



# **AQUETONG CREEK ECOLOGICALLY-BASED WATER QUALITY MONITORING - 2022**

**SOLEBURY TOWNSHIP, BUCKS COUNTY, PA**

**JANUARY 2023**

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## INTRODUCTION

The Aquetong Creek restoration site is located in Solebury Township, Bucks County, PA, at the location of the former Aquetong Lake. Aquetong Lake was a 15-acre impoundment formed in 1870 by the construction of an earthen dam on Aquetong Creek. The main source of Aquetong Creek is Ingham Spring, an artesian spring formed at the contact of two geologic formations that flows at a rate of approximately 2,000 gallons per minute (GPM) (F.X. Browne, Inc., 2004). Aquetong Creek flows approximately 2.5 miles from Ingham Spring to its mouth at the Delaware River in New Hope, PA.

A 2004 study funded by Bucks County Trout Unlimited found that the impoundment was affecting downstream water quality, particularly water temperature (F.X. Browne, Inc., 2004). In 2015, the dam was breached with the goal of reducing thermal impacts on the creek and supporting a high-quality cold-water fishery in Aquetong Creek, while also avoiding the need for continued dam maintenance. With the dam breached and the lake drained, a meandering channel formed through the exposed former lakebed, connecting the upper and lower reaches of Aquetong Creek. Additionally, a small tributary flowing from the north under Route 202 now joins Aquetong Creek in the approximate center of the formerly impounded area.

In 2017 and 2018, Princeton Hydro conducted several monitoring events focusing on the downstream area closer to the dam breach, as well as upstream to the Ingham Spring and within the northern tributary passing under Route 202. This monitoring concluded that conditions within the former lake bed were partially conducive to maintaining a brook trout (*Salvelinus fontinalis*) population as it pertains to temperature, dissolved oxygen, and available forage. However, the physical habitat still needed additional restoration to further increase the stability of streambanks and create more refuge habitat for trout. Another survey was conducted in 2019 focusing on the areas downstream of the breach in order to assess impacts of the removal of several ash trees within the park, and further surveys focusing on the original study area were conducted in the fall of 2020 and the growing season of 2021.

In 2022, Princeton Hydro again conducted a survey of the ecological condition of the six (6) main sites within the study area. In addition, at the request of the Aquetong Watershed Association, two (2) sites outside of the initial study area previously monitored by the PADEP were also sampled. The overall goal of the 2022 study was to continue to assess current water quality conditions, fish, and benthic invertebrate communities within the project site. Comparisons were also made between the 2022 data and that data collected in previous years (where they apply) in order to assess any longitudinal changes occurring in the stream over time.

## METHODS

As in previous years, six (6) points within the old lakebed and in areas downstream were sampled for water quality three (3) total times in 2022 (Figure 1). The downstream-most of these points is located near the eastern property line, while an additional site (ST1) is located approximately 450' downstream of the dam breach. ST2 is sited at the dam breach. ST2, ST3, and ST5 are all located along the mainstem of the Aquetong, while ST4 is located on a small tributary that enters the mainstem from the direction of Rt. 202. Two (2) additional sites were also sampled in 2022, both near locations that have been previously sampled by the PADEP. One of these sites is located over 0.5 miles downstream of the dam breach and approximately 225 m downstream of Reeder Road (AW1). The other site is located along a northern branch of the Aquetong Creek at a reach that runs parallel to Creekside Drive (AW2). A map of locations is provided in Figure 1. A survey of the stream's macroinvertebrate and fisheries communities at each site was conducted on October 11<sup>th</sup>, 12<sup>th</sup>, and 14<sup>th</sup>, 2022.



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## **IN-SITU AND STREAMFLOW DATA COLLECTION**

At each location, Princeton Hydro scientists collected *in-situ* water quality data using an *In-situ* Aquatroll 500 calibrated multimeter water quality probe. This probe measured the following analytes:

- Temperature (°C)
- Dissolved Oxygen (concentration as mg/L and percent saturation as %)
- Specific Conductivity ( $\mu\text{S}/\text{cm}$ )
- pH (standard units)

Additionally, water velocity data was collected at several points along a cross-section at each station using a Marsh-McBirney, Inc. Flo-Mate™ Model 2000 Portable digital flowmeter and a wading rod. Total streamflow was calculated using water velocity, depth, and distance along the cross section collected at each point.

## **DISCRETE WATER QUALITY DATA COLLECTION**

On each water quality sampling date, whole water samples were collected at each station and analyzed for the following:

- Total Phosphorus
- Total Nitrogen
- Total Suspended Solids

Following each sampling event, samples were delivered to Environmental Compliance Monitoring (ECM), a certified laboratory, for analysis.

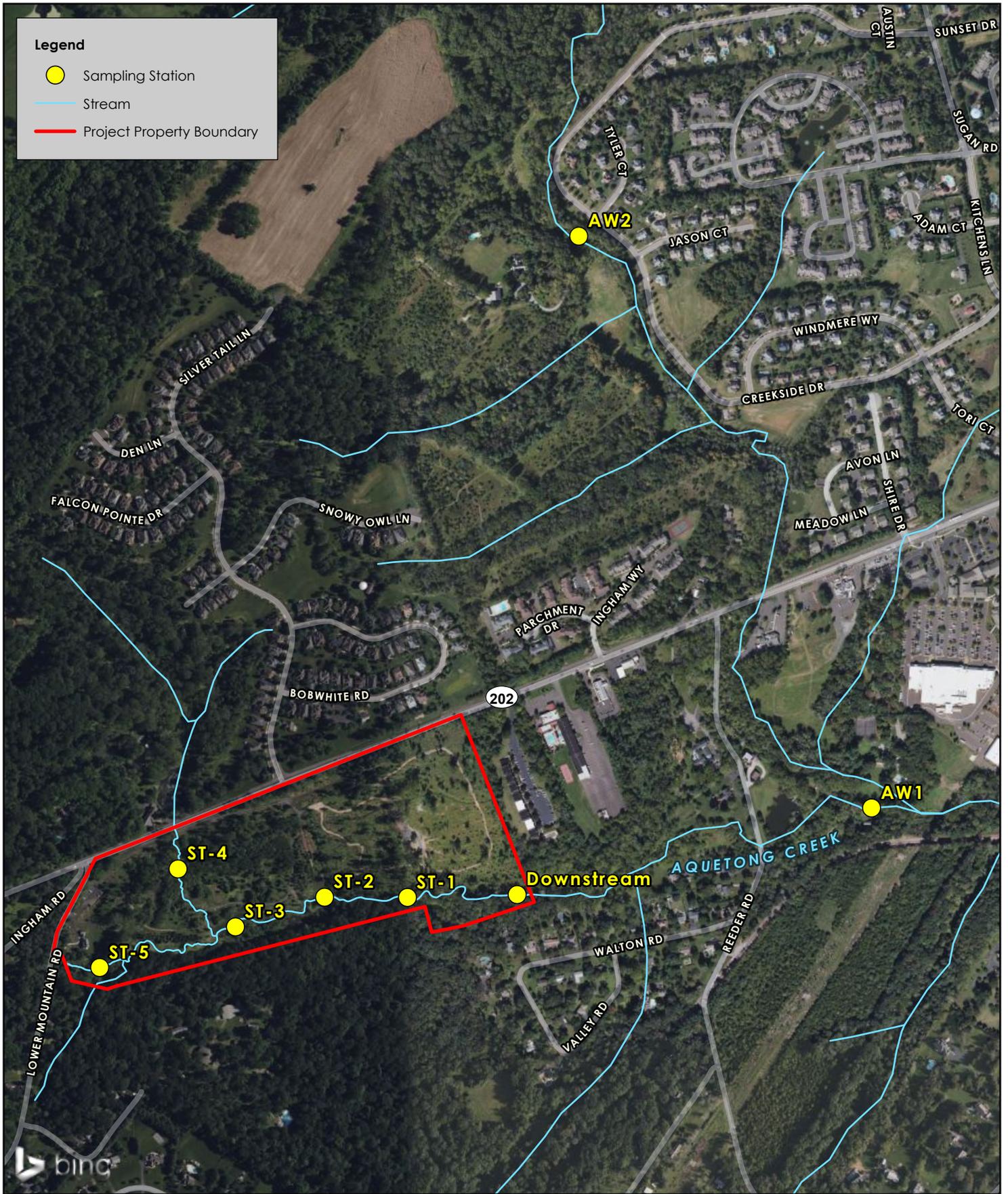
## **FISHERIES SURVEY**

A survey of the fish communities at each site were conducted in mid-October, 2022 using the backpack electrofishing method. During each sampling event, seine nets were placed in the upstream and downstream ends of the reach to prevent fish from moving into and out of the area to be sampled. A length of each reach was sampled three times, beginning at the downstream end of the reach. Captured fish were kept in a temporary holding vessel. After each electrofishing pass the fish were either immediately processed and released outside the sampling area or pooled for the three runs and subsequently processed and released to avoid recapture in the surveyed segment. All captured fish were identified to species, measured for total length, and returned to the stream immediately following measurement. Additionally, all brook trout were weighed using a small digital scale in order to obtain their approximate mass. The resulting data was analyzed for composition, catch per unit effort, Shannon's diversity, and evenness.

## **BENTHIC MACROINVERTEBRATE SAMPLING**

During the October sampling event, the benthic macroinvertebrate community was sampled at each station using a D-net. Ten kicks or jabs were collected per station in various microhabitat types (e.g. riffles, coarse woody debris, aquatic vegetation) and compiled into a single sample. This sample was preserved with alcohol and analyzed in Princeton Hydro's in-house laboratory. A subsample of at least 50 organisms was picked from each sample, and each organism was identified to lowest practical taxon (typically family). The resulting data was used to calculate metrics such as %EPT, richness, diversity, and the family-level biotic index.

File: P:\03888\Projects\03888012\GIS\APRX\WQ\_Sampling\_Map\WQ\_Sampling\_Map.aprx, 1/18/2023, Drawn by bsmflh, Copyright Princeton Hydro, LLC.



- NOTES:
1. Stream sampling locations are approximate.
  2. Property boundary is approximate.
  3. Streams obtained from the Pennsylvania Spatial Data Access (PASDA) website: <http://www.pasda.psu.edu/>
  4. Aerial imagery obtained through ArcGIS Online Bing Maps (C) 2021 Microsoft Corporation and its data suppliers.

Map Projection: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet

### FIGURE 1: ECOLOGICAL SURVEY SAMPLING STATIONS

AQUETONG CREEK RESTORATION PROJECT  
 AQUETONG SPRING PARK  
 SOLEBURY TOWNSHIP  
 BUCKS COUNTY, PENNSYLVANIA

**PH** PRINCETON HYDRO  
 SCIENCE DESIGN ENGINEERING  
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## RESULTS

### GENERAL OBSERVATIONS

Conditions upstream of the dam have largely maintained their improved state in regards to streamside vegetation, sedimentation, and available habitat, however some individual areas still contain some fine sediment deposits. Adaptive management performed over the course of the last few years appear to have fostered preferred habitat for brook trout. As in the past, the stream features an abundance of aquatic vegetation, particularly watercress (*Nasturtium officinale*), aquatic moss (*Fontinalis sp.*), and horned pondweed (*Zannichellia palustris*). This vegetation provides excellent habitat for both fish and macroinvertebrates. A potential barrier to fish movement previously identified between sites ST1 and ST2 now appears largely passable to brook trout. Another potential barrier to fish movement that is still present was observed just downstream of ST5, presenting as a head-cut forming a relatively steep “ramp”, measuring approximately 2.5-3' of vertical height. A study in 2004 by the US Department of the Interior concluded that a vertical height of over 1 meter is enough to prevent the upstream movement of most brook trout under 30 cm (~1') in length, if the plunge pool beneath is less than 10 cm in depth (Myrick and Kondratieff, 2004). Given the swiftness of flows in this area, and the taller height of this feature, this area may serve as a barrier to upstream movement for all brook trout, save for possibly some of the very large individuals.

The substrate for much of the stream is a combination of mixed cobble, gravel and silt. The majority of the stream reaches consist of a single channel, however there are several instances of wandering channels where flow is divided between several smaller channels. Additionally, there is a relative mix of sinuous and low sinuosity reaches of the stream, all consisting of a low slope. In some of the more pronounced meanders, specifically between ST2 and ST3, there are more noticeable cut banks and point bars, formed through sediment deposition and erosion, than in previous years. There are examples present of pools, riffles, runs and glides which can create diverse habitat for stream biota.

### IN-SITU AND FLOW DATA

As has been observed in past years, water temperatures in the mainstem of the Aquetong Creek remained very stable, varying by less than 2.0°C over the three events in the mainstem stations. Water in the Aquetong Creek typically exhibits cold temperatures, with a consistent exception being temperatures recorded in the Rt. 202 tributary (ST4). The two newer sampling stations also typically featured temperatures that differed from those within the initial study area. Along the mainstem within the Aquetong Spring Park, temperatures ranged from approximately 11.6°C to 13.9°C. ST4, however, displayed a larger temperature range, measuring approximately 13.6°C in October 2022 and 25.6°C in July 2022. The higher temperatures are largely attributable to the upstream impoundment, north of Rt. 202, which feeds the tributary. AW1 displayed a slightly shorter range of temperatures than ST4, with a low temperature of 11.1°C measured in October and a high temperature of 17.5°C measured during the July event. AW2 featured a seasonal low temperature of 12°C in October and a seasonal high temperature of 25°C in July. Similar to ST4, AW2 also features an impoundment upstream of the station (Honey Hollow Pond), which may allow incoming water to warm before continuing downstream.

Dissolved oxygen concentrations in the mainstem stations were similarly consistent and well within a preferable range, ranging from approximately 88.2% to 103.4% saturation. ST4 was measured to feature slightly more consistent dissolved oxygen concentrations than in past years, ranging from 98.8% to 108.2% saturation. AW1 and AW2 featured relatively consistent dissolved oxygen concentrations throughout the season, with measured values ranging from between 90.5% and 98.1% saturation. The consistent temperatures and dissolved oxygen concentrations within the preferred range throughout the season in the reaches of the creek within the park are largely products of the stream's origin as groundwater discharged via the spring and high flow velocities, which



allow for continuous mixing with atmospheric oxygen. This is largely consistent with temperature and dissolved oxygen measurements collected in previous surveys.

The mainstem's specific conductivity (SpC) within the Aquetong park was measured on average to be approximately 430.8  $\mu\text{S}/\text{cm}$  in May before decreasing slightly to an average of 424.1  $\mu\text{S}/\text{cm}$  in July. Average conductivity in these sites increased to 431.0  $\mu\text{S}/\text{cm}$  in October. These readings are very consistent and track with those obtained in 2020 and 2021. While these values are slightly elevated, it reflects the limestone geology of the watershed. As in past years, ST4 featured somewhat higher conductivity readings, averaging approximately 550.0  $\mu\text{g}/\text{L}$  over the course of the study. These higher values likely reflect the denser development in that tributary's subwatershed. Sites AW1 and AW2 both featured lower conductivities than the sites within the park, with AW1 averaging 384.9  $\mu\text{S}/\text{cm}$  and AW2 averaging 345.9  $\mu\text{S}/\text{cm}$ .

As in previous years, pH values obtained from stations along the mainstem of the Aquetong ran slightly elevated, averaging approximately 7.72 in May, 7.92 in July, and 7.87 in October. These alkaline values are likely due to local geology, with the stream's origin at Ingham Spring reflecting the limestone geology. To a lesser extent, higher pH values may also in part be contributed by the abundance of plant life in the stream, as photosynthesis typically results in elevated pH. Similar to past years, pH tended to be slightly higher at ST4, particularly during the July event which again is attributable to high levels of primary production and photosynthesis in the upstream pond.



**Aquetong Creek *In-Situ* Data 5/19/2022**

Station	Temperature °C	SpC µS/cm	DO mg/L	DO % %	pH s.u.	Flow CFS
AW1	15.16	324.74	9.61	96.34	7.79	25.67
AW2	15.57	271.12	9.67	98.14	7.8	12.77
Downstream	12.49	420.8	10.08	95.3	7.63	7.34
ST1	12.43	434.7	10.24	96.9	7.83	7.59
ST2	12.46	436.7	10.22	96.7	7.89	5.53
ST3	12.15	433.5	10.19	95.8	7.67	5.74
ST4	15.09	496.9	10.45	104.7	8.07	0.50
ST5	11.66	428.3	9.48	88.3	7.59	6.23
Spring	11.84	418.6	6.72	62.9	7.49	-

**Aquetong Creek *In-Situ* Data 7/6/2022**

AW1	17.48	416.92	9.04	95.22	7.96	11.09
AW2	25.19	397.12	7.42	90.51	7.91	2.71
Downstream	13.4	425.2	10.71	103.0	8.07	6.60
ST1	13.15	423.6	10.73	102.7	8.1	6.48
ST2	13.93	420.1	10.66	103.4	8.02	6.1
ST3	12.16	424.5	10.31	96.7	7.72	3.52
ST4	25.6	555.3	8.77	108.2	8.29	0.10
ST5	11.76	427.2	9.84	91.7	7.71	6.76
Spring	11.87	421.1	7.41	69.0	7.43	-

**Aquetong Creek *In-Situ* Data 10/14/2022**

AW1	11.09	413.12	10.55	94.55	7.63	7.01
AW2	12.01	369.44	10.26	94	7.81	3.59
Downstream	11.58	431.5	10.94	99.5	7.91	7.19
ST1	11.76	431.8	10.83	99.0	7.86	6.96
ST2	11.97	431.2	10.84	99.5	7.93	10.9
ST3	11.88	433.3	10.63	97.5	7.89	6.53
ST4	13.59	596.5	10.36	98.9	8.12	0.32
ST5	11.68	427.3	9.90	90.0	7.75	5.71
Spring	13.35	421.1	7.44	66.5	7.69	-

**Table 1: Aquetong Creek *In-Situ* Data 2022**

As noted above, the mainstem of the Aquetong Creek is characterized by relatively swift, consistent flows. Of the mainstem stations, ST1 and ST5 typically featured some of the highest discharges. ST2, however, featured a relatively high discharge of 10.9 CFS during the October event, possibly contributed to by the previous day's rain event. ST4, which features a shallower and narrower channel, as well as a different point of origin from the mainstem, featured significantly less discharge than any of the other sites. The Downstream station typically featured flows similar to ST1. AW1 featured higher discharges during the earlier portion of the season, reaching as high as 25.67 CFS in May. This is likely in part due to the much larger and more developed watershed this portion of the Aquetong Creek has. While AW2 featured a relatively high discharge of 12.77 CFS during the May event, for the remainder of the year it featured discharges lower than all other stations except ST4.

AW2 generally had minimal change in water depth and velocity for most of the channel transect during each of the monitoring events. AW1 flow velocities varied throughout the transect, with some emergent rocks creating eddy patterns of negative or reduced flow. Flow at the downstream station often was slightly bottlenecked by



watercress along both banks and had a fairly defined thalweg. ST1 often had decent depth and flow velocity resulting in one of the highest total discharges during each event. ST2 consistently had deeper water depths and slower flow velocities across the channel than other stations. The log steps and larger cobble substrate at station 3 resulted in variable flow velocities and discharge from event to event. ST4 is narrow, shallow and slow flowing; discharge was always the lowest at this station, consistent with previous years. ST5, similar to the downstream station, has a slightly bottlenecks flow pattern because of the prevalent watercress along both banks. Flow velocities at this station were generally some of the highest recorded during each of the monitoring events. However, due to the small channel width, total discharge showed variation.

Figures displaying changes in *In-Situ* parameters in Stations ST1-5 over the past several years are provided in the Appendix.

### COMPARISON TO WATER QUALITY CRITERIA

The collected data was also compared to the specific water quality criteria outlined in 25 Pa. Code § 93.7 where applicable. Of the various metrics described during this study, only three have directly comparable analogs in the technical regulations, including temperature, DO, and pH. The criteria and narratives provided below are applicable to Cold Water Fisheries (CWF).

Temperature: Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapters 92a, 96 and other sources where temperature limits are necessary to protect designated and existing use.

<b>Critical Use Period</b>	<b>°F</b>
January 1-31	38
February 1-29	38
March 1-31	42
April 1-15	48
April 16-30	52
May 1-15	54
May 16-31	58
June 1-15	60
June 16-30	64
July 1-31	66
August 1-15	66
August 16-30	66
September 1-15	64
September 16-30	60
October 1-15	54
October 16-31	50
November 1-15	46
November 16-30	42
December 1-31	40

**Table 2. Maximum temperature standards for Pennsylvania streams during several critical use periods. From 25 Pa. Code § 93.7**

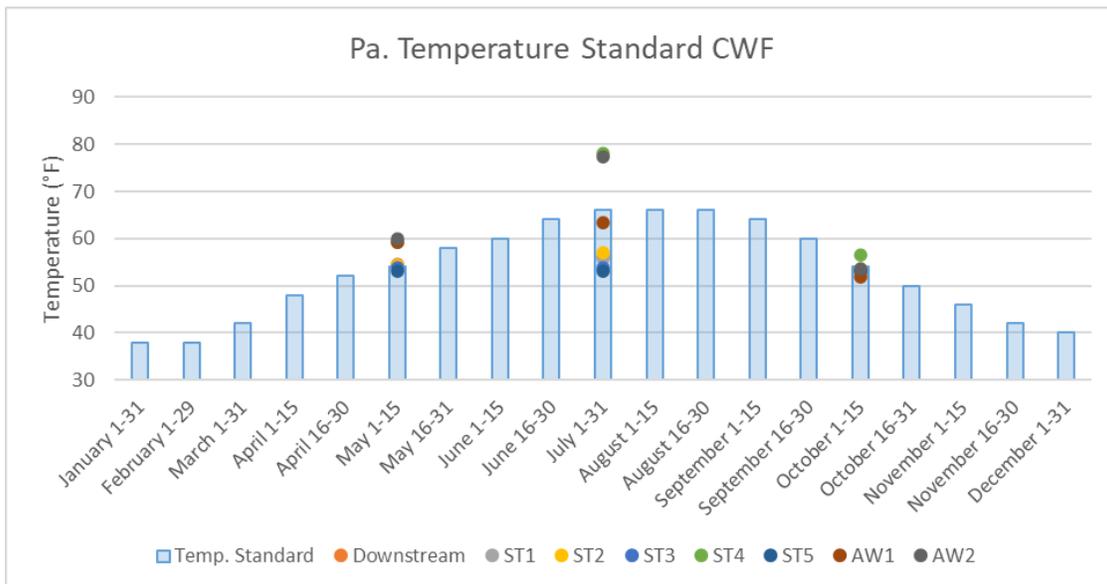
Dissolved Oxygen: For flowing waters, 7-day average 6.0 mg/L; minimum 5.0 mg/L. For naturally reproducing salmonid early life stages, 7-day average 9.0 mg/L; minimum 8.0 mg/L. Early life stage criteria applies from October 1 to May 31.



pH: From 6.0 to 9.0 inclusive.

In general, the site shows compliance with the applicable criteria. Starting with the temperature criteria for CWF it is interesting to note that the standard has dual purposes, sustaining trout populations as well as protecting the temperature regime from heated discharges. The criteria are divided into discrete critical use periods throughout the year recognizing the expected seasonal changes in temperature.

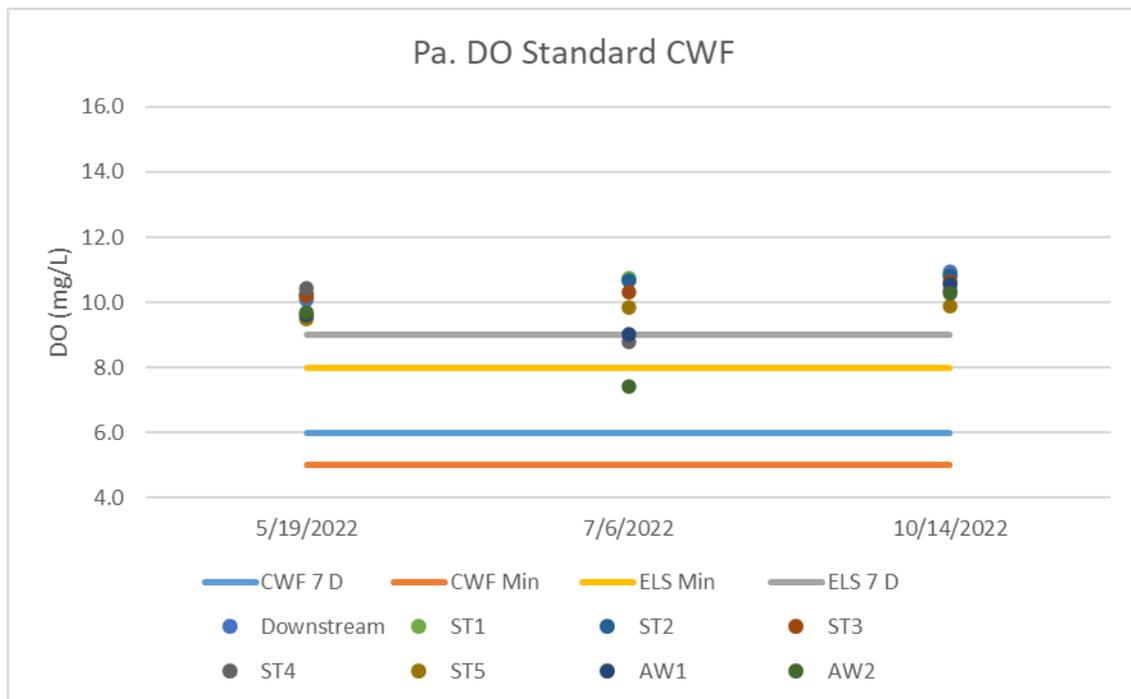
As in 2021, the ST4 station exceeded the maximum temperature criteria for CWF during all events, with the July event showing an exceedance of approximately 12°F. As noted earlier, differing conditions in this reach, such as higher temperatures, are likely in part due to the upstream impoundment and the more developed nature of the tributary's watershed. Station AW1 exceeded the maximum temperature criteria for CWF once during the May event, however temperatures at this site were below maximum criteria for the July and October events. The exceedance earlier in the year may be a product of the increased flows observed upstream at AW2; as this reach typically exhibited higher temperatures, it may influence the temperatures measured at AW1 during periods of higher flows. During the other two events, AW2 displayed much lower discharge, and likely did not influence AW1's temperature as much as the more consistent and colder flows coming from the Aquetong Spring Park did. AW2 exceeded the maximum temperature for CWF during both the Spring and Summer events and was less than 1°F below the maximum temperature in October. As with ST4, this site also features an upstream impoundment that may allow for an increase in water temperature. Temperatures in the mainstem stations within the park largely met the temperature criteria for CWF throughout the study period. While the Downstream station, ST1, and ST2 exceeded the maximum temperature during the early-May critical use period, in all cases this exceedance was by less than 1°F. Temperature in the mainstem is clearly controlled by the spring and does not represent a departure from natural conditions nor thermal impairment. The spring is certainly one of the most outstanding such examples in southeastern Pennsylvania. As such, it is likely that should the need arise, site-specific criteria could be developed.



**Figure 2: Water temperature data collected in Aquetong Creek compared to the Pennsylvania water temperature standard for CWF.**



The DO criteria specify average and minimum values, with the objective of maintaining higher concentrations. Because young-of-year trout have been discovered onsite in past years, the criteria for early life stage (ELS) salmonids were explored in addition to the CWF criteria (Figure 3). All of the mainstem stations within the park, including the Downstream station, satisfied all applicable criteria, even for ELS (although this is only properly applied from October through May). Consistently cool temperatures and energetic streamflow help maintain high DO concentrations throughout the year. ST4 and AW2 did fall below some of the criteria during the July sampling event, but otherwise met all standards during the May and October events. During the July event, ST4 fell slightly below the daily average requirement for early life stages; it should be noted however that this represents only a single point in time of dissolved oxygen and not the daily average. AW2 fell below both the minimum and daily average dissolved oxygen concentration for early life stages, however this site still met the dissolved oxygen criteria for CWF at this time.



**Figure 3: Dissolved oxygen data collected in Aquetong Creek compared to the Pennsylvania dissolved oxygen standards for CWF and ELS.**

Lastly, pH was satisfied at all times at all stations and stayed with the limits of 6.0 to 9.0.

Overall, the mainstem stations were consistent with criteria for CWF, showing the high quality of the system.

### DISCRETE WATER QUALITY DATA COLLECTION

Nutrients such as nitrogen and phosphorus influence growth of primary producers such as plants and algae, including periphyton and often indicate other organic pollutants. Total suspended solids are a measurement of sediment or other particulates. Phosphorus, an important nutrient for plant and algae life, was typically measured in relatively low amounts in the mainstem stations within the park, although some higher concentrations were measured occasionally (Table 2). In May, the downstream station yielded a slightly elevated concentration of 0.04 mg/L. While higher than typically measured in the mainstem stations, this is still relatively low. The mainstem of the stream within the park otherwise usually maintained concentrations of between 0.01 and 0.03 mg/L, while ST4 featured higher concentrations of 0.04 and 0.09 mg/L in May and July, respectively, although October saw



a lower concentration of 0.02 mg/L at this site. It should be noted that stations on the mainstem, as well as ST4, displayed an overall reduction in phosphorus concentrations for May and October when compared with data from 2018. When compared with concentrations from late 2020 and 2021, most of the stations on the mainstem did not see an overall large change in phosphorus concentrations, with the exception of ST5, which saw an overall decrease since 2021. ST4 saw a slight decrease since 2021 in regards to events conducted in May and October, however the July event of 2022 saw a notably higher concentration when compared to the 2021 event. AW1 saw an elevated concentration of 0.06 mg/L in May before decreasing to 0.02 mg/L in July and 0.03 mg/L in October. AW2 featured a similar pattern, with the seasonal high concentration of 0.07 mg/L occurring in May, August yielding a concentration of 0.04 mg/L, and October yielding a concentration of 0.03 mg/L.

As in previous years, total nitrogen concentrations along the mainstem of the Aquetong Creek were generally elevated for ecological purposes, ranging from 2.2 mg/L at the downstream site in May to approximately 4.7 mg/L at ST1 in October. Such high nitrogen concentrations can be expected in streams such as the Aquetong Creek where groundwater dominates flow, as groundwater typically contains higher concentrations of nitrogen than surface waters. As in past years, ST4 typically featured lower concentrations, yielding 0.9 mg/L in May and 1.3 mg/L in July. October, however, saw an increased concentration of 3.9 mg/L. Lower values may reflect uptake of nitrogen in the upstream impoundment, while the increased concentration in October may be explained as a product of the decomposition of organic matter in the upstream impoundment. AW1 yielded intermediate nitrogen concentrations, ranging from 1.4 mg/L in May to 3.1 mg/L in October. AW2 showed somewhat consistent nitrogen concentrations, with the May sample yielding 1.2 mg/L and both the July and October events yielding 1.9 mg/L.

Date	Station	TPO <sub>4</sub> mg/L	TSS mg/L	TN mg/L
5/19/2022	Downstream	2.2	0.0	ND <2
	ST1	2.3	0.0	ND <2
	ST2	2.4	0.0	ND <2
	ST3	2.7	0.0	ND <2
	ST4	0.89	0.0	ND <2
	ST5	3	0.0	ND <2
	AW1	1.4	0.1	9.00
	AW2	1.2	0.1	10.00
7/6/2022	Downstream	2.94	0.0	2.00
	ST1	3.32	0.0	4.00
	ST2	2.44	0.0	ND <2
	ST3	2.92	0.0	3.00
	ST4	1.33	0.1	9.00
	ST5	2.54	0.0	ND <2
	AW1	2.42	0.0	ND <2
	AW2	1.88	0.0	2.00
10/11/2022	Downstream	3.84	0.0	ND <2
	ST1	4.7	0.0	ND <2
	ST2	5.4	0.0	ND <2
	ST3	4.2	0.0	ND <2
	ST4	3.94	0.0	ND <2
	ST5	4.2	0.0	ND <2
	AW1	3.1	0.0	3.00
	AW2	1.85	0.0	ND <2

"ND" = Not detected at or above minimum detection limit

**Table 3: Aquetong Creek Discrete Water Quality Data 2022**



Total suspended solids (TSS) concentrations varied throughout the study period, with generally low amounts measured at most sites for most of the study, but higher spikes being measured occasionally during some individual events. ST4 yielded the highest 2022 value of 9 mg/L in July, however this is lower than most of the concentrations measured in 2021. During both May and October, almost every station featured concentrations below the detectable concentration of 2 mg/L. AW1 and AW2 were the only stations to measure above this in May, yielding concentrations of 9 and 10 mg/L, respectively, while only AW1 yielded a measurable concentration of 3 mg/L in October. Discrete water quality data for the full study is provided in Table 3. Note that results labeled “ND <2.0” denote instances where the parameter was below detection limits. Changes in discrete water quality parameters over time are provided in the Appendix.

## FISHERIES SURVEY

The fisheries community sampled in October of 2022 was marked by a decrease in brook trout numbers since the larger numbers that were sampled in 2021. In total, 343 fish were sampled between the eight (8) reaches, with fifteen (15) species of fish being represented. Stations AW1 and AW2 yielding the largest numbers of fish per reach, at 151 and 121 fish respectively. Longnose dace (*Rhinichthys cataractae*) were the most frequently sampled species in 2022, with most individuals being sampled at sites AW1 and AW2. In the six (6) reaches within the park, pumpkinseed (*Lepomis gibbosus*) were the most frequently sampled fish, with white sucker (*Catostomus commersonii*) also being particularly abundant in reach ST2. The Downstream station was the only station to yield no fish.

Shannon's diversity index, a measure of the general species diversity of a system, was calculated to be 1.56 for ST1 – ST5, an increase from 1.34 in 2021. AW2 featured the highest diversity index, featuring many warmer water fish species, including a single black crappie (*Pomoxis nigromaculatus*). This and some of the other centrarchid (sunfish and black bass) species may have migrated to this reach from the upstream impoundment (Honey Hollow Pond) or possibly from other smaller farm ponds in the watershed.

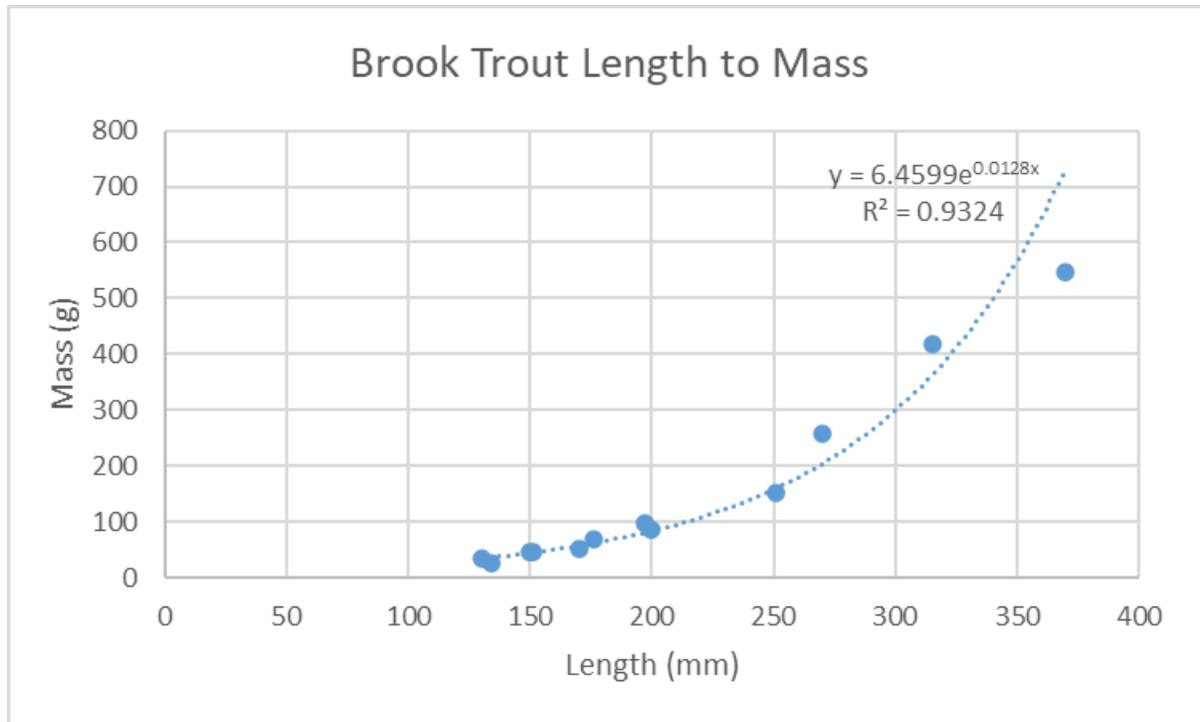
As in past years, it should be noted that a majority of the fish sampled at ST4 were caught in the plunge pool immediately below Rt. 202. In 2022, all of these fish were of the species pumpkinseed, with a single largemouth bass (*Micropterus salmoides*) also being observed but not captured. These likely migrated to this area from the pond on the other side of Rt. 202. This may also be a point of origin for some sunfish obtained at reaches further downstream, although this cannot be confirmed. It also indicates that this feature is a barrier to upstream migration.

Lengths and masses of all brook trout collected are provided in Table 4. In 2022, 12 brook trout were sampled in the reaches within the Aquetong Spring Park, a marked decrease from the 49 individuals captured in 2021. This is higher, however, than brook trout numbers obtained in 2017 or 2018. While multiple larger individuals were captured (the biggest at 370 mm or approximately 14.6 inches), of note was the apparent paucity of smaller fish. Two collected individuals measuring 130 mm and 134 mm are categorized as young-of-the-year (YOY) by the PFBC (2022), which considers fish smaller than 150 mm to be YOY. This is a decrease from the 10 individuals collected meeting this criterion in 2021. While collected fish were not aged, this suggests that the youngest cohort may have suffered large losses to either mortality or emigration out of the study area, or that brook trout spawning was largely unsuccessful in the autumn of 2021. Alternatively, brook trout spawned in the autumn of 2021 may experience a somewhat high growth rate and are largely already over 150 mm by the following year's spawning time. The large prevalence of aquatic macroinvertebrates present in the stream (mostly amphipods), a notable forage group for brook trout, also provides some evidence for this. Both hypotheses may be further explored with the aging of sampled fish in future fisheries assessments, usually by estimating ages using scale samples, which allows for live release of sampled fish.



Brook trout were weighed using a small digital scale to obtain mass in grams. A length-to-mass regression is provided in Figure 4. In total, brook trout biomass in sampled areas in October of 2022 was measured to be approximately 1,829 grams, or approximately 4.03 lbs. When using the combined area of ST1-5 and the Downstream station, this correlates to approximately 13 lbs/acre or 32.14 lbs/hectare. Again, this is a decrease from the brook trout biomass collected in 2021. Despite these decreases, this fulfills conditions listed by the PFBC for Class C wild brook trout streams (total wild brook trout biomass of over 8.9 lbs./acre).

Figures displaying changes in brook trout densities and fisheries diversities over the course of past fisheries surveys are provided in the Appendix.



**Figure 4: Length-to-mass regression for Brook Trout**

<b>Reach</b>	<b>Length (mm)</b>	<b>Mass (g)</b>
ST2	151	47
ST2	270	257
ST3	150	45
ST3	170	51
ST3	176	70
ST3	315	417
ST3	370	547
ST5	130	34
ST5	134	25
ST5	197	96
ST5	200	87
ST5	251	153

**Table 4: Weights and masses of brook trout sampled in 2022**



Common Name	Downstream	ST1	ST2	ST3	ST4	ST5	AW1	AW2	Total	Relative Abundance (fish/acre)
American Eel	.	.	.	2	.	1	10	2	15	60.0
Banded Killifish	.	.	.	.	.	.	.	21	21	84.0
Black Crappie	.	.	.	.	.	.	.	1	1	4.0
Blacknose Dace	.	.	.	.	.	.	4	.	4	16.0
Bluegill	.	.	.	.	.	.	.	1	1	4.0
Brook Trout	.	.	2	5	.	5	.	.	12	48.0
Cornely Shiner	.	1	.	.	.	.	.	21	21	84.0
Green Sunfish	.	.	.	.	.	.	.	.	1	4.0
Largemouth Bass	.	.	.	.	.	.	.	3	3	12.0
Longnose Dace	.	1	8	2	.	.	98	38	147	587.7
Margined Madtom	.	.	.	.	.	.	.	5	5	20.0
Pumpkinseed	.	.	3	2	20	.	.	.	25	100.0
Redbreast Sunfish	.	1	.	.	.	.	.	6	7	28.0
Tessellated Darter	.	.	.	.	.	.	25	21	46	183.9
White Sucker	.	.	18	.	.	.	14	2	34	135.9
Total abundance	0	3	31	11	20	6	151	121	343	686.0
Richness (# Taxa)	0	3	4	4	1	2	5	11	15	-
CPUE (fish/pass)	0.00	1.00	10.33	3.67	10.00	2.00	50.33	40.33	15.59	-
Shannon's Diversity	-	1.10	1.07	1.29	0.00	0.45	1.07	1.86	1.93	-
Evenness	-	1.00	0.77	0.93	-	0.65	0.67	0.78	0.71	-

Table 5: Aquetong Creek Fishery Data 2022



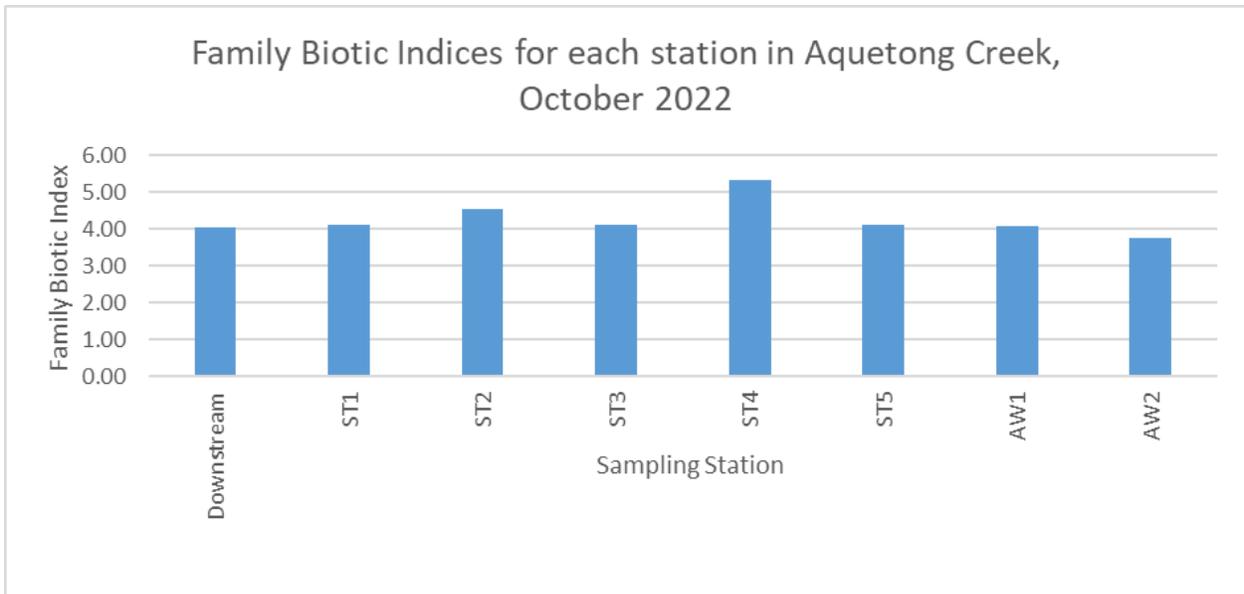
## BENTHIC MACROINVERTEBRATE SURVEY

Historically, the mainstem reaches of the Aquetong Creek have featured a large number of amphipods (“scuds” or “side-swimmers”; order Amphipoda, family Gammaridae), and this trend continued in October 2022. This family made up at least half of the subsamples picked from many of the mainstem stations, with the family representing over 80% of ST3 and ST5’s assemblages. Scuds tend to be common in and often dominate limestone stream systems. Likely as a product of different microhabitat types present in ST4, this reach’s subsample was dominated by non-biting midge larvae (order Diptera, family Chironomidae). This common and extremely diverse family was also found in smaller numbers throughout almost all of the other reaches except for ST3. Chironomids are typically somewhat tolerant of pollution and low-oxygen conditions, and a sample that consists largely of this taxa may be an indication of reduced water quality. It should be noted, however, that this family contains many genera, and some genera are more tolerant of reduced conditions than others. Stations AW1 and AW2 both were dominated by the diminutive riffle beetle (order Coleoptera, family Elmidae), which overall are somewhat less-tolerant of poor water quality conditions. A larger number of this taxa in a sample may indicate less-impacted water quality conditions.

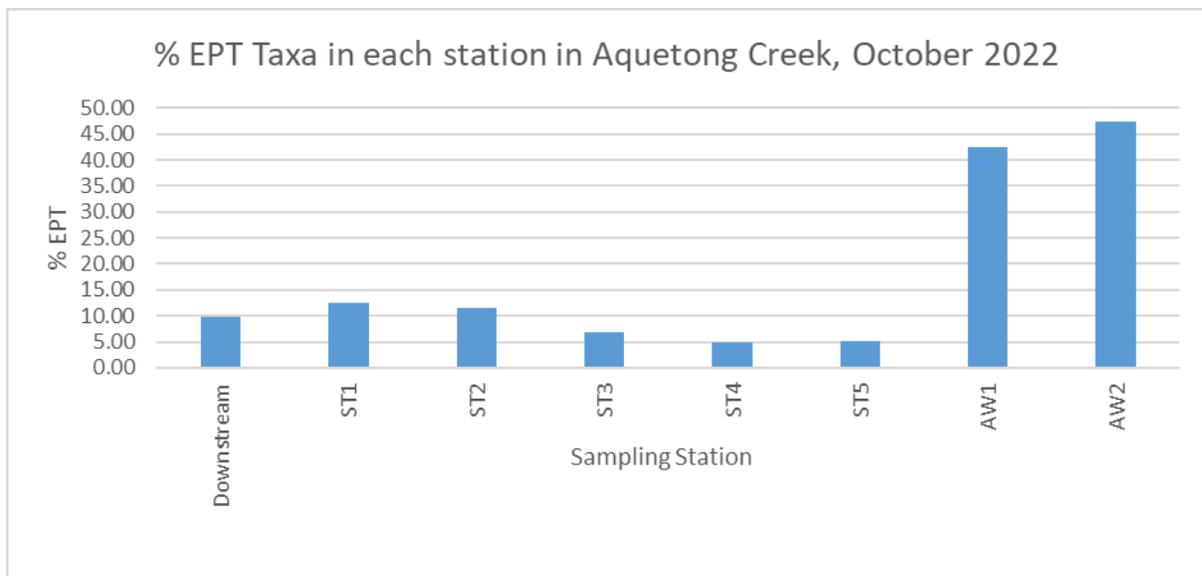
Station	Density per ft <sup>2</sup>	Taxa Richness	Dominant Taxa	Shannon's Diversity	Evenness	% EPT Taxa	Family Biotic Index
Downstream	86.4	9	Amphipoda, Gammaridae (Scuds)	1.17	0.56	9.70	4.04
ST1	133.2	12	Amphipoda, Gammaridae (Scuds)	1.40	0.59	12.60	4.13
ST2	218.4	10	Amphipoda, Gammaridae (Scuds)	1.09	0.48	11.54	4.55
ST3	850.8	13	Amphipoda, Gammaridae (Scuds)	0.76	0.30	6.77	4.10
ST4	124.8	14	Diptera, Chironomidae (Non-biting Midges)	1.98	0.77	4.81	5.32
ST5	39.15	9	Amphipoda, Gammaridae (Scuds)	0.69	0.33	5.17	4.12
AW1	174.2	19	Coleoptera, Elmidae (Riffle Beetles)	2.06	0.73	42.60	4.08
AW2	233.4	16	Coleoptera, Elmidae (Riffle Beetles)	2.20	0.80	47.40	3.76

**Table 6: Benthic Macroinvertebrate Data 2022**

Table 6 and Figures 5-7 display metrics pertaining to the benthic macroinvertebrates collected at each site. Note that these are calculated from the subsample collected for each sample. Using Hilsonhoff’s family-level biotic index, sites along the mainstem were calculated to largely yield values between approximately 4.0 and 4.6, classifying most of these sites as “Very Good” or “Good” in respect to organic pollution. ST4 yielded a value of 5.32, which correlates to “Fair”, suggesting a degree of pollution and/or habitat degradation. AW1 and AW2 received values of 4.08 and 3.76, respectively, classifying both sites as “Very Good” in terms of water quality, with ST2 approaching “Excellent”. Several reaches including ST4 saw increases in Shannon’s Diversity Index scores compared to those assessed in 2021, however the Downstream and ST5 stations both displayed decreases in this metric. AW1 and AW2 both yielded relatively high diversity scores of over 2.00. The percentage of EPT (Ephemeroptera - mayflies, Plecoptera - stoneflies, and Trichoptera - caddisflies), a group of relatively sensitive taxa, displayed variable change between stream reaches when compared to those assessed in 2021. ST1, ST3 and ST4 both yielded increased percentages of these taxa in 2022, however the Downstream station, ST2, and ST5 displayed decreases. As with Shannon’s Diversity Index, AW1 and AW2 yielded much higher percentages of EPT taxa, with AW2 yielding the highest at 47.4%.



**Figure 5: Hilsenhoff's Family Biotic Indices for 8 stations in the Aquetong Creek watershed**



**Figure 6: Percentage of samples comprising individuals from the orders Ephemeroptera, Plecoptera, and Trichoptera**

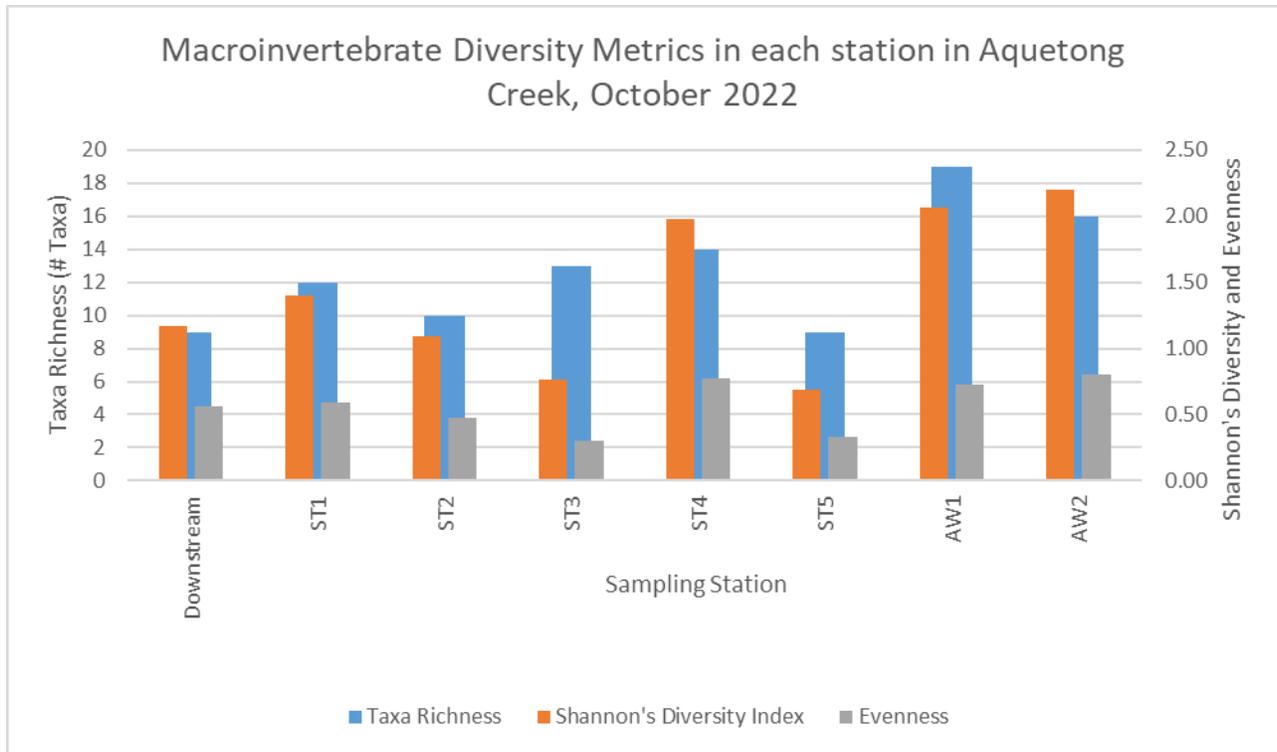


Figure 7: Aquatic Macroinvertebrate diversity metrics for 8 stations in the Aquetong Creek watershed



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## **RECOMMENDATIONS**

Based on the observations and measurements made during the 2022 monitoring of the Aquetong Creek, Princeton Hydro proposes the following recommendations:

### ***BROOK TROUT HABITAT SUITABILITY INDEX***

One of the goals for the Aquetong Creek Park is the establishment of a viable population of naturally reproducing brook trout. In order to facilitate this, Princeton Hydro recommends a full habitat assessment of the stream in accordance with the parameters used in the brook trout habitat suitability index (HSI, Raleigh, 1982). This index features a collection of several habitat metrics and their optimal ranges for different brook trout life stages (e.g. breeding habitat, habitat for larvae and fry, etc.). Many of these metrics within the Aquetong Creek can be obtained while conducting the usual annual stream monitoring, although some of them require taking measurements during certain times of year (e.g. assessing minimum winter temperatures, as this influences larvae survival). By collecting such data on the Aquetong Creek, the exact elements in which the stream needs improvement as they relate to brook trout habitat can be further ascertained. It should be noted, however, that a favorable HSI index for a stream does not necessarily guarantee a high brook trout biomass. This would need to be accompanied with fish surveys such as those that have been conducted in the present study to assess the continued impacts of restoration efforts on the standing stock of brook trout in the stream. Princeton Hydro recommends this assessment occur in 2023 to 2024.

### ***REMOVAL OF BARRIERS TO FISH PASSAGE***

As discussed above, an area immediately downstream of station ST5 was observed in the study area with a rapid change in grade that may be impassable to upstream movement by some fish. Princeton Hydro strongly recommends that this location be addressed, as barriers to fish movement may prevent fish from returning to areas upstream after downstream movement, reducing the populations upstream. This will be particularly important in maintaining brook trout populations. This same area has been noted in the riverine surveys (provided under separate cover) of the last few years with regards to PADEP stream restoration permit reporting requirements.

### ***AGE ASSESSMENT OF BROOK TROUT***

As noted above, there is a degree of uncertainty as to the age and growth rate of some of the smaller and mid-sized brook trout collected in the Aquetong Creek, although the variation in lengths and masses strongly suggests the presence of more than one age class. This can be assessed by collecting scales from each brook trout sampled and assessing them under magnification. While other methods of aging fish also exist, many of them (such as the assessment of otoliths) require that fish be euthanized. Collection of scales, however, is a relatively simple process that causes minimal stress to the fish being assessed and allows for assessed fish to be released. Age data can be paired with length data to produce age-length regressions similar to the length-weight regression performed in 2021 and 2022. If desired, Princeton Hydro can perform scale assessments on brook trout during future fisheries assessments under a new task.

### ***CONTINUED GENERAL MONITORING IN 2023***

Princeton Hydro recommends the continued monitoring of the Aquetong Creek in order to assess the effectivity of continued restoration efforts and the status of the stream's brook trout population. A monitoring event for 2023 should largely follow the same methodology used in 2020-2022. This involves the continued sampling of fish and macroinvertebrates at least once a year in either the Spring or Fall seasons, in order to assess how changes to



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the stream and habitat affect these populations and, in particular, if brook trout populations are reproducing. The Township has already agreed to and contracted for this monitoring in 2023.



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# APPENDIX: HISTORIC WATER QUALITY AND FISHERIES TRENDS IN STATIONS ST1-5

