Coles Creek Watershed Flow and Fisheries Monitoring

Year 1 Report

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March 2017

Background and Objectives

The city of Charlottetown has developed a municipal water wellfield in the Coles Creek watershed (a sub-watershed of the North River) that is scheduled to begin pumping in the latter half of 2017. The Canadian Rivers Institute at the University of Prince Edward Island was contracted by the Province of PEI to begin monitoring Coles Creek in 2016 in order to 1) establish baseline flow data for Coles Creek, and 2) to quantify the fish community and productivity of Coles Creek.

Coles Creek Description and Flow Monitoring

Coles Creek is a relatively small 13 km^2 watershed that is considered part of the North Rivers watershed, though technically it is a distinct watershed in its own right as it drains directly into the North River estuary. Coles Creek land use is heavily dominated by agricultural activity (67% of land area) with 14% forests, and less than 2% wetland, mostly in the form of ponds (Figure 1A). As a small coastal watershed, Coles Creek has a maximum elevation of about 70 m (Figure 1B). Coles Creek has no substantive permanent tributaries, most of the flow into the stream is derived from groundwater input that emerge either in, or in very close proximity to the stream (<50 m). This simplifies biological monitoring as most tributaries are ephemeral and fish habitat outside of the mainstem of the stream is negligible.

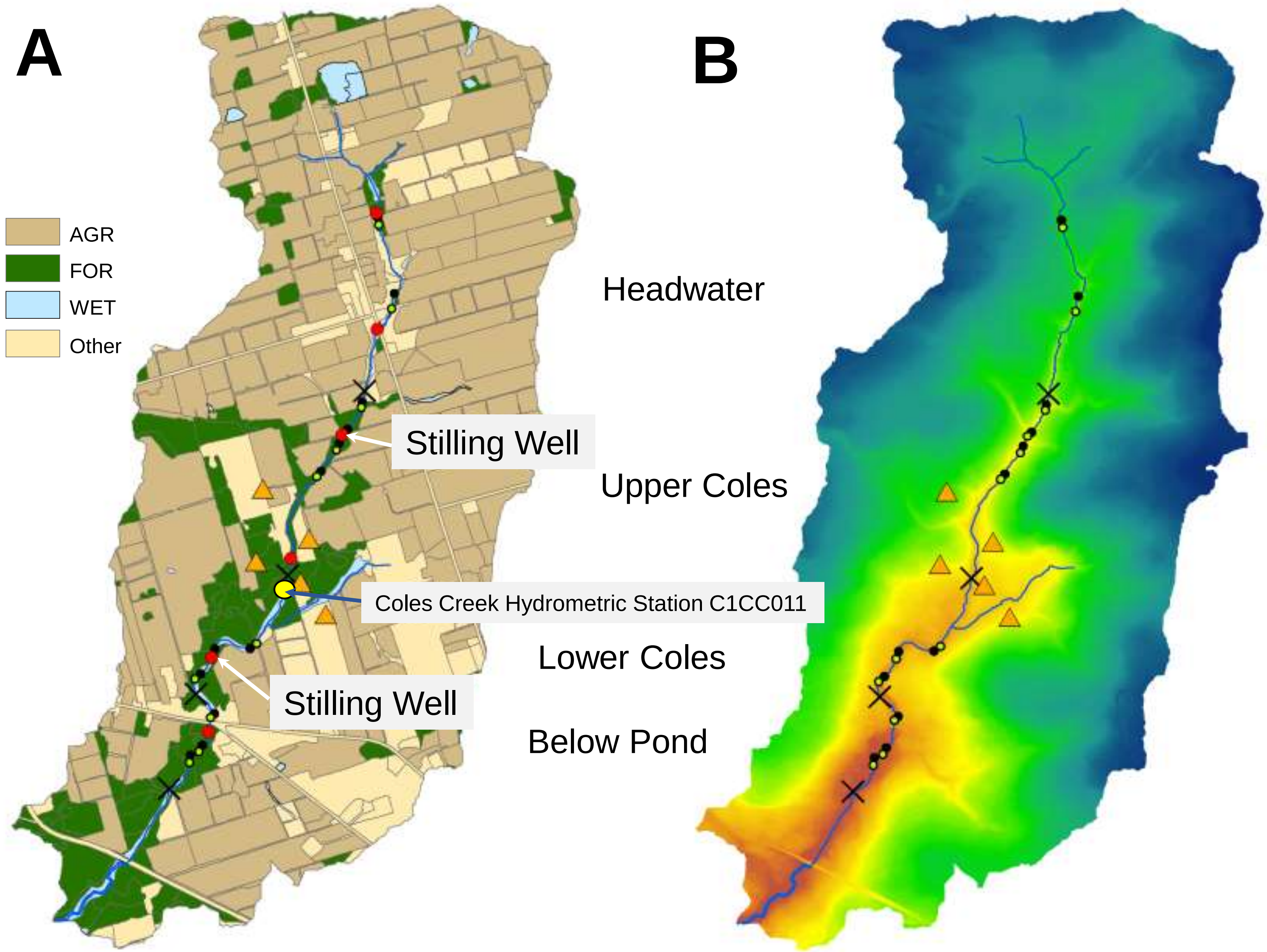

Figure 1. Coles Creek watershed showing A) land use and B) Digital elevation (0-69m). Orange triangles show city of Charlottetown well locations. River segment/reach boundaries shown by an X. Red dots are manual flow monitoring with continual level monitoring indicated by labels. Green and black dots show start and stop boundaries of electrofishing reaches.

In order to monitor flow pre and post wellfield operation, two stilling wells, or permanent stream level loggers were installed in June 2016, above and below the wellfield (Figure 1B). An additional station was also established in an adjacent branch of the North River Watershed. Several additional manual flow stations were examined in September and October 2016 in order to determine the reaches that were the major sources of streamflow in the system. Ongoing manual flow measurement were conducted at the stilling well locations only for flow calibration and these can be found in Appendix I. Approximately 50-60% of the stream flow (in early fall low flow) originates upstream of the wellfield area. While groundwater inputs have not yet been fully characterized at least three major springs were observed in the Upper Coles reach. Fewer springs were observed in the Lower Coles reach that largely consists of and old pond bed. However, below Route 2, two additional major groundwater inputs were observed as is reflected by increasing flow in this region (Figure 2).

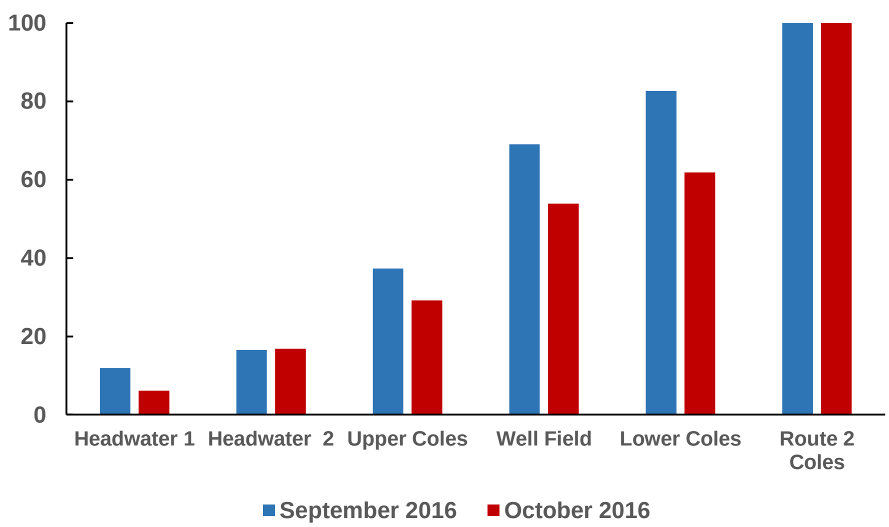

Figure 2. September and October 2016 manually measured flows from upstream to downstream measured at flow stations indicated on Figure 1 and expressed as percentage of total flow measured below Highway 2 near the head of tide.

Stream stage was measured in stilling wells at three locations, Upper and Lower Coles Creek (Figure 1), and in a concrete channel in the Springvale Branch of the North River, near old Route 2. An example for the streamflow is shown for these streams for the period covered by this report (Figure 3). As these data are pre-pumping, they will constitute the flow baseline for the Coles monitoring. In the absence of many years of historical baseline data required to evaluate trends in flow, an approach of examining changes in the relationship between Lower Coles Creek and Upper Coles Creek, and/or the Springvale Branch of the North River has been proposed. As proof of concept, the relatively tight relationship between Upper and Lower Coles Creek flow is illustrated in Figure 4.

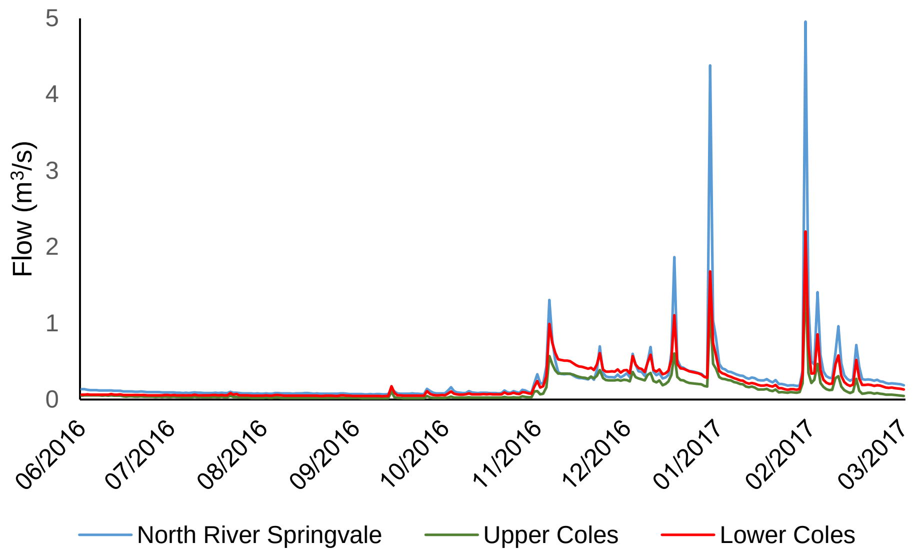

Figure 3. Daily mean measured flow at stilling wells in the Upper and Lower areas of Coles Creek and the Springvale Branch of the North River between June 28, 2016 and March 31, 2017.

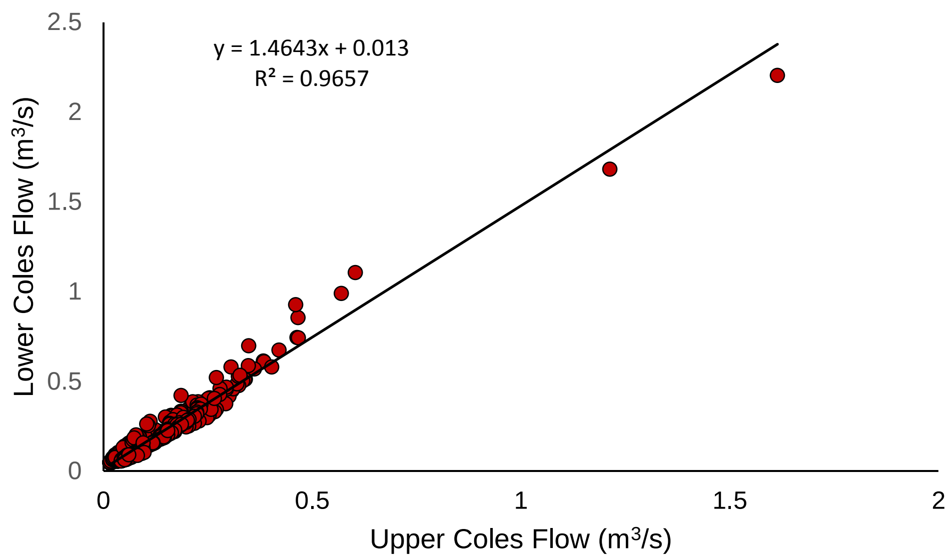

Figure 4. Relationship between daily mean flow in Upper and Lower Coles Creek over the period covered by this report (pre-pumping baseline).

Coles Creek Fisheries Monitoring:

Electrofishing surveys were conducted September 26-30 on 12 reaches of Coles Creek. Reaches were estimated at 50 m and exact length was later determined from the start and stop GPS points (Figure 1; Appendix II) using ArcGIS 10.2 (mean reach length 52 m). The exact start and stop points were also marked in the stream for future surveys. Surveys were conducted using three pass electrofishing without barrier nets. Avoiding continuous current that herds fish upstream negates the need for barrier nets, particularly in such a small stream (allowing us to reach less accessible areas more easily),. Evaluation of electrofishing pass data showed that there was a declining rate of return with each pass (Figure 5). The pass statistics are virtually identical when calculated on all species (below), or calculated on brook trout alone.

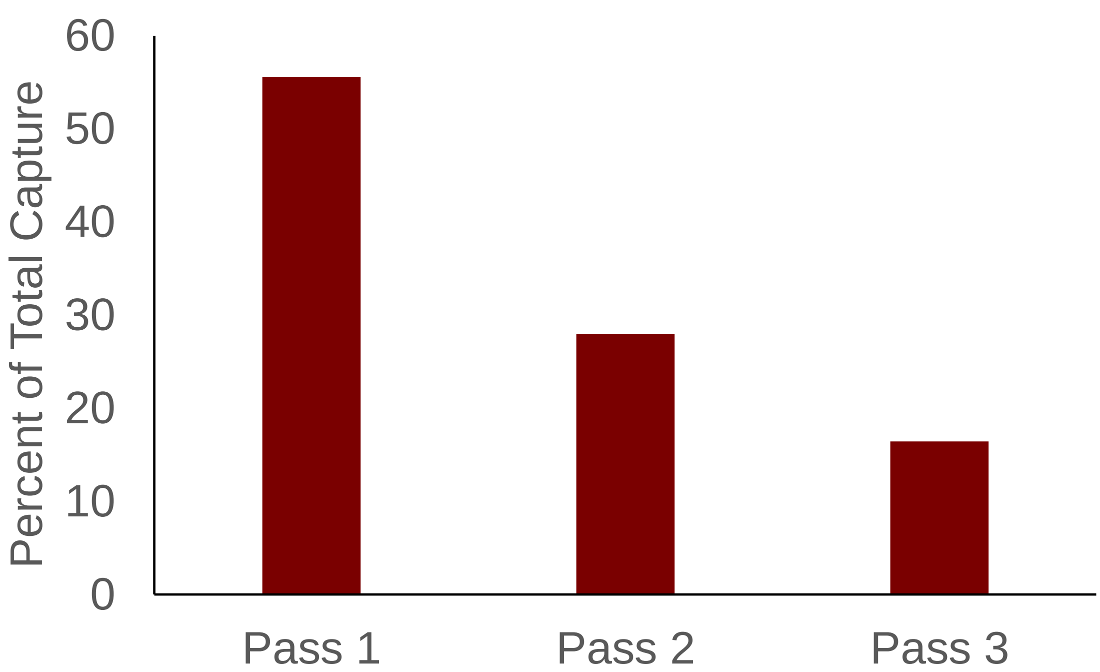

Figure 5. Cumulative percent of total capture for each electrofishing pass at all Coles Creek electrofishing reaches

Based on these data, total fish numbers could be calculated using a rarefaction curve. However, given that each pass is approximately 50% of the previous pass, the fish missed by electrofishing can be roughly calculated at < 15%, which is satisfactory for the purposes of this monitoring. All fish were collected in buckets, identified as to species and whether they were young-of-the-year and weighed in order to obtain biomass. To increase speed of processing, YOY were often separated and weighed as a group. Fish were then returned to the stream alive. A total of four species were collected in Coles Creek, threespine stickleback (*Gasterosteus aculeatus*), brook trout (*Salvenlinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), and Atlantic salmon (*Salmo salar*). Stickleback were most prominent in the uppermost and lowermost reaches, and we have not evaluated these data further. Only one Atlantic salmon post-smolt was captured in the lower reaches, though one other was also captured, but not within one of the electrofishing reaches. This suggests that salmon have spawned in lower Coles Creek at some time in the past, through spawning activity was likely very limited. Lower Coles Creek does have large cobble substrate, and taken together with the presence of Salmon, can be considered to be potential Atlantic salmon spawning habitat.

For the purposes of fisheries monitoring, four stream reaches (Figure 1) were delineated based on habitat features. The headwater reach was dominated by open field with little or no riparian zone (except for small segments) and some of it was unfishable due to extensive vegetation covering the stream. There was a stark change in habitat quality after the initiation of a continuous riparian zone and this occurred concurrently with a number of observed groundwater inputs in the upstream region of the Upper Coles reach making for an obvious division between the Headwater and Upper Coles. The division between Upper and Lower Coles was the upper boundary of a pond that previously existed in the lower reaches. The Lower Coles reach differs significantly than the Upper Coles reach as being less steep with silt accumulation, slower moving and dominated by alders in the riparian zone. The furthest downstream reach, Below Pond, was the area of the stream downstream of the former pond. In this lower reach, there is a transition to tidal freshwater. The lower boundaries of this reach will be more carefully delineated in subsequent seasons through the deployment of salinity loggers to more clearly differentiate tidal fresh water from upper estuary (median 0.5 PSU salinity defining the start of the estuary). As stream reaches were delineated after conducting the survey, this resulted in an uneven distribution of electrofishing sites with 2, 4, 3, and 3 electrofishing reaches from the Headwater, down to the Below Pond reach. Coles Creek also contains a number of pond systems and two of these are in the Headwater reach but it was not possible to estimate fish productivity in these systems using electrofishing, thus the numbers presented here reflect only the stream productivity. Based on observations of high numbers of YOY brook trout above the uppermost pond (not monitored here), those pond systems quite likely contain spawning populations of brook trout.

The total biomass of rainbow trout and brook trout was calculated for the entirely of the four monitoring reaches by multiplying the area of each reach by the average fish biomass per unit area (Appendix II). The area of each monitoring reach was calculated from the total length of each reach using ArcGIS and the mean stream width collected during electrofishing. For brook trout, the four stream reaches had 3.4, 32.8, 31.8 and 31.8% of the biomass for Headwater, Upper Coles, Lower Coles, and Below Pond, respectively. Based on this, more than half the biomass of brook trout in Coles Brook is below the wellfield. Unlike brook trout, rainbow trout were distributed more towards the upper reaches of Coles Brook with 1, 53, 17, and 29% of the biomass for headwater, upper Coles, lower Coles, and below pond, respectively (the lower Coles biomass was dominated by one very large fish).

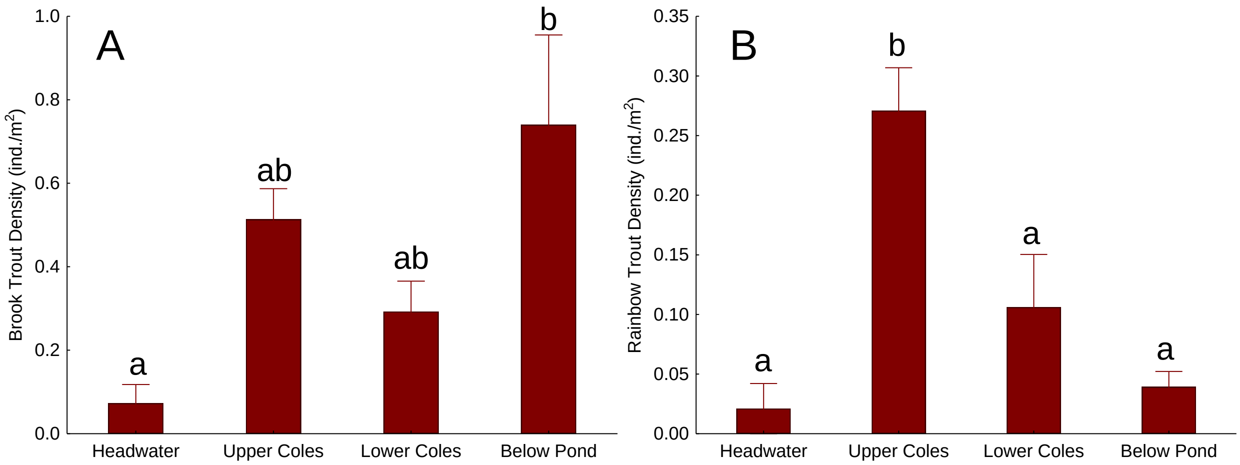

Figure 6. Mean (SEM) density of A) brook trout and B) rainbow trout in Coles Creek reach sections. Reaches with different letters are significantly different.

Brook trout density per unit area data showed that only the Headwater reach had significantly different density as compared to the other three reaches, although Lower Coles had about two-fold lower density than the reaches above and below it (Figure 6). In contrast, rainbow trout density peaked in the Upper Coles reach that had significantly higher density than the other reaches. Similar to density, brook trout biomass per unit area showed the downstream three reaches to be similar and the Headwater lower, though no significant difference were found (Figure 7). Rainbow showed higher biomass in the Upper Coles reach, though no significant differences occurred. The discrepancy between biomass and density for rainbow trout in the Below Pond reach was due to one large rainbow trout. Larger rainbow trout are known to extensively utilize the freshwater tidal and upper estuary habitat on PEI.

Overall, Coles Creek salmonid density and biomass is high as compared to other streams in the region. A summary of electrofishing surveys in 32 streams in Canada, mostly in the Atlantic provinces, showed that the highest salmonid biomass recorded was the Margaree River with 5.47 g/m^2 (Randall et al. 2017). By comparison, the average salmonid biomass for the Coles Creek reaches is 9 g/m^2. A study of the West, Pisquid and Cross Rivers on PEI showed mean salmonid densities (42 reaches; single pass electrofishing, biomass not collected) of 0.046, 0.028, and 0.12 individuals/m^2, respectively (Roloson et al. 2018). Coles Creek brook trout density averaged 0.25 individuals/m^2 for the first pass, again suggestion very high brook trout productivity in this system. However, a study of nearly 70 watersheds on PEI found brook trout density to average 0.78 individuals/m^2, similar to the numbers found for Coles Creek (Guignion et al. 2010)

As young-of-the-year (YOY) salmonids are indicative of spawning in the immediate area, the ratio of YOY to 1+ aged fish was estimated for brook trout and rainbow trout as an indication of spawning activity. This could not be calculated for all of the reaches in the Headwater section. However, for the remaining reaches the mean ratio was 2.4, 1.1, and 4.2 for Upper Coles, Lower Coles, and Below Pond, respectively. This is suggestive that brook trout spawning is occurring throughout Coles Creek and that the region below Hw 2 may be an important spawning area (perhaps used by sea-run trout). The former pond bed in the Lower Coles section is dominated by silt and is relatively slow moving and is likely less important for spawning. For rainbow trout, the YOY:1+ ratio could only be calculated for the

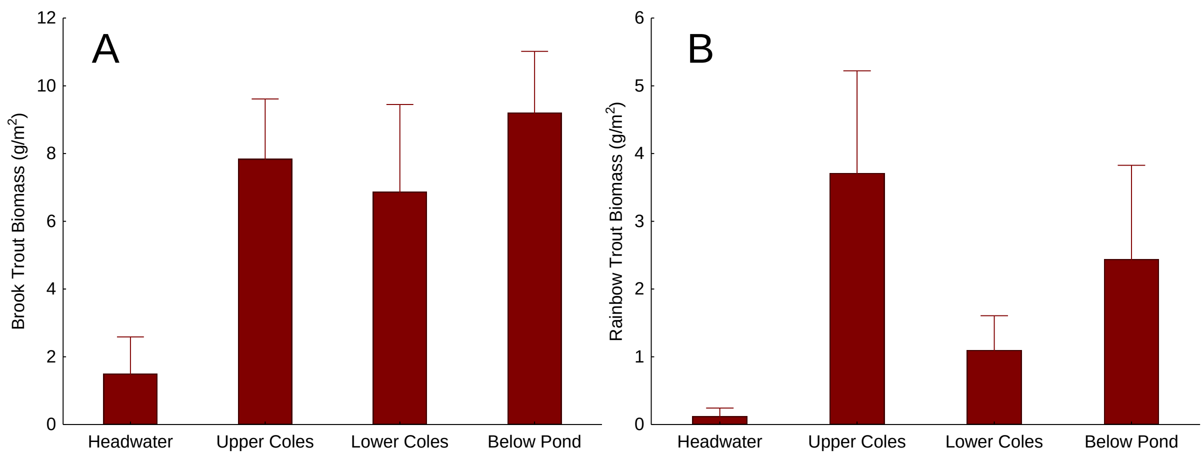

Figure 7. Mean (SEM) biomass of A) brook trout and B) rainbow trout in Coles Creek reach sections. Reaches with different letters are significantly different.

two middle sections and were 3.6 and 2.1 for Upper and Lower Coles, respectively. Only 3 YOY rainbow trout were found in the Headwater and Below Coles sections. This is consistent with rainbow trout preferring to spawn in areas of higher slope, as compared to brook trout that may select spawning sites on PEI largely on the basis of groundwater upwelling.

While we did not conduct redd surveys ourselves as part of the present study, the Cornwall and Area Watershed Group (CAWG) completed redd surveys in 2016. This study found that brook trout spawn over the entirety of Coles Creek (Figure 8). A total of 24 single and 36 multiple redds (2 or 3) were counted by the watershed group. Two redds were considered possible salmon redds. This is consistent with our results that show a high ratio of YOY:1+ brook trout throughout the system. The watershed group has found that Coles Creek has the highest redd counts of any of the tributaries of the North River.

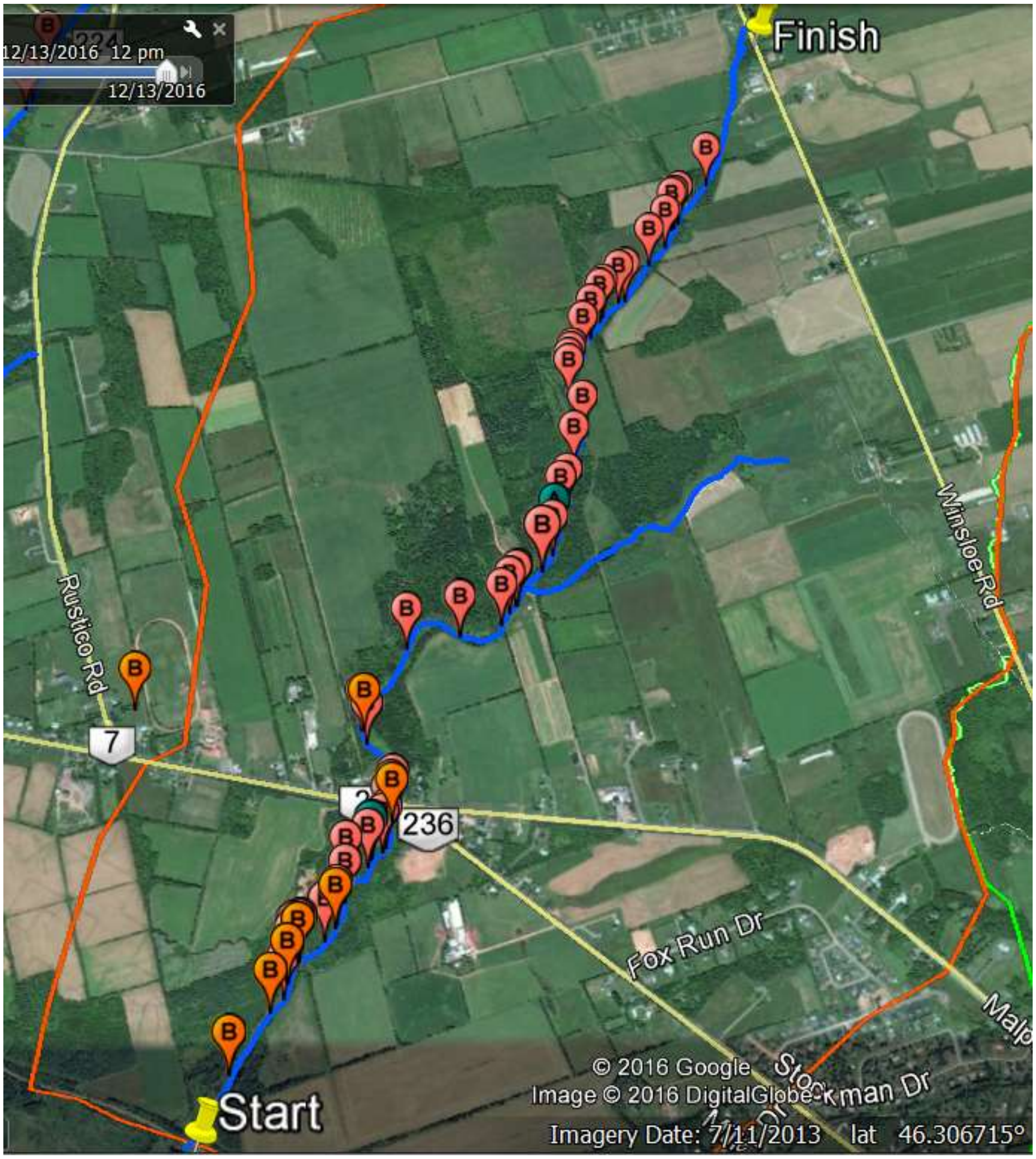

Figure 8. Coles Creek satellite image showing the locations of brook trout redds identified during fall of 2016. Image used with permission of Hilary Shea and Karalee McAskill, Cornwall and Area Watershed Group.

Conclusions and Recommendations

Coles Creek, while having extensive agricultural land use, maintains high quality fish habitat, particularly in the mid to upper regions where riparian zones are dominated by forest. Brook trout use the entire stream habitat, and based on estimates herein, may have higher biomass below the wellfield than above it. As there is certainly considerable spawning activity occurring in the lower reaches of the stream, this species is most at risk from reduced flows. The risk due to the distribution of brook trout is compounded by the reproductive behaviour and preferences of brook trout. Brook trout on PEI can survive almost anywhere that the temperature remains within their tolerance, and they have areas of suitable substrate with groundwater upwelling. Deterioration of this latter habitat requirement (that is found in great abundance on PEI) would seem to pose the greatest potential threat to brook trout as a result of water extraction activities. The area immediately below the wellfield is not currently the best brook trout spawning habitat in Coles Creek, though spawning does occur there. However, these data are also suggestive that the section of river below Hw 2 may be important spawning habitat. The extent to which this could be impacted by water extraction is unknown.

Going forward, this monitoring will evolve into a Ph.D. study that will:

- Continue to measure flow and fisheries for at least three year post-pumping using the sites and method described here.
- Characterize the groundwater inputs into the stream, including in stream upwelling with either thermal remote sensing or direct stream bed temperature measurement.
- Characterize the extent of saline incursion using conductivity loggers in order to more confidently define the Below Pond reach.
- Characterize the spawning areas for brook trout in collaboration with CAWG in the fall months. Spring monitoring may also be carried out for rainbow trout YOY as in indication of spawning success. Monitoring of brook trout fry emergence may also supplement these efforts.

References

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Appendix I – Manual Flow Data

Date	Upper Coles		Lower Coles		Springvale	
	Flow	Stage	Flow	Stage	Flow	Stage
08/11/2016	0.0330	0.625	0.0481	0.543	0.0716	0.718
08/24/2016	0.0205	0.605	0.0492	0.525	0.0652	0.701
08/31/2016	0.0202	0.6	0.0473	0.523	0.0572	0.7
09/13/2016	0.0201	0.597	0.0541	0.521	0.0733	0.709
09/20/2016	0.0233	0.608	0.0517	0.53	0.0604	0.707
10/12/2016	0.0244	0.601	0.0509	0.537	0.0841	0.716
12/13/2016	0.1143	0.679	0.2251	0.748	0.2216	0.8520
01/05/2017	0.2319	0.699	0.4585	0.866	0.6907	1.053
04/07/2017			0.9309	1.071	2.3666	1.388
04/09/2017	0.1512	0.61	0.2683	0.664	0.4710	0.94
05/02/2017	0.1059	0.687	0.2308	0.618	0.3496	0.882
05/11/2017	0.2597	0.652	0.4723	0.772	0.8832	1.05
05/17/17	0.2217	0.621	0.3347	0.693	0.5582	0.947
05/29/17	0.1256	0.585	0.2176	0.617	0.2972	0.876
06/07/2017	0.1012	0.606	0.1604	0.569	0.2630	0.822
06/10/2017	0.1265	0.57	0.2217	0.615	0.3843	0.879
06/30/17	0.0570	0.537	0.0951	0.545	0.1629	0.784
07/14/17	0.0524	0.549	0.0878	0.503	0.1306	0.74
07/22/17	0.0548	0.528	0.1286	0.572	0.1628	0.762
08/03/2017	0.0369	0.523	0.0606	0.494	0.0708	0.719

Appendix II – Fish Survey Data

Table 1. Raw data for each reach in the fish productivity survey, 2016. The Headwater 2 site YOY:1+ ratio could not be calculated as all were YOY.

Reach	Length (m)	Width (m)	Area (m^2)	BT Density Ind./m^2	RT Density Ind./m^2	BT Biomass g/m^2	RT Biomass g/m^2	BT YOY:1+	RT YOY:1+
Headwater 1	60.4	1.97	118.8	0.118	0.042	2.59	0.24	0.08	0.67
Headwater 2	101.2	1.07	107.9	0.028	0.000	0.42	0.00		
Headwater 3	35.8	2.33	83.5	0.455	0.335	5.31	5.70	2.17	0.88
Upper Coles 1	40.3	2.37	95.4	0.482	0.210	9.83	1.23	1.30	1.75
Upper Coles 2	49.6	2.43	120.7	0.389	0.207	4.43	1.04	3.27	11.50
Upper Coles 3	40.1	2.33	93.6	0.727	0.331	11.80	6.88	2.78	0.41
Lower Coles 1	51.8	3.10	160.6	0.380	0.156	5.98	1.16	1.35	3.17
Lower Coles 2	52.8	3.20	169.0	0.148	0.018	2.93	0.19	1.78	2.00
Lower Coles 3	45.8	2.87	131.3	0.350	0.145	11.71	1.94	0.29	1.17
Below Pond 1	40.0	3.63	145.3	1.170	0.014	11.83	0.75	5.25	0.00
Below Pond 2	46.0	3.07	141.1	0.553	0.057	10.06	5.19	3.33	0.00
Below Pond 3	61.6	3.10	191.0	0.497	0.047	5.74	1.38	4.00	0.13

Table 2. Measured reach area and extrapolated fish density.

Reach	Width (m)	Length (m)	Area (m^2)	BT Biomass (kg)	RT Biomass (kg)	% BT Biomass	% RT Biomass
Headwater	1.52	1182	1793	2.69	0.22	3.4	0.9
Upper Coles	2.37	1385	3278	25.70	12.17	32.8	52.9
Lower Coles	3.06	1186	3624	24.91	3.98	31.8	17.3
Below Pond 2	3.27	830	2711	24.97	6.62	31.9	28.8
Total				**78.27**	**22.99**		