A Renewed Conservation Strategy for Atlantic Salmon in Prince Edward Island

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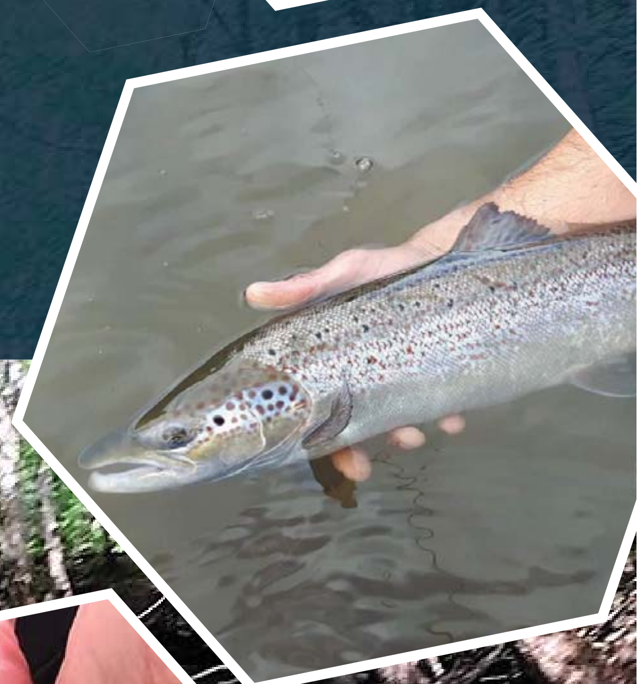
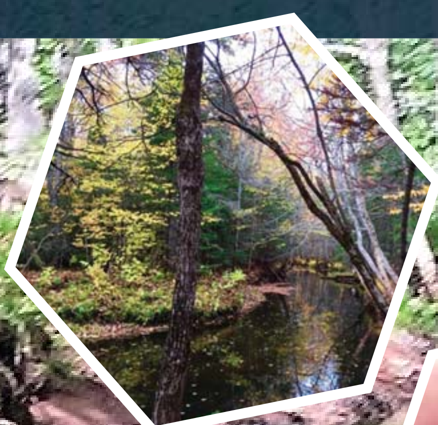
April 2019





A RENEWED CONSERVATION STRATEGY FOR ATLANTIC SALMON IN PRINCE EDWARD ISLAND

APRIL 2019

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PRELUDE

Atlantic salmon are an indicator of healthy aquatic ecosystems and in turn, our own health and wellbeing. We have an opportunity to set an example in Prince Edward Island of how to make rivers more resilient in the face of climate change and provide the environmental, economic and social benefits that result from healthy aquatic ecosystems. Conserving and restoring our salmon populations will require a collaborative effort among watershed and Aboriginal organizations, landowners, and federal and provincial government agencies. More importantly, it will require major changes in the way crops are produced in PEI, as current agricultural practices are unsustainable. The costs associated with dealing with the issues of erosion, sedimentation, and chemical contamination of air, land and water will only increase in future with the effects of climate change. Immediate and strong actions are needed to deal with these threats. We also need to recognize the many values provided by healthy, diverse riparian zones and how these areas will be vital in ensuring that rivers have the resilience needed to maintain healthy fish populations in the years to come.

Different people have asked me why I continue working, long after retirement, to protect and conserve natural areas and restore habitat and fish populations in Prince Edward Island. After more than fifty years of working in the environmental field, I remain optimistic that we can make a difference. I owe that to my children and future generations.

Daryl Guignion and children Evelyn and Harrison canoe the Morell River.

"In the end we will conserve only what we love; we will love only what we understand, and we will understand only what we are taught." Baba Dioum

Daryl Guignion

EXECUTIVE SUMMARY

In response to the alarming rate of decline of Atlantic salmon (*Salmo salar*) across Prince Edward Island, in 2008 the Atlantic Salmon Conservation Foundation commissioned a comprehensive conservation strategy for Atlantic salmon on Prince Edward Island. A decade later, the findings and recommendations of that strategy were revisited to:

- update the status of Atlantic salmon and their habitat across twenty-six Island rivers;
- evaluate the effectiveness of management actions to date;
- recommend management priorities and directions for the next decade.

At the time the first conservation strategy was developed, the future for Atlantic salmon on PEI was uncertain. The number of rivers with salmon runs had dropped from about seventy prior to European settlement, to an estimated twenty-eight in 2000-2002, with a further drop to twenty-two in 2007-2008. There is little question as to why this is happening. Prince Edward Island is one of the most densely populated provinces in Canada[1] with intensive agricultural development[2] and a changing climate – a challenging backdrop for Atlantic salmon conservation. The findings of the current study do however show some promising signs that Atlantic salmon are responding to the intensive conservation efforts of local watershed groups. The presence of juvenile Atlantic salmon was confirmed in the Miminegash River, adding a new river to the list of Island salmon streams; modest numbers of salmon have returned to Clarks Creek where they were considered to be on the verge of disappearing; the Vernon and St. Peters Rivers had higher juvenile salmon densities than would have been expected based on spawning activity in the previous year; the West River in central PEI has responded positively to management efforts and now supports good runs of Atlantic salmon; and many of our "best" salmon rivers – such as North Lake Creek and Cross River in northeastern PEI, the Morell River, and the Mill River – are holding their own. There are also some discouraging signs. Electrofishing results from 2018 show that juvenile salmon density on several rivers is highly variable to declining; rivers in areas of intensive agriculture are struggling to maintain already precariously low numbers of salmon, or have lost them altogether; and even large rivers such as the Morell, that had historical runs of Atlantic salmon numbering in the thousands, are likely functioning well below their potential.

General trends in Atlantic salmon numbers across PEI are difficult to determine due to sporadic sampling and a high degree of variability in results over the years. Of twenty-six rivers included in a 2017 spawning survey, twenty-three had spawning activity (based on the number of redds). However, numbers were very low in some cases, and only seven of these were considered to meet or exceed conservation requirements according to a recent status assessment (Cairns and MacFarlane 2105). In the 2018 electrofishing survey, juvenile salmon were found in only seventeen of the twenty-six rivers studied, although the location and number of sampling locations may have affected results in some rivers. The number of redds recorded in a river did not always

[1] In 2011, PEI had a population density of 24.7 persons per square kilometre. compared to the national population density of 3.7 persons per square kilometer (Statistics Canada 2011 census)

[2] the Island has a total land area of 1.4 million acres with approximately 575,790 acres cleared for agricultural use, and 1,353 farms ranging in size from a few acres to 3,000 acres (Gov of PEI Website, 2016 census)

align with the density of young-of-the-year salmon (YOY) the following year, suggesting that factors affecting emergence and survival of juvenile salmon require much closer attention in future planning and research.

The report includes an overview of the major challenges facing PEI salmon rivers and a description of critical habitat variables. General management recommendations are presented for the twenty-six rivers included in this study. The evaluation for each river includes characteristics of the riparian zone (including forest composition in the 60 metre buffer); current and historical data on Atlantic salmon redds and densities; and habitat quality as related to critical limiting factors for Atlantic salmon (e.g., access to/from sea, connectivity, habitat availability, quality of the stream bottom for adult spawning and juvenile cover).

Each river has its own unique potential, but it is possible to make general recommendations for salmon conservation on PEI. Intensification of agriculture, deforestation, climate change, and ongoing issues with beaver and man-made blockages have created a "perfect storm" of interacting pressures, and it will take a concerted, province-wide effort to navigate through it. The single long-term vision for all our salmon rivers is to restore healthy functioning aquatic ecosystems with the natural resilience necessary to withstand growing pressures. The most productive Atlantic salmon rivers on PEI are those that have retained the greatest degree of *naturalness* – unobstructed rivers with diverse forested riparian zones and clean gravel-cobble substrate. Flagship rivers in this category would include the northeastern cluster of rivers anchored by North Lake Creek and Cross Creek. Other river systems, such as the West River, Morell River and the Trout River (Coleman) have benefitted greatly from the acquisition and/or protection of sensitive land in the riparian zone. At the other extreme are rivers that present a significant challenge to achieving this goal, especially in areas of intensive agriculture, such as the Dunk and Wilmot Rivers in the Bedeque Bay watershed.

While recognizing the importance of agriculture to the PEI economy, there is an urgent need to address the impacts arising from intensive row crop production if viable salmon populations are to be restored to even a fraction of their former range on PEI. This issue has received considerable attention over the years, however sedimentation, fish kills and anoxic events continue to impact our rivers and estuaries. Field consolidation, hedgerow removal, shortened crop rotations and fall tillage, compounded by the vagaries of climate change, are just some of the practices at issue. There is no one piece of legislation, organization or individual that can solve the problem. A multi-pronged approach is needed that includes industry, government, researchers, and environmental groups to find solutions so that productive agricultural operations can co-exist with healthy functioning aquatic ecosystems.

The percentage of forest cover within a 60 metre riparian zone is a good indicator of Atlantic salmon populations. The current 15 metre legislated buffer is insufficient and will need to be expanded in order to provide the multitude of benefits for water quality and quantity, biodiversity, climate change mitigation, and recreation. Actions taken to protect a 60 metre buffer along the Morell River show what can be done with sufficient motivation and cooperation. While a challenge in heavily developed areas, incentive-based programs such as eco-gifting, carbon credits, and acquisition of land to meet goals for protected areas, are just some of the cooperative measures that could be explored to achieve the goal of a 60 metre riparian buffer, along with regulatory measures.

Expanded riparian buffers zones are an important start, but the characteristics of the vegetation within these zones is equally important. For example, areas dominated by mature conifers will have a profound impact on water temperature, nutrient cycling, water runoff to streams, and the diversity of understory vegetation. Restoring native species, for example species characteristic of the Acadian forest once found across PEI, will be important to restoring the conditions that served to maintain the natural balance of our rivers. This is not a modest task and will require changes to the number and types of trees currently grown at the provincial nursery, as well as additional resources and training for watershed groups.

Atlantic salmon are the proverbial "canary in the coal mine" for aquatic ecosystems; their decline signaling the deteriorating quality of rivers and streams across PEI. The costs of acting to restore Atlantic salmon and their habitat may seem high, but if the true value of our natural river systems were tallied, the costs of inaction would seem much higher.

The following general recommendations are included in the report:

- A provincial strategy - including proactive and precautionary regulations, policy, partnerships and incentives - is needed to address erosion and sedimentation and runoff of nutrients and pesticides from agricultural land. This must be made a priority for the provincial government, as the impact and costs of the resulting degradation of our aquatic ecosystems will only increase with the impacts of climate change.
- Run-off and sedimentation from road construction and unpaved road surfaces continue to be a problem, especially in certain regions of PEI. Greater collaboration between the Department of Transportation, Infrastructure and Energy and watershed groups, as well as a more proactive approach to erosion control, would be beneficial.
- Riparian areas need be considered high priority for conservation and protection. There are various tools for protecting riparian areas, but a protected 60 metre zone should be the established target.
- Riparian zone restoration is urgently needed and should focus on the planting of native trees and shrubs, as well as maintaining areas of grasses, sedges and shrubs.
- First and second order tributaries require greater protection and riparian restoration efforts should extend to these areas.
- Other anadromous fish species, such as gaspereau and smelt, are important to Atlantic salmon as a source of food and serve as prey cover during spring migration of smolts and kelts. Habitat restoration efforts for these species, for example improving connectivity, will benefit salmon populations.
- Seal predation may be an increasing mortality factor for salmon during critical spawning and smolt migration periods. A dietary analysis study would help to shed light on this issue.

- Research is needed to determine the cause of fluctuating fry success in some PEI rivers. If it is found to be related to water temperature at time of emergence, applied research could be done to determine potential mitigative measures.
- The extreme weather events associated with climate change will increase in frequency and Atlantic salmon watersheds should be assessed to identify vulnerable points in the system and the ability of infrastructure, such as roads, dams, and bridges to withstand more intense storm and flooding events.
- A number of Atlantic salmon habitat restoration techniques are referred to in this document. Watershed groups working in salmon rivers should refer to the Technical Manual for Watershed Management on Prince Edward Island (Harris et al. 2012).
- All restoration activities should be guided by a Salmon Habitat Management Plan for each river.
- Connectivity is a critical factor in all salmon rivers. A connectivity assessment and completion of a beaver management strategy should be included in every salmon habitat management plan.
- Additional water temperature monitoring is needed on PEI salmon streams, particularly in winter and spring. Water temperature data will determine if action is needed to address temperatures at critical times, e.g., fry emergence.
- Current spawning areas should be identified and efforts made to ensure that these sites have the optimal habitat conditions for egg hatching, emergence and first year salmon.
- An expanded electrofishing program, focusing on current spawning areas, is needed to get a better indication of hatching and juvenile success.
- To build on the information and recommendations in this report, it is suggested that watershed groups working on salmon rivers would benefit from forming a sub-group within the PEI Watershed Alliance. Furthermore, the formation of a multidisciplinary advisory group would establish management priorities and actions into the next decade. Finally, an associated Action team (A-team) would provide additional capacity to implement plans across watersheds.
- Engaging the general public and increasing awareness about Atlantic salmon and their habitats will be essential in fostering stewardship and making long term changes needed to protect habitat and preserve salmon populations. Continuing successful programs, such as the Abegweit Conservation Society's *Salmon are our Friends* program and developing new ways to engage the public will pay dividends into the future.

SECTION 1. INTRODUCTION

1.1. Objectives and Scope

Over the years, human activities have degraded freshwater salmon habitat to the extent that current populations of Atlantic salmon are greatly reduced from their historical presence in Prince Edward Island. Atlantic salmon probably occupied about 71 PEI rivers at the time of European contact; this number fell to 28 in 2000-2002 and to 22 in 2007-2008 (Cairns and MacFarlane 2015). In 2009, a comprehensive conservation strategy for Atlantic salmon was developed to guide restoration efforts and address key issues limiting salmon populations in Prince Edward Island. A decade later, it is time to update the status of Atlantic salmon on PEI, discuss the current and emerging threats to our Atlantic salmon population, and recommend strategies on how to manage salmon rivers into the next decade.

Although marine survivorship in Atlantic Canada is of considerable importance to salmon, this report focuses on the Island's freshwater systems, and to a lesser extent, the freshwater-coastal interface. Habitat improvement, including stemming the ongoing sources of habitat degradation, is the best way to produce the robust salmon populations needed to withstand not only the decrease in survivorship in the marine environment, but the pressures from surrounding land use and a changing climate.

This report includes three key sections:

- An overview of major challenges for Atlantic salmon on Prince Edward Island
- A general discussion of key habitat factors for Atlantic salmon and recommendations to address impacts on salmon habitat
- An assessment of each river in terms of Atlantic salmon status, habitat characteristics, key management challenges and recommendations

Two additional supporting documents are recommended to readers:

1. Prince Edward Island Atlantic Salmon Spawning Survey 2017 (Oak Meadows Inc., March 2018) provides data on Atlantic salmon redds on the same rivers addressed in the current report. We have integrated findings into our assessment for each river, and include that report as a companion report to this document.
2. Technical Manual for Watershed Management on Prince Edward Island (Harris et al. 2012). This manual contains techniques and approaches to implement the habitat enhancement referred to in the current document and should be a reference for all groups working in watershed management on PEI.

1.2. Methodology

The background work for this document began in 2017 with a spawning (redd) survey of twenty-six Atlantic salmon rivers in Prince Edward Island. In 2018, electrofishing surveys were completed in these rivers, often at multiple sites, as well as one additional river. This immense amount of field work was only possible through the cooperation of watershed groups and the Forests, Fish and Wildlife Division.

Each river was visited as part of a general assessment. Rather than classify or rate each river in terms of habitat quality, the focus was on identifying the key habitat factors that are limiting for Atlantic salmon, and providing management recommendations for these factors. These key factors included:

- access to and from the sea
- instream connectivity / blockages
- instream habitat quality (bottom substrate, pools, canopy cover, water temperature, instream cover/large woody debris (LWD)
- riparian buffer zones, including vegetation within 60 metres of the stream.

Watershed coordinators were consulted and provided valuable information on limiting factors in their streams and previous and current habitat restoration efforts. It should be noted that this was not a formal assessment of each river. Such an assessment would be the responsibility of the individual watershed groups.

While individual rivers were assessed, watersheds have been grouped into regional clusters based on geography and proximity. This is important because there is some evidence that salmon returning from sea may not always go to the same river, and if salmon are to have the best chance for recovery, rivers must be managed as a group. In addition, clusters will often have shared pressures and opportunities that can focus rehabilitation and management priorities for a region. The rivers that were surveyed, as well as the identification of river clusters, are shown in Figure 1.

Meeting with the watershed coordinator and group member from Roseville/Miminegash Watersheds Inc.

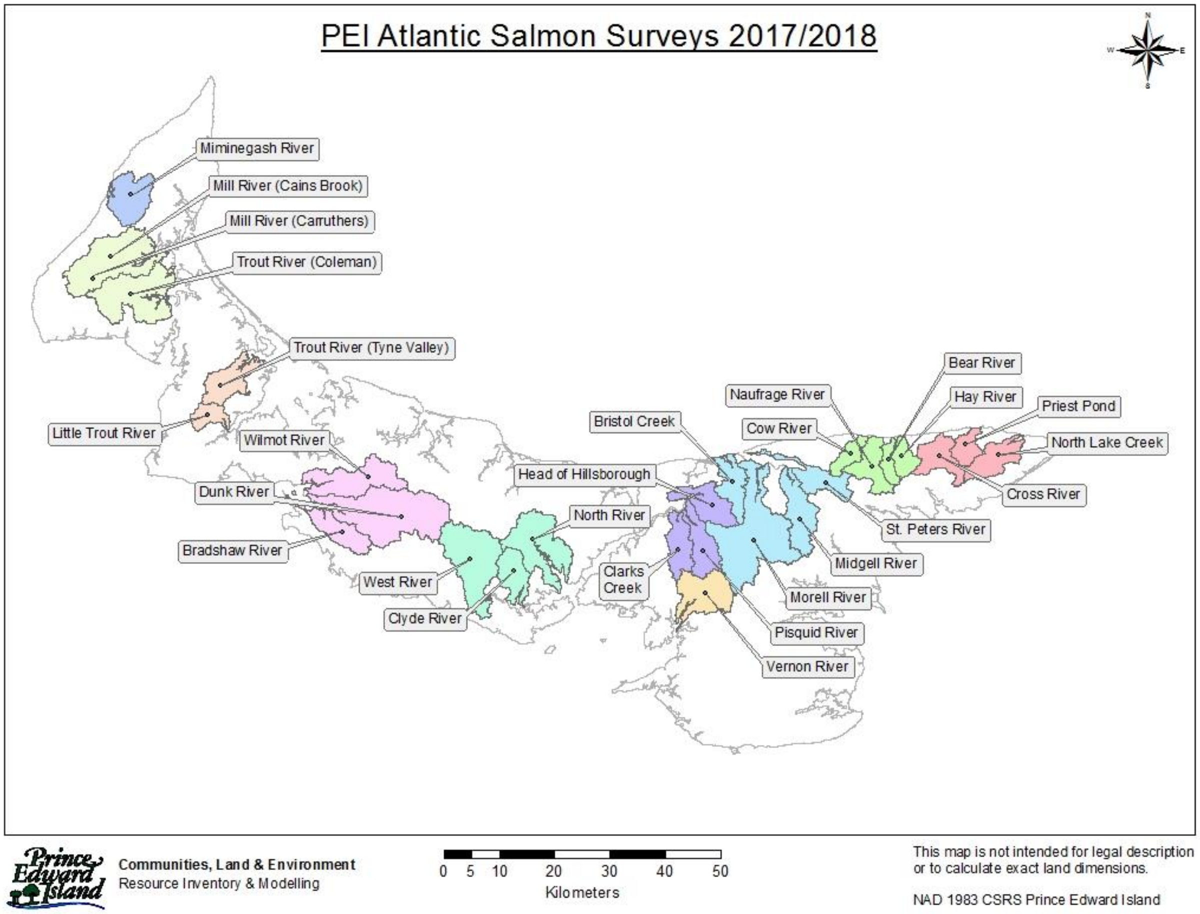


Figure 1. Rivers included in the Atlantic Salmon Conservation Strategy. River clusters are identified by colour.

1.2.1. Spawning Survey

An Atlantic salmon redd survey was conducted in twenty-six rivers in November and December 2017. Experienced field personnel conducted the survey following established protocols. Prior to commencing the survey, many of the participants walked a section of the West River to set parameters used for counting and documenting redds. In each river, surveyors walked upstream, counting all salmon redds and marking their location with a hand-held gps. Some of the larger rivers were able to be surveyed by canoe. A complete description of methodology and results for the 2017 Atlantic salmon spawning survey are documented in a previous report (Oak Meadows Inc. 2018).

1.2.2. Juvenile Density Survey

The density of juvenile salmonids was obtained through electrofishing surveys completed at 47 sites in twenty-four rivers between August and November, 2018. Spot checks were done to determine presence or absence of salmon on an additional four rivers. A battery-powered backpack electrofisher (Smith-Root LR-24) was used to survey each site. For consistency, the same electrofisher operator was used at all sites sampled (Daryl Guignion) and data were consistently collected and analysed by Connie Gaudet. Upstream and downstream barrier nets were used to secure the area and the three-pass removal method was used to determine fish density. A minimum of two additional people made up the crew and diminishing returns were used to determine the number of sweeps. Fish were collected, held in tubs, identified to species and fork lengths recorded. To limit mortality, no sites were surveyed if water temperatures exceeded 20˚C and conditions in the holding tubs were regularly monitored to ensure that temperature and oxygen levels were suitable for fish. The sampling area (m^2) was estimated as the length of the sampling site (between the barrier nets measured along the natural meander of the river) multiplied by the average of five measured stream widths. The width measured was the actual wetted width of stream that had been surveyed. Densities were calculated using the Zippon method.

SECTION 2. EXISTING AND EMERGING PRESSURES

All watersheds in Prince Edward Island are facing challenges related to land use; challenges that are becoming greater with climate change. Unless these issues are addressed, watersheds will be under increasing stress and will have difficulty maintaining populations of Atlantic salmon. If steps are taken to reverse the damage of current land use practices, watersheds may have the resiliency required to withstand the impacts of climate change.

2.1. Soil Erosion

The most significant surface water quality issue across PEI is the movement of water-borne sediment from agricultural lands, primarily lands under intensive row crop cultivation. This is not a new issue. The 1987 *Conservation Strategy for Prince Edward Island* (Stewardship and Sustainability) concluded that soil erosion, particularly row-crop production, is the most serious environmental problem facing the province. The urgency of the issue on PEI was underscored over the following decades in the *Report of the Round Table on Resource Land Use and Stewardship* in 1996 and the *Report of the Action Committee on Agricultural Runoff Control* in 1999.

“Wave” of sediment off Dunphy Road in Pisquid River watershed, summer 2018

Clyde River run-off, April 2017

The problem of soil loss is inextricably tied to the loss of soil organic matter (Science Council of Canada 1986). The loss of soil organic matter has reached critical levels on PEI. A long-term monitoring study of soil organic matter (SOM) in agricultural fields across PEI found significant overall declines in SOM between 1998 and 2015, concluding that under current low-residue cropping systems with intensive tillage, loss of SOM is expected to continue (Nyiraneza et al. 2017). Loss of organic matter creates a downward spiral of environmental degradation. Soil low in organic matter is less resilient to wind and water erosion, high precipitation events, flooding and droughts. In turn, crops require more fertilizer and irrigation, increasing the input of sediment and nutrients to the aquatic environment, and possibly reducing stream flow at critical times of the year.

2.1.1. Impacts of Sedimentation on Atlantic Salmon Habitat

The ongoing issue of sediment input into a river is the major reason for channel and habitat degradation on PEI, and is considered an important limiting factor for Atlantic salmon (e.g., Cairns 1999; Cairns et al. 2012). Newcombe (2003) discusses the profound impact of suspended sediment on fish and their habitat as *…triggering a cascade of impacts, from one trophic level to the next, involving phytoplankton, zooplankton, insects, freshwater mollusks and fish …(with) direct effects (mortality, reduced physiological function, and habitat alienation) and indirect effects (decreased rates of growth, reproduction and recruitment) linked to reduced food supply*. But perhaps the more serious long-term impact arising from sedimentation in PEI streams is the effect on bottom substrates.

Infiltration of sediment into stream bottoms can result in a significant decrease in the survival, emergence and over-wintering success of Atlantic salmon eggs and juveniles. The first and most sensitive stage affected by sediment is eggs in redds, a particularly important issue on PEI as spring runoff often coincides with sensitive stages of egg development. Even relatively small increases in sediment levels in streams have been shown to reduce egg survival (Julien and Bergeron 2006, Levasseur et al. 2006). An unpublished field study in the Morell River (Guignion et al. 1996, Appendix III) found there was no survival of emerging fry in high sediment situations, presumably due to fine sediments reducing the required oxygen during egg development. Embedding of gravel and cobble substrate can also prevent the escape of alevins from the gravel pockets and reduce the spawning success of salmon by "cementing" the substrate making it difficult for spawning salmonids to move substrate and create an effective redd. (e.g., Everest et al. 1987*)*.

The impact on juvenile salmon is also considerable. Sediment fills the interstitial spaces in gravel and cobble that are critical habitat for all but the oldest of juveniles (DFO 2008). Juveniles use these interstitial spaces for cover from predation and to stabilize in swift currents. In general, greater habitat heterogeneity exists when large sediment fractions such as gravel, cobble, and boulders dominate the substrate (rather than silt, sand and clay), which can be important to meeting cover and dietary needs of juvenile salmon (e.g., DFO 2008).

Cobbled stream bottom in St Peters River, 2018

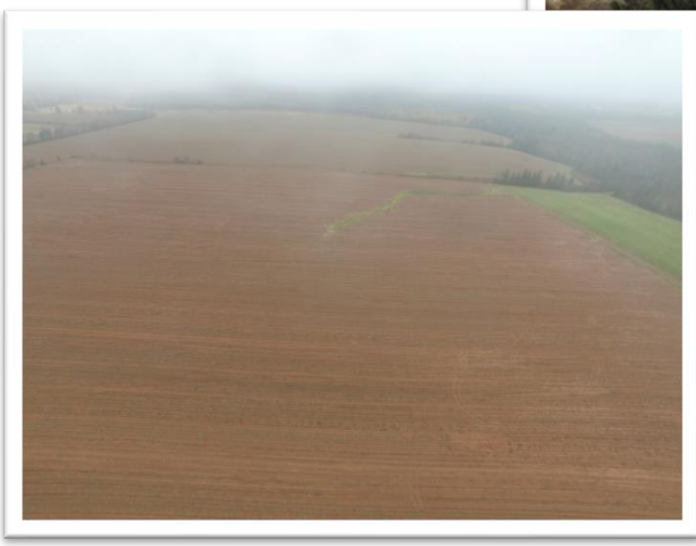
2.1.2. Economic Impacts

Economic impacts of sedimentation are also significant. In 2016, national studies suggested the recreational fishery is worth $6 million to $7 million a year to PEI., and in a study by ASE Consulting and UPEI (1997) it was estimated that this value would be ten times higher without sedimentation. The costs of dealing with instream sedimentation and its effects are also very high, requiring a major effort and expenditures across virtually all watersheds. While outdated, and therefore likely an underestimate of costs in today's dollars, information on economic impacts of off-farm effects of soil degradation for the Great Lakes region of southern Ontario serves to illustrate the scope of costs (*in* Science Council of Canada 1986). It was estimated that sedimentation due to agricultural production caused $91 million in damage annually including sediment damage to inland lakes and waterways, the cost of dredging ditches and harbors, and recreational fishing losses.

2.1.3. Agricultural Practices and Sedimentation Risk

Prince Edward Island continues to have the largest land area devoted to potato production in Canada (Statistics Canada 2016). Although the 2016 census showed that acreage actually decreased slightly between 2011 and 2016 (from 86,560 to 83,326), there is a trend towards more intensive, large scale agriculture. Our observations identified several factors that could increase the impact on our streams and salmon habitat as a result.

Field consolidation - In November, 2018 Cavendish Farms warned a legislative committee about "significant threats to the long-term sustainability of potato farming on Prince Edward Island," while asking government to double land ownership limits imposed on Island potato farmers. The move towards larger and larger fields is causing greater stress on streams. Depending on topography, consolidation of fields can increase slope length, resulting in significant increase in runoff and soil loss. Generally, if the slope length is doubled, the soil loss is increased 1.5 times. Current regulations and incentives (e.g., for the retiring of sensitive agricultural land) address slope (9%) but not slope length. It would be beneficial to incorporate slope length into assessments and regulations.



Field consolidation in the Mill River watershed, 2018 (above left) and Fanning Brook in the Hillsborough River watershed, 2018 (above right).

Hedgerow removal - Hedgerow removal often goes hand in hand with field consolidation, and can expose fields to increased wind and water erosion. This is particularly important for spring runoff. With less snow held on fields, infiltration to soil is reduced and surface runoff is increased. In the Hillsborough River watershed, there was an estimated loss of 78 ha or 16.2% of hedgerow cover between 2000 and 2012 and it appears that this rate of loss is not diminishing (Hillsborough River Association 2018).

Exposed Fields - Late harvested potato fields and fields ploughed in the fall can experience major soil erosion during spring runoff. During the winter, cycles of freezing and thawing have a major effect on exposed soil, with the frozen top layer of soil thawing while bottom layers are frozen, making it more susceptible to accelerated runoff through sheet erosion. This is likely to intensify with the increasing frequency of winter rainfall events due to climate change. Exposed winter soil is also subject to sublimation and increased wind erosion. On PEI, there have been several notable "red snow" events – most recently in February 2019 - due to massive topsoil loss in winter as a result of high winds blowing over exposed fields with minimal snow or crop cover.

Runoff from potato fields in Grahams Road, July 2018 (above left). A road grader was needed to remove soil from the road (above right)

Minimizing the practice of fall ploughing and use of crop residue management techniques would help to reduce soil erosion from exposed fields.

Topsoil covering snow and roadsides due to wind erosion in Covehead area, February 2019

Crop Rotation – The authors of a 2017 report on changes in soil organic matter (SOM) levels in Prince Edward Island concluded that "the current rotation systems in PEI are not sufficient to maintain soil organic matter and further efforts are needed to reverse this trend toward declining soil organic matter" (Nyiraneza et al. 2017). Since 2008, a 3-yr potato crop rotation has been mandatory under the *Agricultural Crop Rotation Act*, however producers can have a 2-yr crop rotation provided that they have filed an environmental farm management plan. In the 1999 *Report of the Action Committee on Agricultural Runoff*, a minimum of a 3-yr crop rotation for potatoes was recommended, although longer rotations were considered preferable. Given ongoing issues with soil loss, a 2-yr crop rotation should not be considered, and even three years will not be sustainable without enhanced soil conservation and enhancement practices.

Howells Brook – West River, 2018

Grassed Waterways - Grassed waterways are constructed channels designed to drain water off fields without causing soil erosion. However, many of these areas were once small, first order streams which now carry water and chemicals directly to streams. Some are properly constructed and well maintained but others serve more as trenches, carrying massive amounts of sediment to the stream and eroding stream banks.

Grassed Headlands - With the narrow 15-metre buffer zone requirements in areas of intensive agriculture, grassed headlands can play an essential role in reducing agricultural impacts as a complement to buffer zones. Although grassed headlands are currently part of the buffer zone regulations on PEI, they are sometimes lacking or highly disturbed. The potential is there to use these more effectively, and current requirements for grass headlands should be strengthened, especially in areas where fall plowing is practiced. It has also been suggested that where fall tillage is practiced, an extended grass headland is needed to mitigate impact on streams (Bedeque Bay Environmental Management Association (BBEMA) pers. comm.). Even a well maintained grassed headland cannot compensate for poor farming practices on the adjacent field.

The use of heavy machinery in the headland and into the buffer zone may accelerate sedimentation. On the northwest branch of the Mill River, for example, trees and shrubs from field expansion were being pushed directly into a stream.

Disturbed headland on Mill River, 2018

Trees were dropped into the stream within the Mill River riparian zone, 2018

There was an urgency in the recommendation from the 1987 *Conservation Strategy for Prince Edward Island*: "We recommend a series of actions designed to alleviate the erosion problem … with a commitment to fund soil conservation at whatever level is necessary in order to get significant improvement*"*. Sadly, this recommendation remains as relevant and urgent today as it was three decades ago. Although several soil conservation and stewardship programs and incentives exist, this problem is far from solved. A renewed focus on proactive and precautionary regulation, policy, partnerships and incentives to address this problem is urgently needed.

Deep (12") sediment runoff from field in floodplain off Dunphy Road, June 2018

While some watersheds are impacted by runoff from multiple agricultural sources, other rivers may have one or two problematic areas that are contributing most of the sediment to a river system. Pinpointing these sources and working cooperatively to address them, as well as increased vigilance on new activities such as field expansion and land clearing, are required.

2.1.4. Highway Erosion

It was noted by some watershed groups that unpaved roads continue to be a significant source of sediment to aquatic systems. There are also areas where the highway ditch serves to direct sediment and pesticides from agricultural fields to a nearby stream. An enhanced program is needed to install sediment catchment basins in the ditches along unpaved roads, including a maintenance component to clean them as required. The addition of gravel or millings in sensitive areas can reduce the amount of erosion from road surfaces.

West River, 2009

The Department of Transportation, Infrastructure and Energy (DTIE) has improved its road construction practices in recent years. During the construction of the new highway alignment in Cornwall, DTIE sought input from the Central Queens Wildlife Federation (CQWF) and incorporated their suggestions into the bridge construction project on the Clyde River. The result was a greatly improved section of river for anadromous fish and the likelihood of better cooperation in future endeavors. There remains a need to strengthen communication between DTIE and watershed groups regarding road maintenance and construction.

2.2. Nutrients and Pesticides

2.2.1. Nutrients - Excess nutrients alter the productivity of freshwater systems in fundamental ways; increasing algal growth, reducing dissolved oxygen, and limiting biological diversity. The provincial government assessment of long-term (1960 to 2016) nitrate trends on PEI shows that nitrate concentrations have increased in each stream sampled and that overall, the streams which have a higher percentage of agriculture and land in potato production have the highest nitrate levels. The rate of increase was highest after the rapid expansion in potato production which occurred in the early 1990s. Results from the last 3-4 years indicate that seven out of the ten streams in this monitoring network are showing increasing nitrate trends while the other three streams have a recent trend that is not changing over time. The release of nutrients to the environment is an issue which extends outside of Prince Edward Island. A group of scientists and graduate students working on the Northumberland Strait (Northumberland Strait-Environmental Monitoring Partnership under the Canadian Water Network) estimated that ninety-five percent of the nitrates that are emptying into the Northumberland Strait are coming from this province, and of these, ninety-one percent are coming from the Island's agriculture industry (as reported in *The Guardian,* March 4, 2016).

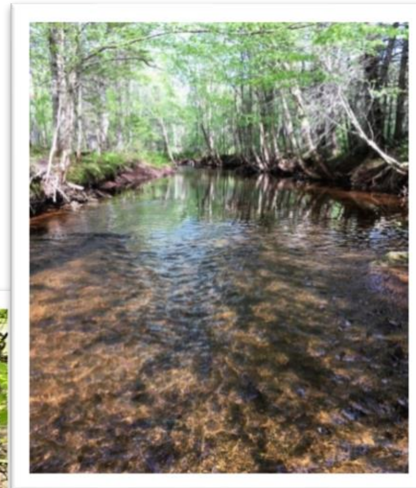
One of the most serious consequences of nutrient loading for Atlantic salmon and other fish is the frequent anoxic events in Island estuaries. North Shore estuaries are more prone to water quality problems because of their low tidal amplitude and limited flushing capacity. Even an estuary with little nutrient input, such as on the Midgell River, can have an anoxic event when low tidal flushing is combined with warm water temperatures. By contrast, there is rarely an anoxic event in the Wilmot River, in spite of 700 kilograms of nutrients going into it daily because the system has a high flush rate and low water temperatures (BBEMA pers. comm.).

2.2.2. Pesticide Related Fish Kills – There have been 29 recorded pesticide-related fish kills in PEI rivers since 2000. While fish kills are devastating for all aquatic life, they are particularly damaging to Atlantic salmon populations. The dead salmon collected in the 2000 fish kill on the Souris River, for example, were the last salmon observed in that river. The factors leading to these pesticide related fish kills are consistent: heavy rainfall, turbidity, and evidence of severe agricultural runoff. The agricultural community has been slow to adjust to the changing weather patterns and intensive rainfall events that are becoming more frequent with climate change.

Salmon parr collected after the 2014 fish kill in North River

Many of the pesticides linked to fish kills enter the river attached to soil particles. Improving soil health and reducing erosion are key to preventing future fish kills, along with use of lower toxicity products. It will require major changes in current agriculture practices for significant improvements to be realized. In the interim, immediate action must be taken to identify and protect sensitive areas. In Trout River (Coleman) for example, an action committee made up of farmers, watershed representatives, and government was established after three concurrent fish kills (2011-2013). Some of the actions taken to reduce the likelihood of future fish kills included the purchase of high-risk land, and use of subsidized lower toxicity fungicides during high risk periods.

2.3. Forest Cover and Riparian Zone Management



Mill River riparian zone, 2018

Loss of riparian habitat along streams, rivers, and estuaries is one of the most significant impacts on wild salmon survival. A good riparian zone can moderate water temperature, reduce sedimentation, enhance nutrient cycling, productivity and biodiversity of a stream, serve as a source of woody debris for cover, and stabilize banks.

Cross River riparian zone, 2018

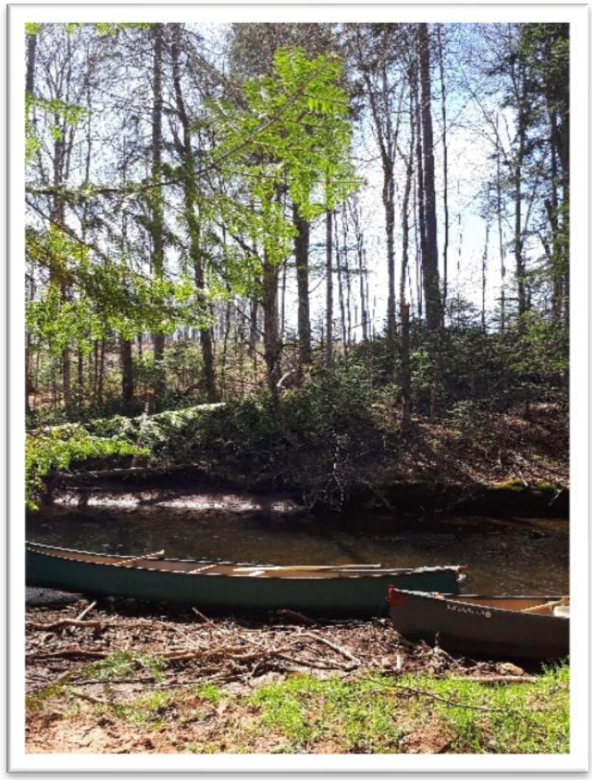
Dunk River off Walls Road, 2017 (photo courtesy of CQWF)

There appears to be a relationship between the amount of forested land in a watershed and the current status of Atlantic salmon. Heavily forested watersheds, especially in northeastern PEI, tend to have more robust salmon populations than those with less woodland. The 2000 Forest Inventory for PEI found that the total forested area had fallen from 48% in 1990 to 45% in 2000, and the 2010 State of the Forest Report found that the decline was continuing, with forest covering only 43.9 percent of the province. Our forests are also very different from the original Acadian forest, and are now heavily fragmented with small stands composed of young, small diameter trees, and softwood monocultures. Riparian zones with deciduous-dominated versus coniferous-dominated cover will function very differently in terms of water retention, temperature modulation, run-off and flashiness, and biodiversity.

The current 15 metre buffer has not been effective in reducing sedimentation, fish kills and anoxic events. In some cases, the buffer does not even extend to the top of the bank, for example in hilly regions of Prince Edward Island. To protect salmon bearing streams, a continuous riparian buffer of 60 metres is recommended as a long-term goal.

Immediate focus for riparian restoration should be planting of appropriate deciduous trees (yellow birch, red maple, sugar maple, red oak) rather than white spruce and fir as is currently a common practice (likely due to availability). This will require a shift in production of seedlings at the J. Frank Gaudet Tree Nursery. Planting should focus on quality, not quantity, of trees. Appropriate planting distances, protection from rodents and beaver, and ongoing maintenance are important to ensuring success of deciduous species. Training and updated guidance on planting may be needed.

Grasses, sedges and native shrubs in the floodplain are important for sediment control, juvenile cover, and nutrient flow. A deciduous canopy will allow these species to grow, while a dense coniferous canopy will not. In some cases, opening patches in the existing canopy may be needed to encourage a well-functioning floodplain.

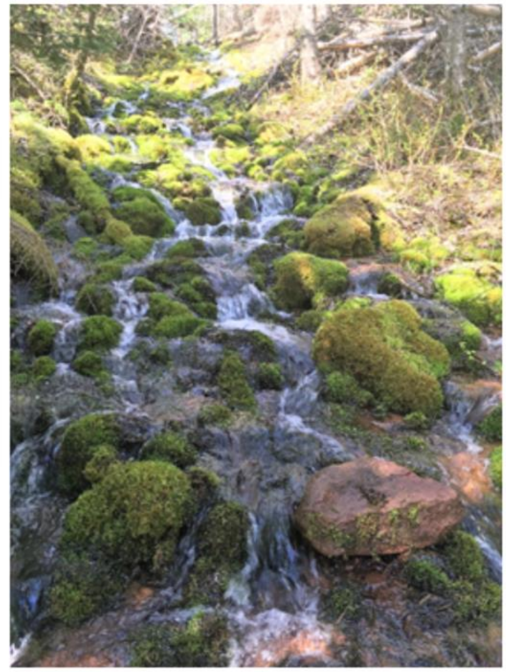


Cutting in the "Horseshoe" section of West River

Cross River, 2018

Consider multiple values in managing and restoring riparian zones. Bonshaw Park is an excellent example of the multiple uses and value of a forested watershed. Mill River could be similarly developed and could provide a key recreational draw for that area.

2.4. Inadequate Protection of Headwaters and Source Water



Spring on Naufrage River, 2018

Headwater streams play a fundamental role in maintaining the health and productivity of river systems (e.g., Freeman et al. 2007; Meyer et al. 2003) such as mitigating flooding, maintaining water quality and quantity, recycling nutrients, and providing critical habitat for a variety of plants and animals. The Genomics Laboratory at the Department of Fisheries and Oceans in Moncton are conducting research on salmon fry foraging and preliminary results indicate that headwater streams may be providing ideal food items for salmon fry. Smaller tributaries may also provide important refugia from extreme events in the main channel. Springs are essential to the quality and quantity of water in streams, and in maintaining the cold water temperatures on PEI that are preferred by salmonids.

Protection of first and second order tributaries in headwater streams is often overlooked and buffer zones in these areas may be narrow or non-existent. In some cases, it appears that headwaters and source waters may have been "channelized" as drainage ditches or grass waterways. It is recommended that buffer zone legislation and other protective measures are applied to headwaters, and that riparian restoration extend to these areas.

Emerging Areas: **Potential Limiting Factors Requiring Further Study**

2.5. Seal Predation

The importance of predation was highlighted in the 2015 report of the Minister's Advisory Committee on Atlantic salmon (Fisheries and Oceans Canada 2015*)*, especially in areas where salmon are concentrated at certain times in their life cycle in rivers and estuaries (for example during smolt migration or salmon spawning runs). While the 2015 report noted that seals, striped bass, sea birds and small mouth bass are all important predators of salmon, seals are of particular and increasing concern on Prince Edward Island. Harbour seals are known to congregate in estuaries and move well upstream into salmon rivers during salmon runs. Their potential impact on salmon is exacerbated by the decline in the abundance of other prey species such as gaspereau (*Alosa pseudoharengus)*, smelt (*Osmerus mordax)* and blueback herring (*Alosa aestivalis)* that were traditionally in rivers in large numbers and provided "prey cover" that reduced predation on salmon smolts in rivers and estuaries.

Further research is needed to address the impact of seal predation on PEI, for example, dietary analysis of seals in estuaries during critical spawning and smolt migration periods. It is also important to co-manage “prey cover” species by restoring and maintaining habitat and access for anadromous species like smelt and gaspereau.

2.6. Survival of Atlantic Salmon Fry

Identifying a salmon redd in Cross River. Photo: Souris and Area Branch of PEI Wildlife Federation

On Prince Edward Island, Atlantic salmon redd counts have been used to estimate salmon population levels by converting numbers of redds to numbers of female spawners and using an estimate of eggs deposited to determine whether or not a river has met its conservation requirements (Cairns and MacFarlane 2015). However, this calculation does not account for the success or failure of the redds. Electrofishing surveys completed in an area of spawning in the following year can provide an indication of success, as young-of-the-year (YOY) salmon do not move far from where they have hatched out. In 2018, no YOY salmon were counted at four sampling locations on Priest Pond Creek despite there being 150 salmon redds counted in the spawning survey the previous fall. Additional stream areas were spot checked in an attempt to find these first year salmon, with no success. This absence of YOYs in survey locations, despite strong redd counts the previous autumn, has been documented on at least two other occasions in this river.

Loss of an entire age class, especially the critical 0+ age class, could be catastrophic to the viability of a local salmon population and further study is needed to pinpoint the possible causes of such a failure. Cunjak et al. (1998) emphasized the importance of winter conditions on over-wintering success of juvenile salmon. An additional factor may involve the relationship between water temperature and initiation of feeding in this vulnerable life stage. In hatchery environments it has been shown that salmon fry require a temperature of at least 12°C to initiate viable feeding. Timing is critical because salmon fry have a limited amount of time after absorption of the yolk sac to forage successfully on their own. Certain watershed characteristics in the area of spawning could contribute to reduced water temperatures at this critical time. The presence of second year salmon in Priest Pond Creek, following a year with no YOYs observed, would suggest that there are pockets of stream where fry are successfully produced. Cow Creek, Bear River and Hay River have also had fewer juveniles than would be expected from the redds present and the lack of notable sediment inputs. A thorough discussion of this phenomenon, its implications, and suggested recommendations are included in Appendix I. Research is needed to pinpoint the cause of fluctuating fry success in particular rivers and its impacts on the salmon populations.

2.7. Climate Change

Changes in timing and intensity of precipitation, increased flooding, water temperature shifts, increased coastal and stream bank erosion, sedimentation, and changes in vegetation are all attributable to climate change and create new challenges for Atlantic salmon recovery. This is a broad area and cannot be addressed in any detail in this report, although it is woven throughout many sections of the report.

Clyde River, April 2017 (photo courtesy of CQWF)

The characteristics of a river are important in building the resilience needed to absorb impacts. For example, flooding will result in increased sedimentation in a stream but diverse and well-connected floodplains can help remove sediment from watercourses. Natural, unobstructed watercourses are more resistant to bank erosion that will occur during flood events.

Greenbay culvert on West River during flood, 2014

Agricultural impacts are also likely to intensify as a result of climate change. In two recent fish kills, extreme runoff events were blamed on climate change, although the inability of the agricultural sector to adapt to climate change – using current farming practices - may be the bigger issue. It is also expected that there will be increased winter rain events with significant consequences for accelerated runoff over exposed soil and consequent sedimentation of watercourses.

Extreme weather events and coastal erosion could also impact access to sea in vulnerable coastal areas. The November 2018 storm surge is an example of the intensity of storm surges. Coastal access points for salmon may have highly exposed access channels, or near-shore berms or dams that may be particularly at risk.

Exposed coastal zone at the exit of Priest Pond Creek

Extreme weather events may become more frequent and will necessitate an integrated strategy addressing vulnerable points in the system e.g., areas sensitive to increased runoff from agriculture and roads, resilience of the river to flooding or temperature extremes (e.g. functional floodplains and riparian zones); and an assessment of the adequacy of fish passages, roads, culverts and bridges to withstand the expected increases in storm events and flooding. The task is daunting, and will first require awareness, followed by sustained effort involving government, ENGOs and experts to find solutions.

SECTION 3. KEY HABITAT FACTORS FOR ATLANTIC SALMON

To be successful, strategies for Atlantic salmon habitat restoration must consider habitat requirements for all life stages in each season. The following section addresses key habitat variables that are considered crucial in restoring salmon runs to Prince Edward Island. The significance of each factor will vary among rivers, however all should be included in any Atlantic salmon management plan. This section identifies key habitat factors for Atlantic salmon and makes general recommendations; we refer groups to the *Technical Manual for Watershed Management on Prince Edward Island* for specific habitat restoration techniques (Harris et al. 2012).

3.1. Habitat Quality

3.1.1. Adult Atlantic salmon

Salmon entering a river require holding areas as they move upstream and select a spawning location. While deep pools are preferred, salmon also find shelter under undercut banks and large woody material. It is important to have a good mix of cover suitable for these large fish. The highest concentration of redds tend to be associated with pools, with spawning taking place at the head and tail of a pool. The wooden cribs installed in North Lake in the mid-1990s, for example, provided excellent spawning habitat and salmon redds are counted in the same locations each year. It should be noted that sections of river downstream from a dam tend to have high densities of juvenile salmon (e.g., Leards Pond on Morell River and Quigleys Pond on St. Peters River), possibly because of the reduced sediment below the dam. Once spawning is completed, salmon spend the winter in pools and ponds.

The nature of the substrate is a major determining factor in whether the redd is successful in producing salmon fry. Atlantic salmon select for a good mixture of gravel and cobble and it needs to be of suitable depth to allow the redd to be thoroughly excavated and eggs covered. Salmon will spawn in substrate that is flat and angular, but the flow of water through the redd may not be as suitable as in rock that is more rounded. Also, if hard pan is close to the surface, sufficient depth may not be obtained. In some rivers, the streambed is so embedded, it resembles cement. Salmon have difficulty excavating this material and the success of the redd would be reduced. Some watershed groups have experienced success in raking existing gravel and cobble beds in known salmon spawning locations, as well as adding granite cobble. This was shown to be effective in the West River in resisting washout under extreme flood conditions. An increase in juvenile salmon density was observed after adding heavier granite cobble in spawning locations.

Recommendations

- The transition area for salmon entering freshwater should be assessed and any blockages or impediments in this zone should be addressed.
- If a river is lacking pools, they can be added using proven pool restoration techniques (refer to Technical Manual for Watershed Management on PEI).
- Raking of gravel-cobble beds is labour intensive but can prove effective if used in specific salmon spawning locations. Addition of granite gravel and cobble can also be used to improve spawning success.

3.1.2. Juvenile Atlantic salmon

While adult salmon use freshwater habitat for a short period of time - entering the river in autumn and leaving in early spring - juvenile salmon in Prince Edward Island rivers spend two years in freshwater. Their habitat requirements change dramatically as they progress through various life stages but the principle habitat factor for juvenile Atlantic salmon is substrate.

3.1.2.1. Substrate

St. Peters River, 2018

Atlantic salmon on PEI are generally associated with cobble substrate (e.g., Roloson et al. 2018). As well, salmon redd quality is determined by the type of substrate located in spawning locations, with coarse, non-embedded substrate directly related to density of young salmon. During the early stages of life, juvenile Atlantic salmon are territorial and are closely associated with the substratum, holding position against the current in the rocks and cobble (aided by their large pectoral fins). The size of the substrate preferred by juvenile salmon differs with life stage. Salmon fry were seen "burrowed" into smaller gravel during the 2018 electrofishing survey. Two salmon fry were inadvertently crushed while walking in the survey site. Second year salmon are found in river reaches where larger cobble provides cover in interstitial spaces. Juvenile salmon may also move into the substrate when water temperatures are at winter lows, most likely to come in contact with warmer groundwater (Heggenes 1990, Wimmer et al. 1984); however, winter survival may be affected by a number of environmental factors that affect habitat availability (e.g., Cunjak et al. 1998). Salmon fry are found in close in proximity to the redds in which they hatched, but second year parr can move considerable distances to find suitable habitat.

Field assessments in 2018 found that the highest density of juvenile salmon, especially for salmon fry, was in well sorted, unembedded, rounded gravel-cobble substrate with adequate interstitial spaces to provide cover. These characteristics are evident in the sample taken from North Lake Creek (right). At this site, high densities of juveniles were found in very shallow water that barely covered the substrate, occupying the interstitial spaces in the gravel. Flatter stones may not provide interstitial spaces for juvenile salmon unless manually manipulated. Several watershed groups have raked existing embedded gravel-cobble substrate or have added cobble to streams to improve salmon habitat.

Gravel-cobble substrate taken from North Lake Creek, 2018

Recommendations

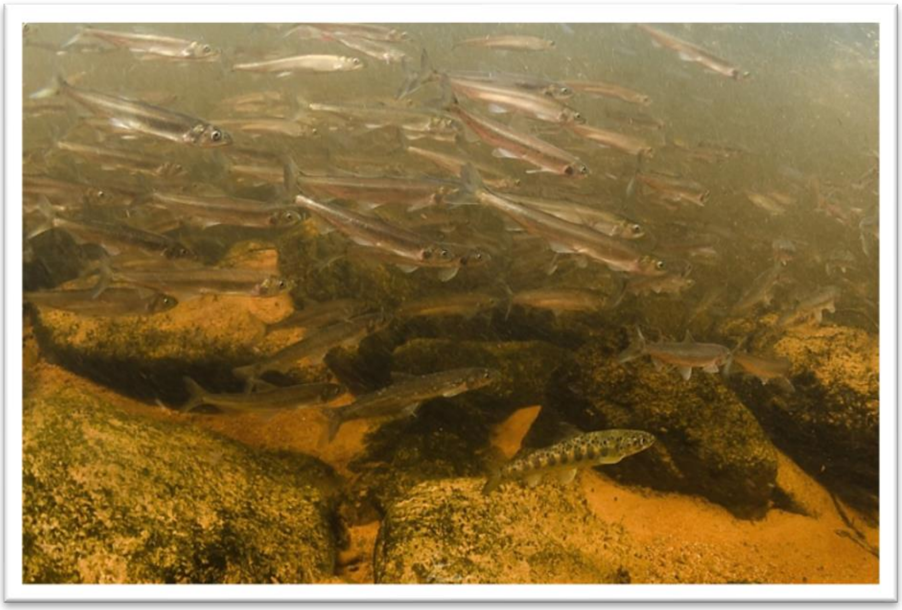
- Where suitable gravel-cobble substrate is embedded, raking the stream bottom in late summer can improve juvenile salmon habitat until sedimentation issues are resolved.
- Addition of a mixture of granite gravel and cobble in suitable locations can improve juvenile salmon habitat in rivers with poor quality substrate.
- Crews accessing a site on a regular basis should walk along trails rather than through the stream itself. Many feet walking over gravel beds has potential to kill a large number of juvenile salmon, particularly in sensitive areas where salmon are known to spawn.

Cobble added to stream bottom in Trout River (Coleman)

3.1.2.2. Other cover

While rocky substrate is of primary importance for juvenile Atlantic salmon, they also use several other types of cover such as medium to large woody debris (LWD) and submergent and emergent vegetation. Floodplain vegetation, such as dense sedges and grasses, could potentially also provide important cover in high water or flood conditions. Predator avoidance is a major function of cover for juvenile salmon. On PEI, all rivers with Atlantic salmon also have trout populations that can be found in similar stream reaches. During their first year, Atlantic salmon can become prey for larger brook and rainbow trout, and they seek shelter in shallow water and vegetation along stream edges or within rooted instream vegetation. Larger parr tend to be in cobble and under banks and woody material.

When smolts leave the river and swim toward the ocean, they encounter a wide variety of predators. Fortunately, there are a variety of fish species in the estuary for predators like seals and cormorants to eat. "Prey cover" refers to the "safety in numbers" effect of the salmon smolts migrating to salt water at the same time as large numbers of blueback herring, gaspereau and smelts are in the estuary. Recent smolt tagging studies in North Lake Creek (see text box) indicate that smolts are quite successful in traveling through the estuary. The abundance of smelts in the North Lake Creek estuary at the time of the smolt exodus may have been a factor in the high survival rate.



A salmon parr is sheltered by a school of smelts in Pisquid River. Photo: Sean Landsman Photography

Recommendations

- Co-manage "prey cover" species by restoring and maintaining habitat and access for these species. A key part of this management is the removal of blockages affecting prey cover species on all watercourses, big and small, which drain into an estuary used by Atlantic salmon.

Smolt Tagging Study in North Lake Creek

From 2016-2018 a salmon smolt tagging study was conducted in North Lake Creek. In 2016, which had the most accurate total smolt count, 1876 smolts were captured heading downstream. A total of 106 salmon smolts were tagged over the three years. Smolts were tracked throughout North Lake and on Ocean Tracking Network (OTN) receivers at the exit points of Cabot Strait and the Strait of Belle Isle (SOBI). Survival to exit of North Lake ranged from 71-95%, and information from 2016 OTN records indicated survival to Strait of Belle Isle was between 40-50%. A surprising observation was the detection of North Lake smolts travelling northward, along the Cabot Strait receiver array. These fish appeared to be hugging the coastline of Cape Breton in their northward migration, and ultimately crossing the Strait of Belle Isle, this information suggests a possible migratory corridor used by North Lake smolts. Departure from North Lake (in 2016) ranged from May 18 - June 13 and arrival at SOBI ranged from July 11 - July 18. Upon complete analysis, the information gathered will be compiled into a peer reviewed journal article. The success of the study was thanks to many contributing partners including Abegweit Conservation Society, Souris Area Branch of PEI Wildlife Federation, Canadian Rivers Institute (UPEI), Atlantic Salmon Conservation Foundation, Atlantic Salmon Federation and the PEI Wildlife Conservation Fund.

Scott Roloson, U.P.E.I.

3.2. Habitat Connectivity

For a species that migrates between fresh and salt water during its life cycle, maintaining access to and between critical habitats is a fundamental determinant of success. When salmon are transitioning from salt to fresh water, it is beneficial to have a long estuary with deep holding pools. Examples of holding areas at or near the head of tide include estuarine pools in the Naufrage River, the TransCanada Highway pool and Crosbys Pond on the West River, and constructed pools in the former Getsons mill pond in Trout River. Other rivers, such as Cow River and Bear River, have an abrupt exit at the shore. With storm events and coastal erosion, such rivers may fan out over a wide swath of beach and Atlantic salmon may have to wait for a very high tide to readily ascend and could experience difficulty attempting passage.

Once in fresh water, salmon encounter natural and man-made obstacles that may prevent them from reaching spawning habitat. The 2017 redd survey found that the first major beaver dam often marked the upper limit of spawning. Connectivity has spatial, seasonal, and life stage dimensions. Put simply, salmon will use different parts of the river at different ages and at different times of the year. For example, delays caused by blockages to downstream passage would impact the successful recruitment of smolts to the marine environment in the spring, while limiting upstream passage for spawning adults later in the year; pointing to the need to check for blockages prior to both the smolt migration and the adult spawning period. The impact also depends greatly on location. Head of tide dams that block the connection between estuary and freshwater and/or access from open sea to coastal ponds are considered a major barrier to successful salmonid runs (ASE Consulting and UPEI 1997).

Removing blockages to salmon access on PEI rivers was a major focus of the 2009 Atlantic Salmon Conservation Strategy and more background on the issue can be found in that report. Since then, a great deal of progress has been made by local watershed groups in clearing beaver dams and other instream blockages, installing fish ladders, and repairing or improving the design of culverts. However, significant issues with connectivity remain.

While many kinds of blockages can occur, beaver dams continue to be one of the most important impediments to Atlantic salmon in many Island streams. Under ideal conditions, salmon can jump as high as 4 metres but a beaver dam, with its lack of defined waterfall and pool, does not provide the right hydraulic lift necessary for salmon to jump. Salmon can negotiate around some dams or work their way through others, but some dams are impassible, especially under low water conditions. This is particularly serious if the dam is located at the head of tide, as was the case in Bear River in 2018. While most people associated dams with blocking the spawning run, a beaver dam can also block downstream movement of smolts, depending upon stream flow conditions in spring. Kelts and smolts were observed holding within a beaver impoundment on the west branch of the Morell River in the mid-1990s (Guignion pers. comm.).

Bear River beaver dam, 2018

In some rivers, where beaver numbers and dams are carefully managed, salmonids and beavers can co-exist. It is when multiple beaver dams lead to long term changes to riparian zones, stream flow and substrate, and water temperature that serious impacts occur on cold water fishes like Atlantic salmon. The Marie River, for example, has lost its run of Atlantic salmon due to the combination of man-made and beaver impoundments, and a large percentage of the Midgell River is currently unsuitable for salmon.

Recommendations

- To effectively assess and manage blockages, a connectivity assessment and completion of a beaver management strategy should be part of a salmon habitat management plan for all salmon bearing streams. The assessment should look at the impact of blockages throughout the salmon's lifecycle, and from headwaters to the sea.
- Ongoing management of beaver populations is needed to maintain salmon habitat. Beaver dams should be assessed seasonally and especially prior to critical migration and spawning periods. Despite the enormous effort involved, ongoing persistence is needed to ensure that annual or seasonal loss of connectivity does not negate years of hard work. Beavers can re-build or move into an area quickly, even after dams were cleared a few weeks prior.
- In some streams, leaving a "sill" at a beaver dam site may assist in warming water temperatures in spring and could provide benefits to salmon fry (see Section 2.6).

3.3. Water Temperature

Water temperature is a key factor controlling vital activities of Atlantic salmon at all life stages. In general, salmonids thrive in the relatively cold, spring-fed waters of PEI. It is when a low gradient river becomes impounded that water temperatures can warm to levels that are inhospitable to cold water fish like Atlantic salmon and brook trout. For example, ASE Consulting and UPEI (1997) found that water temperature in low relief streams with multiple beaver or man-made impoundments often exceeds optimum water levels for salmonids. Although Atlantic salmon are known to tolerate higher temperatures than brook trout (juvenile salmon may tolerate temperatures of 27.8°C), the optimal temperature range for Atlantic salmon productivity would be well below this (e.g., DFO 2012). However, in a river with cold water temperatures, such as the West River that rarely exceeds 13°C in summer, warmer water may be beneficial for salmon.

The importance of colder temperatures as a limiting factor Atlantic salmon is not well understood for PEI rivers. Cold water temperatures in spring that could limit survival of emerging salmon fry is a potential limiting factor that requires additional study (Section 2.6).

Recommendations

- Research is needed to assess the impact of cold water temperatures on salmon fry
- Water temperature monitoring should be done on warm rivers and a management strategy developed to identify options available to improve conditions.

3.4. Food Availability

In "Worldwide decline of the entomofauna: A review of its drivers", Sanchez-Bayo and Wyckhuys (2019) state that over 40% of the world's insect species are threatened with extinction. According to this study, four major aquatic taxa (Odonata, Plecoptera, Trichoptera and Ephemeroptera) are described as having already lost a considerable proportion of species. The primary drivers of species decline, listed in order of importance, are described as: i) habitat loss and conversion to intensive agriculture and urbanization; ii) pollution, mainly that by synthetic pesticides and fertilisers; iii) biological factors, including pathogens and introduced species; and iv) climate change." As well, they conclude that agricultural practices need to change, "in particular a serious reduction in pesticide usage and its substitution with more sustainable, ecologically-based practices, is urgently needed to slow or reverse current trends, allow the recovery of declining insect populations and safeguard the vital ecosystem services they provide. In addition, effective remediation technologies should be applied to clean polluted waters in both agricultural and urban environments."

Biological Conservation. Volume 232, April 2019, Pages 8-27.

The quality and quantity of preferred dietary items has obvious consequences for Atlantic salmon juveniles. It is generally thought that preferred dietary items for juvenile Atlantic salmon are macrobenthic invertebrates, e.g., stonefly or mayfly larvae, and these are often considered an indicator of ideal water and habitat quality. Salmon fry, once their yolk sacs are depleted, are likely to feed on smaller organisms such as zooplankton. The Department of Fisheries and Oceans Genomics Laboratory in Moncton NB have been using sequencing analyses of DNA from Atlantic salmon parr feces to assess their diet (Appendix II). Early results indicate that headwater streams like the upper reaches of the Brookvale branch in West River seem to produce a perfect match of food items for juvenile salmon, likely resulting in better survival.

Recommendations

- Research on the diet of juvenile Atlantic salmon will be important to understanding food availability in various river reaches, and should assist in planning restoration activities in the future.

3.5. Habitat Availability

For many rivers, salmon population growth is limited by habitat availability, either due to a barrier to access or the need to enhance habitat for various life stages. For example, the Morell and Midgell Rivers are maintaining runs of Atlantic salmon but at a level lower than one would expect for such large systems. It may be assumed that salmon spawning is occurring in certain areas because these sites present ideal habitat. However, a blockage up river could be the reason why salmon are currently spawning in a location, and not because it is ideal habitat. Ideally, salmon spawning areas should be distributed throughout the watershed. Salmon populations will suffer if they are restricted to spawning in poor quality habitat or in a limited amount of good quality habitat. Even the highest quality section of river can only support a certain number of juveniles.

Habitat availability in nearby rivers is also important and a key reason why we treat our assessment as "clusters" of rivers rather than isolated rivers. Rivers adjacent to salmon streams can serve as alternate sites for salmon when conditions in nearby rivers are unfavorable, for example a blockage near the head of tide.

Recommendations

- In many of PEI's salmon rivers, salmon are restricted to a short distance of stream and additional upstream habitat would need to be made accessible and restored if the population is to increase.
- Management plans for salmon rivers should include an identification of areas which would historically have been used by salmon and could be restored to productive salmon habitat.
- Salmon rivers should be managed as "clusters" and suitable habitat maintained in adjacent rivers, even where salmon are not currently present.

3.6. Competition

Some of the salmon rivers on PEI have brook trout and rainbow trout, as well as Atlantic salmon. While brook trout and salmon both spawn in late autumn, rainbow trout spawn in April. On the West River, rainbow trout have been observed to excavate their redds on top of Atlantic salmon spawning sites from the previous fall. Rainbow trout were once only found in south side rivers of the Island but are now established in three northside rivers, and it appears as though the range of rainbow trout is moving eastward. Rainbow trout are known to be aggressive and fast growing and their impacts on salmon in PEI streams is not fully understood. Recent studies in PEI suggest that because of habitat separation between the three salmonid species, the impacts of rainbow trout may not be the most significant threat to native salmonid populations (Roloson et al. 2018). A fourth salmonid, brown trout, is now more frequently caught by anglers in PEI and may also be expanding its range.

Brown trout from Clyde River, September 2018

3.7. Impoundments

While dams block access for salmon, the impoundments they create can have far reaching effects (ASE Consulting and UPEI 1997). One of the most significant impacts for salmonids is the warming effect on downstream waters. This is especially important in watersheds such as the Morell where numerous impoundments flood low relief land, changing the temperature regime for the river. The impact is particularly noticeable for brook trout. Normally, good numbers of brook trout are found during electrofishing surveys. In those sites prone to excessively warm summer water temperatures, very few trout (and in one site, zero trout) were found, even though surveys were carried out long after water temperatures had reduced to acceptable levels.

There are many different ways to manage an impoundment for fish and wildlife, depending on the river and the management objectives. Options may include, but are not limited to: seasonal or regular draw downs, bottom draw to improve water temperatures, operating at a lower level, altering the fish passage structure, maintaining the status quo, or decommissioning.

Leards Pond, Trout River, 2018

Recommendations

- River management plans for Atlantic salmon should include an impoundment management strategy.

SECTION 4. 2018 ELECTROFISHING SURVEY

The density of juvenile salmonids in a particular section of river can be estimated using standard electrofishing techniques. While there are a number of variables which can influence the results of an electrofishing survey (e.g. water temperature, timing, crew efficiency, site selection), this technique is an acceptable means of obtaining a general comparison of fish densities between sections of river or between different watercourses and can serve as an index to monitor changes over time. The methodology is described in Section 1.2.2.

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Electrofishing field season, 2018

Sampling results for brook trout, rainbow trout and Atlantic salmon are summarized in Table 1. Spot checks were conducted for Cains Brook, Bradshaw River, Head of the Hillsborough River and the Miminegash River. Results for these rivers are included in Section 5.

Raw data, including data for other incidental catches (brown bullhead, American eel, gaspereau), and site conditions are available in an excel spreadsheet upon request.

Table 1. Salmonid density from 2018 electrofishing survey and 2017 Atlantic salmon redds (from Oak Meadows 2018).

	Location			Water	Density (#fish/100m^2)			# AS[1]		# AS Redds
Date	Latitude	Longitude	River - Site	Temp (˚C)	BT	RT	AS	YOY	1+	2017
Cluster 1										
4-Sep	46.69618	-64.16902	Trout River - Bannys	16.4	67.2	0	**49.6**	52	33	41
4-Sep	46.74329	-64.18587	Mill - Bloomfield Pk	16.2	96.3	0	**57.9**	18	56	119
5-Sep	46.72577	-64.24599	Mill - Howlan	13.2	59.9	0	**13.1**	10	25	
Cluster 2										
1-Oct	46.49628	-63.96713	Little Trout - lower	10.1	38.0	0	**5**	0	10	20
2-Oct	46.50096	-63.98859	Little Trout - Richmond	10.5	51.9	0	**9.2**	0	8	
1-Oct	46.57627	-63.93079	Trout River - Bank Bk	10.2	102.7	0	**0**	0	0	4
6-Sep	46.56922	-63.93103	Trout River - Allen Rd	15.6	22.3	0	**0**	0	0	
Cluster 3										
11-Sep	46.35529	-63.56575	Dunk - Greenan Rd	9.7	48	58.5	**0**	0	0	78
11-Sep	46.35437	-63.49201	Dunk - Dixon Rd	9.7	25.6	39.7	**0**	0	0	
12-Sep	46.39397	-63.66142	Wilmot - Cairns Rd	12.4	44.1	62.6	**0.4**	0	1	6
12-Sep	46.40003	-63.62919	Wilmot - Kelvin Grove	14.5	52.5	34.3	**0**	0	0	
Cluster 4										
20-Aug	46.23043	-63.34079	West - Howells Riverdale	9.8	61.7	6.1	**2.2**	1	3	149
20-Aug	46.24498	-63.31966	West - Howells Wynn Rd	10.2	29.3	10.2	**0**	0	0	
21-Aug	46.23427	-63.33414	West - MacDonalds	9.4	38.2	42.8	**0.5**	0	1	
21-Aug	46.26124	-63.32212	West - Quinn Rd	9.4	38.1	5.2	**0**	0	0	
22-Aug	46.27752	-63.38892	West - Main above Skye	9.4	52.1	13.6	**3**	0	8	
22-Aug	46.27816	-63.38834	West - Skye Bk	10.4	40.5	22.6	**0**	0	0	
23-Aug	46.28518	-63.3481	West - Carraghers	12	12.2	89.4	**0**	0	0	
23-Aug	46.28655	-63.41087	West - Curleys	12.1	74.7	6.2	**7.3**	5	8	
29-Aug	46.27241	-63.37988	West - Cudmores	12.5	45.5	27.9	**2.4**	0	5	
29-Aug	46.23006	-63.34892	West - Bolger Park Rd	14.1	33.7	46.6	**18.4**	24	6	
31-Aug	46.24328	-63.26639	Clyde - Bannockburn Rd	9.7	37.9	64	**0**	0	0	0
25-Sep	46.30133	-63.20141	North - Springvale Rte 2	5.3	87.6	22.5	**0**	0	0	8
25-Sep	46.30029	-63.23749	North - Loyalist Rd	6.8	48.6	1.4	**0**	0	0	
Cluster 5										
4-Oct	46.21358	-62.80499	Vernon- MacMillans	11.5	7.1	0	**40**	49	7	17
4-Oct	46.20139	-62.82316	Vernon- Glencoe Rd	12	38.6	10.5	**10**	4	17	

Table 1 continued

	Location				Density (#fish/100m^2)			#AS[1]		
Date	Latitude	Longitude	River-Site	Water temp. (^{0}C)	BT	RT	**AS**	YOY	1+	# AS Redds 2017
Cluster 6										
5-Oct	46.32382	-62.87869	Clarks Ck	11.8	23	6.7	**0.7**	0	1	4
5-Oct	46.32217	-62.87966	Clarks Ck - Cape B Rd	12.7	4.9	2.4	**7.3**	0	9	
5-Oct	46.30384	-62.8253	Pisquid - East Branch	10.8	62.1	16.6	**7.5**	0	9	28
5-Oct	46.30886	-62.83025	Pisquid - Main Branch	11.8	19.8	10.9	**4**	1	3	
Cluster 7										
2-Oct	46.40014	-62.75139	Bristol Creek	6.5	28.7	0	**0**	0	0	8
2-Oct	46.40657	-62.5465	St. Peters - Mill Rd	9.3	3.2	0	**51**	4	59	19
9-Oct	46.26949	-62.71614	Morell - South Branch	8.2	9.2	0	**19.9**	7	19	
9-Oct	46.29695	-62.74754	Morell - West Branch	8.7	16.8	0	**3.6**	0	7	191
9-Oct	46.3087	-62.69152	Morell - East Branch	8.7	5.4	0	**21.4**	30	33	
10-Oct	46.31596	-62.5941	Midgell - Elm Rd	10.6	15	0	**0.6**	1	0	104
10-Oct	46.36024	-62.59372	Midgell - P MacDonald	11.3	1	0	**22.9**	37	9	
Cluster 8										
17-Sep	46.45623	-62.45422	Cow	11.9	32.9	0	**0**	0	0	38
18-Sep	46.45438	-62.37932	Bear	14.4	40.3	0	**0**	0	0	7
18-Sep	46.4488	-62.42432	Naufrage	17.3	6.7	0	**1**	0	2	89
20-Sep	46.45687	-62.36617	Hay	9.7	68.6	0	**8.9**	8	5	15
Cluster 9										
20-Sep	46.45296	-62.2704	Cross	10.8	11	0	**49**	32	17	192
21-Sep	46.47155	-62.19481	Priest PC - Main	7.4	81.9	0	**5.5**	0	6	150
21-Sep	46.47127	-62.19458	Priest PC - Southwest	7.6	77.2	0	**6.1**	0	5	
21-Sep	46.46838	-62.21238	Priest PC - Bull Creek	8.2	42.7	0	**15.8**	0	20	
21-Sep	46.43498	-62.2177	Priest PC - Dixons Dam	12.2	*					
17-Sep	46.42723	-62.1599	North Lake Ck	13	32	0	**134.7**	148	29	213
24-Sep	46.45522	-62.09015	Mill Creek	8.5	148	0	**1.3**	0	1	10

*incomplete; BT – brook trout; RT – rainbow trout; AS – Atlantic salmon
1- #AS refers to Atlantic salmon in the YOY (young-of-the-year) and 1+ age classes.

SECTION 5. RIVER-SPECIFIC ASSESSMENTS

CLUSTER 1. Mill River (Carruthers), Cains Brook, Trout River (Coleman)

Table 1.1. Juvenile salmonid density (number fish/100m^2) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for Trout River, Mill River and Cains Brook.

Site	AS density	AS size range (cm)	BT density	RT density	*Water temperature (^{0}C)	AS redd count (2017)
Trout River	49.6	4.7-12.1	67.2	0	16.4	41
Mill River upstream from Bloomfield Park	57.9	6.3-12.8	96.3	0	16.2	119
Mill River at Howlan Road	13.1	5.5-12.4	59.9	0	13.2	
Cains Brook	Yes	4 YOY; 8 1+	Yes	No	6.1	75

*water temperature taken at time of 2018 electrofishing survey
AS – Atlantic salmon; BT – brook trout; RT – rainbow trout; Yes/No – present/absent in spot check

This cluster encompasses the principal salmon streams in Prince County - Mill River, Cains Brook, and Trout River (Coleman), all of which flow into Cascumpec Bay. Despite decades of restoration work, intensification of potato production poses a significant threat to the health of these rivers. The provincial water quality report card rates both the Mill and Trout Rivers as having poor water quality due to fish kills, anoxic events, frequent sediment run-off events, and high nitrate levels. The Trout River experienced three fish kills in 2011 to 2013 and the Mill River had fish kills in 2011 and 2013.

Despite these threats to this cluster, there is room for optimism. There have been some major efforts to address agricultural impacts, such as the purchase of sensitive agricultural lands along the Trout River and excellent riparian habitat remains in some sections of river. These rivers are among the best trout rivers in the province.

1.1. Mill River (Carruthers Brook)

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed – 50-60% forested with the balance in agriculture.
- Forest composition in 60 metre buffer – 47.3% mixed hardwood, 19% softwood and the balance non-treed.
- Riparian buffer –30 metre to 40 metre treed riparian buffer (with yellow birch, maple) and well-developed vegetated floodplain. The Howlan Road electrofishing site is restricted by the abutting road with a very narrow riparian buffer in parts.

Instream

- Canopy cover up to 75% except at road crossings.
- Water quality - Nitrate concentration is in the moderate to high range for PEI; anoxic events have been reported in the Mill River estuary and/or its tributaries in each of the last 5 years and 2 fish kills related to run-off have been documented in the watershed in the last 10 years (2011 and 2013); sediment laden run-off events occur very frequently in the watershed *(PEI Communities, Land and Environment, Water Quality Report Card).*
- Good gravel-cobble substrate; ample springs; large woody debris (LWD); sedimentation evident in areas with some embedding; minimal blockages (although some fallen trees could create future blockages). *Note - although composition is not known, the cobble has good, granite-like (hard) characteristics.*
- There is good estuarine access.

Table 1.1.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Mill River.

Atlantic salmon density				**Atlantic salmon redds[1]**	
year	Howlan Road crossing	Upstream from Bloomfield Park	Forestview	**year**	**number**
2018[2]	**13.1**	**57.9**	n/a	2008	(152)
2002[4]	n/a	318.0	n/a	2011	294
2007[4]	n/a	n/a	162.8	2012	131
2008[4]	162.2	n/a	78.4	2013	(98)
2017[3]	n/a	35	n/a	2015	(103)
				2016	94
				2017	119

1- Oak Meadows (2018); **2**- 2018 electrofishing survey; **3**- Forests, Fish and Wildlife ; **4**- Guignion and Oak Meadows (2009); ( ) incomplete count

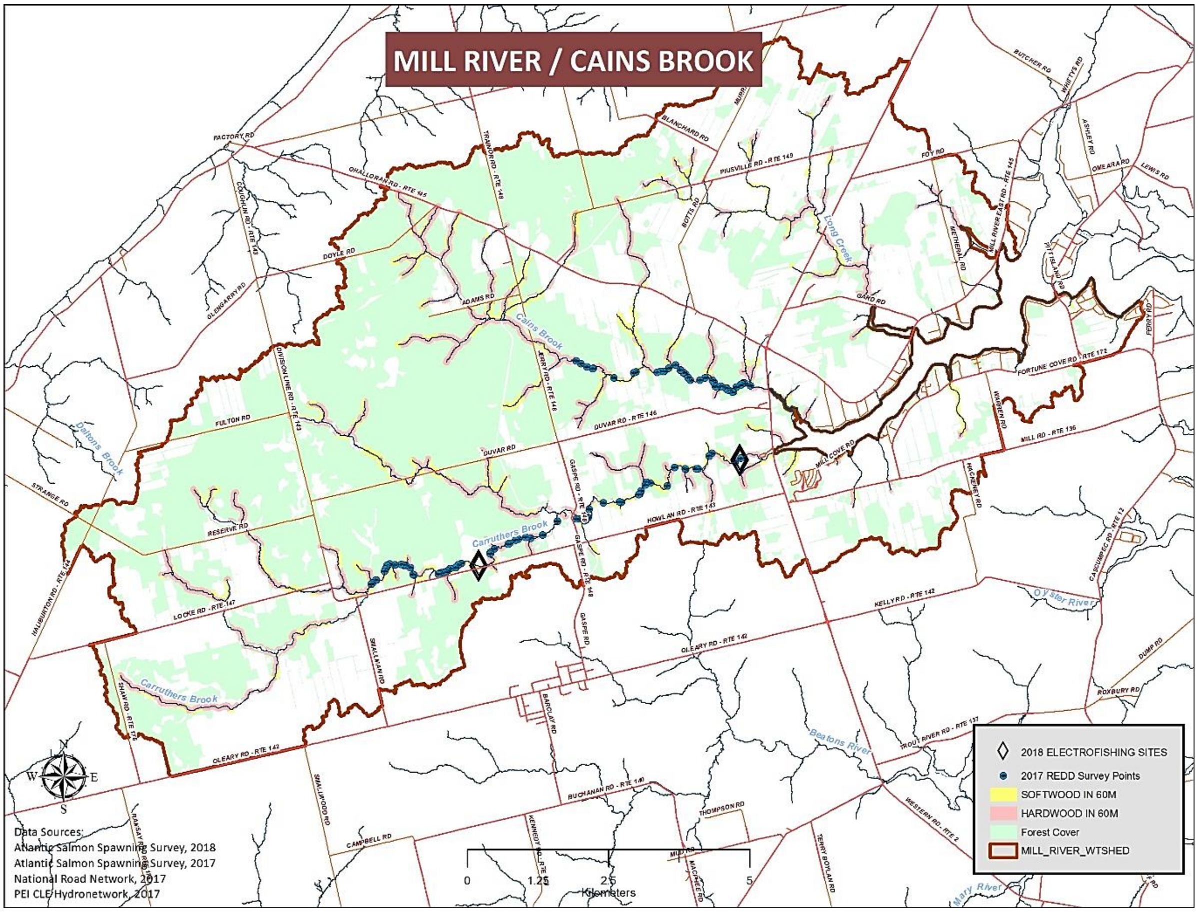


Figure 1.1. Mill River watershed showing location of 2018 electrofishing sites and 2017 redds

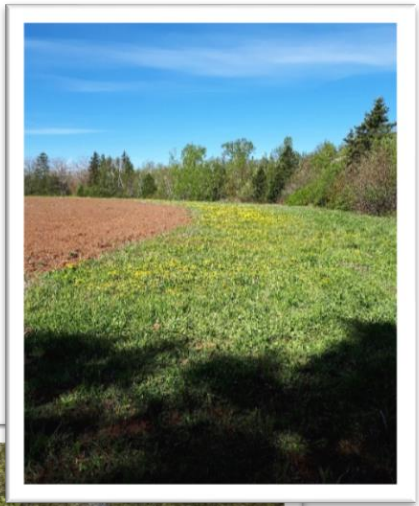
Status – Atlantic salmon redd numbers have been stable over the past decade and are well distributed in upstream reaches. Although the limited number of electrofishing surveys make it difficult to establish trends, the density of juvenile salmon appears to have declined from 2002 /2008 levels. However, the density is still relatively high for PEI salmon streams, and both YOY and 1+ age classes were represented in the 2018 survey.

Potential - With good estuarine access, a well-developed, treed riparian zone, excellent spawning habitat, numerous springs, and moderate water temperature - this river has a high potential for Atlantic salmon if agricultural impacts can be adequately addressed.

Management Issues and Recommendations

Upstream from Bloomfield Park between Western and Howlan Roads there are several points of soil runoff from abutting fields, sometimes combining with water flowing from natural springs. Although the well-developed floodplain in this area helps minimize the direct impact to the river, care should be taken to identify and manage these sources of excess sediment to maintain the high-quality spawning habitat that exists in this zone. There are excellent examples of well managed and protective headlands in the area that could serve as a model for headland management.

Grass headland on Mill River, 2018



A spring carries sediment to Mill River, 2018

Disturbed headland on Mill River, 2018

1. There are minor blockages from fallen trees that should be monitored and cleared as needed to ensure that they do not become an impediment to salmon access or streamflow.

2. Annual maintenance of salmon spawning habitat would be beneficial. In rivers with a modest amount of sediment where spawning usually occurs, using clam rakes in late summer to loosen gravel to a depth of 8 to 10 inches removes much of the sediment and can enhance hatching success.

3. Upstream from the Gaspe Road and in smaller headwater tributaries, there is increasing sedimentation from agriculture, excess instream woody debris in areas, and poorly managed or very narrow buffer zones on smaller tributaries. To increase habitat availability for Atlantic salmon and prevent a buildup of instream sediment, upper reaches should be assessed and management recommendations developed. At a minimum, deleterious practices such as insufficient buffer zones and disturbed or inadequate grassed headlands should be identified for possible resolution.

1.2. Cains Brook

Overview

Watershed/Riparian context (subcatchment of Mill River watershed)

- Riparian buffer – Generally greater than 60 metre treed buffer zone up to the Jerry Road with a mix of hardwoods and conifers, and a wide grassed floodplain at the site of the former MacAuslands Pond. However, tributaries entering from the north have limited or no buffer zones and extensive farmland near their sources.

Instream

- Water quality – The high sediment load in upstream tributaries could impact salmon habitat in lower reaches as it moves downstream. The instream water temperature was relatively cool at 6.1^{0}C (in fall of 2018).
- Substrate is predominately gravel over hardpan, ideal for salmon where there is no sedimentation. The river needs considerable instream work to stabilize banks, restore pools, remove blockages, and reduce sediment.
- There is good estuarine access but bridge reconstruction approximately 7 years ago altered the stream channel as it crosses under Route 2, leading to severe bank erosion downstream.

Table 1.2.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Cains Brook.

Atlantic salmon density			**Atlantic salmon redds**[1]	
Site	**year**	**density**	**year**	**number**
above	**2018**[2]	**Yes**		
MacAuslands			2008	(58)
Mill	2002[3]	60.2	2011	56
	2007[3]	76.8	2012	41
	2008[3]	n/a	2013	38
			2015	(38)
			2016	44
			2017	75

1-Oak Meadows (2018); **2**- 2018 electrofishing survey; **3**- Guignion and Oak Meadows (2009); ( ) incomplete count; Yes/No – present /absent in spot check

Note - in 2018 spot check found both YOY and 1+ Atlantic salmon

Status – Stable to increasing redd counts although currently limited to a 5 kilometre reach upstream from the head of tide. Due to recent beaver activity, we could not complete an electrofishing survey. A spot check found both YOY and 1+ Atlantic salmon but further assessment is needed.

Cains Brook showing wooded riparian zone downstream of the Jerry Road

Potential – With its heavily wooded riparian zone and gravel/cobble substrate, this small river has good potential for increases in salmon numbers provided blockages do not impede movement and sediment input is arrested.

Management Issues and Recommendations

1. This river has an ideal bottom for salmon where sediment is not present, and great potential for increased salmon numbers if sources of sediment are addressed. High sediment loads in upstream tributaries should be thoroughly checked and solutions found as the sediment load upstream from the Jerry Road is continuing to move further downstream.

Cains Brook downstream of the Jerry Road

2. Intensive stream restoration is needed from the Jerry Road to the estuary. This is highly recommended because of the river's high potential for Atlantic salmon.

3. When the dam at MacAuslands Pond was removed, the stream re-routed and the resulting channel is overly wide and shallow, with shale ledges and boulders. When water levels are low, Atlantic salmon would have difficulty navigating this channel to reach spawning areas upstream. A temporary solution is to rake a channel through the substrate. A longer-term solution should be examined.

Clam rakes can be used to temporarily excavate a defined channel to improve passage for adult salmon on Cains Brook

4. In the spring of 2018, there were signs of recent beaver activity. That fall, a recently constructed beaver dam (less than 1 km from the estuary) had interfered with fish passage**.** Beaver blockages should be assessed seasonally to ensure continuous access for spawning.

5. Bridge restructuring on Route 2 at MacAuslands Mill has led to realignment of the stream channel and extensive bank erosion that should be assessed and rectified. The Department of Transportation, Infrastructure and Energy has been made aware of the problem.

Cains Brook downstream from Route 2 crossing

Erosion downstream from Route 2 crossing

1.3. Trout River (Coleman)

Overview

Watershed / Riparian context

- Forest cover/land use in watershed – Approximately 50% forested with the balance in agriculture. In the O'Leary region, large sloping fields with short crop rotations and lack of winter cover leads to much soil erosion, even on gentle slopes.
- Forest cover in 60 metre buffer **-** 38% mixed hardwood, 16% softwood with balance (about 45%) non -treed.
- Riparian buffer – Variable; 30 metre treed slope (with yellow birch, maple and spruce) and a well-developed 15 metre floodplain and abandoned agricultural field or early successional forest in the headland at the Banny's Hole electrofishing site; varying to brush marsh at the Kennedy Road site.

Instream

- Canopy cover up to 75%
- Water quality - Three consecutive fish kills related to run-off have been documented in the last 10 years; sediment run-off events frequently occur in the watershed (*PEI Communities, Land and Environment, Water Quality Report Card).*
- Instream habitat is in good condition in lower reaches surveyed.
- There is good estuarine access, although frequent anoxic events have been reported in the estuary.

Table 1.3.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for the Trout River (Coleman).

Atlantic salmon density			**Atlantic salmon redds[1]**	
Site	**year**	**density**	**year**	**number**
Bannys Hole	**2018[2]**	**49.6**	2008	(2)
			2013	59
	2002[3]	31.9	2014	38
	2007[3]	61.1	2015	38
	2008[3]	n/a	2016	44
			2017	41

1-Oak Meadows (2018); **2**- 2018 electrofishing survey; **3**- Guignion and Oak Meadows (2009); ( ) incomplete count

Status - Despite several fish kills, Trout River has maintained a consistent Atlantic salmon density and number of redds over the past decade.

Potential – The Trout River is one of the most productive trout streams in the province. Despite the high densities of trout, Atlantic salmon are still maintaining a decent population. With the acquisition of sensitive land, and ongoing beaver management and habitat improvement by the local watershed group, this small river has high potential for Atlantic salmon. Recent work on the Kennedy Road branch of the river will improve water temperatures in Leards Pond which, at its lower operating level, provides excellent holding areas for trout and adult salmon.

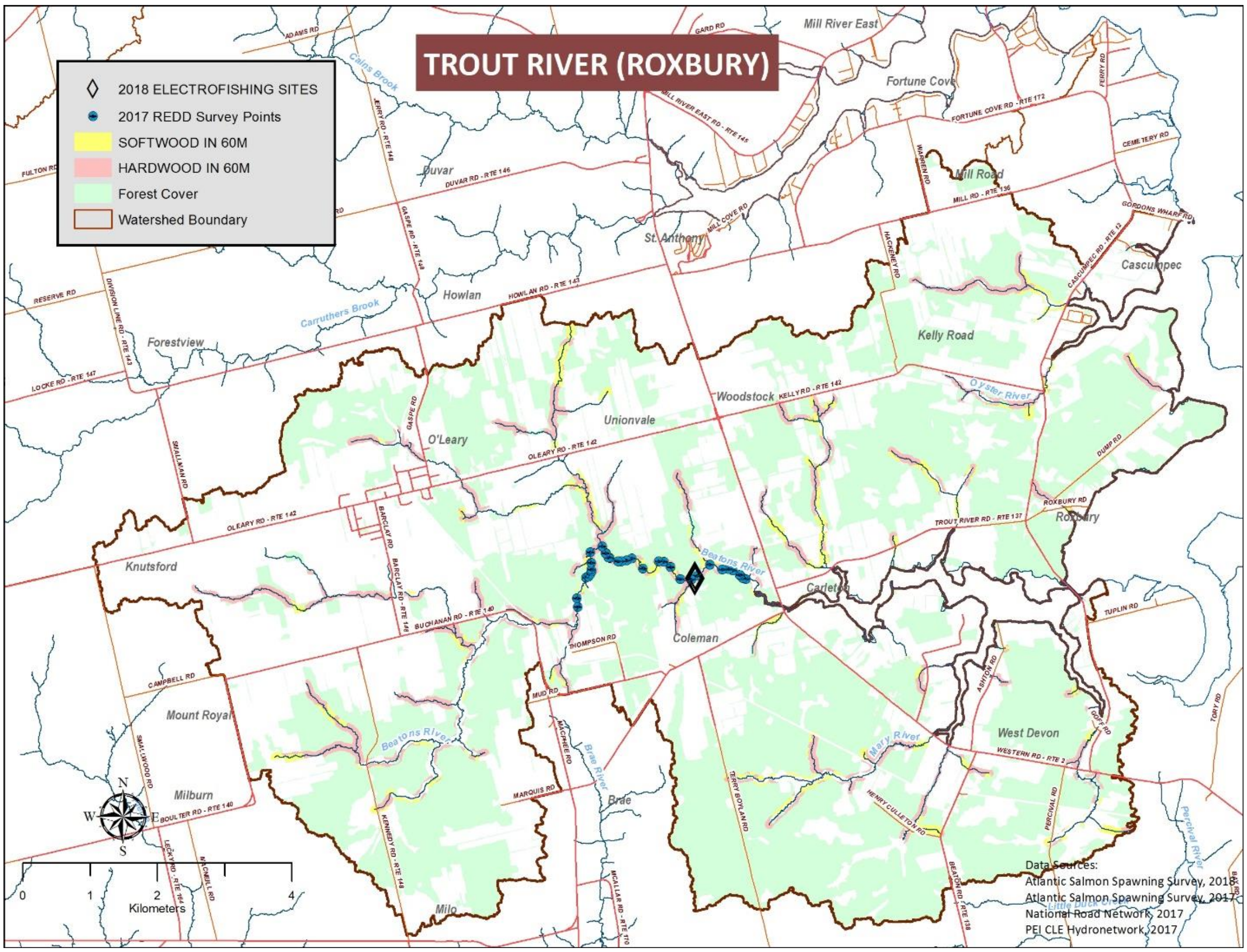


Figure 1.3. Trout River (Coleman) watershed showing location of 2018 electrofishing sites and 2017 redds.

Management Issues and Recommendations

1. The electrofishing site near Bannys Hole appears less affected by agricultural impacts than the smaller, upstream tributaries. Juvenile salmon habitat in this zone has benefitted from the addition of cobble over existing hardpan by the local watershed group. Large numbers of second year salmon were found in large cobble at the upper end, and similar numbers of YOY salmon were found in the smaller gravel at the lower end. However, there was some embedding of the cobble, indicating sediment sources in the area. These sources should be identified and managed to maintain the high quality of this habitat.

2. As more land in the O'Leary branch of the river has been put into potato production, this tributary now carries a large sediment load to the main river. The sources should be identified and corrected or the salmon restoration work completed downstream will suffer.

3. Significant progress has been made in protecting a large section of the Trout River, such as the acquisition of sensitive portions of Barclay Brook in 2014. However, ongoing work is needed to assess and reduce agricultural impacts in the upper reaches. Sensitive areas should be identified, and management recommendations considered such as wider buffer zones, winter cover, continued riparian restoration, coupled with instream habitat enhancement as required.

Bannys Hole electrofishing site, 2018

CLUSTER 2. Trout River/Bank Brook Tyne Valley, Little Trout River Richmond

Table 2.1. Salmonid density (number fish/100m^2) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for Trout River/Bank Brook and Little Trout River.

Site	*Water temperature (^{0}C)	AS density	AS size range (cm)	BT density	AS redds (2017)
Little Trout River lower	10.1	5	10.5-12.5	38.8	20
Little Trout River Richmond	10.5	9.2	9.0-10.4	51	
Bank Brook (Tyne Valley)	10.2	0	n/a	105	(4)
Trout River (Tyne Valley) above Robinsons Pond	15.6	0	n/a	22.3	

AS = Atlantic salmon, BT – brook trout; ( ) incomplete count; *water temperature was taken at the time of the 2018 electrofishing survey

A modest number of salmon redds and juvenile salmon were found in the Little Trout River in 2018. No juvenile salmon were found in 2018 at the Trout River and Bank Brook sites, although a few salmon redds were found the previous fall. The redd count for these streams could not be completed in 2017 due to flood conditions.

In 2009 these rivers were classified as Class III – Atlantic salmon on the verge of disappearing, with extensive beaver blockages and sedimentation considered to be the major limiting factors. Atlantic salmon and their redds are still found sporadically in this cluster, likely as a result of work done by the local watershed group to control sediment, clear blockages, stabilize banks, and enhance habitat and riparian buffers.

A juvenile salmon from 2018 electrofishing survey at Little Trout, Richmond

With ongoing effort, it is possible that a small Atlantic salmon population could be maintained in the Little Trout River. The prognosis for salmon in the Trout River, including Bank Brook, is less clear. Brown bullhead (*Ameiurus nebulosis*) have moved well upstream from Robinsons Pond in Trout River and have been found in Bank Brook. Bullheads are omnivorous bottom feeders and will eat pretty much anything that fits in their mouths. It is possible that they could consume YOY salmon holding in the substrate.

2.1. Trout River/Bank Brook Tyne Valley

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - 62% forested with balance in agriculture and localized commercial/residential development.
- Forest cover in 60 metre buffer - 41.5% mixed hardwood, 18.7 % softwood with balance non-treed (about 40%).
- Riparian Buffer - Variable; heavily disturbed at Bank Brook (with sumac, ash) to 30 plus metres at Trout River site with mature hardwoods (yellow birch, maple), spruce, and young fir in understory.

Instream

- Canopy cover highly variable; from patchy at Bank Brook to 75% in stretches of Trout River.
- Gravel-cobble bottom with sediment covering in areas especially at Bank Brook; riffles, pools at 20m in Trout River; LWD / tree roots for cover.
- Water temperature at the Trout River site was warm at 15.6^0C.
- Access may be affected by clogging of the fish ladder at Robinsons Pond, and it has been suggested that eel nets in the estuary could be an issue, although this has not been confirmed.

Table 2.1.1. Juvenile Atlantic salmon density (number fish/$100m^2$) and Atlantic salmon redds for Bank Brook/ Trout River Tyne Valley.

Atlantic salmon density			**Atlantic salmon redds[1]**	
Site	**year**	**density**	**year**	**number**
Bank Brook	**2018[2]**	**0**	2008 2013 2014 2017	14 0 0 (4)
Trout River (Tyne Valley) above Robinsons Pond	**2018[2]** 2002[3] 2007[3] 2008[3]	**0** 21.3 4.5 4.6		

1-Oak Meadows (2018); **2** – 2018 electrofishing survey; **3** - Guignion and Oak Meadows (2009); ( ) incomplete count

Note - Brown Bullhead were found at both sites.

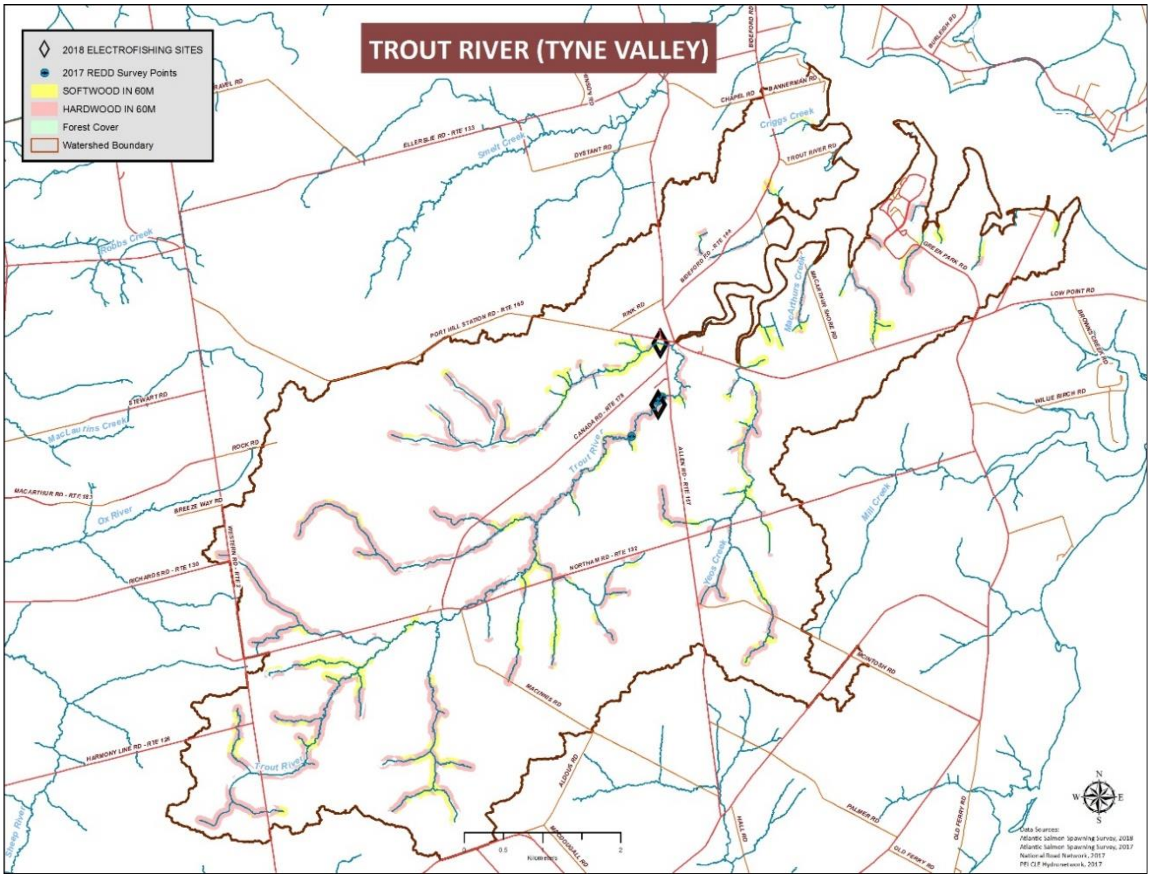


Figure 2.1. Trout River /Bank Brook watershed showing location of 2018 electrofishing sites and 2017 redds

Status - There has been a decline in salmon redds and juvenile salmon in Trout River since 2002, with no juvenile salmon being found in 2018. Salmon were, however, collected in this system in 2017 (S. Roloson UPEI pers. comm.). The redd count could not be completed in 2017 due to flood conditions, and the number may be underrepresented.

The electrofishing site at Trout River (Tyne Valley), 2018.

The electrofishing site at Bank Brook, 2018.

Potential – **(Uncertain)** Trout River and Bank Brook had good runs of salmon over half a century ago (Dan MacLean pers. comm - from Guignion and Oak Meadows 2009). Much work has been done by the local watershed group to clear blockages and control sedimentation, there is a well-developed mixed hardwood riparian zone in areas, and fish kills no longer occur. The reason for low redd counts in recent years is not clear.

The Tyne Valley stream has a high density of brook trout and is known to be a favoured destination for trout anglers. The density of brook trout at the Bank Brook site in 2018 was greater than 100 brook trout per 100m^2.

Management Issues and Recommendations

1. The fish ladder at Robinsons Pond periodically becomes blocked with aquatic vegetation and should be cleared regularly.

Fish ladder at Robinsons Pond clogged with aquatic vegetation

2. There appears to be residential runoff near the post office in Tyne Valley.
3. Flood conditions prevented a complete redd count in 2017, suggesting a "flashiness" to the system that could be limiting to Atlantic salmon spawning.
4. Pesticide runoff was a problem in the past (there was a major fish kill in Trout River in 1999).
5. The watershed group is working hard to control beavers and remove blockages.
6. The presence of brown bullhead may be a limiting factor for Atlantic salmon in these streams.

Brown bullhead from Trout River (Tyne Valley) electrofishing site, 2018

2.2. Little Trout River Richmond

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - 58% forested with balance in agriculture, and some residential and commercial development**.**
- Forest composition in 60 metre buffer - 54 % mixed hardwood, 18.6% softwood and balance (about 30%) non-treed
- Riparian Buffer – Variable; greater than 30 metres in sections, with mixed tree cover (birch, maple, fir/spruce) plus trees planted by local watershed group.

Instream

- Canopy cover 50-75%, open in patches.
- Cobble substrate with some sediment; relatively shallow channel; LWD on banks; many evident improvements by watershed group to clear, create pools, control sediment and stabilize banks.

Table 2.2.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Little Trout River

Atlantic salmon density			**Atlantic salmon redds**[1]	
Site	**year**	**density**	**year**	**number**
Little Trout lower	**2018**[2]	**5**		
			2008	11
	2002[4]	15.9	2009	19
	2007[4]	0	2011	(9)
	2008[4]	0	2012	28
	2017[3]	trace	2013	-
Little Trout Richmond	**2018**[2]	**9.2**	2014	0
			2015	0
	2002[4]	n/a	2016	2
	2007[4]	0	2017	20
	2008[4]	0		
	2017[3]	13.3		

1-Oak Meadows (2018); **2**- 2018 electrofishing survey; **3**- Forests, Fish and Wildlife;
4- Guignion and Oak Meadows (2009)'; ( ) incomplete count

Status – The number of Atlantic salmon redds is low and counts were sporadic between 2012 and 2016. Juvenile salmon were found at both sites in 2018. While juvenile Atlantic salmon numbers are modest, they are significant in light of concerns expressed in our 2009 report that efforts to restore salmon populations may have come too late (no juveniles were detected in survey sites in 2006, 2007 and 2008).

Potential - With ongoing effort, it is possible that a small population of Atlantic salmon could be maintained on the Little Trout River. However, there has been a great deal of variability in the number of redds in recent years, and low water levels in the fall may affect salmon runs.

Management Issues and Recommendations

1. Recent improvements to enhance habitat, control sediment, stabilize banks, and restore the riparian zone should continue to improve salmon runs, although the small size of this river may limit population density.

2. **2.** The raking of the stream bottom in potential redd sites and addition of "cobble clusters" seems to have worked for the watershed group. It would be desirable to expand these efforts further upstream which might result in better juvenile survival.

Lower electrofishing site near the head of tide on Little Trout River

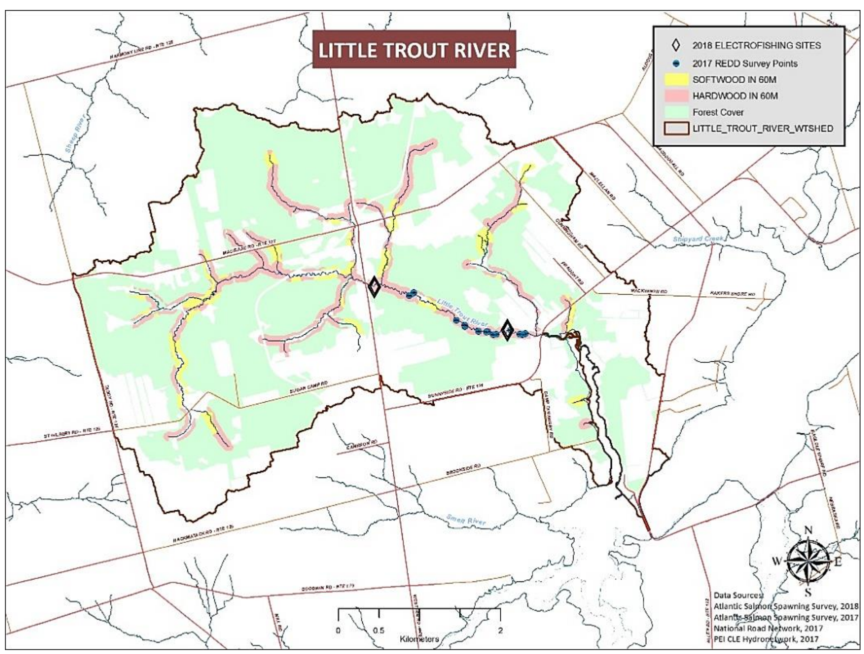


Figure 2.2. Little Trout River watershed showing location of 2018 electrofishing sites and 2017 redds.

CLUSTER 3. Dunk River, Wilmot River, Bradshaw River

Table 3.1. Salmonid density (number fish/100m^2) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for Dunk River, Wilmot River, and Bradshaw River.

River	Site	*Water temperature (^{0}C)	BT	RT	AS	AS size range (cm)	AS redds (2017)
Dunk River	Greenan Rd	9.7	48	58.5	0	n/a	78
	Breadalbane	9.7	25.6	39.7	0	n/a	
Wilmot River	Cairns Rd	12.4	44.1	62.6	0.4	8.5	6
	above Arsenaults	14.5	52.5	34.3	0	n/a	
Bradshaw River**	Bedeque Rink Road	13.6	Yes	Yes	No	n/a	0

BT – Brook trout; RT – Rainbow trout; AS – Atlantic salmon; Yes/ No – present/absent in spot check; * water temperature taken at time of 2018 electrofishing survey; **incomplete count with about 3:1 ratio of RT to BT

This cluster includes the Dunk River, one of the largest rivers on PEI, the Wilmot River, and the Bradshaw River. These rivers are in the Bedeque Bay watershed, one of the most intensively developed agricultural watersheds in the province - about 75% of the watershed is cleared with the majority of this (61%) in intensive, three-year rotation with potatoes being the major cash crop.

Although 78 Atlantic salmon redds were noted on the Dunk River in 2017, they were limited to a small section of the river and only a few redds were found on the Wilmot River. No juvenile salmon were found at the Dunk River electrofishing sites in 2018, although juvenile salmon have been found on this river in recent years (PEI Forests, Fish and Wildlife Division). A single juvenile was found on the Wilmot River in 2018.

Habitat conditions in the Dunk, Wilmot and Bradshaw Rivers reflect the intensity of agricultural activity in the area. A large proportion of these rivers has had forest cover severely depleted (forest cover is 11% for Wilmot; 26% for the Dunk; and 16% for Bradshaw) and deforestation is continuing. With large sloped fields and inadequate buffer zones, it is difficult to keep sediment out of tributaries.

While there are significant challenges to restoration of Atlantic salmon habitat, the Dunk River historically had excellent runs of salmon and could again support viable salmon populations, although dramatic changes in land use would likely have to occur. With their numerous springs and cold water, all of these rivers support good densities of brook trout and rainbow trout, and any restoration efforts to improve salmon habitat should also benefit these species.

3.1. Dunk River

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed **-** 26% forested with balance in agriculture.
- Forest composition in 60 metre buffer **-** 34% mixed hardwood, 18% percent softwood with the balance (47 %) non-treed.
- Riparian Buffer **-** Variable, 15 metres up to 30 metres.

Instream

- Canopy cover patchy varying from 25% to 40% (solar radiation may result in dense algal growth in high nutrient areas).
- Gravel-cobble over hardpan, with sediment and dense algal "mats" covering in areas.
- Water quality **-** No anoxic events have been recorded in the Dunk River estuary in the last 5 years and one fish kill was reported in the watershed in the last 10 years (2007). Sediment runoff events occur frequently in the watershed (*PEI Communities, Land and Environment, Water Quality Report Card*).

Table 3.1.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for the Dunk River.

Atlantic salmon density			**Atlantic salmon redds[1]**	
Site	**year**	**density**	**year**	**number**
Greenan Rd	**2018[2]**	**0**		
	2002[3]	-	2008	17
	2007[3]	0	2012	12
	2008[3]	0	2017	78
Dixon Rd.	**2018[2]**	**0**		
Wall's Bridge	2002[3]	0		
	2007[3]	-		
	2008[3]	yes		
Hal Mills	2002[3]	-		
	2007[3]	-		
	2008[3]	0		
NE tributary	2002[3]	-		
	2007[3]	-		
	2008[3]	0		

1-Oak Meadows 2018**;** **2**- 2018 electrofishing survey; **3**- Guignion and Oak Meadows (2009)

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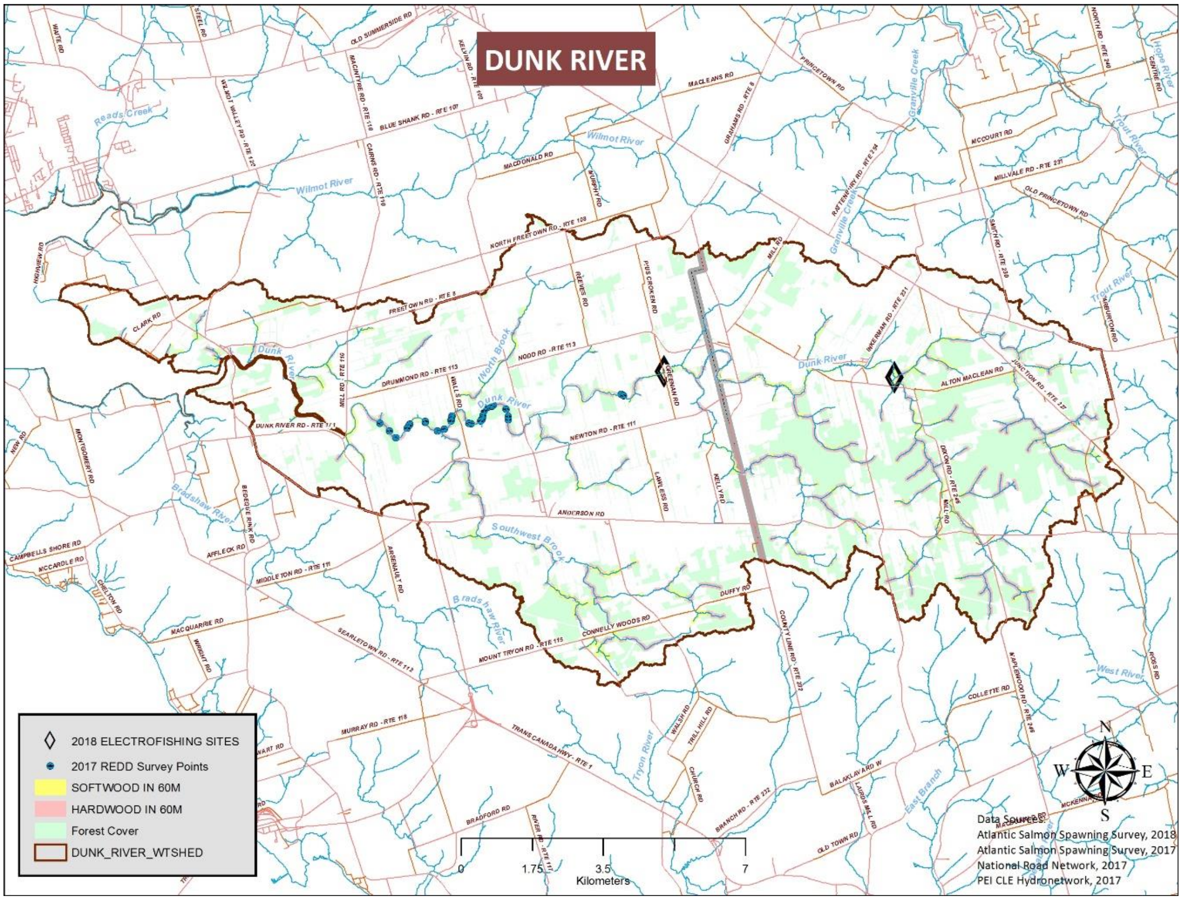
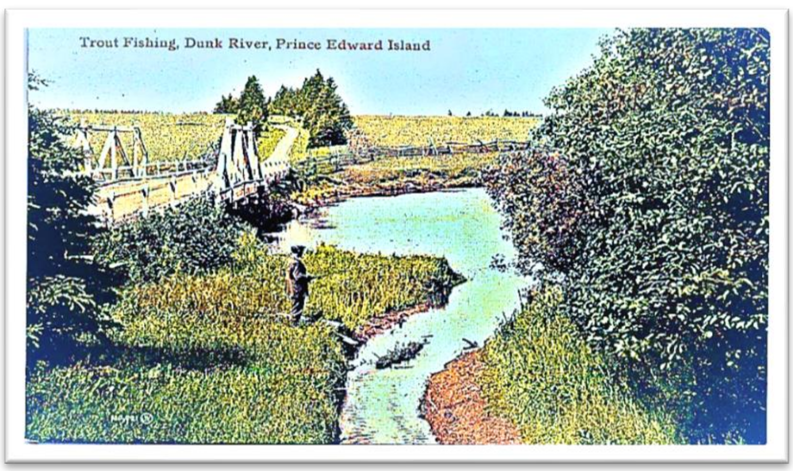


Figure 3.1. Dunk River watershed showing location of 2018 electrofishing site and 2017 redds



The Dunk River was once a favorite destination for anglers.

Status - Once an important salmon fishing river on PEI, only a small section of the main branch of Dunk River currently has evidence of Atlantic salmon spawning. On a positive note, the number of salmon redds has increased significantly since 2008. No juvenile Atlantic salmon were found at the sites we surveyed in 2018. However, the river downstream from Scales Pond at Route 109 was electrofished on multiple occasions in 2018 during educational demonstrations. Low numbers of salmon parr were found during these surveys (PEI Forests, Fish & Wildlife Division). Some spawning takes place below Scales Pond and school children have been releasing salmon fry at this location as part of the *Salmon are Our Friends* program offered by the Abegweit Conservation Society.

Potential – To regain some of its former stature as a salmon river, there would need to be a concerted focus on salmon habitat improvement along with major land use changes from the agricultural community. This river should be able to sustain a viable salmon population if known spawning sites are enhanced and upper tributaries that still have reasonably wide buffer zones are accessible and properly managed. Dramatic changes in land use will have to take place if the Dunk is to again have excellent runs of salmon.

Management Issues and Recommendations

The Dunk River and its tributaries flow through a landscape dominated by intensive agriculture. Sediment and nutrient runoff from cultivated land, continued deforestation and inadequate buffer zones all contribute to Atlantic salmon habitat degradation. Beaver dams have become an access issue in some locations and many tributaries still require habitat restoration. Despite these problems, 78 redds were found in the fall of 2017. Most of these were downstream from Scales Pond with a few found towards the Greenan Road.

The Greenan Road electrofishing site showing intensive agricultural production in surrounding area

The following management strategy is recommended for the Dunk River:

1. A habitat management plan should be completed to guide restoration work. There are several tributaries that have potential as Atlantic salmon habitat. It would be helpful to identify the tributaries that were historically important for Atlantic salmon and assess the current conditions. It is recommended that efforts be focused on one tributary at a time to make the necessary improvements to access and habitat before expanding efforts to other tributaries.

Dense algal mats on stream bottom of Dunk River

2. The Dunk River supports strong runs of brook trout and rainbow trout. Sufficient woody cover must be retained in these areas during restoration efforts for salmon.

3. It will be important to continue annual redd surveys in the Dunk River to pinpoint areas currently used for spawning. Following up the

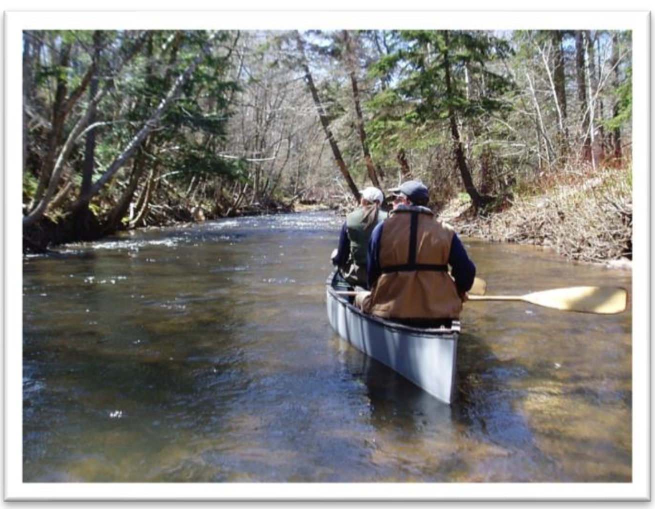
redd surveys with electrofishing surveys in the following year will provide an indication of success. Addition of spawning gravel or cobble in these areas could boost juvenile success.

4. The watershed group has been trying to address a shortage of holding pools for Atlantic salmon on the main branch of the Dunk River. The management plan should identify areas that continue to lack pools and outline a strategy to add holding areas. Previous dam washouts, the flashiness of the river and the large expanse of hard pan substrate make it difficult to restore and create pools in this river.

5. Climate change and increasing intensity of storms will only magnify the land use problems facing the Dunk River. Some reaches of the Dunk River have a spectacular riparian zone but most areas are lacking sufficient buffer zones to minimize runoff and sedimentation. Runoff from unpaved roads, while less of contributor than agricultural erosion, remains a problem in some branches. There are no easy answers to addressing erosion and runoff issues in the Dunk River watershed but without substantive changes, the river will not reach its potential for Atlantic salmon regardless of the instream restoration activities undertaken.

6. Although it appears unrealistic in a watershed as developed as the Dunk River, the long-term goal for all of our salmon rivers should be a 60 metre riparian buffer zone composed mostly of hardwoods, shrubs and grasses. Strategic purchases of land or voluntary buffers by willing landowners would be a good start. Continued planting of trees and shrubs should focus on trees and shrubs that were common in the Acadian forests and all hardwood saplings should be protected from browse following planting.

7. The Dunk River is one of the few PEI rivers large enough to enable a lengthy canoe trip. The section of river between Scales Pond and the head of tide is particularly scenic with it mature wooded riparian zone. This section should be maintained as a canoe route, which would require opening up any deadfalls each spring to allow canoe passage.



Canoeing the main branch of the Dunk River downstream from Scales Pond.

3.2. Wilmot River

Overview

Watershed/Riparian context

- Forest cover/land use in watershed - 11% forested, balance in agriculture.
- Forest composition in 60 metre buffer - 20% alder/mixed deciduous; 18% softwood, with balance (about 60%) non-treed.
- Riparian buffer – Variable; 15 metres up to 45 metres at Cairns Road site with some mature deciduous trees; marshy with tall grass at Kelvin Rd site with alder, older spruce, apple and invasive species (wild cucumber).

Instream

- Canopy cover patchy; 0% to 25% with shrubs/grass providing shade and cover at banks.
- Water quality - Nitrate levels are high for PEI although they have decreased slightly since their maximum recorded levels in 2010 (*PEI Communities, Land and Environment, Water Quality Report Card*).
- Substrate is flat rock and cobble over hard pan at Cairns Rd site; good sized cobble (~10 cm) and gravel at Kelvin Road site; high sediment load over substrate in areas; hardpan may limit depth of redds.

Table 3.2.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for the Wilmot River.

Atlantic salmon density			**Atlantic salmon redds**[1]	
Site	**year**	**density**	**year**	**number**
Cairns Rd	**2018**[2] 2002[4] 2007[4] 2008[4] 2017[3]	**0.4** 0 - 0 0	2008-16 2017	None recorded 6
Kelvin Grove Road above Arseneaults Pond	**2018**[2] 2002[4] 2007[4] 2008[4] 2017[3]	**0** 0 - 0 0		
Marchbanks	2002[4] 2007[4] 2008[4]	- 0/ Yes No		

1-Oak Meadows (2018); **2**- 2018 electrofishing survey; **3-** Forests, Fish and Wildlife;
4- Guignion and Oak Meadows (2009); ( ) incomplete count; Yes/No – present /absent in spot check

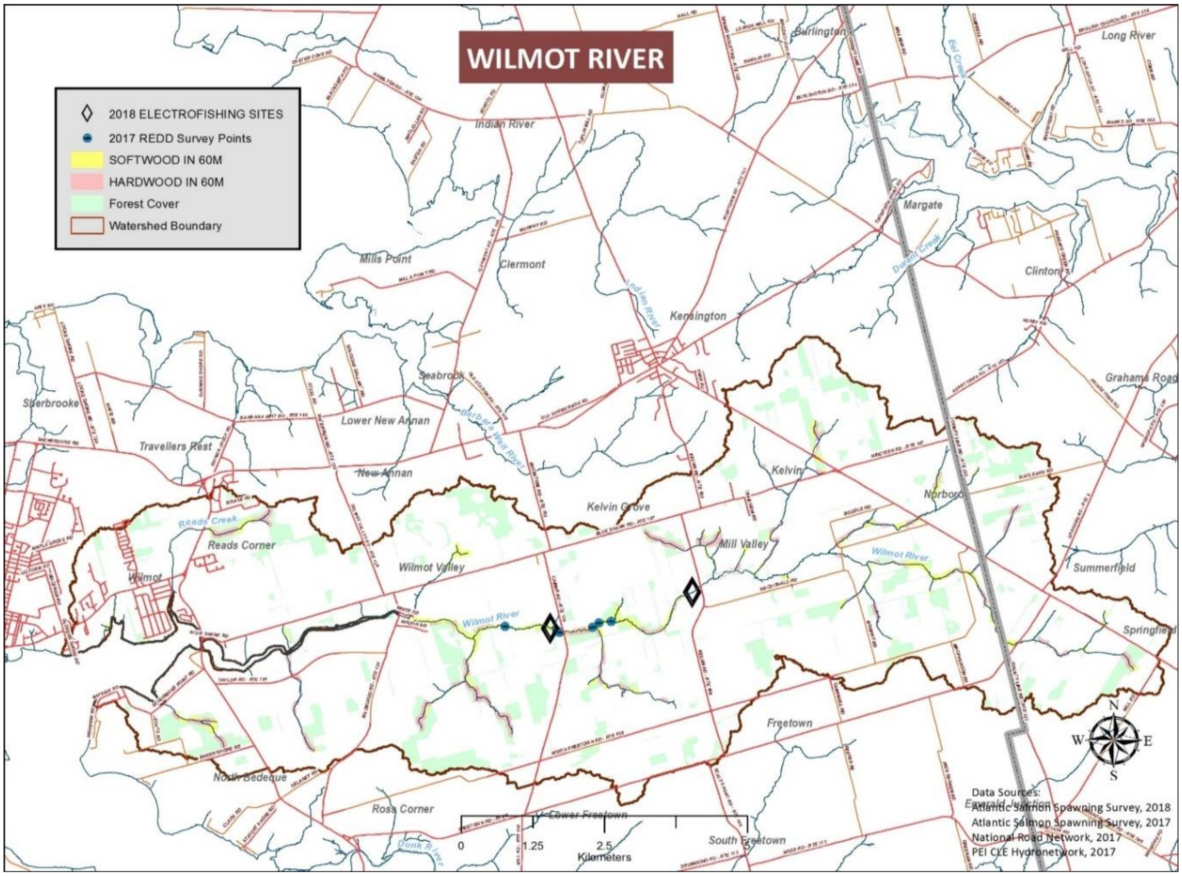
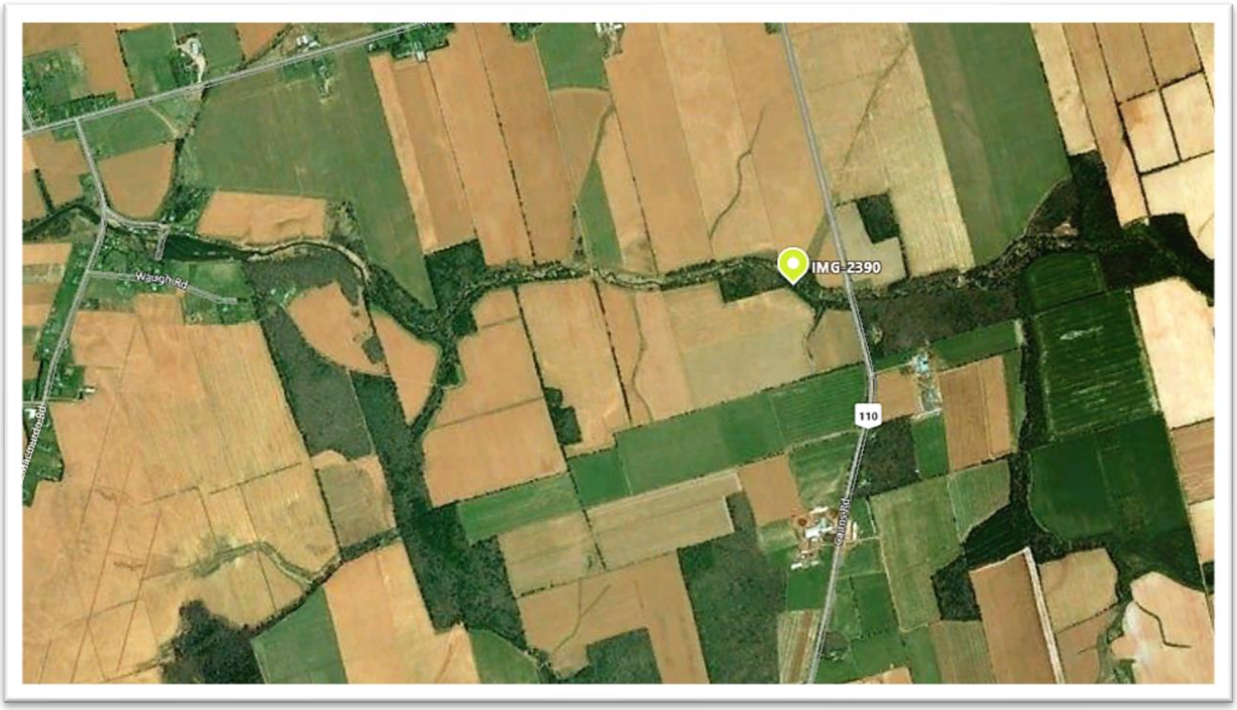


Figure 3.2. Wilmot River watershed showing location of 2018 electrofishing sites and 2017 redds

Status – Only six Atlantic salmon redds were counted in 2017 and a single salmon parr was found in 2018. A beaver dam downstream from Route 109 may have prevented salmon from moving further upstream, as all of the redds were downstream from this obstacle. Electrofishing surveys conducted in various years have never found high Atlantic salmon numbers.

Potential – Like other rivers draining into Bedeque Bay, the Wilmot River is an excellent trout river. The numerous fish kills in the past twenty years, continued agricultural runoff, and high nutrient levels are limiting the recovery of Atlantic salmon. This river could continue to produce Atlantic salmon with removal of blockages, wider buffer zones in key areas (including expanded zones for headland management), and attention to point sources of sediment and nutrients to the river.



Cairns Road electrofishing site showing intensity of agricultural production in surrounding areas.

Management Issues and Recommendations

The Wilmot river may never have had the salmon runs that were historically present on the Dunk. It appears to be more suited for trout production and produces high densities of trout despite its land use challenges. The Wilmot has the dubious distinction of having the lowest percentage of forest cover of all rivers assessed. For Atlantic salmon recovery there are significant challenges and we suggest the following management strategy:

1. Focus on restoring connectivity throughout the river. Salmon can get through the estuary and find deep water in Marchbanks Pond just above head of tide. Beaver management, including spring and fall reconnaissance, and removal of dams that are blocking anadromous fish movement, is required.

2. Grassed waterways are a standard agricultural engineering tool and are designed to direct water off fields and reduce field erosion. Many of these waterways used to be tree-lined streams fed by springs that meandered through farmland before emptying into the river. Depending on their design and on the cultivation practices of the surrounding fields, they can act as a conduit and carry water, soil and pesticides quickly to the watercourse. In some cases where grassed waterways enter the Wilmot, runoff water velocity is so high that banks are “blown out” and the streambed is deep with fine sediment and slimy vegetation. This was evidenced at Cairns Road electrofishing site about 200 metres downstream from the road crossing. Such point sources of sediment to the river should be identified and corrected.

3. Some of the fields downstream from the Kelvin Road need much wider buffer zones between farmland and river, including expanded, vegetated headland zones.

4. Approximately two kilometres downstream from the Kelvin Road, an irrigation system has the intake device on the stream bottom. Water goes underground into a deep holding pond used for irrigation. How common are these systems in the Wilmot River and how much water is being removed from the river?

5. As populations of Atlantic salmon begin to increase in the adjacent Dunk River, there should be more "spillover" of Atlantic salmon into the Wilmot River. Management activities directed at improving trout habitat and addressing land use issues should be sufficient to maintain suitable habitat for salmon in the Wilmot River. If populations of Atlantic salmon start to increase in the Wilmot River, a complete assessment of habitat improvement possibilities should be undertaken.

Wilmot River electrofishing site at Cairns Road

3.3. Bradshaw River

Overview

The Bradshaw River is the smallest of the three rivers flowing into Bedeque Bay. Like the other two rivers, the Bradshaw watershed has a low percentage of forest cover in the drainage basin. The topography is gentle when compared with the Dunk River. At the Bedeque Rink Road electrofishing site, there is a treed riparian zone over 40 metres wide, with mature maples and a well vegetated floodplain.

Status - No juvenile Atlantic salmon were found in two sweeps during the electrofishing survey in summer 2018, and Atlantic salmon have not been picked up in any electrofishing surveys in the past decade. Beaver dams at the upper end of Afflecks Pond have blocked fish passage in previous years and impounded water was observed downstream from the electrofishing site. A 3:1 ratio of rainbow trout to brook trout was found in 2018.

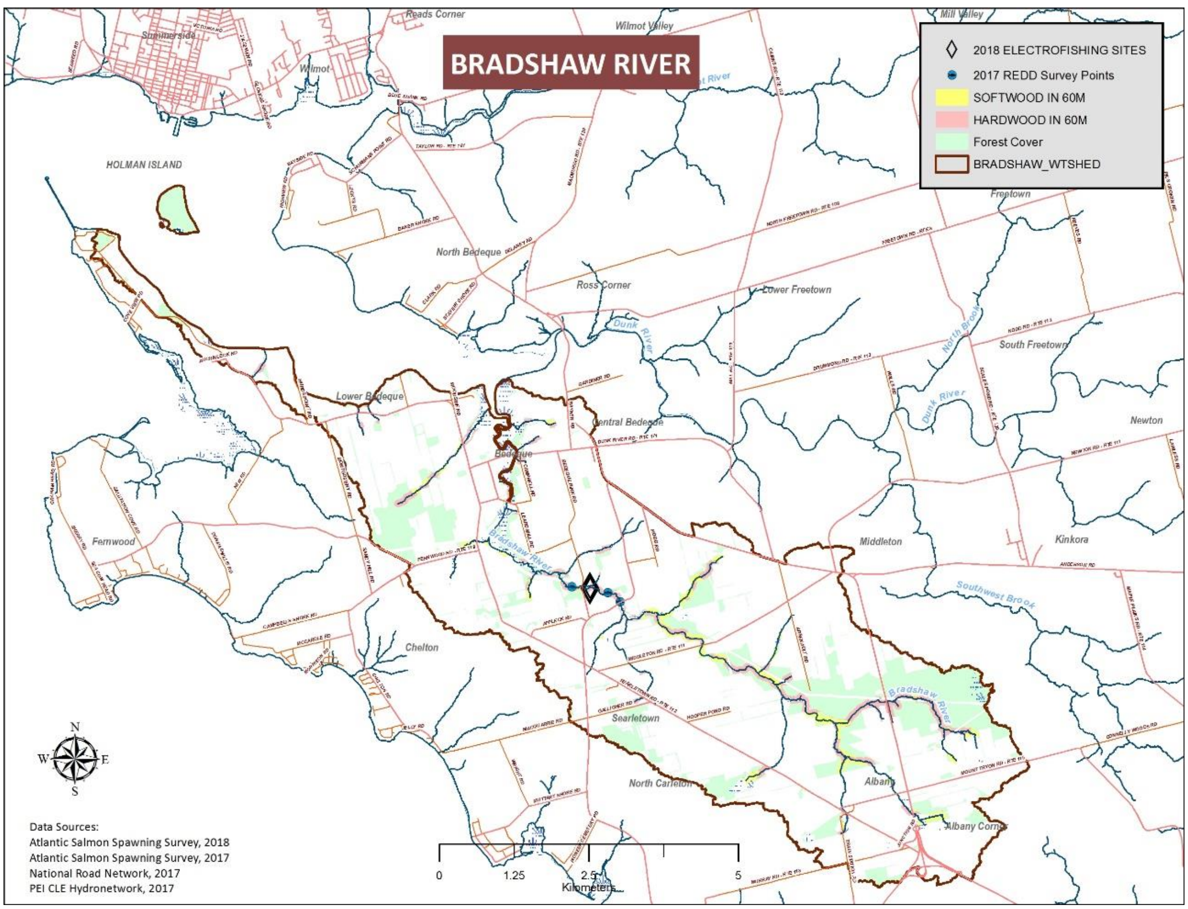


Figure 3.3. Bradshaw River watershed showing location of 2018 electrofishing site

Potential - The Bradshaw River suffers similar land use pressures as its neighboring streams. It is possible that salmon could return to the Bradshaw and if habitat were improved, a small population of salmon could be supported.

The electrofishing site lies in the middle of a wooded section of the Bradshaw River (above)

Aerial view of electrofishing site

Management Issues and Recommendations

1. In previous years, beavers have dammed the stream at the upper end of Afflecks Pond and in the fall of 2017, water in this section of river was impounded. Regular monitoring to identify blockages and remove dams would improve connectivity in this system.

2. The Route 10 crossing in Searletown has been a longstanding blockage to fish passage. The Department of Transportation, Infrastructure and Energy is slated to replace the structure in 2019. This would be an excellent opportunity to provide fish passage as there is a good distance of fish habitat upstream. This bridge replacement will require care to ensure that massive amounts of sediment currently trapped in the Leards Pond basin does not move into downstream habitat.

3. Stream restoration work by the watershed group in the section downstream from the Bedeque Rink Road has exposed good gravel-cobble substrate that could be used by Atlantic salmon.

4. Many of the smaller tributaries are dry in the summer. More assessment would be needed to determine whether water withdrawals are having an impact on water volume in late summer.

CLUSTER 4. West River, Clyde River, North River

4.1. West River

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed – This watershed has a high proportion of provincial parkland/woodland (Strathgartney, Bonshaw Provincial Parks) and recreational land (Mark Arendz provincial ski park) with agriculture in upstream areas.
- Forest composition in 60m buffer - 47.4% mixed hardwood, 22.5% softwood with the balance non-treed (about 30%).
- Riparian Buffer – 30 metres to greater than 60 metres in forest management areas; vegetation in riparian zone is variable e.g.; mixed shrubs/early successional to mature softwood/hardwood, and remnant old growth forest in the "Horseshoe" area between Riverdale Road and Green Bay.

Instream

- Canopy cover variable from 25% to 75%.
- Highly variable substrate from hardpan with large flat rocks to gravel-cobble mix, with sand and sediment sometimes heavy in areas; shallow in stretches with riffles; LWD.
- Note - extensive instream work conducted since 2010 to improve habitat

Status – The number of Atlantic salmon redds has varied from 76 to 149 over the past decade, with the last five years having a consistently high numbers of redds (113 to 168). Distribution of redds in upstream reaches has increased, and for the first time in decades, Atlantic salmon redds were found far upstream in the Brookvale area. In the 2018 electrofishing survey, it was encouraging to find juvenile Atlantic salmon in all four sites surveyed on the main branch and in two of the four sites on Howells Brook.

Potential - With almost 150 km of stream, a high proportion of protected woodland, and ongoing instream habitat restoration to open up new spawning habitat, this river has a high potential to support increased salmon numbers. The West River also has good populations of brook trout and rainbow trout.

The West River and its watershed are an example of the extremely high value of natural areas on PEI. The popularity of the Bonshaw Hills Provincial Park, with its new trail system along the West River, demonstrates the value – and untapped potential – of these beautiful riparian areas.

Table 4.1. Salmonid density and Atlantic salmon redds for the West River.

Site	***Water temp. (^{0}C)**	**Density (number fish/100m^2)**					**[2]AS redds**	
West River (WR)		**BT 2018**	**RT 2018**	**AS 2018[1] (*size range in cm*)**	**AS 2017[3]**	**AS[4] 2002-2008**	**year**	**number**
WR Howell at Riverdale	9.8	61.7	6.1	**2.2** *(7.4-10.3)*	8.8	0 (2008)	2008 2009	141 76
WR Howell at Wynne Rd	10.2	29.3	10.2	**0**	-		2010 2011	88 87
WR below MacDonalds	9.4	38.2	42.8	**0.5** *(11.1)*	-		2012 2013	89 168
WR Quinn Road	9.4	38.1	5.2	**0**	-		2014	113
WR above Skye Brook	9.4	52	13.6	**3** *(9.7-13.8)*	0		2015 2016	113 148
WR Skye Brook	10.4	40.5	22.6	**0**	14.8		2017	149
WR Carraghers	12	12.2	89.4	**0**	**-**	0 (2008)		
WR Curleys	12.1	74.7	6.2	**7.3** *(5.6-14.3)*	24.5			
WR Cudmores	12.5	45.5	27.9	**2.4** *(8.8-11.1)*	35.1	9.9 (2002) 24.7 (2007) 3.6 (2008)		
WR Bolger Park Rd	14.1	33.7	46.6	**18.4** *(3.8-11.5)*				

*****Water temperature at time of 2018 electrofishing survey; **1**- 2018 electrofishing survey; **2**- Oak Meadows (2018); **3**- from Central Queens Wildlife Federation; **4** – Guignion and Oak Meadows (2009)
BT- brook trout; RT- rainbow trout; AS- Atlantic salmon

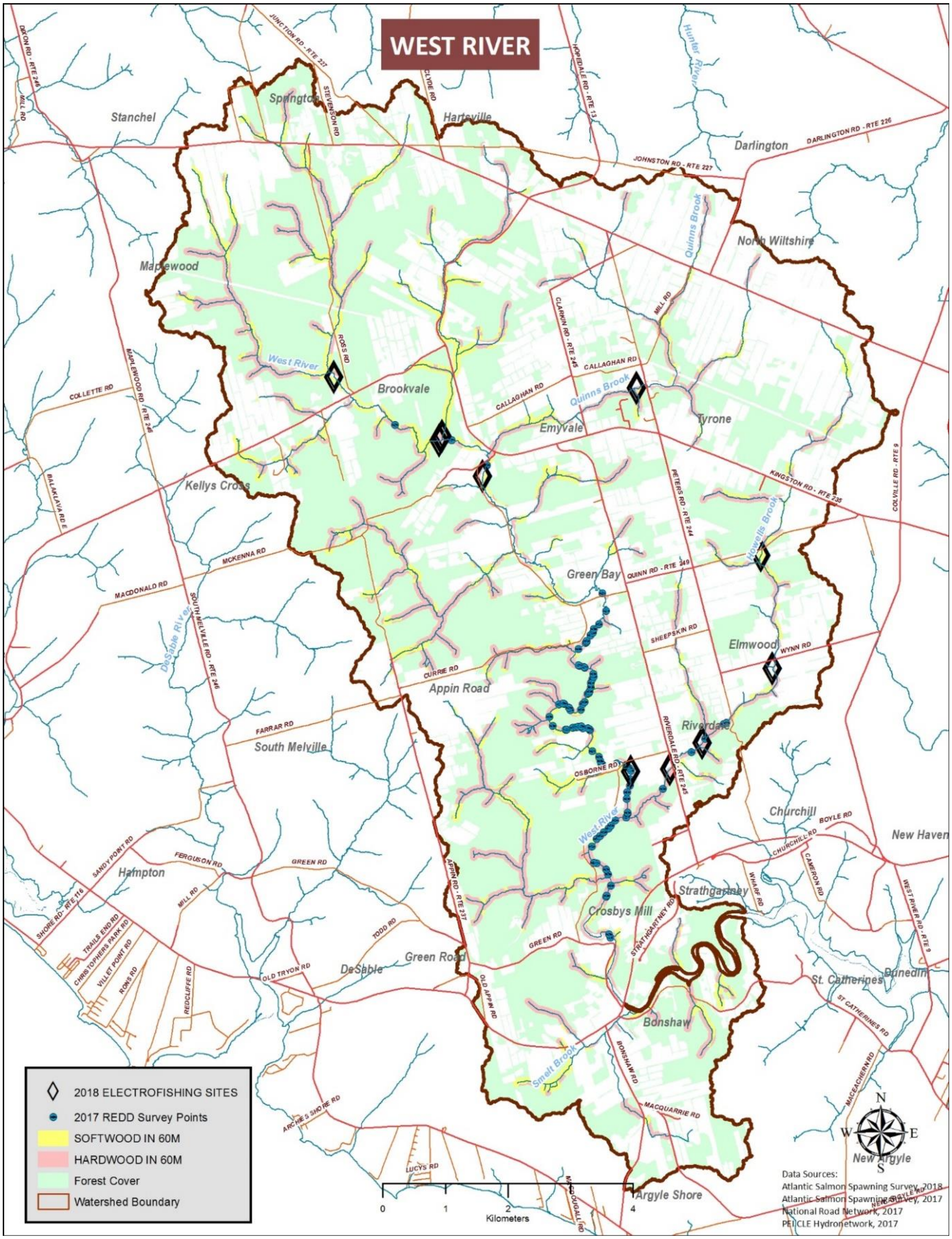


Figure 4.1. West River watershed showing location of 2018 electrofishing sites and 2017 redds

Management Issues and Recommendations

1. Continuous habitat restoration work has been underway on the West River for almost a decade. The strategy of focusing on one tributary at a time and reconnecting the headwaters to the main river appears to be working. "Old timers" living in the community can be a wealth of information on which streams once contained Atlantic salmon. Their reports of good salmon runs on the Brookvale branch, for example, prompted stream restoration efforts. With the aid of the Abegweit hatchery, feeding fry were stocked far upstream in the Brookvale Region. In fall 2017, three Atlantic salmon redds were found in this section after many years without evidence of spawning. These redds were presumably created by grilse because the first multi-sea winter fish are not expected to return to the river until autumn 2019. The additional habitat restoration planned for Howells Brook and Quinns Brook should continue the upward trend in Atlantic salmon numbers.

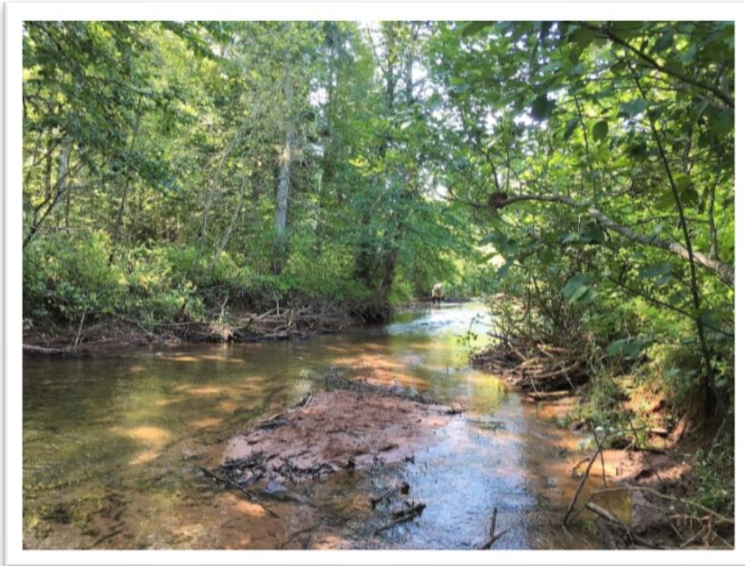
2. Flood events that wash out salmon redds, as was observed in 2017 in Quinns Brook and Howells Brook (Oak Meadows 2018), appear to be occurring more frequently than in the past. Replacement of the existing light sandstone gravel-cobble with heavier granite material from the mainland may assist in making the redds in some areas more flood resistant. In many regions of West River, sediment levels are still high so raking known spawning sites in summer may improve hatching success and provide good holding sites for juvenile salmon. Visual observations have noted high densities of YOY salmon in these prepared sites.

3. Considerable work has been completed near the head of tide to ensure anadromous fish such as blueback herring, gaspereau, brook trout, rainbow trout, and Atlantic salmon have good holding pools between the long estuary and freshwater.

4. There are a number of fields which are contributing sediment to tributaries and the main branch of the West River. Steep slopes and large fields are contributing factors and narrow buffers are inadequate in capturing the sediment eroded. Unpaved roads in hilly regions of the watershed continue to erode and add sediment to various reaches of river.

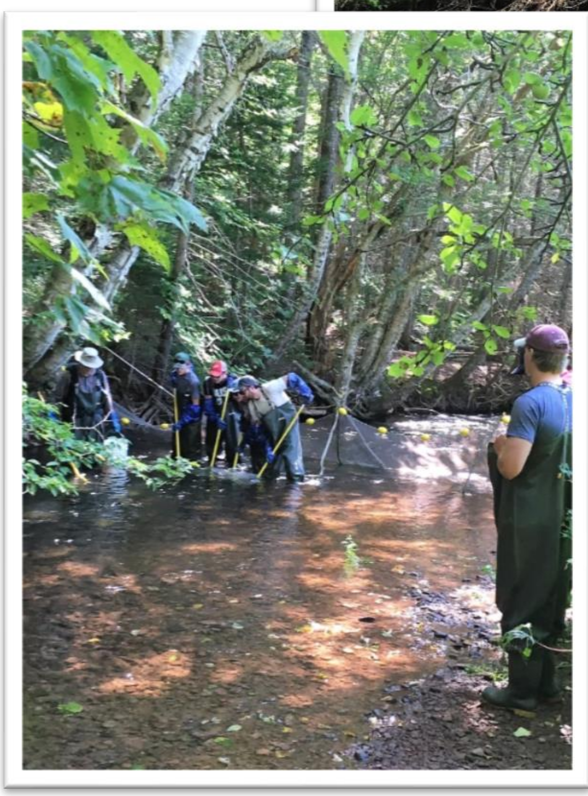
5. A large rainbow trout hatchery in Brookvale has been a concern for the watershed group for decades. In the 1990s, arctic char raised at the facility escaped into the river. In recent years, concerns were expressed around water quality exiting the facility and the quantity of water pumped to operate the hatchery.

6. The "horseshoe" section of the main branch between the Greenbay Road and the Bolger Park Road is an exceptional section of river with old growth Acadian forest. Recent cutting in this section has detracted from the wilderness setting it once was. The 15 metre legislated buffer is inadequate to protect these special riparian areas. Encouraging landowners to protect special areas or outright purchase is needed to afford long term protection.



Electrofishing site at Howell Brook below Cudmore's showing some sediment deposits in channel (left)

Electrofishing sites at Howells Brook at Riverdale Road showing coarse rocky substrate (above)



Bolger Park Road site showing gravel and cobble substrate and mature hardwood riparian vegetation at banks (left)

4.2. Clyde River

Overview

Watershed/Riparian Context

- Clyde River is a major tributary of the West River, with a stream length of about 30km
- Forest cover/land use in watershed - predominately agricultural with a major transportation corridor under development.
- Forest composition in 60 metre buffer - 26.8 % mixed hardwood, 12% softwood, with balance non-treed (about 60%).
- Riparian buffer - Variable; at electrofishing site, a 10-15 metre shrubby slope to pasture headland; less than 15 metres at road (steep slope stabilized with boulders).

Instream

- Canopy cover patchy with approximately 25% canopy cover at electrofishing site.
- Stream bottom is mixed silt and sand over cobble and gravel; several old mill pond basins exist along the river; heavily spring fed with relatively cool water.
- Sediment runoff occurs frequently in the Clyde River watershed.
- Major recent habitat improvements as a result of TransCanada re-routing (see discussion below).

Atlantic salmon data (see also Table 4.2)

No redds were found in 2017 or in an earlier survey in 2011. No juvenile Atlantic salmon were found in 2018 or 2017.

<u>note</u>- a fish kill in 2015 led to closure for 2 years

Table 4.2. Salmonid density and Atlantic salmon redds for the Clyde River**.**

Site	*Water temperature (^{0}C)	Salmonid density (number fish/$100m^2$)				[2]Atlantic salmon redds	
		BT 2018[1]	RT 2018[1]	AS 2018[1]	AS 2012[3]	year	number
Clyde River off Bannockburn Road	9.7	37.9	64	**0**	-	2011 2017	0 0
Below Dixon mill	n/a	-	-	-	1 parr 2 YOY		
Bannockburn Rd	n/a	-	-	-	1 parr		

1- 2018 electrofishing survey; **2**- Oak Meadows (2018); **3**- D. Guignion pers. comm.
*Water temperature taken at time of 2018 electrofishing survey
BT- brook trout; RT – rainbow trout; AS – Atlantic salmon.

Status – No Atlantic salmon redds or juvenile salmon have been found in the Clyde River in recent years. In 2012, one salmon parr was found during electrofishing near the head of tide and two YOY and two parr were found at the old mill site.

Potential - The potential for the Clyde River to support stable Atlantic salmon populations would appear low, due primarily to high percentage of land under cultivation and the frequent soil runoff events that impact salmon habitat. However, the stream realignment work that was completed in 2018 should improve conditions for Atlantic salmon sufficiently for the Clyde River to serve as a "backup" river to the West River.

Management Issues and Recommendations

1. Sedimentation of the Clyde River, primarily from agricultural runoff, is severe and continues to cause problems within the stream and estuary. In 2018 the Central Queens Wildlife Federation (CQWF) worked closely with the provincial Department of Transportation, Infrastructure and Energy (DTIE) when the TransCanada highway was rerouted over the Clyde River. At the site of the new highway crossing, pools and rocks were added to improve meander, stabilize banks and provide holding areas for fish. As well, the stream was realigned at the site of an old mill where previously, the stream banks had been eroding for decades. This cooperation between the PEI Department of Transportation, Infrastructure and Energy and the Central Queens Wildlife Federation not only resulted in a picturesque area to canoe, fish, hike etc., but also demonstrated a *way forward* for watershed groups and government agencies to work together to achieve more desirable results. It is expected that the improved section of stream will provide habitat for not only Atlantic salmon, but also brook trout, rainbow trout, smelts and possibly gaspereau.

Stream realignment project on the Bannockburn Road, Clyde River, 2018.

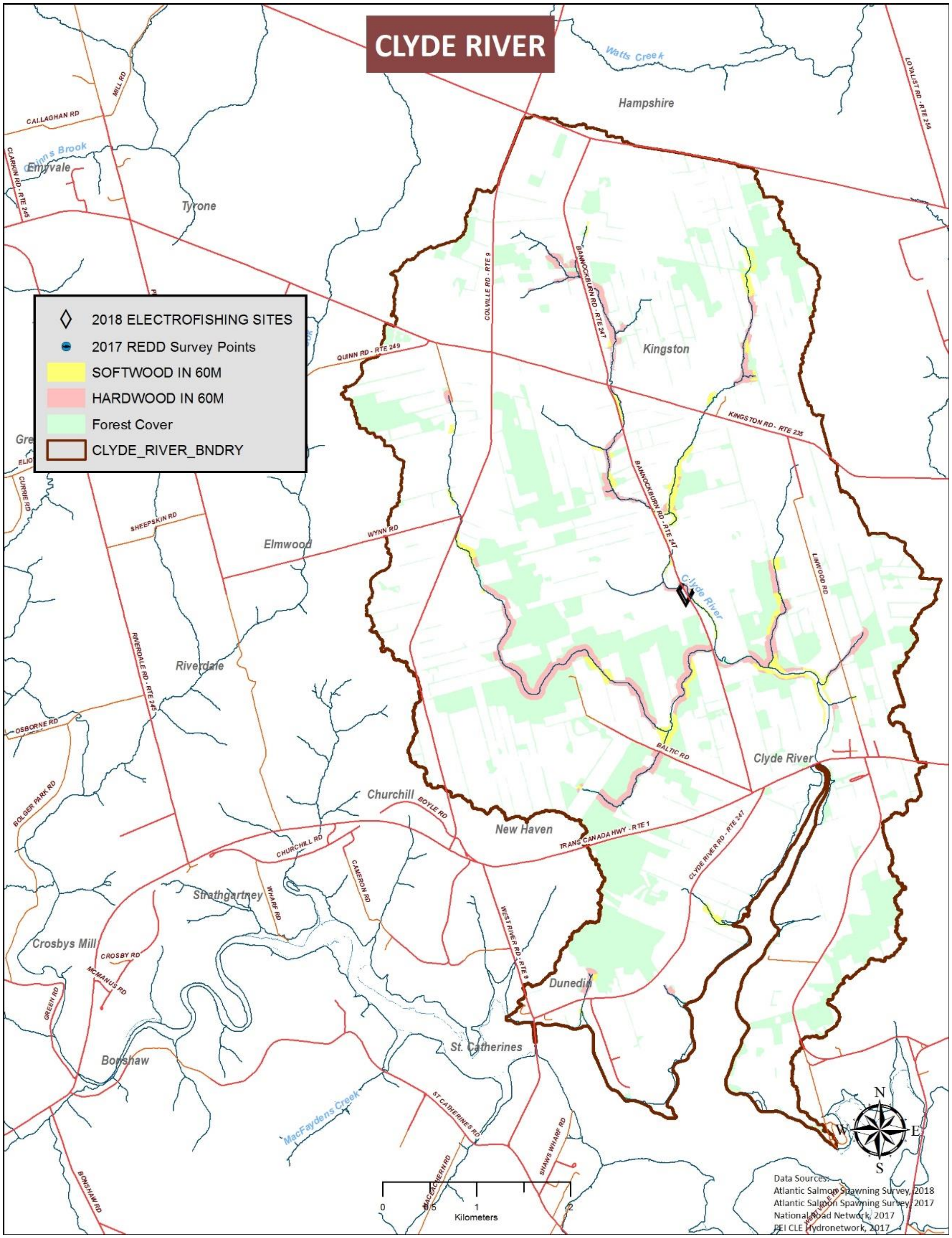


Figure 4.2. Clyde River watershed showing location of 2018 electrofishing site (no redds found in 2017)

4.3. North River

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - less than 20% of the watershed is forested with the balance predominately agricultural and commercial/ residential development.
- Forest composition in 60 metre buffer - 15.6% mixed hardwood, 24.8% softwood and balance non-treed (about 60%).
- Riparian Buffer - Highly variable; from 15 metre shrub/tall grass buffer with residential development in headland at Hwy 2 site, to 30 metres at Loyalist Road site with shallow treed slope (maple and spruce), and agricultural land in headland.

Instream

- Canopy cover highly variable, from patchy at Hwy 2 site to 50% -75% at the Loyalist Rd site.
- Substrate is primarily flat rock and cobble (flat rocks tending to embed); variable flow and width; LWD at banks and banks undercut in places; sediment heavier at banks.
- Water very cool at 2018 electrofishing sites (5.3^0C and 6.8^0C).
  note - spring off Loyalist Rd was 7.7^{0}C.
- One fish kill was recorded in the watershed in the last 5 years (2014).
- Sediment laden run-off events occur frequently (*PEI Communities, Land and Environment, Water Quality Report Card*)

Atlantic Salmon Data (see Table 4.3)

Table 4.3. Salmonid density (number fish/100 m^2) and Atlantic salmon redds for the North River. Note- 2018 electrofishing locations are not identical to historical sites.

Site	*Water temperature (^{0}C)	Salmonid density				[5]AS redds	
North River		BT	RT	AS	year	year	number
Rt 2 (Coles Brook)	5.3	87.6	22.5	**0** Yes	**2018[1]** 2008[3]	2008 2011 2013 2017	18 11 21 8
Loyalist Road	6.8	48.6	1.4	**0** 0 No 0	**2018[1]** 2002[3] 2008[3] 2017[2]		
Springvale (Rt 2)				47.4 6.7 0	2007[3] 2016[4] 2017[2]		

1- 2018 electrofishing survey; **2**- Forests, Fish and Wildlife 2017 survey; **3-** Guignion and Oak Meadows (2009); **4**- Forests, Fish and Wildlife 2016 survey**; 5-** Oak Meadows (2018); BT- brook trout; RT – rainbow trout; AS- Atlantic salmon; Yes/ No – present /absent in spot check; *****water temperature from 2018 electrofishing survey

Status – Atlantic salmon redds have been found on the North River over the past decade, albeit at low numbers. Two sites were electrofished: one on Coles Brook just upstream from Hwy 2, and a second site 100 metres downstream from the Loyalist Road. No juvenile salmon were found at either site in 2018. One salmon parr was found at the Loyalist Road site in 2014. The Springvale Road electrofishing site that has been monitored by the Forests, Fish and Wildlife Division was unable to be surveyed because of current stream conditions. Salmon have regularly been found at this site, but not in high densities.

Potential - The potential for Atlantic salmon recovery in this river may be limited by the intensive agricultural and other development in the watershed, and possibly the very cold water in the river. However, Atlantic salmon continue to spawn in this river, and the habitat at the 2018 electrofishing site looks like it could support salmon.

Loyalist Road electrofishing site, 2018

Coles Brook electrofishing site 2018

Management Issues and Recommendations

1. The watershed group has been improving the habitat on some sections of the river and appears enthusiastic that salmon numbers will rebound. A management plan would help to guide future restoration in this watershed. In the meantime, continuation of instream work

such as removing blockages and improving spawning areas should improve habitat for salmon.

2. In 2008, salmon broodstock for the stocking program were unable to be obtained on the Morell River. Luckily, there were salmon holding in the North River in Milton and these salmon provided eggs for the stocking program that year. Some of the fall fingerlings from these fish were stocked into the North River at the Crabbe Road in autumn 2009. In 2014, a fish-kill occurred on the same tributary, and juvenile salmon were amongst the casualties. With very low numbers of redds in recent years, even isolated events such as this will be catastrophic for Atlantic salmon recovery. The river will not reach its potential for Atlantic salmon production until the issues around erosion from agricultural land are addressed.

3. The City of Charlottetown has opened a new well within the Coles Creek drainage area. It is hoped that water extraction will not impact salmonid habitat in this stream as occurred in the Winter River.

4. The North River has very cold summer water temperatures. It would be worthwhile to install temperature data loggers in each of the tributaries to monitor temperatures throughout the year.

Stream bottom at Loyalist Rd electrofishing site, 2018

Atlantic salmon captured in North River in 2008

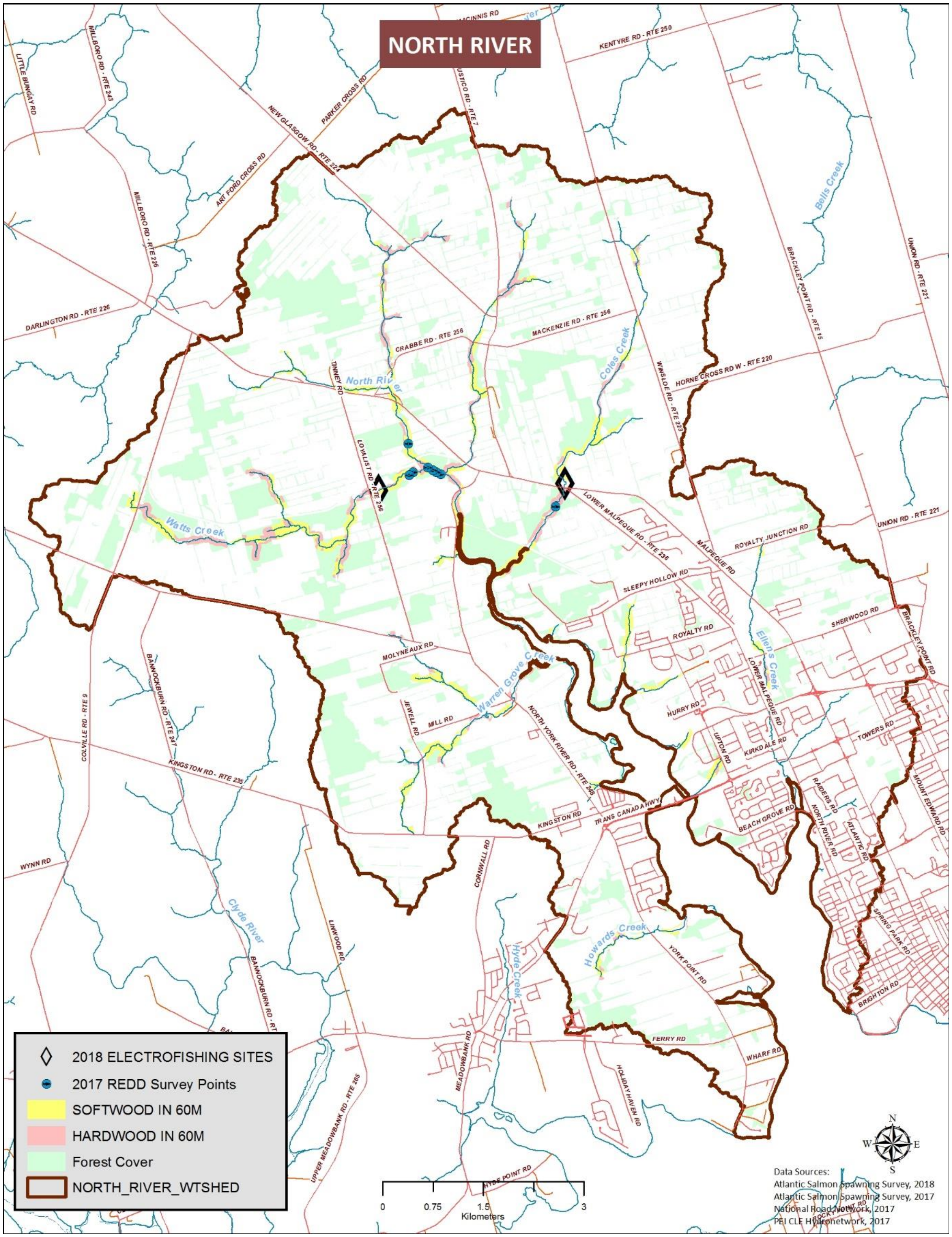


Figure 4.3. North River watershed showing location of 2018 electrofishing sites and 2017 redds

CLUSTER 5. Vernon River

Overview

Watershed/riparian context

- Forest composition in 60 metre buffer - 20.6% mixed hardwood, 39.3% softwood, and balance non-treed (about 40%).
- Riparian Buffer- Variable; 15 metre to greater than 60 metre treed buffer with mature hemlock in areas, and maple, poplar, spruce, and agricultural escapes such as apple; narrow and steeply sloping banks on stretches abutting roads.

Instream

- Canopy cover 50%; higher in areas with mature trees at bank.
- Numerous springs; moderate water temperature; shale with cobble and gravel substrate provides good spawning and parr habitat; sediment building up in areas due to instream blockages; some pools; plentiful LWD.
- Mature trees help stabilize banks on steeper slopes, provide shade and organic input to system but numerous deadfalls and blockages in stream could block access and/or modify channel.

Atlantic salmon data (Table 5.1.)

Table 5.1. Salmonid density and Atlantic salmon redds for the Vernon River. Note that the historical electrofishing sites may not be in identical locations to 2018 sites.

Site	***Water temp. (^{0}C)**	**Salmonid density (number fish/$100m^2$)**					**AS redds[1]**	
		year	**BT**	**RT**	**AS**	**AS size range (cm)**	**year**	**number**
MacMillans Dam	11.5	**2018[2]**	**7.1**	**0**	**40**	5.7 - 12.4	2008	0
							2012	7
		2002[3]	-	-	Yes		2013	11
		2007[3]	-	-	Yes		2014	(8)
		2008[3]	-	-	n/a		2015	0
Forks Glencoe Rd.	12	**2018[2]**	**38.6**	**10.5**	**10**	7 - 14	2017	17
		2002[3]	-	-	0			
		2007[3]	-	-	6.2			
		2008[3]	-	-	n/a			

1- Oak Meadows (2018); **2**- 2018 electrofishing survey; **3**- Guignion and Oak Meadows (2009)
AS- Atlantic salmon; BT – brook trout; RT – rainbow trout; Yes- present in spot check
* water temperature at time of 2018 electrofishing survey

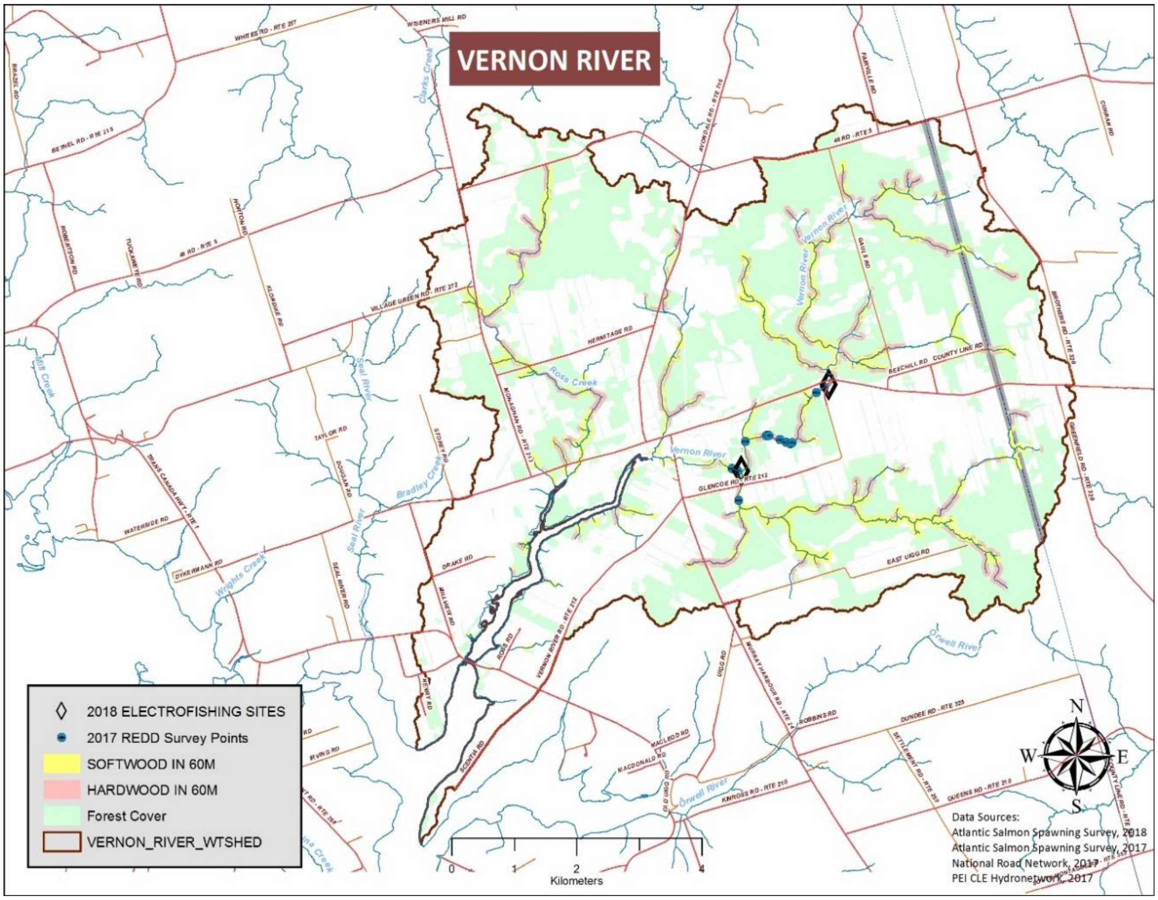


Figure 5.1. Vernon River watershed showing location of 2018 electrofishing sites and 2017 redds

The Vernon River has long been known as a good river for salmonids, including Atlantic salmon. Its primarily wooded riparian zone and extensive wetlands in its headlands provide protection from erosion and runoff evident in other watersheds. In 2009, it was noted that extensive beaver blockages were limiting the potential for Atlantic salmon, in particular a dam at the upper end of MacLeans Pond that appeared impassable for upstream movement of anadromous fish (and likely explained the absence of salmon redds in 2008). Since that time, extensive work by the local watershed group to restore salmon habitat has resulted in the presence of salmon redds in recent years, albeit at low and fluctuating levels. However, the density of juvenile salmon in 2018 is a promising sign for return of good salmon runs to this river with additional habitat restoration.

Status - There was good juvenile salmon density in 2018 and both 0+ and 1+ age classes were present. Salmon redd numbers have varied widely in the past decade but the seventeen redds counted in 2017 is the highest count in recent years.

Potential – The density of juvenile salmon in 2018 was higher than might be expected from the small number of redds found in 2017, pointing to an excellent juvenile survival rate. In the summer of 2018, a beaver dam upstream from MacMillans Pond was removed and there may be opportunities for range expansion in this zone. The density of juvenile salmon that were found from so few redds is impressive and bodes well for the expansion of Atlantic salmon into other accessible streams draining into the same estuary.

Management Issues and Recommendations

1. While some instream woody debris is desirable for salmon habitat, there were a number of severe blowdowns observed between McLeans and MacMillans Ponds during the 2017 spawning survey that had potential to erode banks and lead to stream braiding and a widened channel. Ongoing effort is needed to remove excess debris and open braided channels in this stretch. Much of this work appears to have been completed in 2018.

Potential blockages from fallen trees in Vernon River, 2018

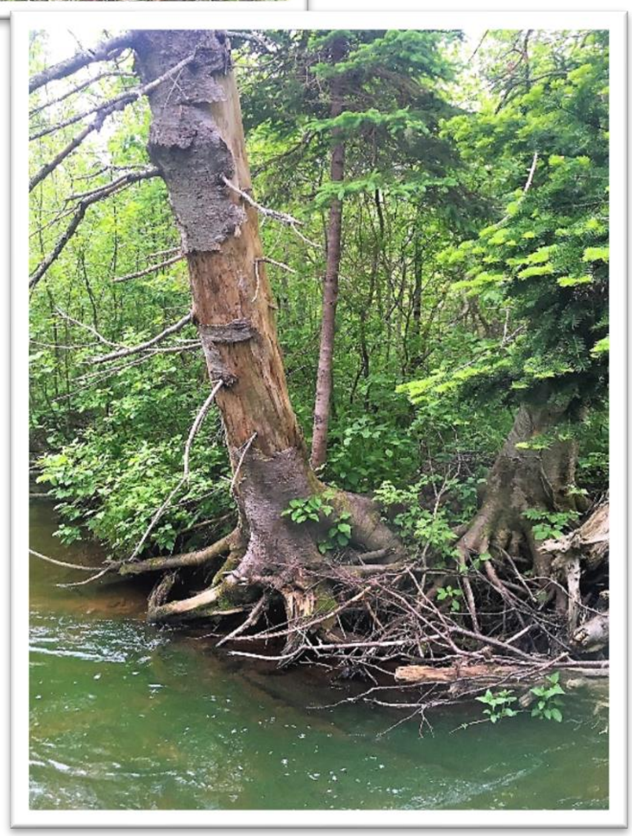
2. Additional restoration work, for example brush mats and pool restoration, should be delayed until major blockages are removed and stream flow is naturalised.

3. The section of stream below MacMillans Pond has excellent spawning gravel which likely explains the high density of juveniles found in this area. Annual raking of spawning beds in other areas in late summer could enhance and maintain spawning and juvenile habitat until habitat work and sediment stabilization is completed.

4. There are pockets of old growth hemlock along the river, and it would be desirable to work with landowners to expand the 15 metre buffer zone and to manage diversity and regeneration in old growth areas.

5. Vernon river is isolated from other rivers so it would be beneficial to improve habitat in nearby rivers that drain into the same estuary. In Seal River, for example, the watershed group has reported seeing salmon redds in 2013 and 2016 but a spot check in the area did not find any juvenile salmon in 2018. This river should be assessed further to see if salmon are present and to identify areas that may benefit from stream restoration work for Atlantic salmon.

Vernon River electrofishing site, 2018



Mature tree growth along Vernon River, 2018

CLUSTER 6. Pisquid River, Clarks Creek, Head of Hillsborough River

Table 6.1. Salmonid density (number fish/100m^2) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for the Pisquid River, Clarks Creek, and Head of Hillsborough River.

Site	*Water temperature (^{0}C)	AS density	AS size range (cm)	BT density	RT density	AS redds (2017)
Clarks a) Callaghan	11.8	0.7	12.2	23	6.7	4
Clarks b) Wiesner	12.7	7.3	11-12.5	4.9	2.4	
Pisquid 800 m above East branch	10.8	7.5	10.1-12.3	62.1	16.6	28
Pisquid 100m above forks on main branch	11.8	4	6.5-11.4	19.8	10.9	
Head of Hillsborough	7.7	No	n/a	Yes	Yes	0

AS – Atlantic salmon; BT – brook trout; RT – rainbow trout; Yes/No – present /absent in spot check; *water temperature at time of 2018 electrofishing survey

Field consolidation in Clarks Creek watershed, 2018

This cluster includes the Pisquid River, Clarks Creek and Head of Hillsborough River located within the Hillsborough River watershed. Intensifying row crop production in this watershed poses significant challenges to these rivers that are still recovering from historical sediment loading. Agricultural field consolidation and hedgerow removal is evident throughout this region and is increasing the severity of soil erosion and sedimentation.

Salmon spawning continues in the east branch of the Pisquid River, but low water levels and a scarcity of pools in the west branch may limit use of that area by salmon. Spawning has returned to Clarks Creek but at very low levels. Juvenile salmon were found in both Pisquid River and Clarks Creek. No salmon were found in the Head of the Hillsborough River although an experienced angler reported catching two Atlantic salmon parr in Warrens Pond in the spring. The Head of Hillsborough River will require extensive and ongoing management for return of salmon, although it does have good densities of brook and rainbow trout. Brown trout are occasionally caught in this region, especially in the Pisquid River.

6.1. Pisquid River

Overview

Watershed/Riparian context

- Forest cover/land use in watershed - 59% of the watershed is forested, 874 hectares is government property, and 31% of the land use is agricultural. The watershed has many areas of ecological significance such as the Dromore Provincial Forest trail, the Auburn Demonstration woodlot trail, and the Pisquid River wildlife management area.
- Riparian Buffer – greater than 60 metres, especially in provincial management areas; variable composition, e.g., at electrofishing site is open in near-stream areas (grass, aster and goldenrod, alders) with mature mixed woods at 10 to 15 metres from bank.
- Forest composition in 60 metre buffer - 21.8% mixed hardwood, 46.1% softwood, and balance non-treed (about 30%).

Instream

- Canopy cover variable; at electrofishing site was 25% (despite dense riparian growth, the canopy closure is low over wider sections of the river).
- Gravel-cobble substrate with minor embedding in areas; channel is shallow and wide, with riffles, shallow pools, some instream aquatic macrophytes and moderate water temperature.

Table 6.1.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for the Pisquid River.

<table>
<tr><th colspan="3">AS density</th><th colspan="2">AS redds[1]</th></tr>
<tr><th>Site</th><th>year</th><th>density</th><th>year</th><th>number</th></tr>
<tr><td>800m above east branch</td><td>2018[2]</td><td>7.5</td><td rowspan="4">2008
2009
2010
2011
2012
2013
2014
2015
2016
2017</td><td rowspan="4">38
-
(37)
68
35
39
(15)
47
29
28</td></tr>
<tr><td>east branch</td><td>2002[3]
2007[3]
2008[3]</td><td>0
12
n/a</td></tr>
<tr><td>100 m above forks on main branch</td><td>2018[2]</td><td>4</td></tr>
<tr><td>Forestry bridge</td><td>2002[3]
2007[3]
2008[3]</td><td>9.4
17.7
n/a</td></tr>
</table>

1- Oak Meadows (2018); **2**- 2018 electrofishing survey; **3**- Guignion and Oak Meadows (2009); AS – Atlantic salmon; ( ) – incomplete count

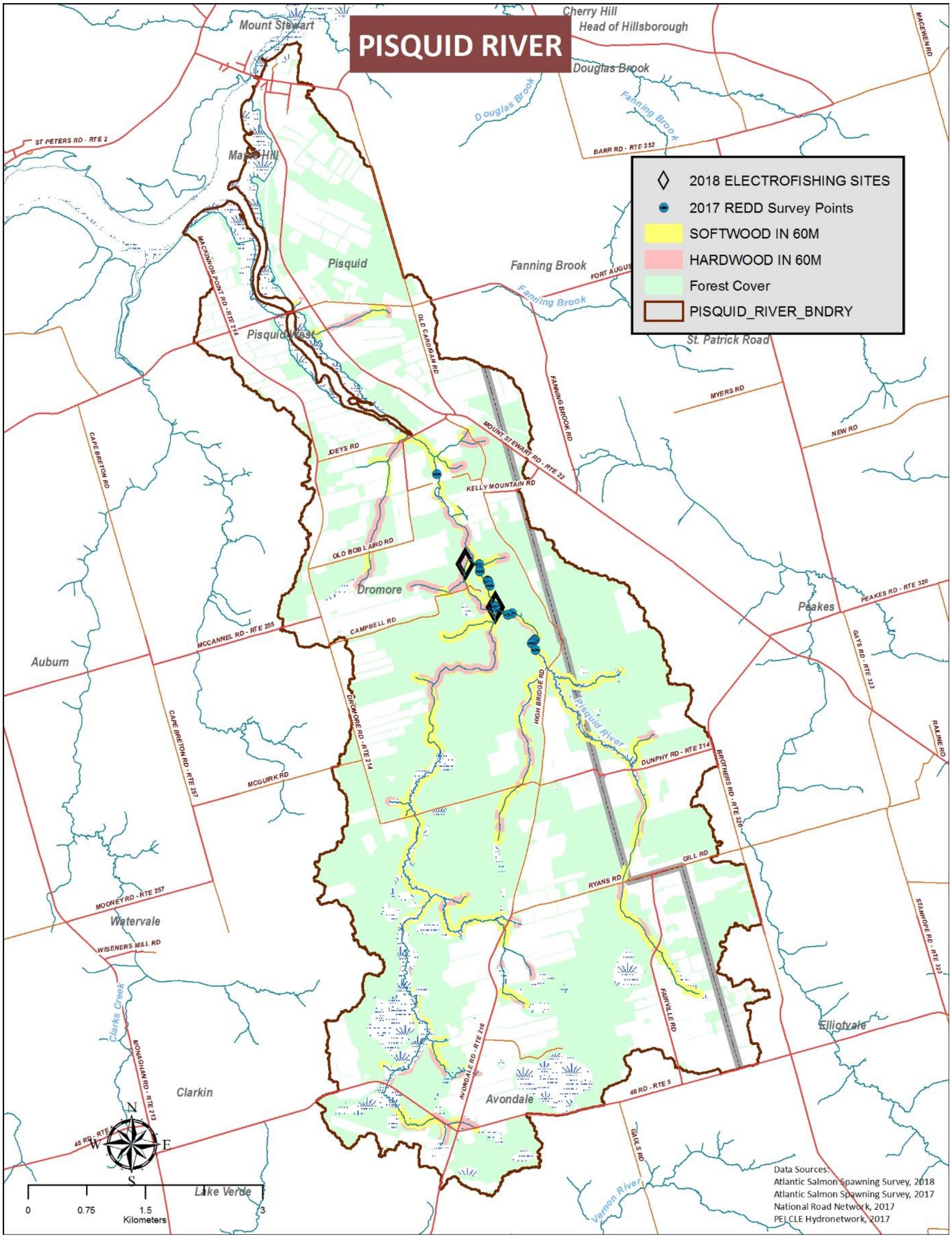


Figure 6.1. Pisquid River watershed showing location of 2018 electrofishing sites and 2017 redds

Status- After some notable gains in the number of salmon redds in the past decade, the number appears to have stabilized at about 30 redds in the east branch of the Pisquid River. Juvenile salmon densities were low in 2018 and have been variable since 2002. Although redd numbers have increased and remained relatively stable, the low juvenile density raises some concern.

Potential - With most other rivers draining into the Hillsborough River having lost their runs of Atlantic salmon, the Pisquid River takes on a special importance as a primary salmon river in the Hillsborough watershed. The high proportion of protected government-owned forested land in the watershed, good nursery and parr habitat in steeper gradient areas, and the extensive habitat restoration and beaver management by the local watershed group should enable this river to support stable salmon populations in the future.

Rich riparian zone and characteristic tea-coloured water in Pisquid River, 2018 (above)

Gravel-cobble substrate with healthy aquatic macrophytes, 2018

Management Issues and Recommendations

1. East Branch – The east branch has a relatively low gradient and flows from southeast with a high ridge to the southwest. Numerous springs are found along this tributary and the bottom is often covered with watercress. Both brook trout and rainbow trout are abundant.

   The salmon redds encountered seemed small, and the two adults observed were grilse. Where salmon redds normally occur, the bottom has good gravel but overhead trees do not provide much shade. This may be fortuitous since the abundance of springs (7˚C year-round) might keep the water temperature too low for salmon fry to commence feeding without the solar radiation (see Section 2.6).

Salmon redd in the Pisquid River, 2017 (photo courtesy of Central Queens Wildlife Federation)

   There have been major efforts to manage the excess sediment load in the river from agriculture, clay roads, and decommissioned impoundments, but it may take several years for the existing sediment to work its way through the system. The amount of sediment that continues to enter the river from intensive agriculture areas upstream is truly discouraging after the immense effort to contain and remove it. These ongoing sediment sources need to be systematically identified and addressed.

2. South Branch – This tributary has a considerable amount of wetland near the headwaters. Downstream from the Floating Bridge road, the gradient increases and habitat down to the forks would appear ideal for Atlantic salmon. Unfortunately, this branch is wide and shallow, and appears to have much less flow in summer than a few decades ago. This may discourage salmon from proceeding upstream to spawn and even though there is an excellent cobble bottom, deep pools are absent. It would be advisable to develop "holding" pools every half a kilometre. Rock cribs used in other rivers have proven successful.

   Beaver blockages should continue to be assessed and managed as needed. As noted in 2009, with low salmon numbers, even intermittent blockages could lead to a collapse of the population.

6.2. Clarks Creek

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - flows into the Hillsborough River, 4350 ha watershed area with 38 km of stream; ~50% forested, balance predominately agriculture.
- Riparian buffer - 15 m up to 60 m plus treed buffer (mixed birch, maple, spruce) in sections; shallow slope, with grassed banks in near-stream areas.
- Forest cover in 60 m buffer zone - 20.3% mixed hardwood, 44.1% softwood and balance non-treed (about 35%)

Instream

- Canopy cover up to 50% with mature trees.
- Good gravel-cobble bottom in reaches; moderate flow but significantly faster and deeper at electrofishing site after a heavy rain; shallow at banks with gravel; some deeper pools, riffles, LWD and bank undercuts.
  Note - The area at the electrofishing site was recently cleared and brush mats added but there was significant sediment loading in fall of 2018, likely from agricultural field expansion.

Table 6.2.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Clarks Creek

Atlantic salmon density			Atlantic salmon redds[2]	
Site	**year**	**density**	**year**	**number**
Clarks Creek a)	**2018[1]**	**0.7**	2008 2012 2013 2015 2017	0 0 3 (0) 4
b) 500 m above forks at Cape Breton Rd	**2018[1]**	**7.3**		
Cape Breton Rd	2002[3] 2007[3] 2008[3]	n/a 52.5 n/a		
Auburn Rd	2002[3] 2007[3] 2008[3]	0 n/a n/a		

1- 2018 electrofishing survey; 2- Oak Meadows (2018); 3- Guignion and Oak Meadows (2009);

( ) – incomplete count

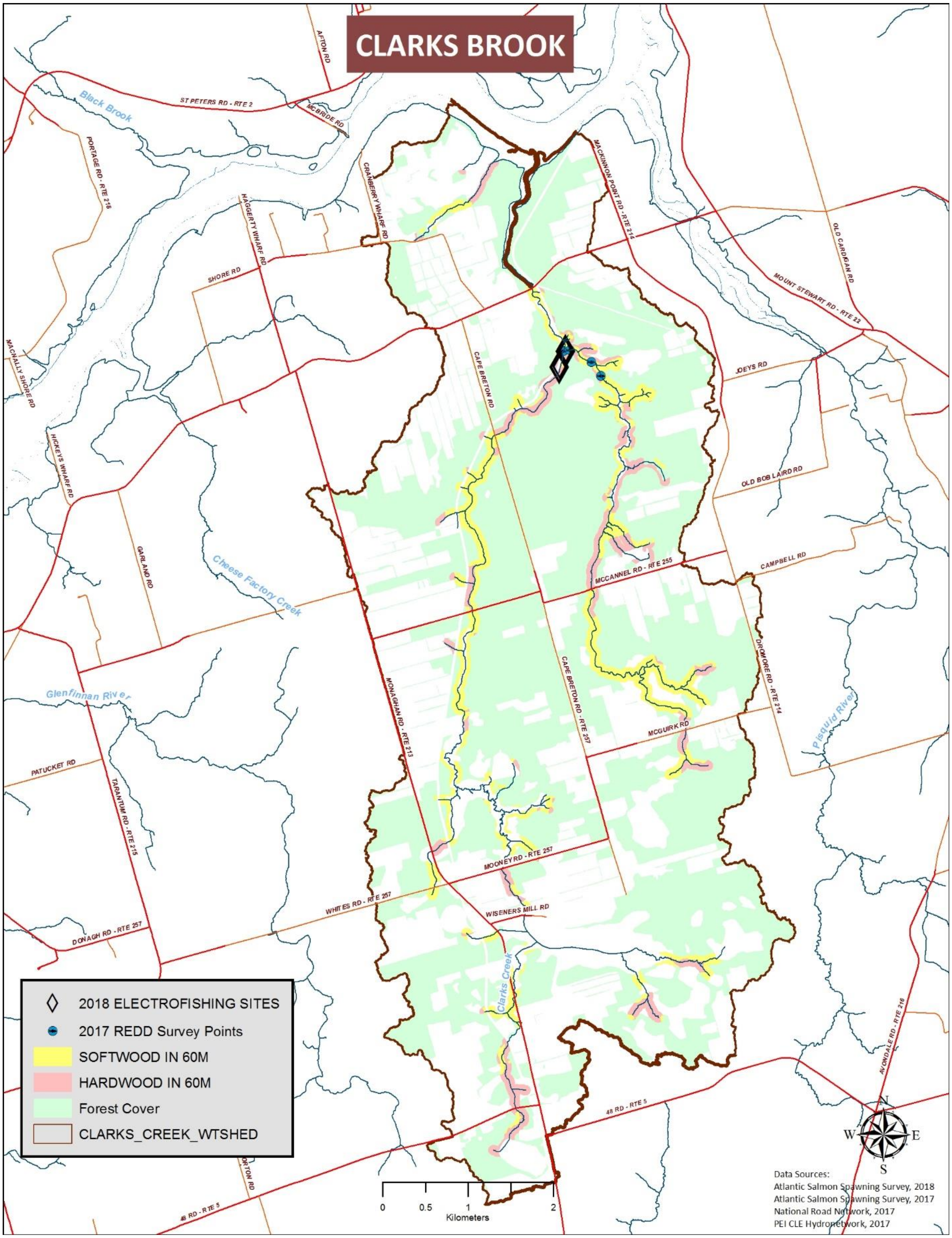


Figure 6.2. Clarks Creek watershed showing location of 2018 electrofishing sites and 2017 redds

Status - Although juvenile salmon density was low in 2018, it was higher than might have been expected from the very low number of redds in 2017. Salmon redds had disappeared from this stream in 2008 and in the 2009 report, there was concern that the deterioration of instream habitat might have already progressed too far for salmon runs to recover. The return of salmon to this river since then is a promising sign.

Potential - Clarks Creek and the Pisquid River are important as the only remaining salmon-bearing streams in the Hillsborough cluster. Together these rivers provide a more resilient basis for salmon recovery in the region. While it is a positive sign that juvenile Atlantic salmon have been found in all four branches of the two rivers, in spite of the challenges, increasing land use pressures are going to make it difficult for a full salmon recovery.

Good gravel-cobble stream bottom at Clarks Creek electrofishing site, 2018

Management Issues and Recommendations

1. Clarks Creek has two major tributaries and flows from the south before entering the Hillsborough River about 1 kilometre downstream from Jays Pond. The western tributary was blocked in many places during the 2017 redd survey. A major storm had uprooted numerous trees which fell perpendicular to the stream flow, creating many possible barriers to fish passage. Energetic workers with chainsaws restored good access in 2018. With such low salmon densities, even intermittent blockages could lead to extirpation of the local population, and we advise ongoing vigilance and clearing as needed, especially after severe weather events.

2. We also noted some channel braiding and blockages that are occurring from accumulated woody debris and sediment buildup that could become future issues. Consideration should be given to clearing of excess woody material and opening braided channels as needed to maintain good flow and access.

Channel braiding on Clarks Creek, 2018

3. Major sediment remediation work over the past decade has significantly reduced the impact of problem areas such as Cape Breton Road. However, agricultural runoff remains an issue, in large part due to agricultural intensification in the watershed such as land clearing, field consolidation and hedgerow removal. There are large clear-cuts adjacent to the river, extending beyond the Cape Breton Road. The 15 m buffer by the river was mostly respected, but there are many springs originating from the clear-cut area that may, depending on land use, carry sediment to the river in the future. Because sedimentation from agricultural intensification may limit the potential for salmon habitat despite major instream habitat restoration efforts, sources should be systematically identified and solutions sought, potentially as part of a larger regional plan.

Field clearing off Cape Breton Road, 2018

4. There have been significant instream habitat improvements made by the local watershed group. They have tried various techniques to create pools but some refinement is needed to find what works best in this type of habitat. Creation of deeper pools, raking to expose gravel-cobble reaches, and ongoing maintenance of sediment ponds will continue to improve habitat for salmon.

Signs of old brush mats on Clarks Creek

Log creating good pool/riffle habitat on Clarks Creek. The addition of rock on the corners would probably improve depth and holding cover for salmon.

6.3. Head of Hillsborough River

Overview

Watershed/riparian context

- Forest cover in 60 m buffer - 33.4% mixed hardwood, 28.5% softwood, and balance non-treed (38%).

Instream

- Canopy cover highly variable from less than 25% with shrubby and grassy banks, to greater than 50% in areas with mature spruce on steep banks.
- Water relatively cool (7.7 °C at electrofishing site); channel is wide with moderate flow; sediment covering substrate in most areas; some deep pools with accumulated sediment and woody debris at bottom.

Table 6.3.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Head of the Hillsborough River.

Atlantic salmon density			**Atlantic salmon redds[2]**	
Site	**year**	**density**	**year**	**number**
below Warrens dam	**2018[1]**	**No**	2008	0
			2011	0
	2002[3]	0	2013	0
	2007[3]	21.4	2015	2
	2008[3]	n/a	2017	0

1- 2018 electrofishing survey**; 2**- Oak Meadows (2018); **3**- Guignion and Oak Meadows (2009); No – absent in spot check

Note – the 2018 spot check found approximately 108 brook trout and 60 rainbow trout ranging in size from 5 cm to 25+ cm (in an approximate 100 metre stretch)

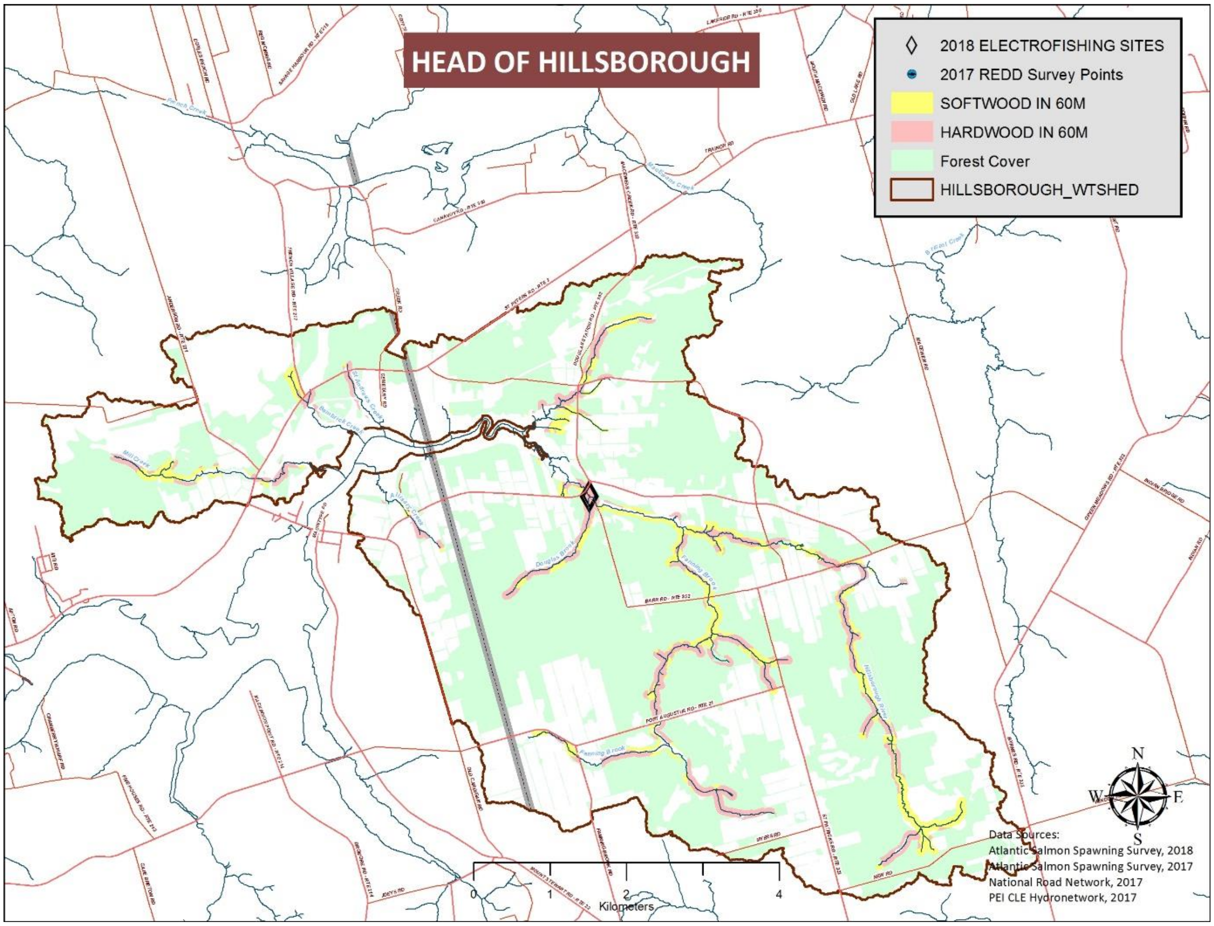


Figure 6.3. Head of the Hillsborough watershed showing location of 2018 electrofishing site (no redds were found in 2017)

Status - The salmon run in this river appears to be gone. Two (2) redds were found in 2015 but no Atlantic salmon redds or juveniles were found in Head of Hillsborough in 2017 and 2018 respectively. However, brook trout and rainbow trout are thriving**.**

Potential – Although this is a cold-water river with some stretches of good gradient and habitat, it has been heavily impacted by beaver dams and large amounts of instream sediment, especially run-off from large potato fields, and from smaller fields with steeper slopes. It will take intensive and ongoing habitat restoration and sediment control to restore salmon runs.

There has been recent effort to rehabilitate the reaches above Warren's Pond. Ongoing assessment would be needed to see if this work is successful.

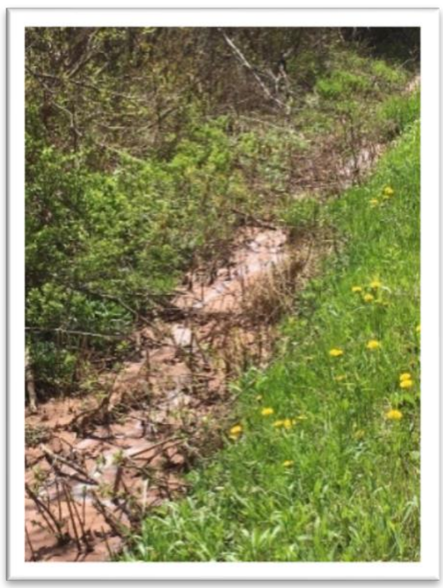
Rehabilitation work on the Head of Hillsborough River by the Abegweit First Nations stream enhancement crew, 2018

Management Issues and Recommendations

1. Roads and highways have often been blamed for the sediment entering the Head of Hillsborough River and this may have been the case in the past. In 2018, very little sediment was entering the river from roads but the opposite was true for the many potato fields in the area. In 2008, potatoes were found 60 metres into a wooded area at the bottom end of a potato field. The Abegweit Conservation Society stream crew has encountered potatoes in the stream itself.

Large sloping field off Rt 352, 2018

2. Sediment control and management will be an ongoing challenge for restoration of this river. Until the bleeding is stopped, it would be appropriate to continue to remove blockages and install brush mats. Realistically, it would not be feasible to expect salmon population recovery under these conditions.



Agricultural runoff in ditch off Old School Rd., 2018

CLUSTER 7. Bristol Creek, Morell River, Midgell River, St. Peters River

The five rivers flowing into St. Peters Bay - the Marie River, Bristol Creek, Morell River, Midgell River, and St. Peters River - have all had historical runs of salmon. The Marie River has lost its run of salmon because of the impacts of impoundments and loss of lotic habitat and is not considered in this assessment. Although redd numbers for the Morell River have decreased slightly in recent years, these numbers are second only to the very productive rivers of the northeast cluster, and the Midgell has maintained fairly consistent number of salmon redds over the past decade. However, these large rivers should be able to support more salmon. Despite low redd counts for the St. Peters River, this river had one of the higher juvenile salmon densities in 2018, likely due to the excellent juvenile habitat. However, this represents a significant drop from historical levels. The redds are restricted to a very small stretch of this river because of beaver expansion in upper tributaries, and opening additional spawning and nursery habitat would likely result in increased salmon runs. Bristol Creek had very low redd numbers and no juvenile salmon were found in 2018. Intensive habitat restoration and beaver management would be required for salmon to return in any number.

Table 7.1. Salmonid density (number fish/100m^2) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for Bristol Creek, Morell River, Midgell River and St Peters River.

Site	Water temp. (^{0}C)	BT density	AS density	AS size range (cm)	AS redds (2017)
Bristol Creek	6.5	28.7	0	n/a	8
Morell South Branch	8.2	9.2	19.9	6.1-14.5	191
Morell West Branch	8.7	16.8	3.6	12-15	
Morell at Cranes	8.7	5.4	21.4	6.5-14.1	
Midgell at Elm Rd	10.6	15	0.6	6.5	104
Midgell below at Pius McDonalds Pond	11.3	1	22.9	5.5-14.5	
St. Peters River	9.3	3.2	51	6.3 – 14.5	19

AS- Atlantic salmon; BT – brook trout

The Morell River is an example of what can be done to protect and enhance our streams and rivers. In 1974 the Morell and Area Land Use Steering Committee - concerned about habitat degradation, declining populations of trout and salmon and proposed development along the river - succeeded in establishing the Island’s first protected conservation zone.

2018 electrofishing site

Working with the cooperation of individual landowners, a 60 m wide buffer zone was designated on both sides of the Morell River. Since that time, the conservation area has expanded to include wider buffers on Crown-owned land, special purchases to protect wetland areas, and donations to organizations such as Island Nature Trust to purchase and protect additional land. The Conservation Zone now extends from the railway crossing at St. Peters Bay upstream to Hazelgreen Road on the east branch, and the headwaters of Leards Pond for the south and west branches. With its large proportion of protected natural areas, this region has become a mecca for angling, bird watching, hiking, canoeing, hunting, and trapping on PEI.

Collectively, the rivers in this cluster have enormous potential for Atlantic salmon but their restoration poses significant challenges:

- The St. Peters Bay drainage basin comprises four major rivers and a few smaller streams and is too large an area for the number of workers currently employed by the Abegweit band and the Morell River Coop. More crews are needed if major improvements in salmon populations are to be gained.

- The continued presence of beaver dams in "beaver free" zones is affecting the recovery of Atlantic salmon in these rivers. A program of paying trappers to remove beavers has been implemented but appears to have had limited success in managing the problem.

7.1. Bristol Creek

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed: 59% forested
- Riparian buffer – 15 to 30 metres; mixed hardwood/softwood with shallow floodplain in first 15 m and agricultural fields (blueberry) in headland at electrofishing site.
- Forest composition in 60 metre buffer - 42.1% mixed hardwood, 31.5% softwood, balance non-treed (about 26.5%).

Instream

- Canopy cover ~50% at electrofishing site.
- Gravel and cobble substrate with some embedding; LWD on banks from fallen trees, undercut bank in areas.

Atlantic salmon data

- Atlantic salmon redds - 8 redds in 2017; highly variable from 2008 to 2016 (range: 0 to 23)
- Juvenile Atlantic salmon – none found in 2018. Present in a spot check in 2008.

Status - Low and variable numbers of salmon redds have been found on this river since 2008, but no juvenile salmon were found in the 2018 electrofishing survey. St. Peters Lake is an especially popular area for angling for spring sea trout.

Potential – In 2009, it was recommended that beavers and their dams be removed from the main tributary and habitat enhancement be continued to prevent the disappearance of Atlantic salmon. Since that time, the Morell River Management Coop has addressed barriers to fish passage, constructed brush mats to contain sediment, and cleared blow-downs as needed but salmon populations have not recovered. However, additional management efforts as identified below may improve this outlook.

Management Issues and Recommendations

1. Maintain access spring and autumn - Beavers and their dams should be removed from the upper end of St. Peters Lake to the Cemetery Road. If this is impractical, passage should be available to the "Big Spring", which is known as a principle spawning area for sea-run brook trout. It would be recommended to do periodic checks, especially in spring and fall, to ensure that salmon can migrate into and out of the river.

2. Spawning habitat – If time and resources were available, the watershed crew should seek advice on where salmon do, or should, spawn and then rake the gravel to improve the quality of spawning and juvenile habitat in these sites.

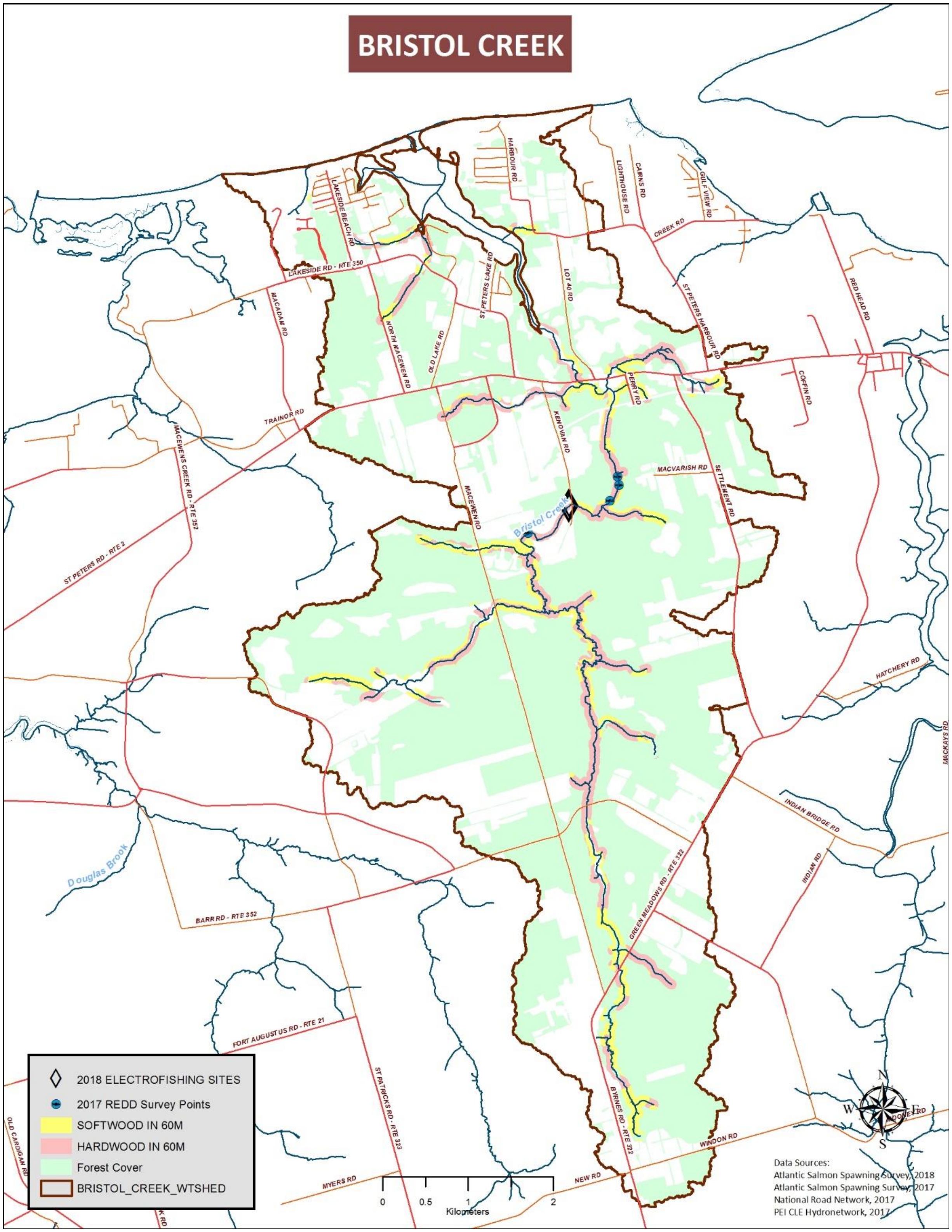


Figure 7.1. Bristol Creek watershed showing location of 2018 electrofishing site and 2017 redds

Riparian zone at Bristol Creek electrofishing site (above and left)

Gravel-cobble bottom with some embedding at electrofishing site

7.2. St. Peters River

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - 55% forested.
- Riparian Buffer - 30 metres plus; steeply sloping in part with mixed tree cover (maple, spruce dominant).
- Forest composition in 60 metre buffer - 42.5% hardwood, 32% softwood, and balance non-treed (about 25%)

Instream

- Canopy cover up to 75%.
- Medium to large cobble substrate; channel wide, fast, with riffles in stretches; cover from uprooted trees on bank, some bank undercutting.

Table 7.2.1. Juvenile Atlantic salmon density (number fish/100 m^2) and Atlantic salmon redds for St. Peters River.

Atlantic salmon density		Atlantic salmon redds [2]	
year	**density**	**year**	**number**
2018[1]	**51**	2008	53
		2009	-
2002[3]	169.8	2010	-
2007[3]	88.7	2011	53
2008[3]	n/a	2012	70
		2013	44
		2014	43
		2015	67
		2016	(20)
		2017	19

1- 2018 electrofishing survey; **2**- Oak Meadows (2018); **3**- Guignion and Oak Meadows (2009);

( ) incomplete count

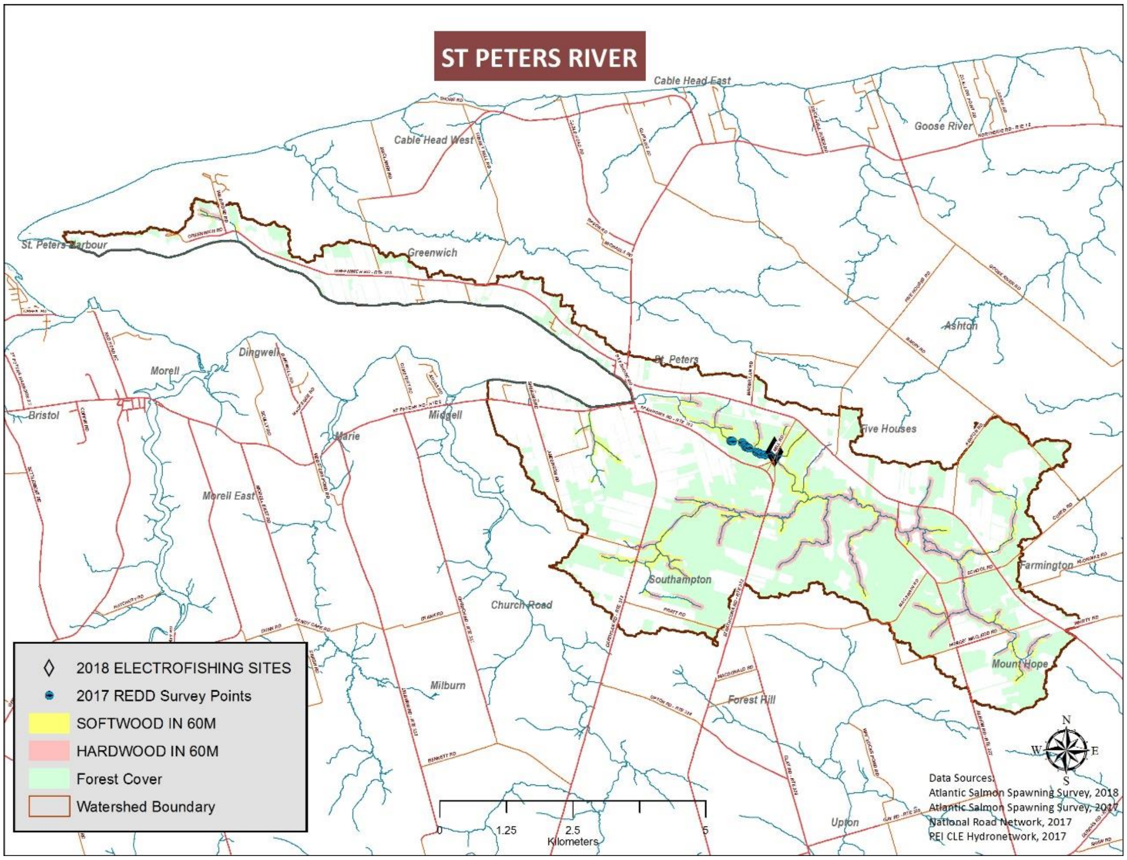


Figure 7.2. St Peters River watershed showing location of 2018 electrofishing site and 2017 redds

Status - St. Peters River had a high density of juvenile salmon in the 2018 survey relative to other PEI salmon rivers, and second only to North Lake Creek. However, this represents a significant drop in density since 2002 for this river. Redd counts were low in 2016 and 2017 compared to previous years (2008 to 2015) and may account for lower juvenile density.

The crib structures installed downstream from the Mill Road in the mid-1990s were successful in providing pools with spawning areas and juvenile habitat in this section. The 2009 Strategy recommended restoration work on the southeast tributary to increase the habitat area available to salmon but its current status is unknown.

Potential – The St. Peters River has an excellent cobbled substrate and this is likely a key contributor to juvenile success. The riparian zone is largely treed and water quality is good with minimal impact from surrounding land use. A large portion of the river is impounded and there the stream is too deep, slow and warm to support salmon. Salmon populations could increase if targeted restoration efforts were made on the remaining stream that retains lotic habitat and suitable substrate.

St Peters River riparian zone

Management Issues and Recommendations

St. Peters River cobble

1. This river should be checked in spring (before smolts go to sea) and again in autumn (before adults arrive) to ensure no beaver dams block migration. This is important because most of the river is riddled with beaver blockages. A vigorous trapping program is needed to control the beaver population in the remaining salmon producing sections of the river. The beaver free section of the St. Peters River, from the head of tide upstream to the Strathcona Road, must remain open as the river cannot afford to lose any of the small amount of salmon habitat remaining.

2. As beaver dams are removed, brush matting will assist with sediment consolidation and channel definition.

3. The productive salmon habitat downstream from the Mill Road should be monitored closely to see if the loss of the crib structures impacts juvenile salmon habitat.

4. The Department of Communities, Land and Environment is assessing former sanitary landfill sites across Prince Edward Island. One such site downstream from Quigleys Pond is close to the river and may be contributing contaminants to the stream.

7.3. Midgell River

Overview

Watershed/Riparian Context

- Forest cover/ land use in watershed- 67% forested.
- Riparian buffer – 60 metres plus; flat floodplain with alder and tall grass, then mature line of spruce infilling with maple, larch (planted by watershed group) at electrofishing site.
- Forest composition in 60 m buffer - 35.3% mixed hardwood, 34.3% softwood, balance non-treed (about 30%).

Instream

- Canopy cover patchy, varying from 25% to 50%
- Cobble substrate; dense milfoil in sections; turbid with sediment except in riffle areas where water is clear with watercress at shore; meandering (old braided channel); deep in stretches
- Water quality - Midgell estuary had an anoxic event in 2016 although nitrates are low, likely due to a combination of low tidal flushing, warm water temperatures and extreme low tides.

Table 7.3.1. Juvenile Atlantic salmon density (number fish/$100m^2$) and Atlantic salmon redds for the Midgell River.

Atlantic salmon density			Atlantic salmon redds[3]	
year	**Elm Road**	**below Pius MacDonalds Pond**	**year**	**number**
2018[1]	**1**	**22.9**	2011	110
2002[4]	-	19.4	2012	81
2007[4]	-	66.7	2013	(36)
2008[4]	-	n/a	2014	76
2017[2]	3	18.9	2015	140
			2016	n/a
			2017	104

1- 2018 electrofishing survey**; 2**- Forests, Fish and Wildlife; **3**- Oak Meadows (2018); **4**- Guignion and Oak Meadows (2009); ( ) incomplete count

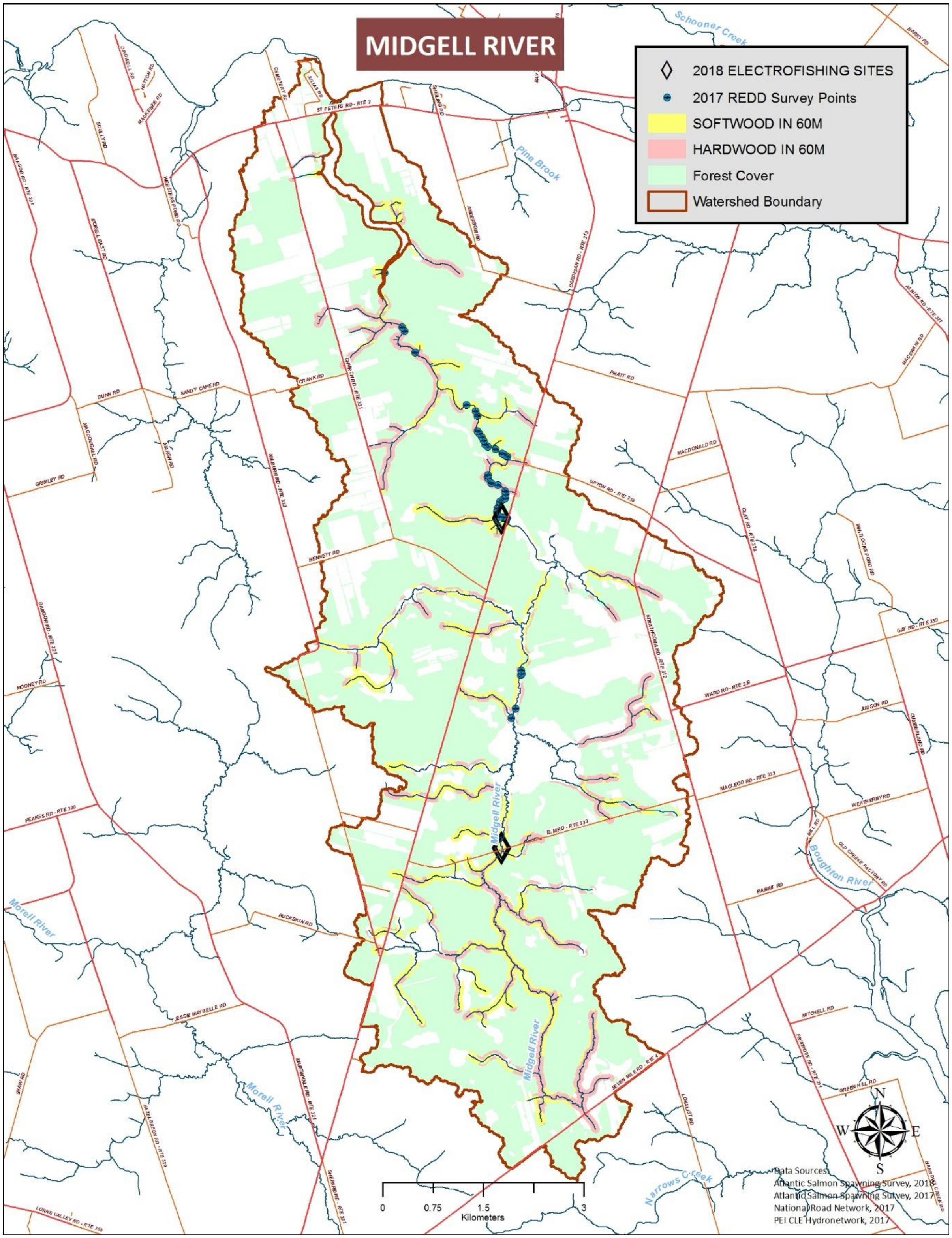


Figure 7.3. Midgell River watershed showing location of 2018 electrofishing sites and 2017 redds

Status – There was a good number of salmon redds in 2017, although there has been a lot of variability in the number of redds over the past decade. The density of juvenile salmon in 2018 is lower than would be expected for such a large system.

Potential - Historically, the Midgell River was a very important salmon river for PEI. In the 1990s the Native Council of PEI maintained the section from Pius MacDonalds Pond to the head of tide free from beaver blockages. In the first salmon conservation strategy it was noted that beaver dams were preventing salmon from reaching prime spawning and nursery habitat downstream from Pius MacDonalds Pond. Due to a renewed effort by the Abegweit First Nations, spawning has increased and juvenile salmon are found at moderate levels, but at levels far below the potential of this river.

Management Issues and Recommendations

Pius MacDonalds Pond lies just upstream from the Cardigan Road (Route 313). Immediately downstream from the road is one of the best Atlantic salmon spawning sites on PEI. Many decades ago it was the site of a former mill pond and since it washed out, over a kilometre of stream contains a mix of graveled riffles and small pools. Numerous salmon spawn in this location and also in other sites further downstream. Pius MacDonalds Pond acts like a giant sediment trap which protects downstream spawning and nursery habitat. Further downstream, the gravel/cobble turns to more of a cobble/small boulder mix, excellent habitat for 1+ Atlantic salmon parr.

The current operating level of Pius MacDonalds Pond is higher than it was in the past. As a result, former spawning and juvenile habitat is no longer suitable for salmon. With enormous acreages of shallow water exposed to solar radiation, the water gets very warm and our dataloggers show that water temperatures leaving Pius MacDonalds Pond reach 27 $^{\circ}$C in summer for long periods of time. This is one of the few sites on PEI where no brook trout were found during a thorough electrofishing survey.

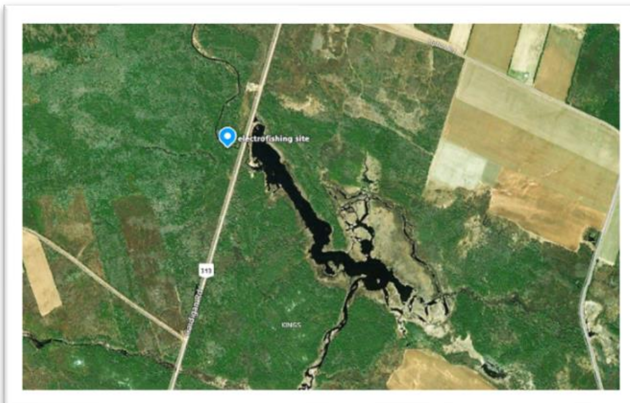
1. Measures are needed to reduce the summer water temperature in and downstream from Pius MacDonalds Pond. The pond was dewatered in 2018, but it should be maintained at a lower level and debris removed from the channel for faster flow to reduce summer temperatures.

2. Juvenile salmon were found at the Elm Road, indicating that successful spawning has occurred upstream from Pius MacDonalds Pond. When the operating level of the pond is reduced, restore salmon habitat upstream from Pius MacDonald Pond where there used to be good salmon spawning locations. This may involve raking to loosen up embedded gravel and cobble substrate or providing cover for adult salmon prior to spawning. In 2017, several salmon redds were observed in a previously raked section of stream bottom just below the former Dr. Wenn MacDonalds Pond (midway between Pius MacDonalds Pond and the Elm Road).

3. An assessment is needed of potential salmon habitat upstream from the Elm Road.

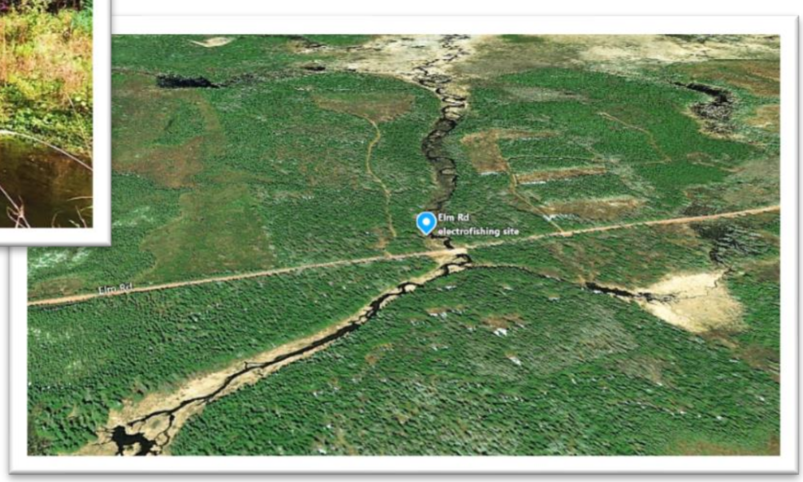
4. Intensive beaver management is required to ensure that the current beaver-free section of river (main branch to the junction of the McCarricks tributary – about 2.5 km upstream from the Elm Road) is maintained. Regular surveillance is needed to ensure that salmon have access into and out of the river.

5. The Abegweit Conservation Society has started a fish counting, tagging and tracking program in the Midgell River. It would be worthwhile continuing and expanding this project.



Electrofishing site downstream of Pius MacDonalds Pond (above and right)

Electrofishing site at the Elm Road



Flat topography at the Elm Road site

7.4. Morell River

Overview

Watershed/Riparian Context

- The Morell is the largest of the St Peters Bay watercourses and splits into many tributaries, yielding a total stream length of approximately 140 km.
- Forest cover /land use in watershed - 58 % forested
- Riparian buffer- Variable; e.g., greater than 60 metre treed buffer in conservation areas; 15 metre buffer with blueberry field in headland; 30 metre alder floodplain with some maple infilling and mature spruce and poplar on slopes.
- Forest composition in 60 metre buffer - 24% mixed hardwood, 46.7% softwood with balance non-treed (about 30%).

Instream

- Canopy cover variable from 25% to 50% (in areas with dense alder at bank)
- Gravel-cobble substrate (with some round large cobble); some sediment embedding; milfoil on rocks; water fast (in fall 2018 seemed higher and faster than usual), riffles, pools (deeper pools at logs); alders on bank provide cover.
- Water quality - The Morell River is cold in the winter (with anchor ice sometimes present) and warmer in the summer than other “large” rivers such as the West River and Dunk River. The Morell has several man-made impoundments as well as beaver dams in the headwaters that cause the water to warm considerably at the main branch below Leards Pond, holding at 24˚C throughout much of the summer.

Table 7.4.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for the Morell River**.**

Atlantic salmon density				**Atlantic salmon redds**[2]	
year	**South Branch**	**West Branch**	**Cranes**	**year**	**number**
2018[1]	**19.9**	**3.6**	**21.4**	2011	450
2002[4]	-	-	21.3	2012	(243)
2007[4]	-	-	62.4	2013	(326
2008[4]	-	-	14.9	2014	388
2017[3]	38.3	-	14.8	2015	(143)
				2016	204
				2017	191

1- 2018 electrofishing survey; 2- Oak Meadows (2018); * 3- Forests, Fish and Wildlife;
4-Guignion and Oak Meadows (2009); ( ) incomplete count

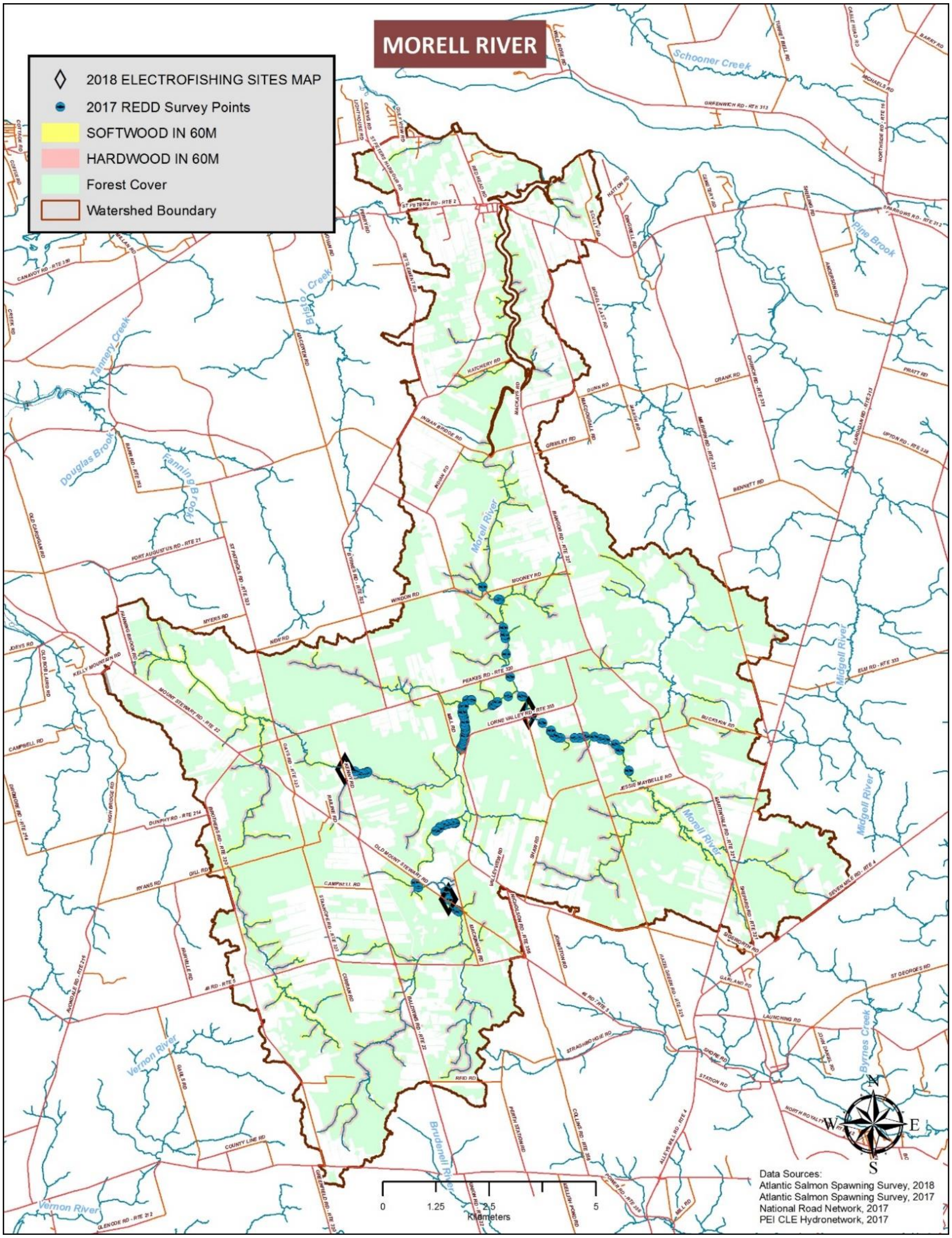


Figure 7.4. Morell River watershed showing location of 2018 electrofishing sites and 2017 redds

Status - The Morell has maintained a good number of redds over the past decade, although there has been a drop from the very high numbers in 2011. Juvenile density is considered low for such a large system. The Morell is the most popular river for salmon angling in Prince Edward Island and its estuary is also a key destination for early season angling for sea trout.

Electrofishing site at Kennys Road

Potential - The Morell has long been considered one of the preeminent salmon rivers on PEI with salmon runs estimated to be in the thousands in the early 1990s. Designation of a 60 metre conservation zone along the river in 1974 was a major accomplishment in protecting the river and its salmon. When the semi-natural rearing program at Mooneys Pond was at its peak, there were an estimated 4000 salmon in the river, 1000 salmon redds were counted and about 9000 rod days were spent fishing in the river in 1992.

With its large protected buffer zone and almost 140 kilometres of total stream length, the Morell has excellent potential to sustain good salmon populations if the following recommendation are implemented.

Management Issues and Recommendations

1. The river should be maintained free from blockages in the main river:
   - upstream to 48 Road on the West Branch above Mooneys Pond;
   - upstream to Jesse Maybelle Road and Martinvale Road on the East Branch;
   - upstream to the 48 Road on the South Branch.

   These should be considered a minimum distance upstream. After restoration work and assessment, these boundaries may be extended.

2. The Morell River is not immune to soil erosion and sedimentation. In the past, unpaved roads were a source of sediment on each of the major branches of the river. Kennys Bridge Road has been ditched and stabilized with gravel. Likewise, the Indian Bridge Road has largely been stabilized by ditching and addition of millings. The Old Mount Stewart Road which crosses the south branch three times, remains a problem and the Department of Transportation, Infrastructure and Energy should work with the watershed group to find a more permanent solution. On the east branch, the Jesse Maybelle Road continues to add sediment to the river, particularly in spring. In recent years, development for blueberry production upstream from Leards Pond on the south branch has added sediment from access roads and disturbance from heavy equipment. An ongoing and serious source of sediment to

the main branch is erosion from potato fields in the Indian Bridge area. This is filling in the holding pools downstream from Indian Bridge. These and other sources of sediment should be identified and addressed.

3. The gravel and cobble spawning substrate in some areas is becoming compacted. Periodic raking may improve spawning and juvenile success in these areas.

4. The wooden crib structures that were installed in the Mooney Road section of river are deteriorating and many anglers are concerned that these important pools will be compromised. All of the original crib structures should be assessed and if necessary, rebuilt.

5. The erosion occurring in the bypass at Leards Pond is a concern and should be assessed in terms of long-term stability.

6. Elevated summer water temperatures are a major issue in the Morell River. Removing blockages will help but an assessment is needed to determine if additional measures are needed.

7. Some areas of the main river are lacking woody cover. Care should be taken when opening up canoe passage to ensure that sufficient amounts of trees are maintained to provide cover for trout and salmon. Some areas may benefit from pool restoration.

8. Additional monitoring, including more electrofishing sites, and the installation of data loggers in various seasons would be beneficial.

Electrofishing site below Cranes

CLUSTER 8. Cow River, Naufrage River, Bear River, Hay River

Cluster 8 is anchored by the Naufrage River which was classified as a Class 1 Wilderness River in 2009, and includes Cow River, Hay River and Bear River that were Class IV and V rivers that had lost their salmon populations at some time in the past. Due largely to the rehabilitation efforts of the Souris and Area Branch of the PEI Wildlife Federation, salmon are now spawning in all of these rivers.

Table 8.1. Salmonid density (number fish/100m^{2}) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for Cow River, Naufrage River, Bear River, and Hay River.

Site	*Water temp. (^{0}C)	BT density	AS density	AS size range (cm)	AS redds (2017)
Cow River	11.9	32.9	0	n/a	38
Naufrage River	17.3	6.7	1.0	8-9	89
Bear River	14.4	40.3	0	n/a	7
Hay River	9.7	68.6	8.9	5.5 – 16.5	15

AS – Atlantic salmon; BT – Brook trout ; * water temperature at time of 2018 electrofishing survey
Note - juvenile salmon were moved from North Lake Creek in 2012 to help jump-start the population

In 2018, there were low densities of juvenile salmon found in the rivers of this cluster. Further assessment is needed to identify trends in juvenile salmon populations and the factors influencing their success.

In addition to issues with blockages due to beaver activity, the proximity of these spawning sites to exposed northeast coastline conditions and increasing climate variability may be negative influences. Although the Naufrage River and North Lake Creek have active harbours at their mouth, many other rivers in this cluster flow directly into small barrier beach ponds. These shallow, exposed access channels may be increasingly affected by extreme weather; e.g. intermittent blockages to access and/or breaching of coastal pond dams; although the near-absence of estuaries in the northeastern cluster of rivers (Clusters 8 and 9) has been identified as a possible explanation of high salmon productivity in this region, possibly due to lower predation and limited or no anoxic events (Cairns and MacFarlane 2015). Seal predation may be an increasing threat to salmon in this region. Commercial fisherman frequently saw seals in brackish areas along the coast in autumn of 2018, including six seals in a small barrier-beach estuary.

These heavily forested watersheds with minimal impact from surrounding land use are important not only for Atlantic salmon but for other wildlife, recreation, the economy (eco-tourism) and climate change mitigation. This area benefits from a relatively high percentage of government owned land, but available cooperative mechanisms such as Natural Areas Protection Act (NAPA) could be used to add to the area that is protected, and ensure the long-term conservation of this important natural asset.

8.1. Cow River

Overview

Watershed/Riparian Context

- Forest cover / land use in watershed - 86% forested, 921 hectares owned by the Government of Prince Edward Island, 216 hectares used for agriculture.
- Riparian buffer - 30 metres to greater than 60 metres; mixed forest with mature spruce dominant in areas.
- Forest composition in 60 metre buffer - 43.3% mixed hardwood, 27% softwood, with balance non-treed.

Instream

- Canopy cover 50-75%.
- Cobbled bottom with no evident sediment; LWD along banks; wide vegetated floodplain.

Table 8.1.1 Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Cow River.

Atlantic salmon density			Atlantic salmon redds[2]	
year	**Selkirk Rd**	***Highway**	**year**	**number**
2018[1]	**0**	**n/a**	2011	4
2002[3]	8.7	39.8	2012	1
2007[3]	No	n/a	2013	50
2008[3]	No	No	2014	12
			2015	67
			2016	46
			2017	38

1- 2018 electrofishing survey; 2- Oak Meadows (2018); 3- Guignion and Oak Meadows (2009)
*location as identified in Guignion and Oak Meadows (2009); No –absent in a spot check.

Status - Thirty-eight (38) Atlantic salmon redds were found in 2017, which is a notable increase since 2011. However, no juvenile salmon were found in the 2018 electrofishing survey. The absence of juvenile salmon in this region following years with good redd counts has been noted by others (Scott Roloson pers. comm).

Spring at Cow River electrofishing site. Photo courtesy of Souris and Area Branch of the PEI Wildlife Federation, 2018

Potential - With its high percentage of forest cover, plentiful springs, excellent headwater wetlands, and over a third of the area under government ownership, Cow River will likely be a very important river for Atlantic salmon and other wildlife in the future.

Riparian zone at Cow River, 2018

Management Issues and Recommendations

1. The near stream riparian zone is dominated by mature woodland. Management of the riparian area should include planting of Acadian hardwood species.

2. In the past, a beaver dam in the coastal pond may have been a major influence on Atlantic salmon numbers. Beaver blockages should continue to be assessed and removed as needed.

3. The access channel from the sea should be checked each autumn prior to the spawning period and opened as needed.

4. A thorough assessment of this watercourse is needed and a management plan developed to guide future management directions.

Access channel at Cow River

5. This river would make an excellent study site to monitor the impact of water temperature on salmon fry survival.

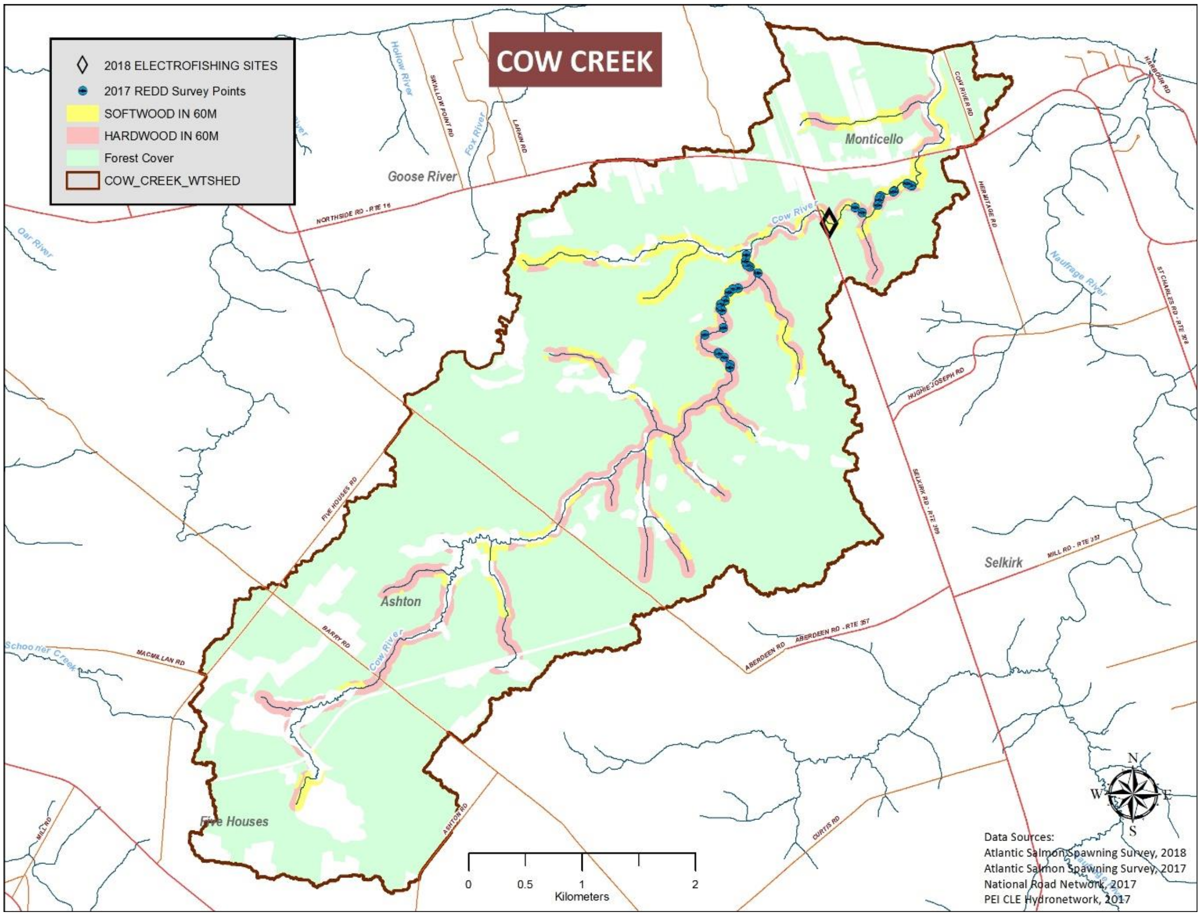


Figure 8.1. Cow Creek watershed showing location of 2018 electrofishing site and 2017 redds

8.2. Naufrage River

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - about 80% of the watershed area is forested with 683 hectares of land owned by the PEI Government and approximately 556 hectares of agricultural land.
- Riparian buffer – Generally greater than 60 metres.
- Forest composition in 60 metre buffer - 38% mixed hardwood, 27.6% softwood with balance non-treed.

Instream

- Canopy cover 40-50%
- Good cobbled bottom (glacial till) from 5cm to 30cm in diameter; deep holding pools; LWD on banks.
- Good access from the sea.

Table 8.2.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Naufrage River**.**

Atlantic salmon density			Atlantic salmon redds[2]	
year	**Hermitage Road**	**Larkins Pond**	**year**	**number**
2018[1]	**1.0**	**-**	2008	100
			2009	32
			2010	33
2002[3]	18.7	21	2011	429
2007[3]	58.7	No	2012	43
2008[3]	n/a	n/a	2013	453
			2014	217
			2015	154
			2016	108
			2017	89

1- 2018 electrofishing survey; **2**- Oak Meadows (2018); **3**- Guignion and Oak Meadows (2009);

Status - The number of redds has been variable since 2008, peaking in 2013 at 453 and then declining to current 2017 levels. Juvenile salmon density was very low in 2018 and may be due to recent issues that are discussed below. This was one of only seven rivers on PEI exceeding conservation requirements for Atlantic salmon (Cairns and MacFarlane 2015).

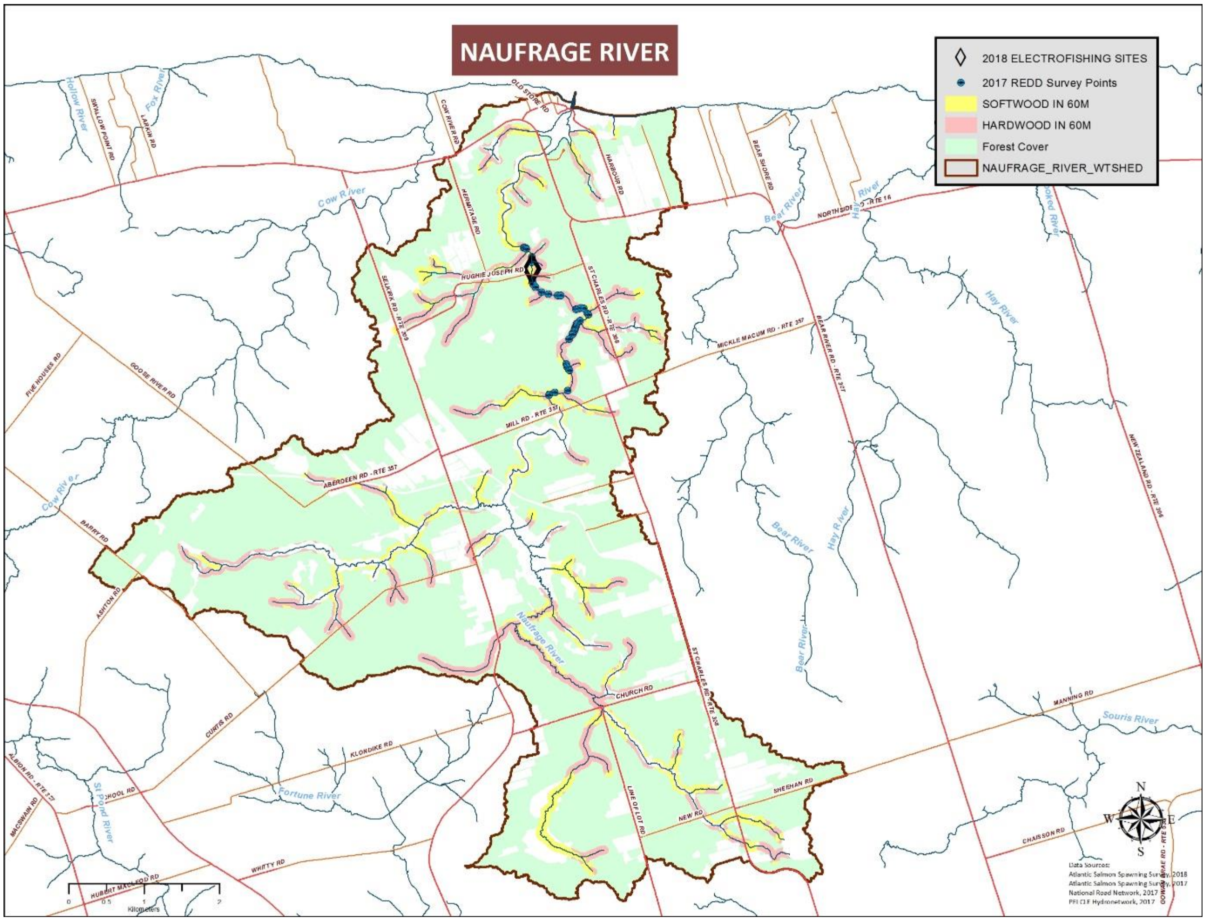


Figure 8.2. Naufrage River watershed showing location of 2018 electrofishing sites and 2017 redds

Potential - The high potential for the Naufrage River to sustain good runs of salmon was recognized in 2009 when it was designated as a Class 1 Wilderness River. It was also noted that it would take extensive effort and several years to restore good fish habitat and get beaver populations under control.

Good cobbled steam bottom at electrofishing site

Management Issues and Recommendations

1. The major limiting factor affecting salmon habitat in the Naufrage River is the elevated summer water temperatures exiting Larkins Pond, where the temperature hovers in the mid 20s during July and August. The warm water is especially hard on brook trout and the site below Larkins is one of the few areas where trout are virtually non-existent during an electrofishing survey. The extensive beaver occupation, especially to the west, makes it impractical to restore the former cold water input

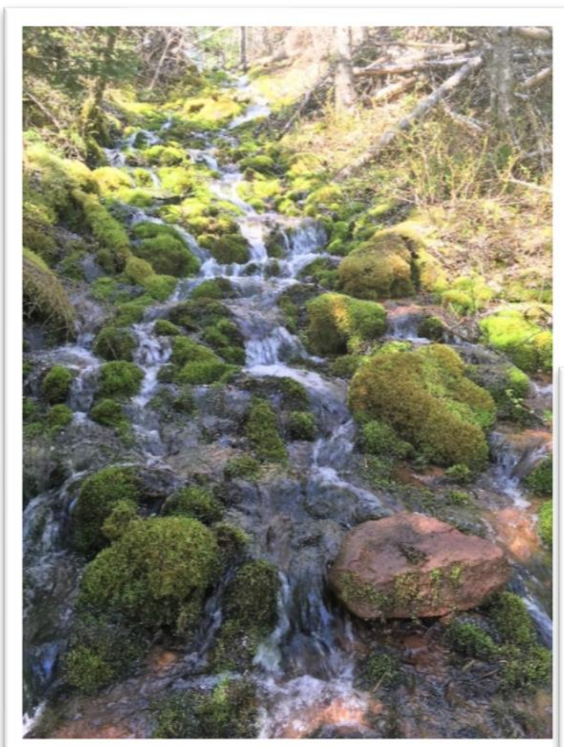
tributaries, although the two large twin springs remain open in the southwest corner. A water temperature strategy is needed for the Naufrage River, which includes recommendations on management of impoundments, including the current management regime for Larkins Pond.

2. Although the Souris and Area Branch of the PEI Wildlife Federation has worked hard to keep the south branch free of beaver dams, beaver activity continues to be a challenge. A recent beaver blockage plugged the tributary where much spawning occurs, and no redds were found in this section in 2017.

3. Lower reaches of the river below Larkins Pond are overly wide and shallow, especially where older beaver dams occurred, and would benefit from installation of wooden structures.

4. The bridge wash out on the Hughie Joseph Road has created a deep and dangerous site for anglers and others at the road culvert. We strongly recommend that the bridge remnants be removed and the site stabilized.

Despite management challenges, the Naufrage River holds many opportunities. The wooded estuary and deep holding pools near the head of tide, and the waterfall-like springs on the river attract numerous visitors to enjoy the abundant and diverse wildlife.



Waterfall-like spring on Naufrage River

Naufrage below Hughie Joseph Road

8.3. Bear River

Overview

Watershed/Riparian Context

- Forest cover/ land use in watershed - > 80% forested.
- Riparian Buffer- > 60 metres.
- Forest composition in 60 metre buffer- 60% mixed hardwood, 10% softwood, and 30% non-treed.

Instream

- Canopy cover generally ~50%
- Gravel-cobble substrate with minor embedding.
- Water quality - Watershed nitrate concentration is 0.3 mg N/L, in the very low range for PEI (*PEI Communities, Land and Forest, Water Quality Report Card*)**.**

Atlantic salmon data

- Salmon Redds - seven (7) redds in 2017; 3 to 35 redds from 2013 to 2016.
- Juvenile salmon – no juveniles found in 2018; parr found in river in late 1960s by D. Guignion (pers. comm).

Status - Atlantic salmon redds have been consistently found in Bear River since 2013. This is a promising sign for a river where salmon disappeared decades ago. However, no juvenile salmon have been found.

Potential - Although juvenile salmon have not been found in recent years, it is too early to give up on this river. The high percentage of forested ecosystem and the location between the Naufrage and Hay Rivers make this an important "refuge" river for salmon when blockages or other impediments limit access to nearby rivers.

Management Issues and Recommendations

1. Active beaver dams were noted during the 2018 field survey in the pond immediately upstream from the outlet channel to the sea. The beaver dam near the shoreline washed out years ago and the pond is now shallow and easily blocked by beaver, creating a barrier to fish passage.

   Beaver blockages should be identified and opened seasonally to ensure spawning access. The dam near the shore was removed during the summer of 2018.

Beaver dam on Bear River, 2018

2. There is no defined estuary and access to the sea is via a wide, shallow channel meandering through exposed sandy shore. It is possible that access could be intermittently blocked and the outlet should be assessed annually and ensure it is open prior to the spawning season. There may be options to increase water level in the pond and improve channel definition at the outlet. A short-term solution would involve raking to deepen the channel as needed.

Aerial photo showing access channel to sea

Shallow access channel at Bear River (above)

Raking to maintain deeper channel

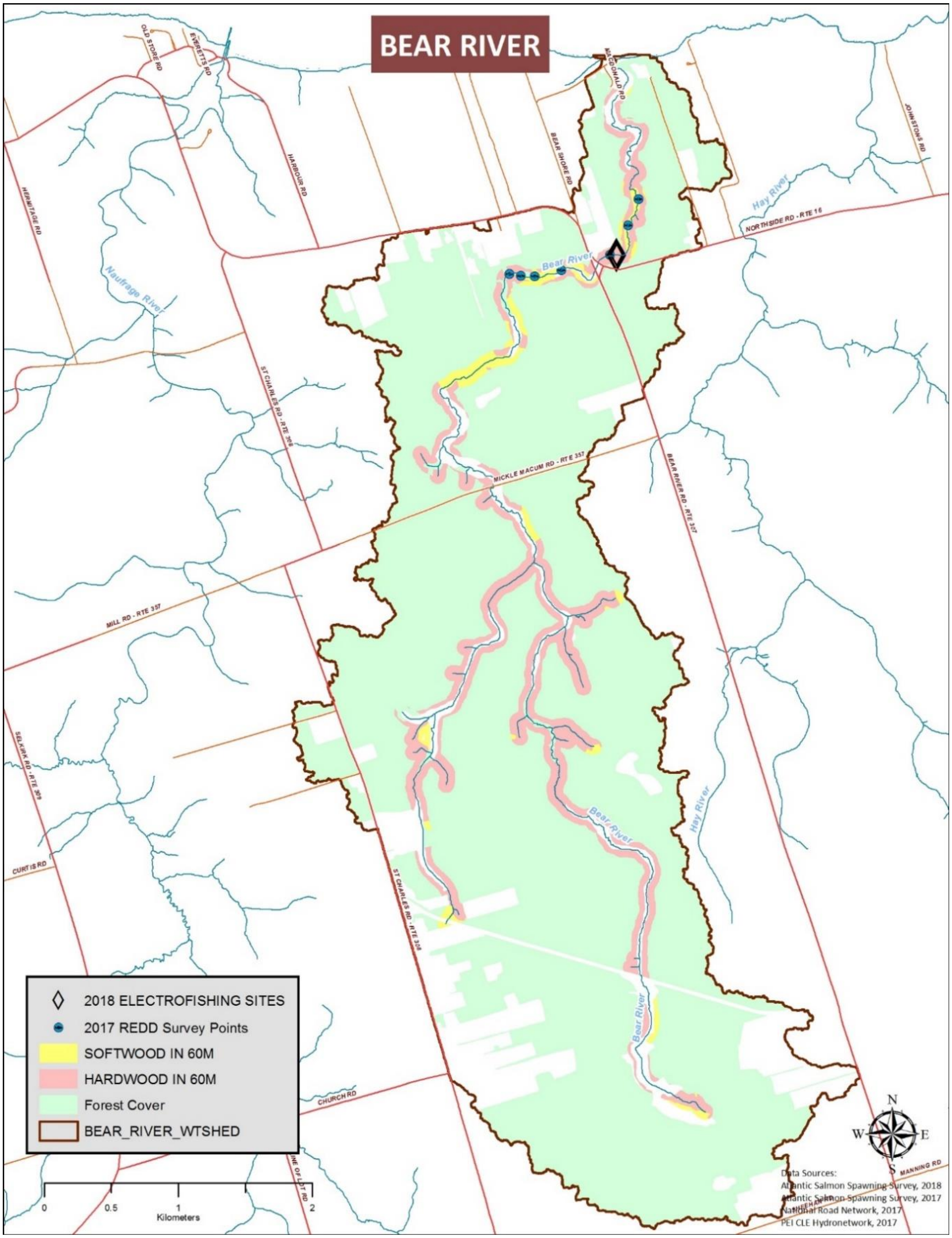


Figure 8.3. Bear River watershed showing location of 2018 electrofishing site and 2017 redds

8.4. Hay River

Overview

Watershed/Riparian Context

- Forest cover/land use in watershed - 84% forested with about 17% owned by the province and 12% in agriculture.
- Riparian Buffer - > 60 metres.
- Forest composition in 60 metre buffer - 45% mixed hardwood, 31% softwood, balance non-treed.

Instream

- Canopy cover ~50%
- Gravel-cobble substrate with minor embedding; filamentous algae; numerous riffles over logs; LWD and bank undercuts for cover; spring at electrofishing site.

Table 8.4.1. Juvenile Atlantic salmon density (number fish/100 m^2) and Atlantic salmon redds for Hay River.

Atlantic salmon density		**Atlantic salmon redds[2]**	
year	**density**	**year**	number
2018[1]	**8.9**	2011	1
		2012	3
		2013	43
2002[3]	14.9	2014	15
2007[3]	0	2015	36
2008[3]	No	2016	41
		2017	15

1- 2018 electrofishing survey; **2**-Oak Meadows (2018); **3**- Guignion and Oak Meadows (2009)
No – absent in spot check

Status – The run of salmon in this river had seemed to disappear but has since rebounded following many years of dedicated habitat restoration and blockage removal. Redd counts have increased significantly since 2011, and both young of the year (YOY) and 1+ salmon were found in low densities in 2018.

Potential – The Hay River watershed is a pristine wooded environment with no surrounding agriculture, and has excellent potential to support stable salmon populations. The section of river upstream from Johnstons Pond has excellent cobble that is ideal for 1+ salmon parr, and south of the Northside Road there is good spawning gravel in heavily forested tributaries.

Aerial view of dense forest cover in Hay River watershed south of the Northside Road

Management Issues and Recommendations

1. One of the biggest challenges for Hay River is the dam within the former "Queens Highway" at the shore. The exposed coastal location makes it vulnerable to storm surges with the risk of breach during an extreme storm. Vulnerability of the road to storm events should be evaluated before a major breach takes place. The Department of Communities, Land and Environment, Ducks Unlimited, and the Department of Transportation, Infrastructure and Energy will need to develop a plan to address this issue.

2. Access from the sea to the fish ladder is via an exposed, short, shallow channel that could be affected by extreme weather events and ongoing shoreline erosion. The channel should be assessed and opened if needed in the fall.

Coastal location of "Queens Highway"

3. The fish ladder at Johnstons Pond poses a challenge to salmon passage. Currently, salmon have to come in on high tide, swim down to enter the culvert and then through the cells of a fish ladder before entering the coastal pond. The fish ladder should be assessed to ensure it is not limiting spawning access.

   The fish ladder also creates an abrupt transition zone for acclimatization from salt to freshwater, although it is not known if this is limiting for spawning adults.

Fish ladder at Johnstons Pond, 2018 (above and right)

4. The Hay River should be maintained as a wilderness river and monitored to prevent blockages to fish migration.

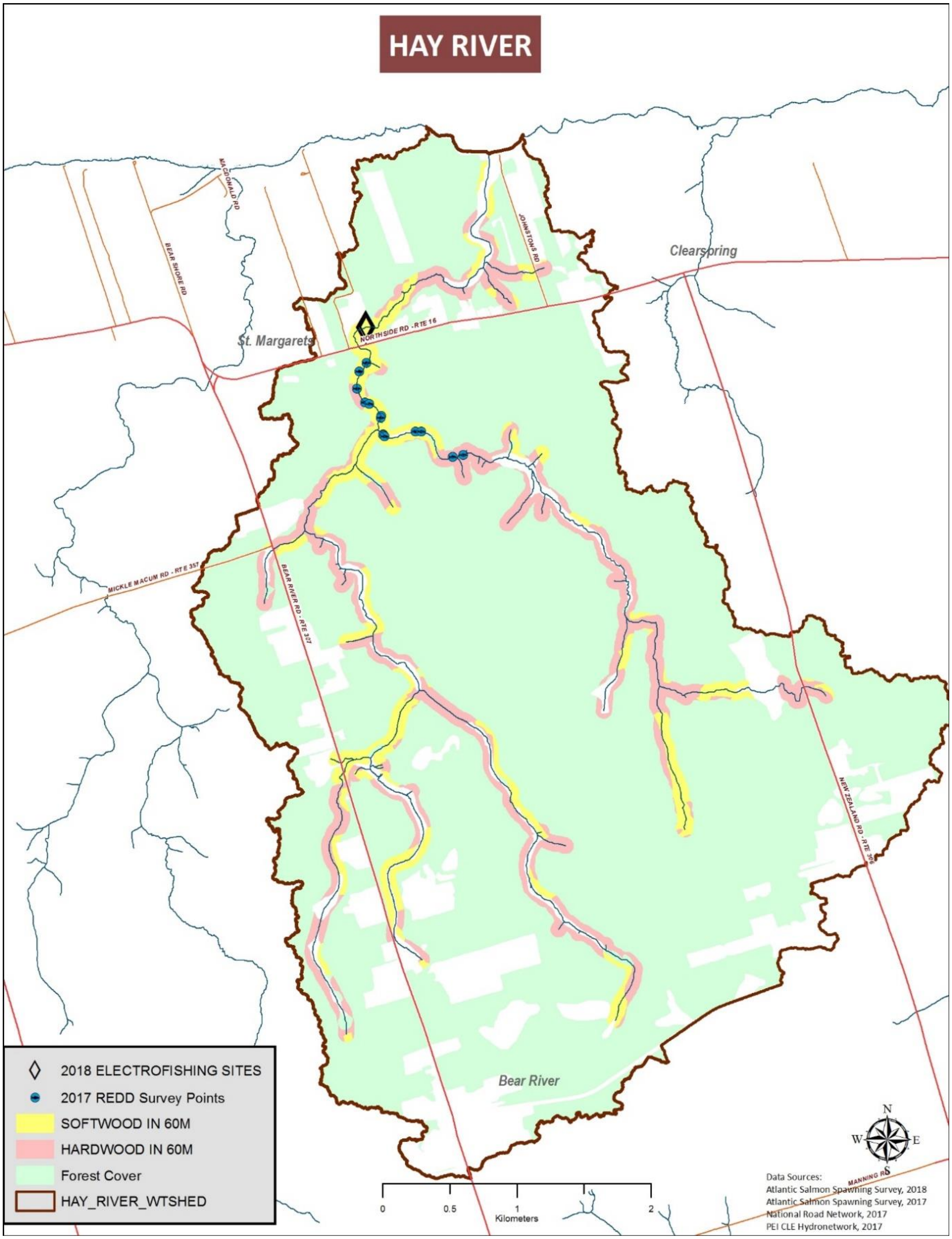


Figure 8.4. Hay River watershed showing location of 2018 electrofishing site and 2017 redds

CLUSTER 9. Priest Pond Creek, Cross River, North Lake Creek

Priest Pond Creek, Cross River, and North Lake Creek are the "gems" of northeastern PEI, and were all classified as Class 1 Wilderness Rivers in 2009. With their spectacular coastal ponds, forested ecosystems, and abundant fish and wildlife, these rivers offer environmental and economic benefits that extend well beyond their importance to Atlantic salmon. Conservation and enhancement of these rivers should be a priority for PEI.

Table 9.1. Salmonid density (number fish/100m^2) from 2018 electrofishing survey and 2017 Atlantic salmon redds (Oak Meadows 2018) for Priest Pond Creek, Cross River and North Lake Creek.

Site		***Water temp. (^{0}C)**	**AS density**	**AS size range (cm)**	**BT density**	**AS redds (2017)**
Priest Pond Creek	Pensioners Rd a)	7.4	**5.5**	10.5-12	81.9	150
Priest Pond Creek	Pensioners Rd b)	7.6	**6.1**	10.5-12	77.2	
Priest Pond Creek	Bull Creek Road	8.2	**15.8**	9.5-12.5	42.7	
Priest Pond Creek	Dixons dam**	12.2				
Cross River	Souris Line Rd	10.8	**49**	5.0-14.5	11	192
North Lake Creek	Baltic Road	13	**134.7**	5.5-15.5	32	213
*Mill Creek****	North Lake	*8.5*	**1.3**	*17.5*	*148*	*<10 (subset of North Lake Cr.)*

AS – Atlantic salmon; BT – brook trout
*water temperature at time of 2018 electrofishing survey; ** spot check found 1 salmon (12 cm), 30+ gaspereau (*Alosa pseudoharengus*), and 6 brook trout; ***Mill Creek was added to survey and is part of the North Lake Creek watershed.

This cluster has had consistently high Atlantic salmon redd counts that are amongst the highest on PEI. Only at Priest Pond Creek were juvenile Atlantic salmon densities lower than expected, and there were no Young of the Year (YOY) found in that river.

These rivers have so far been spared the intense land use pressures found in other regions of PEI. Whereas management of rivers in other parts of PEI is focused on restoration, the primary objective in this cluster should be conservation. All available tools should be used to ensure their ongoing protection. It would be a tremendous set back to see this area experience the degree of field consolidation and intensive row crop production that is happening elsewhere. A protected 60 metre buffer is essential.

9.1. Priest Pond Creek

Overview

Watershed/Riparian Context

- Forest cover/ land use in watershed - 85.1% forested, 660 acres of crown land, 297 acres of agricultural land.
- Riparian buffer - greater than 60 metres in most stretches with agricultural fields within 60 metres in downstream areas.
- Forest composition in 60 metre buffer - 50% alder/mixed hardwood with 35% softwood and balance non-treed.

Instream

- Canopy cover variable from 25% to 75%
- Gravel-cobble substrate with gravel shoals; aquatic macrophytes in patches; minor sedimentation.
- Water temperature was relatively cold in the northeastern sections (7.4 to 7.6 ^{0}C) and 8.2^{0}C at Bull Creek Rd. site.

Table 9.1.1. Juvenile Atlantic salmon density (number fish /100m^2) and Atlantic salmon redds for Priest Pond Creek

Atlantic salmon density				Atlantic salmon redds[2]	
year	**Bull Creek**	**Pensioners Rd a/b**	**Downstream of Dixons Dam**	**year**	**number**
2018[1]	**15.8**	**5.5 / 6.1**	*one 12 cm juvenile found in spot check of 500m stretch**	2008	11
				2009	8
				2010	13
				2011	20
2002[3]	0	19.1		2012	21
2007[3]	9.5	30.8		2013	151
2008[3]	n/a	n/a		2014	129
				2015	138
				2016	70
				2017	150

*Also found 30+ juvenile gaspereau, and 6 brook trout

1- 2018 electrofishing survey; **2-** Oak Meadows (2018); **3-** Guignion and Oak Meadows (2009)

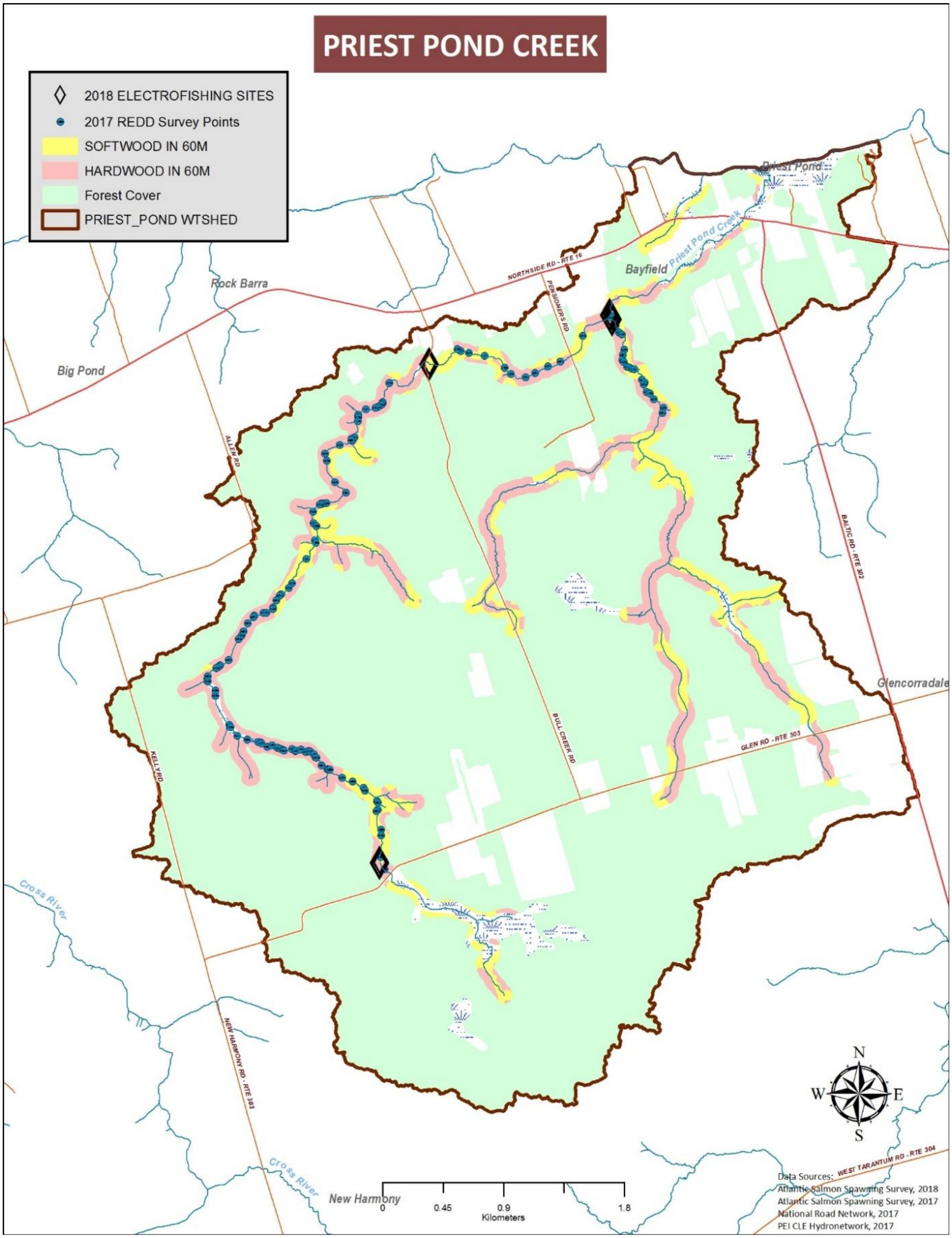


Figure 9.1. Priest Pond Creek watershed showing location of 2018 electrofishing sites and 2017 redds

Status - Although numbers fluctuate, there was a notable increase in the number of Atlantic salmons redds after 2012, possibly in response to removal of beaver blockages that opened up upstream sections of the west branch to Dixons Dam. The pattern is less clear for juvenile salmon. In 2018, several sites were sampled on this river. Juvenile salmon densities were lower than would have been expected based on redd counts, and there were no young of the year (YOY) at any site. There has been an increase in brook trout populations over the same time period, and a high number of gaspereau observed in 2018, suggesting that limiting factor(s) could be specific to Atlantic salmon.

Potential - The natural attributes of this river suggest excellent potential for sustainable runs of Atlantic salmon and this river was classified as Class I in 2009. However, the low density of juvenile salmon, absence of the YOY age class, and fluctuating redd counts suggest that there are unique challenges in this river.

Management Issues and Recommendations

1. Despite a high salmon redd count in 2017, extensive sampling for juvenile salmon in 2018 did not turn up a single YOY in Priest Pond Creek. One potential factor may be the ability of fry to begin successful feeding. This is discussed in greater detail in Appendix 1. A monitoring program which looks at water temperatures and fry success is needed to explain the poor juvenile success in this river.

2. The privately-owned headwater pond at Dixons dam is large and reportedly deep. It would be beneficial to obtain bathymetric data for the pond – depth, volume, water residence time, and water temperature and oxygen profiles - to get a better understanding of the impact of the pond on stream conditions.

3. As with other rivers in this cluster, it is imperative to maintain a wooded riparian zone in Priest Pond Creek.

Headwater pond at Dixons dam, 2018 (electrofishing site is indicated by a red dot)

4. Regular monitoring is needed to ensure that salmon have access into and out of the river.

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5. The outlet to the sea is shallow and subject to change and infilling on a regular basis. There was no barrier to fish passage noted this year, but the outlet should be checked seasonally and opened if necessary.

The photo above shows a deceptively calm day at the coastal outlet channel; the photo at left shows wave action at the shore; and the aerial photos below show how the channel has shifted over the years.

9.2. Cross River

Overview

Watershed/Riparian Context

- Forest cover/ land use in watershed - 85% of the area is forested; 924 ha is government-owned land and 458 ha is used for agriculture.
- Riparian buffer - Generally greater than 60 metres; treed with wide floodplain; some disturbance at McInnis Pond bridge; smaller agricultural fields at less than 30 metres in some locations.
- Forest composition in 60 metre buffer – 40% mixed hardwood, 37% softwood and the balance non-treed.

Instream

- Canopy cover is 50- 75% except at road crossings.
- Variable water depth from shallow riffle areas to almost a metre in depth; cobble and hardpan with sand in areas; steep banks in some stretches; grassy hummocks, LWD from fallen trees along shore.

Table 9.2.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for Cross River

Atlantic salmon density			Atlantic salmon redds[2]	
year	**Souris Line Rd**	**below McInnis Pond**	**year**	**number**
2018[1]	**49**	-	2008	120
			2009	70
			2010	100
2002[4]	53.7	171.2	2011	190
2007[4]	0	36.4	2012	83
2017[3]	-	12.6	2013	268
			2014	193
			2015	238
			2016	170
			2017	192

1- 2018 electrofishing survey; 2- Oak Meadows (2018); 3- Forests, Fish and Wildlife; 4- Guignion and Oak Meadows (2009)

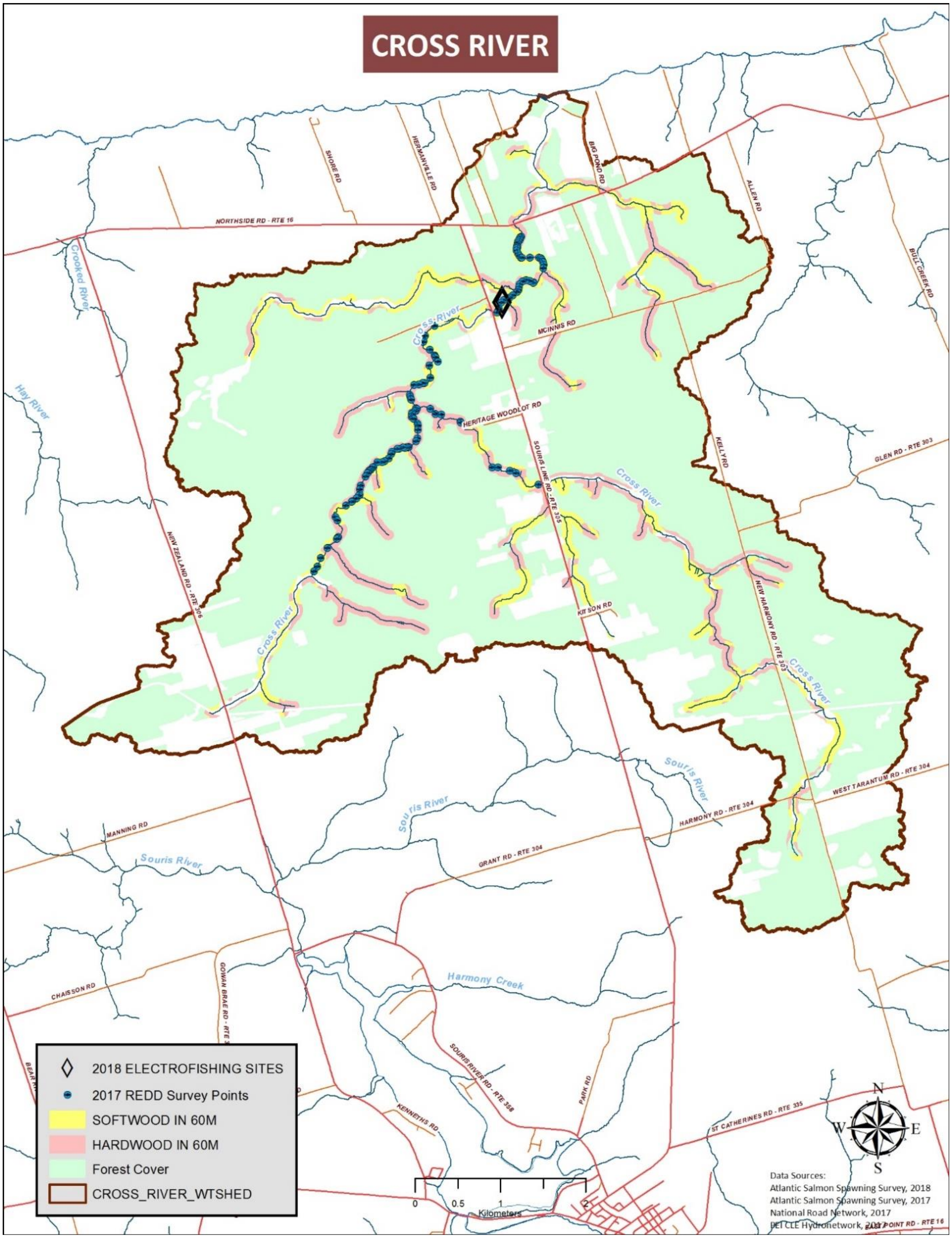


Figure 9.2. Cross River watershed showing location of 2018 electrofishing sites and 2017 redds

Status - The number of Atlantic salmon redds has increased and remained consistently high since 2010. A good density of juvenile salmon was found in 2018, which included 0+ and 1+ year classes.

Potential - The consistency of salmon redds counted, and the high densities of juvenile salmon recorded, ranks this stream second only to North Lake Creek for the region, and amongst the top salmon rivers on PEI. Cross River has two tributaries which wind through heavily wooded ecosystems and provide habitat for brook trout and Atlantic salmon. The east branch, upstream from the Souris Line Road, has been the last section of stream to be worked on and it will take a few more seasons before its full potential is reached.

Cross River riparian zone

Management Issues and Recommendations

1. Cross River flows through "Big Pond", a large barrier beach pond, before entering the Gulf through a sandy shoreline with an established dune system. Despite sedimentation issues arising from a culvert blow-out a number of years ago, Big Pond remains a superb site for brook trout angling, and deeper portions likely provide cover for Atlantic salmon.

Big Pond (above and right)

2. There is a good transition zone from salt to freshwater, and there are no evident limitations to access from the sea. However, too much foot traffic through the dunes is causing a major blow-out which could potentially alter the pond outlet

Blow-outs through the dune at Big Pond

Access channel to sea

3. Dense beds of filamentous algae were noted in open areas downstream from the bridge at McInnis Pond. The cause of the algae is not known but it is providing cover for many juvenile salmon using this area.

4. It is important to monitor the river in spring and fall to ensure that salmon have access into and out of the river.

Algae in Cross River

5. There appears to be an increase in land clearing in the watershed. Given the high natural value of this river, it is hoped that forested ecosystems can be retained and improved. At minimum, work with landowners with the objective of a minimum 60 metre riparian buffer zone.

9.3. North Lake Creek

Overview

Watershed/Riparian Context

- Forest cover /land use in watershed - 78% forested with 403.5 ha owned by the Government of PEI, and 788 ha in agriculture.
- Riparian buffer - greater than 60 metre treed buffer with variable aged mixed forest and well vegetated floodplain in low lying areas.
- Forest composition in 60 metre buffer - 30% mixed hardwood, 50% softwood and balance non-treed.

Instream

- Canopy cover 50% to 75%
- Gravel and cobble substrate with no embedding (YOY salmon were found in cobble even in very shallow areas); bank undercuts but very little LWD instream.

Table 9.3.1. Juvenile Atlantic salmon density (number fish/100m^2) and Atlantic salmon redds for North Lake Creek.

Atlantic salmon density			Atlantic salmon redds[2]	
year	**Dixons Pond (Baltic Rd)**	**Head of Tide**	**year**	**number**
2018[1]	**134.7**	-	2008	200
			2009	213
			2010	205
			2011	355
2002[3]	21.0	2.2	2012	106
2007[3]	109	-	2013	333
			2014	183
			2015	262
			2016	251
			2017	213

1- 2018 electrofishing survey; 2- Oak Meadows (2018); 3- Guignion and Oak Meadows (2009)

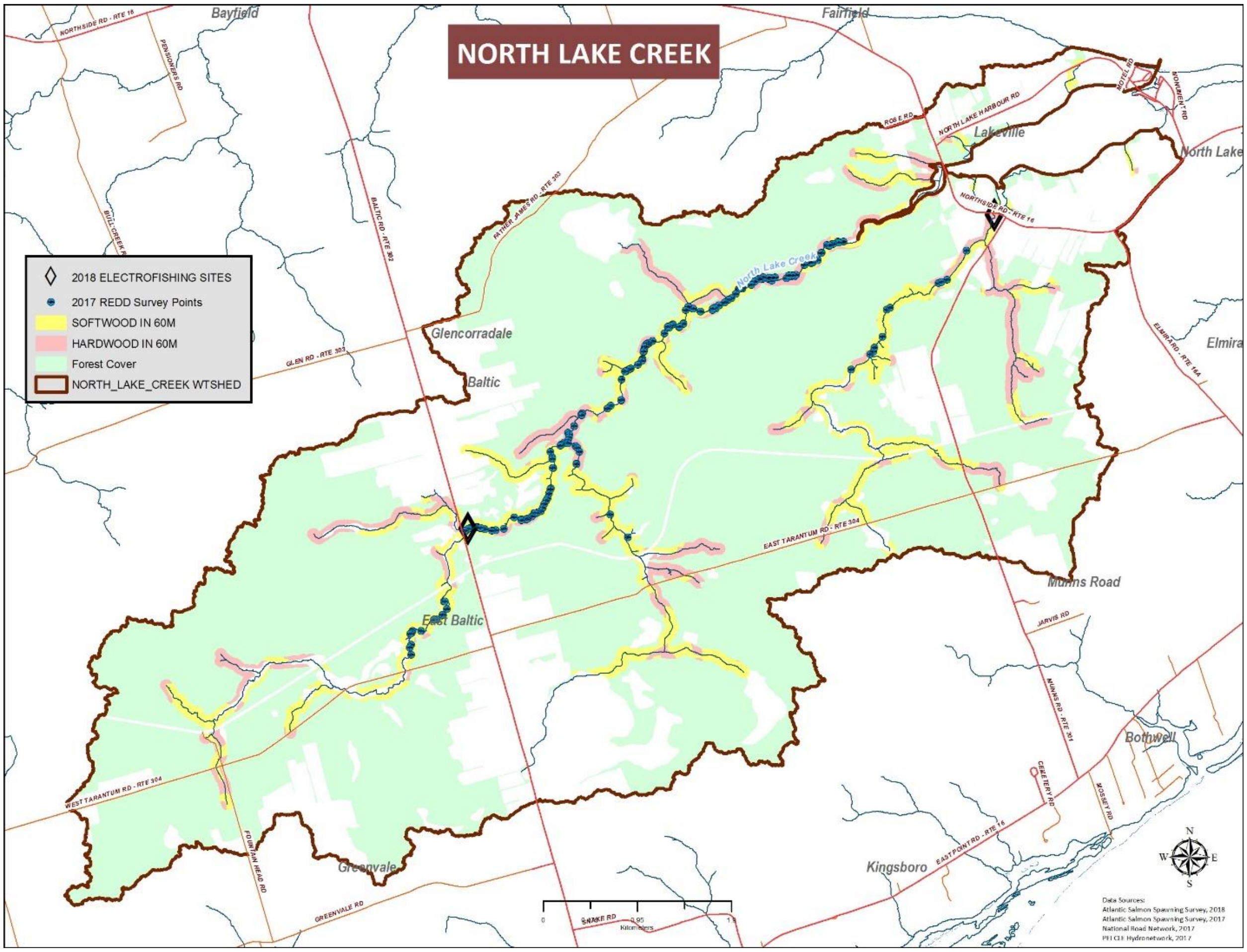
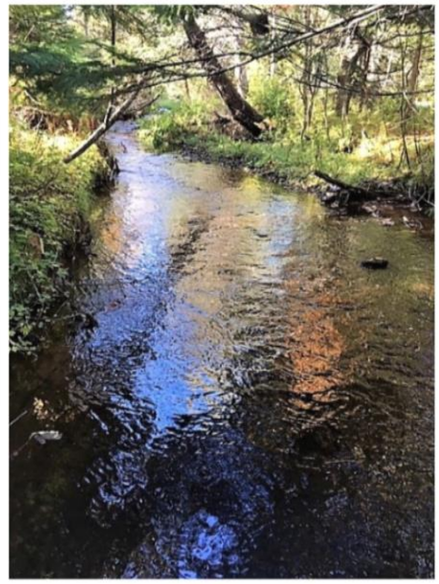


Figure 9.3. North Lake Creek watershed showing location of 2018 electrofishing sites and 2017 redds

Status - North Lake Creek has the highest redd counts and juvenile salmon density of all the rivers assessed on PEI. Young of the year (YOY) and 1+ salmon are well represented in the population and there is evidence of expanded distribution of redds in second order tributaries and headwaters.

Potential - Heavily forested with ample amounts of rich, mixed hardwood, this is the gem of all PEI salmon streams and a high priority for ongoing protection and enhancement to maintain this status.



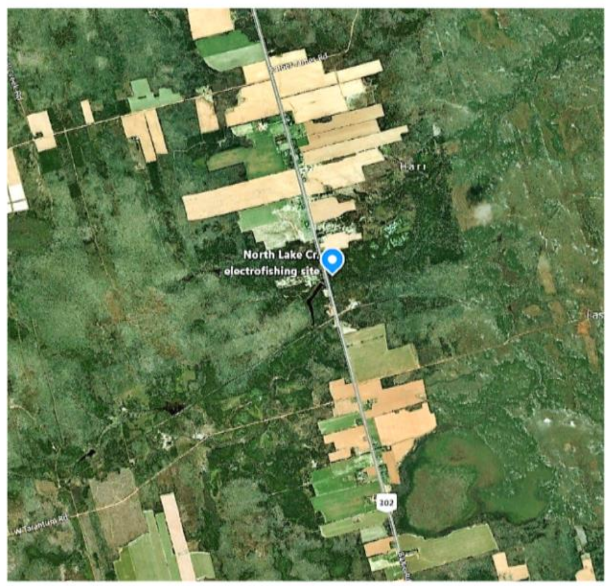
North Lake Creek electrofishing site

North Lake Creek has a number of essential attributes for superior salmon habitat - a largely forested, and wide treed buffer zone; a good transition zone from salt to freshwater; ideal habitat for juvenile salmon due primarily to the characteristics of the cobble substrate; moderate temperatures, and good water quality (*PEI CLF, Water Quality Report Card*).

Management Issues and Recommendations

1. Currently, there is little intensive row crop production in the North Lake watershed. However, an expansion of this activity, as has been observed in other watersheds throughout PEI, will affect the status of this important salmon river. The focus should be on reforestation and protection of this spectacular, and valuable river system. A protected 60 metre buffer will be critical to maintaining the integrity of North Lake Creek.

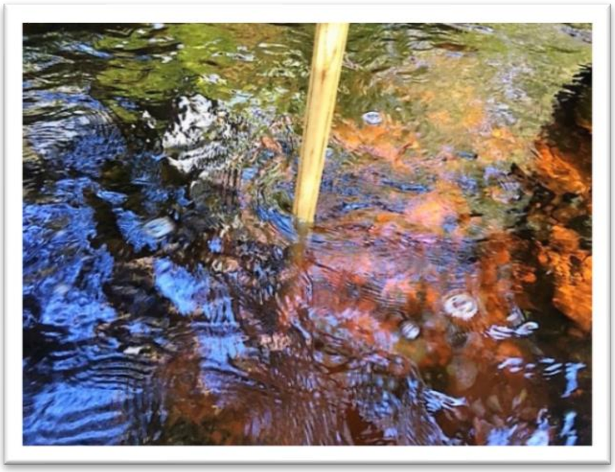
2. North Lake Creek is especially notable for its loose, deep, rounded gravel-cobble substrate. Samples were taken from the 2018 electrofishing site and depth of the gravel-cobble layer exceeded 35 cm. There was very little embedding of cobble and water was clear, fast flowing, and shallow with small pools.



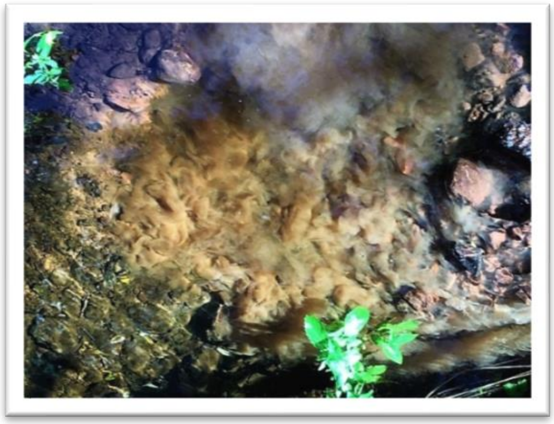
Aerial view of North Lake Creek electrofishing site showing agricultural development in area

3. Continue current beaver management program and ensure access is available to salmon moving into and out of the river.

4. The wooden crib structures that were built in the section downstream from the Baltic Road in the mid 1990s worked very well in providing holding pools for adults and creating excellent gravel/cobble beds for spawning and juvenile habitat. These structures should be maintained and repaired if necessary.



Clean substrate suitable for juvenile Atlantic salmon. at electrofishing site



Substrate downstream from agricultural input of sediment showing a silt plume when disturbed

Gravel-cobble substrate at the 2018 electrofishing site on North Lake Creek

9.3. b) Mill Creek (part of North Lake Creek watershed)

Mill Creek Overview

This creek is part of the North Lake Creek watershed. As this creek was not assessed in previous surveys, no historical data are available.

Watershed/Riparian Context

- Forest cover/land use in watershed – downstream stretches characterized by intensive agricultural land use (see aerial photo below).
- Riparian buffer - 60 metres in sections, shrub/tree mix.

Instream

- Canopy cover patchy; 25% to 50%
- Channel narrow, shallow in sections; variable cover at bank (grass, shrubs); gravel and cobble substrate; relatively cool water temperature of 8.5 ^{0}C.

Atlantic salmon data

- Atlantic salmon redds – the 2017 redd survey shows presence of some redds (~10) on this small creek (estimated from maps in Oak Meadows 2018)
- Salmon density (based on 2018 electrofishing results) – 1 Atlantic salmon parr
  Note – Density of brook trout was high at 148 fish/$100m^2$

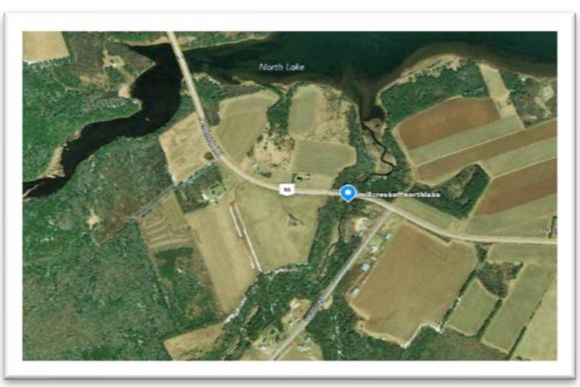
Status – Mill Creek has very high densities of brook trout but only a single juvenile Atlantic salmon was found.

Potential – This creek was not assessed further. It provides an interesting contrast to the adjacent North Lake Creek with its cooler temperatures and greater agricultural development.

Management Issues and Recommendations

1. Ensure that salmon have access into and out of Mill Creek, as some fish may stray from nearby streams.

Mill Creek stream bottom (above)



Mill Creek aerial view showing agricultural land use (left)

10. Other PEI Salmon Rivers

There are three additional rivers which can be added to the list of potential salmon rivers. In two of these rivers – Cardigan River and Murray River – the salmon are believed to originate from fish hatcheries. Marine Harvest, considered the world's biggest player in the salmon aquaculture business, operates the Dover Fish Hatchery and the Cardigan Fish Hatchery which serve as broodstock farms for their marine operations. The third river, the Miminegash River, has recently regained its run of Atlantic salmon.

10.1. Cardigan River

In the 2009 Conservation Strategy for Atlantic Salmon, the Cardigan River was identified as a Class III river, where salmon were considered to be on the verge of disappearing. Two year classes of salmon were found in the survey at that time, although no redds were recorded. The Cardigan River was not surveyed as part of this study. However, the Forests, Fish and Wildlife Division electrofished this river in 2019 to collect young-of-the-year rainbow trout for the Canadian Food Inspection Agency's fish health surveillance project. There were good numbers of salmon parr observed during this exercise. The 2009 strategy predicted that without a fish ladder installed at the head pond, the salmon population would not be expected to survive. It appears that these salmon are persistent and a small population remains, even though there is little favourable habitat in the short distance from the estuary to the fish hatchery.

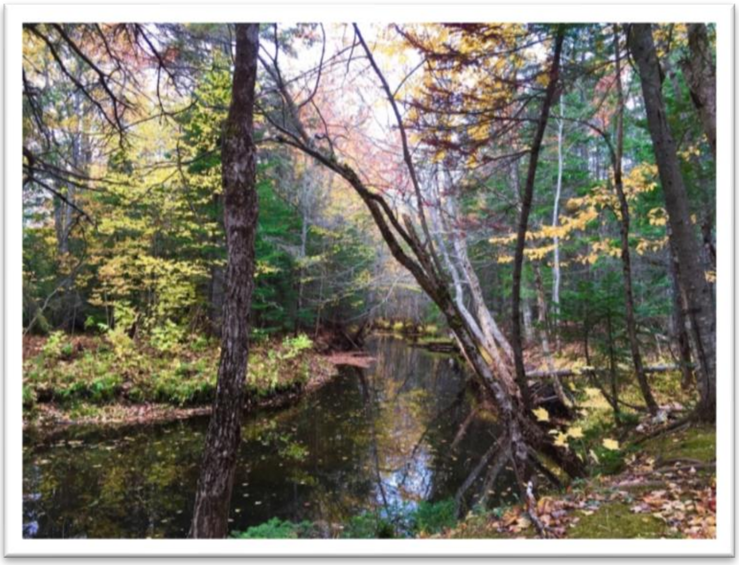
10.2. Murray River

In May 2016, in response to anglers' reports of juvenile salmon being caught in MacLures Pond in Murray River, the Forests, Fish and Wildlife Division electrofished a short section of stream downstream from the Dover Fish Hatchery. In a spot check of approximately 60 metres of stream, eleven salmon parr were captured. Most of the salmon parr were in good condition but one was noticeably stunted. In the 2001 salmonid survey done by the University of Prince Edward Island, no salmon were found in Murray River. No stocking of salmon has been done in that region of PEI since the Valleyfield River was stocked in the mid-1990s. An electrofishing survey at the same site in 2018 did not find any juvenile salmon, although the habitat in this section of river would be favourable for salmon. It is reasonable to assume that the salmon seen in Murray River in 2016 were escapees from the Dover Fish Hatchery. Additional monitoring should be done in subsequent years to determine if the salmon presence in Murray River is continuing.

Two of the eleven salmon parr found in Murray River, 2016. Note that one of the fish is stunted.

10.3. Miminegash River

In the late 1960s, the Miminegash River was lined with elm, cedar and ash and the stream bottom was composed of a mixture of gravel and cobble. It was not unusual to catch salmon parr when fly fishing for brook trout (Daryl Guignion pers comm). In the years since, Atlantic salmon populations seem to have waned as no salmon were found in 2001-02 during intensive graduate research in a number of PEI streams (Gormley 2003). In 2018, a number of salmon parr were being angled in the Miminegash River and it was added to the list of rivers being surveyed in late autumn.



Miminegash River electrofishing site, 2018

It did not take long to verify that Atlantic salmon had indeed returned to the Miminegash River. In an electrofishing survey of a 200 metre stretch of good salmon habitat, eight 1+ salmon parr were netted, along with 33 brook trout. No barrier nets were used.

Salmon parr found in Miminegash River, fall 2018

The Miminegash River is now the only south-draining river in West Prince to have Atlantic salmon. It is recommended that the river be assessed to identify the extent of suitable habitat for salmon and any limiting factors that need to be addressed. The group should continue to remove blockages and ensure that salmon have access into and out of the river as needed.

Electrofishing the Miminegash River, October 2018

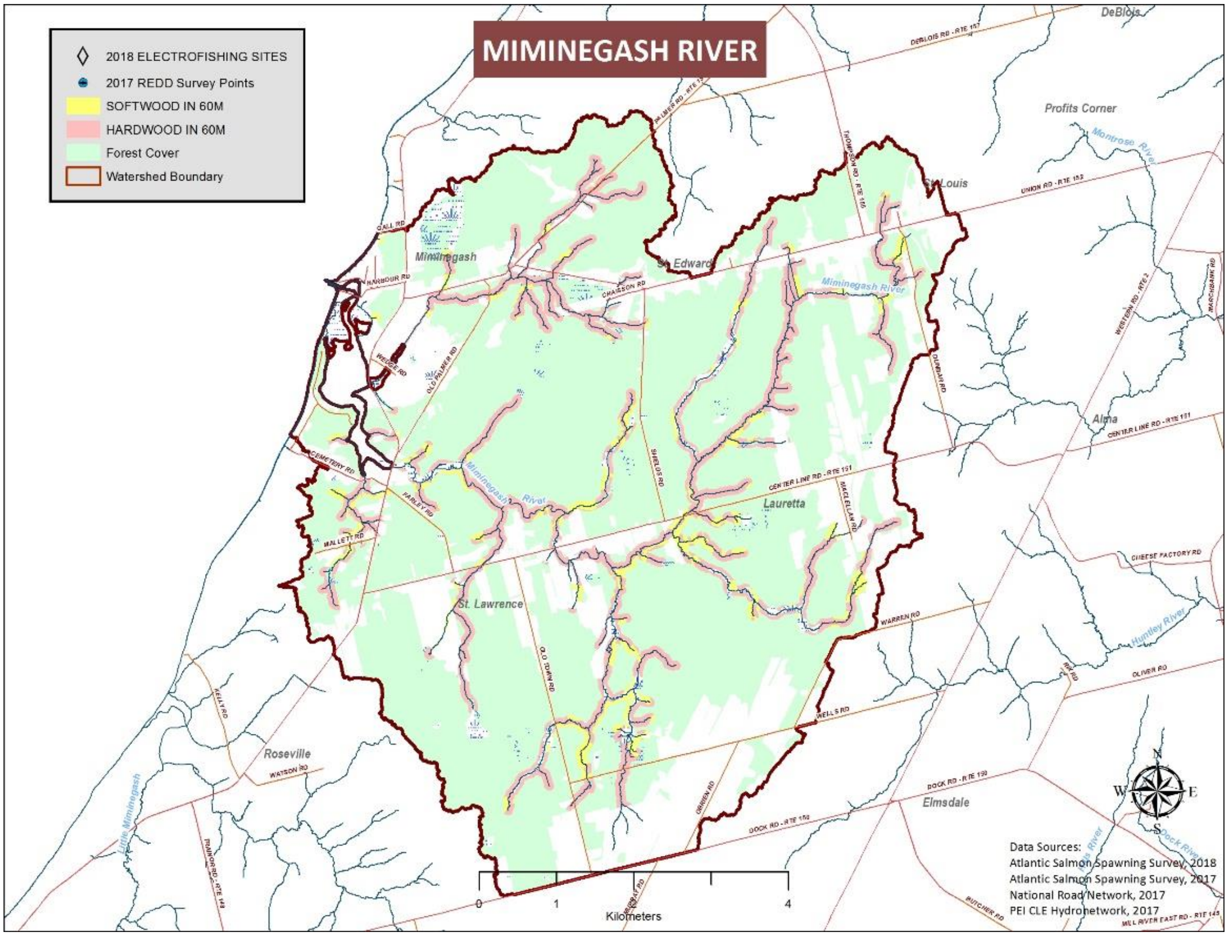


Figure 10. Miminegash watershed. The total stream length is approximately 80 km, and forest composition in the 60 metre buffer is 57.9% mixed hardwood, 14.2 % softwood, with the balance (about 25%) non-treed.

SECTION 6. BROAD RECOMMENDATIONS

6.1. Management Framework

This report contains recommendations to reduce stresses, enhance habitat, and improve future prospects for Atlantic salmon. However, to be fully effective these recommendations must be addressed within a comprehensive planning framework that not only sets short and long-term priorities across PEI, but fosters the capacity, expertise and partnerships necessary for their successful implementation. The current financial support for Atlantic salmon projects can be episodic and fragmented across various funding organizations and their priorities and planning horizons. Watershed groups may struggle on an annual basis to situate Atlantic salmon projects within the immediate requirements of these organizations, rather than working consistently towards long term goals and capacity building. The suggested framework described below could improve the effectiveness and efficiency of salmon conservation activities on PEI.

1. A centralized Atlantic Salmon Advisory Committee and an Atlantic Salmon Action Team should be established to provide oversight, guidance, and support in development and implementation of plans and priorities for Atlantic salmon conservation across PEI watersheds.

   The <u>Atlantic Salmon Advisory Committee</u> would include professionals with advanced experience and knowledge relevant to Atlantic salmon habitat rehabilitation and management on PEI, for example:
   - Provincial Watershed ecologist
   - Provincial recreational fishery biologist
   - Representative from Provincial forestry
   - Representative from Department of Fisheries and Oceans
   - Representative from Canadian Rivers Institute - UPEI
   - Representative from MacPhail Woods Project
   - Representative(s) from Aboriginal community

   The <u>Action Team (A-team)</u> would be a “boots-on-the-ground” group with the specialized expertise and training needed to recommend and conduct stream and riparian zone enhancement work in support of the watershed groups (e.g., chain saw course, first aid, water safety, instream and riparian restoration knowledge etc.). In addition to providing expert advice on techniques and approaches, the team would be equipped to assist with the “heavy slogging”, thereby enabling more rapid completion of labor-intensive projects by the watershed groups.

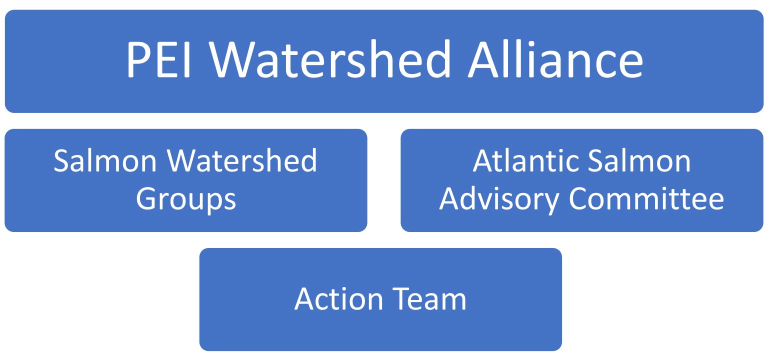
   The A-team would be accountable to the watershed groups and the Atlantic Salmon Advisory Committee and would be guided by that group’s expertise and priorities. Funding will be required to provide the training and salary for this crew, however the efficiency and effectiveness of such a highly trained group in supporting Atlantic salmon priorities across

PEI would more than justify such additional funding. Ideally, there would be two crews available to assist salmon projects across PEI.

2. An Atlantic Salmon Watershed Group could be established under the umbrella of the PEI Watershed Alliance to provide a focal point for information exchange, shared skills development, and collaborative development of plans and priorities across watershed groups.

   A key activity of this group would be development of Atlantic salmon management plans that can serve as an ongoing basis for their work, and for funding requests. Ideally these plans would be prepared in consultation with and under the direction of the Atlantic Salmon Advisory Committee (discussed above) and be based on a common framework. The plans would include clearly articulated priorities, level of effort needed, and expected long-term outcomes. It should be noted that plans should be specific to Atlantic salmon, and focus on key areas and projects that would have the greatest benefit to Atlantic salmon, recognizing that some areas may be more ideally suited to brook trout or other wildlife.

3. There is a need for enhanced coordination across funding organizations to ensure common priorities for Atlantic salmon are addressed, and that long-term stable funding is made available to address these priorities.



6.2. Public Engagement and Outreach

The importance of public awareness and participation in Atlantic salmon conservation cannot be underestimated. There are various ways of encouraging stewardship for Atlantic salmon conservation and restoration in PEI:

- The Abegweit Conservation Society's Plamu'k na Kitapina'q program (*Salmon are our Friends*) has increased awareness and support for Atlantic salmon conservation. This newly adapted version of the former Atlantic Salmon Federation's Fish Friends program emphasizes Lnu'k (Mi'kmaq) traditional ecological knowledge, values and philosophies around environmental stewardship. In 2019, there are twenty-six schools participating. This educational program covers a broad spectrum of topics about Atlantic salmon, including its life cycle, habitat, adaptations, and sustainability. It is based on science but incorporates social studies, language arts, math and art and has been well received by students and teachers.
- In the 1990s, a River Guardian Program was initiated on a number of PEI rivers. Volunteers sported guardian recognizable jackets and hats and kept an eye on a particular river for various types of infractions. This river guardian program has long since fallen by the wayside, but a new and revised river guardian program may encourage the various recreational users of a river – anglers, canoeists, hikers – to play a greater role in monitoring river conditions such as blockages, water temperature, littering, poaching etc. The return of a River Guardian program could foster a volunteer network to support salmon conservation.
- The immediate and overwhelming public response to the Bonshaw Hills Trail system on West River, and the popularity of the Dromore trails along the Pisquid River and the Mooneys Pond trail on Morell River, demonstrate the popularity of these destinations on PEI. Additional trails, along with accompanying educational material, would show Islanders and visitors the values of a healthy, diverse aquatic ecosystem of which Atlantic salmon are a valuable component.
- Designated canoe routes on some of the larger rivers, such as the Morell, Midgell, Mill, West, Dunk and Naufrage Rivers could also bring increased awareness of the importance and value of these areas. The watershed groups on Morell and West rivers are maintaining canoe passage by doing spring blockage removal on the main branches of these rivers.
- Many Islanders are unaware that there are salmon in some rivers, especially smaller tributaries. Signage at selected road crossing with Atlantic salmon symbols would increase awareness of rivers that are important for Atlantic salmon conservation.

6.3. Aboriginal Involvement

The Lennox Island and Abegweit First Nations, as well as the Native Council of PEI, have been involved in salmon restoration and management projects for many years. More recently, the Abegweit Conservation Society has taken on the task of producing brook trout and Atlantic salmon at the Abegweit Biodiversity Enhancement Hatchery for stocking various PEI rivers. There is tremendous value in the Scotchfort hatchery, in terms of fish stocking and in building capacity within the Abegweit First Nation. The success to date of stocking first feeding salmon fry into prepared juvenile habitat in the upper reaches of the West River is very encouraging and could pave the way to an expanded salmon stocking program. In 2018, the three salmon redds found in the Brookvale section of West River mark the first spawning activity in this region in many decades.

The Abegweit Conservation Society also oversees restoration and monitoring projects in a number of rivers including the Morell, Midgell, and Head of Hillsborough. The partnerships that have been developed between the Abegweit First Nation and watershed groups have enriched the watershed management community and serve as a template for future collaboration on salmon restoration projects.

6.4. A Path Forward

6.4.1 Agricultural Issues

Wikipedia defines a crisis as: "*any event that is going (or is expected) to lead to an unstable and dangerous situation affecting an individual, group, community, or whole society.*" It has also been defined as "*a difficult or dangerous time in which a solution is needed – and quickly*". https://www.vocabulary.com/dictionary/crisis. The degradation of our soils in Prince Edward Island, and the off-field environmental damages resulting from land use abuses, is a crisis and requires urgent action. The impacts of climate change, especially more frequent and intense rainfall events and prolonged dry periods, add additional urgency. This report documents the many problems associated with intensive row crop production, primarily potatoes. It is not the mandate of this report to make specific recommendations on how to fix issues around erosion and sedimentation, and nutrient and pesticide run-off. What is needed is targeted action by industry, government, researchers, and environmental groups. The provincial government must take a leadership role and prepare a strategy to deal with the impacts of intensive agricultural production. There have been many reports written and action committees struck to deal with this issue but no noticeable progress has been made. It would set out clear actions and identify the groups and agencies responsible. Establishing short and long term goals, setting specific targets, identifying groups or agencies responsible, and setting dates for completion will be required to ensure that this strategy does not gather dust on a shelf with previous reports.

In the mid-1990s, federal and provincial government agencies collaborated in the development of a Best Management Practices booklet entitled "Soil Conservation for Potato Production". Although there have been new advances in cultivation methods and technology since that time, it remains a tremendous resource for proper land stewardship in PEI.

> *Potato production on Prince Edward Island continues to increase. Unless this rise in production is accompanied by sound land-use planning and management practices, the sustainability of the agricultural sector and our island environment could be threatened. The future of agriculture on Prince Edward Island rests in the top few centimetres of its soil. Soil conservation is an especially important concern for potato producers. Many producers have been following good management practices, especially crop rotation, for years. Despite this, soil losses associated with potato production are at unsustainable levels. Resources valuable to plant production, such as soil particles, organic matter, plant nutrients and pesticides are transported off fields when erosion occurs. These sediments get deposited at off-farm locations where they degrade the downstream environment. This booklet is a practical guide to help farmers avoid causing long-term damage to the soils they cultivate and to assist them to reduce conflicts with other resource users.*
>
> Soil Conservation for Potato Production – Best Management Practices

6.4.2. Riparian Zone Conservation

If we are to achieve our goal of restoring salmon populations to PEI, our remaining salmon rivers and their riparian zones must be considered and treated as 'at-risk', high priority areas for conservation and protection. Central to this is an approach to riparian zone conservation that recognizes:

- the importance of protecting and /or completing continuous linear corridors along sensitive watercourses;
- a minimum 60 metre protective buffer – with a long-term goal that includes "source to sea";
- the importance of restoring native species that are adaptable to climate change and will help restore more natural function to the river;
- the multiple beneficial uses and high value of these areas.

The high percentage of private land ownership, combined with the linear nature of salmon rivers (which means several different private and public landowners and interests exist along a river's course) poses significant challenges. However, the success on the Morell river in establishing a protected conservation zone with a 60 metre wide buffer zone on both sides of the river shows what can be done. There are multiple mechanisms, incentives, and partnerships that could be applied to the protection of PEIs salmon rivers. The *Technical Manual for Watershed Management on PEI* summarizes the mechanisms available to protect private land that is identified as sensitive or ecologically special, as well as incentives under ALUS that may be used to 'retire' sensitive agricultural land, expand buffer zones, or establish grassed headlands. One notable example of a mechanism for protection of natural areas with high potential application to protection of salmon rivers is the Natural Areas Protection Act (NAPA). As of January 2018, PEI has some 9,423 ha classified as protected Natural Areas under the Act, about 1/4 of these lands are owned and managed by individuals and by private organizations such as the Island Nature Trust and the Nature Conservancy of Canada. The PEI Wildlife Federation acquired land on North Lake Creek for conservation and protection purposes and the property will be managed to maintain a forested riparian zone and forest cover while allowing for native species development and wildlife habitat enhancement. The Province also has designated Wildlife Management Areas, public and private lands, which have been protected under the *Wildlife Conservation Act,* and are maintained for the protection, management, and conservation of wildlife and its habitat. Some of these also carry the natural areas designation under the *Natural Areas Protection Act*, restricting certain management activities to protect natural features. Properly valuing the resource would provide a better basis for protecting these areas in light of competing economic and development interests.

While the importance of riparian zones is evident, working within the legislated buffer zone width of only 15 metres for agricultural land and 20-30 metres for forested land is inadequate to protect waterways. We have at least one good example of how larger buffer zones have made a positive contribution to the health of a waterway on PEI - the 60-metre protected area along the Morell River. Although it will cost significant money, there are many reasons a larger buffer zone makes sense:

1. *Thousands of acres that could eventually be part of our natural areas inventory. This only comes with sound restoration practices that aim at creating healthy forests as opposed to plantations. The sites would have to have appropriate management plans created and implemented.*
2. *These areas would store carbon, clean air, provide wildlife habitat, keep silt and pesticides out of streams, and provide a myriad of opportunities for recreation. We don't know how to value some of these things but using a full-cost accounting or "ecological bookkeeping" we would quickly see that it is not all about costs. There would be serious economic and ecological returns as well*
3. *These areas would be perfect places to begin restoring biodiversity to the province. This would be a stepped process and would depend on the existing status of the buffer zone (successional stage for example.) Rarer plants can be added as stands develop. In open areas, we would start with our pioneer species such as white and grey birch, red maple, white spruce, willow and highbush cranberry, eventually moving onto species that thrive in dappled light such as sugar maple, yellow birch and red spruce. Rare plants such as witch hazel, hobblebush, and round-leaf dogwood would be added along the way. We would use natural regeneration as much as possible, and add appropriate species that are missing from the area that would eventually act as seed sources for the surrounding woodland.*
4. *Looking at costs, there would be significant carbon credits, both with storage in soils and the above ground parts of the growing forests. These credits are starting to have value and it may be a place to where the province can jump ahead in an important way.*
5. *The labor to carry this out could be performed by having well-trained staff looking after student crews, especially if we revised some form of the Young Environmentalist program. There would be a lot of work each year, but it would be labor that creates a positive result for our Island.*
6. *There would be benefits to farmers by reducing the risk of fish kills, and the associated costs involved. These will only get higher as the public becomes more aware of environmental problems associated with contaminated water running off fields.*
7. *Prince Edward Island could become a leader in the area of restoration, and be able to transfer this expertise throughout the region.*
8. *The potential jump in revenues for recreational users of the waterways and just general tourism has great potential, as would the increase for shell fishers if we eliminate, or at last reduce, the number of waterways experiencing anoxic events.*

Gary Schneider, McPhail Woods Project Coordinator, Forester and Environmental Educator

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Dr. Connie Gaudet joined the team in spring 2018. Connie's participation was invaluable, as she visited many of the salmon rivers and had the difficult task of taking photos and notes at each site, compiling data, and writing and formatting the final document. Jordan Condon, Coordinator for the Central Queens Wildlife Federation, was a great asset throughout the project, taking part in many of the spawning and electrofishing surveys.

The various watershed coordinators and crew members of the dedicated groups across PEI accompanied us on many of the surveys and site visits, contributing valuable information on the history of the areas, past and current restoration work and major challenges. The crew members often did the heavy work, dragging equipment into and out of the survey sites – without complaint.

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APPENDIX I

Effects of cold spring temperatures on Atlantic salmon fry survival

Redd counts are typically used on PEI as an indicator of spawning success and to support estimates of whether rivers are meeting conservation requirements (in terms of eggs deposited). However, redd counts may not always align with the presence or density of YOY (young of the year) salmon in the following year. There were 150 salmon redds counted in the 2017 spawning survey on Priest Pond Creek but despite extensive sampling in the autumn of 2018, no YOY salmon were observed. The lack of YOY salmon in Priest Pond has been noted before, in 2001, 2003 and 2016. The curious lack of YOY salmon in Priest Pond Creek in areas with intensive spawning indicates that something else may be limiting juvenile success. One potential influence – cold spring water temperature and its impact on salmon fry – may be a critical limiting factor for the YOY age class on PEI, and one that could have significant consequences for our salmon populations.

In hatcheries, salmon fry feed on the remains of yolk sacs and are then are converted to artificial food, a substitute for the small insects or zooplankton that would be present in their normal river environment. Hatchery managers have observed that water temperature should be a minimum of 12°C to get good salmon fry conversion from yolk sac nutrient to artificial food. It can be assumed that a similar water temperature threshold applies for wild salmon fry in our streams. There is field evidence to support this. Data from the Morell River indicates that during the 1996-97 spawning season, Atlantic salmon juveniles emerged from incubation baskets during the month of June, starting when the water temperature was 11.5°C.

The abnormally cold air temperatures in May and June if 2018 could have suppressed water temperatures in specific sections of Priest Pond Creek. Atlantic salmon fry may be present in the mid-reaches of Priest Pond Creek where electrofishing did not occur in 2018. This section of river is different than the upper and lower regions surveyed. It was once heavily impounded by beavers and the wide channels and lack of mature tree cover may have buffered the effects of cold spring weather. Salmon fry do not move far from the redds, as opposed to salmon parr which can move considerable distances to find suitable habitat. It would not be surprising to return to these sites in 2019 and discover good numbers of parr. It points to the need to do a thorough assessment of juvenile salmon throughout the length of a stream to determine which regions have the greatest fry success.

Priest Pond Creek may not be the only river experiencing this phenomenon. Other rivers along the northeast coast of PEI have had either fewer juvenile salmon than expected (Hay River and Cow River) or none at all (Bear River), although redds were found the preceding autumn. Many of our island rivers are very cold due to a combination of factors and temperature extremes as a result of climate change could tip the balance for some systems. The West River would be border-line, as water temperature barely reaches 13°C by the end of June (although tributaries may vary slightly). The relatively warm Morell River (reaching 24 °C in the main stem below Leards Pond midsummer) is likely cooler in winter and anchor and frazil ice has been observed in some winters.

Some key factors that may contribute to stream temperatures reaching 12 °C at the time of fry emergence:

- Orientation of the river e.g. North Lake Creek flows from the southwest to the northeast thus capturing much solar radiation in spring. Bear River, which flows from the south towards the north, captures much less solar radiation. In addition, North Lake Creek has a pond immediately upstream from the Baltic Road and its orientation may contribute to warming temperatures.
- Beaver and man-made dams and impoundments - number, size, orientation, depth, and location may elevate water temperatures in specific areas.
- Dense conifer-dominated stands will limit solar radiation reaching the water's surface during the critical spring period. Deciduous trees along the floodplain would not have leafy cover in this zone until late May or early June, allowing increased solar radiation to occur.
- Conifer monocultures, such as spruce or fir plantations, may also impact the quantity and temperature of snow melt. Snow catching on conifer boughs is prone to sublimation and the ground, with its dense layer of needles, is prone to freezing. A late winter or early spring rainfall can run off these areas, leading to "super chilled" stream water. River temperatures as low as 0^0C have been observed following these rainfall events (Roloson pers comm). With greater snow depth under deciduous trees, and the insulating effect of leaf cover, soil is typically not frozen and allows water to penetrate into the ground as opposed to running off.
- Bottom substrate – it is possible that energy storage in different types of substrate can influence water temperatures, although further research is needed.

Recommendations

While the topography or orientation of a river cannot be changed, there are some management actions which could help in maximum solar radiation reaching streams at critical times for juvenile salmon.

- Due to their warming effects, managing discharge from impoundments, perhaps retaining the sills of old beaver dams to create shallow impoundments, may help moderate temperature extremes in downstream reaches. This would be a situation-specific approach and may not be appropriate for all rivers, especially those with elevated summer water temperatures.
- Focus on planting of original Acadian forest tree species in lieu of plantations of spruce, fir, pine or tamarack. Elms used to provide great shade for streams in summer, and allowed solar radiation to reach the water until at least late May, and suppressed much growth in the understory except grasses and some shrubs. Other trees, such as yellow birch, red maple and possibly red oak, planted 10-15 meters apart will perform a similar function. Sugar maple are ideal on slightly drier parts of the riparian zone while red maple is well adapted to wet zones. It will be important to focus on trees which are predicted to thrive in PEI conditions with long term climate changes.

- While experimental, addition of large heat retaining rocks might help moderate temperatures in areas where solar radiation can reach the water surface in spring. It is even possible that the eddies created downstream edge of large boulders may serve as pockets of warmer water for salmon.
- Additional electrofishing sites are needed in areas of salmon spawning to pinpoint those spawning locations that are having the greatest success. Management strategies could potentially be developed to optimize those areas and improve others to boost production.

Research and Monitoring

- Further research is needed to asses low spring water temperatures as a potential critical limiting factor for Atlantic salmon, and to define the optimal water temperature for Atlantic salmon fry. This could be accomplished through *in situ* field experiments using approaches similar to what was conducted on the Morell in 1996-97 (Appendix III), in combination with laboratory experiments looking at hatching success, emergence and fry survival under different temperature scenarios.
- Research is also needed on the habitat factors (such as riparian zone composition, instream characteristics) that affect spring water temperature on PEI.
- Monitoring programs should be expanded to assess water temperature throughout the year, and especially the critical spring hatching period. Water temperature, at least in salmon redd locations, should include temperature of water in the interstitial spaces in cobble where juveniles are found and which may be different than the overlying water column due to the influence of spring waters.

APPENDIX II

DNA Biomonitoring and Atlantic Salmon Diet

Since the fall of 2016, the Central Queens Wildlife Federation has been collaborating with the DFO to compare benthic invertebrate communities and juvenile salmon diet in agriculture and forest-dominant rivers using DNA as well as traditional morphological methods. This work is part of a 5 year Federal Genomic Resources Development Initiative (GRDI) project, involving multiple departments, tasked with comparing the traditional morphological and molecular means of biomonitoring and food-web determination. Specifically, DFO scientists are comparing the cost and taxonomic resolution of invertebrate identifications in CABIN kick samples and salmon fecal contents with DNA metabarcoding as well as traditional morphological means. The first few years of the project have been focused on sample acquisition, testing and development of efficient and cost-effective molecular techniques, as well as establishing computational analyses to identify the millions of DNA sequences generated by this work down to the Genus level.

The DFO selected PEI as a focal region for their research due to the contrasting land-use patterns across a small scale (high impact agriculture cover and lower impacted forest cover), the relatively uniform substrate and habitat type (sandstone and groundwater-fed streams), availability of juvenile salmon, a good foundation of previous salmonid research conducted in PEI, as well as the availability and willingness of numerous watershed groups to share their expertise. Watershed groups from across PEI have collaborated with the DFO to collect kick samples. In addition to helping with kick-sampling, the Central Queens Wildlife Federation has been electrofishing in order to non-lethally sample fecal matter from juvenile salmon for the past two years from June-September in branches of the West river that are highly impacted by agriculture or highly forested. Opportunistic electrofishing has also been conducted on the Dunk, Mill, and Trout rivers during salmonid population surveys led by Daryl Guignion. These collections have resulted in millions of diet-derived DNA barcode sequences that can be identified to the Genus level and compared to the invertebrate community present at the exact electrofishing sites where kick samples were also collected in order to describe the invertebrate community. As the GRDI project enters the final few years, scientists with the DFO will be turning their focusing to data analysis in order to compare and contrast the invertebrate community structure and how it influences salmon diet in watersheds with differing land use patterns (Royce Steeves, personal communication).

DFO researchers involved: Nellie Gagné, Mélanie Roy, Royce Steeves.

APPENDIX III

Relationship between Atlantic salmon emergence (hatching success) and sediment accumulation using artificial salmon redds on the Morell River (1996-97)

Based on notes by Daryl Guignion

Researchers: Daryl Guignion, Rosie MacFarlane, Rick Cunjak and Mark Hambrook

Summary – To evaluate the relationship between Atlantic salmon young of year (YOY) emergence and sediment accumulation, incubation baskets[i] containing 100 Atlantic salmon eggs[ii] layered in cleaned site gravel were placed in various locations along the Morell River (3 replicates per location) where Atlantic salmon were known to spawn. Emergence baskets were attached in late April. Juvenile Atlantic salmon emergence started on June 1 and continued for 3 weeks, with juvenile salmon being removed after they ascended from the gravel[iii]. Juvenile salmon ranged in length from 27-30 mm. Water temperature during the emergence period was 11.6^0C or greater, very close very close to the 12^0 C target temperature that hatchery managers have suggested is ideal for young to begin feeding. From results, it appeared that the number of YOY salmon emerging varied dramatically with the amount of sediment accumulated in each basket (range = 0 to 55 YOY). It was noted that the sediment input to the river from clay roads was especially high during the winter of 1996-97. Other notable observations are included below[iv].

Results and Discussion

In our incubation basket study on the Morrell River the survival of juvenile salmon from buried baskets was encouraging, especially at Kenny's Bridge 300 m upstream of the 2018 electrofishing site. Previous sediment stabilization had been conducted upstream below the third crossing on the Cardigan Road where the incubation baskets were submerged just downstream from an instream sediment trap that seemed to catch much of the sediment moving downstream, and near Crane's Bridge (remnants of the old dam can be seen just upstream from the new bridge) where there was very little sedimentation. Other sites had much poorer emergence success likely at least in part due to sedimentation. Likely the YOY salmon would have survived better below Leards Pond if the winter water velocity had not been violent enough to wash out some of the baskets and move substrate. The "second crossing" on the old Cardigan Road (one more bridge downstream of the 2018 electrofishing site) at the time of the incubation study the road has serious erosion problems which might explain the poor hatching success.

Atlantic salmon egg hatching time will depend primarily degree days (water temperature) at the level (in the substrate) at which eggs are deposited. Some large females, especially in loose gravel, can dig much deeper than smaller grilse but layering does occur (eggs covered with substrate followed by more eggs). Presumably eggs buried deeper in some regions are exposed to warmer water conditions in winter due to the 7^0C groundwater entering the streambed.

[i] Incubation baskets and screw-on tops for emergence were built at UPEI Maintenance department with oyster spat screen material

[ii] Eggs were obtained from wild salmon spawned at the Cardigan Fish Culture Station

[iii] A few YOY were still alive and healthy in the incubation baskets when the gravel was sorted at Cardigan on June 23

[iviv] The Morell River is cold in the winter (with anchor ice sometimes present) and warmer in the summer than other "large" rivers such as the West River. The Morell has several man-made impoundments as well as beaver dams in the headwaters that cause the water to warm considerably. In the main branch below Leards Pond the water temperature holds at about 24^{0}C throughout much of the summer.