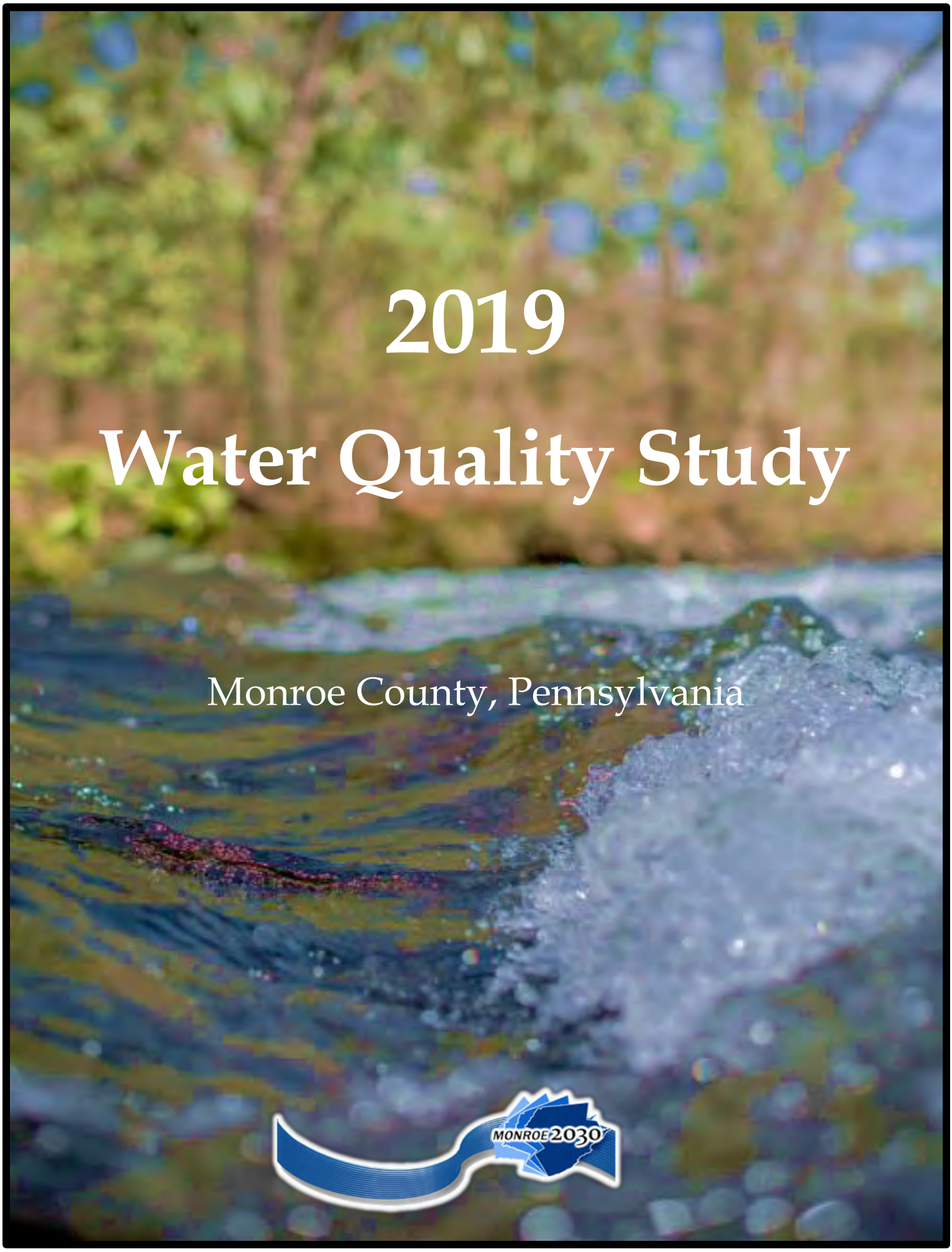

2019
Water Quality Study

Monroe County, Pennsylvania

MONROE 2030

ABSTRACT

The Monroe County Planning Commission along with the Monroe County Conservation District studied 36 stream sites throughout Monroe County in the spring of 2019. The sites were studied based on four parameters, field surface water measurements, laboratory chemistry analysis, macro-invertebrate identification, and habitat assessment.

The Monroe County Planning Commission
and the Monroe County Conservation District
1 Quaker Plaza, Room #106
Stroudsburg, Pa. 18360-2169
(570) 517-3100
Fax (570) 517-3858
www.monroecountypa.gov

Table of Contents

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Fallon Horan, Community Planner

PROJECT PARTICIPANTS

Lead Agencies:

Monroe County Planning Commission (MCPC)
Program Director: Christine Meinhart-Fritz
Program Coordinator: Ryan Hill
Vector Control Program Coordinator: Lee Schuler

Monroe County Conservation District (MCCD)
District Manager: Adam Schellhammer
Resource Conservationist: Steven Baade
Watershed Specialist: Andrea Polkowski
Head Resource Conservationist: Lori Kerrigan

Cooperating Agencies:

Pennsylvania Department of Environmental Protection (PA DEP)
United States Environmental Protection Agency (EPA)
Brodhead Watershed Association (BWA)

Entomology Consultants:

Donald Baylor & Ken Ersbak
Aquatic Resource Consulting (ARC)
Route 715, Saylorsburg, PA 18353

Professional Laboratory Consultant:

Microbac Laboratories
1620 North Main Avenue
Scranton, PA 18508

Materials & Methods

Field Chemistry Sampling (Appendix A)

The following parameters were measured and stored using a hand-held YSI Professional Digital Sampling System (ProDSS) Multiparameter water quality meter and recorded on standard data forms:

-pH
-Temperature
-D.O. Concentration
-D.O. %
-Conductivity

Lab Chemistry Sampling (Appendix A)

The following table shows water chemistry parameters that were tested by Microbac Laboratories for analysis of the stream samples.

Test	Units	Method	PQL
Total Organic Carbon (TOC)	mg/L	SM5310 C-2000	0.500
Aluminum, Total	mg/L	E200.7	0.200
Calcium, Total	mg/L	E200.7	0.500
Iron, Total	mg/L	E200.7	0.100
Magnesium, Total	mg/L	E200.7	0.500
Harness	mg/L	SM2340-B-1997	5.00
Chloride	mg/L	EPA 300.0, Rv 2.1	0.250
pH	pH Units	SM4500 H+ B-2000	0.100
Ammonia as N	mg/L	EPA 350.1, Rv 2	0.0500
Total Kjeldahl Nitrogen (TKN)	mg/L	EPA 351.2, Rv 2	0.500
Nitrate-Nitrate as N	mg/L	EPA 353.2, Rv 2.0	0.0200
Alkalinity to pH 4.5	mg $CaCO_3$/L	SM2320 B-1997	20.0
Total Dissolved Solids (TDS)	mg/L	SM2540 C-1997	20.0
Phosphorus - Total as P	mg/L	SM4500 P E-1999	0.0500
Biochemical Oxygen Demand	mg/L	SM5210 B-2001	3.00

Macroinvertebrate Sampling (Appendix B)

At each site, macroinvertebrates were collected using a 12" 500 micron D-frame net that was held on the stream bottom. The collector thoroughly disturbed the stream bottom to dislodge any macroinvertebrates from the substrate. This process was repeated 6 times for Riffle/Run streams and 10 times for Multihabitat streams.

Riffle/Run 6 Samples (at least one of each)

-Fast & Shallow
-Fast & Deep
-Slow & Shallow
-Slow & Deep

Multihabitat 10 Samples (based on abundance)

-Cobble/Gravel
-Snag
-CPOM (Course Particulate Organic Matter)
-Submerged Aquatic Vegetation
-Sand/Fine Sediment

Habitat Analysis (Appendix C)

The following tables show habitat assessment parameters for Riffle/Run and Low Gradient Streams. Each parameter is rated on a score from 1 to 20; 20 being the highest, and 1 being the lowest.

Riffle Run Streams

1 Instream Fish Cover
2 Epifaunal Substrate
3 Embeddedness
4 Velocity/Depth Regimes
5 Channel Alteration
6 Sediment Deposition
7 Frequency of Riffles
8 Channel Flow Statues
9 Condition of Banks
10 Bank Vegetative Protection
11 Grazing or Other Disruptive Pressures
12 Riparian Vegetative Zone Width

Multihabitat/Low Gradient Streams

1 Epifaunal Substrate/ Available Cover
2 Pool Substrate Characterization
3 Pool Variability
4 Sediment Deposition
5 Channel Flow Status
6 Channel Alteration
7 Bank Stability (score each bank)
8 Vegetative Protection (score each bank)
9 Riparian Vegetative Zone Width (score each bank)

Appendix A
SURFACE WATER PARAMETERS

The chemical characterization of waterways is important for the general description of water quality conditions. The following parameters were measured in the field, water samples were also analyzed by Microbac Laboratories.

Field Measurements

pH
The pH of a solution refers to its hydrogen ion concentration. Measurement of pH is one of the most important and frequently used tests in water chemistry. The pH value of most natural waters falls within the range of 4 to 9. The pH scale ranges from 0 (acid) to 14 (base). Most waters are slightly basic because of the presence of carbonates and bicarbonates (i.e., salts within the geology). Most fish can tolerate pH values from 5.0 to 9.0. However, optimum fishing habitats fall within the range of 6.5 to 8.2.

Temperature
Temperature is essential in determining if acceptable standards exist for individual stream classification. Elevated temperatures from heated water discharges may have a significant ecological effect. Temperature has an inverse relationship with the solubility of dissolved oxygen.

Dissolved Oxygen (DO)
Dissolved oxygen (DO) is a measure of oxygen that is dissolved in water. Different levels of DO are necessary to support various types of aquatic life. These levels in natural and waste waters are dependent on the physical, chemical, and biochemical activities prevailing in the water body. The minimum D.O. levels are: HQ-CWF 7.0mg / L CWF 5.0. mg/L TSF (February 15th – July 31st) 6.0 mg/L; Remainder of year 5.0 mg/L.

Specific Conductance
Conductivity is a numerical expression of the ability of water to carry an electrical current. It is an indication of the dissolved inorganic solids in the water. The higher the specific conductance, the more impurities are in the water. Freshly distilled water has a conductivity of 0.5 to 2.0 microsiemens (µS)/cm. The conductivity of the drinking water in the U.S. generally ranges from 50 to 500 µS/cm. It is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron.

Water Chemistry Laboratory Analysis

TOTAL ORGANIC CARBON (TOC)

Total organic carbon (TOC) is a measurement of the amount of carbon containing compounds in a sample that can be quantified. This measurement is significant because the amount identified in a stream can be an indicator of the organic character of a stream. The larger the carbon or organic content, the more oxygen is consumed, thus a high content equates to an increase in of microorganisms that could contribute to the depletion of oxygen levels. Samples are preserved in the field by the addition of 1 ml of sulfuric acid (H2SO4). There is no numeric standard for TOC.

ALUMINUM

Aluminum is found naturally in the environment and is found in water in a dissolved form. Its concentration is influenced by multiple factors including pH, surface water flow over soil and bedrock, and groundwater flow through soil horizons and underlying geologic material. The Aluminum concentrations of water in healthy streams and rivers usually range from 0.001 to 0.05 mg/L.

CALCIUM

Calcium occurs most commonly in sedimentary rocks in the minerals calcite, dolomite and gypsum. Calcium is an important determinant of water hardness, and it also functions as a pH stabilizer because of its buffering qualities. Rivers generally contain 1-2 mg/L calcium. In limestone areas, rivers may contain calcium concentrations as high as 100 mg/L. There is no numeric standard for calcium.

IRON

Surface and groundwater naturally contain iron along with other metals. Rainwater infiltrates soil horizons and iron bearing rocks, and dissolves the iron into the water solution. There are two kinds of iron that occur in water. The first is called ferrous, which is soluble in the water and results in clear, colorless water. The other state is called ferric, which results in a reddish-brown color because the iron is not completely dissolved in the water. Iron can also be combined with naturally-occurring acids (tannins) which will stain the water a tea color.

MAGNESIUM

This element is essential to chlorophyll and red blood cells. Magnesium commonly occurs in the minerals of magnesite ($MgCO_3$) and dolomite. It contributes to water hardness and is used in alloys, fertilizers, pharmaceuticals, and foods.

TOTAL HARDNESS

Hardness is defined as the total amount of calcium and magnesium salts that are present in the water. Hard water aids buffering capacity. Water can be defined by its total hardness as follows:

Soft Water	0 - 60 mg/L
Moderately Hard Water	60 - 120 mg/L
Hard Water	120 - 180 mg/L
Very Hard Water	180 mg/L and up

CHLORIDES

Chlorides are salts resulting from the combination of the gas chlorine with a metal. Common chlorides are sodium chloride, calcium chloride and magnesium chloride. Most productive fish habitats have a chloride concentration of less than 170 mg/L. The recommended maximum chloride levels are 250 mg/L for water supply.

NITROGEN

Ammonia, nitrite, and nitrate are all commonly found forms of nitrogen in aquatic ecosystems. Nitrogen is considered a limiting nutrient for primary production in aquatic ecosystems along with phosphorus, and excess nitrogen can result in eutrophication.

AMMONIA (NH_3)

Ammonia is naturally present in surface water, ground water, and in wastewater. Pure ammonia is strong smelling and colorless. In nature, ammonia is formed by the action of bacteria on proteins and urea. Ammonia concentrations of 0.06 mg/L can cause gill damage in fish; 0.1 mg/L may indicate domestic or agricultural wastes and levels 0.2 mg/L and above are lethal to trout.

NITRITE (NO_2)

Nitrite is the intermediate stage between nitrate and ammonia. It is relatively short-lived because it is quickly converted to nitrates by bacteria. Nitrite concentrations in drinking water seldom exceed 0.1 mg/L. There is no numeric standard for nitrite.

NITRATE (NO_3)

Nitrate is found only in small amounts in domestic wastewater and is a major ingredient in farm fertilizer. During precipitation events, varying amounts of this chemical wash into nearby waterways. Nitrates stimulate the growth of phytoplankton and algae. When these photosynthetic organisms die, bacteria consume the dead organic material. This process also requires oxygen which depletes dissolved oxygen levels in the water and the fish may not be able to respire. Because nitrate can be the limiting nutrient for plant growth in many ecosystems, the discharge from a septic tank into the aquatic environment can trigger prolific plant growth including algal blooms. There is no numeric standard for nitrate.

TOTAL KJELDAHL NITROGEN (TKN)

T.K.N. is the sum of organic nitrogen and ammonia nitrogen. Samples are preserved in the field by the addition of 1 ml of Sulfuric Acid (H_2SO_4). There is no numeric standard for TKN.

TOTAL ALKALINITY

Alkalinity measures the water's ability to buffer acid or acid neutralizing capacity. It indicates the water's ability to protect fish and other aquatic life against sudden changes in pH. The best fishing waters are those with alkalinity of 100 - 120 mg/L. The minimum level of total alkalinity for aquatic life buffering capacity is 20 mg/L, except where natural conditions are less. Stream alkalinity can be influenced by geologic material, soil horizons, salts, plant activities and certain industrial wastewater discharges. Water flowing through carbonate rich limestone generally has high alkalinity – hence good buffering capacity. Conversely, areas rich in granites and some conglomerates and sandstones may have low alkalinity and therefore poor buffering capacity.

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids (T.D.S.), also termed total filterable residue, refers to the portion of residue that passes through a filter of a particular size. The DEP, as well as the EPA, have established secondary maximum contaminant levels of 500 mg/L of TDS for the Commonwealth's drinking water and waterways. The maximum recommended value for T.D.S. is 750 mg/L.

TOTAL PHOSPHORUS

Total Phosphorus is a measure of all the forms of phosphorus (dissolved or particulate) that are found in a sample. It occurs in natural waters and wastewaters almost solely in the form of phosphates. Phosphates enter waterways from animal wastes, phosphate rich rocks, fertilizers, and from the detritus of aquatic organisms. Phosphorus is essential to the growth of organisms and can be the limiting nutrient to plant growth. If high concentrations are present in streams the algae can grow more rapidly. This increase in algae is eventually consumed by bacteria which require oxygen. This process reduces dissolved oxygen in the water which can impact fish populations. Phosphate levels below 0.03 mg/L are generally considered to be unpolluted. The recommended maximum level is 0.01 mg/L for rivers and streams.

BIOLOGICAL OXYGEN DEMAND (BOD)

BOD is a measure of the dissolved oxygen required for the complete breakdown of organic matter, by aerobic bacteria over a five-day period. It is a key criterion used where organic loading must be restricted to maintain desired levels of dissolved oxygen in water. Sources of BOD, in addition to direct loading from STPs, include decaying algae, macrophytes, and other biota. In streams that are polluted with sewage or high levels of other nutrients, the oxygen use or demand by microorganisms will be high, leaving little oxygen for other aquatic organisms. Most pristine rivers will have a 5-day carbonaceous BOD below 1 mg/L.

Appendix B

Benthic Macroinvertebrates

What is a Macroinvertebrate?

A macroinvertebrate is an organism that is large enough to see with the naked eye (macro) and lacks a vertebral column (invertebrate). The organisms that are collected for this study are called benthic macroinvertebrates. Benthic refers to the bottom layer of an aquatic ecosystem including underneath stream sediment. These organisms include mayflies, caddisflies, stoneflies, snails, clams, crayfish, freshwater shrimp, beetle larvae, midges, leeches, dragonflies, and more.

Why collect Macroinvertebrates?

- They are relatively easy to collect.
- They play a key role in the ecosystem's food web.
- They are used as bio indicators for environmental stress and can show varying responses to water chemistry and physical habitat.
- Due to their relative immobility (unlike fish) they cannot move upstream or downstream to avoid poor water conditions.
- They are extremely diverse. Different macroinvertebrates will live in different water bodies due to water conditions, available food, and absence or abundance of sediment, nutrients, and detritus (dead organic matter).

Macroinvertebrate Analysis

The protocols used in the development for the riffle/run Index of Biotic Integrity (IBI) were based on PADEP wadeable riffle-run stream macroinvertebrate assessment method.
The second protocol type is the multi-habitat assessment for low-gradient streams, which involved sampling a variety of habitat types. The difference between the two assessment protocols involved sampling different micro-habitats for macroinvertebrate collections and different habitat evaluation categories. These bio assessments were employed to cumulatively evaluate the ecological conditions of streams that are present within Monroe County.

Metric Calculations

The following are the riffle/run metrics used for the benthic macroinvertebrate analysis. Metrics are the various counts, indexes, and ratios computed from the results of the subsamples.

Different metrics convey different types of information about the macroinvertebrate community. For example, taxa richness is an index of diversity and the Hilsenhoff Biotic Index measures an organism's pollution tolerance. By using a set of metrics that measures multiple aspects of the macroinvertebrate community, a complete picture of a community can be attained. This enables the reader to understand the importance of measuring the relative stability of the aquatic community.

Source of Photos: http://kentschools.net thebeachschool.eq.edu.au www.fly-fishing-discounters.com

The following is a list of metric calculations utilized during the 2019 study:

Freestone Riffle/Run (6 D Frame):

Modified Beck's Index, version 3 (MBI)
MBI metric is projected to decline in assessment score when anthropogenic stress to a stream ecosystem increases, therefore representing the loss of pollution-sensitive taxa. It should be noted that this index metric for this project, while similar in name and concept, differs slightly from the Beck's Index used in DEP's multihabitat protocol for assessing biological condition of low gradient pool-glide type streams.

EPT Taxa Richness
EPT taxa richness metric is a count of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) in a sub-sample that represents community structure. These orders are commonly referred to as mayflies, stoneflies, and caddisflies, respectively. This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of taxa from these largely pollution-sensitive orders.

Total Taxa Richness
Total taxa richness is a community structure metric, which is a count of taxa in the sub sample. Generally, this metric is expected to decrease with increasing anthropogenic stress to the ecosystem, reflecting loss of taxa and increasing dominance of a few pollution tolerant taxa.

Shannon Diversity Index (SDI)
SDI is a taxonomic composition metric that measures taxonomic richness and evenness of individuals across taxa of a sub-sample. This metric is expected to decrease in values with increasing anthropogenic stress to a stream ecosystem.

Hilsenhoff Biotic Index (HBI)
HBI is a taxonomic composition metric and is calculated as an average pollution tolerance value weighted by the number of individuals of each taxa in the sub-sample. The Hilsenhoff Biotic Index generally increases with increasing ecosystem stress.

Percent Intolerant Individuals
Percent Sensitive Individuals is a taxonomic composition metric which is the percentage of individuals with pollution tolerance values of three or less in a sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem.

Index Calculation-Riffle/Run:

Through the combination of the various metrics noted, standardization is needed. Table 1 depicts the standardization table with the associated standardized and adjusted metric scores with the total producing the IBI score. This index is a way to integrate all of the data that is collected. The sum of these specific metric equations constructs an IBI, which then can be related to reflect the ecology and impacts to the aquatic community being studied. There are six metrics involved, the Hilsenhoff Biotic Index (HBI) is the only one predicted to increase in value if the community is stressed. The other five IBI metrics are predicted to decrease in value if the community is exposed to increased stress. The index calculation and standardization are included in Table 1.

Table 1. Metric Standardization Equations and Index calculations for sub-sampled sites.

Metric	**Standardized Equation**	**Observed Metric Value**	**Standardized Metric Score**	**Adjusted Standardized Metric Score** Maximum = 1.000
Modified Beck's Index	Observed value / 33			
EPT Taxa Richness	Observed value / 19			
Total Taxa Richness	Observed value / 38			
Shannon Diversity Index	Observed value / 2.86			
Hilsenhoff Biotic Index	(10 - Observed value) / (10 – 1.89)			
Percent Intolerant Individuals	Observed value / 84.5			
Average of adjusted standardized core metric scores * 100 = **IBI Score**				

Aquatic Life Use Attainment Benchmarks

Figure 1 depicts the Aquatic Life Use (ALU) IBI scoring benchmarks utilized by DEP for assessment purposes. DEP implements a multi-tiered benchmark decision process for small wadeable freestone riffle/run streams in Pennsylvania that incorporates sampling season as a factor for determining ALU attainment and impairment; this process is outlined in the diagram below (PADEP). Title 25, Chapter 93 of the Pennsylvania Code provides further information on these uses.

Figure 1. Aquatic Life Use (ALU) IBI scoring benchmarks for Instream Comprehensive Evaluation (ICE) assessment purposes (PADEP, 2018).

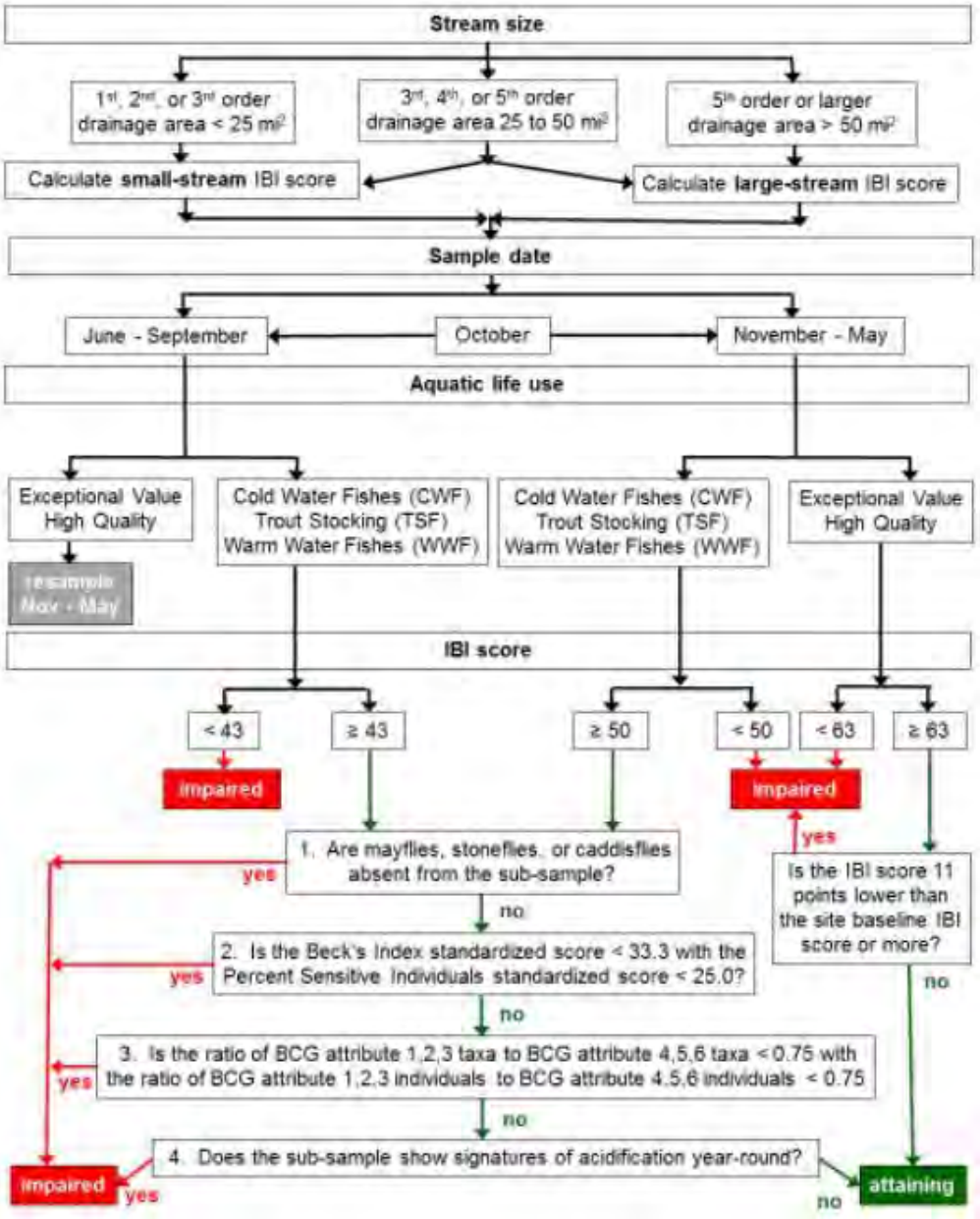


Figure 1 depicts the adjusted and standardized Aquatic Life Use (ALU) IBI scoring benchmarks for Instream Comprehensive Evaluation (ICE) assessment purposes. For samples collected in streams designated as EV/HQ, a score ≥ 63 results in ALU attainment (if the IBI score is not 11 points lower than the baseline) and < 63 results in ALU impairment. For samples collected in streams designated as CWF/TSF, an IBI score < 50 results in ALU impairment. An IBI score ≥ 50 requires further evaluation to determine ALU impairment. Four guidelines may be used (PADEP,2018):

(1) Are mayflies, stoneflies, or caddisflies absent from the sub-sample? If so, this strongly suggests some sort anthropogenic impact.
(2) Is Beck's index standardized score < 33.3 with the Percent Sensitive Individuals standardization score <25.0? This question ensures the sample has substantial richness and abundance.
(3) Is the ratio of Biological Condition Gradient (BCG) attribute 1,2,3 taxa to 4,5,6 taxa < 0.75 with the ratio of BCG attribute 1,2,3 individuals to 4,5,6 individuals <0.75? This evaluates the balance of pollution tolerant organisms with sensitive organisms in terms of taxonomic richness and organismal abundance, which serves as a check against the IBI metrics which account for pollution sensitivity based only on pollution tolerance values.
(4) Does the sub-sample show signatures of acidification year-round? (PADEP, 2018).

Multihabitat - Low Gradient (10 D Frame):

EPT Taxa Richness - Refer to riffle/run definition.
Total Taxa Richness - Refer to riffle/run definition.

Modified Beck's Index (version 4) - This is a pollution weighted taxa richness measure that is based on the Hilsenhoff Biotic Index Score. It is a modified Beck's Index giving organisms with a Hilsenhoff score of 0 or 1 two points and Hilsenhoff scores of 2, 3, or 4 are given 1 point. This metric differs slightly from the Beck's Index used in DEP's riffle/run protocol for assessing the biological condition of freestone type streams.

Shannon Diversity Index - Refer to riffle/run definition.
#Caddisfly Taxa - Total number of Caddisflies (Trichoptera) in the sub-sample
#Mayfly Taxa - Total number of Mayflies (Ephemeroptera) in the sub-sample

Index Calculation, multihabitat:
Through the combination of the various metrics noted above, normalization is needed. This index is a way to integrate data that is collected from the described data. Table 2 depicts the standardization table with the associated normalized and adjusted metric scores with the total generating an IBI score. The sum of these specific metric equations builds an IBI, which then can be related to reflect the ecology & impacts to the aquatic community being studied. Of the six metrics utilized, all are predicted to decrease in value if the community is stressed. The normalized scores above 100 are adjusted to a score of 100

Table 2. Normalization of Metric and Total Biological Score Calculation.

Metric	Standardized Equation	Observed Value	Normalized Metric Score	Adjusted Metric Score Maximum = 100
EPT	(Observed value / 17) x 100			
Taxa Richness	(Observed value / 31) x 100			
Beck4	(Observed value / 22) x 100			
Shannon Diversity	(Observed value / 2.43) x 100			
% Caddisfly Taxa	(Observed value / 11) x 100			
% Mayfly Taxa	(Observed value / 6) x 100			
Total Biological Score				

Aquatic Life Use Attainment Benchmarks

The following depicts the aquatic life use (ALU) IBI scoring benchmarks utilized by DEP for assessment purposes. This multimetric approach simplifies management decisions, being presented as a single index score (PADEP 2018). If the total benchmark score of 55 is not reached, then the stream reach is not attaining the threshold for aquatic life. Title 25, Chapter 93 of the Pennsylvania Code provides further information on these uses.

The following summaries are presented in the sequence they were sampled. They depict the macroinvertebrate community per site, specifically genus level taxonomy, water pollution tolerances values (0 intolerant to 10 tolerant), trophic codes and the statistics that comprise the total standardized biological score. The trophic code is a general classification system, which is based on what type of feeding mechanism the macroinvertebrate utilized or how the food is acquired. These categories are presented to facilitate the descriptions on the following pages:

SC - **Scrapers**: graze or scrape materials from mineral and organic substrates

SH - Shredders: chew on plant and some animal material, breaking it down into smaller particles feeding directly on living vascular hydrophytes, or gouge decomposing wood submerged in streams

CG - Collector/Gatherers: feed primarily on fine pieces of decomposing particulate organic matter (< 1 mm diameter) deposited in streams;

FC - Filterer/Collector: remove particulate matter from suspension

PR - Predators: Organisms that feed on animal tissue by either engulfing or piercing and sucking body contents of prey (Merritt & Cummins 1984).

Monroe County executed two progressive stream evaluation surveys, the riffle-run and the multihabitat protocols, which were conducted within a 100 meter stream reach. These biological screening protocols were modified from the United States Environmental Protection Agency (EPA) rapid bioassessment protocols (RBPs), for assessing stream macroinvertebrate communities (PADEP 2018). These biological screening protocols are specifically designed per stream type, to provide intensive field surveys and water quality assessment approaches. The riffle-run Index of Biological Integrity (IBI) applies to benthic macroinvertebrate samples collected using a handheld 500-micron mesh D-frame net, which employed the semi-quantitative (PADEP-RBP) method, applied for each Instream Comprehensive Evaluation (ICE). Staff conducted six swipes from shallow and deep, fast and slow riffle areas within a 100-meter stream reach. Each swipe disturbed approximately one square meter, immediately upstream of the net for approximately one minute, to an approximate depth of 10 cm, as substrate permits (PADEP 2009). The second sampling protocol was the multihabitat approach for low gradient streams, which required 10 jabs utilizing a 500-micron mesh D-frame net distributed between five possible habitat types: Cobble/Gravel Substrate; Snag; Coarse Particulate Organic Matter (CPOM); Submerged Aquatic Vegetation (SAV); and Sand/Fine Sediment) (PADEP 2018).

For the riffle-run dominated streams, each sample is composited into one container preserved with 95% ethanol in the field and transported to the contracted entomologist for enumeration and identification and placed into a pan marked with 28 four square inch grids. Debris from four grids is randomly selected and extracted using a four-square inch circular "cookie cutter," then placed into another identical empty pan. From this second pan, organisms are randomly selected from the grids until a 200-organism sub-sample (+/- 40 organisms) is obtained. Organisms in the sub-sample are identified according to taxonomic groupings and enumerated. Midges are identified to the family level of Chironomidae. Roundworms and proboscis worms are identified to the phylum level. Flatworms and segmented worms, aquatic earthworms, and tubificids are identified to class. Water mites are identified as Hydracarina, and all other macroinvertebrates are identified to genus level (PADEP 2009).

For low gradient dominated streams, each sample is composited into one container preserved with 95% ethanol in the field and transported to the contracted entomologist for enumeration and identification and placed into a pan marked with 28 2” x 2” grids. Debris from four grids is randomly selected and extracted until a 200-organism sub-sample (+/- 20 %) is obtained. Organisms in the sub-sample are identified according to taxonomic groupings. Midges are identified to the family level of Chironomidae. Roundworms and proboscis worms are identified to the phylum level. Flatworms are identified to Phylum Turbellaria. Segmented worms, aquatic earthworms and tubificids are identified to Class Oligochaeta. Water mites are identified as Hydracarina, weevils to family, sand flies to family Ceratopogonidae, Decapoda, Gastropoda,

and Pelecypoda to family. All other macroinvertebrates are identified to genus level (PADEP 2007). The specifics of the macroinvertebrate analyses are discussed in Appendix B of this report.

Precision Quantification

To quantify precision methods, two of the biological samples were replicated and collected by the same investigator to minimize variability, and complies with the PADEP's quality assurance manual to verify identification work performed on macroinvertebrates. The field data sheets are available for review at the MCPC office.

Quality Assurance

Accuracy was determined through the use of routine laboratory protocols that required random spiking of samples as per *consistency with the Quality Assurance Manual for* PADEP. Data quality requirements were maintained in the field throughout the collections. Calibration of field equipment was performed daily.

During the field sampling, water samples were collected at mid-depth and mid-channel. These water samples were stored in coolers with ice packs in order for stabilization and then transported to Microbac Laboratories, which is EPA certified for analysis. The specifics of the chemical parameters are discussed in Appendix A of this report.

Macroinvertebrate Collection Data

Table 3. 2019 Macroinvertebrate Data

2019 MONROE COUNTY MACROINVERTEBRATE DATA

TAXON	Pollution Toleranc	NUMBER COLLECTED AT SAMPLING STATION												
ORDER		01	02	03	04	05	06	07	08	09	10	11	12	13
GENERA/SPECIES														
AMPHIPODA (shrimp)														
Gammarus spp.	4						1							2
BIVALVIA (clams)														
Pisidium spp.	8													
COLEOPTERA (beetles)														
Berosus spp.	5													
Stenelmis spp.	5					1	8			2	11		1	
Promoresia spp.	2	2				11	4							
Dubiraphia spp.	6													
Optioservus spp.	4	3			2	1	3			8			4	
Ectopria spp.	5			1										
Psephenus herricki	4				4	1	1		2	2	5			
Microcylloepus spp.	2					7		2						
Hydrochus spp.	5													
Lentrochus spp.	6			1										1
Oulimnius spp.	5													
DIPTERA (true flies)														
Chironomidae	6	10	1	2	8	49	16	8	27	11	1	48	47	30
Blephariceridae spp.	0										2			
Tipula spp.	4		1					1	1	1				
Hexatoma spp.	2	5												
Pericoma spp.	4													
Nemerodromia spp.	6					1		1		5			2	1
Tabanus spp.	5													
Atherix spp.	2					1			6					
Antocha spp.	3	3				3	6	2	1	1	2		5	1
Simulium spp.	6	3				1		1		1	3	28	10	10
Dicranota spp.	3	2		1		1						1		
Empididae spp.	6													
Prosimulium	2	9				2			2			2		1
Bezzia spp.	6					1								
Chrysops spp.	7					1								1
EPHEMEROPTERA (mayflies)														
Epeorus spp.	0	19		12				3	2	4	15		1	
Maccaffertium spp.	3		1	18	3	17	3	8	8	13	4	1	4	15
Stenacron spp.	4	1				2								
Ephemerella spp.	1	36	1	72	87	2	9	117	32	80	134	62	51	64
Eurylophella spp.	4					1	3			1				
Drunella spp.	1			2			9		31	4	1			
Danella spp.	2							1						
Attenuatella spp	2													
Serratella spp.	2												2	
Leucrocuta spp.	1													
Paraleptophlebia spp.	1	16		2			3		3				1	
Leptophlebia spp.	4													
Heterocloeon spp.	2						8							1
Chaetagmia spp.	1	2												
Nixe spp.	2													
Rithrogena spp.	0													
Heptageniidae	3													
Isonychia spp.	3			3	9		48	1	18	18	2			1
Baetidae	6													
Baetis spp.	6	20	2	18	6			1	7	7	3	32	13	17
Acerpenna spp.	6												1	
Plauditus spp.	4													
Acentrella spp.	4													
GASTROPODA (snails)														
Physinae	8													
HEMIPTERA (true bugs)														
Microvelia spp.	9													
HIRUDINEA (leeches)	8													
Mooreobdella spp.														
ISOPODA (sowbugs)														
Caecidotea spp.	6													1
LEPIDOPTERA (moths)														
Petrophila spp.	5													
MEGALOPTERA (hellgramites)														
Stalis spp.	6									1				
Corydalus spp.	4													
Nigronia spp.	2		2	1		1	2			1				4
NEMERTEA	6													
NEMATOPHORA (horsehair w	3													

TAXON (continued)	Pollution Tolerance	NUMBER COLLECTED AT SAMPLING STATION (continued)												
ORDER		01	02	03	04	05	06	07	08	09	10	11	12	13
GENERA/SPECIES														
ODONATA (dragon flies)														
Libellula spp.	8													
Calopteryx spp.	6													
Hagenius spp.	3					1								
Boyeria spp.	2					1	1	1				1		1
Ophiogomphus spp.	1													2
Progomphus spp.	5												1	
Gomphus spp.	5							1						1
Lanthus spp.	5	1		2		2							1	
Stylogomphus spp.	4													
calopteryx spp.	6													
Cordulegaster spp.	3													
Tschopteryx spp.	5													
OLIGOCHAETA (worms)	10										2		1	
PLECOPTERA (stoneflies)														
Leuctra spp.	0	2				5			1					
Taeniopteryx spp.	2													
Amphinemura spp.	3	5	2					1	1			6	3	8
Pteronarcys spp.	0					1			1					
Acroneuria spp.	0			2	1	20	6	2	10	3	9			
Paragnetina spp.	1								3					
Agnetina spp.	1			1	1								1	2
Perlesta spp.	4					1								
Suwallia/Sweltsa spp.	0	4							5	2				
Skipsa spp.	2													
Taeniopteryx spp.	0	28												
Diploperla spp.	2			3										
Chloroperla spp.	2													
Diura spp.	2													
Cultus spp.	2				1									
Isoperla spp.	2	4		6	8	1	6	2	2			3	14	4
TURBELLARIA (flatworms)														
Macrostomum spp.	8													
TRICHOPTERA (caddisflies)														
Chimarra spp.	4			1		17		2	1		2		2	2
Wormaldia spp.	0		1											
Dolophilodes spp.	0	7		8				1	2	2				
Neophylax spp.	3	1	1	5	1				4	5	4		1	1
Hydropsyche spp.	5					10		3		1		2	5	3
macrostemum spp.	3						18							
Ceratopsyche spp.	5			13	20	9	14	16	6	9	14	4	8	5
Cheumatopsyche spp.	6	1		10	4	22	23	14	3	12	5	2	5	3
Parapsyche spp.	0	4												
Diplectrona spp.	0	14		4	1	1		4	4	1		1		
Rhyacophila spp.	1	5	4	6	9		2	1	2	6	8		1	1
Lepidostoma spp.	1								1					
Psilotreta spp.	0					1							1	1
Glossosoma spp.	0			1										
Agapetus spp.	0					1								
Protoptila spp.	1													
Psychomyia spp.	2													
Lype spp.	2					1							1	
Micrasema spp.	2			1										
Ceraclea spp.	3													
Helicopsyche spp.	3													
Leucotrichia spp.	6													
Oxyethira spp.	3													
Hydatophylax spp.	2													
Polycentropus spp.	6				1	2	1							
Nectopsyche spp.	3													
Neureclipsis spp.	7						1							
TOTAL														
METRICS		**207**	**16**	**201**	**196**	**202**	**203**	**213**	**186**	**202**	**227**	**199**	**193**	**199**
Total Taxa Richness		26	10	27	18	37	24	25	28	27	19	14	27	30
Shannon Diversity Index		2.76	2.17	2.43	1.98	2.75	2.63	1.85	2.70	2.39	1.74	1.85	3.87	2.46
EPT Taxa Richness		15	7	18	11	15	12	14	19	13	9	5	13	13
Hilsenhoff Biotic Index		1.73	2.56	2.29	2.65	3.92	3.52	2.35	2.45	2.66	1.87	4.02	2.38	3.42
Percent Intolerant Individuals		81.16	75.0	75.6	70.4	38.6	62.1	69.0	74.7	69.3	79.7	41.7	44.6	54.3
Modified Beck's Index		33	16	28	13	28	16	21	36	19	15	8	16	15
IBI SMALL STREAM		**89.5**	**60.9**	**86.6**	**65.0**	**78.2**	**70.6**	**74.2**	**92.6**	**76.1**	**66.6**	**46.3**	**73.2**	72
IBI LARGE STREAM		**95.7**		**95.3**	**75.9**	**89.2**	**83.9**	**88.0**	**97.5**	**89.7**	**74.4**	**54.3**	**84.7**	84.7

TAXON	Pollution Toleranc	NUMBER COLLECTED AT SAMPLING STATION												
ORDER		14	15	16	17	18	19	20	21	22	23	24	25	26
GENERA/SPECIES														
AMPHIPODA (shrimp)														
Gammarus spp.	4													
BIVALVIA (clams)														
Pisidium spp.	8													
COLEOPTERA (beetles)														
Berosus spp.	5													
Lutrochus spp.	6													
Microcylloepus spp.	2				9				4		1			
Stenelmis spp.	5				4					64	9			
Dubiraphia spp.	6													
Promoresia spp.	2		1			17		1		1				
Stenelmis spp.	5								9			1		44
Ectopria spp.	5					1								
Optioservus spp.	4	2		1									1	1
Agabus spp.	5													
Micrenchus spp.	2													
Psephenus herricki	4		2		4	3			7	7	5	11		3
DIPTERA (true flies)														
Chironomidae	6	12	168	31	35	7	9	29	20	11	13	8	55	26
Probezzia spp.	6													
Bezzia spp.	6							2						
Hemerodromia spp.	6									4				22
Bibiocera spp.	0			1				1	1	1		8		1
Limnophora spp.	6													
Muscidae	6													
Tipula spp.	4													
Hexatoma spp.	2	1	6	4				9		1			9	
Atherix spp.	2					4						1		1
Antocha spp.	3	2				1						4	2	
Tabanus spp.	5													
Empididae spp.	6													
Dicranota spp.	3	1												
Prosimulium spp.	0			15	1	3			1			4	5	
Pedicia spp.	6													
Ptychoptera spp.	8													
Chrysops spp.	7			1		3			4		3			
Simulium spp.	6									2		1	3	
EPHEMEROPTERA (mayflies)														
Epeorus spp.	0	7	2	40	15	7		49	21	15	3	10	57	6
Maccaffertium spp.	3	11	1		8	8		2	6	1	11	9		5
Stenacron spp.	4													
Ephemerella spp.	1	37	25	18	52	35	133	34	16	9	16	14	9	4
Eurylophella spp.	4						4					1		
Serratella spp.	2					2					3			1
Leucrocuta spp.	1				3									
Drunella spp.	2								42					
Drunella spp.	1	2		1	7	8				43	33	1		43
Heterocloeon spp.	2													
Paraleptophlebia spp.	1	3	7	1	8	8	2	4						
Isonychia spp.	3	18			2	3			2	1	18			5
Amelotus spp.	0											1		
Caenis spp.	7													
Baetis spp.	6	15	6	24	2	58	10	6	8	27	9	10	19	11
Acerpenna spp.	6	1					3							
Acentrella spp.	4										1			
Ephemera spp.	2													
Pseudiron spp.	4													
Diphetor spp.	6					1				1				
Cinygmula spp.	1			23										
GASTROPODA (snails)														
Gyraulus spp.	6													
T-Shuta spp.	2													
HEMIPTERA (true bugs)														
HIRUDINEA (leeches)														
ISOPODA (Sowbugs)														
Caecidotea spp.	6													
MEGALOPTERA (hellgramites)														
Sialis spp.	6													
Nigrona spp.	2	3						1	3			1		
Corydalus spp.	4													

TAXON (continued)	Pollution Tolerance													
ORDER		14	15	16	17	18	19	20	21	22	23	24	25	26
GENERA/SPECIES														
ODONATA (dragon/damsel flies)	4													
Gomphidae	5					1								
Lanthus spp.	4							1				1		
Progomphus spp.	5									1				
Stylogomphus spp.	10													
Boyeria spp.	2													
Ophiogomphus spp.	1		2											
OLIGOCHAETA (worms)	10			1					1					
PLECOPTERA (stoneflies)														
Paraleuctra spp.	0													
Leuctra spp.	0	1		1				2				3	4	
Amphinemura spp.	3										1			
Pteronarcys spp.	0			3			2	2					1	
Acroneuria spp.	0	3	1		11	4	1	2	4	2	4			3
Paragnetina spp.	1	7	1		1	1			1	3	2	1		4
Agnetina spp.	2	1	2		2			4			2			
Sweltsa/Swoffera spp.	0	2		8				3				3	1	2
Perlesta spp.	4													
Taeniopteryx spp.	0			14			3	1						
Diploperla spp.	2													
Cultus spp.	2							2						
Isoperla spp.	2	10	3	4	4	5	4	18	1	1		1	3	1
Isogenoides spp.	0													
Diura spp.	2													
Chloroperla spp.	2													
Remenus spp.	2													
TURBELLARIA (flatworms)														
TRICHOPTERA (caddisflies)														
Chimarra spp.	4	1							3	1	2			1
Dolophilodes spp.	0	11			1	1	2				1	1	3	1
Hydropsyche spp.	5					3								
Ceumatopsyche spp.	6	16	2	1	21	1		7	17	7	25		1	6
Ceratopsyche spp.	5	8	2		12	15		4	13	5	32	3	1	14
Diplectrona spp.	0					11	24	7		1		4	1	
Rhyacophila spp.	1	16	2	15	3	2	1	10	20	3	24		5	14
Glossosoma spp.	0													
Neureclipsis spp.	1					1								1
Psychomyia spp.	2													
Nyctiophylax spp.	6													
Parapsyche spp.	0													
Lepidostoma spp.	1							4						
Leucotrichia spp.	6													
Micrasema spp.	2					3								
Neophylax spp.	3	3			1				3			2		
Brachycentrus spp.	1													
Agapetus spp.	0													
Psychomyia spp.	2													
Nectopsyche spp.	3													
Athripsodes spp.	4													
Polycentropus spp.	6		1					1	1			1	1	
Pycnopsyche spp.	4												4	
TOTAL														
METRICS		**200**	**234**	**207**	**206**	**215**	**198**	**212**	**208**	**218**	**218**	**105**	**197**	**230**
Total Taxa Richness		26	18	20	22	29	13	26	24	24	22	26	20	25
Shannon Diversity Index		2.8	1.23	2.42	2.49	2.62	1.29	2.57	2.67	2.31	2.60	2.81	2.15	2.52
EPT Taxa Richness		16	9	11	14	14	10	15	11	11	14	13	11	14
Hilsenhoff Biotic Index		2.67	4.90	0.01	2.83	3.21	1.47	2.00	2.86	3.07	3.29	2.55	2.87	3.53
Percent Intolerant Individuals		72.5	22.7	71.5	62.1	57.2	86.9	76.4	60.1	40.4	54.6	64.8	56.9	43.9
Modified Beck's Index		0.29	20	31	25	28	23	38	21	23	20	31	25	29
IBI SMALL STREAM		85.6	**47.9**	**78.2**		**79.7**	**66.3**	**89.5**	**73.1**	**67.5**	**71.9**	**82.8**	**69.1**	**74.3**
IBI LARGE STREAM		97	**59.3**		**89.8**	**92.7**	**74.9**		**87.5**	**81.2**	**86.4**			**85.9**

TAXON	Pollution Toleranc	NUMBER COLLECTED AT SAMPLING STATION										
ORDER		27	28	29	30	31	32	33	34	35	36	37
GENERA/SPECIES												
AMPHIPODA (shrimp)												
Gammarus spp.	4							18		3	4	
BIVALVIA (clams)												
COLEOPTERA (beetles)												
Lutrochus spp.	6											
Microcylloepus spp.	2										2	
Microcylloepus spp.	2											
Stenelmis spp.	5						3				2	
Promoresia spp.	2	4										
Stenelmis spp.	5							3	3			
Optioservus spp.	4	2			9							
Macronyxus pp.	2											
Psephenus herricki	4							6	9	2	6	13
Ectopria spp.	5				1						1	
DIPTERA (true flies)												
Chironomidae	6	40	62	146	6	19	2	30	28	6	15	11
Bliphariceria spp.	0		3			14						
Hemerodromia spp.	6		1					3	4	1	2	1
Empididae	6											
Muscidae	6											
Tipula spp.	4			1	2							
Hexatoma spp.	2	1	6	1	4							
Atherix spp.	2											
Antocha spp.	3	5			5			1	4		7	1
Prosimulium spp.	0		11	16		16	177					3
Simulium spp.	6	6	1					1	2	1	10	6
Dicranota spp.	3	1			3							
Probezzia spp.	6											
Bezzia spp.	6											
Tabanus spp.	5											
Chrysops spp.	7			3								
EPHEMEROPTERA (mayflies)												
Epeorus spp.	0	35	47	12	4	5	1	20				33
Maccaffertium spp.	3	1	6	1	14		1	22		9	4	2
Stenacron spp.	4											
Cinygmula spp.	1	6	9	1	1							
Ephemerella spp.	1	28	19	9	64		1	26	87	15	55	
Eurylophella spp.	4			1	2						1	1
Caenis spp.	7											
Drunella spp.	1			1			1	24	6	7	25	31
Serratella spp.	2							3		2		
Drunella spp.	1											
Paraleptophlebia spp.	1	1	8		3							
Leptophlebia spp.	4											
Habrophlebiodes spp.	6											
Isonychia spp.	3							8		4	1	
Amelotus spp.	0	1										
Baetis spp.	6	12	23	7	12	7	2	4	2		8	7
Diphetor spp.	6		1									
Acerpenna spp.	6		1									
Acentrella spp.	4			1				3	3	2	10	7
GASTROPODA (snails)												
HEMIPTERA (true bugs)												
Microvelia spp.	9											
HIRUDINEA (leeches)												
ISOPODA (sowbugs)												
MEGALOPTERA (hellgramites)												
Stalis spp.	6											
Nigronia spp.	2								1		2	
Corydalus spp.	4										2	1

TAXON (continued)	Pollution Tolerance											
ORDER		27	28	29	30	31	32	33	34	35	36	37
GENERA/SPECIES												
ODONATA (dragon/damsel flies)												
Boyeria spp.	2					1						
Cordulegaster spp.	3											
Gomphidae	4											
Ophiogomphus spp.	1											
Gomphus spp.	5											
Hagenius spp.	3											
Argia spp.	6											
Progomphus spp.	5											
Lanthus spp.	5				6				2			
Stylogomphus spp.	4										1	
OLIGOCHAETA (worms)	10							1		7	1	
PLECOPTERA (stoneflies)												
Leuctra spp.	0	1										
Amphinemura spp.	3				1	2			1			
Pteronarcys spp.	0	4	1	1								
Perlidae	3											
Acroneuria spp.	0			1	2			2	6	3	2	6
Paragnetina spp.	1		1				1		1		3	5
Agnetina spp.	1		1	4								1
Sweltsa/Swoffordia spp.	0		5	1								
Paramemoura spp.	2											
Taeniopteryx spp.	2											
Diploperla spp.	2											
Chloroperla spp.	2											
Diura spp.	2	1			4							
Cultus spp.	2											
Taeniopteryx spp.	2											
Hansonoperla spp.	3					1						
Perlesta spp.	4											
Isoperla spp.	2	9	5		10	4		1	1	1		
TURBELLARIA (flatworms)												
TRICHOPTERA (caddisflies)												
Chimarra spp.	4					7	2		3			1
Brachycentrus spp.	1		1		1							
Dolophilodes spp.	0	11	1	2	1	6	2				1	
Hydropsyche spp.	5							6	2			
Ceumatopsyche spp.	6	1			3		2	15	25	13	26	5
Lype spp.	2							1				
Ceratopsyche spp.	5	18	3	3	1	23	5	8	5	4	21	6
Diplectrona spp.	0				19							
Glossosoma spp.	0								3			
Informalatella spp.	0											
Rhyacophila spp.	1	11	2		9	3	3	1	3	2	4	1
Neureclipsis spp.	7											
Parapsyche spp.	0											
Agapetus spp.	0	1			1							
Coracles spp.	3							1		1		
Lepidostoma spp.	1		1		1			2	1			
Micrasema spp.	3											
Neophylax spp.	3					1				2		
Psilotreta spp.	0											
Agotamis spp.	3											
Micrasema spp.	2				1							
Diplector spp.	6											
Limnephilidae	4											
Phylocentropus spp.	5											
Polycentropus spp.	6			1	2				1			
Pycnopsyche spp.	4				3							
Goera spp.										1		
TOTAL												
METRICS		**200**	**219**	**214**	**197**	**109**	**209**	**212**	**203**	**86**	**216**	**202**
Total Taxa Richness		23	24	21	31	14	14	25	24	20	26	20
Shannon Diversity Index		2.49	2.32	1.40	2.66	2.25	0.78	2.70	2.14	2.64	2.57	2.01
EPT Taxa Richness		13	14	13	19	8	8	13	11	12	10	10
Hilsenhoff Biotic Index		2.75	2.99	4.82	2.17	3.27	2.17	3.24	3.00	3.74	3.07	2.22
Percent Intolerant Individuals		60.5	58.0	22.0	76.1	48.6	91.9	53.8	54.7	57.0	49.1	70.8
Modified Beck's Index		30	33	24	34	14	15	18	18	14	16	11
IBI SMALL STREAM		**77.5**	**78.2**	**55.7**	**93.8**	**56.8**	**58.0**	**72.2**	**67.3**	**66.3**	**67.8**	**65.4**
IBI LARGE STREAM		**88.9**	**88.8**	**67.6**	**98.8**			**86.0**	**80.8**	**78.5**	**80.4**	**74.5**

*Note: Sample 11, 12, 13 are replicate sites with an overflow container resulting in 37 sites being represented on the spreadsheet however, only 36 sites were sampled and analyzed.

Appendix C

Habitat Assessment

Both the quality and quantity of available habitat affects the macroinvertebrate community. A healthy biological community not only requires good water quality, but also a supportive habitat. There are two types of rating systems for 2019. One is for a Riffle/Run prevalent stream, like most of the streams in Monroe County, which incorporates three categories for a total of 12 parameters. Habitat assessment data can be interpreted by summing the twelve habitat parameter scores for an overall assessment value; 161-200: optimal, 101-160: suboptimal, 51-100: marginal, <51: poor.

The second is the multi-habitat, low-gradient stream for the low gradient streams that utilizes 9 parameters. Total habitat site scores can range from 0-180, with 180 being a perfect score. These assessment values are used when assessing a site's attainable biological condition based on a local reference station. Below is an explanation of the habitat parameters:

Habitat Parameter Descriptions *Riffle/Run Streams*

1. **Instream Cover:**
   This is a measure of quantity and variety of natural structures in the stream that will provide a habitat for fish (e.g., fallen trees, branches, logs, undercut banks, and large rocks)

2. **Substrate for Benthic Macroinvertebrates:**
   This measures the amount of hard substrate available for insects and snail habitat. Many insect larvae attach themselves to submerged substrate. Areas with rocky bottoms are critical for maintaining a healthy variety of insects.

3. **Embeddedness:**
   This refers to the degree to which rocks are covered or sunken into the silt, sand or mud. As substrates become embedded in the stream bottom, the amount of adequate surface space for insects to attach themselves decreases and the quantity and quality of the macroinvertebrate community is predicted to decrease.

4. **Velocity/Depth Regime:**
   There are four basic velocity/depth combinations:
   Shallow/fast, shallow/slow, deep/fast, and deep/slow

5. **Channel Alteration:**
   This parameter is a measure of changes to the shape of the stream channel. When streams have been altered in any way (i.e., straightened, deepened, diverted, concrete channelized, artificial embankments or stabilization, dams or bridges), it can affect the macroinvertebrate community.

6. **Sediment Deposition:**
This parameter measures the sediment, which has accumulated on the stream bottom as a result of deposition. Deposition occurs as a result of large-scale movement of sediment caused by watershed erosion. This deposition may cause the formation of islands or point bars in the stream, which decreases the available habitat for macroinvertebrates.

7. **Frequency of Riffles:**
This parameter assumes that a stream with riffles or bends provides more diverse habitat than any straight or uniform depth stream. The ratio is calculated by dividing the average distance between riffles or bends by the average depth. The smaller ratio is an indicator of good habitat.

8. **Channel Flow Status:**
This is a measure of the degree to which the channel is filled with water. When the water reaches the base of both banks and a minimal amount of channel substrate is exposed, optimal conditions exist.

9. **Condition of Banks:**
This parameter addresses stream bank erosion (or potential for erosion). Steep banks are generally more susceptible to erosion and failure. Signs of erosion include crumbling banks, unvegetated banks, and exposed tree roots and soil.

10. **Bank Vegetative Protection:**
This measures the amount of stream bank covered by vegetation. Plant root systems on stream banks facilitate soil stability which reduces erosion. This parameter also provides information such as stream shading and nutrient uptake. Banks that support natural plant growth indicate a healthier habitat for macroinvertebrates and fish.

11. **Grazing Disruptive Pressure:**
This parameter measures the impact to the riparian zone due to livestock grazing or human activities such as urbanization, golf courses, and residential developments.

12. **Riparian Zone Width:**
This is a measure of the width of the natural vegetation from the edge of the stream bank. This zone serves as a buffer to pollutants entering the stream from surface runoff.

Habitat Parameter Descriptions Multihabitat Low-Gradient Streams

1. **Epifaunal Substrate for Macroinvertebrate:**
   The substrate in muddy bottom streams consists mostly of submerged logs, snags and aquatic vegetation.

2. **Pool Substrate Characterization:**
   This is an evaluation of the type and condition of bottom substrates found in pools. Firm sediment types such as gravel and sand as well as rooted aquatic plants support a wider variety of organisms. A pool substrate dominated by mud or bedrock will not support a diverse community.

3. **Pool Variability:**
   This parameter rates the overall mixture of pool types found in the streams. The four basic types of pools are: Large-shallow, small-deep, small-shallow, large-deep. General guidelines include: greater than one half the cross-section to separate large from small and one meter separating shallow and deep.

4. **Sediment Deposition:**
   This parameter measures the sediment, which has accumulated on the bottom as a result of deposition.

5. **Channel Flow Status:**
   This is a determination of the percent of the channel that is filled with water. The flow status changes as the channel enlarges or as flow is decreased as a result of dams or obstructions, diversions for irrigation, or drought. When water does not cover as much of the streambed the available habitat is decreased.

6. **Channel Alteration:**
   This parameter is a measure of changes to the shape of the stream channel. Streams that run through agricultural or urban areas may have been altered many times. When streams have been changed in any way (i.e., straightened, deepened, diverted, concrete channelized, artificial embankments or stabilization, dams or bridges) it can affect the macroinvertebrate community. Streams that have been altered have fewer natural habitats for fish, macroinvertebrates and plants.

7. **Bank Stability:**
   This parameter addresses stream bank erosion or potential for erosion. Steep banks are generally more susceptible to erosion and failure. Signs of erosion include crumbling and unvegetated banks and exposed tree roots and soil.

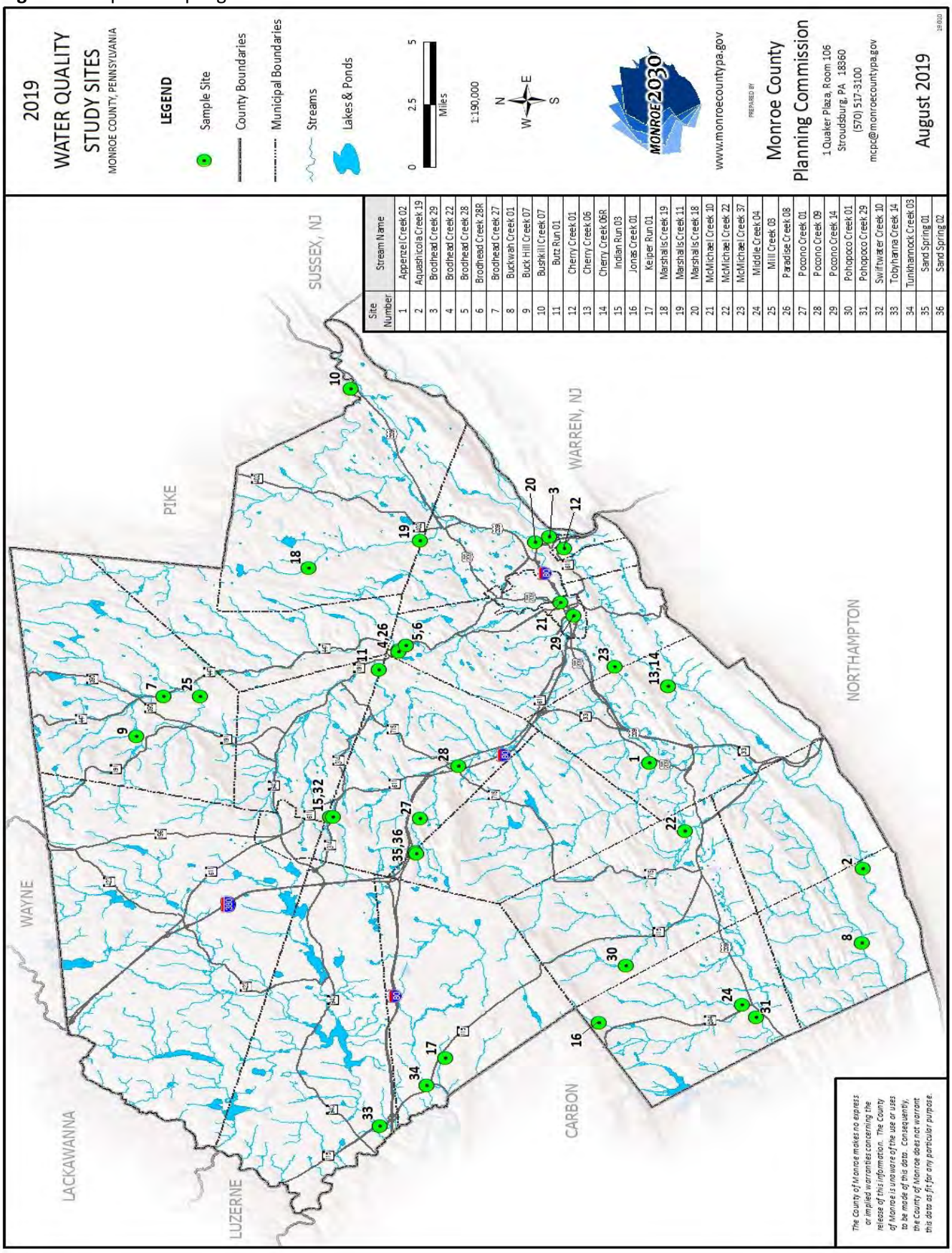
8. **Vegetative Protection:**
   This measures the amount of stream bank, which is covered by vegetation. Plant root systems on stream banks facilitate soil stability, which reduces the stream bank erosion.

Banks that support full natural plant growth indicate a healthier habitat for macroinvertebrates and fish.

9. **Riparian Vegetative Zone Width:**
Refer to riffle/run definition.

Site Map

Figure 2. Map of Sampling Sites



Site Number	Stream Name
1	Appenzel Creek 02
2	Aquashicola Creek 19
3	Brodhead Creek 29
4	Brodhead Creek 22
5	Brodhead Creek 28
6	Brodhead Creek 28R
7	Brodhead Creek 27
8	Buckwah Creek 01
9	Buck Hill Creek 07
10	Bushkill Creek 07
11	Butz Run 01
12	Cherry Creek 01
13	Cherry Creek 06
14	Cherry Creek 06R
15	Indian Run 03
16	Jonas Creek 01
17	Keiper Run 01
18	Marshalls Creek 19
19	Marshalls Creek 11
20	Marshalls Creek 18
21	McMichael Creek 10
22	McMichael Creek 22
23	McMichael Creek 37
24	Middle Creek 04
25	Mill Creek 03
26	Paradise Creek 08
27	Pocono Creek 01
28	Pocono Creek 09
29	Pocono Creek 14
30	Pohopoco Creek 01
31	Pohopoco Creek 29
32	Swiftwater Creek 10
33	Tobyhanna Creek 14
34	Tunkhannock Creek 03
35	Sand Spring 01
36	Sand Spring 02

Site Chart

Table 4. Sampling Site Chart

Site #	Site ID	Stream Name	Location
1	APPECR02	Appenzel Creek	Near residential housing, 160m west of the Foundry St. bridge.
2	AQUACR19	Aquashicola Creek	315 meters east from intersection of Upper Smith Gap Rd and Camp Hill Rd
3	BRODCR29	Brodhead Creek	River's Edge Family Bike Park off of Logging Rd 45061, 245 meters south of LR45061 bridge.
4	BRODCR22	Brodhead Creek	Sugar Cane Ln. access off of Rt. 191 Bridge upstream of confluence of PARACR08.
5	BRODCR28	Brodhead Creek	ForEvergreen Nature Preserve, 600 meters north of parking area.
6	BRODCR28R	Brodhead Creek	ForEvergreen Nature Preserve, 600 meters north of parking area.
7	BRODCR27	Brodhead Creek	170 meters northeast of Pasold Farm Dr. parking area.
8	BUCKCR01	Buckwah Creek	200 meters east of Chestnut Ridge Rd bridge
9	BUHICR07	Buck Hill Creek	165 meters upstream of Buck Hill Golf Club off of Cresco Rd.
10	BUSHCR07	Bushkill Creek	340 meters north of Route 209 through ROW.
11	BUTZRN01	Butz Run	1.14 miles down Sylvan Cascades Rd from intersection of Rt. 191
12	CHERCR01	Cherry Creek	Located near Edge of the Woods Outfitters 100m from the intersection of 611 and Broad St.
13	CHERCR06	Cherry Creek	25 meters south of bridge on Kemmertown Rd.
14	CHERCR06R	Cherry Creek	25 meters south of bridge on Kemmertown Rd.
15	INDIRN03	Indian Run	150 meters north of Manor Dr. Bridge upstrem of confluence with Swiftwater Creek.
16	JONACR01	Jonas Creek	150m north of the Laurel Ln cul-de-sac
17	KEIPRN01	Keiper Run	520m east by northeast of the Schochs Mill Rd cul-de-sac.
18	MARSCR19	Marshalls Creek	40 meters north of one land bridge on Tallyrand Dr.
19	MARSCR11	Marshalls Creek	385 meters north of intersection of Marshalls Creek Rd. and Golfcart Rd.
20	MARSCR18	Marshalls Creek	Next to Minisink Hotel parking lot off of Post Office Rd.
21	MCMICR10	McMichael Creek	360 meters downstream of Broad Street bridge.
22	MCMICR22	McMichael Creek	115m south of intersection of Mcilhaney Rd. and Kennel Rd.
23	MCMICR37	McMichael Creek	Hickory Valley State Park 60m southeast from parking area.
24	MIDDCR04	Middle Creek	Downstream of observation deck on Cliff Woodring Trail.
25	MILLCR03	Mill Creek	560m west of instersection of Sand Spring Rd. and Mill Creek Rd.
26	PARACR08	Paradise Creek	Sugar Cane Ln. access off of Rt. 191 Bridge upstream of confluence of Brodhead Creek.
27	POCOCR01	Pocono Creek	300m south on Camelback Rd from intersection of Camelback Rd. and Wilke Rd.
28	POCOCR09	Pocono Creek	65m north of Old Mill Rd. bridge.
29	POCOCR14	Pocono Creek	70m south from Ensleys Dojo off S. 10th St and Ann St.
30	POHOCR01	Pohopoco Creek	330m southeast from intersection of Merwinsburg Rd. and Burger Hollow Rd.
31	POHOCR29	Pohopoco Creek	700 meters west on Whitey B Ln. from intersection of Whitey B Ln. and Rt. 209.
32	SWIFCR10	Swiftwater Creek	25m north of Manor Dr. bridge.
33	TOBYCR14	Tobyhanna Creek	50m east of Rt. 115 bridge near Austin T. Blakeslee Natural Area.
34	TUNKCR03	Tunkhannock Creek	160m north of Tunhannok Fishing Association Parking area.
35	SASPR01	Sand Spring	600m west of Wilke Rd. dead end.
36	SASPR02	Sand Spring	700m west of Wilke Rd. dead end.

Water Chemistry and Data Pages

APPECR02

Location	Near residential housing, 160m west of the Foundry St. bridge.		
Site #	2019-1	Date	4/17/2019
Stream Name	Appenzel Creek	Time	1:15:00 PM
Township	Hamilton	Latitude	40.946838
Habitat Asmt.	182	Longitude	-75.310513

Field Measurements	
Temp C	11.7
pH	7.75
Press inHg	
DO Percent	106.87
DO mg/L	11.59
Cond (uS/cm)	112

Macroinvertebrate Metrics	
Total Taxa	28
Shannon Diversity Index	2.77
EPT Taxa Richness	19
Hilsenhoff Biotic Index	2.45
Intolerant individuals (%)	74.7
Modified Becks Index	36
Index of Biotic Integrity	**92.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.36
Aluminum mg/L	<0.200
Calcium mg/L	7.03
Iron mg/L	0.147
Magnesium mg/L	2.14
Hardness CaCO3	26.4
Chloride mg/L	19.1
pH	6.79
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.527
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	0.03
Biochemical Oxygen Demand mg/L	<3.00

AQUACR19

Location	315 meters east from intersection of Upper Smith Gap Rd and Camp Hill Rd		
Site #	2019-2	Date	4/16/2019
Stream Name	Aquashicola Creek	Time	9:24:00 AM
Township	Eldred	Latitude	40.845611
Habitat Asmt.	139	Longitude	-75.394982

Field Measurements	
Temp C	8.5
pH	7.55
Press inHg	
DO Percent	94.3
DO mg/L	11.04
Cond (uS/cm)	128

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	1.85
EPT Taxa Richness	14
Hilsenhoff Biotic Index	2.35
Intolerant individuals (%)	69
Modified Becks Index	21
Index of Biotic Integrity	**74.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.32
Aluminum mg/L	<0.200
Calcium mg/L	14.6
Iron mg/L	0.232
Magnesium mg/L	3.48
Hardness CaCO3	50.8
Chloride mg/L	10.1
pH	6.98
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.412
Alkalinity to pH 4.5 mg CaCO3/L	40.2
Total Dissolved Solids mg/L	66
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

BRODCR29

Location	River's Edge Family Bike Park off of Logging Rd 45061, 245 meters south of LR45061 bridge.		
Site #	2019-3	Date	4/25/2019
Stream Name	Brodhead Creek	Time	12:21:00 PM
Township	Smithfield	Latitude	40.991514
Habitat Asmt.	161	Longitude	-75.136366

Field Measurements	
Temp C	12.83
pH	7.69
Press inHg	
DO Percent	103.6
DO mg/L	10.95
Cond (uS/cm)	162

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.7
EPT Taxa Richness	13
Hilsenhoff Biotic Index	3.24
Intolerant individuals (%)	53.8
Modified Becks Index	18
Index of Biotic Integrity	**86**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.72
Aluminum mg/L	<0.160
Calcium mg/L	13.1
Iron mg/L	0.112
Magnesium mg/L	2.08
Hardness CaCO3	41.3
Chloride mg/L	25.6
pH	7.3
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.368
Alkalinity to pH 4.5 mg CaCO3/L	26
Total Dissolved Solids mg/L	110
Phosphorus as P mg/L	0.024
Biochemical Oxygen Demand mg/L	<3.00

BRODCR22

Location	Sugar Cane Ln. access off of Rt. 191 Bridge upstream of confluence of PARACR08.		
Site #	2019-4	Date	4/23/2019
Stream Name	Brodhead Creek	Time	11:35:00 AM
Township	Stroud	Latitude	41.066523
Habitat Asmt.	189	Longitude	-75.220216

Field Measurements	
Temp C	11.5
pH	7.05
Press inHg	
DO Percent	99.66
DO mg/L	10.86
Cond (uS/cm)	60

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.67
EPT Taxa Richness	11
Hilsenhoff Biotic Index	2.86
Intolerant individuals (%)	60.1
Modified Becks Index	21
Index of Biotic Integrity	**87.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.73
Aluminum mg/L	<0.160
Calcium mg/L	4.13
Iron mg/L	0.081
Magnesium mg/L	1.02
Hardness CaCO3	14.5
Chloride mg/L	8.8
pH	6.9
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.154
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	54
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

BRODCR28

Location	ForEvergreen Nature Preserve, 600 meters north of parking area.		
Site #	2019-5	Date	4/23/2019
Stream Name	Brodhead Creek	Time	12:27:00 PM
Township	Stroud	Latitude	41.062718
Habitat Asmt.	169	Longitude	-75.216682

Field Measurements	
Temp C	12.4
pH	7.26
Press inHg	
DO Percent	101.2
DO mg/L	10.8
Cond (uS/cm)	102

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.31
EPT Taxa Richness	11
Hilsenhoff Biotic Index	3.07
Intolerant individuals (%)	40.4
Modified Becks Index	23
Index of Biotic Integrity	**81.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.77
Aluminum mg/L	<0.160
Calcium mg/L	6.56
Iron mg/L	<0.08
Magnesium mg/L	1.65
Hardness CaCO3	23.2
Chloride mg/L	24.2
pH	7.1
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.295
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	64
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

BRODCR28R

Location	ForEvergreen Nature Preserve, 600 meters north of parking area.		
Site #	2019-6	Date	4/23/2019
Stream Name	Brodhead Creek	Time	12:27:00 PM
Township	Stroud	Latitude	41.062718
Habitat Asmt.	169	Longitude	-75.216682

Field Measurements	
Temp C	12.4
pH	7.26
Press inHg	
DO Percent	101.2
DO mg/L	10.8
Cond (uS/cm)	102

Macroinvertebrate Metrics	
Total Taxa	22
Shannon Diversity Index	2.6
EPT Taxa Richness	14
Hilsenhoff Biotic Index	3.29
Intolerant individuals (%)	54.6
Modified Becks Index	20
Index of Biotic Integrity	**86.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.52
Aluminum mg/L	<0.160
Calcium mg/L	6.31
Iron mg/L	<0.08
Magnesium mg/L	1.58
Hardness CaCO3	22.3
Chloride mg/L	22.7
pH	7.1
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.28
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	76
Phosphorus as P mg/L	0.029
Biochemical Oxygen Demand mg/L	<3.00

BRODCR27

Location	170 meters northeast of Pasold Farm Dr. parking area.		
Site #	2019-7	Date	4/18/2019
Stream Name	Brodhead Creek	Time	9:10:00 AM
Township	Barrett	Latitude	41.180941
Habitat Asmt.	197	Longitude	-75.25091

Field Measurements	
Temp C	9.26
pH	6.95
Press inHg	
DO Percent	98.47
DO mg/L	11.32
Cond (uS/cm)	61

Macroinvertebrate Metrics	
Total Taxa	18
Shannon Diversity Index	1.23
EPT Taxa Richness	9
Hilsenhoff Biotic Index	4.9
Intolerant individuals (%)	22.7
Modified Becks Index	20
Index of Biotic Integrity	**59.3**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.75
Aluminum mg/L	<0.200
Calcium mg/L	3.92
Iron mg/L	<0.1
Magnesium mg/L	1.09
Hardness CaCO3	14.3
Chloride mg/L	9.74
pH	6.93
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.192
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	24
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

BUCKCR01

Location	200 meters east of Chestnut Ridge Rd bridge		
Site #	2019-8	Date	4/16/2019
Stream Name	Buckwah Creek	Time	10:42:00 AM
Township	Eldred	Latitude	40.847275
Habitat Asmt.	169	Longitude	-75.451532

Field Measurements	
Temp C	7.8
pH	7.3
Press inHg	
DO Percent	99.7
DO mg/L	11.87
Cond (uS/cm)	95

Macroinvertebrate Metrics	
Total Taxa	27
Shannon Diversity Index	2.39
EPT Taxa Richness	13
Hilsenhoff Biotic Index	2.66
Intolerant individuals (%)	69.3
Modified Becks Index	19
Index of Biotic Integrity	**76.1**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.45
Aluminum mg/L	<0.200
Calcium mg/L	7.92
Iron mg/L	0.136
Magnesium mg/L	2.49
Hardness CaCO3	30
Chloride mg/L	10.7
pH	7.06
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	1.57
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	54
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

BUHICR07

Location	165 meters upstream of Buck Hill Golf Club off of Cresco Rd.		
Site #	2019-9	Date	4/18/2019
Stream Name	Buck Hill Creek	Time	8:20:00 AM
Township	Barrett	Latitude	41.194403
Habitat Asmt.	218	Longitude	-75.281357

Field Measurements	
Temp C	7.4
pH	6.7
Press inHg	
DO Percent	97.63
DO mg/L	11.73
Cond (uS/cm)	39

Macroinvertebrate Metrics	
Total Taxa	20
Shannon Diversity Index	2.442
EPT Taxa Richness	11
Hilsenhoff Biotic Index	0.01
Intolerant individuals (%)	71.5
Modified Becks Index	31
Index of Biotic Integrity	**78.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	19.4
Aluminum mg/L	<0.200
Calcium mg/L	2.59
Iron mg/L	<0.1
Magnesium mg/L	0.729
Hardness CaCO3	9.46
Chloride mg/L	5.4
pH	6.93
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.165
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	6.4

BUSHCR07

Location	340 meters north of Route 209 through ROW.		
Site #	2019-10	Date	4/18/2019
Stream Name	Bushkill Creek	Time	12:15:00 PM
Township	Middle Smithfield	Latitude	41.084861
Habitat Asmt.	196	Longitude	-75.019417

Field Measurements	
Temp C	11.2
pH	7.14
Press inHg	
DO Percent	102.2
DO mg/L	11.22
Cond (uS/cm)	58

Macroinvertebrate Metrics	
Total Taxa	22
Shannon Diversity Index	2.49
EPT Taxa Richness	14
Hilsenhoff Biotic Index	2.83
Intolerant individuals (%)	62.1
Modified Becks Index	25
Index of Biotic Integrity	**89.8**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	4
Aluminum mg/L	<0.200
Calcium mg/L	4.97
Iron mg/L	0.141
Magnesium mg/L	1.2
Hardness CaCO3	17.3
Chloride mg/L	8.6
pH	6.66
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.157
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	28
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

BUTZRN01

Location	1.14 miles down Sylvan Cascades Rd from intersection of Rt. 191		
Site #	2019-11	Date	4/23/2019
Stream Name	Butz Run	Time	9:50:00 AM
Township	Paradise	Latitude	41.076071
Habitat Asmt.	206	Longitude	-75.235002

Field Measurements	
Temp C	11.6
pH	7.48
Press inHg	
DO Percent	97.6
DO mg/L	10.62
Cond (uS/cm)	96

Macroinvertebrate Metrics	
Total Taxa	26
Shannon Diversity Index	2.81
EPT Taxa Richness	13
Hilsenhoff Biotic Index	2.55
Intolerant individuals (%)	64.8
Modified Becks Index	31
Index of Biotic Integrity	**82.8**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.79
Aluminum mg/L	<0.160
Calcium mg/L	7.7
Iron mg/L	0.154
Magnesium mg/L	1.41
Hardness CaCO3	25
Chloride mg/L	13.3
pH	7.2
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.309
Alkalinity to pH 4.5 mg CaCO3/L	20.2
Total Dissolved Solids mg/L	58
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

CHERCR01

Location	Located near Edge of the Woods Outfitters 100m from the intersection of 611 and Broad St.		
Site #	2019-12	Date	4/16/2019
Stream Name	Cherry Creek	Time	12:59:00 PM
Township	Delaware Water Gap	Latitude	40.984712
Habitat Asmt.	161	Longitude	-75.145848

Field Measurements	
Temp C	10.4
pH	7.87
Press inHg	
DO Percent	100.23
DO mg/L	11.19
Cond (uS/cm)	183

Macroinvertebrate Metrics	
Total Taxa	19
Shannon Diversity Index	1.74
EPT Taxa Richness	9
Hilsenhoff Biotic Index	1.87
Intolerant individuals (%)	79.7
Modified Becks Index	15
Index of Biotic Integrity	66.6

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.82
Aluminum mg/L	<0.200
Calcium mg/L	24
Iron mg/L	0.255
Magnesium mg/L	4.77
Hardness CaCO3	79.6
Chloride mg/L	10
pH	7.44
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.265
Alkalinity to pH 4.5 mg CaCO3/L	59.8
Total Dissolved Solids mg/L	128
Phosphorus as P mg/L	0.022
Biochemical Oxygen Demand mg/L	<3.00

CHERCR06

Location	25 meters south of bridge on Kemmertown Rd.		
Site #	2019-13	Date	4/16/2019
Stream Name	Cherry Creek	Time	11:37:00 AM
Township	Hamilton	Latitude	40.93657
Habitat Asmt.	135	Longitude	-75.252769

Field Measurements	
Temp C	10.3
pH	7.86
Press inHg	
DO Percent	103.2
DO mg/L	11.57
Cond (uS/cm)	143

Macroinvertebrate Metrics	
Total Taxa	27
Shannon Diversity Index	3.87
EPT Taxa Richness	13
Hilsenhoff Biotic Index	2.38
Intolerant individuals (%)	44.6
Modified Becks Index	16
Index of Biotic Integrity	**73.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.13
Aluminum mg/L	<0.200
Calcium mg/L	19.5
Iron mg/L	0.176
Magnesium mg/L	4.01
Hardness CaCO3	65.2
Chloride mg/L	5.85
pH	7.48
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.235
Alkalinity to pH 4.5 mg CaCO3/L	50.8
Total Dissolved Solids mg/L	46
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

CHERCR06R

Location	25 meters south of bridge on Kemmertown Rd.		
Site #	2019-14	Date	4/16/2019
Stream Name	Cherry Creek	Time	11:37:00 AM
Township	Hamilton	Latitude	40.93657
Habitat Asmt.	135	Longitude	-75.252769

Field Measurements	
Temp C	10.3
pH	7.86
Press inHg	
DO Percent	103.2
DO mg/L	11.57
Cond (uS/cm)	143

Macroinvertebrate Metrics	
Total Taxa	30
Shannon Diversity Index	2.46
EPT Taxa Richness	13
Hilsenhoff Biotic Index	3.42
Intolerant individuals (%)	54.3
Modified Becks Index	15
Index of Biotic Integrity	**72**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.98
Aluminum mg/L	<0.200
Calcium mg/L	19.4
Iron mg/L	0.17
Magnesium mg/L	4.01
Hardness CaCO3	65
Chloride mg/L	5.83
pH	7.55
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.229
Alkalinity to pH 4.5 mg CaCO3/L	51
Total Dissolved Solids mg/L	104
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

INDIRN03

Location	150 meters north of Manor Dr. Bridge upstrem of confluence with Swiftwater Creek.		
Site #	2019-15	Date	4/23/2019
Stream Name	Indian Run	Time	8:45:00 AM
Township	Pocono	Latitude	41.10221
Habitat Asmt.	194	Longitude	-75.346358

Field Measurements	
Temp C	8.9
pH	7.17
Press inHg	
DO Percent	95.4
DO mg/L	11.03
Cond (uS/cm)	181

Macroinvertebrate Metrics	
Total Taxa	20
Shannon Diversity Index	2.15
EPT Taxa Richness	11
Hilsenhoff Biotic Index	2.87
Intolerant individuals (%)	56.9
Modified Becks Index	25
Index of Biotic Integrity	**69.1**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.45
Aluminum mg/L	<0.160
Calcium mg/L	8.5
Iron mg/L	<0.08
Magnesium mg/L	2.41
Hardness CaCO3	31.2
Chloride mg/L	40.6
pH	6.9
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.499
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	110
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

JONACR01

Location	150m north of the Laurel Ln cul-de-sac		
Site #	2019-16	Date	4/15/2019
Stream Name	Jonas Creek	Time	11:20:00 AM
Township	Polk	Latitude	40.97567
Habitat Asmt.	220	Longitude	-75.507843

Field Measurements	
Temp C	9.6
pH	6.66
Press inHg	
DO Percent	94.2
DO mg/L	10.72
Cond (uS/cm)	79

Macroinvertebrate Metrics	
Total Taxa	26
Shannon Diversity Index	2.76
EPT Taxa Richness	15
Hilsenhoff Biotic Index	1.73
Intolerant individuals (%)	81.16
Modified Becks Index	33
Index of Biotic Integrity	**89.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.2
Aluminum mg/L	<0.200
Calcium mg/L	2.87
Iron mg/L	<0.1
Magnesium mg/L	1.19
Hardness CaCO3	12.1
Chloride mg/L	16.8
pH	6.53
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.551
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	52
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

KEIPRN01

Location	520m east by northeast of the Schochs Mill Rd cul-de-sac.		
Site #	2019-17	Date	4/15/2019
Stream Name	Keiper Run	Time	9:42:00 AM
Township	Tunkhannock	Latitude	41.050417
Habitat Asmt.	191	Longitude	-75.532417

Field Measurements	
Temp C	10.03
pH	6.75
Press inHg	
DO Percent	86.3
DO mg/L	9.66
Cond (uS/cm)	178

Macroinvertebrate Metrics	
Total Taxa	10
Shannon Diversity Index	2.17
EPT Taxa Richness	7
Hilsenhoff Biotic Index	2.56
Intolerant individuals (%)	75
Modified Becks Index	16
Index of Biotic Integrity	60.9

Lab Chemistry Analysis	
Total Organic Carbon mg/L	6.85
Aluminum mg/L	0.65
Calcium mg/L	5.3
Iron mg/L	0.597
Magnesium mg/L	0.711
Hardness CaCO3	16.2
Chloride mg/L	43.7
pH	7.02
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.0694
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	104
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MARSCR19

Location	40 meters north of one land bridge on Tallyrand Dr.		
Site #	2019-18	Date	4/18/2019
Stream Name	Marshalls Creek	Time	10:43:00 AM
Township	Middle Smithfield	Latitude	41.108419
Habitat Asmt.	210	Longitude	-75.155693

Field Measurements	
Temp C	9.5
pH	6.93
Press inHg	
DO Percent	92.6
DO mg/L	10.59
Cond (uS/cm)	48

Macroinvertebrate Metrics	
Total Taxa	13
Shannon Diversity Index	1.29
EPT Taxa Richness	10
Hilsenhoff Biotic Index	1.47
Intolerant individuals (%)	86.9
Modified Becks Index	23
Index of Biotic Integrity	**66.3**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.72
Aluminum mg/L	<0.200
Calcium mg/L	4.46
Iron mg/L	0.128
Magnesium mg/L	0.945
Hardness CaCO3	15
Chloride mg/L	4.44
pH	6.71
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.0705
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MARSCR11

Location	385 meters north of intersection of Marshalls Creek Rd. and Golfcart Rd.		
Site #	2019-19	Date	4/18/2019
Stream Name	Marshalls Creek	Time	11:20:00 AM
Township	Middle Smithfield	Latitude	41.054246
Habitat Asmt.	207	Longitude	-75.13672

Field Measurements	
Temp C	9.7
pH	7.18
Press inHg	
DO Percent	100.1
DO mg/L	11.37
Cond (uS/cm)	86

Macroinvertebrate Metrics	
Total Taxa	29
Shannon Diversity Index	2.62
EPT Taxa Richness	14
Hilsenhoff Biotic Index	3.21
Intolerant individuals (%)	57.2
Modified Becks Index	28
Index of Biotic Integrity	**79.7**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.51
Aluminum mg/L	<0.200
Calcium mg/L	6.86
Iron mg/L	<0.1
Magnesium mg/L	1.59
Hardness CaCO3	23.7
Chloride mg/L	11.2
pH	6.83
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.267
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	38
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MARSCR18

Location	Next to Minisink Hotel parking lot off of Post Office Rd.		
Site #	2019-20	Date	4/25/2019
Stream Name	Marshalls Creek	Time	11:00:00 AM
Township	Smithfield	Latitude	40.998555
Habitat Asmt.	173	Longitude	-75.139952

Field Measurements	
Temp C	13.3
pH	7.73
Press inHg	
DO Percent	101.4
DO mg/L	10.61
Cond (uS/cm)	164

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.14
EPT Taxa Richness	11
Hilsenhoff Biotic Index	3
Intolerant individuals (%)	54.7
Modified Becks Index	18
Index of Biotic Integrity	**80.8**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.38
Aluminum mg/L	<0.160
Calcium mg/L	16.5
Iron mg/L	0.201
Magnesium mg/L	2.1
Hardness CaCO3	49.9
Chloride mg/L	19.9
pH	7.4
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.229
Alkalinity to pH 4.5 mg CaCO3/L	32.4
Total Dissolved Solids mg/L	118
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MCMICR10

Location	360 meters downstream of Broad Street bridge.		
Site #	2019-21	Date	4/25/2019
Stream Name	McMichael Creek	Time	10:05:00 AM
Township	Stroudsburg	Latitude	40.98724
Habitat Asmt.	139	Longitude	-75.186808

Field Measurements	
Temp C	12.2
pH	7.57
Press inHg	
DO Percent	101.15
DO mg/L	10.45
Cond (uS/cm)	175

Macroinvertebrate Metrics	
Total Taxa	26
Shannon Diversity Index	2.57
EPT Taxa Richness	10
Hilsenhoff Biotic Index	3.07
Intolerant individuals (%)	49.1
Modified Becks Index	16
Index of Biotic Integrity	**80.4**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.19
Aluminum mg/L	<0.160
Calcium mg/L	12.7
Iron mg/L	0.147
Magnesium mg/L	2.24
Hardness CaCO3	40.9
Chloride mg/L	28.9
pH	7.4
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.426
Alkalinity to pH 4.5 mg CaCO3/L	26.1
Total Dissolved Solids mg/L	80
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MCMICR22

Location	115m south of intersection of Mcilhaney Rd. and Kennel Rd.		
Site #	2019-22	Date	4/17/2019
Stream Name	McMichael Creek	Time	12:31:00 PM
Township	Chestnuthill	Latitude	40.930902
Habitat Asmt.	204	Longitude	-75.363567

Field Measurements	
Temp C	10.2
pH	7.19
Press inHg	
DO Percent	104.83
DO mg/L	11.77
Cond (uS/cm)	71

Macroinvertebrate Metrics	
Total Taxa	26
Shannon Diversity Index	2.8
EPT Taxa Richness	16
Hilsenhoff Biotic Index	2.67
Intolerant individuals (%)	72.5
Modified Becks Index	0.29
Index of Biotic Integrity	**85.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.6
Aluminum mg/L	<0.200
Calcium mg/L	4.76
Iron mg/L	0.116
Magnesium mg/L	1.67
Hardness CaCO3	18.8
Chloride mg/L	11.2
pH	6.48
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.406
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MCMICR37

Location	Hickory Valley State Park 60m southeast from parking area.		
Site #	2019-23	Date	4/25/2019
Stream Name	McMichael Creek	Time	8:15:00 AM
Township	Stroud	Latitude	40.962041
Habitat Asmt.	179	Longitude	-75.236508

Field Measurements	
Temp C	11.46
pH	7.24
Press inHg	
DO Percent	94.93
DO mg/L	10.36
Cond (uS/cm)	134

Macroinvertebrate Metrics	
Total Taxa	20
Shannon Diversity Index	2.64
EPT Taxa Richness	12
Hilsenhoff Biotic Index	3.74
Intolerant individuals (%)	57
Modified Becks Index	14
Index of Biotic Integrity	**78.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.38
Aluminum mg/L	<0.160
Calcium mg/L	12
Iron mg/L	0.198
Magnesium mg/L	2.17
Hardness CaCO3	38.9
Chloride mg/L	16.7
pH	7.1
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.511
Alkalinity to pH 4.5 mg CaCO3/L	23.8
Total Dissolved Solids mg/L	62
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MIDDCR04

Location	Downstream of observation deck on Cliff Woodring Trail.		
Site #	2019-24	Date	4/15/2019
Stream Name	Middle Creek	Time	12:10:00 PM
Township	Polk	Latitude	40.905822
Habitat Asmt.	185	Longitude	-75.496614

Field Measurements	
Temp C	11.2
pH	7.25
Press inHg	
DO Percent	96.1
DO mg/L	10.55
Cond (uS/cm)	71

Macroinvertebrate Metrics	
Total Taxa	27
Shannon Diversity Index	2.43
EPT Taxa Richness	18
Hilsenhoff Biotic Index	2.29
Intolerant individuals (%)	75.6
Modified Becks Index	28
Index of Biotic Integrity	**86.6**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.22
Aluminum mg/L	0.239
Calcium mg/L	4.4
Iron mg/L	0.293
Magnesium mg/L	1.7
Hardness CaCO3	18
Chloride mg/L	10.6
pH	6.98
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.939
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	72
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

MILLCR03

Location	560m west of instersection of Sand Spring Rd. and Mill Creek Rd.		
Site #	2019-25	Date	4/18/2019
Stream Name	Mill Creek	Time	7:35:00 AM
Township	Barrett	Latitude	41.163201
Habitat Asmt.	212	Longitude	-75.251528

Field Measurements	
Temp C	8.1
pH	7.12
Press inHg	
DO Percent	98.7
DO mg/L	11.65
Cond (uS/cm)	78

Macroinvertebrate Metrics	
Total Taxa	26
Shannon Diversity Index	2.57
EPT Taxa Richness	15
Hilsenhoff Biotic Index	2
Intolerant individuals (%)	76.4
Modified Becks Index	38
Index of Biotic Integrity	**89.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.91
Aluminum mg/L	<0.200
Calcium mg/L	4.44
Iron mg/L	<0.1
Magnesium mg/L	1.23
Hardness CaCO3	16.1
Chloride mg/L	13.4
pH	7.31
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.167
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	36
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

PARACR08

Location	Sugar Cane Ln. access off of Rt. 191 Bridge upstream of confluence of Brodhead Creek.		
Site #	2019-26	Date	4/23/2019
Stream Name	Paradise Creek	Time	10:50:00 AM
Township	Stroud	Latitude	41.066498
Habitat Asmt.	162	Longitude	-75.221395

Field Measurements	
Temp C	11.2
pH	7.46
Press inHg	
DO Percent	100.6
DO mg/L	11.03
Cond (uS/cm)	147

Macroinvertebrate Metrics	
Total Taxa	25
Shannon Diversity Index	2.52
EPT Taxa Richness	14
Hilsenhoff Biotic Index	3.53
Intolerant individuals (%)	43.9
Modified Becks Index	29
Index of Biotic Integrity	**85.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.38
Aluminum mg/L	<0.160
Calcium mg/L	7.77
Iron mg/L	<0.08
Magnesium mg/L	1.89
Hardness CaCO3	27.2
Chloride mg/L	30.7
pH	7.1
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.553
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	102
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

POCOCR01

Location	300m south on Camelback Rd from intersection of Camelback Rd. and Wilke Rd.		
Site #	2019-27	Date	4/23/2019
Stream Name	Pocono Creek	Time	11:12:00 AM
Township	Pocono	Latitude	41.058983
Habitat Asmt.	203	Longitude	-75.34886

Field Measurements	
Temp C	11.5
pH	7.18
Press inHg	
DO Percent	98.2
DO mg/L	10.7
Cond (uS/cm)	103

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.32
EPT Taxa Richness	14
Hilsenhoff Biotic Index	2.99
Intolerant individuals (%)	58
Modified Becks Index	33
Index of Biotic Integrity	**78.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.54
Aluminum mg/L	<0.160
Calcium mg/L	4.25
Iron mg/L	0.114
Magnesium mg/L	0.929
Hardness CaCO3	14.4
Chloride mg/L	22
pH	7
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.0907
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	26
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

POCOCR09

Location	65m north of Old Mill Rd. bridge.		
Site #	2019-28	Date	4/24/2019
Stream Name	Pocono Creek	Time	11:55:00 AM
Township	Pocono	Latitude	41.039252
Habitat Asmt.	201	Longitude	-75.309729

Field Measurements	
Temp C	12.63
pH	7.35
Press inHg	
DO Percent	100.06
DO mg/L	10.63
Cond (uS/cm)	168

Macroinvertebrate Metrics	
Total Taxa	21
Shannon Diversity Index	1.4
EPT Taxa Richness	13
Hilsenhoff Biotic Index	4.82
Intolerant individuals (%)	22
Modified Becks Index	24
Index of Biotic Integrity	**55.7**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	2.14
Aluminum mg/L	<0.160
Calcium mg/L	8.39
Iron mg/L	0.0993
Magnesium mg/L	2.06
Hardness CaCO3	29.4
Chloride mg/L	35.5
pH	7
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.219
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	64
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

POCOCR14

Location	70m south from Ensleys Dojo off S. 10th St and Ann St.		
Site #	2019-29	Date	4/25/2019
Stream Name	Pocono Creek	Time	9:18:00 AM
Township	Stroudsburg	Latitude	40.981165
Habitat Asmt.	197	Longitude	-75.197009

Field Measurements	
Temp C	11.8
pH	7.5
Press inHg	
DO Percent	100.53
DO mg/L	10.87
Cond (uS/cm)	214

Macroinvertebrate Metrics	
Total Taxa	20
Shannon Diversity Index	2.01
EPT Taxa Richness	10
Hilsenhoff Biotic Index	2.22
Intolerant individuals (%)	70.8
Modified Becks Index	11
Index of Biotic Integrity	**74.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	3.25
Aluminum mg/L	<0.160
Calcium mg/L	12.3
Iron mg/L	0.121
Magnesium mg/L	2.42
Hardness CaCO3	40.7
Chloride mg/L	41.4
pH	7.2
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.352
Alkalinity to pH 4.5 mg CaCO3/L	22.4
Total Dissolved Solids mg/L	126
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

POHOCR01

Location	330m southeast from intersection of Merwinsburg Rd. and Burger Hollow Rd.		
Site #	2019-30	Date	4/24/2019
Stream Name	Pohopoco Creek	Time	8:30:00 AM
Township	Chestnuthill	Latitude	40.961684
Habitat Asmt.	202	Longitude	-75.465

Field Measurements	
Temp C	10
pH	6.86
Press inHg	
DO Percent	97.17
DO mg/L	10.96
Cond (uS/cm)	124

Macroinvertebrate Metrics	
Total Taxa	31
Shannon Diversity Index	2.66
EPT Taxa Richness	19
Hilsenhoff Biotic Index	2.17
Intolerant individuals (%)	76.1
Modified Becks Index	34
Index of Biotic Integrity	**93.8**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.37
Aluminum mg/L	<0.160
Calcium mg/L	5.08
Iron mg/L	0.18
Magnesium mg/L	2.11
Hardness CaCO3	21.4
Chloride mg/L	22.4
pH	6.6
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.9
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

POHOCR29

Location	700 meters west on Whitey B Ln. from intersection of Whitey B Ln. and Rt. 209.		
Site #	2019-31	Date	4/17/2019
Stream Name	Pohopoco Creek	Time	11:45:00 AM
Township	Polk	Latitude	40.89951
Habitat Asmt.	205	Longitude	-75.506215

Field Measurements	
Temp C	9.7
pH	7.01
Press inHg	
DO Percent	101.4
DO mg/L	11.53
Cond (uS/cm)	112

Macroinvertebrate Metrics	
Total Taxa	18
Shannon Diversity Index	1.98
EPT Taxa Richness	11
Hilsenhoff Biotic Index	2.65
Intolerant individuals (%)	70.4
Modified Becks Index	13
Index of Biotic Integrity	**75.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.61
Aluminum mg/L	<0.200
Calcium mg/L	6.84
Iron mg/L	0.143
Magnesium mg/L	2.6
Hardness CaCO3	27.8
Chloride mg/L	18.7
pH	6.86
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	1.19
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

SWIFCR10

Location	25m north of Manor Dr. bridge.		
Site #	2019-32	Date	4/23/2019
Stream Name	Swiftwater Creek	Time	9:10:00 AM
Township	Pocono	Latitude	41.100894
Habitat Asmt.	164	Longitude	-75.346355

Field Measurements	
Temp C	8.7
pH	7.15
Press inHg	
DO Percent	95.7
DO mg/L	11.14
Cond (uS/cm)	136

Macroinvertebrate Metrics	
Total Taxa	23
Shannon Diversity Index	2.49
EPT Taxa Richness	13
Hilsenhoff Biotic Index	2.75
Intolerant individuals (%)	60.5
Modified Becks Index	30
Index of Biotic Integrity	**77.5**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	1.41
Aluminum mg/L	<0.160
Calcium mg/L	5.34
Iron mg/L	<0.08
Magnesium mg/L	1.4
Hardness CaCO3	19.1
Chloride mg/L	31
pH	6.9
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.468
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	98
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

TOBYCR14

Location	50m east of Rt. 115 bridge near Austin T. Blakeslee Natural Area.		
Site #	2019-33	Date	4/17/2019
Stream Name	Tobyhanna Creek	Time	9:20:00 AM
Township	Tobyhanna	Latitude	41.082791
Habitat Asmt.	196	Longitude	-75.583083

Field Measurements	
Temp C	10.6
pH	6.78
Press inHg	
DO Percent	95.8
DO mg/L	10.66
Cond (uS/cm)	127

Macroinvertebrate Metrics	
Total Taxa	24
Shannon Diversity Index	2.63
EPT Taxa Richness	12
Hilsenhoff Biotic Index	3.52
Intolerant individuals (%)	62.1
Modified Becks Index	16
Index of Biotic Integrity	**83.9**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	5.63
Aluminum mg/L	<0.200
Calcium mg/L	5.29
Iron mg/L	0.301
Magnesium mg/L	1.08
Hardness CaCO3	17.7
Chloride mg/L	30.1
pH	6.9
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.158
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

TUNKCR03

Location	160m north of Tunhannok Fishing Association Parking area.		
Site #	2019-34	Date	4/17/2019
Stream Name	Tunkhannock Creek	Time	10:15:00 AM
Township	Tunkhannock	Latitude	41.059541
Habitat Asmt.	201	Longitude	-75.552735

Field Measurements	
Temp C	8.2
pH	5.42
Press inHg	
DO Percent	93.5
DO mg/L	11.02
Cond (uS/cm)	53

Macroinvertebrate Metrics	
Total Taxa	37
Shannon Diversity Index	2.75
EPT Taxa Richness	15
Hilsenhoff Biotic Index	3.92
Intolerant individuals (%)	38.6
Modified Becks Index	28
Index of Biotic Integrity	**78.2**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	10.6
Aluminum mg/L	0.222
Calcium mg/L	1.87
Iron mg/L	0.374
Magnesium mg/L	0.649
Hardness CaCO3	7.34
Chloride mg/L	12
pH	5.99
Ammonia as N mg/L	<0.30
Total Kjeldahl N mg/L	<1.25
Nitrate as N mg/L	0.0962
Alkalinity to pH 4.5 mg CaCO3/L	<20
Total Dissolved Solids mg/L	<20
Phosphorus as P mg/L	<0.020
Biochemical Oxygen Demand mg/L	<3.00

SASPR01

Location	600m west of Wilke Rd. dead end.		
Site #	2019-35	Date	4/24/2019
Stream Name	Sand Spring	Time	9:44:00 AM
Township	Jackson	Latitude	41.061595
Habitat Asmt.	173	Longitude	-75.37459

Field Measurements	
Temp C	12.5
pH	6.69
Press inHg	
DO Percent	97.1
DO mg/L	10.36
Cond (uS/cm)	43

Macroinvertebrate Metrics	
Total Taxa	14
Shannon Diversity Index	2.25
EPT Taxa Richness	8
Hilsenhoff Biotic Index	3.27
Intolerant individuals (%)	48.6
Modified Becks Index	14
Index of Biotic Integrity	**56.8**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	
Aluminum mg/L	
Calcium mg/L	
Iron mg/L	
Magnesium mg/L	
Hardness CaCO3	
Chloride mg/L	
pH	0
Ammonia as N mg/L	
Total Kjeldahl N mg/L	
Nitrate as N mg/L	
Alkalinity to pH 4.5 mg CaCO3/L	
Total Dissolved Solids mg/L	
Phosphorus as P mg/L	
Biochemical Oxygen Demand mg/L	

Only field measurements and macroinvertebrates were collected at this site.

SASPR02

Location	700m west of Wilke Rd. dead end.		
Site #	2019-36	Date	4/24/2019
Stream Name	Sand Spring	Time	10:22:00 AM
Township	Jackson	Latitude	41.061234
Habitat Asmt.	154	Longitude	-75.375798

Field Measurements	
Temp C	12.9
pH	6.46
Press inHg	
DO Percent	96.7
DO mg/L	10.22
Cond (uS/cm)	23

Macroinvertebrate Metrics	
Total Taxa	14
Shannon Diversity Index	0.78
EPT Taxa Richness	8
Hilsenhoff Biotic Index	2.17
Intolerant individuals (%)	91.9
Modified Becks Index	15
Index of Biotic Integrity	**58**

Lab Chemistry Analysis	
Total Organic Carbon mg/L	
Aluminum mg/L	
Calcium mg/L	
Iron mg/L	
Magnesium mg/L	
Hardness CaCO3	
Chloride mg/L	
pH	0
Ammonia as N mg/L	
Total Kjeldahl N mg/L	
Nitrate as N mg/L	
Alkalinity to pH 4.5 mg CaCO3/L	
Total Dissolved Solids mg/L	
Phosphorus as P mg/L	
Biochemical Oxygen Demand mg/L	

Only field measurements and macroinvertebrates were collected at this site.

Conclusions and Recommendations

Macroinvertebrates

The sites where IBI Scores did not reach the recommended Aquatic Life Use Attainment Benchmarks are shown below:

(2019-7) **Brodhead Creek 27**: 59.3
(2019-17) **Keiper Run 01**: 60.9
(2019-28) **Pocono Creek 09**: 55.7
(2019-35) **Sand Spring 01**: 56.8
(2019-36) **Sand Spring 02**: 58

The two Sand Spring sites were the lowest scoring systems during the study; however, these two sites were chosen by the Monroe County Conservation District as a Growing Greener grant funded stream restoration project due to significant erosion and sedimentation impacts. The macroinvertebrate scores reflect the impact of channelization, streambank failure, and subsequent sedimentation influx to the waterway.

Keiper Run was tested for a third year in a row due to the complete lack of macroinvertebrate samples that have been gathered each year it was studied. As seen in Table 3, only 16 individuals were collected from Keiper Run, less than the required minimum of 200 individuals for a reliable sample. Although this was an unreliable sample for scoring metrics, this is an increase from prior studies.

The Pocono Creek and Brodhead Creek sites that did not reach the recommended benchmark were uncharacteristic based on the data that has been collected during past studies. The Brodhead Creek 27 and Pocono Creek 09 sites were sampled on 4/18/2019 and 4/25/2019 respectively, which had above average discharge rates due to increase precipitation on the preceding days from when sampling was conducted. The USGS discharge stream gage measurements are provided in Figure 3 and 4. The higher discharge rates offer a potential explanation of the uncharacteristic macroinvertebrate scores until further testing is conducted in 2020.

Figure 3: USGS Stream Gage 01440400 on the Brodhead Creek near Analomink, PA showing the discharge of the stream a month around the time of sampling. Brodhead Creek 27 is located approximately five miles upstream of the gage however, the measurements show a higher than average measurement on April 18th during sampling (noted approximately on the red line). As seen in Figure 3, two peak discharges occurred prior to sampling.

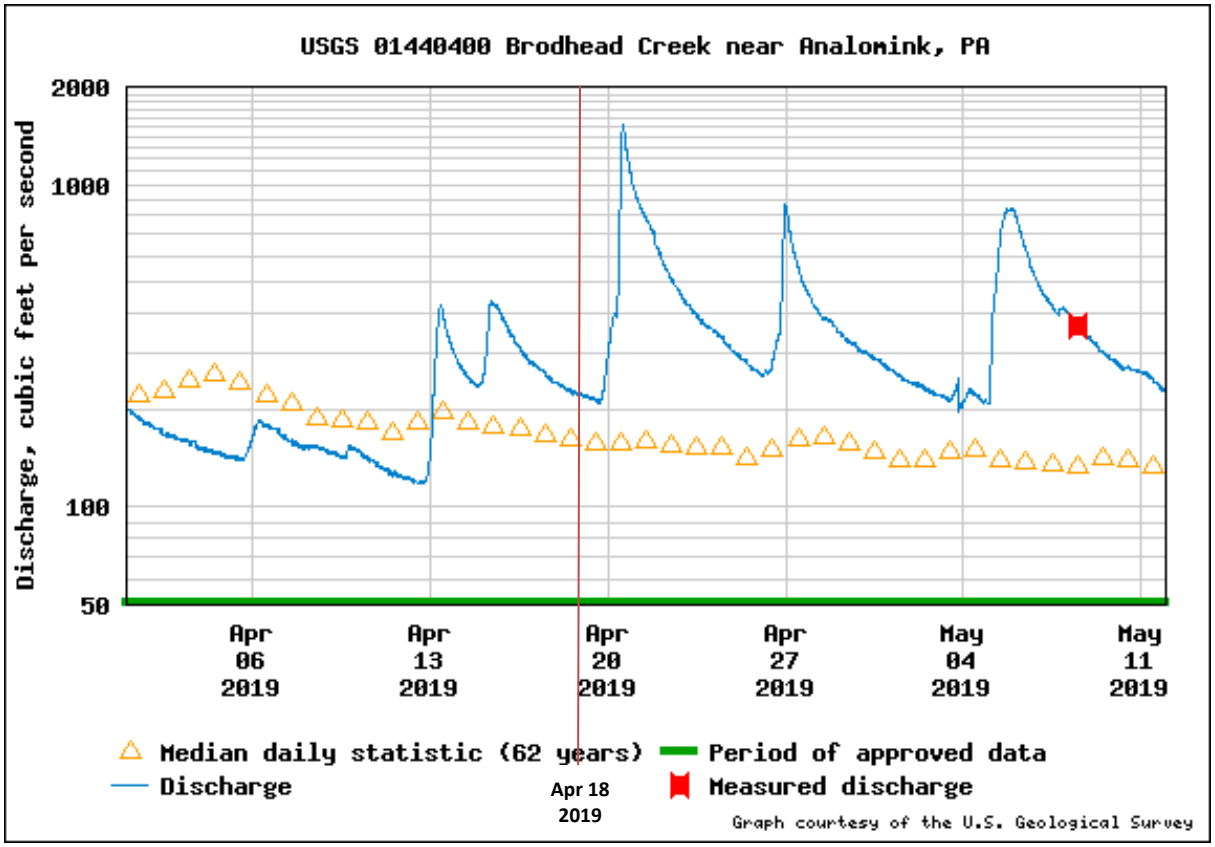
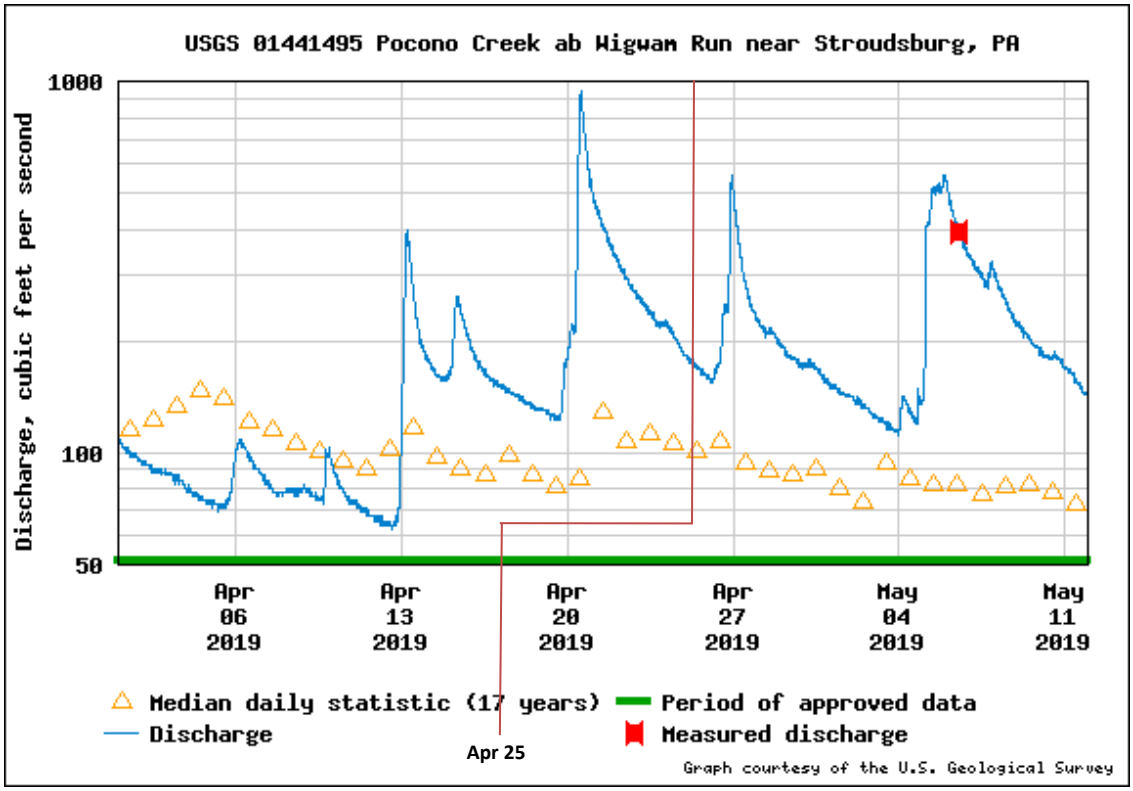


Figure 4: USGS Stream Gage 01441495 on the Pocono Creek near Stroudsburg, PA showing the discharge of the stream during the time of sampling. Pocono Creek 09 is located approximately four and a half miles upstream of the gage however, the measurements show a higher than average measurement on April 25th during sampling (noted approximately on the red line). As seen in Figure 4, three peak discharges occurred prior to sampling.



The peak discharges noted in Figures 3 and 4 can impact collection of macroinvertebrates. Heavy rains can have a scouring effect on macroinvertebrates which ultimately provides an inaccurate reflection of biological conditions if they are displaced downstream (USEPA, 2012). The EPA recommends postponing sampling for a week after storm events but due to the frequency of storm events in the spring, sampling was done when applicable during the available timeframe.

As part of the ongoing trend collection and analysis for sampling sites in Monroe County, the results shown below in Table 5 provide results that have been collected in 2019, and have at least three years of consecutive data since 2015.

Table 5. IBI score trends since 2015:

	IBI 2019	IBI 2018	IBI 2017	IBI 2016	IBI 2015
BRODCR22	87.5	85	87.1	74.1	
BRODCR27	59.3	99	93		
BUCKCR01	76.1	63	73.5		
BUHICR07	78.2	83	86.1	91.3	89.2
BUSHCR07	89.8	91	88.6	95.3	86.7
BUTZRN01	82.8	71	76		
JONACR01	89.5	78	81.6		
MARSCR11	79.7	81	80.5	89.1	95.7
MARSCR18	80.8	71	76		
MCMICR10	80.4	69	69.2		
MCMICR22	85.6	96	81.9		
MCMICR37	78.5	52	78.6	76.2	93.6
MILLCR03	89.5	80	97	83.2	
PARACR08	85.9	87	82.5	85.2	
POCOCR01	78.2	81	75.9		
POCOCR09	55.7	72	80.2		
POCOCR14	74.5	73	82.1	72.5	62.3
POHOCR01	93.8	86	88.5		
POHOCR29	75.9	74	83.8		
SWIFCR10	77.5	48	90.6	83.2	75.8
TOBYCR14	83.9	75	88	64.8	75.8
TUNKCR03	78.2	73	67.8		81.5

Chemistry Analysis

Low Alkalinity throughout Monroe County

Most of the sites showed low alkalinity scores. Low alkalinity is not harmful to a stream. However, low alkalinity decreases the water's ability to buffer acids and protect the aquatic life against sudden changes in pH. These values are normal when considering the geology of Monroe County. Most of the streams that were studied in this report flow within areas of silica rich sandstone and quartzite conglomerates, as well as red and grey sandstone and shales. These rocks generally have low carbonate values which would be responsible for low surface and ground water alkalinity values. Cherry Creek, the lower half of Marshalls Creek, and the mouth of Brodhead Creek flow through carbonate rich shales and siltstones which may be the reason for higher alkalinity values when compared to the rest of the county.

Recommendations

After reviewing the data from the 2019 Water Quality Study, the lead and cooperating agencies recommend the following:

- We plan to ensure consistent trend data for the attaining and exceptional/high quality streams which dominate Monroe County.
- Further inspection of habitat and water chemistry concerning the absence of macroinvertebrates from Keiper Run in the last three years. Additional sampling of Keiper Run is planned for 2020 along with the possibility of additional chemistry analysis.
- Investigation into the IBI decline in the Pocono and Brodhead Creeks, including additional sampling sites.
- Further monitoring of Aquashicola, Appenzel, Marshall's, and Cherry creeks focusing on creating trend data and/or implementing corrective measures for all impaired or possibly impaired streams.

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