The Hammond River Watershed Management Plan

New Nouveau Brunswick
Your Environmental Trust Fund at Work
Votre Fonds en fiducie pour l'Environnement au travail

Acknowledgements

The HRAA acknowledges that the Hammond River watershed exists on land that has never been ceded, and is Traditional Territory of the Mi'kma'ki, Wolastoqiyik and Peskotomuhkatiyik

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Preface

While this document is intended to be a final report, it is in essence a draft- watershed management planning should be considered a fluid, adaptable process, and should not be considered static or final.

The intent of this document is to highlight the work that was complete in 2020, while incorporating HRAA's historic work, and ultimately provide a navigational tool for all future HRAA staff. It is our hope that this document will allow someone who has never been in the Hammond River area to easily navigate through the watershed with confidence, while understanding the work that has been done, and recognize the work to come.

We also hope that this document will be of use to those outside of the organization- that it may guide other watershed organizations in their efforts; that it may inspire future volunteers or conservationists; or that it may guide nature lovers and anglers on new places to explore within the Hammond River area.

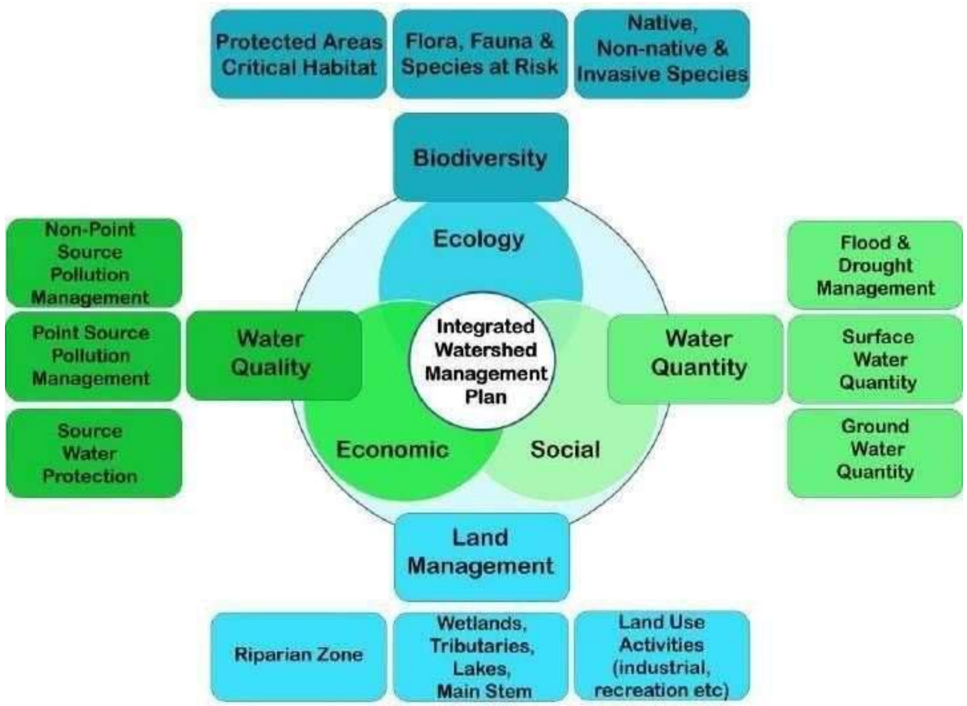
-S. Blenis & J. Kelly

"We must begin thinking like a river if we are to leave a legacy of beauty and life for future generations."
- David Brower

Introduction to Watershed Management Planning

As the Hammond River is a fluid, ever changing presence, so too is our Watershed Management Plan strategy. This plan must not be considered a final, static document on our watershed management, but as an ever-evolving plan, one which incorporates and accommodates changes in the environment and the changing wishes of residents. It serves as a summary of current situations, desires, goals, and concerns, and identifies strategies to achieve these goals in a timely fashion.

The aim of this Integrated Watershed Management approach is to account for social, economic, and environmental issues, as well as local community interests and issues. This will allow us to sustainably manage our water resources and develop an appropriate plan that will improve water quantity and quality; improve flood, drought, and erosion management; recognize and protect biodiversity and critical habitats; sustain economic and recreation opportunities; and ultimately improve life for flora, fauna, and surrounding communities. (**Figure 10**. *S. Blenis*)



Introduction to Watershed Management Planning

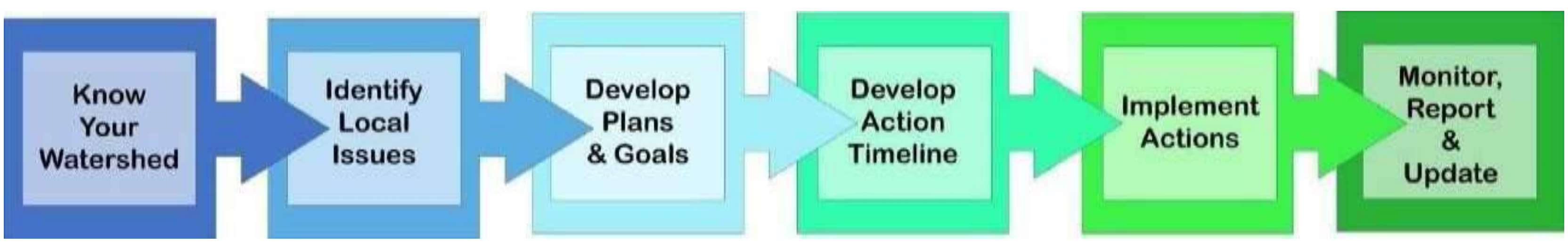
We have divided our planning and management process into 6 stages. These stages will provide direction to human activities in the protection and rehabilitation of water, as well as associated aquatic and terrestrial resources within the Hammond River watershed, while simultaneously recognizing and integrating the benefits of growth and development. This will allow us to model how societies, businesses, industry, and the natural environment can work with each other harmoniously, instead of being considered independent. Ongoing collaboration, with Indigenous communities, various levels of government, academia, surrounding community, businesses, and other watershed and environmental organizations will be the key to long-lasting success.

"It would be hard to dispute the role water plays in Canadian identity, not only in terms of everyday use, but how it relates to our economy, our recreation, our culture, and our environmental health" (Environment Canada, 2012).

Watershed planning provides a context for integration, by using practical, tangible management units that people understand, focusing and coordinating efforts, and finding common ground and meeting multiple needs. Additionally, this process yields better management by generating ecologically based, innovative, cost-effective solutions, forging stronger working relationships, and supporting consistent, continuous management of the resource. (US Environmental Protection Agency).

HRAA'S 6 Stages of Planning & Management

(**Figure 10.** *S. Blenis)*



HRAA’S 6 Stages of Planning & Management

1. Know Your Watershed

- Vision Statement
- Preliminary Goals
- Key Stakeholders
- HRAA History
- Fisheries Management

Watershed Inventory
Collect & Analyze Current Data
Collect & Analyze Past Data
Identify Data Gaps
Identify Issues

2. Identify Local Issues

- Stakeholder Engagement
- Public Engagement
- Identify Local Issues
- Prioritize Issues
- Implement Committees

3. Develop Plans & Goals

- Set Overall Goals and Management Objectives
- Develop Indicators & Targets
- Identify Critical Areas
- Develop Management Measures to Achieve Goals
- Communicate Plans & Goals with Stakeholders & Public

HRAA'S 6 Stages of Planning & Management

4. Develop Action Timeline

- Develop Implementation Schedule.
- Develop milestones to track implementation schedule.
- Develop monitoring component.
- Develop education and information component.
- Develop criteria to monitor progress towards achieving goals.

5. Implement Actions

- Identify technical & financial assistance required.
- Assign responsibility for reviewing, revising & updating plan.
- Implement management strategies.
- Conduct monitoring.
- Conduct education and information activities.

6. Monitor, Report & Update

- Review & evaluate.
- Report to stakeholders & public.
- Ongoing monitoring.
- Create database for projects.
- Adjust plan as necessary.

Vision Statement & Guiding Principles for the *Watershed Management Plan 2020*

Vision Statement: HRAA's *Watershed Management Plan 2020* will become a guiding force in our research, restoration, and rehabilitation of the Hammond River Watershed, offering an inclusive, adaptive strategy to ensure water quality and quantity for flora, fauna, and humans alike for centuries to come.

Guiding Principles: We shall continue to build off the guiding principles from HRAA's founding members in our quest to protect and preserve the Hammond River watershed, and all those who call it home:

- **Inclusivity:** to include all interested parties, peoples, governments et al, and be respectful of their values.
- **Transparency:** to ensure that the information in this document is accurate and easily accessible forall.
- **Adaptivity:** to be able to adjust to unknown and unforeseen issues, including natural and human-made.
- **Creativity:** to think outside of the box and let no stone go unturned.
- **Positivity:** to allow our love for the outdoors and the work we do inspire and uplift others.
- **Compassion:** to treat our environment, resources, and neighbors (human and natural) with love and respect.
- **Integrity:** upholding strong moral principles and professional values of scientific activities.
- **Inspirational:** cultivating environmentally conscious youth to continue to carry the torch of conservationism.

Eventually, all things merge into one, and a river runs through it.
The river was cut by the world's great flood and runs over rocks from the basement of time. On some of the rocks are timeless raindrops. Under the rocks are the words, and some of the words are theirs.
I am haunted by waters" -N. Maclean

Know Your Watershed

Stage 1: Know Your Watershed

This first step in the watershed management planning process involves collecting and analyzing large amounts of data about the watershed, including details on:

- Location, watershed boundary
- Traditional Land, Municipal Boundaries, Local Service District Area
- Key Stakeholders and Rights Holders
- Scientific Methods Used for Data Collection
- Surrounding Land Use
- Neighboring Watersheds and Confluence Points
- Surface Water Quality & Quantity
- Ground Water Quality & Quantity
- Tributary, Wetlands, Lakes, and Other Water Features
- Surrounding Economic and Recreation Uses
- Riparian Buffer and Erosion
- Flooding Events & Stormwater Management
- Bridges, Culverts, Dams, Barriers to Fish Passage and Other Water Diversions
- Ecological Inventory: Endangered/Species At Risk, Invasive Species
- Climate Change Adaptation Plans
- Pollutants, Effluents, and Sediment Transport Loading
- HRAA History & Current Standing
- Fisheries Management
- Geological Terrain and Soil Quality
- Historic Issues, Current Issues, and Potential Future Issues
- Analysis of Historic and Current Data

Once the watershed is characterized, there will be a solid foundation of necessary data to identify and select management strategies to bring about improvements. There will always be more data to collect; however, it is important to keep the process moving forward, to ensure that the management plan does not become stagnant.

HRAA History

In the fall of 1977, after noticing a significant change in Atlantic Salmon populations in the Hammond River, a small group of early conservationists decided that it was the time to act, and the seven founding members drew up a tentative constitution and by-laws, called a public meeting, and elected officers and directors- the Hammond River Angling Association (HRAA) was born.

Figure 3. Sunset view of the Conservation Center, built in 1997, with substantial help from volunteers and J.D. Irving Limited.
Photo: P Wood

The majestic Atlantic Salmon is what inspired these early conservationists to join forces, and an early name of the "Hammond River Salmon Association" was tossed around, before members decided a more angling-inclusive name would be best.

"The Hammond River Angling Association was deliberately instituted as an angling association, and not as a salmon association, with trout being an important component. The Association believes that the trout resource can co-exist with salmon, and that stocks can be increased to their former abundance. There is also an established population of small mouth bass in the Hammond River, particularly in its lower stretches, and it too is worthy of the serious sport fisher. This bass resource also deserves recognition and protection" (*HRAA Position Paper*, Lou Duffley and Randy Giffin).

55 people attended that first official HRAA meeting, all of whom recognized the need for an association to speak with a united voice on all matters affecting the beautiful Hammond River and its precious resources.

"We are working to keep the riverbanks clean, the water pure, and the anglers courteous and law abiding, and the fish population healthy."
(1984 HRAA Position Paper)

HRAA History

The HRAA then became a charter member of the NB Council of the Atlantic Salmon Federation and the Saint John River Management Advisory Committee, and quickly expanded to assist other groups devoted to salmon conservation in New Brunswick, like the former provincial Save Our Salmon Committee, and the New Brunswick Salmon Council.

Some of the organizations earliest successes included the joint creation of the Fish Friends program, in cooperation with the Atlantic Salmon Federation (ASF), in which schools across the province were provided tanks and Atlantic Salmon eyed eggs to raise, and then release, as well as educational materials on the lifecycle of the Atlantic Salmon, in hopes of inspiring youth to become environmental stewards.

Salmon angling etiquette was forefront of the early years, and the HRAA worked tirelessly to promote responsible angling practices, including working with the Department of Fisheries and Oceans to have sections of the river deemed “fly fishing only” after July 15th, to protect migrating Atlantic Salmon. Anti-pollution measures, habitat restoration, school education, public outreach, research and environmental monitoring, and developing partnerships with all levels of government, stakeholders and local landowners, quickly ensued, ultimately establishing the HRAA as a leader in conservation initiatives.

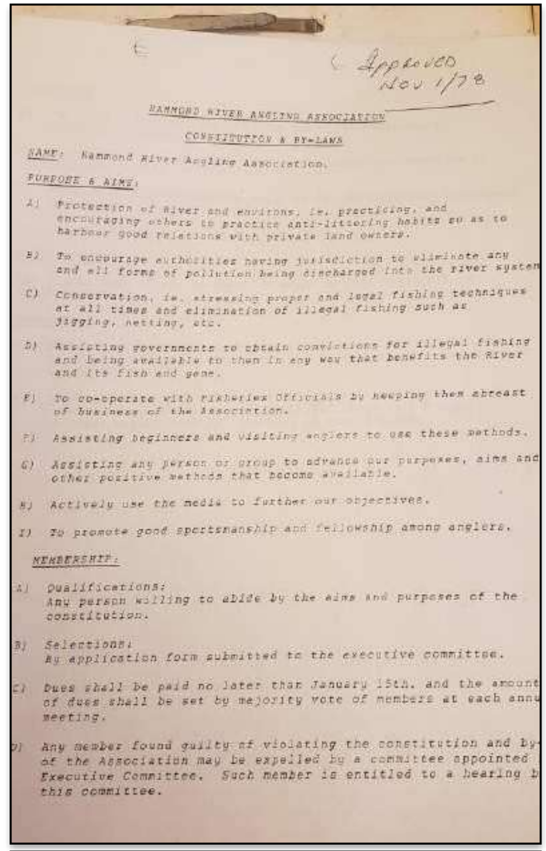
“Memories”, a painting by Andrew Giffin, that proudly hangs over the fireplace at the Conservation Center.

HRAA History

1977 Hammond River Angling Association
Purpose & Aims.

A) Protection of river and environment, ie: practicing, and encouraging others to practice anti-littering habits so as to harbor good relations with private landowners.
B) To encourage authorities having jurisdiction to eliminate any and all forms of pollution being discharged into the river system.
C) Conservation, ie: stressing proper and legal fishing techniques at all times and elimination of illegal fishing such as jigging, netting, etc.
D) Assisting governments to obtain convictions for illegal fishing and being available to them in any way that benefits the River and its fish and game.
E) To co-operate with Fisheries Officials by keeping them abreast of business of the Association.
F) Assisting beginners and visiting anglers to use these methods.
G) Assisting any person or group to advance our purposes, aims and other positive methods that become available.
H) Actively use the media to further our objectives.
I) Encourage landowners and Crown land forest industry to have a covering of trees near the brooks on the rivershed to provide a source of cooling water during the warmer months.
J) To promote good sportsmanship and fellowship among anglers.

"There being no further business, moved by Gordon Fraser, seconded by Randy Giffin, that the meeting be adjourned. Carried.
We all then damaged the President's Scotch…"- notes from HRAA meeting



Approved Nov 1/78

HAMMOND RIVER ANGLING ASSOCIATION

CONSTITUTION & BY-LAWS

NAME: Hammond River Angling Association.

PURPOSE & AIMS:

A) Protection of River and environs, ie. practicing, and encouraging others to practice anti-littering habits so as to harbour good relations with private land owners.

B) To encourage authorities having jurisdiction to eliminate any and all forms of pollution being discharged into the river system

C) Conservation, ie. stressing proper and legal fishing techniques at all times and elimination of illegal fishing such as jigging, netting, etc.

D) Assisting governments to obtain convictions for illegal fishing and being available to them in any way that benefits the River and its fish and game.

E) To co-operate with Fisheries Officials by keeping them abreast of business of the Association.

F) Assisting beginners and visiting anglers to use these methods.

G) Assisting any person or group to advance our purposes, aims and other positive methods that become available.

H) Actively use the media to further our objectives.

I) To promote good sportsmanship and fellowship among anglers.

MEMBERSHIP:

A) Qualifications:
Any person willing to abide by the aims and purposes of the constitution.

B) Selections:
By application form submitted to the executive committee.

C) Dues shall be paid no later than January 15th. and the amount of dues shall be set by majority vote of members at each annu[al] meeting.

D) Any member found guilty of violating the constitution and by-[laws] of the Association may be expelled by a committee appointed [by the] Executive Committee. Such member is entitled to a hearing b[y] this committee.

Figure 5. HRAA's Constitution went through several drafts, before being amended and accepted in 1978. *Photo: S. Blenis*

HRAA Today

Figure 6. HRAA staff of 2020 (L-R)- Josh Kelly, Sarah Blenis, Melissa Crilley, and Isabella van Dam, on a fishing trip to the lower reach of the Hammond River near Darling's Lake, to test out new, biodegradable soft lures from Clean Catch Baits. *Photo: J. Kelly*

"If people concentrated on the really important things in life, there'd be a shortage of fishing poles"
- Doug Larson

Since our humble beginnings in 1977, the HRAA has gone on to complete a wide variety of projects, (a few of which are shown below), all to benefit the river and those that call it home:

1. Educational Programs
   a. Hammond River Nature Camp
   b. Wetland Tours (in partnership with Ducks Unlimited)
   c. Fish Friends (in affiliation with ASF)
   d. Public School Education- Riverkeepers & Ecologic
2. Atlantic Salmon Research
   a. On-going electrofishing study, since 2005
   b. Smolt Assessment (2013-2015)
   c. Annual Redd Counts
   d. Watershed Management Plans (2000, 2008, 2015, 2020-2021)
3. Environmental Restoration
   a. Erosion Control/ bank stabilization through tree planting
   b. Atlantic Salmon habitat restoration
   c. Culvert assessment
   d. Wetland mapping & restoration
   e. Wetland restoration
4. Community Interaction
   a. River Clean-Up Events
   b. Annual Fishing Derby
   c. Annual Holiday Potluck
   e. Annual Dinner & Auction
   f. BioBlitz Events
   g. Clean, Drain, Dry Boat Demonstration
   h. Monofilament collection and recycling

Fisheries Management

Since its inception 44 years ago, the HRAA has faced many challenges and obstacles in its pursuit of effectively managing the Hammond River fishery. Identifying the river's carrying capacity and Atlantic Salmon densities was one of the first endeavors ofthe organization. Identifying which areas could support additional stocking and working with the Department of Fisheries and other stakeholders became paramount to ensure the survival of this now-endangered species.

Early successes included working with the province to create fishing guidelines through a 'watershed by watershed' approach- this included designating part of the Hammond River as "fly fish only" after July 15th. In the early 1980's, appeals were be made to the appropriate government agencies to delay the opening of trout season from April 15th to March 1st. The HRAA felt that there were many 'accidental hookups' of black salmon soon after the opening of trout season, as this coincides with black salmon migration. There were also suspicions of anglers targeting these salmon. The HRAA promoted an opening of trout season at a time when the majority of black salmon have left the system to reduce stress on these fish during this vulnerable time period. Unfortunately, this undertaking to delay trout season did not come to pass.

In 1996, government agencies determined that the Hammond River should be closed to salmon angling in general, to the dismay of the organization. These words, from former HRAA president in 1996, have become eerily ominous in 2020, as the debate heats up on whether or not to list the Outer Bay of Fundy Salmon on the federal Species At Risk Act.

"With the total closure, we all lose. Outfitters, guides, Indigenous fishermen, non-Indigenous fishermen; the economy suffers; volunteer interest will wane; our precious salmon will be more vulnerable to poaching; and our already overburdened enforcement personnel will be taxed even more heavily.

The time to decide is now;

*We can take the **EASY** solution, or we can diligently pursue the **BEST** solution.*

I am certainly not ready to throw in the towel yet, but how long could we continue with outright closure before our interest will begin to wane, 2 years? 4 years?

-former HRAA President, Paul Daigle

Fisheries Management

A major concern for the HRAA has been to devise an appropriate stocking plan and broodstock collection. Over the years, the HRAA tried stocking smolt, parr, fingerlings and unfed fry, and have put over 1 million juvenile salmon into the Hammond River. Broodstock collection was once the most engaging volunteer activity, as adult salmon would be caught, and transported to the Mactaquac Biodiversity Facility. Since 2008, the broodstock collection became limited, with only enough collected to provide eggs for the Fish Friends program. This shift in stocking and broodstock collection was expected to continue until a comprehensive stocking plan could be developed with government agencies; however, this has not transpired.

For the first time since the program was created by HRAA and ASF, HRAA will not be delivering eyed eggs to schools for the Fish Friends program. Over the past few years, the unfed fry that schools released into the Hammond River through Fish Friends has been the sole salmon stocking program. As far as we can foretell, 2021 will not see any salmon being stocked into the Hammond River. Is this due to the global pandemic that has occurred in 2020, or is this potentially as a result of the Department of Fisheries and Oceans desire to list the Outer Bay of Fundy Salmon (OBoF) under the Species At Risk Act (SARA)?

Between 2012 and 2014, the Department of Fisheries & Oceans held consultations on the consideration of listing multiple populations of Atlantic Salmon under the Species At Risk Act (SARA) that were assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2010. The purpose of a listing under SARA is to prevent species from becoming extinct, provide for their recovery, and to conserve biological diversity. COSEWIC estimated that in 2008, the outer Bay of Fundy population was made up of approximately 7,500 adults in just four of the 20 known salmon rivers, a decline of 64% compared to 1993. The Outer Bay of Fundy region once contained North America's most productive river, the Wolastoq-St. John, but in 2019, only 700 salmon were counted at the Mactaquac dam near Fredericton.

Should the decision be made to list OBoF on the SARA registry, it would include prohibitions so that one may not kill, harm, harass, capture, take any individual or its derivative; cannot possess, collect, buy, sell, or trade any individual or its derivative. Listing advice is being finalized for the Minister of Fisheries and Oceans to support the Minister of Environment and Climate Change in making a recommendation to the Governor in Council on a listing decision. DFO is now projecting that an announcement on the proposedlisting decision could be announced in Fall 2021.

Fisheries Management

While it may seem counter-intuitive to disagree with listing an endangered species in the SARA registry, the HRAA cannot help but wonder how this listing will impact our conservation efforts. Could this be the end of our electro-fishing and juvenile salmon density studies? Will this be the conclusion of the Fish Friends program, as it would be prohibitive to possess these eyed eggs? When the Inner Bay of Fundy Salmon were listed on the registry, there was a period of several years when all restoration activities were halted while permissible restoration activities were defined. How will this impact our riparian restoration work? Shall we sit idly by, as our riverbanks continue to degrade and deposit sediment into the river, while government agencies slowly determine what restoration activities are permissible? Will our volunteers still want to assist us, if they feel they are no longer protecting and engaging with one of the most spellbinding fish species? Will our youth, and future environmental stewards, feel the same passion for nature and angling as the forefathers of HRAA felt when they were young? Has our 44 years of time, resources, restoration, and research all been for naught?

Figure 7. One of many empty tanks that sits lonely and unused in classrooms, while the future of Fish Friends and stocking Atlantic Salmon remains unknown. *Photo: S. Blenis*

The HRAA remains committed to the recovery and responsible protection of Atlantic Salmon. We want assurances that our well-developed restoration and research programs will not be delayed or encumbered. DFO has not provided sufficient information in its socio-economic impact summary for the public or stakeholders to accurately assess whether or not they should support a listing, nor have they provided adequate information on a recovery strategy or what activities will be permissible.

As such, we have no other choice but to oppose the listing of OBoF on the SARA registry.

Methods

1. Benthic Macroinvertebrate Study

A macroinvertebrate is an organism that lacks a backbone and is apparent to the naked eye. Traditional water quality sampling has focused on chemical and physical parameters and this method often only provides a snapshot of stream health. Recently, the use of benthic macroinvertebrate (BMI) collection and identification has been used to provide a long-term outlook of community health (CABIN 2009). The Canadian Aquatic Biomonitoring Network (CABIN) provides guidelines for sampling unit effort to standardize methodology in order to make the data comparative across watersheds.

Due to COVID19, staff were not able to participate in the CABIN certification course. Rather than not collect any BMI's, HRAA staff decided to continue with the BMI survey. Due to the lack of certification, staff were comfortable identifying the benthic macroinvertebrates to the Order Level only. Because of this, our results cannot be entered into the online CABIN datahouse.

Staff used the 3-minute kick net sampling protocol, using a WildCo benthic D-net with a 500 µm mesh size and tapered open end for easy insertion and removal of collection bottles. Heel to toe movements were used to disturb the sediment and direct it toward the net. Samples were collected from a riffle and run, in a zigzag pattern from bank to bank. Samples were collected in the fall when most of the community was present. The Hilsenhoff Biotic Index Equation and the Benthic Macroinvertebrate Aggregate Assessment were used for analysis, which can be found in the Discussions chapter.

Figure 8. Samples were collected in 10 locations, and then placed in anhydrous ethanol and brought back to the Conservation Center, where staff examined the organisms under a microscope at 20x magnification. Results were then tabulated, and a broad discussion on the findings will be discussed throughout this book. *Photo: S. Blenis*

2. Culvert Assessment

Results from an extensive culvert analysis in 2011 and 2012 suggest that there are substantial suitable, but inaccessible, salmon habitat on the upstream site of restrictive culverts in the Hammond River tributaries. Our long-term salmon database also suggests that the amount of available parr habitat may be a limiting factor to the growth of the Hammond River salmon population.

As such, over 20 culverts were revisited and assessed in 2020. The main focus of the Culvert Assessment included habitat analysis above the culverts. Staff surveyed approximately 2km above each of the restrictive culverts and documented the suitable fish habitat (with an emphasis on juvenile salmon habitat), including substrate, vegetation, canopy coverage, and general water chemistry (dissolved oxygen, pH, water temperature, salinity, total dissolved solids, and conductivity). Each culvert was also assessed, and information was gathered on road type (including width of road, and distance to culvert lip); culvert type, shape, length, rust line/watermark, and fill; water details (velocity, depth in culvert, depth of culvert lip, depth of scour, channel water width, channel water depth); obstructions, % perched, % eroded, % crushed.

The information that was gathered allowed HRAA staff to prioritize the top 10 culverts for repair and replacement, as these will become the focus of upcoming restoration projects. This culvert assessment has been incorporated into our *Watershed Management Plan 2020* to further our understanding of Atlantic salmon habitat in the Hammond River watershed and identify areas for future projects. These priority culverts are discussed throughout this book, with recommendations on next steps made for each.

Figure 9. A deformed, poorly sloped, eroding, rusted culvert that does not allow fish passage, that was located on the Shepody Road in the Markhamville area on a dirt logging road. It’s a real beauty! *Photo: S. Blenis*

3. Environmental DNA (eDNA)

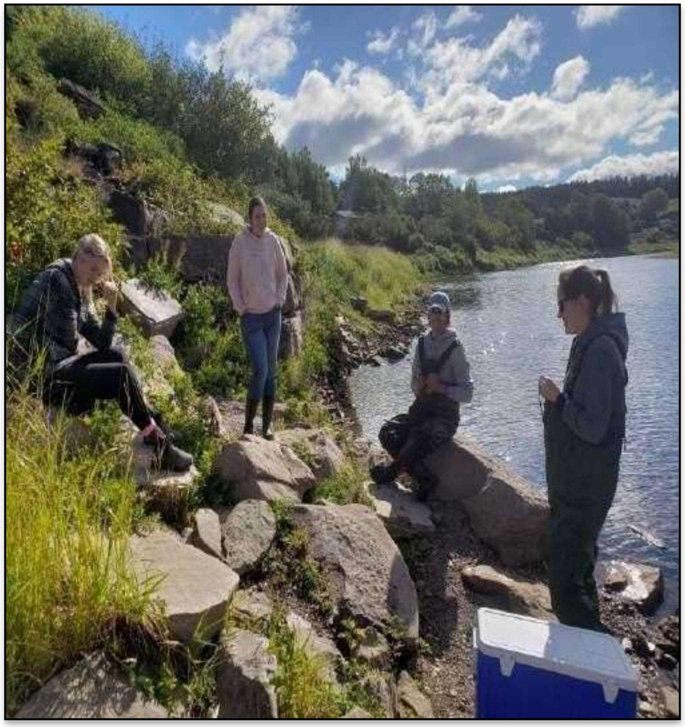


Figure 10. Training day on eDNA sampling protocols with Larissa BLANK from the Scott Pavey Lab. This training opportunity was extended to surrounding watersheds, including the Kennebecasis Watershed Restoration Committee and the Belleisle Watershed Coalition. *Photo: S. Blenis*

The HRAA field staff took 10 samples in total throughout the watershed. Each site required 3 1-liter glass bottles. The first bottle acted as thecontrol, and was opened for 10 seconds, and then recapped, and labelled as “Control”, with the date, time, and location. The second and third bottle contained a water sample, taken upstream of staff to ensure that no unintentional sediment entered the sample. The samples were taken from the middle of the water column. Each bottle was labelled as “Replicate 1” and “Replicate 2”, and included the date, time, and location. The samples were then immediately put into a cooler with ice and transported directly to the Scott Pavey lab at the University of New Brunswick for analysis.

There are three types of negative controls (field, extraction, and quantitative polymerase chain reaction) used throughout the process to detect if contamination occurred at any step. Negative results do not necessarily mean that there are no Atlantic Salmon- only that the signal was below detection limit. Positive results mean that there were Atlantic Salmon present at the site or somewhere upstream, and a positive result is only given if at least one of the two field replicates produced all positive replicates in the lab. The lab also has the ability to test for different eDNA strains within the same sample- the HRAA subsequently requested that 4 samples be tested for the presence of Eurasian Water Milfoil, an invasive aquatic plant that has been documented in the watershed.

The original proposal for the 2020 Watershed Management Plan did not specify locations for eDNA analysis, giving current HRAA staff the leeway to choose their own sites. Site selection was strategic and will be discussed in depth in the following chapters.

4. Juvenile Population Density Survey

Figure 11. Blenis is ready to go!
Figure 12. Salmon parr.
Photos: M. Crilley

The primary source for data regarding juvenile fish is electro-fishing. Electro-fishing uses electricity to cause involuntary muscle contractions in fish, causing them to float up to the surface to they can be easily caught. Sampling fish provides insight to the types of species that populate a particular area, as well as such factors as size, length, and weight. These features provide information about the health of species, as well as the overall health of the stream.

Historically, the data that was gathered from electro-fishing was used to determine which sites were suitable for salmon stocking, as well as to quantify the survival rates of hatchery fish, to determine how stocking is affecting the river. Historically, this information was used to guide HRAA's salmon programs, and to stock the river responsibly.

Given that stocking has almost entirely ceased, the electro-fishing program in 2020 was to determine presence-absence of fish species, while continuing to document size, length, and weight. Historically, the HRAA has volunteers that participate in electro-fishing surveys; however, given the COVID19 pandemic, we were limited to a crew of only 2 field staff, no volunteers. As such, staff used the presence/absence, single pass method to survey 100m² at each of the 18 sites with a Halltech 2000 backpack fisher.

Conductivity readings were taken in advance of electro-fishing at each site in order to ensure the backpack was set at proper settings, and frequency (Hz), voltage (V) and effort (seconds) were recorded. Water temperature, dissolved oxygen and pH were also recorded. Fish were temporarily held in a bucket, to be weighed, counted, and measured, then released into the water. The survey was performed between September 9th-24th, to ensure that water temperatures were well below 20˚C, to not add additional stress on the fish. Staff donned rubber chest waders and shoulder length rubber gloves to avoid getting zapped, as well as polarized sunglasses, hats, and safety vests.

5. Redd Count

The word “redd” is a Scottish word meaning “to make clean or tidy”- it is a nest that the female Atlantic Salmon will create, by using her tail to create a depression in the gravel for her to lay her eggs. Once the eggs have been laid, she will use her tail to cover the eggs with additional gravel. The surface area of a redd is approximately 2-5 meters squared and consists of a raised mound or dome of gravel, under which the eggs are located. The gravel will appear clean, or bright, compared to other rocks in the river. Redds are usually found at the tail of pools on the upstream side of riffles, with relatively high-water velocity, and water depths of 15-70cm. The flow allows for oxygen to reach the eggs, while keeping sand and silt away from the eggs. Look for areas that have lots of gravel, not sand, silt, or bedrock. If the water level or flow is low, there will be more redds clustered together in the middle sections of the river or tributary. When the water level and flow are normal, the redds will be more evenly distributed throughout the whole river, reaching further upstream.

One of our most popular volunteer events, volunteers were provided an initial redd training guide called “Redd Alert” and were assigned a stretch of the river or tributary with an experienced HRAA guide. In November during spawning season, we performed 20 days of redd counts over 12.5km at 17 sites. GPS coordinates of located redds were collected and documented, and average size of redds were tabulated. Extreme caution was used while wading in the water, to ensure we did not disturb any existing redds. SCUBA divers assisted with the survey and provided us with drone footage and underwater footage.

November 2020 was unseasonably warm and may have delayed spawning. In total, we found 49 redds, and our findings will be discussed in further detail throughout this book.

Figure 13. Volunteers searching for redds in Salt Springs Brook.
Figure 14. Some of the redds found at Silver Hill Pool. *Photos: J. Kelly & S. Blenis*

6. Habitat Assessments

Stream Habitat Assessments are one of the most powerful tools to observe and collect data. In total 67 Stream Habitat Assessments were performed throughout the 2020 season, and staff visited 8 lakes, allowing us to experience and document the majority ofthe Hammond River watershed. Stream Habitat Assessments provide us with vital information, including identifying which areas are in need of monitoring and/or restoration, identifying pollution sources, and provide us with the ability to identify and remediate activities that are negatively impacting stream quality.

The following materials are required for Stream Habitat Assessments:

Stream Assessment Data Forms (DFO designed)	GPS Unit
Legal Size Clipboard	Waterproof paper
Pencils	Camera
YSI multi-probe	Measuring Tape
First Aid Kit	Waders
Flagging Tape	Garbage Bags
Water	Sunscreen, bug spray, hats, sunglasses, extra clothes
Safe Travels Sheet (to be filled out and left at the Conservation Center to alert other staff where field staff can be located)	Safety Vests with reflective tape

Before entering a site to conduct an assessment, landowners must be contacted, and permission must be obtained to cross their property. The stream/river name, date, and names of the personal conducting the stream assessment should be recorded on a Stream Assessment Data Form. Stream assessments for the 2020 Watershed Management Plan were on average 600m, with documentation occurring at each 100m interval. Some areas required shorter or longer assessments, and the lengths of assessment have been documented. The data collection method for each parameter is detailed as follows.

Location

A GPS point should be taken at each 100m interval and the points of longitude and latitude recorded. Detailed notes should be made of anything observed that is out of the ordinary or is in any way noteworthy. A location of noted situations should be recorded and pictures should be taken. Documentation should be made, but is not limited to, the following situations:

- Beaver/man-made dam
- Road Ford
- Large Amounts of Garbage
- Manmade structures within or obstructing stream flow
- Cattle Crossings
- Other Notable observations or obstructions to stream flow, bank stabilization, bank/stream vegetation etc.

Figure 15. Small beaver dam in Salt Springs brook- still allows for fish passage.
Photo: S. Blenis

Barriers to Fish Migration

Anything obstructing the movement or migration of fish should be well documented with many pictures and detailed field notes. Depending on the type of barrier, its removal may also be required. Fish migration barriers could include any of the above-listed situations. A barrier could also be comprised of organic matter (ie: logs, branches, leaves etc) or other man-made structures such as culverts. Culverts cannot be removed by field crews, but if it is blocking fish migration, then it should be documented and reported. Any inorganic barrier that is not severely embedded in the streambed should be removed.

Pictures

Pictures should be taken before and after garbage is removed from a site, including pictures of HRAA staff or volunteers in the process of removing garbage. It is extremely important to document each site with a multitude of pictures- memories are unreliable, and pictures can help fill in blanks on stream quality. They are also helpful at assessing the degradation of sites over multi-year spans. It is encouraged that well over 50 pictures be taken to properly document a single site. Upon arrival back at the Conservation Center, all picturesshould be downloaded onto a computer, and stored in the OneDrive for future use.

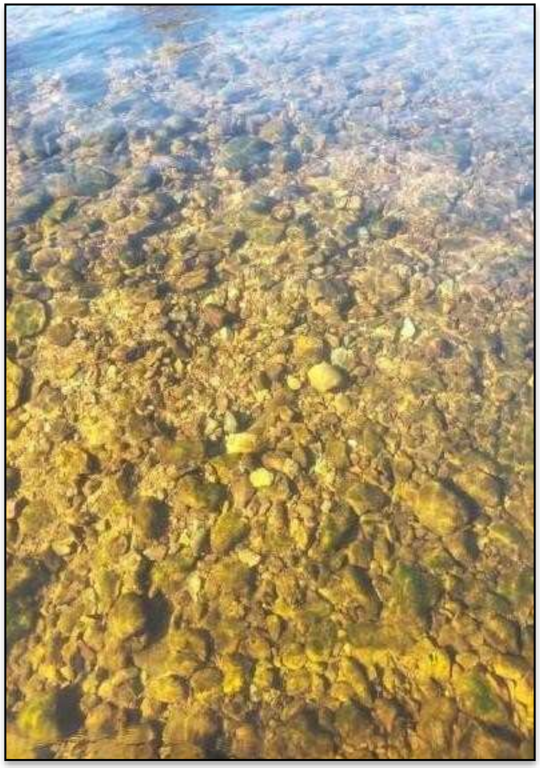


Photo 16. Picture of substrate, embeddedness, and macrophyte coverage.
Photo: S. Blenis.

Substrate

The substrate type (streambed composition) is recorded based on the size of the matter which comprises the streambed at each site. Based on how much substrate falls into each of the following categories a percentage value (0-100%) is given:

Type of Substrate	Size of Substrate
Bedrock	ledge
Boulder	>461mm
Rock	180-460mm
Rubble	54-179mm
Gravel	2.6-53mm
Sand	0.06-2.5mm
Fines	0.0005-0.05mm

Embeddedness:

Embeddedness is an estimate of the amount of substrate that is embedded or entrenchedin silt. It is based on a rating system with the following criteria:

Percent	Embedded
≤ 20%	Majority of substrate is not embedded
20-35%	Substrate is somewhat embedded
35-50%	Substrate is noticeably embedded
≥50%	Substrate is significantly embedded

Undercut Bank:

A percentage value (0-50%) is given for both the left (facing downstream) and right stream banks (for a total of 100% of the site) to estimate the percentage of the bank that is undercut/eroding. For example: a particular site may have a left bank that is 25% undercut (half of the left bank) and a right bank that is undercut 50% (the entire right bank).

Woody Debris: Observations of large woody debris (ie: logs) that lie within or partly within a stream are recorded in meters.

Overhanging Vegetation:

A percentage value (0-50%) is given for both the left and right sides (for a total of 100%) of the stream to estimate the length of water that has vegetation hanging over it. For example: a particular site may have a left bank that has 25% of its vegetation overhanging (half of the water length on the left bank), and a right bank that has 50% of its vegetation overhanging (the entire length of water on the right bank).

Erosion:

At each site, the stability of both the left and right banks are recorded, and a percentage value between 0-50% is given for each bank to total 100%.

Type	Description
Stable	There is no evidence of erosion & bank is secure with vegetation
Bare Stable	There is no evidence of erosion, but bank has little vegetation
Eroding	The bank is unstable and evidence of erosion

Figure 17. Undercut right bank, bare stable left bank, and overhanging vegetation in Salt Springs Brook. *Photo: S. Blenis*

Vegetation:

An estimate is recorded based on the percentage of stream bank vegetation that falls into the following four categories, in which the vegetation estimate should add up to 100%: bare ground, grasses, shrubs, and trees. For example: a stream could have surrounding vegetation that is 20% bare ground, 10% grass, 30% shrubs, and 40% trees.

Crown Coverage:

A percentage value (0-100%) is given based on the amount of water surface that is shaded. The amount of shade is, in most cases, a direct result of the amount of overhanging vegetation, and is also dependent on the time of day and the weather at the time of assessment.

Flow Type:

A percentage value (0-100%) to estimate how the water within the stream flows is given based on the following categories:

Riffle/Run: shallow stretch of stream, where the current is above the average stream velocity and where water forms small, rippled waves as a result
Pool: a stretch of a stream in which the water depth is above average, and the stream velocity is low.

Figure 18. Introducing Josh Kelly- Josh joined the HRAA team in 2017, working as an environmental technician during the summers. He graduated with a BSc in Biology and minor in Earth Science at STFX in 2020 and he is aiming to apply what he has learned to continue helping the HRAA with its conservation, education, and restoration work. When not at work, Josh enjoys snowboarding, golf, and is a jack of all trades and a huge asset to the HRAA team.

Riparian Zone Rating:

Rating the health of the riparian zones surrounding a given eco-reach helps HRAA to correlate readings such as dissolved oxygen, water temperatures, and fish density. The health of the riparian helps stabilize the overall health of the water and the fish populations that inhabit a given reach. Ratings range from excellent to poor, helping HRAA to prioritize future restoration projects.

Excellent: The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Good: The riparian zone is heavily vegetated with 79%-60% of the banks comprised of more shrubs than trees, casting shade across 60% of the reach during mid-day sun. Erosion surrounding the site is isolated to a few locations and can be classified as 11%-25%.

Fair: The riparian zone is vegetated with 59%-40% of the banks comprised of shrubs and few trees, casting less than 60% shade on the reach during mid-day sun. Erosion is occurring during peak water flow times (26%-49%). These areas should be monitored closely to ensure they do not deteriorate further.

At Risk: The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Poor: The riparian zone has little to no trees or shrubs, or less than 39%, and little shade is cast across the reach with minimal crown closure. Erosion occurs more frequently, as more than 50% of the banks are eroding.

Figure 19. Introducing Sarah Blenis. Sarah is a nature enthusiast, who loves fishing, hiking, and exploring. When not in the office, she can be found outside exploring with her 2 young boys!
Photo: P. Walsworth

Figure 20. Josh Kelly using the YSI to take an in-situ water quality sample. The YSI was used throughout the summer and was part of the Atlantic Water Network's Tool Bank- they loan water quality tools to watersheds throughout the province, and we are profoundly grateful for their help! *Photo: S. Blenis*

In-Situ Water Quality: At each site, water quality characteristics can be measured in-situ with a YSI probe, and examine the following parameters:

Temperature: Air and water temperatures must be taken at each interval and recorded in degrees Celsius. This can be done with a YSI probe or conductivity meter.

Conductivity: measured in micro-Siemens (µS/cm), conductivity is a measure of water's ability to conduct electricity. Water that contains a high concentration of Total Dissolved Solids, such as highly polluted water, could have a higher conductivity. Knowing the conductivity per site also allows field staff to properly adjust the electro-backpack fisher.

Salinity: measures the amount of salt (NaCl) that is dissolved in water and is measured in parts per million (ppm). Most freshwater fish cannot tolerate a high level of salt in their environments.

Total Dissolved Solids: measures the number of particles, 2 micrometers or less, that are dissolved in water, measured in milligrams per liter (mg/L). High levels of TDS can be harmful to fish and other wildlife species.

Dissolved Oxygen: the amount of oxygen (O2) that is dissolved in water, measured in parts per million (ppm). A DO level of 9.5ppm supports aquatic species.

pH: is a measure of how acidic or basic a solution is. The pH scale ranges from 1-12. A pH level of 7 is that of pure water and is considered neutral. Any solution with a pH level below 7 is considered acidic, while any solution above 7 is considered basic. Although pH levels vary naturally, a healthy stream would have a pH level between 6-8; however, some readings taken in the fall found below-average levels of pH, as a result of leaf litter in the stream.

7. Water Classification

"Water classification places the water of lakes and rivers or segments of rivers into categories or classes based on water quality goals. Each class is then managed according to the goal. The goals associated with a specific class are set according to the intended uses of the water, and the water quality and quantity required to protect the intended uses" (GNB).

Beginning in 2008, the HRAA, along with 18 other watershed groups, started working with the Department of Environment for over ten years on Water Classification. When ratified, the goal was to provide groups with a valuable resource for protecting the delicate ecosystems that are our watersheds.

The Water Classification Regulation is a regulation under the *Clean Water Act*. The purpose of this classification system was to set goals for water quality and promote management of water on a watershed basis. The goals associated with a specific class are set according to the intended uses of the water, and the water quality and quantity required to protect the intended uses.

There were three original, main classes, designated primarily for rivers and streams. A Class, in which the aquatic life is as it naturally occurs, with dissolved oxygen greater than 9.5mg/L, with *E. coli* as it naturally occurs, and the trophic status shall be

Figure 21. Color difference varies throughout the watershed. *Photo: S. Blenis*

"A watershed is an area of land, usually mountains or forests, that drains into a river.
History is also a river.
Wouldn't you say so?"
-S. King

stable and free of algae blooms. Class B as habitat for aquatic life while allowing primary and secondary contact activity, and fecal coliforms shall be less than 14 cfu/100mL, and *E. coli* shall be less than 200 cfu/100mL. Class C allows for point source or non-point source pollution, providing that releases may cause come changes to the aquatic community are permitted if the receiving water is sufficient quality to support indigenous fish species. Fecal coliforms shall be less than 14 cfu/100mL and *E. coli* shall be less than 400 cfu/100mL. Class O includes Outstanding Natural Waters, which must be sites that are as they naturally occur; water quality and quantity should be as it naturally occurs; aquatic community shall be as it naturally occurs; no release of contaminants; and it must possess outstanding recreational, aesthetic, historical qualities or rare, unique, threatened, or endangered aquatic communities. Class AP is reserved for drinking water, and Class AL is intended for lakes and ponds.

The *Water Classification Regulation* under the *Clean Water Act* was intended to provide a framework for watershed management in New Brunswick; however, there were deficiencies within the regulation that prevented its use. A working group with broad representation developed recommendations on an enhanced approach to watershed management and presented their report to the Minister of Environment and Local Government in December 2017.

The *Water Strategy for New Brunswick 2018-2028* is now underway, containing 29 actions organized under 5 goals, and this project will help create an integrated provincial watershed management approach on a watershed-by-watershed basis. While the Water Classification system has since been abandoned, for the sake of continuity, the *Watershed Management Plan 2020* contains classification as per original regulations, since that has been the norm in the 2008, 2012, and 2015 watershed management plans. A progress report will be released in the Spring of 2021 regarding the *Water Strategy for New Brunswick 2018-2028*, and HRAA should remain engaged with this project and implement its findings into our own management strategies, and at such time, cease the use of the outdated Water Classification guidelines in favor of those regulations and protocols put into action from the updated Water Strategy.

8. Water Quality Analysis

In addition to in-situ YSI probe readings, HRAA field staff collected a total of 48 samples from 15 locations that were sent to the Saint John Laboratory for analysis, including the following list of water quality indicators:

Aluminum	Copper	Lead
Alkalinity	Dissolved Oxygen	Potassium
Mercury	*E. coli*	Antimony
Arsenic	Fluoride	Sulphate
Calcium	Fecal coliforms	Suspended Solids
Cadmium	Total Nickel	Total Kjeldahl Nitrogen
Chloride	Phosphorus	Temperature
Colour	Magnesium	Turbidity
Conductivity	Sodium	Zinc
Chromium	Nitrate and Nitrite	Iron
pH		

These parameters help to identify any major issues in the water quality and allow for potential sources to become easier topinpoint and identify. Samples were collected during normal conditions throughout the spring, summer, and autumn. At each site, HRAA field staff took 1 1-liter sample for general chemistry, and 1 125ml sample for Total Coliforms, Fecal Coliforms and *E. coli*. Samples were taken upstream of the staff, as to avoid unintended sedimentation from entering the jar. Samples were labeled with the date, time, and location ID, and were packed in a cooler with ice, and either delivered to the lab on the same day or were held in the refrigerator at the Conservation Center overnight and delivered the following morning. Organic chemistry samples are time-sensitive and <u>must</u> be delivered to the lab within 24 hours of sampling.

Sample results have been entered into DataStream, a free, open access data portal for water quality data. HRAA staff uploaded 22 years of historical data onto Datastream, from 1998 to 2020. This allows staff to have a greater understanding of the fluctuations of water chemistry, and potential climate change impacts, and how the health of our river is faring.

Geographical Setting

The Hammond River watershed is located on land that has never been ceded of the Mi'kmaq, in northern and eastern New Brunswick; the Wolastoqiyik (Maliseet), along the Saint John River Valley; and the Peskotomuhkatiyik (Passamaquoddy) in the St. Croix River watershed. These three nations are part of the Wabanaki Confederacy, which also includes the Penobscot and Abenaki nations of Maine. Wabanaki is "Land of the Dawn", and designates a large area including Maine and the Maritime provinces.

The Hammond River watershed is situated between Elsipogtog's land claim, filed in 2016, for the district of Siknuktuk, which encompasses 1/3 of the province of New Brunswick, along the South Eastern portion.

The Hammond River watershed is also situated in a title claim that was launched in 2020 by the six Wolastoqey communities that make up Wolastoqey Nation New Brunswick.

The Hammond River watershed is a tributary of the Wolastoq-Saint John River, meaning "the beautiful and bountiful river". Traditionally, the Hammond River was called Nuhwig'ewauk, a Maliseet name with a possible translation of "slow current".

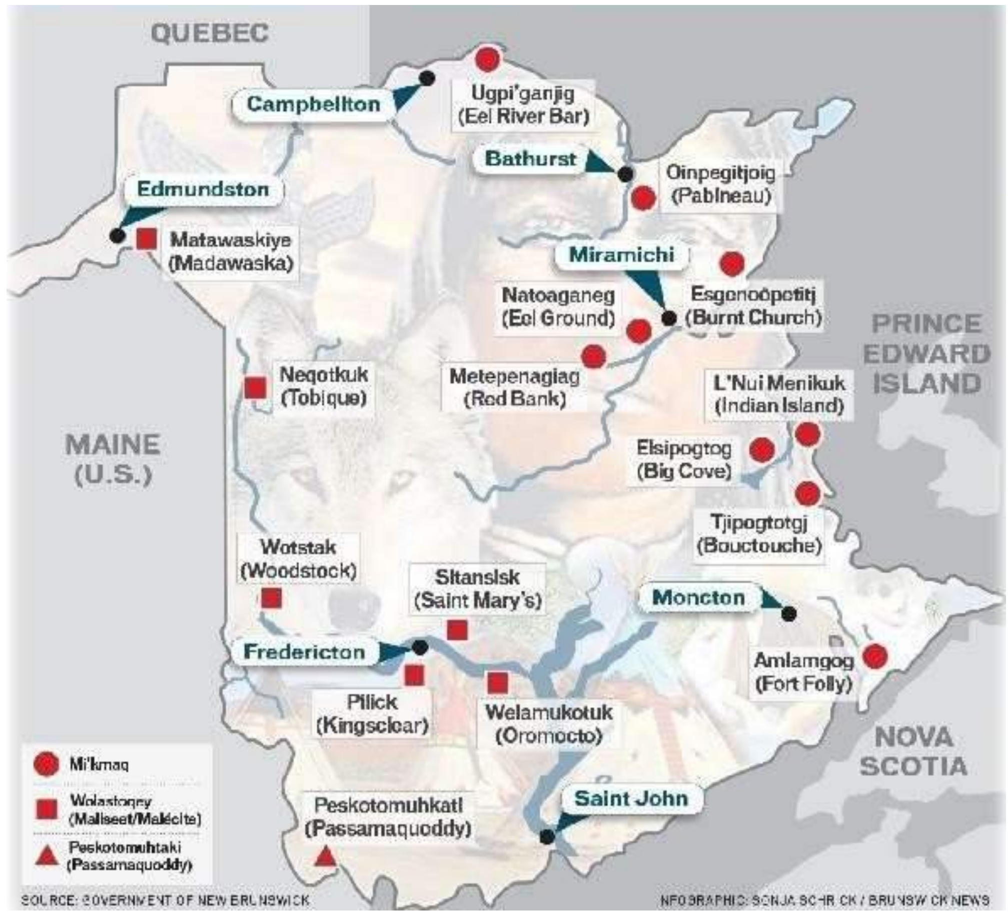


Figure 22. First Nations Communities in New Brunswick. *Photo: GNB*

Geographical Setting

Figure 22. The Outer Bay of Fundy region, in orange. *Photo: DFO.*

Figure 23. Highlands and Lowlands of New Brunswick. *Photo: MapCarta*

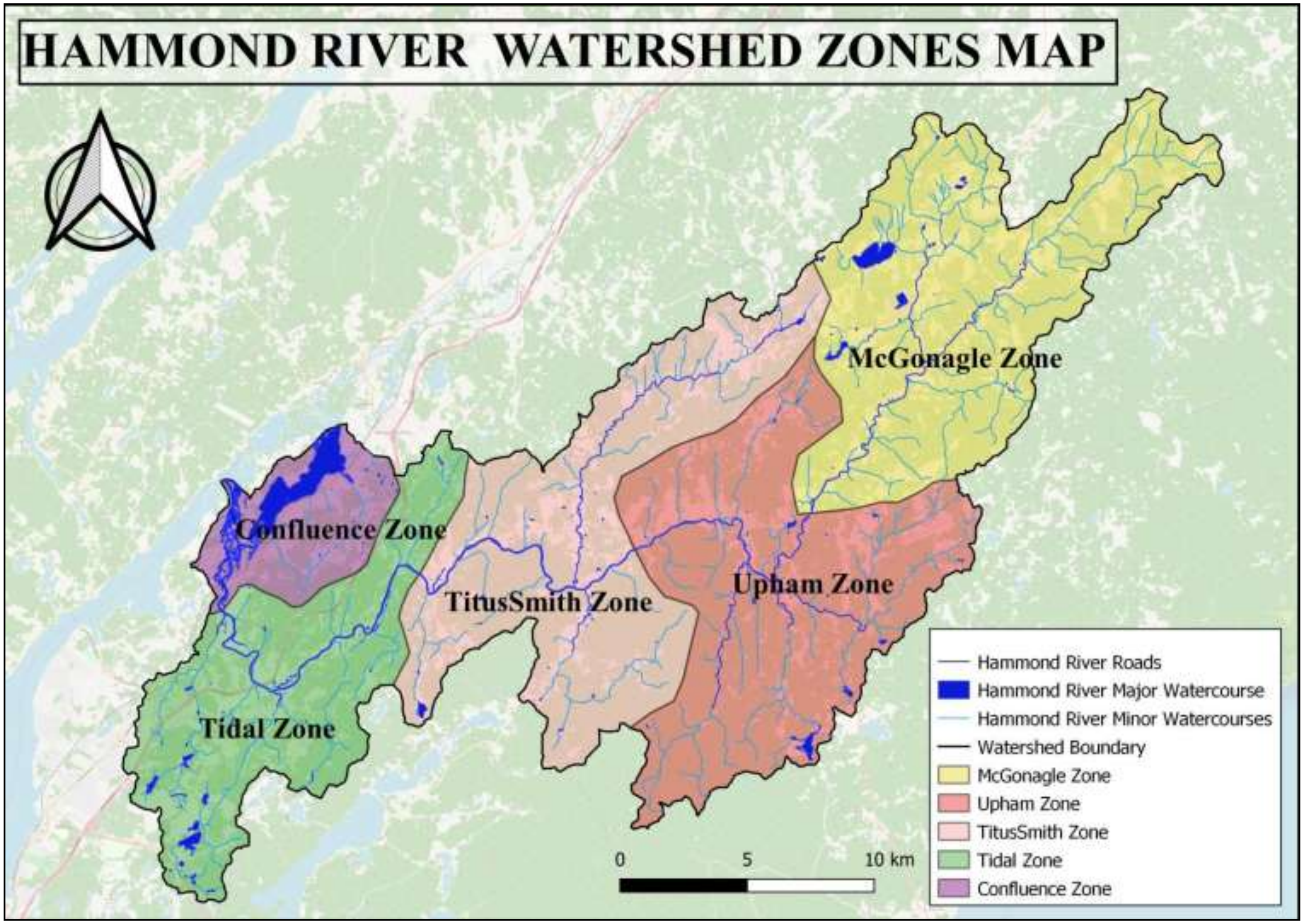
The Hammond River is a tributary of the Wolastoq-Saint John River, whose basin extends throughout New Brunswick, Maine, and Quebec. The Wolastoq-Saint John River is Eastern Canada's longest river, and its drainage basin is one of the largest on the east coast at about 55,000 square kilometers. It includes the Southwest, Northwest, and Baker branches, Allagash and Madawaska Rivers, Aroostook, Tobique and Meduxnekeag Rivers, Nashwaak, Nerepis, Canaan, Washademoak Rivers, Belleisle, Kennebecasis Rivers, and many others, with the Hammond as its most southeasterly tributary.

The Hammond River watershed is located in Kings County, New Brunswick. The Hammond River watershed is also located in the Local Service Districts of Hammond and Upham and is part of the Regional Service Commission District 8, also passes through the municipalities of Hampton and Quispamsis.

The Hammond River watershed contains Outer Bay of Fundy Atlantic Salmon, one of the few remaining wild salmon stocks in the world.

The majority of the Hammond River watershed passes through the Caledonia Highlands, and into the Lowlands of southeastern New Brunswick. The Caledonia Highlands, part of the Appalachian Mountain Range, are the remnant of an older mountain-forming episode, and geologic dating suggests the Highlands range in age from 350-690 million years old. The highlands consist of mainly Late Neoproterozoic volcanic, sedimentary, plutonic rocks. The term “Caledonian” is derived from the Latin word for Scotland, and the highlands extend through Newfoundland, Norway, Ireland, Scotland, and Wales. In the Hammond River watershed, cold-water tributaries flow from multiple mountains into the Hammond River, including Silver Hill, Prospect Mountain, Weatherby’s Peak, Upham Mountain, McShane Hill, Vinegar Hill, Saddleback Mountain and Mount Theobald.

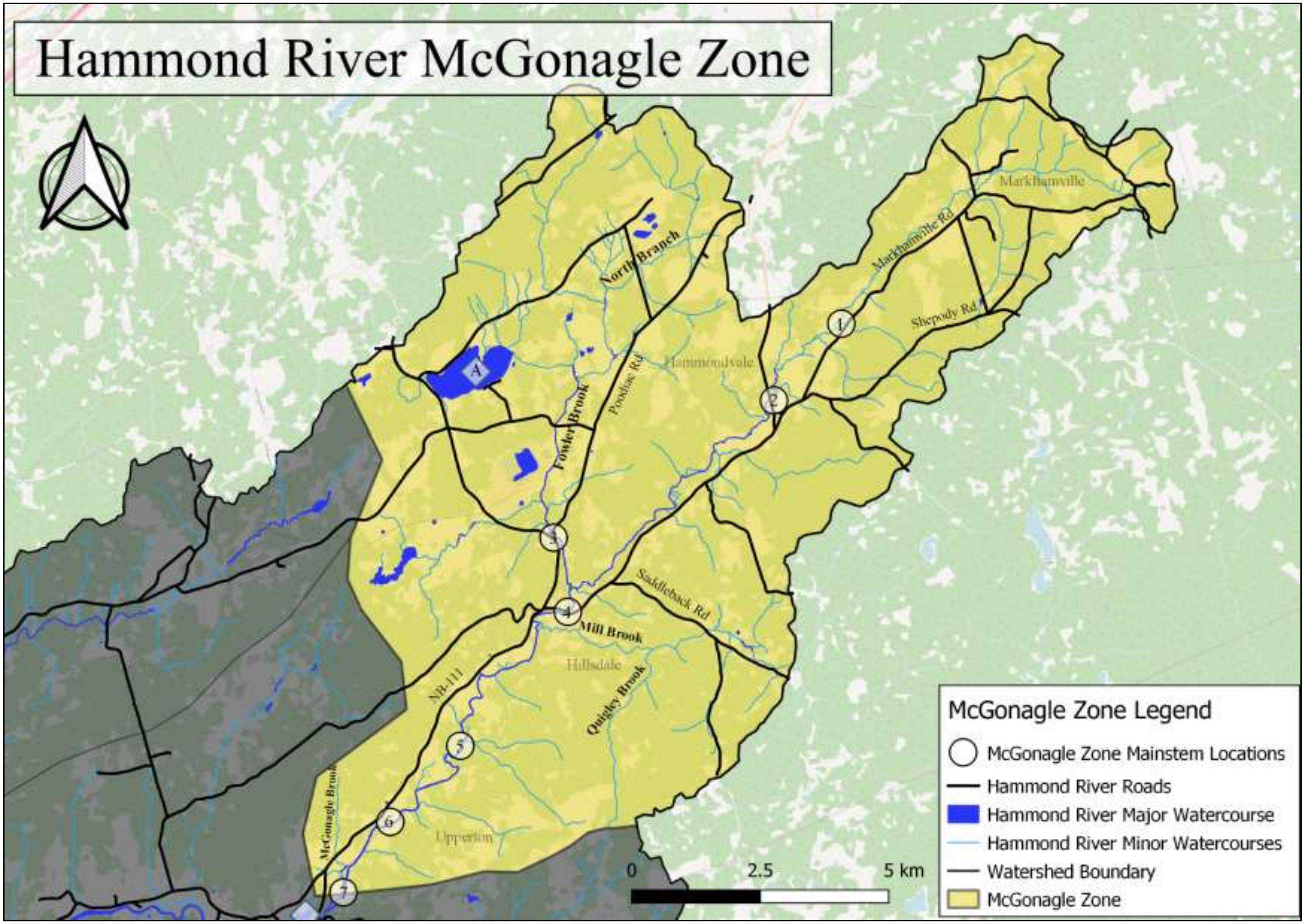
Watershed Zones Map



For ease of use, the watershed has been divided into 5 zones. The McGonagle Zone represents the upper portion of the watershed, whereby fishing regulations come into place on July 15th, restricting the river to fly-fishing only below McGonagle Brook to the CN Bridge in Nauwigewauk. TitusSmith is a made-up name and represents the area from Titusville to Smithtown; often, this area is a source of confusion, between Titusville, Smithtown, and Damascus. As a result, we have given it an all-inclusive amalgamated name. *Map: J. Kelly*

Figure 25 Watershed Zone Map

McGonagle Zone Map



McGonagle Zone Legend & Work Complete (2020)

Site Name	GPS Location	Area Surveyed (m)	WQ	E-Fish	Redds (#)	e-DNA	BMI	Culvert Assessment
MAIN STEM								
1. Markhamville	45.470267 -65.709733	600m	YSI	No	No	**Negative**	No	**Yes**
2. Hammondvale	45.57578 -65.65.50306	1km	Lab	**Yes**	**8**	No	No	**Yes**
3. North Branch	45.55222 -65.55720	1.5km	Lab	**Yes**	**0**	No	**Yes**	No
4. Hillsdale	45.539116 -65.554189	1.5km	Lab	**Yes**	**1**	No	No	No
5. Gold Mine Gully	45.491802 -65.610563	1km	YSI	No	**0**	No	No	No
6. Gravel Pit Pool	45.490643 -65.610946	2km	YSI	No	**14**	No	No	No
7. McGonagle Pool	45.493755 -65.609836	1km	YSI	No	No	No	No	No
TRIBUTARIES								
1. Culligan Brook*	45.521092 -65.518896	300m	YSI	No	No	No	No	No
2. Duffy Brook*	45.532442 -65.508538	300m	YSI	No	No	No	No	No
3. Quigley Brook	45.535527 -65.519793	200m	YSI	No	No	No	No	**Yes**
4. Fowler Brook	45.571935 -65.556933	700m	Lab	**Yes**	No	No	**Yes**	No
5. Hammondvale Culverts	45.563766 -65.517150	350m	YSI	No	No	No	No	No
6. McGonagle Brook	45.496557 -65.612652	1.5km	YSI	No	No	No	No	No
LAKES								
A. Cassidy Lake	45.580444 -65.580687	100m	YSI	No	No	No	No	No
Theobald Lake*	45.480542 -65.523563	100m	YSI	No	No	No	No	No

Table 1McGonagle Zone Work Complete

* Connected to, but not within, watershed boundaries.

McGonagle Zone Main Stem

Markhamville

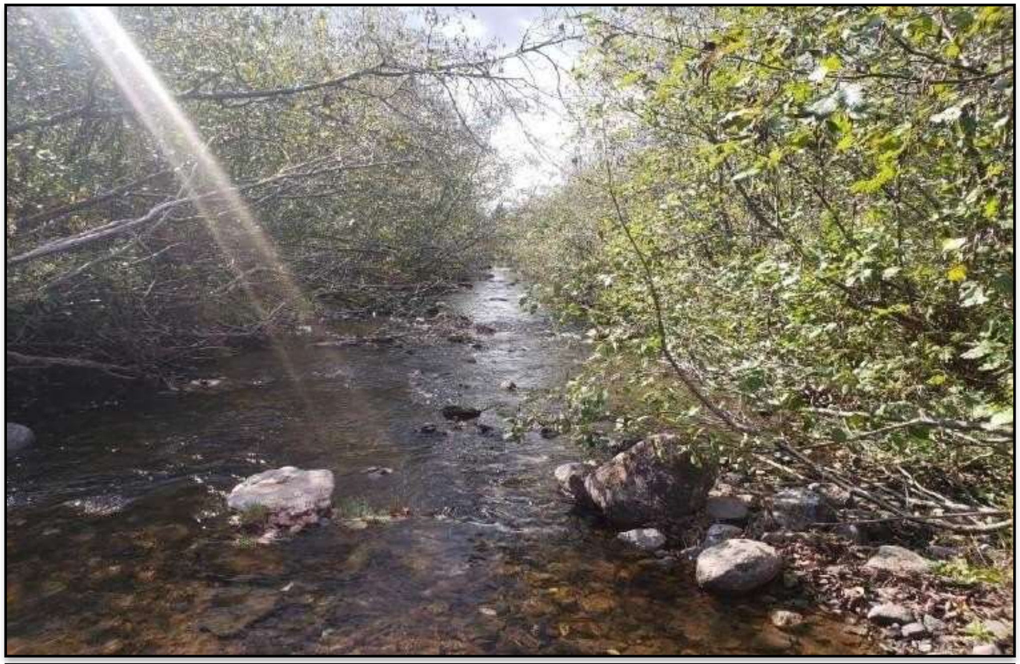


Figure 27. Looking downriver of the Hammond River in Markhamville, the northernmost site we visited in 2020. *Photo: S. Blenis*

Site Characteristics: The most northern site visited in 2020, this is part of the main stem of the Hammond River above Hammondvale, with many minor tributaries flowing into this stretch from the Caledonia highlands region.

Substrate: The substrate is a mix of rock (10%) cobble (50%), gravel (30%) and sand (10%). Substrate is <20% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 80% straight and 20% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure, predominantly of alders, giving the stretch 80% shade coverage.

Riparian Vegetation: Fully mature alders and trees dominate the riparian zone (80%), with some grass and ferns (5%), and juvenile shrubs (5%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

McGonagle Zone Main Stem
Markhamville

Figure 29. Baffled culvert in Markhamville, that baffled HRAA staff. *Photo: S. Blenis*

Observations: Electro-fishing was not carried out in this site in 2020; however, this site should be included in the 2021 electro-fishing season. During the habitat assessment, HRAA staff came across a fairly new culvert that included baffles. These baffles can provide an adequate depth of flow and reduce the water velocity in the culvert in order to facilitate fish passage. HRAA staff attempted to find additional information on this particular culvert and stretch of river, to no avail. Unfortunately, this culvert was not set at a proper slope, and in the hotter summer months, it becomes hung and does not allow great fish passage, despite its baffles.

In 2021, staff should make efforts to continue the habitat assessment upstream of this culvert, to determine its headwaters source (which is more than likely in the Caledonia highland region, potentially connecting to Culligan Brook, or Jenny Lind Brook).

In order to expand our knowledge of this site, HRAA staff collected an eDNA sample to determine presence/absence of salmonid DNA, as electro-fishing was not performed. Results of the eDNA analysis came back negative for salmon DNA; however, this does not necessarily mean that salmon are not present at this site.

Water Classification: Unfortunately, we did not have access to the YSI multiparameter probe during this habitat assessment; however, we believe that this site has the potential to be classified as **Class A**, or even **Class O**- "Outstanding Natural Water Class", as the waters in this stretch remain relatively unaffected by human activities and possess an unaltered, natural water quality, quantity, and biology, found in the headwaters of the river system. HRAA will revisit this site in 2021, and begin a water quality monitoring program, to solidify that this site is worthy of a **Class O** ranking.

McGonagle Zone Main Stem

Hammondvale Bridge Pool

Figure 30. Looking downriver towards the Hammondvale Bridge in October. Site of electrofishing and riparian restoration. *Photo: S. Blenis*

Site Characteristics: Part of the main stem Hammond River, this area in Hammondvale is surrounded by agriculture, and many minor tributaries flow into this area from the Caledonia highlands region.

Substrate: The substrate is a mix of cobble (80%), gravel (10%) and sand (10%). Substrate is <20% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is primarily a run (80%), with scattered pools (20%), and its sinuosity is 40% straight and 60% winding.

Bank Stability: There is significant erosion occurring at this site, with 50% eroded banks on the left, and 10% eroded on the right, with 40% stable. Undercut banks are substantial on the left bank (50%), and minimal (10%) on the right bank.

Crown Closure: There is substantially more overhanging vegetation on the right bank (50%) than the left bank (10%), providing shade to less than half of the site.

Riparian Vegetation: The left bank is primarily agricultural, as a corn field exists along the riparian zone. The right bank is dominated with shrubs (60%), grasses (30%) and some bare areas (10%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. In 2008, this site had received a riparian rating of "Good"; however, this site has degraded significantly. Riparian restoration must become a focus of this stretch.

McGonagle Zone Main Stem
Hammondvale Bridge Pool

Electro-fishing: The Hammondvale stretch was divided into three 100m² areas and was the most productive salmon parr density within the watershed, with 8 parr being observed in the 3 locations. The area has a high brook trout density, with 31 trout observed. The Hammondvale stretch also produced massive American Eels- the largest eel was approximately 3 feet long! Two smallmouth bass were also observed in this stretch, indicating that this species has become well established throughout the watershed.

Redd Count: A 1.2km stretch of the Hammondvale site was covered during our Redd Counts in November. A total of 8 redds were observed within this stretch, giving it the third highest density of redds observed in 2020. Average size of redds was 2.2m². Given that this area is comprised primarily of cobble and gravel substrate, this is suitable spawning area for Atlantic Salmon. Efforts need to be taken to address the significant erosion that is occurring along the banks, in order to ensure that this area retains its spawning habitat.

Action Points: Continue to work with surrounding landowners to address riparian restoration. 600m² of willow stakes were planted in 2020- revisit in 2021 to determine success & re-plant as necessary. Continue to monitor organic chemistry.

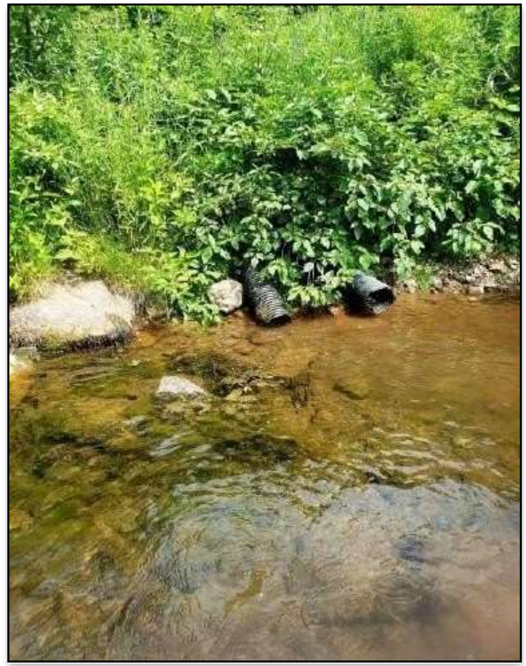


Figure 31. Evidence of nutrient loading & erosion in Hammondvale.
Figure 32. Observed 2 drainage pipes from the field entering the watercourse. This area was willow staked in the summer of 2020. *Photos: S. Blenis*

Water Quality: In 2008, this site had received a Class A ranking from the Provincial Water Quality Classification system. The 2008 Watershed Management Plan also noted occasional spikes of *E. coli* at this location after fertilizer had been applied to the surrounding fields, and after precipitation events. These observations were confirmed in 2020, and this site received a “Good” ranking according to the CCME Water Quality Index, and occasional spikes of *E. coli* were also noted. Restoration activities occurred at this location in the summer of 2020, with 600 willow stakes being planted. Ongoing conversations with landowners should be a priority.

McGonagle Zone Main Stem
North Branch

Figure 33. Looking downstream, brook is surrounded by alders, with patches of bare stable ground. *Photo: S. Blenis*

Site Characteristics: North Branch veers off from the Main Stem at the Hillsdale Bridge, and travels up the Fowler Brook towards Cassidy Lake for 13.1km.

Substrate: The substrate in this tributary is comprised of cobble (25%), gravel (25%) and sand/silt (50). Very muddy bottom made for difficult wading! Substrate is >50% embedded.

Flow: Numerous beaver dams throughout tributary made for slower flow and deeper pools.

Flow Type: The site is primarily a run (90%), with scattered pools (10%) created by beaver dams, and its sinuosity is 30% straight and 70% winding.

Bank Stability: The bank stability is a matrix of stable (L 25% R 40%), bare stable (L25%), and eroding (R 10%).

Crown Closure: Crown closure is primarily alders and shrubs and provides 80% shade.

Riparian Vegetation: Both banks are dominated by alders and shrubs (75%), and grasses (25%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Quality: A YSI multiparameter probe was used to conduct water quality analysis. On average, the North Branch had a conductivity of 109.3µS/cm, pH of 7.5, Total Dissolved Solids of 75.4mg/L, salinity of 0.05ppt, and dissolved oxygen 8.26mg/L. The site visit occurred in July, and registered a water temperature of 21.8°C, a fairly high reading, given the exceptional crown closure of the brook. This stretch receives a **Class B** rating, as its dissolved oxygen is below 9.5mg/L to warrant a Class A.

McGonagle Zone Main Stem
North Branch

Electro-fishing and Redd Counts: Not performed at this location in 2020 but are warranted in the future; it is recommended to begin with an eDNA sample to determine presence/absence of salmonid DNA in advance of electro-fishing, to determine priority ranking if this site should be added to HRAA's electro-fishing sites. Given the close proximity to Cassidy Lake, it may be prudent to use eDNA on occasion to determine if there are any aquatic invasive species entering this area from the lake.

In-Stream Vegetation: Significant in-stream vegetation, including large patches of native milfoil, duckweed, and filamentous algae.

Incidental Observation: Large population of adult damselflies throughout this stretch, in vibrant hues of blue and green. Damselflies are known to habit in still-water areas, and given the high volume of beaver dams, this was not surprising. Damselflies are moderately tolerant of pollution, and this site warrants a full benthic macroinvertebrate study.

According to the *Hydrology of the Hammond River Watershed Delay Discharge* in 1988, a wooden dam was placed in Cassidy Lake to delay the flow. Later, this dam was replaced by a larger dam- it would be wise to revisit this dam in the near future.

Figure 34. One of many damselflies observed; a large patch of duckweed; a large patch of native milfoil. *Photo: S. Blenis*

McGonagle Zone Main Stem
Hillsdale Bridge Pool

Figure 35. Looking downstream from the Hillsdale Bridge.
Photo: S. Blenis

Site Characteristics: Part of the main stem Hammond River, Hillsdale is downriver of Hammondvale, and its major tributaries include Mill Brook and the North Branch.

Substrate: The substrate can be described as rock (25%), cobble (30%), gravel (25%), and sand (20%), and is approximately 35-50% embedded.

Flow: Throughout the summer months, the flow can be described as low velocity. During heavy rain events, the flow increases substantially, with some turbidity; however, the clarity of the water remains fairly clear with a slight tannin tint throughout the year.

Flow Type: The site is primarily a run (90%), with a small pool (10%) underneath the bridge. Its sinuosity is 80% straight and 20% winding.

Bank Stability: The bank stability varies in this area, while the left bank is primarily stable (40%) with some bare stable (5%) and some minor erosion (5%) and slightly undercut banks (15%). The right bank is significantly eroding (50%); with major undercut banks (45%) that are harder to see, due to the overhanging vegetation.

Crown Closure: Crown closure is primarily mature trees and shrubs, giving the area 70% shade.

Riparian Vegetation: Both banks are dominated by mature conifer trees (50%) and shrubs, particularly hawthorn and alders. (50%).

Riparian Rating: Good to Fair. The riparian zone is well vegetated with the majority of the banks comprised of trees and shrubs; however, there has been some scouring from ice that has led to erosion along the right bank. This site should be closely monitored in the future, as planting may be required, should the undercut banks erode completely. Some woody debris was noted, as some of the trees have fallen into the water.

McGonagle Zone Main Stem
Hillsdale Bridge Pool

Electro-fishing: Electro-fishing was performed over 2 100m² stretches, starting under the bridge and working down the river. Two Atlantic Salmon parr were observed, as well as 8 other fish species, including brook trout, American eel, black nose dace, common shiner, golden shiner, sucker, 4 spine stickleback, and sea lamprey.

Redd Counts: An 800m stretch of the main stem at Hillsdale Bridge was covered for the Redd Count Assessment, yielding 1 redd above the bridge. Given the suitable substrate, and historic presence of redds in this location, we believe that we performed the redd count a week or two too early in November. Spawning may have occurred at a later date, given the warmer water temperatures experienced late fall.

In-Stream Vegetation: Significant in-stream vegetation, including large patches of native milfoil, duckweed, filamentous algae, and grass.

Incidental Observations: Throughout the summer, this site seemed to be prone to buildup of algae, especially surrounding the bridge. This may be a future site for cyanobacteria monitoring, given that it, and Hammondvale above, have elevated levels of nutrients.

Figure 36. Upstream view from the Hillsdale Bridge.
Figure 37. Abundance of aquatic plants throughout. *Photos: S. Blenis*

Water Quality: Historically, this site received a Class B rating according to the Water Classification system, as E. coli levels were on average above upper-level limits due to the high density of surrounding farmland. A more in-depth nutrient analysis of this site in 2021 is warranted, to determine if these levels have changed or are relatively the same since 2008.

McGonagle Zone Main Stem
Gold Mine Gully & Gravel Pit Pool

Water Classification: Class A. There are no point source pollution discharges along this stretch. Dissolved oxygen is above 9.5mg/L, and all other water quality parameters are well within limits. This is a wonderfully cold-water stretch, as there are several minor tributaries that feed this stretch from the Caledonia highlands region.

Redd Count Assessment: This stretch has long been the most productive stretch in the Hammond River watershed, with over 300 redds observed at this location in the early 1980's.

During the 2020 Redd Count Assessment, HRAA staff observed 14 large redds, giving this site the 2nd highest redd density in 2020 (second only to Salt Springs Brook).

There are two areas of concern within this stretch, that have become extremely eroded. Any sediment deposition into this stretch could have dire consequences for the few returning Atlantic Salmon.

The first location, Figure 10, should be a fairly easy fix with revegetation efforts. Figure 10 will require a higher level of remediation.

From a salmon perspective, the Gold Mine Gully is the most critical stretch in the Hammond River, and these sites should be addressed as soon as possible.

Figure 38. Hayfield with no riparian buffer and degrading banks.
Figure 39. Eroding hillside. Remediation needed at both sites.
Photos: S. Blenis

McGonagle Zone Main Stem

McGonagle Pool

Figure 40. Looking downriver from the confluence of McGonagle Brook. *Photo: S. Blenis*

Site Characteristics: Main stem river at the confluence of McGonagle Brook. High priority area for riparian restoration on the right bank.

Substrate: This stunning pool is a mixture of boulder (20%), rock (30%), cobble (40%) and gravel (10%), and the substrate is <20% embedded.

Flow: This is one of the faster stretches of the Hammond River, even during the summer months, due to the steep slope of the valley.

Flow Type: The site is primarily a run (90%), with a small pool near the mouth of the McGonagle Brook (10%), and its sinuosity is 10% straight and 90% winding.

Bank Stability: The left bank is predominantly bare stable (50%) with large boulders and rocks along the bank's edge. The right bank is becoming severely eroding (50%), with heavy undercutting (35%).

Crown Closure: There is substantially more overhanging vegetation on the left bank (30%) than the right bank (10%), providing shade to less than half of the site.

Riparian Vegetation: The right bank is primarily agricultural, as a hay field exists along the riparian zone. The left bank is comprised of trees (20%), bare (50%) and grasses (30%).

Riparian Rating: Fair. The riparian zone is vegetated with 59%-40% of the banks comprised of shrubs and few trees, casting less than 60% shade on the reach during mid-day sun. Erosion is occurring during peak water flow times (26%-49%). These areas should be monitored closely to ensure they do not deteriorate further.

Water Quality: Average conductivity 130.9µS/cm, pH 7.78, Total Dissolved Solids 97.5mg/L, salinity 0.07ppt, and Dissolved Oxygen 9.58mg/L. **Class A** Rating.

McGonagle Zone Tributaries

Culligan Brook

Figure 41. Looking upstream of Culligan Brook to the numerous small waterfalls, providing quality dissolved oxygen to the receiving environment. *Photo: S. Blenis*

Site Description: Located off of the Vaughan Creek Road, Culligan Brook is situated in the Caledonia highlands region.

Flow Type: This stretch was visited in November, and had a fast-moving flow, spilling over numerous small waterfalls into small, deep pools. This site should be revisited in the summer of 2021 to observe flow rate during peak summer temperatures.

Bank Stability: Banks are stable, and this stretch is at it naturally occurs.

Crown Closure: Beautiful crown closure, with plenty of overhanging vegetation, creating a wonderfully shaded pool, keeping water temperatures cool.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class O. No point source pollution discharges. Site is as it occurs naturally, allowing for barely measurable changes to water chemistry. Minimal surrounding land use or water use activities. Fecal coliform organisms and *E. coli* are as naturally occurring. High Dissolved Oxygen levels. The exceptional crown closure, bank stability, and steep flow of this tributary are providing a cold-water tributary to the Hammond River, and its discharge point into the main stem is near salmon spawning and holding pools. This site is one of many treasures along the Caledonia Eco-Region.

Exceptionally beautiful tributary of the Hammond River!

McGonagle Zone Tributaries

Duffy Brook

Site Description: Located off the Vaughan Creek Road, Duffy Brook is a cold-water tributary situated in the Caledonia highlands region.

Flow Type: Fragmented flow- the upper stretch of Duffy Brook can be described as medium flow velocity; however, there is a dirt road that goes through the brook, interrupting the flow with major sedimentation.

Bank Stability: The banks of the upper reach of Duffy Brook are stable, with primarily alders and shrubs overhanging the brook. The area around the dirt road is facing substantial erosion (50%) on both banks.

Crown Closure: The upper reach of Duffy Brook has lovely crown closure from the overhanging vegetation, keeping the brook cool in the hot summer months. The area surrounding the dirt road is void of crown closure.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Fish Community: Unknown. This would be an excellent candidate for future electro-fishing, as the upper stretch offers prime fish habitat; however, the lack of a ford, bridge, or culvert in this brook is detrimental to aquatic species. Electro-fishing to identify fish community would assist in creating a mitigation plan to repair the road and riparian zone.

Figure 42. Upstream view of Duffy Brook, showing the degradation caused by trucking through the brook without proper ford, bridge, or culvert. *Photo: S. Blenis*

McGonagle Zone Tributaries
Duffy Brook

View of Duffy Brook as it intersects with a dirt road. HRAA needs to discuss this site with the Department of Environment and create a solution (culvert). Turbidity and Total Suspended Solids are anticipated to be in the high range for this site, detracting from the overall excellent cold-water source this brook provides to the Hammond River. Duffy Brook has the potential to be a **Class A** or **Class O** Brook, given its high dissolved oxygen content and no point source pollution; however, this section needs remediated. *Photo: S. Blenis*

McGonagle Zone Tributaries
Quigley Brook

Figure 43. Looking downstream of Quigley Brook, and the relatively new culvert and the lovely, deep pool at the outflow. *Photo: S. Blenis*

Site Description: Located off the Vaughan Creek Road, Quigley Brook is a cold-water tributary of the Hammond River, located in the Caledonia highlands region.

Quigley Brook offers a strong flow velocity, providing highly oxygenated water. The banks are stable, and this stretch is at it naturally occurs. Beautiful crown closure of predominantly mature trees and shrubs keeps this tributary cool in the hot summer months. Excellent riparian rating. Wonderful, new culvert with a very deep pool at its outflow.

Action Points: Potential future site of electro-fishing, as the current fish community is unknown in this stretch. Quigley Brook offers stunning fish habitat and prime water quality, and an investigation into fish community is warranted. Area has the potential to home rare and endangered species. Recommended to do a full investigation of the entire stretch of Quigley Brook in the 2021 season.

Water Classification: Class O. No point source pollution discharges. Site is as it occurs naturally, allowing for barely measurable changes to water chemistry. Minimal surrounding land use or water use activities. Fecal coliform organisms and *E. coli* are believed to be as naturally occurring; however, no samples were taken in 2020. High Dissolved Oxygen levels, at 9.6mg/L with the YSI multiparameter probe. The exceptional crown closure, bank stability, and steep flow of this tributary are providing a cold-water tributary to the Hammond River, and its discharge point into the main stem is near salmon spawning and holding pools.

McGonagle Zone Tributaries
Fowler Brook

Figure 44. Looking upstream of Fowler Brook from the Poodiac Bridge.
Figure 45. One of many giant boulders in this stretch. *Photos: S. Blenis*

Site Characteristics: Fowler Brook is 13.1km in length and is part of the North Branch, including Lake Brook with Cassidy Lake as its headwaters.

Substrate: The substrate in the lower section of Fowler Brook is bedrock (30%), boulder (30%), cobble (20%) and gravel (20%). It offers excellent substrate for fish habitat and nursery area. Substrate is <20% embedded.

Flow: The lower section of Fowler Brook has a steady flow throughout the summer months, even during high temperatures and lower water conditions.

Flow Type: The site is primarily a run (90%), with scattered pools (10%) surrounded by beautiful, large boulders.

Bank Stability: The banks along the lower stretch are primarily stable (L 40% R 40%), with sporadic erosion (L 10%) with 10% bare stable on the right bank.

Crown Closure: Crown closure and shade are fair in this tributary, with overhanging vegetation of 50% on the left bank, and 45% on the right bank.

Riparian Vegetation: Both banks are dominated by trees (50%), shrubs (25%) and grasses (25%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

McGonagle Zone Tributaries
Fowler Brook

Electro-fishing: Electrofishing was carried out on a 100m² stretch upriver of the Poodiac Bridge. 4 Atlantic Salmon parr were observed. The site also contained 9 other fish species, including brook trout, American eel, black nose dace, slimy sculpin, sucker, 4 spine stickleback, golden shiner, creek chub, and a fall fish. The diversity of fish species suggests that this site has healthy water quality.

Redd Counts: A 500m stretch was covered during the Redd Count assessment of 2020; however, it did not yield any redds. In the summer, staff observed what they believe to be the remnants of 1 redd from the previous year. Given that this site has perfect substrate for spawning and has generally produced redds in previous years, we believe our timing for redds in this stretch was off by a week or two, and this area should continue to be a candidate for future redd count events.

In-Stream Vegetation: Significant in-stream vegetation, including grasses and large patches of native milfoil.

Incidental Observation: This site has a huge mussel population! This site was not explored during the 2018 mussel assessment, and future studies in this area are warranted.

Figure 46. View from the Poodiac Bridge looking downstream; one of the many mussels found in this stretch. *Photo: S. Blenis*

Water Quality: Historically, this site has received a Class A (excellent water quality) rating through NB's Water Classification system. In 2020, the water quality sampling program determined this site to receive a rating of "Fair" in accordance with the CCME Water Quality Index Guide. This site, as well as the North Branch, have potential for point source pollution discharge as a result of the brine in the pond of the defunct Potash mine. Reinvigorating the Potash Mining Monitoring Program should become a priority at this location.

McGonagle Zone Tributaries
Fowler Brook

Figure 47. Habitat Assessment, site has beautiful substrate and large boulders that create cascading, highly oxygenated pools. *Photo: S. Blenis*

Fowler Brook eventually converges into the Main Stem Hammond River at the above the Hillsdale Bridge Pool. This section between the Hillsdale Bridge Pool and Poodiac Bridge Pool in Fowler Brook also offers excellent fish habitat and has been a historic area for redds. Part of this section in between Hillsdale and Fowler Brook was also surveyed in 2020 for redds; however, none were found. Staff believe that given the higher water temperatures in November, that we were a bit off the timing for redd counts. In 2021, it is recommended to survey the area in between the Hillsdale Bridge Pool up to the Poodiac Bridge Pool in Fowler Brook, and then to continue the survey for an additional 500m upstream of Fowler Brook.

1981-1996 HRAA Potash Mining Monitoring Program:

1) North branch sampled daily at the Poodiac road bridge on Fowler Brook for water flow and conductivity.
2) North branch sampled weekly at Sederquest road, at the confluence of Fowler Brook.
3) Site runoff collection pond is sampled daily for flow, conductivity, suspended solids, and pH when a controlled discharge of runoff water to the North Branch takes place.
4) Site runoff collection pond is sampled annually for coliform and fish toxicity.
5) Site runoff collection pond is sampled monthly for metals and oil and grease.
6) 35 ground water monitoring wells are sampled weekly for water level and conductivity. The data from these wells provides information on ground water levels, flow direction and ground water quality.
7) Ten watersheds along the brine line to the bay of Fundy are sampled monthly.
8) An electrofishing survey of the North Branch is conducted annually.
9) A BMI survey is conducted periodically.
10) Recently installed continuous conductivity probes will monitor the North Branch, Fowler Brook and the site collection ponds.

Update this monitoring plan in 2021!

McGonagle Zone Tributaries

Unnamed Minor Tributaries & Culverts

Figure 48 (a,b,c)- Arched culvert that is 91 years old! This culvert only has water flow during heavy rain events. There is a significant blockage at the outflow that could not be removed by staff. Riparian area towards river needs revegetated.

Figure 49 (d,e,f)- Box culvert that is 68 years old! This culvert has a steady flow, and a beautiful outflow pool, with vegetation surrounding the tributary as it flows to the river. Excellent future site for fish population assessment!

McGonagle Zone Tributaries
Unnamed Minor Tributaries & Culverts

Figure 50 (a,b,c)- Surrounding landowners have many concerns for this culvert, tributary, and safety concerns for route 111. The brook only has flow during heavy rain events. Substrate is sharp, indicating that there is not a regular flow. Staff investigated this stretch for approximately 200m- in 2021, the goal should be to follow the entire streambed, to see if the headwaters is a wetland or small lake. The ditch near road does not have adequate slope to accommodate flow towards culvert. *Photos: S. Blenis*

Figure 51 (a,b,c) -Due to improper slope, fast moving water floods the road and landowner property. The culvert is in a poor state, almost entirely rusted. The outflow pool is completely full of sediment and needs to be dredged. There is a small, man-made outflow brook; however, it needs bank stabilization. During heavy rains, it carries huge quantities of sediment into the river. This culvert, brook, and outflow should be addressed in the future as a climate adaptation project. *Photos: S. Blenis*

McGonagle Zone Tributaries

McGonagle Brook

Figure 52. Looking downstream towards the Hammond River in McGonagle Brook. *Photo: S. Blenis*

Site Characteristics: McGonagle Brook is a shorter tributary, with a length of 2.2km, and is surrounding by forest and agriculture.

Substrate: The substrate is a fusion of cobble (60%), rock (20%) and sand/silt (20%), and the substrate is embedded at approximately 20%, and many of the rocks are covered with moss.

Flow: The flow rate decreases substantially during the summer with the warmer temperatures, and the lower portion of the brook has frequently fully dried up, as the brook is fairly wide but shallow.

Flow Type: The site is primarily a run (80%), with a large pool at a culvert (20%), and its sinuosity is 20% straight and 80% winding.

Bank Stability: The left bank is 40% stable, 10% eroding and the right bank is 35% stable, 15% eroding. Undercut banks are contributing to the sediment loading in the brook, with 40%undercut on the left bank, and 10% undercut on the right bank.

Crown Closure: This is a beautifully shaded brook, with 80% crown closure.

Riparian Vegetation: The riparian vegetation is primarily healthy, with the exception of the last 500m.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. In 2008, this site had received a riparian rating of "Fair"; however, this site has degraded significantly. Riparian restoration must become a focus of this stretch.

Water Classification: Class A. There are no point source pollution discharges within this reach, and dissolved oxygen levels are normally above the recommended limits (9.5mg/L)

McGonagle Zone Tributaries
McGonagle Brook

Electro-fishing: To date, no historical records of electro-fishing in McGonagle Brook have been found, nor was a study carried out in 2020. In the *2008 Watershed Management Plan*, HRAA staff noted that “juvenile density surveys have not been conducted on McGonagle Brook; however, the abundance of fish was evident throughout the stream habitat assessment” (Campbell & Prosser). An abundance of black nose dace and brook trout were noted during the 2020 habitat assessment. Given that McGonagle is the boundary line for fishing regulations, and it is in close proximity to known spawning habitat at Silver Hill Pool, Robichaud Pool, and Tabor Bridge Pool, it may be worthwhile considering McGonagle for future electro-fishing surveys, or perhaps using eDNA to determine if there is salmon presence in this stretch.

Redd Count Survey: To date, no historical records of redd counts in McGonagle Brook have been found; further, no records of historical stocking have been found either.

BMI Study: To date, no historical records of any benthic macroinvertebrate studies have been found for McGonagle Brook. This may be a worthwhile endeavor in the future.

Overall, it appears that McGonagle Brook has not been subject to many in-depth studies throughout HRAA’s lifetime, even though it has been a site for major riparian restoration. In the future, McGonagle should be included in additional water quality sampling, given cattle presence in the tributary; electro-fishing survey and eDNA analysis, and a BMI study, in order to expand our overall knowledge on this cold-water tributary.

Figure 53. Josh taking a turbidity sample at the culvert pool in McGonagle Brook. *Photo: S. Blenis*

McGonagle Zone Tributaries
McGonagle Brook

Between 1997-1998, HRAA staff took on a large restoration project along McGonagle Brook. Willows were planted along a 500m stretch of the brook, and their survival rate has been exceptional, as seen in Figure 10, with Josh as a height reference. These willows have helped to restabilize the banks in the upper portion of McGonagle Brook. In 1997-1998, HRAA staff also placed fencing along the field, restricting cattle access. In the 2020 site visit, many of these fences were in disrepair, and cattle once again have unfettered access to the brook. Working with the local landowners to repair these fences should be done in the near future. In 1997-1998, HRAA staff also created a ford by re-sloping part of the property and placing large cobble stones. This area has become severely compacted, and requires new cobble stones. At the confluence point where McGonagle enters the main stem Hammond River, a section of approximately 800m of riverbank has become severely eroded and needs riparian restoration work. Addressing this issue is paramount, because it may be increasing sediment in critical salmon habitat in the pools below (Silver Hill, Robichaud and Tabor Bridge Pools). Overall, McGonagle should be an upcoming focal point for riparian restoration activities- it already offers a solid base from the work performed 23 years ago, and with a little fixing and planting, this site could be a great demonstration site to showcase HRAA's riparian work. Incidental observations of common milkweed throughout the tributary and at the confluence point were also noted. *Photos: S. Blenis*

McGonagle Zone Lakes

Cassidy Lake

Cassidy Lake is situated along the North Branch of the Hammond River. It has an approximate length of 2km by 1.5km wide, with a maximum depth of 30ft. Cassidy Lake was part of the 1978 hydrological assessment for delay flow, and staff build a dam to slow the flow into the receiving environment, which was later upgraded. Cassidy Lake is a popular boating, fishing, and swimming destination, and should be considered a high priority area for invasive species monitoring. In 1948, attempts were made to eradicate nuisance fish from the lake; however, this endeavor was unsuccessful. In the mid 1990's, Cassidy Lake was stocked with splake and tiger trout; however, it has been many years since stocking has occurred in this lake. Each year, this is a popular destination for fishing derbies, both in the summer and in the winter for ice fishing. Cassidy Lake will be part of the upcoming *Lake Assessment*. It is one of the largest lakes in the Hammond River watershed, and efforts need to be taken to better characterize this lake, to engage with the local landowners, and to ensure that it does not become a hotspot for invasive species, like the Eurasian Water Milfoil. **Figure 54-** Cassidy Lake from the boat launch. *Photo: S. Blenis*

McGonagle Zone Lakes

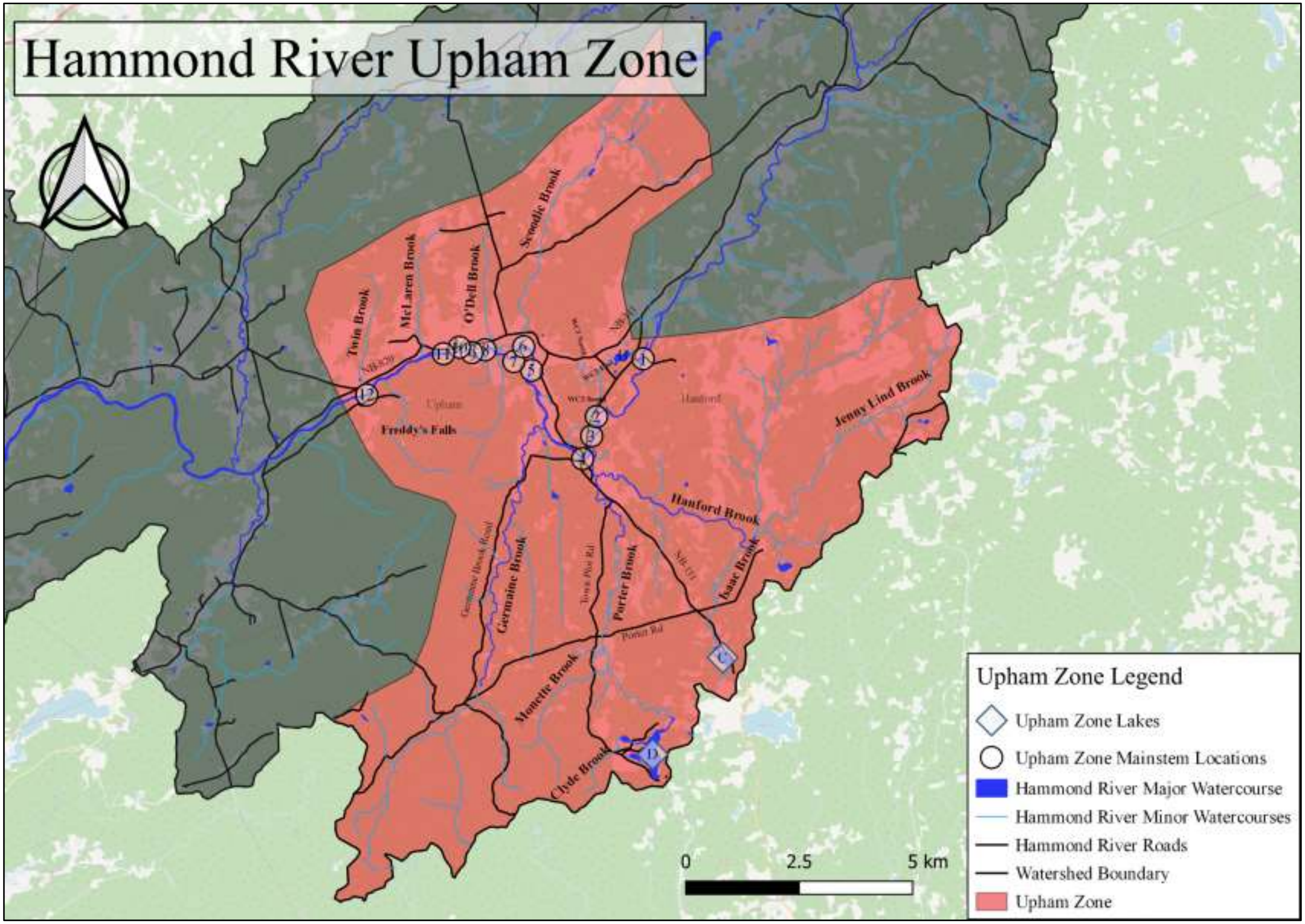
Theobald Lake

Theobald Lake is located off the Vaughan Creek Road and is the headwaters for the Jenny Lind Brook and the Irish River. Theobald Lake is the focal point of HRAA's 2020 proposal for a Protected Natural Area. Theobald lake has a surface area of 26.92 hectares, a perimeter of 3.1 km, a volume of 430,469.46 m^3, and a maximum depth of 3m. Based on topographic maps, Theobald Lake lies on the same contour line as the head of the Jenny Lind Brook (HRAA 1988) and is the headwaters for the Irish River. The lake is approximately 313m above sea level. Between 2014-2016, Theobald Lake was stocked with 3,770 native brook trout, and the lake is open for ice fishing in the winter. Theobald Lake is a medium- sized, high elevation body of water that is providing vital habitat for aquatic and terrestrial organisms, and is a prized destination for hikers, bikers, and anglers. Theobald Lake, with its beautifully treed canopy, stores large amounts of water and releases it during shortages. This beautiful lake is helping to replenish groundwater and surface water, both to the Jenny Lind Brook, and to the Irish River. Geothermal Imaging and a groundwater mapping investigation would be of high interest and use in the future for HRAA, to determine the impact that Theobald Lake has on the Hammond River watershed. Theobald Lake will be included in HRAA's 2021 Lake Assessment. *Photo: S. Blenis.*

Upham Zone

"Fly fishermen, we go through stages- first we want to catch the most fish, then the biggest, then the most difficult, then we get to the conservation of the resource-
now you have got to give something back."- Joan Wulff
Photo: Old Molly Train Bridge across Hammond River. New Brunswick Museum

Upham Zone Map



Upham Zone Legend & Work Complete (2020)

Site Name	GPS Location	Area Surveyed (m)	WQ	E-Fish	Redds (#)	e-DNA	BMI	Culvert Assessment
<u>MAIN STEM</u>								
1. Silver Hill Pool	45.485856 -65.615761	400m	YSI	No	**8**	No	No	No
2. Robichaud Pool	45.474018 -65.628123	400m	YSI	No	No	No	No	No
3. Mine Discharge Pool	45.471159 -65.629558	500m	YSI	No	No	No	No	No
4. Tabor Bridge Pool	45.466504 -65.632431	400m	YSI	No	**0**	**Positive**	No	No
5. Clark's Pool	45.484789 -65.646510	250m	YSI	No	No	No	No	No
6. Firehall Pool	45.488684 -65.649336	800m	YSI	No	**5**	No	No	No
7. O'Dell Pool	45.486273 -65.652668	500m	YSI	No	**1**	No	No	No
8. Old Molly Pool	45.487473 -65.660806	500m	YSI	No	No	No	No	No
9. Swimming Hole Pool	45.487650 -65.662704	500m	YSI	No	No	No	No	No
10. Smith's Pool	45.488539 -65.664934	500m	YSI	No	No	No	No	No
11. Kilpatrick's Pool	45.487656 -65.669545	200m	YSI	No	No	No	No	No
12 (a). Twin Pool #1	45.479999 -65.691898	500m	YSI	No	No	No	No	No
12 (b) Twin Pool #2	45.479077 -65.695737	500m	YSI	No	No	No	No	No
<u>TRIBUTARIES</u>								
1. Jenny Lind Brook	45.481753 -65.533936	600m	YSI	No	No	No	No	No
2. Hanford Brook (upper)	45.450082 -65.578451	300m	YSI	No	No	**Negative**	**Yes**	No
3. Isaac Brook	45.434250 -65.597700	150m	YSI	No	No	No	No	**Yes**
4. Porter Brook	45.460588 -65.628031	700m	Lab	**Yes**	No	No	No	No
5. Germaine Brook	45.462070 -65.649852	600m	Lab	**Yes**	**0**	**Positive**	No	No
6. Clyde Brook	45.408083 -65.624517	800m	YSI	No	No	No	No	**Yes**
7. Monette Brook	45.424068 -65.629544	750m	YSI	No	No	No	No	No
8. WC3 South	45.474143 -65.629747	900m	Lab	No	No	No	**Yes**	**Yes**
9.WC3 East	45.484525 -65.625700	0m	Lab	No	No	No	No	No
10. WC3 North	45.486418 -65.631415	0m	Lab	No	No	No	No	No
11. Scoodic Brook	45.49147 -65.64833	750m	Lab	**Yes**	**1**	No	**Yes**	No
12. O'Dell Brook	45.490070 -65.657580	1km	YSI	No	No	No	No	**Yes**
13. McLaren Brook	45.487283 -65.677323	250m	YSI	No	No	No	No	**Yes**
14. Freddy's Falls	45.479382 -65.678662	1km	YSI	No	No	No	No	No
15. Twin Brook	45.481892 -65.693181	400m	YSI	No	No	No	No	**Yes**
<u>LAKES</u>								
B. Drummond's Lake	45.486201 -65.621864	100m	YSI	No	No	No	No	No
C. Tracy Lake	45.428471 -65.594907	100m	YSI	No	No	No	No	**Yes**
D. Henry Lake	45.405912 -65.523563	100m	YSI	No	No	No	No	No

Table 2 Upham Zone Work Complete

Upham Zone Main Stem
Silver Hill Pool

Figure 57. Looking downriver from the Silver Hill Bridge in November, during the Redd Count Assessment *Photo: S. Blenis*

Site Characteristics: One of the more popular locations in the watershed, Silver Hill is susceptible to littering, and anglers using a worm during fly-fish only regulations.

Substrate: The substrate in this stretch of the river can be described as bedrock (20%), gravel (40%) and sand (40%). The substrate is 20-35% embedded. Medium flow into this pool throughout the summer.

Water Classification: (Tentative) Class A- additional samples required.

Flow Type: The site contains several pools within the area (80%), and the rest can be described as a run (20%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating.

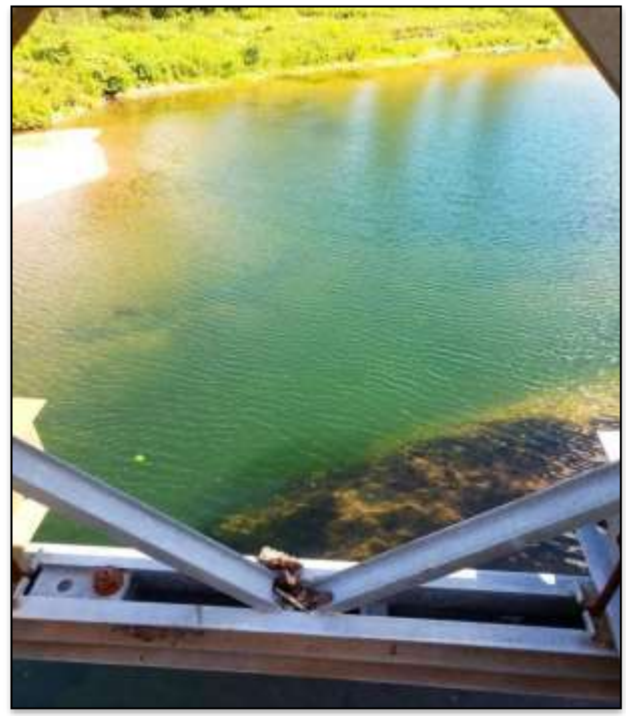


Figure 58. Silver Hill Pool August 26th- severe filamentous algae growth changed the water to turquoise. Samples came back negative for cyanobacteria. *Photo: S. Blenis*

Upham Zone Main Stem
Silver Hill Pool

Bank Stability: As seen in **Figure 59**, the banks surrounding this pool are beginning to become compromised, with large bank washout, and ensuing erosion and sedimentation loading into the river. Many of these trees are beginning to die, and many are falling into the river. There is also a highly active beaver population in the area, who have been chewing down trees in the riparian zone at an alarming rate. This needs a large-scale restoration project, and discussions with contractors and funding partners should become a priority. Silver Hill is upstream of several salmon pools and curtailing this erosion and sediment loading is a matter of urgency.

Redd Count: Approximately 1km of the Silver Hill area was covered in the annual Redd Count Assessment, with 2 medium-size redds being found above the bridge and 2 medium size redds found below the bridge. We were fortunate to have 2 volunteers that had SCUBA gear and a drone and swam throughout the pool looking for Atlantic Salmon and redds; unfortunately, they came up empty handed, as the visibility in the deeper part of the pool was poor.

Action Points: Each summer, Silver Hill Pool changes from a light tannin color to a vibrant turquoise color, as a result of filamentous algae. Increased educational awareness to the public on cyanobacteria versus algae is warranted.

Figure 59. Extreme bank erosion, increasing sediment loading and woody debris into the receiving environment. *Photo: S. Blenis*

Action Points: Silver Hill Pool is one of the more popular swimming holes within the watershed, and as a result, it is one of the most targeted for illegal dumping activities. HRAA and dedicated volunteers made multiple site visits throughout the 2020 season, picking up regular garbage (chip bags, coffee cups, plastic bags etc), to car parts, tires, chairs, and bonfire debris. Increase HRAA presence at this location to deter illegal dumping.

HRAA should continue to engage with our SCUBA volunteers and target the pool throughout the season (spring-winter) to try and capture fish footage. Annual redd counts should continue at this location.

Upham Zone Main Stem
Robichaud Pool

Figure 60. Looking upriver at Robichaud Pool, with a private suspension bridge. *Photo: S. Blenis*

Site Characteristics: Robichaud Pool is located approximately 650m upriver from the Mine Discharge Pool.

Substrate: The substrate is a combination of boulder (40%), rock (20%), cobble (20%), gravel (10%) and sand (10%), and the substrate is approximately 20-35% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is almost equally a pool (50%) and run (50%), and its sinuosity is 40% straight and 60% winding.

Bank Stability: There is significant erosion occurring at this site, with 40% eroded banks on the left, and 30% eroded on the right, with 10% and 20% stable, respectively. Undercut banks are substantial on the left bank (40%), and minimal (10%) on the right bank.

Crown Closure: There is a fair amount of overhanging vegetation on both the left and right banks, at approximately 40% and 30% respectively, allowing for a fairly shaded main stem pool.

Riparian Vegetation: The riparian vegetation consists of trees (30%), with some lovely elm tree species, shrubs (40%) and grasses (30%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. In 2008, this site had received a riparian rating of “Good”; however, this site has degraded significantly. Riparian restoration must become a focus of this stretch.

Upham Zone Main Stem
Robichaud Pool

Water Quality: Water quality in Robichaud Pool was sampled in-situ with a YSI multiparameter probe. On average, the pH level was 7.62, the conductivity was 167.0µS/cm, Total Dissolved Solids at 108.55mg/L, salinity is on the higher end compared to other water quality samples in the watershed at 0.08ppt, and dissolved oxygen slightly below recommended levels at 8.78mg/L. The pool has a strong tannin color. Possibly **Class B** or **Class C** pool.

During our habitat assessment, we noticed many benthic mats in the pool, and along the river shoreline. The majority were bright green and bubbly; however, there were many mats that were brown and free-floating in the river.

The area surrounding Robichaud Pool is primarily agricultural, with several crop fields and livestock upriver from the pool.

Action Plan: Additional organic chemistry samples are required at this location. It is highly likely that there are higher levels of phosphate, nitrate, *E. coli* and total coliforms at this location.

HRAA should also reach out to surrounding landowners to discuss riparian restoration projects and the importance of limiting livestock access to the river.

Figures 61 (a & b) Evidence of nutrient loading & erosion in Robichaud Pool. *Photos: S. Blenis*

Upham Zone Main Stem
Mine Discharge Pool

Figure 62. Looking across the river at the Mine Discharge Pool
Photo: S. Blenis

Site Characteristics: Located downriver of Robichaud Pool, this is the immediate receiving environment for the Upham East Gypsum Mine.

Substrate: The substrate is a blend of boulder (10%), rock (40%), cobble (40%), gravel (5%) and sand (5%), and is approximately 20-35% embedded.

Flow: Flow rate is normally leisurely; however, flow rate can depend upon whether or not the Upham East Gypsum Mine is actively pumping their settling ponds into the receiving environment.

Flow Type: The site is primarily a run (80%), with a small pool at the confluence of the Mine Discharge Brook (20%), and its sinuosity is very straight (80%) with little winding (20%).

Bank Stability: There is a fair amount of erosion occurring on the left bank, with 10% stable, 5% bare stable and 20% eroding. The right bank is in less-than-ideal shape, with 5% stable and 45% eroding. The right bank is also experiencing a fair amount of undercutting at 25%, while the left bank has only 10% undercut banks.

Crown Closure: The left bank is predominantly shrubs, casting minimal shade on the wide pool. The right bank is predominantly mature conifers; however, many are dead or dying, leading to less-than-ideal crown closure at this pool.

Riparian Vegetation: The riparian vegetation is predominantly shrubs (40%), with spruce and aspen trees (30%), and grass/ferns (30%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Upham Zone Main Stem
Mine Discharge Pool

Action Points: This pool is the receiving watercourse for the pumping of two settling ponds from the Upham East Gypsum Mine.

The settling ponds on the mine site do not have a liner, which will allow for water to penetrate the ground naturally. The surface area of the east and west settling ponds is approximately 570m², and they are designed to store the volume of water generated by the 100-year 24hr rainfall event. The pit dewatering pump has a maximum capacity of pumping 3500 gallons/minute into the settling ponds. Water will remain in the settling ponds for a minimum of 24 hours to allow for sediment to sink to the bottom, and the ponds will be periodically dredged to remove sediment build-up. There is also an energy dissipation pool, which includes an armored rock apron 50m before the discharge point.

Ongoing water quality samples are warranted, particularly turbidity, total dissolved solids, and total suspended solids, to ensure that the HRAA is properly monitoring a large-scale mining operation and its potential impacts on the Hammond River. It is recommended that HRAA consider installing HOBO dataloggers for temperature and light.

This site would be a good choice for salmon eDNA presence/absence, to determine if there is a negative impact overtime.

Figure 63. Downriver view from the Mine Discharge Pool. *Photo: S. Blenis*

Water Quality: In-situ water quality samples were taken using a YSI multiparameter probe. The average conductivity was 170.4µS/cm, the pH was 7.68, the Total Dissolved Solids were 113.75mg/L, turbidity was 2.77FNU, and Dissolved Oxygen was 9.03mg/L. This pool receives a **Class B** rating, as it can support habitat for aquatic life, while its dissolved oxygen levels are below the 9.5mg/L needed to obtain a Class A rating. There is a point source pollution source in this pool from the gypsum mine; however, there is ongoing monitoring to ensure releases shall not cause adverse impacts to the aquatic community. Potential **Class A** rating is possible after mine closure.

Upham Zone Main Stem
Tabor Bridge Pool

Figure 64. Arguably the most identifiable pool in the watershed, due to the unusual, yet stunning, rock formation. *Photo: S. Blenis*

Site Characteristics: Historic site for salmon spawning grounds and holding pool, downriver of Silver Hill Pool.

Substrate: The substrate is a mix of bedrock (30%), boulder (10%), and unfortunately higher densities of sand (20%) and silt (40%), and the substrate is 35-50% embedded.

Flow: Slow moving during the summer months and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is primarily a run (80%), with a fair size pool near the Bridge (20%), and its sinuosity is 60% straight and 40% winding.

Bank Stability: The banks are fairly stable at this location, with the left bank being characterized as 50% stable, and the right bank being 45% stable and 5% eroded.

Crown Closure: There is a fair amount of crown closure at this pool, given the rock formation with mature trees, and overhanging vegetation on the opposite bank. The pool stays relatively cool, even during peak summer temperatures.

Riparian Vegetation: Trees, primarily spruce vegetate this location (35%), with mature shrubs and alders (35%), and grass (30%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Observation: There has been a noticeable increase in sediment in this pool over the past 5 years, as a result of the significant erosion that is occurring in Silver Hill Pool. This may have a negative impact on salmon spawning and holding in this pool in the near future, and additional monitoring of this pool is required.

Upham Zone Main Stem
Tabor Bridge Pool

Redd Count: Approximately 400m stretch of the river was covered, from Tabor Bridge Pool to the confluence of Hanford Brook, during the Redd Count Assessment in November. Zero redds were found during this time; however, water temperatures were unseasonably warm leading up to the redd count event, and salmon may not have spawned yet. Given that this area is comprised primarily of cobble and gravel substrate, this is suitable spawning area for Atlantic Salmon.

eDNA: An eDNA sample was taken after the Redd Count event, to determine presence/absence of Atlantic Salmon, to determine if we simply mis-timed our redd count event. The results came back positive for salmon DNA, indicating that we may have been two weeks early for our redd count event, or they spawned further upriver than what we covered.

Action Points: A popular fishing and party spot, Tabor Bridge Pool is often a site for illegal dumping. Increase HRAA presence at this location. Anglers have been spotted at this pool using live bait during fly-fishing only- anglers were redirected to fish past McGonagle Brook. Increase public engagement on fishing regulations and increase public knowledge on the location of McGonagle Brook.

Figure 65. Color shifted in August to bright green. *Photo: S. Blenis*

Water Classification: Class A. No point source pollution discharges within this reach; however, the effluent from the Upham East Gypsum mine is being pumped into the river approximately 200 meters upriver from Tabor Bridge Pool. Dissolved Oxygen levels are above recommended limits (9.5mg/L) and *E. coli* levels are under the upper-level limits (50/100mL). A more robust water quality monitoring plan should be instated in this pool, to help determine the cause of the color shift in late summer, and to ensure that the HRAA is properly monitoring the discharge from the mining project.

Upham Zone Main Stem
Fire Hall Pool

Figure 66. Looking downriver from Firehall Pool. Photo: S. Blenis

Site Characteristics: Scoodic Brook flows into Firehall Pool, HRAA's earliest restoration site.

Substrate: The substrate contains a variety of types, including boulder (10%), rock (20%), cobble (20%), gravel (35%), sand (10%) and silt (5%), and it is 20-35% embedded.

Flow: A medium flow, from the slope of the valley. Increase in velocity, and a slight increase in turbidity, during heavy rain events and spring freshet. Site is prone to flooding and ice jams.

Flow Type: The site is primarily a pool (60%), with a run above and below the pool (40%), and its sinuosity is 65% straight and 35% winding.

Bank Stability: The left can be described as predominantly bare stable (40%) and stable (10%) and slightly undercut (10%). The right bank is a historic restoration site, with large boulders; however, erosion rates on this bank have been increasing.

Crown Closure: There is minimal crown closure at this pool, and very little shade is cast across the water.

Riparian Vegetation: The left bank is a mix of grass and shrubs, while the right bank is predominantly hay field with a few willows from a previous HRAA restoration undertaking.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. Firehall Pool has been the focus of numerous restoration efforts over the past 2 decades, and the time has come again to revisit these efforts- this is a very high maintenance site!

Upham Zone Main Stem
Firehall Pool

Redd Count Survey: Given its high gravel content, as well as a large riffle above and below the pool, Firehall Pool should be one of the most significant salmon spawning areas within the watershed.

During the Redd Count survey in 2020, we started the survey in Firehall Pool with the assistance of two amazing volunteers who were able to perform a drone flyover of the pool. From that footage, we were able to see spawning scratches in thesubstrate.

HRAA staff followed up on the drone footage, and found 5 large redds just below Firehall Pool, and what appeared to be several other scratches. The weather in November during our Redd Count survey was unusually warm, and may have delayed spawning; however, documenting 5 redds in this location was nice to see.

Water Classification: Given that Firehall Pool is receiving the **Class C** waters from Scoodic Brook, this pool would receive a **Class B** rating; however, additional water quality samples in this pool are required. Oddly, the *2015 Watershed ManagementPlan* characterized the condition of Scoodic Brook and Firehall Pool as having "no prominent land management issues…and did not receive a priority rank" (Bradford, Robinson, Doyle), even though they noted that the BMI survey indicated poor stream health, with increased levels of aluminum, *E. coli*, nitrogen, and phosphorus, and found the riparian area to be undercut and eroding. HRAA staff in 2020 believe that Scoodic Brook and Firehall Pool should be classified as high priority sites and should be a focus of upcoming efforts.

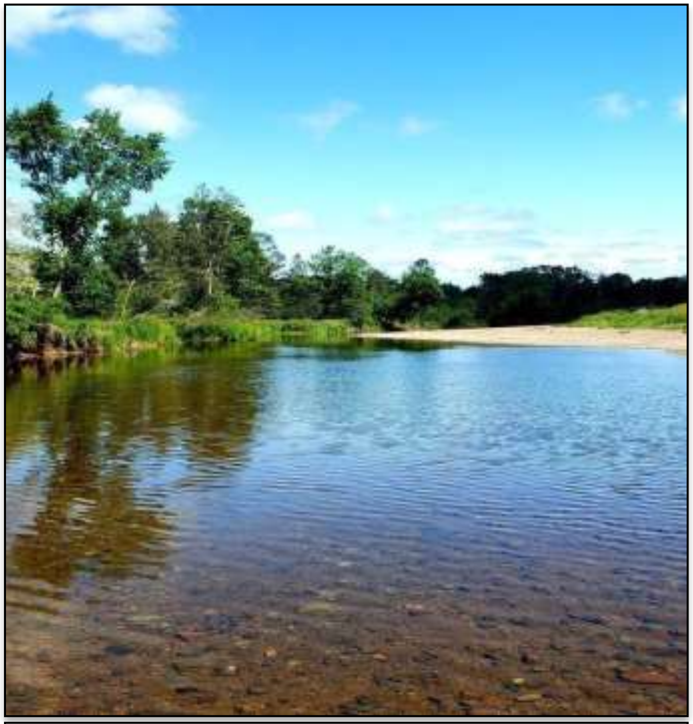


Figure 67. Upriver view of Firehall Pool. Photo was taken early June before the water temperatures reached their peak level. Substrate was clear with minimal benthic mats or algae buildup- a stark contrast to what this pool looked like at the end of July to mid-August- the rocks were covered in benthic mats, and large clumps of algae had formed throughout this pool. Firehall Pool is one of the nicest swimming and fishing holes in the watershed, with minimal littering or garbage. *Photo: S. Blenis*

Firehall Pool: HRAA's Earliest Restoration Site
"Will We Be Heroes or Bums?"

Figure 68. "Believing Confucius that 'a picture is worth a thousand words'", (Alex Gregory, former HRAA President), work begins at Scoodic Brook and Firehall Pool. *Photo: unknown.*

In 1985, HRAA staff began discussing the erosion and flooding issues at Scoodic Brook and Firehall Pool.

By 1987, former HRAA President, Lou Duffley, suggested that HRAA apply for four summer students to assist with restoration work at this location, and this is the earliest documentation of HRAA applying for the SEED (Student Employment Experience Development) program.

Restoration plans were presented to the executive on June 19th, 1987, in which they decided to proceed with 'concrete riprap', even though it would cost the Association some $3,000 above grants expected.

On July 9th, 1987, work began at Scoodic Brook and Firehall Pool.

"This project consists of stabilizing the true right bank of the Hammond river for a distance of approximately 250 feet with bags filled with a mixture of cement and gravel. Also, the bags are to be pinned down with steel bars and the first row of bags are to be set below the possible depth of scour. The purpose of this project is to help prevent future erosion of the bank", writes former HRAA president Alex Gregory. He also noted that the summer of 1987 was the worst drought in 17 years, with absolutely no rain except for a 2cm shower. While the lack of rain was hard on the river system, it made work on-site significantly easier for the crew. "Only time will tell if our efforts at Sherwood Farm are successful. This means of erosion control in ice and freshet ravaged rivers has not been tried before, and next may we will read the results (will we be heroes or bums?) If, as we hope, the project is successful, a qualified construction engineer should assess our work and recommend future employment of this method of control" (Alex Gregory, former HRAA President).

Firehall Pool: HRAA's Earliest Restoration Site
"Will We Be Heroes or Bums?"

For 18 years, the original restoration at Firehall Pool withstood the test of time; past HRAA members proved to be heroes indeed!

HRAA staff in 2020 recreated the original Firehall Pool photograph from 1987. *Photo: S. Blenis*

In 2005, HRAA staff reevaluated the Scoodic Brook and Firehall Pool restoration. In an application for funding to the New Brunswick Department of Environment and Local Government, former HRAA Operations Manager, Mark Roberts, describes the project: "in 1987, a group of volunteers from the HRAA and local community residents made a concerted effort to stabilize riverbank and erosion by placing several hundred bags of pre-mix concrete along the banks and pinning and securing them with rebar stakes. Hayfield encroachment and lack of a riparian buffer gradually took their toll, and this past spring's record runoff has now created a breach in in the old bank stabilization of approximately 9 meters long. Additionally the ice flows then removed much of the upper layer of concrete bags approximately 60 meters long immediately below the level of the meadow, exposing landscape cloth and clay banks to future erosion problems. The displaced concrete bags and attached rebar have fallen into the deepest pool section s or washed down farther to lodge in the streambed at the tail of the pool. This has resulted in a reduction of pool depth in some places by almost 1 meter and is jeopardizing the capacity and capability of the pool as an established mid-late summer staging pool for Atlantic salmon, prior to moving up Scoodic and other tributary brooks to spawn. Repairs and reinforcement to this old-style riprap will prevent further widening of the junction of the main stem of the Hammond river and Scoodic brook. The fine salmon pool that exists at this junction, as well as downstream spawning grounds, will be lost if erosion is allowed to continue. Furthermore, braids that will eat into hayfields as erosion continues will put tons of soil into the river, further destroying downstream pools in near-by Upham (Swimming Hole Pool, Smith's Pool, Kilpatrick Pool and Station Pool) and associated spawning areas. The gradual migration of the main channel into this bank is now also creating an altered channel flow that is causing major erosion problems in the form of a 25m slide of live trees, mud, and rock on a steep embankment leading into a second pool approximately 250m downstream" (Roberts, 2005).

Firehall Pool: HRAA's Earliest Restoration Site
"Will We Be Heroes or Bums?"

Figure 69. Drone footage from 2020, showing remnants of the 2005 structure, and continued erosion. *Photo: M. Adams.*

The 2005 solution to the ongoing erosion issue was to build 'groynes'- approximately 15 rock structures were built instream to deflect the main current of the river away from the unstable outer bank towards the center of the stream. These structures were to protect the bank, allowing it to be stabilized by the addition of riprap and large-scale vegetation. These structures were generally wedge-shaped and were abled upstream at approximately 5 degrees, forcing current towards the center of the stream. This project was designed to ensure long term stabilization, specifically in the groyne portion. The geotextile placed beneath the riprap was to keep the material supporting the rip rap from washing out under precipitation events until further natural stabilization occurs. Staff planted 500 willows along the bank and removed rebar that was in the river.

Additional riparian restoration work continued in 2008 and 2011. Figure 10 demonstrates the current situation of Firehall Pool, 15 years after the last major restoration project.

In 2020, HRAA staff submitted a proposal for funding to revisit the Firehall Pool, and to continue the efforts to stabilize the banks that our HRAA predecessors started. Firehall Pool is critical Atlantic Salmon habitat, and the efforts over the past 33 years were well worth it.

The question remains: will our efforts in the upcoming year make us heroes, or bums? Only time will tell!

Upham Zone Main Stem
O'Dell Pool

Figure 70. Looking downriver at Gerald's Beach in July *Photo: S. Blenis*

Site Characteristics: Located approximately 600m downriver from Firehall Pool, O'Dell Pool is characterized by its gypsum outcrops, which have left banks very unstable and susceptible to erosion.

Substrate: The substrate is bedrock (5%), rock (10%), gravel (15%), and a high density of sand and silt (70%), and the substrate is 35-50% embedded.

Flow: Medium flow through the pool in the peak of summer; velocity increases substantially in the spring, flooding the beach area.

Flow Type: The site contains a fairly large, deep pool (60%), and run (40%).

Bank Stability: The right bank is a beach and is 50% bare stable. Unfortunately, the left bank is extremely unstable, and receives a 50% erosion rating.

Crown Closure: The right bank provides little crown closure, while the left bank provides substantial shade due to trees, overhanging vegetation, and the steep slope.

Riparian Vegetation: The left bank is predominantly trees; however, many of these trees have begun to die, either as a result of age, or bank instability. The riparian vegetation on the right bank is mainly grasses, with few shrubs and ferns.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. This site is greatly contributing to sediment loading in the river system. It is also greatly contributing to woody debris downriver, as many of the large trees are collapsing into the water.

Upham Zone Main Stem
O'Dell Pool

Action Points: In depth water quality analysis is warranted at this location. Gerald's Beach is approximately 600m downriver from Scoodic Brook, which regularly exceeds *E. coli*, coliform, phosphate, and nitrate recommended levels. A water quality monitoring program to sample for organic and inorganic chemistry should begin in 2021 on a monthly basis.

A robust water monitoring program may shed some light into the drastic color changes this pool experiences in the pinnacle of summer. Normally, this pool is quite tannin in color; however, as the summer water temperature increases, so too does the algal bloom and vibrant green discoloration of this pool. Benthic mats were scraped from many rocks in this location and sent to the University of New Brunswick for additional analysis, to determine if they contain cyanobacteria.

HRAA should reach out to the landowner, JD Irving Ltd, to develop a collaborative plan to help address the significant erosion that is occurring along the left bank. Years ago, this beach and pool was predominately gravel, and a known spawning area; now the substrate is primarily sand. Addressing this issue is pivotal for the future success of the Hammond River, as this stretch is greatly influencing the sedimentation overload downriver, impairing salmon spawning grounds, and overall impacting the health of the ecosystem.

Figure 71 (a,b,c) Evidence of nutrient loading and filamentous algae growth in August, as well as floating benthic mats, and mats on substrate *Photo: S. Blenis*

Upham Zone Main Stem
O'Dell Pool

Figure 72. Sections of erosion along the riverbank near a hayfield.
Photos: S. Blenis

Erosion exists along the banks for approximately 1km in length. This is increasing the sedimentation in the Hammond River, particularly into the pools below O'Dell Beach, including Swimming Hole Pool, Smith's Pool, Kilpatrick's Pool, and Station Pool, all of which are known holding pools for Atlantic Salmon.

Landowner is interested in working with the HRAA to restore the riparian buffer, and HRAA has since submitted a large-scale proposal for restoration, approval is still pending.

Remediating this area is a top priority moving forward. Should we fail to promptly address this situation, it will have dire consequences for salmon migration to the northern part of the watershed.

This site is rarely productive for angling, even though it is a deep pool with a decent flow. Perhaps the site contains an overabundance of filamentous algae and sediment, so that it is no longer suitable fish habitat. Perhaps the gypsum outcrops are changing the overall water chemistry, so the site is not appealing to fish. Perhaps the fish are content with the holding pool at Firehall and simply have no interest in O'Dell Pool. Adding this site for an in-depth water chemistry exploration, as well as making this site a riparian restoration priority, should help shed some light on why fish are not abundant in this holding pool.

Upham Zone Main Stem
Old Molly Pool

Figure 73. Looking downriver towards the old train bridge, that the engine "Old Molly" used to run from St. Martin's to Hampton in the late 1800's. *Photo: S. Blenis*

Site Characteristics: Located approximately 1.2km downriver from O'Dell Pool, and 600m from Swimming Hole Pool.

Substrate: The substrate is a mix of boulder (40%), rock (20%), cobble (20%), and gravel (20%), and the substrate is <20% embedded.

Flow: Moderate, shallow flow in the summertime, given the slope of this stretch; increase in velocity during heavy rain events, with minimal turbidity.

Flow Type: The site is primarily a run (90%), with a small pool tucked against an old pillar (10%), and its sinuosity is 90% straight and 10% winding.

Bank Stability: The left and right bank received the same ranking for stability, with bare stable (25%) and stable (25%), with a small section of undercut banks on the left (5%), and the right (10%).

Crown Closure: Adequate crown closure and shade at this pool, given the slope of the valley and the dominate tree landscape.

Riparian Vegetation: The riparian vegetation can be described as a combination of mature trees (40%), shrubs (40%), and grass (20%). This site is as it naturally occurs, or at least since the closure of the rail line in the mid 1900's.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class A. No point source pollution discharge. Water quality within optimal levels to allow for aquatic species to thrive.

Upham Zone Main Stem
Swimming Hole Pool

Figure 74. Josh Kelly taking a YSI reading from Swimming Hole Pool. *Photo: S. Blenis*

Site Characteristics: Sediment is very noticeable in this pool and might be caused by the severe erosion upriver at O'Dell Pool.

Substrate: The substrate is a union of bedrock (20%), boulder (10%), rock (20%), cobble (10%), gravel (20%), and sand (20%), and the substrate is 35-50% embedded.

Flow: Gentle flow during the hot summer months. Flow increases during high rain events, which increase turbidity and decrease water clarity.

Flow Type: This site is an equal mix of run (50%) and a deep pool (50%).

Bank Stability: The left bank is a mix of stable (5%), bare stable (40%), and eroding (5%), while the right bank is stable (10%), bare stable (30%), and eroding (10%). The right bank is a private residence, with little riparian buffer, allowing for bank instability.

Crown Closure: The left bank offers a steep, heavily treed slope, with 20% overhanging vegetation. The right bank provides less shade, with only 5% overhanging vegetation. Shade is approximately 25% of the pool.

Riparian Vegetation: Trees are the dominant feature at this location (50%), while there are mature shrubs, particularly alders (45%), and a grass lawn on the right bank (5%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable. The HRAA should contact the landowner and determine if they would allow revegetation along the riparian zone, or perhaps not mow as close to the river. Potential area for future SCUBA underwater footage.

Water Classification: Class A. All parameters within limits for aquatic life.

Upham Zone Main Stem
Smith's Pool

Figure 75. Looking from the middle of Smith's Pool *Photo: S. Blenis*

Site Characteristics: Beautiful pool with a large bedrock ledge, located just downriver from Swimming Hole Pool.

Substrate: The substrate is a blend of bedrock (40%), boulder (10%), rock (20%), cobble (10%) gravel (10%) and sand (10%), and the substrate is 20-35% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is a large pool, formed from bedrock ledges (95%) and a small run (5%) and its sinuosity is 90% straight and 10% winding.

Bank Stability: Overall, this pool is fairly stable (45%) with minimal undercut banks (10%) with one localized area of erosion near a steep slope on the left bank.

Crown Closure: An equal amount of overhanging vegetation lends to the shade and crown closure of this pool, keeping it cool in the hot summer.

Riparian Vegetation: Trees are the predominant feature (40%), followed by shrubs (20%), grasses (28%) and ferns (2%). This is a fairly secluded pool and exists almost as it naturally occurs.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable. Beautiful fishing pool, worth the trek through the willy-wags.

Water Classification: Class A. No point source pollution discharges. Water quality parameters are all well within the limits to sustain aquatic life. Abundance of freshwater mussels, indicating good water quality as well.

Upham Zone Main Stem
Twin Pool #1

Figure 76. Standing in Twin Pool #1, looking downriver towards Twin Pool #2. *Photo: S. Blenis*

Site Characteristics: Historic HRAA site for SCUBA swim-throughs for adult salmon, this site holds HRAA Board of Directors Louis Duffley's "Lou's Rock"- the perfect rock for casting!

Substrate: The substrate is a combination of bedrock (10%), boulder (20%), rock (30%), cobble (20%) and gravel (20%), and the substrate is <20% embedded. Historic site for redd count surveys.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water begins to flow at a significant rate.

Flow Type: The site is comprised of a large, deep pool (70%) and a short run (30%) that connects to Twin Pool #2.

Bank Stability: There is minimal erosion at this site, with the left bank being stable (45%) and bare stable (5%), while the right bank is stable (25%) and bare stable (25%). No undercut banks.

Crown Closure: Beautiful crown closure, with overhanging vegetation on both banks. The steep slope on both sides also lends itself to shade the pool.

Riparian Vegetation: Riparian vegetation predominately mature trees, particularly cedar trees (80%), mature shrubs (15%) and grasses (5%). This site is as it naturally occurs, and is a beautiful spot to swim and fish, and is never a source of litter.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable. Stunning location!

Water Classification: Class A. No point source pollution discharges. Abundance of freshwater mussels. All water quality parameters within acceptable limits to support aquatic life.

Upham Zone Main Stem

Twin Pool #2

Figure 77. Standing in the middle of Twin Pool #2, looking downriver. *Photo: S. Blenis*

Site Characteristics: Downriver from Twin Pool #1, rock has been added on an eroding left bank, stabilizing the bank.

Substrate: The substrate is a blend of boulder (30%), rock (20%), cobble (10%), gravel (10%), sand (5%) and silt (5%), and the substrate is 20-35% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is a large pool (80%) and a short run (20%) to the next Twin Pool, and its sinuosity is 90% straight and 10% winding.

Bank Stability: The left bank is bare stable (40%) with slight erosion (10%), and the right bank is bare stable (45%), with minimal erosion (5%).

Crown Closure: This pool has beautiful crown closure, as the area is populated with mature trees and situated in a high-sloped valley. Shade is approximately 60%.

Riparian Vegetation: A healthy mixture of trees (30%), mature shrubs (30%), grasses (30%) and ferns (10%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable and is at it naturally occurs. This is a favorite fishing and swimming spot for many locals, with hardly any littering and garbage. Definitely a gem of the Hammond!

Water Classification: Class A. No point source pollution, and all water quality parameters are within acceptable limits for aquatic life.

Upham Zone Tributaries
Jenny Lind Brook

Site Description: Located off of the Vaughan Creek Road, Jenny Lind is a cold-water tributary in the Caledonia highlands region and is part of HRAA's 2021 Protected Natural Area proposal. Jenny Lind's headwaters is a fairly large wetland complex, situated in close proximity to Theobald Lake.

Flow Type: Fast moving flow over primarily rock, cobble, and gravel substrate.

Bank Stability: Banks are stable, and this stretch is at it naturally occurs.

Crown Closure: Beautiful crown closure, with plenty of overhanging vegetation, creating a wonderfully shaded pool, keeping water temperatures cool.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Fish Community: Unknown. This would be an excellent candidate for future electro-fishing, as it offers prime fish habitat. eDNA metabar analysis may be fruitful in this location, to determine which fish species reside in Jenny Lind Brook. Black nose dace were observed during the stream habitat assessment in 2020. Given that this site is as it naturally occurs, with high dissolved oxygen content and exceptional canopy coverage, the Jenny Lind would be a prime candidate for future brook trout (or potentially Atlantic Salmon) stocking activities.

Figure 78. Downstream of the Jenny Lind Brook from the bridge. Photo taken in midday sun, demonstrates the shade quality of this stretch. *Photo: S. Blenis*

Upham Zone Tributaries
Jenny Lind Brook

Action Points: Develop a long-term monitoring plan for the Jenny Lind Brook, and its wetland headwaters. This brook is pivotal for the success of the Hammond River, as it provides cold, highly oxygenated water to the main stem.

This area is Crown Land. While there has been logging and forestry activities in the surrounding area, the Jenny Lind remains as it naturally occurs, with a substantial riparian buffer separating it from logging activities. HRAA should maintain conversations with the Crown and the forestry industry, to ensure that the vegetated buffer remains fully intact.

HRAA should perform a full site assessment throughout the entirety of the Jenny Lind Brook, the surrounding wetlands, and explore the groundwater connection to Theobald Lake. There exists high potential for rare and endangered flora and fauna, as this site is completely untouched.

Efforts to explore, sample, and document the Jenny Lind Brook in detail in the 2021 season should be a priority for HRAA staff.

Figure 79. Upstream view of the Jenny Lind, showing the fast flow over large rock and cobble substrate. *Photo: S. Blenis*

Water Classification: Class O. No point source pollution discharges. Site is as it occurs naturally, allowing for barely measurable changes to water chemistry. Minimal surrounding land use or water use activities. Fecal coliform organisms and *E. coli* are as naturally occurring. High Dissolved Oxygen levels. The exceptional crown closure, bank stability, and steep flow of this tributary are providing a cold-water tributary to the Hammond River, and its discharge point into the main stem is near salmon spawning and holding pools. This site is one of many treasures along the Caledonia Eco-Region.

Upham Zone Tributaries
Upper Hanford Brook

Site Characteristics: Located off the Vaughan Creek road, the upper portion of Hanford Brook is in the Caledonia highlands region.

Substrate: The substrate is a combination of bedrock (5%), boulder (30%), rock (30%), cobble (20%), rock (10%) and sand (5%), and the substrate is <20% embedded.

Flow: High velocity given the steep slope of the surrounding area.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 20% straight and 80% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.
Banks are fortified with large boulders and rocks.

Crown Closure: Beautiful crown closure, predominantly old growth forest that casts shade over the majority of the stretch (70%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class O. This site is as it naturally occurs. There are no point source pollution discharges. Dissolved oxygen is 9.6mg/L, providing highly oxygenated, cold water. All coliforms are naturally occurring. Aside from lumber, there are no residential dwellings, agriculture, or livestock near this tributary. This site is in pristine condition with minimum human impact. This tributary is providing a critical cold-water source to lower Hanford, near known salmon spawning ground.

Figure 80. Looking downstream of the upper portion of Hanford Brook, high water velocity & beautiful stretch. *Photo: S. Blenis*

Upham Zone Tributaries
Upper Hanford Brook

Figure 81. Looking downstream of the upper portion of Hanford Brook, high water velocity is increasing the dissolved oxygen content in this brook. *Photo: S. Blenis*

eDNA- As there was some confusion as to the proper Hanford Brook location (ie: staff performed regular water quality samples & electro-fishing in Porter Brook, not Hanford Brook), staff decided to take an eDNA sample in the upper portion of Hanford Brook to determine salmon presence/absence in lieu of electro-fishing. While the eDNA result came back negative for salmon DNA, it would be worthwhile to electro-fish this upper reach in the future to determine fish community. Additionally, the headwaters of Hanford Brook is Porcupine Lake- this lake will be included in our *2021 Lake Assessment* as it is critical for supplying cold-water to Hanford Brook.

HRAA should begin to engage the primary landowner, JD Irving Ltd, in discussions to create a Unique Area surrounding Hanford Brook. "One of the most complete Cambrian stratigraphic and fossil records in New Brunswick is located near the community of Hanford Brook. This area was the source of most of the fossils described during 19th century exploration of the Cambrian rocks in New Brunswick. The fossils found here in the past are preserved in numerous museum collections in North America and Europe including the New Brunswick Museum, Saint John, the Royal Ontario Museum, Toronto, the Sedgwick Museum, Cambridge (Great Britain), the Smithsonian Museum, Washington, and others." (NB Museum).

Further, it would be wonderful to work with the landowner to ensure a significant vegetated buffer exists along this upper portion of Hanford Brook, of at least 100m. The upper Hanford Brook is providing critical cold water, and beautiful habitat, and efforts should be made to preserve its gloriousness for years to come.

Upham Zone Tributaries

Isaac Brook

Figure 82. Swamp and wetland matrix region of the upper portion of Isaac Brook, with significant beaver activity. *Photo: S. Blenis*

A full habitat assessment of Isaac Brook was not complete during 2020 and should become a priority for the 2021 season. The headwaters for Isaac Brook is Tracy Lake, and eventually Isaac Brook meets up with Hanford Brook, to enter the main stem Hammond River. In the future, HRAA should undertake a full habitat assessment of Isaac Brook, including water quality samples and electro-fishing. Efforts were taken to determine if any historical HRAA work had been done on Isaac Brook; however, nothing has been found yet.

Figure 82 . An extremely compromised culvert under route 111 and connects the beaver area of Isaac Brook to the main outflow of the brook. The bottom of the culvert has completely rusted out, and the culvert has become compacted, with severe erosion issues on the crown. This culvert receives a high priority ranking for repair, as it possesses a future safety concern for traffic. *Photo: S. Blenis*

Figure 82 Isaac Brook

Upham Zone Tributaries
Porter Brook

Figure 83. Looking downstream of Porter Brook. *Photo: J. Kelly*

Site Characteristics: Throughout the 2020 season, HRAA staff believed that they were sampling and assessing Hanford Brook; however, by the end of the season, staff realized they had made an error. All of the work that was believed to have been carried out in Hanford Brook was actually in Porter Brook. The main cause of the problem is that there is a bridge that passes over a tributary on route 111, and the sign above the bridge simply says “Hanford”; ergo, it was assumed that the tributary below the bridge was Hanford Brook. While staff assessed the upper reach of Hanford Brook in a separate assessment, a priority of 2021 will be to assess the REAL Hanford Brook.

Substrate: The substrate is boulder (5%), rock (20%) and silt (75%), and it is >50% embedded. Rock is extremely slippery and difficult to traverse during wading assessment.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 10% straight and 90% winding.

Bank Stability: Significant erosion is occurring along Porter Brook. The right bank can be described as eroded (50%), while the left bank is somewhat bare stable (25%) and equally eroding (25%). Undercut banks exist throughout Porter Brook, with a rating of 30% undercut on the left bank, and 50% undercut on the right.

Crown Closure: Crown Coverage is limited to the right bank (40%), as the left bank is mainly bare stable, providing little shade or canopy.

Riparian Vegetation: Alders and shrubs are the predominate vegetation along Porter Brook, as well as many older or dying trees. This site is in need of restoration in the near future.

Riparian Rating: Poor. The riparian zone has little to no trees or shrubs, or less than 39%, and little shade is cast across the reach with minimal crown closure. Erosion occurs more frequently, as more than 50% of the banks are eroding.

Upham Zone Tributaries
Porter Brook

Figure 84 & 85. A large beaver dam at Hanford Bridge over Porter Brook. Evidence of nutrient loading & filamentous algae. *Photo: S. Blenis*

Electro-fishing: Electro-fishing was carried out in September 2020. Staff believed they were electro-fishing Hanford Brook; however, they performed a fish assessment in Porter Brook.

In the 2008 Watershed Management Plan, it is noted that electro-fishing had been done in Porter Brook; however, discontinuation of the study was recommended, as the survey did not yield any fish, and it was determined that habitat within Porter Brook is insufficient to sustain aquatic life.

During the 2020 electro-fishing survey, staff documented 4 fish species in Porter Brook, including Black Nose Dace, Creek Chub, American Eel, and Common Shiner.

This site is highly fragmented, more than likely due to years of heavy sediment deposition into this brook, which has created multiple grass islands, ultimately decreasing the depth of the brook. This is not the most suitable fish habitat. It may be a worthwhile undertaking to perform a habitat assessment on the upper reaches of Porter Brook for potential restoration sites.

Redd Count: While a redd count was not conducted in Porter Brook (not suitable spawning habitat), the redd count assessment was performed for 300m from Tabor Bridge to the mouth of Hanford Brook (the REAL Hanford Brook, not Porter Brook!) Alas, no redds were documented in this stretch.

Upham Zone Tributaries

Germaine Brook

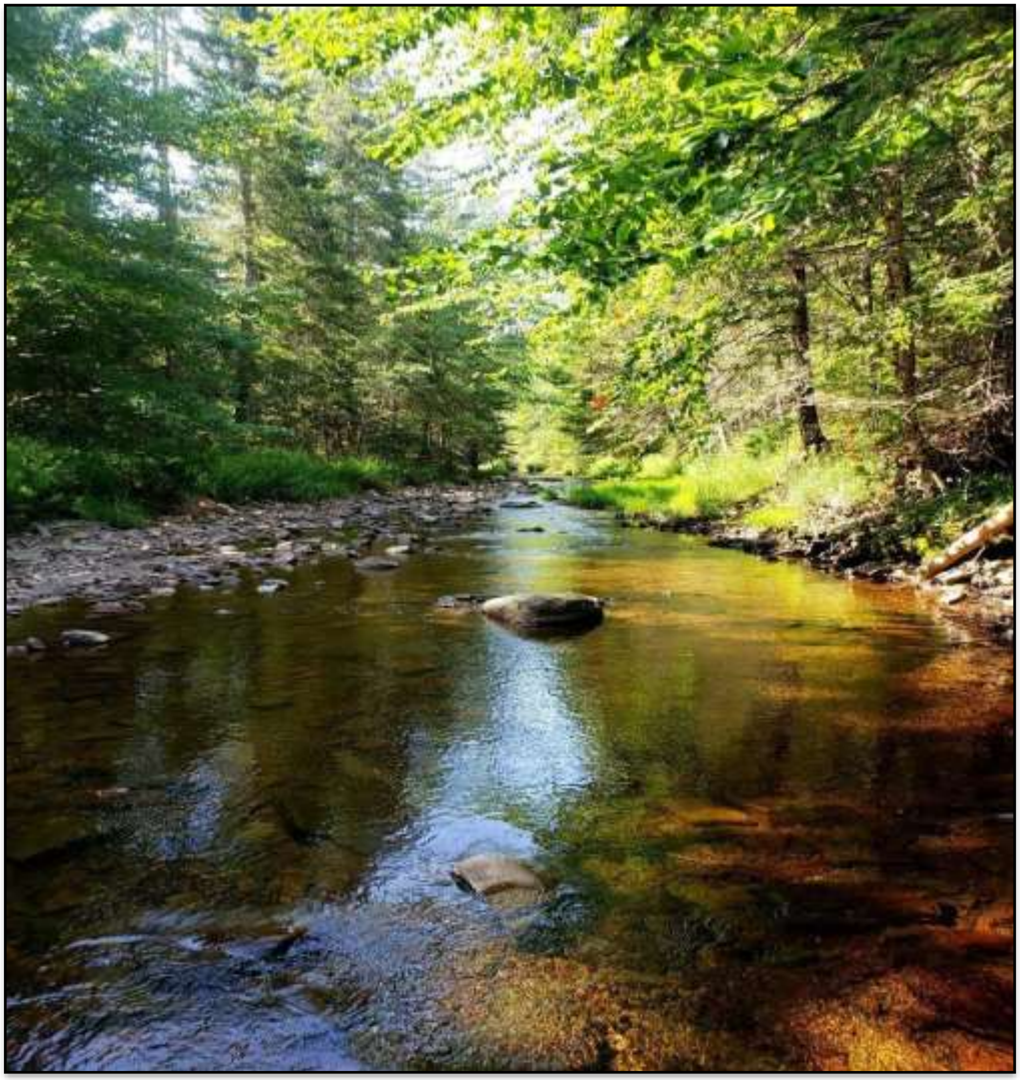


Figure 86. Looking upstream of Germaine Brook. *Photo: S. Blenis*

Site Characteristics: Germaine Brook is a long brook, approximately 13.5km in length and empties into the Hammond Rive less than 1km below Tabor Bridge.

Flow: Moderate flow during the summer months as the slope of the stream is high. Heavy rainfall events increase the flow drastically, and it is usually turbid when discharging into the river, given the erosion that is occurring at the lower reach of this tributary.

Flow Type: This stretch can be described as predominately a run (70%) with small pools (30%), and its sinuosity is 20% straight and 80% winding.

Bank Stability: The upper portion of Germaine Brook varies greatly from the lower portion of the brook. Bank stability in the upper reach is principally stable (45%) with some bare stable (5%) areas. Minimal bank undercutting is happening in the upper portion, as the banks are fortified with bedrock and large boulder. The upper portion is essentially a part of the Caledonia Highlands formation, and exists as it naturally occurs.

Riparian Zone in upper Germaine is highly natural, with little disturbance.

Upham Zone Tributaries
Germaine Brook

Riparian Rating: For the upper portion of Germaine Brook, the riparian rating is **Excellent.** The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable. The brook winds through old growth forest, which offer stunning canopy coverage and cast large amounts of shade on the brook, keeping its waters cool even in the hot summer months.

Water Classification: For the upper portion of Germaine Brook, a classification of **Class O** is possible. There are no point source pollution discharges, and dissolved oxygen is above 9.5mg/L, and all other water quality parameters are well within acceptable limits to support aquatic life.

As the brook progresses towards the river, the last kilometer of the brook takes a turn for the worse and is almost a completely different tributary than its upper counterpart.

The slope surrounding the brook begins to lessen, as it moves away from the highland formation, and enters a flat region that is dominated by heavy farming. There is also a noticeable shift in riparian vegetation, going from old growth forest to a mix of softwood and shrubs.

Figure 87. Upper portion of Germaine Brook, with exceptionally clear water, and gravel substrate, perfect for salmon spawning. *Photo: S. Blenis*

Upham Zone Tributaries
Germaine Brook

Electro-fishing: In September of 2020, HRAA staff completed an electro-fishing survey for 100m². The results of the survey were extremely disappointing: only 3 fish species were found in with low densities (11 total)- Slimy Sculpin, Black Nose Dace, and American Eel. Germaine Brook had the lowest fish population densities in the entire 2020 electro-fishing season.

According to the 2008 Watershed Management Plan, between 2005-2008, Germaine Brook was stocked with 10,680 juvenile salmon. As of 2008, HRAA noted that Germaine Brook had naturally high densities, and concluded that further stocking was not recommended in the future. Not finding any salmon (and very few other fish) in 2020 was extremely disheartening and alarming.

Redd Counts: In November of 2020, staff assessed approximately 300m of Germaine Brook in search of redds- zero were found. In 2008, HRAA staff noted that redds have consistently been found in Germaine Brook, with one of the highest densities of redds in the watershed. Again, it is distressing that neither juvenile salmon or adult redds, were located in Germaine Brook in 2020.

eDNA: After negative results with both electro-fishing and redd count survey, HRAA staff decided to take an eDNA sample in Germaine Brook, to see if there was any presence at all of salmon. The result came back positive for salmon DNA!

Figure 88. Looking downstream of Germaine Brook. *Photo: S. Blenis*

All hope is not lost for salmon in Germaine Brook, one of the most historic, productive habitats for Atlantic Salmon, but we need to act quickly to address the erosion issues along the lower portion of the brook. While the upper portion of Germaine Brook offers pristine water quality, suitable substrate, and plenty of shade, Atlantic Salmon may not be entering this tributary as much anymore due to the high level of stress that can be seen in the lower portion of the brook. Remediating the lower portion may return Germaine Brook to a suitable stocking site in the future.

Upham Zone Tributaries
Germaine Brook

Figure 89 & 90 Lower portion of Germaine Brook, in an agricultural zone, with no riparian buffer. Significant erosion is occurring. *Photos: J. Blenis, 2019*

Restoration: In recent years, poorly vegetated banks and erosion has caused channel instability and a diversion of the brook from its original flow pattern. These changes have coincided with a significant decline in annual redd (salmon nest) and juvenile (fry and parr) counts in the brook. Erosion in Germaine Brook has led to accumulated fluvial deposits and the formation of bars on the stream banks and presumably siltation in the mainstem Hammond River downstream. In 2016 and 2017, a restoration plan was developed to stabilize the stream bank and control erosion in the area (funded by the Recreational Fisheries Conservation Partnerships Program). Detailed restoration plans were completed by Dillon Consulting. Both the restoration reach, and the downstream reach, are excellent salmon spawning habitat which would benefit from decreased sediment supply. Many pools on the mainstem of the Hammond River have experienced infilling and would also benefit from a decreased sediment supply.

Action Plan: Moving forward, HRAA needs to revisit these previous restoration plans. Updates should be made, and then HRAA should seek funding in order to carry out a large-scale restoration project as soon as possible. The basis of a plan exist now we need to find the right funding partners and contractors in order to carry out this project, and it needs to be done immediately. Restoration of Germaine Brook needs to be considered absolutely essential.

Upham Zone Tributaries
Clyde Brook

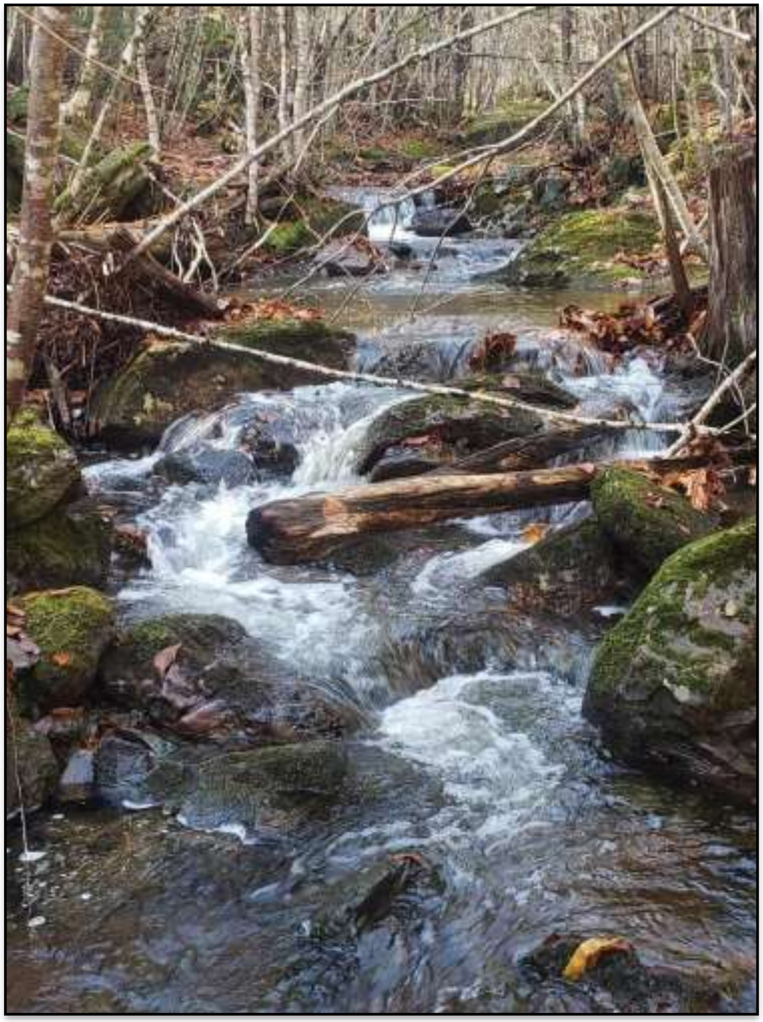


Figure 91. Looking upstream of Clyde Brook to the numerous small waterfalls, providing quality dissolved oxygen to the receiving environment. *Photo: S. Blenis*

Site Description: Located off the Town Plot Road, Clyde Brook is in the Caledonia highland region of the watershed.

Flow Type: This stretch was visited in November, and had a fast-moving flow, spilling over numerous small waterfalls into small, deep pools. This site should be revisited in the summer of 2021 to observe flow rate during peak summer temperatures.

Bank Stability: Banks are stable, and this stretch is at it naturally occurs.

Crown Closure: Beautiful crown closure, with plenty of overhanging vegetation, creating a wonderfully shaded pool, keeping water temperatures cool.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class O. No point source pollution discharges. Site is as it occurs naturally, allowing for barely measurable changes to water chemistry. Minimal surrounding land use or water use activities. Fecal coliform organisms and *E. coli* are as naturally occurring. High Dissolved Oxygen levels. The exceptional crown closure, bank stability, and steep flow of this tributary are providing a cold-water tributary to the Hammond River, and its discharge point into the main stem is near salmon spawning and holding pools. This site is one of many treasures along the Caledonia highland region.

Upham Zone Tributaries
Clyde Brook

Action Points: Truly one of the hidden gems of the Hammond River Watershed, we could have filled an entire book of spectacular pictures from Clyde Brook. This tributary has such a glorious character, with giant boulders, mini waterfalls, and mature forests. Numerous deep pools were found along this stretch, and it appears to be prime salmonid habitat.

This would be a prime location for future electro-fishing surveys, or potential eDNA sampling to determine presence/absence of salmon. This has the potential to be a future salmon fry stocking site, as it offers exceptional habitat, cold water, and high dissolved oxygen content.

HRAA should also keep a close eye on these aging culverts- it should be a priority to keep Clyde Brook as it naturally occurs, with minimal interruption from degrading culvert systems.

This site has a high potential for rare and endangered flora and fauna, like Eastern Waterfan, as it runs through an old growth forest. Efforts should be taken to explore the tributary further in 2021 in search of this aquatic plant species.

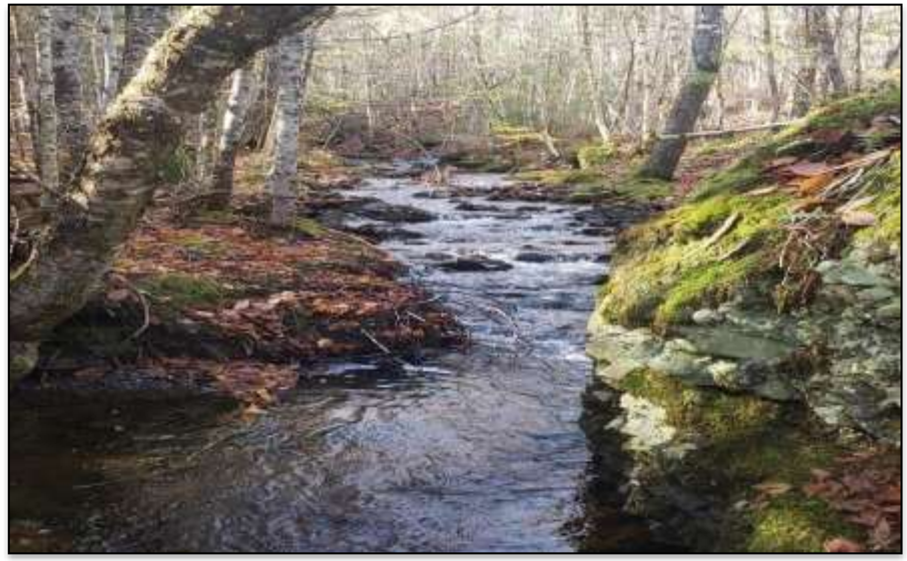


Figure 92 & 93. Older concrete arch culverts clogged with leaf litter, and another upstream view of the stunning Clyde Brook. *Photo: S. Blenis*

Upham Zone Tributaries
Monnett Brook

Figure 94. Looking upstream Monnett Brook from the bridge, the tannin color of this stretch is very pronounced. *Photo: S. Blenis*

Site Description: Located off the Town Plot Road, Monnett Brook is located in the Caledonia highlands region. This site contains part of the buried brine line from the PCS potash mine. The banks surrounding the bridge and roadway along Monnet Brook have been disturbed during the installation of the brine line; however, they are naturally revegetating with shrubs.

Flow Type: This stretch was visited in November and had a fast-moving flow. This site should be revisited in the summer of 2021 to observe flow rate during peak summer temperatures.

Bank Stability: The banks are stable in the upper and lower reach of Monnet Brook; slight undercut banks near the road.

Crown Closure: The upper and lower reach of Monnet Brook is as it naturally occurs, with the exception being the area surrounding the bridge and brine line installation.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class A. No point source pollution discharges. Minimal surrounding land use or water use activities. High Dissolved Oxygen levels. The exceptional crown closure, bank stability, and steep flow of this tributary are providing a cold-water tributary to the Hammond River, and its discharge point into the main stem is near salmon spawning and holding pools.

Upham Zone Tributaries
Monnett Brook

Action Points: HRAA should undertake discussions with PCS Potash Mine and develop a routine water quality monitoring program of Monnett Brook, given its close proximity to the brine line. Any spills or leaks of the aging brine line would be detrimental to the Hammond River, and it is advised to begin a robust monitoring plan in 2021. The substrate in the brook within the first 200m upstream and downstream of the bridge do not appear naturally occurring- discussion should be had with PCS to determine if this was part of the brine line installation. Fish population in Monnett Brook is currently unknown; efforts should be taken to include this stretch in future electro-fishing efforts.

Figure 95. Upstream view showing the fast flow over large rock and cobble substrate, with strong tannin color. *Photo: S. Blenis*

Figure 96. Unusual substrate that does not appear to be naturally occurring. *Photo S. Blenis*

Upham Zone Tributaries
Mine Discharge Brook

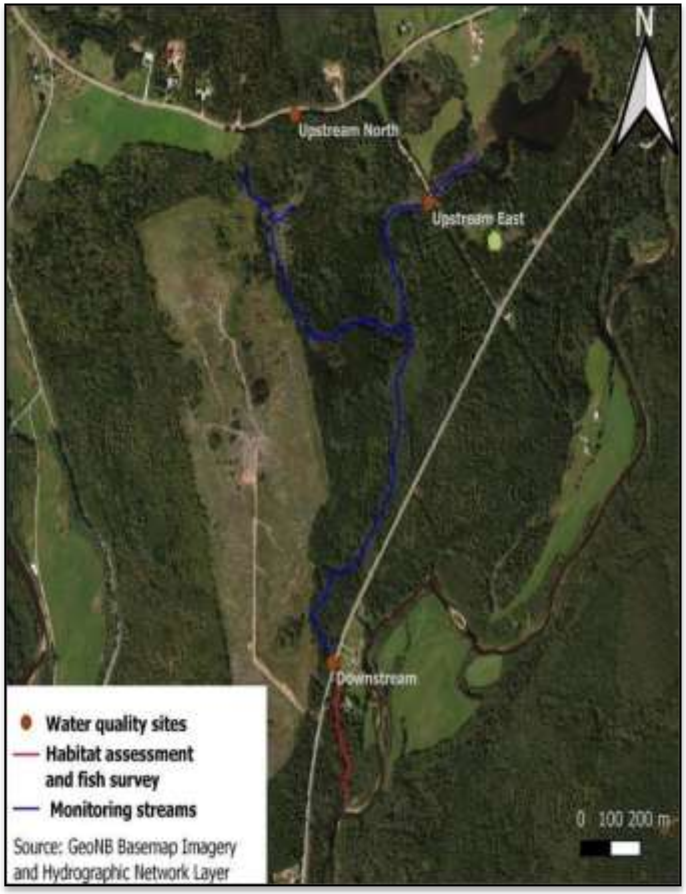


Figure 97. Located in between Silver Hill Pool and Tabor Bridge Pool, HRAA monitors the North, East, and South Watercourse 3 in relation to the Upham Gypsum Mine. *Photo: J. Blenis*

The primary variables of interest for the water quality survey includetotal suspended solids (TSS) and turbidity (as an indicator of TSS). Samples are collected monthly, targeting the first week of the month during the open-water season at two sites upstream of the Project (WC3 North & WC3 East) and one site downstream of the Project (WC3 South). Additional samples are collected after heavy rain events; defined as 30 mm or more over a 24-hour period based on forecast or actual precipitation amounts.

Habitat assessment and fish survey are completed annually. The survey includes a reach measuring approximately 300 m. Six habitat transects (stream cross-sections) were established at approximately 50 m intervals along the reach. At each transect, stream morphology (e.g., wetted and bankfull width), substrate size and embeddedness (underwater camera), and macrophyte coverage were recorded. Streamflow, temperature, pH, conductivity, and dissolved oxygen measurements are recorded. The fish survey is conducted via a single pass with a backpack electrofisher.

A BMI study will be complete annually as well in WC3 South, to determine any changes in benthic macroinvertebrate communities as a result of the Project.

WC3 East connects with Drummond's Lake, and both WC3 East and WC3 South generally have higher conductivity and hardness levels, as the water is passing through a gypsum source.

WC3 South enters the Hammond River at the Mine Discharge Pool, located downriver of Robichaud Pool. Both the Mine Discharge Brooks and Mine Discharge Pool should be carefully monitored to ensure no negative environmental impacts occur.

Upham Zone Tributaries
Scoodic Brook

Figure 98. Upstream view of Scoodic Brook. *Photo: S. Blenis*

Site Characteristics: Scoodic Brook is 8.2km in length and enters the Hammond River at Fire Hall Pool. Scoodic Brook and Fire Hall Pool are historic sites for HRAA restoration projects.

Substrate: The substrate is a mix of rock (20%), cobble (20%), gravel (20%), sand (20%), and silt (20%), and it is 50% embedded.

Flow: In the summer of 2020, the flow of Scoodic Brook into the main stem ceased, and only a small pool remained at the bridge.

Flow Type: The site is primarily a run (70%), with small pools (30%), especially near the bridge on route 820, and its sinuosity is 25% straight and 75% winding.

Bank Stability: The banks are gently sloped, and both the right and left bank can be characterized as being stable (20%), bare stable (10%) and eroding (20%). Undercutting is happening equally on both banks at 20%.

Crown Closure: Crown closure is primarily trees, alders, and shrubs, with overhanging vegetation occurring on both banks at 25%, casting decent shade across the brook.

Riparian Vegetation: The riparian vegetation around Scoodic Brook can be described as primarily mature trees (50%), shrubs (40%), and grasses (10%). Many of the surrounding trees have gone past their prime and have begun to die. Several large logs were noted in the brook. Replanting along Scoodic Brook should occur to replace the trees that have begun to die, in order to protect the riparian zone.

Riparian Rating: Fair. The riparian zone is vegetated with 59%-40% of the banks comprised of shrubs and few trees, casting less than 60% shade on the reach during mid-day sun. Erosion is occurring during peak water flow times (26%-49%). These areas should be monitored closely to ensure they do not deteriorate further.

Upham Zone Tributaries
Scoodic Brook

Electro-fishing: A 100m² stretch of Scoodic Brook was surveyed in September and six fish species were recorded, including Slimy Sculpin, Sea Lamprey, Common Shiner, Black Nose Dace, Brook Trout, and American Eels. Staff recorded a total of 19 American Eels within the stretch; however, this number is only a reflection of how many eels were actually put into the bucket, and not of how many eels were actually present on site. American Eels are by far one of the most difficult fish species to capture during electro-fishing surveys, as they quickly burrow out of sight into the mud or below rocks when the electro-fisher is engaged. Staff estimate that approximately 100 American Eels were observed in the 100m² stretch of Scoodic Brook, but it was near impossible to catch them all.

Salmon stocking occurred in Scoodic Brook between 2005-2008, with a total of 11,497 fingerlings, parr, and fry. It was disappointing that Scoodic Brood did not return any salmon during the electro-fishing survey.

Redd Count Survey: During the November Redd Count Survey, staff and volunteers surveyed from the route 820 bridge to the confluence point with the Hammond River (approximately 600m) and surveyed approximately 300m above the bridge. In total, 1 redd was located above the bridge. The upper reaches of Scoodic Brook are relatively intact; however, there is a stretch above the bridge that is being impacted by livestock access to the brook, and it was surprising to find a redd in this location, even though it was suitable substrate. The upper reach of Scoodic, past the farmland, may be a worthwhile site in the future for eDNA analysis, to determine if salmon are travelling further up the brook.

Figure 99. Scoodic Brook contained the highest density of American Eels during the 2020 Electro-fishing survey and contained eels at each stage of lifecycle. *Photo: J. Kelly*

Our 2020 electro-fishing survey results mirror the results of the 2008 Watershed Management Plan, where they noted that salmon densities were not present during assessment, falling from the 2007 survey, at which time there was a low density of 6.3/100m². Despite historic stocking efforts, salmon have not rebounded in Scoodic Brook.

Upham Zone Tributaries
Scoodic Brook

Figure 100. Sandy Mackay, former Director of Education and Public Outreach, with a sediment tube in Scoodic Brook in 2008.
Figure 101. The recovered tube in 2020!
Photos: S. Campbell & S. Blenis

Sedimentation Studies: Part of the Watershed Management Plan 2008 included a sediment study performed on Scoodic Brook to monitor survival rates of incubating salmon eggs. The results found high levels of sediment caused a mass die off in salmon eggs prior to reaching eyed development stage. In 2006, the first tube had a survival rate of 60%, while the second tube had a mortality rate of 100%. In 2007, the sediment study continued, andthe first tube revealed an 86% survival rate; however, the second and third tube were lost during high water conditions, and the sediment study was then discontinued.

Sedimentation loading in Scoodic Brook continues in 2020. During the habitat assessment, staff noted that the substrate of Scoodic Brook contained a high density of sand and silt, and that the substrate is at least 50% embedded. By a stroke of luck, staff noticed a small, white piece of plastic sticking out of the substrate- it was a sedimentation tube from 2008! It weighed approximately 5lbs and was completely full of 12 years' worth of sediment.

Given the high level of sediment deposition in Scoodic Brook, we assume that the 1 redd that was found in 2020, and subsequently the salmon eggs therein, have an exceptionally low chance of survival. November was also a very mild month, which concluded with several high water and flooding events, which more than likely decimated the 1 redd in Scoodic Brook.

The upper portion of Scoodic Brook may be a worthwhile change in location for the electro-fishing survey in the future. Focus of electro-fishing the lower portion of Scoodic Brook should be to further our understanding of American Eels, which has not been studied in any great depth in HRAA's history, and lower Scoodic Brook may be a prime location to increase our knowledge on this wriggly, catadromous species.

eDNA analysis was not performed at this location but may be worthwhile in the future to determine salmon presence/absence.

Upham Zone Tributaries
Scoodic Brook

Scoodic Brook is a historic HRAA riparian restoration site. While it has been difficult to determine the year that this riparian buffer was planted (and perhaps it spanned over several years), there has been great long-term success on restoring the banks of Scoodic Brook with primarily ash and tamarack trees.

The 2008 Watershed Management Plan notes that this stretch has seen a significant shift from no buffers to 10-meter buffers between the field and the brook. This area is extremely prone to high-velocity flooding events and ice shears, so the success of these plantings is substantial. It would be worthwhile to go through all HRAA historical restoration documents to determine exactly what has been planted in this location, and when. The efforts have created a great first line of defense from future erosion issues, and it would be advisable to continue to revegetate this area, with landowner permission.

Potential Climate Change Adaptation Plan: Scoodic Brook is situated next to the Volunteer Upham Fire Department, which pumps water from Scoodic Brook to fill their fire trucks. As climate change increases, so too do forest fires, while water availability decreases. In the summer of 2020, Scoodic Brook ran dry, and the fire trucks must then fill their tanks from the South Lake Road lake. What if a large, above ground concrete reservoir existed on the same property as the fire department, which sumps excess water from spring flooding events from the Hammond River and Scoodic Brook to fill the reservoir, decreasing the need to rely on pumping water from Scoodic Brook during the summer months, while providing an on-site source of water for their fire trucks year-round? This would be a large-scale project; however, it may decrease flooding events by storing excess water, and provide on-site water supply when Scoodic Brook runs dry in the summer.

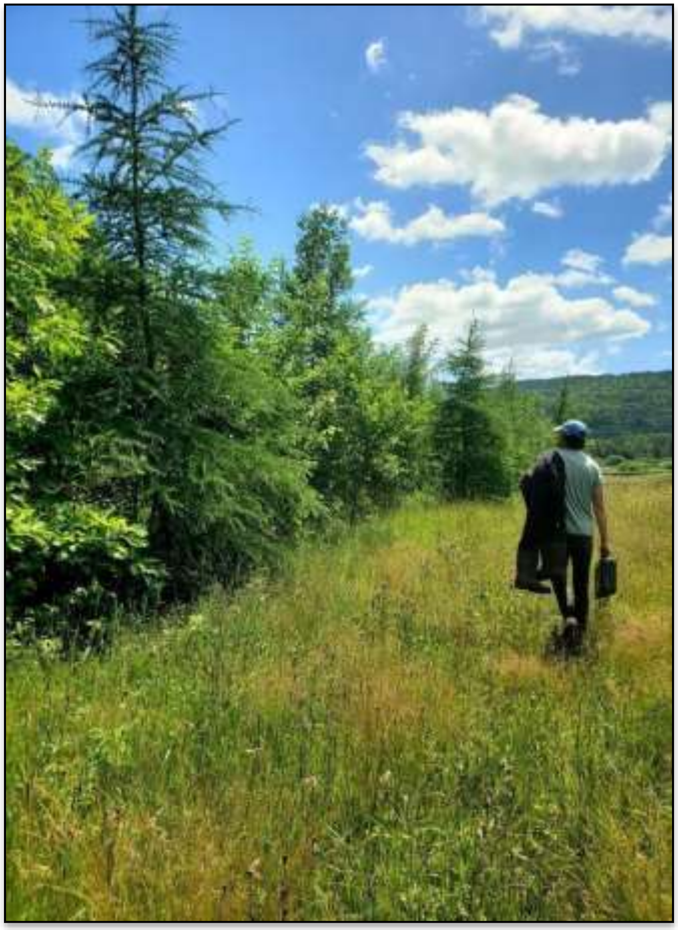


Figure 102. Walking through the field that runs parallel to Scoodic Brook, with former HRAA restoration of Tamarac and ash trees. *Photo: S. Blenis*

Upham Zone Tributaries
Scoodic Brook

Figure 103. Upstream view of Scoodic Brook in the summer.
Figure 104. Potential cyanobacteria mat on rock. *Photos: S. Blenis*

Water Quality: Historically, this site received a Class C Brook (acceptable water quality). It was determined that there were no point source pollution discharges into Scoodic Brook; however, there were signs that this site has been altered from its natural state. In 2020, water quality samples indicate that this site receives a "Marginal" rating according to the CCME Water Quality Index, and it has the third lowest score within the watershed. This site regularly has *E. coli* exceedances, given that the nearby livestock have full access to the brook. Given its extremely close proximity to the government garage (which has a large salt pile, and heavy machinery on-site), it is possible that these elements are also affecting the water quality within Scoodic Brook. Scoodic Brook also had the highest *E. coli* exceedance in 2020, with a whopping 1400 cfu/100mL! This exceedance could be attributed to the amount of livestock that have direct access to the brook. Also, it would be interesting to learn how much water is annually being pumped from Scoodic in order to fill the fire trucks. This site has been a main focus for the HRAA since its inception, and work in this stretch is nowhere near complete.

Cyanobacteria Sampling: Given the high levels of phosphate, nitrate, *E. coli* and fecal coliforms, Scoodic Brook is a prime candidate for cyanobacteria growth. HRAA staff deployed a passive SPATT collection device approximately 600m downstream of Scoodic Brook, and results are still pending. Throughout the summer, staff also collected multiple samples of benthic mats. Some mats were taken when there was still water in the brook, and they were green in color. Other mats that were sent for processing were floating, brown mats. The last round of mat sampling occurred when Scoodic Brook ran dry, and evidence of benthic mats still clung to the rocks. These samples are still being processed by the RPC laboratory in Fredericton.

Upham Zone Tributaries
O'Dell Brook

Site Characteristics: A cold-water tributary that enters the main stem below O'Dell Pool.

Substrate: The substrate is a mix bedrock (10%), rock (30%), cobble (30%), gravel (20%) and sand (10%).

Flow: Slow moving during the summer months due to shallow water conditions. Even during the hottest months, this brook continues to flow.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 20% straight and 80% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure, predominantly of willows, giving the stretch 80% shade coverage.

Riparian Vegetation: Fully mature willows dominate the riparian zone (80%), with some grass and ferns (5%), and juvenile shrubs (5%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

No historical HRAA records could be found on electro-fishing this site. Prime candidate for future fish community survey!

Figure 105. Looking upstream in O'Dell's Brook- a world of difference from 2000! *Photo: S. Blenis*

Upham Zone Tributaries
O’Dell Brook

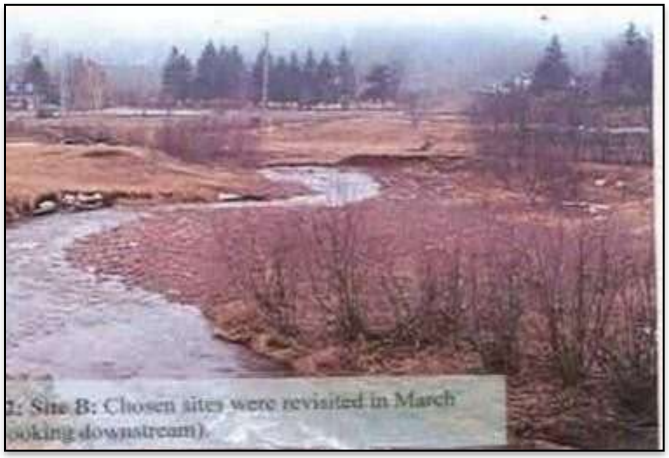


Figure 106. View of O’Dell Brook, and the steep, eroded bank. Photos from *HRAA’s River Restoration 2000.*

An HRAA riparian restoration major success story!

In 2000, HRAA staff planted 2,880 willows and 450 mountain ash along O’Dell Brook, which was severely eroded with little crown closure.

20 years later, and the site is almost unrecognizable!

The banks have almost completely restabilized. There is still one fairly steep slope that is bare stable; however, the landowner is open to having HRAA continue work revegetating these banks.

Figure 107. View downstream- the brook is no longer visible from the growth success of the willows. *Photo: S. Blenis*

Upham Zone Tributaries
O’Dell Brook

Figure 109. Pre-2000, livestock used to have full access to O’Dell Brook. This contributed to the bank degradation, as well as fecal coliforms and *E. coli* entering the watercourse. Water samples were taken after fence installation and determined there was 0 cfu/100mL of *E. coli* or fecal coliforms in the watercourse.

Figure 110. HRAA helped to install 300 meters of fencing along both sides of O’Dell Brook, and created a single area for livestock to access the brook, instead of allowing them to have free range. This access site still exists in 2020; however, some of the fence posts need replaced, and some of the barbed wire along the access point needs replaced as well. Further up O'Dell Brook, there are a few additional sites where livestock can access the brook- new discussions with the landowner should take place to determine if he would be willing to allow the HRAA to install additional fences.

Figure 111. A digger log was installed in O’Dell Brook in 2000, and still exists to this day. Digger logs are wonderful ways of creating small pools, that still allow fish passage. They create a cascading effect, which greatly increases dissolved oxygen in the water, as well as creating a cold-water holding pool for small fish. This is a very cost-effective, long-term, natural infrastructure project that could be used throughout the watershed. This site has great potential to be a demonstration site to promote HRAA’s riparian restoration work and would be of particular interest to landowners who also have livestock.

This site offers excellent fish habitat, and HRAA should include O’Dell Brook in an upcoming electro-fishing survey to determine population density. The brook continues for over 7km in undisturbed habitat that is as it naturally occurs. This is a critical tributary for providing cold-water to the main stem. It may be a worthy site for eDNA sampling for salmonid presence/absence as well. Should stocking resume on the Hammond, this site may be an excellent candidate as well.

Upham Zone Tributaries
McLaren Brook

Figure 112. Looking upstream of the McLaren Brook. Salmon parr were observed during site visit. *Photo: S. Blenis*

Site Characteristics: A beautiful tributary near known salmon spawning area, this stretch should be electro-fished in 2021.

Water Classification: Class A.

Substrate: The substrate is a mix of rock (25%) cobble (40%), gravel (30%) and sand (5%). Substrate is <20% embedded.

Flow: Medium flow in the summer; significant flow increases during rain.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 70% straight and 30% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure, including apple trees, giving the stretch 85% shade coverage.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs.

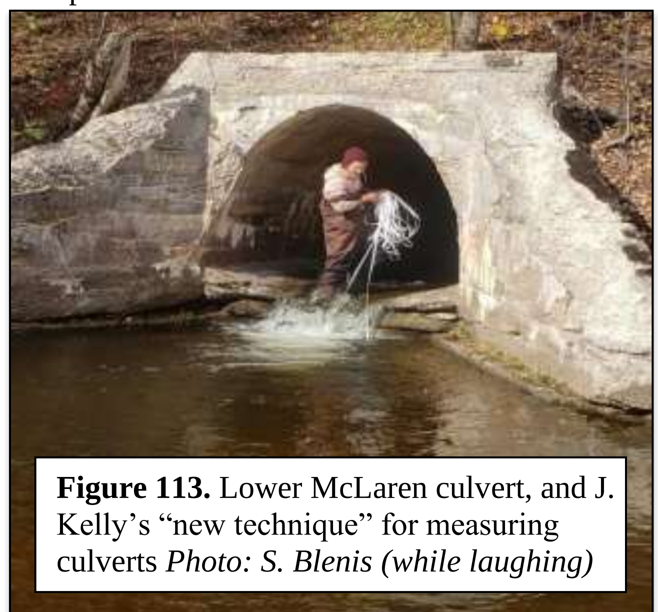


Figure 113. Lower McLaren culvert, and J. Kelly's "new technique" for measuring culverts *Photo: S. Blenis (while laughing)*

Upham Zone Tributaries
Freddy's Falls

Site Description: Located on Upham Mountain, part of the Caledonia Highlands formation, just off the Back River Road, Freddy's Falls is a stunning tributary of the Hammond River that is sure to delight all nature enthusiasts!

Substrate: This stretch is comprised of bedrock (10%), boulder (40%), rock (20%), cobble (20%) and gravel (10%), and the substrate is <20% embedded.

Flow: High water velocity throughout most of the year. Flow slows drastically in the summer months, and the waterfall becomes a slight trickle.

Flow Type: The tributary is mainly a run (80%), with a main pool below the waterfall, and scattered small pools throughout (20%), and its sinuosity is 90% winding, 10% straight.

Bank Stability: Similar to Donnelly Brook, the banks surrounding this tributary are fortified with large boulders, and little erosion is occurring in this stretch.

Crown Closure: Crown closure in this tributary is exceptional. Both banks are dominated by overhanging vegetation, and the entire stretch is heavily shaded.

Figure 114. Freddy's Falls, the highest waterfall in the watershed. *Photo: S. Blenis*

Upham Zone Tributaries
Freddy's Falls

Figure 115. A dirt road crosses through the lower portion of Freddy's Falls tributary. A culvert or ford would assist in decreasing turbidity and sedimentation into the lower stretch of Freddy's Falls, and subsequently the Hammond River. *Photo: S. Blenis*

Riparian Vegetation: Freddy's Falls is predominately mature hardwood (80%) with mature shrubs (20%).

Riparian Rating: Excellent: The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class O. Freddy's Falls tributary has no point source pollution discharge. There are no nearby residential dwellings. The site is as it naturally occurs, and all fecal coliform organisms and *E. coli* are as naturally occurring. Site is in pristine condition, far removed from human activities, and displaces unaltered, natural water quality, quantity, and biology.

Action Points: Conduct juvenile density survey in the lower portion of Freddy's Falls, near the confluence of the Hammond River. Continue to perform site visits to ensure that Freddy's Falls forever remains flawless!

Figure 116. J. Kelly & S. Blenis at Freddy's Falls. Photo: *J. Kelly* (he has longer arms for taking selfies!)

Upham Zone Tributaries
Twin Brook

Figure 117. Looking upstream in Twin Brook *Photo: S. Blenis*

Site Characteristics: This cold-water tributary offers excellent juvenile habitat; however, there is a barrier to fish passage, and fish are not able to access the area above a severely hung culvert.

Substrate: The substrate is a mix of rock (30%), cobble (30%), and gravel (40%), and the substrate is <20% embedded.

Flow: Slow flow during the summer months; significant increase in flow during heavy rain events.

Flow Type: The site is primarily a run (90%), with a main pool at the culvert, and scattered smaller pools throughout the tributary (10%). Its sinuosity is 40% straight and 60% winding.

Bank Stability: The majority of this stretch has stable banks (50% on both right and left); however, there is significant bank undercutting and erosion occurring around the culvert pool.

Crown Closure: Significant crown closure on both the right and left banks (50%) overhanging vegetation, primarily alders and shrubs. Twin Brook is a lovely, shaded brook, providing cool water to the main stem and the two Twin Pools.

Riparian Vegetation: A mix of alders (40%), trees (40%) and ferns (20%). This brook is at it naturally occurs, despite being on private residential property. Landowners have taken great care to maintain riparian buffers.

Riparian Rating: At Risk. While the majority of this tributary would receive an "excellent" riparian rating, the tributary is at risk if steps are not taken to address the significant erosion and pool scouring that are occurring at the culvert pool.

Upham Zone Tributaries
Twin Brook

Electro-fishing: This site was not part of the 2020 electro-fishing season; however, this tributary should be considered a high priority for electro-fishing in 2021, to determine fish community. Given that this tributary meets the main stem above two major salmon holding pools and spawning ground, there is a high potential that this brook may contain juvenile salmon. It offers excellent fish habitat and is a cold-water refuge. eDNA at this site is also warranted. Results of future eDNA and electro-fishing may assist in creating a priority ranking for the culvert repair/replacement.

Water Classification: Class A. There are no point source pollution discharges in this tributary. The water quality is well within acceptable limits to maintain aquatic life.

Action Points: This tributary was assessed during our 2020 Culvert Assessment, which determined that this culvert is ranked 2nd for priority for repair/replacement in the watershed. This culvert is significantly hung and completely obstructs fish passage, and many anglers visit this pool targeting trout. In advance of repair, HRAA should install an educational sign on the fishing restrictions at this pool. The landowners have expressed concern for the scouring and erosion- HRAA should make restoration a priority and begin planting willows and shrubs around the degraded banks in the spring of 2021.

Figure 1. The hung culvert in Twin Brook. Primary option would be to replace current structure with bridge or open-bottom pipe-arch. Secondary option would be to armor banks downstream and construct fish ladder. Removal of obstruction would allow upstream access to approximately 1700 meters of good quality salmonid spawning and nursery habitat. Average bankfull width is approximately 2.5 m. Upstream access would be restored to a total area of approximately 4,250 m² of habitat. Significant additional erosion around the pool occurred in November 2020 after a heavy rainfall event. Landowner is willing to allow HRAA to replant.

Photo: S. Blenis

Upham Zone Lakes

Henry Lake

Action Points: Freshwater mussels were found in abundance in Henry Lake, and this site should be included in an updated study of 2018's Mussel Biodiversity Assessment. HRAA should begin water quality monitoring to ensure surrounding residential dwellings are not impacting the lake (ie: septic tank leaks, fertilizer etc). Lakes are also prime areas for the introduction of invasive species- given high boat traffic, HRAA should educate surrounding landowners on the importance of Clean, Drain, Dry. One landowner stated this lake holds record size trout- fishing investigation in 2021 would be an awesome undertaking for HRAA! One of many mussels found in the lake. *Photos: S. Blenis*

Upham Zone Lakes

Tracy Lake

Tracy Lake is the headwaters for the Isaac Brook. This lake has not yet been assessed by the Province of New Brunswick, and no historical HRAA data on Tracy Lake has been found, and it does not appear that Tracy Lake was ever part of a provincial stocking program. Very little information in general has been obtained on Tracy Lake; however, this lake will be included in HRAA's 2021 Lake Assessment. Part of the lake assessment will include an examination on fish community, which may be extremely interesting in Tracy Lake, given the lack of current information. HRAA staff will set minnow traps in the lake at approximately 2 feet in depth and will leave the traps set for 2 hours before retrieving, counting & recording catch. HRAA will use a beach seine and comb the shallows of the lake, to capture any bottom-dwelling fish, and record our observations and each month, HRAA will set up 4 fyke nets in the lake, perpendicular to the shore. HRAA will retrieve the fyke nets and record the number of fish and species. Expanding our current knowledge on Tracy Lake and how it relates to the Hammond will be key in 2021! **Figure 119.** Tracy Lake. *Photo: S. Blenis*

Upham Zone Lakes
Tracy Lake

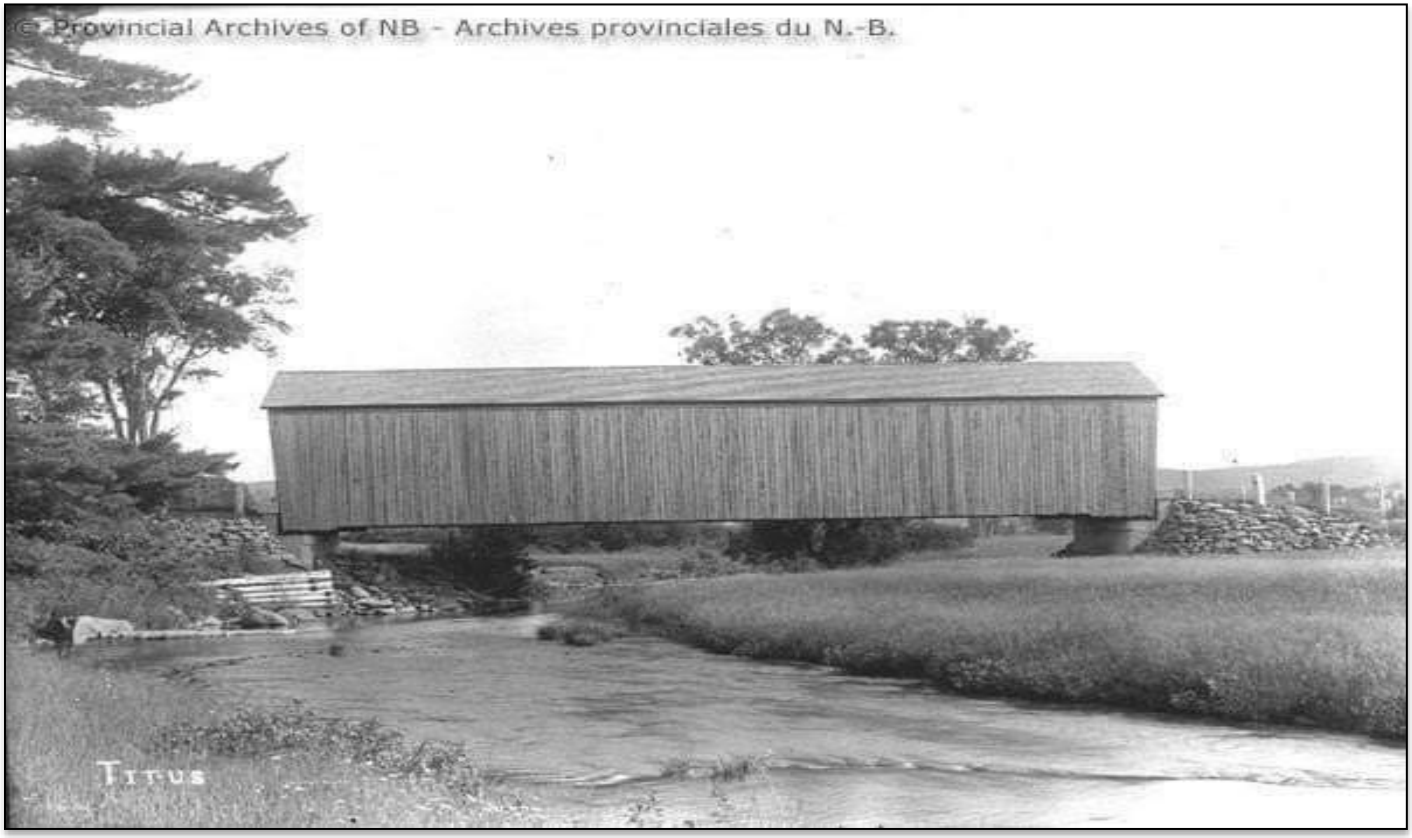
Action Points: The main culvert, that allows flow from Tracy Lake into Isaac Brook, is severely compromised. It is currently completely compacted with organic debris, rocks, and sediment, allowing zero flow. The road that travels overtop of this culvert leads to a JD Irving Ltd woodlot, and HRAA should work with the landowner to install or repair this existing culvert. A smaller, plastic culvert was recently installed; however, it allows for a much smaller flow rate into Isaac Brook. This smaller culvert will not be sufficient during high rain events, and the access road will be susceptible to wash out, and the receiving environment may be compromised. Addressing this culvert issue to allow for proper flow into Isaac Brook is a priority. **Figure 120** and **Figure 121**: blockage and compromised culvert. *Photo: S. Blenis*

Upham Zone Lakes
Drummond's Lake

Drummond's Lake is the headwaters for multiple surrounding wetland areas and flows into Watercourse 3 East in relation to the Upham East Gypsum Mine. Drummond's Lake can be characterized as a gypsum sinkhole lake, and there are several areas of exposed gypsum. Given its geological significance, Drummond's Lake has a high potential of being a "calcareous hotspot" and may house multiple rare and endangered species. Drummond's Lake will be a focus during the 2021 Lake Assessment, and the HRAA will be partnering with the Atlantic Canada Conservation Data Center to explore for species of interest. The landowners surrounding Drummond's Lake are extremely interested in assisting HRAA to maintain the lake's health. HRAA should install data loggers in Drummond's Lake to measure water levels- it is extremely important to closely monitor this lake for any potential impacts resulting from the nearby mining operation, particularly given gypsum's fragile nature and the complexity of groundwater movement between these two locations.

Figure 122. Lower reach of Drummond's Lake, in close proximity to its outflow tributary. *Photo: S. Blenis*

TitusSmith Zone



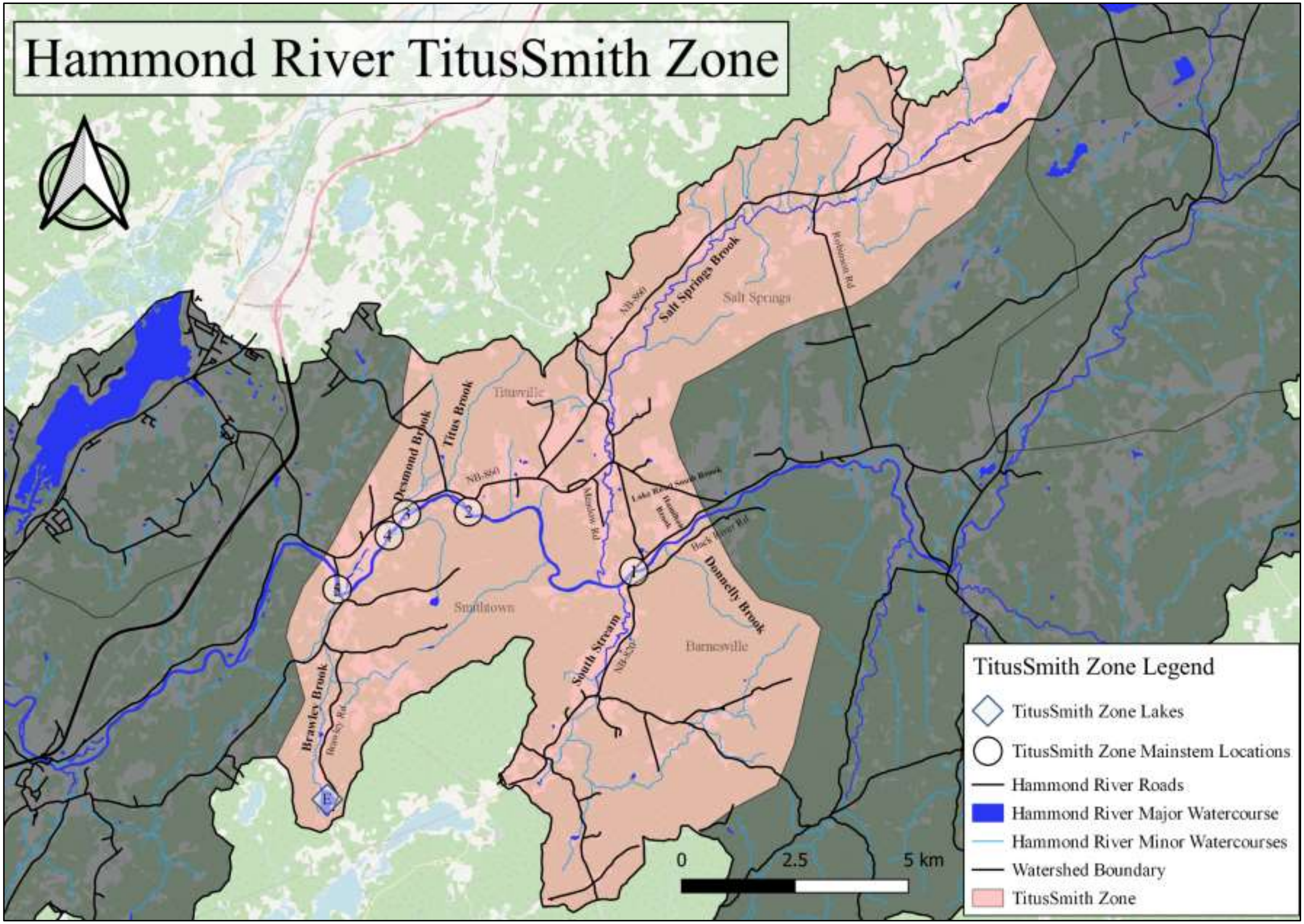
"You know casting is beautiful, it's graceful, and its feminine, you know I love it."- Joan Wulff Photo: Salt Springs Covered Bridge. Provincial Archives of NB.

TitusSmith Zone Legend & Work Complete (2020)

Site Name	GPS Location	Area Surveyed (m)	WQ	E-Fish	Redds (#)	e-DNA	BMI	Culvert Assessment
MAIN STEM								
1. Cusack's Bridge Pool	45.467035 -65.720830	250m	YSI	No	**0**	No	No	No
2. Titus Mill Pool	45.479283 -65.767254	2km	YSI	No	**0**	**Positive**	No	No
3. Carson's Pool	45.478739 -65.785017	600m	YSI	No	No	No	No	No
4. Carter's Pool	45.474739 -65.789896	600m	YSI	No	No	No	No	No
5. Smithtown Bridge Pool	45.464111 -65.804440	300m	YSI	No	**0**	**Positive**	No	No
TRIBUTARIES								
1. Salt Springs #1	45.537927 -65.669222	200m	YSI	**Yes**	No	No	No	**Yes**
2. Salt Springs #2	45.532212 -65.698605	300m	Lab	No	No	No	No	**Yes**
3. Salt Springs #3	45.476234 -65.728018	2.5km	Lab	**Yes**	**15**	No	No	No
4. Titus Brook	45.48300 -65.773363	300m	YSI	No	No	No	No	No
5. Hamilton Brook	45.474964 -65.708338	600m	YSI	No	No	No	No	**Yes**
6. Donnelly Brook	45.476143 -65.709564	3km	Lab	No	No	**Negative**	**Yes**	**Yes**
7. South Lake Brook	45.479634 -65.722362	600m	YSI	No	No	No	No	**Yes**
8. South Stream	45.442658 -65.731801	1.5km	Lab	**Yes**	**0**	No	No	No
9. Desmond Brook	45.480124 -65.784957	500m	YSI	No	No	No	No	**Yes**
10. Brawley Brook (upper)	45.451155 -65.803587	800m	Lab	No	No	**Negative**	**Yes**	**Yes**
11. Brawley Brook (lower)	45.46254 -65.80463	1km	Lab	**Yes**	No	No	**Yes**	No
Lakes								
E. Brawley Lake	45.422414 -65.807905	100m	YSI	No	No	No	No	No

Table 3 TitusSmith Zone Work Complete

TitusSmith Zone Map



TitusSmith Zone Main Stem
Cusack's Bridge Pool

Figure 125. Looking upstream from Cusack's Bridge Pool *Photo: S. Blenis*

Site Characteristics: Much of this section of the main stem is as it naturally occurs. Donnelly Brook enters the main stem upriver from Cusack's Bridge Pool, while Salt Springs Brook and South Stream enter just below this beautiful pool.

Substrate: The substrate of this pool can be classified as bedrock (10%), boulder (15%), rock (35%), cobble (25%), gravel (5%) and sand (10%). The substrate receives a <20% rating for embeddedness.

Flow: Much of this section of the river is as it naturally occurs. It is slow moving in the summer as it is a moderately shallow run. During high water events, the flow increases dramatically.

Flow Type: The site is primarily a run (90%), with a small pool (10%) below the bridge, and its sinuosity is 90% straight and 10% winding.

Bank Stability: There is a high slope surrounding the banks of this stretch, and the banks are primarily bare stable (L 50% R 50%), surrounded by large rocks with trees further up the bank.

Crown Closure: Crown closure is primarily trees, alders and shrubs and provides 60% shade.

Riparian Vegetation: The riparian vegetation around Cusack's is primarily trees (35%), grasses (35%) and bare (30%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees. Minimal erosion is present (<10%) and the banks are stable and fortified with large rocks and boulders. Some erosion is occurring below the bridge, as mature trees begin to die and fall into the river. The overstory is primarily softwoods, and the understory is developing as a tolerant hardwood forest. There exist several hayfields nearby, with little buffer in the riparian zone- efforts should be made to work with landowners to replant.

Water Classification: Class A. This has received a Class A rating since 2008, with little change in water quality over a decade.

TitusSmith Zone Main Stem

Titus Mill Pool

Figure 126. Looking upriver from the Titus Mill Swinging Bridge
Photo: S. Blenis

Site Characteristics: The beautiful bedrock ledges and cliffs make this site a standout within the watershed!

Substrate: The substrate in this stretch of the Hammond can be described as bedrock (30%), boulder (10%), rock (20%), cobble (20%), gravel (10%) and sand (10%). The beautiful bedrock ledges can clearly be seen in **Figure 126.** The embedded criteria of this stretch is described as <20%.

Water Classification: Class A. No point source pollution discharge; minimal surrounding land use; average Dissolved Oxygen 9.0mg/L

Flow Type: The site is primarily a run (60%), with a fairly large, deep pool at Titus Mill, above the treed island in **Figure 126.** (40%) and its sinuosity is 80% straight and 20% winding.

Bank Stability: The bank stability in this stretch can be described as bare stable on the left bank (50%), and a mixture of stable (10%), bare stable (15%) and eroding (25%) on the right bank. The left bank has no undercutting, while the right bank has had a fair extent of undercutting (45%).

Crown Closure: Crown closure is primarily mature conifers (60%), some shrubs (20%) and grasses (20%). The pool has some shade, at approximately 40% crown closure.

Riparian Vegetation: The riparian vegetation is primarily mature conifer trees, with some softwood, shrubs, and grass. There is a degree of habitat fragmentation, with the large island in the middle of the river; however, this island is habitat for the Wood Turtle, observed in 2019.

TitusSmith Zone Main Stem
Titus Mill Pool

Redd Count Survey: In November, HRAA members surveyed approximately 2km along the Titus Mill Pool reach; unfortunately, no redds were located at this time. Staff suspect that spawning may have been delayed as a result of warmer water temperatures in late October and into November.

eDNA: As a result of not finding any redds, staff decided to collect an eDNA sample to determine presence or absence of Atlantic Salmon in Titus Mill. This area was also selected as a mid-point of the main stem for our eDNA study, to determine the distribution of Atlantic Salmon in the watershed. The results of the eDNA came back positive, confirming salmon presence in the area. This reinforces our suspicions that we may have been a bit early in our 2020 Redd Count Survey.

The Titus Mill area used to house a large wood mill over a hundred years ago, and remnants can still be found in the Titus Mill Pool (**Figure 129**). Oddly, HRAA's *Salmon Management Plan 2009* notes: "Historical information cites that damming for use in mechanically powering a lumber mill in the Titusville area caused the obstruction of passage and later the reduction/extirpation of returning spawners in Salt Springs brook (a tributary to the Hammond). Although this threat has been long since removed, very few juvenile Atlantic Salmon appear in electrofishing surveys in this area." Our findings in 2020 contradict these observations from 2009, as Titus Mill tested positive for salmon DNA, and Salt Springs Brook produced juvenile salmon, and had the highest density of redds in the watershed. Perhaps it was an off year in 2009!

This area has a plethora of mussels and should be included in an updated version of HRAA's *2018 Mussel Survey*, and this mussel abundance also confirms salmonid presence, as they are carrying hosts of the mussel larvae.

Remnants of the Old Molly rail line can also be seen along Titus Mill. One of the beautiful gems of the watershed, Titus Mill is as it naturally occurs, with only minimal traces of human interference from long ago.

Figure 128. Some of the stunning cliffs at Titus Mill, with Josh as height reference.
Figure 129. Remnants still remain from the old wood mill. *Photos: S. Blenis*

TitusSmith Zone Main Stem
Carter's Pool

Figure 130. Looking downriver as the sun begins to fade on a beautiful Summer evening. *Photo: S. Blenis*

Site Characteristics: Just downriver from Carson's Pool, Carter's Pool offers similar fishing opportunities and epic natural setting.

Substrate: The substrate contains a variety of types, including boulder (10%), rock (20%), cobble (25%), gravel (25%), sand (15%) and silt (5%), and it is <20% embedded.

Flow: A medium flow, from the slope of the valley. Increase in velocity, and a slight increase in turbidity, during heavy rain events and spring freshet.

Flow Type: The site is primarily a run (60%), with a picturesque pool (40%), and its sinuosity is 65% straight and 35% winding.

Bank Stability: The left bank is only slightly stable (5%), and primarily eroding (45%), while the right bank is mainly stable (40%) and bare stable (10%). There is minimal undercut banks on the right (10%), while there is significant undercut banks on the left (45%).

Crown Closure: The right bank offers a beautiful mature tree buffer area, with overhanging vegetation 45%. The left bank is mainly grass, with little overhanging vegetation. Crown closure is approximately 45%.

Riparian Vegetation: The right bank is a mixture of hardwood and softwood, and cedar is the predominant tree (40%) The left bank is agricultural grass (20%) with a few ferns (10%)

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. Creating a buffer would significantly help.

Water Classification: Class A

TitusSmith Zone Main Stem
Carson's Pool

Figure 131. Looking downriver from Carson's Pool towards Carter's Pool in the distance. *Photo: S. Blenis*

Site Characteristics: Carson's Pool is one of the lesser-known pools in the Hammond River watershed; however, it offers excellent fishing and stunning scenery!

Substrate: The substrate is a combination of bedrock (5%), boulder (5%), rock (60%), cobble (20%), gravel (5%), and sand (5),

Flow: Medium flow, characterized by the medium slope of the valley in this location. Increased velocity during high rain events, with minimal turbidity.

Flow Type: The site is primarily a run (85%), with a modest pool (15%), and its sinuosity is 75% straight and 25% winding.

Bank Stability: The left bank is predominantly bare stable (40%), with vegetated stable (5%), and occasional erosion (5%). The right bank is less stable (5%), with a degree of bare stable (10%), and is mainly eroding (35%). Undercut banks on the left are minimal (5%), while significant on the right (40%)

Crown Closure: Decent shade is offered from the trees and slope of the valley on the left bank, but minimal closure from the grass on the right bank.

Riparian Vegetation: The left bank is mainly mature trees and shrubs (50%), while the right bank is grass and ferns (40%) and bare (10%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. Replanting a riparian buffer on the right bank is a priority.

Water Classification: Class A. No point source pollution. Abundance of freshwater mussels. Water quality within limits to sustain aquatic life.

TitusSmith Zone Main Stem

Smithtown Bridge Pool

Figure 132. View of Smithtown Bridge Pool. *Photo: S. Blenis*

Site Characteristics: Deep pool with bedrock and large boulders, this site is often problematic for littering.

Substrate: The substrate contains some bedrock (20%), boulder (25%), rock (25%), cobble (10%), gravel (10%) and sand (10%); the substrate is <20% embedded, and its sinuosity is 60% straight and 40% winding.

Flow: The flow rate is moderate.

Flow Type: These sites are primarily a run (50%), with a large pool beneath the bridge (50%).

Bank Stability: There is some erosion occurring on the left bank (35% eroding, 15% stable), and the right bank is a mix of stable (20%), bare stable (15%) and eroding (15%).

Crown Closure: There is fair canopy coverage throughout this stretch from overhanging vegetation and large, mature trees.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable. While there are two areas for concern, the majority of this stretch is as it naturally occurs.

Observation: Mussels can be found throughout this stretch, indicating a healthy salmonid presence. This stretch was not part of the 2018 mussel survey and should be included in an updated version in the future.

eDNA & Redd Count: 0 redds were found during the count; however, the site tested positive for salmon eDNA.

TitusSmith Zone Tributaries

Salt Springs Brook

Site Characteristics: Salt Springs brook is the longest cold-water tributary within the Hammond River watershed, with a total length of 22.5km. The land use varies throughout the Salt Springs region, ranging from agricultural, residential, industrial, and natural forest.

Substrate: The substrate is a fusion of boulder (10%), rock (10%), cobble (10%), epic patches of gravel (40%), sand (20%) and silt (10%).

Flow: Steady flow throughout spring to winter, even in the hottest summer months.

Bank Stability: Erosion and undercut banks are taking its toll in Salt Springs brook, with the left and right bank being stable (10%), bare stable (10%) and eroding (30%), with 35% undercut banks.

Flow Type: Salt Springs brook can be described as primarily a run (80%), with small, cool pools dispersed throughout the stretch (20%), and its sinuosity is 5% straight and 95% winding.

Crown Closure: Crown Closure varies throughout Salt Springs, depending on surrounding land use. The area for the habitat assessment, in the lower reach of Salt Springs Brook, found the canopy cover to cast moderate shade over the stretch from overhanging shrub vegetation.

Riparian Vegetation: The riparian vegetation is a mix of bare (10%), moss and ferns (10%), grasses (20%), shrubs (35%) and trees (25%), with sporadic plots of swamp milkweed.

Observation: Area is prone to beaver activity, with multiple dams observed in the upper, lower, and mid sections of Salt Springs Brook, all of which allow fish passage, and are creating cold holding pools for fish.

Figure 133. Looking downstream of Salt Springs brook from the bridge. *Photo: S. Blenis*

TitusSmith Zone Tributaries
Salt Springs Brook

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. **Figure 134 & 135** highlight an area of high concern in the lower reach of Salt Springs brook, which occurred during the summer of 2020. A proposal for funding has been submitted by HRAA in 2020, in the hopes of remedying this major erosion as soon as possible. The landowner has worked with the HRAA for decades, and we hope that we will be able to restore this section of their property in the very near future.

Electro-fishing: Given the length of Salt Springs brook, two sites were selected for the 2020 electro-fishing survey. The first is in the lower stretch of the tributary, near Meadow Drive, while the second site is in the upper stretch, off of the Robinson Road. 5 fish species were documented in the first site, including Golden Shiner, Red Belly Dace, Sucker, Black Nose Dace and Brook Trout. The upper reach of Salt Springs brook yielded 9 fish species, including Sea Lamprey, 4 Spine Stickleback, Sucker, Common Shiner, Golden Shiner, Red Belly Dace, Black Nose Dace, American Eel, and Atlantic Salmon parr. The diversity of fish species in the upper reach suggests that fish are able to pass throughout the tributary despite minimal hindrances. During a second electro-fishing expedition with DFO and the CIPS team, 2 more salmon parr were documented, and adipose finn clips were collected.

Redd Count Survey: During our Volunteer Redd Count day, 4 salmon redds were documented along the lower reach of Salt Springs off Meadow Drive. Given the warm water temperatures in early November, HRAA staff decided to revisit Salt Springs a week later and surveyed from the bridge on route 860 to the confluence point of the Hammond River, finding an additional 11 redds. Throughout our 2020 Redd Count, Salt Springs yielded the highest number of redds overall, with 15 redds documented. This is an interesting find, as historically, the highest density of redds has been in the upper reach of the Main Stem in the McGonagle Zone.

TitusSmith Zone Tributaries
Salt Springs Brook

Figure 136 & 137- Erosion and undercut banks that will soon give way and increase sediment loading into Salt Springs were noted along a 1.5km stretch of the lower Salt Springs, in the area that had the highest density of salmon redds. Some of these redds, like **Figure 138** , were located almost directly below these unstable banks, and any heavy rain events may spell survival disaster for the eggs deposited in these redds.

Salt Springs brook should therefore be considered one of the most vital, and perhaps one of the most overlooked, salmon-bearing tributaries of the Hammond River. Salt Springs should be considered top priority for all future restoration efforts, due to its density of redds, suitable gravel substrate, and salmon parr found during electro-fishing. We need to be proactive, and begin an intense riparian restoration program as soon as possible, if we wish to preserve this critical salmon habitat.

Stocking has been a historical practice in Salt Springs Brook, with many sections being stocked. Between 2005-2008, a total of 21,530 salmon fingerling, fry and parr have been stocked. While stocking practices have since ceased in the Hammond River Watershed, 12 years later since the last stocking of Salt Springs brook and the salmon are still returning to this tributary to spawn.

Other than 1 small redd observed in Scoodic Brook, Salt Springs brook was the only tributary to produce salmon redds in 2020 (all other redds were in the main stem), further solidifying that Salt Springs needs to be considered a top priority for restoration and monitoring.

An additional interesting study would be to survey conductivity levels throughout the tributary. Given that Salt Springs is situated on salt caverns, conductivity levels can be quite high in comparison with the rest of the watershed. Does this extra salt content make this tributary more appealing to the anadromous salmon? What other potential effects is this having? Perhaps in the future, it may be worthwhile to plot out fluctuating conductivity levels throughout this tributary.

TitusSmith Zone Tributaries
Salt Springs Brook

Figure 10. Salmon parr have been observed in the outflow pool of these dual culverts in the upper reach.
Figure 10. Severely compacted dual culverts offer little passage mid reach.
Photos: S. Blenis

Habitat Fragmentation: Given its exceptional length, it is no surprise that habitat fragmentation is occurring throughout Salt Springs brook, for a number of reasons.

Fragmentation is occurring in the middle section of Salt Springs brook, from sedimentation buildup in the stream, leading to grassy islands and more shallow stretches. Erosion is also creating an oxbow effect in the lower stretch of Salt Springs.

There are also numerous culverts, in various states of disrepair, that exist throughout the length of Salt Springs brook- some are completely compacted with organic debris, like **Figure 140**, where newer culverts were designed with a rock slope from the outflow, as seen in **Figure 139**, and may be prone to wash out after heavy rainfalls. These smoother culverts also make fish passage more difficult. These culverts will have to be carefully monitored, to ensure that they are still allowing fish passage, and remediated where necessary.

Given that salmon parr were documented in the upper reach of Salt Springs brook, it is imperative to ensure and maintain full fish passage throughout this tributary.

Water Quality: Historically, Salt Springs Brook received a Class B ranking from the Water Classification Guide, as *E. coli* levels were regularly above the 50 cfu/100mL limits. In 2008, the *E. coli* levels spiked as high as 320 cfu/100mL. In 2020, Salt Springs Brook received a “Fair” ranking according to the Water Quality Index, and *E. coli* levels peaked at 100 cfu/100mL. There is a fair number of livestock and agriculture surrounding Salt Springs Brook and working with landowners to address *E. coli* concerns should be a priority in 2021 and beyond.

TitusSmith Zone Tributaries

Titus Brook

Site Characteristics: Described in *the 2008 Watershed Management Plan* as a "watercourse of little concern", the same holds true today, as this brook is healthy and stable, with little change over the past two decades.

Substrate: The substrate is a combination of bedrock (10%), boulder (25%), rock (25%), cobble (25%) and gravel (15%). The substrate is<20% embedded. The site is primarily a run (90%) with smaller pools throughout (10%). Flow decreases substantially in the summer; however, heavy rain events fill the channel. Its sinuosity is 85% winding and 15% straight.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Little undercutting is occurring, (5%) on both banks. The banks are fortified with large rocks and boulders, ensuring minimal erosion.

Crown Closure: Beautiful crown closure, predominantly cedar, balsam fir, red maple, and speckled alder. Shade is approximately 80%.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Water Classification: Class A. No point source pollutants, and water quality levels are well within range to support aquatic life.

Action Points: Given that Titus Brook is in such close proximity to Titus Mill Pool, a known spawning area that tested positive for salmon eDNA in 2020, including Titus Brook in a future electro-fishing survey would be a worthwhile endeavor. Currently no baseline data on juvenile density exists and including this site in 2021 would fill this data gap.

Figure 141. Looking upstream of Titus Brook. Photo was taken in July, during low water conditions. *Photo: S. Blenis*

TitusSmith Zone Tributaries
Hamilton Brook

Figure 142. Looking upstream of Hamilton Brook *Photo: S. Blenis*

Site Characteristics: Hamilton Brook is a quaint, cold-water tributary, discharging into the Hammond above Cusack's Bridge Pool.

Water Classification: Class A.

Observation: A significantly hung culvert is detrimental to this tributary. Landowners observed multiple dead trout in the summer, as they were not able to get further up the tributary into the shaded section. Electro-fishing or eDNA to determine salmon presence is a priority, to establish this as a worthy candidate for repair. Landowners also concerned about high water events- water floods the road, not through the culvert, increasing scouring of the outflow pool.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 80% straight and 20% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure of mature trees, giving the stretch 80% shade coverage. Site is as naturally occurring.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Figure 143. Severely hung culvert, does not allow fish passage, and poses a safety risk to motorists. *Photo: S. Blenis*

TitusSmith Zone Tributaries
Donnelly Brook

Site Characteristics: Donnelly Brook is 3 kilometers in length, and it is one of the most magnificent gems of the Hammond River watershed. The steep topography surrounded by hardwood trees provide able shade and cooling of this pool. The unique rock features create a cascading effect throughout the tributary, providing highly oxygenated water to the Hammond River.

Substrate: The substrate is a mix of bedrock (5%), boulder (40%), rock (35%), and gravel (20%), and is <20% embedded.

Flow: A strong rate of flow as it surges down the mountainside. During high water events, the brook is filled to capacity, from bank to bank.

Bank Stability: Highly stable banks, fortified by giant boulders and large rock. Minimal erosion is occurring.

Flow Type: Donnelly Brook can be described as a run (50%) with many small, deep pools (50%), with beautiful, clear water.

Crown Closure: The crown closure surrounding Donnelly Brook is exceptional, with 100% overhanging vegetation combined from both banks, keeping this stretch shaded and cool.

Riparian Vegetation: The riparian area is heavily forested, and residential dwellings are set back away from the brook. Yellow birch, sugar maple, and high bush cranberry are some of the tree species that can be found along the streambanks.

Riparian Rating: Excellent. This brook is as it naturally occurs, and the giant boulders are protecting the tributary from erosion.

Figure 144. Looking upstream of Donnelly, with Josh as size reference to the boulders. *Photo: S. Blenis*

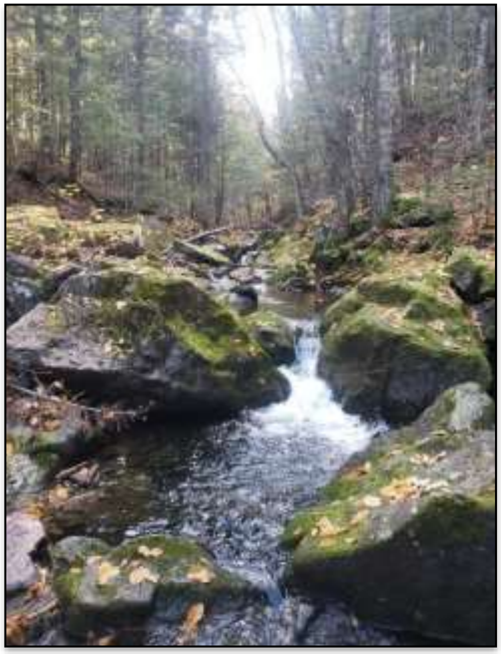
TitusSmith Zone Tributaries
Donnelly Brook

Electro-fishing: In the *2008 Watershed Management Plan*, it was recommended that HRAA conduct a juvenile density survey to create a baseline of data and determine the suitability for salmon. Current staff have not been able to find any further documentation that electro-fishing has ever occurred in this stretch; however, Donnelly Brook should be considered a top priority for expanding new electro-fishing sites, and it will be a real delight to explore this tributary with the backpack fisher in 2021!

eDNA: Since Donnelly Brook was not included in the 2020 electro-fishing program, HRAA staff decided to take an eDNA sample above the culvert to determine presence/absence of salmon DNA. The sample came back negative for presence; however, it is recommended to repeat this sample in 2021, only sampling from below the culvert or near the confluence.

Observations: Donnelly Brook offers prime habitat for the Eastern Waterfan, and potentially other rare or endangered flora and fauna. An examination for this aquatic plant will take place in 2021.

This site would be an excellent candidate as a Protected Natural Area, Conservation Easement Act, or Unique Area, depending on landowner interest.



A newly installed culvert on the Back River Road- at its outflow is a large, deep pool (not shown). Another upstream picture of Donnelly Brook, highlighting the cascading effect of the stream. *Photo: S. Blenis*

Water Classification: Class O

In 2008, Donnelly Brook was classified as a Class A brook; however, we believe that this tributary is worthy of a Class O rating. The brook is as it naturally occurs, with no point source pollution, and has remained absolutely pristine since 2008. In 2020, water quality samples were well within guideline limits to support aquatic life and had above average dissolved oxygen levels.

TitusSmith Zone Tributaries

Lake Road South Brook

Figure 145. Looking upstream of Lake Road South Brook. *Photo: S. Blenis*

Site Characteristics: A very small tributary that flows into Salt Springs Brook. Flow is low and shallow.

Substrate: The substrate is a mix of rock (10%) cobble (50%), gravel (30%) and sand (10%). Substrate is <20% embedded.

Flow: This is a slow, shallow, cold-water tributary of the Hammond River.

Flow Type: The site is primarily a run (90%), with tiny pools (10%), and its sinuosity is 10% straight and 80% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure, predominantly mature trees, giving the stretch 80% shade coverage.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Figure 146. Hung culvert, with fairly deep outflow pool. Tributary should be assessed for fish presence, to determine priority of culvert replacement. Water Quality needs assessed in 2021. *Photo: S. Blenis*

TitusSmith Zone Tributaries

South Stream

Figure 147. Looking downstream of South Stream. *Photo: J. Kelly*

Site Characteristics: South Stream is located in Barnesville, and has a length of 13.5 kilometers, with its headwaters in the Caledonia highlands region. The giant boulders set it apart from most tributaries within the Hammond.

Substrate: The substrate is a mix bedrock (10%) boulder (30%), rock (20%), cobble (10%) and gravel (30%), and the substrate is <20% embedded.

Flow: Constant flow during the hot summer months, this is a crucial cold-water tributary that flows into the Hammond near Cusack's Bridge.

Flow Type: The site is mainly a run (70%), with plenty of pools (30%) that have formed around the glorious boulders.

Bank Stability: The banks are lined with large boulders and rocks, keeping the banks fairly stable. Erosion is occurring at the lower reach of the tributary, near agricultural land where livestock have access to the brook. The majority of the brook is stable (50%), while the small area near the farm is a potential restoration site in the future.

Crown Closure: Beautiful crown closure along the upper portion of this tributary, with a mix of older hardwood and softwood trees. The lower portion of the brook, however, has minimal crown closure or riparian vegetation in the agricultural section.

Riparian Rating: The majority of South Stream would receive an **Excellent** rating, as the riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

The lower portion of South Stream receives a Riparian Rating of **At Risk:** The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating.

TitusSmith Zone Tributaries
South Stream

Electro-Fishing: HRAA did a juvenile population density in September and revisited this site with DFO and the CIPS team to collect adipose finn clips. South Stream was extremely productive, with 15 fish species present, and a total of 69 fish observed in 100m², including 5 salmon parr.

It was noted in the *2008 Watershed Management Plan* that "in 2005, monitoring of both redds and juvenile densities provided ample data to discontinue stocking. If numbers drop in the future, it should be reconsidered for stocking" (Campbell & Prosser). South Stream offers excellent water quality and habitat and could become a future stocking site.

Redd Count Survey: a 600m stretch of South Stream was assessed for redds in November of 2020; however, no redds were located. It was an unseasonably warm fall, which may have delayed spawning, and our efforts may have been a few weeks early. The site offers excellent substrate and is a historic location for redd count success.

Action Plan: Work with the farmer on the lower stretch of South Stream and begin riparian restoration and create cattle fencing to keep cows out of the lower portion of this critical tributary.

A water quality sampling program should be instituted in 2021 below the farmland to determine the severity of nutrient loading, and E. coli.

Figure 148. Looking upstream of South Stream. *Photo: J. Kelly*

Water Quality: Historically, this site has been rated a Class B tributary, as the *E. coli* levels have been regularly above the Class A upper-level limits of 50 cfu/100mL and had spiked as high as 410 cfu/100mL, which would have designated the stretch as a Class C tributary. In 2020, our water quality sampling program determined that South Stream receives an "Excellent" ranking according to the CCME Water Quality Index, and it is the top tributary in the watershed. Out of *E. coli* sampling, South Stream had 3 reports of having 0 cfu/100mL, with an odd spike occurring in September, with 600 cfu/100mL. This spike is a bit of an outlier, and perhaps with precipitation data, we would have been able to better understand what caused this spike (ie: high runoff from heavy rain?). Additional water quality sampling, including the lower portion of the tributary, are needed.

TitusSmith Zone Tributaries

Desmond Brook

Figure 149. Looking upstream of Desmond Brook. *Photo: S. Blenis*

Site Characteristics: Cold-water tributary that enters the Hammond above Carson's and Carter's Pools. Culvert is slightly hung and is in terrible shape. Electro-fishing should be performed in Desmond Brook to assist in prioritizing culvert replacement.

Water Classification: Class A. All parameters within limits for aquatic life.

Substrate: The substrate is a mix of rock (30%) cobble (30%), gravel (30%) and sand (10%). Substrate is <20% embedded.

Flow Type: The site is primarily a run (90%), with scattered pools (10%), and its sinuosity is 10% straight and 90% winding.

Bank Stability: Right bank is stable (50%), and left bank is stable (10%) and bare stable (40%)

Crown Closure: Beautiful crown closure, predominantly cedar trees, giving the stretch 80% shade coverage.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

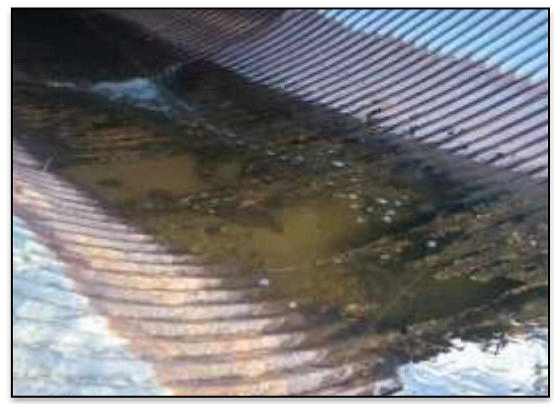


Figure 150. Degraded culvert of Desmond Brook. *Photo: S. Blenis*

TitusSmith Zone Tributaries
Minor Unnamed Tributaries & Culverts

Over the past two years, significant work has occurred on route 860 to upgrade several degraded culverts. The water flowing through these culverts are unnamed tributaries of the Hammond River. **Figure 151 (a,b,c)**, at Lakeside Road, a site that frequently floods in the spring freshet. Dual culverts installed at different heights to accommodate different flow. *Photos: S. Blenis*

Figure 151 (d,e,f)- This area originally had a wooden box culvert, which miraculously survived many generations of ice shears. This ancient culvert has been replaced with a bridge; however, you can still see the original wooden base beneath the bridge. *Photos: S. Blenis*

TitusSmith Zone Tributaries
Minor Unnamed Tributaries & Culverts

Figure 152 (a,b,c)- while new culvert installation is wonderful, each of these areas would benefit from riparian restoration, to increase the crown closure surrounding these minor tributaries, to ensure that the water that is entering the Hammond is as cool as possible. *Photos: S. Blenis*

Figure 152 (d,e,f)- A problematic culvert still exists within this area, and is severely impacted, and a safety concern for traffic. The severe erosion is drastically increasing sedimentation, turbidity, and total suspended solids into the Hammond River. *Photos: S. Blenis*

TitusSmith Zone Tributaries
Brawley Brook

Figure 153. Looking upstream of Brawley Brook *Photo: S. Blenis*

Site Characteristics: Brawley Brook is 5km in length, and discharges into the Hammond River above Smithtown Bridge Pool. Land use is mainly forest with minor residential development.

Substrate: The substrate is a mishmash of bedrock (10%), boulder (20%), rock (30%), cobble (20%) and gravel (20%), and the substrate is <20% embedded.

Flow: The flow in Brawley Brook is slow, yet constant.

Flow Type: The site is primarily a run (80%), with scattered pools (20%), and its sinuosity is 10% straight and 40% winding.

Bank Stability: Banks are essentially stable, with both the left and right bank being stable (40%) and slight, sporadic erosion on both (10%). Left and right bank are also equally undercut in the areas that erosion is occurring (10%).

Crown Closure: Exceptional crown closure, as the brook winds its way through a rich mixture of mature trees that range in species and age class. Shade on the brook is approximately 80%.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

TitusSmith Zone Tributaries
Brawley Brook

Electro-fishing: Electro-fishing was carried out in the lower section of Brawley Brook in September 2020. A total of 7 fish species were observed, including multiple hefty brook trout, and 2 tiny smallmouth bass. The *2008 Watershed Management Plan* documents that juvenile salmon densities were moderate; however, it has been multiple years since electro-fishing has yielded salmon in Brawley Brook.

The *2008 Watershed Management Plan* also highlights that this stretch had two original electro-fishing sites- the first electro-fishing site is near the small bridge across Brawley Brook, which is the location that 2020 staff electro-fished. An additional site is further up the tributary, near a horrendously hung culvert, which will be discussed shortly, and this site should be included in the 2021 electro-fishing season.

Water Quality: In 2008, Brawley Brook was classified as a Class A brook. In 2020, Brawley Brook received a similarly positive ranking, of "Good", with the 4^{th} best score on the Water Quality Index within the watershed. The majority of the brook remains as it naturally occurs, with minimal disturbance. There was one E. coli spike in July, with 900 cfu/100mL- the second highest spike within the watershed in 2020. There may be a connection between this spike and land use at Brawley Lake.

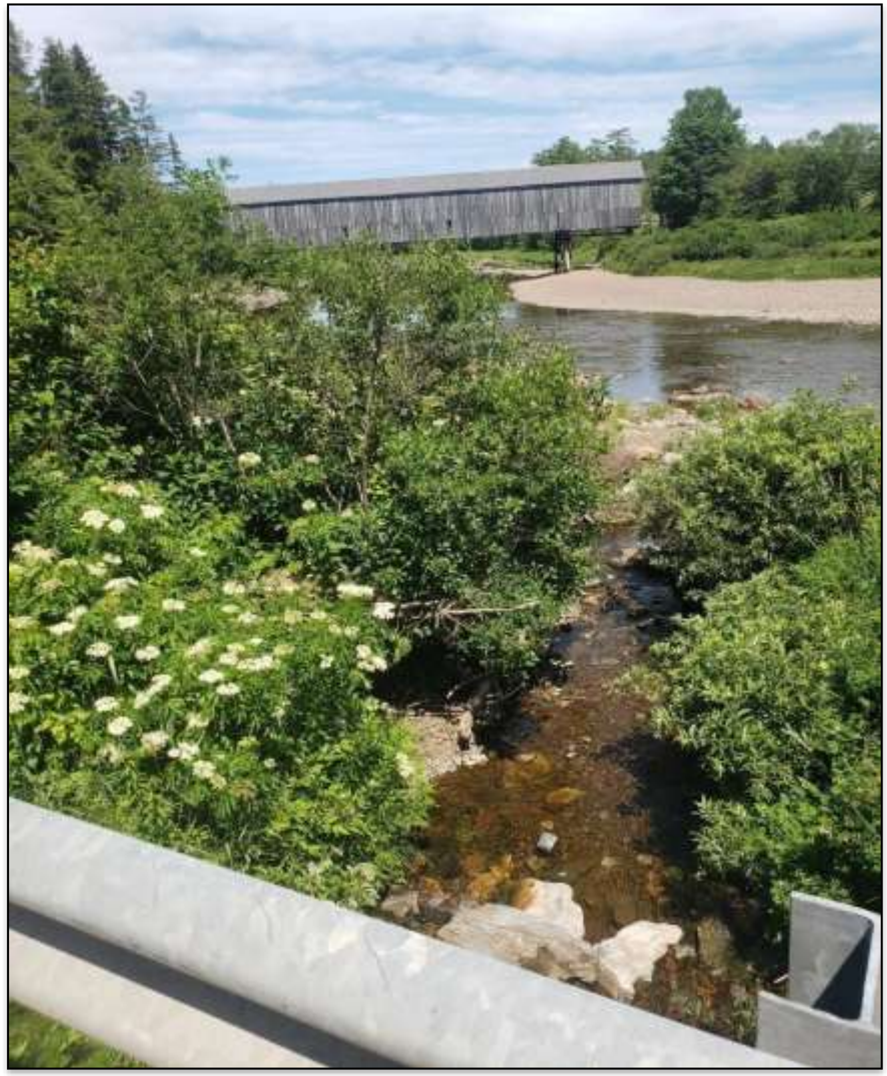


Figure 155. The confluence of Brawley Brook and the Hammond River, featuring the Smithtown Covered Bridge. *Photo: S. Blenis*

TitusSmith Zone Tributaries
Brawley Brook

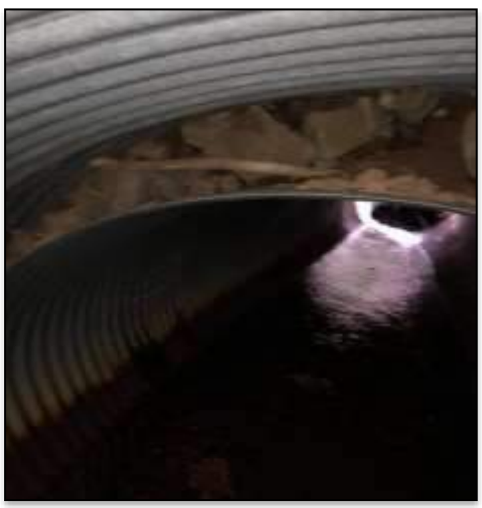


Figure 156 (a,b,c): A severely compromised culvert in the upper reach of Brawley Brook, at the historic 2nd electro-fishing site. This culvert does not allow fish passage, nor does it allow human passage, as the floor of the culvert is almost completely rusted out and it is not safe to walk through. The middle section of the culvert has become severely compacted, and this culvert poses a safety concern for traffic. This culvert is the #1 priority for replacement out of all culverts assessed in 2020.

eDNA: In an effort to justify rapid culvert replacement, HRAA staff decided to take an eDNA sample at the culvert pool, to determine if there was salmon presence, and if salmon were being impacted by the hung culvert. While the sample came back negative for salmon DNA, this culvert still does not allow for fish passage for other fish species, restricting them from entering the rest of Brawley Brook's reach.

Action Point: in 2021, incorporate both electro-fishing sites, and expand to allow for a third site, above the hung culvert. A second round of eDNA samples for salmon presence/absence is also warranted- perhaps next year, we shall try at a different time of the year instead of in November to see if there is salmon eDNA in the water. It may be of value to try sampling later in the winter, or first thing in the spring when there is no leaf litter in the tributary. *Photos: S. Blenis*

TitusSmith Zone Tributaries
Brawley Brook

Figure 158 Above the culvert in Brawley Brook

Figure 157. Upstream view of Brawley Brook, above the culvert. The slope increases significantly in the upper portion of Brawley Brook, providing fast flow that is rich in dissolved oxygen. Boulders become a predominate substrate feature, many covered in moss. Crown Coverage is exquisite in the upper region of this tributary, similar to the lower portion. Brawley Brook would be a suitable brook for future stocking opportunities- either for salmon, or native brook trout, as this site offers pristine habitat and acceptable water quality. We look forward to checking out this location again in 2021!

Figure 158. We also re-found the old turbine discovered by HRAA in 2008! We also noted several digger logs throughout the brook but have yet to find the year they were installed. *Photos: S. Blenis*

TitusSmith Zone Lakes
Brawley Lake

Figure 159. A picturesque Brawley Lake. *Photo: S. Blenis*

Brawley Lake is the headwaters for Brawley Brook. General water chemistry was observed in the summer with the use of a YSI multiparameter probe, and all parameters were within guidelines to support aquatic life. Water quality testing in Brawley Brook determined the brook to have a "Good" Water Quality Index rating. There are a few residential dwellings, and several camp sites surrounding Brawley Lake, which may be contributing to the spike in *E. coli* that occurred in July, with 900 cfu/100mL in Brawley Brook, the 2nd highest spike of *E. coli* throughout the entire watershed in 2020. This lake will be fully assessed in the upcoming Lake Assessment in 2021, with an investigation into the chemical, physical, and biological components within the lake. This lake has a fair amount of boat activity, and educational signage should be placed around the lake to educate the public on Clean, Drain, Dry. HRAA should also work with surrounding landowners to discuss best management practices for leaving a solid vegetated buffer around the lake and educating the public on septic tank care.

Tidal Zone

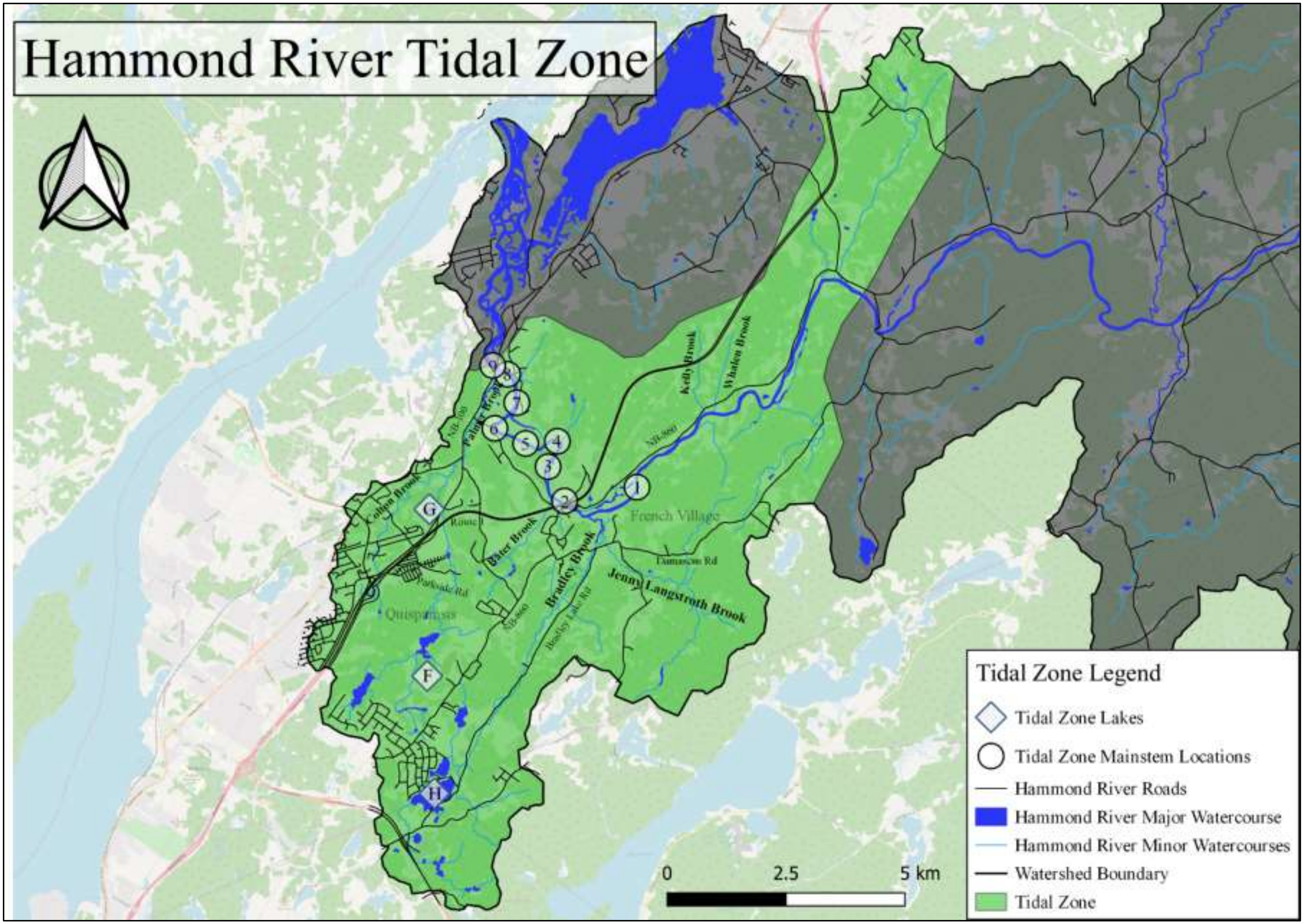
“Some fish are too valuable to be caught only once”- Joan Wulff
Photo: French Village Covered Bridge. Provincial Archives NB

Tidal Zone Legend & Work Complete (2020)

Site Name	GPS Location	Area Surveyed (m)	WQ	E-Fish	Redds (#)	e-DNA	BMI	Culvert Assessment
MAIN STEM								
1. Schoolhouse Pool	45.434125 -65.869700	500m	YSI	No	No	No	No	No
2. French Village Pool	45.430282 -65.886352	1km	YSI	No	**0**	No	No	No
3. Island Pool	45.439609 -65.892534	1km	YSI	No	**0**	No	No	No
4. Deep Hole Pool	45.443164 -65.891546	1km	YSI	No	**0**	No	No	No
5. Len's Pool	45.441643 -65.896493	1km	YSI	No	No	No	No	No
6. Crowley's Pool	45.445657 -65.907884	1km	YSI	No	No	No	No	No
7. Steele's Pool	45.455297 -65.902908	1km	YSI	No	No	No	No	No
8. Rushton Pool	45.455814 -65.903892	1km	YSI	No	No	No	No	No
9. HRAA Bridge Pool	45.457393 -65.907413	1km	YSI	No	**0**	**Positive**	No	No
TRIBUTARIES								
1. Whalen Brook	45.449917 -65.848350	600m	YSI	No	No	No	No	**Yes**
2. Kelly Brook	45.563766 -65.517150	800m	YSI	No	No	No	No	**Yes**
3. Jenny Langstroth Brook	45.423366 -65.877845	800m	Lab	**Yes**	No	No	No	No
4. Bradley Brook	45.42251 -65.880887	800m	Lab	**Yes**	No	**Negative**	**Yes**	No
5. Bater Brook	45.431913 -65.892231	500m	YSI	No	No	No	No	No
6. Palmer Brook Lower	45.453152 -65.908820	800m	Lab	**Yes**	No	No	No	No
7. Palmer Brook Mid	45.43934 -65.91748	300m	Lab	**Yes**	No	**Negative**	**Yes**	No
8. Palmer Brook Upper	45.41834 -65.91919	400m	Lab	**Yes**	No	No	No	No
9. Colton Brook	45.429300 -65.936017	600m	YSI	No	No	No	No	**Yes**
LAKES								
F. Gravel Pit Lake	45.2333 -65.5543	100m	No	No	No	No	No	No
G. Renforth Pit Lake	45.430585 -65.926293	100m	YSI	No	No	No	No	No
H. Bradley Lake	45.378763 -65.920161	100m	YSI	No	No	No	No	No

Table 4 Tidal Zone Work Complete

Tidal Zone Map



Tidal Zone Main Stem
School House Pool

Figure 162. Looking across the pool at Schoolhouse Pool
Photo: J. Kelly

Site Characteristics: A lesser-known pool within the watershed, major erosion begins to occur downriver of Schoolhouse Pool as a result of lack of riparian buffer. Schoolhouse Pool is the first pool of the Tidal Zone.

Substrate: The substrate is a mix of bedrock (10%), boulder (40%), cobble (40%) and sand (10%), and the substrate is <20% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and slow slope. During high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is mainly a run (70%), with a decent pool (30%), and its sinuosity is 80% straight and 20% winding.

Bank Stability: Minimal erosion is occurring on the left bank, as it is bare stable (50%). The right bank is a combination of stable (35%), bare stable (10%), and eroding (5%). Zero bank undercutting was noted for both banks.

Crown Closure: There is almost zero crown closure in this stretch, and both banks received a score of 0% overhanging vegetation.

Riparian Vegetation: The surrounding land use is predominately agricultural, which is putting the riparian zone at risk. The riparian rating can be split between bare (50%) and grass (50%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. Restoration activities are a priority in this stretch to maintain its Class A rating.

Water Classification: Class A. No point source pollution discharges, water quality parameters within limits to support aquatic life.

Tidal Zone Main Stem
French Village Bridge Pool

Figure 163. Looking upriver towards the French Village Bridge
Photo: S. Blenis

Site Characteristics: A contractor's overweight excavator crashed through the decking of the century-old, covered bridge spanning the Hammond River on Oct. 5, 2016, forever changing the look of French Village Bridge Pool.

Substrate: The substrate is a fusion of bedrock (5%), boulder (5%), rock (10%), cobble (50%) and gravel (30%), and the substrate is 20-35% embedded.

Flow: Slow moving during the summer months through a moderately deep run; during high water events, the water velocity increases significantly.

Flow Type: The site is primarily a run (95%), with scattered pools (5%), and its sinuosity is 20% straight and 80% winding.

Bank Stability: Vegetated banks are highly sloped, while those without vegetation were found to be shallow. Left bank is a combination of stable (5%), bare stable (40%), and slight erosion (5%). Right bank is less steep and is bare stable (25%) and eroding (25%).

Crown Closure: There is substantially more overhanging vegetation on the left bank (15%) than the right bank (0%), providing shade to less than half of the site. The right bank is primarily grasses and does not lend to much shade cover.

Riparian Vegetation: The French Village area is dominated by agricultural land, and the rightbank is cause for concern. It is mainly grass with a few small wetland areas, and a riparian flood plain. Unfortunately, this is a site of high ATV activity, that continues to rip up the flood plain, increasing bank instability and sedimentation into the river.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Tidal Zone Main Stem
French Village Bridge Pool

Observations: The French Village Bridge is a site that requires close monitoring, as it is alocal hotspot for swimming, fishing, ATV's- all of which lead to increased levels of illegal dumping activities. The French Village Bridge, and surrounding area, were part of HRAA's Volunteer Streamside Clean Up events, and produced the highest volume of garbage within the watershed.

Many use the surrounding fields to access the Deep Hole, creating many small road systems, that are leading to the degradation of the riparian zone. This area contains a large population of milkweed plants- the largest plot of milkweed that we have encountered in the watershed- and there is concern that ATV and truck traffic may destroy this plot. HRAA should install educational signage around the milkweed plot, to discourage others from driving through it.

In order to access the Deep Hole Pool, many vehicles drive through the river, increasing mud, turbidity, and degrading fish habitat. Signage about crossing should be installed.

French Village Pool, and surrounding area, should be a high priority for future restoration work in the flood plain- without continued monitoring and work, this area will continue to degrade, and have disastrous consequences on the river and its inhabitants.

Figure 1. French V64illage is a prime site for milkweed, the only food source for Monarch Caterpillars. *Photos: S. Blenis*

Water Classification: The French Village Bridge Pool receives a **Class A** rating (excellent water quality). In the summer of 2020, conductivity was found to be 260.4µS/cm, salinity of 0.12ppt, Total Dissolved Solids 163.15mg/L, pH of 7.90 and Dissolved Oxygen 7.44mg/L. Normally, the site has a much higher level of Dissolved Oxygen; however, the summer of 2020 was a record setting summer for temperatures- the day that these water samples were collected with a YSI multiparameter probe, the water temperature was a shocking 27°C, contributing to the lower Dissolved Oxygen rating. There are no point source pollution discharges within this reach.

Monitor: There is a large open pit mine, with another mine currently undergoing the EIA process above French Village Bridge Pool. Both should be closely monitored to ensure no negative impact to the river.

Tidal Zone Main Stem
Deep Hole Pool

Figure 165. Looking across the pool at Deep Hole Pool.
Photo: J. Kelly

Flow Type: The flow type can be divided equally between run (50%) and a large pool (50%).

Bank Stability: The left bank is a large gravel beach and is mainly bare stable (50%). The right bank is a steep slope that is partially stable (25%) and partially eroding (25%). Undercut banks exist on both sides, with left being 10% undercut and right being 15% undercut.

Crown Closure: There is little closure on the left bank, as it is beach with grass. The right bank offers 25% overhanging vegetation, providing some shade (35%) over the pool.

Riparian Vegetation: The right bank offers mature trees, while the left bank is smaller shrubs and grass. Frequent ice jams in the winter and spring limit mature tree growth on the left bank.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating.

Tidal Zone Main Stem
Deep Hole Pool

Redd Count: A Redd Count Assessment was performed in November with HRAA volunteers from the French Village Bridge Pool to the Deep Hole Pool. This area provides suitable substrate (20% gravel) for salmon spawning habitat.

Unfortunately, no redds were found during the 2020 count. We believe that due to the higher-than-average temperatures in late fall, salmon spawning in 2020 was delayed, and we were too early in our redd count assessment. Historically, this stretch, from the French Village Bridge Pool to the Deep Hole Pool has produced redds, and salmon have often been documented in the Deep Hole Pool.

Two HRAA volunteers had SCUBA and drone equipment- underwater footage did not find any salmon; however, an incidental observation of a Wood Turtle in the Deep Hole was rather exciting.

Action Points: This area is one of the most popular swimming holes in the watershed, leading to severe illegal dumping. HRAA must make a greater physical presence at this pool to curtain garbage and littering. Riparian restoration should be a priority, and shrub species should be selected, as they will withstand ice shears and grazing deer. Continue with redd count survey and underwater footage. Vehicles are also known to drive through the river to access this location, and signage should be placed to deter this.

Figure 166. Degradation of the riverbanks. Area should be a priority for restoration to ensure minimal sedimentation into the river, especially given it is a known salmon spawning ground. *Photo: J. Kelly*

Water Classification: This pool is a **Class A** rating. There are no point source pollution discharges. Dissolved Oxygen is at a healthy 10mg/L, and all other water quality parameters are within acceptable limits for aquatic life. The depth of the pool also offers a cool holding pool sanctuary, which is critical for fish species during the peak of summer water temperatures.

Tidal Zone Main Stem
Len’s Pool

Figure 167. Len’s Pool, part of the kayaking adventure. *Photo: J. Kelly*

Site Characteristics: Len’s Pool is one of many leisurely stretches of the Hammond River system and offers excellent fishing opportunities.

Substrate: The substrate is a mix of rock (25%), cobble (25%), gravel (25%) and sand (25%), and the substrate is <20% embedded.

Flow: A relaxed flow throughout the summer, this stretch increases in velocity during high rain events and in the spring freshet and is susceptible to flooding.

Flow Type: The site is primarily a run (80%), with a small pool (20%), and its sinuosity is 90% straight and 10% winding.

Bank Stability: The left bank can be characterized as stable (45%), and the right bank is divided between stable (25%) and eroding (25%). There are some undercut banks (20%) that occur on both the left and right banks.

Crown Closure: There is minimal crown closure at this site, with only 5% overhanging vegetation on the left bank, and 0% on the right bank. Shade is a miniscule 10% of the pool.

Riparian Vegetation: Riparian vegetation in this area is stressed, with minimal shrubs (10%) and mainly grass (40%). This is contributing to a warmer pool with little shade, and banks that are susceptible to erosion.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Water Classification: Class A. No point source pollution discharges. Water quality parameters within acceptable limits to support aquatic life.

Tidal Zone Main Stem
Crowley's Pool

Figure 168. View of Crowley's Pool, taken from Len's Pool.
Photo: J. Kelly

Site Characteristics: A beautiful and productive fishing pool, Crowley's Pool is mired by extreme eroding riverbanks that pose a threat to the river below and the road above.

Substrate: The substrate is a combination of boulder (10%), rock (25%), cobble (25%) and unfortunately very high in silt (40%), and the substrate is 50% embedded.

Flow: Slow moving during the summer months due to shallow water conditions and during high water events, the water becomes turbid and flows at a significant rate.

Flow Type: The site is primarily a run (70%), a fairly deep pool (30%), and its sinuosity is 50% straight and 50% winding.

Bank Stability: Erosion is an understatement. The right bank is slightly more stable (25%) and noticeable erosion (25%); however, the left bank, as seen in **Figure 168** is completely eroding and not stable at all.

Crown Closure: There is minimal crown closure at this pool, attributed to minimal overhanging vegetation.

Riparian Vegetation: This site is bordered by agriculture, with predominately grasses (75%) and the rest of the riparian area is bare (25%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Water Classification: Class A. No point source pollution discharges. Water quality is well within limits to support aquatic life, with a healthy 9.00mg/L of Dissolved Oxygen, pH of 7.5, but high in Total Dissolved Solids-124.80mg/L (probably as a result of major erosion).

Tidal Zone Main Stem
Crowley's Pool

Between 2016-2017, HRAA enlisted the help of Dillon Consulting to perform a preliminary review of the hydraulic mechanisms threatening bank stability and infilling of Crowley's Pool. These drivers formed the basis of subsequent efforts to design remediation measures to stabilize the bank slope and restore habitat in Crowley's Pool. As part of this study, a set of conceptual design recommendations were provided to HRAA to guide future restoration activities at Crowley's Pool.

A hydraulic model was used to simulate the velocities along the study reach during a range of flood flow conditions and took into consideration the force of ice jams. A slope stabilization concept was prepared to support the estimation of probable cost. The intention of this report was to provide HRAA with information in attempts to secure funding and partners to proceed with the detailed design and construction of slope stabilization measures at Crowley's Pool. It was recommended that HRAA share the findings of this report with the Town of Quispamsis and other stakeholders.

HRAA staff in 2020 have yet to find any follow up on Crowley Pool restoration proposal. The approximate budget proposed for this project is $579,004.00, and it is recommended that HRAA staff begin to seek out appropriate funders as soon as possible, and to put this plan into action!

Looking upriver from Crowley's Pool, showing the proximity of the eroded bank to the road. *Photo: J. Kelly*

Action Points: In the Annual General Meeting in 2019, President Jim Gillespie brought to attention that this pool historically had an access trail for anglers to reach the pool. This trail has become overgrown, and the slope and erosion have made this an exceedingly difficult pool to access. HRAA should assess the entrance point to this pool and determine the proper steps forward in making this an accessible pool again; despite the erosion and sedimentation, this pool is generally packed with fish. HRAA should also take efforts in working with the Department of Transportation, as this site is potentially hazardous to driving. Should erosion continue, it is putting the Stockfarm Road at risk.

Tidal Zone Main Stem
Steele's Pool

Figure 169. Looking across the pool at Steele's Pool *Photo: J. Kelly*

Site Characteristics: Steele's Pool is located approximately 600m downstream of Crowley's Pool, and is a common hang out spot for Great Blue Herons.

Substrate: The substrate is a mix of cobble (25%), gravel (25%), sand (25%) and silt (25%), and the substrate is 20-35% embedded.

Flow: Slow moving during the summer months due to shallow water conditions. Frequent site of flooding during the spring freshet.

Flow Type: The site is mainly a run (65%), with a decent pool (35%), and its sinuosity is 25% straight and 75% winding.

Bank Stability: The left bank is fairly stable (40%) with minimal erosion (10%); however, the right bank is the complete opposite, with heavy erosion (40%) and minimally stable (10%).

Crown Closure: Minimal crown closure, as the vegetation is primarily bare or grass. Overhanging vegetation to provide crown closure was given a ranking of 0%.

Riparian Vegetation: Located in a highly developed agricultural landscape, the riparian vegetation is either bare (25%) or grass (75%). Restoration is a priority, with a recommendation of shrubs, as they will better withstand ice shearing in the spring and provide much needed shade in the summer.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Water Classification: Class A. No point source pollution and water quality parameters are all within acceptable limits for aquatic life.

Tidal Zone Main Stem
Rushton Pool

Figure 170. Looking downriver at Rushton Pool, towards HRAA's Conservation Center. *Photo: J. Kelly*

Site Characteristics: Upriver from Palmer Brook, Rushton Pool is a great holding spot for smallmouth bass, perch, and other predatory fish.

Substrate: The substrate is a combination of boulder (25%), rock (25%), cobble (10%), gravel (10%) and sand (30%), and the substrate is 20-35% embedded.

Flow: Slow moving during the summer months due to shallow water conditions, and increased velocity in the spring freshet.

Flow Type: The site is essentially a run (60%), with a medium pool (40%), and its sinuosity is 80% straight and 20% winding.

Bank Stability: There is significant erosion occurring at this site, as the left bank is mainly bare stable (30%) with erosion (20%), while the right bank is barely bare stable (10%) with major erosion (40%). Undercut banks exist on both sides equally, by 20%.

Crown Closure: There is no crown closure, with 0% overhanging vegetation. July water temperatures, on average, were 25˚C due to lack of shade.

Riparian Vegetation: The riparian zone is extremely compromised, with only 10% trees, 40% shrubs and 50% bare.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land. Revegetating this site is a high priority, and native 3-year-old shrubs are recommended, as they will best withstand the ice shears, flooding, and deer grazing.

Water Classification: Class A. No point source pollution; water quality within limits for aquatic life.

Tidal Zone Main Stem

Bridge Pool

Figure 171. Looking downriver from Bridge Pool, view of the Conservation Center. Photo: *J. Kelly*

Site Characteristics: Located just above the Conservation Center, Bridge Pool is clearly aptly named!

Substrate: The substrate is a mix of cobble (20%), gravel (35%) and sand (45%), and the substrate is 35-50% embedded.

Flow: This is part of the tidal area of the river. Slow moving in the summer, and increased velocity in the spring freshet. Area prone to flooding.

Flow Type: The site is a run (70%), with a quaint pool at the bridge (30%), and its sinuosity is 80% straight and 20% winding.

Bank Stability: Erosion is a main concern. The left bank is severely eroded (50%), and the right bank is minimally bare stable (10%) and majority eroding (40%). Undercut banks are increasing sedimentation, with left bank undercut by 40% and the right bank undercut by 30%.

Crown Closure: There is minimal shade in this pool, with only 5% overhanging vegetation on the left bank, and 0% overhanging vegetation on the right.

Riparian Vegetation: The riparian vegetation in this section is poor, with very few trees (10%), and grass is the dominant feature (90%).

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. The predominant grass landscape, with its shallow roots and minimal offering of crown closure, make this pool severely at risk of further degradation and sedimentation into the river. Steps must be taken as soon as possible to begin to remediate the situation and revegetate the riparian zone.

Tidal Zone Main Stem
Bridge Pool

eDNA: Bridge Pool offers a publicly accessible boat launch. HRAA staff took a combination eDNA sample, to determine presence/absence of salmonid DNA, as well as testing for the presence/absence of the invasive aquatic plant, Eurasian Water Milfoil DNA. The eDNA test came back positive for salmon; however, we are still awaiting results for milfoil.

Eurasian Water Milfoil, known as the "zombie plant", has the ability for small fragments to attach to parts of boats, and be introduced into new bodies of water, where it will grow, thrive, and invade. HRAA will install one of the New Brunswick Invasive Species Council's "Clean, Drain, Dry" signs at the boat launch in the spring of 2021 (after flooding event) to help educate the public about the dangers of unintentionally spreading this invasive aquatic plant.

HRAA should make a priority of developing a Climate Change Adaptation Plan with the Quispamsis Municipality.

HRAA should undertake riparian restoration throughout this tidal region, focusing on planting shrubs, instead of trees (as was the previous focus of restoration), as shrubs will be more resilient to climate change. Restoration is a priority, as sand and silt are creating sand bar islands in the river, increasing habitat fragmentation.

Figure 172. Flooding event in the spring of 2018, increasing the erosion and sedimentation issues at Bridge Pool, Steele's Pool, Crowley Pool, et al.

Water Classification
This site receives a **Class B** rating; however, with significant improvements, a Class A is possible. There are no point source pollution discharges within this area. This site is subject to above standards bacteria and coliform limits. Given the lack of crown cover, the Dissolved Oxygen is low, at 7.0mg/L. Salinity is relatively high, as a result of the bridge and road salt, at 0.13ppt, and Total Dissolved Solids of 178.10mg/L. High presence of *planorbidae* (lunged) snails in the summer, leading to outbreaks of swimmer's itch in Nature Camp kids, indicate poor water quality conditions.

Tidal Zone Tributaries

Whalen Brook

Figure 173. Looking upstream of Whalen Brook. *Photo: S. Blenis*

Site Characteristics: The substrate is a mix of rock (40%) cobble (30%), gravel (30%) and Substrate is <20% embedded. Flow is slower during the hot summer months.

Water Classification: Class A. Water quality well within acceptable limits.

Whalen Brook is a success story for HRAA's riparian replanting. The brook is lined with mature willows all the way to its confluence with the Hammond River. These willows are keeping the stretch cool and shaded, ultimately increasing suitable fish habitat. This stretch has not been electro-fished and may be a good candidate in 2021 to assess fish community.

Flow Type: The site is primarily a run (75%), with a decent pool at the culvert mouth, and smaller pools scattered throughout (25%), and its sinuosity is 40% straight and 60% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Minimal undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure, predominantly of mature willows, giving the stretch 90% shade coverage.

Riparian Vegetation: Fully mature willows, planted by HRAA over a decade ago are the dominant feature along this stretch.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Tidal Zone Tributaries

Kelly Brook

Figure 174. Looking upstream of Kelly Brook. *Photo: S. Blenis*

Site Characteristics: Cold-water tributary, water flowing down a mountainous valley through old growth forest. The substrate is a mix of rock (40%) cobble (40%), gravel (20%) and substrate is <20% embedded.

Water Classification: Class A. Water quality well within acceptable levels. Landowner describes the tributary as being abundantly full of trout until the original culvert washed out in the 1970's. The province replaced the old culvert with 2 hung culverts, and "this brook has never been the same". Landowner states there has been major degradation of the brook as a result of these poor culverts. Electro-fishing and/or eDNA in the culvert outflow, to determine fish presence, may assist in having these culverts replaced.

Flow Type: The site is primarily a run (85%), sprinkled with pools (15%), and its sinuosity is 30% straight and 70% winding.

Bank Stability: Both the left and right bank are equally stable (50% for each side). Very little undercutting is occurring, (5%) on both banks.

Crown Closure: Beautiful crown closure giving the stretch 85% shade coverage.

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Figure 175. Dual hung culverts do not allow fish passage. Electro-fishing lower stretch and assessing confluence is a priority. *Photo: S. Blenis*

Tidal Zone Tributaries

Jenny Langstroth Brook

Site Characteristics: Jenny Langstroth is a minor tributary that eventually merges with Bradley Brook.

Flow: Flow is very low and slow in the hot summer months, with many sections of the brook almost completely dry.

Substrate Type: This brook is a mix of boulder (10%), rock (10%), cobble (40%), gravel (10%) and sand (20%), and the substrate is 35-50% embedded, and is slippery to walk on.

Flow Type: The site is primarily a run (95%), with a small holding pool below the bridge (5%) and its sinuosity is 10% straight and 90% winding.

Bank Stability: The left bank can be described as bare stable (25%) and eroding (25%), while the right bank is stable (10%), bare stable (20%) and eroding (20%). Undercut banks dominate, with the left bank at 40% undercut, and the right bank at 25%.

Crown Closure: Medium crown closure throughout the Jenny Langstroth, providing approximately 30% shade to the brook.

Riparian Vegetation: A mix of mature trees (30%), shrubs (30%), and grasses (40%).

Riparian Rating: Excellent. The riparian zone is well vegetated with 80% or greater of the banks comprised of trees and shrubs. Minimal erosion is present (<10%) and the banks are stable.

Figure 176. Upstream of Jenny Langstroth, next to livestock pasture. Shallow, low flow in summer months. *Photo: S. Blenis*

Tidal Zone Tributaries
Jenny Langstroth Brook

Electro-fishing: Electro-fishing was performed in Jenny Langstroth in September. In total, 4 fish species were documented, including American Eel, Brook Trout, Black Nose Dace and Slimy Sculpin. Even during September, the water depth was still minimal within this tributary, with the majority of fish hiding in the pool below the bridge. An investigation into the lower stretch of Jenny Langstroth, where it merges with Bradley Brook, may be warranted for future electro-fishing studies.

Water Quality: The Jenny Langstroth brook was not part of the 2008 Water Classification. In 2020, our water quality sampling program determined that the Jenny Langstroth received a "Good" ranking according to the CCME Water Quality Index. Throughout the season, Jenny Langstroth maintained a 0 cfu/100mL of *E. coli*. This was an interesting discovery in results, as there is a large horse paddock next to the Jenny Langstroth brook; however, there is a vegetated buffer that separates the paddock and the brook (predominantly grasses and shrubs). During the habitat assessment, it did not appear that any of the neighboring livestock had direct access to this tributary.

Figure 176 & 177. Evidence of nutrient loading & erosion in Jenny Langstroth. Abundance of filamentous green algae. *Photo: S. Blenis*

Action Points:
The substrate was almost entirely covered with macrophytes and benthic algae mats. This was also one of the worst sites for filamentous algae. Riparian restoration would also be an asset. The surrounding land use has a high density of mines and gravel pits, and complaints were received and investigated by HRAA staff that extra sedimentation was being deposited into the brook from the construction of a subdivision. Careful monitoring of this site is necessary to ensure future degradation does not occur.

Tidal Zone Tributaries
Bradley Brook

Figure 179. Looking upstream of Bradley Brook. *Photo: J. Kelly*

Site Characteristics: Bradley Brook is 8.2km in length, and its headwaters is Bradley Lakes, in an area with a high concentration of residential dwellings.

Substrate: The substrate is a mix of rock (10%), cobble (40%), gravel (10%), sand (20%) and silt (20%), and the substrate is >50% embedded.

Flow: Slow flow in the summer, partially due to the number of beaver dams. During high rain, brook becomes extremely turbid.

Flow Type: Bradley Brook can be described as 50% run and 50% pools, mostly due to the number of beaver dams that are creating pools throughout the tributary.

Bank Stability: While **Figure 179** shows heavily vegetated banks, the area surveyed for the habitat assessment tells a different bank stability story. The left bank can be described as stable (20%), and eroding (30%), while the right bank is stable (10%) and mostly eroding (40%). Both banks are experiencing high levels of undercutting, with the left being 30% undercut and the right bank being 40% undercut.

Crown Closure: Canopy cover and shade vary greatly throughout Bradley Brook; the area for the electro-fishing survey is densely populated with alders and shrubs, giving the stretch a high level of shade. Other areas of Bradley Brook are bare of riparian vegetation, casting almost no shade over the stretch.

Riparian Vegetation: Riparian vegetation is a mixture along Bradley Brook- shrubs dominate the landscape, primarily alder and choke cherry. Certain sections of Bradley are almost void of vegetation, or simply grass, while sections of the upper stretch of Bradley has mature trees.

Tidal Zone Tributaries
Bradley Brook

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress. Many of the shrubs and alders in the lower stretch of Bradley Brook have surpassed maturity and have begun to die off. Beaver activity is also taking its toll on the riparian zone, and Bradley Brook should be monitored closely in the coming years to ensure that its riparian zone does not continue to degrade. This would be a prime candidate for additional planting, to allow for this site to regenerate and restabilize.

Electro-fishing: Fish densities were extremely low during the electro-fishing survey in 2020. Only three fish species were documented, including Brook Trout, Black Nose Dace and Slimy Sculpin. Our 2020 results vary greatly from the 2019 results- 2019 found significantly higher species abundance as well as higher density, including 1 salmon parr. The *2008 Watershed Management Plan* describes Bradley Brook as poor juvenile salmon habitat, but good brook trout habitat, and these findings are confirmed in the 2019 electro-fishing study but are lacking in the 2020 study. There were numerous beaver dams throughout Bradley Brook, and some may have limited fish passage, decreasing the number of fish observed during electro-fishing in 2020.

eDNA: As a result of the low fish densities, and lack of salmon presence during electro-fishing, HRAA staff decided to take an eDNA sample in the mid-point of Bradley Brook, along Bradley Lake Road. The eDNA result came back as negative for salmon DNA. It may be worthwhile adjusting the electro-fishing location to an area near the mouth of Bradley Brook in 2021.

Figure 180. The beginning of another beaver dam in Bradley Brook. It was also noted that someone had been placing rocks across Bradley Brook, to make a dam or pool below the bridge. *Photo: S. Blenis*

Tidal Zone Tributaries
Bradley Brook

Figure 181. Another beaver dam in the distance. Note that you cannot see any of the substrate, as it is almost entirely embedded in the silt and sand Water clarity is poor and brackish, and quite tannin in color.
Photo: S.Blenis

Redd Count Survey: A redd count survey was not complete in Bradley Brook, as it does not offer suitable substrate or spawning habitat for Atlantic Salmon.

Benthic Macroinvertebrate Study: The *Bridging the Gap Report* found that the BMI Index in Bradley brook indicates a possibly impaired habitat, as the Hilsenhoff Index suggests the nutrient quality at this site is fairly poor. A moderate abundance of worms indicates the site is possibly impaired, and likely receives intermittent organic pollution.

Water Quality Classification: The *2008 Watershed Management Plan* determined that Bradley Brook is a **Class C** tributary, as dissolved oxygen levels are not normally within the recommended limits (9.5mg/L), and *E. coli* levels exceed the Class C limit of 200/100mL, and spikes as high as 830/100mL. These results were further confirmed during the *Bridging the Gap Report*, which recorded that requirements for dissolved oxygen were not met by a deficit of 16%. This report also noted that suspended sediment concentrations exceed the median levels by 114%. The *2015 Watershed Management Plan* also confirms the poor water quality in Bradley Brook. In 2020, the water quality sampling determined that Bradley Brook receives a ranking of "Marginal" according to the CCME Water Quality Index. The highest spike of *E. coli* in Bradley Brook was 200 cfu/100mL in September. While it is encouraging that the *E. coli* did not spike as high as the 2008 sample results, further investigation is warranted into this location.

Tidal Zone Tributaries
Bradley Brook

Discussion: Working with surrounding landowners and gravel pit operators, as well as cottage owners around Bradley Lake, the Bradley Brook reach needs to become a priority. During the 2020 season, there was significant garbage strewn throughout Bradley Brook, some of which appeared to be new, while other items had been there for a long time. Many metal items (including children's bikes) were removed during the summer of 2020.

In the *2008 Watershed Management Plan*, it was noted that the water smelled of raw sewage, and that it was possible that a few landowners' septic systems were directly running into the brook. It was also noted that a septic truck had been seen dumping waste into the brook. The foul smell was documented in the 2020 investigation, and the E. coli and fecal coliform levels documented in 2020 suggest that septic issues may still be ongoing in this tributary.

The problems in Bradley Brook may be impacted due to habitat fragmentation, the high density of gravel pits upstream, and surrounding land use and residential dwellings, particularly around the Bradley Lakes. In 2020, HRAA staff submitted a proposal for an in-depth lake analysis, which will focus on water quality and land use in the Bradley Lakes, which may, for the first time, shed more light on the issues within Bradley Brook.

Efforts need to be taken in the future to identify all gravel pits and define whether they are active or inactive. Inactive gravel pits should become candidates for reclamation and revegetation plans. For active gravel pits, HRAA needs to develop effluent monitoring protocols, as these pits may be increasing sedimentation and turbidity into Bradley Brook. Some gravel pits may benefit from sedimentation fencing; however, the first step is identifying which gravel pits are potentially increasing the problems within Bradley Brook.

Figure 182. Upper Bradley Brook-substrate is completely non-visible. Difficult to wade this stretch. *Photo: S.*

Tidal Zone Tributaries
Bradley Brook

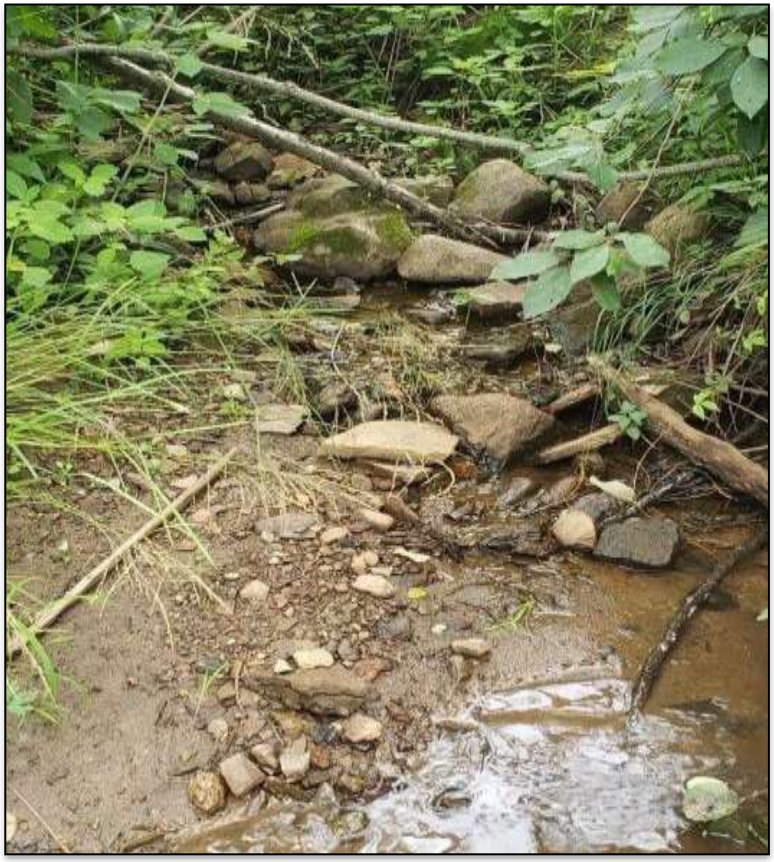


Figure 183. The Jenny Langstroth Brook, as it enters Bradley Brook. Photo was taken at the end of July, during peak summer temperatures; flow into Bradley Brook was minimal. *Photo: S. Blenis*

The *2018 Mussel Biodiversity Analysis* determined that Bradley Brook contained the highest density of Eastern Elliptio mussels in the watershed. While mussels were not observed in Bradley Brook in 2020, the fish species present (brook trout and slimy sculpin) are larval hosts of the Eastern Elliptio. A study in the future to determine mussel abundance in Bradley Brook, to compare to the 2018 results, would be worthwhile- a decrease in mussels may also indicate degrading water quality, as 2020 had the lowest fish abundance during electro-fishing in the past 10 years.

It is recommended that HRAA develop an extremely robust water quality monitoring routine for Bradley Brook, to assist in determining the source of *E. coli*, fecal coliforms, and sediment loading. Gravel pits need to be identified, including monitoring protocols for the active pits, and reclamation plans for the fallow pits. An in-depth examination in the surrounding wetland areas of Bradley Brook would also be worthwhile. Riparian restoration, particularly in the lower reaches of Bradley Brook, should be an undertaking in the near future as well.

The focus for Bradley Brook should be landowner engagement and cooperation. Should illegal dumping activities continue, authorities should be notified. Meaningful discussions with the town of Quispamsis and local residents about best practices for water quality, conservation, and the benefits of preserving their local environment should become the forefront of addressing the issues with Bradley Brook. This brook has potential, but it will require a significant amount of work and dedication.

Tidal Zone Tributaries
Bater Brook

Figure 184. Looking downstream towards the Mackay Highway
Photo: J. Kelly

Site Characteristics: Bater Brook is a relatively short, cold water, spring-fed brook 2.9km in length, and passes beneath the Stock Farm Road.

Substrate: The substrate is a mix of boulder (10%), rock (30%), cobble (30%) and gravel (30%), and the substrate is 20-35% embedded.

Flow: Slower flow due to in-stream organic obstructions. During high water events, overflow fills the surrounding wetland areas.

Flow Type: The site is primarily a run (95%), with a very small pool near the culvert (5%), and its sinuosity is 40% straight and 60% winding.

Bank Stability: Minimal erosion is present. The left bank is stable (15%), bare stable (30%), with minor erosion (5%). The right bank is stable (10%), bare stable (30%) and minor erosion (10%).

Crown Closure: The crown closure was found to be significant throughout the stretch, covering 60% of the water in shade.

Riparian Vegetation: The riparian vegetation can be described as trees (60%), grasses (15%), and bare (25%). In 2008, HRAA staff noted that many of the trees in this stretch had died, but that the site was showing signs of regeneration. This has indeed been the case, as the stretch has rebounded with new growth of trees.

Riparian Rating: Good: The riparian zone is heavily vegetated with 79%-60% of the banks comprised of more shrubs than trees, casting shade across 60% of the reach during mid-day sun. Erosion surrounding the site is isolated to a few locations and can be classified as 11%-25%.

Tidal Zone Tributaries
Bater Brook

Observations: This site was not part of our 2020 electro-fishing assessment; however, it should be considered as a candidate for future electro-fishing assessments. Given the crown coverage and appropriate substrate, this stretch would be fine habitat for aquatic species, and electro-fishing this stretch would increase knowledge of fish community composition in this stretch. This site may be a good candidate for eDNA exploration in advance of electro-fishing, to determine absence/presence of salmonid DNA.

Action Points: Bater Brook passes through a number of culverts in the upper part of the stretch, and the lower stretch passes beneath a highway. This site should be included in a more robust water quality strategy.

This site should also be monitored for its riparian zone, as the older trees continue to die and ensuring that the in-stream organic debris does not block fish passage. The surrounding land use has impacted this brook, particularly as nearby subdivisions continue to expand. HRAA should work closely with surrounding communities and continue to monitor the development and activities surrounding the brook.

An annual Benthic Macroinvertebrate study in Bater Brook would assist in monitoring the overall aquatic health of this tributary.

Figure 185. Shallow, slow flow throughout Bater Brook, with fine canopy coverage. *Photo: J. Kelly*

Water Classification: In 2008, Bater Brook received a classification of **Class A**; however, its water quality in 2020 would indicate that it should be classified as **Class B**- The conductivity in this brook is unusually high, at 588.6µS/cm compared to other tributaries in the watershed. The Total Dissolved Solids are also unusually high, at 200.85mg/L, the salinity is high at 0.15ppt, and the turbidity was the highest in the watershed at 4.03FNU. pH was 7.79, and Dissolved Oxygen is low, at 8.86mg/L. Additional water quality sampling needs to occur in this brook, including *E. coli* and coliform monitoring.

Tidal Zone Tributaries
Palmer Brook

Figure 186. Downstream view of Palmer Brook. *Photo: J. Kelly*

Site Characteristics: Palmer Brook is 8.5km in length, and is one of the most stressed, impacted, tributaries within the watershed.

Substrate: The substrate of the lower reach of Palmer Brook can be described as a poor mix of gravel (10%), sand (70%) and silt (20%), and the substrate is >50% embedded.

Flow: The flow of the lower reach of Palmer Brook is very slow during the summer months, and during heavy rain events, the brook becomes extremely turbid and sediment laden.

Flow Type: Palmer Brook is predominantly a run (80%), with a few holding pools (20%) throughout.

Bank Stability: Palmer Brook offers a mix of bank stability and riparian vegetation throughout its 8.5km stretch, as it winds its way through industrial, agricultural, and residential landscapes. The most impacted part of Palmer Brook is the lower reach, and the right and left banks can be described as eroding (100%) and undercut (100%).

Crown Closure: The crown closure varies, depending on which section of Palmer is investigated. The upper reach has significant canopy coverage, where the middle section has decent, shrub-based crown closure, while the lower portion, as seen in **Figure 186** has 0% crown closure.

Riparian Vegetation: Riparian vegetation varies greatly throughout Palmer Brook. The predominant vegetation throughout the tributary is 10% trees, 40% shrubs, and 50% grasses.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Tidal Zone Tributaries
Palmer Brook

Benthic Macroinvertebrate Study: The *2015 Watershed Management Plan* notes that BMI results from 2015 and 2017 indicate that conditions within Palmer Brook may be declining.

The report notes that chironomid abundance has increased, supporting that environmental conditions are being impacted. Poor environmental quality is also indicated by an increase in the abundance of dipterans, which are also an indicator. The relative abundance of insects at these sites have been declining, which may indicate declining biodiversity. The results presented in the *2015 Watershed Management Plan* indicate an overall trend of worsening conditions.

In the *2018 Mussel Biodiversity Analysis,* HRAA staff noted that the "decline or absence of the Eastern Elliptio from Bradley and Palmer Brook may indicate the extirpation of Atlantic Salmon, American Eel, Brook Trout or Slimy Sculpin." Mussels were observed throughout Palmer Brook, in the lower, mid, and upper stretches surveyed. Should the mussel survey be updated in the future, Palmer Brook and Bradley Brook should be included, as both of these tributaries contained both of these types of mussels. Given the proximity to the boat launch, it may be a worthwhile endeavor in the future to sample Palmer Brook for the presence of zebra and quagga mussels through eDNA sampling.

Water Quality: In 2008, Palmer Brook received a Class C ranking; this ranking has not improved in 2020 and received a "Marginal" ranking according to the Water Quality Index and was the second lowest scoring brook in the watershed- second only to Porter Brook, which had previously never been documented. *E. coli* exceedances are still a regular occurrence in Palmer Brook, spiking as high as 200 cfu/100mL in July, similar to previous years.

Figure 186. An abundance of lunged aquatic snails found throughout the lower reach of Palmer Brook.
Figure 187. Mussels embedded in sandy substrate in lower Palmer Brook.

Photos: S. Blenis

Tidal Zone Tributaries
Palmer Brook

Figure 189. A beautiful brook trout, from the mid-section of Palmer Brook electro-fishing survey. *Photo: J. Kelly*
Figure 190. Substrate of lower Palmer Brook- unsuitable for salmon spawning. *Photo: S. Blenis*

Electro-fishing: The 2020 electro-fishing survey was divided into three 100m² sections throughout Palmer Brook- the lower portion near the confluence, a middle section near Renforth Construction, and an upper section in the Quispamsis trailer park.

According to the *2008 Watershed Management Plan*, the mouth of Palmer Brook was a crucial sanctuary for adult salmon, which hold in this small area for up to four months, and good juvenile salmon densities have been evident; however, juvenile salmon have not been observed in Palmer Brook during electro-fishing for over 5 years, including in 2020. The mouth of Palmer Brook has also been the site for kelt capture for reconditioning at the Mactaquac Biodiversity Facility; however, it has been several years since kelt have been captured at this location, and it is currently uncertain if salmon are still using the mouth of Palmer Brook as a holding pool in 2020.

American Eel and Sea Lamprey populations are increasing in the lower portion of Palmer Brook, while Black Nose Dace and Slimy Sculpin densities have decreased.

The middle section of the electro-fishing survey in Palmer Brook is a wonderful brook trout holding pool- this area represents the best that Palmer Brook has to offer, with more suitable substrate and crown closure.

The upper section of Palmer Brook is also decent brook trout habitat, and an increase in American Eel population was also recorded in 2020.

Tidal Zone Tributaries
Palmer Brook

Redd Count Survey: A redd count was not performed in Palmer Brook, as the lower section does not contain suitable spawning substrate.

eDNA: Given that no salmon were documented during the electro-fishing survey, and the mouth of Palmer Brook no longer offers suitable substrate for spawning, HRAA staff decided to take an eDNA sample in the middle section of Palmer Brook, to determine salmon presence or absence. The result came back negative for salmon DNA, which was not surprising, given the degrading nature of Palmer Brook. It would be an interesting undertaking to increase eDNA sampling in Palmer Brook at various times of the year. Given that the mouth of Palmer Brook is historically a kelt holding pool, before making their way back to the ocean, it would be interesting to take eDNA samples in early spring, to determine if there is still kelt presence. Additionally, it would be interesting to take eDNA samples in the early summer, as the mouth of Palmer Brook has been an important staging pool and is an essential point on the migration path of salmon entering the river each summer to spawn.

Water Classification: Since 2008, Palmer Brook has received a **Class C** ranking. While the authors of the *2008 Watershed Management Plan* were hopeful that a **Class B** upgrade would be possible in Palmer Brook, the area continues to degrade, and it is still the most stressed and impacted tributary within the Hammond River watershed. Palmer Brook has been under significant developmental pressure for decades, as industrial parks, subdivisions, and gravel pits continue to increase in density. Sediment loading and degraded riparian zones are increasing in tandem with surrounding land use development. This brook requires substantial changes in land use techniques, as well as strict enforcement of environmental regulations.

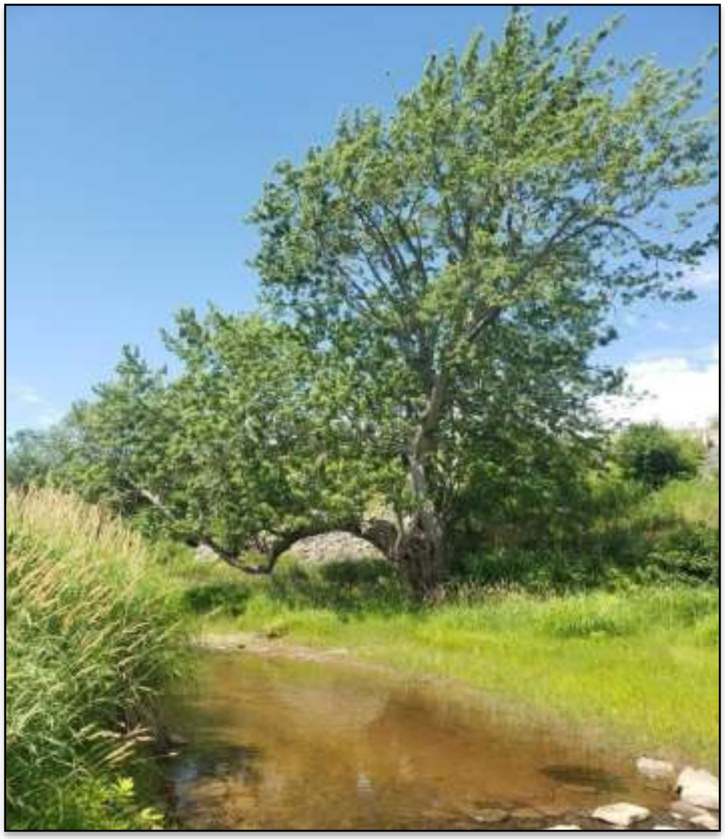


Figure 191. The iconic Silver Maple of the lower Palmer Brook, one of the very few mature trees that line the riparian zone. *Photo: S. Blenis*

Tidal Zone Tributaries
Palmer Brook

Figure 192. Pine Valley sewage lagoon in the upper reach of Palmer Brook. *Photo: S. Blenis*

Action Items: It is time to revisit the 2003 study on the lagoon and begin with an intense water quality sampling program to determine that the lagoon is contributing to these unacceptable levels of *E. coli* and fecal coliforms in Palmer Brook. Emphasis on this sampling program should be placed on sampling around the lagoon after heavy rain events, as that is when the lagoon would be most susceptible to breaching its berms and transporting coliforms into Palmer Brook. A survey of potential wetland areas should also be completed, to determine the possibility of creating wetland areas to naturally treat lagoon effluent. The results should then be conveyed to the public and town of Quispamsis.

In the *Bridging the Gap Report*, it was noted that the upper reach of Palmer Brook is downstream of a sewage lagoon. This site contains phosphorus levels that exceed guidelines for the protection of aquatic life, and it is believed that this lagoon is changing the system from mesotrophic to eutrophic.

The phosphorus exceedances reported coincide with HRAA's findings in 2020- increased phosphorus levels can cause excessive macrophyte and periphyton grown, increasing organic matter and turbidity, while decreasing dissolved oxygen content. This exceptional growth of epilithic algae on rocks was noted on the few rocks that were visible in the lower stretch of Palmer Brook, which are ultimately increasing the retention of fine particulates, further reducing the quality of juvenile salmon habitat.

In 2003, HRAA created a project titled *Pine Valley Mini Home Park Community Action*. HRAA looked specifically at Pine Valley sewage lagoon as an isolated problem and hoped to alleviate Palmer Brook's *E. coli* problem by addressing the community. Investigation into the Palmer and Colton watershed uncovered wider problems. HRAA initiated community meetings and visited with Quispamsis Town Council to outline stakeholder discoveries. Suggested action items included complete water quality testing surrounding lagoon and constructing wetlands around the lagoon to naturally treat effluents- these action items were unfortunately deemed unnecessary until such time as water sampling shows unequivocally that lagoons are exceeding accepted parameters. Lagoon connection to municipal system action item was also deemed unnecessary until such a time that sampling shows lagoons exceed accepted parameters.

Tidal Zone Tributaries
Palmer Brook

Figure 193 & 194- aquatic plants found in Palmer Brook. *Photos: S. Blenis*

Spatterdock, as seen in **Figure 193** dominates the lower stretch of Palmer Brook. Spatterdock is not considered invasive; however, its extensive rhizome system allows it to grow and reproduce rapidly if not managed. Rapid growth occurs in shallow water bodies when there is an excess of nutrients allowing the plants to completely cover the surface in just a few years and control becomes necessary. Potential nutrient sources include runoff from numerous sources, including lawns, agricultural fields, waste from livestock, pets and wildlife, and poorly functioning septic systems. Dense growth of spatterdock in shallow water areas can interfere with boating and other forms of recreation and causes light reduction and oxygen depletion that can kill fish or other plants.

Dense mats of native milfoil are also a predominant aquatic plant in the lower stretch of Palmer Brook. Much like the spatterdock, these dense mats also reduce light and deplete oxygen in the tributary. Given the close proximity to a known location of Invasive Eurasian Water Milfoil (EWM) at Darling's Lake, plus the higher boat traffic near the mouth of Palmer Brook, and its ability to spread through fragmentation, introduction of EWM into the Palmer Brook system should be carefully monitored.

Benthic algae mats, as seen in **Figure 195** were also documented throughout the lower reach of Palmer Brook, and a SPATT collector was installed at the confluence point, to determine if cyanobacteria was present within Palmer Brook. While the results have not yet been determined from the cyanobacteria study, it is recommended that Palmer Brook continue to be monitored and sampled in the upcoming years.

Tidal Zone Tributaries
Palmer Brook

Discussion: Unfortunately, Palmer Brook remains the most stressed tributary within the Hammond River watershed. Intensive steps must be taken in order to slow the rate of degradation.

In 2003, HRAA staff noted that "high levels of sedimentation and its adverse impact on fish health is of major concern in the Hammond River watershed. Palmer Brook suffers the highest level of sediment loading in the Hammond and is believed to be derived from industrial land developments in the Hammond River Industrial park. Bradley Brook also contributes to sediment loading, as residential development has led to partial or full removal of riparian zone vegetation. The contributions of these brooks, combined with lesser contributions of erosion throughout the watershed, cause the river to turn brown and greatly reduce habitat quality during heavy rain events" (*2003 ETF Final Report*).

The implementation of a responsible waste management plan should become the forefront of discussion- is it possible to eliminate the sewage lagoon, and have the trailer park connected to a municipal sewage treatment facility? It would be a worthwhile investigation to collect water samples from Palmer Brook below the sewage lagoon after heavy rain events, and periodically throughout the year, to determine its overall impact on E. coli and fecal coliform impacts on the brook.

Examining Palmer Brook should also happen in tandem with investigations in Colton Brook, which is a tributary of Palmer Brook, as well as the Renforth Pit Lake, to determine their collective impact on Palmer Brook's degradation and update the findings and methods that were explored in 2003 and the 2018 *Bridging the Gap Report*.

Figure 196. Degraded riparian zone lower Palmer Brook. *Photo: S. Blenis*

Riparian restoration at the lower end of Palmer Brook must become a focus. In the past, HRAA has replanted the baren flood plain field with over 30,000 trees; however, this undertaking has had minimal success, due to ice shears in the spring freshet. In 2020, HRAA staff proposed a project to plant shrubs, not trees, along this stretch of Palmer Brook, in hopes that it will mirror the upper shrubbed area of Palmer. The project, *Cutting Hedge Technology: Using Shrubs to Sequester Carbon and Restore Palmer Brook* will begin in the spring of 2021, and will plant 1500 native shrub species, while taking 96 core soil samples for analysis.

Tidal Zone Tributaries
Colton Brook

Site Characteristics: Colton Brook can be described as an "urban brook", as this stretch exists almost entirely within a subdivision and residential area in Quispamsis. It flows through a large matrix of culverts, most of which are in fair condition; however, there are several that require repair. This brook is fairly stressed, as it is under pressure from land development due to a high density of gravel pits, development, and roads.

A habitat assessment was not complete during the 2020 season, nor was water quality or benthic macroinvertebrate studies- this brook was outside of the original 2020 Watershed Management Proposal. Colton Brook was also not included in the *2008 Watershed Management Plan*, or the *2015 Watershed Management Plan*; however, it was included in the *Bridging the Gap Report*.

The *Bridging the Gap Report* noted that this brook received a moderately stressed rating, due to surrounding land use and development. It also noted that *E. coli* greatly exceeded acceptable levels by 505%.

Moving forward, it would be worthwhile to conduct additional water quality samples, particularly *E. coli*. Colton Brook converges with Palmer Brook, a major tributary of the Hammond River, which has had many *E. coli* exceedances over the past decade. Determining the source of *E. coli* and working with the town of Quispamsis to develop an action plan, should be a priority. There exists a fairly large data gap on Colton Brook, and HRAA should seek to remediate this in the future, so we can have a clear picture of what is happening in this brook. It may also be worthwhile expanding the water quality sampling to explore salinity (given proximity to road/road salts), microplastics, and soil sample analysis for bioaccumulation of polychlorinated biphenyl (PCB) and hydrocarbons.

Figure 10. Urban Colton Brook, in close proximity to the road.
Photo: S. Blenis

Figure 197 Colton Brook

Tidal Zone Lakes
Bradley Lake

There are 2 interconnected lakes that make up the Bradley Lake area. During our site visit, HRAA staff spoke with a landowner, who described an industrial dumping operation into the lake that occurred in the early 1990's. According to this landowner, it made the lake toxic, and resulted in fish kill. Staff have yet to find any supporting evidence of this report; however, the search for additional information is on-going. This landowner also related that after the fish kill incident, the lake became overpopulated with Brown Bullhead. Bradley Lake is surrounded by multiple mining and quarry operations, as well as multiple cabins and residential dwellings. An in-depth water quality sampling program is warranted at this location, as well as landowner engagement- it may be possible that this lake is contributing to E. coli levels in Bradley Brook. This lake will be included as part of the 2021 *Lake Assessment*, and it will be interesting to determine the fish community in this lake. This lake is also a high boat traffic area, and native milfoil can be found along the shorelines. Testing to determine if this lake has been exposed to Eurasian Water Milfoil is also warranted, as is raising awareness of Clean, Drain, Dry with the locals. **Figure 198**: Multiple docks along Bradley Lake. *Photo: S. Blenis*

Tidal Zone Lakes
Renforth Pit Lake

Figure 199. Renforth Pit Lake flows into Palmer Brook, and it visually appears to be the most stressed lake within the watershed. It is located near a large lumber and aggregate operation. It is unclear if this lake has ever been stocked, but it is doubtful that this lake provides acceptable fish habitat. This lake will be included in the upcoming *2021 Lake Assessment*. Given surrounding industrial activity, it is recommended that HRAA include an extremely vigorous water quality sampling program, including organic and inorganic parameters, and expanding to include microplastics, BTEX and hydrocarbons etc. There is a large amount of lumber (organic) debris in the lake; however, there are multiple long lengths of plastic pipe, roofing shingles, metal, and other sorts of garbage in the lake. The steep slope along the northern bank is experiencing a fair degree of erosion, and heavy rain events are depositing high levels of sediment into the lake. There is minimal vegetation surrounding the lake's edges, and summer water temperatures are anticipated to be high due to lack of crown closure and shade. *Photo: S. Blenis*

Tidal Zone Lakes
Renforth Pit Lake

In 2008, HRAA created a project titled *Adult Education and Outreach: Integrating Community Stakeholders* (Executive Director Tom Benjamin). Throughout the spring of 2008, Palmer Brook, one of the Hammond's few C Class brooks continued to run brown with run-off from industrial sites upstream.

On April 29th, landowners, stakeholders, and government representatives from DFO, DENV, DNR, and municipal officials from the Town of Quispamsis attended the Palmer Brook Stakeholders meeting. Two major sources of sedimentation on Palmer were identified, and major work by landowners, HRAA volunteers, and High School Students was underway.

Renforth Pit Lake was one of the main sources of sedimentation running into Palmer Brook. Action instigated by DENV resulted in landowner's major renovation of the site, and coupled with planting by HRAA volunteers, resulted in new fish and wildlife habitat instead of causing a net detrimental effect to wildlife. There is a solid area of successful riparian vegetation surrounding the outflow tributary of this lake, and there is still an HRAA Riparian Restoration sign in the area, 12 years later.

Figure 200 a shows the site in February 2008, before work had begun. **Figure 200 b** demonstrates the same view in July 2008 after major restoration work. **Figure 200 c** shows the same view, only in July of 2020, 12 years after project completion.

There has been a significant shift in the land surrounding the overflow culvert; it would be reasonable to believe that this site is continuing to deposit large amounts of sediment into Palmer Brook, based on the eroding slopes seen in Figure 10.

Additional work and assessments need to be performed at this location, including in-depth water quality analysis, and a possible sediment study. Conversations with the landowner should be resumed, especially concerning the inorganic debris that is entering the lake. Taking a cue from past HRAA executive, a Palmer Brook Stakeholders Meeting should happen again in the near future.
Photos: S. Blenis

Confluence Zone

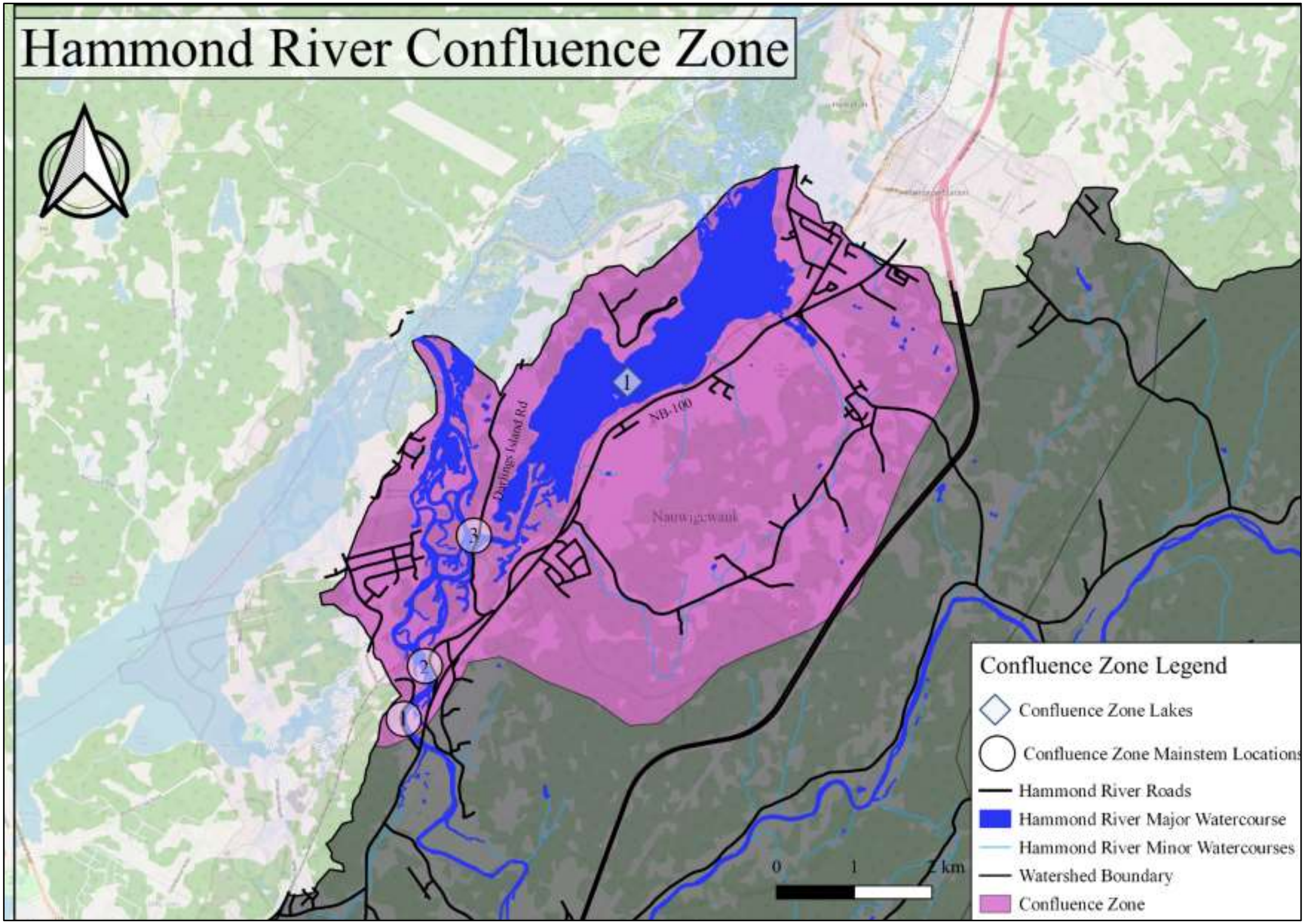
"Some in the sport say that fishing for words is pointless. Just call me a fisherman; we all know what that is,"- Joan Wulff
Photo: Darlings Lake. Provincial Archives NB

Confluence Zone Legend & Work Complete (2020)

Site Name	GPS Location	Area Surveyed (m)	WQ	E-Fish	Redds (#)	e-DNA	BMI	Culvert Assessment
MAIN STEM								
1. Turn Pool	45.460543 -65.909815	500m	YSI	No	No	No	No	No
2. Bull Interval Pool	45.4608085 -65.908737	500m	YSI	No	No	No	No	No
3. Darlings Lake Confluence	45.481851 -65.898166	600m	YSI	No	No	**Positive**	No	No
LAKES								
I. Darlings Lake	45.491533 -65.885198	Eurasian Water Milfoil Assessment-Full Lake	No	No	No	No	No	No

Table 5 Confluence Zone Work Complete

Confluence Zone Map



Confluence Zone Main Stem
Turn Pool

Figure 203. Looking downriver of Turn Pool. *Photo: J. Kelly*

Site Characteristics: An aptly named pool given that it is an almost a 90˚ turn, Turn Pool is a deep, stunning pool.

Substrate: The substrate is a mix of cobble (25%), gravel (25%), sand (25%) and silt (25%), and the substrate is <20% embedded.

Flow: Gentle flow during the summer months due to shallow water conditions and low slope. Higher velocity in the spring freshet.

Water Classification: Class A. No point source pollution; all water quality parameters are well within acceptable limits for aquatic life.

Flow Type: The site is primarily a run (90%), with a smaller pool (10%), and its sinuosity is 75% straight and 25% winding.

Bank Stability: There is a fair amount of erosion occurring in this location. The left bank is bare stable (20%), with erosion (30%), and the right bank is bare stable (30%) with erosion (20%). Both banks have a degree of undercutting, with the left more substantial, at 35% undercut, and the right being 5% undercut.

Crown Closure: There is an adequate amount of crown closure, due to overhanging vegetation on the left bank (10%) and the right bank (25%), providing approximately 35% shade to the pool.

Riparian Vegetation: The riparian vegetation is a mix of trees (70%) and grasses (30%), as part of the pool is in an agricultural zone. Increasing the riparian buffer would substantially assist in reducing sedimentation and would provide additional shade to the pool.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Confluence Zone Main Stem

Bull Interval Pool

Figure 204. Looking down river towards the train bridge from Bull Interval Pool. *Photo: J. Kelly*

Site Characteristics: A beautiful, deep, wide pool near the end of the Hammond River watershed.

Substrate: The substrate is a matrix of bedrock (5%), boulder (20%), cobble (30%), gravel (35%) and silt (10%)

Flow: Flow fluctuates with the tides but is generally a leisurely flow. Increased velocity during heavy rain events, and in the spring freshet.

eDNA: A sample was taken near the mouth of Darlings Lake, just down river from Bull Interval Pool, and came back positive for salmon DNA.

Flow Type: The site is equally a run (50%) and pool (50%), and its sinuosity is 60% straight and 40% winding.

Bank Stability: The left bank can be described as bare stable (50%), with no undercut banks, and the right side is severely eroding (50%) and has equally undercut banks on the right side (50%).

Crown Closure: The left bank provides decent crown closure with 40% overhanging vegetation; the right side, however, has 0% overhanging vegetation, as it is a hay field. This gives approximately 35% crown closure over the pool.

Riparian Vegetation: The left bank is mature conifers. The right bank is agricultural grass and hay and offers little bank stabilization or shade to the pool.

Riparian Rating: At Risk. The current condition of the riparian zone falls within the good to fair rating; however, increased degradation may rapidly reduce the riparian rating. These sites are typically found in agricultural land, and areas under high developmental stress.

Water Classification: Class A. No point source pollution. Water quality is within acceptable limits to support aquatic life.

Data Analysis

1. Benthic Macroinvertebrate Analysis

Tallies were converted into their numeric form using the Hilsenhoff Biotic Index Equation, and community composition was broken into percentages based on order abundance. Next, a tolerance value was assigned to each order. Tolerance values range from 0-10, with the lowest value (0) indicating a species that has very low tolerance for organic waste and the highest value (10) indicating a species that has a very high tolerance for organic waste.

Tolerance values are typically assigned at either an order or family taxonomic level; however, in this survey, organisms were identified mostly to an order level, and occasionally to phylum (i.e.: Annelids, Mollusca). In the instance of Diptera, tolerance values are extremely variable amongst different species. Diptera has been assigned a Tolerance Value of 7, based on calculating an average of Tolerance Values available for Diptera. Annelids have been assigned a Tolerance Value of 5, using an average of only similar families to the species we were finding because the phylum is so broad.

Next, the percentage values and Hilsenhoff Biotic Indexes (HBI) were compared against the Benthic Macroinvertebrate aggregate assessment. A series of parameters, designated by EcoSpark, were used to create an overall assessment on stream health using the presence, absence, and diversity of species of the community found at the given location. Subsequently, three sets of data modeling were produced per location: Hilsenhoff Biotic Index (1), Benthic Macroinvertebrate Aggregate Assessment (2) and plot overall community composition findings (which can be found throughout this book in their respective site chapters).

Each category within this assessment can indicate certain conditions. A high proportion of worms and aquatic sowbugs suggest that a site is enriched with organic matter, and in the case of worms likely receiving some form of organic pollution. A high percentage of midges may indicate poor water quality or that water quality does not support a healthy community. Midges and worms indicate a poor diversity in environmental stream conditions because they both have a competitive advantage over other BMI organisms due to higher rates of reproduction, higher growth rates and are smaller individual body size. An abundance of snails can indicate low dissolved oxygen as they can surface and breathe using their lungs. The number of taxonomic groups will reflect the variety of habitat available, so if taxonomic diversity is low this often indicates pollution will can limit environmental conditions. The proportion of the population can also indicate healthy or poor conditions, depending on the species. For instance, a high proportion of caddisfly can indicate a healthy environment whereas a high proportion of leeches can indicate poor environmental conditions. A high proportion of mayfly, stonefly, and caddisfly is good because they are typical of environments high in dissolved oxygen and high-quality stream environments. Flies and insects are present in every environment and when present in relatively high or low abundance can also indicate impaired stream quality. (EcoSpark 2013).

Data Analysis

Benthic Macroinvertebrate Analysis

1) **Hilsenhoff Biotic Index Equation:** The sum of all tolerance values multiplied by # found per order / total # of BMIs collected.

$$\textit{Biotic Index} = \frac{\sum(n_i \times a_i)}{N}$$

KEY

N = Total number of individuals collected

n_i = Number of individuals of a species

a_i = Tolerance rating of a species

The Hilsenhoff Biotic Index Value can then be used to determine water quality and the degree of organic pollution.

HBI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

2) Benthic Macroinvertebrate Aggregate Assessment: A series of parameters designated by EcoSpark to create an overall assessment on stream health using the presence, absence, and diversity of species of the community found at the given location. If 5 or more of these indices are calculated to be outside of the “Unimpaired” parameters, the site is considered to be potentially impaired.

Index	Impaired	Potentially Impaired	Unimpaired
Worm (%)	>30	10 to 30	<10
Midge (%)	>40	10 to 40	<10
Sowbug (%)	>5	1 to 5	<1
Taxonomic Groups (#)	≤11		>11
Snail (%)		0 to >10	1 to 10
Dominant Group (%)	>45	40 to 45	<40
Mayfly, Stonefly & Caddisfly (%)	<5	5 to 10	>10
True fly (%)	<15 or >50	15 to 20, or 45 to 50	20 to 45
Insects (%)	<40 or >90	40 to 50, or 80 to 90	50 to 80
Hilsenhoff Biotic Index	>7	6 to 7	<6

1. Benthic Macroinvertebrate Analysis

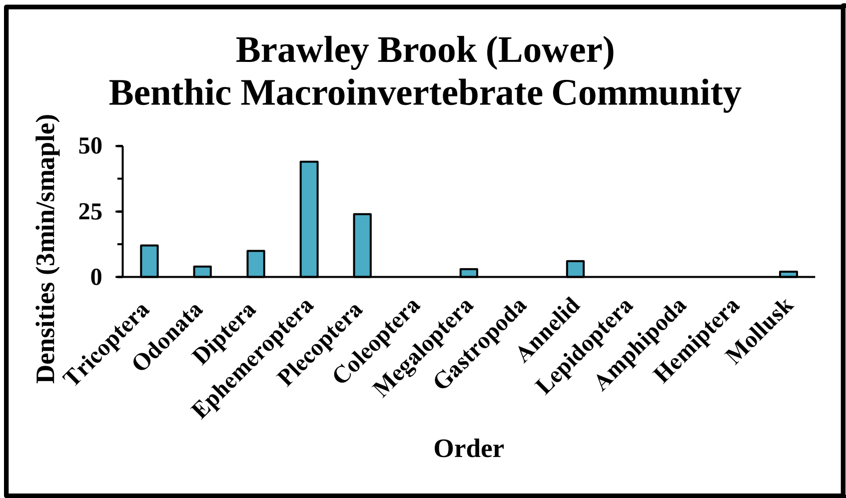
3) **Benthic Macroinvertebrate Assessment- Comparison Between Sites.** The rule of using the EcoSpark BMI Aggregate Assessment is that if you have 5 or more "potentially impaired" or "impaired" indices, the site is classified as being overall Potentially Impaired; however, given the volatility of the criteria designated "potentially impaired", we have chosen to separate the BMI Aggregate Assessment to include one set of results as Impaired Only, and the other represents Impaired + Potentially Impaired.

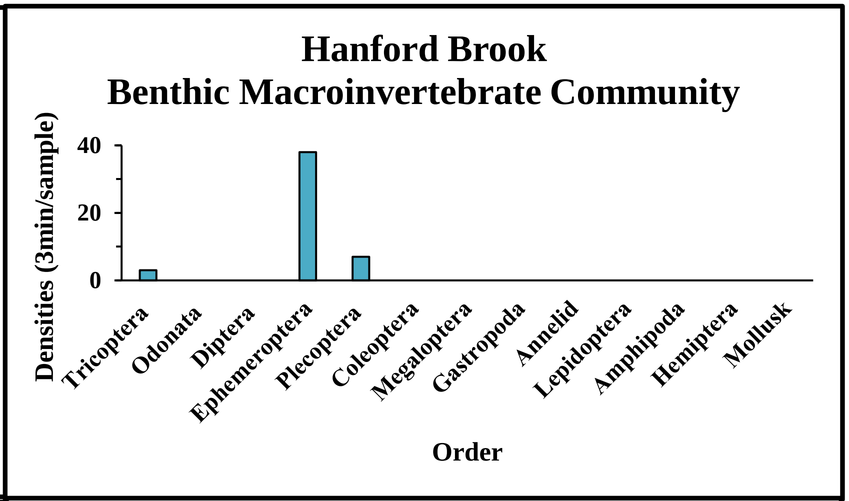
Site Name	**HBI Value**	**Aggregate Assessment (Impaired Only)**	**Aggregate Assessment (Impaired + Potentially Impaired)**
Bradley Brook	3.94	Healthy	Healthy
Palmer Brook	5.60	Healthy	Potentially Impaired
Scoodic Brook	5.34	Healthy	Healthy
Donnelly Brook	4.10	Potentially Impaired	Potentially Impaired
Hanford Brook	4.35	Healthy	Potentially Impaired
Brawley Brook Upper	2.65	Healthy	Potentially Impaired
Brawley Brook Lower	4.17	Healthy	Potentially Impaired
Fowler Brook Upper	4.79	Healthy	Potentially Impaired
Fowler Brook Lower	4.68	Healthy	Potentially Impaired
Mine Discharge Brook	4.97	Healthy	Healthy

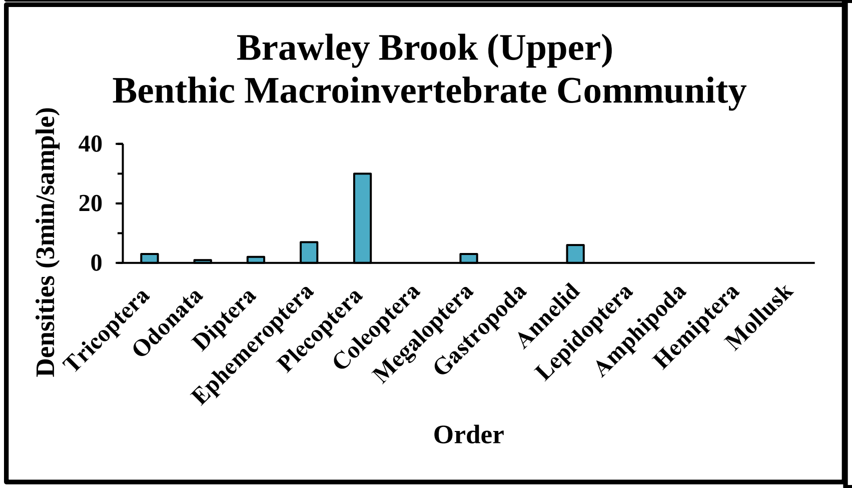
Table 6 BMI Aggregate Assessment

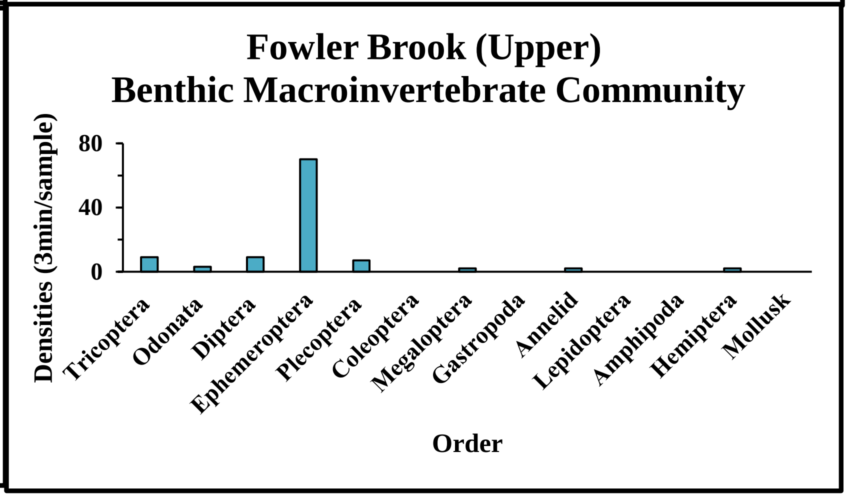
It should be noted that Donnelly Brook yielded very few BMIs compared to all other locations including a sampling round where 0 invertebrates were found with the Kick net. In the future, observing BMIs lower in the tributary where there may be a more established community may lead to a more representative result of the BMI community within the tributary.

1. Benthic Macroinvertebrate Analysis

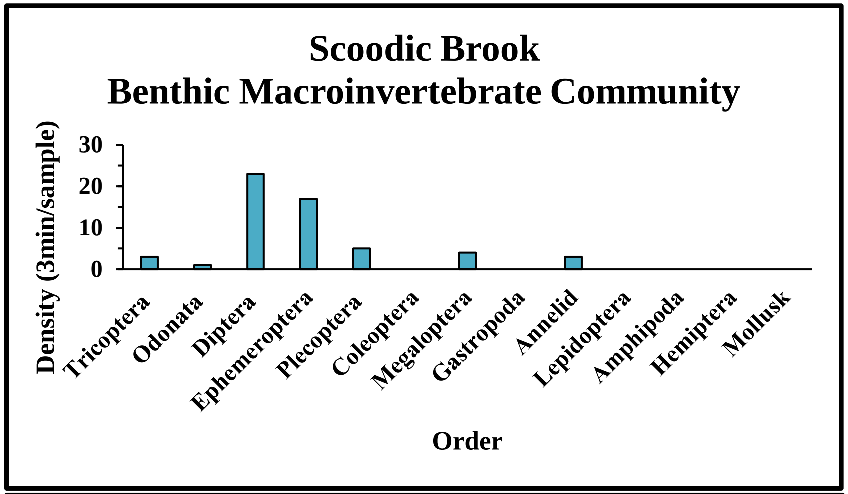


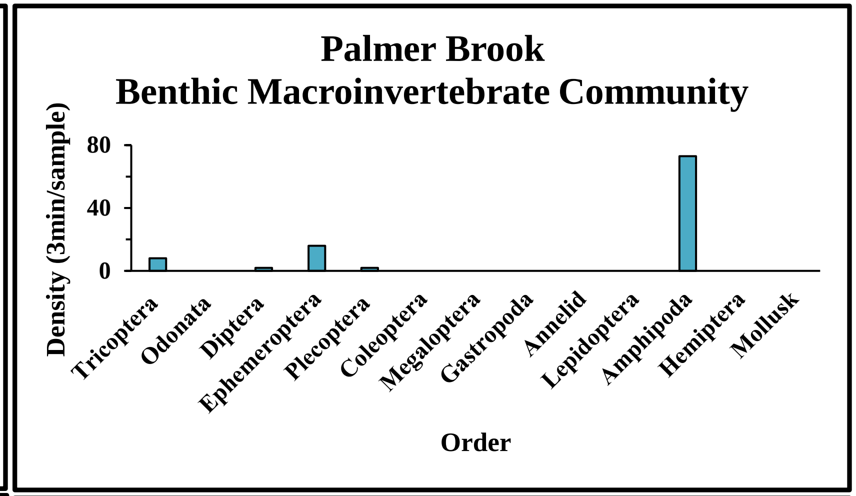


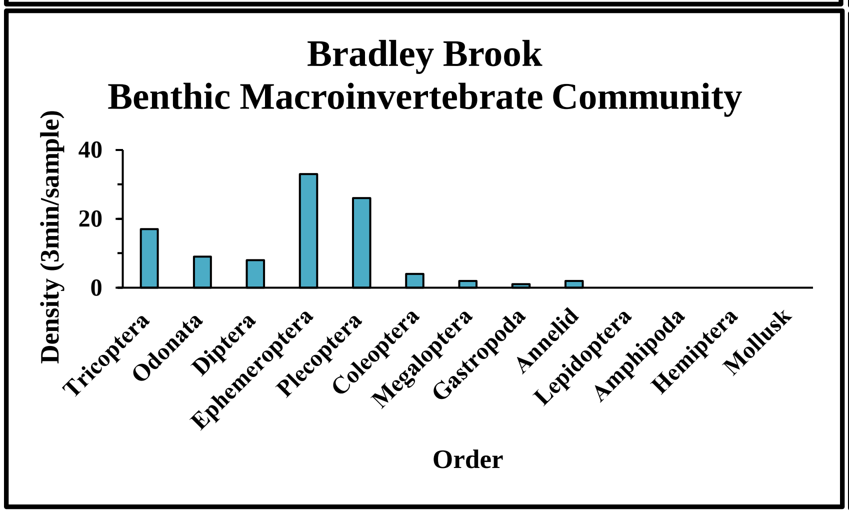


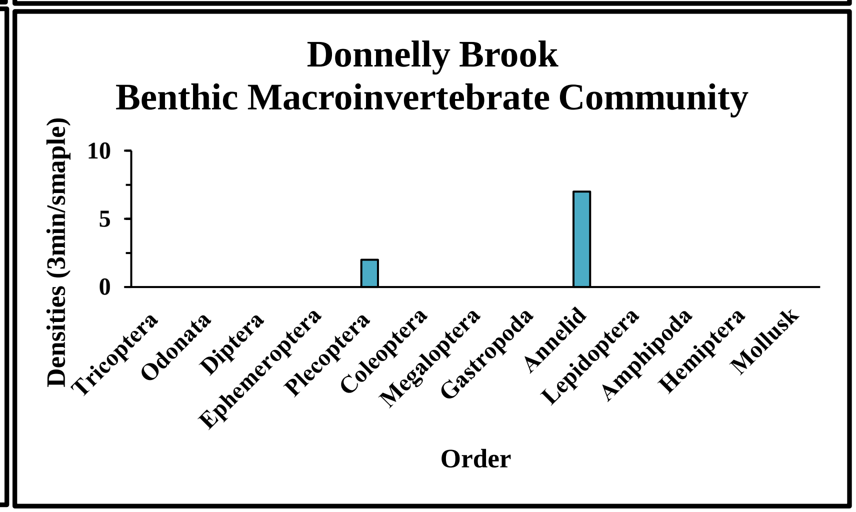


1. Benthic Macroinvertebrate Analysis

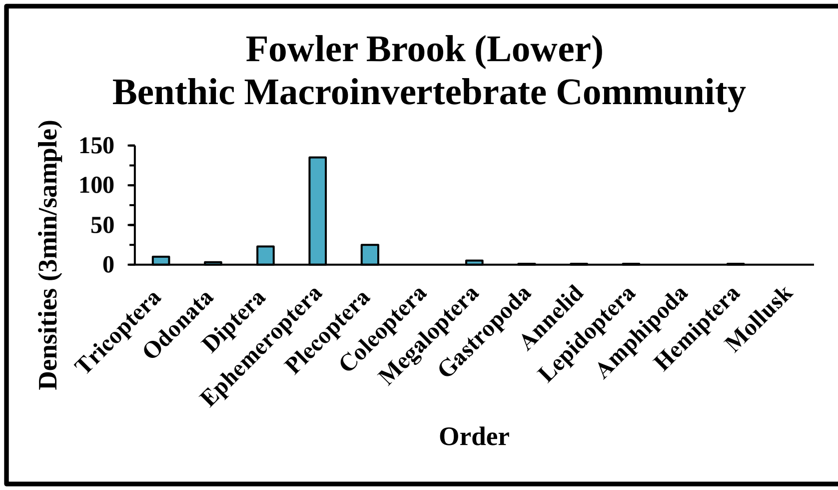


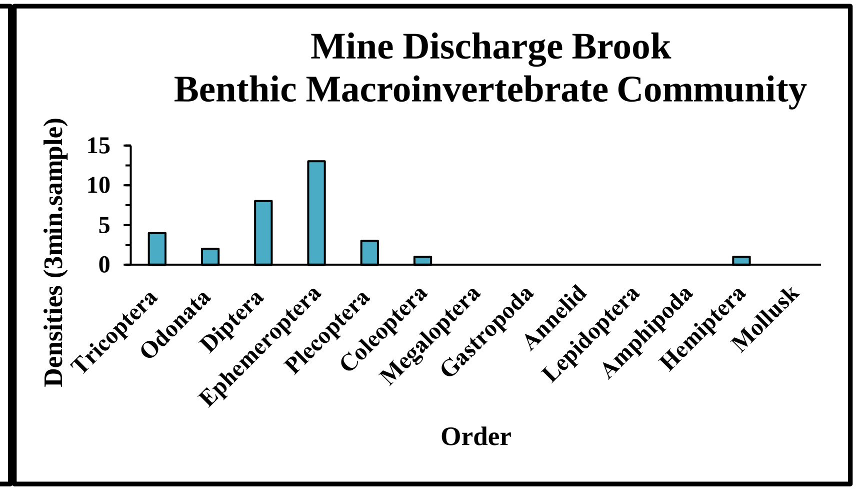






1. Benthic Macroinvertebrate Analysis





Overall, the results found in our BMI study point to the Hammond River watershed tributaries generally having healthy benthic macroinvertebrate communities. Species that typically are representative of healthy stream communities such as *Ephemeroptera* (Mayflies) and *Plecoptera* (Stoneflies) were extremely common among most tributary communities and were reflected in the Hilsenhoff Biotic Index values. *Diptera* were also very common, which typically are tolerant to a lower quality environment and were often the order found to offset otherwise extremely healthy communities. Sources of interest also include our Palmer Brook sample, which was alarmingly rampant with *Amphipoda* (Scuds or Sidewimmers), could this have simply been a hotspot of *Amphipoda* or was this indicative of the overall community? In the future, a study covering a larger area of each tributary may help reach a better understanding of these communities, particularly in instances such as Donnelly Brook and Palmer Brook.

Using the Hilsenhoff Biotic it was determined that the BMI community in the upper region of Brawley Brook is in Excellent condition. Bradley Brook, Donnelly Brook and Hanford Brook and the lower region of Brawley Brook all host Very Good BMI Communities. The BMI communities in Scoodic Brook, Mine Discharge Brook and both areas of Fowler Brook sampled (Upper and Lower) were ranked as Good. Palmer Brook was ranked as having a Fair BMI community.

Data Analysis

2. Water Quality Analysis

The Canadian Water Quality Index (CWQI) provided by the Canadian Council of Ministers of the Environment (CCME) is a means to summarize large amounts of water quality data into simple terms (CCME, 2001). The Index is a series of calculations combining multiple parameters to produce a value for each site based on:

i. The number of parameters that exceed guidelines
ii. The number of times guidelines are exceeded
iii. And the amount by which they are exceeded

For the most accurate measurements, sites should be visited at least 4 times, where at least 4 parameters are monitored. Our results are derived from 13 different parameters selected based on general water quality and water chemistry indicators (see list below). Each site was visited at minimum 4 times, with most sites being monitored more than the minimum requirement.

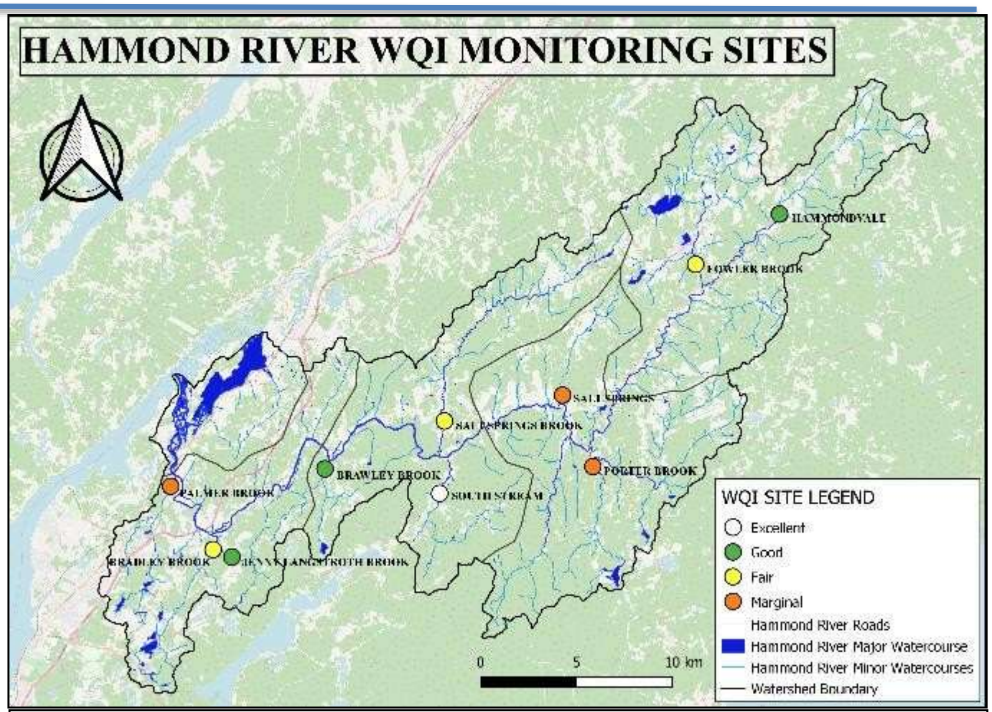


Figure 205 water quality sites within the Hammond River watershed. *Figure: J. Kelly*

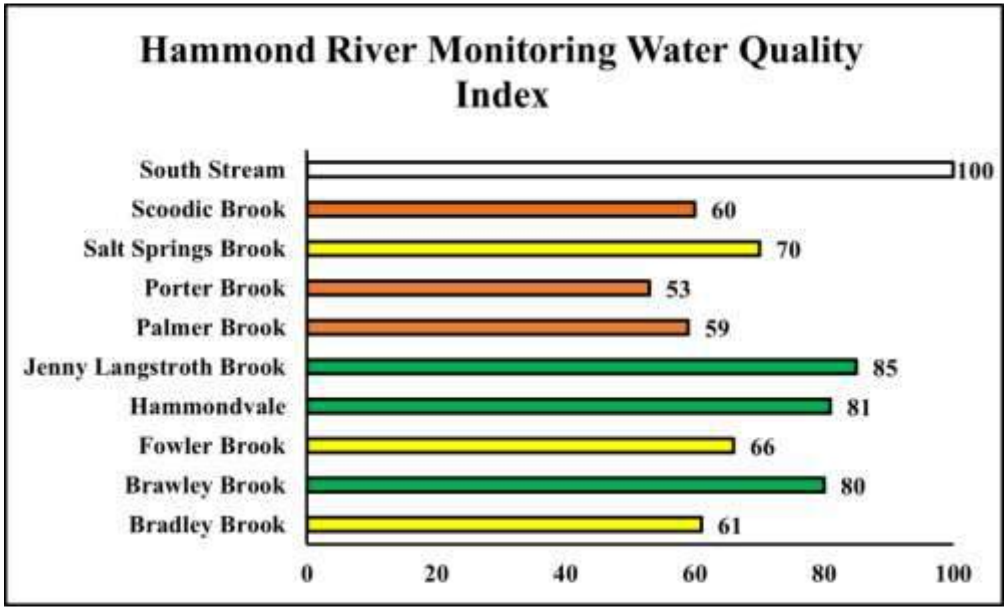
Parameters used in our WQI calculations:

- Conductivity
- Colour
- Turbidity
- DO
- pH
- Alkalinity
- Calcium
- Sodium
- Magnesium
- Potassium
- Sulphate
- Aluminum
- Iron
- *E. coli*

Other general chemistry data was taken; however, lab limitations prevent some data from being precise enough to be used in the calculations which were instead omitted.

Data Analysis

2. Water Quality Analysis



WQI Value	Rating	Degree of Impairment
0-44	Poor	Aquatic life is threatened, impaired, or even lost
45-64	Marginal	Aquatic life frequently may be threatened or impaired
65-79	Fair	Aquatic life is protected, but at times may be threatened or impaired
80-94	Good	Aquatic life is protected, with only a minor degree of threat or impairment
95-100	Excellent	Aquatic life is not threatened or impaired

Table 17. Canadian Council of Ministers of the Environment Water Quality Index Guide For the Protection of Aquatic Life. *Table: J. Kelly*

Of the 10 tributaries with sufficient data for the WQI calculation, 0 were categorized as being Poor (0-44), a category which would be achieved if measurements generally exceeded water quality guidelines by a considerable margin.

Palmer Brook, Scoodic Brook and Porter Brook all were ranked as being Marginal (45-64), a category reserved for measurements that frequently exceed water quality guidelines by a considerable margin.

Bradley Brook, Salt Springs Brook and Fowler Brook all were ranked Fair (65-79), meaning that measurements sometimes exceed water quality guidelines and, probably, by a wide margin.

Brawley Brook, Jenny Langstroth Brook and Hammondvale were ranked as Good (80-94), reserved for measurements that rarely exceed water quality guidelines and, usually, by a narrow margin.

South Stream was the sole tributary monitored within the Hammond River watershed to earn a ranking of Excellent (95-100) indicating that the measurements never or very rarely exceed water quality guidelines.

Data Analysis
2. *E. Coli* Analysis

Tributaries in the Hammond River watershed were measured for *Escherichia coli* up to 5 times based on recommendations of U.S EPA water quality criteria to calculate a geometric average.

E. coli measurements were geometrically averaged, including standard deviation bars for each site calculated, then graphed. The red bar is indicative of the 200 cfu/100ml limit for recreational use of the watercourse. Sites tested any number of times below this threshold were analyzed for *E. coli* exceedances using the single sample concentration value of 400 cfu/100ml.

Overall, the geometric averages calculated were all below the exceedance value of 200 cfu/100ml. As indicated by the standard deviations, this is not to suggest that *E. coli* measurements are consistently below acceptable levels for a variety of potential reasons.

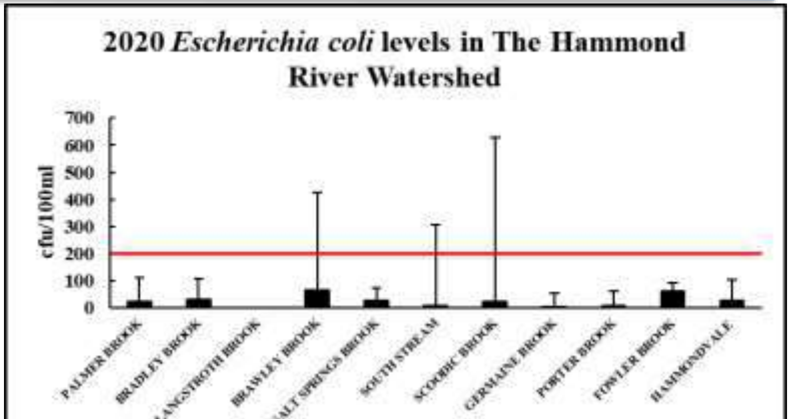


Table 18. *Figure: J. Kelly*

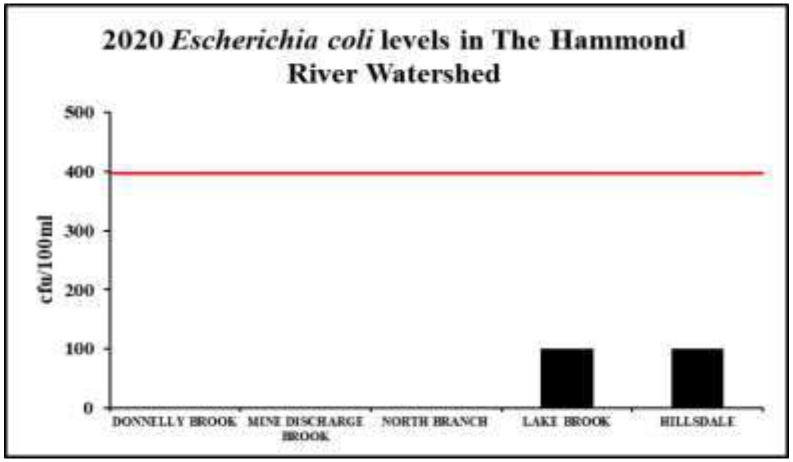
E. coli guideline in fresh water (cfu=colony forming units)	• Geometric mean (minimum of 5 samples) ≤ 200 cfu/100 mL • Single sample maximum concentration ≤ 400 cfu/100 mL (based on 1986 U.S. EPA water quality criteria with acceptable GI illness risk level of 0.99%)

Scoodic brook shows extreme amounts of variance. This is likely due to an isolated event that increased *E. coli* within the watercourse instead of a consistent presence of the bacteria. It is known that a landowner along this brook has allowed cattle into the water, making this a likely possibility. It is worth noting that these drastic jumps in *E. coli* can be the result of a variety of factors including storm run-off, even when cattle are prevented from directly contacting the watercourse.

South Stream and Brawley Brook yielded similar results to Scoodic Brook, with a single event of high *E. coli* creating a massive variance. HRAA will need to look further into the origin of these *E. coli* spikes in the future before reaching any conclusions. Brawley Brook, while still below the recommended exceedance value, was the most consistent *E. coli* containing watercourse within the watershed based on our results. Brawley Lake will be considered a priority lake to investigate, and the HRAA will attempt to work with residents along these lakes and tributaries on proper septic maintenance and education.

Data Analysis

2. *E. coli* Analysis



Of the tributaries sampled below the sufficient number of times to calculate geometric averages, there were no exceedances recorded. The red line represents the single sample exceedance value.

Tributaries sampled under 5 times include Donnelly Brook, Mine Discharge Brook, North Branch, Lake Brook, and main stem Hillsdale Bridge Pool.

In the future, these tributaries will need to be monitored consistently to build a more conclusive database on *E. coli* levels within the Hammond River watershed.

Recommendations for Future E. coli Sampling: Outside of the index sites, we recommend expanding our *E. coli* monitoring to include the following locations: Lake Brook, Hillsdale, Brawley Lake, lower South Stream (towards confluence point), O'Dell Brook, McGonagle Brook, Hanford Brook, and Bater Brook. These selected areas have potential livestock access to the watercourses and increasing our sampling would provide us with a more robust data set.

Data Analysis

3. Electro-Fishing Analysis

Introduction:

The Hammond River is one of the last rivers in the southern New Brunswick – Bay of Fundy region with a returning Atlantic salmon (*Salmo salar*) population, with its own unique genetic composition. Monitoring of this population is important to identify and respond to trends, particularly in the recruitment (*i.e.,* survival of young to a certain stage) of juveniles to the watershed (512 km^2). Accordingly, the HRAA has assessed fish densities of the Hammond River through electrofishing surveys and has established an ongoing time series of baseline levels from 1979 to present. These historical data have provided valuable information on production and overall health of the salmon population as well as other endemic fish species (*e.g.,* brook trout, American eel) towards effective and responsible watershed management.

The project had three objectives, as follows:

i. To assess juvenile salmon (and other fish) populations in the Hammond River watershed at 12 locations (4 locations had multiple surveys), for a total of 18 sites, using electrofishing surveys;
ii. To determine and compare fish densities at the respective sites; and
iii. To compare to current densities to those of historic data.

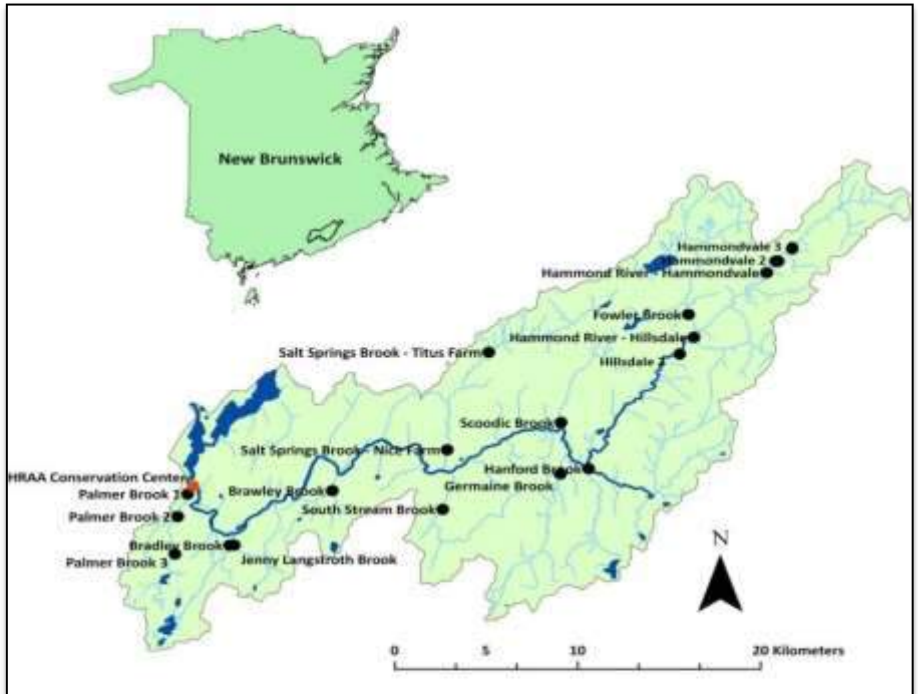


Figure 206. Map of Electro-fishing sites. *Map: S. Blenis*

Methods for the electro-fishing survey have been previously discussed in the Methods chapter of the *Watershed Management Plan 2020.*

Data Analysis

3. Electro-Fishing Analysis

Results:

Sites were electro-fished on September 9th, 14th, 16th, 20th, 21st, 22nd, and 24th. HRAA staff were given an invaluable 1-day field training session with Board of Director, Bruce Moore, to ensure that staff were conducting the survey properly (for both the safety of the fish and themselves!). S. Blenis was the primary electro-fisher, while J. Kelly was able to use the backpack on 2 occasions; Office Manager, Melissa Crilley, stepped in and assisted the project as a netter, and did a phenomenal job catching fish!

12 historic electro-fishing sites were selected, and 4 of these sites were further broken down into additional 100m² survey areas, for a total of 18 100m² sites surveyed. Water quality data was collected at each site in advance of electro-fishing. The water temperature ranged from 10˚to 17.1˚, with an average temperature of 13.4˚, well within acceptable temperature limits as to not add additional stress to the fish. Dissolved oxygen ranged from 7.16mg/L to 11.6mg/L, with an overall average of 8.62mg/L. Conductivity ranged from 46.5µs/cm to 1802.4 µs/cm, with an overall average of 325.94 µs/cm. pH ranged from 5.34 to 8.28, with an overall average of 7.19. On average, the frequency of the electro-fishing backpack was set at 60Hz, voltage ranged from 350V to 450V (with the exception being at Salt Springs Brook, which has exceptionally high conductivity, and required lower voltage at 150V), and the overall average effort was 542.89 seconds per site.

The population assessment found a total of 14 fish species dispersed throughout the watershed, with total fish count being 708.

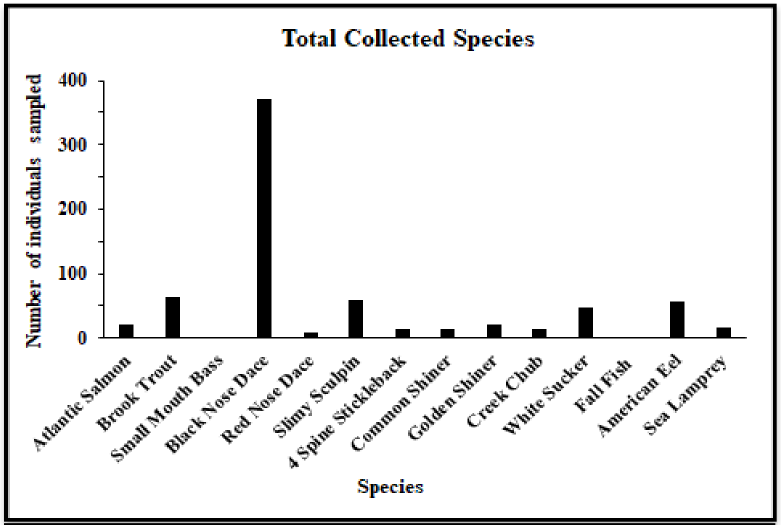


Table 19. Total collected fish species. *Figure: J. Kelly*

Data Analysis

3. Electro-Fishing Analysis

Similar to previous years, Black Nose Dace (*Rhinichthys atratulus*) was the most abundant fish during the electro-fishing survey, comprising 52% of fish assemblage. The next most abundant species was Brook Trout (*Salvelinus fontinalis)* making up 9.2% of the fish community; Slimy Sculpin (*Cottus cognatus*) with 8.5%; American Eel (*Anguilla rostrata*) with 8%; White Sucker (*Catostomus commersonii*) with 6.6%; and Atlantic Salmon (*Salmo salar*) with 2.8%. Other fish species found included Common Shiner (*Luxilus cornutus*) include Creek Chub (*Semotilus atromaculatus*), Lamprey (*Petromyzon marinus*), Stickleback (*Gasterosteidae* sp.), Fall Fish (*Semotilus corporalis*) Golden Shiner (*Notemigonus crysoleucas*) Red Belly Dace (*Chrosomus eos*) and Small Mouth Bass (*Micropterus dolomieu*). **Table 21** demonstrates the total collected species in the 2020 Electro-fishing survey, once we have removed Black Nose Dace from the equation, in order to better see the remaining fish community.

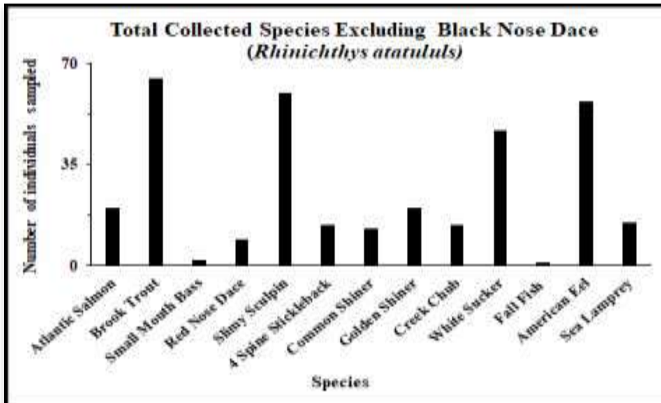


Table 20. Fish species observed, excluding Black Nose Dace. *Figure: J. Kelly*

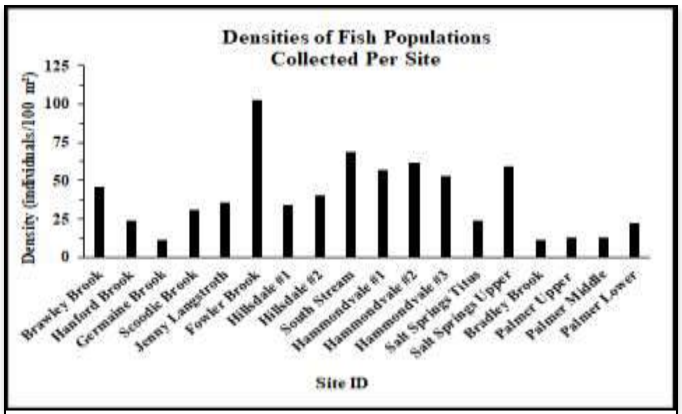


Table 21. Site-specific fish densities. *Figure: J. Kelly*

The top three sites with the highest site-specific densities were Fowler Brook (103/100m²), South Stream (69/100m²), and Hammondvale #2 (62/100m²). Historically, the Jenny Langstroth has, on average, been the top site for site-specific densities; however, this year, it dropped to being the 9th overall (36/100m²). The sites with the lowest site-specific densities were Lower Palmer Brook (22/100m²), Middle and Upper Palmer Brook tied (13/100m²), and the overall lowest site-specific densities tied Bradley Brook (11/100m²) and surprisingly, Germaine Brook (11/100m²), which has historically been one of the top producers. Germaine Brook was the biggest surprise during the electro-fishing survey, as it normally has high fish densities, including juvenile Atlantic Salmon and spawning redds- this year, it contained neither. As such, an eDNA sample was taken in Germaine Brook, and did confirm salmon presence- changing the electro-fishing site in Germaine may help.

Data Analysis

3. Electro-Fishing Analysis

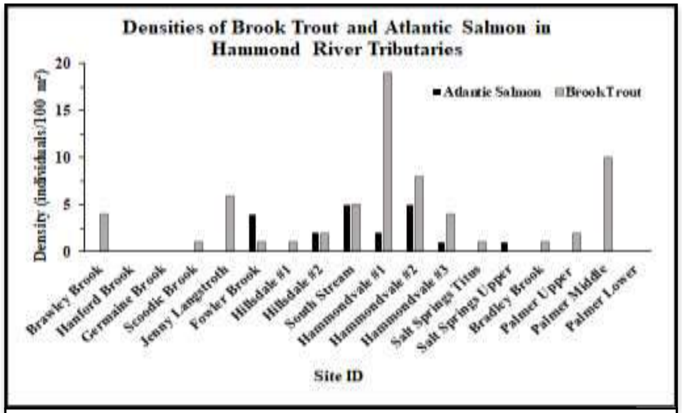


Table 22. Site-specific densities of Atlantic Salmon and Brook Trout. *Figure: J. Kelly*

During the 2020 Hammond River population assessment, juvenile salmon density (from the fry and parr stage) was, on average, 2.8 individuals per 100 m^2 for the 7 sites that contained salmon. Site-specific densities for Atlantic Salmon were tied for the highest at two sites, including Hammondvale #2 site (5/100 m^2) and South Stream (5/100m²). Fowler Brook contained the second highest density of salmon (4/100m²), while Hammondvale site #1 and Hillsdale site #2 tied for third (2/100m²), and Hammondvale site #3 and Upper Salt Springs each contained (1/100m²). A total of 10 sites did not contain Atlantic Salmon, including Germaine Brook, Hanford Brook, Scoodic Brook, Hillsdale site #1, Jenny Langstroth Brook, Lower Salt Springs Brook, Bradley Brook, and all 3 Palmer Brook sites. eDNA samples confirmed the presence of Atlantic Salmon in Germaine Brook; however, eDNA samples in Bradley Brook and all 3 Palmer Brooks came back negative for salmon DNA. eDNA samples were not taken in Jenny Langstroth, Hillsdale, Salt Springs, or Scoodic Brook. It is also interesting to note that while Lower Salt Springs did not produce any juvenile salmon during the electro-fishing survey, it had the highest site-specific density of salmon redds during the 2020 Redd Count Survey.

Site-specific densities of Brook Trout found that the Hammondvale #1 site had the highest density (19/100m²), followed by the Middle Palmer Brook (10/100m²), Hammondvale #2 site (8/100m²), Jenny Langstroth (6/100m²), South Stream (5/100m²), Hammondvale #3 site (4/100m²), Upper Palmer and Hillsdale #2 site (each had 2/100m²), and Scoodic Brook, Fowler Brook, Hillsdale #1 site, Lower Salt Springs Brook, and Bradley Brook each had 1/100m². Germaine Brook, Upper Salt Springs Brook, and Lower Palmer Brook did not yield any Brook Trout. Historically, the Jenny Langstroth has on average, usually contained the highest site-specific densities of Brook Trout- to see that it came third overall is a bit surprising. Another surprise is Fowler Brook; historically, it has on average been one of the top producers for Brook Trout as well. Germaine Brook is yet again a disappointment, perhaps the largest overall disappointment of the 2020 survey. This is usually a bountiful Brook Trout and Atlantic Salmon producing brook, and for the first time in years, it has had the lowest site-specific densities and completely lacking in trout and salmon.

Data Analysis

3. Electro-Fishing Analysis

All salmon encountered during the 2020 assessment were between 40mm and 160mm in fork length, with an average fork length of 82.80mm. A bimodal size distribution observed during previous years was used to differentiate young of the year fry (< 80 mm) and one- to three-year-old parr stages (80 – 180 mm). In total, 1 fry and 19 parr were caught. No salmon encountered during the 2020 assessment were smolts or adults.

Brook Trout were slightly larger and had an average fork length 110.7mm, ranging from 40mm to >220mm in length. Brook trout under 10 cm in length are typically in their first year of growth (GNB, 2015), and 29 trout were caught under that length. In total, 66 Brook Trout were observed in 2020.

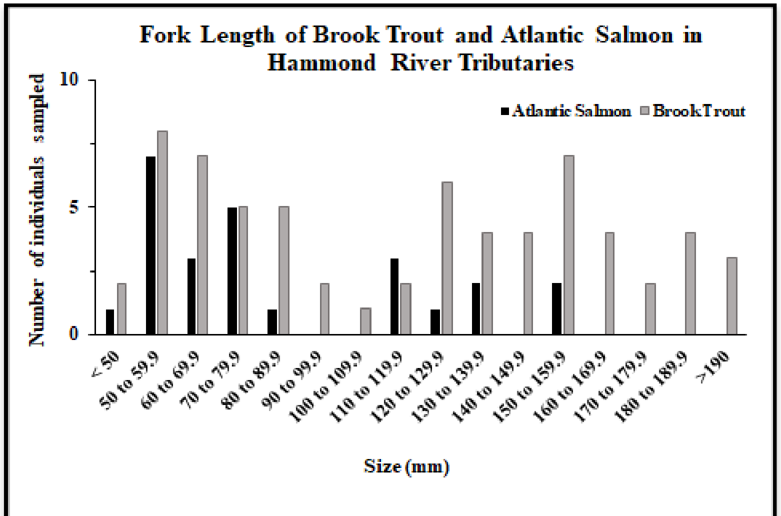


Table 23. Fork lengths of Brook Trout and Atlantic Salmon. *Figure: J. Kelly*

In comparing the historical data collected from 1979 – 2019, fry and parr densities have experienced marked and significant fluctuation between years where intermittent highs and lows (*i.e.*, crests and troughs) were observed. In 2019, a total of 11 juvenile salmon were observed during their electro-fishing study- this marks a 45% increase in juvenile salmon density between 2019 and 2020. In 2019, a total of 60 Brook Trout were observed- this marks a 9% increase of Brook Trout between 2019 and 2020.

The assemblage surveyed during the 2020 electro-fishing population assessment was similar to previous surveys (2005 – 2016), and diversity increased by three species in comparison to the 2019 assessment.

Data Analysis
3. Electro-Fishing Analysis

The low density of salmon fry appears to be resulting in densities of parr below the predicted trend line, in some years. The literature indicates that cool water and healthy habitat is vital to the survival of these juveniles. Managing salmon habitat in the Hammond River is of the greatest importance for the survival of this population. These management practices include riparian restoration, wetland restoration/ enhancement, and sustainable development. In 2019, no fry were observed during their electro-fishing study, while only 1 fry was observed in 2020.

Densities of salmon were higher in the headwaters of the Hammond River, with only the McGonagle EcoReach and TitusSmith EcoReach containing juvenile salmon during the electro-fishing survey, where water conditions are typically more favorable to salmonids with cool, well-oxygenated waters as well as quality spawning and rearing habitat. It is interesting (and disappointing) to note that the Upham EcoReach did not yield any juvenile salmon, despite having a high density of spawning grounds and holding pools for adult salmon, as well as numerous cold-water tributaries. In total, only 2 out of 5 EcoReaches contained juvenile salmon during the electro-fishing survey.

The health and status of Atlantic salmon stocks are assessed relative to a ‘normal index of abundance’ of 29 fry per $100m^2$ and 38 parr per $100m^2$ (Elson 1967); the range of values observed on the Hammond River in 2020 were well below these thresholds and are therefore considered low. Even in considering historic data of predicted average annual densities, fry have been below threshold values since 1991, although observed values have intermittently increased (*e.g.,* 1995, 1997). Conversely, parr have never reached threshold values during the 44 years of population assessment.

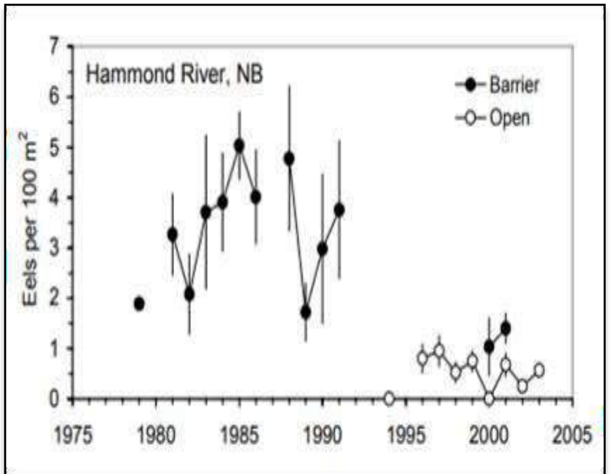
Out of the 20 juvenile salmon observed during 2020, 17 of them had their adipose finn clip removed, to support the Live Gene Bank. Additionally, HRAA staff partnered with DFO and the CIPS team to perform an additional 2-day electro-fishing survey, in which 4 sites were visited. This yielded an additional 30 juvenile salmon and adipose finn collection.

Data Analysis

3. Electro-Fishing Analysis

Since 2012, the invasive smallmouth bass has been observed in the 3 Palmer Brook sites, Bradley Brook, Brawley Brook, and as far up as Hanford Brook. In 2020, it is important to note that 2 smallmouth bass were observed in the upper reach of the Hammond River watershed, in Hammondvale, during the second outing of electro-fishing with DFO and the CIPS team. It can be inferred that this species has naturalized throughout the watershed and is no longer limited to the lower reach of the river. During this second outing with DFO and the CIPS team, an additional

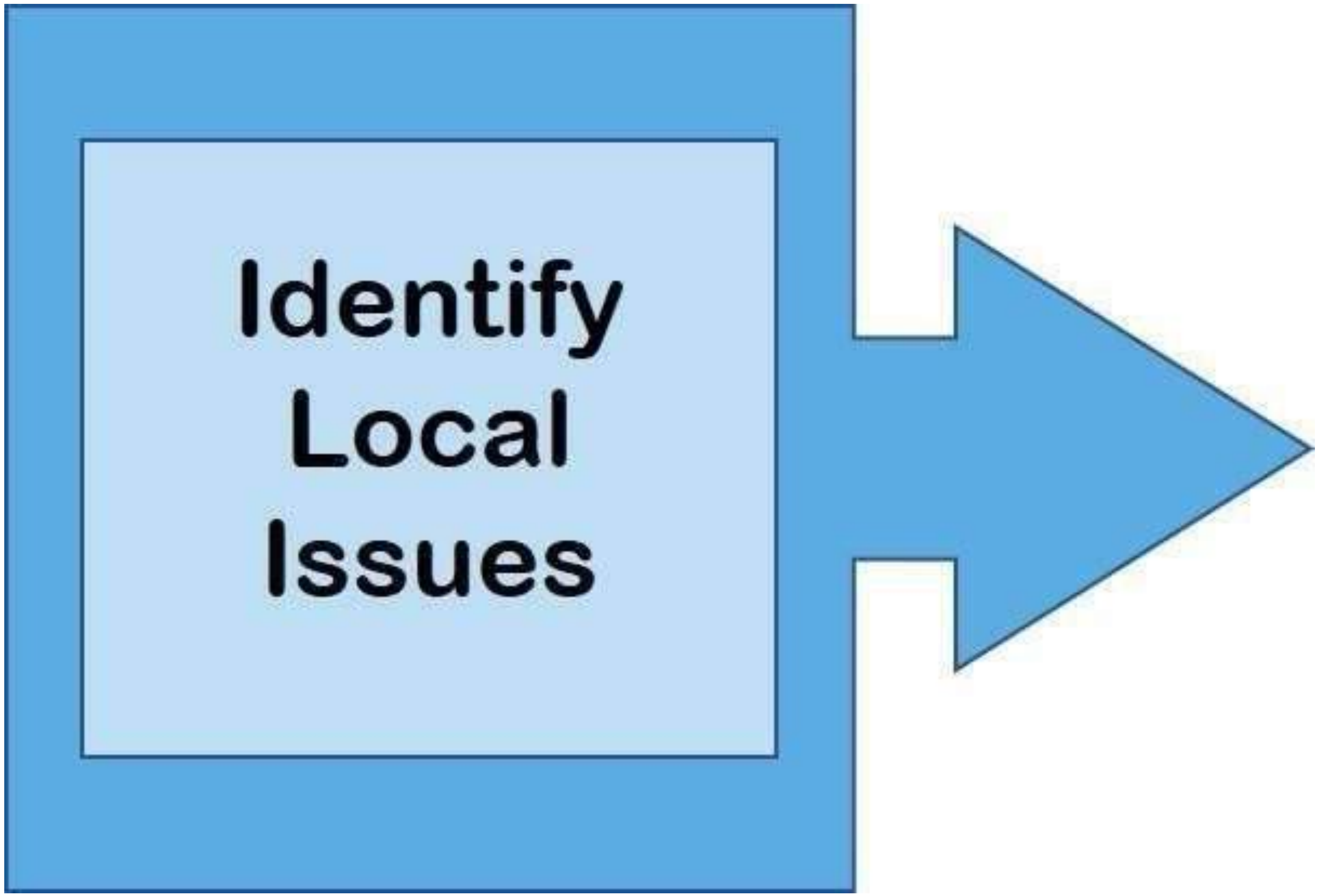
One of the most interesting increases in fish abundance noted in the 2020 electro-fishing survey is the increase in American Eels. The status of American Eel in Canada was assessed as Threatened by COSEWIC in 2012, and a Recovery Potential Assessment was completed by DFO in 2013. The Recovery Potential Assessment identified hydroelectric turbines, habitat loss and fishing of adults as the principal threats to spawners.



Historically low American eel densities per 100m² observed from 1979- 2004.
Figure: DFO COSEWIC Status Report on the American eel Anguilla rostrata in Canada 2006

In 2019, 12 American Eels were observed versus 57 American Eels observed in 2020- this marks a 79% increase of American Eels in one year. Furthermore, the 57 American Eels recorded in 2020 were limited to those staff actually caught and does not reflect the number that were visually observed. In Scoodic Brook alone, approximately 100 eels (or more) were observed in the 100m² stretch that was electro-fished, most of which were elvers or yellow eels. Lower Palmer Brook also had a high density of eels (elver, yellow, and silver) that were visually observed. The Hammondvale site #1 and #2 contained high densities of silver eels, the biggest of which was approximately 3 feet in length, while 8 more silver eels were visually observed.

HRAA staff reviewed electro-fishing data from 2007-2019 for American Eel observations. On average, 27 American Eels have been observed per year over the past 12 years during electro-fishing, compared to 57 observed in 2020 alone. Perhaps previous studies did not fully record densities (they are extremely hard to catch and wriggle below sand/rocks when the electro-fisher is engaged). Moving forward, this may be a remarkably interesting study to undertake.


Identify
Local
Issues

Stage 2: Identify Local Topics & Issues

In the second stage of watershed management planning, we begin to identify local issues, constraints, opportunities, and the strengths and weaknesses of the watershed. Working with municipalities, Indigenous Communities, and stakeholders, with opportunity for input from interested members of the public, will help pinpoint and prioritize focal areas within the watershed. Topics to discuss will include:

- Public Engagement Strategies
- Public Outreach Materials
- Collaboration Opportunities
- Volunteer Opportunities
- Engaging and Educating Youth
- Citizen Science
- Combatting Litter
- Mine and Quarry Site Inventory and Reclamation Plans
- Best Management Practices
- Land Use Changes: Growth and Development
- Climate Change
- Resources: Time, Funding, & Expertise
- Shifts in Provincial and Federal Legislation
- Natural Resource Management
- Identifying and Protecting Critical Habitat
- Invasive Species Management

Once local issues and topics are discussed, it becomes possible to form Steering Committees in Stage 3 to help guide the watershed management plan through the rest of the process and tackle the above-mentioned topics. Many hands make light work and creating a space for the public to engage in assisting with conservation activities will harbor a greater sense of connectivity to nature.

Stage 2: Identify Local Topics & Issues

1. Invasive Species Management

Eurasian Water Milfoil (*Myriophyllum spicatum*) is a macrophyte native to Europe, Asia, and Northern Africa. Since its introduction to North America in the 19th century, Eurasian Water Milfoil has become widely spread across the continent including. This plant prefers shallow waters between 1-3 meters deep but can succeed in depths of up to 10 meters. Eurasian Water Milfoil spreads quickly arising through stolon production. However, it is popularly known for its capacity to successfully spread and establish through fragmentation, earning its commonly used title as “Zombie Plant”. Due to these factors, Eurasian Water Milfoil crowds out native macrophyte species, lower biodiversity, and potentially threatening ecosystem functions by forming mats on the water surface and decimating dissolved oxygen levels.

Working closely with the NBISC (New Brunswick Invasive Species Council) KWRC (Kennebecasis Watershed Restoration Committee) and BWC (Belleisle Watershed Coalition), Hammond River Angling Association staff paddled over 40 kilometers searching for Eurasian Water Milfoil within the Kennebecasis River and Hammond River. Eurasian Water Milfoil was positively identified in lower sections of both the Kennebecasis River and Hammond River, including a large amount in Darlings Lake; a large body of water that serves as one of the two confluence points between the two rivers.

To prevent further spread of Eurasian Water Milfoil to currently unaffected ecosystems all involved organizations have been adamant on encouraging boaters to “Clean, Drain, Dry” when moving their vessels from one body of water to another through signs, social media posting and word of mouth.

The HRAA aims to continue using eDNA technology to monitor Eurasian Water Milfoil within the watershed, making this the first study of its kind in New Brunswick.

Figure 207. Members from HRAA, Kennebecasis Watershed Restoration Committee, Belleisle Watershed Coalition, and the New Brunswick Invasive Species Council get prepared to launch at Darlings Island Bridge to search for invasive Eurasian Water Milfoil. *Photo: Kristin Elton*

Stage 2: Identify Local Topics & Issues

2. Combatting Litter

Figure 208 a. Graffiti covers the bridge pillar at Smithtown- a known hotspot for littering.
Figure 208 b. The inspiration for murals came from this rose on the bridge pillar at French Village.
Photos: S. Blenis

HRAA needs to increase their visibility and presence at known littering hotspots in 2021 and beyond with additional riverside cleanup initiatives.

While having to continuously pick-up others' garbage is extremely disheartening, and seeing our natural areas covered in trash is dismaying, we may be able to increase pride of ownership of these natural areas by covering these graffitied bridge pillars with beautiful murals. The bridge pillar in Smithtown is sending a message that it is ok to be messy, to be destructive, and to simply not care about the aesthetic look of the area. If we could cover this up with a large mural depicting a riverine setting with salmon, or something similar, we will send a new message that we care about this area, and it will inspire others to take better care.

Speaking of spray paint, this should be a mandatory item in HRAA's field work backpack. There were numerous occasions throughout the watershed where people had spray painted inappropriate images on boulders or bridges. On multiple occasions, HRAA staff had to return to the Conservation Center to pick up a can of spray paint, to return to the field and cover hate symbols or obscene drawings- these things have no place in our watershed.

Figure 208 c. One of the many boulders that HRAA spray painted to hide a hate symbol.
Figure 208 d. Paint thinner and elbow grease removed the graffiti off one of HRAA's signs.
Photos: S. Blenis

Stage 2: Identify Local Topics & Issues
Combatting Litter

Littering is a constant issue within the watershed. Areas like the Deep Hole, French Village Bridge Pool, Smithtown Bridge Pool, Tabor Bridge, and Silver Hill are repeatedly overflowing with garbage and debris. This is extremely disheartening; however, it offers an opportunity to pull together with HRAA members, Board of Directors, and local residents to work together and keep our watershed looking beautiful!

HRAA hosted a riverside cleanup day. Attendees were split into groups and were assigned a certain garbage hotspot from the aforementioned trouble areas. Crews worked diligently to remove all garbage and debris from their designated area and brought it back to the HRAA garbage dumpster. Thank you to Green For Life (GFL) Environmental, who gave us a great deal on tipping fees!

In total, we were able to remove 27 bags of garbage from 6 different locations in the watershed! Some of the items included plastic, metal, car parts- all of which take decades(or centuries) to decompose.

While field staff pick up garbage throughout the season, hosting additional riverside cleanup days with volunteers would really benefit the watershed! In 1977, HRAA had an "Anti-Pollution" committee, dedicated to riverside cleanup- we need to re-dedicate ourselves to this important cause!

Figure 209. Volunteers for the riverside cleanup! An awesome crew of HRAA Board of Directors, local citizens, and two future environmental stewards! After the riverside cleanup, volunteers were treated to an awesome BBQ, curtesy of Hammond River Holdings. *Photo: S. Blenis*

Stage 2: Identify Local Topics & Issues
Combatting Litter

Figure 210 b. Many hands make light work! With the assistance of four fantastic camp counselors, we were able to get the site cleaned up in one day! We removed 18 garbage bags, with mostly very old cans, metal, glass bottles, plastic bags, 16 shoes, and 1 unopened ancient beer!

Not only did this group of young individuals do a fantastic job helping the Nature Camp kids all summer, but they are also a wonderful, passionate group of people with very bright futures ahead of them!

Photo: S. Blanis

Figure 210 a. An area along the upper stretch of Palmer Brook was discovered during summer habitat assessments that had an entire bank of embedded garbage and debris. The garbage, which appeared to have been there for many years as it was firmly entrenched in the soil, and it was also found in the brook itself. Field staff recognized that this site was beyond the abilities of just 2 people attempting to clean up the site- it would have taken several days! Field staff discussed the issue with our awesome Nature Camp Councilors, and they agreed to lend us a hand and get the site cleaned up!

Stage 2: Identify Local Topics & Issues

3. Revisiting Restoration

In the summer of 2020, field staff came across an abandoned HRAA restoration project. Less than half of the plastic tree protection tubes were still standing- the majority of these tubes were strewn throughout the site and some were found in wetland areas surrounding the lake's edges. The fiberglass rods had become splintered and were quite hazardous. At least 100 meters of orange mesh and HRAA Restoration signs bordered the property, acting as a hazard for wildlife. Staff began to remove the tubes that were still standing, and the majority of the trees that remained in these tubes were small, dead sticks. Staff estimated that approximately 20 oak and 25 pine were viable. It took two and a half days to clean up the site (the restoration signs were salvaged, and the orange mesh was rolled up and stored for future use; however, the tubes and rods were too damaged for further use.) It is unfortunate, yet necessary, to include this example in the Watershed Management Plan 2020.

Figure 211. Before 2020 site cleanup, with discarded tree protection tubes strewn throughout property.

Figure 212. Same view, only after extensive clean up. *Photos: S. Blenis*

"Life is divided into three terms-that which was, which is, and which will be. Let us learn from the past to profit by the present, and from the present to live better for the future."- W. Wordsworth

HRAA has a history of 44 years, with new faces coming and going every year. HRAA must develop long-term tracking protocols to document the year and location of restoration projects, as well as quantity and types of species used. A plan must be in place to revisit locations, gauge success, and mitigate issues quickly.

The original restoration project that occurred here also included regrading sections of the pit, adding topsoil, and revegetating with natural grasses. These areas are in great condition, and minimal ATV activity is occurring in the revegetated areas. This site has great potential for future restoration activities.

Stage 2: Identify Local Topics & Issues
Revisiting Restoration

Figure 213 a,b- two historic restoration sites, one at Whalen Brook and one at O'Dell Brook, that HRAA staff drove past several times in 2020 before realizing that these were successful restoration sites from 15+ years ago! *Photos: S. Blenis*

One of the first undertakings during the writing of the *Watershed Management Plan 2020* was to go through old filing cabinets in HRAA's Conservation Center, to begin to learn the history and accomplishments of the organization. Staff found multiple handwritten reports, many of which are over 20 years old, of restoration work that was carried out in the watershed. Throughout the 2020 field season, staff revisited several of these sites, and the success of many of these projects was incredible.

Without prior knowledge of the restoration that occurred decades ago, many of the sites that were revisited could have been described as being "as naturally occurs", which is a testament to the restoration work of the HRAA. One staff member lives next to O'Dell Brook, and was astonished see what it looked like before HRAA intervened almost 20 years ago!

These restoration success stories need promotion! The work happened decades ago- land ownership has changed hands; the restoration signs have been removed; the sites appear to be naturally occurring- it can therefore become easy to forget the work of past HRAA members. Tracking down and measuring the success of these historic restoration sites would allow HRAA to have a large inventory of potential demonstration sites, to entice new landowners to allow future work to happen on their properties.

Additionally, tracking our successes (and failures) of restoration will also shed light into which species are best suited in which locations. This will allow us to properly plan and plant future restoration projects to maximize success rates.

HRAA has long since been a leader in riparian restoration, and it is high time to bring these sites back to the forefront and continue the legacy of HRAA members of the past.

Stage 2: Identify Local Topics & Issues

4. Riparian Planting

Riverbank restoration plays a critical role in watershed organizations' goals of enhancing natural ecosystems. By using willow stakes, we can re-engineer riverbanks, restoring their natural functions, while using natural solutions. Maintaining the integrity of riverbanks helps restore biodiversity; provides shade to keep water temperatures lower; provides habitat for flora and fauna; and acts as a buffer against climate change and flooding.

In the summer of 2020, HRAA staff partnered with the Kennebecasis Watershed Restoration Committee, and the Estey landowner family, to plant 300m² of eroding banks in the Hammondvale area with 600 willow stakes.

There was significant nutrient overloading, and substantial filamentous algae at this location. While this section of the pool is deep, the riverbank offers minimal shade, and this pool reached summer water temperatures of 26.2 degrees! Our electrofishing efforts also found juvenile salmon at this location, making it a priority for restoration. The Estey family was also concerned by beaver activity in their area, which had decreased the amount of alder trees that had originally lined the riverbanks, making willow staking paramount to restore this site.

With the support of landowners, and the collaborative efforts with the Kennebecasis Watershed Restoration Committee, the Hammond River Angling Association was able to successfully plant 600 willow stakes along a 300m stretch of the Hammond River in Hammondvale. The HRAA pledges ongoing monitoring of our restoration efforts and will check in on this stretch of river in Hammondvale in order to assess the level of riparian health success. Thank you to the KWRC for your assistance, and continued riparian health efforts, and we look forward to collaborating with the KWRC again in the future!

Figure 214. Volunteer Katie Estey helps to plant willows.
Figure 215. Area planted in Hammondvale. *Photos: S. Blenis*

Stage 2: Identify Local Topics & Issues
5. Effluent Monitoring

The Watershed Management Plan 2008 makes multiple references to monitoring the Cassidy Lake Division of the PotashCorp (PCS) and its tailings pond and brine line. The 2008 document describes a significant brine spill that occurred in the 1980's, 1994, and 2009. HRAA staff had detected that chamber #1, located directly above Fowler Brook, had failed and a large brine spill occurred. Included in the 2008's Action Plan is to "Continue to monitor the PCS brine lines and future brine line work"; however, it has been difficult to track down any newer monitoring of the brine line.

As this line continues to age, the probability of future failures increases. An imperfect liner in the tailings pond of Cassidy Lake Division has also been leaking brine into the environment since 2008, and these leaks continue to happen today.

HRAA must reengage with PCS and reinstate a brine line and tailings pond monitoring plan. Fresh water and salt do not mix, and any leaks or spills can have disastrous impacts on the surrounding environment.

There are also several defunct gas stations within the watershed, including Barnesville and Palmer Brook areas. Additional water testing should be complete at these sites, to ensure that there are no leaky under-storage tanks.

There is also a government garage that is adjacent to Scoodic Brook, that is storing large quantities of salt on site, and heavy equipment that are parked 5-10m away from the brook. As with many heavy equipment machines, seeping of hydraulic fluids and other petroleum products are a constant concern. Additional water quality samples should be taken at this location, and it may be worthwhile to begin to have discussions on the relocation of the salt pile to a separate location, or to create a vegetated buffer between the garage and the brook.

Figure 216. Brine Line signs are throughout the watershed.
Figure 10. View of Cassidy Lake
Photo: S. Blenis & Connell

Stage 2: Identify Local Topics & Issues

6. Monitoring the Upham East Gypsum Mine

In October 2019, Hammond River Holdings Ltd (HRH) received their Certificate of Determination to begin operations at the Upham East Gypsum Mine. The mine, located in Upham, has a reserve of approximately 2.5 million metric tonnes of suitable quality gypsum rock, and will extract approximately 250,000 tonnes per year for the next ten years. The ultimate extent of the open pit at the end of quarry life will be approximately 23 ha. At its deepest point, the open pit will be approximately 75 m deep below ground surface, compared to the current surface elevation of the site.

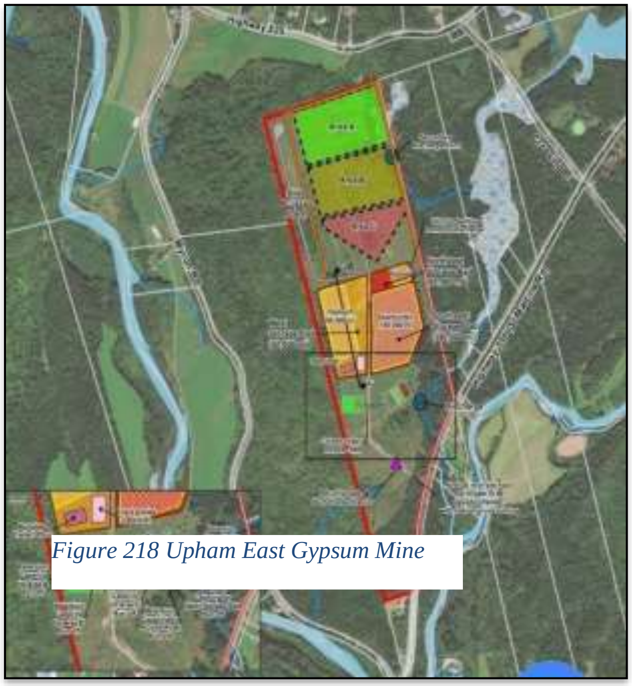


Figure 218 Upham East Gypsum Mine

Figure 218. Map of the Upham East Gypsum Quarry, outlining watercourses and discharge into the Hammond River. *Map: Hammond River Holdings*

The distance between the Project site boundaries and the Hammond River is approximately 600 m to the west, 250 m from the south, and 100 m or more to the east of the site. The Project contains two settling ponds, which will allow any sediment to settle before being discharged into Watercourse 3 South (Mine Discharge Brook).

A review of the project from DFO determined that “the development of the proposed open-pit quarry will result in serious harm to fish. This will therefore require an authorization pursuant to paragraph *35(2) (b) of the Fisheries Act* in order to proceed. If authorized, the proponent will need to develop and implement a plan to offset any residual harm to fish. It will also need to meet the monitoring and reporting requirements included as conditions of authorizations, as per our program’s policies.”

HRH is taking steps to avoid fish-bearing watercourses, and as such, has yet to require applying for the *Applications for Authorization under Paragraph 35(2) (b) of the Fisheries Act.*

Stage 2: Identify Local Topics & Issues
Monitoring the Upham East Gypsum Mine

The Project is subject to 29 Conditions of Approval, pursuant to Regulation 87-83 under the *Clean Environment Act*.

In 2019, the HRAA developed an *Effects Monitoring Plan* in conjunction with HRH. The Effects Monitoring Plan includes water quality assessments, and fish density and habitat surveys.

The primary variables of interest for the water quality survey included total suspended solids (TSS) and turbidity (as an indicator of TSS).
Samples are collected monthly targeting the first week of the month during the open-water season at two sites upstream of the Project and one site downstream of the Project. Additional samples are collected after heavy rain events; defined as 30 mm or more over a 24-hour period based on forecast or actual precipitation amounts. Rain on snow events are also monitored and sampled.

Water released to the natural receiving environment will have a target concentration of total suspended sediments (TSS) of less than 25 mg/L above background levels in the receiving environment (measured as a monthly average of grab samples). Water will be released at a rate that does not overwhelm the capacity of the receiving structures or watercourse.

A habitat assessment and fish survey will be conducted each fall. The survey includes a reach measuring approximately 300m. Six habitat transects (stream cross-sections) were established at approximately 50m intervals along the reach. At each transect, stream morphology (e.g., wetted and bankfull width), substrate size and embeddedness (underwater camera),
and macrophyte coverage were recorded. Streamflow, temperature, pH, conductivity, and dissolved oxygen measurements are recorded. The fish survey is conducted via a single pass with a backpack electrofisher.

HRAA will continue this *Effects Monitoring Plan* annually, throughout the life of the Project, for approximately 10 years, and site reclamation planning should become a focus in the very near future.

Watercourse 3 for sampling (South, East and North). **Figure 219**. 6 transects along WC3 South for habitat assessments.
Figures: HRAA 2019

Stage 2: Identify Local Topics & Issues

7. Mine Site Reclamation

Figure 220 Gypsum Mine Reclamation

Figure 220. Upham East Gypsum Mine site, before and potentially after.
Photo: Hammond River Holdings.

There are over 300 abandoned mines in New Brunswick, most of which have never been properly reclaimed, and there are several within our watershed. HRAA should begin to take stock of the number and locations of the derelict quarries and mines within the watershed and assess them for restoration purposes.

The Upham East Gypsum Mine has a lifespan of approximately 10 years, so the project will be finished by approximately 2028. The proponent, Hammond River Holdings, is more than willing to work with the surrounding community and stakeholders in developing a reclamation plan, and HRAA should begin to discuss what they see for the site.

Upon closure, the approximate depth of the quarry will be roughly 60m deep, approximately 350m wide, and 600m long. The quarry lake will hold approximately 2.5million cubic meters of water and will take approximately 3-4 years to naturally fill in with water. The future of this site has so much potential! Could this become a stocked quarry lake? Could this site act as a sister site for the Conservation Center, allowing us to use the property for our environmentally educational programs?

HRAA must become involved, from the onset, on developing and overseeing mine reclamation plans. It will be a large undertaking to re-naturalize this site and offers the potential for HRAA to engage with surrounding communities and develop a beautiful plan for the future.

After you have exhausted what there is in business, politics, conviviality, and so on- and have found that none of these finally satisfy, or permanently wear- what remains? Nature remains."

W. Whitman

Stage 2: Identify Local Topics & Issues

8. Land Conservation

In 2018 when mineral exploration began in Upham to find a gypsum resource, there was considerable outcry from the local community on the potential impacts to a beloved mountain, Upham Mountain. While the gypsum mine was eventually approved, it was not on the mountain itself, but a nearby site on route 111. The HRAA worked with the local community of Upham to express the social and environmental importance of Upham Mountain, and landowner JD Irving Ltd heard our collective voices. In 2019, JD Irving Ltd established 17 hectares of land on the mountain to become part of their Unique Areas Program. This Unique Areas Program is a voluntary program created by JD Irving Ltd, that now includes almost 80,000 hectares of land and 1561 different sites- 20% of the company's private lands (254,000 ha) have conservation as the first priority, and we are pleased that they decided to include a portion of Upham Mountain into this conservation initiative. Part of the conserved area is surrounding a mated pair of bald eagles' nesting grounds, while the other portion of the conserved land surrounds Chantal's Cave- New Brunswick's 7th longest cave. The HRAA looks forward to exploring these areas and continuing to work with this landowner on establishing additional areas in this Unique Area Program.

Figure 221. Conserved land on Upham Mountain. *Figure: A. Willett*

In the spring of 2021, HRAA staff received a phone call from a landowner, expressing interest in donating their land in the Henderson Lake area near Grand Bay. The land had been in their family for generations; however, they were no longer using it, and wish to donate it for conservation purposes. While this area is not in our watershed, it is important to recognize that all land donations are worthy of conservation, and the HRAA would be pleased to assist in establishing this as a conservation zone. Discussions are currently under way with the landowner and the Nature Trust of New Brunswick to perform a site assessment and determine which conservation option the landowner would like to pursue.

Figure 222. Area near Henderson Lake. *Figure: GNB.*

Stage 2: Identify Local Topics & Issues
Land Conservation

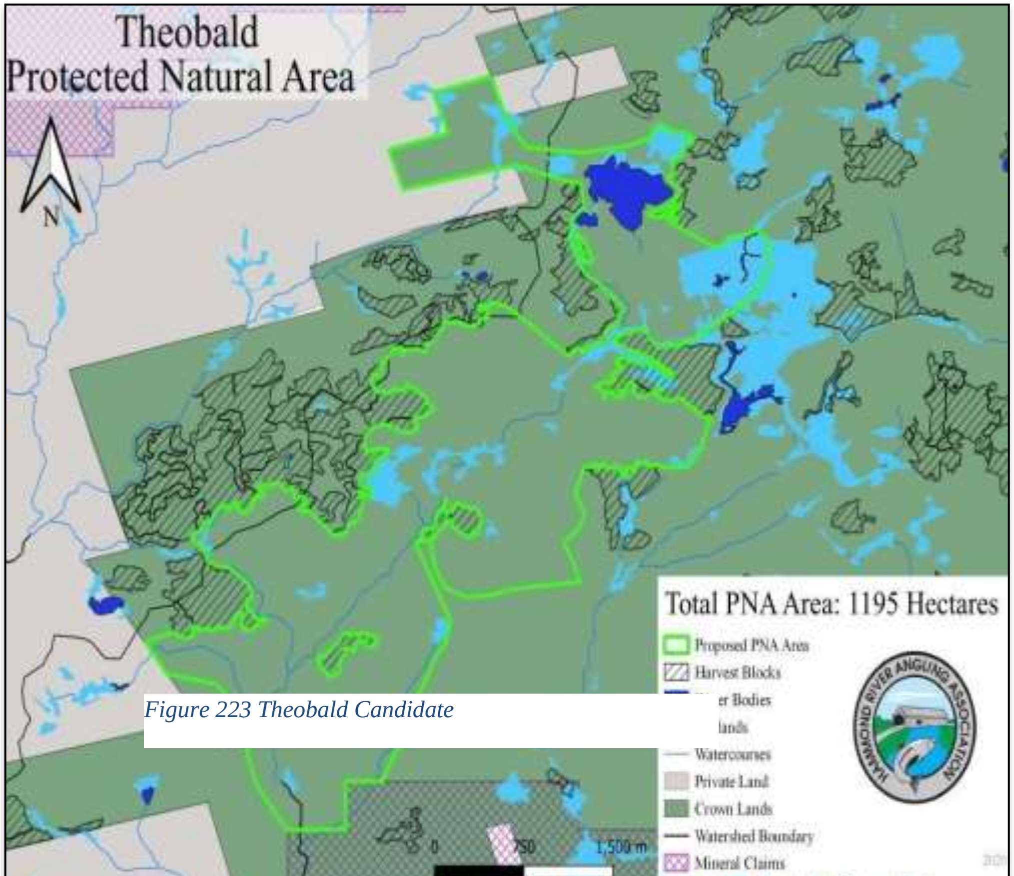


Figure 223. Map of HRAA's proposed Protected Natural Area, "Theobald PNA", which encompasses Jenny Lind Brook, Theobald Lake, Theobald Mountain, Porcupine Mountain, and Irish River. *Map: J. Kelly*

In 2020, the Province of New Brunswick announced that it would conserve an additional 10% of Crown Land through the creation of Protected Natural Areas (PNA). A PNA is a clearly defined geographical space, recognized, dedicated, and managed through legal or other effective means to achieve the long-term conservation of nature associated with ecosystem services and cultural values. The area would have important conservation features like rivers, wetlands, forests, coastlines, and other habitats for wildlife.

The HRAA submitted a proposal to create a PNA that connects to our watershed. The proposed PNA area provides approximately 1100 hectares old growth Acadian forest and acts as a wildlife corridor. Maintaining a large, natural buffer around Theobald Lake is crucial to ease the impact of floods and droughts, as it stores large amounts of water and releases it during shortages or increasing summer temperatures. Theobald Lake also replenishes groundwater, positively influencing water quality downstream and surrounding areas, such as Jenny Lind and Irish River, thus preserving the biodiversity and habitat in the proposed PNA in the face of climate change. Decision will be in June 2021.

Stage 2: Identify Local Topics & Issues

9. Citizen Science

Figure 224. Canadian non-profit Water Rangers kit
Figure 225. Community Collaborative Rain Hail & Snow
Photos: S. Blenis & CoCoRaHS

The term "citizen science" was coined in the mid 1990's and is the "practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, people share and contribute to data monitoring and collection programs" (National Geographic Encyclopedia). HRAA currently offers 2 Citizen Science programs- Redd Counts and Electrofishing- where the general public is able to assist us in data collection; however, there are definitely areas to expand on this important tool!

Increasing our Citizen Science projects will increase our membership engagement, and overall stewardship of the watershed. We have several Water Rangers Kits available at the Conservation Center that contain water quality monitoring tools like pH, conductivity, dissolved oxygen, depth, and temperature. We use these kits in our educational classes for Nature Camp kids and in schools; however, we should consider expanding on this program and engage the surrounding community to use these kits and assist us in collecting additional water quality samples.

Another possibility is engaging the general public on precipitation data collection. Currently, we do not measure or track precipitation, and are therefore missing a vital piece of data for streamflow analysis and climate change adaptation. HRAA should undertake a project to secure precipitation gauges, or to work with the Community Collaborative Rain, Hail and Snow Network, to involve the surrounding community with precipitation data collection.

Offering additional ways for the community to connect to nature, and to connect to our organization, would be extremely beneficial: "We can be ethical only in relation to something we can see, feel, understand, or otherwise have faith in" (Aldo Leopold, historic wildlife conservationist).

Stage 2: Identify Local Topics & Issues
Citizen Science



Citizen Science does not need to be overly complicated or require any fancy tools. Simply engaging the public to document certain stretches of the river on an annual basis can really begin to help shape our data collection on riparian zones.

One neighbor, John Blanchard, began taking pictures of the same stretch in 2004. Each year, he took another picture at approximately the same time of year to document the riparian zone change overtime. From these pictures, we can see how things have changed over a span of 17 years- here we see that land use has not changed; the field is still hayed annually, and as a result, we can clearly see how the lack of a riparian buffer has led to the banks becoming undercut, erosion, sediment deposition into the river, and ultimately the creation of sand bars and habitat fragmentation.

Almost everyone has a camera at their disposal in the form of cell phones; by showcasing this example, we may be able to engage others to undertake similar long-term photographing at particular sites.

Another awesome Citizen Science tool is the iNaturalist app, which allows users to upload pictures of nature for identification. HRAA has recently created the Hammond River Nature Collection on the app and should encourage others to join and share their findings!



Stage 2: Identify Local Topics & Issues

10. Cyanobacteria and Benthic Mat Monitoring

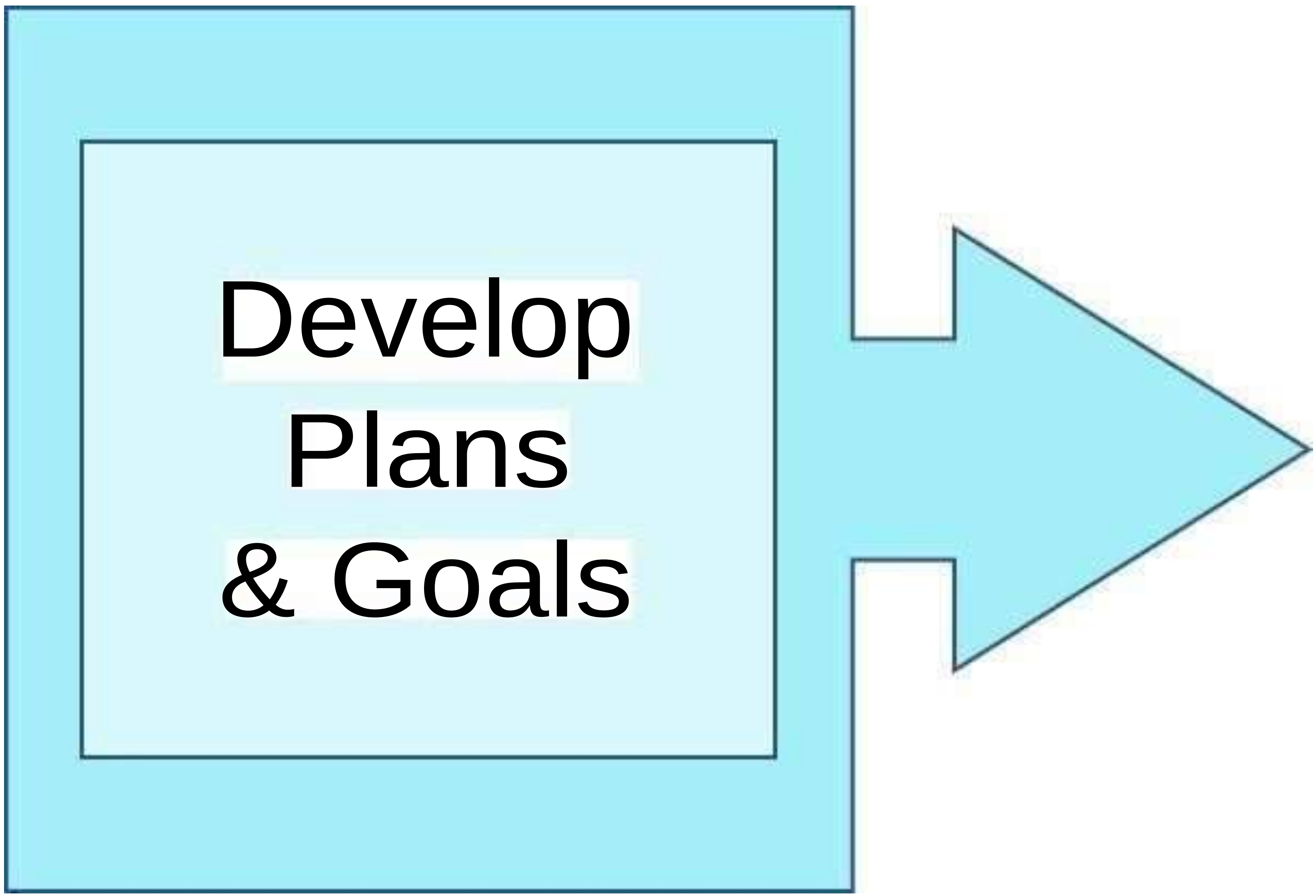
Figure 226. Cyanobacteria SPATT collector &floating benthic mats.
Photos: S. Blenis

Cyanobacteria (commonly known as blue-green algae) are photosynthetic bacterial organisms, naturally found in many types of water systems including lakes, rivers, and wetlands. Under the right conditions, they can increase in numbers quickly to form a bloom or floating algal mats. Blooms can range in color from dark green to yellowish brown. Some blue-green algae species can produce toxins (microcystins), which can impact the health of humans and animals.

In 2020, we partnered with ACAP Saint John, Kennebecasis Watershed Restoration Committee, Belleisle Watershed Coalition, Canaan-Washademoak Watershed Association, Jemseg Grand Lake Watershed Association, Nashwaak Watershed Association, Meduxnekeag Valley Nature Preserve, The St. John River Society, and the Conservation Council of New Brunswick, to test for cyanobacteria presence and assist in public education.

We deployed two SPATT collectors within the watershed, as well as temperature and light data loggers, and have collected benthic cyanobacteria mats (rock slime) for analysis. The first study site is at the confluence point of Palmer Brook, which was chosen for its high nitrate, phosphate, E. coli and coliform levels. The second site was at the confluence of O'Dell Brook, as it had amassed a high density of potential floating benthic mats in the early summer. O'Dell Brook is also approximately 800m downriver of Scoodic Brook, which has the second highest levels of nitrate, phosphate, and total coliforms in the watershed. Analysis of all our samples is still underway, and results from this study are expected early summer of 2021.

This project will be ongoing in 2021, and will help advance our understanding of cyanobacteria, its toxins, and the risk it poses for humans and wildlife.


Develop
Plans
& Goals

Stage 3: Develop Plans & Goals

The third stage in watershed management planning is to begin to develop plans and goals, based on the data collected in Stage 1 and the issues identified in Stage 2, which will allow us to identify data gaps in Stage 3. Stage 3 also includes Steering Committees and public engagement strategies that were also identified in Stage 2. When setting goals and management objectives for your watershed plan, be sure they are:

1) **Achievable:** can you realistically reach these goals?
2) **Financially Viable:** do you have the financial resources, or can you secure resources, to achieve these goals?
3) **Technically Viable:** do you have the necessary tools, equipment, and technology to carry out these goals?
4) **Measurable:** do you have a way to measure project success?

Once specific management objectives and goals have been established, it becomes vital to develop indicators and targets. Environmental Indicators and Numeric Targets will facilitate a quantitative evaluation on whether plans and goals are being achieved. Indicators can be:

1) **Programmatic Indicators**: these will help determine things like whether sound objectives were developed, time frames set, and staff assigned appropriately.
2) **Environmental Indicators:** they will help document environmental results such as tree planting success rates, nutrient reduction, increase in fish population etc.
3) **Social Indicators**: these measure change in awareness or behavior as a result of programmatic activities. These indicators can only indirectly measure environmental impact. For example, if 20 additional people showed up to volunteer with redd count events, that is more environmental data collected than the previous year.

Setting annual targets is a great way to ensure the management plan is moving forward, while challenging staff and the public to exceed these targets. For example, if the annual target has been to restore 500m² of eroded banks, or host 3 riverside cleanup events, and staff and volunteers are able to plant 1000m² of banks and 6 riverside cleanup events instead, then we are able to measure our increased success rate and empower ourselves and our community to continue to strive for excellence!

Stage 3: Develop Plans & Goals

1. Identify Data Gaps

Traditional Knowledge: Not only were we unable to find any historical Traditional Knowledge records in historic HRAA files, but we have also had minimal interaction and engagement with our neighboring Indigenous Communities. Before we, as an organization, begin to reach out for assistance in Traditional Knowledge in our watershed, we **must** begin to educate ourselves, and eliminate our own knowledge gaps on Indigenous history in the province. As an organization, we must first learn about the Peace and Friendship Treaties, *The Indian Act* of 1876, *The White Paper* 1969, residential schools, Missing and Murdered Indigenous Women, The Truth and Reconciliation Commission 2008, and many other important historic documents. As an organization, we **must** be able to name, and place, Indigenous Communities on a map of New Brunswick. As an organization, we need to make the necessary steps to educate ourselves, in advance of reaching out with requests. Once we have taken steps to address our own ignorance, and begin to acknowledge the truth of the land, we can then reach out for assistance, in utmost respect. Traditional Knowledge is exceptionally important to our watershed management planning, as Indigenous have knowledge on our natural environment since time immortal. The ability to combine Traditional Knowledge with scientific methods while provide us with a more robust understanding of our watershed, and how we may better protect its invaluable resources. There is no set timeline on addressing this data gap- our learning process of Indigenous history should be on-going, as our colonial occupation has existed on this land for almost 500 years. Engaging, partnering, and working with our Indigenous neighbors should also be an on-going process, one that may start slowly, respectfully, and will hopefully build over time.

Characterizing our Lakes: Since its inception 44 years ago, the HRAA has performed some small-scale studies on the lakes within the watershed, the majority of studies focused on creating hydrological delays (ie: dams) to slow the flow from lakes into the watershed, as a way of increasing water flow during peak summer months. We need a full inventory, including all chemical, biological, and recreational aspects of these lakes, in order to fully understand what they are contributing to our overall watershed.

Characterizing our Wetlands: 2 historic studies were found during the preparation for the *Watershed Management Plan 2020* on wetlands within the watershed, one from 2013 which delineated 15 wetlands in the Quispamsis area, and one study in 2018, which built off the first study, and delineated an additional 3 wetlands. There are certainly many more wetland areas within the watershed; however, we are currently lacking any additional information. These 18 delineated wetlands should also be revisited in the near future, to determine if they are still intact. Initial efforts to remedy this data gap should focus on training and certification of HRAA staff to delineate wetlands. Wetlands perform and contribute a plethora of valuable functions within the watershed and should never be taken for granted. No wetlands have been included in this management plan, as we did not visit/study/sample any wetland areas in 2020, and this should be corrected in the near future.

Expanding Water Quality Monitoring: For years, 12 index sites have been chosen for routine water quality monitoring ; however, it has become apparent during the 2020 field season that expanding the number of sites to be included in monitoring should be mandatory. We can not properly characterize the watershed if we are only focusing on 12 sites and allowing other areas (such as critical habitat sites, sites near industrial/residential/agricultural uses etc) to go by the wayside.

Stage 3: Develop Plans & Goals
Identify Data Gaps

Ecological Inventory: As an angling association, our overall focus has been on fish, particularly the Atlantic Salmon. The mouth of the Hammond River is the only over-wintering habitat in Canada for the Endangered Short-Nose Sturgeon, yet the HRAA has not undertaken a study to further our understanding of this species. In addition, our watershed is home to many other species at risk, and efforts should be taken to research and create an inventory of other species that call the Hammond and surrounding terrestrial area home.

Microplastics: As our global population continues to increase at a rapid rate, so too does our use, and improper disposal, of plastic. Sampling, research, and education on microplastics and how they are impacting our watershed should become a focus in the future, as no previous studies on this topic have been undertaken by the HRAA.

Soil Quality: Our water quality monitoring tests water for over 40 parameters, some of which can bioaccumulate in our soil. As an organization, we have no data on soil quality to date. Riparian restoration has long been a focus of our efforts as an organization; yet, we do not have a solid foundational understanding of our soil characteristics within the watershed.

Air Quality: Our focus has been on monitoring effluents and point-source discharges into the watercourse; however, pollutants come in a variety of forms, including air. The HRAA has no air quality data and should seek to alleviate this data gap in the future. Air, water, soil- these should form a trifecta of monitoring data.

Confluence Points: Over the past 4 decades, the same areas are surveyed and sampled within the tributaries and main stem Hammond River; however, little has been done to document tributary confluence points with the Hammond River. Gathering data on flow, width, channel depth, substrate etc at these confluence points would allow us to have a better understanding of any geomorphological shifts that are occurring at these confluence points, as well as track sediment transport. These tributary confluence points are like the welcome mats to many aquatic species- should they become impassible, or unsavory, aquatic species may pass them by (an example is of this is already occurring at Germaine Brook- once one of the most productive juvenile salmon and adult salmon spawning habitats, it is now almost void of all fish species, while its confluence point with the Hammond River continues to degrade, erode, and fill with sediment). Further, little research has been done on the Hammond River’s confluence point with the Kennebecasis River, or its overall connecting to the Wolastoq Saint John River basin. An inventory, as well as all relevant data, concerning all the major tributary confluence points with the main stem would be a worthwhile venture indeed.

Ground Water Monitoring: During the preparation for writing this watershed management plan, no historical ground water monitoring data or information was found. Technology has come a long way since the organization’s beginnings 44 years ago, and we should begin to make the appropriate contacts for groundwater modelling to occur within the watershed. This should include geothermal imaging, which will allow us to better define critical habitat areas containing necessary cold-water refuges that are recharging our tributaries and main stem.

Climate Adaptation Plans: To date, we do not have any data, information, or plans pertaining to climate adaptation. This can include, but is not

Stage 3: Develop Plans & Goals
Identify Data Gaps

limited to, stormwater management and green infrastructure projects (ie: permeable asphalt, rain barrels, rain gardens etc). Further, we do not have any data on precipitation amounts (ie: rain, hail, ice, snowpack monitoring etc), which is vital data to understanding our watershed and how it is impacted by climate change.

Benthic Macroinvertebrates: While staff in 2020 did their best to complete a benthic macroinvertebrate study to assess overall stream health, the study lacked official scientific methods, as staff were not CABIN trained or certified. Moving forward, additional training will easily resolve this current data gap.

Effluent Monitoring of PCS: The HRAA had been monitoring the brine line and the decommissioning of the potash mine near Cassidy Lake, until approximately 1998, when no additional records or data have been found. The brine line still exists, and leaks are still occurring from tears in the lining of the on-site settling pond. Updating this monitoring program and beginning to collect data along the brine line will ensure that no catastrophic leaks are occurring.

Database on Past Projects & Historic Data: Given the age of the organization, it stands to reason that the majority of the early data collected was on paper, and not digital. Many of these early data collection records still exist today, on paper, in a filing cabinet; however, the HRAA experienced a major flood in 2018, and many paper files, records, and old computers were lost, and the data is gone. Additionally, when an organization has existed for over 4 decades, it **must** have an easily accessible database on past projects. During 2020, HRAA staff struggled to find all of the historical data required in order to complete a full data analysis and comparison. Furthermore, the HRAA has experienced high staff turnaround over the past 2 years, and with this revolving door of staff, so too has data come and gone. We are currently experiencing a data gap on data collected over the past 44 years. Efforts should be taken to digitize all paper copies of data (ie: electro-fishing results, water quality monitoring etc), and to retrieve as much historic data from defunct 3rd parties (ie: NB's Aquatic Data Warehouse, FishStream etc)

Stage 3: Develop Plans & Goals

2. Setting Overarching Annual Goals

While these will be subject to approval from the Watershed Steering Committee, we can easily set overarching annual targets that will ensure that our watershed management goals are staying on track. These targets have been set at the minimum acceptable level of action and can easily be surpassed.

- **Annual Riparian Target:** 500m² planted per year.
- **Annual Water Quality Expansion:** include 1 new site per year; should it warrant future monitoring it can become part of the water quality monitoring index sites. Should all of the water quality parameters be within acceptable CCME guidelines, a report on the site can be made, the data stored in a database, and the site can be shelved.
- **Annual Electro-Fishing Expansion:** include 1 new site per year; should it warrant future monitoring it can become part of the electro-fishing index sites. Should 1 year at this location suffice, a report on the findings can be made and its data can be stored in a database for future revisitation.
- **Annual Engagement Expansion:** a target of engaging 100 additional people from the previous year should be set.
- **Annual Watershed Characterization Expansion:** complete a stream habitat survey of 500m in a previously undocumented tributary, lake, wetland or mainstem. At the end of the year, a report should be made on the findings, and potential additional work that should occur within the area surveyed.
- **Annual "New" Topic:** investigate and implement one new topic that has not occurred to date within the watershed (this could include a new sampling parameter, a new piece of equipment, a new technology etc). This will keep the organization current and exciting!
- **Annual State of the Watershed Report Card:** this will summarize and highlight the year's actions, including all Annual Target accomplishments, and will be distributed to the community and all relevant partners. This will also assist us in keeping progress on track, and keeping the public engaged.

Stage 3: Develop Plans & Goals

3. Forming a Steering Committee & Study Teams

A Watershed Management Steering Committee should be formed, in order to ensure that the goals, actions, and activities listed in this document are executed in a timely, professional, inclusive, and cost-effective manner. The Steering Committee will be a non-governmental committee; however, it will include those in government agencies. The Steering Committee should include:

1) Hammond River Angling Association Board of Directors
2) First Nations Representatives
3) Fisheries and Oceans Canada
4) Department of Environment and Climate Change
5) Department of Agriculture, Aquaculture, and Fisheries
6) Department of Health
7) Department of Tourism, Heritage, and Culture
8) Department of Natural Resources
9) Regional Service Commission 8
10) Local Service Districts
11) Stakeholders
12) Up to 5 citizens from the watershed

The Steering Committee, which will contain a Project Manager and Study Teams, should also include a broad representation of interests within the watershed, and the committee would be responsible for developing the Terms of Reference; providing guidance, input, and expertise; obtaining scientific guidance as needed; and working with the Project Manager. The Project Manager will oversee all activities and will act as the mediator between the Steering Committee and the Study Teams. The Study Teams will carry out the actions in the watershed management plan in accordance with the Terms of Reference (including monitoring, assessing, reporting, report writing, restoration plans, public education, etc.)

Stage 3: Develop Plans & Goals
Forming a Steering Committee & Study Teams

The Terms of Reference shall be decided upon during the first Steering Committee meeting, but should contain aspects of the following, including sections from New Brunswick's *Recommendations for Enhanced Watershed Management Report*:

1) **Purpose:** describe the purpose of the committee (what they will do, why it was created).
2) **Scope:** clearly describe what is in and out of scope for the committee.
3) **Authority:** describe the decision-making authority of the committee (decides, approves, recommends, etc).
4) **Members**: type and number of members, how members are appointed, how the chair and co-chair are appointed and a list of members (name and functional role).
5) **Meeting Arrangements:** meeting frequency and location, meeting procedures, quorum, details about agendas and minutes (how these will be distributed, available online, who prepares them etc), and communication in between meetings.
6) **Reporting:** describe who the committee will report to, in what format, and how often.
7) **Resources and Budget:** describe available resources (people, rooms, equipment etc) available to the committee, as well as funds to ensure the actions in the management plan are completed.
8) **Deliverables:** describe the requested required committee output.
9) **Review:** the review frequency and the next review date.
10) **Data Collection & Reporting**: (including consolidation of existing information) as required to characterize baseline water quality and establish the "state of the watershed".
11) **Action Timeline**: short-term and long-term schedules to complete action items.
12) **Documentation Led by Indigenous People:** current and historical Indigenous Knowledge related to the watershed area.
13) **Proposed Water Quality Objectives:** for all or a portion of the watershed, which may differ from Provincial Water Quality Objectives.

Based on the findings of in Stage 2: Identifying Local Issues, it is recommended to build sub-committees, or Study Teams. These Study Teams should be heavily volunteer-based and should involve local youth as well. These teams may focus on the following topics, subject to approval from the Steering Committee and Project Manager. Additional teams may be created as needed.

1) **Riparian Restoration Team:** to assist with planting.
2) **Green Team/Riverside Clean-up Crew:** to assist with garbage and litter.
3) **Citizen Science Team:** to assist with volunteer water quality sampling with Water Rangers kits; precipitation monitoring; snowpack monitoring etc.
4) **Environmental Education Team:** to develop materials to deliver to classes/social media etc.
5) **Invasives Team:** to survey and identify invasive species within watershed.
6) **Fisheries Team:** to assist with redd counts, electro-fishing, and anglers' creel survey.
7) **Water Team:** to monitor water quality, quantity, and other related topics.

Stage 3: Develop Plans & Goals

4. Watershed Management Goals

Goals are the outcomes you want to achieve. Goals tend to be broad expressions of values and aspirations. Watershed planning goals should address the various features, values, or threats to a watershed including water quality, water quantity, aquatic species, flood protection, natural features, recreational values, etc. The goals will relate to the aspirational outcomes anticipated for your watershed if you accomplish everything that will be set out in your objectives and targets, which will be discussed in Stage 5.

Goals of the *Watershed Management Plan 2020*:

#1- Develop, Implement, Monitor and Update the Watershed Management Plan

#2- Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed.

#3- Protect and Improve Riparian Buffer Zones and Critical Habitats

#4- Fully Characterize the Watershed (including all wetlands, lakes, tributaries, and main stem)

#5- Protect and Enhance Fisheries Management Strategies

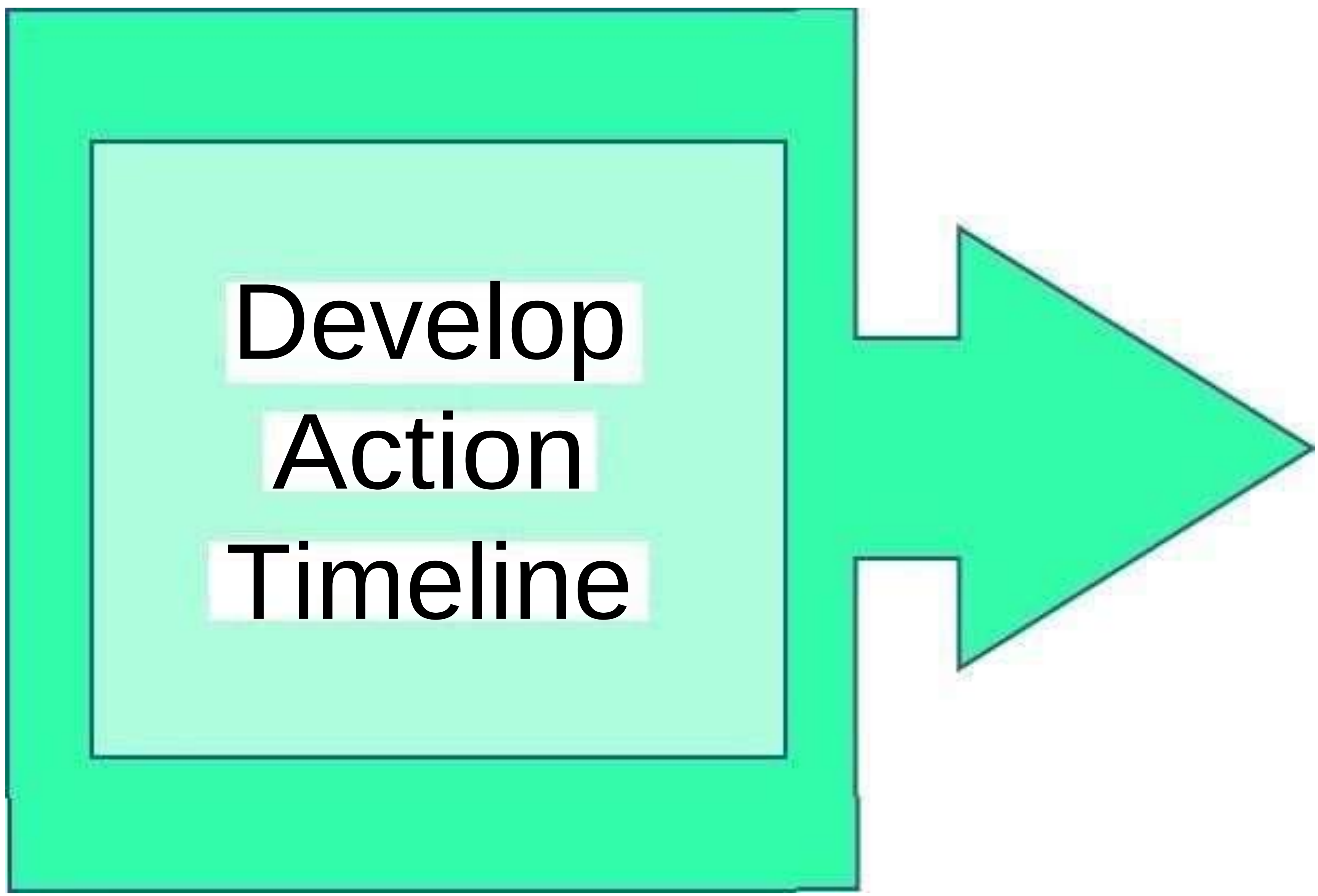
#6- Increase Ecological Inventory and Knowledge- Traditional Knowledge, Endangered/Species at Risk, Invasive Species

#7- Increase Engagement, Knowledge, and Best Practices with Public, Forestry, Agriculture, and Industrial

#8- Develop and Implement Climate Adaptation Plans and Strategies

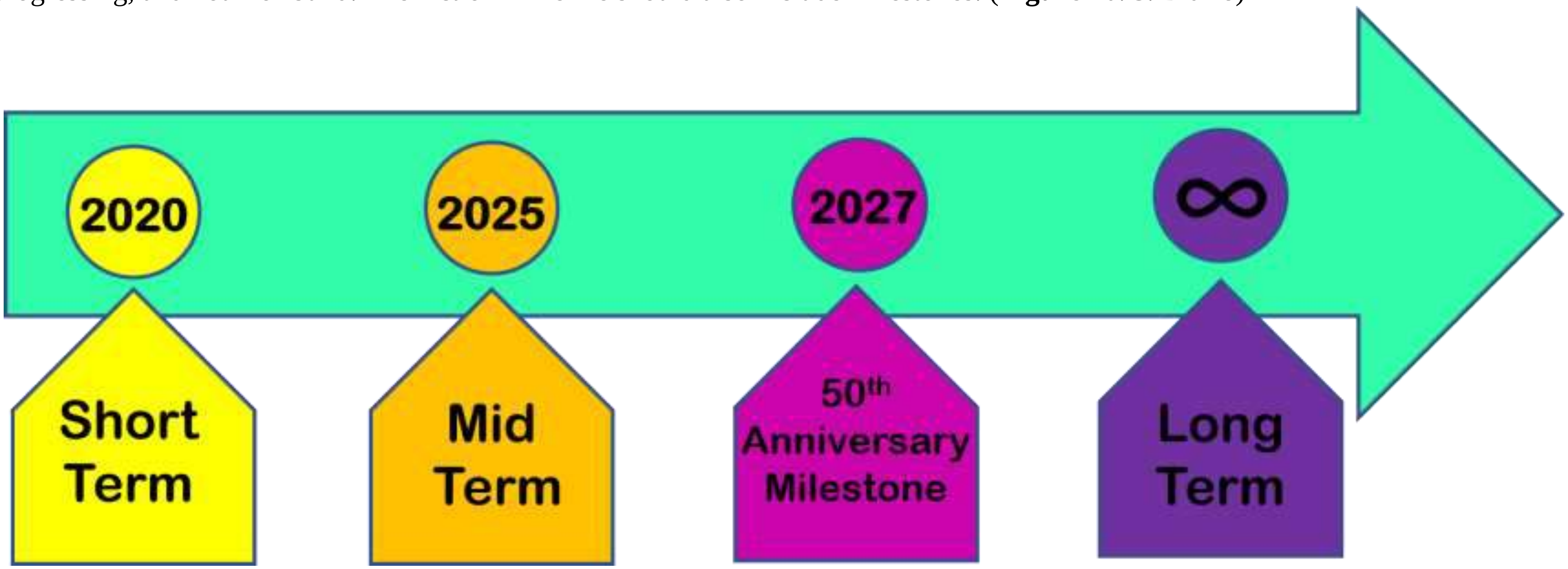
#9- Enhance Recreational Opportunities and Sustainable Practices in the Watershed

#10- Amalgamate, Digitize, and Make Accessible Historic HRAA Projects and Data


Develop
Action
Timeline

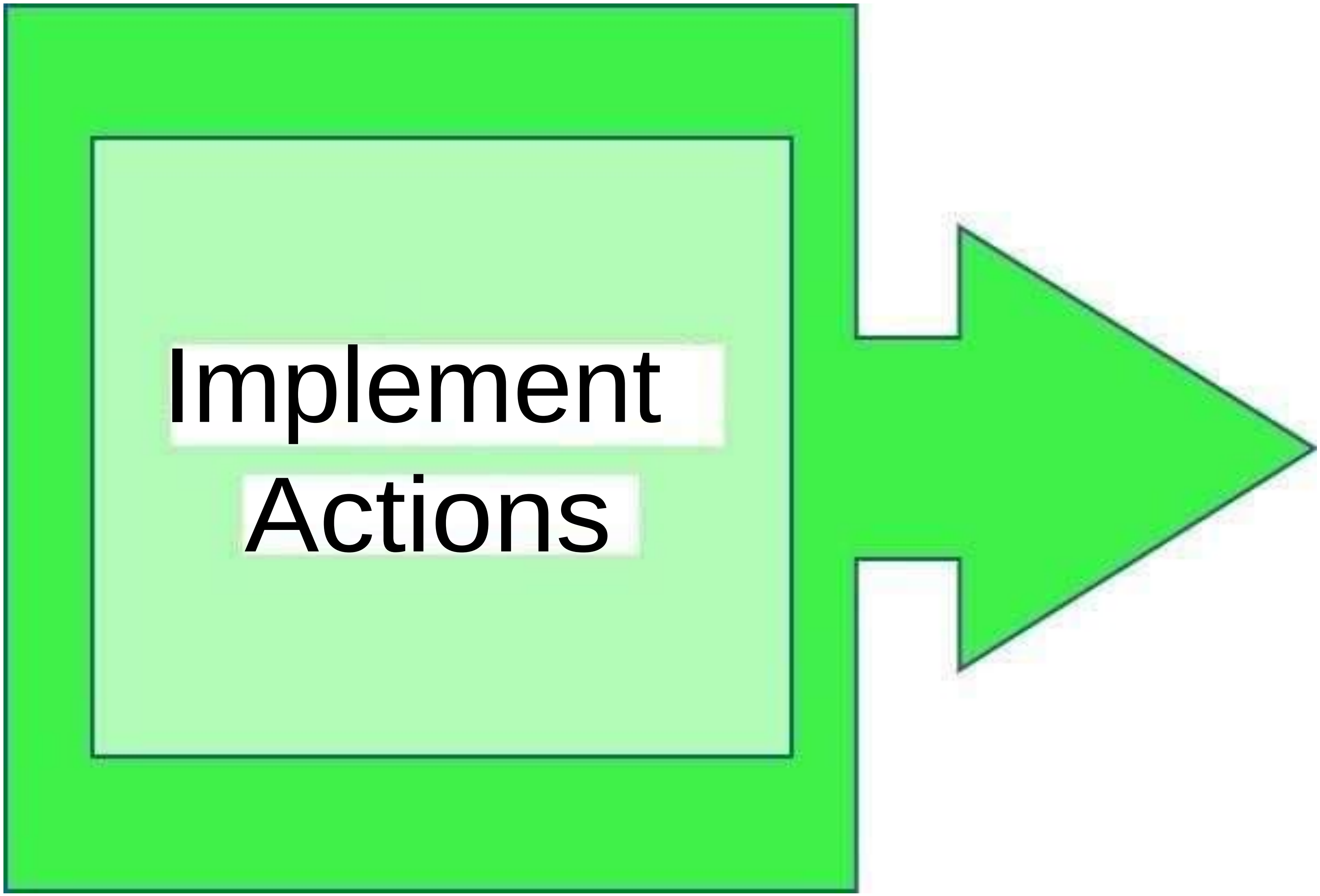
Stage 4: Develop Action Timeline

The first three stages have been integral in establishing the 'who, what, how, and where', and Stage 4 begins to shape the 'when'. By establishing a timeline for achieving the predetermined goals, we will be able to keep the watershed management plan on track and set us up for long-term success. This stage also includes developing a monitoring component, to track and evaluate the effectiveness of the implementation efforts using the criteria developed in previous stages, as well as ensuring that the management plan is progressing, and not moribund. The Action Timeline should also include milestones. (**Figure 10**. *S. Blenis*)



` *Figure 227 Action Timeline*

The Short Term should include actions that take less than 2 years to complete; the Mid Term should include actions that take less than 5 years to complete; the Milestone includes HRAA's 50th Anniversary in 2027, and celebratory actions should be complete; Long Term includes all actions that take greater than 10 years to complete. This Action Timeline will allow us to properly allocate funding, time, and resources, while ensuring the management process is on track for success.


Implement
Actions

Stage 5: Implement Actions

Stage 5 is when we get to start taking actions, instead of passively planning! Before diving in, we need to:

- Identify Technical and Financial Assistance Required
- Assign Responsibility for Reviewing, Revising & Updating Plan
- Implement Management Strategies
- Conduct Monitoring
- Conduct Education & Information Activities

Developing a monitoring component to track and evaluate the effectiveness of your implementation efforts using the criteria developed in the previous section is a vital step before implementing actions. Before any actions take place, we need to select monitoring designs, sites, parameters, and sampling frequencies. Communication, both within the organization and its Steering Committees, and outside of the organization (with Indigenous Communities, municipalities, stakeholders, government agencies, and general public) should also occur, to ensure that everyone is on the same page of how to execute the actions, and how to monitor the results of said actions. Doing so will decrease the chance that aspects get overlooked and will increase the probability of achieving the goals on time and on budget.

Goals should be broad and reflect what the committees hopes to accomplish as a result of the watershed management plan. Objectives should reflect the general actions necessary to obtain the goals. Implementation steps are specific actions that are measurable and can have estimated costs, anticipated project partners, and rough schedules. With a secure monitoring plan in place, and all other steps secured, it is time to implement the actions!

Ongoing updates in regard to the actions in progress is a great way to keep public interest in your projects. Conducting educational site demonstrations, information booths, in-class lessons to youth, are great ways to keep the public engaged in the project, and more willing to volunteer. During these sessions, be sure to stress WHY you are doing these actions, and the positive OUTCOME that will occur as a result. Your passion and commitment to these projects should be infectious and inspire others to lend a hand. Everyone involved in the actions should know their role, the expectations, targets, and VALUE of why we are undertaking these actions!

Goal 1: Develop, Implement, Monitor, and Update the Watershed Management Plan						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
1. Submit WMP to the Department of Environment & Climate Change		HRAA Office Manager	1 Watershed Management Plan			
2. Submit WMP to stakeholders, Indigenous Communities, Watershed groups & Public		HRAA Office Manager, HRAA Project Manager	20 Copies of Watershed Management Plan to be printed & distributed			
3. Public Commentary, Surveys, and Feedback on WMP		HRAA Office Manager, HRAA Project Manager	1 Online Survey, 5 Social Media Posts, Feedback Forms			
4. Create Steering Committee for the Watershed Management Plan		HRAA Board & Members, Government Agencies, First Nations, Public	12 Steering Committee Members			
5. Create Study Teams to work under Steering Committee		HRAA Board & Members, Government Agencies, Steering Committee	7 Study Teams with 5 people per team= 35 people			

Table 24 Goal #1

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action Complete

Incomplete

Study Team

T1- Riparian Restoration Team
T2- Riverside Clean Up Crew
T3- Citizen Science Team
T4- Engagement Team
T5- Invasives Team
T6- Fisheries Team
T7- Water Team

Goal 1: Develop, Implement, Monitor, and Update the Watershed Management Plan						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
6. Initiate 1st Meeting with Steering Committee, Study Teams, and Project Manager		Steering Committee, Study Teams, Project Manager, HRAA Office Manager	48 People to Attend First Meeting to discuss Watershed Management Plan			
7. Review and Feedback, Surveys, and Comments Submitted During Commentary Period		Steering Committee, Study Teams, Project Manager, HRAA Office Manager	Minimum of 10 feedback/completed surveys/commentaries			
8. Review, Evaluate, and Quantify Feedback (ie: prioritize main concerns)		Steering Committee, Study Teams, Project Manager, HRAA Office Manager	Create 1 Chart that Quantifies Feedback, Commentaries, Concerns			
9. Make Necessary Adjustments to the Watershed Management Plan to Incorporate Feedback		Project Manager	1 revised edition of the Watershed Management Plan, reflecting adjustments			
10. Begin to Implement the Actions and Goals of the Watershed Management Plan		Steering Committee, Study Teams, Project Manager, HRAA Office Manager				

Goal 2: Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
11. Decrease E. coli Levels in Specified Brooks (Palmer, Bradley, South Stream, Scoodic)		Project Manager & T7	Obtain <50 cfu/100mL			
12. Implement Water Quality Testing in Bater Brook (follow up from 2020 results)		Project Manager & T7	Obtain Minimum 4 General Chemistry/Bacterial Water Quality Samples			
13. Ground Water Mapping & Geothermal Imaging of Watershed		Project Manager & T7	Obtain Maps of Watershed Groundwater & Imaging			
14. HRAA staff to receive CABIN training.		Project Manager	1 Certified Project Coordinator, 1 Certified Field Tech, 1 Certified Analysist			
15. Update the BMI survey that was complete in 2020, only with proper CABINprotocols.		Project Manager	15 sites surveyed for BMI			

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action Complete

Incomplete

Study Team

T1- Riparian Restoration Team
T2- Riverside Clean Up Crew
T3- Citizen Science Team
T4- Engagement Team
T5- Invasives Team
T6- Fisheries Team
T7- Water Team

Table 25 Goal #2

Goal 2: Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
16. Minimize livestock access in priority tributaries (Scoodic Brook, South Stream)		Project Manager, T4, T7	Install approximately 1000m of fencing			
17. Create pamphlets on the importance of livestock diversion from streams, based on **Action 16** & distribute		Project Manager & T4	Distribute approximately 200 pamphlets			
18. Reduce excess nutrients in watershed originating from human activities (ie: phosphorus, nitrogen etc)		Project Manager & T7	All streams in watershed will be within CCME guidelines for supporting aquatic life			
19. Distribute pamphlets on nutrient reduction; develop Eco-Logic class on nutrient reduction.		Project Manager & T4	Distribute approximately 200 pamphlets, social media engagement, youth engagement			
20. Riverside Cleanup Events		Project Manager & T2	Host 2 riverside cleanup events per year			

Goal 2: Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
21. Reinstate PSC Monitoring & Sampling Program (revise 1998 monitoring plan)		Project Manager, T7, Potash Corporation, Department of Environment	Sampling protocol to be determined			
22. Create sampling program for defunct gas stations in watershed, "LUST" sampling (leaky understory testing)		Project Manager, T7, Department of Environment	Sampling protocol to be determined			
23. Create microplastics sampling program & educational program		Project Manager, T4, T7, T2	Sampling protocol to be determined; 1 Eco-Logic class to be developed, 200 pamphlets distributed			
24. Create soil sampling program-identify key areas to sample; bioaccumulation of toxins/carbon sequestration		Project Manager, HRAA staff	Sampling protocol to be determined; key areas to be determined			
25. Review hydrological assessments & assess old dam at Cassidy Lake		Project Manager, T7, T6	1 Review & Assessment Report on Cassidy Lake dam			
26. Create sampling program for tributaries within the Caledonia Highlands (Culligan, Quigley, Fletcher, Mill etc)		Project Manager, T7	Obtain 4 samples per site to determine water quality			

Goal 2: Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
27. Create report combining **Action 13** & **Action 26** to identify Critical Habitat		Project Manager, T7, Department of Environment	1 final report investigating the link between highlands & groundwater			
28. Install data logger at Mine Discharge Pool		Project Manager, T7	1 data logger installed			
29. Identify key sites within watershed for additional data loggers (salmon holding pools)		Project Manager, T7	Install approximately 15 data loggers throughout watershed			
30. Secure funding & install culverts at areas that require culverts (Freddy's Falls, Duffy Brook, Gravel Pit Lake)		Project Manager, T7, T6, Department of Transportation, Department of Environment	Install 3 culverts in areas that do not have culverts, but are allowing traffic in-stream			
31. Sediment transport study & geomorphological assessment of confluence points		Project Manager, T7, T1, T6, Department of Environment	Assess a minimum of 15 tributary confluence points with the main stem			
32. Cyanobacteria sampling, benthic mat testing, community outreach		Project Manager, T7, ACAP Saint John, Department of Health, Department of Environment	Annual collection of samples from minimum of 2 locations in watershed			

Goal 2: Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
33. Investigate salt content in Salt Springs Brook.		Project Manager, T4, T7	Perform conductivity & salinity testing along 15km of the brook			
34. Investigate feasibility of magnet fishing to remove metal debris from watershed; partner with SCUBA Mike to remove debris		Project Manager, T7	Complete feasibility study on magnet fishing; remove debris from river in at least 5 areas			
35. Implement Effects Monitoring Plan of the Upham Gypsum Mine, in tandem with **Action 28**		Project Manager, T7, T6, Hammond River Holdings, Department of Environment	Produce Annual report for life of the mine (approx. 9 years)			
36. Update HRAA's Bridging the Gap report, including Water Quality sampling around Quispamsis Lagoon (incl. heavy rainfall events)		Project Manager, T7, Department of Environment, Town of Quispamsis	Perform minimum of 20 water quality samples to determine source of nutrient/E. coli exceedances			
37. Re-engage with residents in the Pine Valley Mini Home park in regard to septic tank maintenance.		Project Manager, T7, T4, Town of Quispamsis, Department of Environment	Host minimum of 2 community meetings; distribute 150 pamphlets			

Goal 2: Protect and Improve Surface Water and Ground Water Quality and Quantity within the Hammond River Watershed						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
38. Develop monitoring plan of Colton Brook (road salts, lawn fertilizer, car oil etc)		Project Manager, T7, T4	Identify key areas for water sampling; perform 4 water quality samples per site			
39. Increase Citizen Science Water Quality Monitoring with Water Rangers kits in communities		Project Manager, T3, T4, Water Rangers Organization	Minimum of 4 Community Water Rangers Volunteers for monthly sampling			
40. Geological Assessment of the Hammond River watershed, to understand geological impact on ground & surface water		Project Manager, T7, New Brunswick Museum, Government of New Brunswick	1 updated Map of watershed highlighting bedrock geology			

Goal 3: Protect and Improve Riparian Buffer Zones and Critical Habitats						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
41. Secure funding & implement activities in Dillon Consulting's report for restoration of Crowley's Pool		Project Manager, T1, Dillon Consulting, Department of Environment, Department of Transportation	1 successfully restored salmon pool (Crowley's Pool)			
42. Secure funding & implement activities outlined in Dillon Consulting's report for restoration of Germaine Brook		Project Manager, T1, Dillon Consulting, Department of Environment, Department of Transportation	1 successfully restored salmon pool (Germaine)			
43. Hire Dillon Consulting to perform restoration assessment of Salt Springs Brook		Project Manager, T1, Dillon Consulting, Department of Environment	1 report on restoration requirements of Salt Springs Brook			
44. Hire Dillon Consulting to perform restoration assessment of Scoodic Brook		Project Manager, T1, Dillon Consulting, Department of Environment	1 report on restoration requirements of Scoodic Brook			

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action Complete

Incomplete

Study Team

T1- Riparian Restoration Team
T2- Riverside Clean Up Crew
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T6- Fisheries Team
T7- Water Team

Table 26 Goal #3

Goal 3: Protect and Improve Riparian Buffer Zones and Critical Habitats						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
45. Hire Dillon Consulting to perform restoration assessment of Palmer Brook		Project Manager, T1, Dillon Consulting, Department of Environment	1 report on restoration requirements of Palmer Brook			
46. Hire Dillon Consulting to perform restoration assessment of O'Dell Pool		Project Manager, T1, Dillon Consulting, Department of Environment	1 report on restoration requirements of O'Dell Pool			
47. Plant 1000m² of shrubs along Palmer Brook		Project Manager, T1, World Wildlife Fund	Plant approximately 1000 shrubs along Palmer Brook & soil sampling			
48. Willow staking along 600m² at McGonagle Pool		Project Manager, T1	Plant approximately 300 willow whips			
49. Willow staking surrounding Twin Brook culvert		Project Manager, T1	Plant approximately 75 willows & shrubs			
50. Create riparian planting database to easily track species, #, and success rates of planting		Project Manager, T1	1 easily accessible database, containing all historical + current planting data			
50. Review & document success rate of willow staking at Hammondvale Bridge Pool in 2020		Project Manager, T1	Enter success rates into riparian restoration database			

Goal 3: Protect and Improve Riparian Buffer Zones and Critical Habitats

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
51. Engage youth & Nature Camp kids to assist with shrub planting in Palmer Brook, **Action 47**		Project Manager, T1, T4	Have the assistance of 50 kids to plant shrubs along Palmer Brook			
52. Create educational materials & promote no-mow zones along riverbanks		Project Manager, T1, T4	Create & distribute approximately 200 pamphlets on no-mow zones			
53. Work with the Government of New Brunswick & Department of Environment to increase riparian buffer setbacks from 30m to 100m		Project Manager, T1, T4, Department of Environment	1 Amendment to the Alteration Regulation 90-80 Clean Water Act C-6.1			
54. Identify & create database of Critical Habitat Zones within watershed as result of **Action 13**		Project Manager, T1, T4, Department of Environment	1 updated map of all designated Critical Habitat zones within the watershed			
55. Work with JDI landowners to survey Upham Mountain as a Critical Habitat and potential JDI Unique Area		Project Manager, T1, JD Irving Ltd.	Delineate wetlands & ecological inventory			
56. Follow up with GNB on Theobald PNA proposal		Project Manager, T1, Department of Environment	Implement monitoring plan as per PNA proposal			

Goal 3: Protect and Improve Riparian Buffer Zones and Critical Habitats

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
57. Conservation evaluation of Henderson Lake property		Project Manager, T1, Nature Trust of NB	1 report on ecological inventory			
58. Work with the Nature Trust NB to promote land donation opportunities		Project Manager, T1, Nature Trust of NB	Host 2 community meetings, distribute pamphlets, social media engagement			
59. Design and install anti-littering educational signage at party hotspots (Deep Hole, Tabor Bridge, Silver Hill)		Project Manager, T2	Install educational 3 signs			
60. Work with JDI landowner on upper Hanford Brook to create Unique Area		Project Manager, T1, JD Irving Ltd.	Include approximately 300 hectares as Unique Area			
61. Create "Restoration Demonstration Sites" as a result of **Action 50** to showcase & promote HRAA restoration work to the general public		Project Manager, T1, T4, landowners of historic HRAA restoration sites	Identify 5 successful restoration areas for promotion; design educational pamphlets to promote work; social media engagement			
62. Re-engage landowner of Renforth Pit Lake for further restoration		Project Manager, T1, T4, landowner	Develop restoration plan			

Goal 4: Fully Characterize the Watershed (including all wetlands, lakes, tributaries, and main stem)

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
63. HRAA staff to receive wetland delineation certification		Project Manager, HRAA staff, Maritime College of Forest Technology	At least 2 HRAA staff to obtain certification			
64. Wetland delineation of all wetland areas within watershed		Project Manager, certified HRAA staff, T7, Ducks Unlimited	Over 10 years, to delineate all wetlands in watershed			
65. Identify & characterize (ie: stream assessments, habitat assessments) of all headwaters & confluence points within watershed		Project Manager, T7	Over 10 years, identify and characterize all headwaters & confluence points within watershed			
66. Lake assessment of all lakes within the watershed		Project Manager, T7, T6, T5, New Brunswick Alliance of Lakes Association	4 water quality samples (minimum) from each lake within the watershed			

Timeline

- Short Term <2 years
- Mid-Term <5 years
- Milestone 2027
- Long-Term >5 years

Indicators

- Programmatic Indicators
- Environmental Indicators
- Social Indicators

Monitoring

- Performance Monitoring
- Results Monitoring

Status

- Planning Stage
- Stakeholder Engagement
- In Progress
- Action Complete
- Incomplete

Study Team

T1- Riparian Restoration Team
T2- Riverside Clean Up Crew
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T7- Water Team

Table 27 Goal #4

Goal 4: Fully Characterize the Watershed (including all wetlands, lakes, tributaries, and main stem)						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
67. Continue with stream habitat assessments that were begun in 2020 to characterize all unnamed minor tributaries within the watershed (ie: we surveyed, characterized & named Clyde Brook, Hamilton Brook etc)		Project Manager, T7	Approximately 35 unnamed minor tributaries to be assessed & characterized before the 50th anniversary milestone of the organization			
68. Obtain drone footage of the entire watershed & review VHS tapes of old HRAA ariel footage & create comparison		Project Manager, T7,Top Notch Photography, Mike Adams	Create 1 video that highlights the shift in the watershed from original VHS arial footage and new footage			

Goal 5: Protect and Enhance Fisheries Management Strategies						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
69. Expand electro-fishing sites to include areas of interest from 2020 (Maclaren Brook, Donnelly Brook, McGonagle Brook, O'Dell Brook etc)		Project Manager, T6, DFO, CIPS	Expand electro-fishing sites by 1 site/year			
70. Create culvert repair/replacement strategy		Project Manager, T6, Department of Transportation	Replace/repair 1 culvert per year			
71. Fish Friends- will it continue? Replace with trout?		Project Manager, T6, Mactaquac Biodiversity Facility, NB Salmon Council	1 report on status of Fish Friends			
72. Identify areas for potential stocking		Project Manager, T6, DFO	1 report on potential stocking sites			
73. Research & implement different in-stream incubation methods		Project Manager, T6, DFO, Mactaquac Biodiversity Facility	1 research report on in-stream incubation methods that would suit the Hammond watershed			

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action Complete

Incomplete

Study Team

T1- Riparian Restoration Team
T2- Riverside Clean Up Crew
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Table 28 Goal #5

Goal 5: Protect and Enhance Fisheries Management Strategies						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
74. Educate the public on fishing etiquette, fishing regulations on the Hammond River		Project Manager, T6, T4, work with DFO to track # fishing violations in watershed	4 educational signs posted in watershed at common locations, social media engagement			
75. Build & install 10 monofilament recycling bins		Project Manager, T6, T4	Install 10 bins			
76. SCUBA in main salmon pools to acquire underwater footage		Project Manager, T6, SCUBA Mike	Obtain underwater footage from 5 salmon pools			
77. American Eel population survey		Project Manager, T6, Indigenous Communities/CIPS	Electro-fish 15 Eel hotspots in watershed for density survey			
78. Shortnose Sturgeon population survey		Project Manager, T6, Canadian Rivers Institute	Program & target to be determined			
79. Bait Fish density survey (black nose dace, sculpin etc)		Project Manager, T6	Electro-fish 15 sites to determine bait fish density			
80. Creation of Kids' Fishing Club		Project Manager, Camp Manager, T4	20 kids to sign up to Kids' Fishing Club, with 1 meeting per month			
81. Annual Fishing Derby to promote connection between recreation and conservation		Project Manager, HRAA staff & board, T6, T4	50 participants over 2-day derby			

Goal 5: Protect and Enhance Fisheries Management Strategies

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
82. Continue to collect adipose finn clips to support the Live Gene Bank, as needed		Project Manager, T6, DFO, CIPS, Houlton Band of Maliseet Indians, Maliseet Nation Conservation Council	Obtain approximately 20 samples per year, or as needed			
83. Create, promote, and distribute an annual creel survey		Project Manager, T6	Engage 50 local anglers to complete creel survey			
84. Expand e-DNA sampling program to address priority culvert replacement as per **Action 70**		Project Manager, T6, Scott Pavey Lab	Sample approximately 10 areas above & below hung culverts			
85. Reinstate the kelt reconditioning program		Project Manager, T6, ASF, Mactaquac Biodiversity Facility, DFO	Capture approximately 10 kelt for reconditioning at the MBF			
86. Work with DFO to increase presence at areas below McGonagle Brook during fly-fish only restrictions & Palmer Brook closure zone		Project Manager, T6, DFO	Minimum 3 site visits per month during fishing season			
87. Create new database to house all historic + current electro-fishing data ("DataFish")		Project Manager, T6	Enter all historic + current data into system			

Goal 6: Increase Ecological Inventory and Knowledge- Traditional Knowledge, Endangered/Species at Risk, Invasive Species

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
88. Develop relationship with Indigenous Communities for assistance with Traditional Knowledge of the watershed		Project Manager, T4, First Nations Communities	Engage with at least 5 First Nations communities, complete 1 Traditional Knowledge Survey within the watershed			
89. Use e-DNA to identify potential wood turtle habitat		Project Manager, T4, T5, Scott Pavey Lab	Collect minimum of 5 e-DNA samples			
90. Install 4 bat SONAR boxes throughout watershed		Project Manager, T4, T5, Boreal Environmental	Install 4 bat data collectors			
91. Host instructional classes on how to build duck boxes; songbird boxes; install throughout watershed		Project Manager, T4, T5, Ducks Unlimited, KWRC, Jim Wilson, NatureNB	Host 2 building workshops; install 20 boxes			

Timeline

- Short Term <2 years
- Mid-Term <5 years
- Milestone 2027
- Long-Term >5 years

Indicators

- Programmatic Indicators
- Environmental Indicators
- Social Indicators

Monitoring

- Performance Monitoring
- Results Monitoring

Status

- Planning Stage
- Stakeholder Engagement
- In Progress
- Action Complete
- Incomplete

Study Team

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T7- Water Team

Table 29 Goal #6

Goal 6: Increase Ecological Inventory and Knowledge- Traditional Knowledge, Endangered/Species at Risk, Invasive Species

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
92. Create milkweed inventory of watershed; educate public on importance of milkweed		Project Manager, T4, T5, Southern NB Monarch Watchers	1 data map of milkweed locations, 2 educational signs at known milkweed sites, social media engagement			
93. Increase number of Eco-Logic Classes for ASD-S & Nature Camp		Project Manager, Camp Director, T4, ASD-S Educators	Increase classes from 20 to 40 classes annually			
94. Create pollinator gardens at the Conservation Center		Project Manager, Camp Director, T3, T4, T5	Create 4 new pollinator gardens			
95. Host Bioblitz events and expand on Hammond River Nature Collection on the iNaturalist app		Project Manager, T3, T4, T5, Camp Director	Increase members on HRAA's iNaturalist group to 50			
96. Partner with the NB Invasives Species Council to promote Clean, Drain Dry (and other programs)		Project Manager, T3, T4, T5, NBISC, KWRC	Host 2 Clean Drain Dry events per year			
97. Sample all lakes in watershed for EWM & invasive mussels		Project Manager, T5, T7, NBISC	Obtain 2 samples from priority lakes (boat hotspots)			
98. Update 2018 mussel biodiversity study		Project Manager, T5, T6, T7	Survey 15 locations throughout watershed			

Goal 6: Increase Ecological Inventory and Knowledge- Traditional Knowledge, Endangered/Species at Risk, Invasive Species

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
99. Survey the Caledonia Highland tributaries for the endangered Eastern Waterfan		Project Manager, T5, Fundy National Park	Survey 8 upper watershed tributaries			
100. Work the Atlantic Canadian Conservation Data Center for ecological inventory in calcareous hotspots in the watershed		Project Manager, T5, AC CDC	Survey Drummond's & Tracy Lake			
101. Inventory of rare/endangered trees within the watershed (ie: ash vs emerald ash borer)		Project Manager, T5, Kelly Honeyman, NBISC	Survey forested areas throughout watershed for tree inventory			

Goal 7: Increase Engagement, Knowledge, and Best Practices with Public, Forestry, Agriculture, and Industrial

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
102. Create mine and quarry inventory; define which are active vs inactive		Project Manager, GNB, T4	Create 1 database of all quarries and mines in the watershed + map			
103. Reach out to defunct quarry owners to discuss reclamation or land donation possibilities		Project Manager, T4	Target to be determined after **Action 102** is complete			
104. Engage in discussions Crown Land, landowners & forestry industry on increasing buffer zones surrounding Caledonia highlands tributaries		Project Manager, T4, JD Irving Ltd, GNB, local landowners	Increase setbacks from 30m to 100m surrounding these cold water tributaries			
105. Promote farmers who display awesome agricultural best practices		Project Manager, T4	Promote 2 farmers/landowners per year			

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Table 30 Goal #7Complete

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action

Study Team

T1- Riparian Restoration Team
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Goal 8: Develop and Implement Climate Adaptation Plans and Strategies

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
106. Engage Dillon Consulting to develop action plan for Albert Tabor Culverts to divert flooding & control sediment		Project Manager, T4, Department of Environment, Department of Transportation	Install 2 new culverts, settling pond, and properly sloped ditches			
107. Develop action plan to create a water reservoir for the Upham Fire Department		Project Manager, T4, Department of Environment, local landowner, Upham Fire Department	Create & implement plan to build a large, above ground water reservoir for fire department; redirect pumping activities from Scoodic Brook			
108. Install eaves troughing and rain barrels at the Conservation Center		Project Manager, T4	Install eaves troughing along entire building; install 2-3 rain barrels			

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action Complete

Incomplete

Study Team

T1- Riparian Restoration Team
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Goal 8: Develop and Implement Climate Adaptation Plans and Strategies						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
109. Create Citizen Science opportunity with precipitation monitoring and snowpack monitoring		Project Manager, T4, CoCoRAHS, Department of Environment	Install 10 precipitation gauges throughout watershed			
110. Research & outreach on developing rain gardens and green infrastructure projects		Project Manager, T4, ACAP Saint John, Town of Quispamsis	To be determined after research & engagement			
111. HRAA Boat launch improvements		Project Manager, Community Investment Fund, T4	Regrade & improve boat launch			
112. Create Eco-Logic classes that focus on climate change & adaptation		Project Manager, Environmental Educator	Create and distribute 1 new lesson to 20 classes			
113. Work with the Town of Quispamsis and Hampton to develop storm water by laws, best management practices (bioretention systems, holding ponds, constructed wetlands etc)		Project Manager, T4, ACAP Saint John, Town of Quispamsis & Hampton, Department of Environment	To be determined upon review			

Table 31 Goal #8

Table 32 Goal #9

Goal 9: Enhance Recreational Opportunities and Sustainable Practices in the Watershed						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
114. Create brochure of natural recreation areas (kayaking, hiking)		Project Manager, T4	Distribute 100 pamphlets & social media engagement			
115. Promote businesses that offer recreation in watershed		Project Manager, T4	Social Media engagement			
116. Create Geocaching Box adventure (boxes filled with sponsors' items etc)		Project Manager, T4	Hide 6 geocache boxes within the watershed; have at least 50 people find them			
117. Increase vegetable gardening at the Conservation Center to promote sustainable food		Project Manager, T4, Camp Director	Create 4 new vegetable gardens			
118. Paint murals on bridge pillars beautification & to deter littering		Project Manager, T4, local artists	4 murals on bridges in watershed			

Timeline

- Short Term <2 years
- Mid-Term <5 years
- Milestone 2027
- Long-Term >5 years

Indicators

- Programmatic Indicators
- Environmental Indicators
- Social Indicators

Monitoring

- Performance Monitoring
- Results Monitoring

Status

- Planning Stage
- Stakeholder Engagement
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Study Team

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Goal 10: Amalgamate, Digitize, and Make Accessible Historic HRAA Projects and Data

Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
119. Create database of all final project reports, in chronological order		Project Manager, HRAA staff	1 large, accessible database of all projects			
120. Review and determine which historic projects need updated based on **Action 119**		Project Manager, HRAA staff	Begin updating projects as necessary			
121. Transfer all historic photographs into digital format		Project Manager, HRAA staff	All old photos will become digitized			
123. Scan historical handwritten documents from the filing cabinet to have digital copy to preserve HRAA history		Project Manager, HRAA staff	All handwritten documents uploaded into OneDrive account for preservation			

Timeline

Short Term <2 years

Mid-Term <5 years

Milestone 2027

Long-Term >5 years

Indicators

Programmatic Indicators

Environmental Indicators

Social Indicators

Monitoring

Performance Monitoring

Results Monitoring

Status

Planning Stage

Stakeholder Engagement

In Progress

Action Complete

Incomplete

Study Team

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Goal 10: Amalgamate, Digitize, and Make Accessible Historic HRAA Projects and Data						
Actions	Timeline	Partners/Lead	Numeric Target	Indicators	Monitoring	Status
124. Contact all former HRAA board of directors, project managers etc, to discuss their past projects, favorite memories, and their general history with the HRAA		Project Manager, T4, HRAA staff	Contact at least 25 former HRAA board members			
125. Update GIS mapping and land use mapping; make comparisons from historic data		Project Manager, T4, HRAA staff	1 updated report on GIS mapping of the watershed, land use mapping & comparison to historical reports			
126. Contact GNB and discuss retrieval of all historic data (defunct programs like FishStream, Aquatic Data Warehouse)		Project Manager, T4	1 report on historic data retrieval			
127. Plan and execute the most fantastic anniversary party to celebrate HRAA's 50th year!		Project Manager, HRAA Staff	At least 50 guests, of past and present HRAA board of directors, members, and local community!			

Table 33 Goal #10


Monitor,
Report
&
Update

Stage 6:
Monitor, Report & Update

The final stage in watershed management planning! Stage 6 is an on-going, cyclical process of continuing to monitor, track, report, adjust and update the progress that you are making as a result of the first 5 stages. Work that will be carried out in Stage 6 includes:

- Review & Evaluate
- Report to Stakeholders & Public
- Ongoing Monitoring
- Database for Projects
- Adjust Plan as Necessary

The majority of the actions and undertakings can be updated annually, while some projects may require 6-month check ins to ensure that they are on track for success. Annual summary reports, including the work that has been done, timeline, and budget, can be a great way to keep things rolling smoothly, and keep the community and partners engaged.

Keeping track of any technical difficulties, shortfalls, over-budget items, and problems that you have encountered while carrying out the goals and activities will assist in adjusting and adapting future goals and actions. We cannot learn from our mistakes if we do not keep track of those mistakes!

Creating an easily accessible database for projects (both past/completed projects, ongoing projects, and future projects) will allow for ease of reference. HRAA has been actively pursuing projects for over 40 years, and it can become very easy to let some of these projects fall by the wayside if they are not correctly placed in an accessible database! This will also allow for ease of transition when new staff arrive, as they will know exactly where to look for past, ongoing, and future projects.

Always keep in mind that the watershed management planning process should never become a static, stagnant, inert plan- it is a living document. It is designed to change and flow year to year, just like the river itself. Make adjustments as necessary- perhaps a new tool or technology has become available that was not around 5 years ago, or perhaps a new funding opportunity or partner has come up. Incorporate these shifts into the plan!

"Be fluid. Be like water. Flow around the obstacles"- Master Choa Kok Suii

Glossary of Terms

Algal Bloom- A sudden burst of nutrients within a water body allowing algae to flourish, often reducing dissolved oxygen levels in the water, posing a hazard to aquatic inhabitants.

Alkalinity- is a measure of water's capacity to neutralize an acid and resist changes in pH. Alkalinity measures the amount of alkaline compounds in the water, such as carbonate, bicarbonates, and hydroxide. (New Brunswick Department of the Environment Analytical Service Laboratory 1999)

"As it naturally occurs"- referring to a watercourse which displays physical, chemical, and biological characteristics that are not affected or are only minimally or temporarily affected by human activity.

Bailey Bridge- A prefabricated bridge often used by military personnel as a temporary crossing; few can still be found crossing the Hammond in its upper reaches.

Benthic Invertebrates- Aquatic insects and other invertebrates that spend part or all of their life cycle in or on the bottom of a watercourse and are capable of being seen without magnification (DELG 1999)

Brine- Salt or seawater, in most cases within the Hammond River is a waste effluent of potash mine. It is disposed of through "brine lines" which run throughout the watershed.

Broodstock- Sexually mature salmon and grilse collected for reproduction. These fish are then sent to Mactaquac, a fertility facility where they are spawned and released to the river again and the juveniles are reared streamside.

Dissolved Oxygen- The amount of oxygen while present in a given medium, in our case water. This measurement is an essential factor in the overall quality of environment for aquatic inhabitants.

Drainage Area- The contours of the land running from high points to low points through which water travels. It is at the lowest point of these areas where streams and rivers often form.

***E. coli*-** (*Escherichia coli*) is a bacterium frequently used as an indicator for bacteria and possible pathogen contamination of inland and coastal water. Often generated in the intestines of warm-blooded mammals passing through fecal matter.

Eco-Reach- A section of the river system divided for ease of classification. The division was made in 1998 using bridges as landmarks and naming the reaches accordingly.

Electro-fish- The use of electrical current to temporarily demobilize fish, allowing a sample to be taken of a given fish population. This methodology is widely used throughout the scientific community and has proved to be successful at the HRAA.

Embeddedness- The degree to which larger particles, such as boulders, rubble, or gravel, are surrounded or covered by fine sediment.

Fecal Coli Forms- A group of bacteria within the coli form family specific to the intestinal tract of warm-blooded animals and humans. Presence of fecal coliforms is an indicator of fecal pollution.

Ford- Locations at which crossing of a river or stream has historically taken place. The water level is typically low and the crossing is preferred to be at 90 degrees to the water flow to reduce detrimental effects.

Fry- A recently hatched salmon, one which has fully absorbed its yolk sac and can now hunt and consume live food.

GIS- Geographical Information System. Widely used computer mapping software. This has been a highly valuable tool in the creation of maps depicting the locations of streams and work performed by HRAA.

Habitat- The total environment required by plans and animals to sustain all of its life functions. Habitat requirements of fish include food, space, shelter, and water quality (DFO 1988)

Median Substrate- The materials making up the streambed; usually described as bedrock, boulder, cobble, gravel, sand, or silt.

Non-point Source- A pollution discharge that is from multiple sources. The source of origin is often difficult to determine.

Overhanging Cover- Is vegetation that hangs over a waterway and provides shade, cover, food, and a breeding place for aquatic organisms.

Parr- Juvenile fish, one preparing to leave the fresh waters of its home.

pH- The measure of the acidity or basicity of a given solution. All aquatic inhabitants have a tolerance to pH levels most often near the 7.0 reading.

Point Source- Pollution discharged directly into the environment, usually through a discharge pipe. Includes industrial and commercial process effluent and collected human wastes.

Pool- Water of considerable depth for the size of the stream; pools generally have slowly flowing water and a smooth surface, but they often have a swift, turbulent area where the water enters them (DFO 1988)

Presence/Absence- Often used to determine the probability of a given habitat to be assessed further.

Redd- A gravel nest which salmonids lay their eggs.

Riffle- A shallow water with a rapid current and surface flow broken by gravel or rubble.

Riparian Area- Land adjacent to a stream or other body of water.

Run- Moderate to rapid current flow in a deeper, narrower channel than a riffle; the depth and materials found in runs make them excellent cover locations for salmonids.

Sedimentation- deposition of eroded soil material on the streambed

Silvics- The study of forests and their ecology, including the application of soil science, botany, zoology, and forestry.

Smolt- This is the stage where salmonids become physiologically adapted to saltwater and begin their trek to a salt water environment.

Stakeholder- An individual or an organization who has a direct and/or indirect interest in the watershed.

Substrate- The composition of the stream bed.

Tannin- Binding agent found in many plants and trees. This agent breaks down into water during defoliation of trees and often changes water a deep brown “cola” color.

Three Sweep Regression- A method of electro-fishing, where a section of stream is isolated by two barrier nets and three passes are made through the given area with an electro-fisher to determine the overall fish density.

Tolerant hardwoods- Hardwood trees that can thrive under the canopy/cover of surrounding trees prior to being opened up to full sunlight. These trees often have large canopies and are able to shade large amounts of surrounding ground. These trees tend to be longer lived species, far exceeding the non-tolerant species.

Total Kjeldahl Nitrogen (TKN)- Represents the nitrogen equivalent to the sum of ammonia and organic nitrogen. TKN levels are important for assessing the amount of nitrogen available for biological activities (DELG 1999)

Total Phosphorus (TP)- Phosphorus originating from weathering of bedrock, decomposition of organic matter, domestic sewage, phosphate from detergents, and drainage from fertilized land.

Turbidity- The cloudiness created within water as suspended particles become active (like smoke in the air). Often seen in areas with large scale erosion.

Water Classification- A technical and administrative procedure that can be used to manage water by setting goals for use and protection. Rivers, tributaries, and lakes or segments of rivers are placed into categories based on the desired level of protection (Eastern Charlotte Waterways Inc 1999)

Watershed- An area of land from which water drains downhill into a body of water such as a lake or river. A watershed is comprised of hills, valleys, lakes, streams, rivers, and smaller tributaries (Fergus Lea et al 1990)

Water Velocity- A measurement of water speed recorded as distance traveled over time, ie: feet or meters per second.

Zipping- Program used following electro-fishing data collection to determine fish densities standardized per 100 square meters. This program allows data from many samples to be compared on a standard basis.

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Afterword

2020 was an interesting year, to say the least. The global pandemic certainly made things difficult- not only for writing this document and completing the proposed work, but in all of our day to day lives. The silver lining that came from the pandemic was a global reawakening to the importance of connection to nature.

2020 was also noteworthy from the Association's perspective- there was a high staff turnaround, and the original proposal for this undertaking was written by former staff, who were not available to assist or guide the new staff. As such, we took this project and ran with it, to the best of our abilities.

Our main focus was to see as much of the Hammond River watershed as possible- how can one begin to manage a watershed if you do not know it intimately? The learning curve of data collection was huge, and this document represents only the beginning. The summer of 2020 became an adventure of discovery: "let's just go around one more bend in the river, to see what we can see" was often the theme of each outing.

While the world was in lockdown,
we were free to roam the river and its
tributaries, and all the beauty therein.

S. Blenis & J. Kelly