The Nova Scotia Fish Habitat Suitability Assessment

A Field Methods Manual
Nova Scotia
Freshwater Fish Habitat Suitability Index Assessment
NSHSI

Version 2.1, June 2018

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1. INTRODUCTION

The Nova Scotia Fish Habitat Suitability Index Assessment (NSHSI) is intended to standardize freshwater fish habitat assessment while making use of habitat suitability variables and values specific to the rivers of Nova Scotia. This index standardizes field method assessments for variables such as site identification, water quality, channel cross-sections, substrate, cover, riverbanks, riparian areas, and benthic macroinvertebrates.

The field methods are based on a Habitat Suitability Index (HSI) methodology developed by the USFW specifically the Brook trout (*Salvelinus fontinalis*) HSI and have been modified to represent the unique features of Nova Scotian watercourses. Additional HSI variables for Atlantic salmon (*Salmo salar*) have been drawn from the literature and used in the salmon habitat assessment. The methods are based on freshwater hydrology and geomorphology that develop the physical habitat and water quality that are commonly degraded by anthropogenic (human) impacts on the quality of fish habitat.

The NSHSI is designed to aid individuals and groups involved in freshwater fish habitat conservation. It provides a tool for groups and individuals to assess sites prior to potential degradation of fish habitat, and to examine and quantify their impacts. The NSHSI is to be used to determine the degree of harm and the weaknesses within the habitat in order to aid in restoration planning. Once evaluated in the NSHSI habitat variables can offer an accurate assessment of fish habitat quality.

This manual provides information that should be consulted before completing assessments, as well as a data collection form and suggested list of field equipment. Sections 2-9 outline the field methods for site identification, water quality, channel cross-sections, substrate and cover, riverbanks and riparian areas, and benthic macroinvertebrates biomonitoring. A field data sheet and field reference sheet can be found in appendices 1 and 2. For the assessment of culverts, please refer to the culvert assessment protocol on the NSLC AAS website.

1.1 Field Work Considerations

The field methods outlined in this manual are intended to be completed during the spring, summer and early fall months, when weather and river conditions permit the work. It is recommended that field crews observe the local weather and river conditions and conduct assessments for those habitat variables affected by flows and temperature during critical periods. A field crew of three is ideal for completing assessments on individual stretches of river, however it can be done with two people.

1.2 Safety Considerations

Water levels can change dramatically and can be hazardous to those working in large river flows. Field crews should not enter watercourses with swift water or dangerous currents. A Swift Water safety course should be taken if there is a possible risk associated with completing field work. A remote access plan should be created in case of emergency, especially when working in isolated areas. A first aid kit, including a cell phone, should be available to field crews at all times. Sunblock and bug repellent are also valuable items when working in the field.

1.3 Habitat Assessment

The assessment of fish habitat outlined in this manual is based on habitat requirements and limiting factors for salmonids. The features being assessed in the field methods are largely based on suitability curves developed for the HSI for Brook trout that have been adapted to include Atlantic salmon and to suit conditions in Nova Scotia. Both species are considered to be indicator species in the rivers of Nova Scotia, meaning that their presence, absence, or overall health can indicate changes in environmental conditions.

In 1982, the Fish and Wildlife Service of the U.S. Department of the Interior produced an HSI for Brook trout, written by Robert F. Raleigh (http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-024.pdf). The HSI describes the specific ecological characteristics of Brook trout through evaluations of all habitat components using suitability models. The 15 criteria which are calculated in the NSHSI Excel spreadsheet are based on this suitability modeling approach.

For each criterion, graphs with suitability curves are used to model the specific qualities of habitat based on field and laboratory tests. For each variable, a range of habitat suitability, from 0.0-1.0 are established and grouped from poor quality (0.0-0.39), moderate quality (0.4-0.8), good quality (0.81-1.0) to optimal quality (1.0).

Using temperature as an example, Table 1 and Figure 1 illustrate how the suitability index and quality rating are obtained from field measurements.

Suitability Value	Water Temperatures	Results due to temperature
0.0-0.39	< 3 ˚C, > 22˚C	Will support none or small numbers of Brook trout, high risk of fish mortality
0.4-0.8	3- 6.5 ˚C & 19 to 22 ˚C	Will support some Brook trout, some risk of fish mortality
0.81-1.0	6.5-10 & 16-19 ˚C	Will support many Brook trout, moderate growing temperature, no risk of fish mortality
1.0	10- 16 ˚C	Optimum temperature range during the growing season

Table 1 - Brook trout summer growing season water temperature suitability

Figure 1 - HSI graph for maximum water temperature

Using either table 1 or figure 1 it can be inferred that Brook trout prefer a temperature range of 6.5-19˚C, with optimal temperatures between 10-16˚C, during the growing season but will tolerate ranges of 3-6.5˚C and 19-22˚C with lower rates of growth. Once temperatures drop below 3˚C or rise above 23˚C, the temperature becomes a limiting factor, and Brook trout will not survive extended periods of time. For example, if the temperature recorded in the field was 19˚C then the suitability value would be 0.8, a moderate value and trout usually begin to seek cooler water.

1.4 The NSHSI Excel Spreadsheet

The NSHSI Excel spreadsheet evaluates data collected in the field based on suitability models so that limiting factors can be easily identified for both Atlantic salmon and Brook trout. The program calculates 15 important criteria for each species in a range from 0-1, where poor quality is given a value of less than 0.4, moderate quality has a value between 0.4 and 0.8, and good quality has a value of greater than 0.8. For easier identification, the program gives poor quality variables a red color, medium quality a yellow color and good quality a green color. The criteria evaluated are: percent pools, pool class rating, percent instream cover for adults and juveniles, the dominant substrate type in riffle run areas, vegetation along the streambank, rooted vegetation and stable rocky ground, water temperature, pH, size of substrate in spawning areas, % fines in spawning areas, percent fines in riffle-run areas, substrate size class for winter escape, thalweg depth during late growing season, and percent stream shade.

This gives a picture of how Brook trout and Atlantic salmon populations are limited by each variable and identifies aspects that need restoration. Or for example, changes in habitat can be identified before and after instream or adjacent construction helping to quantify habitat damage and required offsetting requirements or the success of the restoration done to offset unavoidable damage to habitat. Habitat variables that are unsuitable can be improved, and valuable habitat can be identified and protected.

1.5 Adopt A Stream Template

The NSLC Adopt A Stream (AAS) *Watershed Based Fish Habitat Restoration Plan Template* is a useful and effective tool designed to organize habitat-related information collected in a watershed. It is meant to encourage more watershed scale planning of restoration efforts in Nova Scotia and can be applied to sub-watersheds within larger river systems. Completed sub-watershed plans contribute to the overall watershed plan for the larger river system.

The five-part template consists of: a list of restoration plan objectives (Part 1), watershed overview information (Part 2), a watershed mapping exercise (Part 3), a table including habitat descriptions and restoration opportunities (Part 4), and a summary and prioritization of proposed restoration projects (Part 5). The template and introductory information document can be found on the NSLC Adopt A Stream website (http://www.adoptastream.ca/planning-and-funding/develop-plan).

Detailed information regarding fish habitat can be found in Parts 3 and 4 of the AAS Template. Part 3 outlines the methodology for gathering site specific information from sections of the river, and plots important habitat features on local maps. Information can be gathered by walking the stream, reviewing maps, and/or collecting information from past reports. Part 4 involves filling in a table with details of all habitat features of the river. Suggested restoration projects for individual sites, where applicable, are also included in Part 4.

The NSHSI is intended to expand the level of detail in the AAS template to allow reach-specific restoration plans. The template can be completed for entire rivers, or for specific reaches identified by the more general planning process that need detailed assessments, using relatively few resources. When the data entry is completed, poor criteria, outlined in red, can be referenced and inserted into the template. These results, together with the template, can be used to develop a restoration plan.

The AAS template is used by groups involved in fish habitat assessment and restoration to gain an understanding of the habitat quality in their river. The first level of information put in the template is general and acts as a guide to complete further assessments. As the template is filled in, areas requiring a more detailed level of assessment will be identified and included.

1.6 River Terminology

Water flow and its effect on processes, patterns and sediment deposition, as well as on the surrounding areas have been well studied and common terminology has been developed to describe these features. This section outlines several of the processes and formations that play a role in fish habitat remediation. (Figures 2 to 4).

1.6.1 Landscape Features

Floodplain – the relatively flat area of land adjacent to a river channel which gets submerged when water levels are high. Floodplains can extend a few meters in width or up to a few hundred meters, depending on the slope of the land.

Rivers, Brooks, Streams, Tributaries – although these terms indicate different sizes of watercourses, they are used interchangeably in this manual when describing all watercourses that are not lakes, ponds, or wetlands.

Watershed/Drainage area –land that drains surface water to a common point. The watershed of a river can be identified by joining the highest points of land on a topo map that surround and slope down to the watercourse. The area with in the polygon drawn is the watershed. Most computerized mapping programs will give you the area of the watershed. If you are using paper maps there are do grids that can be used to get the area.

1.6.2 Channel Measurements

Bankfull Level – the level of water flow in a river just before it spills over the banks into the floodplain. The bankfull level can be identified by changes in bank angle, vegetation, and soils (*see Section 4*). **In a well-formed river, this is the channel that holds the 1-in-2 year mean daily flow.**

Bankfull Height – the height or elevation of the bankfull level above the streambed.

Bankfull Width or **Channel width** – the width of the river channel at the bankfull level.

Thalweg – the deepest location in a channel cross-section, and the area where water will be found during low water events.

Wetted Width – the width of the river that contains water at the time of measurement.

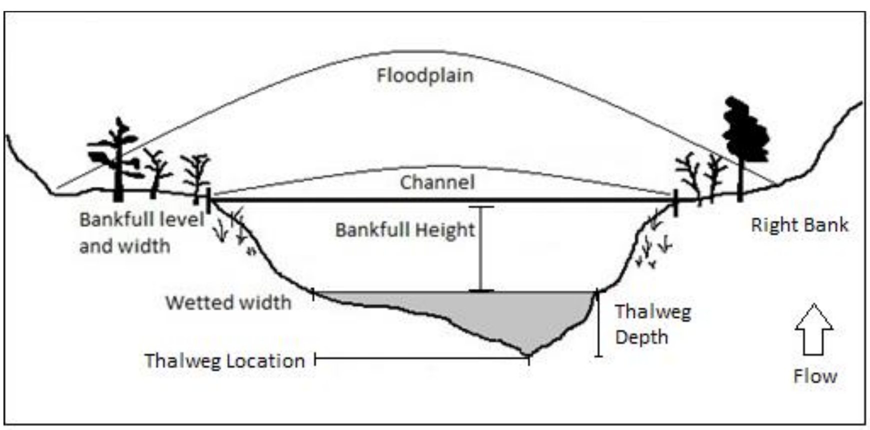

Figure 2 - Landscape and channel components

1.6.3 River Meander Pattern

Meander Sequence (full) – the meandering or sinuous pattern many rivers follow that features steps, pools, riffles, and runs. A full meander sequence usually has two pool, riffle, and run areas in low gradient rivers and steps, pools and runs in higher gradient rivers. The number of step-pool segments in a meander sequence is dependent on stream grade and substrate rock size.

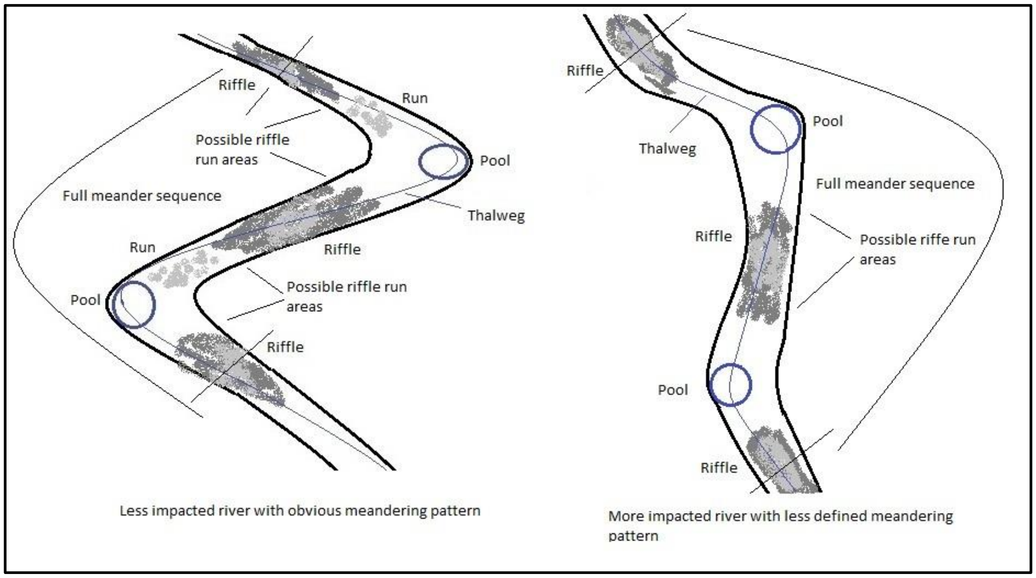

Figure 3 - Full meander sequence and habitats in two hypothetical rivers

Habitat Unit – a habitat unit is half of a full meander sequence. It is generally comprised of one pool, riffle and run area or a series of steps.

Pool – a deep and slow section of river used by salmonids for cover and resting. A good pool is greater than 30cm in depth and is up to 20% of the river width. Pools generally occur near the corners of the meander.

Riffle – a shallow (generally less than ~10cm deep) and fast section of river that occurs between pools at crossover points in the meander pattern. Riffles are important for benthic macroinvertebrate (insect) production that are food for fish and Salmon feeding areas.

Run – a moderately deep section, somewhat slower than a riffle, that occurs in varying locations in a river pattern and is used by salmonids for feeding cover and holding.

Riffle/Run – areas with both riffle and run characteristics.

Step-pool – a series of staircase like pools, which occur in steeper channel sections. Each pool has a defined step made of larger substrate, such as cobble or boulder, followed by a drop into a pool. Figure 4 provides an illustration of a step-pool. In this diagram S_d represents the depth of the pool at low flow, Z_s represents the drop over the step-pool section and S represents the slope of the section.

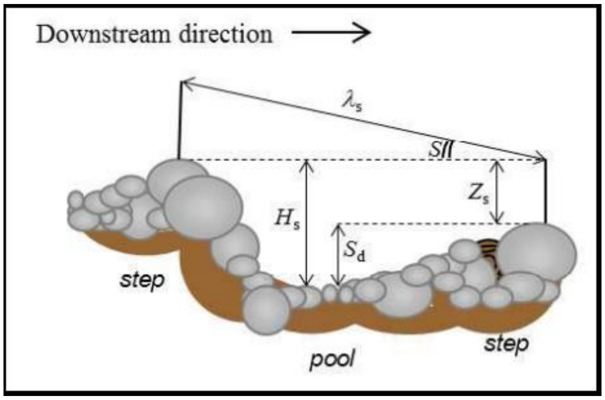

Figure 4 – illustration of a step-pool

(Sourced from http://archive.rrnw.org/docs/2012/Session%205/3Burke_020112-final.pdf)

Tail of Pool, Crest of Riffle – the area at the most downstream end of a pool or the most upstream end of a riffle, where a slow, deep section of river becomes a shallow and fast section. This area is used to estimate pool depths during low flows, because it controls the pool depth by holding water back during low flow periods. The depth of flow on the crest of a riffle can be found by picturing a transect across the highest point of the riffle and measuring the depth at the lowest point (the thalweg) in this line. This is the last place water will drain from the pool.

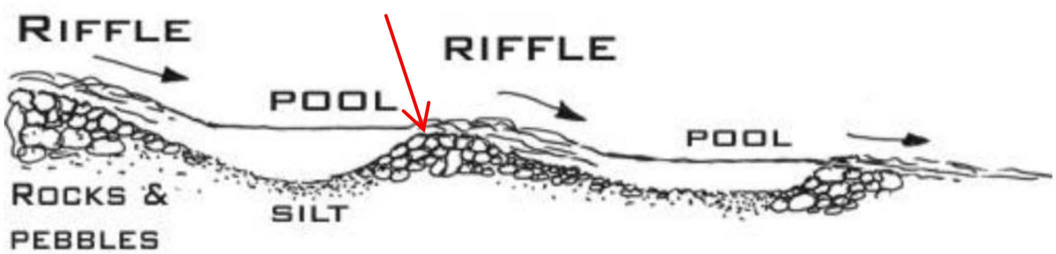

Figure 5 - Where to find the crest of a riffle, tail of a pool

1.7 Equipment

Certain equipment is needed to complete the field methods outlined in this manual. While working outside, in or near water, field crews should wear weather-appropriate clothing and pack the safety items. It is a good idea to label and brightly mark (orange paint or flagging tape) all equipment used in the field, read all instructions and manuals, and be aware of usage and storage best practices for sensitive equipment. Following these simple steps will ensure equipment remains in good working condition. See appendix 2.

1.7.1 Community Based Environmental Monitoring Network

The Community Based Environmental Monitoring Network (CBEMN) (http://www.envnetwork.smu.ca/) is based out of St. Mary's University in Halifax. Their role is to connect community groups in the region who are involved in watershed stewardship and to assist them with their monitoring. The CBEMN offers assistance to individuals or groups working in environmental monitoring by providing support and field equipment. Some water quality monitoring and other field equipment is available free of charge through the Environmental Stewardship Equipment Bank at CBEMN, and can be loaned upon request. A spokesperson for the CBEMN can be reached at 902-491-6243, or at environmental.network@smu.ca

1.7.2 Water Quality Monitoring

There are several types of equipment that can be used in water quality monitoring, which are outlined in Section 3. The water quality parameters outlined in this manual are sampled by multi-probe devices (YSI, Hydrolabs, handheld testers), or single parameter units that use digital probes or sensors to measure different variables. When using digital devices, calibration and proper storage are very important in order to keep the device in working order and to maintain accuracy.

The two water quality measurements required for habitat assessment are pH and temperature; while conductivity and total dissolved solids measurements are optional. If more information is required on water quality, certified laboratories will provide the sampling bottles and process water samples for parameters not usually measured by in-field devices, such as metals, fecal coliforms, and others. For more information, typical water quality in Nova Scotia can be found on the AAS website. (http://www.adoptastream.ca/project-design/interpreting-water-quality)

1.7.3 Benthic Macroinvertebrates Biomonitoring

There are two options for completing benthic macroinvertebrates biomonitoring. The first option is participation in the Canadian Aquatic Biomonitoring Network (CABIN), a set of equipment can be loaned out by CABIN or CBEMN upon request. A bucket or tray (preferably white) is needed to sort and identify benthic macroinvertebrates, and a dip net (or any net with a fine mesh) is required when using the three-minute kick sampling method. Buckets and nets used to collect benthic macroinvertebrates can be loaned out from CBEMN.

The second option is the rock grab method which doesn’t require any special equipment, but a bucket or tray may be preferred to help identify benthic macroinvertebrates.

2. SITE IDENTIFICATION & TRANSECT ESTABLISHMENT

2.1 Introduction

Perhaps the most important section of this manual is the process of site identification and the proper spacing of transects. Sections 2.2-2.5 should be completed before entering into the field. When a site has been identified and evaluated, results from the collected data apply to the habitat found within the site boundaries. Geographic coordinates and unique naming ensures the data is tied to habitat conditions. This is especially important when a site is to be revisited in the future.

2.2 Naming

All sites are identified by their field sheet number, river/tributary name, and watershed code. A field sheet number is used to separate individual sites and assessments in a given river, while river names (e.g. LaHave River, West LaHave River branch, Harley Lake Mill Brook) allow sites to be grouped in their respective rivers. Watershed codes (e.g. 1EF) allow sites in the same watershed to be grouped together and keep rivers across the province with the same name from being mixed up. Watershed codes can be obtained through the Nova Scotia Environment website (http://www.novascotia.ca/nse/water.strategy/docs/WaterStrategy_NSWatershedMap.Secondary.pdf). When sites are evaluated more than once, assessments are separated by dates in addition to unique field sheet numbers.

2.3 Site Bankfull Width

The site bankfull width should be determined mathematically before entering the field. In general, rivers in Nova Scotia are over widened by 20% (DFO, 2006), due to degradation. Because of this, a formula based on watershed area and annual precipitation is used to develop an estimate of the proper stream width, rather than field measurements. The easiest way to calculate the site bankfull width is by entering the watershed area and annual runoff into the Excel AAS Stream Width and Flow Calculator, which can be obtained from the NSLC AAS.

Topographic maps can be used to obtain watershed areas. Geographic Information Systems (GIS) such as ESRI's ArcGIS online web map, (http://www.arcgis.com/home/webmap/viewer.html), Mapsource/Basecamp Garmin topographic maps or printed topographic maps are all effective choices. The Mean Annual Runoff Map for Nova Scotia (below) is used to find the annual runoff in the specific watershed the river is within. Runoff varies within the province from 600 mm/year to 1600 mm/year. Use the lines of equal Mean Annual Runoff to estimate the runoff at your site to the nearest 50mm. If several lines intersect your watershed area estimate the runoff at your site between two of the lines.

Once these values are found, the watershed area in km^2 and the mean annual runoff in mm can be entered into the AAS Stream Width and Flow Calculator to find site bankfull width, site length and transect spacing. Alternatively, the 'Watershed Area & Bankfull Width' formula can be used, where W is the site bankfull width in meters, A is the watershed area in km^2 and R is the mean annual runoff in mm. This is the same formula used in the AAS Stream Width and Flow Calculator excel sheet and is based on forested watersheds with gradients under 1%. If you are working in an urban area or in a very steep watershed, please consult AAS to assist with the sizing.

Watershed Area/Bankfull Width Formula

$$W = (3.397)*(A*R/1200)^{0.2891}$$

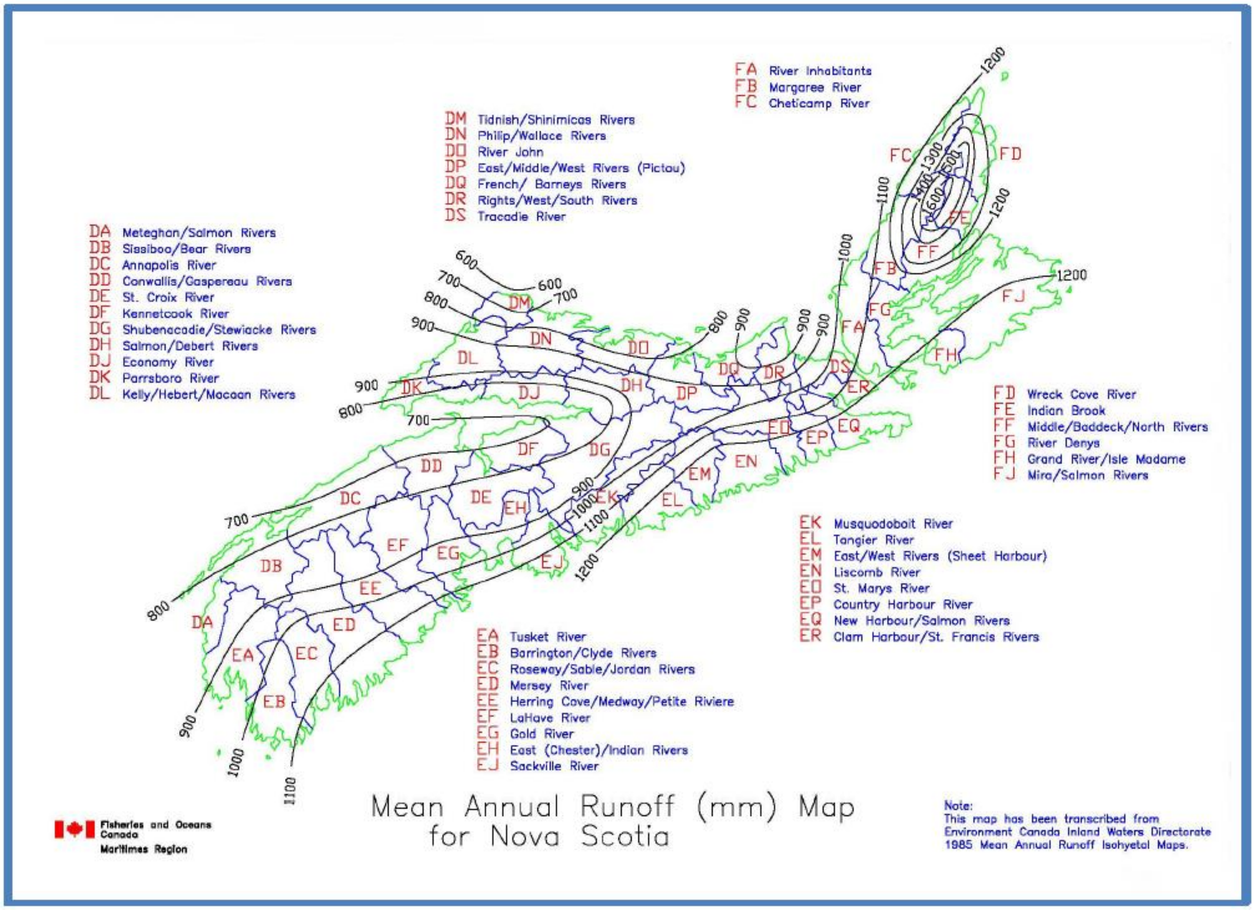

Figure 6 Mean Annual runoff (mm) map for Nova Scotia

(http://www.novascotia.ca/nse/surface.water/docs/nsmuseum_freshwaterhydrology.pdf for more detail)

2. 4 Transect Spacing and Site Length

As described in Newbury and Gaboury (1993), many rivers form a sinuous meandering pattern where areas of sediment scour and deposition create deep pools and shallow riffle areas in low gradient gravel cobble bed streams. In addition, the distance between similar features in a stretch of river (riffle to riffle or pool to pool) is related to the bankfull width, which is 5-7 bankfull widths for streams in Nova Scotia (Rutherford, 2011). This distance is called a half meander length and is our habitat unit of choice. Newbury and Gaboury, also found that bankfull widths can be calculated from watershed areas if you know the 1-in-2 year mean daily flow.

Sites outlined in this manual are a half meander sequence in length and should start and end at the crest of a riffle (Figure 5). A habitat unit is 5 to 7 bankfull widths and can be obtained directly from the AAS Stream Width and Flow Calculator or by multiplying the site bankfull width by 6. For consecutive sites along a stretch of river, the upstream boundary of the lower site would act as the downstream boundary for the upper site and GPS coordinates between adjacent boundaries should be the same. The site bankfull width calculation should be re-evaluated when a tributary or storm sewer enters the main river channel as the watershed area significantly changes at these points.

Transects are located every two bankfull widths but can be adjusted slightly to sample pools and riffles when these features are discernible. When pools and riffles are identified, transects should ideally sample the deepest part of the pool and areas with characteristic riffle features. See section 1.6.3 for habitat descriptions.

2.5 Stream Order

The stream order can be determined most easily by examining topographic maps. Label the first stream at the head of the watershed as 1 and increase the order by 1 each time two streams of the same order join until you reach the sampling area. When labeling streams in this way the smallest streams have the lowest numbers and the streams closest to the ocean have the largest numbers. Be sure to note the map scale used in this determination as 1:10,000 maps show more streams than 1:50,000 scale maps.

2.6 Where to Take Transects

Transects should be taken in sets of three with two site bankfull widths between them, take one set of transects below and one set obove each tributary and one in the tributary, or above and below a bridge or culvert. Also take a set of transects each time there is a 20% change in average stream width, a noticable change in substrate composition or a large change in slope, as these alter assesment results.

Remember to take pictures upstream and downstream on each transect, as well as of built structures (beaverdams, bridges, outlet pipes, etc.), erosion and unvegitated pointbars.

3. WATER QUALITY

3.1 Introduction

Obtaining an understanding of water quality will significantly aid in the assessment of fish habitat. However, water quality monitoring can be a complex and highly variable process, so when completing habitat assessments, be aware of how measurements are influenced by a variety of factors. The AAS website has a detailed explanation of water quality (http://www.adoptastream.ca/project-design/interpreting-water-quality). This section outlines methods for the assessment of water and air temperature, pH, conductivity, and total dissolved solids (TDS) in addition to important information to consider when initiating water quality monitoring. The components are regarded as important habitat variables for salmonids and the outlined methods should be followed to assist in the assessment of fish habitat quality. Only temperature and pH are required components of the assessment, while conductivity and TDS measurements are supplemental but very useful if they can be collected.

3.2 Field Methods

The following methods should be completed with spatial and temporal factors considered in order to obtain the most accurate picture of water quality and impacts on fish habitat. Water quality sampling locations located inside the site boundaries and are recorded in the spaces provided at the top of the field sheet. Although the evaluation is likely to be completed in a single field day, returning to the field to evaluate water quality at critical times can provide a more accurate assessment.

3.2.1 Water and Air Temperature

Brook trout and Atlantic salmon are cold water species preferring water in the mid to upper teens in centigrade degrees. The maximum water temperature is the most dominant factor in governing overall habitat quality for salmonids. Maximum temperatures are likely to be found in late summer at midday when the sun has the greatest influence on water temperatures. If sampled multiple times per day for multiple days, the critical value used in the HSI is the average of daily maximum temperatures. Where mid-afternoon temperatures exceed 20^{o}C temperature data loggers should be used to document the range of daily fluctuation and maximum temperatures. Monitoring air temperature and fluctuations in water temperature can indicate the ability of a river to stay cool during warm periods.

- During a low water period on a hot late summer day (if possible), measure water temperature at or near the site being assessed
- While taking water temperature, place a thermometer in the shade along the river to take air temperature. The thermometer should stay in the shade for 5-10 minutes to stabilize and needs to be far enough away from the water to avoid its cooling effect
- Record both values on the field sheet

3.2.2 pH

The acidity of rivers and lakes, or pH, is a measure of the charged hydrogen atoms (H+) present in the water column. pH is a significant water quality parameter for aquatic organisms including salmonids. Acid rain has caused a long-term reduction in the buffering capacities of many of the Nova Scotia soils that results in acidic water in our rivers and lakes. Groundwater base flow, found in the summer, generally has a higher pH than during rain events or snow melt when the rain is running off the land surface and not buffered by the soil and wetlands are being flushed of their organic acids. Organic acids from the breakdown of organic material can cause the pH value to drop as well, but do not have the same negative biological effects as low pH caused by the inorganic acids in acid rain. The colour of the water should also be noted, as the presence of organic acids causes darker colored water. Some points to consider:

- pH in poorly buffered areas will change quickly after a large rain events or snow melt. If pH is in the mid to low 5 range consider more sampling immediately after rain events or during the spring melt to determine the minimum pH level.
- Using a pH or multi-sensor probe, measure pH in the site being assessed.
- Record the value and the presence of organic acids in the notes section of the field sheet as 1) none 2) medium or 3) dark, as shown in Figure 7 (below).

Figure 7 - Presence of organic acids in water sample

3.2.3 Conductivity

Conductivity is a measure of the ability of water to carry an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) as well as ions that carry a positive charge (known as cations), that include sodium, magnesium, calcium, iron, magnesium and aluminum. It can also be affected by other pollutants. Conductivity is greatly affected by temperature; the warmer the water, the higher the conductivity. For this reason, conductivity is reported with the temperature. Changes in conductivity measurements taken while moving along a river are an indicator of changes in land use and geology. These can be further investigated as possible sources requiring remediation. The exact reason for a change would require a lab analysis of the water.

- Using a conductivity specific or multi-sensor probe, measure the conductivity.
- Record the value on the field sheet.

3.2.4 Total Dissolved Solids

Total dissolved solids (TDS) is a measure of dissolved or very small organic and inorganic particles and can indicate amounts of groundwater and surface runoff in a sample. Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants.

- Using a multi sensor probe or a conductivity probe measure the TDS.
- Record the value on the field sheet.
- Be aware that most probes use a formula to estimate TDS from the conductivity. This number may be quite different from the amount obtained from laboratory analysis.

4. CHANNEL CROSS-SECTIONS

4.1 Introduction

Obtaining an accurate depiction of fish habitat requires an understanding of a river's flow, and how changes in flow effect fish habitat. The critical times for salmonids and all other fish species are the low flow periods of late summer and winter, when rivers receive less rainfall and depend more on groundwater sources to maintain volumes of water. During these times, less habitat may be available to fish as some areas become inaccessible when water depths or temperature are not suitable to allow passage.

Channel cross-sections are used to measure bankfull and wetted level depths and widths across identified transect locations. This is compared to the expected channel width calculated in Section 2. Completed cross-sections are important to consider when evaluating fish habitat, as they can give an indication of sediment transport, thalweg development, overwidening and the condition of the river's flow within its floodplain.

4.2 Field Methods

Cross-sections are completed at each of the three transect locations as outlined in Section 2 and should run across the channel perpendicular (at a right angle) to the river's flow. The measuring tape used should span across the river from left to right looking downstream when all bankfull and wetted level measurements are made.

4.2.1 Floodplains

The floodplain can be identified by a relatively level topography outside the banks of a river that is bordered by sloped land (Figure 8). The presence of an obvious floodplain helps to indicate historical impacts and how the river handles floodwaters.

- Measure the average widths of the floodplain from the bankfull level of both the left and right banks and record it on the field sheet.
- If the floodplain is greater than 10m, you can write >10m on the field sheet.
- If the floodplain is not obvious, then measure 30cm above the bank height and visualize how far the water would flood from the river bank
- It is ok to estimate the floodplain width

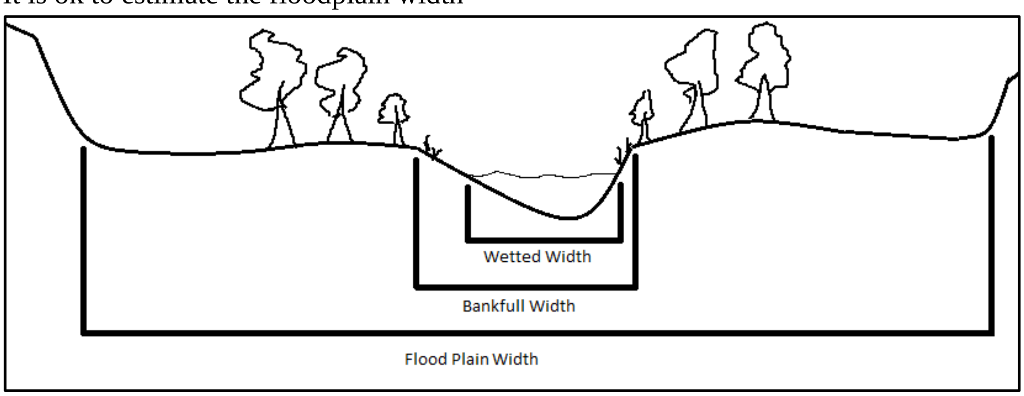

Figure 8 Wetted, bankfull, and floodplain widths

4.2.2 Identifying Bankfull Level

The bankfull flow is referred to as the channel shaping or defining flow, meaning much of the sediment movement (erosion and deposition) and thalweg development happens when flows reach this level. The bankfull level can be identified by visual features, some of which may or may not be present at each cross-section (Figures 8 and 9):

- **Major Inflection Point:** inflection points are found where the angle of the bank changes. The major inflection point moving from vertical to sloping, sloping to vertical, or vertical or sloping to flat can indicate the bankfull level;
- **Erosion/Scour Line, Changes in Sediment**: obvious changes in sediment, horizontal scour lines, or evidence of erosion can indicate bankfull level;
- **Changes in Vegetation:** obvious changes in vegetation with varying tolerances of water saturation in soils can also indicate the bankfull level. Changes from no vegetation to grasses, grasses to small herbaceous plants, and herbs and grasses to shrubs and trees often indicate bankfull level.

- Bankfull heights should be the same across both banks.
- A hand level can be used to compare or identify indicators on opposite sides of the bank to confirm the bankfull level.
- When the exact level is inconspicuous, pick the side that is lowest and has an obvious floodplain.

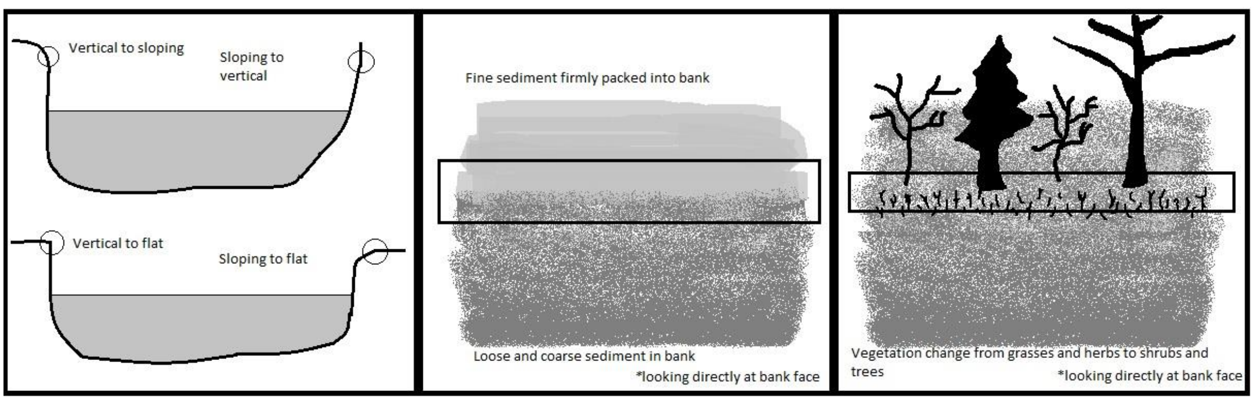

Figure 9 - Bankfull level indicators

Figure 10 - Bankfull levels in the field (left: inflection point and change in sediment, right: inflection point and change in vegetation)

4.2.3 Measuring Bankfull Widths and Heights

- At each cross-section, a bankfull width and its height above the water level is taken
- Start measuring from the left bank looking downstream
- Pin the measuring tape into the banks or have a colleague hold the tape at the bankfull level and record the width on the field sheet (Figures 10 and 11)
- Using a meter stick or second measuring tape, measure the bankfull height from the water surface to the top of the bank and record it on the field sheet

Figure 11 - Bankfull height and width measurements

4.2.4 Wetted Widths and Depths

- At each cross-section, a wetted width and three wetted depths are taken at distances of ¼, ½, and ¾ across the wetted portion of the cross-section from left to right looking downstream (Figures 12 and 13*)*

- Pin the measuring tape into the banks or have a colleague hold the tape perpendicular to the banks at the edge of the water and record the width on the field sheet under wetted width.
- Divide the wetted width by 4 to determine the length of each quarter section
- Starting at the left bank use the meter stick to determine the depth of the water at distances of ¼, ½, and ¾ across the wetted portion of the cross-section
- Use the water level on the downstream side of the meter stick to determine depth as the level on the upstream side may be affected by stream velocity
- An estimated negative depth, or height above the water level, should be taken if a measurement is located with no water depth in the adjacent area (an island or section of riffle with no significant depth or flow). A measurement of zero can also be taken if the river bottom is approximately the same height as the water level
- A depth can be taken in a nearby representative area of the location if a depth location is on a rock or other feature that would misrepresent the cross-section (a boulder above the water level but with the adjacent area exhibiting depth)

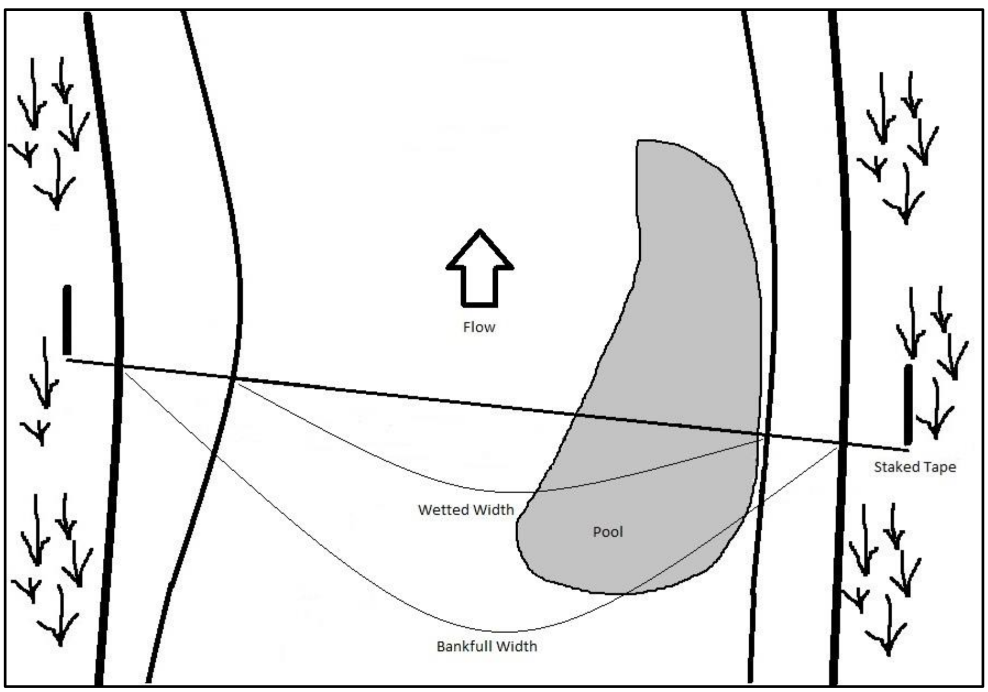

Figure 12 - Wetted and bankfull widths

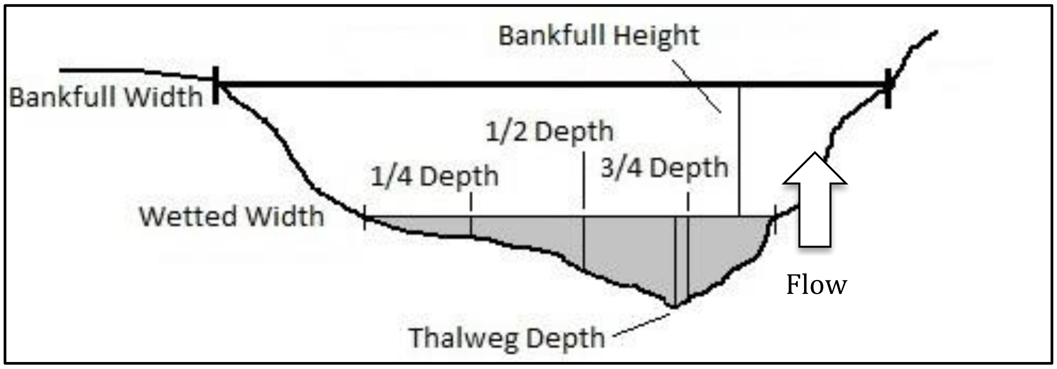

Figure 13 - Measured widths and depths at cross-sections

4.2.4 Thalweg Depth and Location

- The thalweg, or highest water depth, and its location are measured across each transect.
- Use the meter stick to identify the thalweg, measure its depth, and record it on the field sheet. Greater than 1m (>1 m) can be used if the water level is too deep to measure.
- Measure the location of the thalweg along the wetted width (distance from the edge of the water on the left side) and record it on the field sheet as well.

5. SUBSTRATE AND COVER

5.1 Introduction

Throughout all life stages of salmonids and other fish species, substrate and cover are crucial to survival. Suitable substrate and cover facilitates successful migration to and use of spawning and rearing areas, allows protection from predators and swift water, and provides important food sources. Small gravels are used by salmonids for spawning whereas larger cobble and boulders provide cover and resting for juveniles and adults. Substrate size class percentages and embeddedness are limiting factors to salmonid distribution and reproduction. Salmonids are likely to avoid areas where these habitat components are lacking, which make them important to evaluate.

The assessment for substrate and cover requires visual observations of substrate type (fines, gravel, cobble, boulder, bedrock/hardpan) percentages, substrate embeddedness, and unembedded in-stream cover.

Late summer is a critical time for salmonids when water depths decrease and in-stream cover is reduced. Usually deep pools will remain viable for fish as water levels decrease. For consideration in this section, unembedded cover should ideally be assessed during low water flows. Substrate is not normally affected by water levels and can be assessed at any time.

5.2 Field Methods

At each transect record the GPS location and habitat type (riffle, run, pool, or step) on the field sheet under substrate and cover. Then, estimate substrate percentages along each quarter section of the wetted width, evaluating embeddedness at the thalweg. Estimate cover for the entire transect.

5.2.1 Substrate Percentages

Table 2 outlines size ranges for each substrate type. Field crews should familiarize themselves with substrate sizes before completing field work to improve sampling accuracy. The median (intermediate) axis across the substrate is used when measuring all substrate (Figure 15).

- At each transect, substrate percentage evaluations are made along the wetted width of the transect at each quarter section.
- Place the 50cm by 50cm grid in the middle of the quarter section and record the dominant substrate type within each of the 20 squares.
- Each square in the grid is equal to 5% of the area,
- Multiply the number of squares of each substrate type by 5 and record the percentages on the field sheet

Substrate	Size (cm)
Fines (sand, silt)	< 0.2
Gravel	0.2-6.4
Cobble	6.4-25.6
Boulder	>25.6

Table 2 - Substrate Sizes

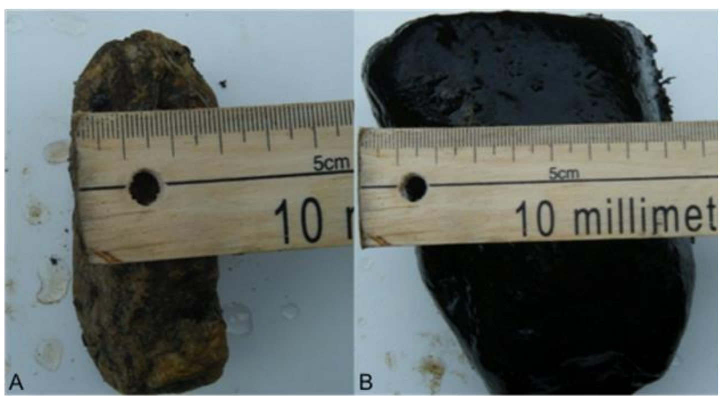

Figure 14 - A: Gravel, B: Cobble

Figure 15 - Using the grid

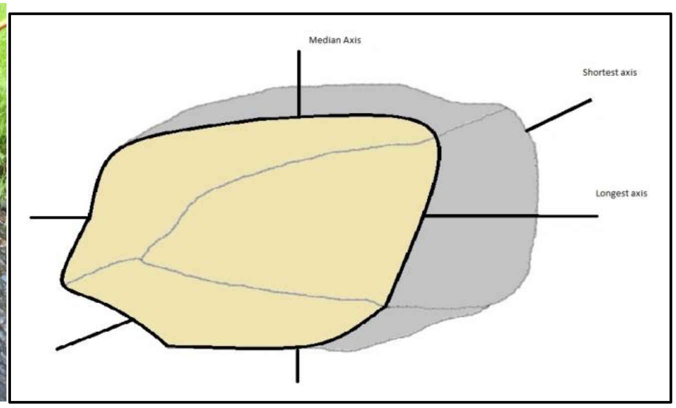

Figure 16 - Axis of substrate (Adapted from Stanfield, 2010)

5.2.2 Embeddedness

Embeddedness refers to the degree that boulder, cobble, and gravel substrate is surrounded by finer sand and silt material that fills in spaces between the individual rocks. Highly embedded substrate limits spawning and rearing success of fish, reduces habitat for benthic macroinvertebrates, and impairs a river's ability to form a thalweg and transport material.

- To assess embeddedness, lift up several top rocks in the thalweg of the transect.
- Estimate the percentage of fines (< 2mm in size) underneath and record it under embeddedness on the field sheet.
- If it is difficult to lift the top rocks because they are cemented into the sandy material below, it is considered 100% embedded.
- If the transect is composed entirely of bedrock, this is also considered 100% embedded.

5.2.3 Instream Cover

The presence of unembedded substrate, aquatic vegetation, large woody debris (LWD), and undercut banks, offer valuable refuge and resting for fish. Fish use these features to escape both aquatic and terrestrial predators and fast flowing water. As the instream features become embedded by fine silt and sand, cover for fish is reduced. To be considered viable instream cover for this assessment, areas must be obscured from the surface by the cover element itself (boulder, LWD, vegetation, bank) and be able to cover at least one 10cm-long fish for juveniles and one 20cm-long fish for adults.

Cover is assessed by considering the number of fish which are able to hide within a visualized band 50cm along each side of the transect. Good instream cover provides enough spaces for at least 2 fish per square meter.

- At each transect, assess unembedded cover below the water surface for both adult and juvenile fish within 50cm along either side of the transect
- Cover for one adult fish is counted when the dowel fits under cover until the 20cm line is no longer visible.
- Larger areas of cover may hide several fish. Leave a dowel width between each fish counted in larger areas of cover.
- Record the number of adult fish that can find cover on the field sheet.
- Use the eye bolt or 10cm dowel to find the number of juvenile fish which can find cover.
- Record the number of juvenile fish that can find cover on the field sheet.
- Larger areas of cover may hide several fish. Leave an eye bolt or 10cm dowel width between each juvenile fish counted in larger areas of cover.
- Once cover for at least two fish per meter of wetted width are found in a transect it ok to stop counting as this will obtain a suitability value of 1, make a note of this.
- Figure 16 shows cover presence along the transect

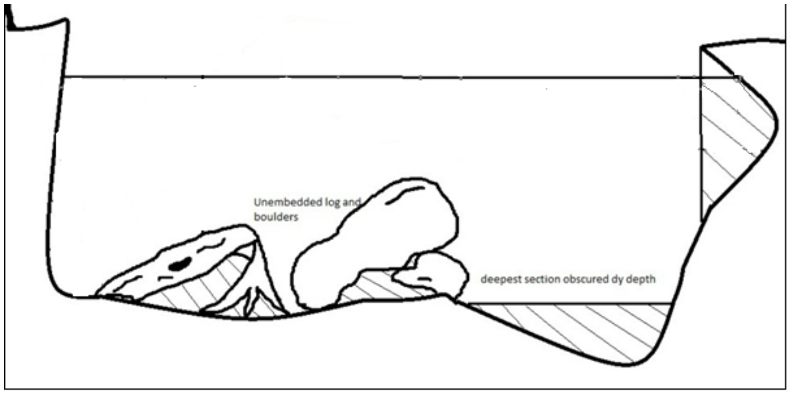

Figure 17 - Cover types and occurrence within a transect

6. RIVERBANKS AND RIPARIAN AREAS

6.1 Introduction

The condition of both the riparian area (strip of land adjacent to all waterbodies) and the riverbanks play a vital role in the productivity and health of the rivers that they border and can indicate how a river is functioning within its channel and floodplain. Measuring the state of the riparian area and riverbanks can provide important information when assessing fish habitat and can contribute to the quality of other habitat variables. This section outlines methods for assessing riparian area and riverbank health and is based on the use of established transects.

A healthy riparian area is considered to be several meters wide with a mixture of dominant trees, shrubs, and undergrowth. This vegetation functions in multiple ways: reducing flooding by slowing runoff into the river; creating stable riverbanks that protect against erosion; providing important shading and cover to fish; and directing nutrients from the land into rivers through leaf litter (allochthonous input). Riverbanks with vegetative roots and stable rocky substrate protect the bank from eroding and depositing fine silt material into the river. Evaluating where sediment is being eroded (degradation) and deposited (aggradation) can indicate how a river's flow fits the channel and floodplain it runs through and relates to river width and volume of flow.

Riparian vegetation plays many functional roles for maintaining productivity in streams. Besides creating stable banks, vegetation also provides important sources of food for benthic macroinvertebrates in the form of fallen leaves (allochthonous input), which are food sources for insects and in turn fish. Large shrubs and trees also contribute to shade over the stream helping to keep it cool. The percentage of trees, shrubs, grasses and bare soil are used in the NSHSI to calculate the vegetation index using the formula below. Multiplication factors are used for each vegetation type and added together to obtain the index value.

Vegetation Index calculation:

Vegetation Index = 2(% shrubs) + 1.5(% grasses and sedges) + (% trees) + 0(% bare ground)

6.2 Field Methods

The methods outlined in this section are based on left and right bank estimates for the entire site rather than using transects. Left and right banks are indicated when looking downstream. The assessment for riverbanks includes evaluating bank stability and erosion as well as the presence and condition of deposition areas (gravel point bars) (see section 8.2.2). The riparian area assessment includes evaluating riparian tree, shrub, and grass vegetation, stream shade, the presence of ice scarring and a functioning floodplain.

For each half meander sequence, a total of two assessments are made, one for the left and one for the right banks that represent the entire site. In some cases, the site may exhibit features that do not change significantly, making full site assessments fairly simple. In other cases, traversing the site a few times will help to evaluate conditions.

6.2.1 Riparian Vegetation

The health of vegetation is indicated by the presence of foliage, and low flows reveal more bank area for evaluation. When assessing bank conditions during low flows, consider the bankfull level where water normally flows, which may be several meters away from the water at low flow to avoid assessing bank areas that would be submerged during higher flows.

- For each bank, estimate the percentage of ground covered by trees, shrubs, grasses and sedges, and bare ground within 10m from the bank's edge and record them on the field sheet.
- These values may add to more than 100%, as there can different levels of vegetation covering the same area of ground

6.2.2 Riverbank Stability

Rooted vegetation and stable rocky substrate protect riverbanks from the erosive power of water. Rooted vegetation is alive (has green leaves) and is close enough to the bank to provide stability through its network of roots (roughly within 5m of the bank's edge). Dead plant material or debris stuck in the bank does not count towards rooted vegetation.

Stable rocky ground is defined as banks comprised of more than 65% boulder and/or cobble substrate (*Hamilton and Bergerson, 1985*). Where rooted vegetation and rocky ground is absent, active erosion may be taking place and can be noted by an obvious lack of soil, collapsed banks, exposed tree roots, and fallen trees and shrubs (Figure 21).

- Estimate the percentage of both left and right riverbanks (within bankfull) with active erosion. If sites are varied, multiple evaluations can be made and averaged
- For each riverbank, estimate the percentage of rooted vegetation or stable rocky ground for the entire site and record it on the field sheet under stable ground. If sites are long and vary in quality, smaller sections may be evaluated and averaged together

- As some areas of riverbank may not have rooted vegetation or active erosion. For this reason, stable and eroding ground together may not total 100% of the riverbanks. For example, 50% of site could have stable ground, 20% of the site could be eroding, and the remaining 30% could be potentially unstable but not actively eroding.

Figure 18 - Stable rocky bank and actively eroding bank

6.2.3 Stream Shade

The canopy cover created by riparian vegetation creates shade that helps maintain cooler temperatures in rivers during the summer months. This is of special concern for rivers with known high summer temperatures. Midday sun is the most direct and influential on stream temperatures, so shade estimates should be made between 10:00 am and 2:00 pm.

- For the entire site, estimate the canopy cover percentage visually or by using a densiometer and record it on the field sheet
- A single observation can be made for relatively consistent sites, or multiple observations through the site can be made and averaged together in more diverse sites

6.2.4 Ice Scarring

When river levels fluctuate during the winter, thick ice can form and cause critical damage to riparian vegetation and salmonid incubation areas. Signs of this damaging ice movement can be observed in scarring along riparian trees and shrubs (Figure 18).

- For both left and right banks, observe whether ice scarring is present, measure the average height from the bank to the top of the ice scar, and record it on the field sheet

Figure 19 - Ice scarring

7. POOL MEASUREMENTS

7.1 Introduction

Pools are very important for fish habitat, providing cover and resting, and should ideally comprise more than 25% of the habitat for salmon and 50% for trout. The greater depth intercepts flow through the substrate or ground water which provides cooler water where fish find refuge during the hot summer months.

Cross-sections located on pools contribute to the pool class rating and percentage of pools for the site. The pool class rating is based on the percentage of the site containing first, second, and third-class pools, also called class A, B and C pools. The pool classes are determined by the water depth and amount of cover (Table 3). The pool class rating is ideally evaluated based on flows found during late summer when low flows put additional stress on pools. When evaluating pool depth when there is greater discharge, the depth of the pool tail is subtracted from the pool depth to calculate the low flow maximum depth. The pool tail is located on the crest of the downstream riffle and controls the water depth in the pool. The pool cover will have to be evaluated visually to account for low flow depths. Measurements of the pool area also contribute to the percentage of pools criteria, which is based on the total area of each transect which is covered by pools. In addition to pools found on cross-sections, measurements for the pool class rating and percent pools should be taken at pools throughout the site.

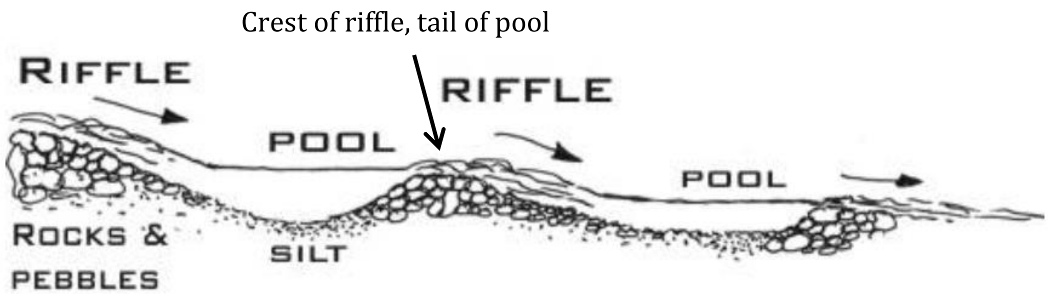

Figure 20 - Estimating low flow

Pool Class	Depth	Amount of Cover
First-class Pool (A)	> 1m, or >15% of width	> 30%
Second-class Pool (B)	≤15% of width, and ≥15cm	5-30%
Third-class Pool (C)	< 15cm	< 5%

Table 3 - Pool class descriptions

7.2 Field Methods

The measurements of each pool within the transects must be taken to obtain a good assessment of pool quality. It is recommended when walking up the stream to measure each pool as you encounter it. Pools are often found on the outside of river bends and are characterized by a concave drop in bed surface. Generally, anytime the water starts to get even a hand length deeper, take pool measurements.

- First note which transect you found the pool in under transect # on the field sheet. A pool found between the first and second transect would be marked as 1, between the second and third transect would be marked as 2, and within 2 site bankfull widths after the third transect would be marked as 3.

7.2.1 Depth of Pool and Pool Tail

- measure the depth of the pool at the deepest section in centimeters and enter it into the field sheet under max depth. Greater than 1 m (> 1 m) can be used if required.

The depth of the pool tail, is used in the spreadsheet to calculate pool depth in low flow. The pool tail is the thalweg of the crest of the first riffle downstream. It is what is controlling the water level in the pool. As the water level in the pool drops it would be the last place that water would drain out of.

- measure the depth of water on pool tail or pool control in centimeters and record it under depth of pool tail on the field sheet.

Figure 21 - Estimating depth of pool tail on a step pool stream

7.2.2 Pool Length and Width

Use the depth of the pool tail to aide in visualizing the edges of the pool, those which will still contain a few centimeters of water in low flow.

- measure the length of the pool (parallel to flow) in meters and record on the field sheet
- measure the width of the pool in meters, remembering that it does not necessarily span the entire wetted width and record on the field sheet.

7.2.3 Pool Cover

The percentage pool cover indicates the amount of the pool bottom which is hidden by water color, depth, or high surface velocities. Pool cover is measured within the previously determined length and width of the pool. To estimate how much of the pool will be covered in low flows, hold a dark object at a height above the bottom equaling around that of the measured pool tail. Objects such as your boot or a bolt on a string work well.

- estimate what percentage of the bottom or the pool is obscured and record it on the field sheet under % pool cover.

8. Additional Considerations

8.1 Introduction

This section covers areas which may occur between transects and should be marked on the field sheet as you come across them.

8.1.1 Spawning Areas

Brook Trout prefer to spawn in areas of groundwater upwelling which contain 2.5-6 cm gravel substrate. These areas are often located near the head of pools, on the inside corners of river meanders or ground water springs anywhere in pools or lakes. Groundwater upwelling can also be located randomly through a river depending on the local water table, making them sometimes difficult to find (Hendry K & Cragg-Hine D, 1997). In warmer water they can be identified as areas where cooler groundwater is coming up through the substrate.

Atlantic Salmon spawn in areas of downwelling, such as the tail of a pool (most downstream end of a pool) or above a digger log. Salmon prefer to spawn in areas dominated by substrate between 2 and 9.5 cm, without many fines (less than 5%) (Moir et al. 1998).

8.1.2 Deposition areas

Gravel bars or point bars are areas where sediment is deposited in slow moving areas of rivers, usually on the inside of meanders opposite pools (Figures 21 and 22). The presence and shape of gravel bars can indicate the rate of deposition, which in turn indicates how the river is interacting with in its channel and if the flows are in a natural state.

8.2 Field Methods

8.2.1 Spawning Areas

- estimate the average substrate size in cm in spawning areas for both Brook trout and Salmon, and record on the field sheet.
- determine the percent fines for spawning areas in the same manner that you would for embeddedness (see section 5.2.2), by lifting the top rocks in an area and determining the percentage of fines below.

8.2.2 Deposition Areas

- For each site, indicate whether gravel bars exist and record the information on the field sheet
- Record the general slopes (gradual or sharp) and note any diagonal bars across the channel in the notes section of the field sheet.
- Photographs (and accompanying GPS coordinates) of gravel bars are also useful.

Figure 22 – Gravel Bar

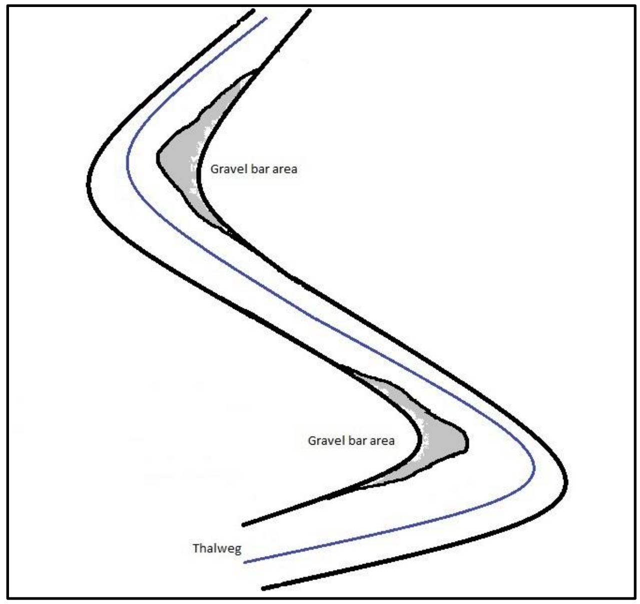

Figure 23 - Typical locations of gravel bars

9. BENTHIC MACROINVERTEBRATE MONITORING

9.1 Introduction

Biomonitoring is a unique type of environmental monitoring and assessment where organisms are sampled and studied because they indicate changes to their surrounding environment. The monitoring and assessment of benthic macroinvertebrates is a valuable tool for individuals concerned with the health of local aquatic ecosystems. Benthic macroinvertebrates biomonitoring should be considered when completing fish habitat assessments because of their extremely vital role in the food web in freshwater ecosystems and for the supplemental information they can provide.

Unlike other organisms used for biomonitoring, benthic macroinvertebrates populations are ideal because they are abundant, relatively long-lived (1+ years), and can be sampled in virtually all freshwater environments. They are a main source of food for fish while simultaneously facilitating the transfer of energy through trophic levels. Most importantly, the wide variety of taxa (individual family, genus, and species level groups) have varying tolerances to different types of pollution and thus provide a useful indicator of water quality and freshwater ecosystem health. Significant ecological changes are usually first observed in benthic macroinvertebrates populations.

9.1.1 Canadian Aquatic Biomonitoring Network

Groups or individuals undertaking benthic biomonitoring are encouraged to participate in the Canadian Aquatic Biomonitoring Network (CABIN). CABIN is the national benthic biomonitoring program developed by Environment Canada that standardizes the sampling of benthic macroinvertebrates. The program utilizes the Reference Condition Approach (RCA), meaning there are reference conditions for generally pristine environments. Potentially impacted, or test sites are compared against these reference conditions. This means individual sampled sites can be compared to the set of reference sites and conclusions about potential negative environmental conditions can be made. CABIN requires standard sampling techniques facilitated during field training and certification as well as minimum family level benthic macroinvertebrates identification which is usually completed by a trained individual or taxonomist.

Users of this manual interested in benthic macroinvertebrates biomonitoring are suggested to complete CABIN assessments (https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network.html *)*. The University of New Brunswick's Canadian Rivers Institute (http://canadianriversinstitute.com/training/cabin/) offers CABIN training sessions.

9.2 Field Methods: Rock Grab & Three Minute Kick

Although there are numerous benefits to participating in the CABIN program, it is resource intensive, requiring training, equipment, and taxonomical analysis, which may prohibit its use by some groups. To promote biomonitoring as a supplemental method of assessment, a simpler methodology is outlined below.

Methods for sampling benthic macroinvertebrates described here are less rigorous and detailed but are still a valuable tool in water quality and fish habitat assessment. The 'Rock Grab' and 'Three Minute Kick' methods (adapted from Stanfield, 2010) are rapid benthic macroinvertebrates sampling techniques that collect a general representation of the benthic community at the specific site sampled. There are several indices given below with which data from course detail assessments can be evaluated to broadly track changes. Literature and manuals to assist with benthic macroinvertebrates identification include: Merrit and Cummings, 1996; Voshell, 2002; Jones et al. 2004; and Stanfield, 2010. They are listed in References and may be available online.

9.2.1 Sampling Locations

All benthic sampling is done in riffle habitats as this is where sensitive taxa are expected to be found. The sampling methodology to be used depends on the amount cobble found at the riffle to be sampled. If there are greater than 5 cobbles the rock grab method is recommended, while for less than 5 cobbles the three minute kick method is required.

9.2.2 Rock Grab Sampling

- Within the chosen riffle, randomly select 3 cobble sized (6.4 – 25.6cm) rocks from the riverbed.
- Identify all of the organisms on each sample rock using Appendix 4 or the literature mentioned above.
- On the field sheet, record the quantity of each taxa and the sampling method used.

9.2.3 Three Minute Kick Sampling

- At the chosen riffle, select an area 1m x 1m with substrate representative of the entire riffle

- Place the net downstream of the area and proceed to kick and disturb the substrate for three minutes, dislodging the benthic macroinvertebrates from the riverbed. A 500-micron dip-net or other types of fine mesh kick nets work best.
- The current should direct the benthic macroinvertebrates into the net, but sweeping back and forth downstream of the area being kicked will capture most individuals.
- After three minutes, remove the net from the river and transfer the sample to a white tray or bucket. Ensure that no individuals are attached to the net by washing with a spray bottle, or by splashing water from the river onto the net. Cleaning the net well is especially important when sampling multiple sites.
- Identify all benthic macroinvertebrates and record the numbers of each taxa on the field sheet.
- Record the sampling method used and the type and mesh size of the net on the field sheet.

9.2.4 Additional Information

Proper identification must be completed with the aid of literature. The focus of the assessment is on the proportions of the sample comprised of 'indicator benthic macroinvertebrates' that are both sensitive and tolerant to pollution as described in Table 6. Other benthic macroinvertebrates are important but are less significant in the indication of water quality. It is recommended that users identify all benthic macroinvertebrates to the best of their ability and to record unknown taxa as such.

Sensitive Taxa	**Tolerant Taxa**
Caddisflies (Trichoptera)	Midges (Chironomidae)
Mayflies (Ephmeroptera)	Aquatic Earthworms (Oligochaeta)
Stoneflies (Plecoptera)	Leeches (Hirunidae)
Beetles (Coleoptera)	Sowbugs (Isopoda)
Fishflies, Alderflies (Megaloptera)	Snails, Limpets (Gastropoda)

Table 4 - Indicator Taxa (Modified Hilsenhoff Index, Kilgour, 1998)

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APPENDIX 1: FIELD SHEET

NSFHAP Field Sheet #:

River Name: ____________ Watershed Code: ____________ Date: ____________ Time: ________ Crew: ____________

Site Boundary Coordinates: D/S ____________ ____________ U/S ____________ ____________

Site Bankfull Width: ________ Site Length: ________ Transect Spacing: ________ Stream Order: ________

Air Temp: ________ Water Temp: ________ pH: ________ Conductivity: ________ TDS: ________ DO: ________

Channel Cross-sections

	Floodplains		Height and Widths			Wetted Depths				
	Average Left Width	Average Right Width	Bankfull Width (m)	Bankfull Height (m)	Wetted Width (m)	1/4 of Width (cm)	2/4 of Width (cm)	3/4 of Width (cm)	Thalweg (cm)	Thalweg Location (m)
T1										
T2										
T3										

Substrate and Cover

	GPS Coordinates		Habitat Type	¼ Width					1/2 Width					¾ Width							
				Fines	Gravel	Cobble	Boulder	Bedrock	Fines	Gravel	Cobble	Boulder	Bedrock	Fines	Gravel	Cobble	Boulder	Bedrock	% Embedded	Instream Cover for Juveniles (# of fish)	Instream Cover for Adults (# of fish)
T1																					
T2																					
T3																					

Riverbanks and Riparian Area

	% Trees	% Shrubs	% Grass	% Bare Soil	% Eroding	% Stable Ground	% Stream Shade	Ice Scar Height
Left Bank								
Right Bank								
Vegetation Index:					Avg:	Avg:		

Pool Measurements

Transect #	Max Depth (cm)	Depth of Pool Tail (cm)	Est. Low Flow Max Depth (cm)	Average Length (m)	Average Width (m)	Final Pool Area (m^2)	% Pool Cover	Percentage of Pools	Pool Class Rating

Pictures

#	Description

Avg. Substrate Size in Spawning Areas (*Brook trout*) (cm): ____________________

Avg. Substrate Size in Spawning Areas (*Atlantic salmon*) (cm): ________________

% Fines (*Brook trout Spawning*): ________________________

% Fines (*Salmon Spawning*): ________________________

Point Bar Presence/Condition: ________________________

Rock Grab: ☐ 3 Minute Kick: ☐

Net Type/Mesh Size: _____ /____

% EPT: ____ %Chironomids: __

Common Name				Tally
Midges				
Snails, Limpets				
Sow Bugs				
Aquatic Earthworm				
Beetles				
Mayflies				
Fishflies, Alderflies				
Stoneflies				
Caddisflies				

Notes and Section Sketch: Indicate right and left banks, tributaries and inflows, flow direction, and general river form description

APPENDIX 2: FIELD EQUIPMENT LIST

To complete the full assessments outlined in this manual (not including CABIN assessments) a crew will need:

- Hip/chest waders or rubber boots
- Camera
- Thermometer for air temperature
- Multi-probe water quality device (that includes temp, pH, conductivity, TDS)
- Long measuring tape (at least 30m)
- Meter stick
- Dip net or other fine mesh net**
- Squeeze bottle to rinse net**
- Bucket or tray to sort macroinvertebrates (preferably white)**
- Tweezers to identify and sort macroinvertebrates**
- GPS receiver
- Flagging tape
- Wooden/metal stakes or short pieces of rebar
- 5/16 inch x 10cm long eye bolt or dowel
- ¾ inch dowel with 20cm marking
- 50x50 cm substrate grid
- Calculator
- Maps featuring access and general area of assessments
- Field sheets, definition sheet and field procedure sheet (laminated or on waterproof paper)
- Permanent markers, pencils
- First-aid kit

**for 3 minute kick

APPENDIX 3: FIELD PROCEDURE

Before going into the field calculate the site bankfull width and transect spacing

At the first transect

- Start on a riffle
- Perform water quality measurements
- Perform evaluation of benthic macroinvertebrates

At each transect

- Measure floodplains
- Measure bankfull width and depth
- Measure wetted width, keeping the measuring tape pinned to the banks
- Measure wetted depths
- Use 50cm grid to estimate substrate percentages, stopping at thalweg to evaluate embeddedness
- Use the dowel to find instream cover for adult fish along the entire transect
- Use the eye bolt or 10cm dowel to find instream cover for juvenile fish along the entire transect

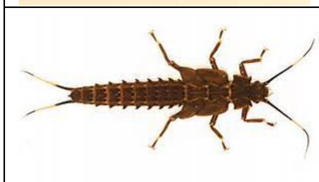
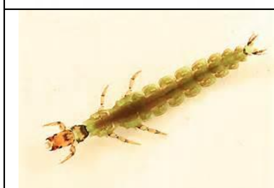
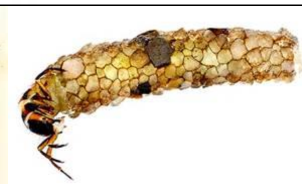
As you walk to the next transect

- Measure any pools as you come across them
- At the tail of every pool (just upstream of the crest of the riffle) estimate avg. size of substrate and % fines for Salmon Spawning
- In areas of upwelling (such as the head of a pool) estimate avg. size of substrate and % fines for Trout Spawning
- Note any point bars
- Measure the height of any visible ice scarring along the banks

At the end of each habitat unit

- Estimate riverbanks and riparian area

APPENDIX 4: AQUATIC INSECT ID

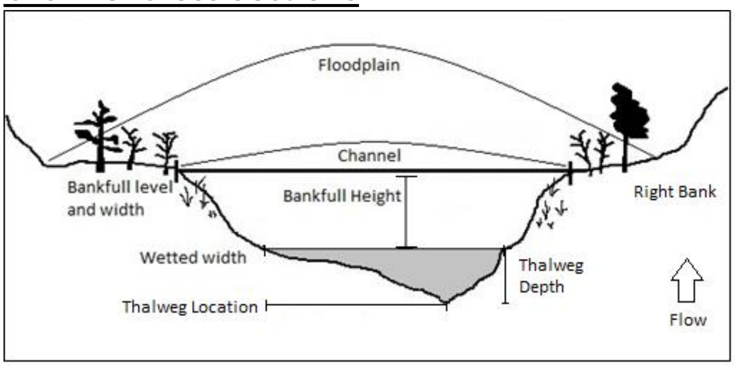
 	Midge larvae are a group of small flies Includes Blackflies and Sandflies
	Mayfly larvae
	Stonefly larvae
 	Caddisfly larvae
	Aquatic Sowbug larvae
	Aquatic worms
	Alderfly larvae
	Freshwater Snails
 	Water Beetles

APPENDIX 5: DEFINITION SHEET

The site length should be at 5-7 channel widths of the site bankfull width, which is calculated using the annual runoff and watershed area. Transects should be taken approximately every 2 bankfull widths and each pool within the site length should also be sampled. Measure three transects each time there is a 20% change in stream width, a tributary, change in substrate composition or large change in slope. Take one set below and one set obove each tributary or road crossing. Remember to take pictures upstream and downstream of each transect, built structures (beaverdams, bridges, outlet pipes, etc.), erosion and pointbars.

Stream Order – determine the stream order by labeling the first stream at the head of the watershed as 1 and increasing the order by 1 each time two streams of the same order join until you reach the sampling area

Channel Cross Sections



Measurements for ¼, ½ and ¾ widths, as well as thalweg location are to be taken left to right looking downstream. Left and right banks used on the form are from a viewpoint looking downstream.

Floodplain width – the distance from bankfull level to where the slope steepens or the area that would be covered by 30cm of water above bankfull (use >10m if floodplain is larger than 10m)

Bankfull Width – the width of stream at the highest water level before it spills into the floodplain, which can be identified as the point where the slope becomes flatter and is often where shrubs begin growing

Bankfull Height – the height of the bankfull level above the water surface

Wetted depth – the depth from the stream bottom to the current water level

Thalweg depth – the depth of the deepest part of the transect below the wetted surface

Thalweg location – the distance of the thalweg from the edge of the water on the left side

Substrate and Cover

Habitat Type – riffle, run, pool, or step (area just before a drop in a step-pool sequence)

Substrate – record the percentage of each substrate size according to the adjacent chart using the 20 square (5%) grid for estimations

% Embedded – lift up several top rocks in the thalweg and estimate % fines underneath them. If the top rocks are cemented in fines then it is considered 100% embedded

Substrate	Size (cm)
fines (sand, silt)	<0.2
gravel	0.2-6.4
cobble	6.4-25.6
boulder	>25.6

Instream Cover includes undercut banks, unembedded substrate, and aquatic vegetation. It is measured within 50cm along each side of the entire transect

Instream cover for juveniles – # of places that can provide cover one 10cm long fish (use 5/16" eye bolt or dowel)

Instream cover for adults – # of places that can provide cover one 20cm or larger fish (use ¾" dowel)

Riverbanks and Riparian Area

The **% of trees, shrubs, grass and bare soil** are observed on vegetation within 10m of the banks and can add to more than 100%.
% eroding – this is the percentage of the bank which is actively eroding into the stream (take pictures)
% Stable ground - this includes rocky ground (> 65% boulder and/or cobble) and areas with rooted (alive) vegetation. (% eroding and % stable ground may add to less than 100%)
% of stream shade - this is the canopy cover created by riparian vegetation above the stream and is preferably measured between 10:00am and 2:00pm.
Ice scar height - the height from the bank full mark to the top of scarring along riparian trees and shrubs

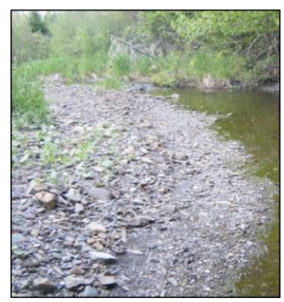
Ice Scarring

Pool Measurements

Max depth – the deepest part of the pool
Depth of pool tail – the thalweg depth at the first riffle or step downstream
Length and Width – the largest length and width of the area containing deeper water
% pool cover – the percentage of the pool bottom which is obscured by depth or color in low flows

Spawning Areas

*****If unsure about where to find spawning areas chose the tails of pools for both brook trout and salmon
Brook Trout – prefer to spawn in areas of groundwater upwelling which contain 2.5-6cm gravel substrate. These areas are often located near the head of pools, on the inside corners of river meanders or ground water springs anywhere in pools or lakes. In warmer water they can be identified as areas where cooler groundwater is coming up through the substrate.
Salmon – spawn in areas of downwelling, such as the tail of a pool (most downstream end of a pool) or above a digger log.
Avg. Substrate Size in Spawning Areas – this is the average substrate size in cm for spawning areas of both Brook trout and Atl. Salmon
% Fines - To determine the percent fines in spawning areas lift the top rock and determine the percentage of fines below.
Point Bar Presence/ Condition – This is an area where sediment is deposited on the inside of bends. Record the slopes (gradual or sharp) of the downstream end in the notes section.



Point Bar

Rock Grab or 3 min Rock Kick

Rock Grab - Choose the rock grab method when there are greater than 10 cobbles at the riffle to be sampled. Randomly select 3 cobble sized rocks and identify all benthos on the selected rocks. Check the rock grab box and tally the numbers from each sample rock in the table.
3 min Rock Kick - When there are less than 10 cobbles chose the 3 min rock kick method. Select 1m x 1m area, place the net downstream and proceed to kick and disturb the substrate for 3 minutes. Then remove the net from the river and identify all benthos, recording their numbers on tally section. Remember to check the 3 min kick box and record the net type and mesh size.