A Descriptive Habitat Study of Low Impacted Streams of the Bay of Fundy

Final Report
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Executive Summary
The rivers entering the Bay of Fundy coastline of Nova Scotia have had a long history of use by our residents. Virtually none of the forests remain unharvested within the last 400 years, and many areas are in second or third rotation. This project was undertaken to study and describe the current stream habitat characteristics of some of the least impacted stream reaches between Cape Chignecto and the Annapolis Basin.

One hundred and seventy candidate stream reaches were identified within the project area through an office based GIS Analysis as flowing through a mature to old growth forest corridor of 30+ m width on both sides of the waterway for 300 m or more, having a gradient of 0.5-5.0%, and a channel width grater than 2 m. Through prioritization, 29 of the candidate reaches were visited in the field. Only 50% of the field verified sites actually met the intended minimum criteria. Those 15 sites on 10 rivers that did meet the criteria underwent a complete quantitative stream habitat assessment and a riparian description. However, it should be noted that none of the locations were believed to be truly unimpacted or pristine in nature, and such habitats, if they do exist, must be very limited within the project area.

Upon completing the field surveys, data was assessed and collated. Three sites were field to be poor representatives of low impacted channels, and as such, the data was evaluated for all sites collectively, for the “best” low impact sites, and for the “poor” low impact sites surveyed. The “best” sites had considerably higher LWD frequency than the other sites, and at 2.25 pieces / Wbf (channel width) approximated numbers observed in Western North America where >2 / Wbf is equated with unlogged natural

systems. Residual pool depth for primary pool habitats exceeded 0.80 m and the % total riffle length was less than 50. Riffle pool ratio approached 3:1, and primary pools were spaced at more than 26 Wbf. Both of these results are much higher than the 1:1 riffle pool ratio and 6 Wbf pool spacing for undisturbed alluvial systems that is documented in the literature and so often used in designing stream habitat restoration in Atlantic Canada. An inverse relationship exists in the project data between the frequency of LWD (large woody debris) and pool spacing, meaning that pools were found more numerous in systems with higher amounts of LWD.

The observations made and data collected during this project allow us to describe the "best" low impacted stream habitat of the surveyed reaches in streams < 10 m Wbf and between 0.5-5.0% gradient that enter the Bay of Fundy between Cape Chignecto and the Annapolis Basin as having > 2 pieces of LWD / Wbf, decreased pool spacing with increased LWD frequency, residual pool depths of > 0.80 m, and a number of embedded habitats that increase overall complexity of the channel.

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1.0 Introduction

Salmonid streams around the Bay of Fundy, Nova Scotia no longer flow through old growth streams. Such riparian stands have a sizeable influence on the quality of stream habitat. Therefore, it is increasingly important that we understand the changing relationships between stream geomorphology and riparian management in second and third growth forests that now border nearly all stream reaches. Adding urgency to that need for knowledge is the salmonid population reductions being observed around the Bay form a number of impacts including ocean survival, acid precipitation, and fresh water habitat changes. In 2001 the Council on the Status of Endangered Wildlife In Canada (COSEWIC) listed the Inner Bay of Fundy Atlantic Salmon (*Salmo salar*) populations as endangered. The current project area covers much of these populations' freshwater habitats. More recent data collection on fry and parr in many of these rivers indicates the decline in abundance is continuing (Gibson et. al. 2003).

In the spring of 2004, the Environmental Damages Fund awarded funding to a project proposed by the Annapolis Fly Fishing Association, a non-profit community based organization in the Annapolis Valley, Nova Scotia. That proposal stated the following goal and objectives:

> *Project goals, objectives, and activities:*
> The Descriptive Habitat Study Project contributes to the goal of achieving long-term sustainability of Atlantic salmon populations. The project objective is to increase our knowledge of low impacted Atlantic salmon stream habitat characteristics by developing a quantified habitat description of low impacted streams, preferably Inner Bay of Fundy streams, in Atlantic Canada.

The relevant activities to achieve the project objective and contribute to the stated goal included:1. Determining an accepted minimum set of criteria for high value salmon stream habitat characteristics through an Advisory Team; 2. Identifying candidate stream reaches that meet those minimum criteria; 3. Carrying out quantitative, replicable, stream channel and habitat surveys of those identified candidate stream reaches; and, 4. Analyzing and reporting the results of those habitat surveys. This report is the presentation of the project data and analysis.

Finally, it should be noted that this project is not meant to meet full scientific defensibility. However, it has been completed with the expectation that the habitat description that has been produced will be a reasonable representation of actual conditions of low impacted stream reaches in the project area, and as such may serve to fuel discussion on the need to expand or build on the works completed, and more fully understand from where we have come in order that we may better manage for the future of our freshwater stream habitats that flow to the Bay of Fundy shoreline in Nova Scotia for our salmon and trout populations.

2.0 Methodology

The original proposed approach to the project was used with little alteration. The following seven steps were completed as a means of contributing to the goal and meeting the objectives of the Descriptive Habitat Study of Low Impacted Streams project.

1. The project began with a meeting of the Project Advisory Team to establish basic criteria that candidate stream reaches ought to meet in order to develop the Descriptive Habitat Study of Low Impacted Streams. These characteristics included riparian vegetation age (minimum 80-100yrs, preferable 100+) in order to ensure that some natural recruitment of large wood to the stream channel was likely; minimum riparian corridor (30m on both sides of stream channel) representing the perpendicular distance from the stream that a large tree might fall and still land within the channel width and influence channel morphology; a stream width range (2^{nd}-4^{th} order) that would capture that most productive for salmonids (Bardonnet and Bagliniere 2000, Scruton and Gibson 1993), yet be small enough to allow physical survey by hand measurements; stream slope range (0.5-5%) to capture the most important range for salmonid habitats of all life stages (Gray et. al. 1989); and a minimum length of stream channel to exhibit the previous noted characteristics (300+m) to try and avoid impacts occurring within the study reach associated with conditions upstream or downstream of the study area being overrepresented in the data.
2. The minimum criteria were then used to complete a GIS analysis of the project area to identify candidate reaches that met all conditions set by the Advisory Team. One hundred and seventy (170) candidate streams reaches were identified. A GIS ARC Reader product was then produced that mapped location and attributes of each of the 170 sites.
3. The 170 candidate sites were then sorted by such characteristics as total candidate reach length, geographic distribution, access to the site, gradient, and stream order to prioritize those for field visitation. Fifty-two sites were placed on a priority list for field visitation.
4. Visitation began with the longest candidate reaches with fair to good access, in order that the proposed targets of 10 locations and 10 kilometers of channel might be met within the capacity of the project. Priority candidate locations were confirmed in the field as meeting the minimum criteria. Teams of 2 persons surveyed reaches. All locations, were in the IBoF watershed of Nova Scotia, with the exception of two in the Annapolis River Watershed.
5. All field survey data was entered into a spreadsheet format for analysis.
6. Summary analysis and results were presented to the Project Advisory Team to discuss strengths and weaknesses in collected and analyzed results, and to make recommendations regarding the final presentation of the habitat description for low impacted streams.

Understanding the detail methodology of both the GIS Analysis and the field surveys is necessary in order to fully understand both the limitations and use of the collected data and reported analysis. The GIS methodology is presented in detail in Appendix 4, and the stream survey methodology is presented in detail in Appendix 3.

2.1 GIS Analysis

Geographically, the intent of the project was to focus on Bay of Fundy streams. The capacity of the project was such that the GIS analysis began with a smaller scale by including all watershed areas from Cape Chignecto Nova Scotia east around the Inner Bay of Fundy to the mouth of the Annapolis River at the Digby Gut (see Figure 1). It was felt that this geographic area would likely produce an adequate number of potential candidate stream sites to meet the proposed targets of a minimum of 10 streams that satisfied the criteria established by the advisory team.

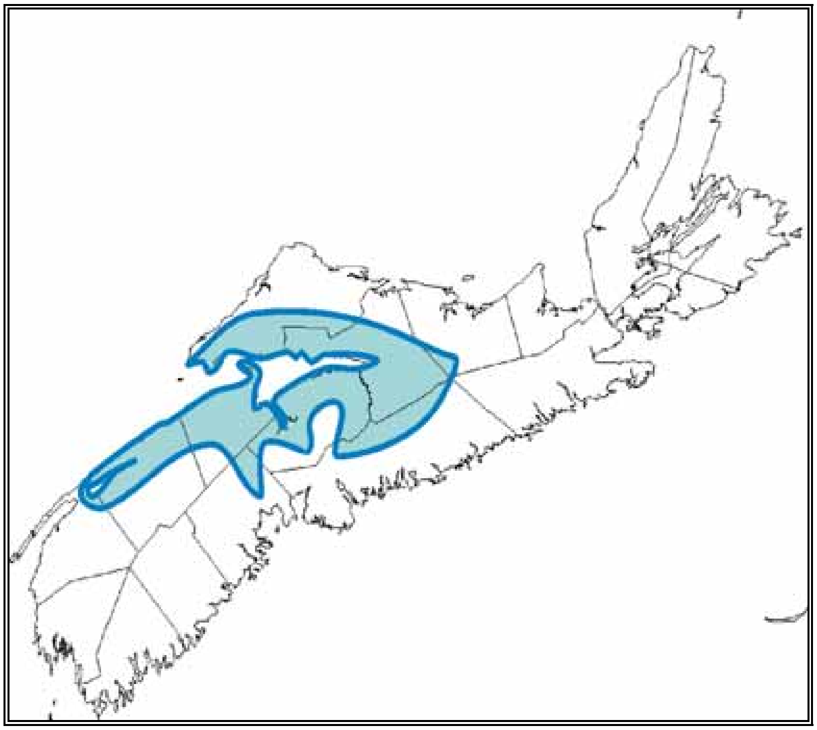

Figure 1: Approximate project area boundary, defined by all waters flowing to the Bay of Fundy from Cape Chignecto southwest to the Digby Gut.

The details of the GIS analysis methodology were recorded in a student project proposal (Peacock 2004), and are attached as Appendix 4. In short, the base map layer used was the Nova Scotia Department of Environment and Labour SOUF (Significant and Old Growth Forests) map. This map identifies all areas within the province that contain a significant or old growth forest stand identified through air photo interpretation. One of the weaknesses of using this base layer was that unique stands were not differentiated from old growth stands, and field verification had not been conducted. That meant that anticipated old growth stands did not always exist when the site was located in the field.

The SOUF map layer was then crossed with stream and contour data to find stream reaches that met the Advisory Group defined criteria of slope, length, riparian character, and location within the project area. In total 170 potential candidate streams were identified that appeared to meet all of the criteria. These systems were then prioritized for field visitation based on longest stream length, geographic distribution around the project area, stream order, and ease of access. Fifty-two sites made the first priority list based on these parameters, and fieldwork began with focus on the longest reaches identified.

For more information on the GIS Arc Reader product that was produced for this project, David Colville at the Applied Geomatics Research Group (AGRG), Centre of Geographic Sciences (COGS), Nova Scotia Community College in Middleton, Nova Scotia may be contacted.

2.2 Field Techniques / methods

Fieldwork consisted of several components. First, the conformity of each site identified in the GIS Analysis to the minimum required criteria had to be verified in the field. Typically, an identified reach would first be traversed while making qualitative visual observation of riparian characteristics and stream habitat quality. If the streams reach had apparent good mature or old growth character on both banks and little significant in channel habitat impacts, a detail quantitative stream habitat assessment would commence.

Detail quantitative stream habitat assessment was carried out on all field-visited locations confirmed as appearing to meet all criteria (see Figure 2). Drawing on habitat survey methods from Newfoundland (Sooley et al 1998) and British Columbia (Johnston and Slaney 1996), East Coast Aquatics Inc. (ECA) developed the field assessment methodology (ECA 2004) used in the quantitative assessment of stream channel characteristics. Details of this method are provided in Appendix 3. The methodology creates a georeferenced, longitudinally continuous survey of primary habitat units, LWD tally, disturbance indicators, and riparian characteristics. This data set is further enhanced with appropriate detail measurements of a characteristics such as width, depth, gradient, residual pool depth, bed material, and in stream cover for a sub-sample of the habitat units surveyed. For this project 100% of the primary pools were measured in detail and one in three of all other types of habitat units underwent detailed documentation.

The benefit of the approach used is that it is georeferenced, quantitative, and replicable. As such habitat units must meet the minimum size criteria set out in the methodology to be counted as primary units. This removes subjectivity of deciding if a primary pool or riffle unit exists. The method thereby allows for a quantified comparison of habitat between streams, and could allow for future assessment of habitat changes that may occur over time within a single stream reach.

The methodology employed allows for the development of a quantified habitat description by documenting up to 29 physical characteristics in each primary habitat unit (e.g. pool, riffle, glide etc.). This project is *not* a description of fish habitat productivity. The approach used acknowledges that impacts such as dams, ocean survival, and acid precipitation may have severely limited or eliminated salmonid fish production at the surveyed site, but suggests that the physical characteristics of a low impacted stream reach may remain in place to be surveyed. Furthermore, no water chemistry analysis or fish surveys were part of the current project, although it is acknowledged that in future efforts they may be appropriate. Fish surveys and water chemistry analysis would be necessary in order to complete a productivity description of the surveyed habitats. However, the intent and resources of the current project were limited to conducting a physical habitat assessment only.

Primary habitats constitute the basic unit of assessment in this project. A primary unit is any habitat type that is greater than one average bank full channel width in length and that covers at least 50% of the wetted width at the time of the survey. Additionally, pools must have a residual depth exceeding a guideline based on the bankfull channel width of the stream being assessed. For all streams surveyed under this project, a minimum of 40 cm difference (residual depth) between the maximum pool depth and pool outlet crest needed to exist to classify as a primary pool habitat. Embedded habitat units are those that meet some of the criteria mentioned above, but not all, and therefore exist "embedded" within a primary habitat unit. Embedded units were noted, but not measured in detail.

In most instances the diameter at breast height (DBH) was measured for a few of the largest trees that were representing the mix of species present along the surveyed reach. These riparian measures were secondary to the collection of stream channel characteristics, but were meant to provide a rudimentary indication of riparian character.

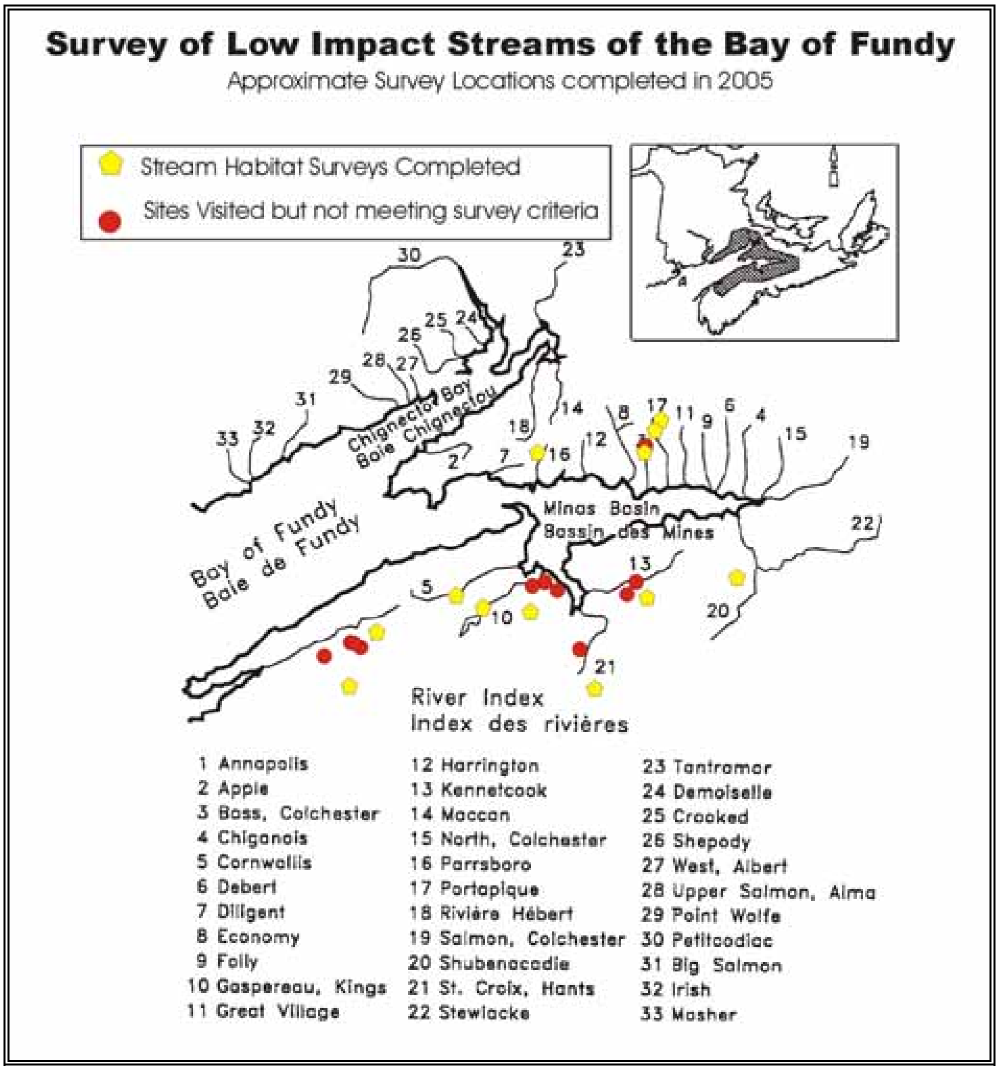

Figure 2: The approximate locations of all field visited sites, identifying those for which full detail surveys were completed. (Image modified from Atlantic Salmon Federation website.)

3.0 Results and Discussion

During the 2005 Descriptive Habitat Study of Low Impacted Streams of the Bay of Fundy project, some twenty-seven candidate stream sites were visited based on their potential to meet the basic project requirements (see Table 1). However, when visited in the field, nearly 50% of

Table 1: Field visited sites, sorted by stream order and site length, with various GIS predicted site parameters indicated and field visit comments. These were the 27 sites field verified during the 2005 Descriptive Study of Low Impacted Streams. As indicated, 15 sites underwent complete field habitat surveys.

GIS Analysis								
Site ID	**Length**	**Gradient**	**River/Brook**	**1:50,000 Map Sheet**	**Approx. Stream order**	**Predicted Veg**	**Field Surveyed**	**Field Comments**
6, 67	1366	3.91 – 2.9	Bass River of Five Islands	Parrsboro	**1**	Spruce	Yes	Bedrock controlled in places with incised canyon sections. Not true alluvial system.
4	1183	1.09	Shubenacadie / Grumbley Brook	Kennetcook	1	Mixed conifer/decid.	Yes	Clear cut across brook immediately upstream relatively recently. Somewhat constrained floodplain promotes braiding and less dense tree stocking. Good pool formation with LWD.
8	878	4.78	Gaspereau/ Deep Hollow	Wolfville	**1**	Mixed conifer	No	Recent bed load movement. Dry at time of field visit. Primarily hemlock.
109, 164	683	2.1 – 1.9	Annapolis / Up. Zekes Bk	Gaspereau Lake	1	White Pine	No	System too small bankfull width with extremely little flow.
29	558	3.39	St. Croix /Starks Lake	Windsor	1	Mixed conifer	No	Riparian is young forest with few older trees. Powerline crossing in mid reach.
56	463	1.94	Parrsboro / Farrells River	Parrsboro	1		Yes	Full reach has been selective cut over time, with very little natural large wood recruitment.
57	460	3.9	Economy / Big Pine Fire Bk	Parrsboro	1	Spruce	No	Given steepness and small size a step pool channel form exists. Not appropriate for survey needs.
5,14	1929	1.82- .64	St. Croix/Shady Brook	Windsor	**2**	Mixed conifer	Yes	Clear cuts were visible in many areas just outside of immediate riparian, although much wood in system. Primarily boulder controlled in steeper gradients.
3	1187	1.93	BoF/ Harolds Crk	Wolfville	2	spruce	No	Completely dry. No old growth in lower part of reach, possibly further upstream.
48, 77	927	1 – .92	Portapique / Gleason Brook	Oxford	**2**	Spruce	Yes	Varying floodplain from constrained to open. Some bedrock control areas.
80, 82	851	0.7 – 1.18	Nictaux / Grimm Lake Bk	Bridgetown	2	White Pine	Yes	Does not appear to be old growth, more mature growth. Long stillwater and flat sections.
12	785	0.89	Cornwallis /Elderkin	Wolfville	2	Hemlock	Yes	Recent 2004 storm event has added to volume of large wood in channel through heavy bank erosion. Many development impacts up and downstream of site.
upstream of 48	672		Portapique / Gleason Brook	Oxford	**2**	Spruce	Yes	Upstream of site 48, continued old riparian growth, better alluvial characteristics.
21	628	2.38	Gaspereau / Curry	Wolfville	**2**	Mixed conifer	No	Discontinuous flow through reach.

Site ID	Length	Gradient	River/Brook	1:50,000 MapSheet	Approx. Stream order	Predicted Veg	Field Surveyed	Field Comments
31	555	2.87	Annapolis / Gehues Brk	Bridgetown	2	Deciduous	No	Mostly maple stand of 6-10" DBH. A couple of larger trees 15". Several 4-6" trout at road culvert. Very little flow, although it felt cold.
34	540	2.95	Annapolis / South Annapolis	Gaspereau Lake	2	Mixed conifer	Yes	Hydro dam regulated flows likely interfere with natural processes. Decent riparian, some channel braiding appears unnatural.
44	505	0.98	Halfway River	Wolfville	2	Mixed decide/conifer	Yes	GIS section surveyed, but mostly young forest with a few older trees. Many stream crossings and impacts from cottage development.
105	386	3.36	Annapolis / Zekes	Gaspereau Lake	2	White Pine	No	System too small bankfull width with extremely little flow.
163	307	3.89	Annapolis / Millers Brook	Bridgetown	2	Mixed conifer	No	Likely cut not too many years ago. Old logs piled near by. Trout at culvert crossing. High flow impacts evident.
9	874	1.6	Gaspereau River	Windsor	3	Hemlock	Yes	Difficult access. Recent logging within/near 30m buffer on right bank. Very boulder controlled. Little wood recruitment to system.
19	674	0.59	Herbert / Meander	Kennetcook	3	mixed decid, spruce	No	Beautiful riparian, but wood in stream is being cut out by someone with resulting erosion and heavy bed load movement.
26	606	0.65	Kennetcook / Little River	Kennetcook	3	Conifer	No	In stream habitat is poor, riparian is partly cut and not on both banks for 30m.

sites identified as candidates through the GIS analysis proved not to meet all of the criteria established by the Advisory Team. This is a significant amount, more than anticipated, and needs to be considered in any future projects relying on a similar GIS analysis. Of those 27, 15 sites on ten separate rivers underwent full quantitative habitat surveys. These reaches ranged from 453 m (Gaspereau River) to 1729 m (Shady Brook) in length. In total, more than 9.15 kilometers of channel were surveyed in detail.

The GIS Analysis proved extremely valuable in identifying candidate sites, however, each site must still be field verified prior to initiating surveys, and an adequate amount of time must be made available to include this task. Lack of a continuous base flow, and / or lack of mature/old growth riparian corridor with width of 30 m were the primary reasons for not completing surveys of field visited site locations. It is further noted that several sites did not meet the riparian conditions because of recent (<10 years) riparian cutting (and not incorrect identification of a SOUF stand). As the SOUF map layer is based on aging air photo records, it can only be anticipated that the number of GIS identified candidates that do not truly meet the criteria will increase in number with time if the information sources used in this project are not updated.

Stream channel size, channel gradient, and surficial geology all have significant roles in determining the habitats of a stream channel. As such these parameters are regular components of stream evaluation (Rutherfurd et al. 2000, Sooley et al 1998, Newbury and Gabury 1992, Scruton et al 1992), and habitat diagnostics have been developed that categorize streams based on these parameters (Johnston and Slaney 1996). When initiating this project it was not known whether there would be an adequate number of mature/old growth candidate streams available to allow the categorization of results for different combinations of these three parameters. The bankfull width (Wbf), sometimes referred to as the channel width, of the surveyed streams ranged from 6.0 m at Grumbley Brook to 17.7 m at the Gaspereau River, and likely covered three stream orders. The majority of Wbf measures fell in the 10 – 14 m range. All channel gradients were selected to be between 0.5-5 %, as this range is generally considered to cover the gradients that support all critical life cycle requirements for the majority of salmonids (Gray et al. 1989). Surveyed reaches ranged from 0.64 % (Shady Brook) to 3.9 % (Bass River of Five Islands) with most being between 1-2 %. In the selection criteria, no limits were placed on the geology through which the streams had to flow. Much water chemistry and resulting productivity are related to the geology of a system, but these two characteristics were not being evaluated during the study. However, geology will also influence morphological character of a stream and associated habitat characteristics. Although the number of sites assessed during this project did not warrant evaluation on geological differences, the geological variability of the sites needs to be noted for it may explain some of the variability observed by location in the collected data.

Since land forming processes around the Bay of Fundy that created the Appalachian Mountains ended some 360 million years ago, erosional processes associated with rains and rivers along with glacial processes have worked to create the landforms now visible in the project area. This long erosional history means that streams in the project area typify fluvial systems; channels formed by deposition and re-deposition of glacially and stream eroded materials. As can be seen in Figure 3, several types of surficial geology exist in the project area. However, they can be generally categorized into two primary groups: the Avalon Terrane north of Minas Basin and the

Meguma Terrane south of the Basin. The Cobequid-Chedabucto Fault separates these two geologically different zones (Davis and Browne 1996).

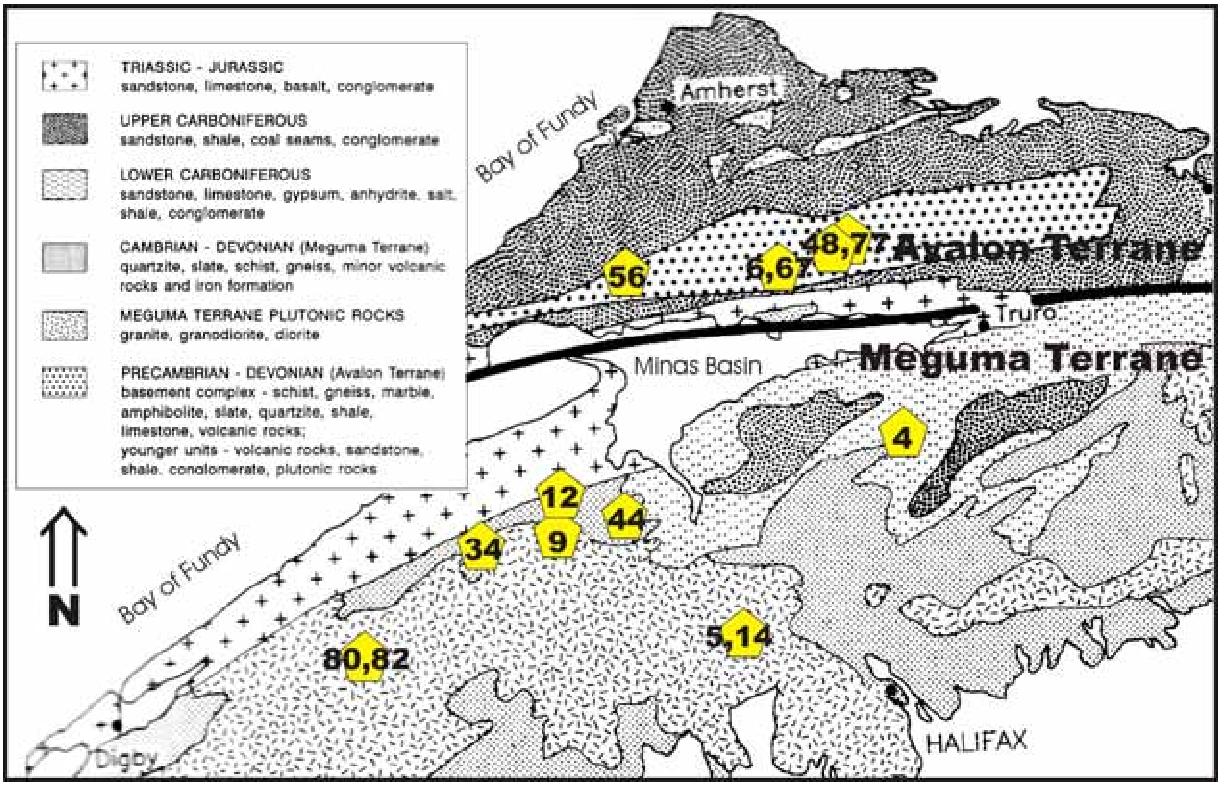

Figure 3: Simplified geology within the stream survey project area, with survey sites and numbers indicated. (Imaged modified from Davis and Browne 1996).

The northern project survey sites in the Avalon Zone all were located in the Cobequid highlands where the hard weather resistant Silurian rocks are found. These rocks are mostly volcanic in nature, and interbedded with softer sedimentary rocks. The more southern project survey sites fall on softer more erodible rock types, predominantly fine grained sandstones and shales. Although it would be appropriate to evaluate stream morphology within these two primary Terrane zones, the small data set from the current project is not appropriate for such an exercise. More focused and extensive stream evaluations however, should consider such examination for regional geological differences in stream channel morphology.

As the average Wbf (channel width) of a system was not known at the time of initiating the field survey, field crews had to estimate which habitat units met the minimum “1 Wbf in length” criteria, based on their experience in order to determine which units ought to be measured. Review of completed data allows some determination of technician error in applying this selection criteria. In the current project 8 of 233 primary habitat units measured in the 15 stream reaches surveyed did not meet the minimum length requirement. Three pools and five riffles were slightly shorter in length than the criteria, yet were measured as primary habitat units. These habitats should only have been noted as embedded habitat units. This misidentification equates to 3% of the total habitat units measured.

Upon completion of the field survey, all data was entered into a number of Microsoft Excel spreadsheets to calculate key diagnostic results. The detail survey results and diagnostics are presented in Appendix 1. The discussion reported here is categorized into both an inter-stream evaluation and a collective evaluation. The inter-stream evaluation allows for identification of significant differences between sites, and assesses issues regarding the quality and uniformity of the data set. The collective evaluation then assesses the summation of results based on groupings of streams that appear appropriate given the understanding of the inter-stream evaluation.

3.1 Stream Level Evaluation

A total of fifteen stream reaches on ten different streams were surveyed in detail. Atlantic salmon are known at one point in time to have occupied all but one of these Rivers, the Halfway (Gibson et al. 2003). There was not a single location for which the survey team felt the survey site was completely unimpacted or pristine. That is to say that there was always some visible sign of human activity that likely had some effect on the stream channel. Such sign may have been evidence of selective harvest many years ago, active or old vehicle ford crossings, bridges or culvert crossings within the reach, visible clear cut logging or agricultural land immediately above or below the site, recent bed load accumulations related to impacts above the reach, and points of significant erosion within the reach related to heavy storm activity in November 2004 (and that arguably would not have had as significant impact had the complete system or watershed been in a natural or pristine state).

Given the long history of settlement in Nova Scotia, impacts to our streams are not unexpected, even if they are not readily visible. In 1881-82, Frederick Veith traveled Nova Scotia to examine its rivers and report back to the Fisheries Committee of the House of Assembly. He completed his R*eport Upon the Condition of the Rivers in Nova Scotia* in 1884. In it he mentions sawdust from mills, broken fishways and dams, and poaching and drift netting as impacting the salmon and their river habitats on some of the same rivers assessed during the current study (Veith 1884). Several of the river specific excerpts from his notes are presented in Appendix 5. One of his more colorful passages, regarding the Gaspereau River, reads,

> "As it was late when I visited the gaspereaux on the 30th April, I had no means of fully seeing the river, so I drove over this day to examine the means, if any, that were taken to save the sawdust, a quantity of which I had before seen high up on banks of the river. The owner of the mill has told me he used every means to keep the stream clear, but that sometimes sawdust, &c., accidentally fell in. I, however, saw for myself far below the mill, immense quantities of shavings, sweepings of the mill, &c., and I immediately wrote to the County Overseer and told him of this breach of the law. I should have called upon him personally, but he lived to far away from Kentville, and I wished to save the expense of hiring a conveyance. I, however, attach his answer."

There were also sites for which the maturity of the riparian vegetation was estimated to be at the minimum or just below the selection criteria (80+ yrs), but for which capacity to make exact stand level determination in the field was not available. Notes on all such observations were made on field data sheets, and are discussed where it is believed relevant in this section of the report.

The number of pools, pool depth, and riffle pool ratio are several key parameters used in Atlantic Canada for assessing stream habitat quality (Sooley et al. 1997, Parker 1993, Scruton et al. 1992). Large Woody Debris (LWD tallies), that have been recognized as important in assessing habitat in alluvial systems elsewhere (Rutherfurd et al 2000, Chesney 2000, Johnston and Slaney 1996), have not been widely assessed in Atlantic Canada. Along with channel type, slope and width, LWD loading influences pool spacing (Montgomery et al. 1995). LWD is most strongly correlated with pool spacing and pool area in moderate slope channels of 2-5% (Beechie and Sibley 1997). The in stream LWD figures documented here are believed to be some of the more extensive recorded for Nova Scotia habitats. Table 2 summarizes some of these key stream habitat survey results.

Community based habitat restoration in Atlantic Canada has long targeted a pool riffle ratio of 1:1 and pool spacing of once every 6 Wbf (bankfull channel widths) (Parker 1993). These measures are based on well established characteristics of fluvial geomorphology (Leopold and Wolman 1957, 1960; Keller and Melhorn 1978). Pool spacing can be expected to shorten as gradient increases above about 1% and as step pool channel morphology becomes more prominent. Given that this survey was to be of the lowest impact sites that could be identified in the Bay of Fundy project area, it is of importance to note that not a single location approached a pool spacing of 6Wbf, and only three of the fifteen sites assessed had a riffle: pool ratio less than 2. If the sites assessed are in fact the least impacted that exist in the project area, then either they still exhibit a fair amount of morphological impact, or these target levels for pools are not appropriate for the project area. Regardless, it should be assumed that the closer the pool spacing and, generally, the lower the riffle pool ratio, the more unimpacted the site. The South Annapolis, Gleason, Elderkin, Grumbley, and Bass River all had primary pool spacing of between 12-16 Wbf, and represent the best in the survey. This spacing does not take into account embedded pools, which do not meet some size minimums such as residual depth or length, necessary to be considered primary pools.

There was reasonably good correlation between sites with the lowest pool spacing and those with the lowest riffle pool ratios. The one exception is Grimm Brook, which had a 27 Wbf spacing and a 0.8:1.0 ratio. It was the only site with a ratio below 1:1. However, in reviewing the data, it was found that only 22 % of the total surveyed length was riffle, and this was the lowest in the survey. The % riffle and 27 Wbf pool spacing reflects the relatively large number of habitat units that were types other than riffles and pools, including glides, flats, and stills in this lower gradient system.

As demonstrated with the Grimm Brook example, pool spacing and the percentage of channel length that is riffle habitat both need to be considered when assessing riffle pool ratio. Even low to moderate gradient streams with an absolute 1:1 ratio, one would expect the % riffle habitat may be above 50 % as riffle units are typically longer than pool units in length. Although the number of pools surveyed in this project relative to riffles did not always approach a balance, the % of riffle observed was usually less than 60 % in the 12 “best” low impact habitat sites surveyed. In the three sites, (Halfway , Gaspereau, and Farrell) riffle % approaches 100 % indicating a sizeable lack of habitat diversity within the surveyed reaches of these streams. The high riffle % and low number of pools are two of the reasons these three sites were considered “poor” representatives of low impact habitat sites.

Table 2: Summary of select field habitat measures by survey site.

Site ID	River/Brook	Surveyed Length (m)	Approx. Stream order	Width bank full Wbf (m)	Pool Spacing (#/Wbf)	Riffle / Pool Ratio	Total Length as Riffle	Total LWD/Wbf	Total >30cm LWD/Wbf	Riparian Character
6, 67	Bass River of Five Islands	883	**1**	10	15	1.3:1	58%	1.25	0.24	Spruce, 26% canopy closure 85% mature forest
4	Shubenacadie / Grumbley Brook	800	1	6	15	2.1:1	28%	1.86	0.55	98% mature, Mixed conifer/decid. With 47% canopy closure
56	Parrsboro / Farrells River	562	1	6.9	No pools	NA	94%	0.93	0.18	72% canopy closure, 72% young forest
5,14	St. Croix/Shady Brook	1729	**2**	14	62	4.5:1	55%	5.63	0.99	79% Mature, mixed conifer Forest with 53% Canopy closure.
48, 77	Portapique / Gleason Brook	985	**2**	10.6	47	7.5:1	55%	0.96	0.21	Spruce, 24% Canopy closure, 96% Mature Forest
80, 82	Nictaux / Grimm Lake Bk	848	2	7.7	27	0.8:1	22%	1.97	0.40	52% canopy closure, 60% mature forest of White Pine with 31% shrub along one long Stillwater section.
12	Cornwallis /Elderkin	993	2	9.4	12	1.7:1	67%	2.99	0.82	95% mature, Hemlock, with 62% canopy closure
upstream of 48	Portapique / Gleason Brook	672	**2**	7.0	16	2.3:1	65%	1.18	0.23	Spruce, 44.8% Canopy closure, 75% Mature forest
34	Annapolis / South Annapolis	632	**2**	14.2	15	2.0:1	26%	2.36	0.63	97 % Mature, Mixed conifer forest with 71% canopy closure
44	Halfway River	605	2	10.4	29	2.5:1	60%	0.78	0.19	94% Young Forest, Mixed decide/conifer 9% avg. canopy closure
9	Gaspereau River	453	3	17.7	No pools	NA	100%	5.34	1.09	17% canopy closure in Hemlock of 72% mature forest

Figure 4: A scour pool on the South Annapolis River with >1.0m residual pool depth provides good deep water cover and holding for salmonids.

A third component of stream evaluation that relates to pools is the residual pool depth. This is the depth of the water that would be left in a pool if water levels became too low to flow out the tail crest. Residual depth is calculated by measuring the maximum pool depth at the time of the survey, and subtracting the depth of water at the pool tail crest. Residual pool depth is arguably the most important measure in assessing quality of a pool. Good pool depth provides important refuge at critical times of low flow and during flood flow. Deep pools also provide holding area during migration, and can provide visual cover because of depth alone, particularly in the dark tanic waters found in much of Nova Scotia. Cunjak et al. (1998) suggest that large pools are important for the overwinter survival of post spawning kelt salmon.

Given the survey methodology used, a pool was not counted as a primary pool if the residual depth did not meet a minimum of 0.4 m in streams <5 m Wbf and 0.5 m in streams from 5-<10 m Wbf. Overall, the average residual depth was over 0.8 m for primary pools assessed in the survey. This number is based on some 44 pools that were measured in detail. The South Annapolis River (see Figure 4), Shady Brook, and Bass River of Five Islands were the three locations with average residual pool depths greater than 1.0 m (see Appendix 1for details). The average for residual pool depth at each site was often underestimated as measurements made for individual pools while wading were often limited to just over 1m depth because of safety concerns. Therefore, any pools exceeding that depth could not be accurately measured for residual depth.

LWD counts in this project consisted of counting every piece of wood that was >10cm diameter and 2 m length lying within the bankfull channel cross section throughout the full length of the site surveyed. LWD counts were tallied in two size classes in every habitat unit encountered. It has been estimated that less than 40 % of this wood is usually functional; influencing channel geomorphology by causing scour and impoundment (Montgomery et al. 1995). In Western North America, LWD counts >2 pieces / Wbf are considered good and equivalent to unlogged, whereas less than 1 is poor and equivalent to a logged stream, in channels less than 15 m wide and 5 % gradient (Chesney 2000, Slaney and Martin 1997). As little evaluation of the frequency of large wood in streams has been conducted on the Atlantic Coast it is not possible to determine how appropriate the use of these guidelines is for streams in Nova Scotia. Table 2 presents project results by stream for Total LWD / Wbf and LWD > 30 cm / Wbf.

Figure 5: Gaspereau River, showing several large pieces of wood parallel to the channel that offer bank protection but little direct habitat value.

The highest frequency of LWD was found in Shady Brook (5.63 pieces / Wbf). Because of the remote location of this site, it is likely one of the more natural systems within the study. Although watershed scale impacts from logging may exist, other anthropogenic impacts that may affect stream morphology do not occur. A close second was the Gaspereau River (5.34 pieces / Wbf), a result that would seem to contradict the previous suggestion that this system is a "poor" example of a low impact stream. However, nearly all of the wood counted on the Gaspereau system was parallel to the stream bank and not functioning to create scour or damming (see Figure 5). The wood observed at the Gaspereau River site would provide greatest benefit in armouring the stream bank from erosion, but would provide little in terms of direct habitat value to stream biota. The other LWD results that are likely misleading are those for Elderkin Brook. That reach had very large trees in the riparian zone, however, impacts from a recent flood event had caused significant bank erosion and recruitment of trees to the channel that likely resulted in some inflation of LWD numbers.

Evaluation of LWD >30 cm / Wbf tells us how many very large and mature trees are found within the channel. It might be expected that those sites that have long undisturbed riparian areas, that would allow trees to become old growth and naturally fall into the channel, may be the "best" representatives of low impact conditions and would have a higher proportion of large wood pieces within the stream channel. Very large wood is less likely to move out of a system without significant flood events capable of floating and moving such mass. Because of the sheer mass of this largest wood, it is more likely it will influence local hydraulic conditions. Elderkin (0.82 pieces >30 cm / Wbf), Shady (0.99), and Gaspereau (1.09) had the most LWD >30 cm diameter within the channel. As mentioned, Gaspereau wood was largely parallel to the banks, and existed in a much larger channel, whereas that in Elderkin and Shady (see Figure 6) was very functional in forming pools through damming and scour.

Figure 6: A naturally recruited piece of LWD >30cm diameter laying perpendicular to the channel, providing cover and scour at a range of stream flows on Shady Brook.

Based on the evaluation of all the data collected, three sites appear to be "poor" representatives of low impacted stream habitat. They are Farrell's Brook site (56), the Halfway River site (44), and the Gaspereau River site (9). Each had a number of characteristics that precluded them from being good representative sites for low impact stream habitat. Farrell's Brook had several bridge crossings and a road parallel to the system in the flood plain, evidence of selective timber harvest in the past to the stream bank, a predominantly young forest buffer, no primary pool habitat, moderately low wood counts, and 94 % riffle habitat. The surveyed reach in the Halfway River was almost all young forest, and therefore did not meet the selection criteria. It further had areas of heavy erosion and bed load movement, several ford crossings, cottage development within meters of the bank, and relatively low large woody debris counts. The Gaspereau River had no pools in the surveyed reach and consisted of 100 % riffle. Large wood counts were quite good at the site, although their orientation to the stream and the boulder controlled nature of the section meant that they had little impact on stream morphology. The riparian corridor was not all mature forest, and because of the larger size of the river had lower canopy closure over the waterway. For these reasons, the results from these three sites was separated in the collective evaluation of "best" low impacted stream habitats of the Bay of Fundy presented in Section 3.2 of this report.

Figure 7: LWD has fallen into the Halfway River because of stream bank erosion, not natural recruitment through collapse of mature or old growth. High flows have moved that wood parallel to the banks where it provides some armouring and slows further erosion in the stream reach through young forest.

The remaining 12 surveyed sites were generally categorized as "best" examples of low impacted stream habitats based on all sites surveyed. This categorization was used to examine a summary of the survey results discussed in section 3.2 – Collective Evaluation.

3.2 Collective Evaluation

For the collective evaluation, all stream data collected was tallied to provide a number of "average per parameter" results for low impacted streams. For example, average residual pool depth for all sites surveyed was 0.82 m. Due to the nature of the exercise, both good and poor representative streams were surveyed during the project, requiring some categorization of data. Therefore, a "best examples" of low impacted streams, a "poor examples" of low impacted streams, and an "all streams surveyed" category are reported on. Finally, for comparison, the results from another unrelated study conducted by East Coast Aquatics of impacted stream reaches in the Inner Bay of Fundy are presented.

Twenty-nine physical habitat parameters were measured, tallied and assessed as part of this project. A summary of the data is presented in Table 3, based on details collected by stream (see Appendix 1). Two of these measures are often used to assess stream habitat quality and to guide habitat restoration in Nova Scotia and Atlantic Canada, and it is with these measures that the discussion on the collective results begins.

Table 3: Quantitative habitat survey summary. Results have been categorized as all sites surveyed, those sites believed to be either the "best" or "poor" representatives of low impacted stream habitats, and those believed to be representative of higher impact. Averages are not weighted.

	"Best" Low Impact Habitat Summary Data	"Poor" Low Impact Habitat Summary Data	All AFFA Low Impact Habitat Summary Data	East Coast Aquatics Other Impact Sites	Units
Streams Tallied	8	3	11	5	**streams**
Total length surveyed:	7542	1620	9162	2608	**m**
Average Dbf:	0.79	0.80	0.79	0.54	**m**
Average Dw:	0.33	0.29	0.32	0.20	**m**
Average Wbf:	9.85	11.66	10.35	7.2	**m**
Average Ww:	6.83	7.81	7.10	5.4	**m**
Avg. Residual Pool depth:	0.83	0.72	0.82	0.57	**m**
riffle/pool ratio	2.8	4.5	3.0	1.96	**:1**
Est. pool spacing @ 6Wbf:	59	70	62	43	**m**
Actual avg. primary pool spacing	280	386	323	185	**m**
Actual avg. primary pool spacing	26	45	31	26	**Wbf**
Actual avg. pool habitat spacing (primary and embedded)	136	281	175	NA	**m**
Actual avg. pool habitat spacing (primary and embedded)	14	24	17	NA	**Wbf**
% total length riffle	47.1	84.6	57.3	71	**%**
Total LWD/Wbf:	2.27	2.35	2.29	0.47	**pieces/Wbf**
Total 10-30cm LWD/Wbf:	1.77	1.86	1.79	0.31	**pieces/Wbf**
Total >30 cm LWD/Wbf:	0.51	0.49	0.50	0.20	**pieces/Wbf**
Average Embeddedness:	11	21	11	NA	**%**
Average Canopy Closure:	47	32	43	NA	**%**
Average Stream Gradient (GIS):	1.56	1.51	1.54	NA	**%**

First, it has long been suggested that a pool should be found spaced regularly in low impacted alluvial systems once every six times the bank full channel width (6 Wbf). Second, it is suggested that the most productive salmonid habitats are those with a 1:1 pool riffle ratio. Most community based stream habitat restoration projects are designed to implement a rock sill or "digger" logs once every 6 Wbf apart as a means of achieving these targets (Parker 1993).

Based on the current surveys, which were intended to document actual habitat characteristics of low impacted stream reaches in Nova Scotia, even the 12 least impacted of the stream reaches surveyed had primary pool spacing that did not approach the estimated 6 Wbf. Instead average pool spacing was just over 26 Wbf. A low number of holding pools has been considered a limiting factor for Atlantic salmon production, and may force high colonization rates of these holding areas that subsequently stop upstream movement of late arrivals to a river (Hawkins and Smith 1986 and Frenette et al. 1975 cited in Bardonnet and Bagliniere 2000).

If one was to use the argument that embedded pools (those that did not meet the minimum size requirements in this survey and that were not measured in detail) should have been included in the count because they could simply be slightly impacted pools that once would have been primary pools, it would bring the current result of primary and embedded pools being found on average every 14 Wbf for the twelve least impacted of the stream reaches surveyed. This result would still be more than double that which is suggested.

A second possible explanation of observed pool spacing exceeding predicted spacing is suggested by the observation that many sites exhibited a fairly regular riffle glide pattern. Similar to the embedded pool argument, if glides are just old primary pools that have slightly in filled due to bed load movement associated with past impacts or current activities and conditions within the watershed, then it may be appropriate to count glides as well for indication of the historic riffle pool ratio and spacing. Table 4 summarizes, by stream, this argument for the twelve least impacted sites (or eight streams) surveyed.

Table 4: A summary by stream of how riffle pool ratios and pool spacing would be altered if the hypothetical argument that every glide be counted as a primary pool that had been degraded over time were accepted.

	Surveyed R:P ratio	R:P ratio if all Glides converted to Pools	Predicted Pool Spacing based on surveyed 6 Wbf	Estimated Pool Spacing if all Glides converted to Pools
South Annapolis	2.0:1	1.0:1	85	105
Gleason Brook	2.3:1	0.9:1	42	45
Portapique River	7.5:1	0.9:1	63	62
Grumbley brook	2.1:1	0.7:1	36	30
Elderkin Brook	1.7:1	0.9:1	56	58
Averages	**3.1:1**	**0.88:1**	**56.4**	**60**
Grimm Brook#	0.8:1	0.4:1	46	106
Bass River *	1.3:1	1.1:1	59	126
Shady Brook**	4.5:1	4.5:1	84	865

Low gradient flats and stills *Bedrock controls, **No glides, but flats .

Table 4 shows how consideration of all glides as pools brings riffle pool ratios and pool spacing for most locations very close to the predicted 1:1 ratio and 6 Wbf spacing that are also used as restoration targets in Atlantic Canada. There are countless arguments as to why such conversion is inappropriate, and certainly 100% of the glides are unlikely to have been primary pools. However, the observation does provide fuel for discussion and future study. The three systems that do not particularly conform to the conversion all have apparent possible explanations. Grimm Brook (Figure 8), and Shady Brook did not have any glide habitats surveyed; but instead had flats and stills. These are similar habitat types, but do vary from glides. Therefore, there was not change in the ratio or spacing based on altering glide habitats to pools in these two systems. The Bass River had numerous bedrock controls throughout the surveyed reach associated with its location on the Cobequid Highlands, and therefore is unlikely to have had the same riffle pool ratio and pool spacing as would be predicted for a more truly alluvial system where virtually all substrates are moveable at some flood stage.

Figure 8: A long flat water section of habitat on Grimm Brook measured 264m in length.

Given that all sites evaluated likely have some anthropogenic impact, whether from long ago activities or more current watershed scale hydrological impacts, it is possible that some of the deep glides measured would have more naturally been pools as well. However, it is not possible to determine this from the data collected, and it can only be concluded that existing low impact conditions do not approach a pool every 6 Wbf apart, and have nearly triple the riffle pool ratio expected for low impacted streams.

Regardless of the actual pool spacing observed, a strong inverse relationship between pool spacing and LWD frequency has been observed in studies of moderate slope stream channels (Beechie and Sibley 1997; Montgomery et al. 1995). Therefore, collected data was evaluated to determine if pool spacing appeared to decrease with increased amount of LWD per unit length of stream channel in the low impact reaches of the Bay of Fundy being studied. All but one of the eight “best” low impact locations supported this more widely observed relationship (see Figure 9). Shady Brook had a very high wood count, but low pool spacing because of a significant number of “flat” habitat units being identified, and few pools. The data for Shady therefore supports a positive relationship between LWD and pool spacing, the opposite of all other sites.

Given that the data used in Figure 9 is only for low impact sites, the same data, along with data from the five other impacted Nova Scotia Bay of Fundy sites for which East Coast Aquatics has collected data was also plotted. The same inverse relationship was apparent. Therefore, it would seem that pool spacing decreases with increased LWD frequency in Bay of Fundy streams of the project area.

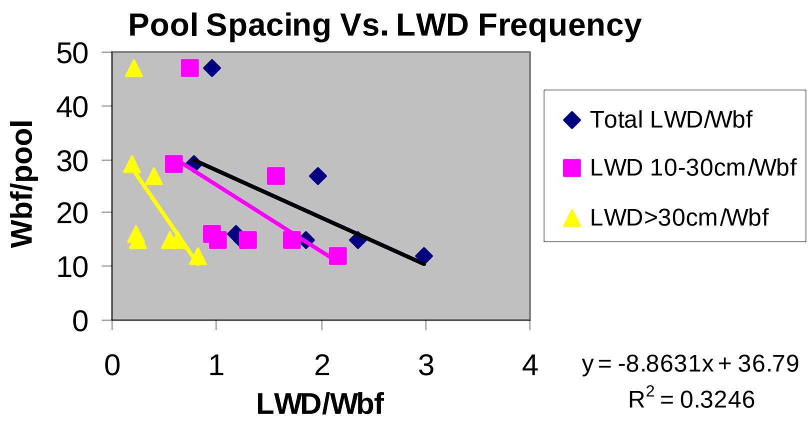

Figure 9: Plot of LWD frequency versus pool spacing shows that pool spacing decreases with increased LWD frequency for the project area. Shady Brook data, which does not follow this inverse relationship, has been removed from the plot data.

In Western North America, channels less than 15 m wide and 5 % gradient that have LWD counts >2 pieces / Wbf are considered good and equivalent to unlogged, whereas less than 1 are classified as poor and equivalent to a logged stream (Chesney 2000, Slaney and Martin 1997). As little evaluation of large wood in streams has been conducted on the Atlantic Coast it is not possible to determine how appropriate the use of these guidelines is for streams in Nova Scotia. However, at an average of over 2.2 pieces / Wbf for the "best" low impacted stream habitat reaches relative to an average of 0.47 pieces / Wbf for known impacted streams, it would seem a similar relationship may exist. It should be noted that the higher result for the "poor" low impacted sites (2.35 pieces / Wbf) is entirely due to the very high counts on the Gaspereau River, where numbers were high but orientation to the stream channel and function was very poor. In fact, if the counts for Gaspereau are removed from the average for the "poor" sites, LWD would be 0.85 pieces / Wbf and LWD >30 cm would be 0.19 pieces / Wbf. These numbers are much more in line with the other impacted sites data collected by East Coast Aquatics, and would be representative of previously logged sites in Western North America. As might be expected, LWD > 30 cm tally was higher in the "best" low impact reaches.

LWD has been shown to be of great importance for biological productivity; particularly in small to medium size streams less than 15 m Wbf (Chesney 2000). Tree removal in the riparian forest reduces the rate of LWD recruitment to a stream channel for decades, and existing wood in the channel continues to deplete over this period of low recruitment. This can result in sustained low amounts of LWD for up to 100 years after logging (Murphy and Koski 1989 cited in Beechie and Sibley 1997). If this scenario occurs in moderate slope channels it is predicted that there will be declines in the number and area of pools (Beechie and Sibley 1997). Given that much of Nova Scotia forests have had a second or third harvest, it is quite possible that channels have gone through more than one rotation with little to no LWD recruitment to the stream. Bay of Fundy streams may exhibit unnaturally low LWD frequency, resulting in fewer and smaller pools. Such may even be the case in streams where riparian areas are approaching maturity and channels appear stable.

Figure 10: Farrell Brook near Parrsboro, identified as a candidate stream, had extensive riffle zone, no pool habitat, and the riparian area had been selectively logged over time.

As shown in Table 3, the average % length of surveyed channel that was riffle was much less (47 %) for the "best" low impact sites than it was for the "poor" low impact sites (85 %). Although riffles can be key feeding zones for juvenile salmonids, pool habitats are needed for adult holding and overwintering by a number of age classes. Extensive riffle zones may also impede migration of anadromous species.

As noted, average residual depth of pools was 0.82 m. Directly related to this measure is another component of habitat assessment, instream cover. Like overhead cover, instream cover is subjectively estimated (see Table 5). This qualitative measure provides an estimate of the surface area for which there is a related in stream cover component such as boulders, LWD, undercut bank, and deep pool. The most frequently observed in stream cover components noted during assessments were boulders and deep pools. The greatest percentage of stream area covered per assessed instance was for deep pools at 43 % of the surface area of the measured habitat unit being covered.

Table 5: Subjective evaluation of in stream cover components within given habitat units assessed.

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetation	12	5
Large woody debris	21	11
Undercut bank	21	7
Boulder	37	21
Deep pool	25	43

Deep pool cover was not limited to just primary pool habitat units, as an embedded pool found within a primary riffle unit might still have been deep enough to meet the instream cover criteria of 1 m of max depth in clear water systems and 50 cm in tanic waters. Although deep pools provide the greatest area of in stream cover observed, boulders were the most frequently observed cover type. Boulder cover has been shown to provide cover to significant densities of juvenile salmonids (McCubbing and Ward 1997, 2000). The history of logging in Nova Scotia included log drives down many streams. These drives would have impacted both pool and boulder habitats. Stories of the removal of boulders and woody debris from stream channels to ease log drives have also been told (Ernst 1996). No evaluation of such activities was conducted for the streams that were assessed during this project.

Collected measures of embeddedness and canopy closure do not provide much comparative information. Canopy closure needs to be evaluated based on Wbf stream classes as the crown diameter of a tree may fully cover a smaller stream, but provide only 10-15 % closure on a larger order stream. There were not adequate numbers of reaches surveyed in different stream orders to allow comparison of crown closure based on stream widths. Individual tree crown diameter is further a function of tree species and maturity, and riparian data collected during the study was not intended to be detailed enough to allow such analysis. However, at 47 % average overhead canopy closure, surveyed reaches would receive moderate shading and small organic debris (SOD) contribution.

Embeddedness is a measure the degree to which larger stream substrates are firmly surrounded by fine substrates. Recently, Atkinson and Mackey (2005) have shown juvenile Atlantic salmon densities in Maine to be inversely related to embeddedness levels. However, the capacity of this project to carry out time intensive detail measures of embeddedness did not exist. With lack of a quick field survey methodology that has been assessed in the scientific literature to follow, an approach of trying to find an approximately standardized cobble (15 cm x 15 cm x 15 cm) and estimating the % to which it was embedded was used. Few such samplings were made, and the results provide little more than a general characterization that embeddedness appeared to be less in the “best” low impacted stream reaches.

Since initiation of the project a methodology using a randomly placed 60cm diameter hoop, and measuring embeddedness of up to thirty 4.5-30 cm diameter cobbles to calculate a weighted cobble embeddedness (WEMB) and interstitial space index (ISI) (Atkinson, Mackey and Trial 2004) has been examined. Evaluation of the methodology is ongoing. Incorporating this type of approach in future studies may be appropriate.

It has also been shown that quantitative methods, as described by Atkinson et. al. (2004), yield higher values of embeddedness than do visual approaches, as used in our study, at low levels of cobble embeddedness, while the reverse is true at high levels (McHugh and Budy 2005). Realizing this difference is important when assessing results.

The intent of the current study was to document physical stream habitat characteristics of reaches in low impact mature to old growth riparian areas flowing into the Bay of Fundy in Nova Scotia. The riparian characteristics were based on the Nova Scotia Department of Environment and Labours’ SOUF (Significant Old Growth and Unique Forests) GIS map layer. The SOUF layer was created through air photo interpretation of stand age and composition, without on the ground confirmation. Therefore, although it was not within the capacity of the current project to fully document and characterize the riparian areas of the surveyed stream reaches, some measures were taken and observations made to provide a description of the riparian vegetation present. This included measuring the diameter at breast height (DBH) of a randomly selected number of trees along the surveyed reach that appeared to be the largest of particular species' present. Between 3-9 trees total were measured at each stream surveyed site. This accounted for 70 trees measured. Details are presented in Appendix 2.

Figure 11: A core sample is taken from an old stream side fir tree on Portapique River.

The Nova Scotia Department of Natural Resources provides the following definitions for old and mature growth in the *Interim Old Forest Policy* (NSDNR 1999).

- *Old Growth* is any forest stand with a minimum of 30% crown closure, ≥ 50% of the basal area is in climax species, and ≥ 30% of the stand's basal area is ≥ 125 years old. Climax species are normally Hemlock, Red Spruce, White Pine, Sugar Maple, Yellow Birch or American Beech but may also include 'intermediate' species such as Balsam Fir, Red Maple and Black Spruce in some environments e.g. highlands, bogs, fens.

- *Mature Climax* is any forest stand that has a minimum of 30% crown closure, ≥ 50% of the basal area is in climax species and ≥ 30% of the stand's basal area is ≥ 80 years old.

- *Old Forest* is any stand or collection of stands containing old growth or mature climax forests

The study reported here aimed to survey streams within riparian corridors in which the trees were a minimum of 80 years old and preferably more than 100 years. Meeting this objective was expected to be a challenge as 91 % of the Nova Scotia forest consists of even-aged stands less than 100 years old (NSDNR 2000). Additionally, only 0.6 % of our forests are over 100 years of age and just 4.0 % are more than 80 years (Lynds and LeDuc 1995). A recent study by the Nova Scotia Department of Natural Resources (NSDNR) on old growth forests in Nova Scotia provides a description of both hardwood and softwood stands. The NSDNR study uses two hardwood and two softwood stands to produce an "old growth reference age and diameters" regression model. Both hardwood stands are in Cape Breton, and therefore are somewhat removed from the most probable hardwood climax forests of our project area, those sites found north of the Minas Basin. One of the softwood sites was within the current project area, and within a couple of kilometers of the Shady Brook site on Panuke Lake.

The "reference" age is determined by the smallest diameter of the largest third of the basal area present. Based on reference DBH between 51-57 cm at four uneven old growth sites in Nova Scotia, reference ages ranged from 164-214 years (NSDNR 2000). The average DBH site of the trees measured in our project ranged from 39 cm to 83 cm (see Table 6). This result can not be directly compared to the reference data presented, as our samples were the largest trees found on site. Furthermore, the relationship between age and diameter is non-linear, and although diameter provides some indication of average age, it is a poor predictor of the age of an individual tree. Individual tree growth is influenced by such factors as site fertility, species, tree history (disease, fire etc), and growing space. None of these factors were assessed in our study.

Table 6: Average random tree sample diameter at breast height (DBH) for the *largest* riparian trees of most species present for each stream location.

Location	Average DBH (cm)	No: of Trees
Gaspereau	50	5
Farrell	53	3
Elderkin	83	9
Grumbley	49	9
Shady	74	9
Grimm	60	9
South Annapolis	63	8
Bass River	39	8
Portapique	47	7
Gleason	55	3

Although the tree data collected does not allow us to scientifically confirm the stand age of each project sites, they do indicate presence of some quantity of adequately mature trees to provide natural recruitment of LWD to the stream channel. The tree species of the specimens that were measured are also those that most normally compose the climax forest stand in Nova Scotia (NSDNR 2000).

The recent evaluation of selected old growth forests in Nova Scotia also provides some insight into LWD counts within the Province. In the NSDNR study (2000), softwood stands were found to contain almost twice the volume of dead wood as the hardwood stands, which was quite similar to the difference found in the volume of live wood between the two stand types. Therefore, it is more likely that a high count of LWD may be found in streams that run through mature softwood stands in Nova Scotia, and this may explain some of the variability observed in LWD counts between surveyed sites (see Table 2).

3.3 Conclusions and Recommendations

Several conclusions and recommendations fall from this study and the discussion presented herein. They are listed here in point form for consideration of others who may carry out similar or related work on low impacted reaches in Nova Scotia and Atlantic Canada. They are presented in no particular order of priority.

- No truly unimpacted old growth stream reaches appear to exist within the studied project area of Nova Scotia. Every site assessed had some visible indication of past or current anthropogenic use either in, or adjacent to the stream channel.

- Although the streams surveyed are not pristine, they do represent some of the least impacted within the Bay of Fundy area of Nova Scotia. Additional surveys need to be completed to add to the data set and provide greater confidence in the observed results. Any new data should be added and assessed based on stream order, as morphological character will vary with stream size.

- It is much more difficult to find 3rd order streams that exhibit even moderate low impact habitat qualities. These streams are more susceptible to impacts from outside of the candidate reach, as hydrological impacts and land use impacts upstream are somewhat more cumulative in nature, meaning that higher peak flows, bedload movement, and sedimentation are more likely to continue into the reach with old forest characteristics.

- The collected data indicate a higher frequency of large woody debris exists in the less impacted reaches of the project area. Frequencies of LWD >2 pieces/Wbf for the "best" low impacted stream reaches surveyed is consistent with west coast data that indicates >2 pieces/Wbf as good and representative of unlogged systems and <1 piece/Wbf as indicative of logged riparian areas.

- An inverse relationship appears to exist between LWD frequency and pool spacing within the project survey sites. This means a greater number of pool habitats exist in those systems that have higher wood counts than those with lower wood counts per unit length.

- Although the data collected in this study generally seem to support what has been documented in the literature for western Canada and the Pacific Northwestern United States in terms of LWD tallies, the data set collected here is not large enough to confirm that the observed results are representative of streams in Nova Scotia entering the Bay of Fundy. However, collection and analysis of additional data would help confirm or refute the observed results of this study; and, such knowledge would ultimately be a valuable resource to freshwater stream habitat management in Nova Scotia.

- The collected data indicate reduced riffle habitats in less impacted reaches. A sizeable difference between % length as riffle habitat in the survey for “best” (47 %) and “poor” (85 %) sites was observed.

- Even in the least impacted of the stream reaches surveyed the actual spacing of primary pools did not approach the estimated 6 Wbf that is used as a guide in Atlantic Canada for restoration, but instead was 26 Wbf. Although inclusion of embedded pool habitats in the count, or consideration of every glide as a former pool that has been impacted would bring the pool spacing more closely in line with that predicted for low impacted locations, it is not possible to determine from the data collected whether either scenario is likely. Furthermore, if either case is likely, an impact exists and therefore the survey does not truly represent low impacted streams. It can only be concluded that existing conditions in the “low impacted” reaches surveyed do not approach a pool spacing of every 6 Wbf, nor a riffle pool ratio of 1:1.

- Primary pools (those that exceed a minimum depth, cover more than 50 % of the wetted width, and are greater than 1 Wbf in length) measured in the study averaged over 0.80 m residual depth given an average channel width of about 10 m for all streams surveyed. As the minimum residual depth criteria to be counted as a primary pool is 0.4-0.5 m for streams <10 m Wbf, it would appear that primary pools are well formed in the lower impact reaches of the Bay of Fundy streams studied.

- Slope, geology, and stream size are major factors that influence the channel morphology and how wood interacts with that channel. Therefore, further evaluation should examine low impact data sets within categories that consider these three factors. Such a categorized evaluation would require a larger data set than that which has been collected here. On mainland Nova Scotia, streams to be assessed should be categorized by stream order, slope, and by the geological Avalon and Meguma Zones.

- Of the 170 candidate sites identified through the GIS Analysis, 52 sites were selected as a first priority for field evaluation, and 29 of those were actually visited. Only fifteen of the 29 visited met the minimum selection criteria and were actually surveyed. That means that as many as 141 candidate sites could still be field assessed. Although this may seem a large untapped potential, only 17 % (30) are >500 m long. Based on the experience of this project, reaches <500 m are unlikely to provide quality data on low impact characteristics in the majority of instances. Additionally, the higher the stream order, the longer the reach ought to be to provide good data. If this guideline is followed, the current candidate list of low impact stream reaches, based on the current 50 % field confirmation rate, would only provide another 15 sites for survey. Therefore it is recommended that if additional similar work is pursued, consideration to expanding the project area boundary to include New Brunswick Inner Bay of Fundy streams be given.

- Finally, a key component to creating an accurate description of low impacted stream habitats is ensuring the streams flow through riparian stands of mature and old growth. Future surveys should endeavor to more fully and accurately describe these riparian stands in terms of age, species composition, and basal area.

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http://www.annapolisflyfishing.com/

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Appendix 1: Stream Habitat Field data

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project:	AFFA Low impact Habitat			**Site #**	44	
Watershed:	Halfway River			**Site Description:**	Not an old growth section. Clear water, poor condition. Area 1.5km upstream better, mature growth.	
UTMds:	20T	399516	4984566			
UTMus:	20T	39911	4984104			
Surface velocity: m,	T1	T2	T3		**@ hab. Unit no:**	
Est. Velocity	#####	m/s @ hab unit	0			
Est Discharge = Dwavg hab unit no:	0		**Ww hab unit no:**	0		
Est. Discharge m³/sec =	#DIV/0!	m³/sec a hab unit	0			
Subsampling Fractions: R/	3	P/ 1	Rn/ 3	C/ 3	O/ 3	

Weather:	Sunny
Survey Date:	29/08/05
Water Temp :	(C⁰)

Total length surveyed:	605	m
Average Dbf:	0.80	m
Average Dw:	0.35	m
Average Wbf:	10.4	m
Average Ww:	5.7	m
Avg. Residual Pool depth:	0.7	m
riffle/pool ratio	2.5	:1
Est. pool spacing @ 6Wbf:	62.6	m
Acutal avg.pool spacing	303	m
% total length riffle	60%	
Total LWD/100m:	0.78	pieces/Wbf
Total 10-30cm LWD/100m:	0.59	pieces/Wbf
Total >30 cm LWD/100m:	0.19	pieces/Wbf

Average Stream Gradient (GIS):	0.98	
Average Canopy Closure:	9	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
72	0	28	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	6	94	0

Average Embeddedness:	18	%
Embedded pools	1	
Acutal avg. pool habitat spacin	202	m
Acutal avg.pool spacing	29	Wbf/pool
Acutal avg. pool habitat spacin	19	Wbf/pool

	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Depth: Dw$_{avg}$	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Pools Only: Crest (m)	Pools Only: Residual (m)	Pools Only: Pool Type	Bed Material Type: Dominant	Bed Material Type: Sub - Dom.	Bed Material Type: Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators			Riparian Vegetation: Type	Riparian Vegetation: Structure	Canopy Closure	Comments
1	0	R	15																0	0	0					UB			D	YF	5	
2	15	G	18																0	0	0								D	PS	5	1 embed pool, 2 embed riffle
3	33	R	85																3	1	4								D	YF	15	
4	118	G	91																3	2	5								D	YF	10	crossing
5	209	P	13		0.6					8.3	6.8	0.84	0.21	0.63	scour	cobble	sand	5	5	5	10	LWD	10	UB	5				D	YF	10	
6	222	G	43		0.35	0.34	0.8	0.6	0.58	11.7	3.9					cobble	sand	0	7	0	7	LWD	5						D	YF	15	2 embedded riffles
7	265	R	35		0.45	0.1	0.15	0.12	0.12	10.5	5.7					rubble	cobble	50	1	0	1								D	YF	15	
8	300	P	17		0.4					11.2	6.4	1	0.2	0.8	scour	rubble	sand		8	3	11	LWD	5	UB	10	EB			D	PS	10	roadside LB
9	317	R	62																3	0	3								D	YF	5	1 embedded glide
10	379	G	59																0	0	0								D	YF	5	2 embedded riffles
11	438	R	167																4	0	4								M	YF	5	a few older trees
12	605																				0											

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	3	6.7
Undercut bank	2	7.5
Boulder	0	#DIV/0!
Deep pool	0	#DIV/0!
Instream vegetation	0	#DIV/0!

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project: AFFA Low Impact Habitat **Site #** US 48
Watershed: Gleason Brook - Portapique River **Site Description:** Section upstream of site 48, section not on GIS
UTMds: 20T 443665 5042821
UTMus: 20T
Surface velocity: m. **T1** **T2** **T3** **@ hab. Unit no:**
Est. Velocity ###### **m/s @ hab unit** 0
Est Discharge = Dwavg hab unit no: 0 **Ww hab unit no:** 0
Est. Discharge m³/sec = #DIV/0! **m³/sec a hab unit** 0
Subsampling Fractions: R/ 3 **P/** 1 **Rn/** 3 **C/** 3 **O/** 3

Weather: sunny clear
Survey Date: 14/09/05
Water Temp : (C⁰)

Total length surveyed:	672 m
Average Dbf:	0.71 m
Average Dw:	0.33 m
Average Wbf:	7.0 m
Average Ww:	5.2 m
Avg. Residual Pool depth:	0.76 m
riffle/pool ratio	2.3 :1
Est. pool spacing @ 6Wbf:	41.8 m
Acutal avg.pool spacing	112 m
% total length riffle	65%
Total LWD/100m:	1.18 pieces/Wbf
Total 10-30cm LWD/100m:	0.95 pieces/Wbf
Total >30 cm LWD/100m:	0.23 pieces/Wbf

Average Stream Gradient (GIS):	1
Average Canopy Closure:	44.8 %

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
12	24	40	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	19	57

Average Embeddedness:	#DIV/0!	%
Embedded pools	8	
Acutal avg. pool habitat spacin	48	
Acutal avg.pool spacing	16	Wbf/pool
Acutal avg. pool habitat spacin	7	Wbf/pool

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	0	#DIV/0!
Undercut bank	0	#DIV/0!
Boulder	6	21
Deep pool	2	45
Instream vegetation	0	#DIV/0!

#	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Dw_{avg}	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Bed Material Type: Dominant	Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators	Riparian Vegetation: Type	Structure	Canopy Closure	Comments
1	0	G	18																2	0	2						M	MF	80	spruce cored at end of section 108yrs
2	18	R	90																5	0	5						M	MF	50	3 embed pool
3	108	P	13		0.35					6.6	5	1.08	0.53	0.55	scour	rubble	cobble		0	0	0	DP	25	B	5		C	MF	50	
4	121	R	36																5	0	5						C	MF	15	2 embedded pools
5	157	G	17																0	0	0						M	MF	5	RB 80ft rock wall
6	174	R	32		0.33	0.22	0.29	0.3	0.27	7.5	3.5					cobble	rubble		4	0	4	B	10				M	MF	20	
7	206	G	10			0.23	0.34	0.46	0.34	9.1	6.5					rubble	sm boulder		1	0	1	B	20				M	MF	20	
8	216	R	6																0	0	0						M	MF	20	
9	222	G	8			0.45	0.45	0.45	0.45										0	0	0						D	YF	10	
10	230	R	70																3	0	3						D	YF	10	1 embedd pool 2 glide
11	300	G	21																1	1	2									
12	321	R	41		0.4	0.32	0.18	0.14	0.2133	7.7	5.8					sm boulder	gravel		3	1	4	B	40				M	MF	40	2 embedded pools
13	362	P	10		0.35					6.5	5	1.15	0.2	0.95	scour	sm boulder	rubble		1	0	1	DP	65	B	20		M	MF	60	0+405 confluence with brook
14	372	R	47																3	3	6						C	MF	65	
15	419	G	8																3	1	4						C	MF	60	
16	427	R	9																2	0	2						C	MF	60	
17	436	P	7		0.4					5	4.2	0.62	0.16	0.46	scour	rubble	cobble		0	0	0	B	30				C	MF	60	
18	443	R	26																3	2	5						C	MF	75	
19	469	P	6							5	3.8	0.56	0.15	0.41	scour	rubble	pebble		1	0	1						C	MF	80	
20	475	R	9																1	0	1						C	MF	40	
21	484	G	48		0.4	0.42	0.48	0.29	0.40	8.3	7.6					cobble	pebble		22	4	26						M	YF	70	1 embedded riffle
22	532	R	25																6	1	7									
23	557	G	19																5	0	5									
24	576	R	18																4	0	4									
25	594	G	28																10	3	13									
26	622	R	16																2	1	3									
27	638	P	22									1	0.19	0.81	scour				3	2	5									
28	660	R	12																2	3	5									
29	672	P										1.5	0.1	1.4	scour	bedrock			0	0	0						M	MF	50	

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project:	AFFA low impact habitat			Site #	48 - 77
Watershed:	Upper Portapique			Site Description:	Begins in Gleason above Fountain Brook, through this confluence to become upper Portapique River.
UTMds:	20T	442539	5042059		
UTMus:	20T	443263	5042446		
Surface velocity: m,	T1		T2	T3	@ hab. Unit no:
Est. Velocity	###### m/s @ hab unit 0				
Est Discharge = Dwavg hab unit no:	0	Ww hab unit no:	0		
Est. Discharge m³/sec =	#DIV/0!	m³/sec a hab unit	0		
Subsampling Fractions: R/ 3	P/ 1	Rn/ 3	C/ 3	O/ 3	

Weather: Clear
Survey Date: 14/09/05
Water Temp : 11.5 (C⁰)

Total length surveyed:	985	m
Average Dbf:	0.67	m
Average Dw:	0.32	m
Average Wbf:	10.6	m
Average Ww:	6.7	m
Avg. Residual Pool depth:	0.79	m
riffle/pool ratio	7.5	:1
Est. pool spacing @ 6Wbf:	63.4	m
Acutal avg.pool spacing	493	m
% total length riffle	55%	
Total LWD/100m:	0.96	pieces/Wbf
Total 10-30cm LWD/100m:	0.74	pieces/Wbf
Total >30 cm LWD/100m:	0.21	pieces/Wbf

Average Stream Gradient (GIS):	0.96	
Average Canopy Closure:	24.4	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
21	66	14	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	4	96

Average Embeddedness:	11	%
Embedded pools	1	
Acutal avg. pool habitat spacin	328	
Acutal avg.pool spacing	47	Wbf/pool
Acutal avg. pool habitat spacin	31	Wbf/pool

	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Depth: Dw avg	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Pools Only: Crest (m)	Pools Only: Residual (m)	Pools Only: Pool Type	Bed Material Type: Dominant	Bed Material Type: Sub - Dom.	Bed Material Type: Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators	Riparian Vegetation: Type	Riparian Vegetation: Structure	Canopy Closure	Comments
1	0	G	61			0.7	0.7	0.7	0.70										3	1	4						M	MF	20	bedrock
2	61	R	23																5	0	5						D	MF	40	
3	84	G	24																0	0	0						D	MF	80	
4	108	R	19																0	0	0						D	MF	40	bedrock
5	127	G	25		0.35	0.47	0.51	0.39	0.46	8.4	6.3					cobble	bedrock	30	1	1	2	B	5	UB	5		D	MF	50	
6	152	R	107		0.4	0.13	0.15	0.14	0.14	11.5	5.1					bedrock	cobble	5	7	6	13	B	10				C	MF	10	bedrock, 1 embedded pool
7	259	G	15																1	1	2						C	MF	15	bedrock
8	274	R	27																4	1	5						M	MF	10	
9	301	G	25																1	1	2						C	MF	20	1 trout ~ 12cm vis obs.
10	326	R	8																0	0	0						D	MF	65	
11	334	G	22		0.35	0.4	0.55	0.54	0.50	11.9	6.4					rubble	cobble		0	0	0	B	10				D	MF	50	
12	356	R	29		0.35	0.11	0.15	0.1	0.12	10.3	5.1					cobble	rubble	5	1	0	1	B	10	OV	5		D	MF	30	few inverts on stones
13	385	G	33																3	0	3						D	MF	50	
14	418	R	19																1	0	1						D	MF	20	
15	437	G	25																6	1	7						M	MF	5	
16	462	R	32																2	0	2						C	MF	15	
17	494	G	21		0.37	0.75	0.61	0.34	0.57	6.2	5					cobble	rubble	5	0	0	0	B	15				M	MF	40	picture ds
18	515	R	46			0.17	0.2	0.16	0.18	7.4	3.4					cobble	sm boulder		4	1	5	B	15				C	MF	20	1 embedded glide
19	561	G	36																0	0	0						C	MF	15	0+585 Fountain brook. FB ~1/3 flow Gleason 2/3 at confluence, 2 embed riffle
20	597	R	26																0	0	0						C	MF	15	
21	623	G	15																0	0	0						C	MF	15	
22	638	R	40																5	0	5						C	MF	10	
23	678	G	23		0.3	0.2	0.26	0.37	0.28	10.2	8.8					pebble	gravel	10	1	0	1						C	MF	5	
24	701	R	44			0.13	0.1	0.14	0.12	16.6	9					pebble	cobble		4	3	7						C	MF	5	
25	745	P	13							9.8	8	0.93	0.32	0.61		cobble	pebble		3	0	3	B	5				C	MF	25	
26	758	G	48																5	1	6						C	MF	20	
27	806	R	23																1	0	1						C	MF	15	
28	829	P	18							7.8	5.3	1.2	0.24	0.96		cobble	gravel		1	1	2	DP	30	B	5		C	MF	20	small hand built dam at crest of pool
29	847	R	29																2	0	2						C	MF	10	
30	876	G	39																1	0	1						C	YF	10	
31	915	R	70		0.35	0.13	0.13	0.17	0.14	16.2	10.8					pebble	cobble		7	2	9						C	MF	10	picture us
32	985																				0									

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	1	5
Large woody debris	0	#DIV/0!
Undercut bank	1	5
Boulder	8	9
Deep pool	1	30
Instream vegetation	0	#DIV/0!

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project: AFFA Low Impact Habitat **Site #**
Watershed: Bass River of 5 Islands
Site Description: Start at confluence with Big Pine Fire Brook. Confined flood plain in top section through canyon, so done as two segments.
UTMds: 20T 418202 5035684
UTMus: 20T 417935 ?
Weather: overcast
Survey Date: 13/09/05
Water Temp : 13 (C⁰)
Surface velocity: m, T1 T2 T3 **@ hab. Unit no:**
Est. Velocity ##### m/s @ hab unit 0
Est Discharge = Dwavg hab unit no: 0 **Ww hab unit no:** 0
Est. Discharge m^3/sec = #DIV/0! m^3/sec a hab unit 0
Subsampling Fractions: R/ 3 **P/** 1 **Rn/** 3 **C/** 3 **O/** 3

Total length surveyed:	883	**m**
Average Dbf:	0.88	**m**
Average Dw:	0.18	**m**
Average Wbf:	10.0	**m**
Average Ww:	7.5	**m**
Avg. Residual Pool depth:	1.09	**m**
riffle/pool ratio	1.3	**:1**
Est. pool spacing @ 6Wbf:	59.7	**m**
Acutal avg.pool spacing	147	**m**
% total length riffle	58%	
Total LWD/100m:	1.25	**pieces/Wbf**
Total 10-30cm LWD/100m:	1.01	**pieces/Wbf**
Total >30 cm LWD/100m:	0.24	**pieces/Wbf**

Average Stream Gradient (GIS):	3.4	
Average Canopy Closure:	25.6	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
11	22	67	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	15	85

Average Embeddedness:	0	%
Embedded pools	4	
Acutal avg. pool habitat spacin	88	
Acutal avg.pool spacing	15	**Wbf/pool**
Acutal avg. pool habitat spacin	9	**Wbf/pool**

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	0	#DIV/0!
Undercut bank	0	#DIV/0!
Boulder	6	12.5
Deep pool	4	42.5
Instream vegetation	0	#DIV/0!

	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Dw_{avg}	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Pools Only: Crest (m)	Pools Only: Residual (m)	Pools Only: Pool Type	Bed Material Type: Dominant	Bed Material Type: Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators	Riparian Vegetation: Type	Riparian Vegetation: Structure	Canopy Closure	Comments
1	0	R	31																1	0	1						C	MF	5	
2	31	P	16		0.55					5.4	5.1	0.85	0.2	0.65	scour	sm boulder	rubble		0	0	0						C	MF	30	
3	47	R	18																0	0	0						M	MF	50	
4	65	G	33																5	0	5						M	MF	15	
5	98	R	66		0.6	0.08	0.2	0.12	0.13	11.5	7.6					cobble	rubble	0	3	0	3	B	5				C	MF	20	
6	164	P	46		1.5							2.4	0.24	2.16	scour	sm boulder	cobble	0	8	4	12	DP	90	B	5		C	MF	20	Cascade, picture us
7	210	R	20																5	0	5						C	MF	5	
8	230	P	14		0.55					9	6.7	0.92	0.15	0.77	scour	sm boulder	rubble	0	0	0	0	DP	20	B	20		C	MF	40	
9	244	R	47		0.5	0.21	0.17	0.31	0.23	7.3	4.8					cobble	rubble	0	19	3	22	B	10				M	MF	25	us
10	291	P	10							12	9.9	0.82	0.25	0.57	scour	cobble	sm boulder	0	4	0	4						M	MF	45	
11	301	R	29																1	0	1						M	MF	15	
12	330	C	96																19	10	29						D	YF	25	3 embedded pools 80cm, 1.5m
13	426	R	105																7	1	8						M	MF	20	very incised channel
14	531	C	95																6	2	8	DP	40	B	20		M	MF	30	1 embedded pool
15	626	P	21		0.57					11	7.7	1.5	0.34	1.16	scour	gravel	sm boulder		2	0	2						M	MF	35	2 tree cores
16	647	R	199																9	1	10						M	MF	40	
17	846	P	37		0.6					13.5	10.8	1.46	0.23	1.23	scour	cobble	rubble		1	0	1	DP	20	B	15		M	YF	15	valley widens.
18	883																				0									

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project: AFFA Low Impact Habitat **Site #** 5,14
Watershed: Shady Brook - St. Croix River
Site Description: very boulder controled, stable with lots of moss on rocks, small gravel deposits behind boulders, lots of SOD, much is low gradient, long stretch of dry weather previous to survey / base flow conditions.
UTMds: 20T 414214 4964252
UTMus: 20T 414817 4966270
Surface velocity: m, T1 T2 T3 @ hab. Unit no:
Est. Velocity ##### m/s @ hab unit 0
Est Discharge = Dwavg hab unit no: 0 **Ww hab unit no:** 0
Est. Discharge m³/sec = #DIV/0! **m³/sec a hab unit** 0
Subsampling Fractions: R/ 3 **P/** 1 **Rn/** 3 **C/** 3 **O/** 3

Weather: sunny clear
Survey Date: 5/9/2005
Water Temp : 16 (C⁰)

Total length surveyed:	1729	m
Average Dbf:	0.79	m
Average Dw:	0.41	m
Average Wbf:	14.0	m
Average Ww:	11.4	m
Avg. Residual Pool depth:	1.00	m
riffle/pool ratio	4.5	:1
Est. pool spacing @ 6Wbf:	83.7	m
Acutal avg.pool spacing	865	m
% total length riffle	55%	
Total LWD/100m:	5.63	pieces/Wbf
Total 10-30cm LWD/100m:	4.63	pieces/Wbf
Total >30 cm LWD/100m:	0.99	pieces/Wbf

Average Stream Gradient (GIS):	1.23	
Average Canopy Closure:	52.8	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
9	49	42	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	21	79

Average Embeddedness:	10	%
Embedded pools	11	
Acutal avg. pool habitat spacin	133	
Acutal avg.pool spacing	62	Wbf/pool
Acutal avg. pool habitat spacin	10	Wbf/pool

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	2	12.5
Undercut bank	1	5
Boulder	5	22
Deep pool	5	47
Instream vegetation	0	#DIV/0!

					Depth					Width		Pools Only				Bed Material Type											Riparian Vegetation			
	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Bankfull (m)	Wetted (m)			Dwavg	Bankfull (m)	Wetted (m)	Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Dominant	Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators	Type	Structure	Canopy Closure	Comments
1	0	R	27																13	2	15						M	YF	70	
2	27	F	38																27	2	29						C	MF	30	up to 55cm deep
3	65	R	87																5	2	7						C	MF	75	3 embedded pools 45-73cm, picture of LWD and us riffle
4	152	P	30							17.2	13.9	1.1	0.11	0.99	scour	rubble	gravel	10	20	6	26	DP	90	LWD	10		M	MF	15	vis obs fish, good LWD
5	182	R	86		0.38	0.09	0.09	0.06	0.08	9	6.1					sm boulder	gravel	20	18	6	24	B	60				C	MF	65	2 embedded pools
6	268	F	34																4	1	5						C	MF	80	
7	302	R	62																3	4	7						C	MF	80	backchannel, little flow, 1 embedded pool
8	364	F	149													gravel	bedrock		143	20	163	DP	40	LWD	15		D	YF	40	1 embedded riffle
9	513	R	94																22	4	26						M	YF	50	picture ds of riffle
10	607	F	41																6	3	9					bridge	M	YF	40	road crossing, cleared
11	648	P	44		0.3					20.9	18.9	1.2	0.2	1	dammed	bedrock	gravel		32	7	39	DP	70	B	10	JW	M	MF	40	wood jam at ds end
12	692	F	32													gravel	bedrock		21	2	23						C	YF	10	cut LB, flat 30cm deep
13	724	R	100		0.4	0.03	0.11	0.09	0.08	10.2	4					rubble	gravel	0	12	3	15	B	20	UB	5		C	MF	70	
14	824	F	95		0.35	0.82	1	0.7	0.84	16.8	15.9					rubble	gravel		39	3	42	DP	30	B	10		M	MF	40	
15	919	R	15																1	1	2						M	YF	60	
16	934	F	91																71	14	85						M	MF	50	
17	1025	R	252																27	7	34						C	MF	80	backchannel and 3 embedded pools, 45cm deep
18	1277	F	69																27	6	33						M	MF	70	60cm+ deep
19	1346	R	226		0.45	0.09	0.11	0.14	0.11	7.1	5.9					bedrock	gravel		4	8	12	DP	5				M	MF	80	picture ds 0+1412, 2 embedded pools 40cm deep
20	1572	F	157		0.4	1	1	0.85	0.95	16.5	15					rubble	gravel		79	22	101	B	10				C	MF	10	end part way through final flat, logged on LB
21	1729																				0									

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project:	AFFA Low Impact Habitat			Site #	12	Weather:	Overcast
Watershed:	Elderkin Brook - Cornwallis River			Site Description:	Kentville Research Station, large amounts of recent deadfall in brook from Nov 2004 storm.	Survey Date:	24/08/06
UTMds:	20T	383934	4991401			Water Temp :	14 (C°)
UTMus:	20T	383564	4990996				
Surface velocity: m,	T1	T2	T3	@ hab. Unit no:			
Est. Velocity	######	m/s @ hab unit	0				
Est Discharge = Dwavg hab unit no:	0	Ww hab unit no:	0				
Est. Discharge m³/sec =	#DIV/0!	m³/sec a hab unit	0				
Subsampling Fractions: R/	3	P/ 1	Rn/ 3	C/ 3	O/ 3		

Total length surveyed:	993	m
Average Dbf:	0.67	m
Average Dw:	0.17	m
Average Wbf:	9.4	m
Average Ww:	4.9	m
Avg. Residual Pool depth:	0.66	m
riffle/pool ratio	1.7	:1
Est. pool spacing @ 6Wbf:	56.5	m
Acutal avg.pool spacing	110	m
% total length riffle	67%	
Total LWD/100m:	2.99	pieces/Wbf
Total 10-30cm LWD/100m:	2.17	pieces/Wbf
Total >30 cm LWD/100m:	0.82	pieces/Wbf

Average Stream Gradient (GIS):	0.09	
Average Canopy Closure:	61.6	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
9	39	51	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	4	95

Average Embeddedness:	22.5	%
Embedded pools	9	
Acutal avg. pool habitat spacin	55	
Acutal avg.pool spacing	12	Wbf/pool
Acutal avg. pool habitat spacin	6	Wbf/pool

Instream Cover

Type	# Instances Major Cover Type	Average % Of surface area covered / instanse
Overhanging vegetati	0	#DIV/0!
Large woody debris	7	13.6
Undercut bank	7	5
Boulder	0	#DIV/0!
Deep pool	1	60
Instream vegetation	0	#DIV/0!

					Depth					Width		Pools Only			Bed Material Type														Riparian Vegetation			
	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Bankfull (m)	Wetted (m)			Dw_{avg}	Bankfull (m)	Wetted (m)	Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Dominant	Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators			Type	Structure	Canopy Closure	Comments
1	0	R	14																4	1	5					EB			M	MF	15	
2	14	G	28																3	3	6								M	MF	40	undercut banks
3	42	R	43																17	5	22	LWD	15			UB	MB	EB	M	MF	70	
4	85	P	13		0.73					9.6	6.6	0.4	0.11	0.29	Scour, LWD	sand	pebble	40	8	2	10											
5	98	R	29		0.5	0.11	0.1	0.6	0.27	10.1	1.5					cobble	gravel	0	5	1	6	UB	5			EB			M	MF	40	embedded pool
6	127	P	7		0.75					11.5	8.5	0.53	0.1	0.43	Scour, LWD				5	3	8	LWD	15			MB			D	YF	10	
7	134	R	13																2	0	2								D	YF	30	
8	147	P	15		0.46					8	3.9	0.65	0.11	0.54	scour	sand	pebble	40	0	0	0	UB	5						D	YF	10	pool under bridge
9	162	R	17																2	0	2					EB			D	MF	60	
10	179	G	19																0	0	0								M	MF	80	
11	198	R	29																4	3	7								M	MF	80	
12	227	P	10		0.5					8.8	3.9	0.65	0.08	0.57	scour	cobble	sand	30	8	2	10	UB	5						M	MF	80	stable area
13	237	G	34		0.33	0.4	0.11	0.04	0.18	7.3	4.2					cobble	pebble	20	7	2	9	UB	5						D	MF	90	embedded riffle
14	271	R	68		0.45	0.02	0.06	0.03	0.04	7.9	2.6					cobble	pebble		19	7	26					MB			M	MF	75	embedded pool
15	339	G	25																2	1	3								M	MF	90	embedded pool
16	364	R	24																8	0	8								C	MF	70	
17	388	G	27																14	6	20					JW			C	MF	10	LWD jam
18	415	R	56																9	0	9					UB	EB		C	MF	90	
19	471	G	32																5	3	8								C	MF	70	Picture of bank failure, embedd pool.
20	503	R	36		0.6	0.04	0.05	0.06	0.05	10.3	2					cobble	pebble		4	4	8	LWD	5			UB			C	MF	80	
21	539	P	10		0.4					14.7	11.3	1.4	0.1	1.3	scour	sand	pebble		5	4	9	DP	60	LWD	15	JW			M	MF	70	picture of deep pool
22	549	R	38																13	2	15								M	MF	60	
23	587	P	20		0.47					10.9	8.2	0.76	0.06	0.7	scour	cobble	sand		4	1	5					EB	UB		M	MF	80	
24	607	R	102																27	10	37					MB	JW		M	MF	60	Bridge, embedded pool
25	709	P	20		0.45							1	0.1	0.9	scour	pebble	sand		11	5	16	LWD	30			MB	JW		M	MF	50	
26	729	R	31																9	2	11					EB	UB		M	MF	40	
27	760	G	12		0.4	0.34	0.48	0.49	0.44	9.7	3.7					cobble	pebble		1	4	5	UB	5			EB	UB		M	MF	90	
28	772	P	13		0.5					8.1	5.7	0.7	0.06	0.64	scour	cobble	sand		1	4	5	LWD	10	UB	5	UB			M	MF	90	embedded riffle
29	785	R	146		0.45	0.05	0.06	0.06	0.06	7.7	1.7					cobble	pebble	5	24	10	34	LWD	5			UB			C	MF	80	4 embedded pools at LWD
30	931	G	29																5	0	5								C	MF	70	
31	960	R	23																3	1	4								C	MF	70	
32	983	P	10		0.45					7.3	4.5	0.67	0.1	0.57	scour	cobble	gravel		0	0	0	UB	5			UB			C	MF	60	
33	993																				0											

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project:	AFFA Low Impact Habitat			Site #	56
Watershed:	Farrel Brook -			**Site Description:**	Small tributary west of Farrel River, likely logged 60 years ago, several year classes of trout vis. Some mature wood.
UTMds:	20T	393933	5036023		
UTMus:	20T	393813	5035601		
Surface velocity: m,	T1	T2	T3	@ hab. Unit no:	
Est. Velocity	#####	m/s @ hab unit	0		
Est Discharge = Dwavg hab unit no:	0	**Ww hab unit no:**	0		
Est. Discharge m^3/sec =	#DIV/0!	**m^3/sec a hab unit**	0		
Subsampling Fractions: R/	3	P/ 1	Rn/ 3	C/ 3	O/ 3

Weather: Sunny
Survey Date: 13/09/05
Water Temp : (C^0)

Total length surveyed:	562	m
Average Dbf:	0.47	m
Average Dw:	0.10	m
Average Wbf:	6.9	m
Average Ww:	4.2	m
Avg. Residual Pool depth:	#DIV/0!	m
riffle/pool ratio	#DIV/0!	:1
Est. pool spacing @ 6Wbf:	41.4	m
Acutal avg.pool spacing	#DIV/0!	m
% total length riffle	94%	
Total LWD/100m:	0.93	pieces/Wbf
Total 10-30cm LWD/100m:	0.75	pieces/Wbf
Total >30 cm LWD/100m:	0.18	pieces/Wbf

Average Stream Gradient (GIS):	1.94
Average Canopy Closure:	71.7 %

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
69	0	31	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	72	28

Average Embeddedness:	5	%
Embedded pools	3	
Acutal avg. pool habitat spacin	187	
Acutal avg.pool spacing	81	**Wbf/pool**
Acutal avg. pool habitat spacin	27	**Wbf/pool**

	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Dw$_{avg}$	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Bed Material Type: Dominant	Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators			Riparian Vegetation: Type	Structure	Canopy Closure	Comments
1	0	R	159																21	2	23								M	MF	70	Recent selective cut RB
2	159	G	15																6	1	7								M	YF	80	2 trout vis. Obs.
3	174	R	140																15	5	20					EB	JW		D	YF	70	1 embedded glide, 1 embedded pool
4	314	G	21																2	0	2								D	YF	70	
5	335	R	227		0.37	0.08	0.16	0.05	0.10	6.9	4.2					cobble	pebble	5	17	7	24								D	YF	70	
6	562	Riffle continues																			0								D	YF	70	2 embedded pools, 2pictures from bridge us and ds

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	0	#DIV/0!
Undercut bank	0	#DIV/0!
Boulder	0	#DIV/0!
Deep pool	0	#DIV/0!
Instream vegetation	0	#DIV/0!

Fish Habitat Survey Data Form

East Coast Aquatics
P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project:	AFFA Low Impact Habitat		**Site #**	
Watershed:	South Annapolis - Annapolis River		**Site Description:**	Substrate without moss cover, bars building, banks with sign of erosion, power dam influences peak flows.
UTMds:	20T	359202	4984000	
UTMus:	20T	359620	4983571	
Surface velocity: m,	T1	T2	T3	@ hab. Unit no:
Est. Velocity	#####	m/s @ hab unit	0	
Est Discharge = Dwavg hab unit no:	0	**Ww hab unit no:**	0	
Est. Discharge m^3/sec =	#DIV/0!	**m^3/sec a hab unit**	0	
Subsampling Fractions:	R/ 3	P/ 1	Rn/ 3	C/ 3 O/ 3

Weather: sunny
Survey Date: 23/08/05
Water Temp : (C^0)

Total length surveyed:	632 m
Average Dbf:	0.98 m
Average Dw:	0.58 m
Average Wbf:	14.2 m
Average Ww:	8.6 m
Avg. Residual Pool depth:	1.08 m
riffle/pool ratio	2.0 :1
Est. pool spacing @ 6Wbf:	85.1 m
Acutal avg.pool spacing	211 m
% total length riffle	26%
Total LWD/100m:	2.36 pieces/Wbf
Total 10-30cm LWD/100m:	1.73 pieces/Wbf
Total >30 cm LWD/100m:	0.63 pieces/Wbf

Average Stream Gradient (GIS):	2.95
Average Canopy Closure:	71.2 %

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
15	0	82	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	0	97

Average Embeddedness:	0 %
Embedded pools	1
Acutal avg. pool habitat spacin	158
Acutal avg.pool spacing	15 Wbf/pool
Acutal avg. pool habitat spacin	11 Wbf/pool

					Depth					Width		Pools Only				Bed Material Type													Riparian Vegetation			
	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Bankfull (m)	Wetted (m)			Dw_{avg}	Bankfull (m)	Wetted (m)	Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Dominant	Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators			Type	Structure	Canopy Closure	Comments
1	0	R	62																23	9	32					MC			D	MF	85	
2	62	P	33		0.4	0.72	0.81	0.35	0.6267	11.5	8.9	0.99	0.15	0.84	scour	rubble	cobble	0	0	0	0	DP	50	B	5				D	MF	75	
3	95	R	19																10	2	12								M	MF	90	
4	114	G	21																0	0	0								M	MF	90	
5	135	R	21																2	0	2											
6	156	P	48		0.35					17	10	1.25	0.25	1	scour	cobble	pebble	0	10	3	13	DP	70			MC	PW		M	MF	90	substrates not moss covered
7	204	R	19		0.48	0.1	0.15	0.14	0.13	14.9	6					cobble	pebble		1	1	2	B	5						M	MF	80	
8	223	P	40		0.35					13.5	11	1.5	0.09	1.41	scour	cobble	pebble		1	2	3	DP	85			MC			M	MF	90	picture ds, embedded riffle
9	263	R	30																1	0	1								M	MF	45	start of CARP restoration
10	293	RN	55																1	0	1					UB			M	MF	70	2 embedded riffles
11	348	G	32																0	0	0								M	MF	60	
12	380	R	14																3	1	4								M	MF	40	
13	394	G	238		0.4	1.15	1.1	0.71	0.99	14	6.9					cobble	pebble		25	10	35	DP	40	B	5				M	MF	40	long glide
14	632																				0								M	YF	70	3 embedded riffles, 1 embedded pool

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	0	#DIV/0!
Undercut bank	0	#DIV/0!
Boulder	3	5
Deep pool	4	61.25
Instream vegetation	0	#DIV/0!

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project:	AFFA Low Impact Habitat			Site #	80,82	Weather:	sunny clear
Watershed:	Grimm Brook - Nictaux River - Annapolis			Site Description:	Boulder controlled system in riffles, long glides, stills. Not well defined pools, yet decent deep water areas duirng base flow with mix of organic and gravel substrates.	Survey Date:	23/08/05
UTMds:	20T	336127	4959241			Water Temp :	20 (C^0)
UTMus:	20T						
Surface velocity: m,	T1	T2	T3	@ hab. Unit no:			
Est. Velocity	#####	m/s @ hab unit	0				
Est Discharge = Dwavg hab unit no:	0	Ww hab unit no:	0				
Est. Discharge m^3/sec =	#DIV/0!	m^3/sec a hab unit	0				
Subsampling Fractions: R/	3	P/	1	Rn/	3	C/ 3	O/ 3

Total length surveyed:	848	m
Average Dbf:	1.03	m
Average Dw:	0.54	m
Average Wbf:	7.7	m
Average Ww:	6.4	m
Avg. Residual Pool depth:	0.69	m
riffle/pool ratio	0.8	:1
Est. pool spacing @ 6Wbf:	46.4	m
Acutal avg.pool spacing	212	m
% total length riffle	22%	
Total LWD/100m:	1.97	pieces/Wbf
Total 10-30cm LWD/100m:	1.57	pieces/Wbf
Total >30 cm LWD/100m:	0.40	pieces/Wbf

Average Stream Gradient (GIS):	0.94	
Average Canopy Closure:	51.7	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
10	0	59	31	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	31	0	8	60

Average Embeddedness:	20	%
Embedded pools	0	
Acutal avg. pool habitat spacin	212	
Acutal avg.pool spacing	27	Wbf/pool
Acutal avg. pool habitat spacin	27	Wbf/pool

	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Depth: Dw_{avg}	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Pools Only: Crest (m)	Pools Only: Residual (m)	Pools Only: Pool Type	Bed Material Type: Dominant	Bed Material Type: Sub - Dom.	Bed Material Type: Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators	Riparian Vegetation: Type	Riparian Vegetation: Structure	Canopy Closure	Comments
1	0	F	81																6	1	7						D	MF	10	flat to lake confluence
2	81	STILL	34																10	3	13						M	YF	10	stillwater
3	115	R	43																3	2	5						M	MF	40	picture us
4	158	P	5		0.54	0.29	0.54	0.5	0.44	7.7	6.15	0.66	0.06	0.6	dammed	sm boulder	lg boulder	30	0	1	1	DP	70	B	20		M	MF	80	
5	163	F	78																23	5	28						M	MF	40	1.2m deep or more
6	241	G	41																4	1	5						M	MF	60	0.75m deep in areas
7	282	F	264		0.17	0.75	0.8	0.85	0.80	9.7	9.1				mud / clay				51	15	66	DP	85	OV	5		SH	SHR	15	picture us
8	546	G	66																24	5	29						M	MF	80	sandy
9	612	R	46																7	1	8						M	MF	80	boulder control
10	658	P	16		0.6	0.46	0.63	0.38	0.49	5.6	5.2	0.65	0.07	0.58	scour	rubble	sm boulder	50	5	0	5	B	50	DP	5		M	YF	80	long shallow
11	674	G	21		0.42	0.51	0.61	0.45	0.52	8.6	7.1					gravel	lg boulder	5	7	2	9	B	5	LWD	5		M	YF	60	
12	695	R	96		0.87	0.15	0.23	0.1	0.16	7.35	5.8					sm boulder	lg boulder	30	19	2	21	B	80				M	MF	70	broken flow around boulders
13	791	P	18		0.2	0.56	0.81	0.61	0.66	8.4	6.6	0.85	0.06	0.79	dammed	rubble	gravel	5	3	3	6	DP	60	B	30		M	MF	60	nearly a glide
14	809	G	23																7	3	10						M	MF	40	
15	832	P	16		0.65	1	0.7	0.4	0.70	6.8	4.7	1.25	0.48	0.77	scour	gravel	sm boulder	0	3	0	3	DP	50	B	5		M	MF	50	
16	848																				0									embeddedness tends to be sand/gravel not silt with infrequent invert colonization still possible in some locations

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	1	5
Large woody debris	1	5
Undercut bank	0	#DIV/0!
Boulder	6	32
Deep pool	5	54
Instream vegetation	0	#DIV/0!

Fish Habitat Survey Data Form

East Coast Aquatics
P.O. Box 129, Bridgetown, NS B0S 1C0
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Project:	AFFA Low Impact Habitat			**Site #**	9	
Watershed:	Gaspereau			**Site Description:**	Short distance below Gaspereau Lake, all riffle, shores well vegetated with grasses, good algal growth on rocks, large caddisfly	
UTMds:	20T	383430	4983118			
UTMus:	20T	383001	4982950			
Surface velocity: m,		T1	T2	T3		**@ hab. Unit no:**
Est. Velocity	#####	m/s @ hab unit	0			
Est Discharge = Dwavg hab unit no:	0			**Ww hab unit no:**	0	
Est. Discharge m³/sec =	#DIV/0!	m³/sec a hab unit	0			
Subsampling Fractions: R/	3	P/ 1	Rn/ 3	C/ 3	O/ 3	

Weather:	light overcast
Survey Date:	24/08/05
Water Temp :	22 (C⁰)

Total length surveyed:	453	m
Average Dbf:	1.15	m
Average Dw:	0.42	m
Average Wbf:	17.7	m
Average Ww:	13.5	m
Avg. Residual Pool depth:	#DIV/0!	m
riffle/pool ratio	#DIV/0!	:1
Est. pool spacing @ 6Wbf:	106.0	m
Acutal avg.pool spacing	#DIV/0!	m
% total length riffle	100%	
Total LWD/100m:	5.34	pieces/Wbf
Total 10-30cm LWD/100m:	4.25	pieces/Wbf
Total >30 cm LWD/100m:	1.09	pieces/Wbf

Average Stream Gradient (GIS):	1.6	
Average Canopy Closure:	16.7	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
0	0	72	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	0	72

Average Embeddedness:	#DIV/0!	%
Embedded pools	0	
Acutal avg. pool habitat spacing	#DIV/0!	
Acutal avg.pool spacing	26	Wbf/pool
Acutal avg. pool habitat spacing	26	Wbf/pool

				Depth					Width		Pools Only				Bed Material Type														Riparian Vegetation			
	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Bankfull (m)	Wetted (m)			Dw_{avg}	Bankfull (m)	Wetted (m)	Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Dominant	Sub - Dom.	Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators			Type	Structure	Canopy Closure	Comments
1	0	R	60	2	0.55	0.31	0.35	0.44	0.37	19.9	12					sm boulder	rubble		19	4	23	B	40	DP	10				M	MF	20	Hemlock LB, YF RB
2	60	R	203		1.15	0.54	0.64	0.49	0.56	16.1	13.6					sm boulder	rubble		61	16	77	B	40	DP	10	PW			M	MF	10	picture, >70cm diam log in stream
3	263	R	127																21	6	27										20	picture 0+174 parallel LWD
4	390	R	63		0.47	0.25	0.47	0.31	0.34	17	15								8	2	10	B	60	DP	5				M	MF		
5	453	R																			0											picture us from 0+453, end of SOUF riparian, riffle

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetati	0	#DIV/0!
Large woody debris	0	#DIV/0!
Undercut bank	0	#DIV/0!
Boulder	3	47
Deep pool	3	8

Fish Habitat Survey Data Form

East Coast Aquatics
P.O. Box 129, Bridgetown, NS B0S 1C0
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Project:	AFFA Low Impact Habitat			Site #	4		
Watershed:	Grumbley Brook - Shubenacadie River			Site Description:			
UTMds:	20T	457284	4991223				
UTMus:	20T	457907	4991187				
Surface velocity: m.	T1	T2	T3	@ hab. Unit no:			
Est. Velocity	##### m/s @ hab unit 0						
Est Discharge = Dwavg hab unit no:	0	Ww hab unit no:	0	4.7			
Est. Discharge m^3/sec =	#DIV/0!	m^3/sec a hab unit	0				
Subsampling Fractions: R/	3	P/	1	Rn/	3	C/ 3	O/ 3

Weather: Sunny Clear
Survey Date: 6/10/2005
Water Temp : (C^0)

Total length surveyed:	800	m
Average Dbf:	0.57	m
Average Dw:	0.14	m
Average Wbf:	6.0	m
Average Ww:	4.1	m
Avg. Residual Pool depth:	0.57	m
riffle/pool ratio	2.1	:1
Est. pool spacing @ 6Wbf:	36.2	m
Acutal avg. primary pool:	89	m
% total length riffle	28%	
Total LWD/100m:	1.86	pieces/Wbf
Total 10-30cm LWD/100m:	1.31	pieces/Wbf
Total >30 cm LWD/100m:	0.55	pieces/Wbf

Average Stream Gradient (GIS):	1.09	
Average Canopy Closure:	47.3	%

% Riparian Type / Surveyed Length

Deciduous	Coniferous	Mixed	Shrub/Herb	Grassland	Unvegetated
88	0	10	0	0	0

Riparian Structure / % Surveyed Length

Initial	Shrub	Pole/ sapling	Young Forest	Mature Forest
0	0	0	0	98

Average Embeddedness:	10	%
Embedded pools	4	
Acutal avg. pool habitat spacing	62	m
Acutal avg.pool spacing	15	Wbf/pool
Acutal avg. pool habitat spacing	10	Wbf/pool

Instream Cover

Type	# Instances Major Cover Type	Average % Bf surface area covered / instance
Overhanging vegetation	10	5.5
Large woody debris	8	16.9
Undercut bank	10	10.5
Boulder	0	#DIV/0!
Deep pool	0	#DIV/0!
Instream vegetation	0	#DIV/0!

#	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Depth: Bankfull (m)	Depth: Wetted (m)			Depth: Dw_{avg}	Width: Bankfull (m)	Width: Wetted (m)	Pools Only: Max. Depth (m)	Pools Only: Crest (m)	Pools Only: Residual (m)	Pools Only: Pool Type	Bed Material Type: Dominant	Bed Material Type: Sub - Dom.	Bed Material Type: Embedd. %	LWD 10-30cm	LWD >30 cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators	Riparian Vegetation: Type	Riparian Vegetation: Structure	Canopy Closure	Comments
1	0	R	12																4	1	5						D	MF	50	1 embedded pool
2	12	G	12																4	3	7						D	MF	70	1 embedded riffle
3	24	P	12		0.2					6.5	5.1	0.67	0.06	0.61	Scour	cobble	rubble	0	4	2	6	UB	10	OV	5	ED	D	MF	20	LWD sill logs, picture.
4	36	R	5																5	1	6						D	MF	30	
5	41	G	26																9	8	17						D	MF	30	1 embedded riffle
6	67	P	11		0.25					5.0	4.0	0.59	0.07	0.52	Scour	cobble	pebble	0	4	6	10	LWD	20	OV	5		D	MF	10	6 root ball cover
7	78	R	10		0.38	0.05	0.08	0.07	0.07	6.4	2.6					cobble	pebble	0	2	1	3	OV	5				D	MF	90	
8	88	G	11		0.4	0.07	0.12	0.11	0.1	6.6	2.9					pebble	gravel		1	2	3	LWD	5	OV	5		D	MF	60	
9	99	R	6																1	0	1	OV	10				D	MF	50	
10	105	G	62																6	3	9						D	MF	50	
11	167	CULVERT	13																0	0	0									Concrete Culvert crossing.
12	180	P	9		0.25					7.5	6.6	0.81	0.07	0.74	Scour	cobble	rubble	0	1	3	4	UB	5	OV	5		D	MF	40	Pool because of concrete
13	189	R	13																4	1	5						D	MF	40	
14	202	G	7																5	0	5						M	MF	60	
15	209	P	7		0.3					6.3	5.8	0.83	0.11	0.72	Scour	pebble	cobble	0	3	3	6	UB	15	LWD	5		D	MF	90	LWD scour pool
16	216	G	32		0.6	0.22	0.36	0.31	0.30	7.6	4.5					pebble	gravel	0	3	3	6						D	MF	80	
17	248	P	11		0.65					4.4	2.5	0.44	0.03	0.41	Scour	pebble	gravel	0	11	7	18	LWD	50	UB	10	JW	D	MF	50	Channel braid from jam
18	259	G	44																10	15	25					JW	D	MF	30	1embedded pool, picture
19	303	R	7																0	0	0						D	MF	30	
20	310	G	18																9	2	11						D	MF	15	
21	328	R	10		0.5	0.06	0.06	0.06	0.06	3.75	0.95					cobble	pebble	40	1	0	1	UB	5				D	MF	60	
22	338	P	7		0.55					4.75	4.4	0.56	0.07	0.49	Scour	rubble	cobble	15	2	0	2	UB	15	LWD	10		D	MF	50	LWD scour
23	345	R	8																3	0	3						D	MF	75	1 embedded glide
24	353	G	12																0	0	0						D	MF	20	Braid from 17 back in
25	365	R	8																5	0	5						D	MF	5	
26	373	G	26		0.4	0.07	0.27	0.25	0.20	5.0	3.0					cobble	sand		3	1	4	UB	5	OV	5		D	MF	85	
27	399	R	9			0.07	0.06	0.3	0.14	4.8	1.75					gravel	pebble		0	0	0	OV	5				D	MF	60	
28	408	G	47																10	0	10						D	MF	75	1 embedded riffle
29	455	R	37																1	1	2						D	MF	10	1 embedded pool
30	492	G	21																10	1	11						D	MF	20	
31	513	R	7																0	0	0						D	MF	60	
32	520	P	10		0.57					6.4	5.1	0.58	0.11	0.47	Scour	gravel	pebble		1	1	2	UB	20				D	MF	60	
33	530	R	32		0.45	0.11	0.11	0.05	0.09	6.5	4.8					pebble	cobble	50	0	0	0	OV	5				D	MF	75	
34	562	G	10		0.55	0.11	0.21	0.18	0.17	6	4.4					pebble	cobble		0	1	1	LWD	10	UB	5		D	MF	30	
35	572	R	23																0	0	0						D	MF	40	1 embedded glide
36	595	G	38																9	0	9						D	MF	10	1 embedded riffle, 1 pool
37	633	R	16																1	0	1						M	MF	70	
38	649	G	44																7	0	7						M	MF	80	1 embedded riffle
39	693	R	8		0.34	0.08	0.06	0.05	0.06	5.7	3.7					rubble	cobble	5	0	0	0						M	MF	90	
40	701	G	12		0.45	0.25	0.16	0.16	0.19	5.8	4.5					sand	gravel		2	1	3	OV	5				D	MF	10	RB select cut
41	713	R	8																0	0	0						D	MF	5	
42	721	P	16		0.55					6.65	4.9	0.73	0.06	0.67	Backflood	sand	gravel		6	1	7	LWD	15	UB	15		D	MF	5	RB select cut ends
43	737	G	34																8	1	9						D	MF	30	1 embedded Riffle
44	771	R	7																1	0	1						D	MF	80	
45	778	G	14																3	1	4						D	MF	60	
46	792	P	8		0.35					7.4	4.7	0.6	0.07	0.53	Scour				15	3	18	LWD	20				M	MF	70	
47	800	R																			0									

Appendix 2: Riparian Field Data

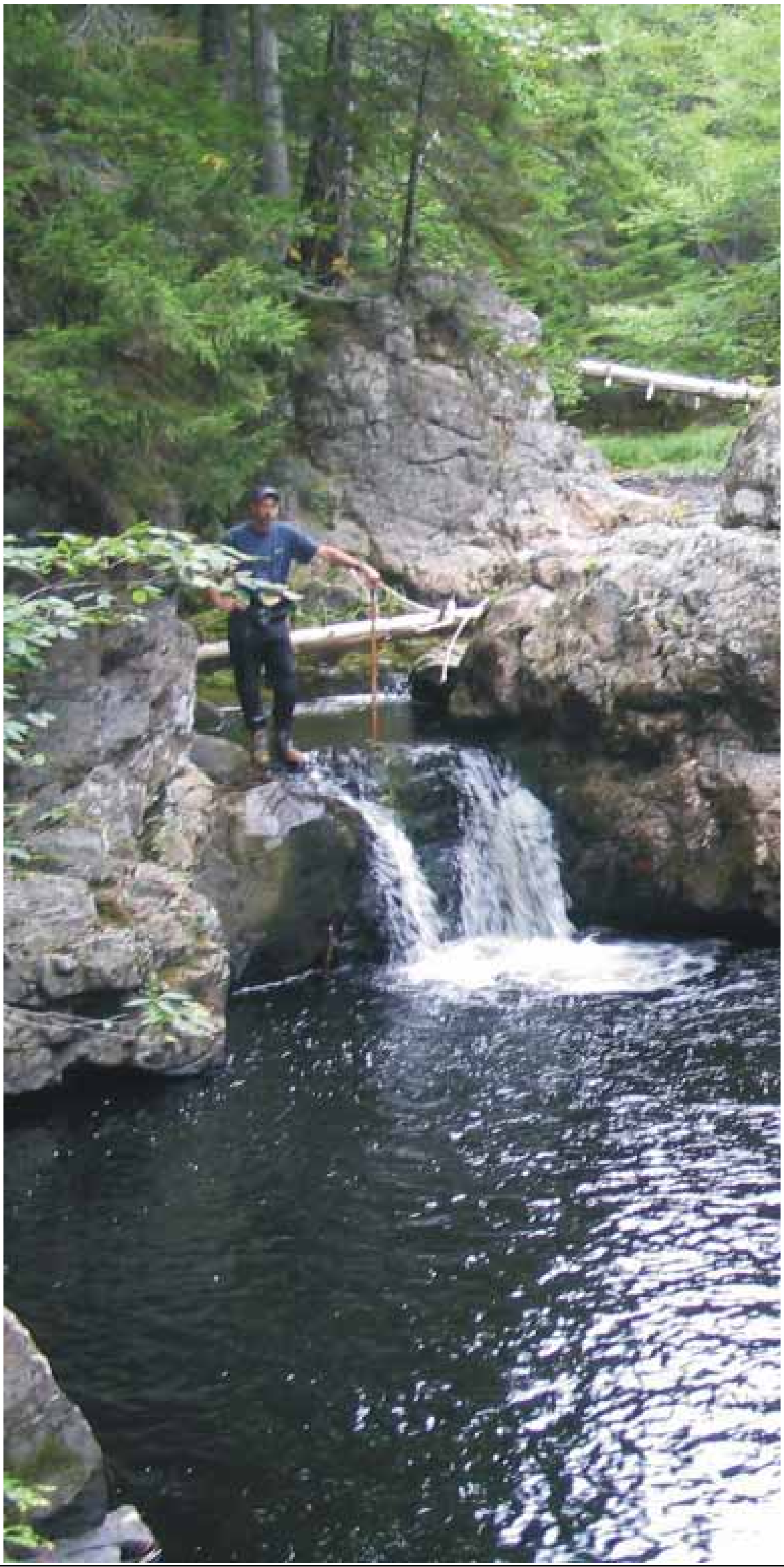
TableA2: A random sample of large tree diameter at breast height (DBH) in centimeters at each location. No measures were collected at the Halfway River site as riparian was estimated to be young forest only.

Location	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
Gaspereau	70 Hemlock	34 Birch	42 Birch	43 Birch,	60 Hemlock				
Farrell	65 Maple,	52 yellow Birch	43 Spruce						
Elderkin	110 Pine,	110 Hemlock	45 Birch	115 Pine	110 Pine	80 Hemlock	40 Birch	63 Birch	75 Hemlock
Grumbley	71 maple,	50 hemlock	45 maple	27 white birch	46 spruce	45 maple	58 white birch	43 yellow birch,	60 pine
Shady	115 pine	53 maple	85 hemlock	60 yellow birch	52 yellow birch	70 hemlock	60 spruce	95 hemlock	80 hemlock
Grimm	80 white pine	40 maple	57 pine	47 maple	47 maple	80 pine	55 maple	70 pine	65 pine
South Annapolis	80 yellow birch	70 maple	78 hemlock	45 beech	62 hemlock	58 birch	45 birch	65 hemlock	
Bass River	44 red spruce	38 red spruce	31 yellow birch	40 yellow birch	37 spruce	35 yellow birch	48 red spruce	40 yellow birch	
Portapique	51 yellow birch	47 spruce	41 fir	46 spruce	35 fir	52 yellow birch	59 spruce		
Gleason	75 red spruce	43 yellow birch	46 yellow birch						

Location	Average DBH (cm)	No: of Trees
Gaspereau	50	5
Farrell	53	3
Elderkin	83	9
Grumbley	49	9
Shady	74	9
Grimm	60	9
South Annapolis	63	8
Bass River	39	8
Portapique	47	7
Gleason	55	3

Appendix 3: Fish Habitat Survey Guide

The following is a fish habitat survey guide developed by East Coast Aquatics Inc. for use by that organization and its employees. It may not be referenced or reproduced without written permission of East Coast Aquatics Inc. This methodology reflects the survey approach completed during the Descriptive Habitat Study of Low Impacted Streams project.



Fish Habitat Survey Guidelines

January 2006

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Fish Habitat Survey Guidelines

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The following are a short explanation of how to complete all sections of the East Coast Aquatics fish habitat survey data form. The intent of the survey methodology is to provide a quantitative georeferenced survey of stream habitats that can be replicated after a period of time to allow not only determination of habitat quality, but to allow comparison between surveyed reaches and tracking of changes. The measures are based on a combination of recommendations from both the Level 1 FHAP from British Columbia Ministry of Environment[1], the DFO Standard Methods Guide for Newfoundland and Labrador[2], and the Department of Fisheries and Oceans Small Stream Survey Methods[3]. The basic premise is to create a continual longitudinal measure of primary habitat units, large woody debris, disturbance indicators, and riparian characteristics are recorded. Based on a sub sampling, detail characteristics of these habitat units, such as width, depth, and substrate are measured. For this methodology, a primary habitat unit is considered a riffle, pool, run, cascade, or glide that is at least 50% of the wetted width and 100% of the average bankfull width in length. All habitat units that do not meet this minimum are considered embedded in the primary unit, and are counted but not measured. Embedded habitat units are a measure of habitat complexity.

It is the intent of this methodology to remove as much subjectivity as possible from the habitat assessment process. A quantitative assessment allows for different field survey teams to produce similar results for the same surveyed reach, something more qualitative methods does not. However, to achieve this objective it is important that all measures be collected in full.

The following text does not present the scientific evidence of why individual measures are important to assess stream habitat quality. The text does explain how to complete the survey form in full in a manner that will be replicable and fully document the habitat quality of the surveyed stream.

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[1] Johnston, N.T. and P. A. Slaney. 1996. *Fish Habitat Assessment Procedures.* Watershed Restoration Technical Circular No. 8. British Columbia Ministry of Environment Lands and Parks. 97pp.
[2] Sooley, D.R., E. A. Luiker and M.A. Barnes. 1998. *Standard method guide for freshwater fish and fish habitat surveys in Newfoundland and Labrador: Rivers and Stream.* Fisheries and Oceans. St. John's, NF. Iii+50pp.
[3] Scruton, D. A., T.C. Anderson, C.E. Bourgeois, and J.P. O'Brien. 1992. *Small Stream Surveys for Public Sponsored Habitat Improvement and Enhancement Projects.* Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2163: v +49p.

Project
Name given to the client project.

Watershed
Common watershed or sub-basin name.

UTMds
UTM coordinate at the downstream end of the habitat survey reach.

UTMus
UTM coordinate at the upstream end of the habitat survey reach

Survey Direction
Record the direction in which stream data was recorded as US (upstream) or DS (downstream).

Surface Velocity
Four entries are necessary here. The length of stream over which a floating object is timed, the time in seconds for the floating object to travel the measured length of stream on each of three trials, and the habitat unit number in which the velocity trials were taken. This latter measure should refer to the left hand column number on the data sheet, and velocity measures should be taken in a primary habitat unit that is being subsampled for complete detail habitat measures (ie. width and depth measures). Detail velocity measures within a detailed measured habitat unit will allow for approximation of stream discharge. An orange, or small container partially filled with water, are good choices as floating objects as they will be partially submerged and less influenced by surface conditions such as wind.

Subsampling Fraction
Although a continual longitudinal measure of primary habitat units is recorded, detail measures of specific types of habitat units are collected a subsampling fraction. The ratio to be used is recorded for the riffle, pool, run, cascade, glide, and other primary habitat units prior to beginning the habitat survey. Generally, a 1:3 riffle, 1:1 or 1:2 pool, 1:3 run, 1:3 cascade, 1:3 glide, 1:1 for other infrequent habitats is typically appropriate. However, objectives of the project may dictate alternative ratios. Those actually used need to be recorded in this section of the form. The first instance of any particular primary habitat unit encountered should undergo detail measurements, with the subsampling occurring thereafter at the ratio selected. The following definitions, as provided by DFO, should be applied.

Run – Swiftly flowing and relatively deep water with some surface agitation but no major flow obstructions, coarser substrate (gravel, cobble, boulders). May have confined width.

Riffle – Shallower section with swiftly flowing and more shallow, turbulent water with some partially exposed substrate (usually cobble or gravel dominated).

Glide – Wide, shallow area flowing smoothly and gently, with low to moderate velocities and little or no surface turbulence. Substrate usually consists of cobble, gravel and sand. Shallow to moderate depth.

Pool – Deeper area comprising full or partial width of stream, due to the depth or width flow velocity is reduced. Pool has rounded surface on bottom. Additionally, pools must have a minimum residual depth as guided by the British Columbia MELP and presented below.

Bankfull width (m)	Min. Residual Depth (m)
0-2.5	0.2
2.5-5	0.4
5-10	0.5
10-15	0.6
15-20	0.7
>20	0.8

Flat – Similar to a pool but longer, with a flat bottom, and a substrate made up of organics, sand, mud and fine gravel. Very little velocity.

Cascade – Areas of steeper gradient with irregular and rapid flows, often with turbulent white water.

Weather

Current observations of local weather including precipitation, cloud cover, wind and possibly air temperature.

Survey date

Current date of field works.

Water Temperature

Current temperature of water within the survey reach in degrees Celsius.

Survey Crew

Record the last names of the field technicians completing the survey.

Distance

This is a continuous measure from the beginning of the surveyed reach (0+00m) to the end (0+??m). The distance is measured with aid of a hip chain, and recorded at the beginning of every new primary habitat unit.

Habitat Unit

The type of primary stream habitat being entered (as defined in Subsampling fraction, above), and for which the current distance measure has been recorded. Basic criteria are that a primary unit be >1 avg Wbf in length and > 50% of wetted width, otherwise the unit is considered an embedded habitat unit within the currently assessed primary habitat unit. Additionally, pools must meet the minimum residual depth criteria to be counted as primary pools. Embedded units are tallied and recorded by type later in the form.

Length
Length of the current habitat unit, to be calculated in field or later in the office by subtracting the Distance measure for the next unit from the distance measure of the current unit. Ensure that length is at least one average Wbf to meet minimum requirement as a primary habitat unit.

Gradient
Gradients should be taken primarily in riffles and cascade habitat units, and over the longest distance visible. Gradient may be taken over several habitat units if a clear line of site is available. A clinometer is used, with a marking or two personnel at opposite ends of the visible distance, and recorded in %. Gradient is only necessary to be recorded where a reach break has been encountered that presents significantly different habitat ratios above and below.

Bankfull Depth
Recorded as a "+m" measure from the current water surface to the rooted height of the first riparian herbaceous vegetation, or top of the bank. This measure can be added to the wetted depth average in order to approximate the depth at bank full flows. Only taken at the defined subsampling fraction of any habitat unit.

Wetted Depth
Measured in meters at ¼, ½, and ¾ of the distance across the wetted channel from the surface of the water to the substrate. These measures can later be averaged to get an average wetted depth measure. Only taken at the defined subsampling fraction of any habitat unit. Not taken for pool habitats, as pools have specific depth measures collected to calculate residual depth.

Bankfull Width
Recorded measure from the rooted height of the first riparian herbaceous vegetation, or top of the apparent bank on one side of the stream across to the same point on the other side of the stream. The measure is taken perpendicular to the flow and should not be taken at a point of obvious disturbance or overwidening unless this is representative of the whole stream reach. If braiding occurs in the location of measure, the distance across seasonally exposed bars should be included. Similarly, the distances on either side of an 'island', although not that width of the "island" that projects above bankfull, should be summed. Only taken at the defined subsampling fraction of any habitat unit.

Wetted Width
Wetted width measures are from the current water level on one stream bank perpendicular across the line of flow to the water line on the opposite bank. This measure should not be taken at a point of obvious disturbance and overwidening unless this is representative of the whole stream reach. If braiding occurs in the location of measure distances on either side of a 'island' or bar that projects above the water surface should be summed. Only taken at the defined subsampling fraction of any habitat unit.

Pool Max. Depth

Maximum pool depth, recorded in meters, is the maximum wetted depth at any location within the current pool habitat being surveyed. Only taken at the defined subsampling fraction for pools.

Pool Crest

Also known as the invert or outlet crest, this is the shallowest downstream point flowing out of the pool habitat and marks the interface between the pool habitat unit and the next downstream habitat unit. Only taken at the defined subsampling fraction for pools.

Residual Pool Depth

Residual pool depth is a calculation that can be conducted in the field or office. It is simply the difference between the pool maximum depth and the pool crest. This is the depth that, in theory, would remain if the river stopped flowing, and is approximately the depth of the pool habitat at extreme low flows. This measure is used in part to define if a habitat unit is a pool as described in Subsampling fraction above. Only taken at the defined subsampling fraction for pools.

Pool Type

Pools are generally of three types. Scour, dammed, and plunge. Scour pools are created by water scour and maintain a clean substrate and obvious pool crest. Scour pools may be formed by large woody debris, a bedrock structure, or directly by the thalweg. Dammed pools are created by some structure that ‘backwaters’ or holds flow back in a channel. Beaver dams and debris jams are examples of a dammed pool. They may be less permanent than a scour pool. A third type of pool, plunge pools, may be formed by a hanging culvert or dam where water “plunges” vertically to form a pool. Pool type is recorded for every pool.

Bed Material Dominant Type

The dominant bed material type is that which covers the greatest amount of the stream bed within the bankfull width. Bed materials are classified according to DFO standards as presented in the table below.

Bedrock (B)	Continuous rock
Large Boulder (LB)	>1m
Small Boulder (SB)	25cm-1m
Rubble (R)	14-25cm
Cobble (C)	6-13cm
Pebble (P)	3-5cm
Gravel (G)	2mm-3cm
Sand (S)	0.06-2mm
Mud /Clay (MC)	<0.06mm

Only recorded at the defined subsampling fraction of any habitat unit. Substrate particles should be measured periodically to ensure proper classification.

Bed Material Sub-dominant Type

Only recorded at the defined subsampling fraction of any habitat unit. The second most dominant substrate type within the bankfull channel width, as defined in the table above.

Cobble Embeddedness

Only taken at the defined subsampling fraction of any habitat unit. If available, a number of stones of 15cm diameter in the two visible planes (x and y) is pulled from the stream bottom. The third plane (Z or depth) is now visible. If the stone was embedded, a line is typically visible crossing the Z plane. The average depth, in %, that was embedded in the stream bed should be visually estimated and the relevant category number (1-5) recorded. Five percentage categories are used. If the standard size stone is not available for examination in the sample habitat unit, the closest size cobble and or an experienced estimate based on a toe kick can be made. If the standard size stone is not available, the alternative method used should be recorded in the comments section.

Embeddedness category	Avg. Visual Estimate
1	>75%
2	50-75%
3	25-50%
4	5-25%
5	<5%

LWD 10-30cm

Large woody debris, (LWD) is defined as any piece within the bankfull channel cross section (ie. Would be in the water at bankfull flows) with the minimum dimensions of 10 cm diameter and 2 meters in length. Pieces the meet the minimum size requirements and that span the full channel width above the bankfull cross section are also counted, as these pieces will be recruited directly to the channel within a relatively short time frame. Two size categories of LWD are defined. For the first, any such pieces that meet the definition and are less than 30cm diameter are tallied and recorded. Recorded for every primary habitat unit along the complete surveyed reach.

LWD >30cm

The second category of LWD is those within the bankfull channel cross section with the minimum dimensions of 30cm diameter and 2 meters in length. Any such pieces that meet this definition are tallied and recorded. Pieces the meet the minimum size requirements and that span the full channel width above the bankfull cross section are also counted, as these pieces will be recruited directly to the channel within a relatively short time frame. The 30cm diameter corresponds to the typical diameter at breast height (DBH) for several tree species in most Nova Scotian locations that would likely be mature to old growth. Recorded for every primary habitat unit along the complete surveyed reach.

Total LWD Tally

Large woody debris, (LWD) is defined as any piece within the bankfull channel cross section with the minimum dimensions of 10cm diameter and 2 meters in length. The total of the <30cm and >30cm classes should equal the Total LWD tally.

Instream Cover Type

Instream cover is recorded as the two greatest cover component percentages present in a given habitat unit. It is only taken at the defined subsampling fraction of any habitat unit. The cover codes are as presented below. Only recorded at the defined subsampling fraction of any habitat unit.

LWD	Large woody debris in the wetted area or within 1m of the water surface.
B	Boulders within the wetted area.
C	Undercut banks in the wetted area.
DP	Deep pool exceeding 1m max. depth in clear waters, or 50cm max depth in tannic waters.
OV	Overhanging vegetation within 1m of the water surface.
IV	Instream vegetation.
N	No cover in the habitat unit.

Instream Cover Type %

The percentage of the wetted surface area within the surveyed habitat unit corresponding to the cover type is recorded to the nearest 10%. Recorded for the two greatest cover components. Only recorded at the defined subsampling fraction of any habitat unit.

Disturbance Indicators

Up to three disturbance indicators can be recorded in this section for every habitat unit within the surveyed area. The proper codes are as shown in the table below.

Bed Characteristics	SC	Extensive areas of scour
	UB	Extensive areas of unvegetated bar
	SW	Large and extensive sediment wedges
	MB	Elevated mid channel bars
	RZ	Long uninterrupted riffle zones
	PF	Limited pool frequency and extent.
Channel Pattern	MC	Multiple channels (braiding)
Banks	EB	Heavily eroding banks
	BC	Isolated side channels or backchannels
LWD	PW	Most LWD parallel to the banks
	JW	Recently formed LWD jams

Barriers	C	Culvert with a drop >15cm
	D	Dam
	F	Bedrock falls>1m, not cascade
	O	Other barrier

This measure is taken continuously, but not quantified.

Riparian Vegetation Type
Record the dominant vegetation type in the riparian area. If left and right bank vary significantly record that with the greatest influence on stream habitats, considering southern aspect, adjacent land use, floodplain slope etc. This measure is taken continuously.

N	Largely unvegetated, with much bare mineral soil visible
G	Grasslands or bog
SH	Shrub / herb, dominated by herbaceous or shrubby vegetation
D	Dominant deciduous forest
C	Dominant coniferous forest
M	Mixed deciduous - coniferous

Riparian Vegetation Structure
Record the structural stage of the dominant vegetation in the adjacent area as recorded in the preceding. This measure is taken continuously, but only recorded whenever a change occurs along the surveyed reach. Riparian corridor width will vary with stream channel width, but for the purposes of this assessment riparian vegetation should be characterized based on everything within approximately 30m of the stream bank unless otherwise noted by the survey team.

INIT	The non-vegetated or initial colonization stage following disturbance with less than 5% cover
SHR	Shrub/herb stage, with less than 10% tree cover
PS	Pole sapling stage, with trees overtopping the shrub layer, usually less than 15-20 years old
YF	Young forest. Self thinning is evident and the forest canopy is differentiating into two distinct layers. Typically 30-80 years age.
MF	Mature forest with well developed understory.

Riparian Vegetation Canopy Closure
Record the average canopy closure over the stream surface area for the current primary habitat unit. This measure is taken continuously, and estimated to the nearest 10%.

Embedded Habitat Units
Embedded habitat units are those that are close to, but do not meet all of the minimum size requirements to be considered primary habitat units as outlined "Habitat Unit" at the first of this document. Generally these are units that are <1Wbf in length or cover

less than 50% of the wetted width. For pools, they may also be units that do not meet the minimum residual depth requirements. Embedded units are a very important component of habitat complexity, and therefore are recorded continuously throughout the survey reach. Every embedded unit type is tallied by the number present within the primary habitat unit. For example, 2 pool, 1 riffle.

Comments
This section should include observations of fish or biota, surrounding land uses, obstructions, and conditions at time of survey etc.

Equipment
The following is a list of equipment necessary to complete the stream habitat survey form.

Metre stick
Hip Chain
Clinometer
Thermometer
GPS
20+ m Measuring tape
Stop watch
Floating ball
Waders
Non – skid Wading boots
Data sheets on waterproof paper
Pencil
Binder
Polarized sun glasses
Hat
Suntan lotion

Fish Habitat Survey Data Form

East Coast Aquatics

P.O. Box 129, Bridgetown, NS B0S 1C0
(902)665-4682

Project: Site #: Weather:

Watershed: Survey Date: dd / mm / yy

UTMds: Water Temp (C^0):

UTMus: Site Description:

Survey Direction: US | DS

Surface velocity: m, T1, T2, T3 @ hab. Unit no:

Subsampling Fractions: R/ P/ Rn/ C/ G/ Oth Survey Crew:

					Depth				Width		Pools Only				Bed Material Type		
	Distance (m)	Habitat Unit	Length (m)	Gradient (%)	Bankfull (m)	Wetted (m)			Bankfull (m)	Wetted (m)	Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Dominant	Sub - Dom.	Cobble Embed %
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	

	Large Woody Debris			Instream Cover				Disturbance			Riparian Vegetation			Embedded Habitats	
	LWD 10-30cm	LWD >30cm	Total LWD Tally	Instream Cover Type	%	Instream Cover Type	%	Disturbance Indicators			Type	Structure	Canopy Closure	Embedded Units (# and type of each)	Comments
1															
2															
3															
4															
5															
6															
7															
8															

Appendix 4: GIS Analysis methodology

The following is the proposed methodology used by Roderick Peacock to complete the GIS Analysis that identified potential candidate stream locations that met the minimum criteria for site selection that were established by the Advisory Team. Final methodology may have changed from this proposed document, and further details could be determined by contacting David Colville at the Applied Geomatics Research Group (AGRG), Centre of Geographic Sciences (COGS), Nova Scotia Community College in Middleton, Nova Scotia.

Habitat Suitability Analysis Using GIS

Identifying Low Impact Reaches for Salmonids

By: Rod Peacock
For: David Colville – Applied Geomatics Research Group and
Mike Parker - East Coast Aquatics
Date: January 31, 2005

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Acknowledgements

Initial acknowledgements at this early stage include the following:

David Colville Applied Geomatics Research Group for his concept support, input and guidance.

Mike Parker of East Coast Aquatics – For allowing me to be a part of this worthwhile project and for his early aid and support.

Dave MacLean, Centre of Geographic Sciences: For helping me with my early GIS methodology.

1.0 Introduction

In May of 2001 the Inner Bay of Fundy (IBoF) population of Atlantic Salmon was declared to be Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). According to COSEWIC IBoF populations of Atlantic Salmon have declined by 90% or more in abundance; they were estimated at 40,000 adults in some years, but have declined to less than 500 in 1998 and less than 250 in 1999 (COSEWIC 2005).

There is no shortage of studies, theories and opinions on such a precipitous decline. Despite this, loss or limitation of habitat is widely considered a major cause. It is obvious to state that the long-term sustainability of the IBoF Salmon population cannot be maintained or improved if the problems concerning habitat are not acknowledged and accounted for.

The "Descriptive Habitat Study Project" (Parker, 2004 - hereafter the "Project") is attempting to address this problem. With an over-arching goal of long-term sustainability, the Project's objective is to increase knowledge of low impacted Atlantic Salmon stream habitat characteristics by developing a quantified habitat description of low impacted streams (Project Summary). Geographically, the foci of the Project are the IBoF Atlantic Salmon streams. The Project's two initial activities include(d): established a minimum set of criteria for high value salmon stream characteristics and 2) identifying candidate stream reaches that meet those criteria (Parker, 2004). These two activities are the subjects of this proposal.

To date, the first activity of the Project has been achieved with a set of criteria having been established (Parker, 2004). The current stage is candidate reach identification. This identification can best be achieved through the use of Geographic Information Systems (GIS) technology. GIS-based analysis can provide a systematic tool for targeting candidate reaches by quickly characterizing (based on the pre-determined criteria) Atlantic Salmon habitat over large geographic regions in a timely, cost-effective and accurate manner.

2.0 Problem Definition

Identifying candidate reaches is essentially a matter of identifying habitat suitability. Habitat suitability analysis faces two main problems both of which are relevant to Atlantic Salmon:

1) The logistics of Candidate Reach identification

For the Project, candidate stream reaches must conform to the following criteria:

- Gradient between 0.5 – 5 (%).
- Length 300m to 2km
- Riparian width 30m – both sides
- Forest Composition: Overmature forest **or** areas 80-100 years of known low impact (may be defined as old-growth).
- 2^{nd} to 4^{th} Order streams (but all orders should be mapped)

A quick glance at a hydrological map of Nova Scotia reveals a spider's web network of waterways. Over such a large area and with so many possible candidates to choose from, how does one identify Reaches meeting the established criteria? The most reliable and accurate method would be field surveys but this is not an option since they would require an impossible amount of time and resources. GIS can be used to solve this problem. Using GIS, a coarse, yet effective, habitat suitability map can be created quickly over a wide geographical range.

2) Criteria Agreement

For any given species there are numerous attributes that contribute to necessary habitat. However, in many instances there is no consensus on the full criteria lists and the relative importance of each criterion. Atlantic Salmon is an excellent example. There is disagreement between many authorities on the impact of land use on salmon streams – some argue that activity within 30-100m of the stream bank is the most influential, others believe the problem must be analyzed on a watershed-scale, while many others fall between the two extremes. Although this problem was addressed somewhat in the first stage of the project (Parker, 2004) any hard selection of criteria will be subject to some scrutiny.

3.0 GIS Project Goals

This proposed project has two main goals.

1) Identification and Mapping of Low Impact Reaches within the IBoF Using GIS.

2) Creation of an automated GIS Program for Identifying Salmon Habitat. This program will identify suitable habitat for Atlantic Salmon based on user- entered criteria. The program will also allow the user to specify the geographical focus of the query and, as well, allow criteria to be evaluated on multiple scales and over user-defined areas of relevance. Lastly, the program will include a user defined weighting scheme which will allow for the further refinement of candidate areas and allow areas to be ranked on the basis of suitability. This program will account for the lack of consensus between habitat criteria and allow researches to customize their searches and allowing for multiple iterations and combinations of criteria.

Although the second goal/product defined in this proposal was not required by the Project it could prove extremely useful. As mentioned above it could be used to run numerous criteria scenarios. Also, its weighting and ranking functions may enable the Project to identify second-tier candidate reaches if necessary.

4.0 Literature Review

The use of GIS technology for habitat identification and mapping is widespread. Examples of its application include assessing winter ranges for Black-tailed deer in British Columbia (Brumovsky and Haarveit, 2003), and assessing critical habitat for two endangered species of bird, the California Gnatcathcher (Ackakaya and Atwood 1997) and the Helmeted honeyeater (Ackakaya 1995). GIS habitat identification and evaluation in Nova Scotia include Northern Goshawk (Beazley et al. 2003) and Moose (Snaith and Beazley 2003).

Of more relevance is the fact that GIS has been used in habitat analysis for freshwater fish including Pacific Salmon populations. In Australia, for example, David Ball (2003) of the State of Victoria, Department of Primary Industries combined the spatial distribution of preferred habitats for selected fish species in order to create a predictive map of the location of important fishery habitat.

Most relevant is the 1997 study by (Lunetta et al.) which provided a qualitative measure of the extent and location of potential salmon stream habitats throughout western Washington State using GIS-based evaluations. In this study, a combination of reach slope and forest seral stage data layers (criteria) were used as coarse indicators of channel conditions. Reach slopes were derived using a 30 m Digital Elevation Model (DEM) to identify slopes with less than 4% gradient. Statistical analysis of their findings established that the accuracy rate for this reach classification was 96% with error of commission and error of omission rates at 24 and 4.0% respectively. It was the authors conclusion that GIS-based analytical products can be used to predict the locations of response reaches likely to provide salmon habitat. Further, they concluded that GIS can help accomplish prioritization more rapidly with great reliability and objectivity.

5.0 Description of Data Sets

The following data will be utilized to identify candidate reaches (Goal 1):

Table 1: Study Data sets.

Data	Scale	Format	Description
Roads	1:10000	Vector	“RR” feature codes
Streams	1:00000	Vector	“ST” feature Codes
Waterlines	1:10000	Vector	“WA” feature codes
Forest	1:10000	Vector	Info pertaining to NS Forest Inventory
SOUF		Vector	Old-growth and unique forests
Slope20m		Grid/Raster	Slope values based on 20mDEM
Strmnet 20M		Grid/Raster	Values representing stream order
DEM20m		Grid/Raster	Digital elevation model 20m resolution

With the exception of the SOUF layers all the above data will come from the Nova Scotia Geographic Database (Wahl, et al. 2002). The SOUF layer will be obtained from the Nova Scotia Department of Environment and Labour.

6.0 Methodology:

This methodology section will have two parts each describing the separate methodology for the two goals outlined above.

6.1 Identifying and Mapping Candidate Reaches.

In its simplest form the process will concern identifying where (spatially) all of the predetermined criteria exist simultaneously. Thus any reaches between 300m and 2km possessing all the predetermined criteria will be identified. The following is the methodology for this identification process. (Please see Appendix 1 for Flowchart Schemata)

6.1.1 Data Management and Organization:

This project will utilize a Personal Geodatabase Data Model within ArcGIS 9.0. All geographic data will be stored and centrally managed within one database. All GIS data layers will be stored in this database with vector data layers stored as feature classes within a single feature dataset. This organization will ensure spatial conformity among layers.

6.1.2 Data Clipping

Most of the criteria are already available in GIS layers (see section 7.0). The datasets, however, are of the whole province of Nova Scotia – they are excessively large. Thus the first task will be to limit these datasets to cover only the specified geographical area of interest(IBoF) and include only relevant data. Along this vein, the area of interest will be defined as all Nova Scotian watersheds draining into the Bay of Fundy. All data sets will be delimited to included data within those watersheds.

Similarly, the Forest data layer will also be reduced to include only the relevant stand types. Again in ArcMap, the Select tool will be used to extract only Overmature forest stands from the Forest Layer. This will create a new feature dataset with only Overmature forests. Please see Figure 1 Appendix 1).

6.1.3 Creation of a Stream Gradient Layer.

Stream gradients will be determined by overlaying the stream and/or waterways layers with an existing DEM grid layer. One possible method for identifying slope is the use of basic euclidean geometry. This technique requires using a “rise over run” calculation. For each end of a reach an elevation value can be found using the DEM – the difference in elevation is the rise. The length of the reach is the run. Thus in the example below (figures 1 and 2) the calculation would be (5m/400m * 100) giving a slope of 1.25%. This provides a coarse slope estimate. However, this represents just one possible method; others will be considered..

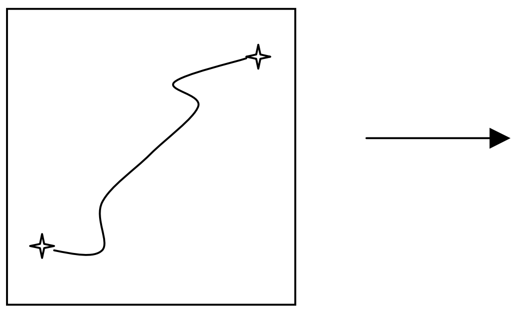

Figure 1: 2d representation of a 400m long reach. Stars represent start and end points.

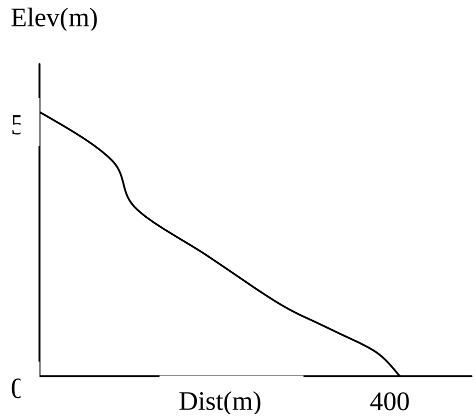

Figure 2: Surface profile of reach from figure 1. Intersections with axes represent limits of the reach

6.1.4 Creating a Forest Criteria Layer

This data layer will include SOUF and Overmature forests only.   This step is necessary since both layers come from different sources and there may be some overlap in the data. For example what is classified as old-growth in the SOUF layer may be Overmature in the original Forest layer. Old-growth forest is a higher priority than Overmature stands and thus needs to be clearly identified. This will be accomplished using the Update overlay in ArcMap. Using Update, the attribute and geometry of an input feature are replaced by those of the Update feature. Thus if the SOUF layer is used as the Update feature, where the old-growth and Overmature features overlap the old-growth will take precedence and replace the Overmature. The feature dataset created by this process will be a layer identifying areas of exclusive Old-growth and areas of Overmature forest. If desired, this layer can be further delimited by species type (i.e. Spruce) if desired. See Figure 2 – Appendix 1.

6.1.5 Creating the Final Criteria Layer

The previous two steps created two layers which, when combined, will identify areas that fulfill all the Project's established criteria. This again will be accomplished using the Intersect Overlay. The Reaches (from 6.1.3) layer will be intersected with the Forest-Type layer (From 6.1.4). Using intersect will return only those areas where the two overlap. The resulting map will show only those areas conforming to all established criteria. See Figure 3 Appendix 1.

6.1.6 Map Creation

The output map will be created in the Layout View of ArcMap. Road information will be added to the Criteria Map at this stage. The roads will be added to facilitate field work; allowing reaches to be further prioritized on the basis of accessibility.

6.2 Creation of the Automatic Habitat Delineation Program.

It is envisioned that the Automated program will have 2 main functionality components: a User Interface and Processing. The program will be created using Python, AML and/or Visual Basic programming languages. Since programming is largely iterative, the methodology for this section will be limited to generalities..

6.2.1 Functionality – User Interface

The program will perform activities very similar to those specified in section 6.1 (above). The fundamental difference is that a user will not manually create a GIS product rather they will input/specify various criteria through a Graphic User Interface (GUI) and the program will automatically produce a GIS layer based on their criteria.

The interface will likely be created using Visual Basic. The exact configuration of the GUI interface has not been designed but it will contain combinations of drop down lists linked to accessible databases, selection boxes or radio buttons and/or text boxes for manually inputting criteria. Criteria selection will include, but is not limited to: datasets, geographical extents, specific areas of application, criteria weighting and combination options.

6.2.2 Functionality – Processing

Using Python or AML as programming languages the automated program will be designed to produce habitat suitability data layers (in a fashion similar to the methodology in 6.1) based on the user inputs from the GUI interface. Thus the necessary GIS functions will need to be coded into the program.

As well as this base function, some other potential options that may be programmed into the system are:

1) Area of Application (AOA) definition. The area of application will be the geographic area of interest extending out from the selected streams. A user may only be interested in the habitat characteristics within 30m of a stream. The GUI will allow them to input this distance. Along this vein the program may also allow the user to define the Area of Interest by the "pour point" of a particular reach. The pour point defines the source of all water into a particular point. In this way sub-watersheds (or larger/smaller) could be defined as the AOA.

2) Criteria Weighting and Combinations

In the analysis performed in 6.1 it is assumed that each criterion has equal influence. This is rarely the case. The automated program will allow the user to place relative weights on various criteria. The program will also give the option of whether an area must satisfy all criteria or just some. The weighting and combinations options are particularly effective when used together.   The use of these options will enable a user to identify not only which areas are best ,but also provide a relative quality assessment for the whole area – ranking areas by suitability.

7.0 Final Products:

The following three products will be produced:

1) A map (digital and hardcopy) identifying candidate reaches within the IBoF.
2) An automated GIS program for identifying Salmon Habitat.

3) Product documentation. This will be a document defining the project and the results. It will also include a description of the methodology used and a listing of the programming code developed.

Digital copies of the map as well as the automated program and product documentation will be held at and can be accessed through the Applied Geomatics Research Group in Middleton, Nova Scotia.

8.0 Key Milestones

Milestones	**Timelines**
Proposal	January 31, 2005
Data Acquisition	February 14, 2005
Final Conceptualization of Automated Program	February 15, 2005
Program Coding and Overlay Analysis	February 21, 2005 – April, 2005
Completed Candidate Reach Map	April 1, 2005
Automated Program Debugging/Testing	April 1 – April 30
Completed Program and Project documentation	April 30, 2005
Presentation of Project at COGs Conference	May, 2005

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Appendix 5: 1884 Documentation of Stream Impacts

The following are excerpts from a *Report Upon the Condition of the Rivers in Nova Scotia in Connection with the Fisheries in that Province,* written by Frederick Veith in 1884. These excerpts refer to the streams for which habitat surveys were completed during the current project.

30th April

Took the train at Paradise station for Kentville, to visit the Gaspereaux River in King's County.

FRED. H. D. VEITH.

1st May.

Sunday.

2nd May.

As it was late when I visited the gaspereaux on the 30th April, I had no means of fully seeing the river, so I drove over this day to examine the means, if any, that were taken to save the sawdust, a quantity of which I had before seen high up on banks of the river. The owner of the mill has told me he used every means to keep the stream clear, but that sometimes sawdust, &c., accidently fell in. I, however, saw for myself far below the mill, immense quantities of shavings, sweepings of the mill, &c., and I immediately wrote to the County Overseer and told him of this breach of the law. I should have called upon him personally, but he lived too far away from Kentville, and I wished to save the expense of hiring a conveyance. I, however, attach his answer.

DIARY

FOR THE MONTH OF NOVEMBER, 1881.

I visited the Parsboro' River and found the mills upon it as follows: Nearest the tide, which flows to its base, stands Fred. Yorke Dickie's, with its delapidated, broken ladder, never at any time serviceable, but now represented by a few decayed boards. The miller stated to me that salmon always leap it; but I cannot readily believe this assertion, especially as the mill pond above is so blocked, from end to end, with old logs and *débris*, that a fish could only land on that, instead of in the water. The next two above are close together, and are, respectively, owned by Mr. Newcomb and Messrs. Viccory & York. The dam here is 8 feet in height, and on the far side, from the mill propped against the stringer of the dam at an agle of 45 degrees, is a more feeble representation of a ladder than Mr. Dickie's.

These mills have been forced to save their rubbish, and but little is seen in the stream. Mr. Smith's saw mill above, however, is less cared for, and I saw a good deal of edgings, slabs, &c., about in the water. Salmon, so I am informed by an old resident, seldom, if ever, went up beyond this point when no mill-dams existed. The rest of the river is clear for many miles up. Leaving Parsboro' River, I drove back, on the Amherst road, to Southampton, and visited Messrs. Atkinson & Co.'s dam at the woollen factory, on the Maccan River. It is in height about 10 or 12 feet, and unprovided with a fish-ladder, or any other means of allowing fish to ascend further. Below this place, 1 mile, Mr. M. L. Tucker, has erected his saw and grist mill; although the dam is a low one, it requires a ladder upon it, for, at present, salmon could only surmount it with difficulty, on account of its protruding apron. Descending the Maccan further on, I discovered, about 2 miles below Tucker's, a new mill in course of erection. The dam is not yet built, and it might be deemed advisable to order the miller to put in a suitable ladder while it is in the course of being constructed, and to be under the supervision of a competent person to avoid any difficulty hereafter. W. C. Filmore is the proprietor of the new mill, and proposes erecting his dam either this fall or next spring.

River Advocate, flowing into Advocate Harbor, is entirely free from obstructions, as are also Nassau, Laplanche and Missiquash, the latter visited yearly by thousands of gaspereaux.

12th June.

Took the train for Kentville, having been specially requested by some of the principal people of that locality to visit and report upon the existing state of the Gaspereaux River. The fisheries of which are, it is said, ruined. Before doing so I consulted the Inspector, and he approving, I went.

I visited the lower part of the Gaspereaux, from the first fresh water pool upwards to Benjamin's mill, and I found, as described, the river banks and bottom covered with sawdust and shingle shavings. While the mill is in operation between six in the morning and six in the evening the water more resembles porridge than anything else I can compare it to. The inhabitants here make most grievous complaints. They say their gaspereaux fishery is destroyed, that, whereas at one time, before this mill was erected, they had multitudes, both for sale and domestic use, of these fish; now they can get none. It does appear most unjust that one man should have such a monopoly, and to be permitted to drive his mill without any care for the rubbish, daily falling from the saws, being kept out of the water and destroying a most valuable fishery.

I inspected, also, the fish-ladder. This has been a bone of contention ever since its erection, and there are numbers of people who still disbelieve in its efficiency. I can only say that I can see no fault to be found in the ladder itself, for I, having a guide with me who carried his rod and line, killed a salmon between 2 and 3 miles above it—a positive proof that salmon do ascend by its aid. Still the fact of their being so many mill hands about, who poach, makes me more than suspicious of its being used as a means to trap fish while ascending, and I know that much poaching does exist, for I have had a reliable statement made to me of a party of men, whose names were withheld, sweeping with nets in the upper pools. It would be very desirable to place one of Mr. Rogers' new ladders in this dam of Benjamin's, and so prevent the unfair catching of fish, for it would be placed in mid-stream, and not easy to get at, while the present one is quite close to the bank.

I, this day, ascended the river as far as Lane's mill, about, I should say, 8 miles from Benjamin's, or the White Rock Mills. Here fish can pass, but, I think, salmon can spawn below this structure. There are good and ample grounds for that purpose, before reaching it.

Between Benjamin's mill and Lane's, I found two rolling dams, used only for stream driving, but when the gates are lifted, there is nothing to hinder fish coming up. Salmon have been caught in former years at Lane's mill and above it; but I can get no information of their being seen there recently. They were in those days found late in the fall of the year, far above Lane's, spawning on the gravel beds. Very few gaspereaux, this year, came into this river. They have been decreasing, year by year, without doubt. It is believed, and with good reason, that they are abandoning the locality on account of the sawdust, &c.; and I am told that a numerously signed petition is on foot, begging the Department to enforce the law against the pollution of the water, and to assist in restoring to the residents on the river their fisheries.

15th June.

I visited the Cornwallis River, which I had to omit last year. There is but one mill upon it, called West's. It is situated about 5 miles from the tide-way. Salmon ascend the Cornwallis River for about 7 or 8 miles, where they reach good spawning grounds. Gaspereaux do not frequent this stream.

14th August.

I arrived at Middleton Station in the afternoon and, after driving across to the hotel, on the post road, some distance away, I set about gaining all the information possible to facilitate my inspection, and made arrangements for conveyance, &c., the following morning.

15th August.

The junction of the Nictaux and the Annapolis River is about 9 miles from the tide-way. I began to-day at this point and found the Nictaux quite clear of edgings and sawdust, up to and about the first mill, which is situated 1½ miles from the confluence. The dam here is not a high one, being only 3 or 4 feet in time of heavy freshet, and salmon and grilse have been observed jumping over it, but as both this tributary of the Annapolis, and the Annapolis River itself, are frequented by shad, a ladder of simple and inexpensive structure would be of much benefit to assist these valuable fish. The conformation of the bank on the south-east side is admirably adapted for such a purpose. I should mention that the water falls here very rapidly, and at no other time than the high freshet do salmon and grilse succeed in getting over.

A resident here informed me that this season, when the water fell some 2 feet, he saw the fish trying to jump it; but most of them fell back, unable to do so, and became an easy prey to the night poachers with their sweep-nets. This mill and dam is owned by a widow, whose husband, J. Rogers, died a short time ago. She is in very indifferent circumstances, and barely ekes out a living in trying to conduct her late husband's business, and it would be a charity if some assistance were given her to enable her to have this ladder erected.

I proceeded upwards from here, and 1 mile above, came upon the dam where Chipman and Beale's mill stood. It was destroyed some little time ago by fire, but the dam remains intact. It is situated at the Nictaux Falls, so called, from which the settlement near here takes its name. These falls are about 200 feet long, and in time of freshet, must be very formidable for fish to attempt ascending. They could be much improved by a small outlay in blasting. Two or three good shots, judicially placed, would be all that is necessary to remedy their abruptness. The dam is 10 or 12 feet in height, and I saw, in the centre, the remains of an old ladder, now broken, decayed and useless. Indeed, it must have been always the latter, for, on measurement, I found the grade was only about 1 foot in 4 or 5, at the outside, which is, notably, too steep for any description of fish. It appeared almost upright. A good ladder is much needed here—one of the new patent would be the best in a dam of such height.

I then went on to Ward & Gate's grist, carding and shingle machine mill. It has a dam 10 feet in height, and has never been supplied with a ladder. But, on crossing over the dam to the west side, I found a gate cut in it, and a small, most inefficient, channel cut round into the bank, and joining the river some 10 or 15 feet below. It is possible that, were this much widened and deepened, it might be made to answer; but it is too accessible to poachers. I learn this firm is very well to do, and, I should say, could not well object to build a proper ladder in the centre of the dam, which would last for many years and open up this formidable barrier to both salmon and shad. I fear their run round, as it is called, was never sufficiently large to have been of any service. Some considerable distance up, I should say over a mile, I reached Samuel and Robert Nickson's saw mill, with a dam about 10 feet in height. There is here no provision made for fish to get above it—neither fish-pass nor ladder. Should a proper one be erected, there would be then a clear run of nearly 7 miles of good water, without any hindrance to shad and salmon, until they reached the gang saw mills belonging to Freeman & Mitchell, formerly owned by Pope, Voce & Co. I may mention here, that gaspereaux are unknown to either the Nictaux or the Annapolis, at least so far up as this, from the latter's junction with the salt water. But besides the shad and salmon, there is a very large species of trout, attaining sometimes 4 and 5 lbs. in weight. I observed, at all the mills I have just described, that a great deal of care seems to be taken in keeping the water free from mill rubbish. Edgings, &c., are carted away for the residents' firewood, and the sawdust is in some cases taken away and spread as manure over the fields, and in others, piled in great heaps, sufficiently far away from the river's bank to ensure its not falling in. At the grist mill, which was not working when I arrived there, they told me they make a compost heap of the shells on husks, and they find them too valuable to top-dress their land with, to allow them to be thrown in the river ; a in practice too common in many other grist mills throughout the Province, and which is more fatal to the fish than even sawdust. Rain setting in, I was obliged to return to the inn, deferring my inspection of Freeman & Mitchell's mills, 7 miles above Nickson's, the last mill visited.

16th August.

Before going up any further on the Nictaux, I determined to see the main river at Lawrencetown mills, which are 6 miles below the mouth of the Nictaux, to ascertain in what condition the dam was, for it would be necessary to make this barrier accessible to fish, before it became necessary to open up its tributary. I visited this place on the 29th April, 1881, and then found the mills in disuse, the gear all removed from them, and everything about them out of repair, whilethe dam remained intact, and totally obstructing the river. I determined then to make this inspection to-day, and so drove over. I found that a great change had taken place since I had last been there. The property had fallen into other hands, and Mr. Brown had become the purchaser, and intending to run these mills again, had begun to repair them and refit them with new waterwheels and other gear. He had rebuilt and raised the dam some feet, and I found was then employed, when I arrived, in making a cutting or sluice-way on the side nearest the south shore. He contemplated making it 5 feet in width, and proposed driving piles at intervals on either side, which would not only act as braces to secure the dam, but also make breaks, something after the manner of a ladder's buckets. The idea was an ingenious one, and I could not help approving of this measure, assisting, as it would undeniably, the fall run of salmon. I remained all day here, advising him as he proceeded, and by night fall we had the job nearly completed. A false dam had to be made above the cutting as there was a good head of water on. I left him, with a promise to return next day and superintend the finishing, and returned to Middleton.

28th September.

I to day took passage by rail to Londonderry, and drove in to Great Village, and thence on to Upper Economy, where Mr. Davison resides. On my way I examined the Port au Pique River. It is all clear of obstructions, and is considered the best salmon stream on this side of the county. The fish have an uninterrupted run up to the falls.

I stopped also at Bass River and inspected the ladder at the Union Company's Furniture Factory. It is old and somewhat out of shape now, but its grade at the outset was made too steep. I found it to be but 1 foot in 5, and built on the old principle, running down stream from the top of the dam. The length is quite 30 feet. The buckets are but 3 feet apart, placed at that limited distance, I should say, on account of its steep pitch, but inadequate, in distance from each other, for a serviceable salmon ladder, as it makes the turns too short for good sized fish, and gives but insufficient room in passing round. I trust it will soon be replaced by one of Mr. Rogers' patent. The other dam is 1½ miles up, owned by Mr. McLaughlin, and very low, being only from 2 to 3 feet in height at time of freshet, which salmon would think nothing of leaping over. It only remains, then, for a good ladder to be placed at the Furniture Company's dam to put the Bass River in perfect order up to the natural falls, 6 miles from the sea. I reached Mr. Davison's house this evening.

He told me he was positive that no salmon or shad had been caught for many weeks between Five Islands and Great Village—that he should have known of it, were it so; but he strongly suspected some of the people about Mass Town being the culprits. On his advice I went no further towards Five Islands, and he further requested me to leave the affair in his hands, as he thought he would have more certain means than I of tracing the parties who caught and sold the salmon. I consented to do so, and directed him to use every means to discover the offenders and, in the event of success, to report the whole matter to Mr. Rogers, for his instructions in dealing with the case. This I did, believing it the best thing to do under the circumstances, as his duty constantly takes him among the fishermen at Mass Town, while my appearance there alone might excite suspicion.

I find that it is most unusual for shad to be found at such a late season of the year in the Basin of Minas, such a thing not having occurred for a considerable time; but, in any case, there are neither instructions concerning shad in the Fishery Act in the Revised Statutes of Nova Scotia, chapter 95, nor in the local regulations for Colchester County.

I hope to be permitted to bring forward for approval, in next month's report, necessary alterations and additions in the printed circular issued for the guidance of the officers of that county.