Reducing Acidification in Endangered Atlantic Salmon Habitat

Baseline Data Summary

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Introduction

Despite restored access to historic Atlantic salmon (*Salmo salar*) habitat in eastern Maine, population sizes have remained low (USASAC 2018). Most Downeast waters have been identified as acidic (pH <6.5), with headwaters chronically acidic and main stems episodically acidic (Haines et al. 1990; Whiting and Otto 2008). Loss of fish populations due to acidification of surface waters has been well documented in the North Atlantic region (as reviewed by Clair and Hindar 2005; Dennis and Clair 2012). In addition, numerous studies have demonstrated that episodic exposure to low pH can have detrimental, sub-lethal impacts when coinciding with key salmon life stages during snow melt and spring runoff (e.g., Kroglund et al. 2008; Lacroix and Knox 2005; as reviewed by McCormick et al. 1998). Adding lime to acidic waters, through application of agricultural lime or lime slurry, has increased salmon populations in Scandinavia and Nova Scotia (as reviewed by Clair and Hindar 2005; Halfyard 2007; Hesthagen et al. 2011), and has been a recommended restoration action for Maine's acidic rivers and streams (NRC 2004). A 2009 Project SHARE pilot study investigating the efficacy of using clam shells to lime small streams suggested a trend towards improved habitat quality (Whiting 2014). For a more detailed project background, see Zimmermann (2018). To further investigate the efficacy of using clam shells as a mitigation method, a multi-year liming project in the East Machias River watershed will be conducted in collaboration with the Downeast Salmon Federation (DSF). Clam shells will be spread along treatment reaches both along the stream bottom and along the banks to capture high flow events (when episodic acidity is expected). The project goal is to increase juvenile salmon abundance by application of clam shells to achieve a target pH, and to evaluate changes in the macroinvertebrate community. The first two years of the project were used to characterize baseline conditions of the study area.

Methods

Four tributary streams to the East Machias River were monitored to collect baseline data (Fig. 1 and Appendix I, Table 1). The East Machias River watershed is typical of coastal eastern Maine, with extensive wetlands resulting in colored waters high in organic materials and low pH, with high summer temperatures (Project SHARE-USFWS 2009). The existing salmon population in the East Machias River system is small (median large parr density 13.1 per habitat unit, 100m^2), with 4 redds observed and an estimated 1501 ± 253 parr exiting the system in 2017 (USASAC 2018). In 2018, preliminary estimates show only 15 adults returned (Department of Marine Resources, MDMR). Richardson Brook and Creamer Brook are both stocked by DSF, and the average large parr density observed during fall electrofishing is 12 parr/100m^2 and 16 parr/100m^2 respectively (Fig. 2, MDMR data). The bedrock geology in the study area is predominantly marine sandstone and slate with some volcanic rocks, especially around Creamer Brook (see Appendix I, Table 2 for stream characteristics). Roaring Brook has a natural fish barrier at its mouth and in 2017, the Brook went dry. Therefore, in 2018 Roaring Brook was replaced by Beaverdam Stream. Beaverdam Stream has been stocked with 9-month old salmon parr for six years by DSF and it has some of the most productive salmon habitat in the watershed, with an average of 15 parr/100m^2 (Fig. 2, MDMR data). Continuous monitoring devices provided hourly water quality data that was supplemented by bi-monthly grab samples (Zimmermann 2018). Macroinvertebrate samples were collected using rock bags following the MDEP protocol (2014) and by DSF staff using rock bags, following USEPA's Rapid Bioassessment Protocol (Barbour et al. 1999).

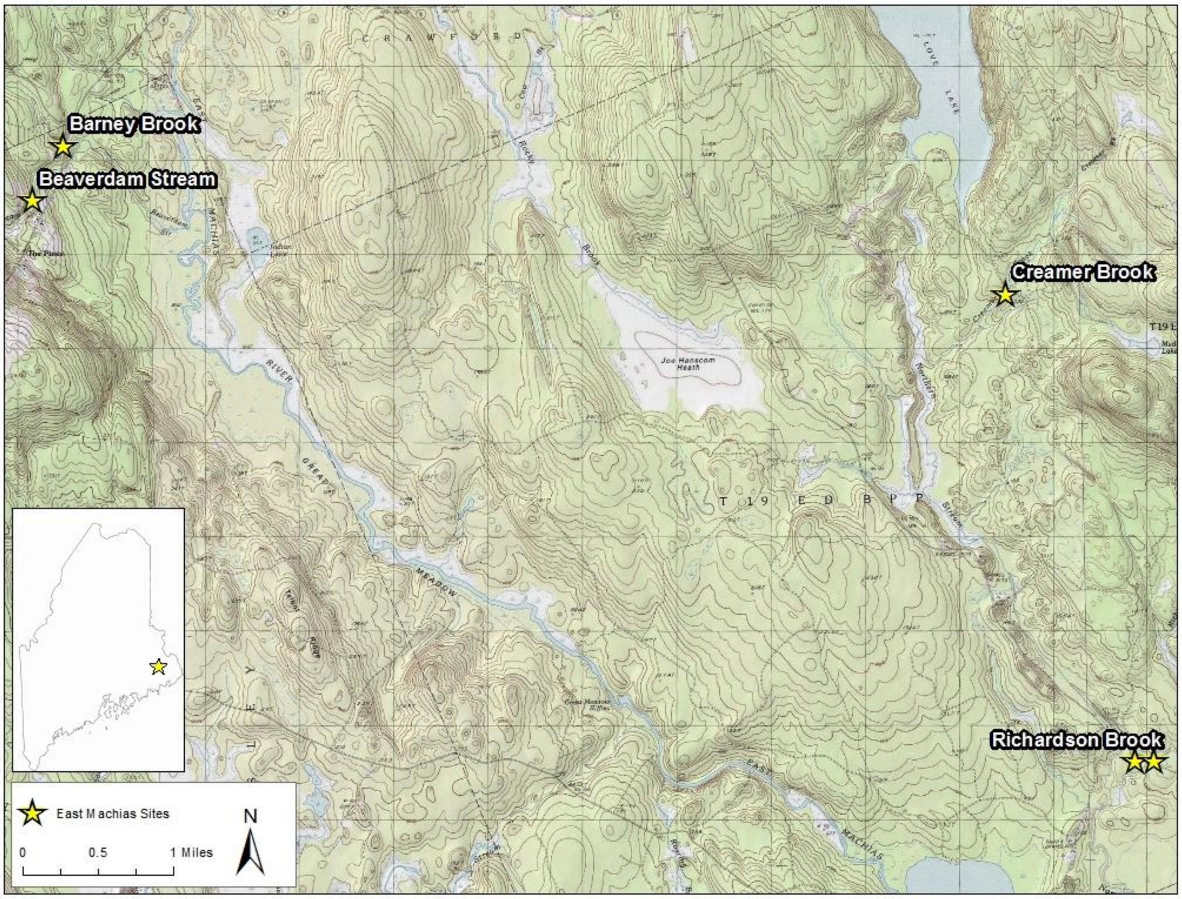

Figure 1. Map of the five study sites on four tributaries to the East Machias River. On Richardson Brook, samples were taken upstream and downstream of the road.

Statistical Analysis

Data were analyzed using R 3.5.1 (R Core Team 2018). Plots were created using *ggplot2* (Wickham 2009). All data are presented as mean ± standard deviation, unless otherwise stated. Only 3% of data were rejected due to data quality issues, with less than 1% of pH data rejected, 2% temperature rejected, 6% specific conductance rejected, and 6% dissolved oxygen rejected (due to equipment failure).

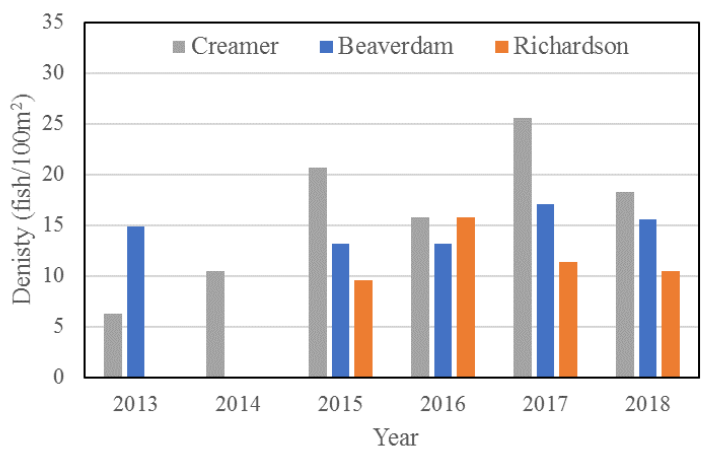

Figure 2. Salmon density in three of the study streams from 2013-2018. Data from MDMR electrofishing surveys.

Results and Discussion

Weather

Eastern Maine experienced a cold, dry spring followed by a much warmer than average summer with record warm overnight lows (NOAA 2018). This followed two summers of drought. The dry summer was punctuated by heavy rain events. Drought-induced low flows have significant impacts on stream water quality and aquatic biota. Low flows can reduce fish mobility, potentially trapping them in isolated pools where they could experience higher temperatures, lower dissolved oxygen, and reduced foraging opportunities. The influence of cold groundwater during low flows may reduce stream temperature.

pH

For the two baseline years, 77% of pH values remained above the threshold of 5.4, where no adverse impacts to salmon are expected (Fig. 3; Appendix II; Haines et al. 1990; Stanley and Trial 1995). pH remained above the state water quality criterion of 6.0 for 43% of the baseline (54% in 2017, 39% in 2018; Appendix II; 38 MRS Section 464.4.A.5). Barney Brook and Beaverdam Stream had the highest pH (6.25 ± 0.40 and 6.01 ± 0.50, respectively; Appendix II), possibly due to the underlying limey protolith which may provide a higher buffering capacity than the marine volcanics in the rest of the study area (MGS 2017). Specific to 2018, early spring rain-on-snow events reduced low pH levels a further 0.5 unit. Snow was present until early May, after which stream pH increased. A large summer storm (more than 46 mm of rain over 24 hours) following two dry months resulted in a sharp pH depression with recovery to 5.4 in 4-15 days. To attain pre-storm levels, recovery took more than a month. As in 2017, the largest pH depression occurred in the fall, when organic acids from leaf drop may contribute to low pH (Zimmermann 2018). In early October 2018, pH fell below 5.4 and stayed low for the last two months of the study, decreasing further with each subsequent rain event. Beaverdam Stream briefly recovered to 5.4 after 25 days before experiencing further depressions.

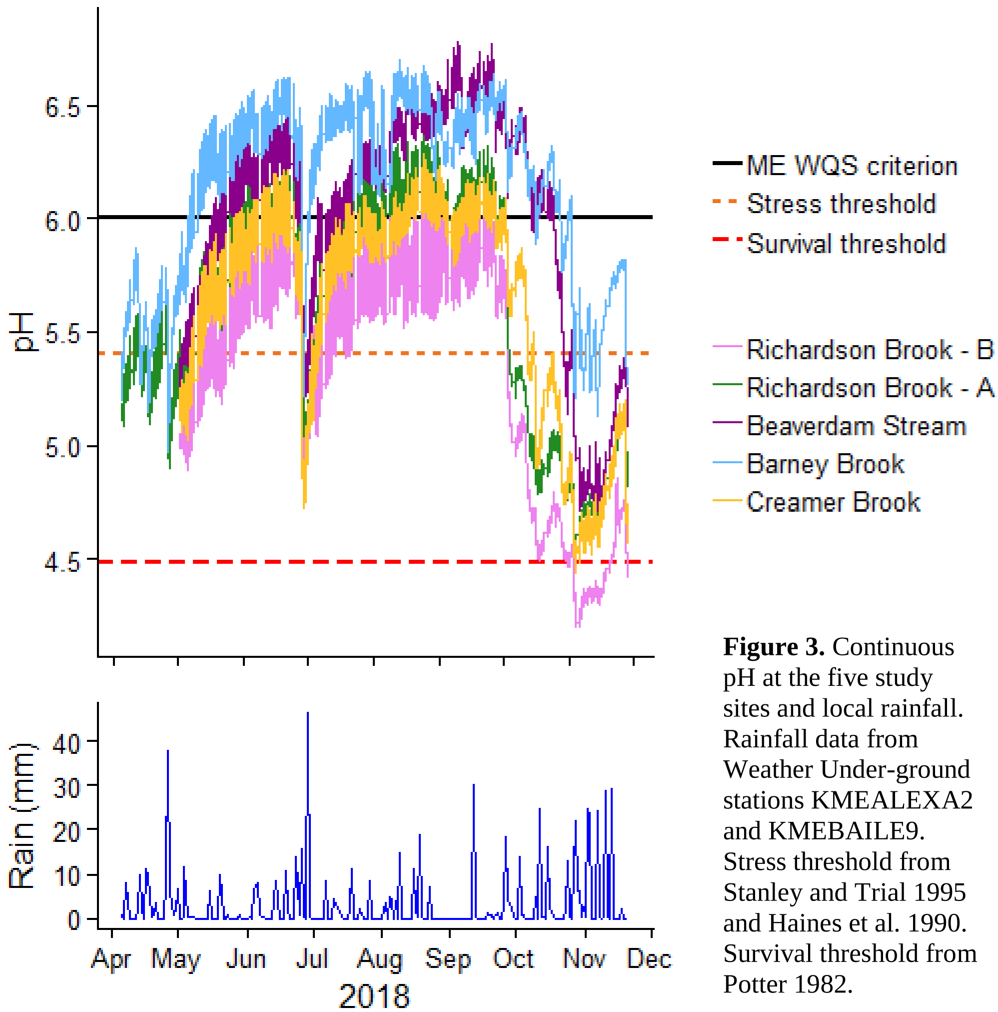

Figure 3. Continuous pH at the five study sites and local rainfall. Rainfall data from Weather Under-ground stations KMEALEXA2 and KMEBAILE9. Stress threshold from Stanley and Trial 1995 and Haines et al. 1990. Survival threshold from Potter 1982.

As in 2017, Barney Brook showed the best buffering capacity, only briefly dipping below 5.4 (Zimmermann 2018). The survival threshold of 4.48, below which harm occurs to all salmonid life stages (Potter 1982), was exceeded 9% of the time in 2018 at the downstream site on Richardson Brook, lasting for 16 days with a minimum value of 4.19, and at Creamer Brook for 2 hours with a minimum value of 4.44. Compared with 2017, 14 cm more rain fell in 2018, and pH was lower, with values below 5.4 occurring 3-20% more in 2018 (Zimmermann 2018). Although eastern Maine streams are not chronically acidic, as in Norway and Nova Scotia (Clair et al. 2004; Haines et al. 1990; Halfyard 2007; Hesthagen et al. 2011), the two years of baseline data indicate sub-lethal stress is likely occurring during episodic, precipitation-driven acidity events (Baker et al. 1996; Henriksen et al. 1984; Lacroix and Knox 2005; Magee et al. 2003).

<ins>Stream Temperature</ins>

For the two baseline years, temperature remained below the threshold for optimal growth of 20°C for most (86%) of the sampling period (Fig. 4; Appendix II; USEPA 1986). Across the baseline period, including winter, the stress threshold of 22.5°C (Elliott and Hurley 1997; Stanley and Trial 1995) was exceeded only 4.2% of the time, USEPA's short-term maxima for survival of 23°C (USEPA 1986) was exceeded 3.2% of the time, and the maximum temperature for salmon survival of 27°C (Stanley and Trial 1995) was exceeded 0.1% of the time. Maximum temperatures occurred primarily in July (16% >22.5°C) and August (13% >22.5°C). Temperatures remained within or below the 16-19°C preferred temperature range for 85% of the baseline period (Stanley and Trial 1995). Higher temperatures were observed in 2018 than in 2017, with exceedances 3-13% higher (Zimmermann 2018). The relatively short duration of stressful temperatures (12 hours on average in 2018), in addition to the diel fluctuations (2.7 ± 1.6°C across both years) that may provide a nightly temperature refuge, suggest that recovery from thermal stress events is feasible. However, summer temperatures remained above 22.5°C for a maximum of 5 days at most sites, likely causing some sub-lethal stress.

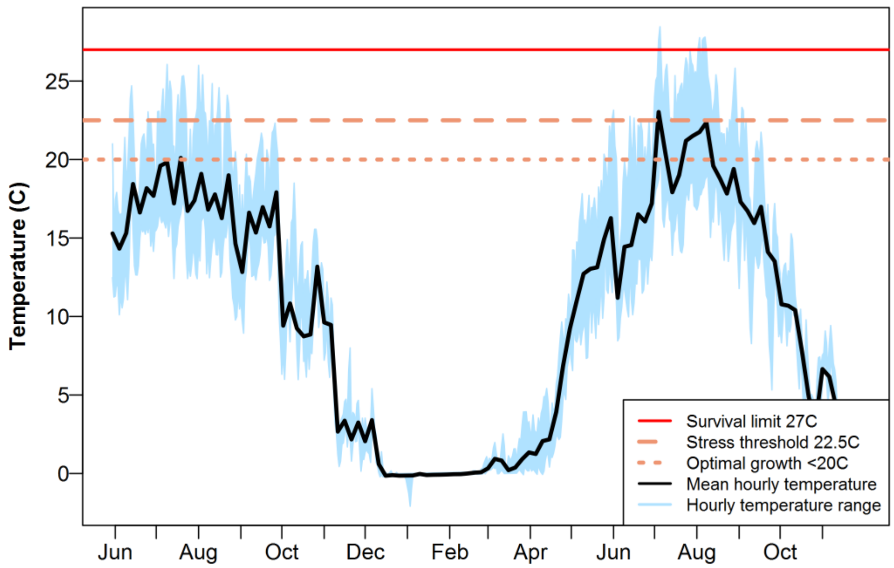

Figure 4. Mean hourly temperature across all study sites 2017-2018. Optimal growth limit from USEPA 1986. Stress and survival thresholds from Elliott and Hurley 1997 and Stanley and Trial 1995.

<ins>Dissolved Oxygen (DO)</ins>

DO levels were within a healthy range for fish and aquatic life, in addition to the preferred range for salmon of >6-7 mg/L for most (92%) of the baseline period (Appendix II; Stanley and Trial 1995). In both years, during extreme low flows DO decreased below both the Maine Water Quality Standard of 7 mg/L and USEPA's threshold for acute impairment of 5 mg/L for 1.7% of the study (38 MRS Section 465.2.B; USEPA 1986; Zimmermann 2018). In 2018, DO <5 mg/L only occurred at the downstream Richardson Brook site and Barney Brook, persisting on average 11 hours, with the longest duration of almost 2 days in Barney Brook in early August when it is likely flows ceased. DO minima coincided with the warmest temperatures as well as with low flows, increasing stress and possibly preventing fish movement to refugia, if any existed nearby.

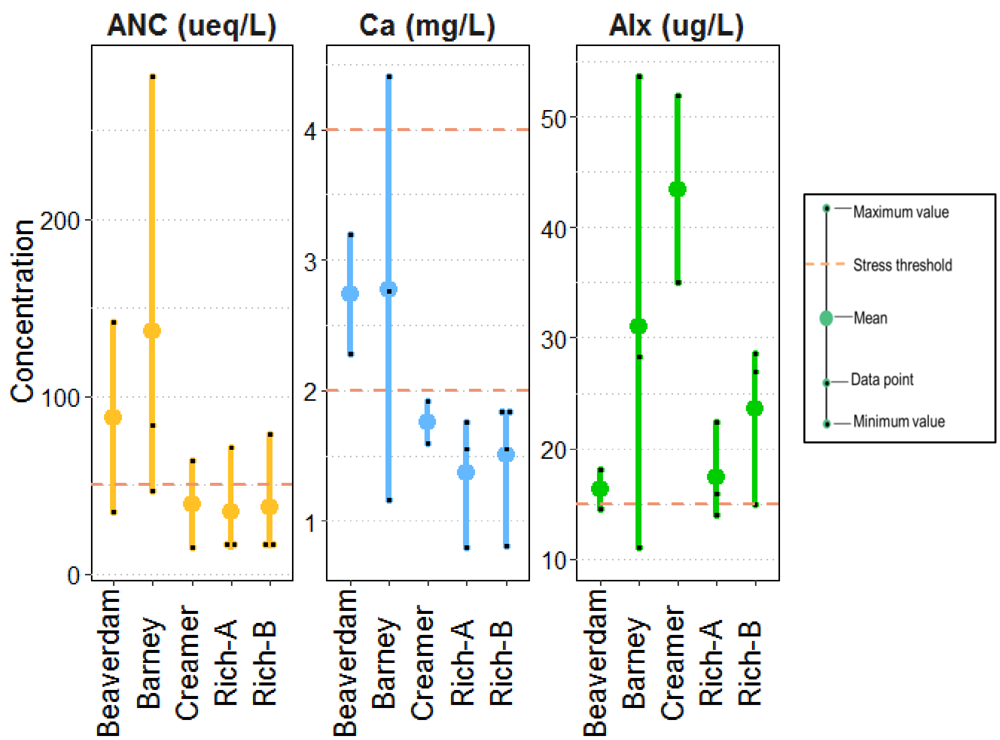

Figure 5. Acid neutralization capacity (ANC), calcium (Ca) and exchangeable aluminum (Alx) for 2017 and 2018. n = 6 except for Creamer Brook, n = 5, and Beaverdam Stream, n = 3. ANC stress threshold of <50 μeq/L from Driscoll et al. 2001. Calcium stress thresholds of <4 mg/L from M. Whiting (pers. comm.) and <2 mg/L from Baker et al. 1990 and Baldigo and Murdoch 2007. Alx stress threshold of >15 μg/L from EIFAC as cited in Dennis and Clair 2012. Small dots represent data points, large dots represent means.

<u>Acid Neutralization Capacity (ANC)</u>

Summer baseflow ANC remained above the threshold of acid sensitivity of 50 μeq/L (Fig. 5; Appendix II; Driscoll et al. 2001). However, ANC was below the Norwegian 20-30 μeq/L critical limit for salmon (Baker et al. 1990; Lien et al. 1996; Kroglund et al. 2002) in all samples following a rain-on-snow event in late April 2018. ANC was even lower in late fall after several large rain events in all samples except for Barney Brook and Beaverdam Stream. Higher ANC gives greater buffering capacity and correlates with higher pH (lower acidity), as observed at Barney Brook. Only one sample, at Barney Brook during baseflow, was above USEPA's recommended AWQC of 20 mg/L alkalinity, however this threshold doesn't apply where values are naturally lower (USEPA 1986). Relatively low ANC values in the other study streams indicate a deficit of buffering materials in the watershed due to thin soils (Potter 1982), allowing volatile swings in pH after rain inputs (Fig. 3) and increasing the potential for salmon mortality (MacAvoy and Bulger 1995). Due to low buffering capacity, if liming mitigation is pursued, it is expected that these watersheds would revert to the pre-treatment acidified state relatively quickly if mitigation ceased (Halfyard 2007).

<u>Calcium</u>

For both baseline years, calcium was below the survival threshold of 2 mg/L at all sites for most of the sample events, and remained below 2 mg/L at every sample in the upstream Richardson Brook site. (Fig. 5; Appendix II; Baker et al. 1990; Baldigo and Murdoch 2007). Only Barney Brook occasionally had calcium levels above the suggested threshold of 4 mg/L to prevent deformities (M. Whiting pers. comm.). Calcium minima coincided with low pH, high aluminum, and low ANC. The capacity of calcium to buffer against the detrimental impacts of exchangeable aluminum (Alx) decreases when calcium concentrations are below 1 mg/L at pH 6.5, and around 2 mg/L Ca when pH is <6.5 (Baldigo and Murdoch 2007; MacDonald et al. 1980, Wood et al. 1990). It is expected that some buffering of Alx is occurring in the study streams during summer baseflow, when calcium values are highest, but not during spring rain-on-snow events (Baker et al. 1990; Wood et al. 1990).

Aluminum

Average total aluminum per stream ranged from 169.7 to 286.5 μg/L, well below the Maine AWQC maximum of 750 μg/L which is based on a pH of 6.5-9 and dissolved organic carbon (DOC) <5 mg/L, significantly different from values observed in the study streams (Appendix II; MDEP CMR Chapter 584). Aluminum was also mostly below USEPA's site-specific maximum criteria (CMC) which ranged from 18-1200 μg/L depending on DOC, total hardness, and pH (USEPA 2018). Total aluminum levels exceeded the CMC at Beaverdam Stream and both Richardson Brook sites following the rain-on-snow event in late April, and at all sites in November following several rain events. Organic aluminum was the dominant species, likely due to DOC concentrations, which can reduce the impact of aluminum toxicity (Appendix II; Lacroix and Kan 1986). Exchangeable aluminum (Alx) represented 10.8 ± 4.9% of aluminum species per sample, ranging from 0.8% to 18.0%, with the highest percentage observed during summer baseflow, as seen in Nova Scotia (Lacroix and Kan 1986, Zimmermann 2018).

For protection of aquatic life, including macroinvertebrates, the European Inland Fisheries Advisory Commission (EIFAC) recommends that Alx should not exceed 0.015 mg/L at pH 5.0-6.0, even for short durations (Howells et al. 1990 as cited in Dennis and Clair 2012; Kroglund and Staurnes 1999; McCormick et al. 2009). All streams exceeded this criterion during summer baseflow when pH was relatively high (between 5.53 and 6.51), when aluminum solubility (and therefore toxicity) is reduced (Fig. 5; Appendix II; Dennis and Clair 2012; Driscoll et al. 2001). Alx was low during the rain-on-snow event in late April 2018, but high in late November, concurrent with the biggest pH depression. The abundance of acid-sensitive species decreases when Alx is >72 μg/L and pH is ≤5, conditions not observed in the discrete samples collected in the two years of baseline data (Driscoll et al. 2001). The risk of salmon mortality in the study streams due to high Alx concentrations is unlikely (Baldigo and Murdoch 2007; Haines et al. 1990), however sub-lethal stress may decrease smolt tolerance to saltwater (Kroglund and Staurnes 1999; McCormick et al. 2009; Monette et al. 2008; Staurnes et al. 1995). Recovery from low pH/high Alx events can take up to 3 days in neutral waters (Kroglund and Staurnes 1999) and up to 3 weeks for early life stages (Wood et al. 1990). Based on pH and Alx, reduced salmon populations are expected at all streams except for Barney Brook (Kroglund et al. 2002).

Dissolved Organic Carbon (DOC)

DOC is a strong determinant of fish mortality (for brook trout, Baldigo and Murdoch 2007) and can be used as an indicator of organic acidity to determine the role of anthropogenic activity in acidic streams (Garmo et al. 2014). Downeast streams, including those studied here, are naturally highly colored, with relatively high organic content due to wetlands and coniferous forests (Haines et al. 1990). DOC ranged from 6.9 to 19 mg/L, with an average of 12.4 ± 3.9 mg/L across all streams (Appendix II). A positive correlation between DOC and pH was observed following the late April 2018 rain-on-snow event and in October 2017 (r = 3.8, R^2 = 0.84, p = 0.009), suggesting pH depressions are driven by anthropogenic acidification. In contrast, the negative correlation between DOC and pH observed during base flows (r = -3.3, R^2 = -0.67, p = 0.006) suggests baseflow pH is driven by natural organic acids. Above pH 5.5, and at DOC concentrations greater than 2.0-5.0 mg/L, DOC can buffer against the toxic impacts of Alx, by binding the aluminum into inert organic complexes (Baldigo and Murdoch 2007; Kroglund et al. 2008; Tipping et al. 1991). It is expected that some buffering of Alx is occurring in the study streams despite low pH values.

Nutrients

Nutrient levels were similar across all study streams, although Barney Brook had approximately twice as much biologically available nitrogen (nitrate + nitrite, N+N) as the other streams (Appendix II). N+N was on average 0.063 ± 0.03 mg/L, total Kjeldahl nitrogen (TKN) was on average 0.75 ± 0.13 mg/L, and total phosphorus was on average 21.2 ± 0.3 µg/L. TKN was higher than the 0.5 mg/L maximum usually seen in natural, undisturbed streams in Maine (based on MDEP's Biomonitoring dataset), however this is not surprising due to the highly colored, tannin-rich streams in the study area. Phosphorus and N+N levels were similar to other class A streams in Maine, such as the West Branch Sheepscot (MDEP 2018), however phosphorus in the study area is on the high end of the spectrum for class A streams based on MDEP's Biomonitoring dataset. Nitrogen and phosphorus levels were typical of natural, undisturbed streams in Maine.

Macroinvertebrates

All study streams, except for Beaverdam Stream, attained Maine's highest aquatic life water quality classification (Class A; Appendix III; Davies et al. 2016). The dominant taxa were mayflies and caddisflies that most often occur in cool springs and streams, usually in areas of little current, such as were found in the low flow conditions both years. Mayflies are the most sensitive group of aquatic insects to acidity (Weiderholm 1984) and represented around 50% of the generic richness, suggesting a healthy macroinvertebrate assemblage requiring good water quality. Beaverdam Stream did not attain its class A aquatic life criteria, with the macroinvertebrate community attaining only class B, however this is likely due to the unbalanced diversity, with 48% of the sample represented by one, ubiquitous genus of Chironomid (midge; Appendix III), which may be an artifact of habitat or sampling technique. Other sensitive taxa were present at Beaverdam Stream in similar numbers to the other sites. Rainfall driven decreases in pH (<5) may have a detrimental impact on any acid-sensitive macroinvertebrates present, although the most critical period for macroinvertebrates is likely emergence, so species that reproduce in the fall and spring would be most affected (Bradley and Ormerod 2002; Weiderholm 1984). However, as episodic acidity events have been occurring for decades, the macroinvertebrate assemblage in Downeast streams may be tolerant to low pH pulses. Salmon are thought to be opportunistic feeders, changing their diet to the most abundant prey available, so changes in macroinvertebrate abundance may have a stronger impact on salmon than changes in composition (Scott and Crossman 1973 as cited in Stanley and Trial 1995).

Conclusion

Two years of baseline monitoring indicate that under moderate baseflow conditions, water quality in the study streams is decent for salmon. Sub-lethal stress could occur during extreme low flows during droughts that lead to low dissolved oxygen and high temperatures, and during high-discharge, high acidity events. All streams experienced episodic acidification due to precipitation events, particularly in the spring and fall when natural organic acid levels are low, indicating acidity from anthropogenic sources. Cumulative sub-lethal stress is likely causing detrimental impacts to salmon due to the combined impact of low pH and aluminum toxicity. Exposure to physiological stressors, such as changes in salinity and acidity, has been shown to reduce anti-predatory behavior in smolts, in addition to increasing residence time in estuaries, an area of high smolt predation (Handeland et al. 1996). Salmon are more susceptible to these negative impacts if further stress events occur during the recovery period (3+ days) following acidic events (Magee et al. 2003). The most sensitive life stages to acidity are alevins (from hatch to swim up) which are present in the study area from March through June, and smolts (especially as they out-migrate), which are present from April through June. This time range also coincides with snow melt, when streams become episodically acidic, increasing the severity of detrimental impacts to salmon. By decreasing exposure to acidity, smolt survival may increase during their seaward migration. As clam shells are added to the target area, monitoring efforts will continue for at least five years to determine the efficacy of using this approach to mitigate acidity.

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Appendix I – Stream Characteristics

Table 1. Study site locations and watershed characteristics. Watershed area and percent wetlands calculated from MEGIS 2017a,b.

Stream Name	Site Code	Town	Latitude	Longitude	Watershed Area (km^2)	Percent Wetlands (%)	Percent Wetlands excluding ponds (%)	Mean # of fish species present (MDMR data)
Barney Brook	NMCEMBDUB02	Wesley	44.98689397	-67.63584802	3.63	5.8	5.8	unknown
Beaverdam Stream	NMCEMBD20	Wesley	44.98169	-67.64014	27.78	18.3	13.8	6
Creamer Brook	NMCEMRLNSCB09	T19 ED BPP	44.97112996	-67.50932403	13.73	7.5	7.2	5
Richardson Brook	NMCEMRLNSRD05-A	T19 ED BPP	44.92615904	-67.49053298	13.47	13.4	8.4	6
	NMCEMRLNSRD05-B	T19 ED BPP	44.92616097	-67.49302299				

Table 2. Study site physical characteristics. Mean stream depth was measured every three weeks while sondes were deployed.

Stream Name		Bankfull stream width (m)	Mean stream depth (cm)	Substrate (%)				
				Bedrock	Boulder	Cobble	Gravel	Sand/Silt
Barney Brook		2.3	29	-	5	35	45	15
Beaverdam Stream		6.6	28	-	10	75	10	5
Creamer Brook		6.2	35	-	55	25	18	2
Richardson Brook	A	6.5	44	-	15	65	15	5
	B	5.5	32	-	5	75	15	5

Appendix II – Summary Data Tables

Continuous Data Summary. Summary statistics (mean, standard deviation (SD), minimum and maximum) of measurements from YSI 600 XLM sondes and Onset Hobo U26 dissolved oxygen loggers, May to Nov. 2017 and 2018 (n ~ 14,000)*. Temperature data include Onset Hobo pendant temperature logger data from Nov. 2017 to May 2017 (n ~ 30,000). Dissolved oxygen data for Beaverdam Stream (n = 17) and all 2017 sites except Richardson Brook are discrete measurements from a Eureka Manta2 Sub2 sonde (n = 9).

Stream Name	pH				Temperature (°C)				Specific Conductance (µS/cm)				Dissolved Oxygen (mg/L)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Barney Brook	6.25	0.40	4.97	6.88	11.29	6.10	-0.12	23.06	37.53	15.77	10.7	206	9.31	2.13	0.06	14.11
Beaverdam Stream	6.01	0.50	4.68	6.78	14.92	7.10	-0.16	28.46	51.44	17.55	22.3	121.2	13.77	1.05	12.7	14.96
Creamer Brook	5.69	0.46	4.44	6.37	12.12	6.40	-2.09	24.9	31.56	10.87	13.6	105.1	9.84	1.44	6.83	13.92
Richardson Brook - A	5.69	0.48	4.54	6.36	13.38	6.92	-0.36	27.62	23.44	5.78	13	49.5	9.03	1.56	3.36	13.8
Richardson Brook - B	5.50	0.55	4.19	6.32	13.92	7.06	-0.18	27.8	26.0	4.69	16.6	47.2	8.92	1.98	2.66	14.12

*Barney Brook and Richardson Brook -A were deployed in April 2018. Beaverdam Stream was only sampled in 2018 (n ~ 10,000).

Discrete Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected June 20, Aug. 1, and Oct. 11, 2017 and April 18, July 23, and Nov. 5, 2018 (n = 6)*.

Stream Name	Calcium (mg/L)				Dissolved Organic Carbon (mg/L)				ANC (µeq/L)				pH (closed-cell)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Barney Brook	3.72	1.79	1.16	5.98	13.1	5.3	7.4	19	220.7	149.9	46.6	435.9	6.51	4.47	5.82	6.96
Beaverdam Stream	2.74	0.65	2.28	3.2	15	2.8	13	17	68.9	63.0	30.2	141.7	5.89	0.66	5.28	6.59
Creamer Brook	2.17	0.89	1.42	3.66	11.8	4.6	8.3	17	61.9	33.0	14.8	94.9	5.83	0.52	4.96	6.26
Richardson Brook - A	1.47	0.38	0.80	1.86	12.5	4.2	6.9	17	55.4	34.4	13.3	104	5.78	0.51	4.92	6.25
Richardson Brook - B	1.69	0.62	0.81	2.85	12.0	3.5	7.2	17	65.6	49.1	13.9	147	5.83	0.55	4.94	6.34

* Creamer Brook was not sampled in April 2018 (n = 5). Beaverdam Stream was only sampled in 2018 (n = 3).

Aluminum Species Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected June 20, Aug. 1, and Oct. 11, 2017 and April 18, July 23, and Nov. 5, 2018 (n = 6)*.

Stream Name	Total Aluminum (µg/L)				Dissolved Aluminum (µg/L)				Exchangeable Aluminum (µg/L)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Barney Brook	196.7	125.9	40.0	423	168.3	114.0	32.1	377	24.4	17.4	6.3	53.6
Beaverdam Stream	169.7	63.6	119	241	154.7	56.7	112	219	11.23	9.0	1	18.1
Creamer Brook	232.9	131.8	94	424	218.8	123.1	92	399	33.9	18.9	12	53
Richardson Brook - A	202.0	64.9	131	300	191.5	60.1	129	279	18.3	12.3	3	40
Richardson Brook - B	192.7	67.3	129	293	181.6	63.4	122	278	19.9	10.2	2	28.6

* Creamer Brook was not sampled in April 2018 (n = 5). Beaverdam Stream was only sampled in 2018 (n = 3).

Nutrient Data Summary. Grab samples were collected July 23, 2018 (n = 1).

Stream Name	Nitrate + Nitrite as Nitrogen (N+N; mg/L)	Total Kjeldahl Nitrogen (TKN; mg/L)	Total Phosphorus (µg/L)
Barney Brook	0.034	0.87	18
Beaverdam Stream	0.11	0.66	25
Creamer Brook	0.047	0.56	19
Richardson Brook - A	0.073	0.81	22
Richardson Brook - B	0.052	0.84	22

Macroinvertebrate Summary. Samples were collected in August 2017 and 2018 using rock bags following the DEP protocol (2014) and analyzed by a certified taxonomist to the lowest possible level (species). Metrics are presented as the mean of both baseline years, except for Beaverdam Stream which was only sampled in 2018. EPT taxa include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera).

Stream Name	Total Mean Abundance	Generic Richness	EPT Generic Richness	Relative Ephemeroptera Abundance	Dominant Taxa
Beaverdam Stream	163.67	39	14	14%	*Polypedilum* *Rheotanytarsus*
Creamer Brook	227 ± 28	39 ± 2	18 ± 3	53 ± 35%	*Lepidostoma* Leptophlebiidae (*Paraleptophlebia*)
Richardson Brook - A	105 ± 1	34 ± 4	16 ± 4	46 ± 5%	*Lepidostoma* *Paraleptophlebia*
Richardson Brook - B	73 ± 23	37 ± 8	17 ± 6	31 ± 1%	*Lepidostoma* Leptophlebiidae (*Paraleptophlebia*) *Promoresia*

Exceedance Summary. Percentage of data observations that exceeded stress threshold values.

Stream Name	Continuous Data					Grab Sample Data		
	pH (n ~ 14,000)		Temperature (n ~ 30,000)	Dissolved Oxygen (n ~ 10,000)		Calcium (n = 6)*		Exchangeable Aluminum (n = 6)*
Thresholds	*<5.4*	*<6.0*	*>20.0 °C*	*<5 mg/L*	*<7 mg/L*	*<2.0 mg/L*	*<4.0 mg/L*	*>15 µg/L*
Barney Brook	4.0	23.3	2.1	4.5	10.0	16.7	50	50
Beaverdam Stream[a]	15.8	34.3	28.4	0	0	33.3	100	33.3
Creamer Brook	24.3	76.1	8.1	0	0.2	60	100	80
Richardson Brook – A	30.5	61.2	17.6	0.4	6.9	100	100	50
Richardson Brook – B	32.5	82.4	20.3	2.0	13.0	16.7	100	83.3

* Creamer Brook was not sampled in April 2018 (n = 5). Beaverdam Stream was only sampled in 2018 (n = 3).

[a] Beaverdam Stream was only sampled in 2018 (n ~ 10,000).

Appendix III – Biomonitoring Key Reports

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-1149
Waterbody: Beaverdam Stream - Station 1149
Town: Wesley
Directions: 25M UPSTREAM FROM ROAD CROSSING.

River Basin: Maine Coastal
HUC8 Name: Maine Coastal
Latitude: 44 58 54.09 N
Longitude: 67 38 24.5 W
Stream Order: 1

Sample Information

Log Number: 2687
Subsample Factor: X1
Type of Sample: ROCK BAG
Replicates: 3
Date Deployed: 7/25/2018
Date Retrieved: 8/21/2018

Classification Attainment

Statutory Class: AA
Model Result with P≥0.6: B
Date Last Calculated: 1/31/2019
Final Determination: B
Reason for Determination: Model
Comments:
Date: 2/1/2019

Model Probabilities

First Stage Model

Class A	0.23	Class C	0.23
Class B	0.54	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	0.68
Class C or Non-Attainment	0.32

A Model

Class A	0.30
Class B or C or Non-Attainment	0.70

Model Variables

01 Total Mean Abundance	163.67
02 Generic Richness	39.00
03 Plecoptera Mean Abundance	1.00
04 Ephemeroptera Mean Abundance	23.00
05 Shannon-Wiener Generic Diversity	3.22
06 Hilsenhoff Biotic Index	5.13
07 Relative Abundance - Chironomidae	0.71
08 Relative Generic Richness Diptera	0.54
09 *Hydropsyche* Abundance	0.00
11 *Cheumatopsyche* Abundance	0.33
12 EPT Generic Richness/ Diptera Generic Richness	0.67
13 Relative Abundance - Oligochaeta	0.00
15 Perlidae Mean Abundance (Family Functional Group)	0.67
16 Tanypodinae Mean Abundance (Family Functional Group)	2.01
17 Chironomini Abundance (Family Functional Group)	83.48
18 Relative Abundance Ephemeroptera	0.14
19 EPT Generic Richness	14.00
21 Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	2.35
23 Relative Generic Richness- Plecoptera	0.05
25 Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	5.36
26 Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	4.17
28 EP Generic Richness/14	0.57
30 Presence of Class A Indicator Taxa/7	0.29

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Polypedilum*	48.34
2	*Rheotanytarsus*	11.47
3	*Paraleptophlebia*	3.67
4	*Lepidostoma*	3.67
5	*Leucrocuta*	3.56

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-1149 Town: Wesley Date Deployed: 7/25/2018

Log Number: 2687 Waterbody: Beaverdam Stream - Station 1149 Date Retrieved: 8/21/2018

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL WINNELL

Waterbody Information - Deployment		Waterbody Information - Retrieval	
Temperature:	24.9 deg C	Temperature:	20.2 deg C
Dissolved Oxygen:	8.45 mg/l	Dissolved Oxygen:	9.71 mg/l
Dissolved Oxygen Saturation:	100.3 %	Dissolved Oxygen Saturation:	105.6 %
Specific Conductance:	55.6 uS/cm	Specific Conductance:	51.8 uS/cm
Velocity:	18.3 cm/s	Velocity:	12.2 cm/s
pH:	6.52	pH:	6.51
Wetted Width:	4.9 m	Wetted Width:	5 m
Bankfull Width:	7.4 m	Bankfull Width:	7.4 m
Depth:	22 cm	Depth:	22 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Swamp Conifer	Partly Open	Rolling
Upland Conifer		
Upland Hardwood		

Potential Stressor	Location	Substrate	
	Above Road Crossing	Boulder	40 %
		Gravel	5 %
		Rubble/Cobble	50 %
		Sand	5 %

Landcover Summary - 2004 Data

Sample Comments

Station Number: S-1149 Waterbody: Beaverdam Stream - Station 1149 Town: Wesley

Log Number: 2687 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Placobdella	08030101006		0.33		--		0.2
Placobdella papillifera	08030101006003	0.33			--	0.2	
Leuctra	09020204020	0.33	0.33	0	SH	0.2	0.2
Acroneuria	09020209042		0.67	0	PR		0.4
Acroneuria lycorias	09020209042125	0.67			--	0.4	
Boyeria	09020301004		1.33	2	PR		0.8
Boyeria vinosa	09020301004012	1.33			--	0.8	
Acerpenna	09020401007		0.67	5	CG		0.4
Acerpenna macdunnoughi	09020401007001	0.67			--	0.4	
Heptageniidae	09020402	1.33			--	0.8	
Leucrocuta	09020402011	5.00	5.83	1	SC	3.1	3.6
Maccaffertium	09020402015	1.00	3.50	4	SC	0.6	2.1
Maccaffertium luteum	09020402015049	2.00			--	1.2	
Leptophlebiidae	09020406	5.33	5.33		--	3.3	3.3
Paraleptophlebia	09020406026	6.00	6.00	1	CG	3.7	3.7
Eurylophella	09020410036	1.67	1.67	3	CG	1.0	1.0
Chimarra	09020601003		0.33	2	CF		0.2
Chimarra aterrima	09020601003002	0.33			--	0.2	
Plectrocnemia	09020603012	2.67	2.67	6	PR	1.6	1.6
Cheumatopsyche	09020604015	0.33	0.33	5	CF	0.2	0.2
Pycnopsyche	09020610049	0.33	0.33	4	SH	0.2	0.2
Lepidostoma	09020611064	6.00	6.00	1	SH	3.7	3.7
Oecetis	09020618078		3.67	8	PR		2.2
Oecetis persimilis	09020618078157	3.67			--	2.2	
Nigronia	09020701003		2.33	0	PR		1.4
Nigronia serricornis	09020701003003	2.33			--	1.4	
Chironomidae	09021011	0.67			--	0.4	
Ablabesmyia	09021011001		0.34	8	PR		0.2
Ablabesmyia mallochi	09021011001004	0.33			--	0.2	
Conchapelopia	09021011004	0.67	0.67	6	PR	0.4	0.4
Larsia	09021011009	0.33	0.34	6	PR	0.2	0.2
Paramerina	09021011013		0.34		--		0.2
Paramerina anomala	09021011013001	0.33			--	0.2	
Trissopelopia	09021011021		0.34		PR		0.2
Trissopelopia ogemawi	09021011021042	0.33			--	0.2	
Pagastia	09021011025		0.34	1	--		0.2
Pagastia orthogonia	09021011025001	0.33			--	0.2	

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-1149 Waterbody: Beaverdam Stream - Station 1149 Town: Wesley

Log Number: 2687 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Cricotopus	09021011037		0.34	7	SH		0.2
Cricotopus bicinctus	09021011037057	0.33			--	0.2	
Parametriocnemus	09021011053	1.00	1.01	5	CG	0.6	0.6
Rheocricotopus	09021011057	0.67	0.67	6	CG	0.4	0.4
Thienemanniella	09021011062	0.33	0.34	6	CG	0.2	0.2
Tvetenia	09021011065		1.34	5	CG		0.8
Tvetenia paucunca	09021011065114	1.33			--	0.8	
Micropsectra	09021011070	2.33	2.35	7	CG	1.4	1.4
Rheotanytarsus	09021011072		18.77	6	CF		11.5
Rheotanytarsus pellucidus	09021011072128	18.67			CF	11.4	
Stempellinella	09021011074		1.01	2	--		0.6
Stempellinella leptocelloides	09021011074001	0.67			--	0.4	
Stempellinella fimbriata	09021011074002	0.33			--	0.2	
Tanytarsus	09021011076	4.33	4.36	6	CF	2.6	2.7
Microtendipes	09021011094		2.68	6	CF		1.6
Microtendipes rydalensis group	09021011094168	2.67			--	1.6	
Nilothauma	09021011095	0.67	0.67	2	--	0.4	0.4
Phaenopsectra	09021011101		1.01	7	SC		0.6
Phaenopsectra obediens	09021011101182	1.00			SC	0.6	
Polypedilum	09021011102		79.12	6	SH		48.3
Polypedilum aviceps	09021011102181	77.00			--	47.0	
Polypedilum flavum	09021011102182	1.33			--	0.8	
Polypedilum albicorne	09021011102195	0.33			--	0.2	
Simulium	09021012047		0.33	4	CF		0.2
Simulium tuberosum	09021012047067	0.33			--	0.2	
Roederiodes	09021016058	1.33	1.33	3	PR	0.8	0.8
Promoresia	09021113069		4.67		--		2.9
Promoresia elegans	09021113069051	0.33			--	0.2	
Promoresia tardella	09021113069052	4.33			--	2.6	

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-1116
Waterbody: Richardson Brook - Station 1116
Town: T19 Ed Bpp
Directions: PARK AT WIDE SPOT IN ROAD JUST SOUTH OF THE BRIDGE TO WALK DOWNSTREAM TO THE LOWER SITE.

River Basin: Maine Coastal
HUC8 Name: Maine Coastal
Latitude: 44 55 34.18 N
Longitude: 67 29 34.88 W
Stream Order: 2

Sample Information

Log Number: 2688
Subsample Factor: X1
Type of Sample: ROCK BAG
Replicates: 3
Date Deployed: 7/25/2018
Date Retrieved: 8/21/2018

Classification Attainment

Statutory Class: A
Model Result with P≥0.6: A
Date Last Calculated: 1/31/2019
Final Determination: A
Reason for Determination: Model
Comments:
Date: 2/1/2019

Model Probabilities

First Stage Model

Class A	0.85	Class C	0.00
Class B	0.14	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	1.00
Class C or Non-Attainment	0.00

A Model

Class A	1.00
Class B or C or Non-Attainment	0.00

Model Variables

01	Total Mean Abundance	88.67
02	Generic Richness	43.00
03	Plecoptera Mean Abundance	3.33
04	Ephemeroptera Mean Abundance	27.00
05	Shannon-Wiener Generic Diversity	4.56
06	Hilsenhoff Biotic Index	4.05
07	Relative Abundance - Chironomidae	0.29
08	Relative Generic Richness Diptera	0.35
09	*Hydropsyche* Abundance	0.67
11	*Cheumatopsyche* Abundance	0.00
12	EPT Generic Richness/ Diptera Generic Richness	1.40
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	3.00
16	Tanypodinae Mean Abundance (Family Functional Group)	2.43
17	Chironomini Abundance (Family Functional Group)	1.73
18	Relative Abundance Ephemeroptera	0.30
19	EPT Generic Richness	21.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	2.77
23	Relative Generic Richness- Plecoptera	0.07
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	4.85
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	9.28
28	EP Generic Richness/14	0.79
30	Presence of Class A Indicator Taxa/7	0.57

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Promoresia*	11.93
2	Leptophlebiidae	11.28
3	*Orthocladius*	9.38
4	*Maccaffertium*	7.46
5	*Boyeria*	5.26

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-1116 Town: T19 Ed Bpp Date Deployed: 7/25/2018
Log Number: 2688 Waterbody: Richardson Brook - Station 1116 Date Retrieved: 8/21/2018

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT Taxonomist: MICHAEL WINNELL

Waterbody Information - Deployment		Waterbody Information - Retrieval	
Temperature:	23.8 deg C	Temperature:	18.5 deg C
Dissolved Oxygen:	9.84 mg/l	Dissolved Oxygen:	10.61 mg/l
Dissolved Oxygen Saturation:	114.2 %	Dissolved Oxygen Saturation:	111 %
Specific Conductance:	23.1 uS/cm	Specific Conductance:	23.1 uS/cm
Velocity:		Velocity:	3.1 cm/s
pH:	6.2	pH:	6.19
Wetted Width:	3.6 m	Wetted Width:	4 m
Bankfull Width:	6.6 m	Bankfull Width:	6.6 m
Depth:	22 cm	Depth:	24 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Upland Conifer	Partly Open	Rolling
Upland Hardwood		

Potential Stressor	Location	Substrate	
	Below Road Crossing	Boulder	30 %
		Gravel	5 %
		Rubble/Cobble	60 %
		Sand	5 %

Landcover Summary - 2004 Data

Sample Comments

7/25/18: Flow visible.

Station Number: S-1116 Waterbody: Richardson Brook - Station 1116 Town: T19 Ed Bpp

Log Number: 2688 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Paracapnia	09020203018	0.33	0.33	1	SH	0.4	0.4
Perlidae	09020209	0.33	0.33		--	0.4	0.4
Acroneuria	09020209042	0.67	2.67	0	PR	0.8	3.0
Acroneuria internata	09020209042124	0.33			--	0.4	
Acroneuria lycorias	09020209042125	1.67			--	1.9	
Boyeria	09020301004		4.67	2	PR		5.3
Boyeria vinosa	09020301004012	4.67			--	5.3	
Calopteryx	09020307043		0.67	5	PR		0.8
Calopteryx maculata	09020307043088	0.67			--	0.8	
Acerpenna	09020401007		1.33	5	CG		1.5
Acerpenna macdunnoughi	09020401007001	1.00			--	1.1	
Acerpenna pygmaea	09020401007011	0.33			--	0.4	
Heptageniidae	09020402	2.00			--	2.3	
Leucrocuta	09020402011	2.67	3.31	1	SC	3.0	3.7
Stenacron	09020402014	0.33	0.41	7	SC	0.4	0.5
Maccaffertium	09020402015	2.00	6.61	4	SC	2.3	7.5
Maccaffertium luteum	09020402015049	3.33			--	3.8	
Leptophlebiidae	09020406	10.00	10.00		--	11.3	11.3
Paraleptophlebia	09020406026	1.67	1.67	1	CG	1.9	1.9
Ephemerellidae	09020410	0.33	0.33		--	0.4	0.4
Eurylophella	09020410036	3.33	3.33	3	CG	3.8	3.8
Cernotina	09020603006	1.00	1.00		PR	1.1	1.1
Hydropsychidae	09020604	0.33	0.33		--	0.4	0.4
Hydropsyche	09020604016	0.67	0.67	4	CF	0.8	0.8
Oxyethira	09020607028	0.33	0.33	3	P	0.4	0.4
Brachycentrus	09020609043		0.33	0	CF		0.4
Brachycentrus appalachia	09020609043096	0.33			--	0.4	
Limnephilidae	09020610				--		
Pycnopsyche	09020610049	0.33	0.33	4	SH	0.4	0.4
Lepidostoma	09020611064	3.67	3.67	1	SH	4.1	4.1
Psilotreta	09020614068		3.00	0	SC		3.4
Psilotreta indecisa	09020614068132	3.00			--	3.4	
Mystacides	09020618075		0.33	4	CG		0.4
Mystacides sepulchralis	09020618075147	0.33			--	0.4	
Oecetis	09020618078		0.67	8	PR		0.8
Oecetis persimilis	09020618078157	0.67			--	0.8	
Chironomidae	09021011	1.00			--	1.1	

Station Number: S-1116 Waterbody: Richardson Brook - Station 1116 Town: T19 Ed Bpp

Log Number: 2688 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Labrundinia	09021011008		0.35	7	PR		0.4
Labrundinia pilosella	09021011008022	0.33			--	0.4	
Meropelopia	09021011010	1.00	1.04		--	1.1	1.2
Paramerina	09021011013		0.35		--		0.4
Paramerina anomala	09021011013001	0.33			--	0.4	
Trissopelopia	09021011021		0.69		PR		0.8
Trissopelopia ogemawi	09021011021042	0.67			--	0.8	
Cricotopus	09021011037		4.51	7	SH		5.1
Cricotopus bicinctus	09021011037057	4.33			--	4.9	
Orthocladius	09021011050		8.32	6	CG		9.4
Orthocladius annectens	09021011050092	8.00			--	9.0	
Psectrocladius	09021011056	0.33	0.35	8	CG	0.4	0.4
Synorthocladius	09021011061	0.33	0.35	2	CG	0.4	0.4
Thienemanniella	09021011062	0.33	0.35	6	CG	0.4	0.4
Cladotanytarsus	09021011068	0.33	0.35	7	CG	0.4	0.4
Micropsectra	09021011070	2.67	2.77	7	CG	3.0	3.1
Rheotanytarsus	09021011072		4.51	6	CF		5.1
Rheotanytarsus exiguus group	09021011072127	1.33			CF	1.5	
Rheotanytarsus pellucidus	09021011072128	3.00			CF	3.4	
Tanytarsus	09021011076	0.33	0.35	6	CF	0.4	0.4
Microtendipes	09021011094		1.04	6	CF		1.2
Microtendipes rydalensis group	09021011094168	1.00			--	1.1	
Polypedilum	09021011102		0.69	6	SH		0.8
Polypedilum aviceps	09021011102181	0.67			--	0.8	
Hydrobius	09021105047	0.33	0.33		--	0.4	0.4
Elmidae	09021113	0.33			--	0.4	
Dubiraphia	09021113064		2.05	6	--		2.3
Dubiraphia minima	09021113064036	2.00			--	2.3	
Promoresia	09021113069		10.57		--		11.9
Promoresia elegans	09021113069051	0.67			--	0.8	
Promoresia tardella	09021113069052	9.67			--	10.9	
Stenelmis	09021113070		2.05	5	SC		2.3
Stenelmis crenata	09021113070055	2.00			--	2.3	
Amnicola	10010104013	1.33	1.33		SC	1.5	1.5

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-1117
Waterbody: Richardson Brook - Station 1117
Town: T19 Ed Bpp
Directions: DRIVE 250 FEET FURTHER SOUTH ON 19 RD THAN S-1116. PARK IN SMALL PULL OFF ON LEFT. WALK UPSTREAM THROUGH WOODS.

River Basin: Maine Coastal
HUC8 Name: Maine Coastal
Latitude: 44 55 34.17 N
Longitude: 67 29 25.92 W
Stream Order: 2

Sample Information

Log Number: 2689
Subsample Factor: X1
Type of Sample: ROCK BAG
Replicates: 3
Date Deployed: 7/25/2018
Date Retrieved: 8/21/2018

Classification Attainment

Statutory Class: A
Model Result with P≥0.6: A
Date Last Calculated: 1/31/2019
Final Determination: A
Reason for Determination: Model
Comments:
Date: 2/1/2019

Model Probabilities

First Stage Model

Class A	0.91	Class C	0.00
Class B	0.09	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	1.00
Class C or Non-Attainment	0.00

A Model

Class A	1.00
Class B or C or Non-Attainment	0.00

Model Variables

01 Total Mean Abundance	104.33
02 Generic Richness	31.00
03 Plecoptera Mean Abundance	1.67
04 Ephemeroptera Mean Abundance	44.00
05 Shannon-Wiener Generic Diversity	3.85
06 Hilsenhoff Biotic Index	2.88
07 Relative Abundance - Chironomidae	0.07
08 Relative Generic Richness Diptera	0.32
09 *Hydropsyche* Abundance	0.00
11 *Cheumatopsyche* Abundance	0.00
12 EPT Generic Richness/ Diptera Generic Richness	1.30
13 Relative Abundance - Oligochaeta	0.00
15 Perlidae Mean Abundance (Family Functional Group)	1.67
16 Tanypodinae Mean Abundance (Family Functional Group)	0.67
17 Chironomini Abundance (Family Functional Group)	0.67
18 Relative Abundance Ephemeroptera	0.42
19 EPT Generic Richness	13.00
21 Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.33
23 Relative Generic Richness- Plecoptera	0.03
25 Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	1.67
26 Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	9.51
28 EP Generic Richness/14	0.57
30 Presence of Class A Indicator Taxa/7	0.29

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Lepidostoma*	25.24
2	*Paraleptophlebia*	14.38
3	Leptophlebiidae	8.63
4	*Maccaffertium*	7.52
5	*Leucrocuta*	6.54

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-1117	Town: T19 Ed Bpp		Date Deployed: 7/25/2018
Log Number: 2689	Waterbody: Richardson Brook - Station 1117		Date Retrieved: 8/21/2018

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL WINNELL

Waterbody Information - Deployment		**Waterbody Information - Retrieval**	
Temperature:	22.6 deg C	Temperature:	18.7 deg C
Dissolved Oxygen:	8.83 mg/l	Dissolved Oxygen:	10.22 mg/l
Dissolved Oxygen Saturation:	100.2 %	Dissolved Oxygen Saturation:	107.4 %
Specific Conductance:	22.6 uS/cm	Specific Conductance:	22.5 uS/cm
Velocity:		Velocity:	12.2 cm/s
pH:	6.08	pH:	6.09
Wetted Width:	1.7 m	Wetted Width:	1.5 m
Bankfull Width:	6 m	Bankfull Width:	6 m
Depth:	24 cm	Depth:	26 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain	
Upland Conifer	Partly Open	Rolling	
Upland Hardwood			

Potential Stressor	Location	Substrate	
	Above Road Crossing	Boulder	60 %
		Rubble/Cobble	40 %

Landcover Summary - 2004 Data

Sample Comments

7/25/18: Flow visible.

Station Number: S-1117 Waterbody: Richardson Brook - Station 1117 Town: T19 Ed Bpp

Log Number: 2689 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Acroneuria	09020209042	1.67	1.67	0	PR	1.6	1.6
Boyeria	09020301004		1.33	2	PR		1.3
Boyeria vinosa	09020301004012	1.33			--	1.3	
Calopteryx	09020307043	0.33	0.33	5	PR	0.3	0.3
Acerpenna	09020401007	0.33	2.00	5	CG	0.3	1.9
Acerpenna pygmaea	09020401007011	1.67			--	1.6	
Plauditus	09020401012	0.33	0.33		CG	0.3	0.3
Heptageniidae	09020402	0.33			--	0.3	
Leucrocuta	09020402011	6.67	6.82	1	SC	6.4	6.5
Maccaffertium	09020402015	2.33	7.84	4	SC	2.2	7.5
Maccaffertium luteum	09020402015049	5.33			--	5.1	
Leptophlebiidae	09020406	9.00	9.00		--	8.6	8.6
Paraleptophlebia	09020406026	15.00	15.00	1	CG	14.4	14.4
Eurylophella	09020410036	3.00	3.00	3	CG	2.9	2.9
Polycentropodidae	09020603	1.00			--	1.0	
Cernotina	09020603006	2.67	3.24		PR	2.6	3.1
Plectrocnemia	09020603012	2.00	2.43	6	PR	1.9	2.3
Hydroptila	09020607026	3.00	3.00	6	P	2.9	2.9
Lepidostoma	09020611064	26.33	26.33	1	SH	25.2	25.2
Oecetis	09020618078	1.00	6.33	8	PR	1.0	6.1
Oecetis inconspicua complex	09020618078156	1.33			--	1.3	
Oecetis persimilis	09020618078157	4.00			--	3.8	
Hexatoma	09021001008	0.33	0.33	2	PR	0.3	0.3
Meropelopia	09021011010	0.33	0.33		--	0.3	0.3
Trissopelopia	09021011021		0.33		PR		0.3
Trissopelopia ogemawi	09021011021042	0.33			--	0.3	
Cricotopus	09021011037		1.67	7	SH		1.6
Cricotopus bicinctus	09021011037057	1.67			--	1.6	
Orthocladius	09021011050		0.33	6	CG		0.3
Orthocladius annectens	09021011050092	0.33			--	0.3	
Tvetenia	09021011065		0.67	5	CG		0.6
Tvetenia vitracies	09021011065113	0.33			--	0.3	
Tvetenia paucunca	09021011065114	0.33			--	0.3	
Micropsectra	09021011070	0.33	0.33	7	CG	0.3	0.3
Paratanytarsus	09021011071	0.33	0.67	6	--	0.3	0.6
Paratanytarsus longistylus	09021011071126	0.33		6	--	0.3	
Rheotanytarsus	09021011072		2.33	6	CF		2.2

Aquatic Life Taxonomic Inventory Report

Station Number: S-1117 Waterbody: Richardson Brook - Station 1117 Town: T19 Ed Bpp

Log Number: 2689 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Rheotanytarsus exiguus group	09021011072127	0.67			CF	0.6	
Rheotanytarsus pellucidus	09021011072128	1.67			CF	1.6	
Polypedilum	09021011102		0.67	6	SH		0.6
Polypedilum flavum	09021011102182	0.33			--	0.3	
Polypedilum albicorne	09021011102195	0.33			--	0.3	
Psephenus	09021108058		0.33	4	SC		0.3
Psephenus herricki	09021108058028	0.33			--	0.3	
Dubiraphia	09021113064		1.67	6	--		1.6
Dubiraphia minima	09021113064036	1.67			--	1.6	
Macronychus	09021113065		0.33	4	--		0.3
Macronychus glabratus	09021113065040	0.33			--	0.3	
Promoresia	09021113069		2.33		--		2.2
Promoresia tardella	09021113069052	2.33			--	2.2	
Stenelmis	09021113070		2.33	5	SC		2.2
Stenelmis crenata	09021113070055	2.33			--	2.2	
Amnicola	10010104013	0.67	1.00		SC	0.6	1.0
Amnicola limosus	10010104013018	0.33			--	0.3	

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number:	**S-1115**	River Basin:	Maine Coastal
Waterbody:	Creamer Brook - Station 1115	HUC8 Name:	Maine Coastal
Town:	T19 Ed Bpp	Latitude:	44 58 16.07 N
Directions:	SITE IS DOWNSTREAM OF THE OLD BRIDGE LOCATION.	Longitude:	67 30 33.57 W
		Stream Order:	2

Sample Information

Log Number:	**2690**	Type of Sample:	ROCK BAG	Date Deployed:	7/25/2018
Subsample Factor:	X1	Replicates:	3	Date Retrieved:	8/21/2018

Classification Attainment

Statutory Class:	**AA**	**Final Determination:**	**A**	Date: 2/1/2019
Model Result with P≥0.6:	A	**Reason for Determination:**	**Model**	
Date Last Calculated:	1/31/2019	Comments:		

Model Probabilities

First Stage Model

Class A	0.84	Class C	0.00
Class B	0.15	NA	0.00

C or Better Model

Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model

Class A or B	1.00
Class C or Non-Attainment	0.00

A Model

Class A	1.00
Class B or C or Non-Attainment	0.00

Model Variables

01	Total Mean Abundance	246.33
02	Generic Richness	37.00
03	Plecoptera Mean Abundance	0.33
04	Ephemeroptera Mean Abundance	190.33
05	Shannon-Wiener Generic Diversity	2.64
06	Hilsenhoff Biotic Index	2.51
07	Relative Abundance - Chironomidae	0.04
08	Relative Generic Richness Diptera	0.41
09	*Hydropsyche* Abundance	1.00
11	*Cheumatopsyche* Abundance	0.67
12	EPT Generic Richness/ Diptera Generic Richness	1.07
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	0.00
16	Tanypodinae Mean Abundance (Family Functional Group)	4.00
17	Chironomini Abundance (Family Functional Group)	1.33
18	Relative Abundance Ephemeroptera	0.77
19	EPT Generic Richness	16.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.33
23	Relative Generic Richness- Plecoptera	0.03
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	2.00
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	13.99
28	EP Generic Richness/14	0.50
30	Presence of Class A Indicator Taxa/7	0.43

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	Leptophlebiidae	40.19
2	*Paraleptophlebia*	29.77
3	*Lepidostoma*	6.90
4	*Plectrocnemia*	6.73
5	*Maccaffertium*	5.68

Maine Department of Environmental Protection
Biological Monitoring Program

Aquatic Life Classification Attainment Report

Station Number: S-1115	Town: T19 Ed Bpp		Date Deployed: 7/25/2018
Log Number: 2690	Waterbody: Creamer Brook - Station 1115		Date Retrieved: 8/21/2018

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL WINNELL

Waterbody Information - Deployment		Waterbody Information - Retrieval	
Temperature:	20.3 deg C	Temperature:	15.7 deg C
Dissolved Oxygen:	9.5 mg/l	Dissolved Oxygen:	10.57 mg/l
Dissolved Oxygen Saturation:	103.4 %	Dissolved Oxygen Saturation:	105 %
Specific Conductance:	27.2 uS/cm	Specific Conductance:	27.9 uS/cm
Velocity:		Velocity:	
pH:	5.99	pH:	6.48
Wetted Width:	4.7 m	Wetted Width:	6 m
Bankfull Width:	6.5 m	Bankfull Width:	6.5 m
Depth:	28 cm	Depth:	25 cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Swamp Conifer	Partly Open	Rolling
Upland Conifer		
Upland Hardwood		

Potential Stressor	Location	Substrate	
	Minimally Disturbed	Boulder	60 %
		Gravel	10 %
		Rubble/Cobble	30 %

Landcover Summary - 2004 Data

Sample Comments

7/25 and 8/21: Flow visible.

Station Number: S-1115 Waterbody: Creamer Brook - Station 1115 Town: T19 Ed Bpp

Log Number: 2690 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Paracapnia	09020203018	0.33	0.33	1	SH	0.1	0.1
Boyeria	09020301004		0.33	2	PR		0.1
Boyeria vinosa	09020301004012	0.33			--	0.1	
Neurocordulia	09020305026	0.33	0.33	2	PR	0.1	0.1
Plauditus	09020401012	1.00	1.00		CG	0.4	0.4
Heptageniidae	09020402	0.33			--	0.1	
Leucrocuta	09020402011	0.33	0.34	1	SC	0.1	0.1
Maccaffertium	09020402015	4.33	13.99	4	SC	1.8	5.7
Maccaffertium luteum	09020402015049	9.33			--	3.8	
Leptophlebiidae	09020406	99.00	99.00		--	40.2	40.2
Paraleptophlebia	09020406026	73.33	73.33	1	CG	29.8	29.8
Eurylophella	09020410036	2.67	2.67	3	CG	1.1	1.1
Polycentropodidae	09020603	1.00			--	0.4	
Cernotina	09020603006	1.33	1.41		PR	0.5	0.6
Plectrocnemia	09020603012	15.67	16.59	6	PR	6.4	6.7
Cheumatopsyche	09020604015	0.67	0.67	5	CF	0.3	0.3
Hydropsyche	09020604016	0.33	1.00	4	CF	0.1	0.4
Hydropsyche morosa	09020604016030	0.33			--	0.1	
Hydropsyche sparna	09020604016032	0.33			--	0.1	
Rhyacophila	09020605019		0.33	2	PR		0.1
Rhyacophila minora	09020605019063	0.33			PR	0.1	
Hydroptila	09020607026	3.00	3.00	6	P	1.2	1.2
Lepidostoma	09020611064	17.00	17.00	1	SH	6.9	6.9
Psilotreta	09020614068		0.33	0	SC		0.1
Psilotreta labida	09020614068133	0.33			--	0.1	
Oecetis	09020618078	2.00	3.67	8	PR	0.8	1.5
Oecetis persimilis	09020618078157	1.67			--	0.7	
Chironomidae	09021011				--		
Labrundinia	09021011008		1.00	7	PR		0.4
Labrundinia pilosella	09021011008022	1.00			--	0.4	
Meropelopia	09021011010	1.33	1.33		--	0.5	0.5
Trissopelopia	09021011021		1.00		PR		0.4
Trissopelopia ogemawi	09021011021042	1.00			--	0.4	
Zavrelimyia	09021011022		0.67	8	PR		0.3
Zavrelimyia thryptica group	09021011022045	0.67			PR	0.3	
Cricotopus	09021011037		0.33	7	SH		0.1
Cricotopus bicinctus	09021011037057	0.33			--	0.1	

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-1115 Waterbody: Creamer Brook - Station 1115 Town: T19 Ed Bpp

Log Number: 2690 Subsample Factor: X1 Replicates: 3 Calculated: 1/31/2019

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Orthocladius	09021011050		0.33	6	CG		0.1
Orthocladius annectens	09021011050092	0.33			--	0.1	
Parametriocnemus	09021011053	0.33	0.33	5	CG	0.1	0.1
Rheocricotopus	09021011057		0.33	6	CG		0.1
Rheocricotopus robacki	09021011057105	0.33			--	0.1	
Rheotanytarsus	09021011072		0.33	6	CF		0.1
Rheotanytarsus exiguus group	09021011072127	0.33			CF	0.1	
Stempellinella	09021011074		0.67	2	--		0.3
Stempellinella leptocelloides	09021011074001	0.67			--	0.3	
Tanytarsus	09021011076	0.67	1.00	6	CF	0.3	0.4
Tanytarsus buckleyi	09021011076139	0.33			CF	0.1	
Dicrotendipes	09021011085	0.33	0.33	8	CG	0.1	0.1
Microtendipes	09021011094		0.67	6	CF		0.3
Microtendipes rydalensis group	09021011094168	0.67			--	0.3	
Polypedilum	09021011102		0.33	6	SH		0.1
Polypedilum aviceps	09021011102181	0.33			--	0.1	
Atherix	09021015055	0.33	0.33	2	PR	0.1	0.1
Dubiraphia	09021113064		0.33	6	--		0.1
Dubiraphia minima	09021113064036	0.33			--	0.1	
Promoresia	09021113069		0.67		--		0.3
Promoresia tardella	09021113069052	0.67			--	0.3	
Stenelmis	09021113070		0.67	5	SC		0.3
Stenelmis crenata	09021113070055	0.67			--	0.3	
Amnicola	10010104013		0.33		SC		0.1
Amnicola limosus	10010104013018	0.33			--	0.1	