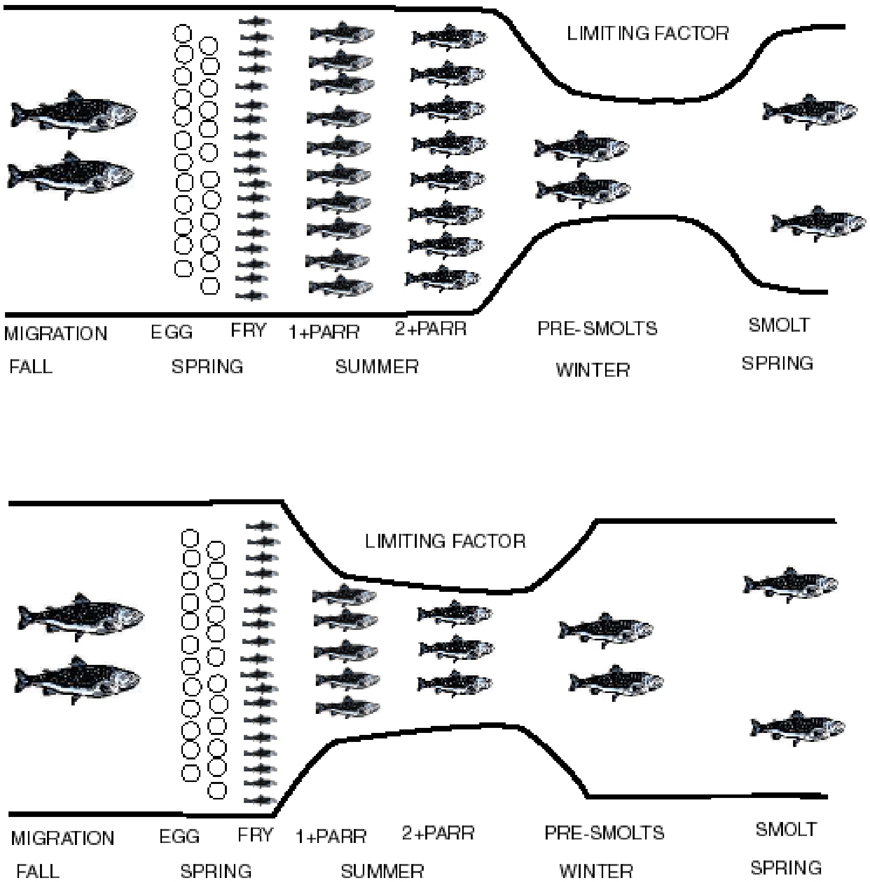
Changing flood and flow patterns, past use of the river, ice scour, new man made control points which restart meander patterns, and the lack of slow but regular input of large organic debris all contribute to degraded physical habitats. The fact sheets at the end of this manual focus on instream techniques to restore the natural functions of the stream ecosystem.

If you do not have a degraded habitat or have been successful in your restoration efforts the most important thing is to enjoy the healthy environment you are living in.

Looking for the limiting Habitat variables.

Habitat assessment is a process of determining the limiting factors and is a critical pre-requisite to determining the productive capacity of the habitat and the restoration requirements. Such information is not available for watercourses in the Maritimes despite intensive surveys on some rivers. If it were available it would make the design of a restoration project much easier. Unfortunately, it is not easy to identify all of the limiting factors and each watercourse can have its own unique combination of factors that interact to limit the productivity throughout the year.

Limiting factors should be thought of as bottlenecks through which all the fish and wildlife have to pass. If the bottleneck habitat will only allow a few individuals to survive, then that habitat controls or limits the productivity. The diagram below is a depiction of how a limiting habitat can effect the population of Atlantic salmon.



EXAMPLE OF HABITAT LIMITING FACTORS A) WINTER PRE-SMOLT HABITAT, B) SUMMER PARR HABITAT (TEC Ltd 2005)

Generally you can divide Nova Scotia into four major groups of watersheds: the Inner Bay of Fundy, southwest Nova and the Eastern shore, the Gulf shore, and Cape Breton.

The Inner Bay of Fundy rivers have good pH, and gravel cobble substrates ideal for salmonids but the salmon populations have collapsed due to what appears to be at-sea mortality. The objective in this area is to undertake stream habitat restoration to optimize the productivity for the fish that do return from the sea and their offspring, and the resident species. Inner Bay rivers have the lowest summer rainfall of anywhere in the Province, and recent weather patterns have brought the warmest driest summers on record over the past 15 years; throughout the year rainfall events have been shorter and more intense, increasing the size of the 1-in-2 year flood flow. The more intense storms cause more runoff and less percolation of water into the ground to recharge the water table. The result has been a widening of the watercourses and a lengthening of the meander patterns, resulting in poor quality pools for juveniles in low flow and for migrating adults to use for holding and resting. The lowered water tables are resulting in dry tributaries and extremely low summer and winter flows. This has been aggravated in some watersheds due to poor land-use practices and the need to harvest budworm-killed forests in Cumberland County. These rivers respond well to restoration, but in some cases the lowered water table has reached the point where even restored pools go dry.

Southwest Nova and the Eastern shore have thin soils and granitic bedrock that have not been able to buffer acid rain. The resulting low pH in the rivers has lead to extinction or near extinction of salmon in many rivers and has stressed the trout populations. This area has also suffered from the change in rainfall patterns; however, the heavy boulder cobble substrates are holding the meander patterns in place. Good water quality is still available in areas with drumlins or other glacial deposits with water buffering capacity. The heavy boulder substrate in most of these rivers makes it difficult to use the habitat restoration structures, so the focus for restoration is on water quality and getting the most out of the small tributaries with high pH and cool water. Rivers with good gravel cobble and pH or sections with these features need to be optimized to maintain stocks while the pH is restored.

The Gulf shore rivers have good substrate and pH and so still support healthy salmon and trout populations. Past and present land use impacts are the main source of habitat decline. These can be corrected with best management practices and the habitat restoration techniques. The fish populations respond well to restoration. These watersheds are also stressed by climate change, but they do receive more storms in the summer than the rest of the mainland which keeps the water level up, especially in the lower reaches.

Cape Breton rivers have been affected by the change in climate which was compounded in many watersheds by the budworm forest harvesting; both of which have increased the size of the 1-in-2 year flood flow, widening the rivers and lengthening meander patterns. As the forest reestablishes, these flows are decreasing in size and the rivers are trying to reestablish narrower channels with shorter meanders. The lower reaches of many rivers have been seriously impacted. Summer rainfall on the Gulf side watershed is still good but many areas in the shadow of the highlands face serious summer droughts. The good pH in this area gives us the opportunity to restore habitats where the runoff patterns are stabilizing.

These are generalizations of rivers in large areas with highly variable geology and land use patterns. In every area there are exceptions. You have to get to know your river and fish habitats. The limiting factors may be as described above but there are refuges the fish can use in times of stress and improving these refuges can show significant results.

The best approach for a community group is to "***think like a fish***". To do this you select common species in your watershed and starting with the spawning migration, think through the needs of the species in each life stage and season. What do they need to be healthy and grow in your estuary and river? To answer this question the tables on the page that follow, lists the variables, which individually or in combination, commonly limit the fish habitat productivity of watercourses in the Maritimes. In the adjacent columns are the ranges for the variables that are considered to be excellent, good and not sustainable for a selection of common sport fish and indicator fish species. These values are intended for use in identifying limiting habitat variables; they are not to be considered the levels at which everything falls apart and the population collapses. Use them as guides to determine where to focus the restoration work. **For values used in habitat violations or environmental impact assessment you should contact your local DFO biologist.**

Next is a brief description of the sampling protocols for each variable so that your data will be consistent throughout your assessment from year to year for monitoring and be comparable to other assessments in the region. For those who are interested in different sampling methods and standard techniques, contact the Adopt-a-Stream coordinator.

Our objective in the restoration of the habitats is to work with nature to move the limiting variables into the good or excellent range. So, when you have the assessment done, the Adopt-a-Stream coordinator will help you select the appropriate techniques to restore the habitat. You will find that many of the techniques used to restore the physical habitat solve problems with many of the limiting variables.

The actual layout of instream structures is not explained in detail and requires someone trained in the hydrology of watercourses, and the design and layout restoration techniques to complete the plan for the project. Layout is very important because if the structures are not sited properly, they may not create the improved habitat, they may becoming buried, washed out, or in rare cases create their own limiting factor. A poor design is the most common reason for the failure of restoration projects. To avoid wasting all your efforts, get a trained person to spend a couple of days doing a proper layout.

The spacing between instream structures is normally six channel widths, and the scale of instream structures and of the other techniques can be determined from surveying the sites and using the information provided in the restoration fact sheets in Section 9. With this information, you can develop a good estimate of the extent of the work required and estimate costs and the logistics of getting the work done. In some cases there will be additional techniques better suited to the site, which will need to be used. However they are not currently approved under guidelines so will be used only as needed with approval of NSEL and DFO.

Assessment methodology:

Select the species that frequent your stream or you are trying to restore the habitat for and should be present. Then think about each life history stage and consider all of the variables that are listed below for each of the species you have selected. Based on existing data or local and traditional knowledge, select those variables that have the potential to be limiting in your watershed and provide an explanation of why you think the other variables are not limiting. For example, if you know the pH in your river and in all the tributaries stays in the Excellent or Good range for salmonids all year long, then it can be eliminated from the survey. If, however, the summer temperature rises into the mid-20’s in the lower reaches or any of the tributaries, then it is important to measure temperature throughout the watershed during the warmest part of the year to find the viable habitats and identify reaches that can be rehabilitated. Basically you build the data collection needs to assess and monitor the limiting variables for the community of species which are or should be inhabiting the watercourse if it were healthy.

It is almost impossible to do a complete assessment in one pass along the stream. Some experienced assessors can see the problems, which will exist at other times of the year, but even this expert opinion is often wrong because each watershed has its own characteristics. So be prepared to get to know your stream in all four seasons particularly the critical low flow periods in summer and winter and the spring fry emergence and fall spawning periods.

The information provided below is for three common salmonids because they are usually used as indicator species for watercourse restoration projects. Information is available for a wide range of species.

Sampling Protocol

For all samples and data it is important that you accurately record the site:

- The location either with GPS, topo map grid references, permanent markers such as sites numbers painted on trees or boulders, or accurately described i.e. Nine Mile Brook at the outlet of the culvert on Highway 14. Mark the location on as detailed a map or aerial photo as you have available. 1:50,000 maps are good but 1:10,000 are better.
- The time and date the sample or measurement was taken.
- The equipment used to take the measurement or sample.
- The name of the person taking the sample or measurement and the recorder.
- The weather during sampling.
- Photograph the area, noting the photo number, and the direction you are facing.
- All right – left directions in the fact sheets and plans are given as if you were facing downstream.

Measurements are normally taken on a reach-by-reach basis. The length of a reach can be set at a standard length (i.e. each 50m) or each habitat unit, which is six times the channel width. This last method will give you a new reach length at the junction of each tributary. For initial surveys of a watershed, assessments may be taken just at the junction of tributaries. Reaches would be assessed on the main stem above and below the tributary and one in the tributary. This will give you an overview of the health of the habitats and help identify where to focus your efforts.

Salmonids (Atlantic salmon, Brook trout, Brown trout)

Migration

Estuary

Salmonids coming in from the estuary hold in depressions in the bottom in salt/brackish water at the head of tide. They hold in these areas for various lengths of time and if conditions for river migration are not good they return to the near coastal areas to feed, checking on the river conditions some weeks later. When the river flows are right for migration, they move up into the fresh water. If this holding area is impacted by development or is changing due to sedimentation the number of fish that can hold in the area can be reduced. This will limit the number of fish that will migrate on a freshet and the numbers that move into the river over the spawning migration.

Spawning migration, river water depth (cm), and velocities (cm/sec)

Species	Min depth cm	Preferred velocity cm/sec	Max velocity cm/sec	Notes
Brown trout	>18	60	250	
Atlantic salmon	>18	75	250	
Brook trout	4 to 18	20 to 45	120	Fish Size dependant

Notes

- Adults require these depths and velocities only during migration to spawning areas. Values less than this will commonly be found in summer and fall low flow periods and will halt migration at these times.
- Adults will swim against the preferred velocity or as close to it as they can find, mid-water in shallow flows, and secchi disc depth in deeper waters. Secchi disc depth is the depth to which you can see a white object lowered into the water.
- Using burst speed the fish can get past short sections with higher velocities. They can swim at velocities up to 10-body lengths/sec for up to 10 seconds. If this velocity is enough to cover the required distance, swimming against the flow, then it is passable but should be considered a partial barrier if the flow is greater than the Max. velocity listed.
- To fully utilize the fish habitat, spawners should be able to go as far up the stream as possible to get the optimum distribution of fry. Even the larger salmon and trout will use small first and second order streams if access and holding pools are good.

Sampling protocol

Walk up the river during migration season and follow the route the fish would take based on depths, velocities, (table above) and pool quality and frequency (tables below). Note the areas of river the fish would have trouble passing through. These may be wide shallow sections without pools, or culverts, dams or debris jams.

Equipment

Meter sticks, floats, stopwatch and camera

Percent pools during migration and spawning

Species	Excellent	Good	Non sustainable	Notes
Brown trout	50 to 90	15 to 25	<15	
Atlantic salmon	20 to 25	10 to 30	<5	
Brook trout	35 to 65	12 to 90	<5	

Notes

This classification of pools should be done in conjunction with the percent pool, and pool frequency assessment.

Salmonids need to hold in the stream near the spawning areas and they all look for good water depth, low velocities, and cover.

The holding capacity of the pools can regulate the number of spawning fish in well-stocked streams.

Pool class rating during migration and spawning

Species	Excellent	Good	Non sustainable	Notes
Brown trout	>30% of the area is composed of 1st class pools.	>10% but <30% of the area is 1st class pools or >50% is 2nd class pools.	<10% of the area is 1st class pools and <50% is 2nd class pools	See pool class descriptions below

Atlantic salmon	20% of the area is composed of 1st class pools	>10% but <20% of the area is 1st class pools or >30% < 50% is 2nd class pools.	<10% of the area is 1st class pools and <30% is 2nd class pools	
Brook trout	>30% of the area is composed of 1st class pools	>10% but <30% 1st class pools or >50% 2nd class pools	< 10% 1st class pools and <50% 2nd class pools	

Notes

This classification of pools should be done in conjunction with the percent pool, and pool frequency assessment.

Salmonids need to hold in the stream near the spawning areas and they all look for good water depth, low velocities, and cover.

The holding capacity of the pools can regulate the number of spawning fish in well-stocked streams.

Sampling protocol

Rate all pools according to the following classification scheme.

First-class pool: Large and deep. Pool depth and size are sufficient to provide a low velocity resting area. More than 30% of the pool bottom is obscured due to depth, surface turbulence, or the presence of structures such as logs, debris piles, boulders, or overhanging banks and vegetation. Or, the greatest pool depth is >1.5 m in streams <5 m wide or >2 m deep in streams >5 m wide.

Second-class pool: Moderate size and depth >45cm at low flow. Pool depth and size are sufficient to provide a low velocity (>0.5m/sec) resting area. From 5% to 30% of the bottom is obscured due to surface turbulence, depth, or the presence of structures. Typical second-class pools are large eddies behind boulders and low velocity; moderately deep areas beneath overhanging banks and vegetation.

Third-class pool: Small or shallow or both < 45cm at low flow. Pool depth and size are sufficient to provide a low velocity resting area. Cover, if present, is in the form of shade, surface turbulence, or very limited structures. Typical third-class pools are wide, shallow, reduced velocity areas of streams or small eddies behind boulders. Virtually the entire bottom area of the pool is discernible.

Fourth class pool: shallow sections of stream with low gradient and size and depth are sufficient to provide resting areas for parr. Cover is limited to spaces under the substrate. The entire bottom is discernible.

Frequency of holding and resting pools for migration

Pools are very important for fish spawning migrations. The fish can swim against the currents for distances that are related to their species, length, and condition. Then they require low velocity water to hold or rest in before moving though the next section of river. The pools have to provide cover, low velocities, and enough space for all the fish that need to rest there. For migrating fish we are looking for the frequency of first and second-class pools.

Species	Excellent	Good	Non sustainable	Notes
Brown trout	6 channel widths	12 channel widths	> 24 channel widths	
Atlantic salmon	6 channel widths	12 channel widths	> 24 channel widths	
Brook trout	6 channel widths or more in step pool streams	12 channel widths	> 24 channel widths	

Sampling protocol

Channel widths are measured in stable sections of stream straight across, between the base of the perennial terrestrial vegetation on each side. Watercourses in the Maritimes tend to be over widened by 20% due to ice activities and past uses. This is particularly true in sections where the pools are poorly developed. If this is the case at the sampling site, reduce the width measurement by 20% and use this number in assessing pool frequency.

Equipment Measuring tape

Spawning areas

Salmon and Brown trout spawn where the water is drawing down through the gravel. These areas are typically at the tail of a pool where there is a head difference between the water level in the pool and the downstream riffle or run. The head difference causes the water to seep through from the tail of the pool, under the crest of the riffle, and emerge on the riffle. A seepage of 100cm /hr is excellent to bring oxygen to the eggs and remove wastes, but this flow is hard to find and measure. Other areas with similar hydrology, such as the areas above digger logs and small debris jams, and the edges of pools where the seepage goes under the flood plain before returning to the stream are also good sites. For the fish to use the site the flow under the gravel has to parallel the surface flow. Short steep riffles which cross the river at more than 30 degrees have seepage and surface flows which are not parallel and the fish are seldom able to build successful redds. The sites are hard for assessors to find but where the head differences exist, the riffles are aligned closely with the flow, the bottom gravels are not silted in, the area can be counted as a spawning area.

Brook trout will use the same sites as the salmon, but prefer areas where the water is upwelling. These areas can be found along the edge of lakes and streams were the ground water is at least 30cm higher than the watercourse water level or where water is returning to the stream after seeping under the flood plain. These areas can be detected by the difference in water temperature in the summer (colder) and winter (warmer) between the seep temperature and the temperature of the stream.

Spawning area depth and velocity during spawning

Species	Depth cm	Excellent Velocity over redd cm/sec	Velocity over redd cm/sec Good	Notes
Brown trout adult	>24	40 to 70	30 to 80	
Atlantic salmon	>25	60 to 80	35 to 90	
Brook trout	>15	N/a	N/a	Spawn primarily in springs and seeps having >40cm head

Sampling protocol

Must be sampled in the late fall October, November or December, during moderate freshets. Measure the velocity over the tail of the pool.

Equipment

Meter stick or survey rod for the depths, and a float (an orange is good) and a stopwatch.

Spawning substrate

Species	Excellent	Good	Non sustainable	Notes
Brown trout	<3% fine sand <15% sand 40 –50% gravel 40-50% cobble	Degrades with increasing sand and silt content	>20% fine sand &silts	
Atlantic salmon	<3% fine sand <15% sand 40 –50% gravel 40-50% cobble	Degrades with increasing sand and silt content	>20% fine sand &silts	
Brook trout	<3% fine sand <15% sand the rest gravel	Degrades with increasing sand and silt content	>20% fine sand &silts	

Notes

- fine sand (0.06-0.50 mm);
- coarse sand (0.5-2.2 mm);
- gravel (2.2-22 mm);
- and cobble (22-256 mm) (Peterson 1978).

Sampling protocol
This is best done by measuring off an area 50 cm X 50 cm at the tail of a pool and visually estimating the percent of each substrate size class. Other methods are available see Hamilton (1984).

Equipment
Meter stick

Percent of total study area consisting of spawning gravel

Species	Excellent	Good	Non sustainable	Notes
Brown trout A	5	2	1	Measure gravel sizes of 0.3 to 10 cm in areas >0.5 m2 and at depths >15 cm only Class A = 1 to 7 cm
B		5	2.5	Class B = 0.3 to <1 and >7-10 cm
Atlantic salmon	5	2	1	
Brook trout	5	2	1	

Sampling protocol
This should be estimated for each reach.

Cover

Spawning adults need to have suitable cover to use during the day to avoid predators. The closer the cover is to the spawning area the better. This may be deep pools with either colour, broken surface water, or organic debris as cover; or undercut banks or digger logs, over-hanging vegetation, rate the availability of suitable sized cover.

Egg habitats

The eggs remain buried in the gravels over winter, and need a flow or seepage of water to bring them oxygen and remove wastes. It is also important that the stream is stable and the redds are not washed out or scoured by ice.

The average minimum daily dissolved oxygen level (mg/L) during embryo development.

Species	Excellent	Good	Non sustainable	Notes
Brown trout <10 C^0	>10	>7	<6	
>10 C^0	>13	>10	<9	
Atlantic salmon	>13	>10	<9	

Brook trout <15 C^0	>6.5	4.5	<4	
>15C^0	>8.5	6.5	<6	

Notes
Saturated is preferred for all water temperatures.

The average maximum daily water temperature ^{0}C during the embryo development.

Species	Excellent	Good	Non sustainable	Notes
Brown trout	7 to 13	4 to 14	<3 or >14	
Atlantic salmon	3 to 7	1 to 8	<0.5 & >9	
Brook trout	4 to 11	2 to 15	<1 to >17	

Alevin

When the eggs hatch in the early spring, the alevins move between the spaces in the gravel. It is at this point there are large losses of young fish if there is sand and silt filling the spaces as the alevins cannot get out of the shell or straighten out and move freely. When the alevins absorb the yolk sac and become fry they swim up through the gravel to live in shallow low velocity areas in the stream. Again the sand and silt content of the gravel has to be very low to allow them to swim up and to provide them cover from predators. The process of digging the redd cleans the sand and silt out of the redd area, but if the sand and silt content is high in the substrate, it works back into the redd gravels over the winter.

Sand and silt content of substrate

Species	Excellent	Good	Unsustainable
All salmonids Alevins	<3%	3 to 20%	>30%
Swim up fry& 0+ fry	< 3%	3 to 15%	>15%

Fry habitat

Emergent fry move out of the redd up to 100m of stream mainly in the downstream direction seeking suitable habitat. If the densities are too high for the available habitat, the excess fry die in a few days. It is important that low velocity shallow areas with abundant cover in un-embedded gravel be readily available for these young fish.

Substrate in shallow areas , <10cm

Species	Excellent	Good	Non sustainable
Brown trout fry	Gravel	Cobble	Embedded gravel, cobble or sand
Atlantic salmon fry	Gravel	Cobble	Embedded gravel, cobble or sand
Brook trout fry	Gravel	Cobble	Embedded gravel, cobble or sand

Parr Habitats

Parr habitat summer and over winter

The primary limiting factors on parr are water temperature, which is directly related to reduced oxygen and the lack of suitable instream cover.

Summer Water Temperature ^{0}C

Species	Excellent	Good	Non sustainable	Notes
Brown trout adult	11 to 19	8 to 21	<6 or >24	
fry				
Atlantic salmon	7 to 15	7 to 19	<6 or > 20	
fry				
Brook trout	10 to 16	5 to 20	<3 to >22	
fry				
Salmonid	10 to 16	8 to 20	<6 or >22	Mixed population
fry				

Notes

- This is a very simple variable to monitor and a very common limiting factor.
- Temperature has to be combined with oxygen to find suitable habitats.
- For salmonids in streams or crowded conditions -- oxygen > 6mg/L;
  in ponds or lakes where there is no current-- oxygen > 3mg/l. Levels below 6mg /l must not last more than two weeks.

Sampling protocol

Average maximum daily water temperatures have a greater effect on trout growth and survival than minimum temperatures. The temperature that supports the greatest growth and survival is optimal.

Percent pools during the late growing season, low-water period

Species	Excellent	Good	Non sustainable	Notes
Brown trout	50 to 90	15 to 25	<15	
Atlantic salmon	20 to 25	10 to 30	<5	
Brook trout	35 to 65	12 to 90	<5	

Notes
Assessments should be done at low flows, if this is not possible you should measure the depth of the water at the crest of the riffle below the pool and then estimate how much pool there would be if the flow were lowered by that amount.

Sampling protocol
Polls are areas in the watercourse that are deeper than the average depth of the watercourse. This is measured or estimated on a reach-by-reach basis.

Equipment
Measuring tape and meter stick or survey rod

Pool class rating during the late growing season, low-flow period

Species	Excellent	Good	Non sustainable	Notes
Brown trout	>30% of the area is composed of 1st class pools.	>10% but <30% of the area is 1st class pools or >50% is 2nd class pools.	<10% of the area is 1st class pools and <50% is 2nd class pools	See pool class descriptions below
Atlantic salmon	20% of the area is composed of 1st class pools	>10% but <20% of the area is 1st class pools or	<10% of the area is 1st class pools and <30% is	Pools are critical for parr in low flow conditions and over-wintering pre-smolt

		>30% < 50% is 2nd class pools.	2nd class pools	
Brook trout	>30% of the area is composed of 1st class pools	>10% but <30% 1st class pools or >50% 2nd class pools	< 10% 1st class pools and <50% 2nd class pools	

Notes

This classification of pools should be done in conjunction with the percent pool assessment.

Sampling protocol
Rate all pools according to the following classification scheme;

First-class pool: Large and deep. Pool depth and size are sufficient to provide a low velocity resting area. More than 30% of the pool bottom is obscured due to depth, surface turbulence, or the presence of structures such as logs, debris piles, boulders, or overhanging banks and vegetation. Or, the greatest pool depth is >1.5 m in streams <5 m wide or >2 m deep in streams >5 m wide.

Second-class pool: Moderate size and depth >45cm at low flow. Pool depth and size are sufficient to provide a low velocity (>0.5m/sec) resting area. From 5% to 30% of the bottom is obscured due to surface turbulence, depth, or the presence of structures. Typical second-class pools are large eddies behind boulders and low velocity, moderately deep areas beneath overhanging banks and vegetation.

Third-class pool: Small or shallow or both < 45cm at low flow. Pool depth and size are sufficient to provide a low velocity resting area. Cover, if present, is in the form of shade, surface turbulence, or very limited structures. Typical third-class pools are wide, shallow, reduced velocity areas of streams or small eddies behind boulders. Virtually the entire bottom area of the pool is discernibl**e.**

Fourth class pool: shallow sections of stream with low gradient and size and depth are sufficient to provide resting areas for parr. Cover is limited to spaces under the substrate. The entire bottom is discernable**.**

Equipment
Meter stick or survey rod to measure depths

Substrate used for escape cover and over winter habitat for small juveniles

Species	Excellent	Good	Non sustainable	Notes
Brown trout	Cobble	Gravel	Sand	Non embedded
Atlantic salmon	Cobble	Cobble	Sand	Non embedded
Brook trout	See note	Cobble	Sand	Undercut banks, and large organic debris provide cover in pools. Small fish use instream non embedded cobble for cover

Note
Trout can use streams with sand/silt bottoms if they have sufficient cover for all life stages.

Sampling protocol
Measure 50 X 50 cm plots on the stream bottom and estimate the percentage of each bottom type suitable for cover in riffle, run, and pool areas.

Equipment
Measuring tape

Percent cover during the late growing season and over winter habitats

Species	Excellent	Good	Non sustainable	Notes
Brown trout	>30	20	15	low-water period at depths >15 cm and near bottom velocities <l5 cm/s
Juvenile	>15	10	5	
Atlantic salmon	>40	20	10	Un-embedded cobble is excellent Un-embedded gravel is good
Brook trout	>25	15	5	Substrate as for salmon or vegetation, large organic debris, or undercut banks

Sampling protocol
Visual estimate of the percentage cover in a reach.

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Pre-smolt habitats

Atlantic salmon pre-smolts spend the last winter in the river in pools feeding actively. The best habitat is in first or second-class pools with ice cover. This provides a diversity of cover, large enough for the pre-smolts, and the ice cover helps regulate the water temperature. These pools are often lacking in salmon habitats and can limit the population by restricting survival during this last stream stage.

Downstream migration

Salmonids moving downstream face into the current, moving out into the stream to find velocities of 45 to 60 cm/sec to carry them down. In ponds and lakes where the velocities fall below 15cm/sec they turn and swim with the current or follow the bank, seeking the outlet. Swimming depth is mid-water where you can see the bottom and secchi disc depth in deeper and coloured water. Obstructions include debris jams and especially dams because they have unnatural outlets. Dams often force the fish to go deeper in the water to find bottom outlets or rise to the near surface without the guidance of a sloping bottom to find surface outlets. To assess these obstructions you have to determine if the fish will find the outlet at their preferred swimming depth and velocity.

General water quality

Annual maximal or minimal pH. Use the highest and lowest measurement.

Species	Excellent	Good	Non sustainable	Notes
Brown trout	6.8 to 7.8	6 to 8.4	<5.5&> 8.6	
Organic acid		5.5+	<5.0	
Atlantic salmon	>6	>5.5	<5.0	
Organic acid		5.0 to5.4	<4.7	
Brook trout	6.5 to 8	5.5 to 8.5	<5 & >9	
Organic acid			< 4.2	Need pH5.5 to 8 in springs or seeps for spawning

Note:
For lacustrine habitats, measure pH in the zone with the best combination of dissolved oxygen and temperature.

Sampling protocol
During low flow periods the majority of the water in a stream is ground water and this flow will have the highest pH you can expect to find during the year. Low pH is found during high flow

period especially with the spring snowmelt. Rain events from the west and southwest are also very acid. Regular sampling assessments or continuous monitoring is best but time consuming. For general assessments to find limiting factors, sample during the period when the pH is expected to be at its lowest value.

The average minimum daily dissolved oxygen level (mg/L) during embryo development and the late growing season.

Species	Excellent	Good	Non sustainable	Notes
Brown trout $<10\ C^0$	>10	>7	<6	
$>10\ C^0$	>13	>10	<9	
Atlantic salmon	>10	>7	<6	
Brook trout $<15\ C^0$	>6.5	4.5	<4	
$>15C^0$	>8.5	6.5	<6	

Notes
Saturated is preferred for all water temperatures.

Sampling protocol
This is an important variable but very difficult to sample during the winter. This sampling should be done if you expect there is a high biological or chemical oxygen demand created by land use activities in the watershed. This is not a common limiting factor.

Clarity

Percent of time water is not muddy (more than 25mg/l suspended solids) see below

Species	Excellent/ good	Poor	Unsustainable
All salmonids	>90%	90 to 70%	>70%

General Stream Structure and Stability

Sedimentation and Suspended Solids

A large volume of suspended sediment will reduce light penetration, reducing photosynthetic activity of phytoplankton, algae, and rooted aquatic plants, especially those farther from the surface. Overall, suspended sediment leads to fewer photosynthetic plants available to serve as food sources for insects and, in turn, a lower food supply for fish.

Sediment introduced into surface water is either deposited on the bed of the stream or lake or suspended in the water column (suspended load). Bedload is large sediment particles that move by bouncing and rolling along the bottom. Generally, the suspended load in flowing water consists of grains less than 0.5 mm in diameter. Lake suspended loads usually consist of the smallest sediment fractions, such as silt and clays.

The current transports particles in both the bedload and the suspended load. Because the particles in the bedload move by rolling or bouncing along the bottom, bedload transportation occurs in flowing waters. These bed load particles fall into the spaces between the gravel and cobble in the stream bottom reducing insect habitat, filling in juvenile fish escape and over-winter cover, and plugging spawning beds. The volume of sediment transported and whether or not it is suspended or bedload is dependant on the particle size and the flow velocity. A high flow velocity can transport a greater number of larger particles than can a slower current. Any sediment transported by water is subject to deposition as flow velocity decreases.

The amount of sediment deposited on a rocky substrate can be quantitatively defined by an estimation of the percent embededness. The percent embededness is the degree to which fine sediments such as sand, silt, and clay fill the interstitial spaces between rocks in a substrate.

A 70% embedded substrate will cause changes to occur in the structure of macro-invertebrate fauna and most fry and small parr will leave an area or die when embededness levels reach 50-60%.

Optimal Ranges

0 to 10% embededness	Excellent Conditions
< 25% embededness	Good Conditions
25 - 50% embededness	Fair Conditions
50 - 75% embededness	Poor Conditions
> 75% embededness	Non sustainable

Note that trout can thrive in streams with high embededness if the springs and seeps used for spawning are clean and there is abundant instream cover in the form of undercut banks and large organic debris.

A guide to percent embededness: Hamilton 1984

- *0% embededness* = No fine sediments on substrate.
- *25% embededness* = Rocks are half surrounded but not covered by sediment.
- *50% embededness* = Rocks are completely surrounded but are not covered by sediment.
- *75% embededness* = Rocks are completely surrounded and half covered by sediment.
- *100% embededness* = Rocks are completely surrounded and completely covered by sediment.

Suspended solids should be kept to a minimum. USA and European guidelines for salmonid streams set an upper limit of 25mg/l as the long-term average and 80mg/l in a grab sample. Canadian (CCME) guidelines for aquatic life set a limit of 10 mg/l above background levels for watercourses with background less than 100mg/l. As the levels of suspended solids rise above 25 mg/l, salmonids lose the ability to see the drifting food and insects become detached from the substrate and drift. The growth and condition of the fish is reduced the longer the suspended solids are > 25mg/l during the growing season.

Bed loads in Maritime streams are primarily sands and silts from erosion caused by poor land use and poorly designed work around instream structures such as culverts and bridges etc. As this bedload in fills the gravel/cobble/boulder substrates, it prevents the river from sorting these heavier substrates by “cementing “ them into the bed. The result is a river that has a shallower cross section with poor thalweg and pool development, and is approximately 20% over widened.

Restoration
Digger logs, rock sills, deflectors

Percent of stream area shaded between 1000 and 1400 hr (for streams >50 m wide).

Species	Excellent	Good	Non sustainable	Notes
Brown trout	50 to 75	>25	<10	Do not use for cold <18^0 C summer max
Atlantic salmon				
Brook trout	50 to 75	>25	<10	Do not use for cold <18^0 C summer max

Sampling protocol
Estimate the percentage of the reach shaded on a sunny day. There are hand held convex mirrors with grids marked on then for the estimation of forest crown cover that are useful but not necessary.

Dominant substrate type in riffle-run areas & food production.

Species	Excellent	Good	Non sustainable	Notes
Brown trout	A	B	C	See below
Atlantic salmon	A	B	C	See below
Brook trout	A	B	C	See below

For all salmonids the dominant substrate (>50% of the area)

A) Rubble or small boulders, or aquatic vegetation in spring areas, dominate; limited amounts of gravel, large boulders, or bedrock.
B) Rubble, gravel, boulders, and fines occur in approximately equal amounts or rubble-large gravel mixtures are dominant Aquatic vegetation may or may not be present.
C) Fines, bedrock, small gravel, or large boulders are dominant. Rubble and small boulders are insignificant < 25%.

Percent fines (<3 mm) in riffle-run

Species	Excellent	Good	Non sustainable	Notes
Brown trout	<10	10 to 25	>35	
Atlantic salmon	<10	10 to 25	>35	
Brook trout	<15	15 to 35	>45	

Sampling protocol
Combine the estimate of the two variables above
Measure 50cm X 50cm plots on the riffle areas and estimate the substrate types.

Average percent vegetation (trees, shrubs, and grasses) along the stream bank during the summer for allochthonous (leaf litter) input.

Species	Excellent	Good	Non sustainable	Notes
Brown trout	>120	60 to 120	<40	
Atlantic salmon	>120	60 to 120	<40	
Brook trout	>120	90	<60	

Note: Vegetation Index = 2 (% shrubs) + 1.5 (% grasses) + 1(% trees) + 0 (% bare ground).

Average percent rooted vegetation and stable rocky ground cover along the stream bank during the summer

Species	Excellent	Good	Non sustainable	Notes
Brown trout	>75	40 to 75	<30	
Atlantic salmon	75	40 to 75	<25	
Brook trout	75	40 to 75	<25	

Sampling protocol

Visual estimates of the vegetation types and percent rooted vegetation on both banks by taking sections of 10m (5m to your right and 5m to your left) as you face the bank. Sum up the totals for the reach.

Average annual base flow regime during the late summer or winter low-flow period as a percentage of the average annual daily flow (cfs).

Species	Excellent	Good	Non sustainable	Notes
Salmonids	50	30	20	

Average annual peak flow as a multiple of the average annual daily flow.

Species	Excellent	Good	Non sustainable	Notes
Salmonids	2 to 3	>1 and < 4.5	<1 and >5	

Note: For embryo and fry habitat suitability, use the average and highest flows that occur from time of egg deposition until two weeks after fry emergence.

Sampling protocol

These are difficult variables to monitor if the stream does not have a gauging station or a staff gauge with flow duration curves. However, you can see if there is a problem by observing the flows and estimating which category your stream falls into. Generally forested watersheds with permeable soils fall into the excellent category and more developed watersheds with hard impermeable surfaces fall into the poorer categories.

Restoration techniques

Run off control and ensure ground water areas are recharged.

Lake Habitat

The same water quality, cover, and physical habitat variables apply to lakes. Lakes are often holding areas for adult salmon during the summer and may have small population of parr when the population in the watershed is high or during times when the stream habitats are unsuitable and the young fish fall back into lakes. Shallow lakes warm to the bottom and usually have water temperatures that are too high for good habitat during the mid-summer. Deeper lakes stratify with the warm water on the surface and cool water suitable for the fish 3 to 6 m down. The fish seek the preferred water temperature. If the organic loading in the lake is low, then the decaying material in the cool waters will not reduce the oxygen level below 6mg/l and the salmon will hold and trout will grow well. If organic loading or nutrient loading is high, the oxygen will be depleted and these cool water refuge areas are lost. Temperature and oxygen profiles during the late summer define this limiting factor.

Similar information is available for other species either by using information in the USFW habitat suitability indexes that can be found at http://el.erdc.usace.army.mil/emrrp/emris/emrishelp3/list_of_habitat_suitability_index_hsi_models_pac.htm

The only assessment provided here is for salmonid stream habitats but there are other assessment procedures available for lakes, all freshwater and saltwater wetland types, estuaries, and other coastal habitats.

Contact your NSSA adopt-a stream coordinator and local experts for assistance in assessing these habitat types.

The stream survey form can be completed on a reach-by-reach basis for detailed surveys or a more general sub-watershed basis for general surveys.

Stream Survey summary form

River	**Date**	**Assessor**
Reach number	**Start GPS**	**Finish GPS**
Weather	**Air temp**	**Water temp**
Life stage	**Variable**	**Quality**
Migration	**River water depth**	
	Water velocity	
	% Pool	
	Pool class	
	Frequency of pools	
Spawning	**Water depth**	
	Water velocity	
	Substrate quality	
	Availability of gravels	
	Cover	
Egg	**Winter O_2**	
	Max daily temp	
Alevin	**Embededness**	
Fry	**Substrate quality**	
	Shallow areas	
Parr	**Summer water temp**	
	% pool fall and over winter	
	Pool class	
	Substrate cover	
	Over-winter cover	
Pre-smolt	**Pools with ice cover**	
Down stream migration	**Velocities**	
	Barriers	
Water quality	**pH**	
	O_2	
	Clarity	
General stability	**Embededness**	
	Shade	
	Vegetation index	
	Vegetation vs. bare	
	Low flow as % of annual	
	Peak flow	

7.11. Concluding Activity

Do not be intimidated by the task of reporting.

A report does not have to be complicated to be useful.

Get someone from the community who is good at putting a report together (municipal official, teacher) to help you, or ask a high school class to do it as a project.

Prepare a report that contains the following headings:

1.**Historical Review** - Provide information on what the watercourse was once like. Include your map and research results (from written and oral sources).

2. **Current Conditions** - Provide information on what the watercourse is like now. Include your map, land-use forms, and stream survey forms.

3. **Changes and Problems** - Summarize what your group considers to be the watercourse's problems and their causes.

4. **Recommendations** - Provide some ideas on how the watercourse can be improved (clean-ups etc.). If you want to get some ideas see the section **Enhancing Your Watercourse**. In order to get ideas, break your group into small discussion sessions and brainstorm. Four or five people putting their heads together can come up with a list of things.

5. **Resources** - Summarize what you and your group have already put into the project (time, money, etc.) and what resources you will be able to provide for rehabilitation.

Once your report has been completed you are ready to create a rehabilitation plan with habitat officials. Probably you have been in contact with them already. Let them know you are now ready to sit down and make plans. Before you begin clean-up or enhancement activities, make sure you read the next Section (**Before You Begin Restoration**).

Sample Report Outline

1. Cover Page - Name of Group
    Name, address, phone of contact person
    Watercourse reported on, location
    Date of report

2. Background
    Brief description of your group, and how you came together
    Brief description of the watercourse, and why you chose to study it

3. Historical Review
    Map of how the watercourse used to look
    Oral History Reports
    Other research (old maps, photographs)

4. Changes and Problems
    Map of how it looks now
    Survey results
    Problems and their causes

5. Habitat assessment, the limiting factors
    An assessment, reach by reach if necessary, to highlight all the bottlenecks and problems

6. Recommendations
    What you would like to do

7. Resources
    How many people you have
    How much time you have
    How many resources you have (equipment, money etc.)

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

TRUE AND FALSE QUIZ

	True	False
1. The past history of your watercourse is just as important as what's happening to it now.		
2. Scientists understand the history of most streams and rivers in Nova Scotia and this information is well documented.		
3. The best way to collect historical and background information on your watercourse is to talk to as many people as possible in your community.		
4. Surveys of watercourses should only be done where you know there has been pollution or some change.		
5. When you prepare a report on your research and surveys you will need an expert to write it.		

ANSWERS CAN BE FOUND AT THE END OF THIS MANUAL