2023/24

Nashwaak Watershed Aquatic Connectivity Report

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Nashwaak Watershed Association Inc

2023/24

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BACKGROUND AND OBJECTIVES

Urbanization and industrialization have increased significantly in the Nashwaak Watershed during the last decade, leading to an increase in roads and associated stream crossings. Culverts and dams that are poorly designed, installed, and maintained can be a limiting factor for endangered diadromous fish species such as Atlantic salmon (*salmo salar*). These barriers prevent salmon and similar species from reaching upriver spawning habitat, feeding grounds, and cold-water refugia, which can have significant impacts on the population capacity of the entire watershed. A single barrier culvert can restrict fish from accessing several kilometres or more of vital upstream habitat.

Aside from causing barriers to fish passage, culverts can also change the hydrology of the river system. They risk becoming blocked with debris, which may cause flooding and costly damage to infrastructure. Habitat fragmentation is also a prolific issue in the Maritimes. The Clean Annapolis River Foundation found that 70% of assessed culverts were barriers to fish passage and 80% of the culverts surveyed by the Petitcodiac Watershed Alliance in 2015 were either partial or full barriers to fish passage.

Prior to 2017, information regarding aquatic connectivity in the Nashwaak Watershed was largely unknown. It is because of this knowledge gap that the Nashwaak Watershed Association Inc. (NWAI) requested funds to conduct a multi-year project to assess, prioritize, and restore barrier culverts in the Nashwaak Watershed from the mouth of the river working upwards. This was a priority strategy to re-establish fish access to crucial upstream habitat, with 2023 being our sixth field season for assessment.

The Nashwaak River is crucial for the survival of Atlantic salmon at a variety of life stages. As a tributary of the greater Wolastoq River, the Nashwaak is one of the Department of Fisheries and Oceans (DFO's) priority index rivers listed in the 2014 "Recovery Potential Assessment." This work is also in line with the Atlantic Salmon Federation's 2018-2023 "Blueprint for saving Wild Atlantic Salmon." Habitat fragmentation and blocked access to cold-water, spawning habitats have long been recognized as limiting factors for salmon populations.

<u>The primary objectives of the project are:</u>

1) To increase the capacity of the NWAI to survey for aquatic connectivity,
2) To increase our knowledge of the aquatic connectivity and fragmentation of the watershed,
3) To decrease habitat fragmentation within the Nashwaak watershed and create an overall increase in habitat availability for fish, and
4) To communicate the importance of watershed connectivity to the public.

DELIVERABLES

SHORT-TERM

The annual, short-term goals of the project are to:

1) Conduct a desktop survey of the remaining culverts to visit,
2) Conduct a field survey of at least 25 culverts in the central and upper watershed:

    a. Remove all garbage and debris from assessment sites,
3) Map and prioritize culverts for remediation in terms of barriers to fish,
4) Conduct a hydraulic survey of the top barrier(s) with an engineering firm:
    a. Prepare stamped drawings,
    b. Inform the NB Department of Transportation and Infrastructure (DTI), NB Department of Natural Resources and Energy Development (DNRED), or other culvert owners and start conversation about remediation,
5) Update our aquatic connectivity map of the watershed, which will be made public, and
6) Raise awareness regarding aquatic connectivity through outreach and social media efforts.

LONG-TERM

The long-term goals of the project are to:

1) Expand our understanding of the health and connectivity of the Nashwaak Watershed,
2) Increase the amount of available upstream aquatic habitat for migratory fish, especially the endangered Atlantic salmon, by facilitating fish passage through culverts assessed as barriers, and
3) Communicate this information to the public through our outreach programs.

RESULTS

Over the last seven years, NWAI's capacity to survey the Nashwaak Watershed has greatly increased, as has our knowledge regarding the connectivity and fragmentation of our watershed. We have been able to inform the public about habitat fragmentation on our online platforms as well as through the distribution of printed resources. We have further solidified our working relationship with the NB Department of Transportation and Infrastructure (NBDTI), and we have now completed four major remediation projects in collaboration. We have also partnered with multiple non-profit, municipal, and Wolastoqey groups to complete our largest barrier project to date: the removal of the Campbell Creek Dam. Surveys were conducted utilizing the Nova Scotia Adopt-a-Stream program guidelines. This program has offered Aquatic Connectivity Assessment Training since 2010. This training enables watershed stewardship groups to plan, prioritize and complete surveys of water crossings in their local watersheds. The survey sheet can be found in Appendix I.

There are approximately 985 stream-road crossings in the Nashwaak Watershed. In May 2017, the NWAI began to map, assess, and improve these crossings. Below are a summary of sampling and remediation events by year. Work accomplished each year is dependent on weather, vehicle access, funding, and landowner cooperation. The first several years of the project involved surveying road-stream crossings in the lower, more urbanized areas of the watershed. The later years of the project were focused on surveying the upper reaches, where access and conditions are more restrictive and less predictable.

HISTORY OF NWAI PROGRAM:

2017: This was the first field season for road-stream surveys. Surveys were completed on 75 culverts, and 70% of crossings in fish habitat were determined to be full or partial barriers to fish passage.

2018: NWAI started by mapping out priority areas in the central watershed to survey, then visited 114 sites and conducted a full survey of 67 crossings. The organization began using an updated survey form so that full surveys included the collection of water temperature, pH, conductivity, DO, and total dissolved solids. Several other additional measurements and observations that were not included in 2017 surveys were also added. The Manzer Brook fish ladder was installed (see full description in past projects).

2019: The NWAI visited 83 sites and conducted a full survey on 50 culverts.

2020: 50 sites were visited, and a full survey was completed on 24 culverts. This year, the focus was on culverts in the headwaters of the watershed. This approach required the use of logging or forest service roads, which meant increased driving time. East Ryan Brook, McGivney Brook, and Limekiln Brook fish passage projects were completed. This involved installing baffles and fish chutes at each location (See past projects for more information).

2021: In the 2021 field season NWAI conducted surveys on 21 culverts and fully assessed 6. As these sites were focused on the upper watershed, which is less populous and industry heavy, many sites were deemed inaccessible. Electrofishing surveys were conducted at 4 fish passage remediation sites completed between 2018-2020.

2022: Over 35 sites were attempted for assessment but were not surveyable due to poorly maintained roads, flooding, or culvert blockages. NWAI was able to survey 26 culverts and conduct a full survey on 12. Two historically assessed sites were revisited to recheck the condition after speaking with landowners. All previous fish passage remediation sites were visited to confirm condition.

2023: This season saw unprecedented levels of precipitation. This limited the safety, accessibility, and reliability of surveys. A strategic decision was made to review and revisit older survey locations to gain an up-to-date understanding of the conditions of these crossings. In total, 22 road-stream crossings were visited across the watershed. The selection of these locations was based on barrier type, whether there was ideal habitat for certain native species present, and the extent of upstream habitat blocked for fish passage. Our results showed that none of the barriers had been remediated by the landowners or leaseholders. NWAI is following up on this information with landowners and relevant government departments. Funding is confirmed for two major barrier removal/remediation projects on Municipal and provincially owned properties. An additional two top barriers were submitted to engineers for project design in late summer 2023. All four previously remediated sites were visited to check on the condition of the structures.

SUMMARY OF RESULTS TO DATE

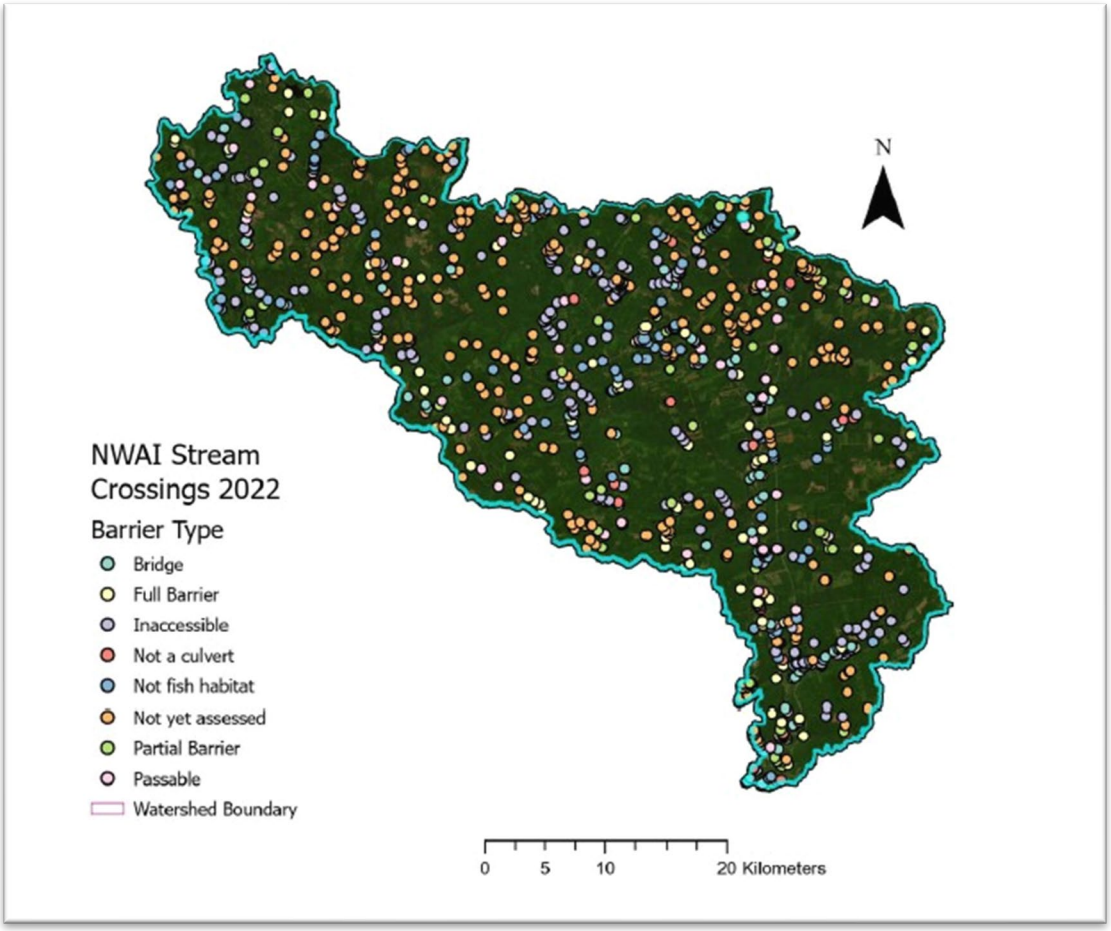

Figure 1. GIS map of the Nashwaak Watershed, with all road-stream crossings. Crossings are categorized in terms of access for fish species, accessibility for assessment, assessment status, and crossing type. Although the data was updated in 2022 and the map remains unchanged in 2023.

Thus far, the NWAI has visited 457 of the 961 road-stream crossings in the watershed (Fig 1). Over 272 culverts have been surveyed, which includes almost all the priority crossings on public paved roads and the main forest roads. There have been >10 major debris removals and >26 smaller debris removals, which have improved flow, water quality and fish passage at these crossings. Of the 457 stream crossings surveyed in the watershed thus far, 227 of the culverts assessed were identified as fish habitat, and 71 % were either full or partial barriers to fish passage.

In 2023, due to unprecedented high flows, NWAI was unable to assess road-stream crossings safely and effectively as barriers to fish passage. Instead, culverts that had been identified as “priority” barriers were revisited to update their condition. Many of the culverts assessed over 5 years ago have

continued to degrade or collapse since the initial assessment (Figure 2). Over 20 road-stream crossings were visited in 2023.

Figure 2. EBN3 from Upstream 2023 (left) vs 2019 (Right)

Table 1. Summary of culverts visited in 2023.

Crossing ID	Road_Cross	Type	StreamName	BarrierTyp	Longitude	Latitude
Dunbar2	Dunbar Rd.	Culvert	Unnamed triburary to Dunbar Brook	Full Barrier	-66.6281	46.1361
Rice02	Gibson Trail	Culvert	Rice Brook	Partial Barrier	-66.6067	45.9530
EBN3	Valley Forest Road	Culvert	Unnamed	Partial Barrier	-67.0919	46.4526
EBN5	Valley Forest Road	Culvert	Unnamed	Full Barrier	-67.1191	46.4542
EBN6	Valley Forest Road	Culvert	Unnamed	Partial Barrier	-67.1313	46.4388
ENap2	Napadogan Shortcut Rd.	Culvert	Unnamed	Full Barrier	-66.9853	46.3723
Nixon01	Tay Valley Rd.	Culvert	Nixon Brook	Full Barrier	-66.6871	46.2056
Nixon02	English Settlement Rd.	Culvert	Nixon Brook	Partial Barrier	-66.6823	46.2201
Ryan10	None	Culvert	Ryan Brook	Partial Barrier	-66.8732	46.3895
Sands02	Rte. 107	Culvert	Sands Brook	Full Barrier	-66.7324	46.2944
Youngs6	Irving	Culvert	Youngs Brook	Partial Barrier	-66.4439	46.2801
Youngs9	Iriving	Culvert	Youngs Brook	Full Barrier	-66.4296	46.2912
UN01	Canada St.	Culvert	Unnamed Stream	Full Barrier	-66.5918	46.0306

UN02	Rte. 148	Culvert	Unnamed Stream	Partial Barrier	-66.6139	46.1130
UN44	Rte 8	Culvert	Unnamed	Full Barrier	-66.5958	46.2475
UN46	Penniac Rd.	Culvert	Unnamed Stream	Full Barrier	-66.5066	46.0540
UN50	Rte. 148	Culvert	Unnamed	Full Barrier	-66.6078	46.2410
UN52	Cross Creek Rd.	Culvert	Unnamed	Full Barrier	-66.6327	46.2586
UN53	NB Trail	Culvert	Unnamed	Full Barrier	-66.6340	46.2582
Manzer01	NB Trail	Culvert	Unnamed	Partial Barrier	-66.5974	46.0708

PAST PROJECTS

Several target culverts have been identified for remediation since the project's inception. Post-remediation, we regularly check on each of these culvert sites to ensure that they are structurally sound and working effectively. Each site has been electrofished to give an accurate picture of the fish species that are above and below the culvert both prior to and post-remediation. Electrofishing data varies based on the time and conditions at the time of sampling.

MANZER BROOK

We have been regularly checking on the Manzer Brook fish ladder (Figure 2), installed in 2018. It survived the last four winters well and has not been catching debris. Electrofishing in August 2018 prior to remediation found seven species downstream and five species upstream (a total of 54 fish downstream and 55 fish upstream). Electrofishing in September 2020 found six species downstream and five species upstream (a total of 154 fish downstream and 104 fish upstream). In 2021, using a sweep and shock method, we determined there was an increase in fish movement upstream.

Figure 3. The Manzer brook fish ladder, installed in August 2018.

Table 2. Electrofishing results from 2018, before the Manzer Brook fish ladder was installed.

Site	American eel	Atlantic salmon	Black nose dace	Brook trout	Burbot	Creek chub	Sea lamprey	Slimy sculpin	White sucker	Grand Total
Manzer Downstream	5	1	25	3	1	0	0	18	1	54
Manzer Upstream	0	0	16	3	0	4	5	27	0	55
Grand Total	**5**	**1**	**41**	**6**	**1**	**4**	**5**	**45**	**1**	**109**

Table 3. Electrofishing results from 2020 (post-remediation).

Site	American eel	Blacknose dace	Brook trout	Common shiner	Sea lamprey	Slimy sculpin	Grand Total
Manzer Downstream	1	67	11	69	2	4	154
Manzer Upstream	0	43	11	32	8	14	108
Grand Total	**5**	**133**	**119**	**101**	**10**	**33**	**411**

Table 4. Electrofishing results from 2021 (post-remediation).

Site	American eel	Blacknose dace	Burbot	Pearl dace	Slimy sculpin	White sucker	Grand Total
Manzer Downstream	5	14	1	2	7	2	31
Manzer Upstream	1	10	0	2	15	0	28
Grand Total	**6**	**24**	**1**	**4**	**22**	**2**	**59**

EAST RYAN

Through the 2019 fall and winter, we worked with NBDTI and HILCON Ltd. on the design of fish passage structures involving baffles and chutes for three barrier culverts, which were built and installed by Tek Steel. The East Ryan Brook fish passage project was completed in July 2020.

At East Ryan Brook, located along Route 107, a cast in place 2,750 x 1,800 mm concrete box was installed in the 1950s. The crossing was too steep (2.3% over 20 m) and had a 30 cm step at the outlet, preventing fish passage through the pipe. Water in the pipe was very shallow due to its wide, flat bottom. Electrofishing in 2019 showed that there were many brook trout using this cold-water stream along with a single American eel.

The remediation took place in two phases: First, a baffle was placed at the end of the enclosed pipe and another just before the drop (Fig 3). Baffle height was 350 mm, and notch width and depth were 200 mm and 150 mm, respectively, for both. These allowed the water in the pipe to back-flood and velocity to decrease. A short chute was installed over the drop at the end of the structure. The chute contained roughness bars to prevent sheet flow. The second baffle was fitted with a small slide to allow fish to swim up and over. The second phase, installed a few weeks later, involved three shorter baffles that extended 4/5ths of the way across the pipe (Fig 4). We alternated which side of the baffle was opened to create a sinuous channel through the pipe. These helped back-flood the remainder of the pipe. Large rocks were placed throughout the pipe to create microhabitat, allowing water to eddy behind the rocks, providing protection for small fish.

This project opened 1.8 km^2 of habitat and 800 m of stream length above it. Electrofishing results pre- and post-remediation showed similar numbers of the same species (brook trout and a few American eel). A temperature logger installed over the summer of 2020 gave an average temperature of only 13.33°C and a peak temperature of 18.7°C between 21 June and 21 September., indicating that this brook is an excellent thermal refuge for salmonids in the summer.

Figure 4.Before (left) and after (right) of the East Ryan Brook fish passage project.

Figure 5. Details of the East Ryan Brook fish passage project showing the chute and first two baffles (left) and the upper three partial baffles (right) as well as the large rocks placed to provide microhabitat in the pipe.

Table 5. Electrofishing results from 2019, before the remediation structures were installed.

Site	American eel	Brook trout	Grand Total
East Ryan Downstream	1	50	51
East Ryan Upstream	0	23	23
Grand Total	**1**	**73**	**74**

Table 6. Electrofishing results from 2020 (post-remediation).

Site	American eel	Brook trout	Grand Total
East Ryan Downstream	2	40	42
East Ryan Upstream	0	19	19
Grand Total	**2**	**59**	**61**

Table 7. Electrofishing results from 2021 (post-remediation).

Site	Brook trout	Grand Total
East Ryan Downstream	16	16
East Ryan Upstream	6	6
Grand Total	**22**	**22**

MCGIVNEY BROOK

The McGivney Brook pipe is a cast in place concrete box (4,580 x 1,260 mm) on Route 625. The remediation work at this site was completed in October 2020. This culvert was slightly too steep (0.9% over 9.8 m) to allow for fish passage. Its wide, flat bottom meant that there were only a few millimetres of water depth during low flow. Pre-remediation electrofishing found three species downstream and four species upstream (American eel was found upstream but not downstream). Similar numbers of brook trout were found up and downstream but higher numbers of black nose dace and slimy sculpin were found downstream compared to upstream. A total of 43 fish were found downstream versus 25 upstream. A temperature logger installed over the summer of 2020 gave an average temperature of only 15.04°C and a peak temperature of 20.6°C between 21 June and 21 September, indicating that this brook is an excellent thermal refuge for salmonids in the summer.

Remediation work involved the installation of one aluminum baffle and chute at the outlet of the pipe. The baffle was 300 mm high with a notch width and depth of 400 mm and 300 mm, respectively. The chute was 400 mm wide and 615 mm long. The baffle allows water to back-flood in the culvert, becoming deeper and slower (and easier for fish to swim in). The chute allows fish to swim into the culvert during low flow and it was fitted with roughness bars to prevent sheet flow. This project opened 10.2 km^2 of habitat and 8,913 m of stream length above it.

Figure 6. Before and after of the McGivney Brook fish passage project. Picture on the right was taken during a site check in 2023.

Table 8. Electrofishing results from September 2020 (pre-remediation).

Site	American eel	Blacknose dace	Brook trout	Slimy sculpin	Grand Total
McGivney Downstream	0	16	13	14	43
McGivney Upstream	1	5	18	1	25
Grand Total	**1**	**21**	**31**	**15**	**68**

Table 9. Electrofishing results from September 2021 (post-remediation).

Site	White sucker	American eel	Blacknose dace	Brook trout	Slimy sculpin	Grand Total
McGivney Downstream	5	0	5	6	14	30
McGivney Upstream	0	1	1	6	4	12
Grand Total	**5**	**1**	**6**	**12**	**18**	**42**

LIMEKILN BROOK

The Limekiln Brook pipe is a cast in place concrete box (3,000 x 2,400 mm) on route 620. The remediation work at this site was completed in October 2020. This culvert was too steep (2.11% over 28 m) to allow for fish passage. Its wide, flat bottom meant that there were only a few millimetres of water depth during low flow. Pre-remediation electrofishing found 4 species downstream and 2 species upstream. American eel and black nose dace were not found above the pipe. A total of 14 fish were found downstream versus 6 fish upstream. Post-remediation electrofishing will be completed in 2021. A temperature logger installed over the summer of 2020 gave an average temperature of 18.41°C and a peak temperature of 24.73°C between 21 June and 21 September, indicating that this brook would be an excellent thermal refuge for salmonids in early/late summer. However, in peak summer, it may be too warm (temperature exceeded 23°C on 20 days).

The remediation involved the installation of four fish weirs spaced 7 m apart throughout the pipe. The baffles were 500 mm high, with a notch width and depth of 300 mm and 200 mm, respectively. This project opened 7.25 km^2 of habitat and 10,732 m of stream length above it.

Figure 7. Road-stream crossing at Limekiln Brook in 2020 (left) before remediation and in 2023 (right) during high-flow after structure was installed in 2020.

Figure 8. A close-up shot showing the weirs installed for the Limekiln Brook fish passage project in 2020. The weirs were not fully installed at this point, so water was just starting to flow over the chute.

Table 10. Electrofishing results from September 2020 (pre-remediation).

Site	American eel	Blacknose dace	Brook trout	Creek chub	Grand Total
Limekiln Downstream	1	2	5	6	14
Limekiln Upstream	0	0	2	4	6
Grand Total	1	2	7	10	20

Table 11. Electrofishing results from September 2021 (post-remediation).

Site	American eel	Atlantic salmon	Brook trout	Fallfish	Grand Total
Limekiln Downstream	3	1	1	0	5
Limekiln Upstream	1	0	1	1	3
Grand Total	**4**	**1**	**2**	**1**	**8**

NEXT PROJECTS

MCCONNAGHY BROOK CULVERTS

The two culverts of primary concern are both located on McConaghy Brook (Figures 13 and 14). Both are located on property owned by of the City of Fredericton. These barriers are blocking over 4200 m^2 of functional upstream habitat. When moving upstream from the mouth of McConaghy Brook, the first culvert (MC02) is located at 45.9875, -66.5879 and crosses the NB walking trail system. The culvert is newer and in good condition but is too steep with a slope of 9.32% for fish passage. Further to this, the outflow drop is also too high at 0.61m.

Figure 9. Picture looking upstream in McConaghy brook (MC01). This site is a full barrier to fish passage, blocking 4.2 km^2 of viable upstream habitat.

The second culvert (MC01), located at 45.9891, -66.5883 is a road-stream crossing at Canada Street (Route 148), a road located in the city of Fredericton. The culvert is a box culvert that is quite old and in poorer condition. The slope, at 6.5%, is too steep for fish passage, with a 0.29 m outflow drop. NWAI is proposing that both barriers be remediated in tandem to provide maximum net habitat gain due to their proximity. Both have been identified as severe barriers regarding anadromous and diadromous fish passage. Preliminary engineering drawings have been created by HILCON Ltd. for the profile for MC02 (Figure 15). Design options for the replacement of MC02 will be available from the firm in 2024. Historic DFO consultations with the city have recommended a bridge structure to replace the existing culvert. Designs for MC01 have also been contracted to HILCON Ltd. and will be completed in 2024. Preliminary discussions at this location included a proposal for replacement, or a temporary remediation by installing a “naturally” replicated bottom. Boulders would be embedded into the base to imitate a meandering pattern and provide resting locations for fish. Landowner consultations are still in progress, but there is support and interest in the project from the City of Fredericton based on available funding.

Figure 10. McConaghy Brook (MCC02) culvert outflow looking upstream. Picture taken in 2017.

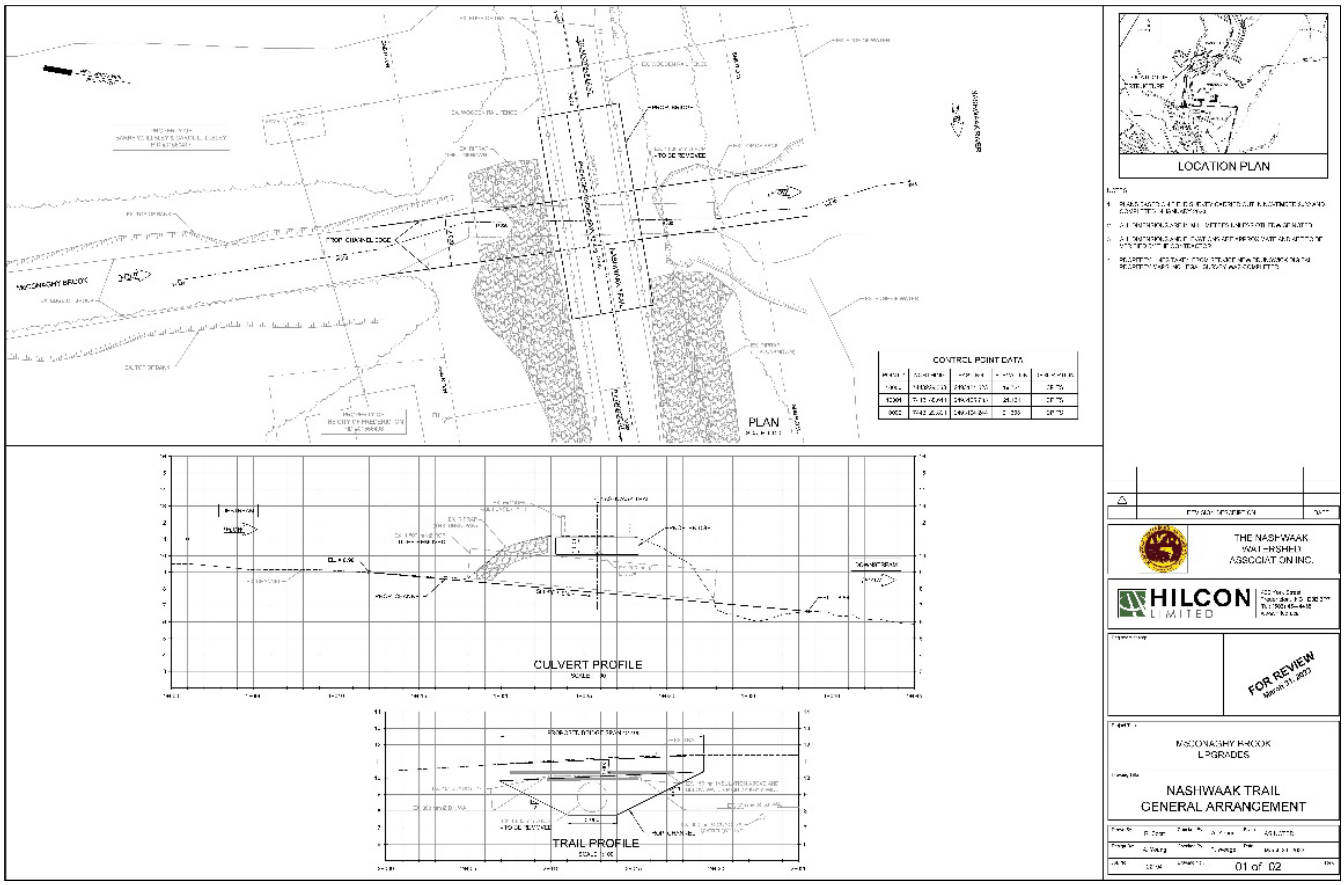

Figure 11. Preliminary engineering design showing the proposed bridge to replace the culvert MC02, crossing the NB trail on McConaghy Brook. Design completed by HILCON Ltd.

PORTERS BROOK

Porters Brook is a culvert located on Nashwaak West Road and is the property of NBDTI. It is understood that this culvert has been impeding fish passage in this cold-water tributary for many decades. The Porters Brook culvert is an 1,800 mm diameter corrugated steel pipe (Figure 11). The slope of the culvert is 14.96% with an outflow drop of approximately 1m. Collectively, the high slope and outlet drop confirm that this culvert is a full barrier to fish passage according the DFO's criteria. Currently the culvert is blocking access to over 4.9 km^2 of fish habitat.

Figure 12. The outlet of the Porters Brook culvert in high water conditions in 2017 (L) and in low water conditions in 2023 (R).

Figure 13.The inlet of the Porters Brook culvert in 2017 (L) and in 2020 (R). Many large trees have fallen in the stream and debris has started to clog the stream just above the inlet.

NBDTI closed this section of Nashwaak West Road more than 15 years ago, with no plans to reopen it. Despite the road being closed, ATVs, trucks and tractors are still driving through the blockade, which creates a safety liability for the province. As the road and culvert have not been maintained since the road was closed, the condition of both have deteriorated. Sediment fabric can be seen hanging inside the pipe, indicating that there are cracks in the top of the culvert (Figure 11). Significant erosion was noted both upstream (many large trees in the stream) and downstream in the plunge pool (Figures 11 and 12). The turbulent jet of water coming through the pipe is causing scour, which dislodges particles from the stream bed and banks. Deposition of that sediment is occurring in the pool at the mouth of the brook when water velocity slows. If the pipe and road were to collapse or washout, it would send road fill and sediment into the watercourse, which would irreversibly damage the brook as well as the important cold-water pool at the mouth. It is crucial to protect the integrity of this pool and prevent further damage due to ongoing sedimentation from the deteriorating culvert and

scour from the plunge pool. Furthermore, fine sediments have already infilled many pools and spawning areas in the Nashwaak, increasing the importance of protecting those that are remaining.

An initial comprehensive survey for Porters Brook (Nashwaak West Road) was completed in 2021, which included flow monitoring, habitat assessment and site assessment. A brief electrofishing baseline survey was also performed with help from the DFO Community Indigenous partners in science program (Table 11). In March 2021, a tentative plan for the removal of Porters Brook culvert was designed by the engineering firm HILCON Ltd and presented to DTI (Figure 13).

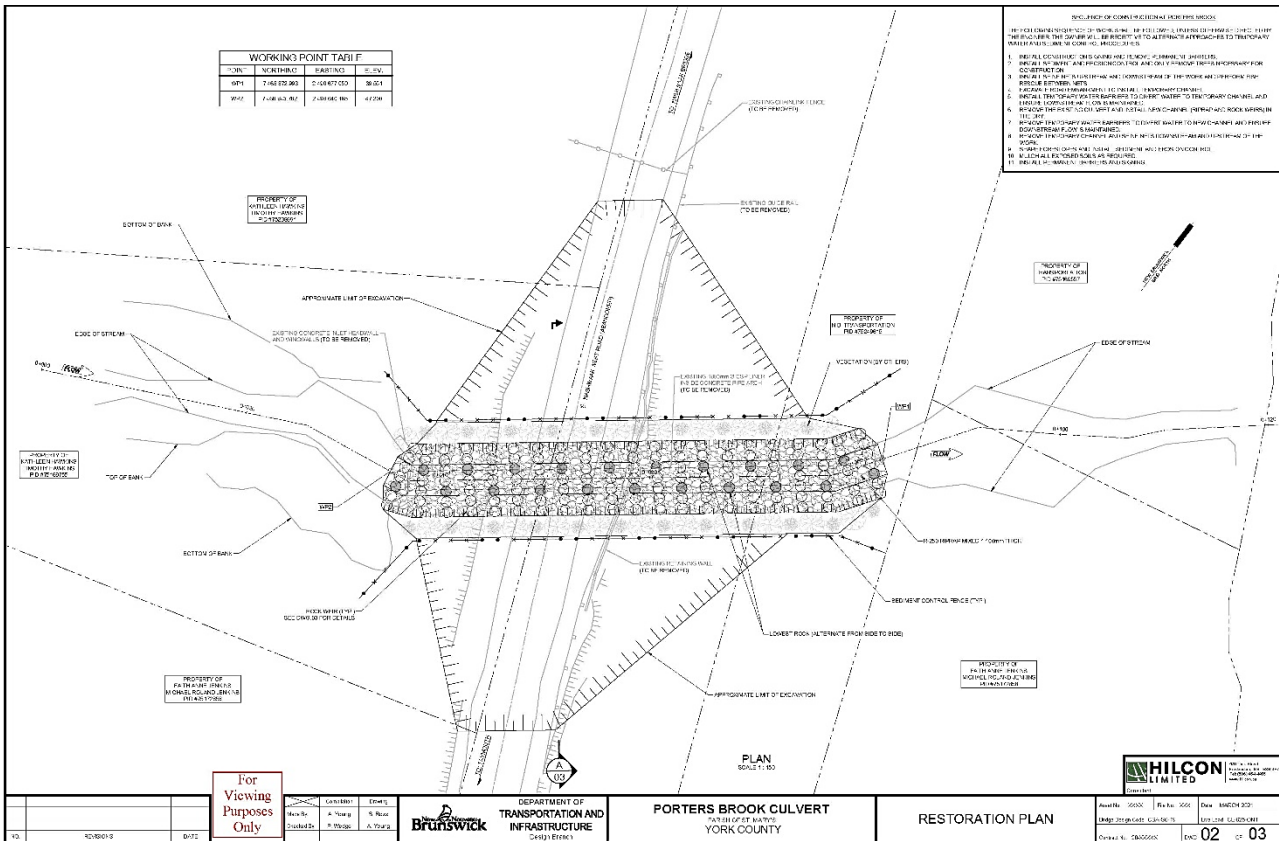

Figure 14. Preliminary engineering drawing for the removal of Porters Brook culvert. Designed in 2021 by HILCON Ltd.

In 2022 and 2023, NWAI continued collecting baseline CABIN, water quality, and fish assemblage data. NWAI has secured funding, and the project is slated to begin in spring of 2024. NWAI is currently awaiting confirmation from DTI to finalize the date.

Figure 15. Staff holding one of several Brook trout caught during an electrofishing assessment in 2023 at Porters Brook.

In 2023, NWAI continued conducting baseline assessments of the culvert by monitoring water quality and fish assemblage.

Table 12. Electrofishing results collected at Porters Brook, New Brunswick in 2023. Results show predicted species, with total counts of each. Assessments were done both upstream and downstream from the existing culvert.

Site	Brook trout	Smallmouth bass	Blacknose dace	Grand Total
Porters Brook Downstream	18	0	0	18
Porters Brook Upstream	5	0	0	5
Grand Total	**23**	**0**	**0**	**23**

Table 13. Electrofishing results collected at Porters Brook, New Brunswick in 2022. Results display the predicted species, with total counts of each. Assessments were done both upstream and downstream from the existing culvert.

Site	Brook trout	Smallmouth bass	Blacknose dace	Grand Total
Porters Brook Downstream	13	1	1	15
Porters Brook Upstream	9	0	0	9
Grand Total	**22**	**1**	**1**	**24**

Table 14. Electrofishing results collected at Porters Brook, New Brunswick for 2021. Results display the predicted species, with total counts of each. Assessments were done both upstream and downstream from the existing culvert.

Site	Brook trout	Smallmouth bass	Blacknose dace	Grand Total
Porters Brook Downstream	29	0	0	29
Porters Brook Upstream	9	0	0	9
Grand Total	**38**	**0**	**0**	**38**

OTHER TARGETS

In 2021, a list was created consisting of 20 priority barriers for rehabilitation to present to DTI, DNRED, and other stakeholders. The barriers were prioritized based on the quantity of inaccessible, functional upstream habitat that would be gained with removal of the barrier. Of the 20 culverts identified, 12 were full barriers to fish passage and 8 were partial barriers. This list is updated annually based on newly collected data.

Similarly, a GIS aquatic connectivity map is updated annually to display newly assessed and remediated barriers. This information is shared with partners and promoted during the "Healthy Nashwaak" social media campaign to further inform the public about the importance of connected stream habitats.

PRIORITY BARRIER SELECTION

Every winter, new barriers are selected using the Nature Conservancy's GIS Barrier Assessment Tool. These barriers will be ground-truthed and surveyed in the subsequent field season. The Barrier Assessment Tool is a GIS add-on developed by the Nature Conservancy to prioritize culverts for assessment and remediation and quickly calculate upstream habitat gain, land use information, and other parameters. NCC's Freshwater Ecological Classification and Aquatic Blueprint includes NWAI data. The partnership created from this, and other projects will eventually contribute to an international effort focused on restoring connectivity for both ecological and climate change adaptation (flooding – emergency services provisioning – risk to culverts) purposes: the North Atlantic Aquatic Connectivity Collaborative.

PROJECT EVALUATION AND REFLECTIONS

SUMMARY AND PARTNERSHIPS

The first seven years of the NWAI Aquatic Connectivity Project have been, in many measurable ways, a success. The organization continues to surpass the projected goals for the number of culverts to map and survey. So far, nine staff, three board members, ten summer students, and five volunteers have been trained on the culvert survey protocol. This has increased the capacity of the organization to understand the connectivity and fragmentation of the Nashwaak Watershed.

To date, five restoration projects have been completed, opening more than 44 km in stream length of habitat that was previously inaccessible to fish and other aquatic species. The largest of these

barrier removal projects, the Campbell Creek Dam removal, began in 2021 and involved the Maliseet Nation Conservation Council, the City of Fredericton, and the Atlantic Salmon Federation. This was a major achievement as this dam had been blocking upstream fish passage for over a century.

PARTNERS:

Over the years, NWAI has also partnered with several organizations to collect water quality, conduct surveying, and collect fish assemblage data at these barriers. These partners include, but are not limited to:

- DFO's Collaboration of Indigenous Partners in Science (DFO-CIPS),
- The Aboriginal Fisheries Strategy (AFS)
- Sitansisk Wolastoquey (St. Mary's First Nation)
- Woodstock First Nation
- Welamukotuk (Oromocto) First Nation
- Bilijk (Kingsclear) First Nation
- ACAP Saint John
- Maliseet Nation Conservation Council
- The City of Fredericton
- The Atlantic Salmon Federation
- NB Department of Transportation and Infrastructure
- NB Department of Natural Resources and Energy Development

PROBLEMS ENCOUNTERED & SOLUTIONS:

While the organization is still learning more about the aquatic connectivity of the entire watershed, we have been able to gather a more comprehensive picture of the scale, timeline, feasibility, and cost of the remaining high-priority barriers. The number of culverts we can address within a year frequently depends on the timeline of obtaining approvals from DTI, municipalities, or landowners to proceed with projects. The duration of this process can extend over several years, depending on the priorities of the federal, provincial, and municipal governments at the time.

Further to this, the results of our surveys showed that remediation of the most severe barriers will be larger in scale, cost, and timelines compared to the smaller projects NWAI has already completed. In fact, many of the barriers on our priority list cannot be remediated/adapted to allow for fish passage due to the age, condition, or location of the structure. The reality is that several of the barrier culverts will simply need to be replaced with newer and more adequately designed infrastructure. This reality is unfortunately outside of the ability and scope of the organization. Therefore, it is important for grass-roots organizations like ours to put pressure on governments to change policies and priorities to support this work.

Communications with DTI have improved, and we have now also started conversations with DNRED about culverts on woods roads. However, the timelines for approval of projects and remediation remain lengthy. There are also still many culverts that are not able to be surveyed in the watershed for

a variety reasons. These include poorly maintained roads, placement on private land, and remote locations that pose challenges for access.

We will collaborate with partners to develop a strategy regarding these sites and will reach out to the landowners who are responsible for their maintenance. Many of the non-surveyable sites are on crown land that has been leased to logging companies. Many of these roads are either decommissioned, poorly maintained, or completely deteriorated/collapsed. Due to a lack of resources, the province is not well-positioned to enforce provincial guidelines regarding road-stream crossings. As a result, many of the companies have not adhered to these guidelines. Our next steps will involve communicating our impediments and sharing our current data with the Department of Fisheries and Oceans (DFO), the Department of Natural Resources and Energy Development (DNRED) and the Department of Transportation and Infrastructure (DTI). In doing so, we hope to get additional resources to assess and remediate these inaccessible barriers.

APPENDIX

Road-stream crossing survey field sheets, adapted from Nova Scotia's Adopt-a-Stream barrier assessment project.

Nashwaak Watershed Association
Aquatic Connectivity Assessment Form

Site information					
Crossing ID				**# Culverts**	
Observers				**Date**	
Stream Name				**Time**	
Road Name				**Fish Habitat**	□ Yes □ No
Ownership	□ Public Road □ Public Trail □ Private Road			**Fish observed**	□ Yes □ No
Latitude			**Longitude**		
Beaver activity	□ Yes □ No □ Dam		**Debris Block**	□ Yes □ No	
Description of Debris					
Erosion	□ Upstream □ Downstream		**Description**		
Photo Range					
Weather					

Stream Characteristics					
Description of upstream habitat					
Description of downstream habitat					
Dominant Substrate					
Temperature		**TDS**		**DO**	
pH			**Conductivity**		
Bankfull Width	Upstream:		Downstream:		

Culvert Information			
Material	□ Concrete □ Corrugated Metal □ HDPE □ Wood □ Other		
Shape	□ Circular □ Box □ Pipe Arch □ Open Arch □ Ellipse □ Other		
Entrance	□ Projecting □ Headwall □ Mitered □ Wingwall □ Other		
Deformation	□ Yes □ No	**Deterioration**	□ None □ Moderate □ Severe
Bottom	□ Natural □ Unnatural	**Variable Slope**	□ Yes □ No
Baffles	□ Present □ Absent	**Alignment**	□ Aligned □ Skewed
Backwatered	□ 0% □ 25% □ 50% □ 75% □ 100%	**Plunge Pool**	□ Present □ Absent
Embedment	□ Upstream □ Downstream	**% Embedment**	□ 0% □ <20% □ >20%
Dimensions	Width	Height	Length
Depth in crossing	□ Similar to stream □ Shallower □ Deeper		

Velocity in crossing	□ Similar to stream □ Faster □ Slower				
Elevations					
	BS	**HI**	**FS**	**Elevation**	**Distance between**
Upstream Riffle					
Inlet					
Outlet					
Tailwater Control					
2nd Riffle					
Left Bankfull @ TWC					
Right Bankfull @TWC					
Road Height					
Upstream Slope [(USR-I)/distance]*100			**Downstream Slope** [(TWC-2R)/distance]*100		
Culvert Slope [(I-O)/distance]*100			**Outflow Drop** [O-TWC]		
Height of Fill (Road-O)+Diameter					
Baffle Information					
Number		**Material**	□ Concrete □ Metal □ Wood □ Other		
Height (cm)			**Notch Depth (cm)**		
Notch Width (cm)			**Baffle to outlet (m)**		
Type	□ Straight □ Diagonal □ Right Angled □ Other				
	BS	**HI**	**FS**	**Elevation**	**Distance between**
Upstream Baffle					
Adjacent Baffle					
Drop b/w baffles (m)					
Notes / Sketch					