Year 2 Post Project Monitoring Report

Southwest Mabou River Fish Habitat Restoration Project

Completed as per Membertou Development Corporation

Harbourside Commercial Park

Marine In-filling Project

DFO file No. 18-HMAR-00564

Work completed by

MacInnis Natural Resources Services Inc.

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Contents

1.0 Introduction and Background

In 2019, Membertou Development Corporation received permission to carry out activities that required authorization under the *Fisheries Act* for undertaking activities resulting in residual serious harm to approximately 9,773 square meters of fish habitat. Approval for this authorization was contingent on the implementation of instream fish habitat restoration of the Southwest Mabou River in Inverness County, Nova Scotia at a ratio of 3:1 for restored area requirements per square meter of habitat destroyed. The proposed work and monitoring framework for this project were included a DFO approved offsetting plan, DFO File No. 18-HMAR-00564. The offsetting plan requires a monitoring framework be used to evaluate the effectiveness of the proposed restoration work. Monitoring for this project included water temperature data collection, habitat suitability index surveys (HSI) to measure changes to the physical habitat and finally the completion of spawning surveys (redd counts) to measure changes in biological productivity.

The site for this offsetting restoration work was chosen based on known habitat conditions in the Southwest Mabou River system. A local watershed stewardship group, Inverness South Anglers Association (ISAA) had hired habitat consulting firm MacInnis Natural Resources Services Inc. (MNR) to complete watershed-based habitat assessments in 2017 followed by the completion of a restoration plan in 2018. These reports found highly degraded instream habitat throughout the upper reaches of the Southwest Mabou River, which could be described as over-simplified and incised. The poor state of instream habitat throughout this watershed can be attributed to wide-spread deforestation in the early 1900s and subsequent log-drives and dam construction. Using well-established restoration techniques, the legacy impacts of these activities can be reversed through the installation of large-woody debris (LWD) structures which mimic the natural geomorphic response of accumulated LWD found in functioning ecosystems (DFO, 2008).

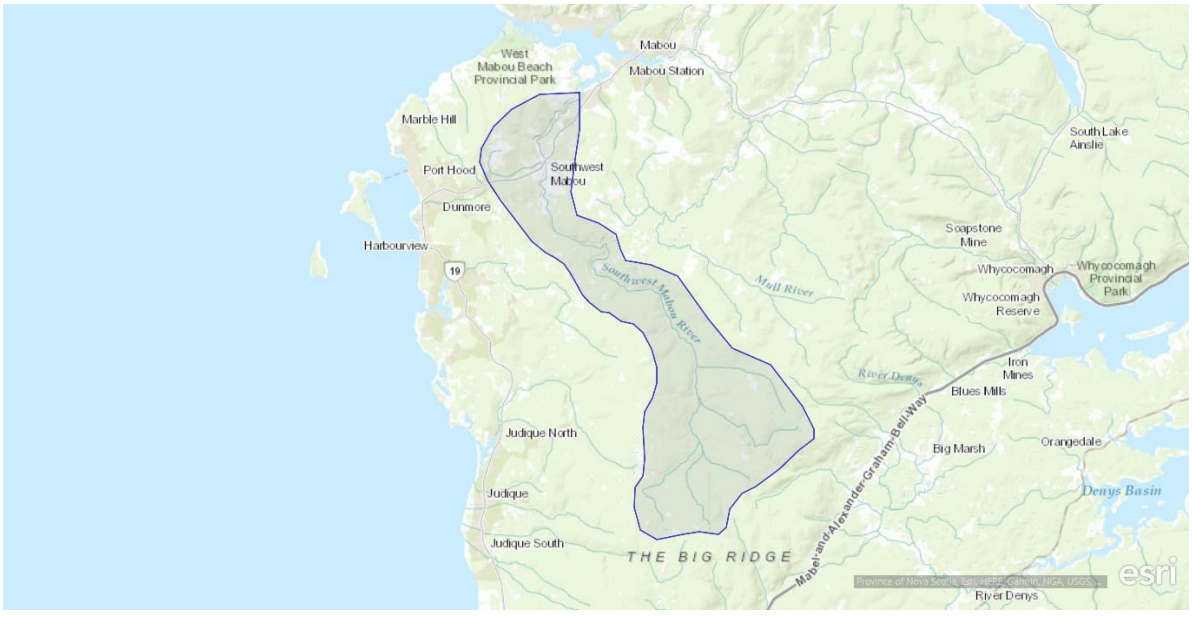

Figure 1: Map depicting drainage basin (i.e. watershed area) of the Southwest Mabou River.

Figure 2: Baseline conditions of instream habitat in Southwest Mabou River. The channel lacks thalwag definition and complexity.

Figure 3: Baseline habitat conditions; streambed substrate is embedded and lacks available spawning habitat.

2.0 Scope of work

As specified in the Offsetting Plan for Membertou Corporation Harbourside Commercial Park – Marine Infill (hereafter referred to the Offsetting Plan) restoration of 30,000 sq. meters of fish habitat in the Southwest Mabou was completed through the installation of log deflectors (figure 4) which are designed to mimic the natural conditions of LWD inputs that occur in undisturbed aquatic ecosystems. These structures are designed and installed in order to create a naturally productive and stable meander pattern which creates pool habitat, improves instream cover for juvenile and adult fish and creates and improves spawning habitat for salmonids.

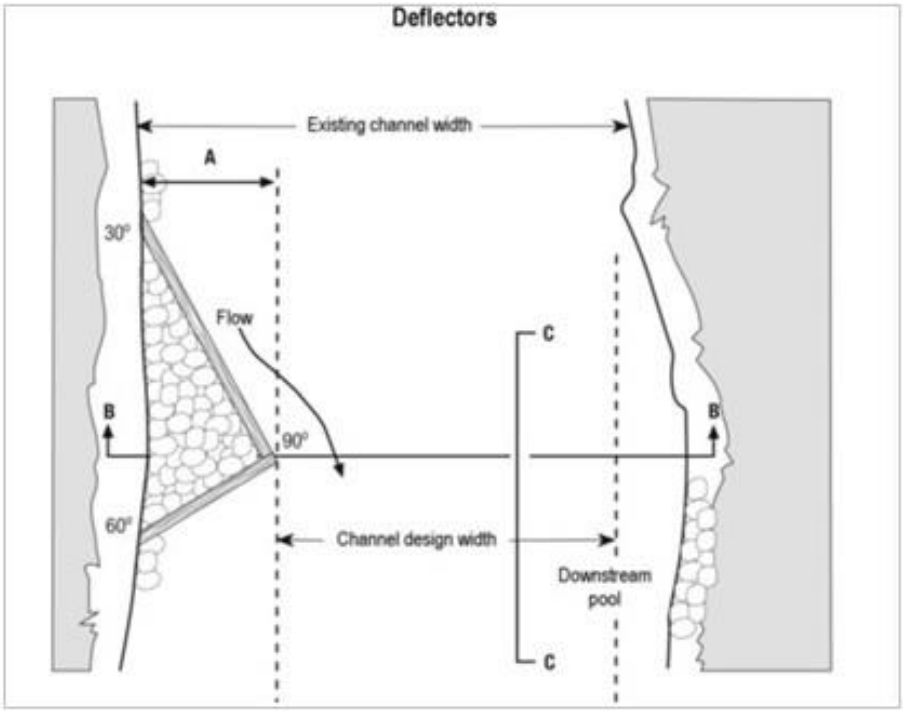

Figure 4: Conceptual design of log deflector (DFO, 2008).

Restoration work and baseline monitoring was completed in 2020 with two years of post-project monitoring scheduled for 2021 and 2022. This report presents the finding of the first year of post project monitoring. The monitoring plan for this project were developed in the DFO Offsetting Plan (**DFO file** No. 18-HMAR-00564) and is designed to measure changes in water temperature, physical habitat features and biological indicators (redd counts). Changes in biological activity will be completed through redd counts (e.g., spawning surveys) and changes to water quality will be completed using temperature probe deployment.

Redd counts were conducted in November and early December 2020 to assess first year spawning numbers. During this time the structures were also observed for stability and to gauge their ability to withstand bankfull discharge events. Water temperature probes were installed in late June and they were retrieved in early October.

3.0 Temperature Monitoring

Water temperature data was collected using deployable Hoboware temperature loggers which were deployed on June 1, 2021, and retrieved on October 1, 2021. Brook trout and Atlantic salmon are both coldwater fish species and particularly vulnerable to high water temperatures during the summer months. Therefore, the monitoring of water temperatures outside the June to October time frame is not necessary in evaluating the effectiveness of restoration work. Probes were deployed at the same location and for the same duration in 2021 as they were in the previous year 2020.

The data from 2021 indicates that average daily water temperatures across all four probe locations decreased by 1.09° Celsius in comparison to 2020 date. Probe 1 had the highest daily temperatures which are likely the result of a localized warm water input from the cumulative effects of several beaver dams and an over-widened channel with a bedrock dominant substate that characterizes much of the 400 meters of channel directly upstream from the restoration site. The greatest decrease in year over year temperatures occurred during the month of July which is an important time of year for juvenile Atlantic salmon and adult Brook trout. Probes 2 and 3 were located within the reaches of the restored site that had experienced the most channel narrowing and had the coldest summer temperatures.

Table 1: Summary of water temperature monitoring data year 2020 and 2021.

	Daily Average		June Average		July Average		August Average		September Average	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Probe 1	18.16	17.02	17.82	17.44	18.23	16.71	18.75	17.72	17.87	16.24
Annual Decrease	1.14°C		0.38°C		1.52°C		1.03°C		1.63°C	
Probe 2	17.39	16.52	17.32	16.92	17.1	15.61	18.35	17.56	16.8	16.01
Annual Decrease	0.87° C		0.4°C		1.49°C		0.79°C		0.79°C	
Probe 3	17.70	16.53	17.82	16.93	17.32	15.61	18.44	17.55	17.25	16.04
Annual Decrease	1.17°C		0.89°C		1.71°C		0.89°C		1.21°C	
Probe 4	17.87°	16.67	17.89	17.45	17.44	15.65	18.51	17.55	17.65	16.06
Annual Decrease	1.21° C		0.44° C		1.79°C		0.96° C		1.59° C	
Overall Average Decrease	1.09° C		0.52° C		1.62° C		0.91° C		1.30° C	

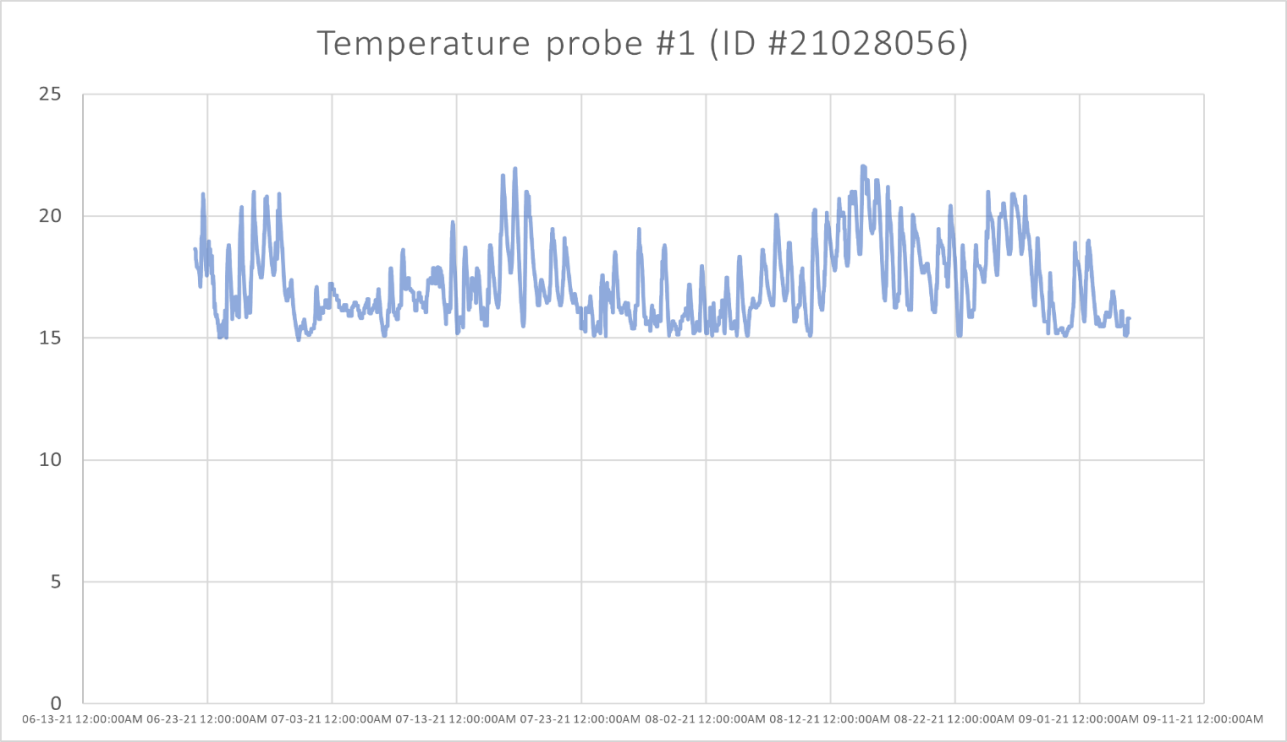

Figure 5: Recorded temperature data for probe #1.

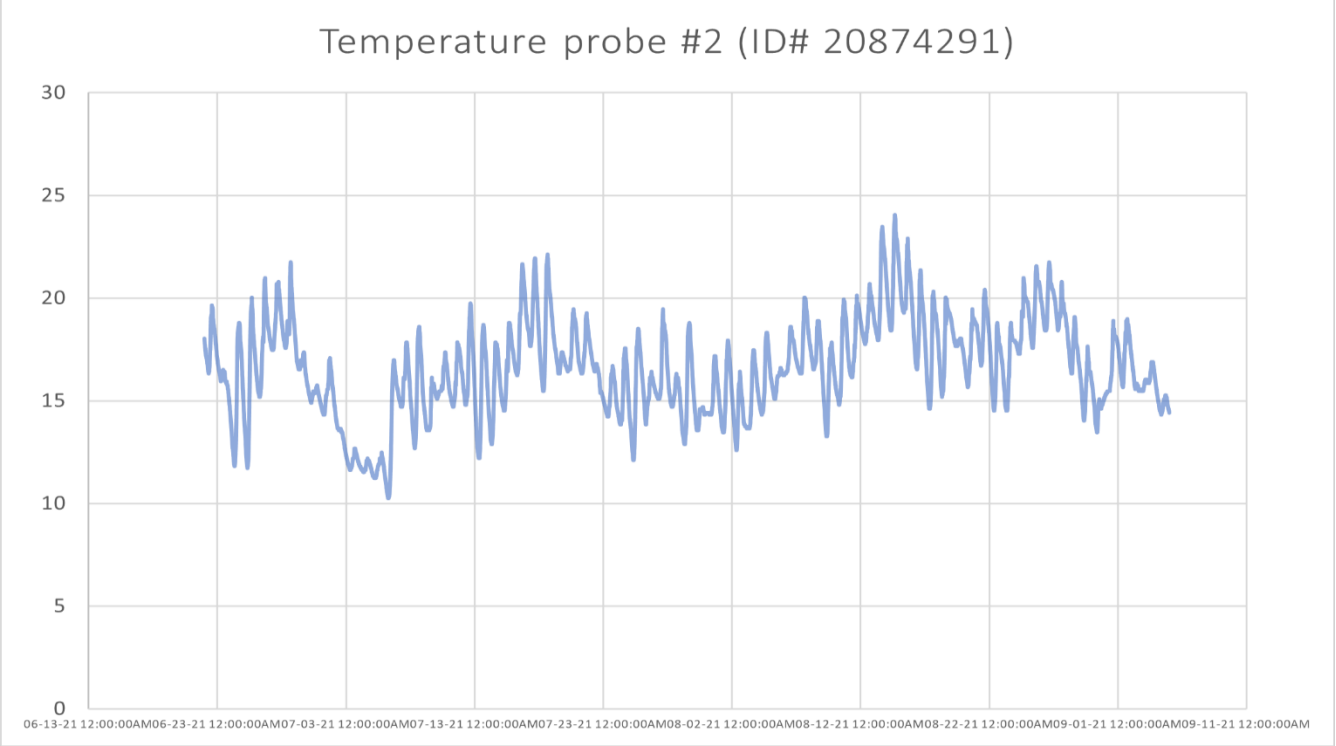

Figure 6: Recorded temperature data for probe #2.

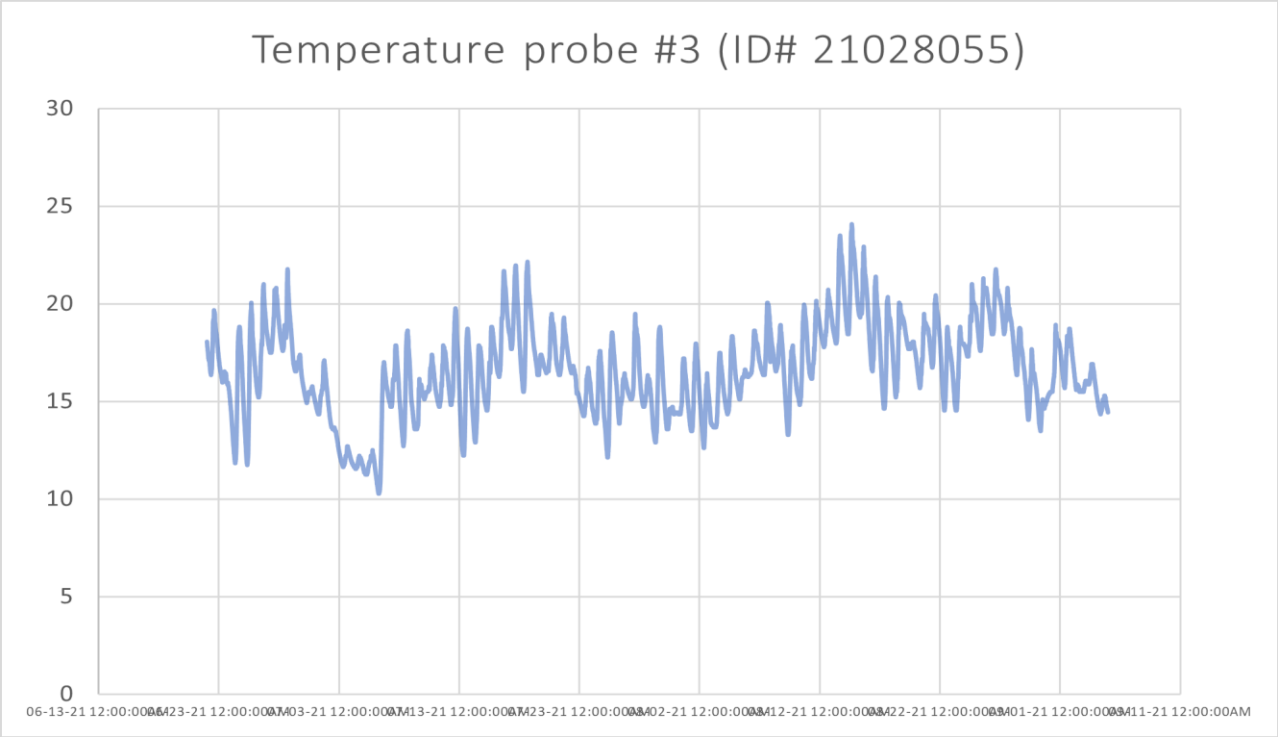

Figure 7: Recorded data for temperature probe #3.

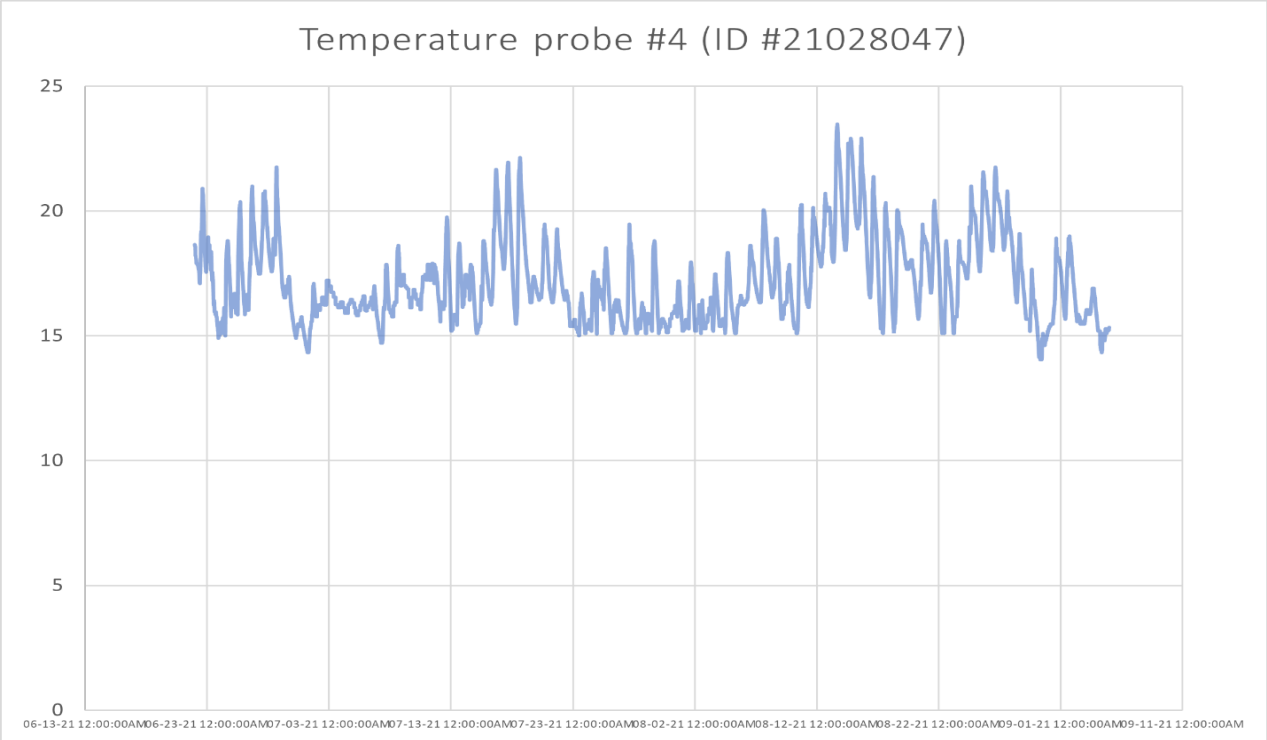

Figure 8: Recorded temperatures for probe #4.

4.0 Physical Habitat Monitoring

HSI surveys were conducted in September 2021. In total 20 sites were surveyed beginning at the downstream extent of the restoration site. Overall, the surveys depict an instream environment that has gone from an average width of 34 meters with a range of 20m to 45m to an average width of 28m with a range of 16m to 36m. The narrowing of the channel one-year post-restoration has facilitated the recovery of pool depths, the accumulation of appropriately sized and sorted spawning substrate as well as the creation of abundant levels of instream cover for Atlantic salmon parr. The greatest improvements occurred below the confluence of MacLeod's Brook. This area covers HSI sites 1 through 13 and the extent of recovery in this section can likely be attributed to the supply of substrate that is emptying out of MacLeod's Brook. The upstream extent of the restoration site, while improved across a variety of metrics, was not as advanced as the lower reaches of the site. This lag in recovery is attributed to the lack of sediment supply coming from the area upstream of the restoration site. Figures 10 and 11 show a comparison between habitats below and above MacLeod's Brook. A survey of this upstream habitat in the summer of 2021 found that much of the upper Southwest Mabou River had been colonized by beavers and their dam structures were withholding the downstream transport of materials.

Table 2: Coordinates of HSI sites.

	Downstream Boundary		Upstream Boundary	
HSI Site #	Latitude	Longitude	Latitude	Longitude
1	N45.92469	W61.35943	N45.92417	W61.35695
2	N45.92417	W61.35695	N45.92392	W61.35661
3	N45.92377	W61.35634	N45.92340	W61.35639
4	N45.92319	W61.35648	N45.92276	W61.35643
5	N45.92251	W61.35632	N45.92213	W61.35638
6	N45.92197	W61.35654	N45.92157	W61.35667
7	N45.92138	W61.35638	N45.92138	W61.35584
8	N45.92120	W61.35552	N45.92078	W61.35548
9	N45.92056	W61.35558	N45.92021	W61.35545
10	N45.92010	W61.35534	N45.91977	W61.35481
11	N45.91953	W61.35474	N45.91895	W61.35490
12	N45.91888	W61.35496	N45.91822	W61.35516
13	N45.91820	W61.35515	N45.91765	W61.35522
14	N45.91736	W61.35513	N45.91690	W61.35539
15	N45.91622	W61.35428	N45.91624	W61.35500
16	N45.91607	W61.35522	N45.91570	W61.35550
17	N45.91553	W61.35572	N45.91520	W61.35610
18	N45.91507	W61.35645	N45.91447	W61.35695
19	N45.91426	W61.35694	N45.91371	W61.45694
20	N45.91345	W61.35695	N45.91321	W61.35781

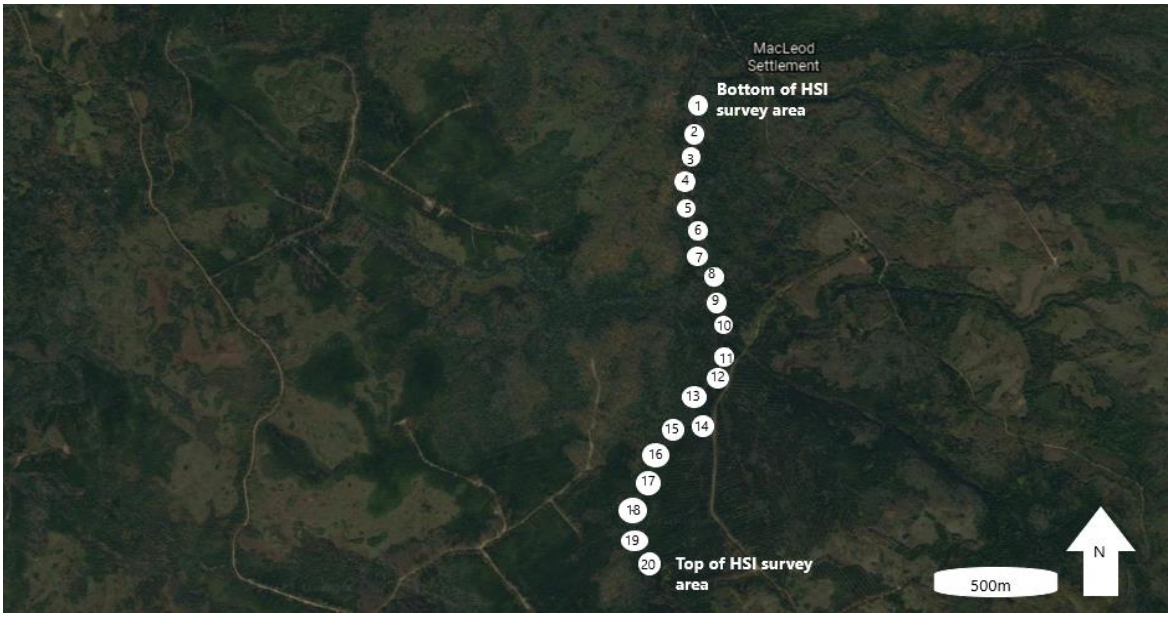

Figure 9: Map of HSI sites.

HSI surveys are designed to measure habitat quality and quantity as it relates to Atlantic salmon (*Salmo salar)* and Brook trout (*Salvelinus fontinalis*) known collectively as "salmonids". Atlantic salmon and Brook trout are highlighted in the data as indicator species that depend on good ecological complexity and aquatic health. The presence of salmonids and / or salmonid habitat is a good indicator for overall ecosystem health and aquatic biodiversity. The HSI survey is designed to measure channel formations that are indicative of complex and healthy salmonid habitats.

The HSI data is used to measure the quality of various instream habitat features (e.g., instream cover for parr etc.). Each category produces a number between 0 and 1 based on the data collected in the field. A suitability rating of less than 0.4 represents highly degraded habitat and is highlighted in red, 0.4-0.8 is marginal habitat and is highlighted in yellow. Categories that score over 0.8 are highlighted in green and represent high quality habitat that is conducive to Atlantic salmon productivity. The score found in the bottom row of each category is the overall score for the full reach surveyed (20 sites). HSI surveys are designed to measure a range of habitat features that are critical for various life stages of Atlantic salmon. The results of the surveys are found in the Table 3 and Table 4 depicting the results for Atlantic salmon and Brook trout respectively.

Figure 10: Upstream from MacLeod Brook confluence, this photo is taken from HSI site 17.

Figure 11:HSI photo from site 9 approximately 300 meters downstream of the MacLeod's Brook confluence.

4.1 HSI Results for Atlantic Salmon

HSI for Atlantic salmon showed considerable improvements across most metrics, except for a slight decline in stream shade, although this metric may not indicate any real detriment to Atlantic salmon productivity as it is related to the narrowing of the channel which removed created gravel bars near where open channel once existed. The open channel, located next to the forested bank would have received more shade as a percentage of total area than the newly adjusted channel. As gravel bars develop and vegetate this metric should improve. The amount of instream cover for Atlantic salmon parr was significant, with an improvement of 712%.

Table 3: Summary Table of Atlantic HSI values.

Field Sheet Number	% Pools	Pool Class Rating	% Instream Cover (fry)	% Instream Cover (Parr)	Dominant Substrate Type in Riffle-Run Areas	Spawning Present	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Fry Water Depth	Parr Water Depth	% Stream Shade
HSI #1	0.85	0.81	0.85	0.68	1	Yes	0.55	0.55	1	0.79	0.65
HSI #2	0.61	0.6	0.7	0.7	0.45	Yes	0.61	0.45	1	1	0.37
HSI #3	0.82	0.6	0.88	0.6	0.61	Yes	0.93	0.67	1	1	0.79
HSI #4	0.43	0.6	0.61	0.55	0.47	Yes	0.82	0.7	1	1	0.65
HSI #5	0.67	0.58	0.56	0.51	0.42	Yes	0.86	0.74	1	1	0.72
HSI #6	0.86	0.78	0.66	0.45	0.42	Yes	0.72	0.52	1	1	0.79
HSI #7	0.83	0.75	0.78	0.45	1	Yes	0.71	0.66	1	1	0.44
HSI #8	0.81	0.83	0.59	0.54	1	Yes	0.76	0.54	1	1	0.37
HSI #9	0.78	0.6	0.79	0.72	1	Yes	0.77	0.61	1	1	0.65
HSI #10	0.45	0.6	0.75	0.36	1	No	0.68	0.13	1	1	0.65
HSI #11	0.45	0.6	0.82	0.61	1	Yes	0.81	1	0.83	0.42	0.51
HSI #12	0.54	0.55	0.65	0.55	1	Yes	1	1	1	0.74	0.51
HSI #13	0.31	0.38	0.78	0.38	0.39	No	0.79	0.27	1	0.84	0.51
HSI #14	0.52	0.6	0.87	0.68	0.58	Yes	0.64	0.13	1	0.9	0.51
HSI #15	0.46	0.6	0.46	0.45	1	Yes	0.81	0.94	1	0.58	0.51
HSI #16	0.49	0.6	0.66	0.45	0.51	Yes	0.53	0.81	1	0.82	0.51
HSI #17	0.67	0.6	0.52	0.47	1	Yes	0.56	0.45	1	1	0.37
HSI #18	0.80	0.6	0.52	0.71	0.6	Yes	0.63	0.65	1	0.85	0.37
HSI #19	0.53	0.6	0.66	0.82	0.6	Yes	0.54	0.61	1	1	0.44
HSI #20	0.53	0.6	0.66	0.69	0.6	Yes	0.45	0.52	1	1	0.44
Overall	0.6205	0.624	0.6885	0.5685	0.7325	0.9	0.7085	0.5975	0.9915	0.897	0.538
2020 Results	0.44	0.51	0.64	0.07	0.69	0.9	0.4	0.57	1	0.82	0.58
Annual Change	40%	18%	6.20%	712%	6.15%	Same	77%	5%	Same	9.30%	-7%

The improvement in cover for Atlantic salmon parr can be attributed to the narrowing channel, but also with the establishment of cobble and boulder substrate in runs where bedrock cover was once the dominant feature. HSI surveys indicate a considerable improvement in salmon spawning substrate, especially in the area located downstream of MacLeod's Brook confluence. The influx of sediment supply from MacLeod's Brook, which was restored a year earlier than the Southwest Mabou, interacted favorably with the log deflectors, narrowing up the channel between 30 and 50% (wetted width).

Figure 12: An adult Atlantic salmon (female) resting on top of a newly dug redd. This photo provides an example of the substrate composition of spawning habitat.

The frequency of pools capable of holding adult Atlantic salmon increased by 40% and the overall quality of pools increased by 18%. The process of gravel bar formation on the downstream side of deflectors created many beneficial habitat features, including the changes recorded in the pools (frequency and quality), the narrowing of the channel and the creation of narrow runs with cobble and boulder substrate. Figure 8 and 9 (below) shows an example of the gravel bar formation. The newly deposited gravel will begin to vegetate next summer and there was evidence of sprouting willow shrubs on the near existing vegetation.

Figure 13: Gravel bar formation. Pre-restoration wetted width at this site (HSI #11) was 26 meters, current wetted width was 11 meters at time of photo (September 10th, 2021).

Figure 14: Looking upstream at newly formed gravel bar at site 11.

4.2 HSI Results for Brook trout

Habitat features that promote Brook trout productivity showed significant improvements in 2021 versus the baseline data collected in 2020. The amount of area within the restored site classified as pool areas for Brook trout increased by 31% while the pool class rating, a measure of pool quality increased by 11.76%. The biggest measured gains for Brook trout found during the HSI surveys were in the metric that measures the % of instream cover for adults, where habitat quality had increased by 710%.

Table 4: Results of HSI data for Brook trout. Bottom row contains comparative change between 2021 and 2020.

Field Sheet Number	% Pools	Pool Class Rating	% Instream Cover (Juvenile)	% Instream Cover (Adults)	Dominant Substrate Type in Riffle-Run Areas	Spawning Present	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Avg. Thalweg depth during late growing season	% Stream Shade
HSI #1	0.75	0.6	0.4	0.68	1	Yes	0.55	0.55	0.37	0.65
HSI #2	0.52	0.6	0.44	0.7	0.45	Yes	0.61	0.45	0.86	0.37
HSI #3	1	0.6	0.61	0.6	0.61	Yes	0.93	0.67	0.96	0.79
HSI #4	0.61	0.6	0.61	0.55	0.47	Yes	0.82	0.7	0.91	0.65
HSI #5	0.66	0.3	0.72	0.51	0.42	Yes	0.86	0.74	0.42	0.72
HSI #6	0.71	0.6	0.68	0.45	0.42	Yes	0.44	0.52	0.82	0.79
HSI #7	0.69	0.6	0.73	0.45	1	Yes	0.48	0.66	0.69	0.44
HSI #8	0.79	0.6	0.65	0.54	1	Yes	0.51	0.54	0.86	0.37
HSI #9	0.42	0.6	0.74	0.72	1	Yes	0.43	0.61	0.47	0.65
HSI #10	0.48	0.6	0.76	0.36	1	Yes	0.44	0.55	0.85	0.72
HSI #11	0.67	0.6	0.82	0.61	1	Yes	1	1	0.62	0.51
HSI #12	0.73	0.3	0.81	0.55	1	Yes	1	1	0.56	0.51
HSI #13	0.64	0.6	0.78	0.38	0.39	Yes	0.51	0.46	0.35	0.51
HSI #14	0.53	0.6	0.87	0.68	0.58	Yes	0.46	0.13	0.47	0.51
HSI #15	0.41	0.6	0.46	0.45	1	Yes	0.81	0.94	0.44	0.51
HSI #16	0.74	0.6	0.66	0.45	0.51	Yes	0.58	0.81	0.34	0.51
HSI #17	0.69	0.6	0.52	0.47	1	Yes	0.56	0.45	0.58	0.37
HSI #18	0.81	0.6	0.52	0.71	0.6	Yes	0.63	0.65	0.64	0.37
HSI #19	0.53	0.6	0.66	0.82	0.6	Yes	0.54	0.61	0.66	0.44
HSI #20	0.55	0.6	0.48	0.69	0.6	Yes	0.68	0.52	0.31	0.37
2021 Overall	0.6465	0.57	0.646	0.5685	0.7325	1	0.642	0.628	0.609	0.538
2020 Results	0.49	0.51	0.63	0.07	0.73	1	0.1	0.65	0.35	0.58
YoY Change	31.94%	11.76%	2.54%	712.14%	0.34%	0.00%	542.00%	-3.38%	74.00%	-7.24%

There were gains of 543% in available spawning area for Brook trout as indicated by the HSI results. The biggest improvements were found between HSI Site 1 and Site 12, the area below the confluence with MacLeod's Brook. As mentioned previously, several large beaver dams located upstream from the project site were withholding considerable bed-load which prevented the development of spawning habitat in HSI sites 13 through 20 at the same rate as the lower sites. Beaver dams are often temporary structures, lasting 1 to 3 years, therefore we anticipate the eventual transport of materials from upstream to occur soon. A significant flood event was experienced in the Mabou region in late November which may have removed the dams, but field surveys were not conducted after that event.

5.0 Biological Monitoring – Redd Counts

Table 5: Summary of redd count data.

Year	Dates of Redd Surveys	Total number of redds observed
2020	November 4, 15, 22, 2020	60
2021	November 5, 19, 29, 2021	87
2022		

Redd counts were conducted in November 2021 by Charles MacInnis. Several adult salmon were observed in both the main channel (restoration site) as well as nearby MacLeods Brook. In total 87 redds were observed within the restoration site, with 25 redds being observed in the upper portion of the site (upstream from MacLeod's Brook confluence) and the remaining redds (62 total) observed downstream from MacLeod's Brook. were observed in the section of restored site above the MacLeods Brook confluence. Redd counts were conducted following two bankfull discharges in November and the influence of structures was already being observed throughout the project site. Gravel bar formations were found below deflectors and spawning substrate was beginning to accumulate at the tail-end of pools. The majority of redds being distributed downstream of MacLeod's Brook confirms the findings of both the HSI surveys and water temperature monitoring which found that conditions below MacLeod's Brook had a greater extent of recovery due to sediment supply and subsequent gravel bar formation.

Figure 15: A large Atlantic salmon redd built near a log deflector.

Figure 16 (detail of what this is)

6.0 Structure Stability

Structures were observed during field inspections in June 2021 and minimal damage to three structures was observed. The damage entailed the displacement of some rock material from within the log deflector structure from ice flows in March 2021. These issues were quickly remediated using a restoration crew and future damage is unlikely to occur again as the extent of ice formation should be much lower moving forward as the channel narrows. Observation of structure stability occurred following spring melt-off and three bankfull discharge events in November 2021. The Structures will be observed for stability again in the spring of 2022.

7.0 References

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