WINTER RIVER - TRACADIE BAY WATERSHED ASSOCIATION

Work Report for 2019-20

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1 Executive Summary

This year the Winter River – Tracadie Bay Watershed Association (WRTBWA) crew planted 3,273 trees, created 7 brush mats, cleared debris from 3.6 km of stream, and collected 1340 kg of waste from shoreline cleanups. There were 153 waypoints taken for stream assessments, encompassing things like blockages and erosion, and 498 water chemistry readings taken in the estuary, streams, springs, and ponds of the Watershed. In addition, the crops growing in 472 fields were recorded for our crop mapping project. In the fall, 11 culverts underwent Part 3 of culvert assessments to determine those in greatest need of repair. With this information the coordinator and board will be able to prioritize work for the Coastal Restoration Fund project.

There were 6 depth loggers, 7 temperature loggers, and 3 dissolved oxygen loggers deployed throughout the watershed this field season. From the data collected, flow levels, tolerable temperatures, and low oxygen conditions were monitored and used to assess aquatic habitat health. Pond water temperatures continued to be high, causing barriers for species like Brook Trout, which prefer temperatures between 11°C and 18°C. This summer, the highest surface temperatures recorded at the ponds approached 30°C. This year, the weirs at the Brackley branch went dry for a much shorter period than in previous years. It was a wet year, but nonetheless the operation of the Miltonvale Pumping Station shows promise for lessening the strain on our Watershed.

A great deal of restoration work went into a site where the stream had been silted in, looking more like a wetland than a stream. The stream was near a field where hedgerows had been removed and potatoes had been in rotation the year before. As a result, there were several large trenches in the field, causing major silt runoff. Work was completed to re-shape and narrow the stream, and the riparian zone was enhanced through the planting of several trees and shrubs.

Work was also underway at the donated Watershed property this year. A trail was marked and cleared, water crossings built, and trees planted. A brush pile and insect hotel were also created on the property, which can act as a demo for building these structures in the future. The foundation hole from the old house was filled in this fall, eliminating a safety hazard. The trail will be open to the public upon completion.

There were 9 community outreach events held this year, including fundraising U-pick events, the Lady’s Slipper Hike and Snowshoe events, educational activities, and volunteer events with groups from Stantec, DVA, Stonepark Intermediate School, and UPEI.

2 Staff

Sarah Wheatley is the Watershed Coordinator for WRTBWA, working with the watershed since 2015. Vanessa Jackson has been with the watershed since 2017, assuming the role of Field Supervisor / Natural Resource Technician. Brittany Steele started this year as Watershed Monitoring and Restoration Intern, focusing on the water monitoring activities within the watershed. Evan Cahill, Shamus Koughan, Chayla Exner, Trent MacSwain, Samantha MacSwain and Sarah McBride were hired on as summer staff to help with watershed enhancement. Trent and Shamus were our chainsaw operators this year.

Table 1. Staff employed for the 2019 field season.

Name	Term of Employment
Sarah Wheatley	Year Round
Vanessa Jackson	Spring-Fall
Brittany Steele	Summer-Winter
Evan Cahill	Spring-Fall
Shamus Koughan	Spring-Summer
Chayla Exner	Spring Only
Trent MacSwain	Spring-Summer
Samantha MacSwain	Summer Only
Sarah McBride	Summer Only

Figure 1. From left: Sarah Wheatley, Vanessa Jackson, Sarah McBride, Brittany Steele, Samantha MacSwain and John Hughes at our annual fun day this August.

3 Project Activities 2019

3.1 Tree Planting

3.1.1 Introduction

In total, there were 3,273 trees and shrubs planted at 22 sites this year. This included shoreline and riparian zone enhancement, hedgerows, diversity plantings, adding cover for fish and wildlife, and a pollinator garden. Hedgerows are an important component of ecosystems, for both wildlife and agriculture. The trees and shrubs act to catch soil that is moved by wind and water, keeping it upland and out of the waterways. Hedgerows also provide wind breaks, shade, and refuge areas for wildlife to rest or evade predators as they travel between otherwise disconnected pieces of habitat.

3.1.2 Hughes Farm, Millcove

A new hedgerow was planted, joining with an existing hedgerow, on the property of a local farmer. Another hedge on the property was gradually falling down, decreasing wind cover, allowing greater snow accumulation, and causing flooding come spring. The WRTBWA crew added a double, staggered White Spruce hedgerow between fields. This will increase wind cover, decrease soil erosion and flooding, and create a wildlife corridor.

Table 2. Trees planted for Hughes Farm in 2019.

Species	#
White Spruce	138

Figure 2. Yellow line indicates where trees were planted to create a new hedgerow.


Figure 3. White Spruce planted at Millcove site to create hedgerow.

3.1.3 Officer's Pond, Suffolk

Trees were planted in this area to increase diversity, stabilize pond banks, and increase fish cover in the pond. Milkweed was also added in the hope of attracting more pollinators to the area.

Table 3. Trees and shrubs planted at Officer's Pond.

Species	#
Yellow Birch	6
Milkweed	65
Total	**70**

Figure 4. Locations planted at Officer's Pond site.

Figure 5. Trent planting a tree at Officer's Pond site.

3.1.4 Suffolk Pit

There are fields on either side of the road at the entrance to the Suffolk Pit, with a stream passing through on one side. The crew added trees and shrubs to this area to expand the riparian zone, thus adding habitat and cover for wildlife.

Table 4. Trees and shrubs planted at Suffolk Pit.

Species	#		Species	#
Red Maple	102		Aronia m	6
Yellow Birch	12		Aronia p	6
Eastern White Cedar	6		Willow spp.	6
Red Pine	12		Milkweed	16
White Spruce	18		Wild Rose	36
Total	**220**			

Figure 6. Location of planting at Suffolk Pit.


Figure 7. Red maple planted at Suffolk Pit.

3.1.5 Bysterveldt Hedgerow, Bedford

A local farmer contacted the watershed about adding to their hedgerow, as their existing one is falling down. The crew added a Spruce double staggered hedgerow bordering their existing one. This should create a better wind break and reduce erosion from the adjacent field.

Table 5. Trees planted at Bysterveldt's, Bedford.

Species	#
White Spruce	74

Figure 8. Yellow line on map indicates where hedgerow was planted.


Figure 9. White spruce hedgerow at Bedford site.

3.1.6 Planting at Queen's Point

The crew added trees and shrubs to help prevent erosion and add diversity to this shoreline property. Willows and other water-loving species were planted in some of the wet areas on the property. This site was greatly impacted by Hurricane Dorian, so we may return for further planting in the future.

Table 6. Trees and shrubs planted at Queen's Point site.

Species	#		Species	#
Balsam Fir	12		Steeplebush	6
White Spruce	12		White Birch	6
Eastern larch	18		Yellow Birch	18
Eastern Hemlock	6		Red Maple	6
Red Osier Dogwood	12		Willow	12
Meadowsweet	12			
Total	**120**			

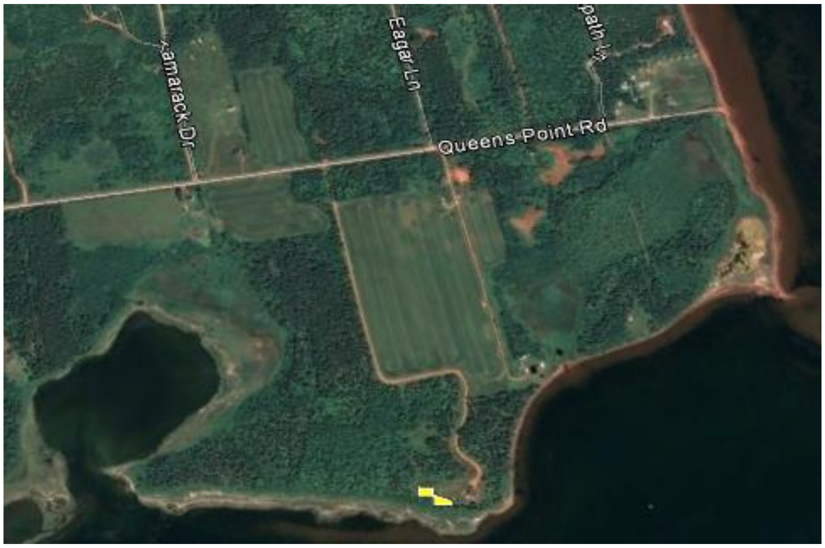


Figure 10. Location highlighted in yellow shows where trees and shrubs were planted.

Figure 11. Staff member Brittany standing by tree planted at Queen's Point site.

3.1.7 York Bridge Planting

This site was under construction a few years ago, leaving areas bare of trees. The Watershed crew planted at this location last year and returned this year to increase diversity. Shrubs and Milkweed were planted to support populations of bees and butterflies.

Table 7. Number and species of trees and shrubs planted at York Bridge.

Species	#		Species	#
Sweet Fern	12		Milkweed	18
Wild Rose	6		Willow	12
Eastern larch	12			
Total	**60**			

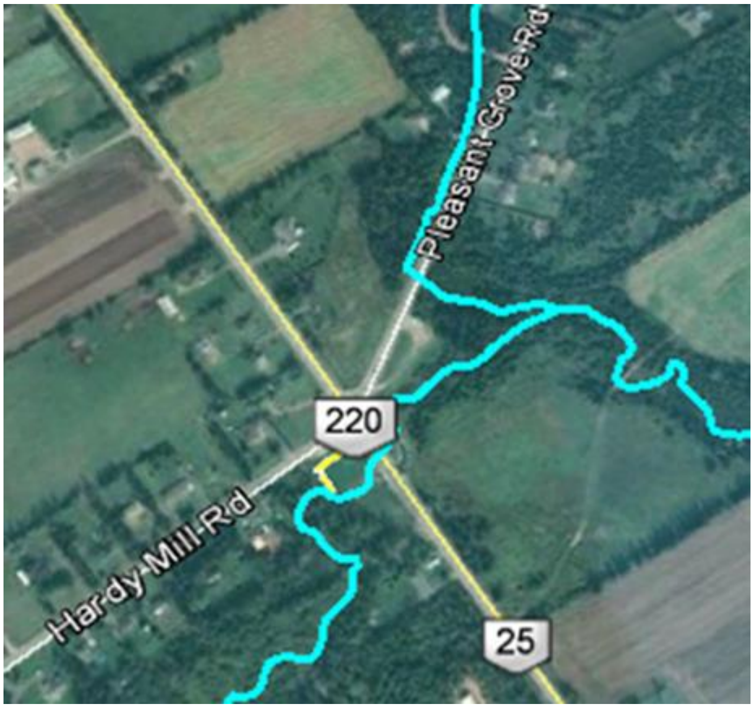


Figure 12. Yellow line indicates planting area at York Bridge.

3.1.8 City-owned property in Brackley

Formerly a ball diamond, this property has grown up with mostly Spruce and Balsam Fir. There were some bare patches throughout, where we planted a variety of trees and shrubs to provide food, cover, and habitat for wildlife. We planted in 4 different areas on the property, selecting tree species based on their habitat preferences and dividing up the different trees and shrubs between the sections to create greater diversity.

Table 8. Number and species of trees and shrubs planted at Brackley city-owned property.

Species	#		Species	#		Species	#
Black Chokeberry	6		Balsam Fir	42		Aronia m	6
Red Berried Elder	12		Red Pine	84		Aronia p	6
Honey Suckle	6		White Pine	102		White Ash	48
Sweet fern	6		White Spruce	42		White Birch	107
Wild Rose	12		Eastern Larch	24		Red Maple	72
Eastern White Cedar	6		Eastern Hemlock	36		Red Spruce	6
Total				**623**			

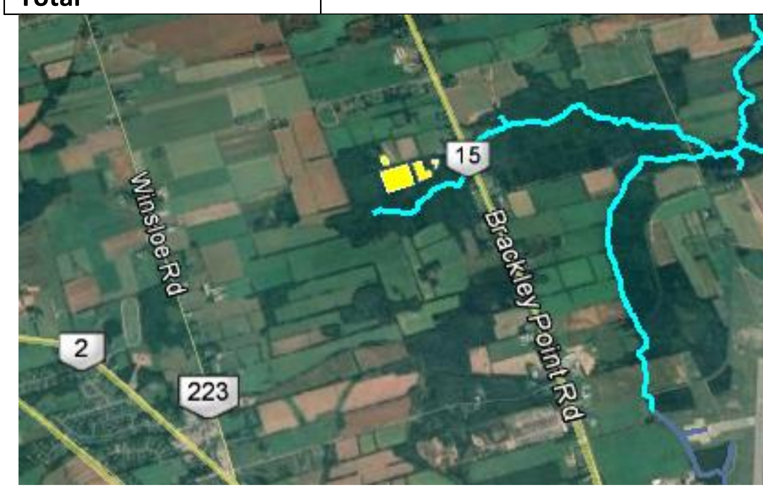


Figure 13. Yellow highlight indicates planting areas for the city-owned property.

Figure 14. Staff member Evan planting a tree at Brackley city-owned property.

3.1.9 Glenaladale

WRTBWA worked with the Glenaladale Trust to diversify the 529-acre estate by adding native trees and shrubs to the property. There were 7 different tree planting projects that took place on the property this year, named Site A through G. Site A was a woodlot cut years ago and replanted with a monoculture of white spruce. The Glenaladale Trust asked for our assistance with enhancing this site. Gary Schneider, Project Coordinator for the MacPhail Woods Ecological Forestry Project, came out to walk the woodlot with Sarah W. and Aggi-Rose. Gary suggested adding diversity to this woodlot by planting a mix of native trees and shrubs and cutting down some of the many Pin Cherries and Gray Birch. The crew cleared any that were choking out Spruce or other desirable species popping up.

The crew also planted a hedge of Common Elder to help create an orchard on the property (Site F). The rest of the planting areas were designed to extend wooded areas and combat coastal erosion on the property. This will extend wildlife corridors, add habitat, and provide cover and food sources. The shoreline planting will also help slow coastal erosion. Between all 7 sites, there were 810 trees planted at Glenaladale this year.

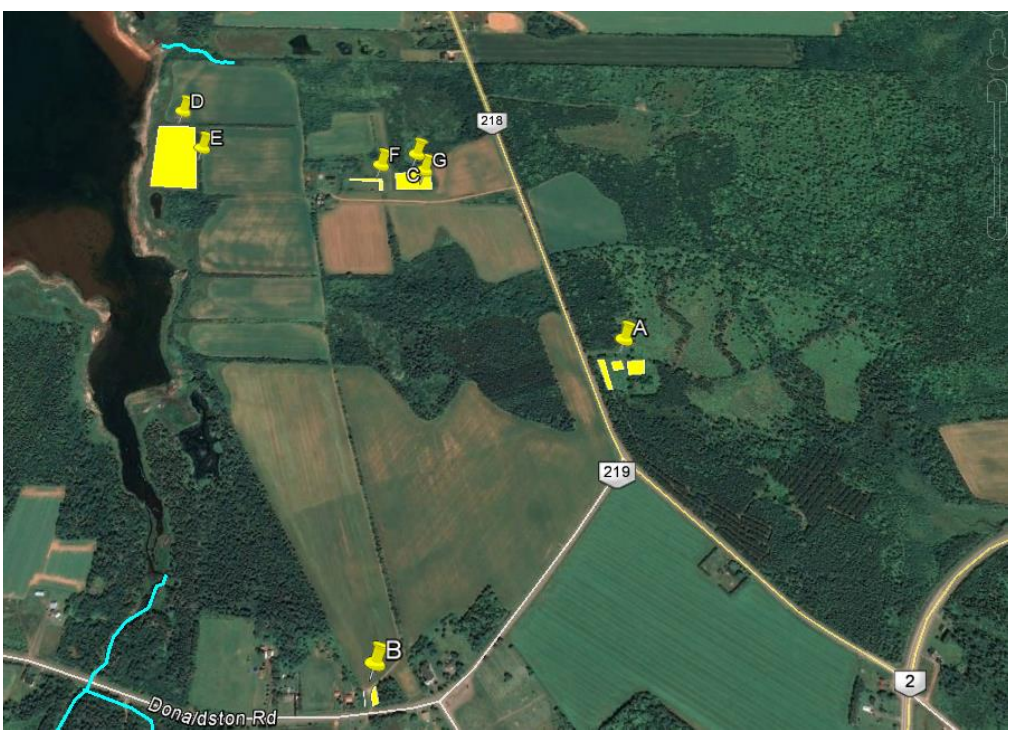


Figure 15. Planting sites at the Glenaladale property are marked in yellow.

3.1.9.1 Glenaladale Site A: white spruce stand

Table 9. Number and species of trees and shrubs planted at Glenaladale Site A.

Species	#		Species	#
Eastern Hemlock	6		Yellow birch	6
Red Osier Dogwood	12		Sweet Gale	6
White Birch	12			
Total	**42**			

Figure 16. A yellow birch planted at the Glenaladale woodlot.

3.1.9.2 Glenaladale Site B: adjacent to Donaldston Rd

Table 10. Number and species of trees and shrubs planted at Glenaladale Site B.

Species	#		Species	#		Species	#
Bayberry	2		Sweet fern	12		Balsam Fir	12
Black Chokeberry	6		Honey suckle	12		Red Pine	12
Purple Chokeberry	6		Wild Rose	24		White Pine	15
Common Elder	6		Eastern White Cedar	12		White Spruce	22
Red berried Elder	18						
Total	**159**						

Figure 17. Staff member Chayla ready to plant at Glenaladale Site B.

Figure 18. Staff member Evan planting at Glenaladale Site B.

3.1.9.3 Glenaladale Site C: field in front of homestead

Table 11. Number and species of trees and shrubs planted at Glenaladale Site C.

Species	#		Species	#
Bayberry	22		Eastern White Cedar	18
Common Elder	24		White Spruce	20
Sweet Fern	6		Eastern Larch	12
Total	**102**			

3.1.9.4 Glenaladale Site D: near the shore, Student Planting Day

Table 12. Number and species of trees and shrubs planted on Student Planting Day at Glenaladale Site D.

Species	#		Species	#
Bayberry	60		Red Osier Dogwood	24
Wild Rose	18		Meadowsweet	12
Eastern larch	12		Steeplebush	12
Total	**138**			

Figure 19. Students planting by Glenaladale shore.

3.1.9.5 Glenaladale Site E: near the shore

Table 13. Number and species of trees and shrubs planted at Glenaladale Site E.

Species	#		Species	#
White Ash	12		Yellow Birch	12
White Birch	6		Red Maple	6
Total	**36**			

Figure 20. Trees planted at Glenaladale Site E.

3.1.9.6 Glenaladale Site F: shrub hedge

Table 14. Number of shrubs planted at Glenaladale hedge.

Species	#
Common Elder	48

3.1.9.7 Glenaladale Site G: DVA Planting

Table 15. Number and species of trees and shrubs planted by DVA staff at Glenaladale Site G.

Species	**#**		**Species**	**#**
Milkweed	45		Willow	42
Speckled Alder	12		Eastern Larch	24
Yellow Birch	48		Red Spruce	60
Bayberry	24		White Spruce	30
Total	**285**			

Figure 21. Staff from DVA planting at Glenaladale Site G.

3.1.10 Union Station by the bridge

The bridge at this site was replaced last year, and although grass had grown up since then, trees and shrubs were needed to provide better fish cover.

Table 16. Number and species of trees and shrubs planted at Union Station by the bridge.

Species	#		Species	#
Sweet Fern	12		Milkweed	18
Wild Rose	6		Willow	12
Eastern Larch	42			
Total	**90**			

Figure 22. Yellow area indicates where planting took place at Union pumping station by the bridge.

3.1.11 Union Rd site, by stream

An assortment of trees and shrubs were planted here to enhance the riparian zone.

Table 17. Number and species of trees and shrubs planted at Union Rd site by stream.

Species	#		Species	#
Honey Suckle	6		White Pine	12
Wild Rose	18		White Birch	12
Total	**48**			

Figure 23. Yellow highlighted area indicates where planting took place.

Figure 24. Trees planted at Union Rd site.

3.1.12 Pleasant Grove planting area

At the Pleasant Grove site, species were planted that would provide pollinator habitat and food sources. Along the stream banks, trees were planted to provide cover for fish, as well as provide food and habitat for birds and other wildlife.

Table 18. Number and species of trees and shrubs planted at Pleasant grove planting area.

Species	#		Species	#
Meadowsweet	6		Willow	12
Steeplebush	6		Joe Pye Weed	40
Yellow Birch	6		Red maple	18
Total	**88**			

Figure 25. Highlighted area indicates where planting took place at Pleasant Grove site.

Figure 26. Staff member Brittany planting at Pleasant Grove site.

3.1.13 Tim's Creek Planting

At Tim's Creek, trees were planted in the buffer zone to help with soil erosion, diversify the area, and add cover for wildlife.

Table 19. Number and species of trees and shrubs planted at Tim's Creek.

Species	#		Species	#
Eastern White Cedar	24		Eastern hemlock	6
White Pine	6		Red Spruce	12
White Spruce	6			
Total	**54**			

Figure 27. Highlighted area indicates where planting took place at Tim's Creek.

3.1.14 Donated Woodlot Planting

At the property donated to WRTBWA, trees and shrubs were planted along the trail we are constructing. The trees were added to increase biodiversity in the area, and milkweed to provide a food source for pollinators. These additions will also add to the aesthetic of the trail as they grow and mature.

Table 20. Number and species of trees and shrubs planted at the donated woodlot.

Species	#
Red Maple	12
White Pine	6
Milkweed	45
Total	**69**

Figure 28. Highlighted area indicates where planting took place at the donated woodlot

3.1.15 Soil Erosion Control Site

At this location, a stream with an agricultural field directly above had experienced a severe amount of soil erosion into it. In an effort to restore this site, a number of trees and shrubs were planted.

Table 21. Number and species of trees and shrubs planted at erosion control site.

Species	#		Species	#		Species	#
Eastern larch	54		Red Osier Dogwood	24		Eastern White Cedar	12
Red Maple	3		Northern bayberry	12		Milkweed	45
Willow	108		Black Chokeberry	6		Red Spruce	60
Red Elderberry	24		Speckled Alder	24		Yellow Birch	48
Common Elder	6		Bog Birch	12		White Spruce	30
Total				**468**			

Figure 29. Planting completed at erosion control site.

3.1.16 Suffolk Rd Properties

At the end of the planting season there were leftover trees and shrubs from cancelled plans. At one of the properties, Wild Rose was planted to add to the hedge on the property. At the other, White Spruce was added to the hedgerow to replace some that were falling down, and some trees and shrubs were planted by the stream bank. There was also a pollinator garden created here.

Table 22. Species planted in pollinator garden on Suffolk Rd property.

Species	#		Species	#
Purple Chokeberry	11		Red Maple	2
Wild rose	6		Milkweed	90
Red Osier Dogwood	10		Sweet gale	6
Meadowsweet	6		Joe Pye Weed	42
Total	**173**			

Table 23. Species planted in yard and hedge of Suffolk Rd property.

Species	#
White Spruce	36
Milkweed	90
Eastern Hemlock	6
Total	**132**

Table 24. Species planted in hedge of Suffolk Rd property.

Species	#
Wild rose	36

Figure 30. Highlighted area on map indicates where trees and shrubs were planted at Suffolk Rd properties.

3.2 Soil Erosion Site

There was a major soil erosion event within the Watershed this year. In the 2018 growing season, the field was planted in potatoes, with the rows toward the stream. As there had been problems with this area in the past, some precautions had already been taken. We anticipated that some silt would end up in the stream, especially since the hedgerows in the field had been removed in recent years. To prepare for this, a double layer of straw bales was staked in the section of field deemed most vulnerable to catch eroding soil before it reached the stream.

Upon checking the site in spring 2019, it was found that a large section of the riparian zone on either side of the stream had been covered in silt. There were several trenches formed and sediment was running directly into the stream. The straw bales had been pushed out of place from the force of the water coming off the field, and silt completely covered the straw bales in some areas. The stream in this section (approximately 50 m) looked more like a wetland covered in silt than a stream.

Mary Finch, the Watershed Ecologist with the PEI Watershed Alliance, did a stream walk with Sarah to give us some guidance on how to restore the stream. Following these instructions, we located where the stream was trying to make its new path and helped shape it into a narrower channel. To achieve this, we placed logs on either side of the stream and dug out some of the silt to keep them in place. We removed all blockages from downstream and felled all of the dead trees. After the stream started to take on a better shape, we planted the riparian zone with trees and shrubs to help build the area back up. The Watershed has been working with the landowner to prevent any further damage to the stream.


Figure 31. Silt covering the riparian zone at the soil erosion site.


Figure 32. Silt runoff from the field, covering the riparian zone at the soil erosion site.


Figure 33. Silt in the stream at the soil erosion site.


Figure 34. Staff member Sam digging out silt from the stream at the soil erosion site. The logs pictured here were used to help redirect flow and shape the stream channel.

Figure 35. Rail inserted at stream edge at the soil erosion site.

3.3 Forest Enhancement at Glenaladale

There are several woodlots on the Glenaladale property. We are working with the Glenaladale Trust to enrich these areas with quality wildlife habitat. The woodlot at Glenaladale Site A (mentioned in Tree Planting section 3.1.9) had previously been clear-cut and planted as a white spruce stand. In addition, there was an aggressive growth of Pin Cherry coming up, choking out the Spruce and other species trying to grow.

After recording an inventory of what was growing in the woodlot, a crew cut down Pin Cherries that were preventing other species from establishing. Sections were also cleared to make room for other species to be planted here. In these patches, Yellow Birch, Eastern Hemlock, White Birch, and various shrubs were planted to diversify the woodlot.

3.4 Stream Clearing

The crew cleared 3.6 km of stream blockages this year. All blockages removed were along the main branch of the Winter River. Stream clearing is needed to keep fish passage open, and some debris should be left in the stream for cover. Where possible, fallen trees are limbed which allows animals to use them to cross the stream.

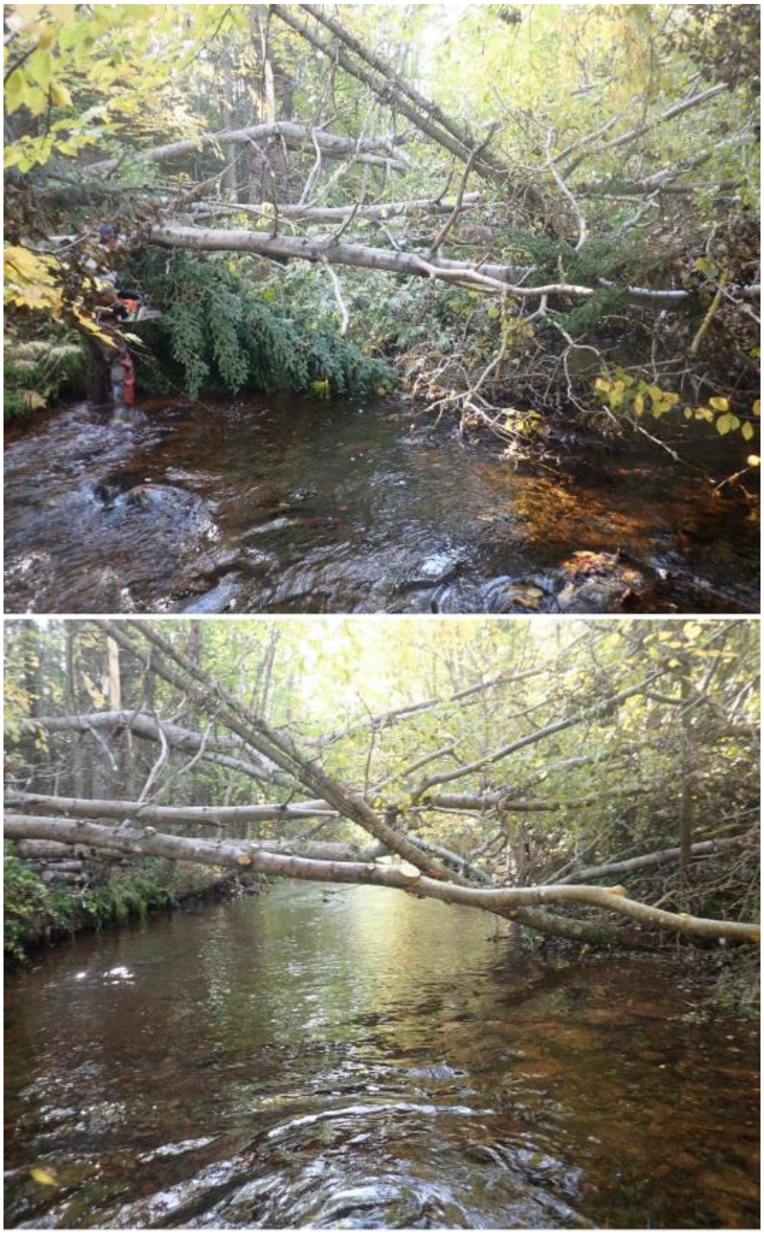


Figure 36. Above: blockage before removal work. Below: after the blockage was cleared. This site was along the main branch of the Winter River, off Suffolk Rd.

3.5 Brush Mats

In summer 2019 the crew installed 7 brush mats: 6 in-stream brush mats and 1 land brush mat. There were 4 in-stream brush mats installed on the Cudmore branch, 1 at Vanco, and 1 at Friston North. The land brush mat was installed at Vanco. Upon walking the streams, it was evident these areas could benefit from brush mats to trap silt and build up the banks. The land brush mat was installed at the top of the stream bank to catch sediment from the field above, preventing it from entering the stream.

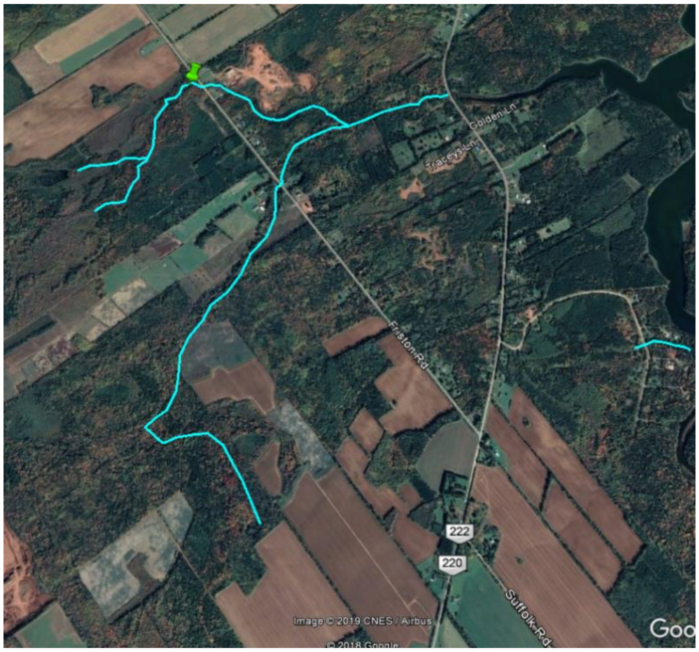


Figure 37. Green marker indicates where brush mat was created at Friston North.

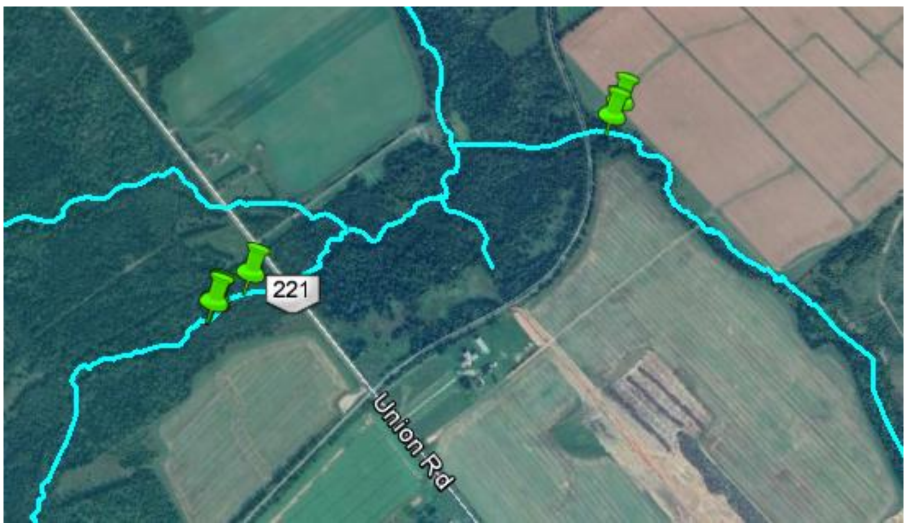


Figure 38. Green markers indicate where brush mats were created at Cudmore and Vanco branches.

3.6 Shoreline Cleanup

A total of 1340 kg of garbage was collected from our shoreline cleanups this year. The crew picked up garbage from Tracadie beach, all around Tracadie bay, and Blooming Point Beach. A large portion was aquaculture waste, such as buoys and mussel socks. After Hurricane Dorian, we went out again to tackle the debris washed up from the bay.

3.7 Nest Boxes

Nest boxes had been put up in previous years, targeting American Kestrels, Wood Ducks, Northern Saw-whet Owls and Tree Swallows. These are all cavity nesters, which rely on holes or hollowed out structures for their nesting sites. Nest boxes were put up in areas that have limited natural options, such as snags, for the birds to use. Increased development and the removal of dead or damaged trees has greatly reduced prime nesting habitat for these species. Providing nest boxes can help a species regain its numbers amidst limited habitat availability. Brittany and Vanessa used a map of all the nest boxes deployed and took inventory of which were still present, repairing those that needed it.

3.8 Community Outreach

This year we held 2 fundraising events, invited 4 groups to volunteer and learn with us for the day, operated a booth at a Canada day event, and held our annual Lady's Slipper Hike. Our annual Snowshoe Event also took place over the winter. The 2 fundraisers included a sunflower U-pick and raspberry U-pick. Several staff members helped out with these events, and Wheatley's Raspberries was kind enough to donate all proceeds to the Watershed.

The Stonepark green team, Stantec employees, DVA employees, and UPEI students in a summer program all came out to help plant and water trees, clean up garbage, and learn about the work WRTBWA does. Sarah W. and Sam volunteered at a Canada Day event held at the North Shore Community Centre, educating the public on our Watershed and running a fishing game for children. Our Lady's Slipper Hike was held again this year on the Winter River Trail, where board members and staff led the hike and educated the public on plant and animal species, the history of the Watershed and, of course, looked at Lady's Slippers.

Members of the crew had an opportunity to participate in electrofishing surveys with the Hunter-Clyde Watershed Group, coordinated by Hillary Shea, who had previously worked with WRTBWA for 2 field seasons. Electrofishing provides data on the density and diversity of fish in our waterways. Collecting this data provides indicators of stream quality and can guide us in addressing potential issues.

Figure 39. UPEI students carry buckets to water recently planted trees.

Figure 40. Raspberry U-pick fundraiser held at Wheatley's Raspberries.

Figure 41. Volunteers from Stantec posing with some of the garbage collected from the shoreline.

3.9 Donated Woodlot

A couple years ago, a parcel of land was gifted to WRTBWA. The 2018 field season was spent removing garbage from the property, and this year's main focus was creating a trail. Board members went out and flagged a route for the trail, then staff cleared a path with the chainsaw and clearing saw. Bridges were created from trees that were cut down while clearing the trail. These were placed over springs and tied together with twine to make the crossing. Trees, shrubs, and pollinator species were also planted just off the trail. These will add diversity, habitat, and beauty to the trail as they grow. The crew also created a brush pile and insect hotel on the donated woodlot. Due to their proximity to the trail, they serve more as demonstration structures for future staff or anyone else interested in making them.

Figure 42. The donated woodlot property where a trail is under construction. The pins mark the locations of the insect hotel and demo brush pile, the blue is the stream.

4 Monitoring and Assessments

4.1 Stream Assessments

Stream assessments are a useful way to monitor what is happening in the Watershed. With the information they provide, we can begin working to correct any urgent issues. Most issues cannot be assessed from a roadside and require the crew to walk along the stream with a GPS, camera, and notebook to record the conditions. This includes blockages, beaver activity, buffer zone violations, erosion, siltation deposits, wildlife signs, substrate composition, and any other notable features. All data is entered into an Excel sheet and waypoints are uploaded to Google Earth. From here we plan the next step. For example, if there was a buffer zone violation, we would contact the landowner and work with them to correct the issue.

This year, stream assessments were performed along the main river and other branches, shown in Figure 43. There were 153 waypoints taken during stream assessments this season, and some of the things marked included erosion sites, blockages, beaver activity, fish habitat, future brush mat sites, areas that could use tree planting, and wildlife sightings (e.g., Wood Frog, Muskrat, and Brook Trout).

Figure 43. Locations of 2019 stream assessments.

Figure 44. Stream assessment along Vanco Branch in November 2019.

4.2 Headwater Surveys

4.2.1 Introduction

Headwater surveys give an indication of where streams are experiencing dry conditions. The headwater streams are assessed visually and classified into 1 of 5 categories to document changes in surface water connectivity and water velocity throughout the length of the stream. By obtaining this data year after year, it aids in understanding how water extraction and other conditions affect water levels and flow.

4.2.2 Methods

Headwater surveys must be conducted between May 1-15 and September 1-15, without any significant rainfall or snowmelt events occurring in the previous 3 days. Sections of the stream are classified into 1 of 5 categories based on a visual assessment: 0 – no surface water, 1 – surface water in pools only, 2 – surface water present but no visible flow, 3 – flow only interstitial, 4 – surface flow continuous.

This year, headwater surveys were performed along the Affleck, Brackley, Island Coastal, and Piper's Creek branches, in May and September. The map below shows the 2019 sites. Staff walked up headwater streams until they reached a point that was dry or until the most upstream point was reached. Along the way, GPS points were taken as the streambed shifted into each of the 5 categories. Photos were taken at each point, and notes recorded in a field book.

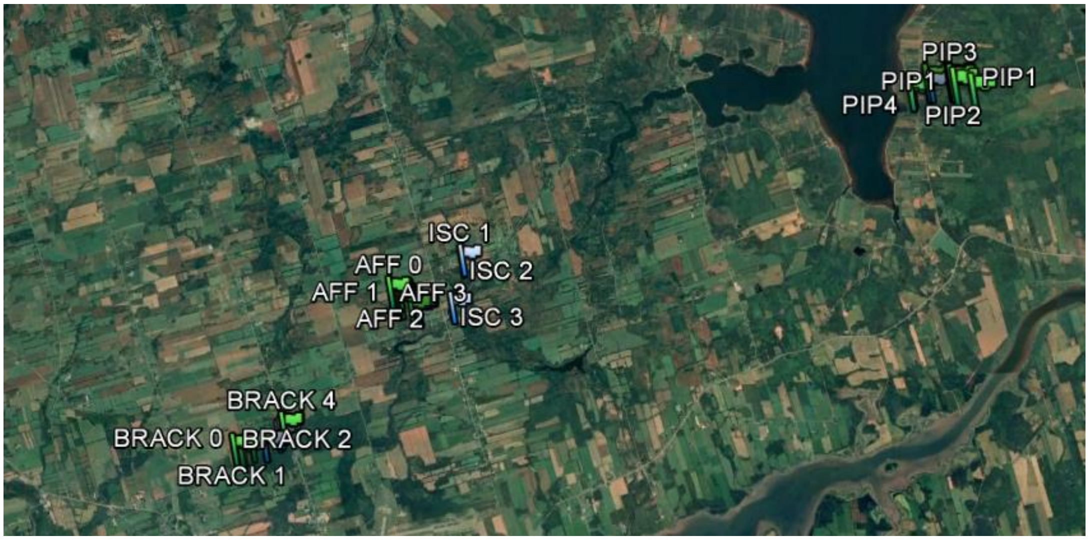


Figure 45. 2019 headwater survey locations. Surveys were completed in both May (green flags) and September (blue flags), at Brackley, Affleck, Island Coastal, and Piper's Creek branches.

Figure 46. Left: May headwater survey along Brackley branch. This is an example of a Category 1. Right: September headwater survey along Brackley branch. This is an example of a Category 0, where the headwater dries up.

4.2.3 Results & Discussion

The location at which each of the 5 categories occurs provides useful information for determining stream health. It provides data on approximately when and at which points the streams go dry, from which seasonal comparisons of spring upwelling can be made. These surveys also provide important data for streams near high-capacity wells.

Generally, streams are drier in the fall, after a season of heat, than in the spring. At the Affleck branch, the distance to a Category 0, or dry streambed, was far less in September than it was in May (see Figure 47). The same was found at the Brackley branch. For the September survey at Piper's Creek, the crew ran out of time within the acceptable dates/weather conditions to finish the survey, so the exact point at which the Category 0 occurs is unknown. The Island Coastal branch was only surveyed in September this year.

This year, 2 of the branches surveyed were less dry than previous years, and 1 had an additional section go dry. The Brackley branch had much less stream go dry this year than in previous years, only about half the distance it did in 2018. This is the closest stream to the Union Pumping Station and has historically gone dry for long periods of time. The amount of dry stream for the Island Coastal branch showed a dramatic drop, with 1244 m less than the last time it was surveyed in 2016. The 2019 value was only 3% of the 2016 distance. The Affleck branch had a greater distance of stream go dry in 2019 than 2018, increasing by 108 m. This was the first year of headwater data collection for Piper's Creek. It is important to note that this was a particularly wet year and should be considered when comparing year-over-year data.

Table 25. Summary of headwater survey results from the past 4 years at the 2019 sites.

	Distance of Dry Stream (m)					
Tributary Name	**2016**	**2017**	**2018**	**2019**	**# Springs mapped on branch**	**Approximate Distance to Wells (m)**
Brackley	3,295	2,285	2,369	1,195	28	1,000
Affleck			450	558	8	1,900
Island Coastal	1,284			40	3	3,850
Piper's Creek				600	12	9,800

Figure 47. Affleck branch headwater survey in May (green flags) and September (blue flags) 2019.

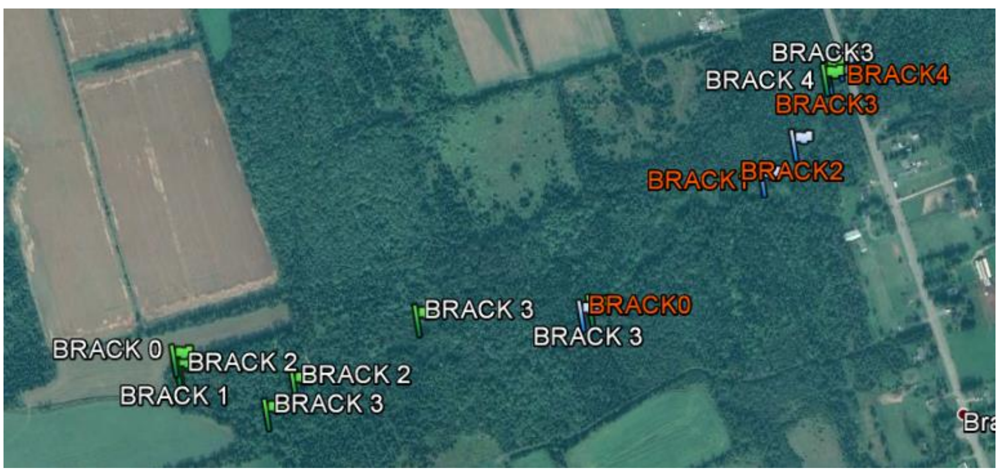


Figure 48. Brackley branch headwater survey in May (green flags) and September (blue flags) 2019.

4.3 Groundwater Monitoring

4.3.1 Introduction & Methods

Groundwater monitoring surveys are useful for determining where variability in nitrate levels occurs. This can indicate problem areas with high nitrate inputs. The streams monitored this year included Friston Main, Friston North, Black River, and Beaton's Creek. These were checked in October and November, following GPS points from previous years. A survey was also completed in May for Black River.

For this survey, staff walked along streams with a YSI Professional Plus and Garmin GPSMap 64s GPS unit, stopping at marked locations with springs. At each site, a reading was taken with the YSI, and if nitrates read unusually high (e.g., over 6 mg/L), a water sample was also taken for testing by the PEI Analytical Lab. Readings were also taken every few hundred meters along the river to monitor contrasts between the springs and the main channel. The values measured in the field with the YSI were then compared with the values reported back from the lab to provide an accuracy benchmark.

Figure 49. YSI reading being taken at a spring along Black River for groundwater monitoring survey.

4.3.2 Results

This year, 56 sample points were assessed with the YSI for groundwater monitoring surveys. YSI readings were under 6 mg/L 86% of the time nitrates were measured (the YSI loaned to us from DFO for a period in late July and August did not have a nitrate probe). There were 9 times the nitrate reading was higher than 6 mg/L, but values were usually under 10 mg/L. The average reading was 3.51 mg/L, and the median 3.02 mg/L.

In May, 5 samples were taken to the lab to be tested for nitrates, and 3 in October. In the first set, the highest value that came back was 6.3 mg/L. There were springs with nitrate values reading as high as 8.40 mg/L for the second set in the fall. Our YSI showed close accuracy with the lab values at most sites measured.

4.3.3 Discussion

The natural level of nitrates in ground water is a few milligrams per litre, with exact numbers depending on soil type. Changes in land use, increased use of artificial fertilizers, and waste disposal are key factors that have raised the level of nitrates present in groundwater worldwide over the past few decades (WHO, 2011). The maximum level considered safe for drinking water is 10 mg/L in Canada (Health Canada, 2014). When there are high levels of nitrates in drinking water, it interferes with the ability of blood to carry oxygen when converted to nitrites (McCasland et al., 2020).

Concentrations over 10 mg/L also have a negative effect on freshwater environments. Sensitive species, such as salmon, have recommended levels around 0.06 mg/L (Behar, 1997). However, typically the effect on fish and aquatic insects is indirect—the increased levels of nitrates cause excessive growth of plants and algae in the water. This growth can lead to eutrophication and anoxic events, which can have detrimental effects on fish and their communities (for more detail, see section 4.12.4 Dissolved Oxygen Loggers & Estuary Discussion). We also found nitrates approaching or at the 10 mg/L mark with the YSI, which may be cause for concern if readings this high are a common occurrence.

There were a few issues with nitrate readings this field season. For a brief period in the spring, there was an issue where one of the probe ports was stripped and allowed water to get into the YSI unit, yielding some unreliable data. The unit was sent away for repairs and the issue resolved. In the fall, as the field season was ending, the nitrate probe displayed some end-of-life issues, where the accuracy slowly tapered off.

4.4 Soil Sampling

4.4.1 Introduction

Soil sampling is a practice that is beneficial to both farmers and the environment. Fertilizers are a major cost when producing crops and have the potential to cause environmental damage. Knowing the soil's nutrient and mineral content prior to application helps avoid over-fertilizing. By testing soil in a field prior to the planting season, the nutrient and lime requirements can be determined to maximize crop yields, save money, and reduce environmental harm for the upcoming growing season.

Several soil samples were taken mid-October from various agricultural fields throughout the watershed. These were then processed by the PEI Analytical Lab and are a great aid in assessing soil health. With the detailed reports they send back, a baseline of soil nutrient composition can be provided to farmers and lead to more precise and cost-effective soil amendment applications.

Figure 50. Vanessa and Brittany taking a soil sample from a potato field.

4.4.2 Methods

Soil sampling was performed in late fall in order to predict the field's requirements for the upcoming growing season. Tools used for soil sampling included: a shovel, bucket, and notebook. At each field, 4-6 sampling points were chosen in a zigzag formation, based on the size and shape of the field. Areas to be avoided for sampling included tire tracks and areas of low elevation with respect to the rest of the field, as these would not represent the soil of the field as a whole.

At each sampling point vegetation was kicked off the soil surface, and a square hole was dug. A slice was taken from one side of the hole, the width of the shovel (roughly 8 inches), by about 1 inch thick and 6 inches deep, and placed in the bucket. Once soil was taken from each sampling point for that field, it was thoroughly mixed in the bucket and 2 small bags were filled, provided by the PEI Analytical Lab, 1 to be tested for soil chemistry and the other for soil health.

4.4.3 Discussion

There were 2 sets of analyses performed by the PEI Analytical lab, testing different components of the soil. The first provided a Soil Analysis Report, checking the levels of organic matter, pH, phosphate, potash, calcium, magnesium, boron, copper, zinc, sulfur, manganese, iron, sodium, aluminum, and lime in the soil. The report they send back also provides a recommendation of how much limestone to apply to achieve the desired pH, and how much nitrogen, phosphate, and potash to apply per hectare/acre based on the conditions of the field.

The second yielded a Soil Health Test Report. This details the soil texture (percent sand, silt, and clay), organic matter, active carbon, soil respiration, aggregate stability, biological nitrogen availability, pH, and indices for phosphorous, carbon, and nitrogen levels. From these values, a score out of 100 is assigned, and the field is given a rating from high to low in each of the test categories. Below is a figure describing the rating system.

Rating	Interpretation
Low (0-25)	The "Low" rating means the test value is among the lowest 25% for all sites sampled across PEI and may be limiting the productivity of the system. Short and long term management strategies should be implemented to build up the soil health within the field.
Low+ (26-50)	The "Low +" rating means the test value is below average of all sites sampled across PEI. Review management practices and consider including additional short and long term management. Re-test again after one full rotation to determine if the field is trending towards improvement or decline.
Medium (51-75)	The "Medium" rating means the test value is above average of all sites sampled across PEI. Consider which practices are currently working on the farm and where areas for improvement may exist. Prioritize this against the status of other tests and fields reported to determine where resources and time should be spent.
High (76-100)	The "High" rating means the test value is among the top 25% of all sites sampled across PEI. Consider field history and previous management practices to identify ways of maintaining the strong rating. If making changes to cropping practices, consider how it may affect soil health and in this event, plan future re-sampling to observe changes or trends. Focus management strategies on other lower-rated soil health test results if they exist.

Figure 51. The rating system used to characterize field health, from the PEI Analytical Lab Soil Health Test Report. The categories rated include: Organic Matter, Active Carbon, Soil Respiration, Aggregate Stability, and Biological Nitrogen Availability.

4.5 Crop Data

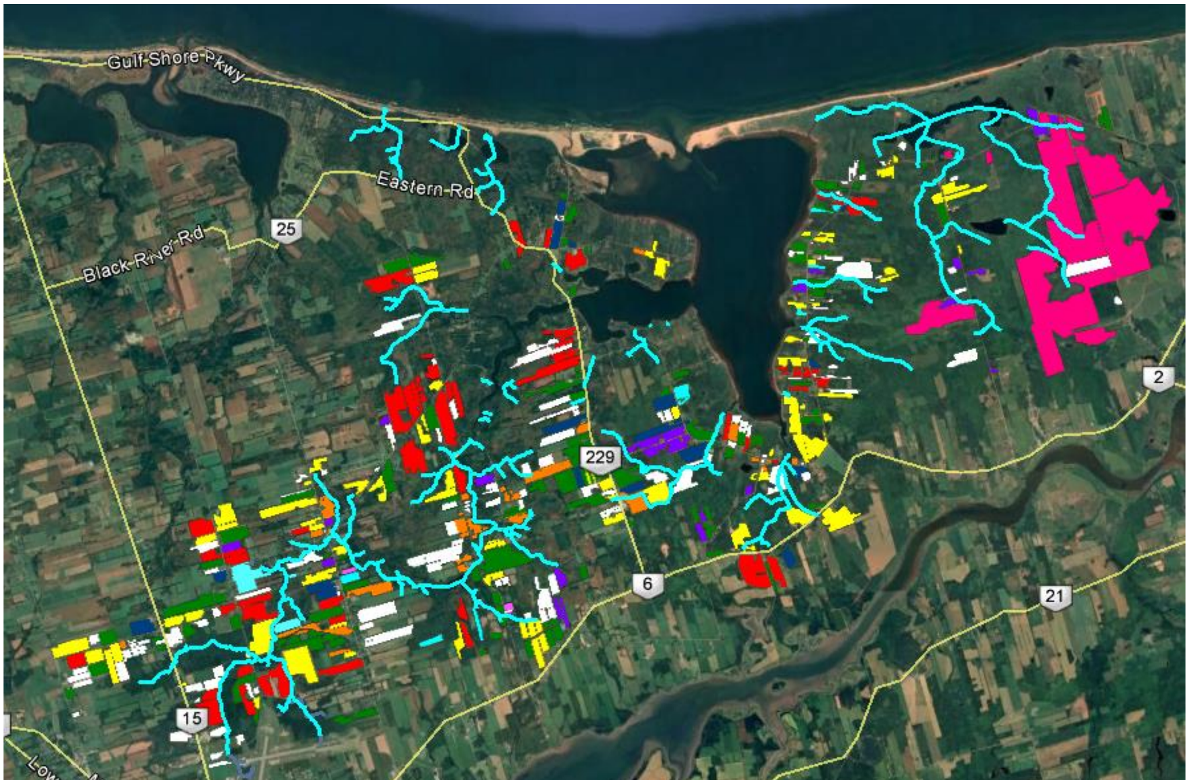
4.5.1 Introduction & Methods

During the 2019 growing season Trent and Evan ventured around the watershed to record what was growing in the agricultural fields visible from public roads. Once all fields had been checked, the data was transferred to a Google Earth map, where the fields were labelled and colour coded by crop type. This information can be used to determine which crops occupy the most land within the watershed, how land use changes over time, and provides foresight for areas that may pose problems in the next field season.

Figure 52. A field of buckwheat recorded within the watershed.

4.5.2 Results & Discussion

Below is a map of the agricultural lands within our Watershed area. Over the years, data can be compared to see changes in crop rotations, field usage and size. In recent years, a lot of fields have been joined to make larger fields, and several hedgerows have been removed. Hedgerows are important both from wildlife habitat and soil stability perspectives. They catch soil that is moved by wind and water, keeping it on the field and out of our waterways. Hedgerows also provide wind breaks, shade, and refuge areas for wildlife to rest or evade predators as they travel between otherwise disconnected pieces of habitat.



Crop	Hay	Grain	Potato	Corn	Soy	Pasture	Perennial	Other
Color	Green	Yellow	Red	Blue	Purple	Orange	Pink	Aqua

Figure 53. Map of 2019 crops growing in Winter River – Tracadie Bay watershed, each color represents the crop type for that piece of land.

4.6 Redd Surveys

4.6.1 Introduction

Redd surveys are completed around the end of October to late November, when Brook Trout are spawning (there are no longer Atlantic Salmon in our Watershed). Brook Trout typically choose sites near springs to spawn, where the temperature is fairly consistent, near 7-8°C, and there is coarse substrate (e.g. cobble and gravel) (Franssen, 2011). The fish make a nest in the stream bed by pushing their tail side to side to move rocks around and dig away fine sediment. This is where they deposit their eggs. When looking into the stream, the redd appears as a lighter patch (often reddish in colour) in the stream bed, and you can see overturned rocks.

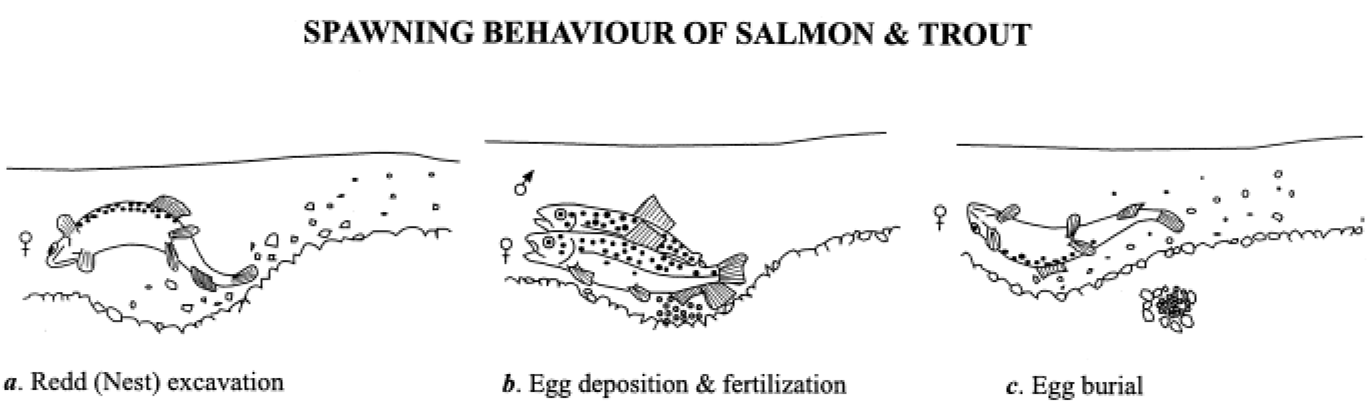


Figure 54. Diagram showing the redd formation process used by Brook Trout (sourced from Soulsby et al., 2001).

4.6.2 Methods

Staff walk the length of streams where it is probable to find Brook Trout redds, areas with good habitat or previous years' evidence. When a redd is located, a GPS waypoint is marked, a photo taken, and notes are made regarding its size, available cover, the presence of fish, etc. Polarized glasses are used to cut the glare and allow easier viewing of the stream bed. Redd data is then entered into an Excel sheet and uploaded to Google Earth every year to compare changes in timing, abundance, and location choices over time. Though useful, these surveys can prove to be very subjective since, depending on experience level, it's easy to overestimate or underestimate the actual number of redds.

4.6.3 Results & Discussion

Unfortunately, we were unable again this year to complete redd surveys because the water was too murky; there was no visibility of the stream bottom. That time of year has quite frequent rainfall, and we suspect that soil erosion into the stream is a key factor for the poor visibility. We are looking at ways to correct this issue. Streambeds with high levels of fine sediment in the areas where spawning or incubation occur can have a negative impact on fish reproductive success. It can lead to silt infiltration in the nest over the winter months, collecting around the eggs and limiting the amount of oxygen available to the developing embryos (Franssen, 2011).

4.7 Beaver Management

4.7.1 Introduction

WRTBWA has a beaver management plan for the main branch of the Winter River. This plan was put in place to prevent beavers from blocking important fish passage and reducing water quality and quantity. While the main branch is a beaver-free zone, beavers are permitted on the side branches from the river. Every spring and fall the staff performs beaver assessments of the main branch, walking along the streams and checking for any beaver signs. This could include beaver trails, chew marks on trees, or the presence of a lodge or dam. Any beavers located in the beaver-free zone are to be trapped by local trappers. We try to have this completed within trapping season, so the beaver pelt is of value and not wasted. However, if the beaver is creating a problem in the off season, it will be removed. Figure 55 below shows all marked beaver locations found in fall 2019.

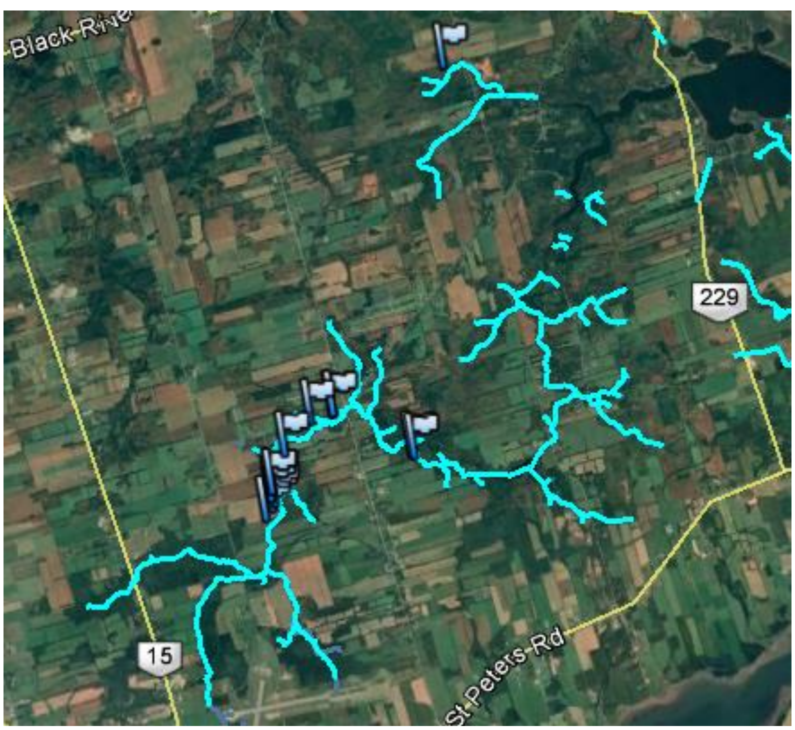


Figure 55. Locations where signs of beaver activity were found in 2019.

Figure 56. Beaver lodge below Hardy Mill Pond and flooding of the area in November 2019.

Figure 57. Left: Beaver dam on main branch of Winter River below Hardy Mill Pond before work. Right: the dam after opening it up for fish passage, December 2019.

4.7.2 Methods

A local trapper was hired in November to trap out beavers in the beaver-free zone below Hardy Mill Pond, on the main course of the Winter River. Shortly after trapping began, the beaver dam was notched, where a small section of the dam was removed to allow water to flow. If there were any more beavers in the area, they would be attracted to the sound of the flowing water and come to patch up the hole. If the hole was not patched up on our next visit, it was safe to assume all the beavers had been trapped out. After checking on the dam and finding it unrepaired, beaver hacks and saws were used to loosen up the dam and remove the intertwined sticks and muddy debris the beavers used as building materials. This allowed for better fish passage until more work can be done to fully remove the dam.

4.7.3 Results & Discussion

Beavers can have a number of impacts on fish and stream health, both positive and negative. They can greatly alter habitat in a short period of time, influence stream discharge, and affect water temperature (Pollock et al., 2003). The ponds created by dams provide habitat for wetland species but can impede fish migration upstream and downstream. Dams also flood out forested riparian zones and act as a holding place for shallow water, allowing it to warm.

Balance is important, which is why our Watershed Management Plan includes a beaver-free zone for areas where dams would impede fish passage along important spawning routes. American Eel, Rainbow Smelt, Gaspereau, and sea run Brook Trout spend part of their life at sea, and the other part in freshwater systems, relying on open passage to migrate between them. Beaver dams can also block fish from seeking out cooler water at springs during warm summer conditions. Brook Trout, for example, cannot survive temperatures at or above 23°C, and higher temperatures have been recorded in the ponds in the watershed.

In total, 4 beavers were trapped below Hardy Mill Pond, and the dam was partially deconstructed in early December to allow for better fish passage. The remainder can be removed next field season as the weather becomes more favorable.

4.8 Culvert Assessments

4.8.1 Introduction

Culvert assessments were undertaken at 11 culverts within the Watershed this year, from late September to early November. These surveys were performed by Vanessa, Evan, and Brittany. Prior culvert assessments have been completed since 2015 (Part 1 and Part 2), but the 2019 set (Part 3) provided additional information to assess our most at-risk culverts that should be replaced. In March, Sarah attended a fish passage workshop on culvert assessment. This was the first half of a workshop series with the NSLC Adopt a Stream Program. Sarah and Brittany attended the second half of the workshop, focusing on fish passage improvement strategies, in September.

This workshop was presented by Will Daniels, a habitat restoration and fish passage specialist, and provided great information for assessing and improving problematic culverts. The goal was to provide various tools and techniques for improving fish passage that are low cost and low complexity. Options for culvert remediation include the installation or an outflow chute, tail water control modification, or baffles (see Figure 58). When a culvert is undersized, the only remediation option is replacement. Where possible, the best solution is to replace culverts that are posing a barrier to fish passage, as improvement modifications are only a short-term solution.

Culverts causing passage barriers limit the level of aquatic connectivity throughout the Watershed. Aquatic connectivity refers to how much movement can occur within the aquatic ecosystem. It is important to both residential and migrating fish species, as it dictates their access to seasonal and spawning habitat, cold water refuges, food sources, and opportunities to evade predators. Systems with little connectivity are limited in their levels of biodiversity and flows of nutrients, organic matter, sediment, and water.

Figure 58. Example of an outflow chute and baffles installed in a box culvert in Nova Scotia, from NSLC Adopt a Stream Fish Passage Workshop materials.

4.8.2 Field Survey Methods

The majority of culverts assessed were arches with wooden bottoms, but there were also circular corrugated metal pipes, a plastic corrugated pipe, and a concrete box culvert. The equipment used for culvert assessments included data sheets (see Appendix 1 in section 7.1), clipboard, pencil, calculator, GPS, camera, spare batteries, tripod, surveyor level and rod, 30 m tape measure, meter stick, thermometer, YSI, flashlight, and tennis balls.

First, a "Rapid Assessment" checklist was completed to determine whether to continue with a full assessment. This included questions regarding the depth of water in the culvert, how backwatered the culvert was, and if there was a visible outflow drop. Every culvert surveyed this fall needed a full assessment.

Visual qualities were noted, including the culvert material, shape, entrance type, bottom material, the presence/absence of baffles, and any signs of deformation or deterioration. The upstream substrate composition (fines, gravel, cobble, etc.), percent backwatered, degree of embedment, evidence of beaver damming, and presence of fish were also recorded. Photos were taken toward the inflow, toward the outflow, looking upstream, looking downstream, and through the culvert from both the upstream and downstream ends for our records.

Figure 59. Culvert Assessment at PU-028 (Friston South), checking that the surveyor's level can see all necessary downstream points before final adjustments to the equipment. This culvert is an example of an arch with a wood bottom and headwall.

The culvert dimensions were recorded, including the width and height at the opening, the width and height of the corrugations, culvert length, and depth of water in the culvert. YSI readings were taken for temperature, pH, dissolved oxygen, and conductivity. The velocity was measured using the tennis ball method over a set distance (usually 3 m if the stream conditions would allow).

Upstream, the wetted and bankfull widths were measured at the nearest pool, riffle, and run, to obtain a stream width ratio. Other measurements taken included the distance from the upstream riffle to inflow invert, plunge pool bankfull width, outflow to tailwater control, and tailwater control to second riffle downstream.

The level was set up in a location whereas many elevation measurements as possible could be read without moving to a new sighting location (called turning points); the fewer turning points, the less chance of error when taking readings throughout the site. Upstream of the culvert, elevation measurements were taken at the culvert inflow and crest of the first riffle upstream. Downstream was a little more complex, with measurements at the culvert outflow, plunge pool surface and bottom, first riffle after the outflow (called the tailwater control), and crest of the second riffle. On the downstream side, at the tailwater control, a cross section of 6 equally spaced elevation readings were taken from left to right along the bankfull width.

After all field measurements were taken, calculations were completed back in the office and values were put into the stream analysis software FishXing. FishXing uses a model to predict fish passage rates for given culvert scenarios.

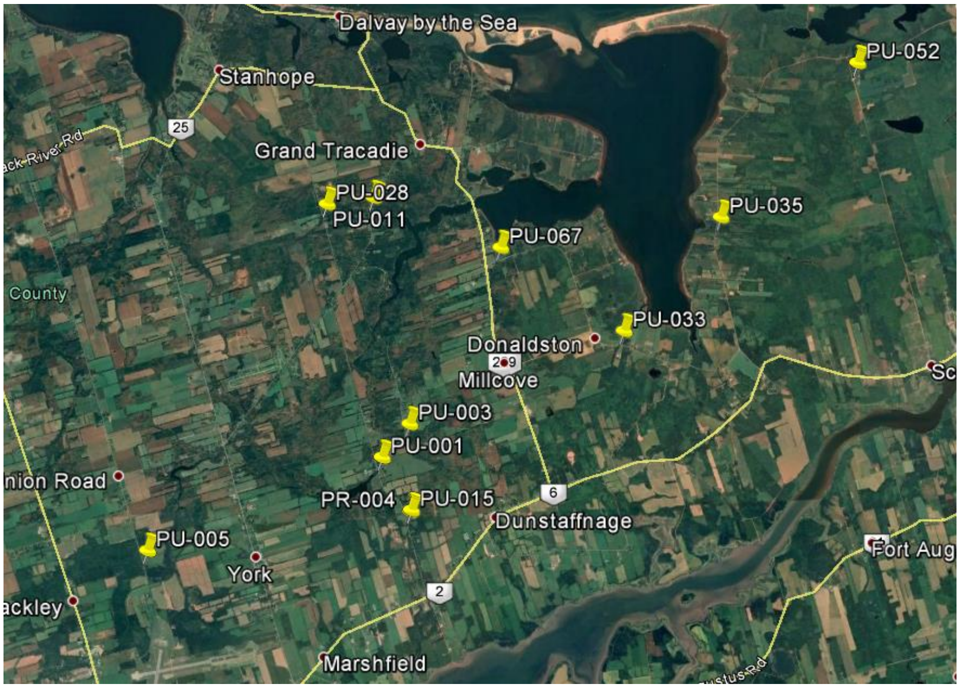


Figure 60. Part 3 culvert assessment locations, 2019.

4.8.3 FishXing Methods

The culvert parameters measured in the field were entered into software called FishXing. FishXing was created for evaluating and designing culverts for successful fish passage, using culvert hydraulics and fish performance values in their calculations. With our culvert measurement inputs, FishXing gives output values indicating a culvert's passable ability for different scenarios.

The culvert slope, outflow drop, and up- and downstream channel slopes were calculated from data collected in the field. These values, along with species-specific fish abilities, were put into FishXing to establish a ranking of fish passage for each of the culverts. We used Gaspereau as the target species for culvert passable ability, and our methodology for using FishXing can be found in 0: Appendix 2. Maps on Google Earth were used to determine the catchment area for each culvert assessed, which in turn were used to calculate the high and low flow rates experienced by the culverts. Documents from a prior culvert replacement project within the PEI National Park were used as a guide while figuring out the software (Giroux et al., 2014).

4.8.4 Results

From FishXing, barriers were determined for both high and low flow situations. It assessed the following types of barriers: depth, outlet drop, velocity, pool depth, and fish exhaustion at burst speed. Depth was a barrier at all culverts surveyed. The next most common barrier to fish passage was an outlet drop. The table below summarizes the barrier data. The culvert surveyed with the largest catchment area was PU-001, below Officer's Pond, at 35.7 km^2. The smallest was the combined culvert of PR-004 and PU-015 on Suffolk Road, at 1.18 km^2. The culvert PU-005 on the Brackley branch is the furthest distance to the ocean and is tied for the greatest number of road crossings to get there, with 2, but it does have one of the higher amounts of upstream habitat. The culverts that are closest and with the fewest crossings are PU-067 and PU-035, however they have a smaller amount of upstream habitat available. A summary of the data can be found in the tables below. Additional site information can be found in Appendix 4, in section 7.4.

Table 26. Fish passage barriers determined by FishXing for 2019 culvert assessments. Check marks indicate the presence of a barrier, X indicates conditions listed as "not a barrier," categories with numerical values are only barriers within the specified flows (given in cubic meters per second).

Culvert		Total # Barriers	Barrier Type									
			Depth		Outlet Drop		Velocity		Exhausted at Burst		Pool Depth	
Culvert ID	Stream Name		Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
PR-004	Wheatley	4	✓	✓	✓	✓	×	×			×	×
PU-001	Officers	2	✓	✓	×	×	0.45 cms to 17.27 cms				×	×
PU-003	Mazer South	4	✓	✓	✓	✓	×	×			×	×
PU-005	Brackley	2	✓	✓	×	×	×	×			×	×
PU-011	Friston Main	2	✓	✓	×	×	×	×			×	×
PU-015	Wheatley	4	✓	✓	×	×	0.04 cms to 4.48 cms		✓	✓	×	×
PU-028	Friston South	4	✓	✓	×	×	0.03 cms to 2.65 cms		✓	✓	×	×
PU-033	Black River	4	✓	✓	✓	✓	0.07 cms to 4.48 cms				×	×
PU-035	Pipers Creek	2	✓	✓	×	×	×	×			×	×
PU-052A	Afton	2	✓	✓	×	×	×	×			×	×
PU-052B	Afton	4	✓	✓	✓	✓	0.08 cms to 4.98 cms				0.05 to 0.08 cms	
PU-067	Peters Creek	6	✓	✓	✓	✓	×	×			✓	✓
		Total # Culverts with Barrier Type	**12**	**12**	**5**	**5**	**0**	**0**	**2**	**2**	**1**	**1**

*Table 27. Recommended improvements from the NSLC Adopt a Stream Fish Passage Workshop materials. (Only applicable to culverts under 20 m in length.) TWCE=tailwater control elevation, OFD=outflow drop. *Modifications depend on site conditions.*

OUTFLOW DROP AND BACKWATERING	CULVERT SLOPE		
	0%-0.5%	0.5%-2.5%	2.5%+
TWCE-Inflow = >0.15m & OFD is less than 0m	Outflow Chute	Outflow Chute	Outflow Chute
OFD=>0m-0.3m	Outflow Chute	Outflow Chute and Vertical Slot Baffles	Replacement
OFD=0.3m-0.45m	Outflow Chute & Tailwater Modification*	Outflow Chute, Tailwater Control Modification* & Vertical Slot Baffles	Replacement
OFD=<0.45m	Fish Ladder	Fish Ladder and Vertical Slot Baffles	Replacement

Table 28. Suggested improvements for culverts assessed in 2019, based off recommendations from NS Adopt a Stream resources

Culvert ID	Stream Name	Upstream Catchment Area (km2)	Distance to Ocean (km)	# Road Crossings	Suggested Improvement (based on measurements)
PR-004	Wheatley	1.18	9.64	1	Replacement
PU-001	Officer's	35.7	8.06	0	Outflow chute
PU-003	Mazer South	1.41	7.36	0	Outflow chute
PU-005	Brackley	7.76	16.61	2	Outflow chute
PU-011	Friston Main	7.15	2.57	0	Outflow chute & tailwater modification (depends on site conditions)
PU-015	Wheatley	1.18	9.64	1	Outflow chute & vertical slot baffles
PU-028	Friston South	3.19	3.59	1	Replacement
PU-033	Black River	7.28	1.10	0	Outflow chute & vertical slot baffles *floorboards need replacement
PU-035	Piper's Creek	4.24	0.32	0	Outflow chute
PU-052A	Afton	8.37	5.49	2	Not enough info, low priority anyway
PU-052B	Afton	8.37	5.49	2	Not enough info, low priority anyway
PU-067	Peter's Creek	1.97	0.41	0	Outflow chute & vertical slot baffles

4.8.5 Discussion

This round of assessments was completed on culverts that were already deemed the most problematic in the Watershed. With this new information, the ones in most need of replacement (and most feasible to replace) can be determined. Based on the FishXing assessment, the culverts that present the greatest number of barriers to fish passage are PU-067, PR-004/PU-015, PU-003, PU-028, PU-033, and PU-052B. Gaspereau approaching these culverts most commonly encounter a depth barrier, velocity barrier, and outlet drop.

All culverts assessed had a depth barrier. Depth barriers occur when the water in the culvert is too shallow for fish to swim through. This depth varies by species, but our calculations were based off of Gaspereau metrics. Generally, the minimum depth to allow passage is 1.5x the body thickness of the target fish species (Maine DOT, 2004). However, Gaspereau are a schooling fish, and as they migrate to spawning habitat, they require water deeper than that standard to pass as a group (FishXing, 2006). We used a minimum depth of 0.68 m for our calculations, as the U.S Fish and Wildlife Service found it to be the minimum depth for successful Gaspereau passage (USFWS, 2017).

In total, 5 sites had an outlet drop barrier. When the elevation difference between the water surface in the culvert outlet and the tailwater surface is too great, it is considered a barrier for fish passage. The calculations were based off of a maximum allowable drop of 15 cm at the outlet, which is considered a general guideline for fish passage (DFO, 2015). If tailwater pools are not of sufficient depth, they can also create a barrier; fish require a certain depth of water to build up the speed to leap into the culvert. Gaspereau can swim in quick bursts, but rarely leap (DFO, 1986). As such, drop barriers can be detrimental to their passage, cutting them off from quality spawning grounds.

If the water velocity is too high and there are no rest points for fish to take a break, they may become exhausted or simply not have the swimming power to navigate the culvert. Burst speed, the fastest a fish can swim, can only be sustained for a few seconds (Maine DOT, 2004). In FishXing, this barrier is referred to as "exhausted at burst." Enhancements, such as baffles, can both raise the water level within the culvert and provide rest stops for fish.

To determine which culverts are of highest priority to replace, a cost-benefit analysis must also be considered. This is based on the complexity of remediation, quantity and quality of upstream habitat, water quality, density of upstream water crossings, number of downstream crossings, and proximity to the ocean (NSLC Adopt a Stream, 2018). See Table 28 above.

This is an important component for prioritizing which culverts should be fixed or replaced. For example, after consulting with Will Daniels from the NSLC Adopt a Stream workshop, it was found the culvert at Mazer North (not included in Part 3 of culvert assessments) had many issues that would turn it into an expensive and laborious project.

There are both private and public barriers to this site, and a pond which reduces habitat quality, all making high input into the site less attractive. A quick and easy fix is not possible. There is too much of an outflow drop for a chute alone to fix the problem. There is no plunge pool, which does not allow fish a chance to pick up speed to enter the culvert. To help with this issue, a deeper plunge pool could be dug, or the drop could be reduced by bringing the water level up. However, there is bedrock at the outflow, preventing the creation of a plunge pool, and the stream banks are so low here that it would be expensive to build the whole bank up enough to make a difference. Because of these conditions, any solution would need to be highly engineered and customized, making it quite expensive. Due to the number of complexities, this project is not likely to happen.

With the data collected from the culvert assessments and methods learned from passage workshops, the coordinator and board members will be able to prioritize activities for the Coastal Restoration Fund projects.

4.9 Temperature Loggers

4.9.1 Introduction

There were 7 temperature loggers deployed for the 2019 field season: 2 at Hardy Mill Pond (1 at the surface and 1 at the bottom), 2 at Officer's Pond (1 at the surface and 1 at the bottom), and 1 each at the Mazer North, Mazer South, and Mazer Outlet sites. Our depth loggers also record temperature, so calculations could be done for these sites as well; Hardy Mill Pond Outlet, Officer's Pond Outlet, Winter River at Union Pumping Station, Winter River at Tim's Creek, and Beaton's Creek. The depth logger at the Apple Orchard site and temperature logger at the bottom of Officer's Pond were lost, so there is no data for these sites. The surface logger also malfunctioned at Officer's Pond, so it only provides data up to July 20th.

The Nature Conservancy of Canada uses a rating system for freshwater systems based off the mean summer temperature of the water. There are 3 categories: "Cold" for average summer temperatures less than or equal to 18°C, "Cool" for averages between 19 and 21°C, and "Warm" for averages greater than or equal to 22°C. We used this temperature class system to assess our streams.

Temperature provides an indication of stream health, and whether the conditions are hospitable for fish. Typically, water will increase its temperature in ponds, due to the greater surface area exposed to the sun's warming rays. Downstream from ponds this effect is felt as well, as the warm water from the surface is fed into the stream below, with potential to drastically increase the stream temperature. Warmer water has many effects on aquatic life, influencing growth rates, changes to community structure, and the amount of available dissolved oxygen in the water (Credit Valley Conservation, 2011). Therefore the loggers were generally set up in locations to measure the temperature of water before entering and after exiting pond systems, as well as within the pond itself.

4.9.2 Methods

This field season, 4 HOBO Pendant UA-001-08 Temperature Data Loggers, and 3 HOBO TidbiT MX Temp 400 Loggers that were borrowed from the Watershed Alliance, were used. The loggers were deployed from late June (26th and 28th) to October 7th and took a temperature reading every hour throughout this time period.

The loggers at Hardy Mill Pond and Officer's Pond were positioned in the middle of the ponds. The surface and bottom temperature loggers were both attached to a rope, with an anchor of bricks at the bottom and buoys at the top. These had to be accessed by canoe for deployment and retrieval.

Figure 62. Temperature logger retrieval in October at Hardy Mill Pond.

Figure 61. Temperature logger set up at Mazer Outlet.

Each of the Mazer temperature loggers were affixed to a piece of rebar with wire and pounded into the stream bed. The Mazer North and South loggers were located shortly after culverts, upstream of the pond, and the Mazer Outlet logger was downstream from the pond before it merges with the main channel of the Winter River. This placement was designed to capture the changes in temperature between upstream and downstream of the pond, showing how much the presence of the pond influences the temperature of the stream. (For the reasons mentioned above in section 4.8.5 Culvert Assessments Discussion, this project will not likely go through.) The depth loggers also recorded temperature, each attached to rebar that was pounded into the stream bed (a full description can be found in section 4.10 Depth Loggers). These captured temperature data from May until November.

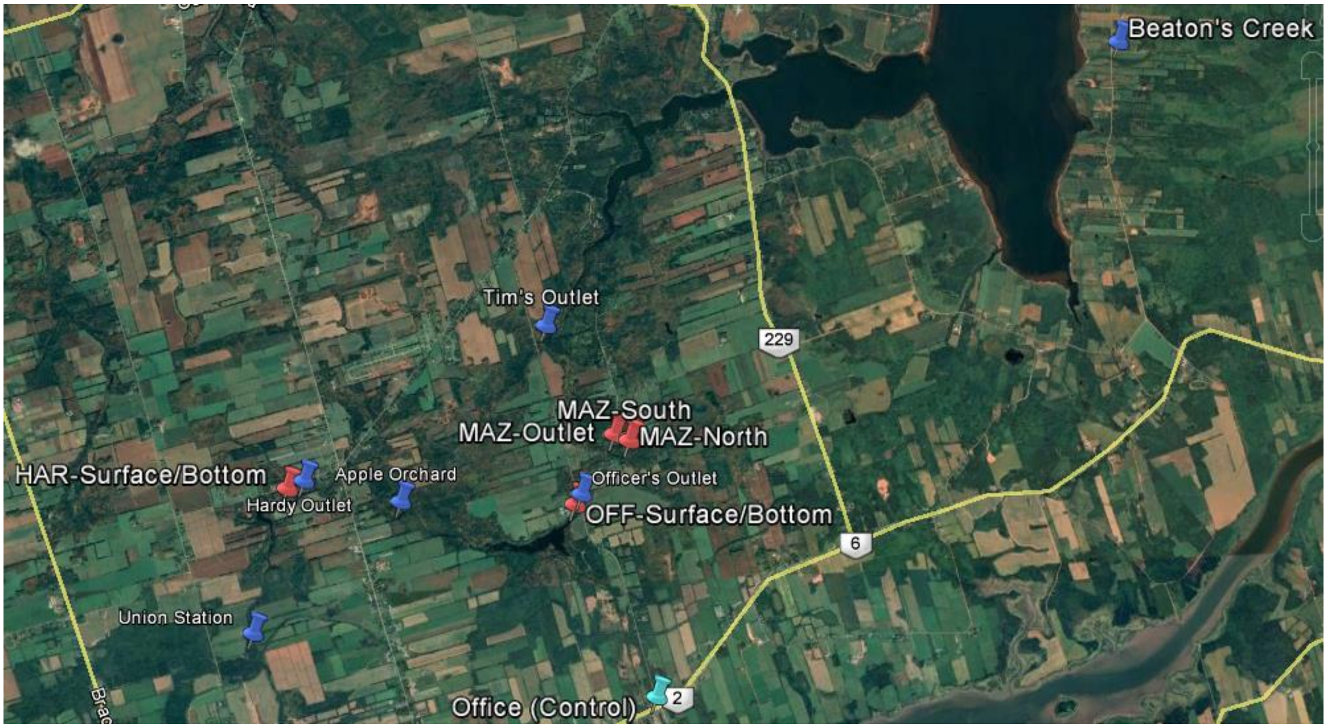


Figure 63. Locations where temperature data was recorded for the 2019 field season. Red pins are temperature loggers, blue pins are depth loggers. (HAR=Hardy Mill Pond, OFF=Officer's Pond, MAZ=Mazer).

4.9.3 Results

All depth loggers recorded temperature for the period of June 1st to August 31st, but the temperature-only loggers began near the end of June, so we are missing part of that period used to calculate temperature class. The values for these sites were calculated with the data we had. The logger at Officer's Pond Surface malfunctioned and only provided data until July 20th.

The maximum water temperatures ranged between 13.8 and 28.6°C across all sites. The highest average temperatures were recorded at the pond sites. Hardy Mill Pond's surface logger recorded the highest average summer temperature and the highest maximum temperature. The lowest temperature recorded for all sites was 0.34°C at the Officer's Pond depth logger site.

Table 29 below shows a summary of the 2019 data.

Table 29. Summary of 2019 temperature data from WRTB Watershed. Temperature classes determined according to Nature Conservancy of Canada (NCC) guidelines. Includes temperature data from both temperature loggers (TL) and depth loggers (DL).

Logger	Logging Period (days)	NCC Temperature Class	Average Temperature (°C)	Average Summer Temperature (°C)	Maximum Temperature (°C)	Longest # Hours in Stress Zone
Officer's Pond Surface TL	25	Cool	20.4	20.4	27.3	181
Officer's Outlet DL	176	Cool	15.7	19.5	23.8	356
Hardy Mill Pond Surface TL	104	Cool	18.9	20.9	28.6	238
Hardy Mill Pond Bottom TL	104	Cold	9.7	9.7	13.8	0
Hardy Mill Outlet DL	176	Cold	14.3	17.4	23.9	36
Mazer North TL	101	Cold	10.7	10.9	15.9	0
Mazer South TL	101	Cold	10.6	11.0	14.7	0
Mazer Outlet TL	101	Cold	11.1	11.6	15.1	0
Union Station DL	171	Cold	10.5	11.7	17.2	0
Beaton's Creek DL	171	Cold	12.8	15.1	20.4	4
Tim's Creek DL	171	Cold	13.3	15.7	19.2	0

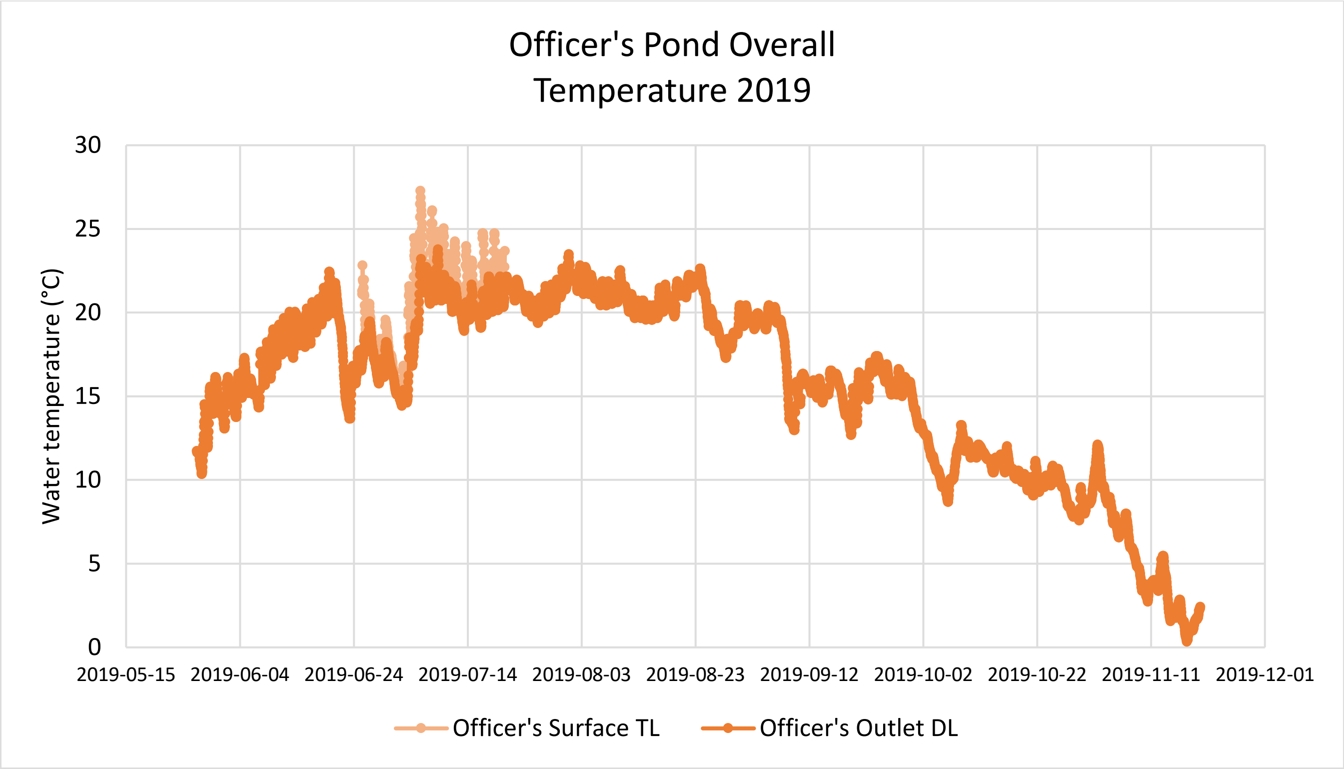


Figure 64. Officer's Pond 2019 temperature regime across all loggers.

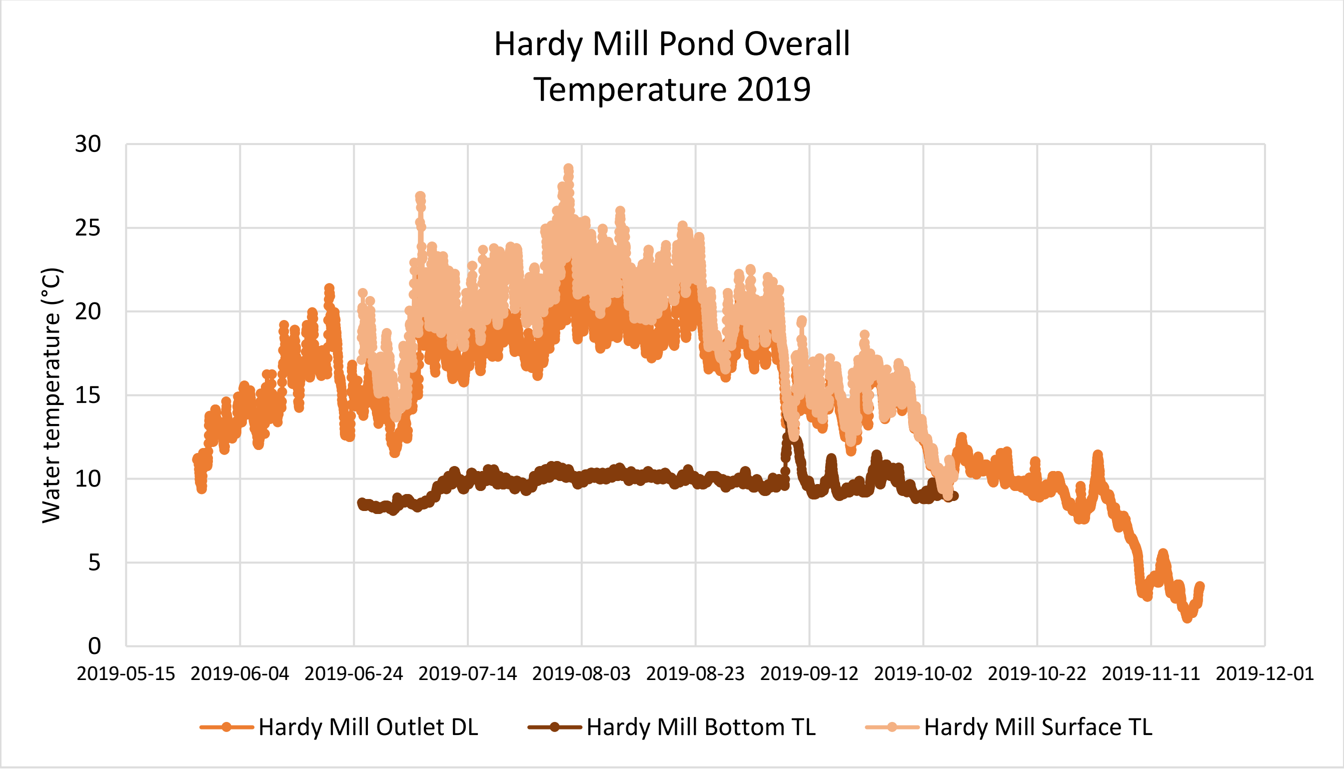


Figure 65. Hardy Mill Pond 2019 temperature regime across all loggers.

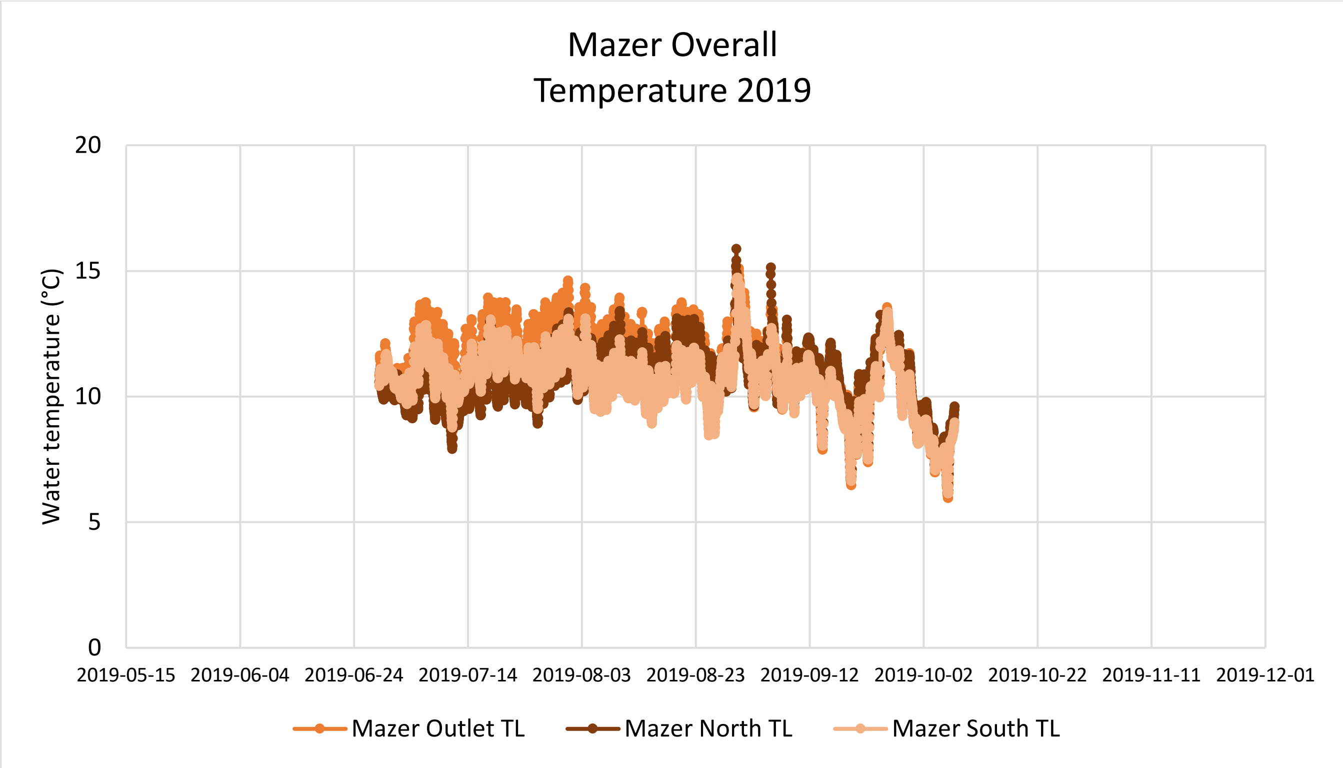


Figure 66. Mazer 2019 temperature regime across all loggers.

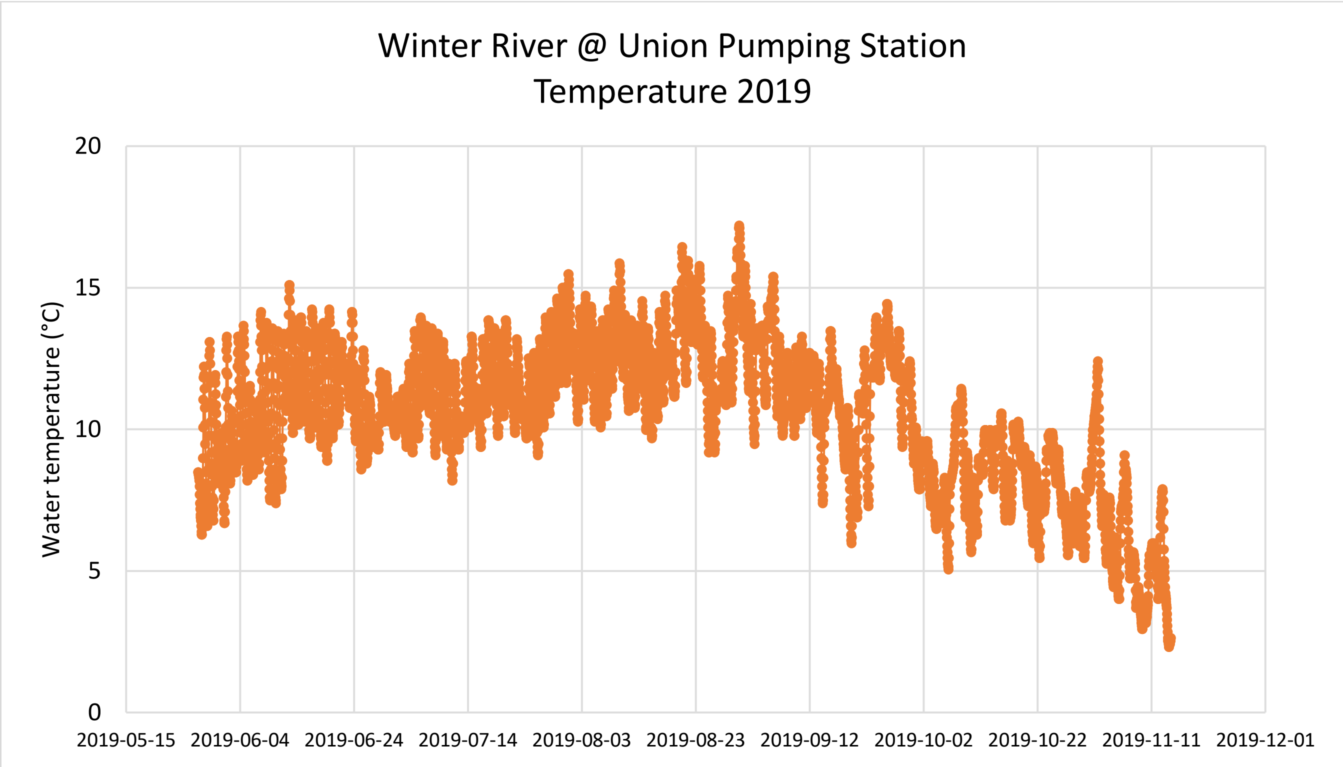


Figure 67. Temperature monitored at the Union Pumping Station depth logger, along the main channel of the Winter River, in 2019.

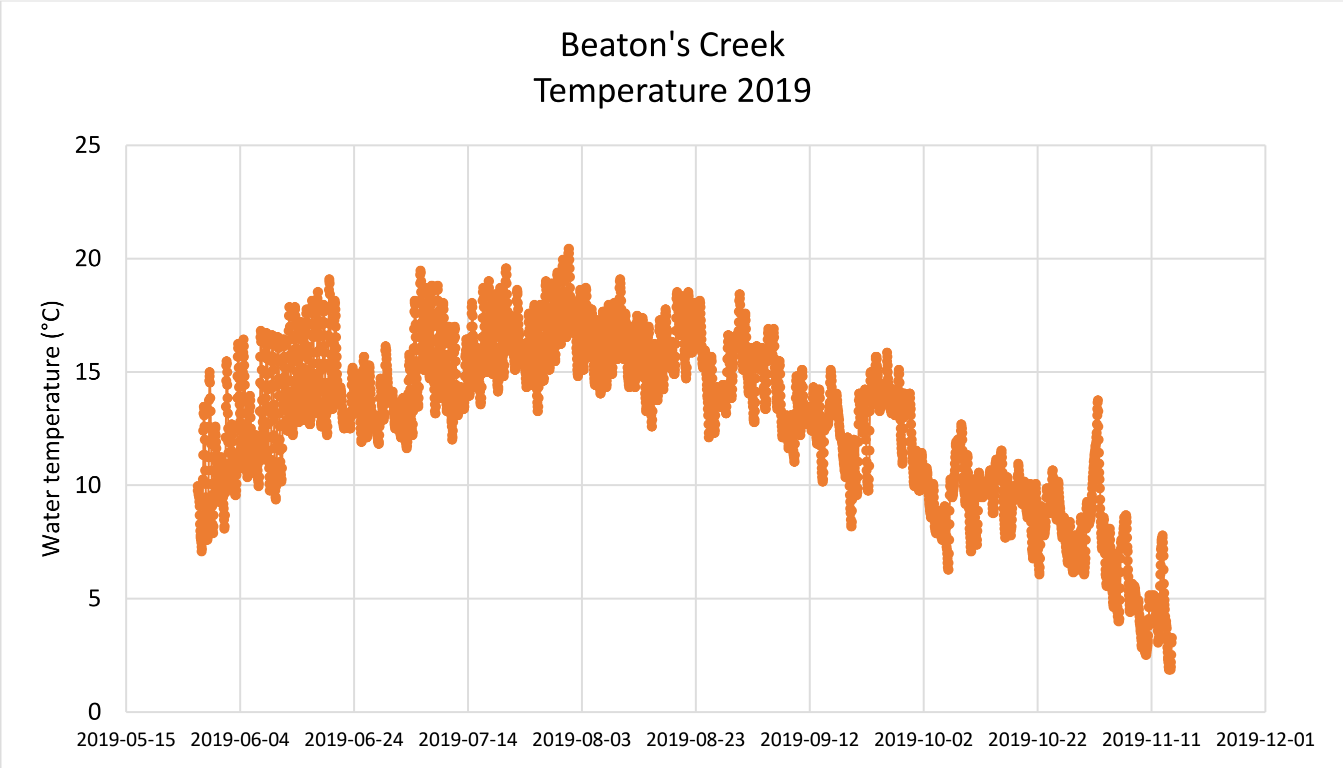


Figure 68. Temperature monitored at the depth logger at Beaton's Creek in 2019.

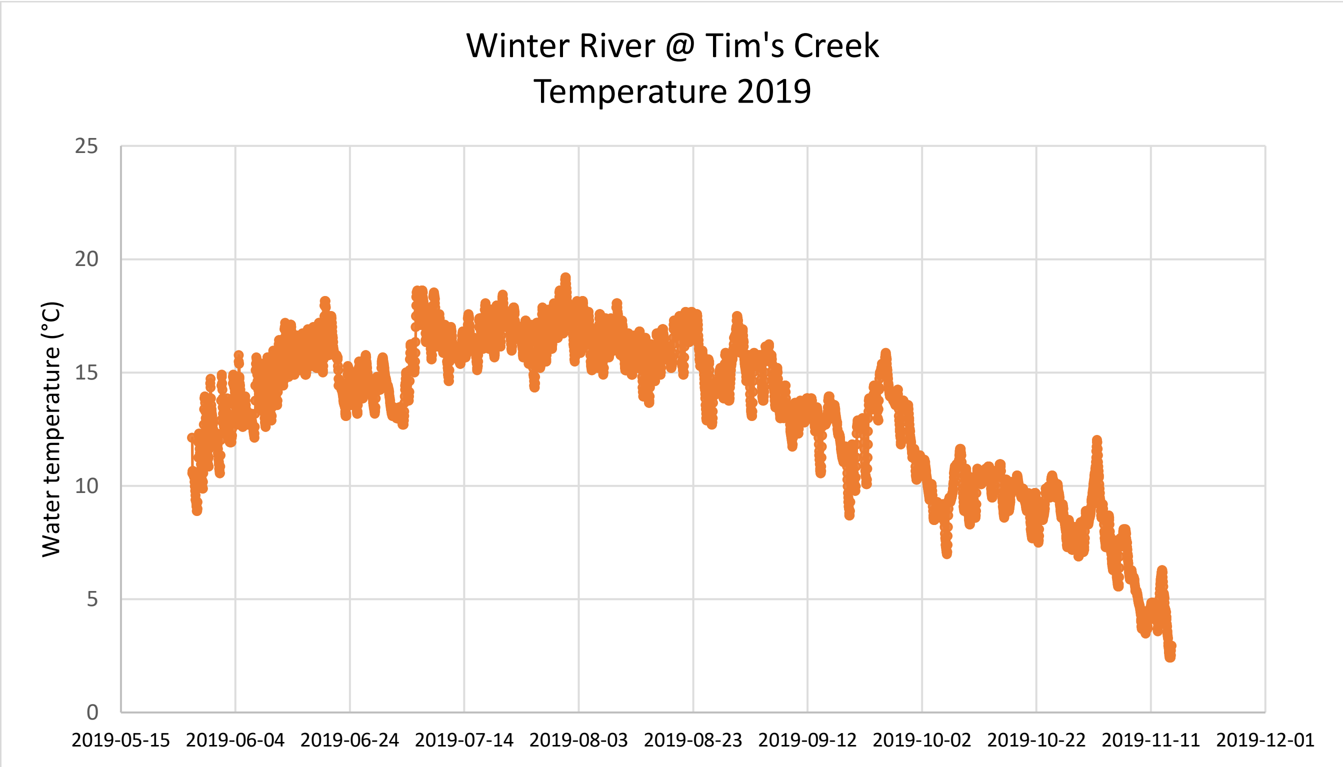


Figure 69. Temperature monitored at the Tim's Creek outlet depth logger, along the main channel of the Winter River, in 2019.

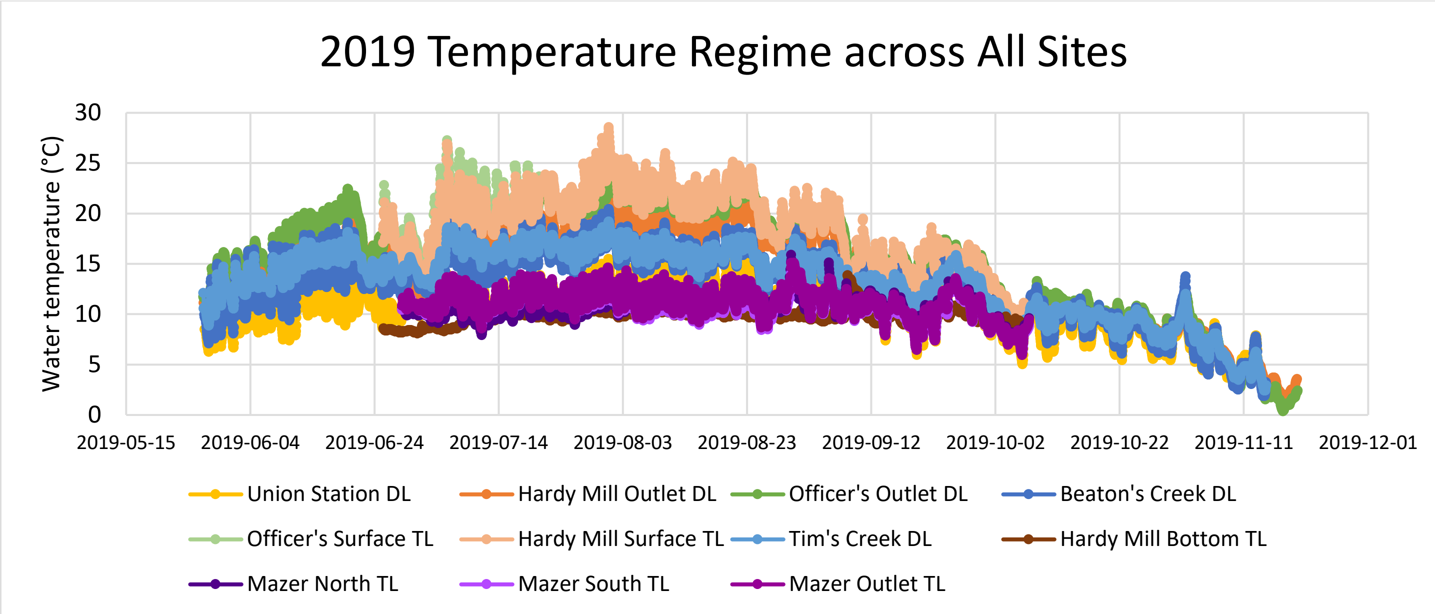


Figure 70. Temperature monitored across the Winter River – Tracadie Bay watershed for the 2019 field season, at both temperature logger (TL) and depth logger (DL) sites.

4.9.4 Discussion

Of the 7 loggers, 5 successfully captured data for their full deployment. The surface logger at Officer's Pond malfunctioned and only collected data until July 20th, and the bottom logger at Officer's Pond was lost.

Brook Trout can tolerate temperatures ranging from 0°C to 20°C, with their optimal growth occurring between 11°C and 18°C (Millar et al., 2019). Of the 11 monitoring sites, 7 were within the tolerated temperature range 100% of the time. Officer's Pond and Hardy Mill Pond were the only areas monitored that had significant time in the Stress Zone of over 20°C.

According to the NCC ranking system, none of the 2019 sites fell into the Warm category. However, there were logger malfunctions and losses that may account for this. All loggers that were placed in stream channels were ranked as Cold, with little to no time spent in the Stress Zone. The pond surfaces and outlets, however, had up to 356 consecutive hours in the Stress Zone, pushing the physiological limits of Brook Trout (Millar et al., 2019).

During the 2018 field season, temperature data was recorded at some of the same locations and may be compared. The site locations carrying over from 2018 to 2019 were the temperature loggers at Hardy Mill Pond and Officer's Pond, and the depth loggers at Union Pumping Station, Hardy Mill Outlet, Officer's Outlet, Tim's Creek, and Beaton's Creek. Most site parameters showed little difference between 2018 and 2019, but there were some that really stood out. Both years, the warmest temperatures occurred at Hardy Mill Pond, Officer's Pond, and their outlets. However, the Hardy Mill Outlet logger recorded 382 hours in the Brook Trout Stress Zone for 2018. This number dropped to 36 hours for 2019. It also showed a small decrease in average summer temperature to 17.4°C, sliding it into the Cold classification for 2019. The surface logger at Hardy Mill Pond also showed a drop in Stress Zone hours, from 847 to 238. While this is still high, at least it is an improvement from last year.

The logger at Officer's Pond outlet saw a decrease in Stress Zone hours from 833 to 356. The Officer's Pond surface logger showed differences as well, but only captured 25 days' worth of data. Despite this, there were still 181 consecutive hours, or about 7.5 days in the Stress Zone. The 2018 season had 859 hours, over the span of 133 days, for comparison. From the 2019 data, it appears that Officer's Pond has changed classifications to Cool this year, down from last year's Warm. However, since the logger at the Officer's Pond surface site malfunctioned and only recorded data midway into July, before the hottest temperatures of the summer came into effect, it's hard to say anything conclusive for the full summer. Had the logger been working normally, the data may have shown another year in the Warm classification.

At the Union Pumping Station site, the maximum temperature recorded was 5.7°C cooler than in 2018. This was the greatest temperature change between the 2 years. There were no significant changes between the 2018 and 2019 data sets for the Tim's Creek depth logger and Beaton's Creek sites. For a full comparison summary, see 7.5: Appendix 5.

During the summer months in smaller lakes and ponds, where the water is calm, it is expected that the surface water would be quite a bit warmer than the water near the bottom, due to little vertical mixing. Hardy Mill Pond displayed an example of this, with the average water temperature for the summer being 20.9°C at the surface, and a much cooler 9.7°C at the bottom. Streams that are fed by springs may also be cooler and act as refuges for Brook Trout, as they maintain a relatively constant temperature of 7-8°C. This keeps them closer to the optimal and tolerated temperature ranges (Franssen, 2011).

4.10 Depth Loggers

4.10.1 Introduction

HOBO U20L-01 Water Level Loggers were deployed in 6 locations throughout the Watershed. They were located at Beaton's Creek, the outlets of Hardy Mill Pond and Officer's Pond, and along the main branch of Winter River at the Tim's Creek, Union Pumping Station, and Apple Orchard sites. A logger was also set up outside the office as a control, about a meter above the ground. This gave a reading of the atmospheric pressure. These are the same site locations as 2018, excluding the Beaton's Creek logger, which was deployed at Friston for the first half of the 2018 field season, before moving to its current location. With the readings from the depth loggers and stream measurements taken in the field, flow values were determined for each of the sites.

Flow, or discharge, is defined as the volume of water moving past a designated point over a fixed time period (USEPA, 2012). Stream flow is affected by weather, seasonal changes, and water withdrawals. The depth logger data provides information regarding the flow of streams and how "flashy" they are. The flashiness of a stream is determined from the number of times the discharge reaches 3x that of the median flow in a season (Hawkins, 2014). In our data, the number of high flow pulses, where the flow was greater than 3x the median, was counted to compare flashiness between stream sites.

With this data, calculations were performed to determine the Richard-Baker Flashiness Index (R-B Index) of the streams as well. "The R-B Index is a measure of flow variability and flashiness. The index measures oscillation in discharge relative to total discharge, and as a result, characterizes the way a catchment processes inputs into its stream flow outputs" (Hawkins, 2014). For example, when water flows from the land into a stream during heavy rain events, if it causes a large, rapid increase in the stream's discharge each time before settling to normal, it likely has a high R-B Index value and is a flashy stream. This is typically seen in smaller streams, as larger water courses tend to absorb the input without a drastic change from the normal flow rate (Baker et al., 2004).

4.10.2 Methods

The depth loggers took readings once every hour for temperature and barometric pressure. Depth values were calculated through a comparison of the pressure the loggers were experiencing under water in the streams and the pressure readings from the logger set up outside the office (titled ATMO). This data was then analyzed in the winter and cleaned up of abnormalities due to logger malfunctions. Unfortunately, the logger set up at the Apple Orchard site was lost and no data could be retrieved from it.

The loggers were monitored weekly from their deployment at the end of May/beginning of June to their retrieval the third week of November. Each depth logger was affixed to a piece of rebar with wire looped through its cap. The rebar was then pounded into the streambed with a mallet until the logger sat level with the bottom. Every week, they would be cleared of any sediment or debris, and water quality and channel measurements would be taken.

These measurements included water chemistry, velocity, distance from bank to logger, depth at logger, wetted width, and depth measurements at every 1/6th across the wetted width. A measuring tape was stretched across the wetted width from the left to right bank (when facing downstream), and a meter stick was used to take the depth readings. The YSI was used to measure the temperature, dissolved oxygen, conductivity, pH, and nitrate levels of the water. For the period of July 22nd to August 21st, our YSI was out for maintenance, and we had a loaner unit, so the pH and nitrates could not be measured during this time.

To measure the stream's velocity, the tennis ball and wooden ball methods were used. A distance of 3 m was measured from the depth logger, and a stopwatch recorded how long it took for the ball to travel that distance downstream. This was repeated at the left, right, and center of the stream, to get an average velocity value. The velocity and channel measurements were used to calculate the discharge from the stream. The discharge values were then graphed for each site and provided an equation that was used to perform flow statistics for each depth reading. The maximum, minimum, and average flows were calculated, and the number of high flow pulses per site recorded. Through these sets of calculations, the flashiness and R-B Index values were determined for each stream site.

On November 26th, the depth loggers for Tim's Creek and Hardy Mill Pond outlet were redeployed to gather flow data over the winter months as part of a research project partnership. To prepare for potential high-water events during this time, an alternate method for measuring water velocity and stream characteristics over the winter was devised. A transect was mapped out across the floodplain at both locations, and all elevation changes were measured along this line. With this information, we should be able to extrapolate the depths across the wetted width from what limited measures we will be able to take in the field. Rebar was also set up in the stream, 2 pieces, 3 m apart, so velocity could be measured over winter during high flow events by throwing an orange into the stream from the bank and measuring the time it takes to travel between the 2 pieces of rebar.

Figure 71. Depth logger set up at Hardy Mill Pond outlet, November 2019.

Figure 72. Evan measuring water depth at the logger below Officer's Pond. The measuring tape is stretched across the wetted width of the stream, where depth measurements were taken at equal intervals.

4.10.3 Results

The minimum flows for each of the 5 depth logger sites were all less than 0.40 m^3/s. The maximum flow values had quite a bit of variation, ranging from 0.20 to 4.59 m^3/s. Note that Union Station and Hardy Outlet had quite a difference between their maximum and minimum recorded flows (see Table 30). These were found to be the flashiest sites, having the highest R-B Index values and most pulses above the high flow threshold. The other 3 sites were relatively stable in comparison. Beaton's Creek had the lowest R-B Index value, therefore was the least flashy. It also had the least variation between its maximum and minimum flow values in 2019.

The dates for minimum flow at each site were scattered between late summer and fall. The lowest flow for Officer's Outlet was on August 25th, for Hardy Outlet, September 11th, and Beaton's Creek, Tim's Creek, and Union Station were all in the third week of October. The maximum flows occurred on September 8th for Beaton's Creek, Tim's Creek, and Officer's Outlet. For Hardy Outlet it occurred quite early compared to the other sites, on June 22nd. Union Station had its maximum flow on October 23rd, only a week after its lowest recorded flow.

Environment Canada has 2019 flow data that may be compared with ours at the Union Pumping Station and Officer's Pond Outlet sites. This data spans the entire year, while our depth loggers go from May to November, providing further insight into flows throughout the winter and spring months. There was little variation between the R-B values for our data set and that of Environment Canada at Union Station; 0.62 and 0.60 respectively. There was a greater difference between the values at Officer's Outlet; 0.14 at our site and 0.28 at theirs. The winter and spring have more precipitation and thawing events, which can explain the greater number of high flow pulses in the Environment Canada data sets.

Table 30. Flow data for 2019 sites. The number of high flow pulses represents how many times the flow was over the high flow threshold (3x the median flow). Higher numbers signify flashier streams. R-B Index values are another measure of flashiness; streams with numbers closer to 0 are more stable. Environment Canada data spans the whole year, while the depth loggers were deployed from May to November.

Site	**Average Wetted Width (m)**	**Depth Logger Data**		**Environment Canada Data**	
		# High Flow Pulses	**R-B Index Value**	**# High Flow Pulses**	**R-B Index Value**
Beaton's Creek	2.47	3	0.09	n/a	n/a
Tim's Creek	9.70	1	0.12	n/a	n/a
Officer's Outlet	8.80	3	0.14	17	0.28
Hardy Outlet	3.39	14	0.48	n/a	n/a
Union Station	4.39	20	0.62	30	0.60

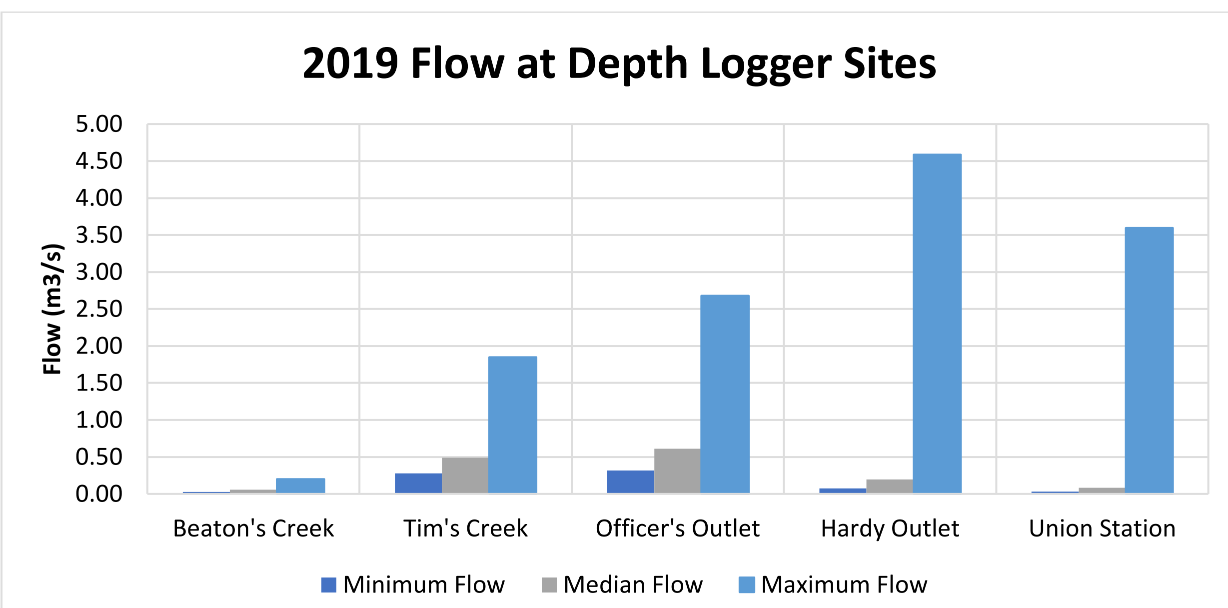


Figure 73. Maximum, minimum, and median flow values for the 2019 field season at each of the depth logger sites.

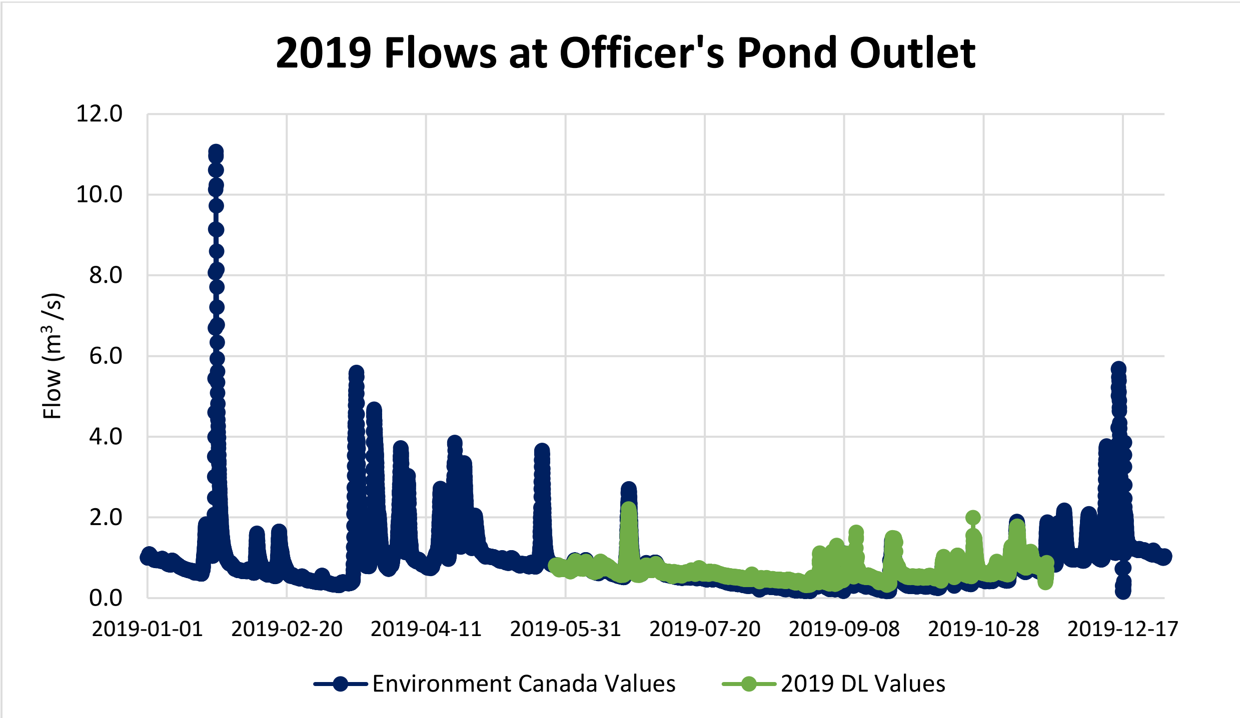


Figure 74. A comparison between flow data collected at our depth logger and the nearby Environment Canada station in 2019.

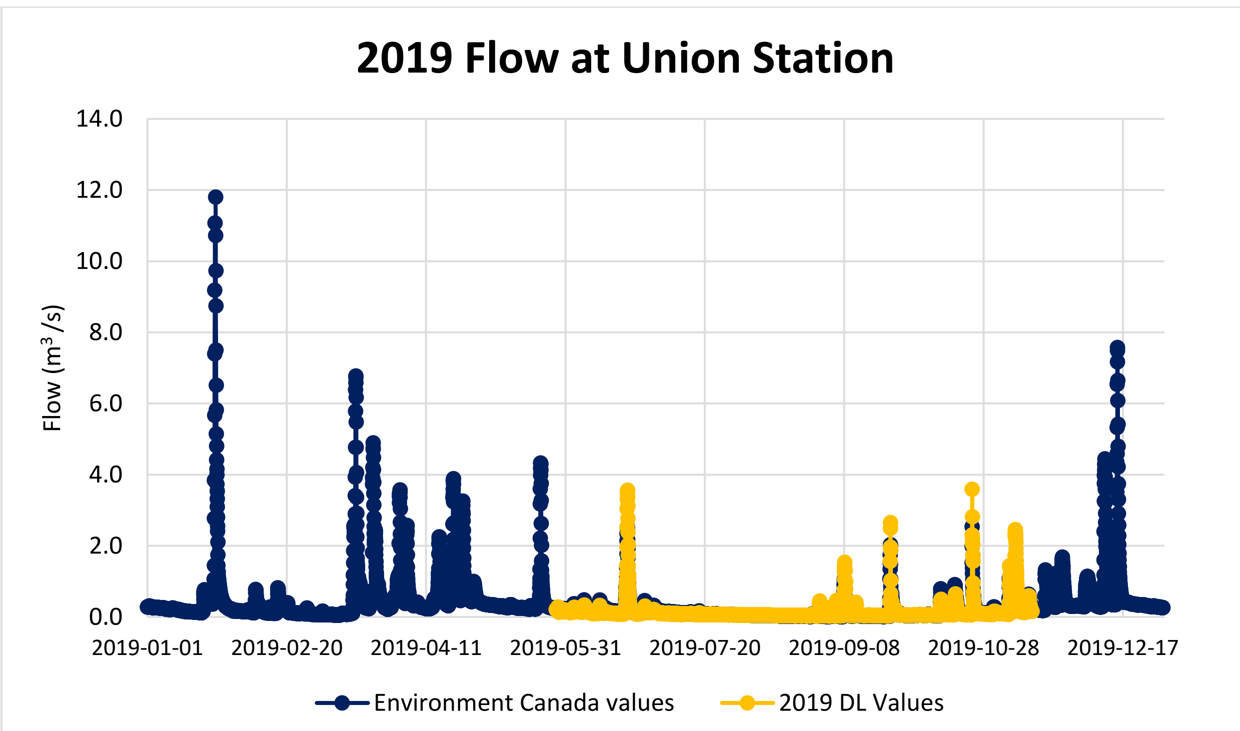


Figure 75. A comparison between flow data collected at our depth logger and the nearby Environment Canada station in 2019.

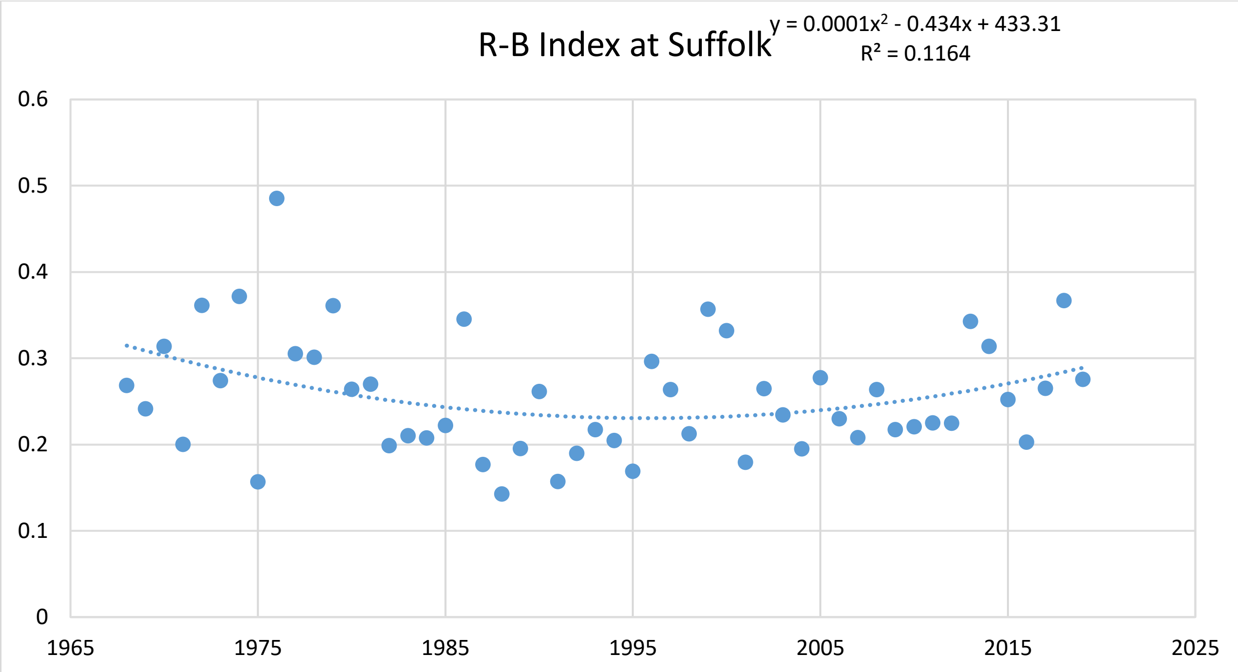


Figure 76. Historical R-B Index values recorded at the Environment Canada station in Suffolk from 1968 to 2019.

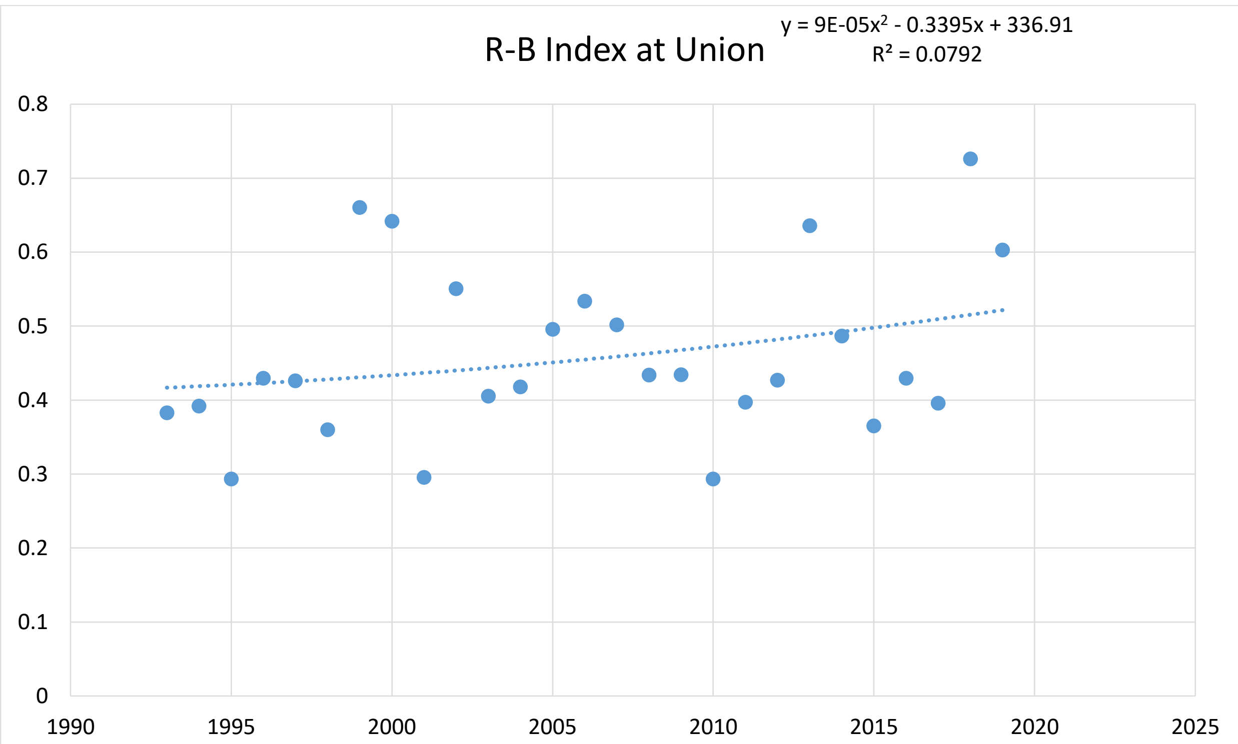


Figure 77. Historical R-B Index values recorded at the Environment Canada station in Union from 1993 to 2019.

4.10.4 Discussion

As the fall high waters came, the meter stick was pushed to its limit, especially at the Apple Orchard site, with depth measurements approaching a meter high. The increase in rain events also caused visibility problems, as the streams carried high levels of silt, blocking out the view of the depth loggers. This created an issue for logger retrieval, as Vanessa and Brittany had to go by feel to ensure the loggers were not carried downstream while being removed. Kick nets were used to aid in this; however, there was 1 depth logger casualty. Despite later efforts to locate it downstream, the Apple Orchard logger was not found.

Data collected from the depth loggers was used to determine which of the streams were most flashy. The term 'flashiness' refers to the frequency and rapidity of short-term changes in stream flow. This is especially evident during runoff events (Baker et al., 2004). Monitoring the flashiness of streams provides insight into how dramatic an impact heavy rain events have on particular streams and their inhabitants. Changes in the flashiness of streams can greatly affect the presence and distribution of stream biota (Hawkins, 2014). To compare streams in a standardized way, the R-B Index can be used. The R-B Index measures oscillations in flow relative to total flow, providing a useful characterization of the way watersheds process hydrologic inputs into their streamflow outputs (Baker et al., 2004). The index has a scale of 0 to 1, where streams with values closer to 1 are most flashy, and those near 0 are more stable.

R-B Index values tend to decrease with increasing watershed size, and it has commonly been observed that small streams are flashier than large streams (Baker et al., 2004). This was somewhat true for the streams monitored this season. Generally, the streams with the greatest wetted widths were less flashy. However, Beaton's Creek was the smallest stream monitored and the least flashy. The larger streams have more opportunity for the increased volume of water to be absorbed with little change to the flow rate. This could be seen at the Officer's Pond Outlet and Tim's Creek sites.

Union Station had the highest R-B Index value, as well as the greatest number of high flow pulses. As such, it was the flashiest stream monitored this year. It was a mid-size stream, but located right next to the pumping station, and water extraction can play a role in increasing the flashiness of a stream. Hardy Outlet was the second most flashy stream, which makes sense based on its small, wetted width. Although, one would expect the pond to mute some of the effects more than it did. Of the sites along the Winter River, those closest to the headwaters were the flashiest sites, and those closest to Tracadie Bay were the least flashy.

Areas with greater urban and agricultural land use tend to disrupt the natural flow regimes of streams towards becoming flashier and decreasing their base flow. Much of our Watershed, and PEI for that matter, is made up of residential and agricultural land (note Figure 78 map). These are among the main contributors to increased flashiness through the creation of large impermeable surfaces. The pathway for runoff water to reach the stream is much more direct, not slowed in the way that forest or wetland ecosystems do (Baker et al., 2004). More stable streams are healthier in terms of both biotic and abiotic factors. With sudden high discharge events, banks can be scored out, heavy erosion can occur, and the normal activity of aquatic species can be disrupted. Therefore, reestablishing a more natural streamflow regime is an important factor for stream restoration (Baker et al., 2004).

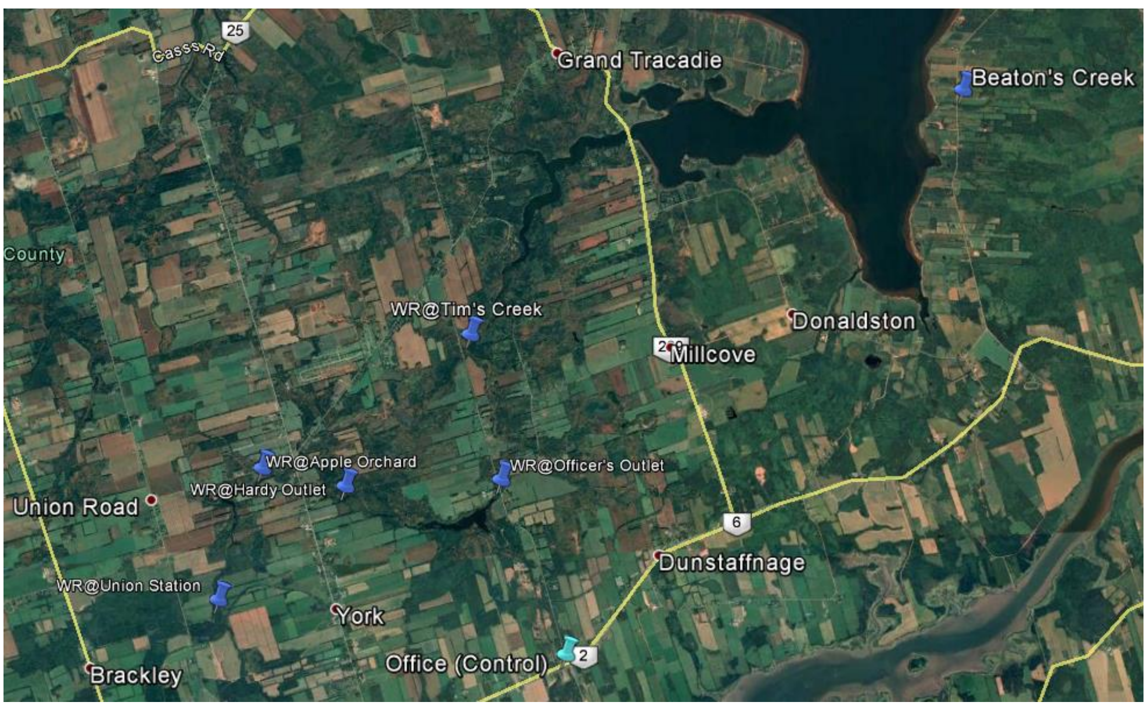


Figure 78. Map of depth logger locations for the 2019 field season.

Every stream is unique in its own rates and processes, but generally seasonal patterns of stream flow depend on precipitation patterns (USGS, n.d.). Data between years can be compared to identify dry versus wet years, and to note changes to the typical trends. In the historical data for the Suffolk and Union Environment Canada stations (Figure 76 and Figure 77 above), it can be seen that yearly weather differences are a big factor influencing changes in R-B Index values from year to year. Last year, the depth loggers were deployed in the same locations (Beaton's Creek logger was only there for end of summer 2018). Generally, the R-B Index values were higher (indicating greater flashiness) in 2018 than 2019. The year 2019 was particularly wet, which may have played a role. All of the 2018 sites fell in the same order for most to least flashy as was found in 2019.

The logger set up outside the office (ATMO) had a few instances where it malfunctioned, resulting in some inaccurate depth data points. These were corrected and a complete list can be found in section 7.6: Appendix 6. When compared with Environment Canada weather data, the malfunctions seemed to generally occur around times of thunderstorms or other quickly moving pressure systems.

4.11 V-Notch Weirs

4.11.1 Introduction

There were 12 weirs in place throughout the Watershed this year. There were 5 along the Brackley branch, 2 along the Pleasant Grove and Tim's Creek branches, and 1 along the Cudmore, Vanco and Affleck branches. An old weir site (Cudmore #3) was monitored for water depth all season as well, but there was no longer a weir installed here. The weirs are made from sheet metal, cut with a v-shaped notch to control the flow of water through it. They are installed at spring outflows to give a standardized measure of water flow from each. The weirs were first installed in these locations in 2013 and have been maintained in the following years. Most of the weirs were removed for the winter on November 12th, 13th, and 14th this year. The weirs at Tim's Upper, Cudmore #6, Brackley #3, and Brackley #8 were very securely positioned into the ground and remained in place for the winter.

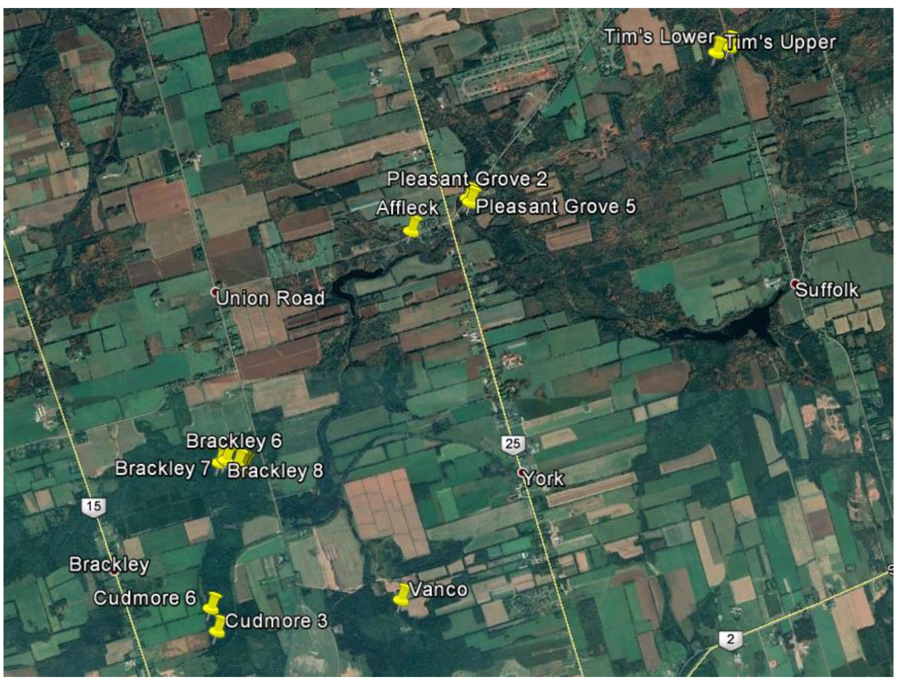


Figure 79. Locations of weirs monitored for the 2019 field season.

4.11.2 Methods

Every second week, from May to November, the weirs were checked, and maintenance performed as required. The weirs were first inspected for any leaks around the sides or bottom of the metal sheet. If there were leaks, a mallet or maul was used with a 4x4 block of wood to pound the weir lower into the ground. Leaks around the sides of the weir were patched with sticks and sod.

The depth of water flowing through the notch of the weir was measured with a ruler, recorded in a notebook, and added to an Excel sheet. Later the flow rate from the spring was determined, converting water height into flow using a conversion chart. If a weir had no water flowing through it, it was marked as dry.

Figure 80. Taking water quality measurements with the YSI (left) and Brittany measuring the water height through the weir notch with a ruler (right).

4.11.3 Results

Monitoring checks were typically performed biweekly. This season, there were only 2 weirs that were dry when checked for flow, Brackley weirs #7 and #8. Brackley #7 was first dry for 10 days, beginning July 22nd, and again for 27 days, beginning September 19th. Brackley #8 was dry when monitored August 19th but had water again 10 days later. This is a positive change from 2018; when all 5 weirs along the Brackley branch were dry at some point over the summer, for between 5 and 9 consecutive monitoring checks, or about 3 to 4 months. Brackley #3 was dry the longest in 2018 at 117 days, from July 7th to November 1st.

Measurements taken in November had the highest discharge of the 2019 season, up to 0.048 m^3/s on 1 occasion at Brackley #7; however, this was a time of frequent rain events and is not reflective of the normal situation. Discharge was generally between 0 and 0.01 m^3/s across all weir sites. The Vanco weir regularly had the highest discharge readings. The sites with the lowest average flows in 2019 were Tim's Lower, Tim's Upper, and Brackley #3. These springs were all below 0.00079 m^3/s. The sites with the highest average flows in 2019 were Vanco, Brackley #7, and Pleasant Grove #2, which ranged from 0.0031 to 0.0040 m^3/s. The greatest change compared to past years occurred along the Brackley branch. The increased discharge for 2019 can be seen in Figure 83 to Figure 87 below.

Groundwater Spring Monitoring 2019

YYY-MM-DD

Spring Location	Wellfield Distance (m)	2019-05-07	2019-05-14	2019-05-15	2019-05-30	2019-06-11	2019-06-12	2019-06-24	2019-06-25	2019-07-08	2019-07-09	2019-07-22	2019-08-01	2019-08-06	2019-08-08	2019-08-13	2019-08-19	2019-08-29	2019-09-05	2019-09-19	2019-09-30	2019-10-02	2019-10-03	2019-10-15	2019-10-16	2019-10-17	2019-10-29	2019-10-30	2019-11-12	2019-11-13	Days monitored
Brackley #3	698	W	W	X	W	X	W	X	W	X	W	W	W	W	X	W	W	W	W	W	W	X	X	X	W	X	X	W	X	W	18
Brackley #4	736	W	W	X	W	X	W	X	W	X	W	W	W	W	X	W	W	W	W	W	W	X	X	X	W	X	X	W	X	W	18
Brackley #6	764	W	W	X	W	X	W	X	W	X	W	W	W	W	X	W	W	W	W	W	W	X	X	X	W	X	X	W	X	W	18
Brackley #7	871	W	W	W	W	X	W	X	W	X	W	D	W	W	X	W	W	W	W	D	D	X	X	X	W	X	X	W	X	W	19
Brackley #8	932	W	W	X	W	X	W	X	W	X	W	W	W	W	X	W	D	W	W	W	W	X	X	X	W	X	X	W	X	W	18
Vanco	1386	X	W	X	W	X	W	W	X	X	W	W	X	X	W	W	W	X	W	W	W	X	X	W	X	X	W	X	X	W	15
Cudmore #6	1572	W	W	X	W	X	W	X	W	X	W	W	X	W	X	X	W	X	W	W	W	X	X	W	X	X	W	X	X	W	15
Cudmore # 3	1710	W	W	X	W	X	W	X	W	X	W	W	X	W	X	X	W	X	W	W	W	X	X	W	X	X	W	X	X	W	15
Affleck's Upper	2472	W	W	X	W	X	W	X	X	W	X	W	X	W	X	X	W	X	W	W	X	W	X	W	X	X	X	W	X	W	14
Tim's Creek Lower	2692	W	W	X	W	W	X	W	X	W	X	W	X	W	X	X	W	X	W	W	X	W	X	X	X	W	W	X	W	X	15
Tim's Creek Upper	2696	W	W	X	W	W	X	W	X	W	X	W	X	W	X	X	W	X	W	W	X	W	X	X	X	W	W	X	W	X	15
Pleasant Grove #2	2926	W	W	W	W	X	W	W	X	W	X	W	X	W	X	X	W	X	W	W	X	X	W	X	W	X	W	X	X	W	16
Pleasant Grove #5	2927	W	W	W	W	X	W	W	X	W	X	W	X	W	X	X	W	X	W	W	X	X	W	X	W	X	W	X	X	W	16

W Water
D Dry
X Not monitored

Figure 81. Monitoring summary of 2019 weir sites, showing dry spells that occurred this season. Cudmore #3 is no longer an active weir, but depth measurements were still taken here.

Table 31. Average discharge at 2019 weir sites.

Site	Average Discharge (m3/s)
Tim's Lower	0.0004
Brackley #3	0.0006
Tim's Upper	0.0007
Affleck	0.0008
Brackley #8	0.0014
Brackley #4	0.0022
Pleasant Grove #5	0.0029
Cudmore #6	0.0029
Brackley #6	0.0030
Pleasant Grove #2	0.0031
Brackley #7	0.0032
Vanco	0.0040

Figure 82. All 2019 weir sites, with position shown in relation to water pumping stations.

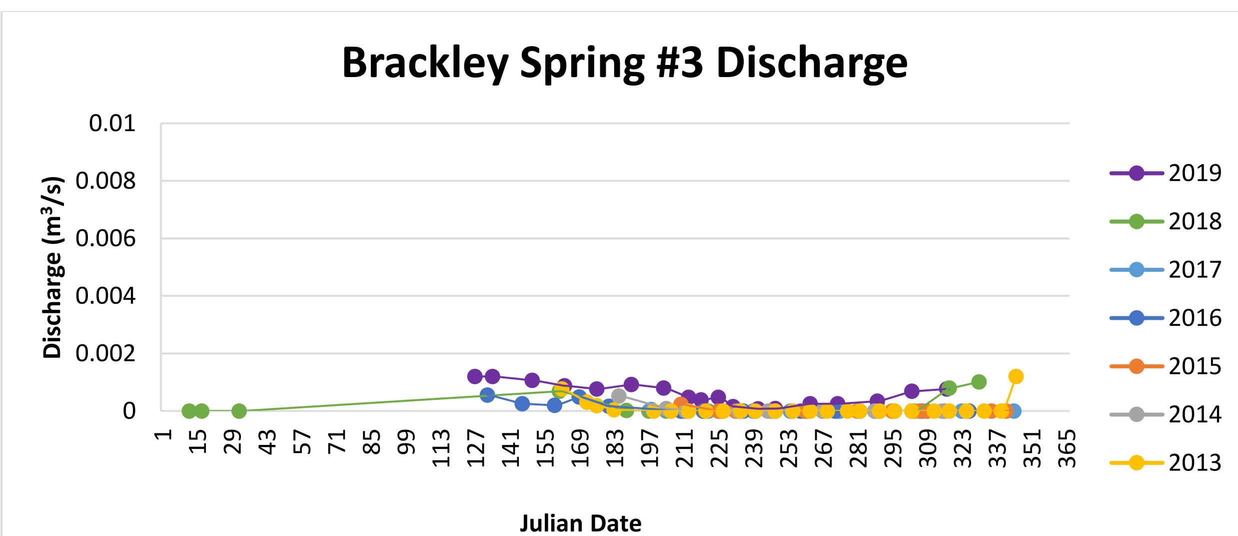


Figure 83. Discharge calculated at the Brackley #3 weir; note the increase for the 2019 field season.

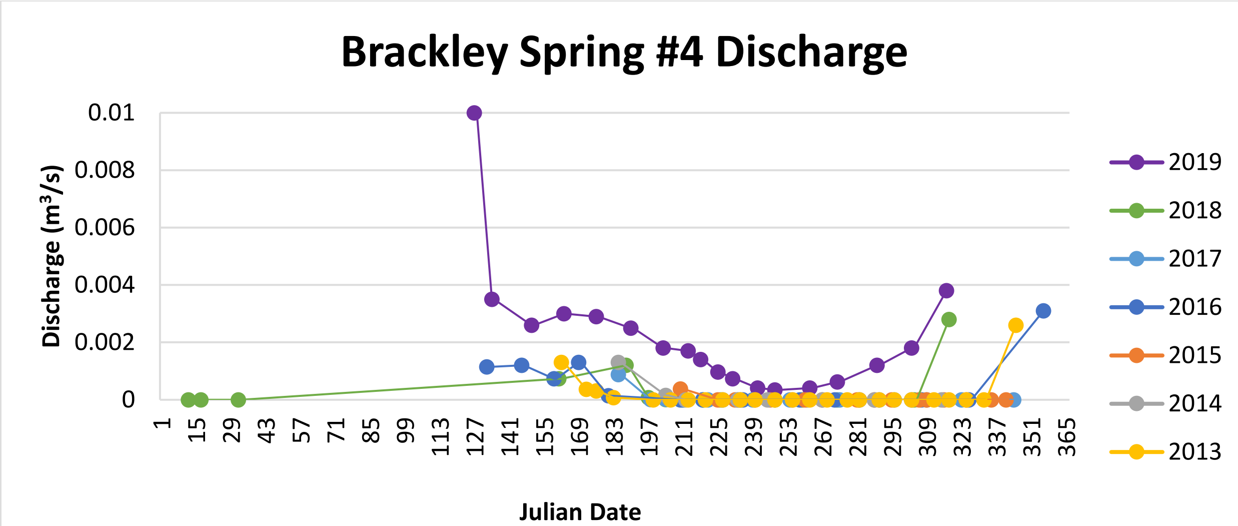


Figure 84. Discharge calculated at the Brackley #4 weir; note the increase for the 2019 field season.

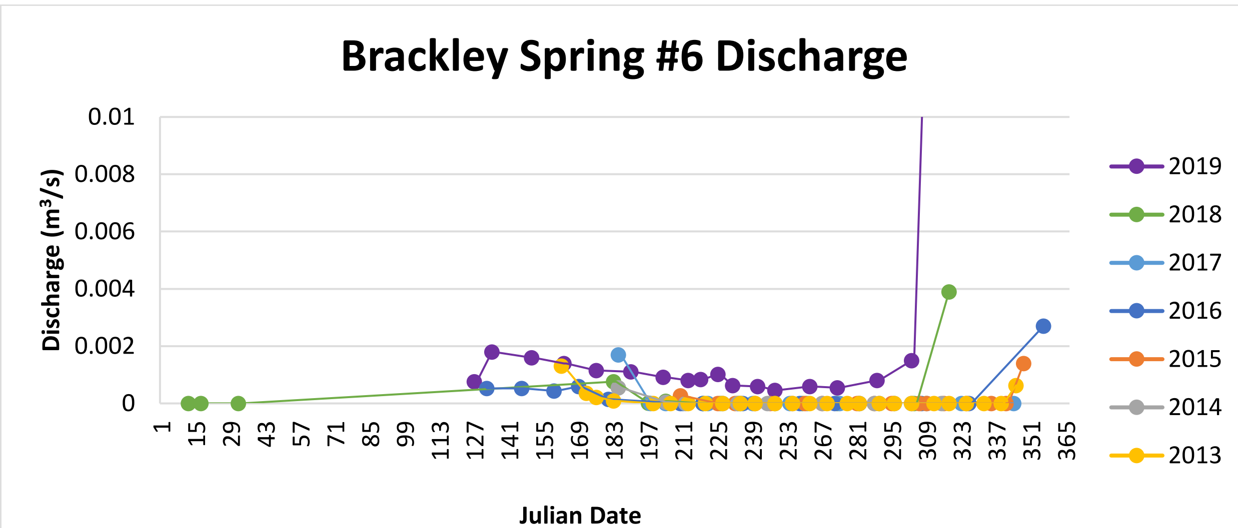


Figure 85. Discharge calculated at the Brackley #6 weir; note the increase for the 2019 field season. Values higher than 0.01 are not characteristic and were omitted from the graph for easier viewing. The value extending beyond the chart for 2019 was 0.037 m^3/s.

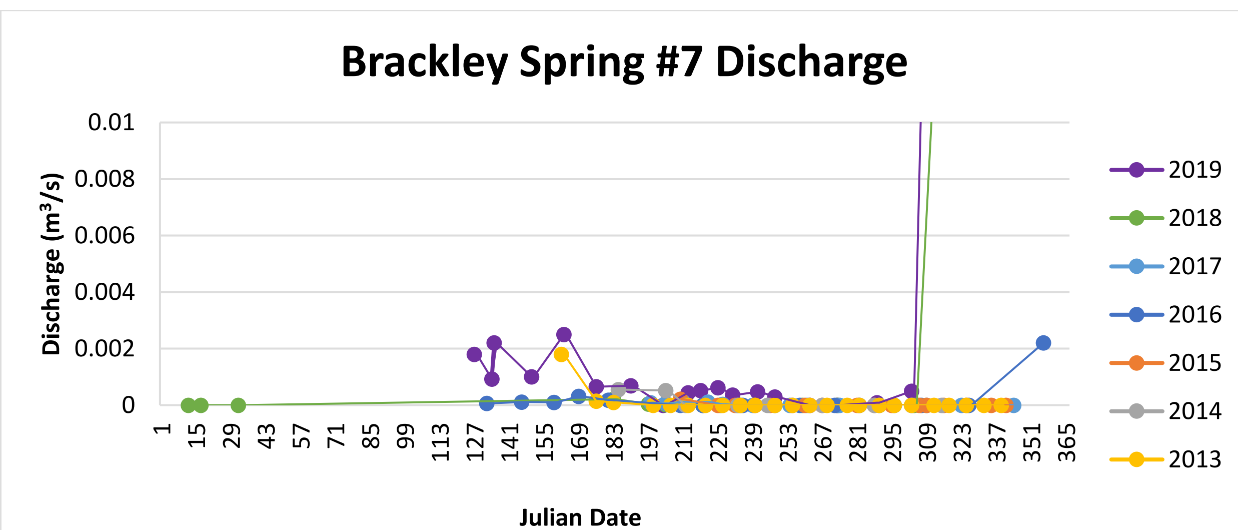


Figure 86. Discharge calculated at the Brackley #7 weir; note the increase for the 2019 field season. Values higher than 0.01 are not characteristic and were omitted from the graph for easier viewing. The value extending beyond the chart for 2019 was 0.048 m^3/s and for 2018 was 0.022 m^3/s.

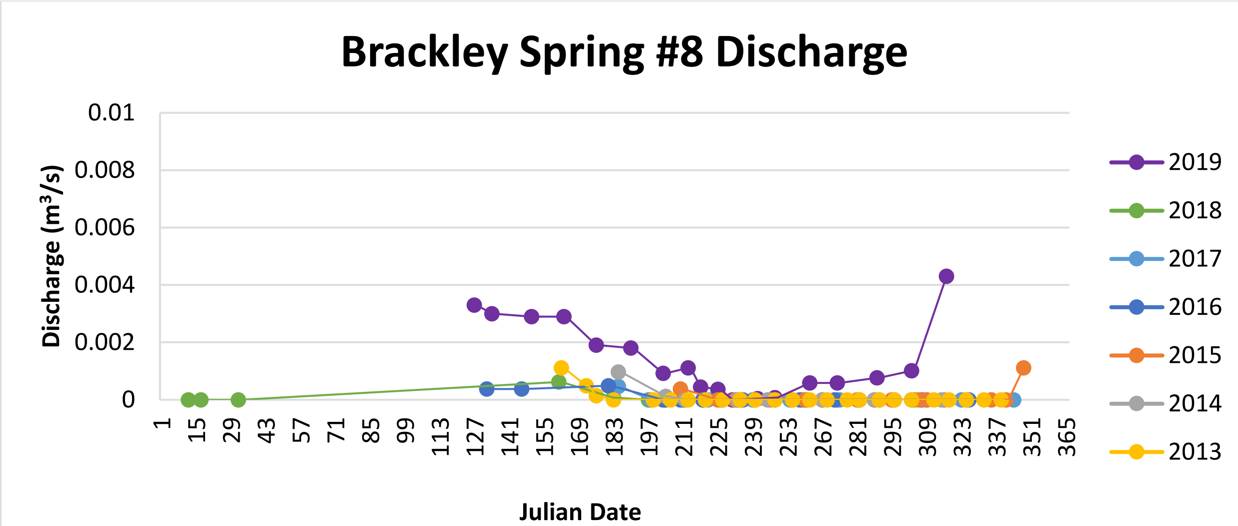


Figure 87. Discharge calculated at the Brackley #8 weir; note the increase for the 2019 field season.

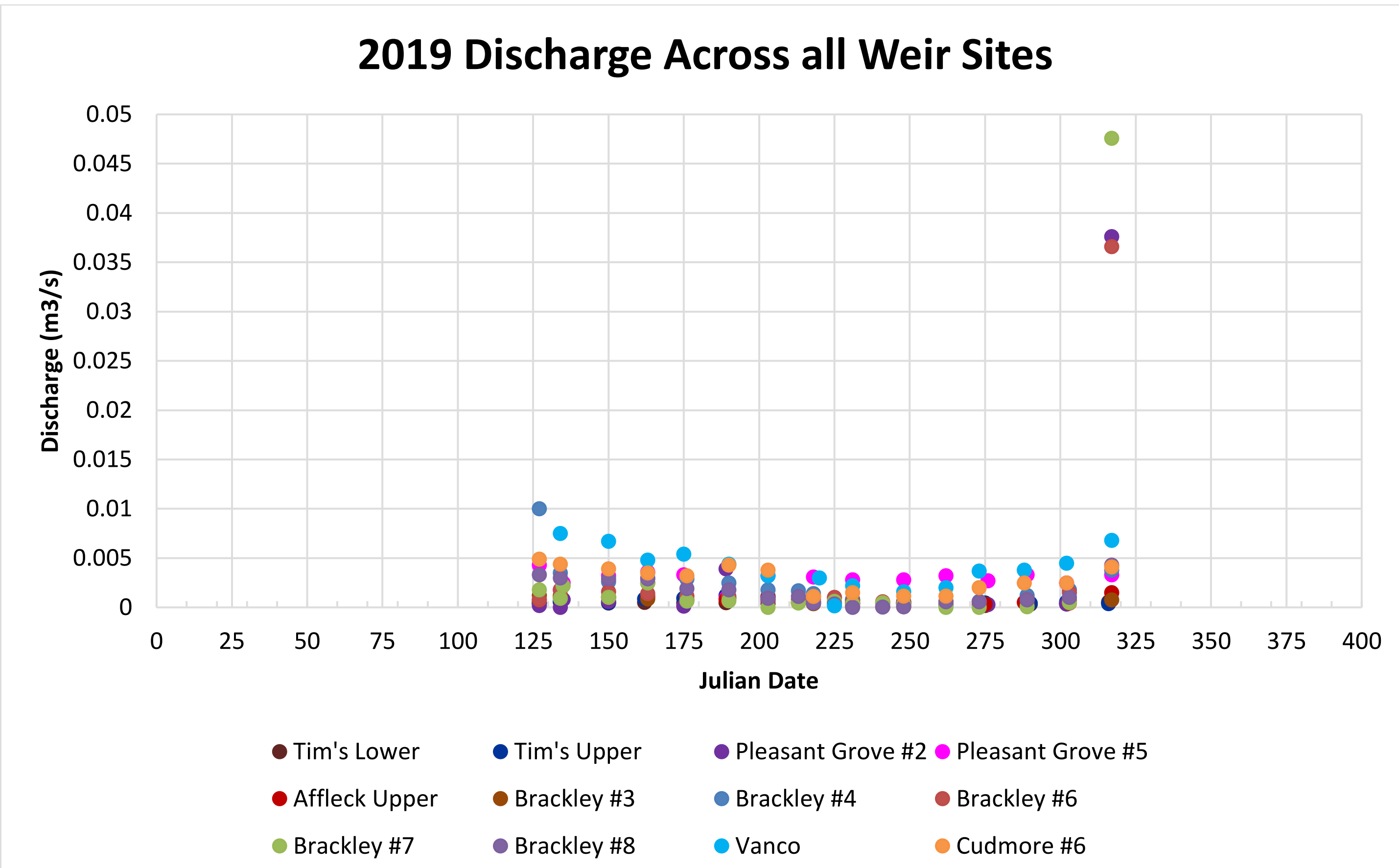


Figure 88. Discharge values across all weir sites for the 2019 field season.

4.11.4 Discussion

The springs below the headwaters are those at the Tim's Creek, Pleasant Grove, and Affleck sites. At the Tim's Creek Upper weir, 2019 was among the years with highest discharge levels. The lower weir at Tim's was a little higher in 2019, but about the same as previous years. This year was quite variable for the Pleasant Grove #2 weir compared to previous years, with very high highs and low lows. Pleasant Grove #5 was generally higher than previous years, and the Affleck weir showed a noticeable increase in discharge for the spring season, but summer and fall values were typical of prior years.

The headwater springs are those located along the Brackley, Vanco and Cudmore branches. Discharge data from 2013 to 2018 show extended dry periods in the summer and fall for the Brackley branch weirs. Historically, all water for the City of Charlottetown has been extracted from the Winter River Watershed, from pumping stations located upstream and downstream of this branch. In 2019, the most notable increase in discharge occurred at this set of weirs. The Vanco and Cudmore #6 weirs also experienced higher rates than previous years.

The increase in stream discharge may have been due to it being a particularly wet year, as weirs located at the springs above and below the headwater streams both showed increases. The recent addition of the Miltonvale Pumping Station, which became fully operational in spring 2019, may have also contributed towards the reduction in dry spells for the Brackley branch of streams, but it is too soon to tell. The first year of reduced water extraction has shown promising results, but continued monitoring will be needed to check year over year variation—will the streams still go dry in a dry year? Hopefully, the operation of this pumping station will be successful in lessening the strain on our Watershed.

Figure 89. Brackley weir sites in relation to the Union Pumping Station.

4.12 Dissolved Oxygen Loggers & Estuary Monitoring

4.12.1 Introduction

Indicators of anoxic events can be observed both visually and through collecting water chemistry data. Dissolved oxygen (DO) loggers were deployed in 2 locations, collecting data 24 hours a day to help monitor when and where anoxic events occur. Estuary monitoring surveys were also performed in conjunction with these, measuring additional water quality parameters. Both of these methods were used to monitor for hypoxic (oxygen poor) or anoxic (depleted of oxygen) conditions. It is important to monitor for anoxic events because of their negative effects on aquatic life; anoxic events can lead to fish kills. This information is valuable for determining potential sources of the problem and the appropriate actions to try to remedy the situation.

4.12.2 Methods

HOBO U26-001 Dissolved Oxygen Loggers were deployed from July 10th to October 3rd at 2 locations in the Winter River estuary: 1 near the Pleasant Grove boat launch and the other near the Corran Ban Bridge. The loggers were attached to a rope with zip ties and duct tape, with buoys at the top and a concrete anchor. At the Corran Ban Bridge site, 2 loggers were set up, 1 close to the surface and another near the bottom. The loggers had to be accessed by canoe and were retrieved, cleaned, and had their data downloaded periodically. During each check, a YSI reading was taken at the logger and recorded with the time, to make sure the DO loggers were still reading with accuracy. Each time a logger was removed from its site, it had to be cut free from the duct tape and zip ties holding it in place. The loggers were wiped with vinegar on a J-cloth to remove any buildup and were re-taped and zip tied on securely for redeployment.

To monitor the conditions of the estuary, staff paddled from the Corran Ban Bridge near Tracadie Bay to the end of tidal influence upstream. Using the YSI, readings were taken for DO, conductivity, pH, and temperature at 14 waypoints set 200 m apart (the nitrate probe must be removed before use in saltwater). In addition, notes were made of visual indicators of anoxic events where applicable. The estuary surveys were first performed July 24th, then every week from August 14th to September 4th. There was a period where a loaned YSI unit without a pH probe was used, so there are no pH readings for that time.

Figure 90. Sam and Evan checking the DO logger in Pleasant Grove.

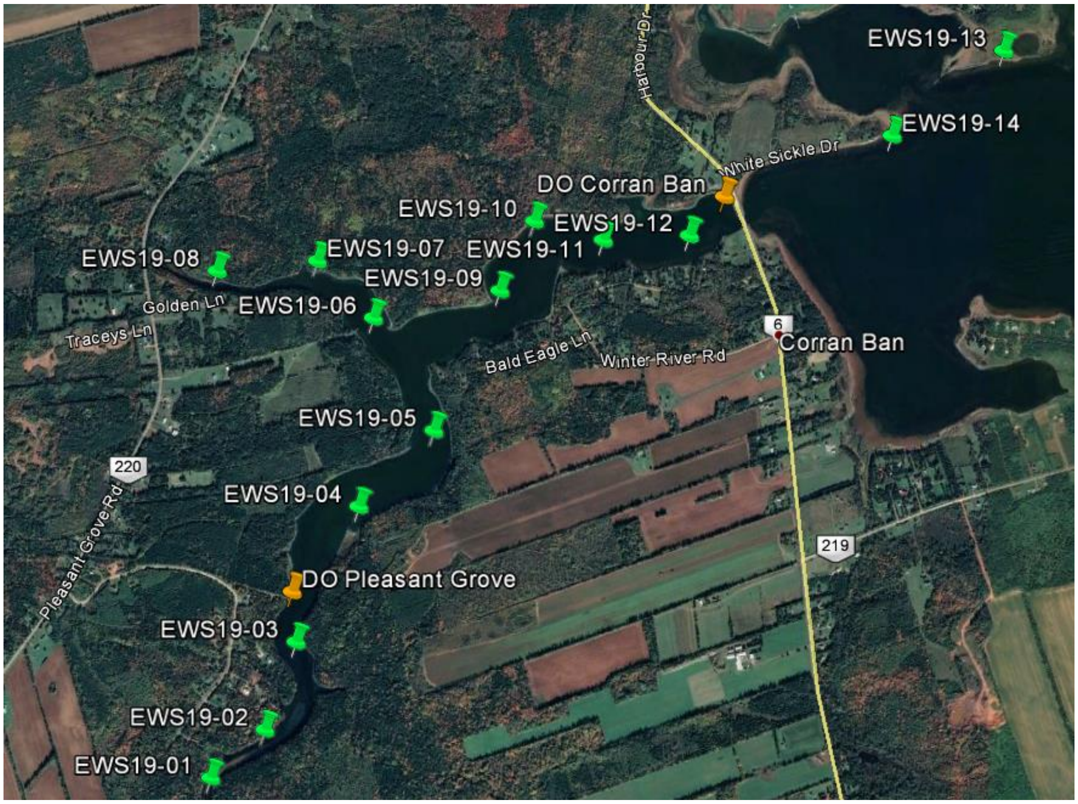


Figure 91. Locations of the estuary check survey points (green) and DO loggers (orange) in 2019.

4.12.3 Results

There were data quality issues with the DO loggers this year, so these results will not be made public. However, water chemistry results from the Estuary Monitoring surveys can be found below. It should be noted that this data was not recorded 24/7, but only when weekly surveys were performed.

Table 32. YSI water chemistry data from the 2019 Estuary Monitoring surveys. See Figure 91 for map of locations (DOPG=Pleasant Grove DO logger). Note: there was a period where pH wasn't measured while using a loaned YSI unit.

		Reading	Date	Location
Dissolved Oxygen	Highest	19.63 mg/L	2019-07-24	EWS19-07
	Lowest	0.41 mg/L	2019-08-28	DOPG
	Average	9.72 mg/L		
Temperature	Highest	26.8 °C	2019-08-14	EWS19-08
	Lowest	7.2 °C	2019-07-24	EWS19-02
	Average	16.1 °C		
pH	Highest	8.47	2019-09-04	EWS19-03
	Lowest	7.26	2019-08-28	DOPG
	Average	7.84		
Conductivity	Highest	36408 µs/cm	2019-07-24	EWS19-14
	Lowest	640 µs/cm	2019-09-04	EWS19-08
	Average	13819 µs/cm		

4.12.4 Discussion

Excessive inputs of nitrogen, often from land sources, leads to eutrophication. This is where an excess of nutrients causes a rapid and dense growth of plant/algal life. When these plants or algal blooms die, their decomposition process uses up oxygen in the water, leading to hypoxia or anoxia (little or no dissolved oxygen in the water). This lack of oxygen then leads to the death of animal life, for example fish kills (NOAA Ocean Service Education, 2020).

DO levels that are 0.1 mg/L or lower are considered anoxic, and those around 2 mg/L or lower are considered hypoxic for bottom water (Hale et al., 2016). Species such as crabs and oysters only need levels of oxygen around 1- 6 mg/L, but fish living in shallow waters require levels closer to 4-15 mg/L for respiration (Fondriest Environmental, Inc., 2013). There were 6 occasions during the survey period where the dissolved oxygen read under 4 mg/L on the YSI, and 3 where it was below 2 mg/L. The lowest values tended to occur in mid-August and September. Not only are individuals affected by reduced oxygen conditions, but areas with hypoxia have been found to have half the species richness, lower abundance of species, and a different community structure than healthy systems (Hale et al., 2016).

The data obtained from the DO loggers and Estuary Monitoring surveys can also be compared with results from Estuary Watch Surveys, where local volunteers can report the conditions of estuaries in an effort to monitor anoxic conditions, recording cues such as abundance of sea lettuce, water colour, and odour (see section 7.7: Appendix 7 for assessment criteria). This information is then processed and graphed by the PEI Department of Communities, Land and Environment to indicate changes in water quality. For the last 2 years, estuary watchers reported a couple of anoxic events and extended periods of impaired water quality. This year, there were a couple anoxic events reported as well.

4.13 Community Aquatic Monitoring Program (CAMP)

4.13.1 Introduction

In the months of June, July and August, Monica Boudreau, the coordinator for CAMP from Fisheries and Oceans Canada (DFO) Moncton, came to conduct a day of sampling at 6 sites in our Watershed. The locations at which samples were taken were Queens Point, White Sickle Drive, Bald Eagle Lane, Pleasant Grove boat launch, Court's Island, and Boland's Point Road. Refer to Figure 92 for a labeled map showing each CAMP location.

Figure 92. CAMP monitoring sites around Winter River estuary for the 2019 season.

4.13.2 Methods

CAMP sampling began by taking a seine net out to capture fish and counting the species collected. A YSI reading was taken for dissolved oxygen, pH, and conductivity and a water sample was collected to go to the lab. Habitat characteristics were also recorded, including substrate composition and vegetative cover.

Figure 93. Monica Boudreau (in pink) from DFO, along with the field crew, sifting through sea lettuce to sort and count the fish collected with a seine net near White Sickle Drive.

4.13.3 Results

Referring to Figure 94, the CAMP data shows a total abundance of 33,192 individuals captured in the Winter River area in 2019, with the most common species captured being Mummichog at 87%. While the remaining species were far fewer overall, others with notable numbers included Sand Shrimp at 6.4%, Fourspine Stickleback at 2.3%, Atlantic Silverside at 2.2%, and Grass Shrimp at 1.2%.

Results of each separate month show the transitions in fish community structure that took place over the summer (Refer to Figures 95 to 97, created by our watershed board member, Matt Steeves). Throughout the 3 months of sampling, the large amount of Mummichog remained consistently high, and Atlantic Silverside reduced in numbers each month, while the number of Sand Shrimp and Fourspine Stickleback increased each month.

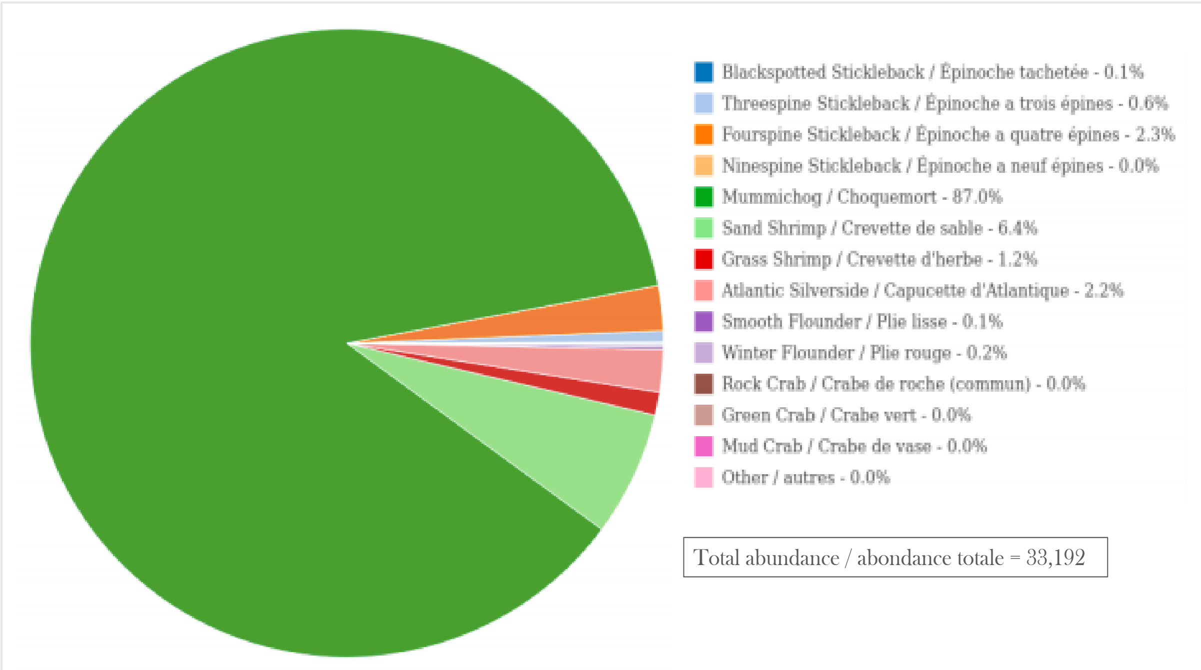


Figure 94. The following pie chart represents the most common species captured during CAMP sampling in the Winter Rive area in 2019 (This chart was provided by Fisheries and Oceans Canada.)

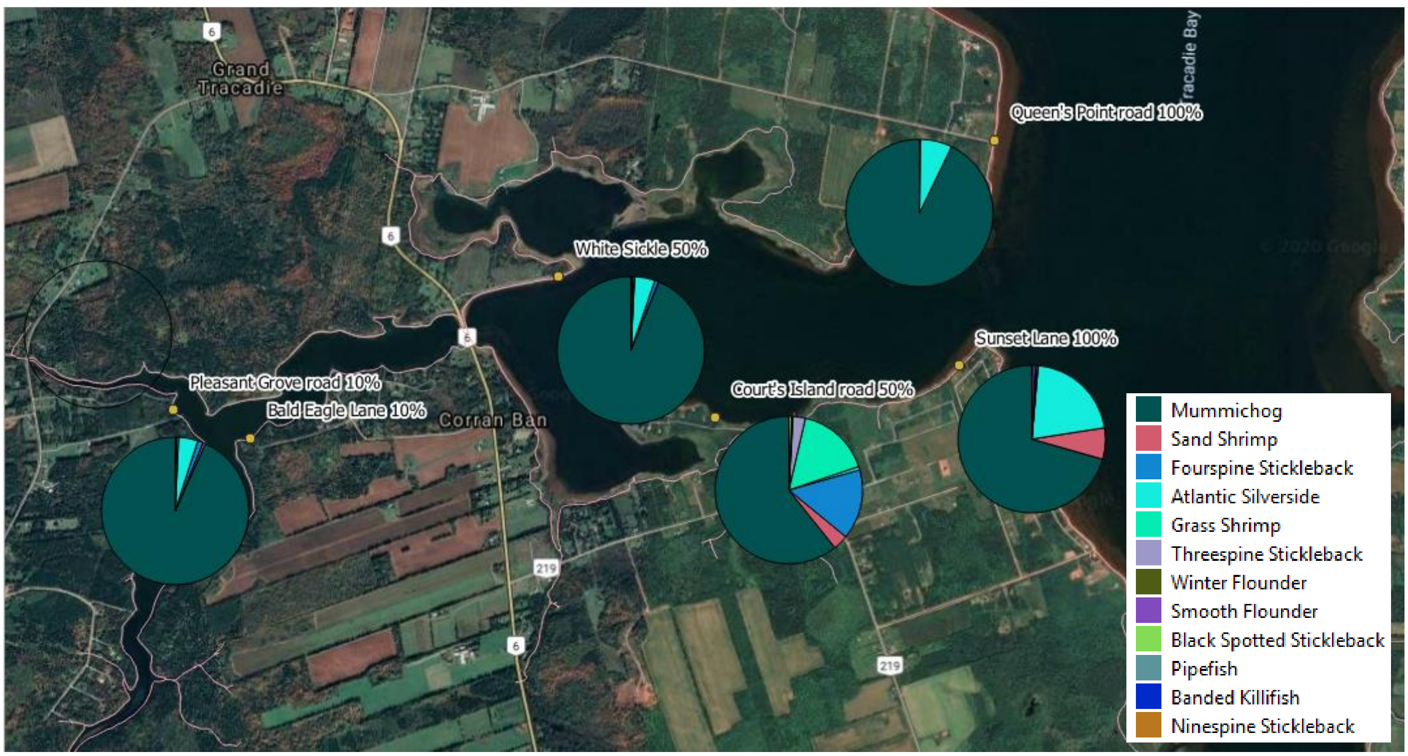


Figure 95. Winter River CAMP Data (June Data - Total All Life Stages). The most common species captured were Mummichog, Atlantic Silverside, Grass Shrimp, Fourspine Stickleback, and Sand Shrimp. (This figure was created and provided by our watershed board member, Matt Steeves.)

Figure 96. Winter River CAMP Data (July Data - Total All Life Stages). The most common species captured were Mummichog, Sand Shrimp, Fourspine Stickleback, and Threespine Stickleback. (This figure was created and provided by our watershed board member, Matt Steeves.)

Figure 97. Winter River CAMP Data (August Data - Total All Life Stages). The most common species captured were Mummichog, Sand Shrimp, and Fourspine Stickleback. (This figure was created and provided by our watershed board member, Matt Steeves.)

4.13.4 Discussion

The Community Aquatic Monitoring Program is performed to monitor what fish species are living in our estuaries, water quality and quantity, substrate composition, macrophyte cover, nutrient analysis, and physical measures. With this knowledge, we can get an idea of the health of the ecosystem. The level and type of macrophyte cover is linked to the amount of nutrients in a body of water. Fish species diversity and abundance (especially of indicator species) can signal changes in the aquatic community over time and give an indication of how hospitable the water is for more sensitive species.

Throughout Prince Edward Island, the Winter River area had the highest number of fish caught from any other species and an average amount of species richness. These findings suggest our Watershed has a very productive estuary.

5 Recommendations

- As we were unable to perform redd surveys the past 2 years, it would be beneficial to have a fish population survey completed to know how Brook Trout populations are doing in our Watershed. Hilary is coming out in the spring to do some electrofishing so this should help us collect data. If Hilary does not end up coming out, we should request either Rosie or Angela come out to help the watershed perform an electrofishing survey. Another way to collect information is to ask local fishermen what they are catching (creel surveys).
- Local fishermen over the years have been asking us why there are no longer fish at Deroche Pond. It would be beneficial to look into the health of the pond. Suggestions would be to kayak from the estuary up the Deroche branch and see more of the area that cannot be seen from land.
- Afton Lake currently has only 2 access points that are both residential driveways to people's homes, both marked "no trespassing". The lake has never had much done with it. Taking samples and YSI measurements would be helpful to know what the water health is like. Also look into making a trail into the lake so there is better access. Is there sufficient wildlife habitat?
- Looking into the areas with high amounts of soil erosion going into the stream, especially in areas where redds were found in previous years. This is mostly taking place in areas with a steep slope. Working with farmers to expand the buffer zone and adding some preventative measures would be necessary.
- Beaver dam will need to be removed or breached at Hardy Mill.
- Depth loggers should have their cap taped on with brightly coloured duct tape to lessen the chance of it getting lost during retrieval, or at least increase the chance of it being found.
- The creation of a list of hazardous plants that one may run into in the field and their identification features, including locations you'd be most likely to find them (e.g., stinging nettle, water hemlock, woodland angelica, poison ivy, hawthorn, etc.)
- Undertake some wildlife/bird surveys, e.g., survey hay fields for bobolink in the summer, and look for bank swallow nests while performing beach cleanups in areas with suitable habitat.
- Some of the nest boxes would benefit from being cleaned out/putting in nesting material such as wood shavings before nesting season (although available staff at appropriate time may be an issue).
- Bank remediation/brush piles or brush mats to try to catch the silt running into the streams in some of the really bad erosion spots found in fall 2019 (especially upstream of Tim's Creek, near Cudmore weirs, between Union station and Hardy Mill Pond).
- Monitoring and removal/management of invasive species, such as glossy buckthorn, which seems to be quite prevalent throughout the watershed.
- New canoe paddle for the third person (tend to go on sale at Canadian Tire for ~$12 in the spring)
- Wear orange in the woods while performing surveys during hunting season.
- Mark the weirs with their numbers (for sites with multiple weirs) to eliminate confusion and improve accuracy.
- Plant trees/shrubs/flowering plants to provide year-round food sources (e.g., in an area plant early, mid-season, and late blooming or berry-producing plants)—for bees, birds, other wildlife.
- For shoreline cleanup: the plastic garbage bags aren't large enough to hold very many buoys (ones without anything to hook rope onto), could put them in/on a sled or floaty to pull them? Or make a large bag by sewing up 2 sides of a folded old sheet to carry Santa-style?
- Hurricane Dorian may have knocked down a lot of snags in some areas, can create more where they are lacking by girdling a few trees in otherwise young stands.
- Deploy temperature loggers for full period of June 1st to August 31st to calculate the NCC stream temperature classifications more accurately.
- Could do a bird project with multiple components: nest boxes, planting seasonal food source trees/shrubs, hold educational event (bird walk, identifying birds, what they eat, their role in the ecosystem, identifying trees that are important to particular species), info sheets about birds in our watershed and what landowners can do to help or encourage these species, build your own bird box event.

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7 Appendices

7.1 Appendix 1: 2019 Field Data Sheet for Part 3 of Culvert Assessments.

Complete IN FIELD	Optional	To calculate	Instructions	May not apply

U/S = Upstream D/S = Downstream

Date	yyyy-mm-dd	Time	
Technicians			
Crossing ID	PU = public, PR= Private		
Stream Name		Road Name	
Coordinates	Not needed if prior assessment done		
Crossing Type	☐ Single Culvert ☐ Multiple Culverts ☐Bridge* ☐ Dam ☐ Ford ☐ Other _________		
Debris present?	If yes, describe		
Fish habitat?			

Rapid Assessment

Is there a visible outflow drop?	☐Yes ☐ No
Is the water depth less than 15cm anywhere in the culvert?	☐Yes ☐ No
Is the culvert backwatered only part of the way or not at all?	☐Yes ☐ No
Is the stream width noticeably different above and below the culvert?	☐Yes ☐ No
If the response to any of these questions is YES, then continue with the full assessment.	

Culvert Information

Culvert Material SEE FIG 11 Check ALL that apply	☐ Concrete ☐ Corrugated Metal Pipe (Spiral) ☐ Corrugated Metal Pipe (Annular) ☐ Corrugated Plastic ☐ Wood ☐ Other	Culvert Shape	☐ Circular ☐ Box ☐ Pipe Arch ☐ Open Arch ☐ Arch w/Wood Floor ☐ Other	Entrance Type	☐ Projecting ☐ Headwall ☐ Mitered ☐ Wingwall ☐ Other
Is Culvert Deformed?	☐ Yes ☐ No	Deterioration	☐ None ☐ Moderate ☐ Severe	Baffles	☐ Present ☐ Absent
Culvert Bottom	☐ Unnatural ☐ Natural If Natural, Dominant Substrate: ___________		Variable Slope in Culvert? SEE FIG. 15	☐Yes ☐ No	

If Baffles are present, fill in Baffle Information on pg.5

Photo Files					
Upstream		File Names/Notes	Downstream		File Names/Notes
Toward Inflow	☐Yes ☐No		Toward Outflow	☐Yes ☐No	
Through Culvert	☐Yes ☐No		Through Culvert	☐Yes ☐No	
Looking Upstream	☐Yes ☐No		Looking Downstream	☐Yes ☐No	
Other(s)	☐Yes ☐No		Other(s)	☐Yes ☐No	

Culvert Dimensions

Culvert Measurements (m)	WIDTH - *A*	HEIGHT	Corrugation (cm) SEE FIG. 17	WIDTH	HEIGHT

Additional Information

Inflow Habitat Type	☐ Pool ☐ Riffle ☐ Run ☐ Drop	Beaver Dam Present	☐ Yes ☐ No
Backwatered SEE FIG. 19	☐ 0% ☐ 25% ☐ 50% ☐ 75% ☐ 100%	Fish Observed	☐ Upstream ☐ Downstream
Embedment	☐ Embedded from Upstream ☐ Embedded from Downstream	Degree of Embedment SEE FIG. 20	☐ 0% ☐ <20% ☐ >20%
Length of Culvert with Embedment		☐ 0% ☐ 25% ☐ 50% ☐ 75% ☐ 100%	

Upstream Substrate composition (particle diameter) – must add to 100%

Fines (<0.2cm)		%
Gravel (0.2-6.4cm)		%
Cobble (6.4-25.6cm)		%
Boulder (>25.6cm)		%
Bedrock		%

YSI readings	Upstream	Downstream	
Water Temp			°C
pH			n/a
DO			mg/L
Conductivity			µS/cm
Air Temp (with second thermometer)			°C

Y	Velocity calculation – using tennis ball method	Upstream	Downstream	
Y1	Distance			m
Y2	Time			s
Y3	Velocity *(Y1/Y2)*			m/s

		Upstream/Inlet		Downstream/Outlet	
G	Water Depth: meter stick parallel to flow		R		cm
H	Stagnation Depth: meter stick perpendicular to flow		S		cm

Upstream Channel Measurements

	Pool	Riffle	Run	Average (Pool, Riffle, Run)	
Wetted Width (m)					B
Bankfull Width (m)					C
Stream Width Ratio: C (avg bankful width) / A (width of culvert)					D

I	Upstream Riffle to Inflow Invert (m)	

J	Culvert Length (m)	

Elevation Measurements 1 DECIMETER = 0.1 METERS

	Upstream	HI (m) (tripod height)	FS (m) (survey rod value)	Elevation (m) (HI - FS)	NOTES
E	Crest of Riffle Upstream	set at 10 to start			
F	Inflow				

Turning Point calculations: if you can't see everything upstream & downstream without moving the tripod, you need turning point(s)

	Downstream	HI (m)	FS (m)	Elevation (m)	NOTES
M	Outflow				
N	Plunge Pool Bottom				
Q	Pool Surface Elevation				
O	Tailwater Control (1ST riffle)				
P	Crest of 2nd Riffle				

Tailwater Cross Section		Intervals (m) O6/5	HI (m)	FS (m)	Elevation (m)	Water Depth (m)
O1	Left Bankfull	0				Should be 0
O2	20% Bankfull Width					
O3	40% Bankfull Width					
O4	60% Bankfull Width					
O5	80% Bankfull Width					
O6	Right Bankfull					Should be 0

Wetted Width		m	Bankfull Width		m	Bankfull Width / 5		m

BAFFLES if applicable	HI (m)	FS (m)	Elevation (m)	
Most D/S baffle				a
Adjacent Baffle to U/S				b
Drop Between Baffles (m)				a - b

Downstream Channel Measurements

T	Plunge Pool Bankfull Width		m
U	Outflow to Tailwater Control (m)		m
V	Tailwater Control to 2nd Riffle Downstream (m)		m

Baffle Information (ONLY Complete if culvert is baffled) SEE FIG. 28

Baffle Height (cm)		Baffle Material	☐ Concrete ☐ Metal ☐ Wood ☐ Other
Notch Depth (cm)		Baffle Type	☐ Straight ☐ Diagonal ☐ Right Angled ☐ Other
Notch Width (cm)		Notch Chutes	☐ Yes ☐ No
Number of Baffles		Notch Chute Material	☐ Concrete ☐ Metal ☐ Wood ☐ Other
Distance Between Baffles (m)			

Office Calculations

W	Culvert Slope: (Inflow elevation – outflow elevation) / Length of culvert	(F – M) / J	%
X	Outflow Drop: Outflow elevation – Tailwater control elevation	M – O	cm

L	Upstream Channel Slope: (Crest of riffle upstream – Inflow)/ Upstream riffle to invert x 100	(E-F) / I x 100	%
Z	Downstream Channel Slope: TC elev – Elev. 2nd riffle/Distance from TWC to 2nd riffle x 100	(O-P/V x 100	%

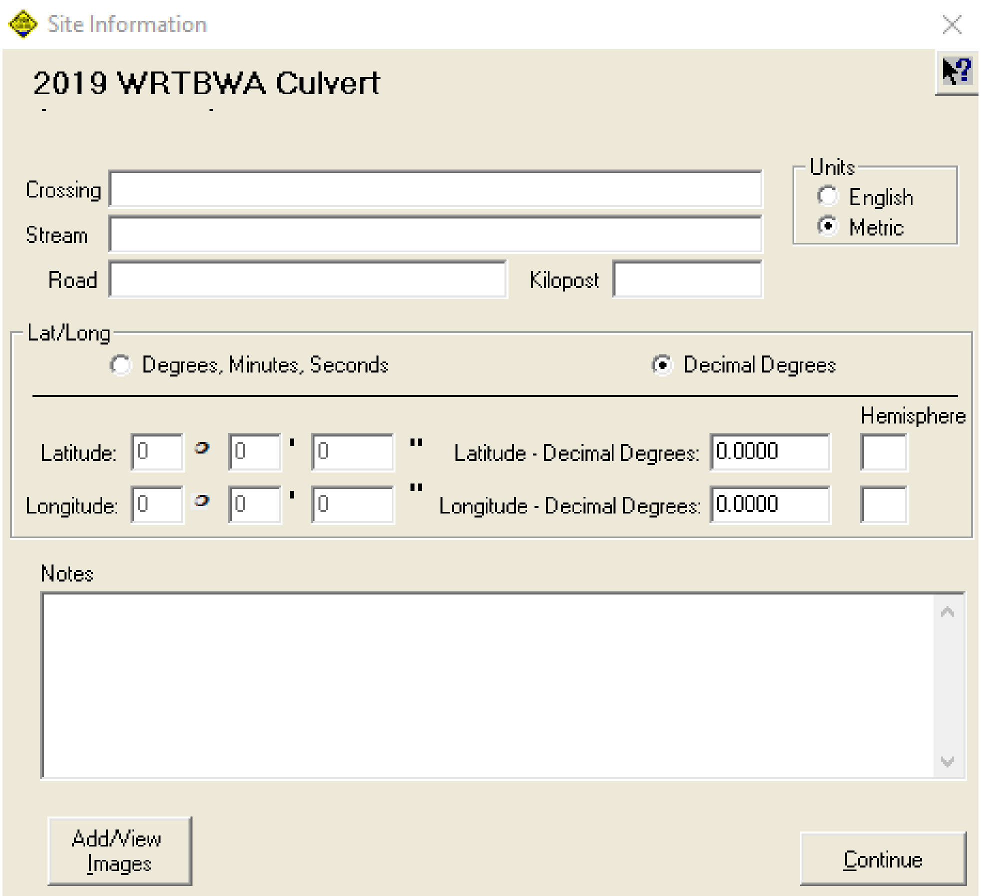
Notes & Sketch

7.2 Appendix 2: FishXing Software User Guide

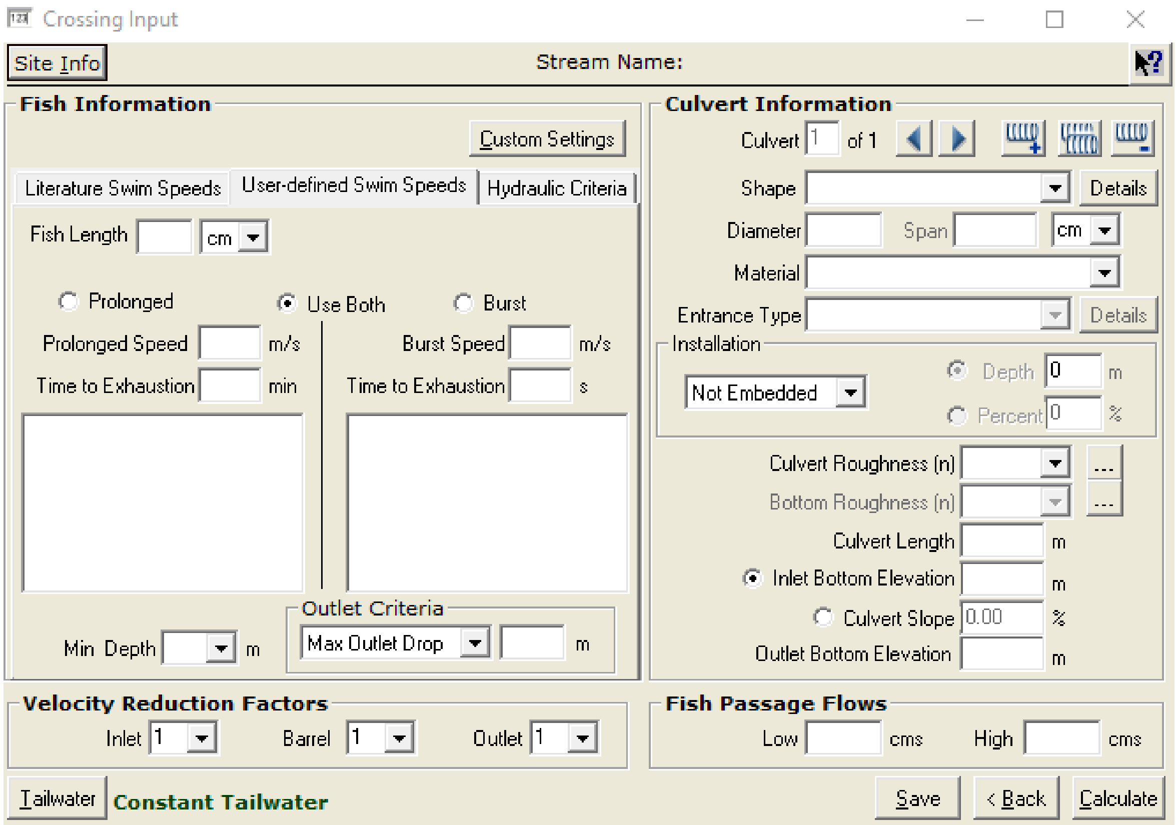
7.2.1 Opening FishXing

Open folder titled “2019 WRTBWA Culvert Assessments” under “FishXing V3” folder in Program Files. Select Continue. Select a culvert ID and click open to edit a preexisting culvert file or click new to begin work on a new culvert file.

7.2.2 Site Information



To create a new file, begin by filling out the Site Information. Select metric for units (in the top right corner). Site coordinates may be input in decimal degrees from the Excel file containing all culvert assessment coordinates. Then press Continue to move on to the next screen.



7.2.3 Fish Information

Under the Fish Information box, on the left side of the window, swim speeds must be input manually for Gaspereau/Alewife (*Alosa pseudoharengus*), as literature values are not provided within the FishXing software for this species. Select the tab User-defined Swim Speeds and enter values from "FishXing Input Data" word document for the target fish size for that crossing.

Note: Fish swimming can be divided into 3 categories: 1) sustained, 2) prolonged and 3) burst swimming (Richardson, 2004).

Sustained swimming (or cruising speed): can be maintained indefinitely (i.e., longer than 200 minutes)

Prolonged swimming: moderate speed that can be maintained for specific period of time (i.e., up to 200 minutes)

Burst swimming: the fastest speed achievable and can only be maintained for short durations (uses more anaerobic metabolism than other swimming modes)

Typically, the minimum/critical depth for passage would be 1.5× the body thickness for the target species. However, as a schooling fish, Gaspereau require a greater depth to move as a group (Maine DOT, 2004). The U.S. Fish and Wildlife Service found the Minimum Depth for Gaspereau passage to be 0.6858 m (USFWS, 2017).

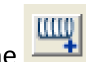
For Outlet Criteria, select Max Outlet Drop from the dropdown list. DFO determined the minimum flow depth to be 15 cm above the notch sill in baffled culverts, so enter 0.15 m for this section (Fisheries and Oceans Canada, 2015).

To save these Fish Information settings, click Custom Settings at the top of this box, and Save Current Settings. Choose a name and save. There seems to be an issue where these settings will only stay saved in the Custom Settings window for that day, however they will stay entered in the blanks for that culvert site. If entering multiple culvert sites in 1 day, you can open a site file from an earlier day to resave the custom settings and they will show up; saves time entering data.

7.2.4 Velocity Reduction Factors

The Velocity Reduction Factors section has dropdown options for Inlet, Barrel, and Outlet; KEEP THESE VALUES AT 1.0 unless the actual values are known. Changing the numbers in this section allows one to account for the areas of reduced velocity within culverts that small fish can use to conserve energy while swimming. However, the Help page states, Use caution when applying velocity reduction factors. These factors vary substantially and are influenced by many factors, such as the shape and roughness of the culvert, the culvert alignment with the upstream channel, outlet conditions, and the size of the fish. Various hydraulic situations can eliminate the existence of a continuous path of lower velocities. Also, larger fish will not be able to avoid the regions of higher velocities due to their increased body size, making reduction factors inappropriate to use.

7.2.5 Culvert Information

Under the Culvert Information box, on the right side of the window, additional culverts can be added with the  button if there are 2 or more culverts at this crossing site. The culvert Shape is selected from a dropdown list. The most common ones we have are circular, arch, and box. Then enter either the diameter or width and height, selecting cm for units.

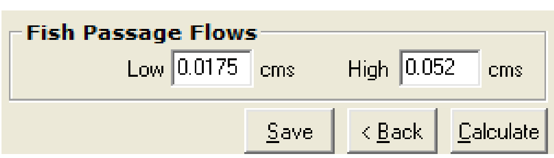
Under the Material dropdown, there are various options. For corrugated plastic culverts, choose PVC. The list of annular and helical culverts with measurements assumes it is a corrugated metal culvert. For corrugated metal culverts most will be Annular, choose the option with the closest values for the corrugation height and width. Enter the Entrance Type, and this will automatically input the proper values in the Details window.

Choose Not Embedded unless the culvert bottom was countersunk below the level of the streambed when installed. The standard method of installation is "At Grade," where the culvert bottom was placed on the surface of the channel bed. This is the case for most, if not all, of our culverts. This option assumes the bottom material is the same as the rest of the culvert, except for in the case of arches and metal boxes, which assumes open bottoms.

The value for Culvert Roughness is input automatically based on your selection of material. Bottom Roughness will only be entered manually for arch culverts. The other types will have it greyed out. Click the ... button to find the value that fits most closely with the current culvert. For arch culverts with wooden bottoms, type 0.012 into the box. This is the value listed for "wood: planed, untreated."

Fill in Culvert Length, Inlet Bottom Elevation and Outlet Bottom Elevation, and it will automatically enter the Culvert Slope.

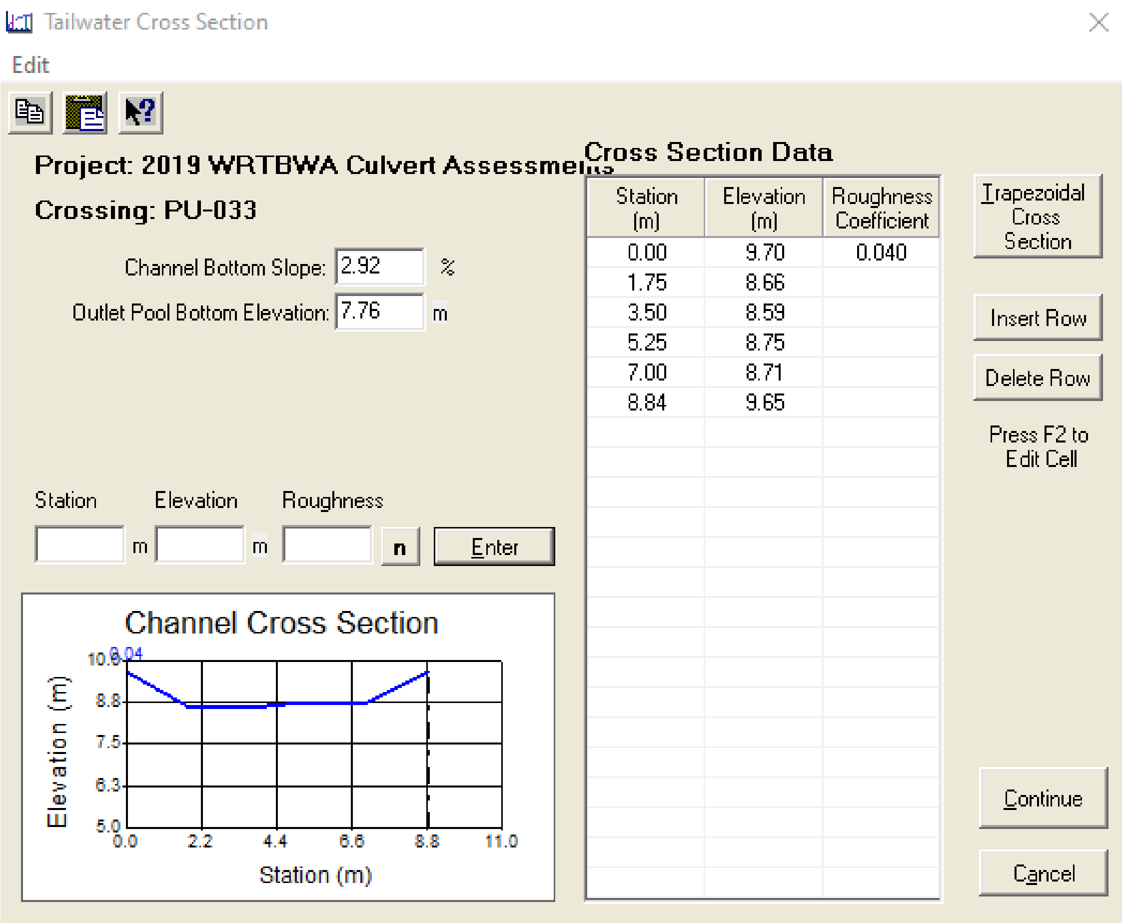
7.2.6 Fish Passage Flows



These were calculated using the size of the catchment area for each culvert (measured from Google Earth). The calculated values for Low and High Fish Passage Flows for each culvert can be found in the Excel file "Culvert Assessment Barriers 2019."

	Flow	
Culvert ID	Low Flow (cms)	High Flow (cms)
PR-004	0.0165	0.049
PU-001	0.163	0.489
PU-003	0.0175	0.052
PU-005	0.0444	0.133
PU-011	0.0418	0.126
PU-015	0.0165	0.049
PU-028	0.025	0.075
PU-033	0.0424	0.127
PU-035	0.0295	0.088
PU-052A	0.047	0.141
PU-052B	0.047	0.141
PU-067	0.0199	0.06

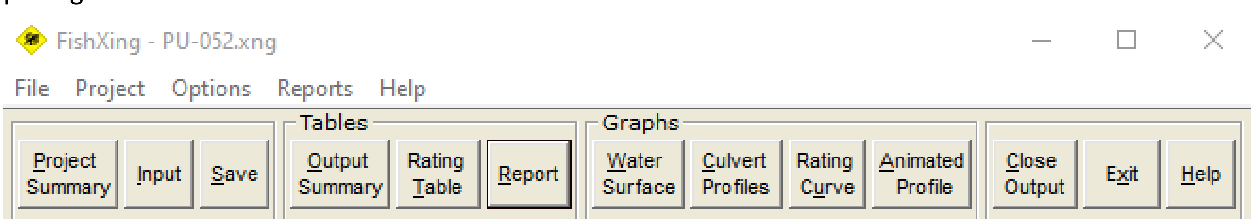
7.2.7 Tailwater



On the bottom left corner of the main Crossing Input window, there is a Tailwater button. Clicking this brings up the option to choose Channel Cross-Section. Select this and Enter Data. Enter the Channel Bottom Slope from the "Downstream Channel Slope" value on our *Detailed Culvert and Stream Assessment Form*. The Outlet Pool Bottom Elevation is the "Plunge Pool Bottom" elevation value. Enter the values from the "Tailwater Cross Section" data. Station is filled in with the numbers for "Intervals" on the datasheet, starting with the Left Bankfull of 0 m. For Roughness, click the **n** button and choose a streambed description that looks similar, based on the "Substrate Composition" section of the datasheet and site photos. The Roughness value only needs to be filled in for the first point and is usually around 0.030-0.050. As the Station and Elevation values are entered for each point of the cross section, it draws a graph mapping the shape of the streambed. When all points are entered, click Continue.

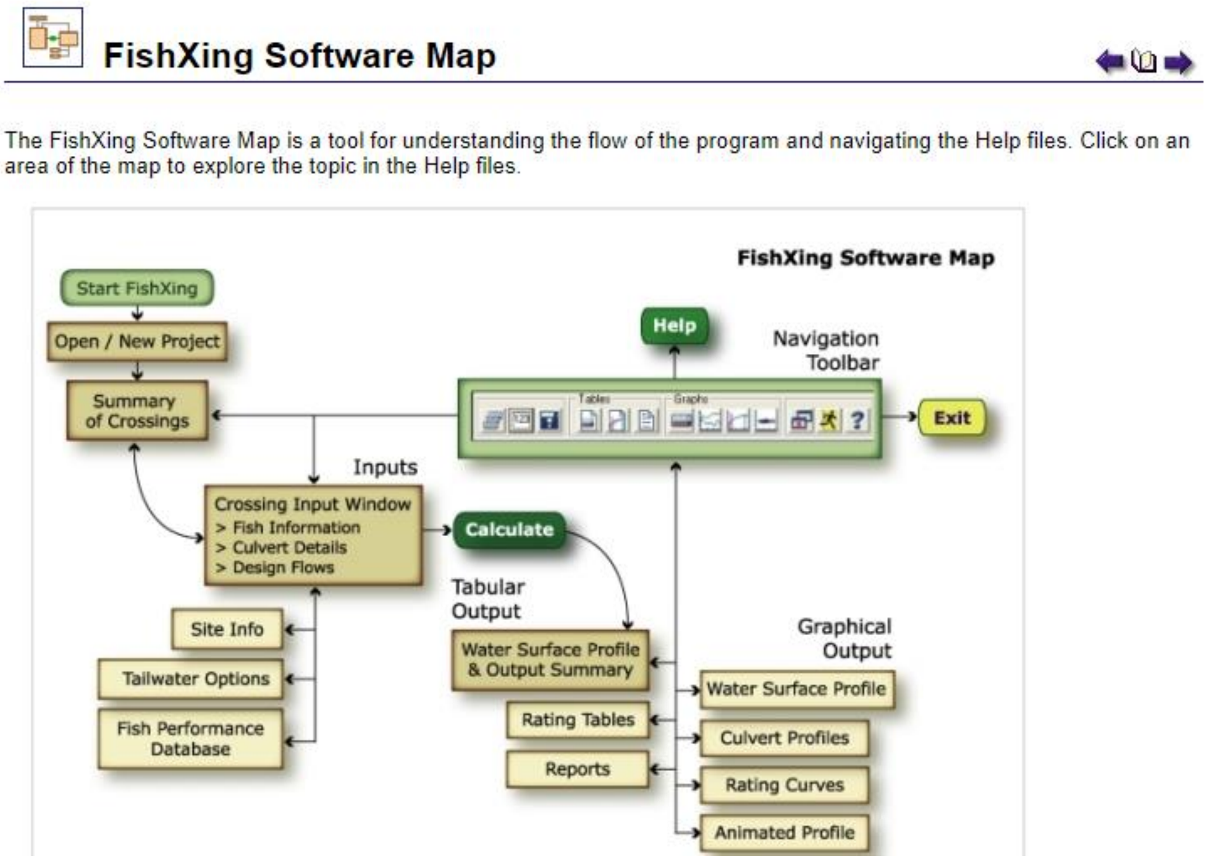
7.2.8 Calculations

When all values are input, click the Calculate button at the bottom of the window. This will bring up an Output Summary window. Choosing different options across the top bar will show various Tables and Graphs which outline barriers to fish passage for the culvert.



7.2.9 Help

If in doubt, the Help page is very detailed. From the contents page there is a Software Map with links to in-depth descriptions for every section. It can be found here: http://www.fsl.orst.edu/geowater/FX3/help/FX3_Help.html



7.2.10 References

Fisheries and Oceans Canada. 2015. Guidelines for the design of fish passage for culverts in Nova Scotia. Fisheries Protection Program, Maritimes Region. Retrieved from: https://novascotia.ca/tran/publications/asphalt/DFO%20Guidelines%20for%20the%20Design%20of%20Fish%20Passage%20for%20Culverts%20in%20Nova%20Scotia.pdf

Maine Department of Transportation. 2004. Fish passage policy & design guide. Retrieved from: https://www.fs.fed.us/biology/nsaec/fishxing/fplibrary/MDOT_2004_Fish_Passage_Policy_and_Design_Guide.pdf

Richardson, J. E. 2004. Winnicut dam removal feasibility study; Hydraulic fish passage and alternatives analysis. Alden Research Laboratory Inc., Holden MA. Retrieved from: https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf

USFWS (U.S. Fish and Wildlife Service). 2017. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, MA. Retrieved from: https://www.fws.gov/northeast/fisheries/pdf/USFWS_R5_2017_Fish_Passage_Engineering_Design_Criteria.pdf

7.2.11 Gaspereau Swim Speeds

Age class	Body length (cm)	Prolonged speed (m/s)	Time to exhaustion (s)	Burst speed (m/s)	Time to exhaustion (s)	Reference
Juvenile	4.32-11.43	0.18-0.30	-			Maine Dept of Transportation Fish Passage Policy, pg 21, March 2004 https://www.fs.fed.us/biology/nsaec/fishxing/fplibrary/MDOT_2004_Fish_Passage_Policy_and_Design_Guide.pdf
Adult	6.6-23.9	0.91-1.52				Maine Dept of Transportation Fish Passage Policy, pg 21, March 2004 https://www.fs.fed.us/biology/nsaec/fishxing/fplibrary/MDOT_2004_Fish_Passage_Policy_and_Design_Guide.pdf
n/a				1.83		Technical Memorandum Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes May 2016 James Turek , Alex Haro , and Brett Towler PAGE 160 OF DOCUMENT https://www.fws.gov/northeast/fisheries/pdf/USFWS_R5_2017_Fish_Passage_Engineering_Design_Criteria.pdf
Adult	22.5		unknown	2.75		https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf
Juvenile	4.6-15.0	0.426-0.535	3600			https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf
Juvenile	13.6	0.636				https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf
Juvenile	13.7	0.357				https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf
Maximum predicted swim	23.9			4.54		https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf

speed for mean-length fish						Note: not all individuals would be able to negotiate water velocities as strong as what was used in this study
?				2.89	15	Gaspereau speed from CSAS Research Document: Fish swimming performance database and analyses. C. Katopodis and R. Gervais. 2016 Optimal swim speeds for traversing velocity barriers: an analysis of volitional high-speed swimming behavior of migratory fishes. Theodore Castro-Santos. 2005.

Note: Another measurement of fish swimming ability commonly reported in the literature is Ucrit (critical swimming speed), which is a standardized calculation of the maximum swimming speed a fish can maintain for a predetermined period of time. As these times are typically between 10 and 200 minutes, Ucrit falls under the category of prolonged swimming speed (Richardson, 2004, p. 22).

Table 1: Summary of Swimming Speeds for both Target and Surrogate Species

Species	Common Name	Life Stage[a]	Mean Length[b] (mm)	Water Temp (°C)	Time (s)	Swimming Mode	Swimming Speed (cm/s)	Reference
Anguilla rostrata	American eel	Elver	56 (TL)	17-23	600	Sustained	15	Barbin and Krueger 1994
Anguilla rostrata	American eel	Elver	56 (TL)	17-23	600	Prolonged	25	Barbin and Krueger 1994
Anguilla rostrata	American eel	Elver	56 (TL)	17-23	Unknown	Burst	40	Barbin and Krueger 1994
Anguilla australis	Short-finned eel	Glass eel	54 (TL)	20-22	1800	Sustained	29	Langdon and Collins 2000
Anguilla australis	Short-finned eel	Glass eel	54 (TL)	20-22	180	Prolonged	35	Langdon and Collins 2000
Anguilla australis	Short-finned eel	Glass eel	54 (TL)	20-22	3	Burst	79	Langdon and Collins 2000
Anguilla reinhardtii	Long-finned eel	Glass eel	51 (TL)	21-23	1800	Sustained	32	Langdon and Collins 2000
Anguilla reinhardtii	Long-finned eel	Glass eel	51 (TL)	21-23	120	Prolonged	42	Langdon and Collins 2000
Anguilla reinhardtii	Long-finned eel	Glass eel	51 (TL)	21-23	5	Burst	75	Langdon and Collins 2000
Hypomesus transpacificus	Delta smelt	Adult	35-74	12-21	600	U_{crit}	27.6	Swanson et al. 1998
Osmerus mordax	Rainbow smelt	Adult	70-163	10	3600	Sustained	39-59	Griffiths 1979 *in* Katopodis and Gervais 1991
Alosa aestivalis	Blueback herring	Juvenile	85	10	Unknown	U_{crit}	22.7	Terpin et al. 1997 *in* EPRI 2000
Alosa aestivalis	Blueback herring	Juvenile	89	15	Unknown	U_{crit}	34.7	Terpin et al. 1997 *in* EPRI 2000
Alosa aestivalis	Blueback herring	Adult	205	15	Unknown	Burst	250[c]	Castro-Santos 2002
Alosa pseudoharengus	Alewife	Juvenile	136	20	Unknown	U_{crit}	63.6	Wyllie et al. 1976 *in* EPRI 2000
Alosa pseudoharengus	Alewife	Juvenile	137	29	Unknown	U_{crit}	35.7	King 1971b *in* EPRI 2000
Alosa pseudoharengus	Alewife	Juvenile	46-150	15	3600	U_{crit}	42.6-53.5	Griffiths 1979 *in* Katopodis and Gervais 1991
Alosa pseudoharengus	Alewife	Adult	225	15	Unknown	Burst	275[c]	Castro-Santos 2002

[a]Unless specified in the literature, life stage was assumed based on fish length.
[b]Mean length is fork length unless otherwise noted (TL = Total Length)
[c]Swimming speed based on volitional ascent in an open flume and indicates the water velocity at which 50% of the fish are able to ascend at least five meters.

Table 2. Summary of design guidelines for NLFs and related to swimming capabilities and safe, timely and efficient passage for Atlantic Coast diadromous fish species. Note: units are expressed in both metric (cm) and English units (feet or feet/sec). See text for informational sources.

Species	Minimum TL (cm)	Maximum TL (cm)	Body Depth/ TL Ratio	Maximum Body Depth (cm)	Minimum Pool/Channel Width (ft)	Minimum Pool/Channel Depth (ft)	Minimum Pool/Channel Length (ft)	Minimum Weir Opening Width (ft)	Minimum Weir Opening Depth (ft)	Maximum Weir Opening Water Velocity (ft/sec)	Maximum Fishway Channel Slope
	TL_{min}	TL_{max}	BD/TL	BD_{max}	W_p	d_p	L_p	W_N	d_N	V_{max}	S_0
Sea Lamprey	60	86	0.072	6.2	10.0	2.00	20.0	0.75	0.75	6.00	1:30
Shortnose Sturgeon	52	143	0.148	21.2	30.0	4.00	30.0	2.75	2.25	5.00	1:50
Atlantic Sturgeon	88	300	0.150	45.0	50.0	7.00	75.0	5.50	4.50	8.50	1:50
American Eel ≤ 15 cm TL	5	15	0.068	1.0	3.0	1.25	5.0	0.25	0.25	0.75	1:20
American Eel >15 cm TL	15	116	0.068	7.9	6.0	2.00	10.0	0.75	1.00	1.00	1:20
Blueback Herring	20	31	0.252	7.8	5.0	2.00	10.0	2.25	1.00	6.00	1:20
Alewife	22	38	0.233	8.9	5.0	2.25	10.0	2.50	1.00	6.00	1:20
Hickory Shad	28	60	0.221	13.3	20.0	2.75	40.0	4.00	1.50	4.50	1:30
American Shad	36	76	0.292	22.2	20.0	4.00	30.0	5.00	2.25	8.25	1:30
Gizzard Shad	25	50	0.323	16.2	20.0	3.25	40.0	3.50	1.75	4.00	1:30
Rainbow Smelt	12	28	0.129	3.6	5.0	1.50	10.0	1.00	0.50	3.25	1:30
Atlantic Salmon	70	95	0.215	20.4	20.0	3.75	40.0	6.25	2.25	13.75	1:20
Sea Run Brook Trout	10	45	0.255	11.5	5.0	2.50	10.0	1.50	1.25	3.25	1:20
Juvenile Salmonid ≤ 20 cm TL	5	20	0.250	5.0	5.0	1.75	10.0	1.25	0.50	2.25	1:20
Atlantic Tomcod	15	30	0.202	6.1	5.0	2.00	10.0	2.00	0.75	0.75	1:30
Striped Bass	40	140	0.225	31.5	20.0	5.25	30.0	9.25	3.25	5.25	1:30

Alewife (FL=225)

	Distance Traversed (m)		
Water Velocity (cm/s)	**5**	**10**	**15**
050	0.920	0.858	0.802
100	0.881	0.789	0.705
150	0.823	0.686	0.561
200	0.737	0.534	0.353
250	0.609	0.315	0.101
300	0.421	0.070	0.000
350	0.172	0.000	0.000
400	0.006	0.000	0.000
450	0.000	0.000	0.000

Fish passage parameters for Gaspereau/Alewife (USFWS, 2017, p. 26)

Parameter	**Values from paper**	**Metric conversion**
Minimum pool/channel width	5.0 ft	1.524 m
Minimum pool/channel depth	2.25 ft	0.6858 m
Minimum pool/channel length	10.0 ft	3.048 m
Minimum weir opening width	2.50 ft	0.762
Minimum weir opening depth	1.0 ft	0.3048
Maximum weir opening water velocity	6.0 ft/sec	1.8288
Maximum fishway/channel slope	1:20	1:20

7.2.12 Relevant Websites Used for Background Info:

- https://waves-vagues.dfo-mpo.gc.ca/Library/362248.pdf
- https://scholar.acadiau.ca/islandora/object/theses%3A2701/datastream/PDF/view
- http://www.earthpoint.us/Convert.aspx
- http://www.fsl.orst.edu/geowater/FX3/help/FX3_Help.html
- https://jeb.biologists.org/content/jexbio/208/3/421.full.pdf
- https://www.annapolisriver.ca/
- http://www.adoptastream.ca/
- http://www.fishprotectiontools.ca/userguide.html#fatigue_equations
- http://www.fsl.orst.edu/geowater/FX3/FX3_manual.pdf
- https://www.dfo-mpo.gc.ca/species-especes/profiles-profils/alewife-gaspareau-eng.html
- https://coastalecology.acadiau.ca/tl_files/sites/cel/Publications/2017%20Nau%20et%20al.%20RRA%20Multiyr%20alewife%20%20passage%20through%20fishways%20improved.pdf
- https://www.calculatorsoup.com/calculators/algebra/exponent-fractions.php
- https://fortress.wa.gov/ecy/publications/documents/0510070.pdf
- https://www.fws.gov/fisheries/fishmigration/alewife.html
- https://www.conteches.com/knowledge-center/pdh-article-series/culvert-hydraulics-basic-principles
- http://learn.hydrologystudio.com/culvert-studio/knowledge-base/estimating-scour/
- http://www.fsl.orst.edu/geowater/FX3/help/9_Fish_Performance/_Water_Depth_for_Swimming.htm
- https://novascotia.ca/tran/publications/asphalt/DFO%20Guidelines%20for%20the%20Design%20of%20Fish%20Passage%20for%20Culverts%20in%20Nova%20Scotia.pdf
- https://www.fs.fed.us/biology/nsaec/fishxing/fplibrary/MDOT_2004_Fish_Passage_Policy_and_Design_Guide.pdf
- https://www.fws.gov/northeast/fisheries/pdf/USFWS_R5_2017_Fish_Passage_Engineering_Design_Criteria.pdf
- https://www.des.nh.gov/organization/divisions/water/wmb/coastal/restoration/projects/documents/winnicut_appendix_7.pdf

7.3 Appendix 3: FishXing Input Data for 2019 Culvert Assessments

Culvert ID	Stream Name	Road Name
PU-001	Officers	Suffolk Rd
PU-003	Mazer South	East Suffolk Rd
PU-005	Brackley	Union Rd
PU-011	Friston Main	Pleasant Grove Rd
PU-015	Wheatley	Suffolk Rd
PU-028	Friston South	Friston Rd
PU-033	Black River	Donaldston Rd
PU-035	Pipers Creek	Blooming Point Rd
PU-052	Afton	Afton Rd
PU-067	Peters Creek	Donaldston Rd
PR-004	Wheatley	Suffolk Pit Rd

7.3.1 PU-001—Officers

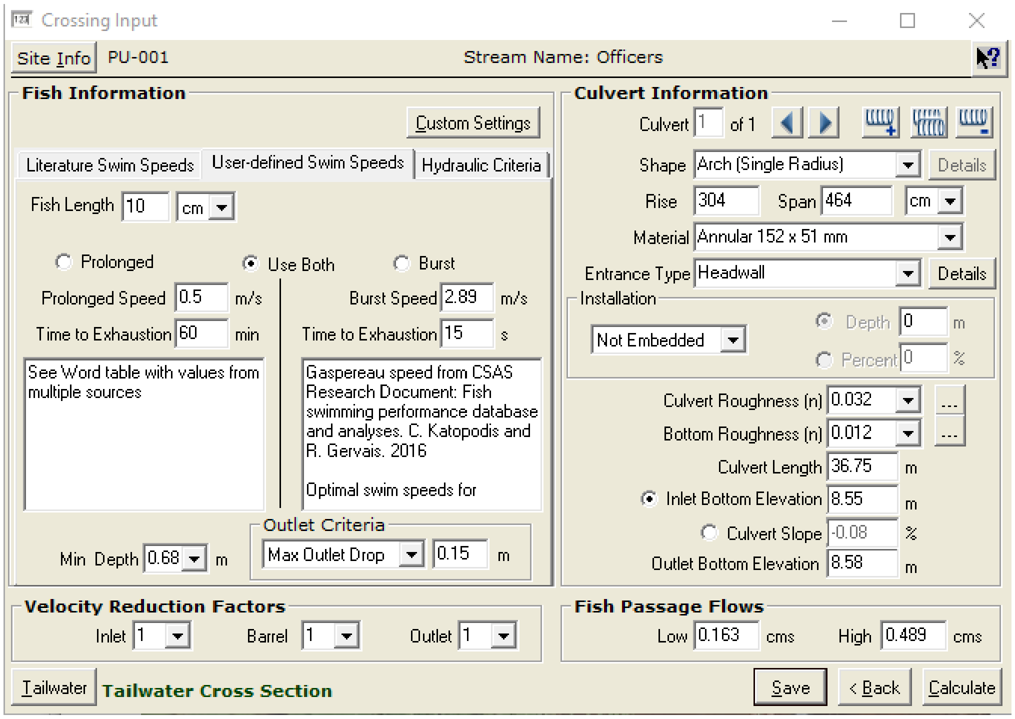


Figure 92. Crossing input values for culvert PU-001.

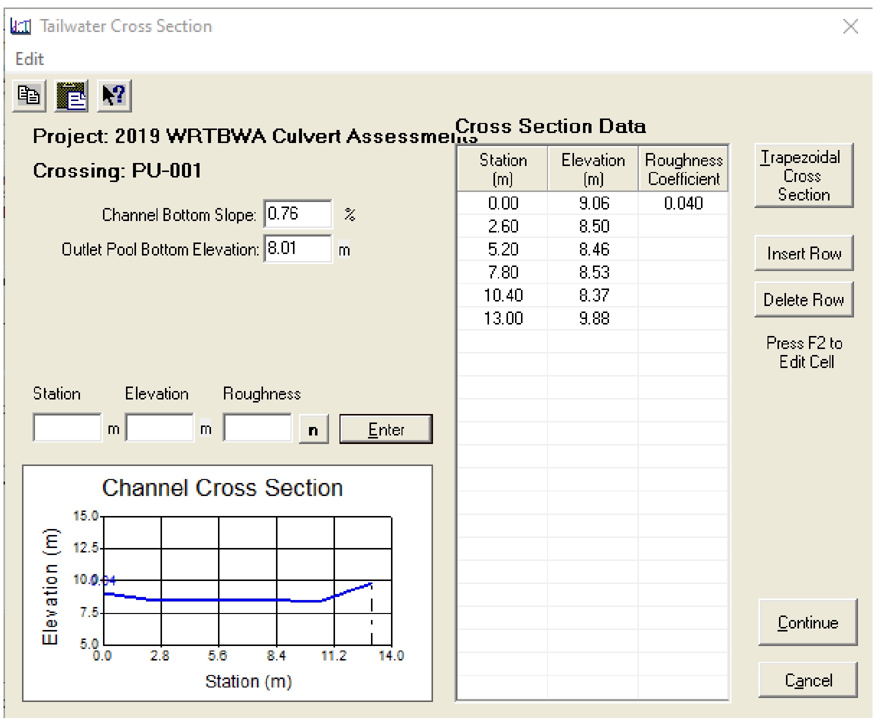


Figure 93. Tailwater control cross section values for culvert PU-001.

7.3.2 PU-003—Mazer South

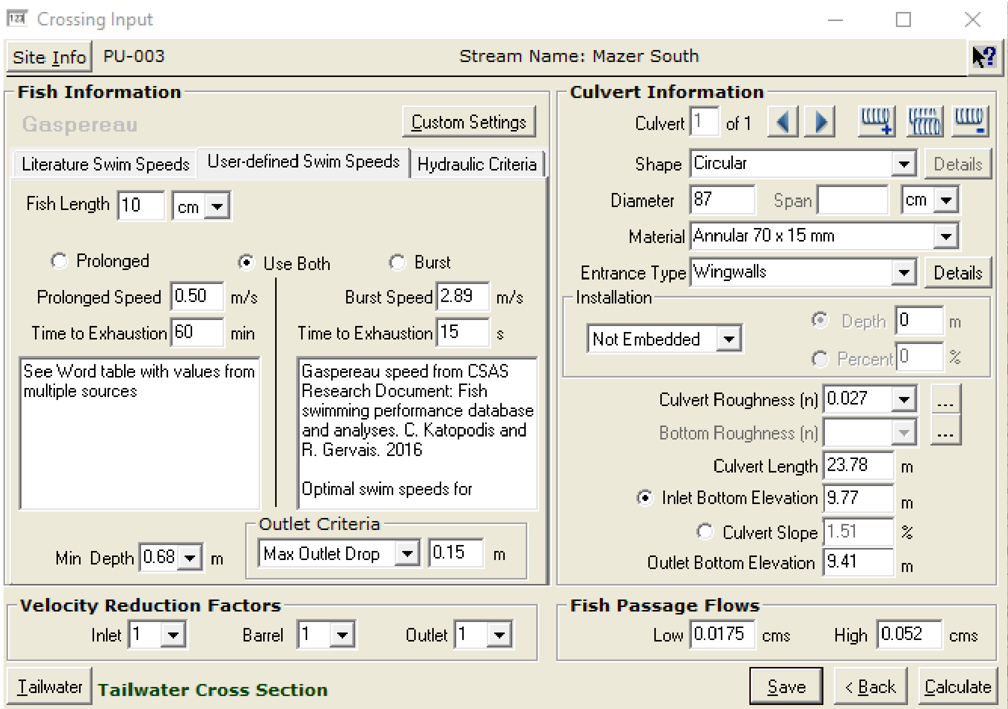


Figure 94. Crossing input values for culvert PU-003.

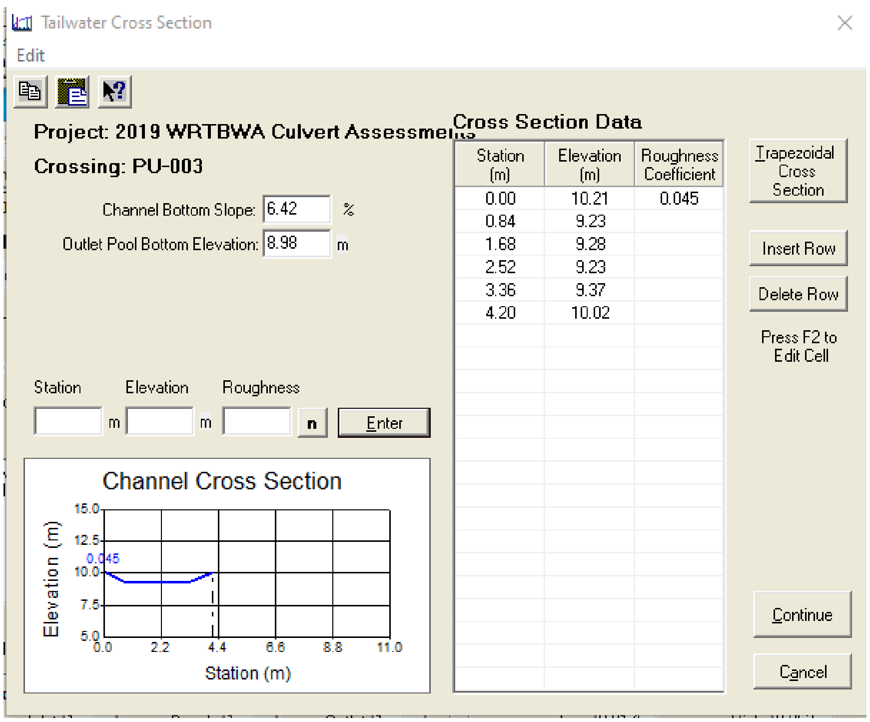


Figure 95. Tailwater control cross section values for culvert PU-003.

7.3.3 PU-005—Brackley

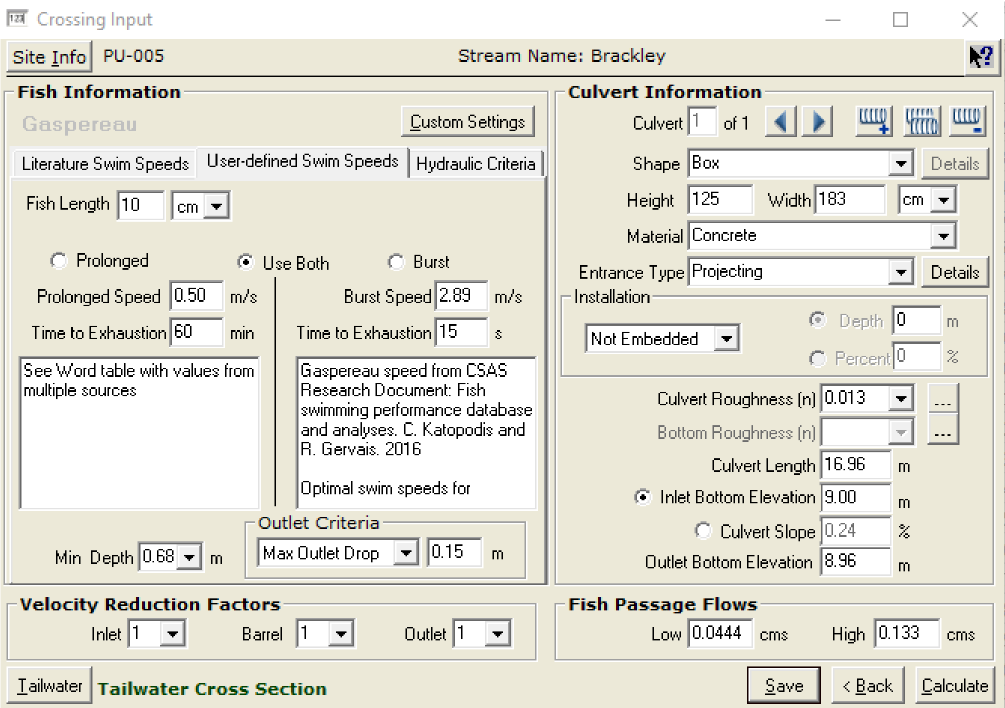


Figure 96. Crossing input values for culvert PU-005.

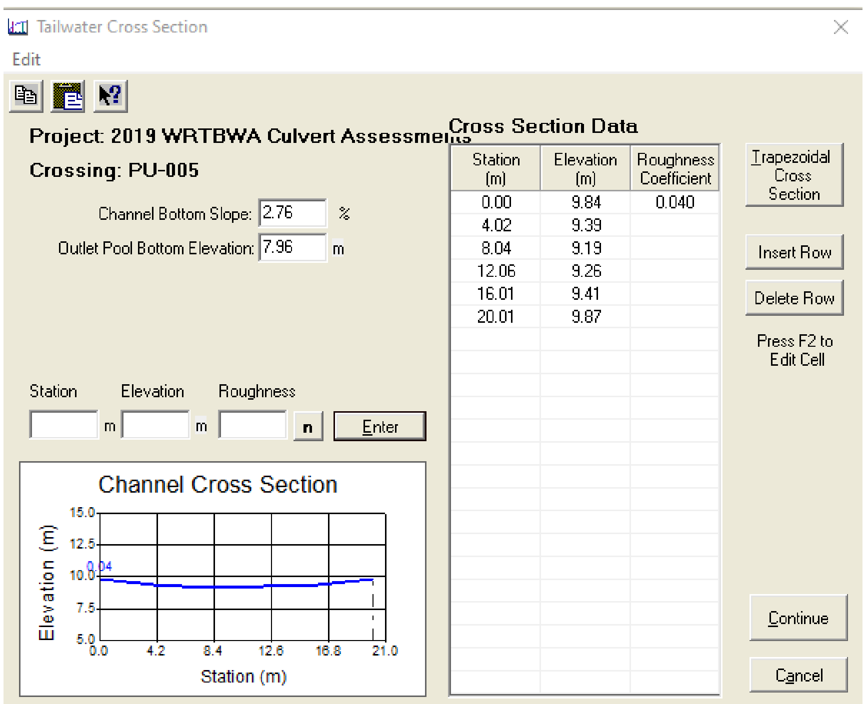


Figure 97. Tailwater control cross section values for culvert PU-005.

7.3.4 PU-011—Friston Main

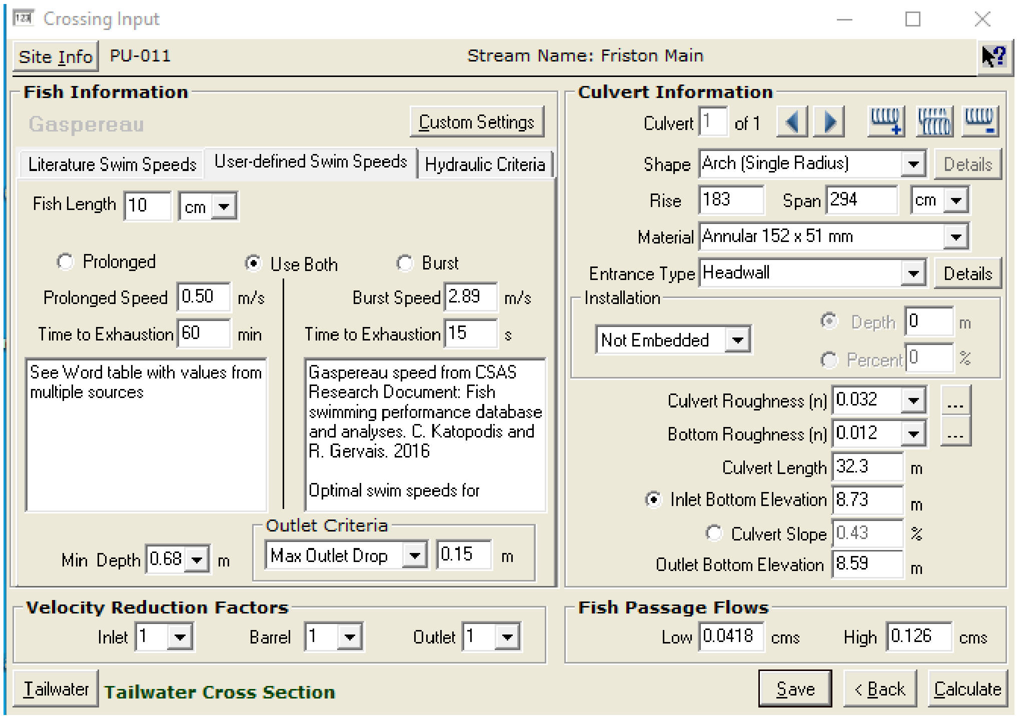


Figure 98. Crossing input values for culvert PU-011.

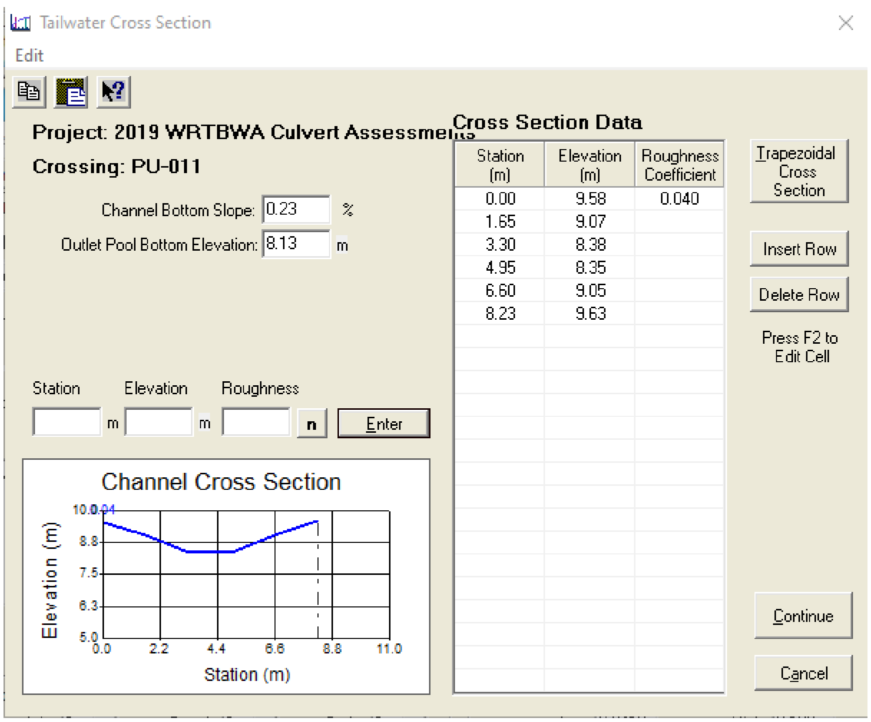


Figure 99. Tailwater control cross section values for culvert PU-011.

7.3.5 PU-015—Wheatley

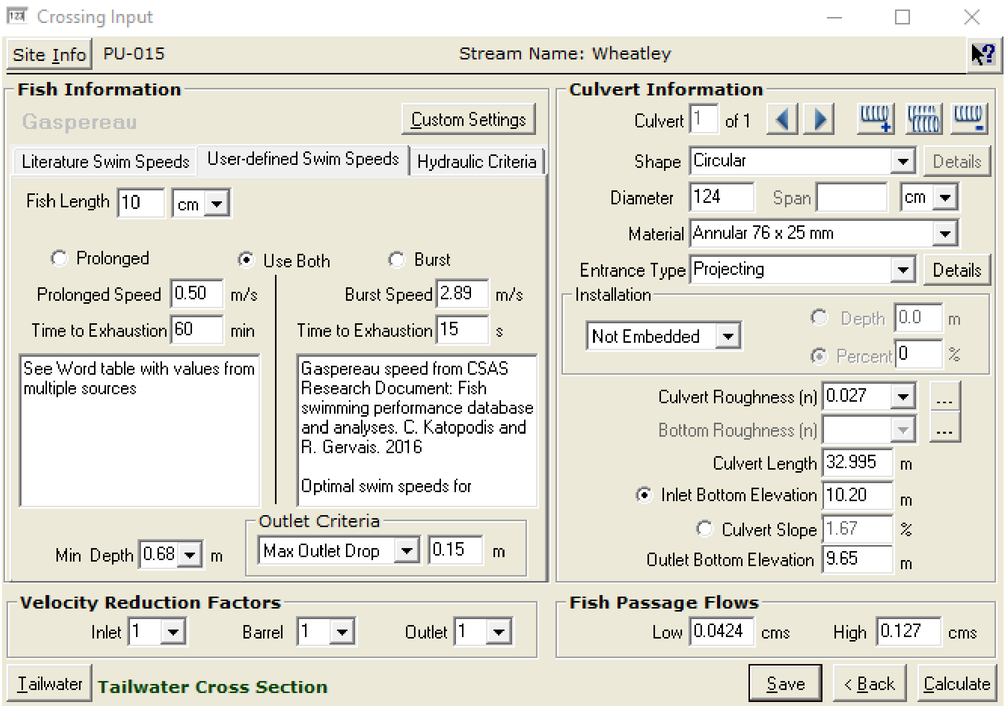
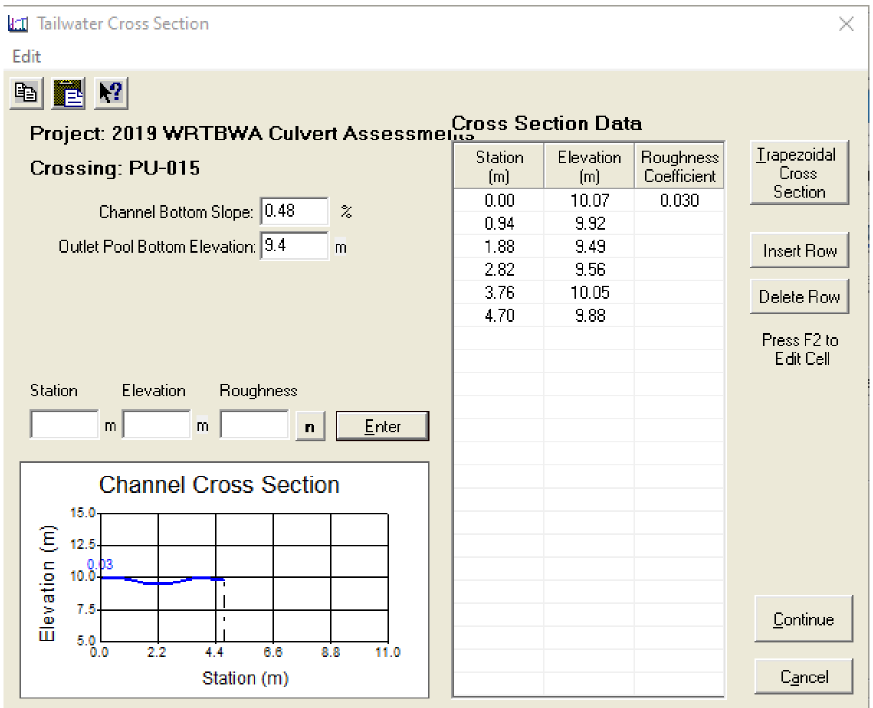


Figure 100. Crossing input values for culvert PU-015.



Station (m)	Elevation (m)	Roughness Coefficient
0.00	10.07	0.030
0.94	9.92	
1.88	9.49	
2.82	9.56	
3.76	10.05	
4.70	9.88	

Figure 101. Tailwater control cross section for culvert PU-015.

7.3.6 PU-028—Friston South

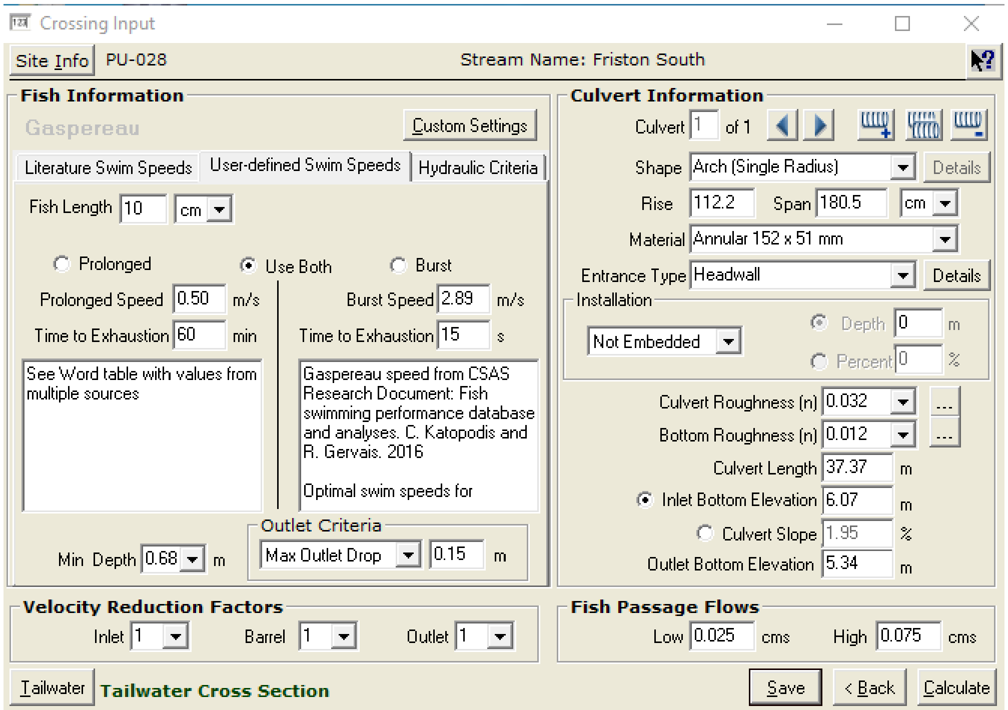


Figure 102. Crossing input values for culvert PU-028.

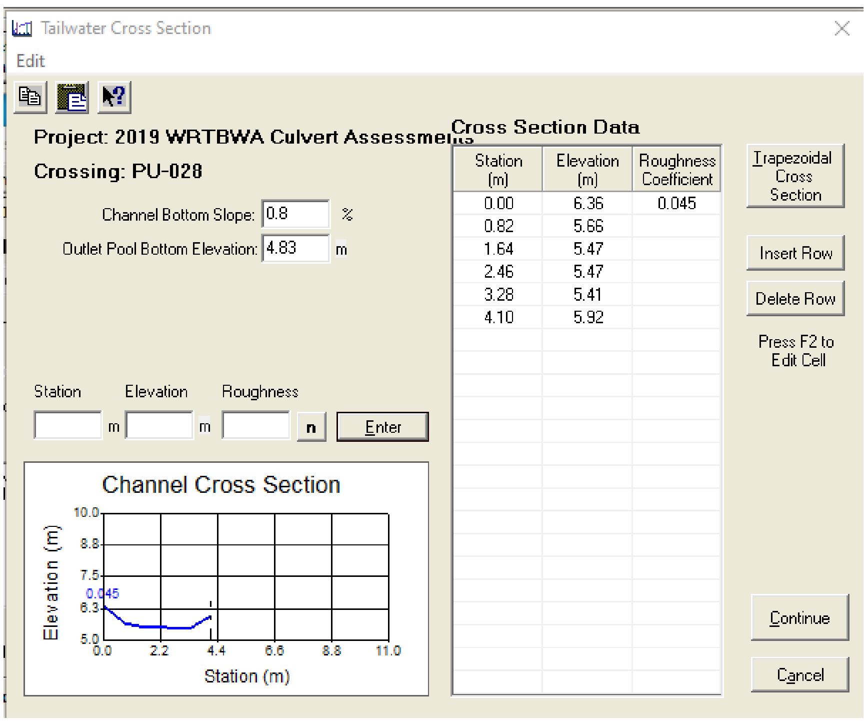


Figure 103. Tailwater control cross section values for culvert PU-028.

7.3.7 PU-033—Black River

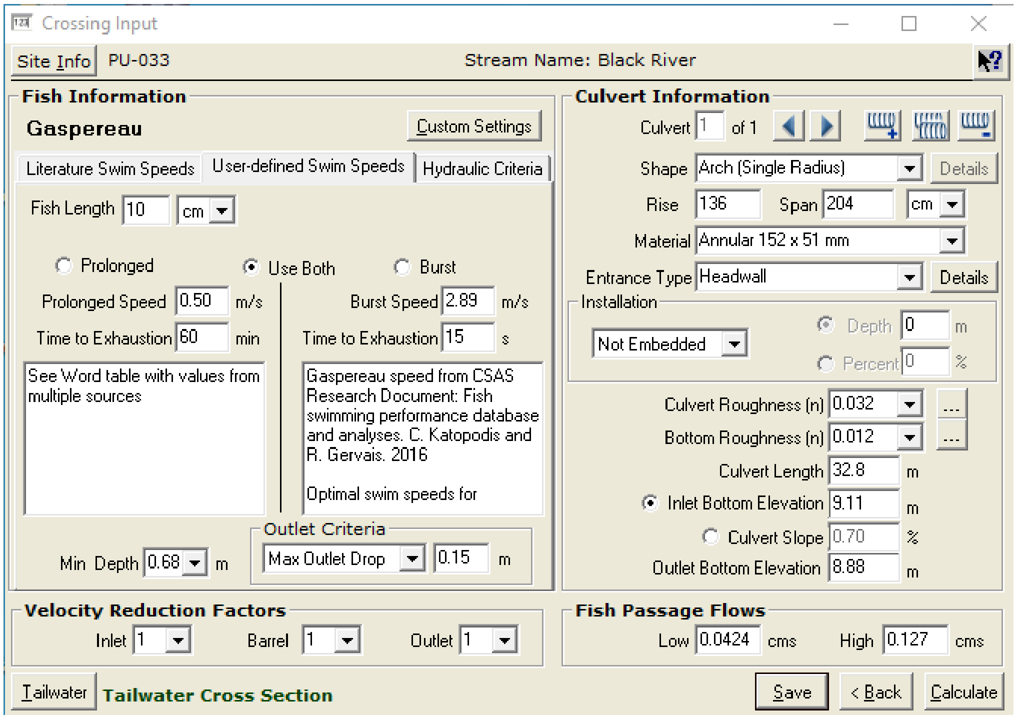


Figure 104. Crossing input values for culvert PU-033.

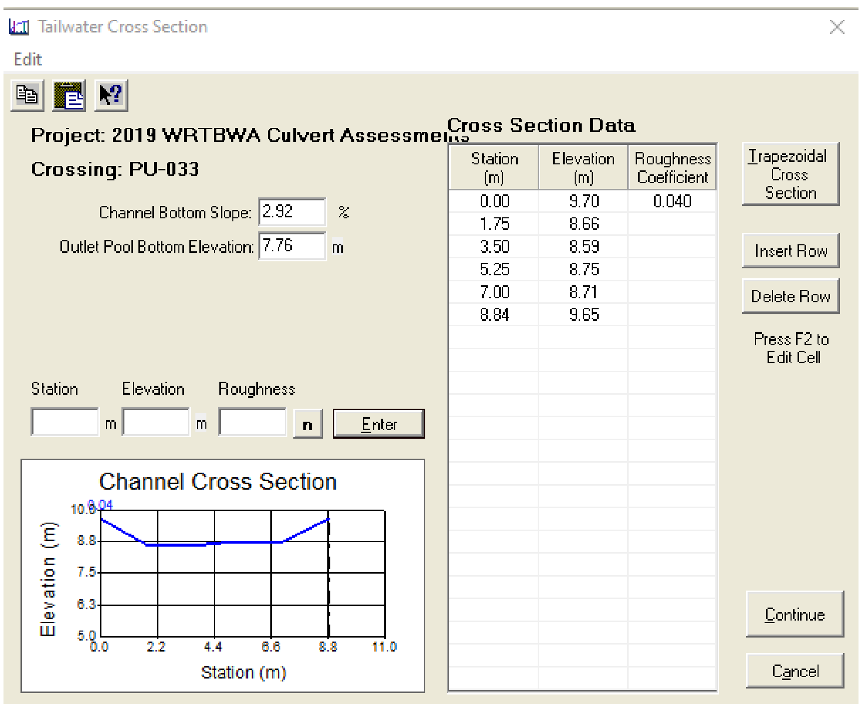


Figure 105. Tailwater control cross section values for culvert PU-033.

7.3.8 PU-035—Pipers Creek

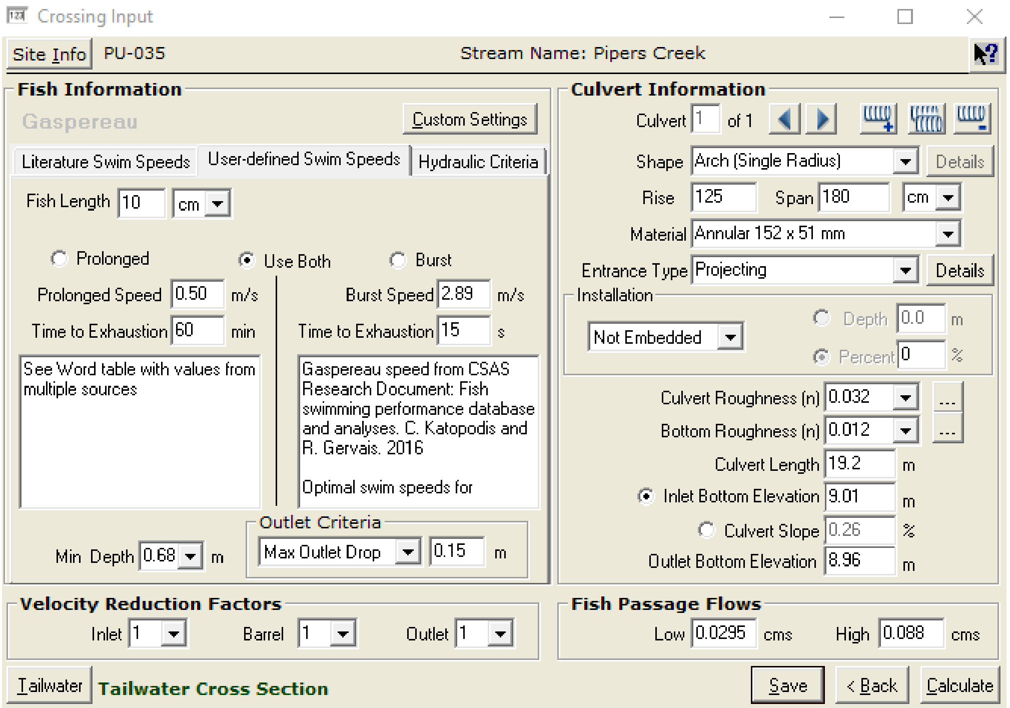


Figure 106. Crossing input values for culvert PU-035.

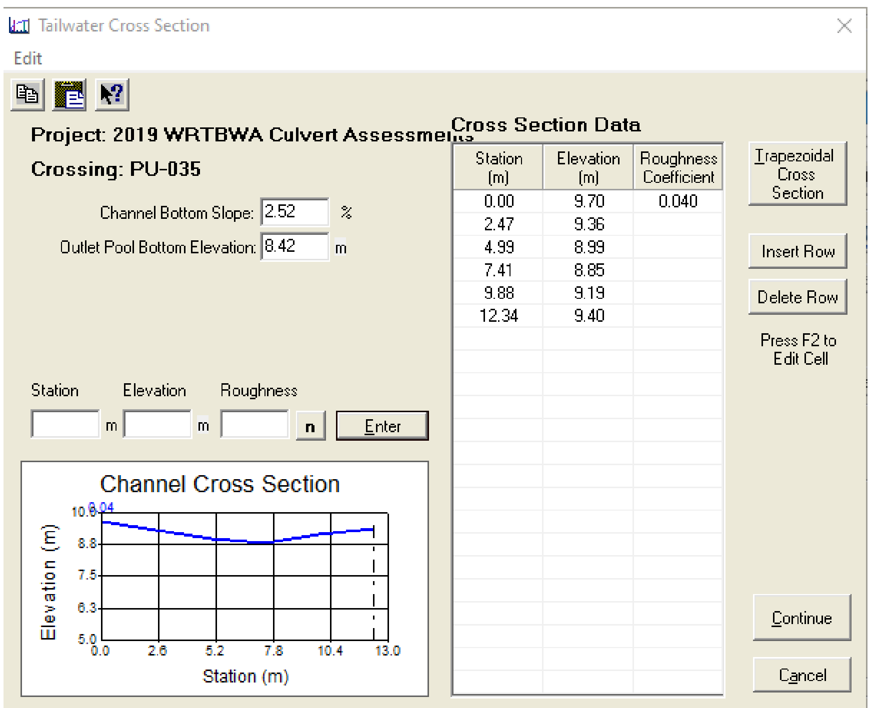


Figure 107. Tailwater control cross section values for culvert PU-035.

7.3.9 PU-052—Afton

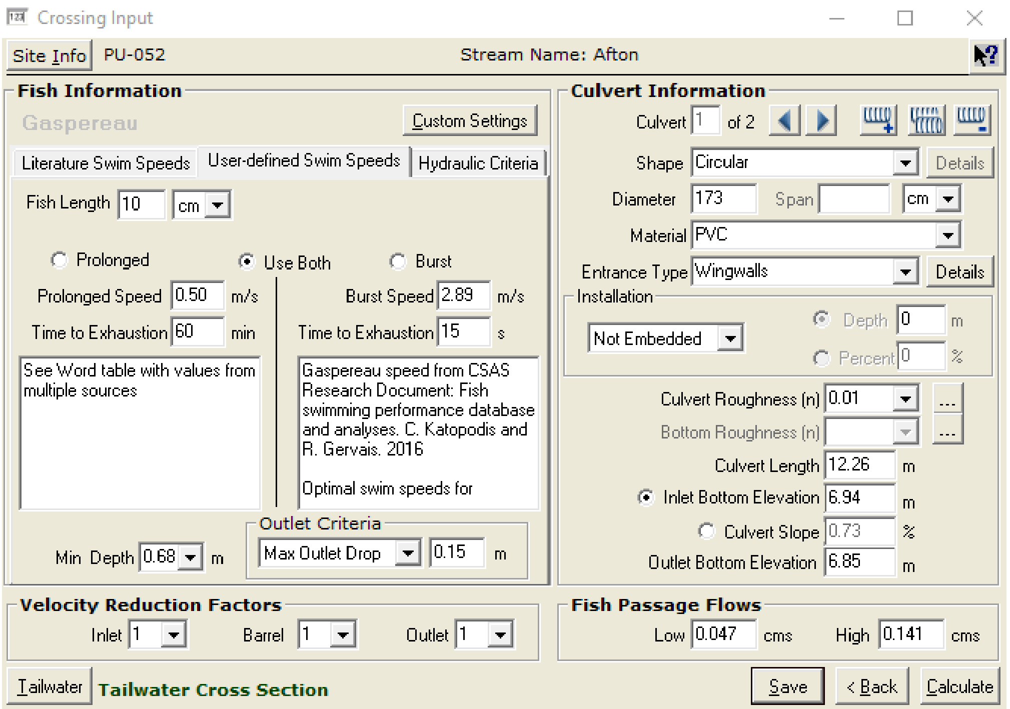


Figure 108. Crossing input values for culvert PU-052A (left).

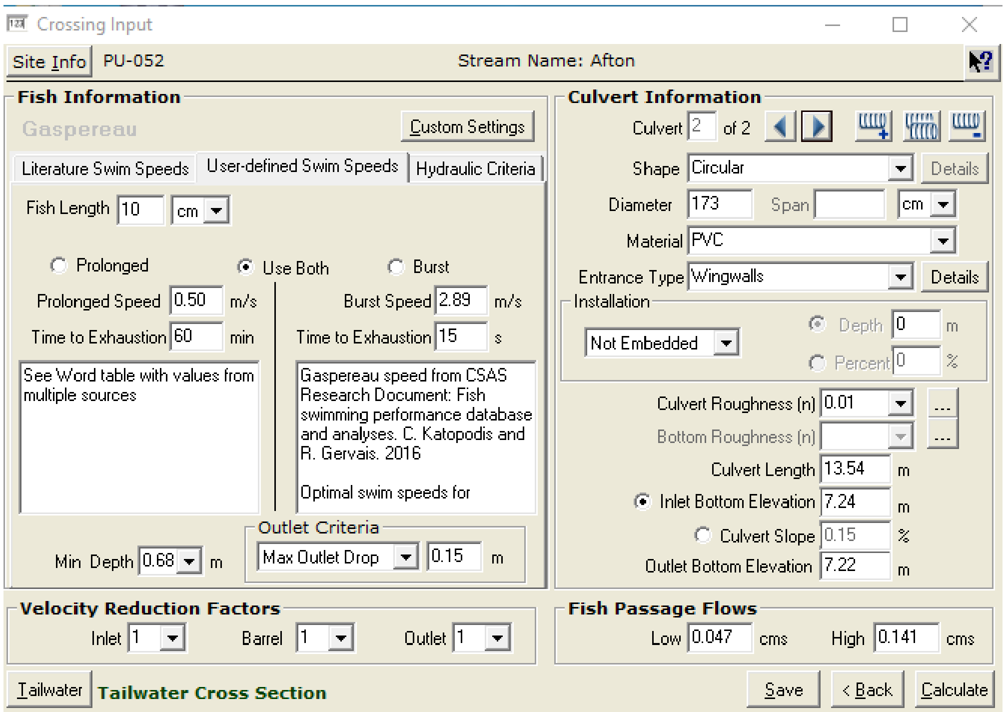


Figure 109. Crossing input values for culvert PU-052B (right).

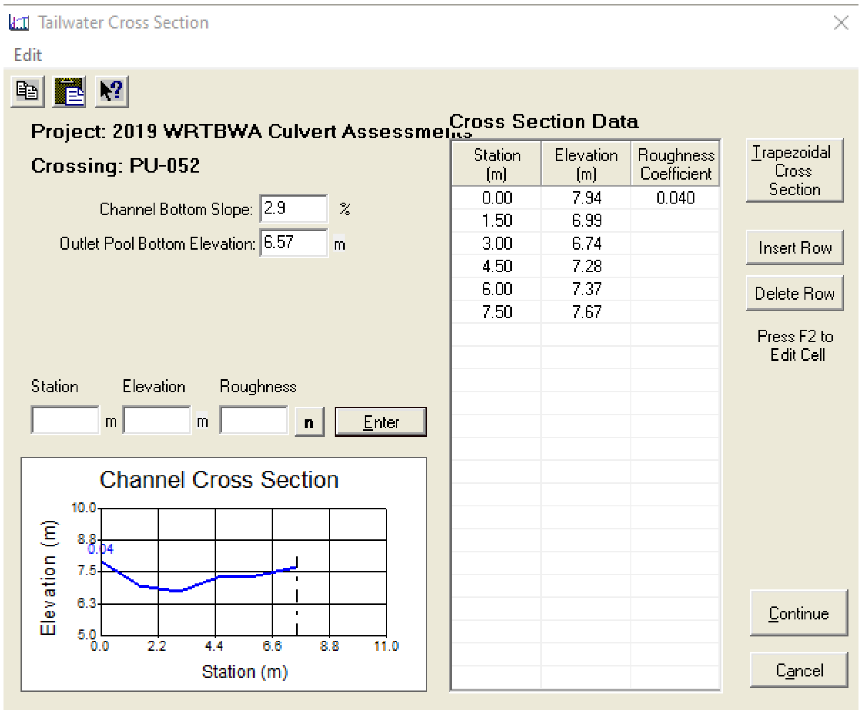


Figure 110. Tailwater control cross section values for culvert PU-052 (same tailwater control for A & B).

7.3.10 PU-067—Peters Creek

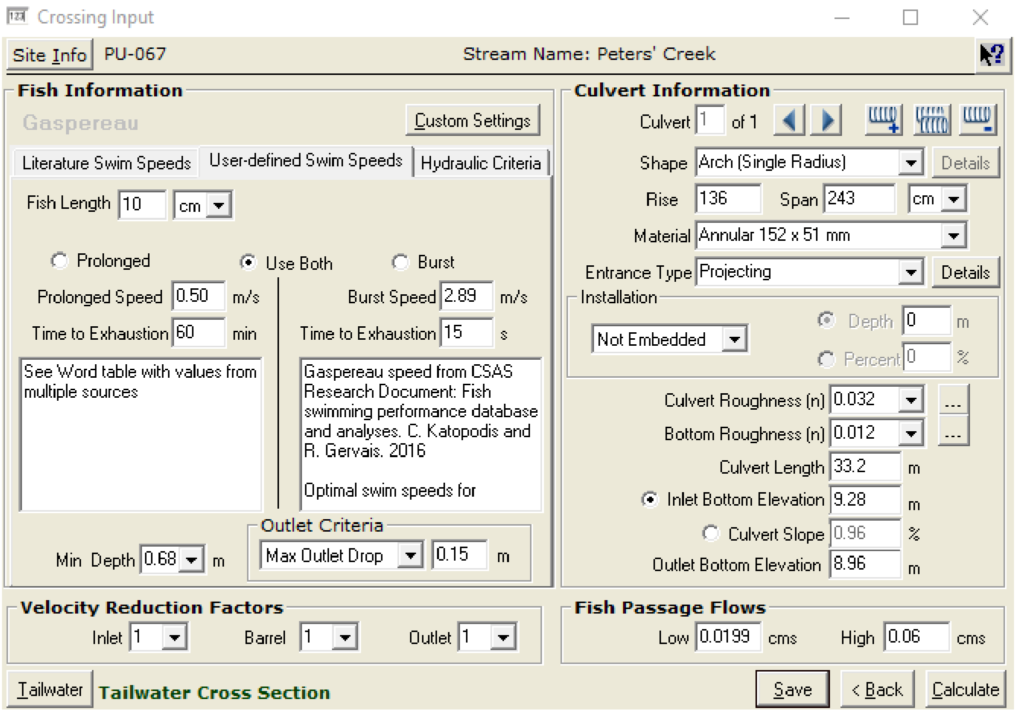


Figure 111. Crossing input values for culvert PU-067.

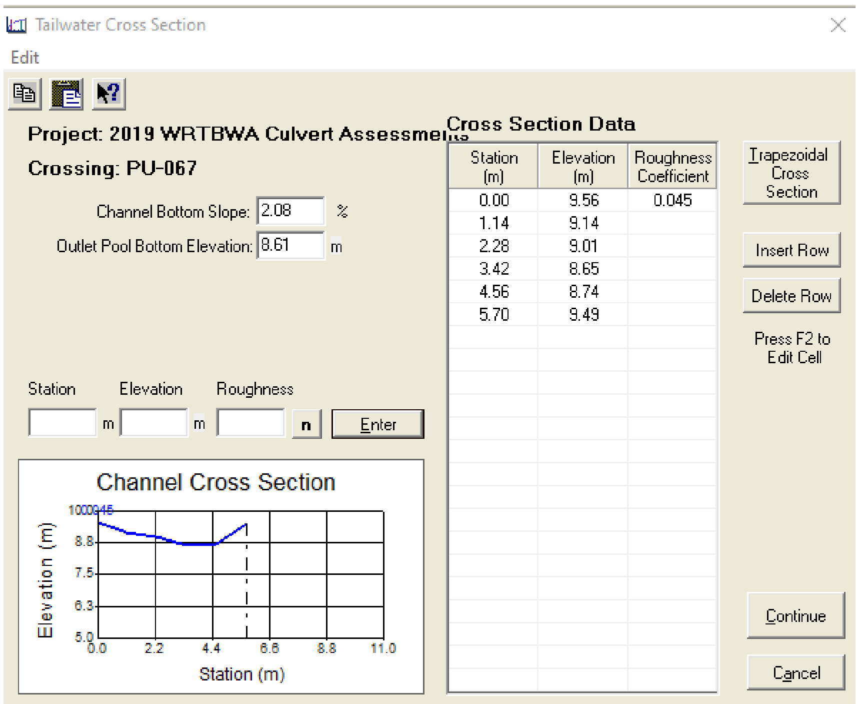


Figure 112. Tailwater control cross section values for culvert PU-067.

7.3.11 PR-004—Wheatley

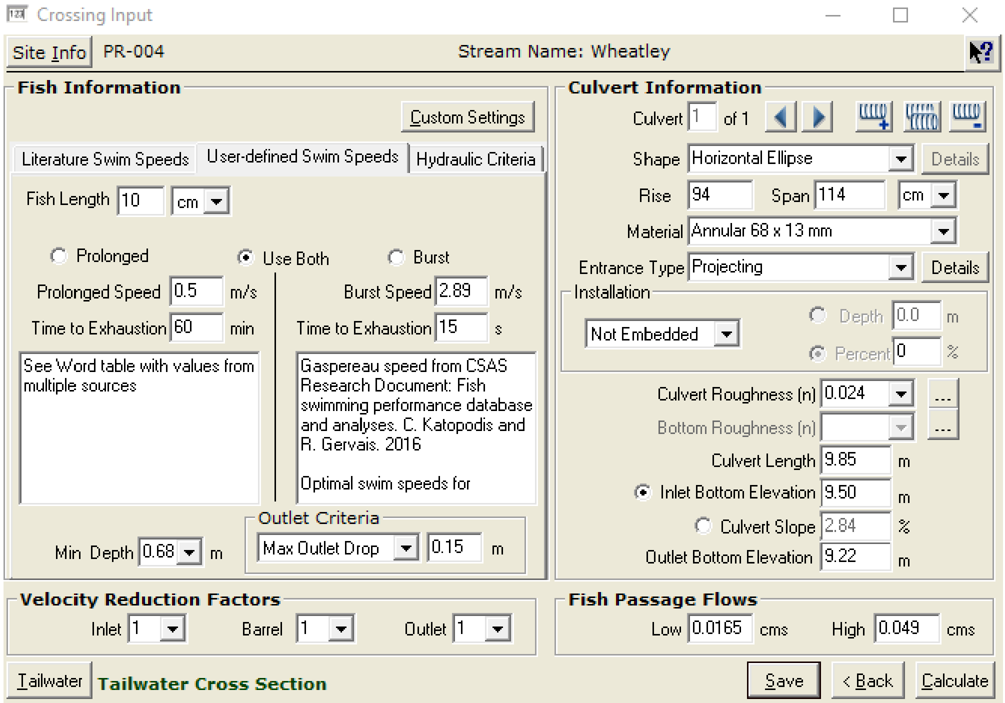


Figure 113. Crossing input values for culvert PR-004.

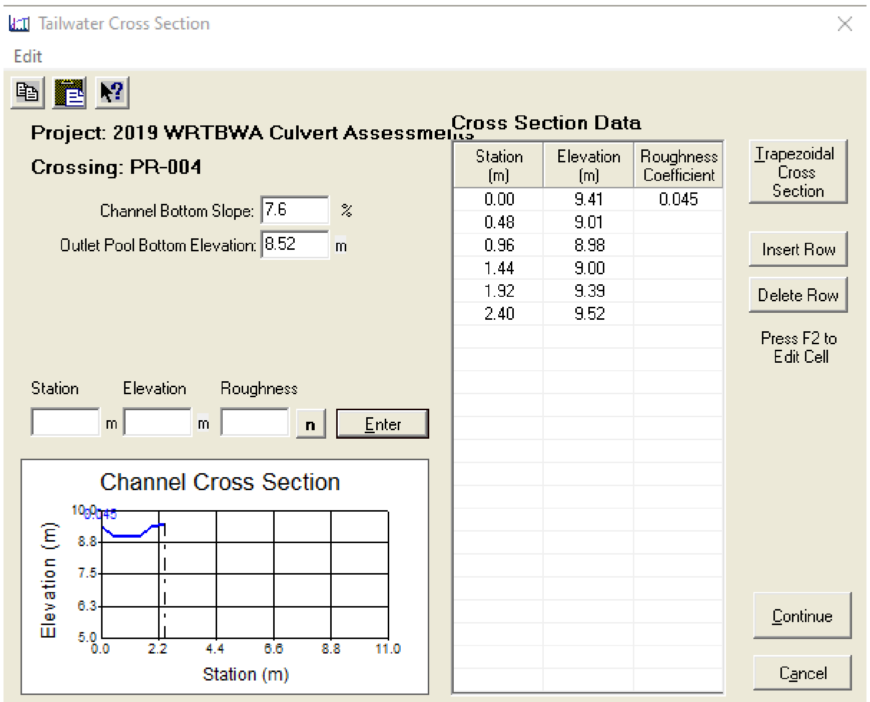


Figure 114. Tailwater control cross section values for culvert PR-004.

7.4 Appendix 4: Culvert Site Information from 2019 Assessments

Culvert											Flow	
Culvert ID	Stream Name	Road Name	Lattitude	Longitude	Culvert Type	Entrance Type	Culvert Length (m)	Catchment Area (km2)	# Road Crossings	Proximity to Ocean*	Low Flow (cms)	High Flow (cms)
PR-004	Wheatley	Suffolk Pit Rd	46.32183333	-63.05681667	Circular, CMP	Projecting	9.85	1.18	1	9.64	0.0165	0.049
PU-001	Officers	Suffolk Rd	46.33189139	-63.06452028	Arch with wood floor, CMP	Headwall	36.75	35.7	0	8.06	0.163	0.489
PU-003	Mazer South	East Suffolk Rd	46.33811423	-63.05705612	Circular, CMP	Wingwall	23.78	1.41	0	7.36	0.0175	0.052
PU-005	Brackley	Union Rd	46.31445938	-63.12790858	Box, concrete	Projecting	16.96	7.76	2	16.61	0.0444	0.133
PU-011	Friston Main	Pleasant Grove Rd	46.380345	-63.066879	Arch with wood floor, CMP	Headwall	32.3	7.15	0	2.57	0.0418	0.126
PU-015	Wheatley	Suffolk Rd	46.32204978	-63.05658477	Circular, CMP	Projecting	32.995	1.18	1	9.64	0.0165	0.049
PU-028	Friston South	Friston Rd	46.37912378	-63.0794396	Arch with wood floor, CMP	Headwall	37.37	3.19	1	3.59	0.025	0.075
PU-033	Black River	Donaldston Rd	46.35546111	-62.99909167	Arch with wood floor, CMP	Headwall	32.8	7.28	0	1.1	0.0424	0.127
PU-035	Pipers Creek	Blooming Point Rd	46.37669726	-62.97283499	Arch with wood floor, CMP	Projecting	19.2	4.24	0	0.32	0.0295	0.088
PU-052A	Afton	Afton Rd	46.405503	-62.93575	Circular, CPP	Wingwall	12.26	8.37	2	5.49	0.047	0.141
PU-052B	Afton	Afton Rd	46.405503	-62.93575	Circular, CPP	Wingwall	13.54	8.37	2	5.49	0.047	0.141
PU-067	Peters Creek	Donaldston Rd	46.371029	-63.032475	Arch with wood floor, CMP	Projecting	33.2	1.97	0	0.41	0.0199	0.06

- *Length to ocean was measured to the Corran Ban Bridge for Winter River branches, and to Tracadie Bay for the branches adjacent to it.
-

7.5 Appendix 5: Comparison of 2018 & 2019 Temperature Data

Year	Logger Location	Max Temp (°C)	Min Temp (°C)	Average Temp (°C)	% Time in Optimal Growth Range for BT: 11-18 °C	% Time in Tolerant Range for BT: 0-20 °C	% Time in Stress Zone for BT: >20°C	Longest # of Hours in Stress Zone	Average Summer Temp (°C)	NCC Temperature class	Logging Start	Logging End	Logging Period (days)
2019	Union Depth Logger	17.189	2.303	10.483	46%	100%	0%	0	11.692	COLD	2019-05-27	2019-11-14	171
2018	Union Pumping Station	22.9	0.5	12.0	46.88%	97.67%	2.33%	15	15.251	COLD	2018-05-14	2018-11-25	195
		-5.7	1.9	-1.5	0.0	0.0	0.0	-15.0	-3.6				
2019	Hardy Mill Depth Logger	23.869	1.656	14.329	49%	92%	8%	36	17.405	COLD	2019-05-27	2019-11-19	176
2018	Hardy Mill Outlet	26.4	0.5	15.1	38.84%	74.67%	25.33%	382	19.462	COOL	2018-05-14	2018-11-25	195
		-2.5	1.2	-0.8	0.1	0.2	-0.2	-346.0	-2.1				
2019	Officer's Depth Logger	23.773	0.343	15.682	35%	71%	29%	356	19.506	COOL	2019-05-27	2019-11-19	176
2018	Officer's depth logger	26.0	0.0	15.6	33.95%	69.96%	30.04%	833	20.264	COOL	2018-05-14	2018-11-25	195
		-2.2	0.3	0.1	0.0	0.0	0.0	-477.0	-0.8				
2019	Tim's Creek Depth Logger	19.187	2.410	13.253	71%	100%	0%	0	15.667	COLD	2019-05-27	2019-11-14	171
2018	Below Tim's	20.0	0.2	12.4	57.39%	99.98%	0.02%	1	15.742	COLD	2018-05-14	2018-11-25	195
		-0.9	2.2	0.9	0.1	0.0	0.0	-1.0	-0.1				
2019	Beaton's Depth Logger	20.424	1.872	12.811	66%	100%	0%	4	15.120	COLD	2019-05-27	2019-11-14	171
2018	Beaton's Creek (TL)	21.1	6.4	14.9	67.17%	98.61%	1.39%	8	15.878	COLD	2018-05-23	2018-10-08	138
		-0.7	-4.5	-2.1	0.0	0.0	0.0	-4.0	-0.8				
2019	Hardy Mill Surface	28.555	8.978	18.915	34%	55%	45%	238	20.852	COOL	2019-06-25	2019-10-07	104
2018	Hardy Mill Surface	28.3	11.0	19.3	37.75%	53.31%	46.69%	847	20.526	COOL	2018-05-24	2018-10-04	133
		0.3	-2.0	-0.4	0.0	0.0	0.0	-609.0	0.3				
2019	Officer's Surface	27.272	14.804	20.396	22%	35%	65%	181	20.396	COOL	2019-06-25	2019-07-20	25
2018	Officer's Surface	31.0	12.2	20.2	32.56%	46.94%	53.06%	859	21.470	WARM	2018-05-24	2018-10-04	133
	**	-3.7	2.6	0.2	-0.1	-0.1	0.1	-678.0	-1.1				

**Officer's Surface logger was only active for 25 days in 2019 due to a malfunction; comparisons cannot be made between years.

7.6 Appendix 6: Depth Logger Malfunction Dates

Dates where depth logger data had to be modified for all sites, due to malfunction of depth logger at office measuring atmospheric pressure changes. Some logger malfunctions likely due to pressure changes during thunderstorms and quickly changing weather.

Dates of Atmospheric Logger Malfunction

2019-05-28	2019-09-07	2019-09-12	2019-10-16	2019-11-01
2019-07-25	2019-09-11	2019-09-24	2019-10-17	2019-11-12
2019-09-05	2019-09-17	2019-09-26	2019-10-31	

7.7 Appendix 7: Estuary Watch Survey Categories for Assessing Conditions

There are 4 Estuary Condition Categories corresponding to the Estuary Watch Index Score: Healthy, Impaired, Hypoxia, and Anoxia. Healthy water is clear, with little to no colour, no odour, and less than 25% sea lettuce coverage. Here, the dissolved oxygen level is within 10% of its normal value and the sea lettuce looks mostly healthy. Water in the Impaired category is clear to slightly cloudy, with some light greenish colour, no odour or a very faint odour, and sea lettuce coverage of over 25%. The sea lettuce appears mostly healthy, with some die off, and dissolved oxygen levels are more than 10% above or below normal levels.

Water that is considered Hypoxic is slightly to very cloudy, may be olive, lime green, or gray in colour, and has a mild to medium odour. There is sea lettuce coverage of more than 25% and dissolved oxygen levels are under 50% of the normal value. The sea lettuce also appears to be dying or unhealthy. When water is anoxic, it is very cloudy, with a white or gray colour, and medium to strong odour. The sea lettuce coverage may have quickly decreased as other conditions worsened, and most sea lettuce present is dead.