Executing a long-term watershed monitoring plan for the West Fundy Composite level 1 watershed

ETF Project # 210178

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Executive Summary

Watersheds have been widely monitored at a variety of scales throughout New Brunswick. This leads to inconsistent and incomparable data between watersheds. Consistent and comparable data is critical to adequately assess water quality in New Brunswick. To facilitate this, Eastern Charlotte Waterways Inc. (ECW) created an integrated watershed management plan (2020). This plan utilized multiple parameters under three broad categories, biomonitoring, physiochemical, and hydromorphological, to assess the state of watersheds in New Brunswick.

This project aims to assess the plan created by ECW to determine whether the chosen parameters and the staff, time, and equipment necessary to monitor those parameters achieve their purpose in the most efficient way possible. This project also aims to add one year of data to the baseline dataset for the West Fundy Composite level 1 watershed. Eleven sites were monitored in the four major rivers in the West Fundy Composite level 1 watershed: the Magaguadavic River, Digdeguash River, Lepreau River, and New River. On each river, a site was established in the upper reaches, the mouth, and a central point in order to get an understanding of water quality in the largest portion of the river. Collected data is stored according to ECW's data storage protocol to begin an in-depth baseline dataset for the West Fundy Composite level 1 watershed.

After use of the integrated watershed monitoring plan for one season it has been updated to reflect lessons learned regarding staff time, site selection, and other considerations, effectively streamlining the plan for use in other watersheds. Between two and three staff are needed to complete the sampling within the time required, depending on the number of staff within a group and the level of experience of those participating. Overall, it is determined that watershed groups will be able to utilize this plan to effectively assess the water quality in their watersheds.

1. Introduction

This project is designed to address goals from the New Brunswick Water Strategy: promoting better understanding of the watershed (Goal 1), monitoring drinking water sources (Goal 2), providing data which will help in preserving aquatic biodiversity and habitats (Goal 3) and by encouraging collaborative work with other stakeholders, fostering strong and open communication by reporting results to all stakeholders and communities in a transparent and accountable manner (Goal 4) (DELG, 2017). To facilitate this, a standardized way of monitoring watersheds was initiated in the West Fundy Composite level 1 watershed in 2021. This monitoring plan was designed using an integrated and holistic approach to ecosystem management, incorporating research on global best-practice and comparison with the various efforts presently being carried out in the province. Monitoring efforts in the plan include water quality, aquatic biodiversity, cyanobacteria, and watershed land usage, among others, and will align NGO, indigenous partners, and other community groups to ensure maximum impact.

This project produced the first year of in-depth baseline data in the West Fundy Composite level 1 watershed and tested the aforementioned Watershed Monitoring Plan. This first year of data collection will assist ECW in understanding the long-term sustainability of the monitoring plan. For example, it will demonstrate whether the frequency of sampling suggested in the plan is maintainable. It will also give ECW the foundation to continue to use the plan in the coming years.

The objectives of this project were twofold. The first objective was to use the monitoring plan to broaden the baseline knowledge of the West Fundy Composite level 1 watershed to include key parameters in addition to the usual water quality metrics. This was done by adding widely-used methods to the monitoring plan, such as the use of CABIN benthic invertebrate assessments, and by using innovative practices from the plan, such as the use of environmental DNA to understand aquatic biodiversity. Future data can be compared with this broadened baseline to more thoroughly understand environmental changes resulting from, for example, climate change or environmental degradation due to industrial development within the watershed. This data will be comparable to data collected elsewhere in New Brunswick, as efforts already being carried out by other environmental groups have been taken into account during the development of the Watershed Monitoring Plan, and as other groups adopt the plan themselves. Additionally, the dataset will serve as an example of the high-caliber, comprehensive version of watershed monitoring that is possible in New Brunswick. This rigorous, integrative approach to watershed monitoring provides a framework to other watershed groups in the province which results in a uniform and streamlined approach for data collection, facilitating knowledge transfer.

The second objective was to make an effort to understand the functionality and sustainability of the Watershed Management Plan. The plan has been designed to incorporate global best-practices in watershed management, and is intended to shape best-practice into a practical effort in New Brunswick. It includes a host of monitoring efforts such as the CABIN methodology for monitoring invertebrates, as well as environmental DNA technology for understanding fish biodiversity. Ultimately, since a plan this diverse and intensive has never been carried out in this region, it is a working document and will continue to be adjusted based on lessons learned during use of the plan. Next steps for this monitoring plan include: updating the monitoring document to factor in what was learned from this pilot year, and helping other groups to adopt the plan in regions that they monitor.

2. Methods

2.1. Study Area

This project was executed in the West Fundy Composite Level 1 watershed. This watershed is located in southwest New Brunswick between the Saint John River Basin and the Saint Croix River Basin. It encompasses the water catchment areas from the Musquash River in the east, the Magaguadavic River in the north, the Digdeguash river in the west, and everything in between. With a total area of 372,774.1 hectares (ha), it is one of the largest watersheds in the province. It is comprised of a further 11 level 2 watersheds, including the Magaguadavic River (186,072ha), the Musquash River (46,660ha), the Digdeguash River (45,936ha) and another 8 level 3 watersheds. This watershed provides ecosystem services and drinking water to 6 of New Brunswick's 15 counties, and is made up of ecologically and socially important areas including rivers, lakes, estuaries, and wetlands. Land resource use that is influential on the habitat in the West Fundy Composite watershed includes natural mixedwood forest, barren land, cropland, pasture, and forestry practices (Figure 1). It also provides important grounds for indigenous, cultural, recreational, and socioeconomic activities including fishing, hunting, hiking, swimming, and boating.

Sampling in this project was undertaken in the four main/largest watercourses in the watershed: the Magaguadavic River, Digdeguash River, New River, and Lepreau River. Precise site determination required the use of GIS, Google maps, and ground truthing. Initially, sites were selected based on ease of access with proximity to roads or ATV trails a main priority. GIS was utilized to delineate the watershed identifying the stream order of each site and create a land use map. Each river had three sites selected for monitoring, one in the upper reaches, one at the mouth, and one in the middle (Figure 2). This method of site selection was used to foster an understanding of the river ecosystem for the majority of the river without sampling an excessive number of sites. The first month of sampling required the selected sites to be ground truthed. This ground truthing determined if the site was as accessible as maps originally indicated and if the site would accurately represent the habitat of the river. The upper site for the Digdeguash River (Digdeguash 3) was removed due to the site not being an accurate representation of habitat for the river (swamp/no flow). A replacement site was not determined due to the lack of accessible sites a sufficient distance from the second site to warrant sampling.

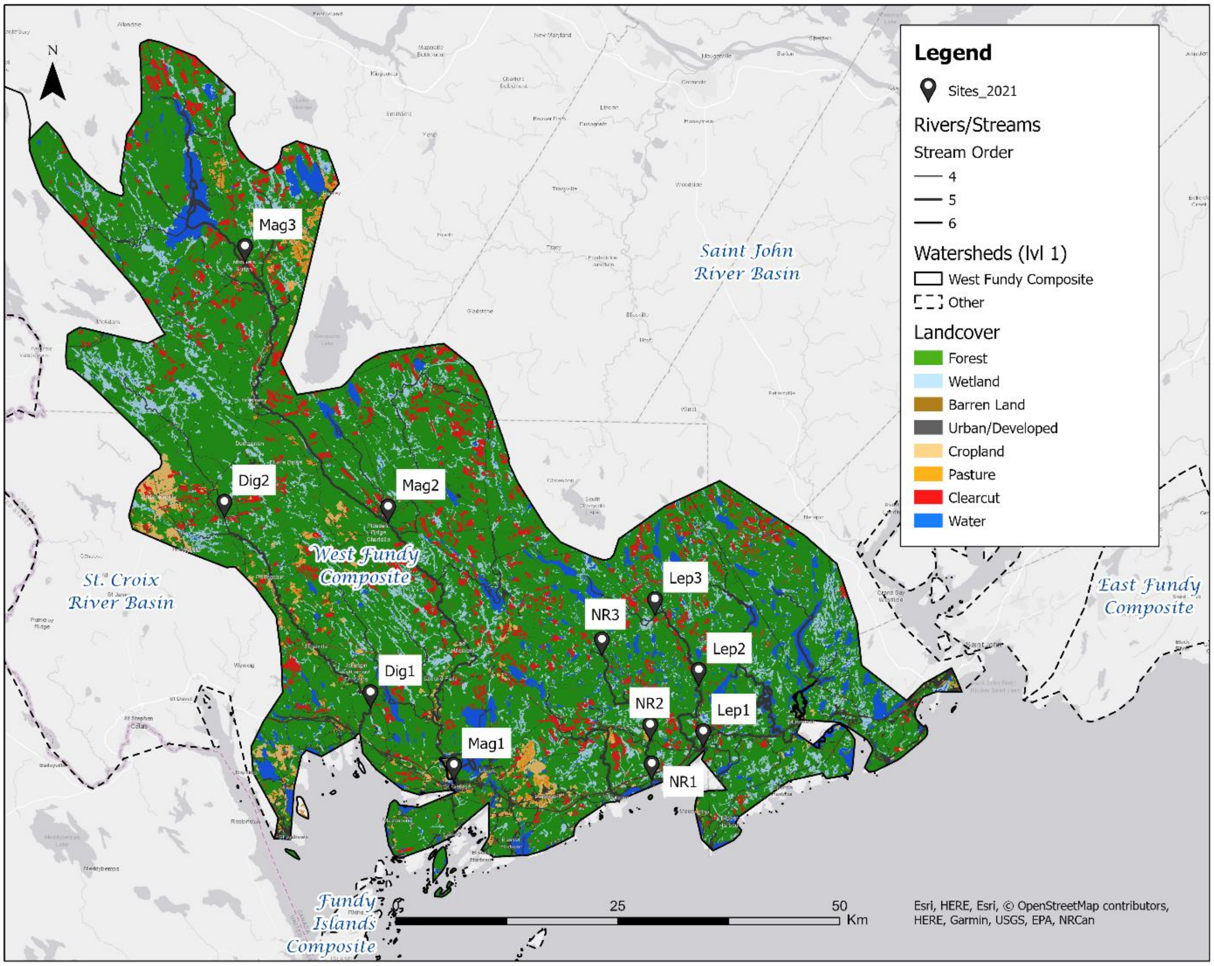

Figure 1. Land Resource usage of the West Fundy Composite Level 1 watershed including the monitored sites (Mag=Magaguadavic, NR=New River, Lep=Lepreau, Dig=Digdeguash).

2.2. Biomonitoring

Fish Community and Invasive Species

Fish community and the assessment of invasive fish species in the rivers was carried out using environmental DNA (eDNA). Sampling eDNA to determine the biodiversity of fish species present requires new technology, and is an innovative approach for this region. This new technology utilizes the combination of a Smith-Root™ Citizen Scientist eDNA sampler and a self-preserving filter created by Precision Biomonitoring Incorporated. Upon arrival at a site, the eDNA sample must be taken first or upstream of other measurements in order to limit contamination. Nitrile gloves were utilized at each site in order to limit contamination and the 1.2 micron (μm) self-preserving filter was attached to the intake hose of the eDNA sampler. Water was pumped through the filter via suction filtration until 1.9 litres of water had passed through the filter. The filter was then inverted and the seal opened slightly while the pump remained on for 30-40 seconds to air dry the filter. This air drying step allowed for the eDNA to be preserved and sealed in the filter for extraction up to six months later. Precision Biomonitoring labs extracted the DNA from the filter and analyzed the DNA using two genetic markers: the MiFish 12S and COI. For quality control, to check for contamination, a field blank was completed after each sampling day which required carrying out these methods with distilled water. Sampling for eDNA occurred twice during the summer, once in the summer (July) and once in the fall (October). Samples were sent to Precision Biomonitoring for analysis in November.

Benthic Invertebrates

Assessments of benthic invertebrates were completed utilizing Canadian Aquatic Biomonitoring Network (CABIN) standards. CABIN standards for collection of benthic invertebrates include the use of a standard kick net 400 μm in size. Benthic invertebrates are loosened from the substrate by shuffling in a zig-zag pattern back and forth across the stream. The net faces upstream so the current carries invertebrates into the net. Captured invertebrates are stored in jars and preserved in ethanol. This occurred seasonally (June, August, October) at the most upstream site. If that site was unsuitable for sampling due to depth, velocity of water, or insufficient substrate, the middle sampling site was used.

Total Coliforms and *Escherichia coli*

Water samples to test for total coliforms and *Escherichia coli* (*E. coli*) were collected in autoclaved sample bottles procured from the Eastern Charlotte Waterways laboratory. Bottles were dipped three successive times at least 10 centimeters (cm) deep with the lid on to rinse off any contaminants. The lid was then removed and the bottle was dipped at least 10 cm deep to collect the water sample. Once returned to the lab, the samples were analysed using Colilert and Quanti-tray methods where they were left in a 35 degree Celsius (^{o}C) incubator and read twenty-four hours later in units/100mL. Samples were also diluted by a factor of 1/10 to allow for a clearer picture of the level of total coliform and *E. coli* present. A blank was completed after each sampling period utilizing the same procedures for testing with distilled water. Testing for total coliforms and *E. coli* occurred monthly at each site.

2.3. Physiochemical

Water Quality

Water quality parameters were measured in a variety of ways. On a monthly basis at each site, a Yellow Springs Instrument (YSI) Professional Plus with a Quattro cable was used to measure temperature (^{o}C), dissolved oxygen (% and mg/L), pH, and conductivity (µS/cm). A more in-depth water quality analysis consisting of minerals and nutrients was also completed using the surface water analysis package from the RPC labs. These samples were collected using RPC bottles and were shipped directly to RPC. The surface water package measured a variety of parameters including: sodium, potassium, calcium, magnesium, alkalinity (as $CaCO_3$), chloride, fluoride, sulfate, bromine, ammonia (as N), Kjeldahl nitrogen, nitrate (as N), nitrite (as N), total phosphorus, dissolved organic carbon, aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, potassium, rubidium, selenium, silver, sodium, strontium, tellurium, thallium, tin, uranium, vanadium, and zinc. This mineral and nutrient analysis occurred at each site on a seasonal/bi-monthly basis (June, August, October).

2.4. Hydromorphological

Hydromorphological characteristics were measured in a variety of ways from monitoring the water level, turbidity, riparian structure, and other characteristics. The water level was monitored using a ruler that was attached to a piece of rebar left on-site. The first measurement in the spring (fresh melt) was used as a reference for the rest of the sampling days. The rulers used for water level measurements were left at the mouth of each river and water level was recorded on a monthly basis. The riparian zone was also visually assessed for the possibility of erosion and the health/type of the vegetation present on a monthly basis at each site. Other characteristics including the presence of oil, garbage, ATV crossings, construction, and algae were measured visually each month at each site.

3. Results

3.1. Biomonitoring

Fish Communities and Invasive Species

Combining both markers, twenty-four (N = 24) unique taxa were identified to species level across all submitted samples, representing thirteen unique families of fishes: Anguillidae (N = 1), Catostomidae (N = 1), Centrarchidae (N = 1), Clupeidae (N = 1), Cyprinidae (N = 8), Esocidae (N = 1), Gasterosteidae (N = 2), Ictaluridae (N = 1), Lotidae (N = 1), Moronidae (N = 1), Osmeridae (N = 1), Percidae (N = 1), and Salmonidae (N = 1) (MacLeod-Bigley, 2022). More species were detected using the MiFish 12S rRNA metabarcode, identifying nineteen (N = 19) unique taxa, whereas the PS1 COI metabarcode identified fifteen (N = 15) unique taxa. Ten species were common across both metabarcodes. Nine species were identified solely from amplifying the 12S rRNA region: smallmouth bass (*Micropterus dolomieu*), alewife (*Alosa pseudoharengus*), common shiner (*Luxilus cornutus*), chain pickerel (*Esox niger*), burbot (*Lota lota*), white perch (*Morone americana*), rainbow smelt (*Osmerus mordax*), yellow perch (*Perca flavescens*), and lake trout (*Salvelinus namaycush*) (MacLeod-Bigley, 2022).

Conversely, five species were identified solely from amplifying the COI region: blacknose dace (*Rhinichthys atratulus*), fallfish (*Semotilus corporalis*), nine-spined stickleback (*Pungitius pungitius*), brown bullhead (*Ameiurus nebulosus*), and brook trout (*Salvelinus fontinalis*). These results highlight the benefit of using the dual-locus approach when metabarcoding for fish diversity, as different metabarcodes can capture differing taxa based on available databases, and therefore better elucidate the biodiversity of a sampled area (MacLeod-Bigley, 2022). Species found that are confirmed to be invasive include smallmouth bass and chain pickerel.

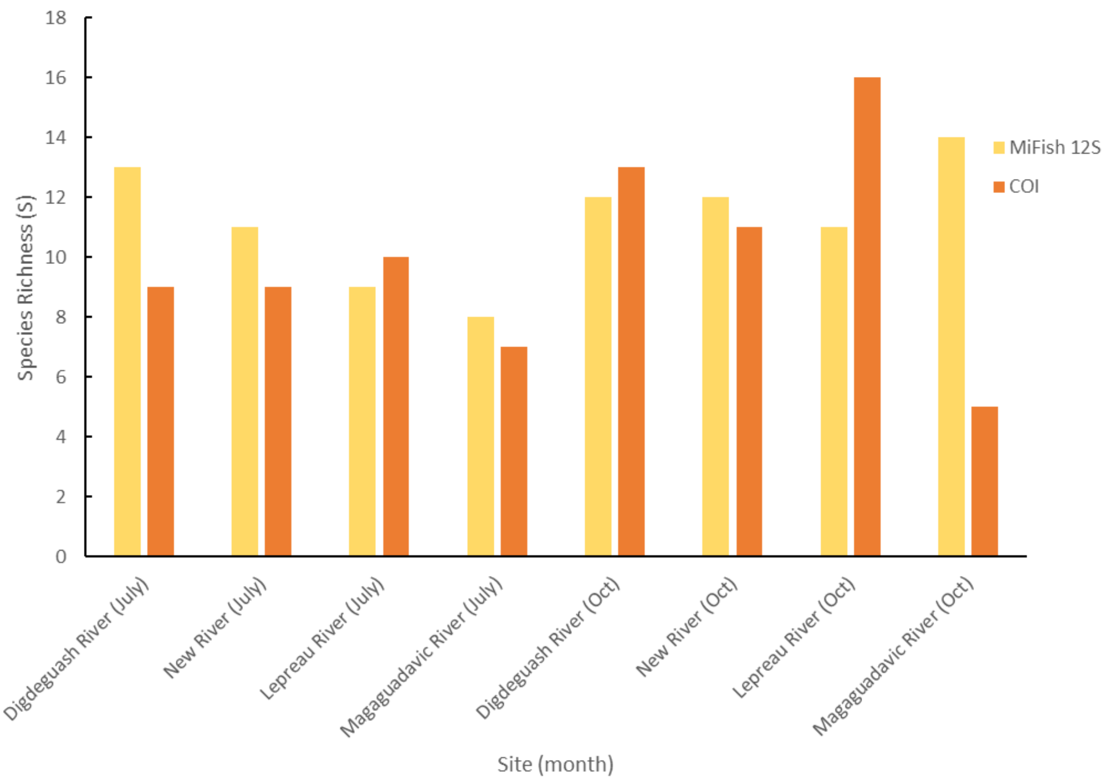

Figure 2. Fish species richness in each river (at the most downstream site) in July and October identified utilizing two genetic markers (MiFish 12S and COI).

Benthic Invertebrates

Due to budget constraints and other unforeseen circumstances, no analysis was completed on the benthic invertebrates collected at each site. Despite the absence of analysis, conducting these CABIN assessments was valuable in that it provided an accurate assessment of resources required for the extensive protocols, including staff numbers, time, training, and equipment.

Total Coliforms and *Escherichia coli*

Total coliform levels within the West Fundy Composite Level 1 watershed had broad variation from month to month as well as site to site. Total coliform levels were adequate for 77% of river water samples in each site except in months where the units/100 mL is greater than 2005 (Table 1). *E. coli* levels at each site are unacceptable for human consumption except for areas that had <10 units per 100 mL. Ideal levels of *E. coli* (<10 units/100 mL) were present in 15% of all samples (Table 1).

Table 1. Total coliform (TC) and *E. coli* levels at each site (NR=New River, LEP=Lepreau, MAG=Magaguadavic, DIG=Digdeguash) per month measured in units/100 mL.

Site	May (TC/*E.coli*)	June (TC/*E.coli*)	July (TC/*E.coli*)	August (TC/*E.coli*)	September (TC/*E.coli*)	October (TC/*E.coli*)
NR1	697/87	1013/31	1445/53	782/10	1445/238	531/271
NR2	1445/31	1184/20	>2005**/64	1445/42	1298/178	560/10
NR3	2005/<10***	>2005**/<10***	1005/20	782/31	659/99	945/75
LEP1	>2005**/42	885/42	>2005**/137	1445/10	>2005**/222	406/10
LEP2	1445/<10***	624/10	1298/42	1652/42	1298/111	344/<10***
LEP3	1652/<10***	429/<10***	>2005**/42	>2005**/20	1184/64	782<10***
MAG1	200.5*/4.2*	344/10	1298/42	429/10	885/53	429/31
MAG2	>200.5*/3.1*	560/10	738/20	782/31	>2005**/429	364/10
MAG3	>200.5*/3.1*	2005/53	1298/20	>2005**/<10***	>2005**/344	384/10
DIG1	>200.5*/23.8*	384/20	1445/31	885/20	>2005**/697	>2005**/831
DIG2	>200.5*/13.7*	1652/75	1652/31	>2005**/178	>2005**/364	1013/<10***

*Sample was not diluted as these samples indicated dilution was necessary.
**Sample above upper limit of test.
*** Sample below lower limit of test.

3.2. Physiochemical

Water Quality

Water temperature measurements in the rivers ranged from 7.3 to 25.3 ^{o}C (Table 2). Dissolved oxygen levels ranged from 80.3 to 120 % and 6.69 to 11.72 mg/L. Larger than normal values (above 100%) could be accounted for with a calibration error. The pH values ranged from 4.2 to 7.51 (Table 2). pH values less than 6 are likely due to a calibration error because normal pH values for rivers are between 6.5 and 8.5 (Table 2). The possible calibration errors occurred in 23% of the samples. Conductivity levels in the rivers ranged from 18.7 to 80.8 µS/cm (Table 2). A sample of the RPC analysis results are outlined at the end of this document (Appendix A).

Table 2. YSI measured water quality results from each site (NR=New River, LEP=Lepreau, MAG=Magaguadavic, DIG=Digdeguash) per month.

Site	Parameter	May	June	July	August	September	October
NR1	Temperature (^{o}C)	14.9	16.8	18.3	20.5	15.7	7.7
	Dissolved Oxygen (%/mg/L)	106.4/10.88	95.1/9.18	96.5/9.06	95.4/8.5	91.1/9.06	97.4/11.58
	pH	6.96	7.3	6.17	6.64	5.4	7.23
	Conductivity (µS/cm)	26.8	34.3	25.2	31.7	24.3	29.4
NR2	Temperature (^{o}C)	14.6	17	18.6	21.1	15.6	7.3
	Dissolved Oxygen (%/mg/L)	106.5/10.81	90.8/8.76	102.6/9.58	87.9/7.8	91.9/9.15	95.9/11.54
	pH	6.54	6.8	5.63	6.14	4.58	6.97
	Conductivity (µS/cm)	21.4	26.6	21.7	24.9	22.9	24.5
NR3	Temperature (^{o}C)	16.4	20.4	19	25.3	16.1	8.5
	Dissolved Oxygen (%/mg/L)	115.2/11.42	99.5/9.53	82.3/7.58	94.1/7.68	87.6/8.62	96.2/11.18
	pH	6.36	6.14	5.4	5.66	4.65	6.46
	Conductivity (µS/cm)	18.9	21.7	19.9	21.2	20.7	21.1
LEP1	Temperature (^{o}C)	16.3	17	20	22.3	16.2	8.0
	Dissolved Oxygen (%/mg/L)	119.5/11.72	97.9/9.45	104.5/9.49	96.3/8.39	113/11.13	94.7/11.22
	pH	6.02	7.34	5.56	6.18	4.33	7.29
	Conductivity (µS/cm)	21.7	31.7	25.2	26.2	22.9	24.7
LEP2	Temperature (^{o}C)	17.9	19.4	21.7	24.4	16.3	10.6
	Dissolved Oxygen (%/mg/L)	114.9/10.95	99.5/9.54	101.2/8.87	91.8/7.73	120/11.18	90.4/10.07
	pH	5.85	6.23	5.18	5.89	4.28	6.91
	Conductivity (µS/cm)	17.4	20.3	18.4	18.8	21.6	19.9
LEP3	Temperature (^{o}C)	18.6	18.9	21.3	24.3	16.1	10.4
	Dissolved Oxygen (%/mg/L)	110.5/10.45	96.9/9.12	94/8.4	92/7.7	114.5/11.59	88.8/9.87
	pH	5.65	6.25	5.16	5.79	4.2	6.41
	Conductivity (µS/cm)	17.4	19.7	18.8	18.7	23.6	20.0
DIG1	Temperature (^{o}C)	15.6	20.4	21.3	24.2	16.7	9.1
	Dissolved Oxygen (%/mg/L)	105.1/10.47	87.7/8.02	90.6/8.03	80.3/6.69	82.6/7.99	94.4/10.89
	pH	7.51	7.7	7.08	7.34	6.74	7.23
	Conductivity (µS/cm)	53.7	80.8	45.1	79.5	45.3	53.5

DIG2	Temperature (^{o}C) Dissolved Oxygen (%/mg/L) pH Conductivity (µS/cm)	14.6 106/10.67 7.17 52.7	22.9 95.4/8.2 7.21 79.1	20.1 94.6/8.67 6.86 47	23.8 80.4/6.81 6.66 82.2	15.3 89.4/8.96 6.5 69.8	8.3 92.3/10.94 7.02 53.2
MAG1	Temperature (^{o}C) Dissolved Oxygen (%/mg/L) pH Conductivity (µS/cm)	16.4 109.5/10.76 6.5 35	20.7 98.4/8.65 7.18 38.4	20.9 90/8 6.8 33.7	24.5 82/6.76 6.47 42.2	18.6 87.2/8.11 6.1 35.4	11.5 89.4/9.64 6.72 38.3
MAG2	Temperature (^{o}C) Dissolved Oxygen (%/mg/L) pH Conductivity (µS/cm)	18.2 114.1/10.49 6.53 35.7	18.8 99.9/9.47 6.9 38.8	19.1 94.2/8.7 7.14 34.3	23.1 97.5/8.35 6.6 41.1	16.9 89.5/8.68 6.15 39.4	8.7 96.7/11.25 6.97 36.4
MAG3	Temperature (^{o}C) Dissolved Oxygen (%/mg/L) pH Conductivity (µS/cm)	16.1 109.7/11.16 6.65 24.3	19 92.9/8.7 6.94 24.8	19.9 87.5/8 7.36 29.1	22.9 86.4/7.26 6.57 27.6	17.3 89.1/8.42 6.44 29.4	10.5 94.7/10.57 7.37 27.3

3.3. Hydromorphological

The water level in each river fluctuated from 0.2 to 1 meter. The lowest water level was recorded in June. The highest water level was recorded in September but this can be accounted for with the higher than normal accumulation of rain in the month of September. The turbidity levels ranged from 0.41 to 8.3 NTU. The riparian zones at the sites ranged with a variety of species from grasses, shrubs, and rocky areas. These were not exclusively in one area and sites often had a mix of two or even all three. All sites have the possibility of erosion with most riparian zone substrate including sand and other soft sediment. The majority of the time, no "other" characteristics were observed except for some algae in June and August as well as road construction all summer at the Lepreau river sites.

4. Future Application by External Organizations

Future applications of this project by external organizations may be limited by number of staff and time availability. Sampling for this project was carried out by two or three ECW employees from May to October. Sampling all four rivers took approximately four days (30 hours) per month to complete depending on characteristics measured in that particular month (Table 3). The first month usually required the most time due to the lack of experience completing the sampling, notably for new methods such as eDNA sampling. This is especially the case when CABIN sampling as it is a very extensive and time-consuming sampling technique. ECW employees completed CABIN assessments three times throughout the summer, requiring a minimum of two staff but preferably having three. The first time took the longest: 2 hours per sampling site. In total, it took 8 hours to complete the CABIN assessments during the first set, but sampling time decreased each time and eventually only took between 1.25 to 1.5 hours per site. This trend was seen in other methods as well, where the first time took the longest and the time required decreased with each practice. However, the West Fundy Composite level 1 watershed covers a significant area which may inflate the time requirements for sampling due to distance between sites and remote sites requiring ATV access. All in all, the watershed monitoring plan as a whole is sustainable and can be maintained by watershed groups of various sizes for use in watersheds of various sizes. The monitoring document is now being updated to factor in what was learned from this pilot year of broader baseline data collection. Next, ECW will assist other groups in adopting the plan in an effort to promote this consistent data collection throughout southwest New Brunswick and beyond.

Table 3. Approximate monthly requirement for completion of a plan with this sampling intensity for four rivers with 2-3 staff available.

Month	Number of Personnel	Tasks	Duration (hours)
May	2-3	12x coliforms/*E.coli* 12x YSI Water Quality 12x Riparian Zone 12x Turbidity Other visual assessments	13.5
June	2-3	4x CABIN Assessments 11x coliform/*E. coli* 11x YSI Water Quality 11x RPC Water Quality 11x Riparian Zone 11x Turbidity and water level Other visual assessments	30.5
July	2	4x eDNA sampling 11x coliform/*E. coli* 11x YSI Water Quality 11x Riparian Zone 11x Turbidity and water level Other visual assessments	16.5

August	2-3	4x CABIN Assessments 11x coliform/*E. coli* 11x YSI Water Quality 11x RPC Water Quality 11x Riparian Zone 11x Turbidity and water level Other visual assessments	29
September	2	11x coliform/*E. coli* 11x YSI Water Quality 11x Riparian Zone 11x Turbidity and water level Other visual assessments	13
October	2-3	4x eDNA sampling 4x CABIN Assessments 11x coliform/*E. coli* 11x YSI Water Quality 11x RPC Water Quality 11x Riparian Zone 11x Turbidity and water level Other visual assessments	26

5. ETF Priority Area Measures

An Environmental Trust Fund (ETF) priority area targeted in this project was categorized under the 'Protecting Our Environment – Water quality improvements' section. During completion of this project, there was a goal to prioritize at least three management actions improving water quality in the West Fundy Composite level 1 watershed. This project successfully completed three management actions which were outlined as biomonitoring, physiochemical, and hydromorphological. A first-year broadened baseline dataset has now been established for half of the major rivers within the West Fundy Composite level 1 watershed. These three management actions assessed a different aspect of water quality within the West Fundy Composite level 1 watershed and if the steps outlined in the Integrated Watershed Monitoring Plan are able to be followed by external organizations, there will be adequate comparable data within the province of New Brunswick.

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Appendix A – Sample RPC Analysis

RPC Sample ID:			400286-1	400286-2
Client Sample ID:			17/21/15009	17/21/15010
Date Sampled:			14-Jun-21	14-Jun-21
Analytes	**Units**	**RL**		
Sodium	mg/L	0.05	3.89	3.92
Potassium	mg/L	0.02	0.40	0.48
Calcium	mg/L	0.05	8.43	9.14
Magnesium	mg/L	0.01	1.57	1.55
Alkalinity (as $CaCO_3$)	mg/L	2	25	27
Chloride	mg/L	0.5	7.5	5.7
Fluoride	mg/L	0.05	0.17	0.21
Sulfate	mg/L	1	3	3
Bromine	mg/L	0.01	0.04	0.02
Ammonia (as N)	mg/L	0.05	< 0.05	< 0.05
Un-ionized @ 20°C	mg/L	-	< 0.001	< 0.001
Nitrate + Nitrite (as N)	mg/L	0.05	< 0.05	0.06
Nitrite (as N)	mg/L	0.05	< 0.05	< 0.05
Nitrate (as N)	mg/L	0.05	< 0.05	0.06
Nitrogen - Total	mg/L	0.2	0.5	0.6
Phosphorus - Total	mg/L	0.002	0.011	0.013
Carbon - Total Organic	mg/L	0.5	10.2	13.8
Colour	TCU	5	67	88
Conductivity	µS/cm	1	79	78
pH	units	-	7.3	7.3
Turbidity	NTU	0.1	1.0	0.7
Calculated Parameters				
Bicarbonate (as $CaCO_3$)	mg/L	-	24.9	26.9
Carbonate (as $CaCO_3$)	mg/L	-	0.047	0.050
Hardness (as $CaCO_3$)	mg/L	0.2	27.5	29.2
TDS (calc)	mg/L	-	51	55
Saturation pH (20°C)	units	-	9.0	8.9
Langelier Index (20°C)	-	-	-1.69	-1.62

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Appendix A cont.

RPC Sample ID:			400286-1	400286-2
Client Sample ID:			17/21/15009	17/21/15010
Date Sampled:			14-Jun-21	14-Jun-21
Analytes	**Units**	**RL**		
Aluminum	mg/L	0.001	0.060	0.064
Antimony	mg/L	0.0001	< 0.0001	< 0.0001
Arsenic	mg/L	0.001	0.002	0.002
Barium	mg/L	0.001	0.003	0.004
Beryllium	mg/L	0.0001	< 0.0001	< 0.0001
Bismuth	mg/L	0.001	< 0.001	< 0.001
Boron	mg/L	0.001	0.008	0.017
Cadmium	mg/L	0.00001	0.00002	0.00002
Calcium	mg/L	0.05	8.43	9.14
Chromium	mg/L	0.001	< 0.001	< 0.001
Cobalt	mg/L	0.0001	0.0002	0.0002
Copper	mg/L	0.001	< 0.001	< 0.001
Iron	mg/L	0.02	0.32	0.22
Lead	mg/L	0.0001	0.0002	0.0001
Lithium	mg/L	0.0001	0.0010	0.0006
Magnesium	mg/L	0.01	1.57	1.55
Manganese	mg/L	0.001	0.051	0.094
Molybdenum	mg/L	0.0001	0.0002	0.0001
Nickel	mg/L	0.001	< 0.001	< 0.001
Potassium	mg/L	0.02	0.40	0.48
Rubidium	mg/L	0.0001	0.0012	0.0016
Selenium	mg/L	0.001	< 0.001	< 0.001
Silver	mg/L	0.0001	< 0.0001	< 0.0001
Sodium	mg/L	0.05	3.89	3.92
Strontium	mg/L	0.001	0.038	0.050
Tellurium	mg/L	0.0001	< 0.0001	< 0.0001
Thallium	mg/L	0.0001	< 0.0001	< 0.0001
Tin	mg/L	0.0001	< 0.0001	< 0.0001
Uranium	mg/L	0.0001	< 0.0001	< 0.0001
Vanadium	mg/L	0.001	< 0.001	< 0.001
Zinc	mg/L	0.001	0.006	0.006