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DEPARTMENT OF ENVIRONMENTAL
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OFFICE OF WATER PROGRAMS

BUREAU OF CLEAN WATER

EUTROPHICATION CAUSE METHOD TECHNICAL REPORT

2023

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ABBREVIATIONS

Abbreviation	Definition
A	Drainage Accrual
Ag	Agriculture
AIC	Akaike Information Criterion
Alk	Total Alkalinity
ALU	Aquatic Life Use
ANOVA	Analysis of Variance
C	Degrees Celsius
CA	Correspondence Analysis
Ca	Calcium
DCA	Detrended Correspondence Analysis
DE	Discrimination Efficiency
DEP	Pennsylvania Department of Environmental Protection
Devel	Developed Land
DL	Detection Limit
DO	Dissolved Oxygen
DOMT	Dissolved Oxygen Minimum Tolerance
DORT	Dissolved Oxygen Range Tolerance
DO %Sat	Dissolved Oxygen Percent Saturation
ECDF	Empirical Cumulative Distribution Function
ECM	Eutrophication Cause Method
ECDP	Eutrophication Cause Determination Protocol
ER	Ecosystem Respiration
ETI	Eutrophication Tolerance Index
ETV	Eutrophication Tolerance Value
ft	Feet
ft^2	Square Feet
Hard	Total Hardness
High-S	Highly Stressed by Eutrophication
IBI	Index of Biological Integrity
K	Exchange of Oxygen with the Atmosphere
km^2	Square Kilometers
Mg	Magnesium
mg/L	Milligrams per Liter
mi^2	Square Miles
Min	Minimum
Min-S	Minimally Stressed by Eutrophication
NJDEP	New Jersey Department of Environmental Protection
O_2	Oxygen
OHEPA	Ohio Environmental Protection Agency
p25	25th Percentile
p75	75th Percentile
PA	Pennsylvania
PCA	Principal Components Analysis
R	Ecosystem Respiration

Abbreviation	Definition
r_s	Spearman Correlation Coefficient
t	Time
TN	Total Nitrogen
TP	Total Phosphorus
USEPA	United States Environmental Protection Agency
WO	Dissolved Oxygen mg/L
WX	Dissolved Oxygen Percent Saturation

1. EXECUTIVE SUMMARY

This document summarizes the technical background behind the development of the Pennsylvania Department of Environmental Protection (DEP) Eutrophication Cause Method (ECM). The ECM will replace the existing Eutrophication Cause Determination Protocol (ECDP McGarrell 2018) currently used by the DEP to identify eutrophication as a cause of impairment in aquatic life use-impaired streams with a drainage area of ≤50 mi^2, and is applicable to streams with a drainage area of up to 500 mi^2. This document also describes the relationships observed between water column nutrient levels, continuously measured dissolved oxygen characteristics, and benthic macroinvertebrate community structure and composition and how these relationships were used in the development of the ECM.

The U.S. Environmental Protection Agency (USEPA) conceptual model diagram for stream dissolved oxygen was used as the framework upon which ECM data were organized, analyzed, and reported (Figure 2a). Within the context of the conceptual model, annual mean in-stream concentrations of total phosphorus (TP) and total nitrogen (TN) were used as interacting stressors and daily range and daily minimum values of dissolved oxygen percent saturation (DO %Sat) were used as proximate stressors and as surrogates for primary productivity and ecosystem respiration, respectively. Two measures of benthic macroinvertebrate community structure and composition were used as biological responses variables: (1) sample correspondence analysis (CA) axis 1 score and (2) sample eutrophication tolerance index (ETI) score.

To account for seasonal variations in abiotic factors influencing stream ecosystem metabolic rates (e.g., water temperature, air temperature, day length, canopy cover, stream discharge conditions, etc.), data were analyzed within the context of four distinct sample periods. To enhance the ability to detect important relationships in the dataset, stations were categorized into one of three stream type classes using a combination of abiotic attributes linked to stream metabolism and USEPA nutrient ecoregion data. Samples were also delineated into eutrophication stress classes based on the biological integrity of their benthic macroinvertebrate community and their eutrophication stress level. Pairwise adonis and Akaike information criterion (AIC) results confirm that the selected suite of stressor and response variables, the sample periods, and the stream type and eutrophication stress classification systems used in the ECM agree with the linkages implied in the USEPA conceptual model diagram for stream dissolved oxygen (Figure 2a).

In the ECM, eutrophication is identified as a cause of impairment in an impaired stream when its DO %Sat characteristics fail to meet the appropriate stream type, sample period-specific benchmark values. ECM benchmark values provide a means for categorizing individual months of data into one of the following monthly ECM status categories:

ECM Status 1	Both proximate stressor benchmarks supported (primary productivity and ecosystem respiration rates comparable to benchmarks)
ECM Status 2	The p25DailyMin_WX proximate stressor benchmark supported , but the p75DailyRange_WX proximate stressor benchmark not supported (elevated primary productivity rate)

ECM Status 3	The p75DailyRange_WX proximate stressor benchmark supported, but the p25DailyMin_WX proximate stressor benchmark not supported (elevated ecosystem respiration rate)
ECM Status 4	Both proximate stressor benchmarks simultaneously not supported in the same month, eutrophication is identified as a cause of impairment (elevated primary productivity and ecosystem respiration rates)

ECM results show clear discrimination between the eutrophication stressor and macroinvertebrate community response variables of samples that show no sign of being eutrophic and support a healthy macroinvertebrate community vs. samples identified as being eutrophic and not supporting a healthy benthic macroinvertebrate community. This clear discrimination in the eutrophication stressor and biological response variables used to develop the ECM also confirms that ECM results strongly align with the linkages implied in the USEPA conceptual model diagram for stream dissolved oxygen (Figure 2a).

The data used to develop the ECM (calibration dataset) consisted of data from 148 spatially unique stations in Pennsylvania. Data were collected during multiple years at 18 stations, and at an additional nine stations that were located on the same stream as, and in close proximity to, a calibration sample, yielding an additional 32 samples (ancillary samples) that were not used in the development of the method. Ancillary samples were used in evaluations of temporal and spatial variability. In the evaluation of temporal variability (comparisons of ECM results generated from samples collected at the same station in different years), sample results agreed in 21 of the 26 paired-sample comparisons (80.8%). Sample pairs ranged from one to three years apart. In evaluations of spatial variability (comparisons of ECM results generated from data collected at stations located on the same waterway with similar land cover conditions during the same year), sample results agreed in nine of the 11 paired-sample comparisons (81.8%).

The average duration of sonde deployment in the dataset used to develop the ECM was 5.9 months. However, the minimum amount of data required to identify eutrophication as a cause of impairment in an ALU impaired stream (one month of data categorized as ECM Status 4) could be as little as 14 days of usable data collected within a given calendar month.

In addition to their use in the development of the ECM, macroinvertebrate sample ETI scores and DO %Sat benchmark values also can be used as a screening tool for identifying impaired streams as candidates for implementation of the ECM. Sample ETI scores can be used to categorize impaired streams as having high, moderate, or low potential for eutrophication as a cause of impairment. Discrete measurements of late-afternoon and early-morning stream DO percent saturation values can be compared to the appropriate p75DailyRange_WX benchmark value to determine if the waterway shows signs of elevated primary productivity, and early-morning discrete measurements of stream DO percent saturation can be compared to the appropriate p25DailyMin_WX benchmark, to determine if the waterway is subject to elevated ecosystem respiration rates. In addition, discrete measurements of late-afternoon and early-morning stream DO percent saturation values can be used to delineate the upstream and downstream extent of eutrophication impacts in impaired streams in which eutrophication is identified as a cause of impairment using the ECM.

2. TECHNICAL BACKGROUND

The USEPA describes nutrient pollution as one of America's most widespread, costly, and challenging environmental problems. The term eutrophication (eu=well – troph=nourish) was originally used to describe the natural aging process by which a lake becomes rich in nutrients and organic matter over time and evolves into a bog and ultimately a terrestrial ecosystem. Within the context of nutrient pollution of streams, and throughout this document, the term eutrophication refers to the process by which elevated nutrient levels (phosphorus and/or nitrogen) stimulate the growth of algae and/or aquatic plants, and alters the quantity and quality of organic matter available as food for aquatic organisms, changes physical habitat conditions, and impacts stream dissolved oxygen characteristics.

Pennsylvania does not currently have numeric nutrient criteria that can be used to identify nutrients as a cause of impairment in streams. This is due to the complexity of the response of stream biological communities to nutrient enrichment. In the absence of directly toxic conditions associated with ammonia or nitrite, most nutrient-related impacts on stream biological communities are indirect and associated with altered trophic conditions which are reflected in their primary productivity and ecosystem respiration rates, and thus, their dissolved oxygen (DO) characteristics. The focus of this method was placed on relationships between surrogates for primary productivity (DO percent saturation (%Sat) range) and respiration (DO %Sat minimum) and biological community structure and composition.

Increased stream nutrient levels, in conjunction with favorable abiotic conditions (substrate, light, temperature, scour regime, etc.), stimulate the growth of aquatic plants and algae (Chambers and Prepas 1994, Biggs 2000, Dodds et al. 2002, Carr et al. 2005, Stevenson et al. 2006, Warnaars et al. 2007, Frankforter et al. 2009, Gucker et al. 2009, Valenti et al. 2011). Changes in stream algal and plant communities alters the quantity and quality of food available to primary consumers (herbivorous macroinvertebrates and fish) (Miltner and Rankin 1998, Stevenson et al. 2006), modifies physical habitat conditions (Dodds and Biggs 2002), can stimulate the growth of particular forms of algae that produce toxins (Heisler et al. 2008), and can produce large daily fluctuations in dissolved oxygen (DO) and pH conditions that in some cases fall below or rise above levels protective of aquatic life (Wright and Mills 1967, Guasch et al. 1998, Nimick et al. 2011, Valenti et al. 2011, Jones and Graziano 2013).

Eutrophication also modifies stream ecosystem metabolism (Gucker et al. 2009). In general, metabolism is a biophysical process that pertains to how energy is acquired and used within an organism or ecosystem. Stream ecosystem metabolism is the biophysical process by which energy, in the form of organic matter, is: 1) acquired from outside sources (i.e., riparian vegetation, point and non-point pollution discharges), 2) generated in-stream via aquatic plant and algal photosynthesis (primary production), and 3) used by stream organisms (ecosystem respiration).

Aquatic ecosystem metabolism is a fundamental concept of freshwater ecology, the importance of which was documented in the ground-breaking work of Lindeman (1942) and Odum (1956). These

authors described stream ecosystems based on the sources of energy (organic matter) fueling ecosystem respiration and the relative productivity (nutrient and organic matter availability) of these systems. Stream ecosystems fueled primarily by organic matter from outside of the stream are termed heterotrophic systems. Stream ecosystems fueled primarily by organic matter from within the stream via aquatic photosynthesis are referred to as autotrophic. The terms oligotrophic, mesotrophic, and eutrophic are used to describe relative levels of productivity ranging from low, to moderate, to high productivity, respectively. By the 1980s, the significance of metabolic conditions, as they pertain to the overall health of freshwater ecosystems, was well understood. Wetzel (1983) stated that managing freshwater resources in a meaningful way requires an understanding of the metabolic responses of aquatic ecosystems to the effects of human activity on these resources.
Odum's (1956) open-water diel DO method of measuring aquatic ecosystem metabolism measures ecosystem metabolism as changes in DO concentration associated with primary production (photosynthesis) during the day and respiration at night. The method has not changed fundamentally since the late 1950s and has been used extensively over the past several decades in a wide variety of aquatic ecosystems (Staehr et al. 2010; Staehr et al. 2012). In its simplest form, the open-water diel DO method, as it's applied to stream ecosystem metabolism, is typically written as:

$$\Delta O_2/\Delta t = P - ER - K - A \qquad \text{Equation 2a}$$

where $\Delta O_2/\Delta t$ is the change in DO over time (usually 24 hours), P is primary production, ER is ecosystem respiration, K is the exchange of oxygen with the atmosphere, and A is the rate of drainage accrual (influx of oxygen with accrual of ground water and surface drainage along the study reach). Primary production is the generation of energy via plant and algal photosynthesis which converts light energy into chemical energy in the form of organic matter and produces oxygen as a byproduct.

$$6CO_2 + 6H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 \text{ (Organic Matter)} + 6O_2 \qquad \text{Equation 2b}$$

Ecosystem respiration is the process by which the energy contained in organic matter is utilized by decomposers (bacteria and fungi) and herbivores. In contrast to P, ER consumes oxygen.

$$C_6H_{12}O_6 \text{ (Organic Matter)} + 6O_2 \longrightarrow 6CO_2 + 6H_2O \qquad \text{Equation 2c}$$

An obvious effect of stream metabolic conditions (primary production and respiration rates) on water quality is the cyclic pattern of a daily increase in DO levels associated with daytime photosynthesis and a subsequent daily decrease in DO associated with the consumption of oxygen via ecosystem respiration during times of little or no photosynthetic activity ("night").

Ecosystem metabolism is a functional attribute of stream ecosystems, in contrast to a structural attribute such as nitrogen or phosphorus concentration, benthic chlorophyll-*a* concentration, or the number of different algal, macroinvertebrate, or fish taxa. Palmer and Febria (2012) describe structural attributes as those that can be evaluated with point-in-time measurements that are assumed to reflect the existing status or condition of an ecosystem. Typically, ecosystem health determinations using structural measurements are based on the similarity of these measurements to a least-impacted, reference, or historical condition.

In contrast to structural measurements of stream ecosystem characteristics, functional measurements attempt to capture system dynamics through repeated measurement that quantify a key biophysical process (Palmer and Febria 2012). Ideally, a combination of structural and functional attributes of stream ecosystems should be used to obtain a more complete understanding of ecosystem health (Matthews et al. 1982; Young et al. 2004; Palmer and Febria 2012).

Quantification of stream ecosystem metabolism is an example of a functional measurement of stream ecosystem condition. Reach-scale measurements (several riffle-run-pool sequences) of stream ecosystem metabolic conditions monitored over extended periods of time are affected by a wide range of abiotic and biotic factors. Factors that influence stream ecosystem metabolism include water temperature, light and nutrient availability, water surface turbulence, water depth, stream discharge/ scour regime, channel substrate materials, and grazing of algae and aquatic plants. Thus, measurements of reach-scale stream ecosystem metabolism conducted over timeframes ranging from days to years provide an integrated measure of environmental conditions, ecological disturbance, and stream ecosystem health (Young and others 2004, Young and others 2008, Mulholland et al. 2005, Bunn et al. 2010, Palmer and Febria 2012). Izagirre and others (2008) described stream metabolism as one of the most integrative ecosystem functions that is relevant across all sizes and types of streams and is sensitive to stressors such as eutrophication and changes in riparian cover.

Although stream metabolism is an important measure of stream ecosystem health, detailed measurements of reach-scale stream ecosystem metabolism are laborious and deceptively complicated because they require accurate modeling estimates or direct measurement of parameters that are notoriously difficult to accurately model or directly measure (e.g., gas exchange at the air-water interface, reach homogeneity, ecosystem respiration rate homogeneity, groundwater inputs, etc.) (Staehr et al. 2012, Demars et al. 2015). To obviate the necessity of modeling assumptions or direct measurements of these difficult or untenable parameters, simple DO metrics from diel DO profiles have been successfully used as proxies or surrogates for detailed measurements of stream ecosystem metabolism (Chapra and Di Toro 1991, Wang and others 2003, Mulholland and others 2005, Diamond and others 2021). Diel DO profiles are records of stream DO concentrations typically recorded at 15- or 30-minute intervals over 24 hours. Diamond and others (2021) stated that where broad spatiotemporal patterns are of focal interest, and where the exacting precision of metabolism computations are not required or the assumptions untenable, DO time series (DO profile) attributes may be informative regarding stream and river metabolic function.

The “simplified” methods for estimating reach-scale rates of stream ecosystem metabolism developed by Chapra and Di Toro (1991), Wang and others (2003), and Mulholland and others (2005) include the use of the amplitude of the diel DO saturation deficit values generated from DO profiles. Mulholland and others (2005) stated that diel profiles of DO concentration contain much of the information needed for stream metabolism determinations and are good indicators of reach-scale metabolic rates and the effects of watershed-scale disturbance on stream metabolic conditions.

The findings of Mulholland and others (2005) suggests that the amplitude of diel DO concentrations alone could be a meaningful indicator of stream metabolic conditions. This assumption is supported by the fact that the amplitude of diel DO concentrations has been used as an indicator of general stream ecosystem metabolism conditions in a wide range of geographic locations and environmental settings. For example, Frank (2009) used the amplitude of diel DO concentrations, in conjunction with measures of production and respiration, to characterize metabolic conditions in coastal plain streams of Virginia. Results demonstrated that streams experiencing higher light levels exhibited greater diel DO amplitudes, elevated primary production and respiration rates, and that diel DO amplitudes were significantly and positively correlated with benthic chlorophyll-*a* at less shaded sites.

In a seven-year study of a snowmelt-dominated montane stream ecosystem in New Mexico, Shafer (2013) used the amplitude of diel DO concentrations as an objective measure for identifying periods of peak productivity. Observations included that the maximum amplitude of diel DO values showed seasonal and annual variation and that periods of maximum diel DO amplitude occurred during extended periods of baseflow conditions.

Bunn and others (2010) used a rigorous, objective process to identify indicators of stream ecosystem health to be included in a freshwater monitoring program in South East Queensland, Australia. They identified both stream ecosystem metabolism and the amplitude of diel DO concentrations as variables that respond strongly to watershed disturbance and selected these variables for inclusion in their program.

In an assessment of eutrophication in the lower Yakima River Basin in Washington, Wise and others (2009) observed nutrient concentrations high enough to support abundant growth of periphytic algae and macrophytes. They reported that the metabolism associated with this growth caused large daily fluctuations in DO levels.

Clune (2021) analyzed relationships between nutrient concentrations and the diel amplitude and diel minimum DO concentrations in 46 streams in Maryland, Pennsylvania, Virginia, and West Virginia. A statistically significant relationship ($p \leq 0.05$) was observed between the amplitude of diel DO concentration and instream photosynthesis (GPP) estimated using the USGS stream Metabolizer R package (Appling et al. 2018a, 2018c), and that this relationship varied by season. Clune (2021) concluded that using the amplitude of diel DO concentrations as a surrogate for stream metabolism shows promise for use by states developing stream eutrophication protocols and standards.

Minnesota’s numeric eutrophication standard (MN Administrative Rule 7050.0222) includes numeric criteria for diel DO swings (Heiskary and Bouchard 2015). Ohio’s narrative nutrient criteria (Ohio Administrative Code 3745-1-04(E)) do not include specific language pertaining to diel DO swings, but the stream nutrient assessment procedure developed by the Ohio Nutrient Technical Advisory Group for quantitatively assessing the attainment of Ohio’s narrative nutrient criteria includes benchmark values for diel DO swings (Miltner 2010, OHEPA 2016).

Despite having numeric criteria for total phosphorus in streams, New Jersey's water quality standards also include narrative criteria for nutrients (NJ Administrative Code 7:9B-1.14(d)). The New Jersey Department of Environmental Protection uses a "translator" to quantitatively assess attainment of their narrative criteria. Included in this translator are criteria for minimum DO levels and diel DO swings (NJDEP 2012, NJDEP 2013).

New Jersey Department of Environmental Protection's 2012 Integrated Water Quality Monitoring and Assessment Methods Document (NJDEP 2012) describes the relationship between excess nutrients and the potential for excess levels of algal growth, broad swings in DO (resulting from high rates of daytime photosynthesis coupled with nighttime respiration), depressed DO levels, and changes to aquatic ecosystems as being long-established, and that these cause/response relationships are better indicators of adverse nutrient impacts on aquatic ecosystems than an assessment of the in-stream concentration of total phosphorus alone.

Pennsylvania's aquatic life; recreation; water supply for drinking, agriculture, and industry; and other water uses are protected under Pennsylvania's General (Narrative) Water Quality Criteria in (25 Pa. Code Section 93.6(a) and (b) as follows:

> *(a) Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to water uses to be protected or to human, plant or aquatic life.*
> *(b) In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances that produce color, tastes, odors turbidity or settle to form deposits.*

In 2018, DEP developed the ECDP as a translator for quantitatively assessing the impact of nutrient enrichment on streams in Pennsylvania (McGarrell 2018). The 2018 ECDP was developed within the context of Pennsylvania's General (narrative) Water Quality Criteria in 25 Pa. Code Section 93.6(a) and for determining if eutrophication is a cause of impairment, in ALU impaired streams. The 2018 ECDP was limited to streams with a drainage area ≤ 50 mi^2, based on data availability at the time of its development.

Since the development of the 2018 ECDP, DEP staff have collected additional nutrient, continuously monitored chemical water quality, and benthic macroinvertebrate data, expanding the spatial extent and stream size distribution of the dataset to include streams with a drainage area of up to 500 mi^2. In addition, DEP staff have developed the ability to collect, grade, and approve for use, continuously monitored DO percent saturation data, which were not available at the time of the development of the 2018 ECDP.

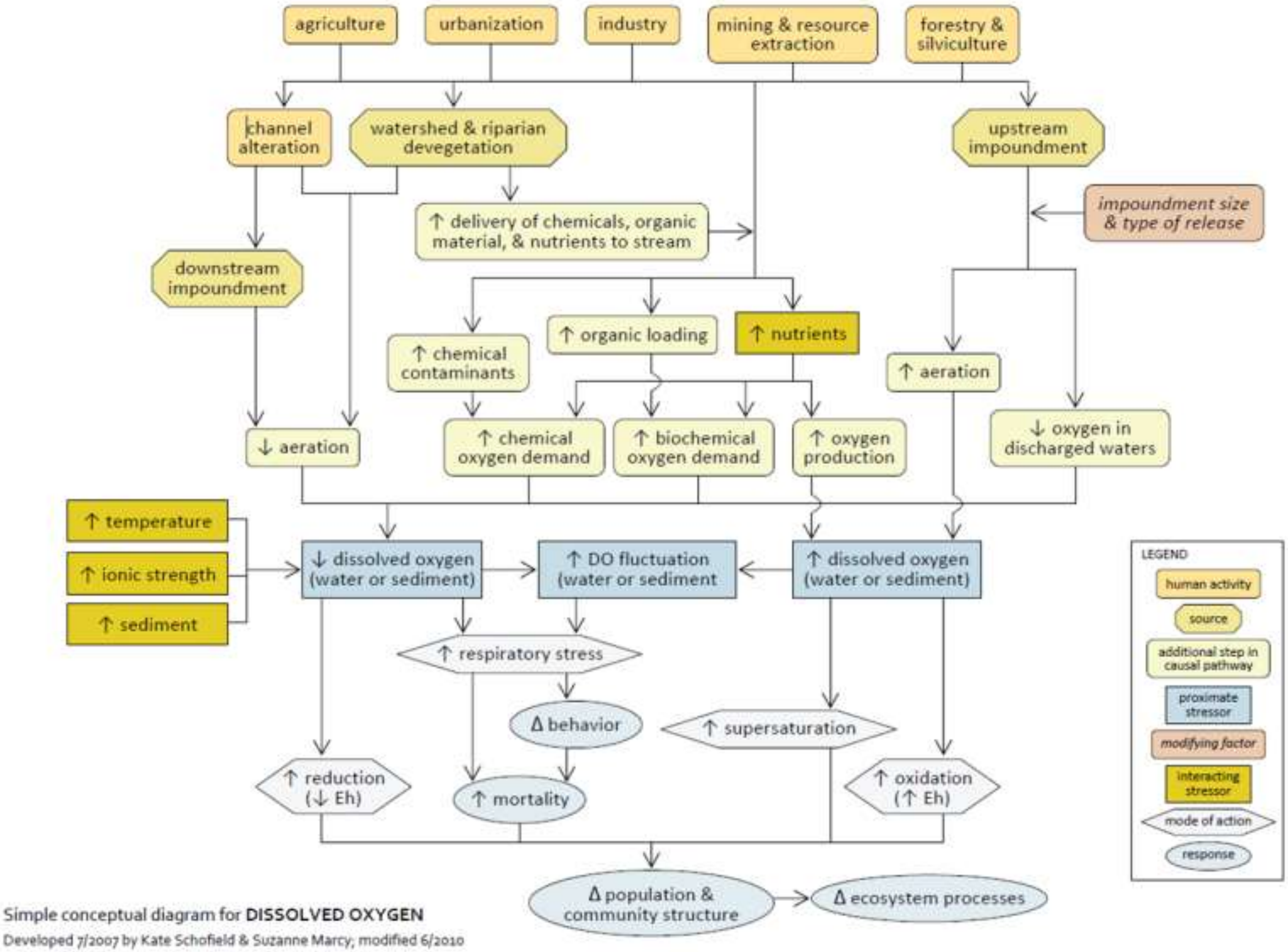
The 2018 ECDP used diel fluctuations in DO mg/L in conjunction with diel fluctuation in water temperature to confirm that diel fluctuations in DO mg/L were not simply a reflection of diel fluctuation in water temperature. In addition, the 2018 ECDP used diel fluctuations in DO mg/L in conjunction with diel fluctuation in pH as an added measure to confirm that diel fluctuations in DO were being driven by stream photosynthesis and respiration, and not solely by diel water temperature fluctuations. DO percent saturation values consider water temperature and provided a means to streamline the rather cumbersome method used in the 2018 ECDP.

The objectives of this new eutrophication cause method (ECM) are to:

1. Develop a method for use on streams with a drainage area larger than 50 mi^2
2. Refine the system used to classify streams
3. Enhance the linkage between stream eutrophication stressor variables and aquatic biological community response variables
4. Streamline the proximate stressor(s) while still accounting for the influence of water temperature on stream DO characteristics

The remainder of this document summarizes the stressor/response relationships observed in the dataset and how these relationships were used to develop a new method (ECM) for identifying eutrophication as a cause of impairment in streams with a drainage area of up to 500 mi^2. The ECM is intended to replace the 2018 ECDP previously used on streams with a drainage area of up to 50 mi2. During the development of the ECM, the USEPA conceptual model diagram for stream dissolved oxygen was used as the framework upon which data were organized, analyzed, and reported (Figure 2a). Within the context of the conceptual model, DO percent saturation daily fluctuation and daily minimum values were used as proximate stressors and annual mean total phosphorus (TP) and annual mean total nitrogen (TN) values were used as interacting stressors.

To account for seasonal variations in abiotic factors influencing stream ecosystem metabolic rates (e.g., water temperature, air temperature, day length, canopy cover, stream discharge conditions, etc.) data were analyzed within the context of four distinct sample periods: 1) April, 2) May & October, 3) June & September, and 4) July & August. Sample periods were constructed around the mid-summer (July-August) peak in water temperature and minimum DO values. These values were recorded by DEP staff between 2013 and 2021 in continuously monitored streams supporting a healthy benthic macroinvertebrate community (Figure 2b). Information about how macroinvertebrate community biological integrity was determined is provided below in Section 4.2.



Simple conceptual diagram for **DISSOLVED OXYGEN**

Developed 7/2007 by Kate Schofield & Suzanne Marcy; modified 6/2010

Figure 2a. USEPA conceptual model diagram for stream dissolved oxygen.

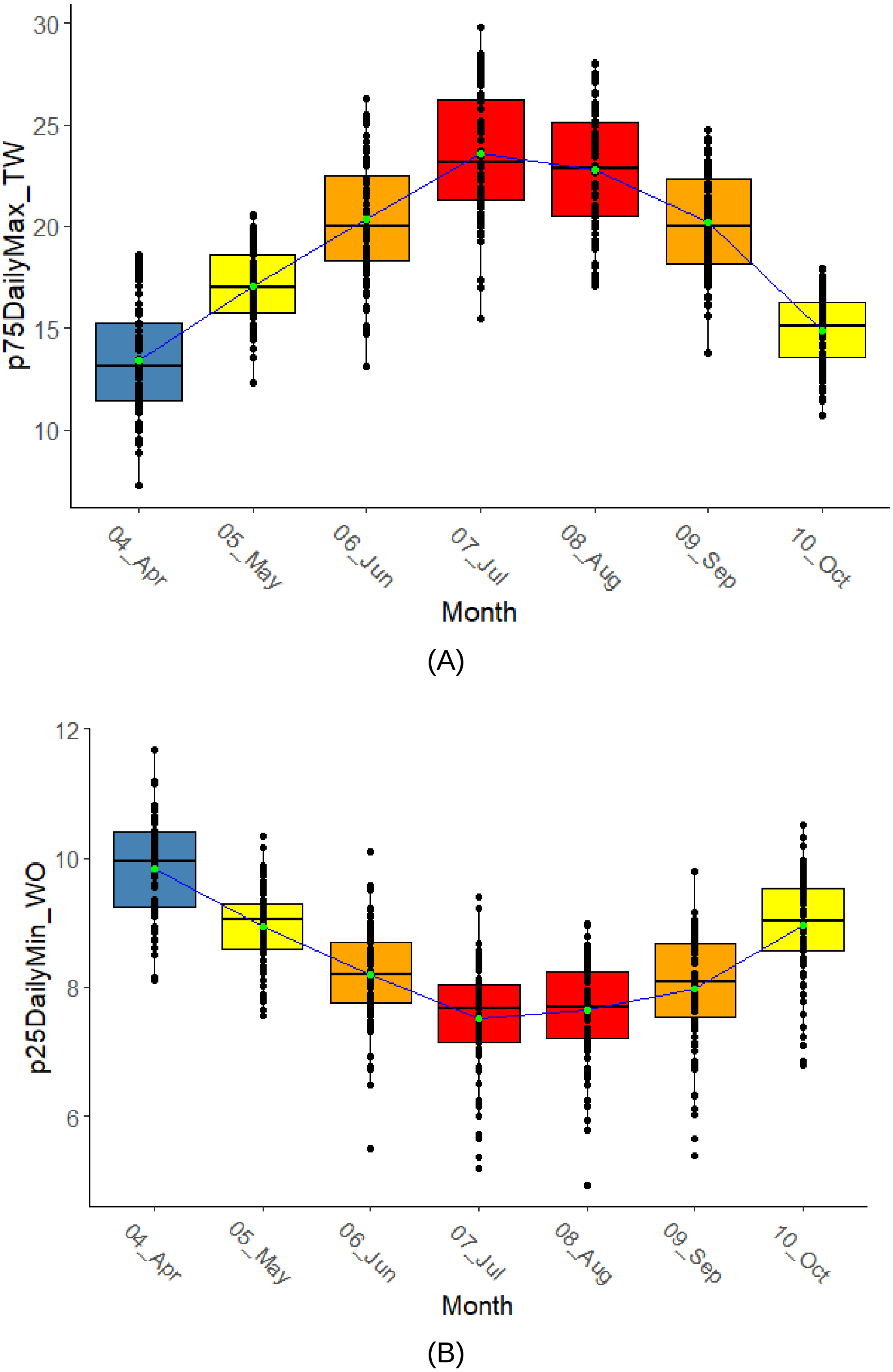


Figure 2b. Monthly 75th percentile value of continuously measured daily maximum water temperature in degrees C (A) and monthly 25th percentile value of continuously measured daily minimum dissolved oxygen in mg/L (B) recorded by DEP staff between 2013 and 2021 in Pennsylvania streams supporting a healthy macroinvertebrate community. Boxes are color-coded by four sample periods (April, May & October, June & September, and July & August).

3. STRESSOR VARIABLES

3.1 Stressor Variable Dataset

The data used to develop the ECM (calibration dataset) consisted of data from 148 spatially unique stations in Pennsylvania. Throughout the remainder of this document, the term station refers to a specific location where data were collected, and the term sample refers to data collected at a given station during a specific calendar year. Data were collected during multiple years at 18 stations, and at an additional nine stations that were located on the same stream as, and in close proximity to, a calibration sample, yielding an additional 32 samples (ancillary samples) that were not used in the development of the method. The geographic distribution of calibration and ancillary samples is shown in Figure 3.1a.

Modeled data from the Model My Watershed Program (Stroud Water Research Center 2021) were used to characterize station watershed land cover, air temperature, and TP and TN loading rates. Station watershed drainage area, percent carbonate geology, and estimated values of bankfull width and bankfull depth were obtained from the USGS StreamStats website (USGS 2016). Station elevation and channel slope values were generated from NHD segment data obtained from the USGS National Map website (USGS 2019).

Data sondes were deployed between April 1 and October 31 during the 2013 through 2021 field seasons. During sonde maintenance visits (approximately monthly), discrete water chemistry samples were collected for laboratory analysis of total phosphorus (TP), total nitrogen (TN), and total alkalinity (Alk) in accordance with Shull and Arnold (2023). Results that were reported as being below the detection limit (DL) were estimated to be equal to $DL/\sqrt{2}$ as recommended in Croghan and Egeghy (2003). Discrete water chemistry data (TP, TN, and Alk) collected over the period a sonde was deployed in a given calendar year were summarized and reported as mean annual concentrations.

The calibration dataset encompassed a wide range of environmental conditions with watershed drainage areas ranging from 1.1 to 498.0 mi^2, channel slope values ranging from 0.03 to 4.01%, percent carbonate geology ranging from 0 to 100%, and mid-summer (July-August) mean air temperature values ranging from 18.3 to 24.3 C. Percent forest cover ranged from 0.1 to 97.3%, annual mean TP values ranged from 0.003 to 1.637 mg/L, and annual mean TN values ranged from 0.17 to 21.86 mg/L. Descriptive statistics of calibration sample environmental parameters are summarized in Table 3.1a and Figure 3.1b. Location, land cover, nutrient, and other information about calibration and ancillary samples is summarized in Appendix A.

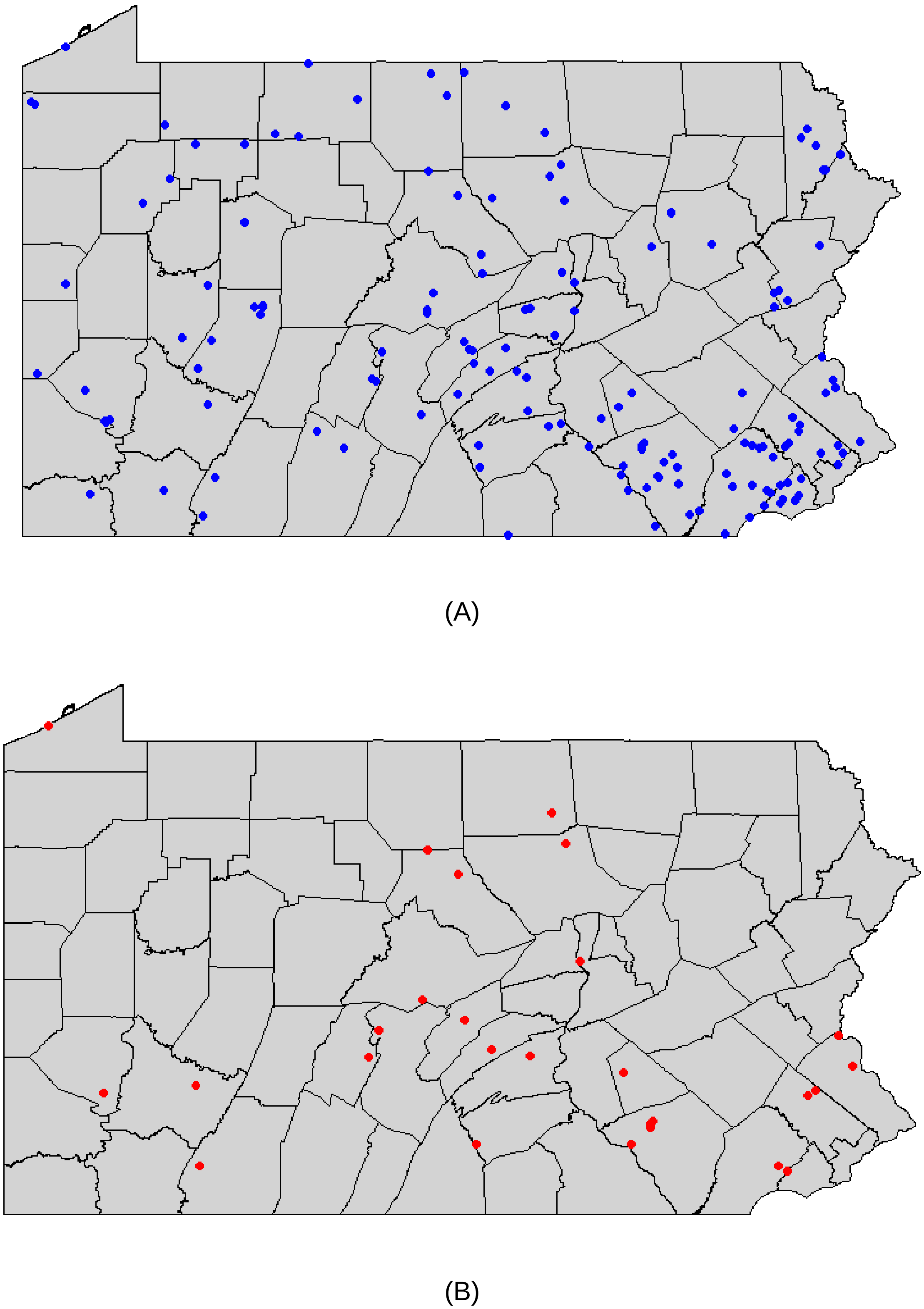


Figure 3.1a. Geographic distribution of (A) 148 calibration samples used in the development of the ECM and (B) 32 ancillary samples.

Table 3.1a. Summary table of descriptive statistics of calibration dataset.

Parameter	Min	Q1	Median	Mean	StDev	Q3	Max	N
DrainageArea_mi2	1.1	11.2	26.8	71.7	106.2	78.9	498.0	148
Elev_Station_ft	46	284	568	660	440	1009	1995	148
Latitude	39.73	40.12	40.45	40.61	0.62	40.99	42.07	148
Longitude	-80.47	-78.17	-76.93	-77.09	1.57	-75.61	-74.96	148
AirTemp_JulAug_Mean_C	18.3	20.5	21.8	21.6	1.5	22.9	24.3	148
Carbonate_%	0.0	0.0	0.0	11.8	23.9	10.8	100.0	148
Alk_mg/L_AnnualMean	4.6	28.1	59.5	73.5	56.7	102.0	265.0	145
ChannelSlope_TNM/NHD_%	0.03	0.23	0.41	0.60	0.60	0.79	4.01	148
Forest_%	0.1	28.8	54.2	51.1	26.5	72.7	97.3	148
Agriculture+Developed_%	0.4	23.7	40.8	44.3	26.7	65.5	99.5	148
TP_mg/L_AnnualMean	0.003	0.015	0.032	0.110	0.221	0.101	1.637	148
TN_mg/L_AnnualMean	0.17	0.54	1.53	2.67	3.16	3.60	21.86	148

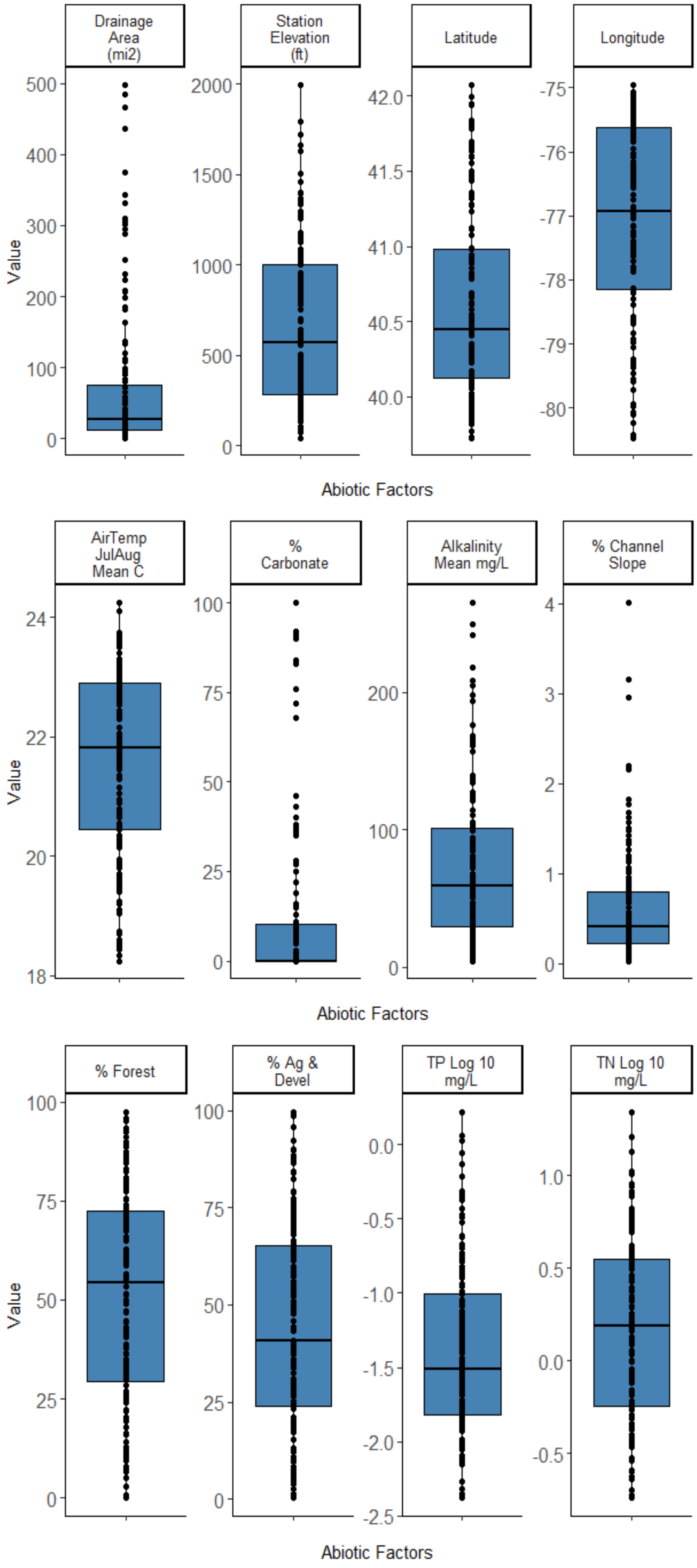


Figure 3.1b. Box plots showing the distribution of selected environmental parameter values of calibration samples.

3.2 Proximate Stressor Variables

Continuously measured DO %Sat daily range and daily minimum values were used as proximate stressor variables (see conceptual model diagram Figure 2a). The duration of data sonde deployment at a given station ranged from one to seven months (calibration dataset average = 5.9 months) between April 1 and October 31 during the 2013 through 2021 field seasons. Dissolved oxygen, water temperature, specific conductance, and pH were continuously measured at half-hour intervals, and data were collected, graded, and approved for use in accordance with the DEP *Continuous Physicochemical Data Collection Protocol* (Hoger and Arnold 2023). Continuous data that did not meet the usability criteria were removed from the dataset and excluded from these analyses. Diel values were calculated for days with continuous data representing at least 75% of the day (e.g., a minimum of 36 readings at ½ hour intervals). Days that were monitored for less than 75% of the day were not included in the dataset.

Percent saturation values were used to compensate for the influence of water temperature on stream dissolved oxygen levels. Daily range values were calculated as the difference between the maximum and minimum value recorded on a given calendar day, and daily minimum values were the minimum value recorded on a given calendar day. Proximate stressor variables (%Sat daily range and %Sat daily minimum) were summarized by month using the 75th percentile value (p75) of %Sat daily range (p75DailyRange_WX) and the 25th percentile value (p25) of %Sat daily minimum (p25DailyMin_WX) values recorded at a given station within a given month (Figure 3.2a).

Monthly p75DailyRange_WX and p25DailyMin_WX values were used to characterize the degree of metabolic activity (primary production (P) and ecosystem respiration (ER)) occurring under peak conditions (highest P and ER rates) at a given station within a given month. Monthly p75 and p25 values were generated for months that had approved daily values recorded for a minimum of 14 days in that month. For example, if a sonde was deployed at Station X from April 1 to April 31 but yielded less than 14 daily values after applying the usability thresholds from Hoger and Arnold. (2023), and the 75% daily coverage requirement described above, no monthly p75 or p25 values were calculated for that month. Calibration and ancillary sample monthly p75DailyRange_WX and p25DailyMin_WX values are shown in Appendix B.

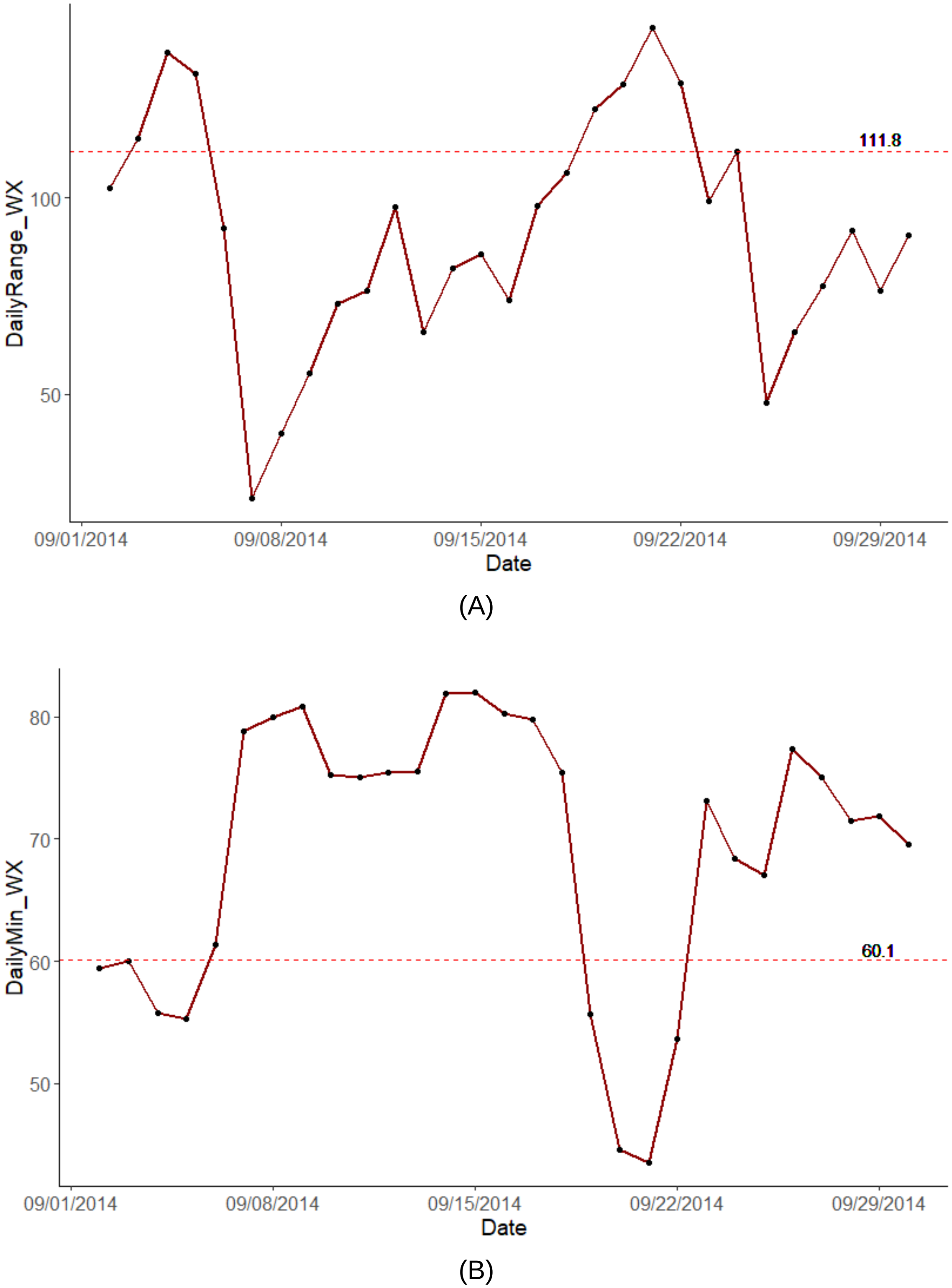


Figure 3.2a. Graphic representation of (A) daily and monthly 75th percentile values of DailyRange_WX (p75=111.8 %Sat) and (B) daily and monthly 25th percentile values of DailyMin_WX (p25=60.1 %Sat) recorded at Indian Creek (Rt 63) in September of 2014. Points represent daily values and horizontal lines represent monthly percentile values.

4. STREAM-TYPE CLASSIFICATION AND EUTROPHICATION STRESS CLASSES

USEPA eutrophication-related guidance documents strongly encourage classifying streams to reduce variability within identified classes and to maximize inter-class variability so that data can be compared or extrapolated within classes (USEPA 2000, USEPA 2010). USEPA (2000) prescribes a two-phased approach to classifying streams. Initially, streams are classified based primarily on physical parameters associated with regional and site-specific characteristics such as climate, geology, channel morphology (width, depth, slope, substate composition), and stream discharge characteristics. The second phase involves classifying streams by eutrophication gradient.

A similar two-phased approach was used, and the results showed that classification enhanced the ability to detect and document the relationships outlined in the conceptual model diagram linking nutrients, DO characteristics, and macroinvertebrate community structure and composition (Figure 2a). First, stations were classified based on natural abiotic factors, using a combination of landscape-level geographic features and watershed drainage area (stream-type classification). The emphasis of this phase of classification was to classify streams using practical, readily available regionalization classes and abiotic attributes linked to Odum's metabolism equation (Equation 2.1). The second phase of classification is anthropogenic-related and involved classifying samples into eutrophication stress classes, discussed below in Section 4.2.

4.1 Stream Type Classification

The purpose of the stream-type classification was to see if classification could enhance the ability to detect important relationships in the dataset using practical, readily available regionalization classes and abiotic attributes. The goal was to identify station attributes that would allow for the modeling of expected monthly p75DailyRange_WX and p25DailyMin_WX values of streams subject to low levels of eutrophication stress, given their natural physical attributes.

Sample eutrophication stress levels were determined using principal components analysis (PCA) to linearize the combined signal of the four intercorrelated eutrophication stressor variables (TP, TN, p75DailyRange_WX, and p25DailyMin_WX) into one synthetic eutrophication stress gradient. Stressor variable values were standardized by their z-score prior to running PCA so that each variable contributed equally to the analysis. Stressor variable z-scores were calculated as:

$$z = \frac{value - mean}{standard\ deviation} \qquad \text{Equation 4.1}$$

For each calibration sample, the four-sample period z-scores were calculated independently for both proximate stressors (p75DailyRange_WX and p25DailyMin_WX). These z-scores were used in conjunction with mean annual TP and TN z-scores in the PCA. Thus, the data matrix used in the PCA consisted of 148 rows (calibration samples) x four columns (sample z-scores of annual mean TP, annual mean TN, four sample period mean p75DailyRange_WX and four sample period mean p25DailyMin_WX). The PCA was run on the covariance matrix using function prcomp in base R (R Core Team, 2018).

Samples were categorized as low, moderate, and high eutrophication stress samples based on their PCA Axis 1 score percentile rank value, with percentile rank values <0.333 categorized as low eutrophication stress samples, percentile rank values from 0.333 to 0.666 categorized as moderate eutrophication stress samples, and percentile rank values >0.666 categorized as high eutrophication stress samples (Figure 4.1a).

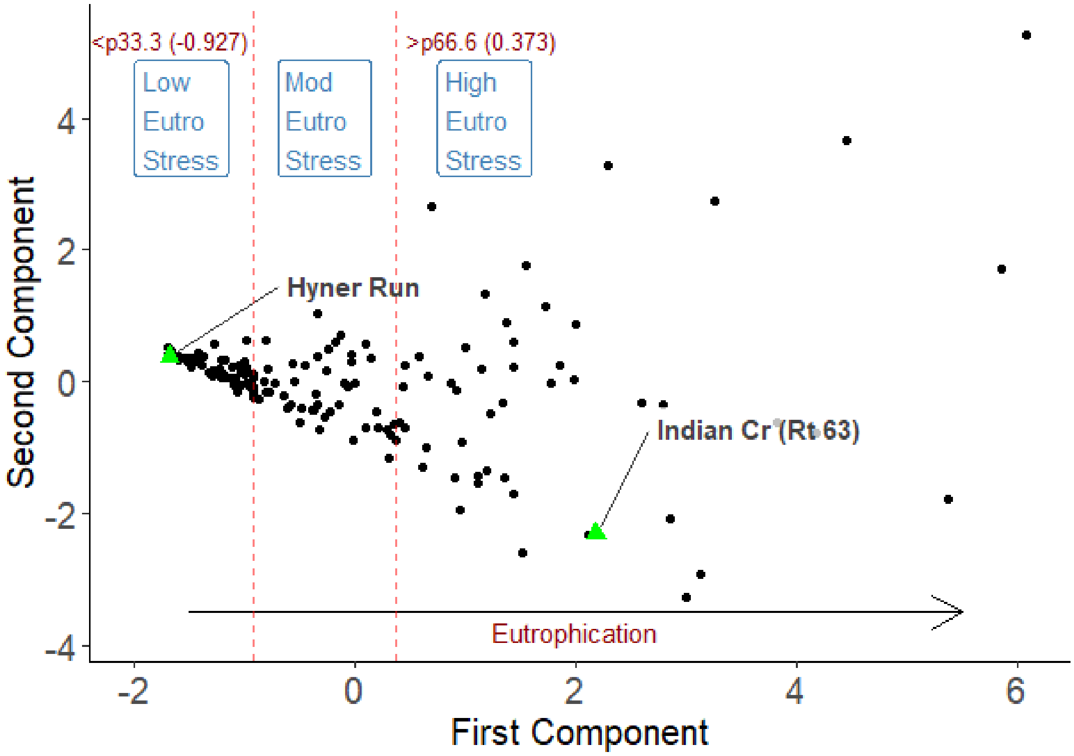


Figure 4.1a. Calibration sample PCA axis 2 vs PCA axis 1 scores by eutrophication stress level. Hyner Run-2015 is an example of low eutrophication stress sample and Indian Cr (Rt 63)-2014 is an example of a high eutrophication stress sample.

Spearman correlation analysis run on PCA axis 1 scores vs. interacting and proximate stressor variables confirm that PCA effectively linearized the combined signal of four stressor variables into one synthetic eutrophication stress gradient (Table 4.1a).

A suite of 13 station attributes were evaluated as potential classification variables (Table 4.1b) using bootstrap-aggregated regression tree analysis (bagged CART Classification and Regression Training) using the caret package in R, method = “treebag” (Kuhn 2008). Regression tree analyses were run on low eutrophication stress samples (discussed above) that had a supporting benthic macroinvertebrate community (discussed in Section 5 below). Regression tree analyses were run with the 13 potential classification variables shown in Table 4.1b as predictors and sample period p75DailyRange_WX and p25DailyMin_WX values as response variables. Regression tree variable importance plots are shown in (Figures 4.1b and 4.1c). These plots show the relative importance of the predictor variables most important in predicting p75DailyRange_WX and p25DailyMin_WX values.

Regression tree results, indicate that the importance of predictor variables varied by sample period, with elevation, longitude, air temperature, and channel slope identified as the most important variables in April and drainage area, channel slope, and elevation being most important variables from May through October (Figure 4.1d). Focusing on the most important predictor variables identified in the regression tree analysis, a practical classification system that is driven by these variables and reflects the eutrophication gradient of the dataset was constructed. First, the effectiveness of using physiographic province, physiographic section, level 3 and level 4 Omernik ecoregions, and USEPA nutrient ecoregions (Omernik 2000) as existing regional classification systems to account for differences in station elevation values was explored. After exploring these regional classification systems, a conclusion was made that the USEPA nutrient ecoregion classification system was the system that best reflected regional patterns in elevation. In addition, it was determined that USEPA nutrient ecoregions could be aggregated to classify Pennsylvania into two distinct regions, a northern tier (nutrient ecoregions VII, VIIIa, and VIIIb) and a southern tier (nutrient ecoregions VIIIc, IX, and XI) with distinct elevation characteristics (Figure 4.1e).

Next, the ridges and high elevation areas of the southern tier (Omernik level 4 ecoregions 66a, 66b, 67c, 67d, 67e, 67m, 69a, and 69b) were placed with the northern tier, dividing the state into the two eutrophication regions shown in Figure 4.1f. Categorizing the state into two eutrophication regions provides a practical means for delineating the state into higher- elevation vs. lower-elevation regions of Pennsylvania and also reflects the geographic patterns in the remaining three variables of highest importance in April (Figure 4.1g).

Table 4.1a. Spearman correlation results of PCA axis 1 scores vs interacting and proximate stressor variables.

Parameter	**PCA Axis1 Score**	**TP mg/L Annual Mean**	**TN mg/L Annual Mean**	**p75 Daily Range WX Apr**	**p75 Daily Range WX MayOct Mean**	**p75 Daily Range WX JunSep Mean**	**p75 Daily Range WX JulAug Mean**	**p25 Daily Min WX Apr**	**p25 Daily Min WX MayOct Mean**	**p25 Daily Min WX JunSep Mean**
TP mg/L Annual Mean	0.84									
TN mg/L Annual Mean	0.79	0.75								
p75 Daily Range WX Apr	0.92	0.81	0.76							
p75 Daily Range WX MayOct Mean	0.86	0.63	0.59	0.87						
p75 Daily Range WX JunSep Mean	0.81	0.54	0.47	0.81	0.92					
p75 Daily Range WX JulAug Mean	0.78	0.48	0.43	0.77	0.91	0.96				
p25 Daily Min WX Apr	-0.87	-0.77	-0.66	-0.90	-0.74	-0.70	-0.66			
p25 Daily Min WX MayOct Mean	-0.85	-0.66	-0.52	-0.78	-0.79	-0.74	-0.69	0.83		
p25 Daily Min WX JunSep Mean	-0.84	-0.61	-0.43	-0.72	-0.77	-0.79	-0.76	0.78	0.89	
p25 Daily Min WX JulAug Mean	-0.79	-0.56	-0.37	-0.65	-0.76	-0.78	-0.78	0.71	0.84	0.96

Table 4.1b. Regionalization classes and abiotic attributes linked to Odum's metabolism equation (Equation 2.1) used in bootstrap-aggregated regression tree analysis. Daily DO % saturation range and daily DO % saturation minimum values were used as response variables.

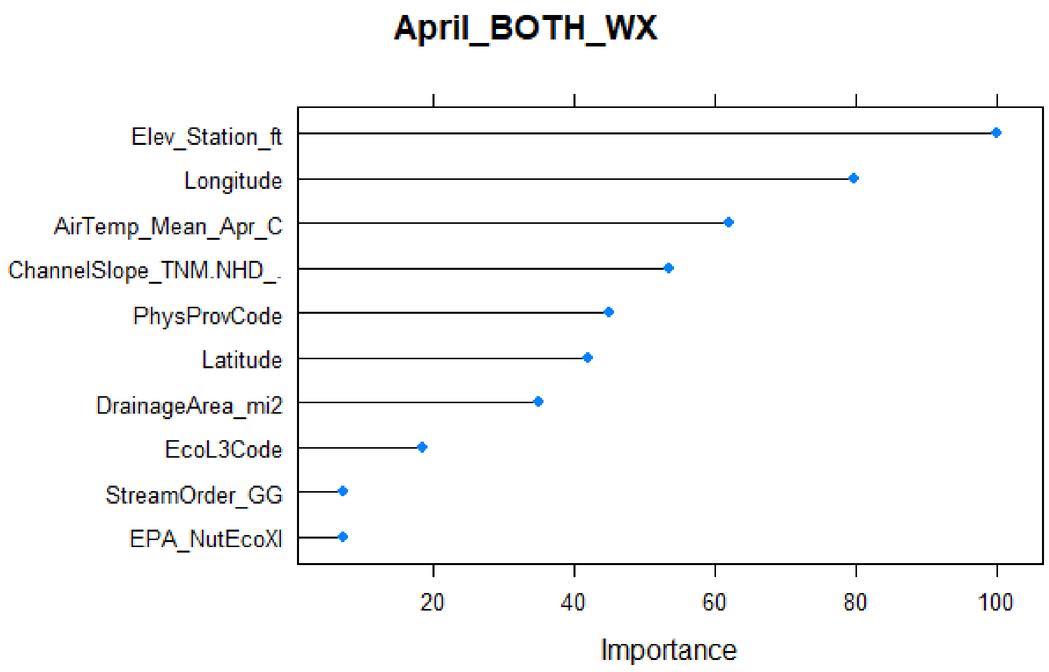
Abiotic Attribute	**Description**	**Attribute Type**	**Odum's Eq. Primary Parameter(s) Influenced***
PhysProvCode	Physiographic province	Regionalization	
PhysSecCode	Physiographic section		
EPA_NutEco	USEPA nutrient ecoregion		
EcoL3Code	Omernik level III ecoregion		
EcoL4Code	Omernik level IV ecoregion		
DrainageArea_mi2	Drainage area (mi^2)	Stream Size	P, R, K
StreamOrder	Strahler stream order		
Slope_TNM.NHD	NHD modeled channel slope	Channel Morphology	K
Latitude	Latitude of station	Temperature and Light	P, R, K
AirTemp_Mean	Modeled mean air temperature (C)	Temperature	P, R, K
Elev_Station_ft	Station elevation (ft)		
Longitude	Longitude of station		
Carbonate_%	Watershed percent carbonate geology	Geology	A

[1] P=primary production

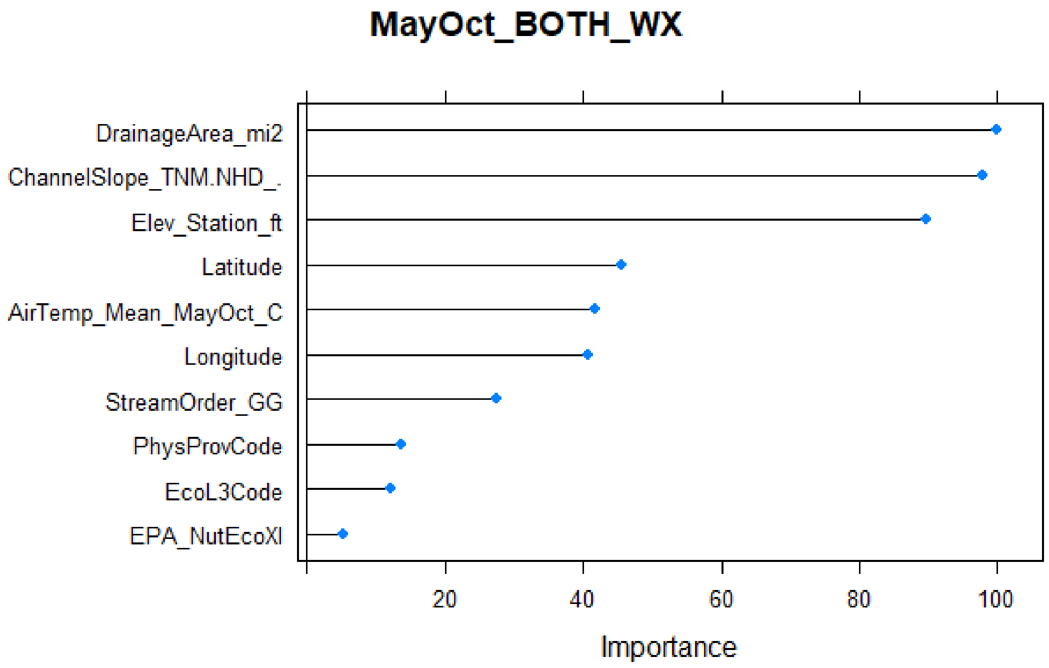
[2] R=ecosystem respiration

[3] K=oxygen exchange with the atmosphere

[4] A=rate of influx or loss of oxygen with accrual of ground and surface water

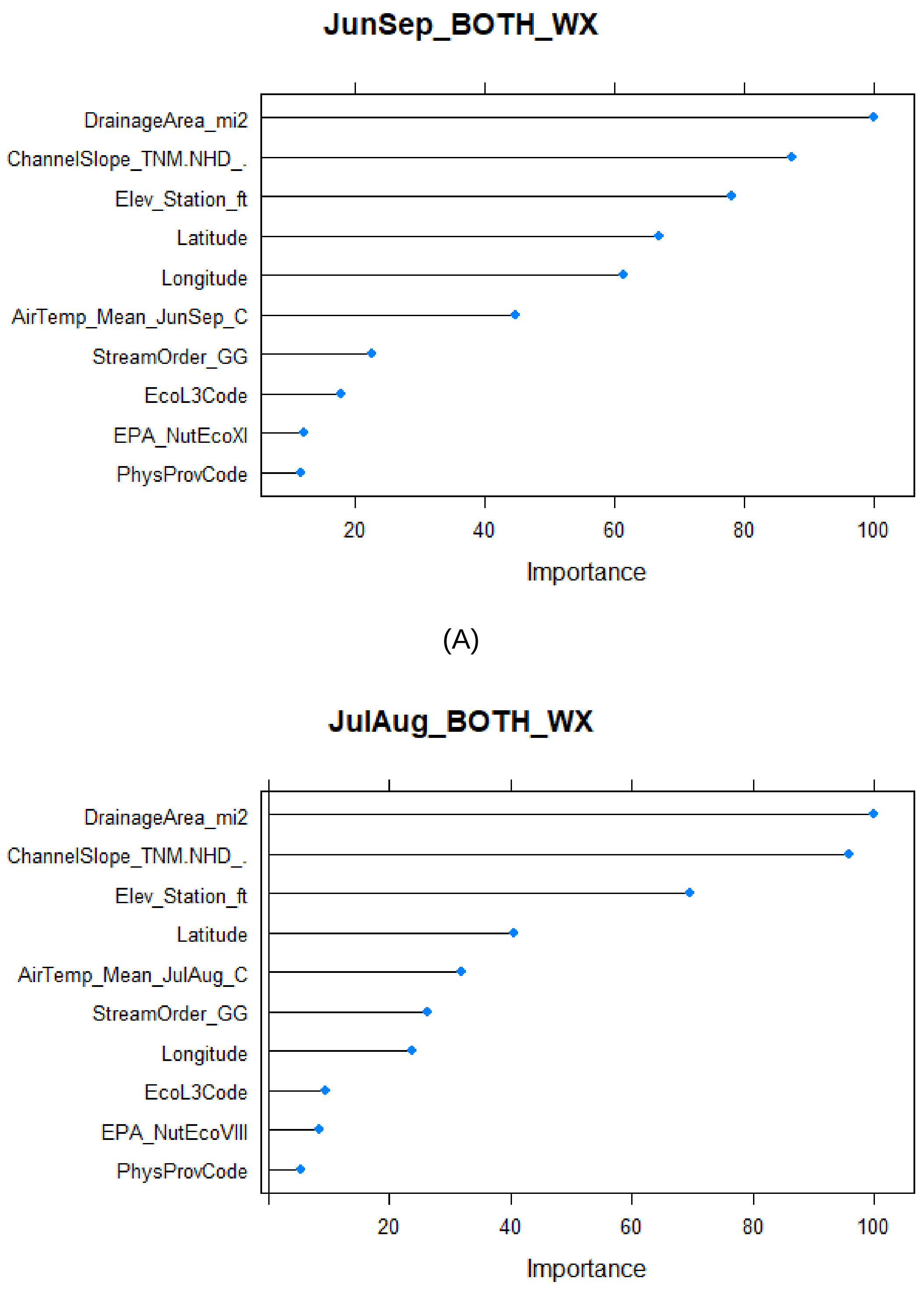


(A)



(B)

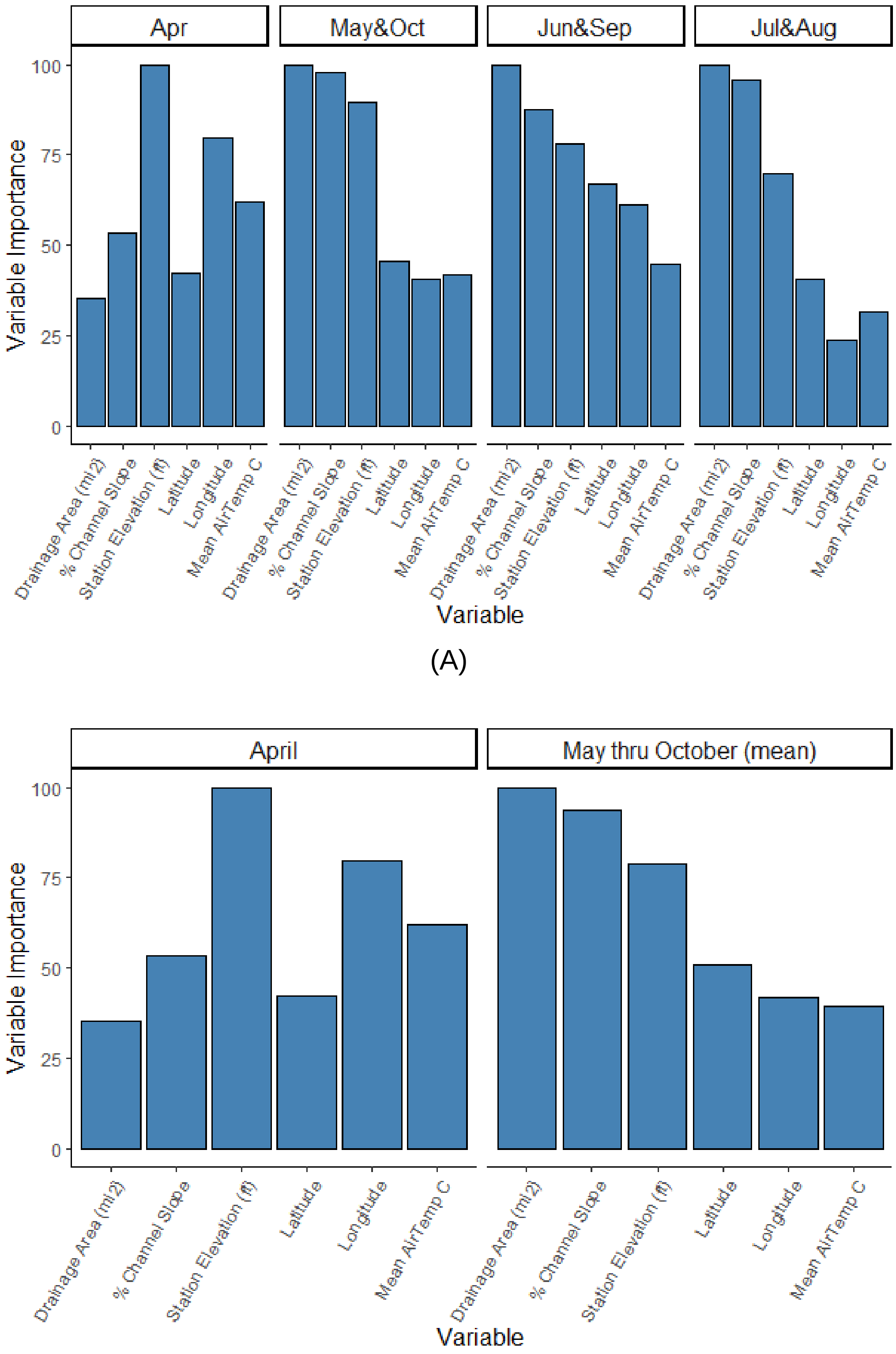
Figure 4.1b. Bootstrap-aggregated regression tree variable importance plots of low eutrophication stress samples had an aquatic life use- supporting macroinvertebrate community using April (A) and May & October (B) DO saturation response variables.



(A)

(B)

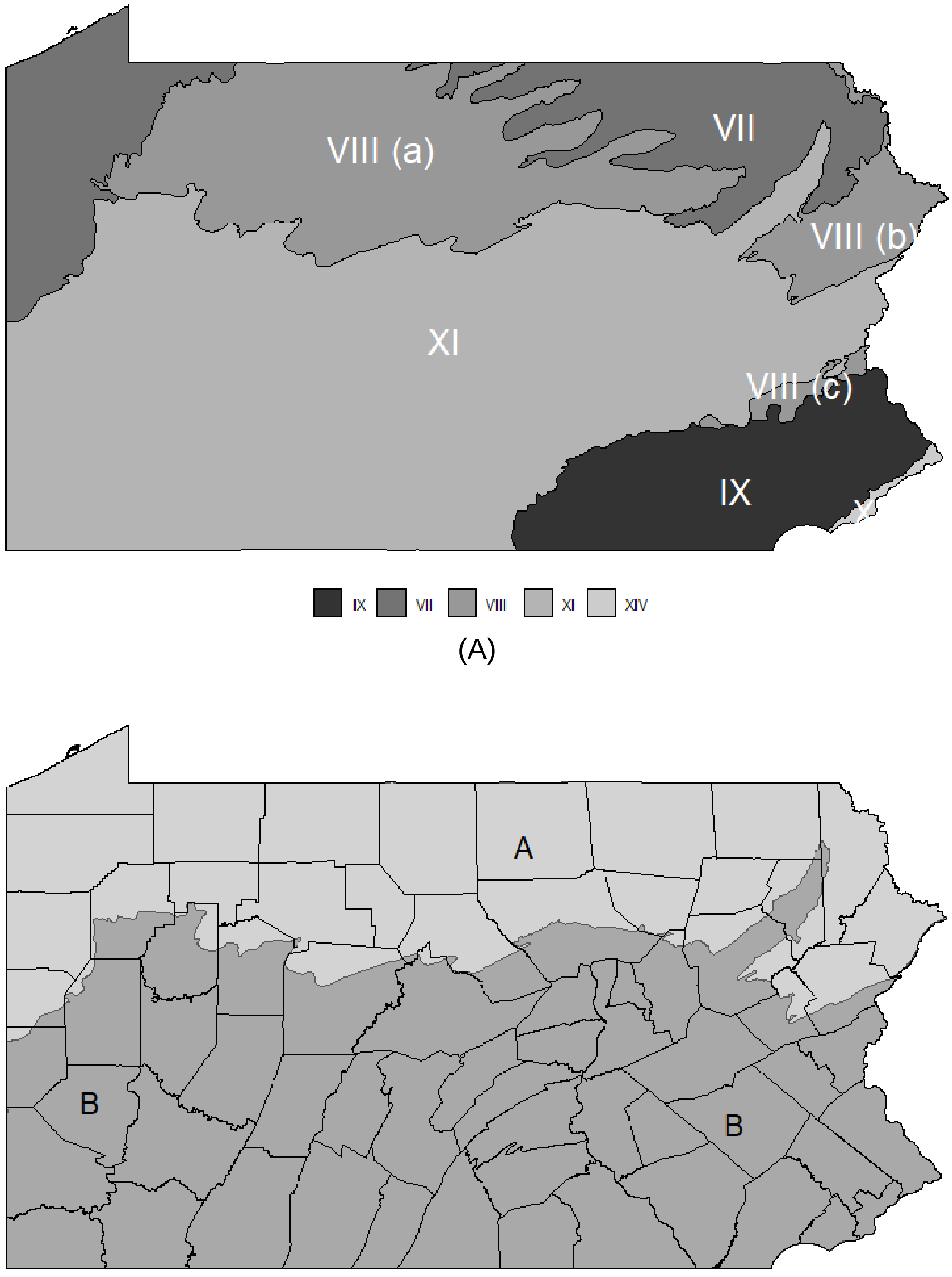
Figure 4.1c. Bootstrap-aggregated regression tree variable importance plots of low eutrophication stress samples had an aquatic life use- supporting macroinvertebrate community using June & September (A) and July & August (B) DO saturation response variables.



(A)

(B)

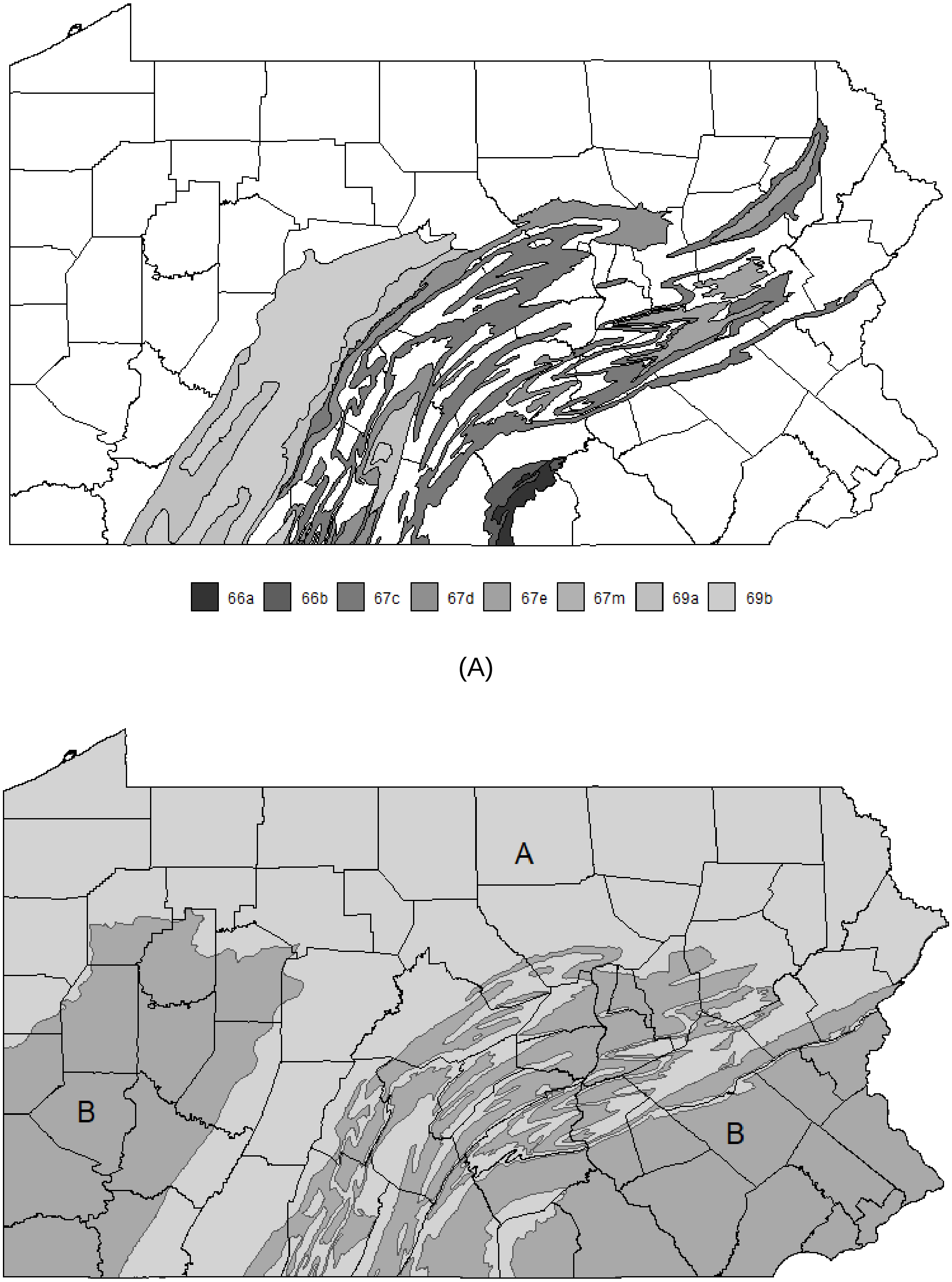
Figure 4.1d. Bootstrap-aggregated regression tree variable importance plots by sample period (A) and by April vs May through October combined (B).



(A)

(B)

Figure 4.1e. USEPA nutrient ecoregions of Pennsylvania (A) and aggregated USEPA nutrient ecoregions delineating Pennsylvania into two broad regions, a northern tier (USEPA nutrient ecoregions VII and VIII(a) and (b)) and a southern tier (USEPA nutrient ecoregions VIII(c), IX, XI, and XIV).



(A)

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Figure 4.1f. Ridges and high elevation areas in the southern tier merged with the northern tier (A) and Pennsylvania eutrophication regions (B).

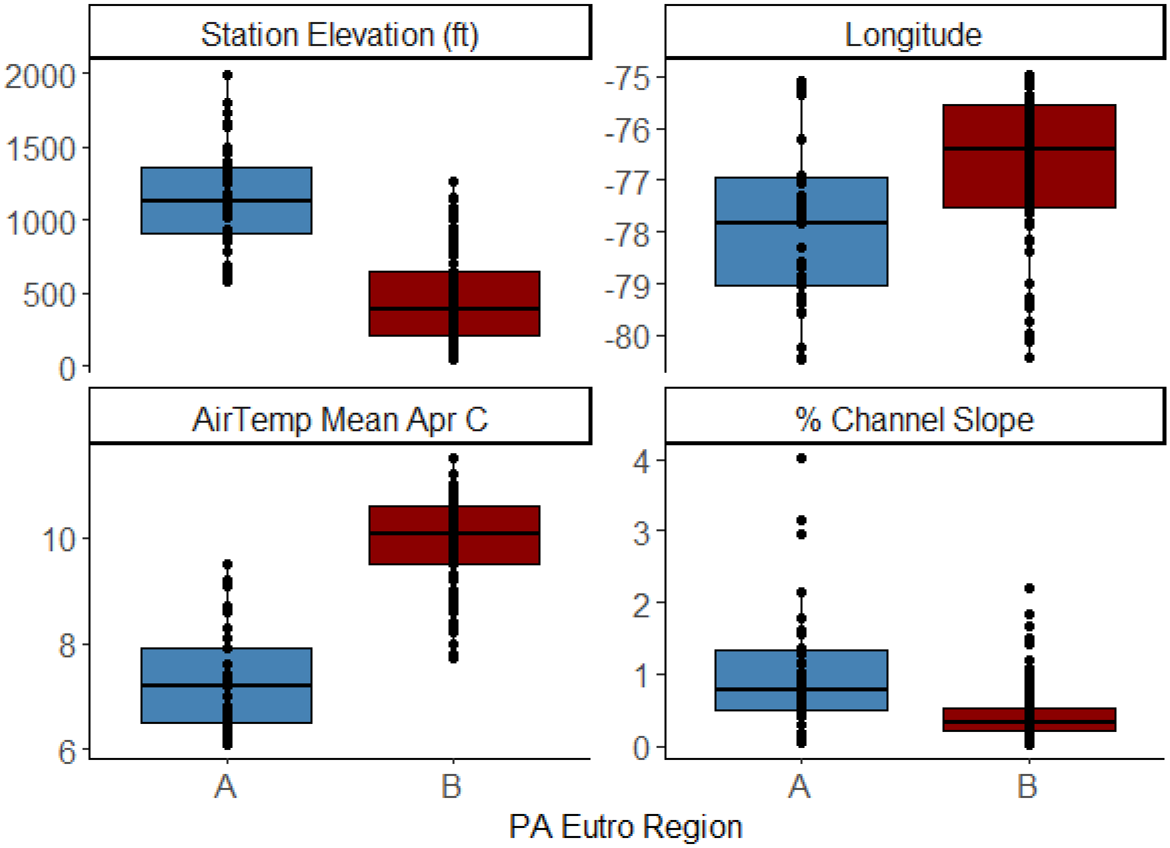


Figure 4.1g. Station elevation, longitude, April mean air temperature, and channel slope values by PA eutrophication region.

Since PA eutrophication regions alone account for the four most-important classification parameters identified in April bootstrap regression tree analysis and drainage area is of minimal importance in April, samples are classified based solely on PA eutrophication regions in that sample period.

Bootstrap regression tree analysis from May through October indicate that drainage area, channel slope, and elevation are the most important variables during those sample periods (Figure 4.1d). Similar to the May through October regression tree results, Olivero Sheldon et al. (2015) identified drainage area and channel gradient as important variables for classifying natural aquatic habitats of streams and small rivers in the Appalachian region, which includes nearly all of Pennsylvania and parts of 16 other states. Olivero Sheldon et al. (2015) identified a drainage area of 38.6 mi^2 as an ecologically meaningful initial major division between the biota (macroinvertebrates and fish) of “headwaters and creeks” vs. the biota of “rivers”.

The drainage area of 38.6 mi^2 identified by Olivero Sheldon et al. (2015) was used as a breakpoint for organizing samples into two distinct size classes (<38.6 mi^2 and 38.6-500 mi^2), whereby accounting for the strong effect stream size has on stream ecosystem metabolism and biological assemblages (Vannote et al. 1980, Diamond et al. 2021). Interestingly, the drainage area breakpoint of 38.6 mi^2 in the calibration dataset corresponds very closely to the approximate third order breakpoint used in the River Continuum Concept (RCC) (Vannote et al. 1980) separating heterotrophic “headwater streams” from autotrophic “medium-sized rivers”. In addition, organizing the dataset at a drainage area of 38.6 mi^2 separated stations into two distinct channel slope classes (Figure 4.1h).

The classification system described above yielded a classification system consisting of the two eutrophication regions shown in Figure 4.1f (B) and two drainage area classes (<38.6 mi^2 and 38.6-500 mi^2) during the May through October timeframe. Classifying stations by the two eutrophication regions and two drainage area classes categorizes samples into one of four stream types:

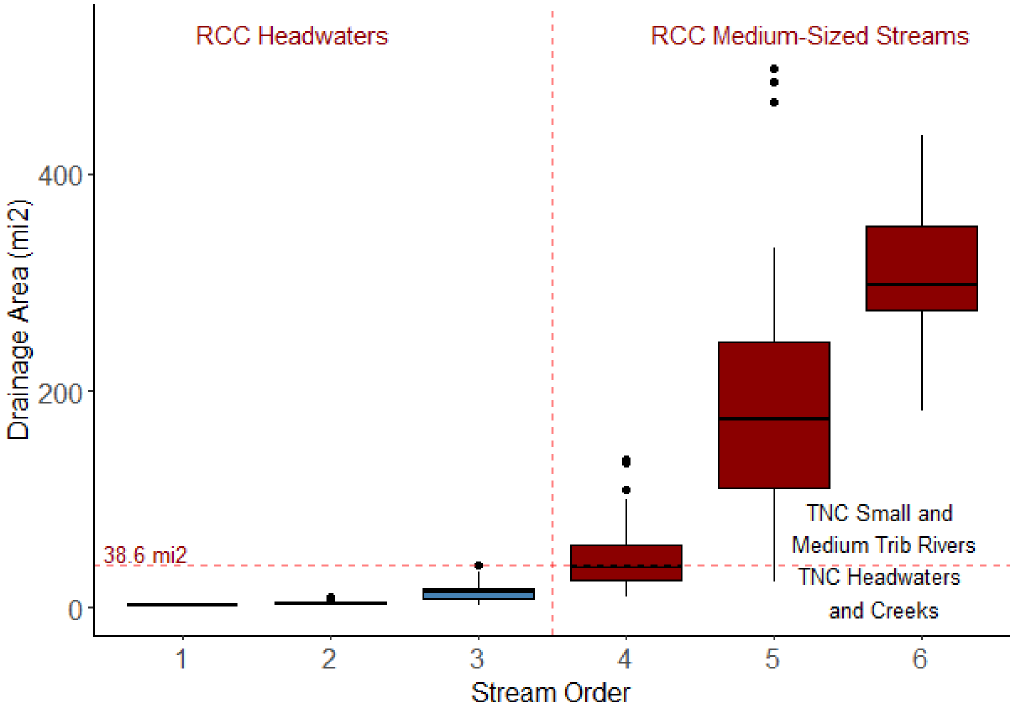
1. <38.6 mi2 – Pennsylvania eutrophication region A
2. <38.6 mi2 – Pennsylvania eutrophication region B
3. 38.6-500 mi2 – Pennsylvania eutrophication region A
4. 38.6-500 mi2 – Pennsylvania eutrophication region B

After classifying calibration samples into the four stream types described above, it became apparent that the number of samples with a drainage area between 38.6 and 500 mi^2 in Pennsylvania eutrophication region A was considerably less than the other three stream types. In addition, Tukey test results indicate that channel slope values of 38.6-500 mi^2 streams are similar, regardless of their eutrophication region (Figure 4.1i).

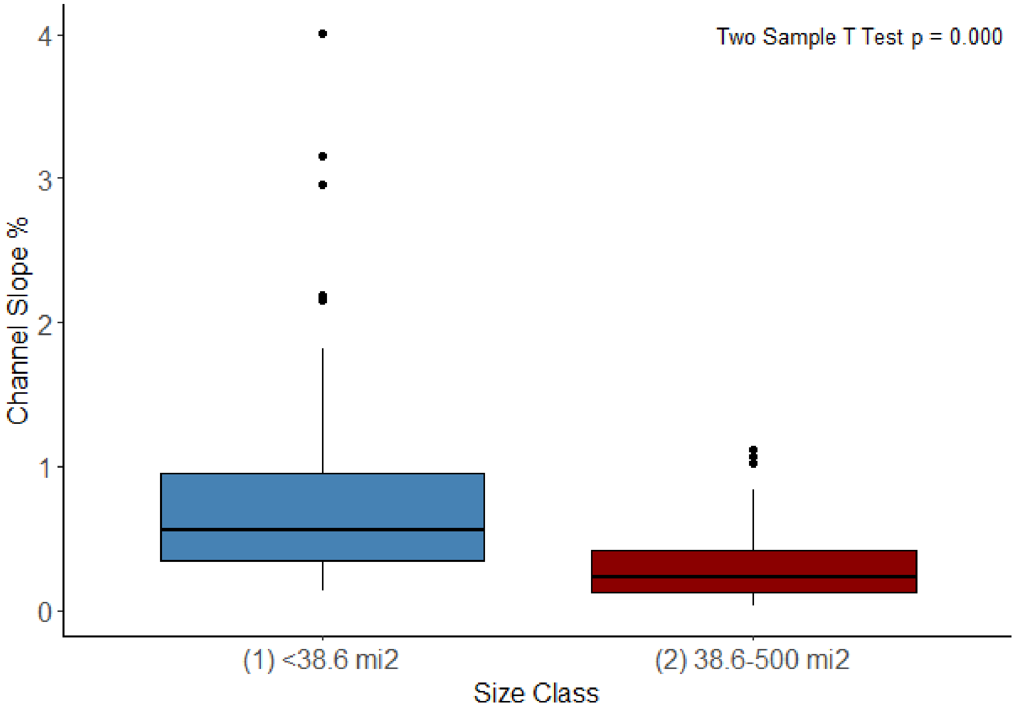
Based on these observations, all 38.6-500 mi^2 streams were combined into a single statewide stream type class resulting in a stream type classification system consisting of the following three stream types:

1. <38.6 mi2 – Pennsylvania eutrophication region A
2. <38.6 mi2 – Pennsylvania eutrophication region B
3. 38.6-500 mi2 – Statewide

The classification system described above provides a practical means for categorizing samples in a manner that reflects the four predictor variables of highest importance in April (elevation, longitude, air temperature, and channel slope, Figure 4.1g) and the three predictor variables of highest importance between May and October (drainage area, channel slope, and elevation, Figure 4.1j). The geographic distribution of calibration stations by stream type is shown in (Figure 4.1k). Station stream type information is summarized in Appendix C.



(A)



(B)

Figure 4.1h. Station drainage area vs Strahler stream order (A) and channel slope values by stream size class (B). Reference line at 38.6 mi^2 in (A) is from Olivero Sheldon et al. (2015).

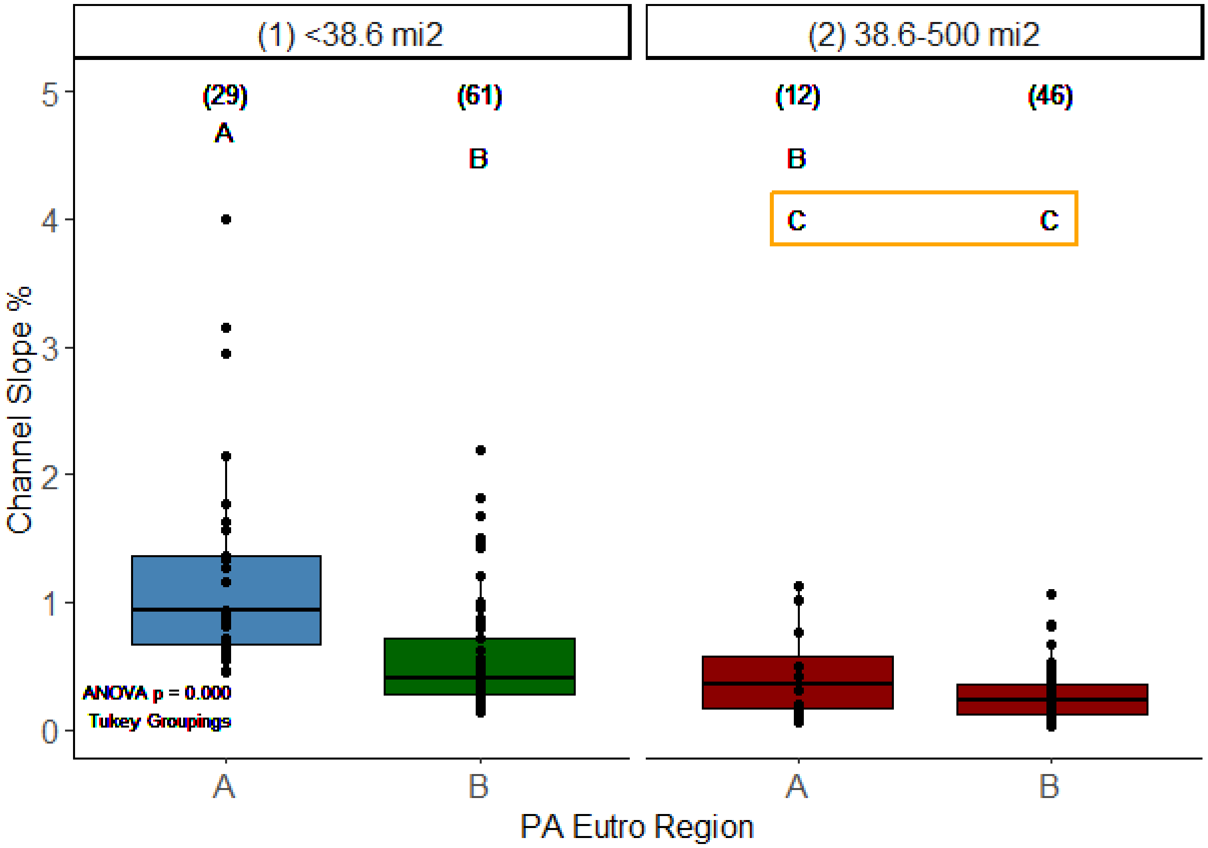


Figure 4.1i. Channel slope values of calibration samples by size class and PA eutrophication region with Tukey comparison groupings labeled as A, B, and C above boxes.

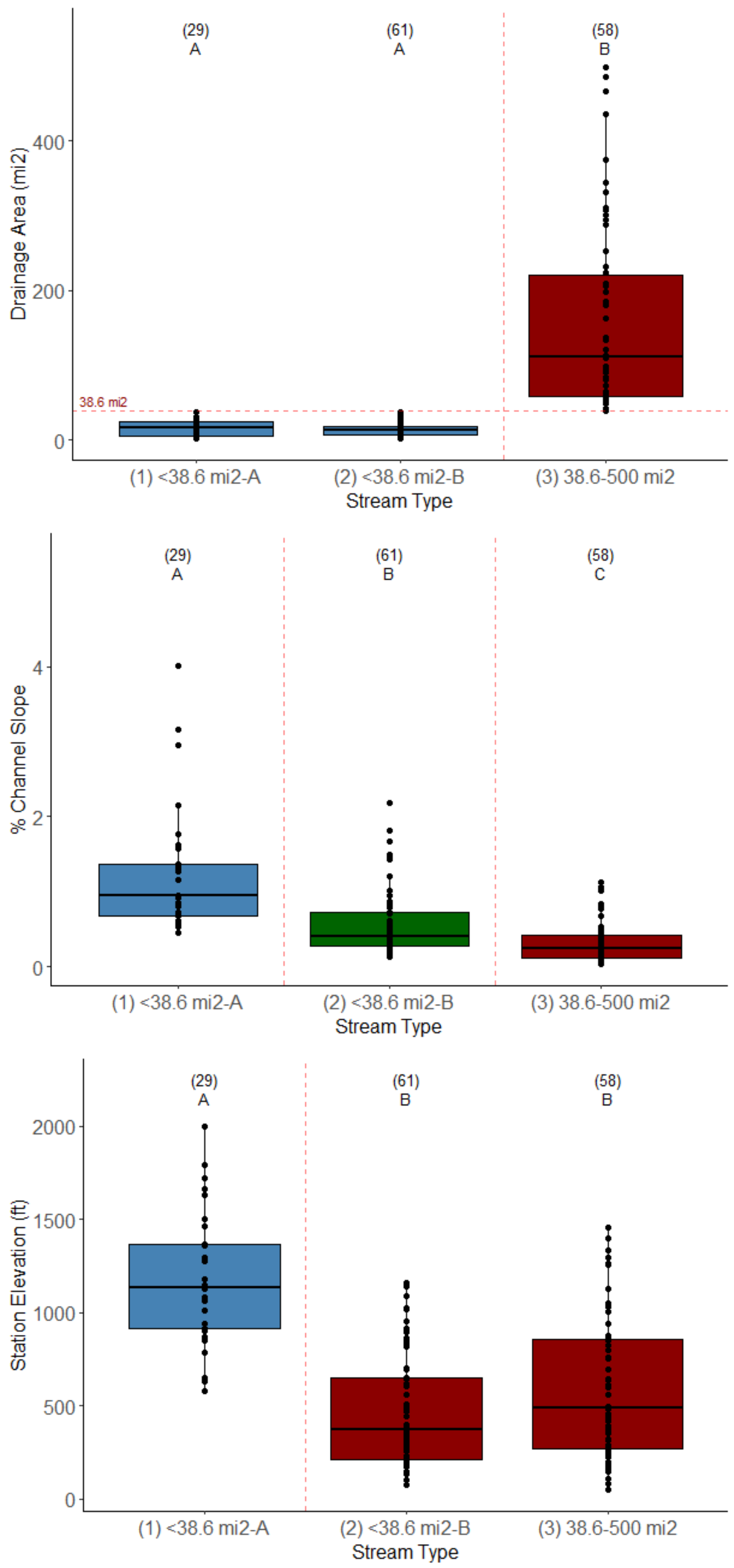


Figure 4.1j. Station drainage area, channel slope, and elevation values by stream type. ANOVA and Tukey test results are significant at α=0.05 for all three predictor variables.

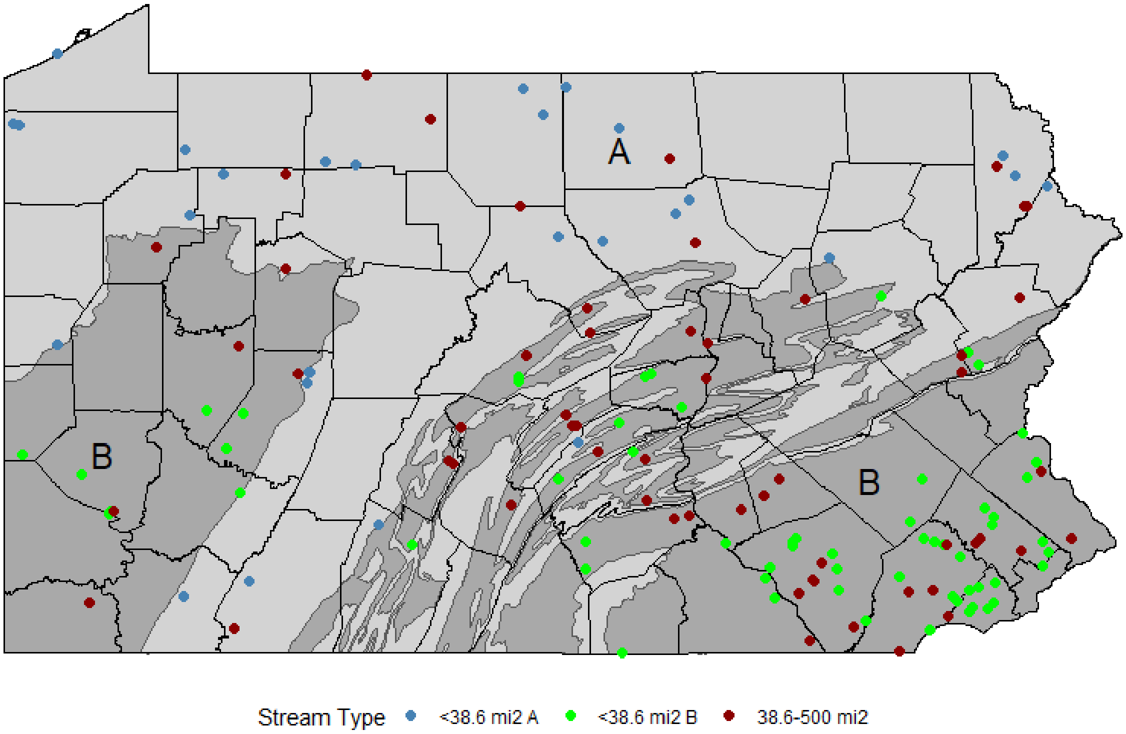


Figure 4.1k. Geographic distribution of calibration stations by stream type.

4.2 Eutrophication Stress Classes

This phase of classification involved classifying samples into one of following three eutrophication stress classes:

1. Minimally stressed by eutrophication (Min-S)
2. Moderately stressed by eutrophication (Mod-S)
3. Highly stressed by eutrophication (High-S)

Samples were delineated into eutrophication stress classes based on the biological integrity of their benthic macroinvertebrate community and their eutrophication stress level. At each station, a single benthic macroinvertebrate sample was collected typically at or shortly after the end of data sonde deployment. In freestone streams, benthic macroinvertebrate samples were collected and processed in accordance with (Shull 2017a). Small stream IBI scores were generated for all samples from freestone stations with a drainage area of <38.6 mi^2, and large stream IBI scores were generated for all samples from freestone stations with a drainage area ≥38.6 mi^2. In limestone streams, benthic macroinvertebrate samples were collected and processed in accordance with Williams (2017a). All benthic macroinvertebrate samples were collected between the months of November and April with the majority of samples collected in November or December (Table 4.2a).

Table 4.2a. Timeframe of the collection of benthic macroinvertebrate samples.

Timeframe	Number of Calibration Samples	Percent of Calibration Samples	Number of Calibration & Ancillary Samples	Percent of Calibration & Ancillary Samples
Nov-Dec	130	87.8	155	86.1
Jan-Feb	9	6.1	9	5.0
Mar-Apr	9	6.1	16	8.9
Total	148	100	180	100.0

The biological integrity of each sample was categorized as either supporting or not supporting a healthy benthic macroinvertebrate community based on information from DEP's assessment methods (Shull (2017b and Williams 2017b). Freestone stream samples were categorized as supporting a health benthic macroinvertebrate community with a freestone index of biological integrity (IBI) score of ≥50 and answers of "No" to all four screening questions (Shull 2017b). Freestone samples with a freestone IBI score of <50 were categorized as not supporting a health benthic macroinvertebrate community (Shull 2017b). Freestone samples with an IBI score ≥50 and an answer of "Yes" to one or more of the four screening questions also were categorized as not supporting a health benthic macroinvertebrate community (Shull 2017b). Limestone stream samples with a limestone IBI score of ≥60 were categized as supporting a health benthic macroinvertebrate community (Williams 2017b). Limestone stream samples with a limestone IBI score <60 were categorized as not supporting a healthy benthic macroinvertebrate community (Williams 2017b).

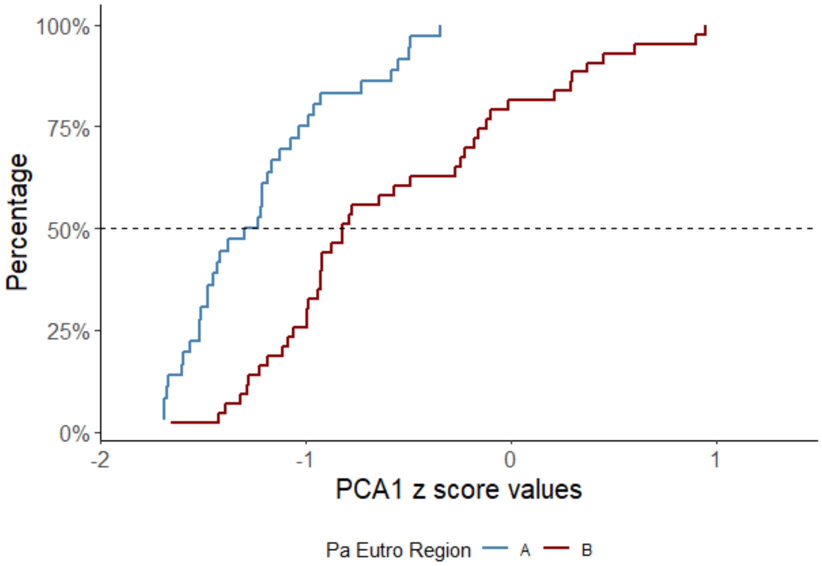
Sample eutrophication stress levels were determined by comparing sample PCA axis 1 scores (described above in Section 4.1) to stream type-specific benchmark values derived from supporting streams in the same PA eutrophication region (April) or stream type class (May through October). Benchmark values were based on the 95th percentile values of ALU supporting samples in PA eutrophication region A streams in April, and for samples with a drainage area <38.6 mi^2 in eutrophication region A from May through October. Benchmark values were based on the 90th percentile values of supporting samples for streams in PA eutrophication region B streams in April, and for samples with a drainage area <38.6 mi^2 in eutrophication region B and streams with a drainage area between 38.6 and 500 mi^2 statewide from May through October.

The empirical cumulative distribution function curves (ECDFs) shown in Figure 4.2a illustrate the differences in the degree of eutrophication stress (PCA axis 1 scores) of supporting samples between PA eutrophication regions and among stream types. Due to these differences in the degree of eutrophication stress, different percentile values were selected for the development of benchmarks (95th vs. 90th percentiles). Sample PCA axis 1 scores and benchmark values by support status, PA eutrophication region, and stream type are shown in Figure 4.2b and PCA axis 1 benchmark values are summarized in Table 4.2b.

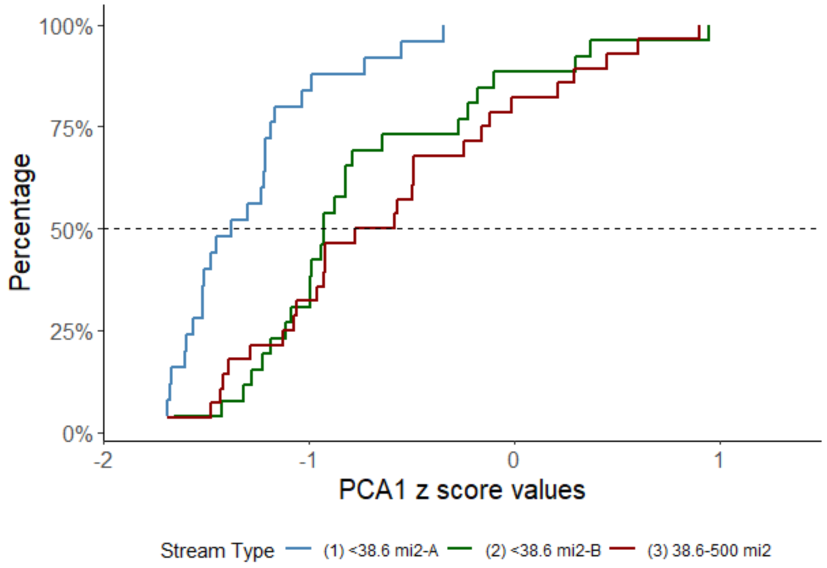
Samples supporting a healthy macroinvertebrate community and having a PCA axis 1 score less than the appropriate PA eutrophication region (April) or stream-type (May through October) PCA axis 1 benchmark value were classified as minimally stressed by eutrophication (Min-S). Over 59% of the 71 samples identified as Min-S distributed across the three stream types are Special Protection Use waters. Samples not supporting a healthy macroinvertebrate community and having a PCA axis 1 score greater than the appropriate PA eutrophication region (April) or stream-type (May through October) PCA axis 1 benchmark value were classified as highly stressed by eutrophication (High-S). Samples that did not meet the criteria discussed above for Min-S or High-S, were given a eutrophication stress class designation of moderately stressed by eutrophication (Mod-S). The eutrophication stress class designation of the vast majority of samples remained consistent between the two classification systems (PA eutrophication region (April) vs. stream type (May-October)) with 141 of the 148 calibration samples (95.3%) showing no change between the two classification schemes (Table 4.2c). The geographic distribution of Min-S stations is shown in Figure 4.2c.

Station mean annual TP, mean annual TN, p75DailyRange_WX, and p25DailyMin_WX values indicate the process used to delineate samples into eutrophication stress classes, effectively categorizing samples across the eutrophication gradient of the dataset. Min-S samples were consistently associated with lower TP, TN, and p75DailyRange_WX values and higher p25DailyMin_WX values, relative to High-S samples (Figures 4.2d through Figures 4.2g).

Once samples were delineated into eutrophication stress classes, a series of pairwise analysis of variance tests were run on square root-transformed macroinvertebrate relative abundance data (with rare taxa, taxa present in <5% of the samples, removed) using pairwise adonis, a wrapper for the adonis function from the Vegan package (Martinez 2020). Pairwise adonis results were used to determine if the taxonomic composition of samples included in each of the unique pairwise comparisons were statistically different at α=0.05 and to evaluate the overall effectiveness of the process used to assign samples into stream type-specific eutrophication stress classes.

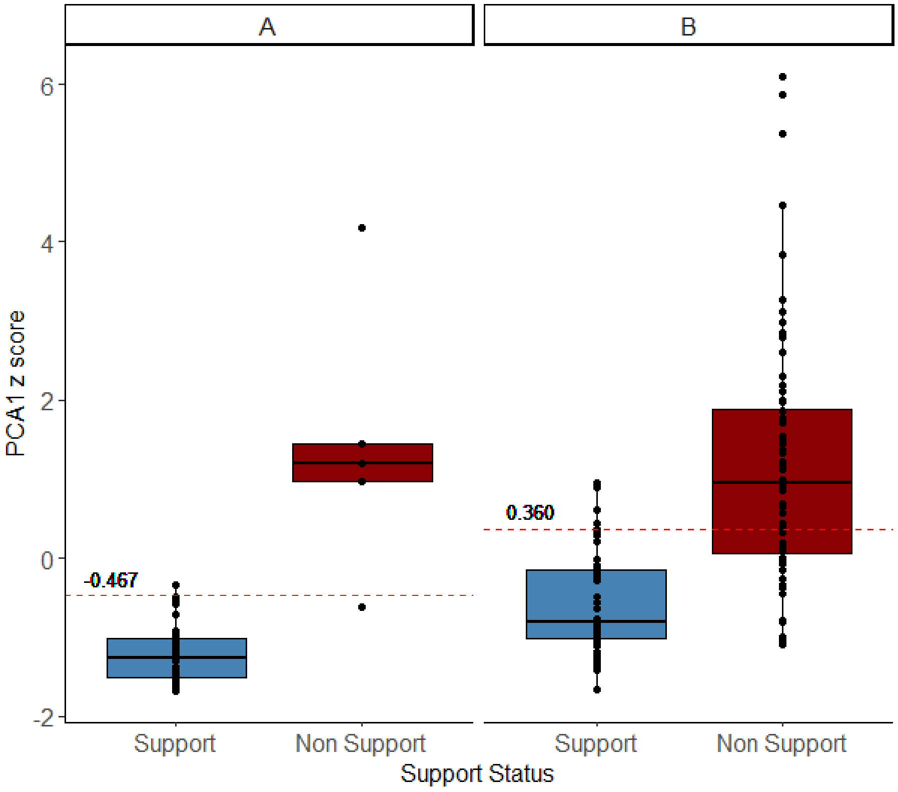


(A)



(B)

Figure 4.2a. Empirical cumulative distribution curves of PCA axis 1 scores of supporting samples by PA eutrophication region (A) and stream type designation (B).



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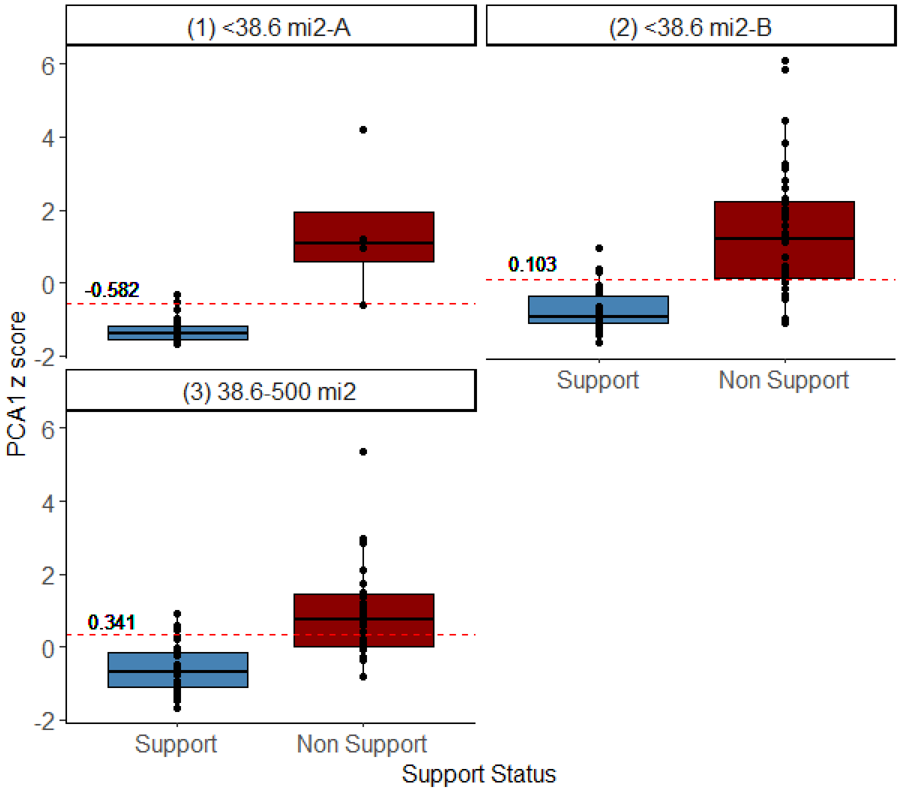


(B)

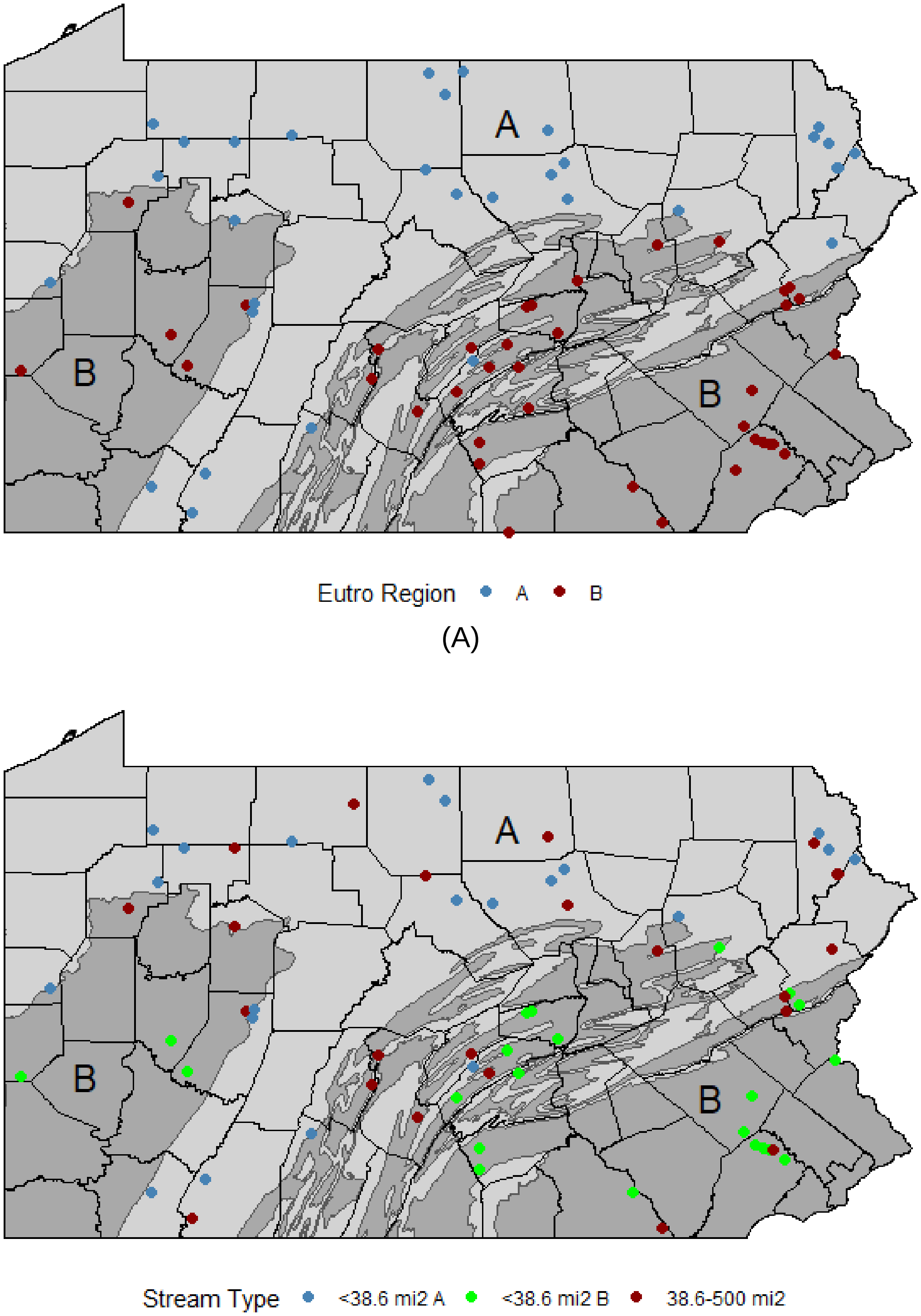
Figure 4.2b. Calibration sample PCA axis 1 scores and eutrophication stress class benchmark values by PA eutrophication region (A) and stream type (B).

Table 4.2b. Eutrophication stress class PCA axis 1 benchmark values.

Parameter	Eutro Reg A	Eutro Reg B	<38.6 mi2 Eutro Reg A	<38.6 mi2 Eutro Reg B	38.6-500 mi2 Statewide
Benchmark Percentile Used	0.95	0.90	0.95	0.90	0.90
PCA Axis 1 April Benchmark	-0.467	0.360			
PCA Axis 1 May-October Benchmark			-0.582	0.103	0.341

Table 4.2c. Sample eutrophication stress class results by PA eutrophication region and stream type.

Eutrophication Stress Class Based on PA Eutrophication Region	Eutrophication Stress Class Based on Stream Type	Number of Samples	Percent of Calibration Dataset (N=148)
Min-S	Min-S	70	47.3
Min-S	Mod-S	2	1.4
Mod-S	Min-S	1	0.7
Mod-S	Mod-S	26	17.7
Mod-S	High-S	4	2.7
High-S	High-S	45	30.4
No Change		141	95.3
Changed		7	4.7



(A)

(B)

Figure 4.2c. Geographic distribution of Min-S stations by PA eutrophication region (A) and by stream type (B).

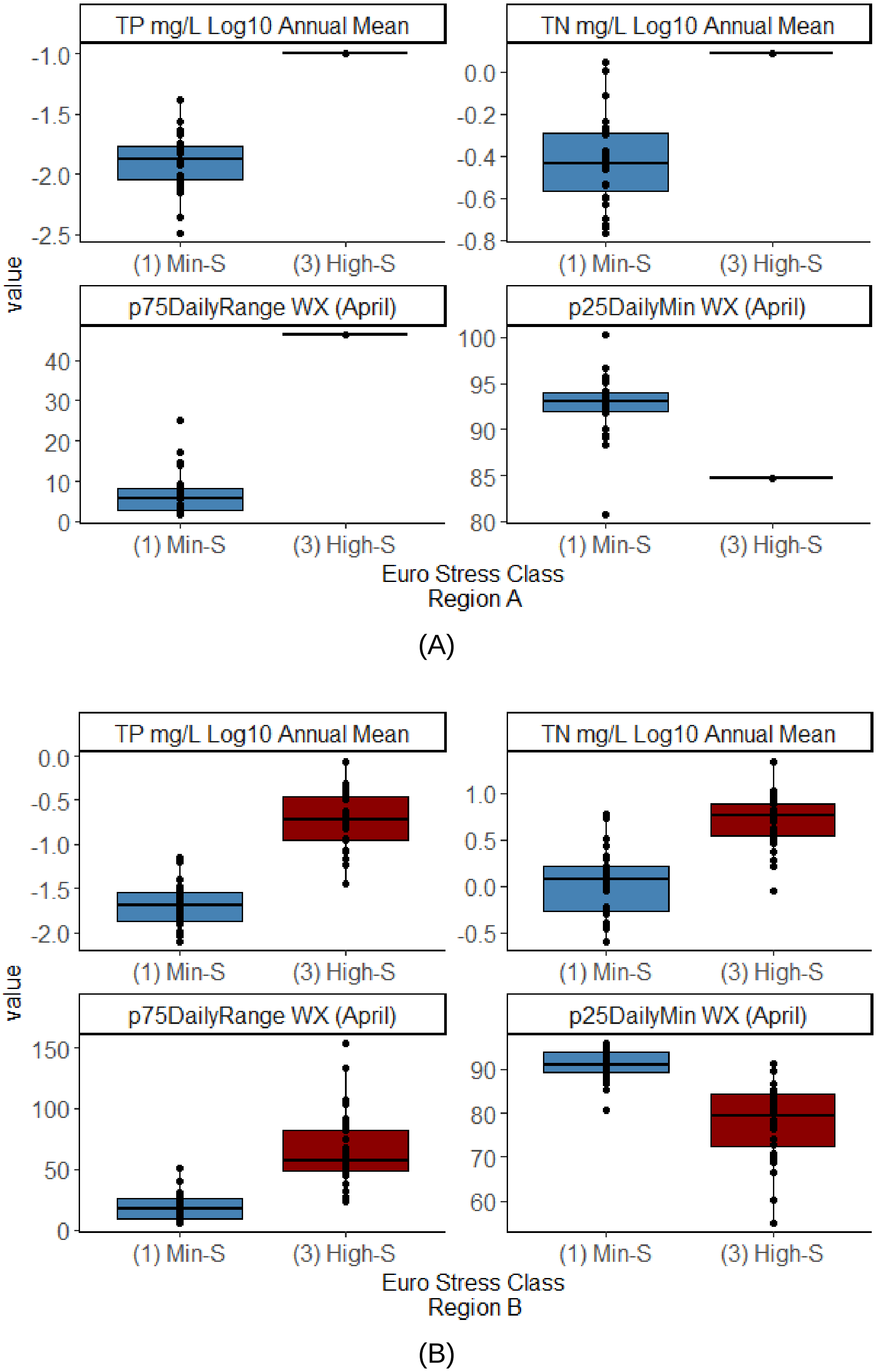


Figure 4.2d. Min-S vs. High-S sample annual mean TP and TN values and April p75DailyRange_WX and April p25DailyMin_WX values by PA eutrophication region A (A) and PA eutrophication region B (B).

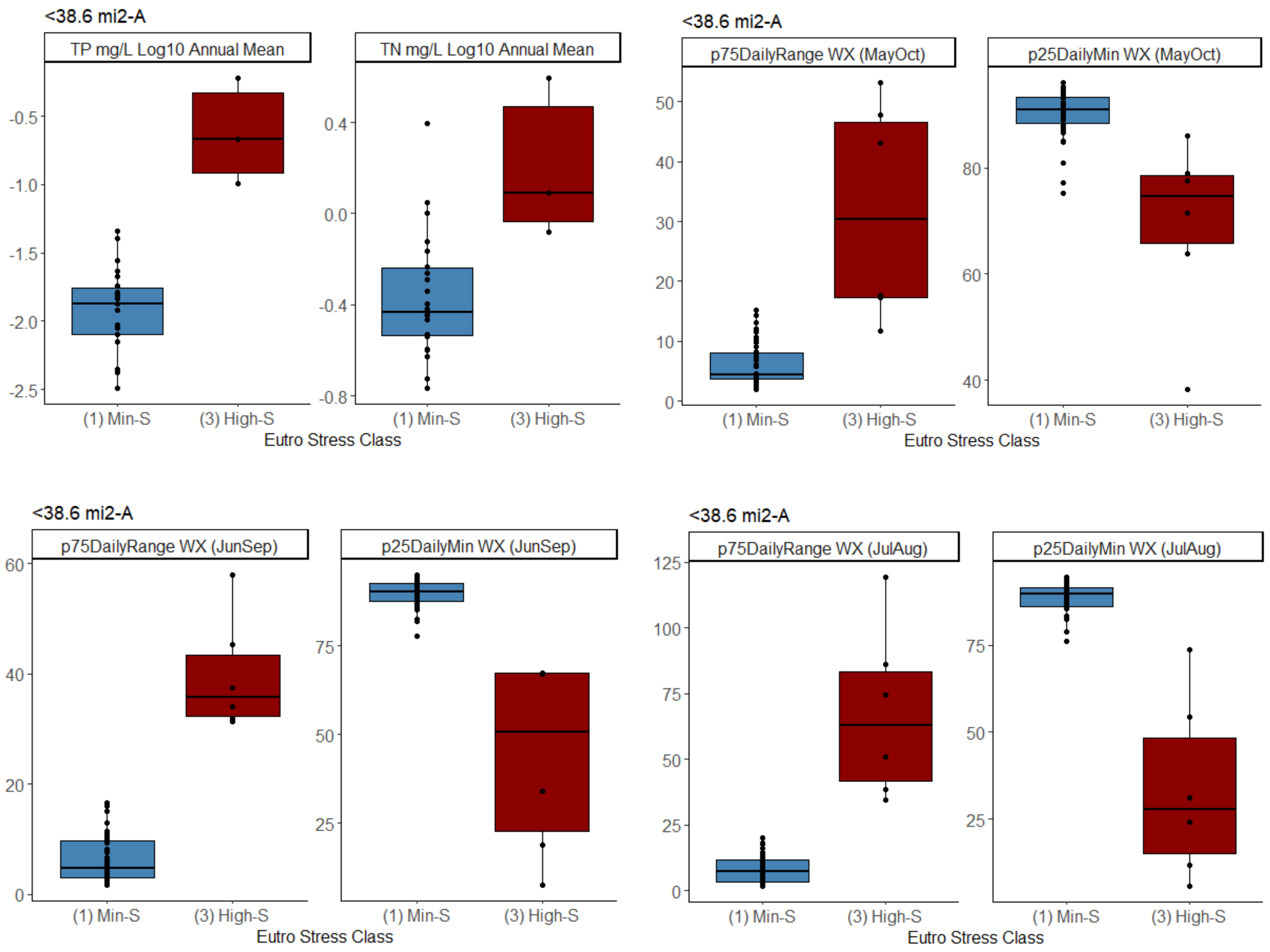


Figure 4.2e. Stream type <38.6 mi^2-A Min-S vs. High-S sample annual mean TP and TN values and p75DailyRange_WX and p25DailyMin_WX values by sample period.

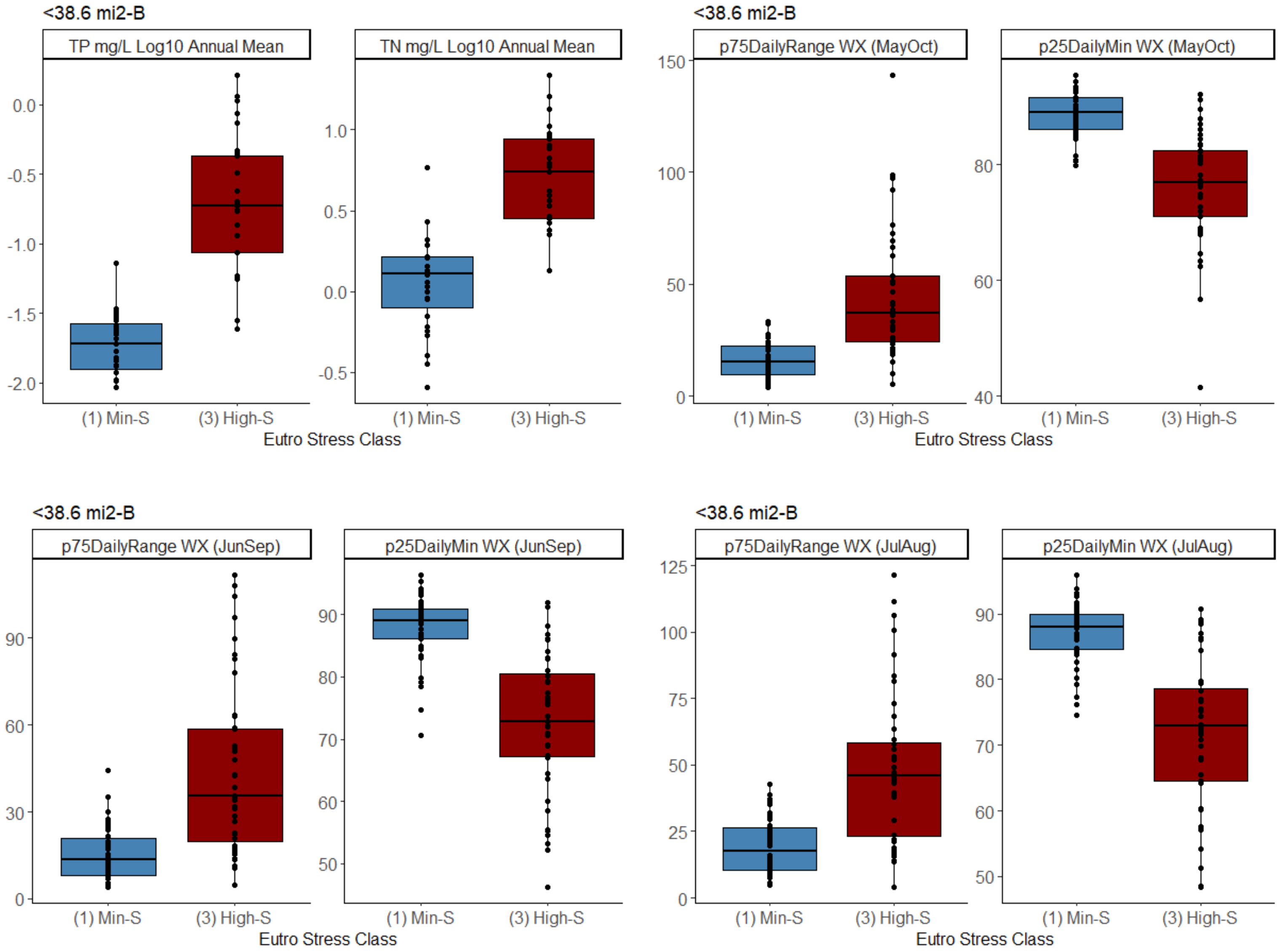


Figure 4.2f. Stream type <38.6 mi^2-B Min-S vs. High-S sample annual mean TP and TN values and p75DailyRange_WX and p25DailyMin_WX values by sample period.

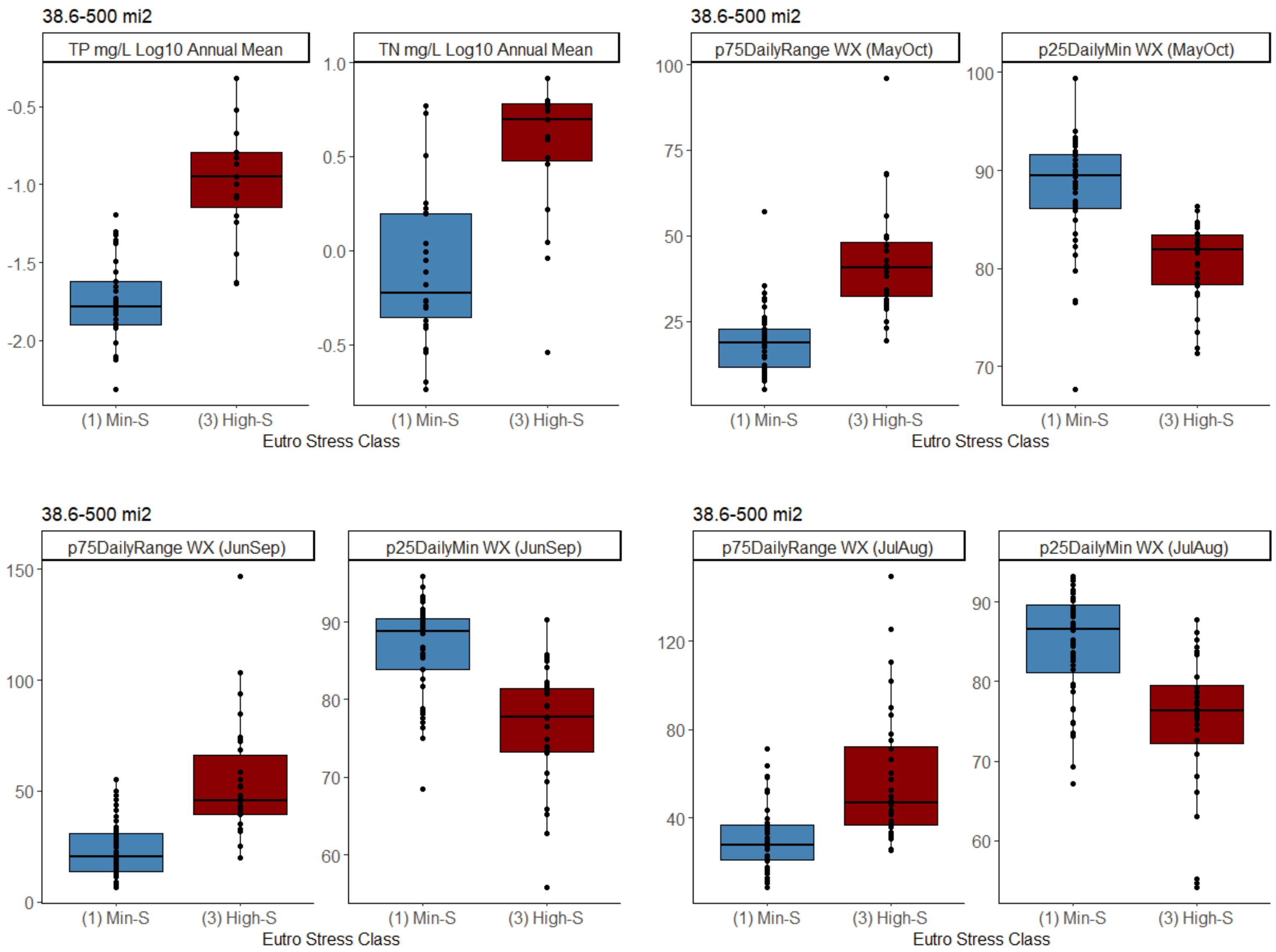


Figure 4.2g. Stream type 38.6-500 mi^2 Min-S vs. High-S sample annual mean TP and TN values and p75DailyRange_WX and p25DailyMin_WX values by sample period.

Pairwise adonis results confirm a significant difference ($\alpha=0.05$) in macroinvertebrate community taxonomic composition between Min-S samples and High-S samples between each of the PA eutrophication regions and among each of the three stream-types. In addition, pairwise adonis results confirm a significant difference ($\alpha=0.05$) in macroinvertebrate community taxonomic composition between the Min-S and the High-S samples between each of the PA eutrophication regions and among each of the three stream-types. Pairwise adonis results are summarized in Table 4.2d. Overall, pairwise adonis results and station eutrophication stressor variable data shown in Figures 4.2d through Figures 4.2g indicate the process used to delineate samples into stream type-specific eutrophication stress classes effectively categorized samples across the eutrophication gradient of the dataset. The one instance of similar macroinvertebrate community composition ($p> 0.05$) was between the two highly stressed small stream-type communities

Table 4.2d. Summary table of pairwise adonis results.

Classification	Pairs			Df	SS	F_Model	R^2	p-Value	p-Adjusted
PA Eutrophication Region	Eutro Reg A Min-S	vs.	Eutro Reg B Min-S	1	1.17	7.9	0.101	0.001	0.001
	Eutro Reg A Min-S	vs.	Eutro Reg A High-S	1	0.93	5.9	0.140	0.001	0.001
	Eutro Reg B Min-S	vs.	Eutro Reg B High-S	1	2.83	19.1	0.199	0.001	0.001
	Eutro Reg A High-S	vs.	Eutro Reg B High-S	1	0.33	2.1	0.047	0.022	0.022
Stream Type	<38.6 mi2-A Min-S	vs.	<38.6 mi2-B Min-S	1	1.17	8.3	0.158	0.001	0.001
	<38.6 mi2-A Min-S	vs.	38.6-500 mi2 Min-S	1	1.38	9.8	0.176	0.001	0.001
	<38.6 mi2-B Min-S	vs.	38.6-500 mi2 Min-S	1	0.30	2.0	0.043	0.016	0.016
	<38.6 mi2-A Min-S	vs.	<38.6 mi2-A High-S	1	0.84	6.0	0.201	0.002	0.002
	<38.6 mi2-B Min-S	vs.	<38.6 mi2-B High-S	1	2.16	15.3	0.246	0.001	0.001
	38.6-500 mi2 Min-S	vs.	38.6-500 mi2 High-S	1	1.49	9.9	0.187	0.001	0.001
	<38.6 mi2-A High-S	vs.	<38.6 mi2-B High-S	1	0.27	1.9	0.067	0.054	0.054
	<38.6 mi2-A High-S	vs.	38.6-500 mi2 High-S	1	0.38	2.4	0.102	0.012	0.012
	<38.6 mi2-B High-S	vs.	38.6-500 mi2 High-S	1	0.55	3.8	0.079	0.001	0.001

5. BIOLOGICAL RESPONSE VARIABLES

Two metrics were used as macroinvertebrate community eutrophication response variables: 1) sample correspondence analysis (CA) axis 1 score (discussed below in Section 5.1) and 2) sample eutrophication tolerance index (ETI) score (discussed below in Section 5.2).

5.1 Correspondence Analysis Axis 1 Score

Correspondence analysis (CA) was run on square root-transformed relative abundance taxonomy data of all calibration samples, with rare taxa (present in <5% of the calibration samples) removed, using the cca function from the vegan package in R (Oksanen et. al 2019). Sample and taxa CA scores were generated from a dataset of 148 calibration samples and 77 macroinvertebrate taxa. Sample CA scores were generated using scaling 1 in which samples were centroids of the taxa, and taxa CA scores were generated using scaling 2 in which taxa were centroids of the samples (Borcard et. al 2018). Plotting sample and taxa CA axis 1 scores vs. CA axis 2 scores places taxa in ordination space near samples in which the taxa are relatively abundant (Figure 5.1a).

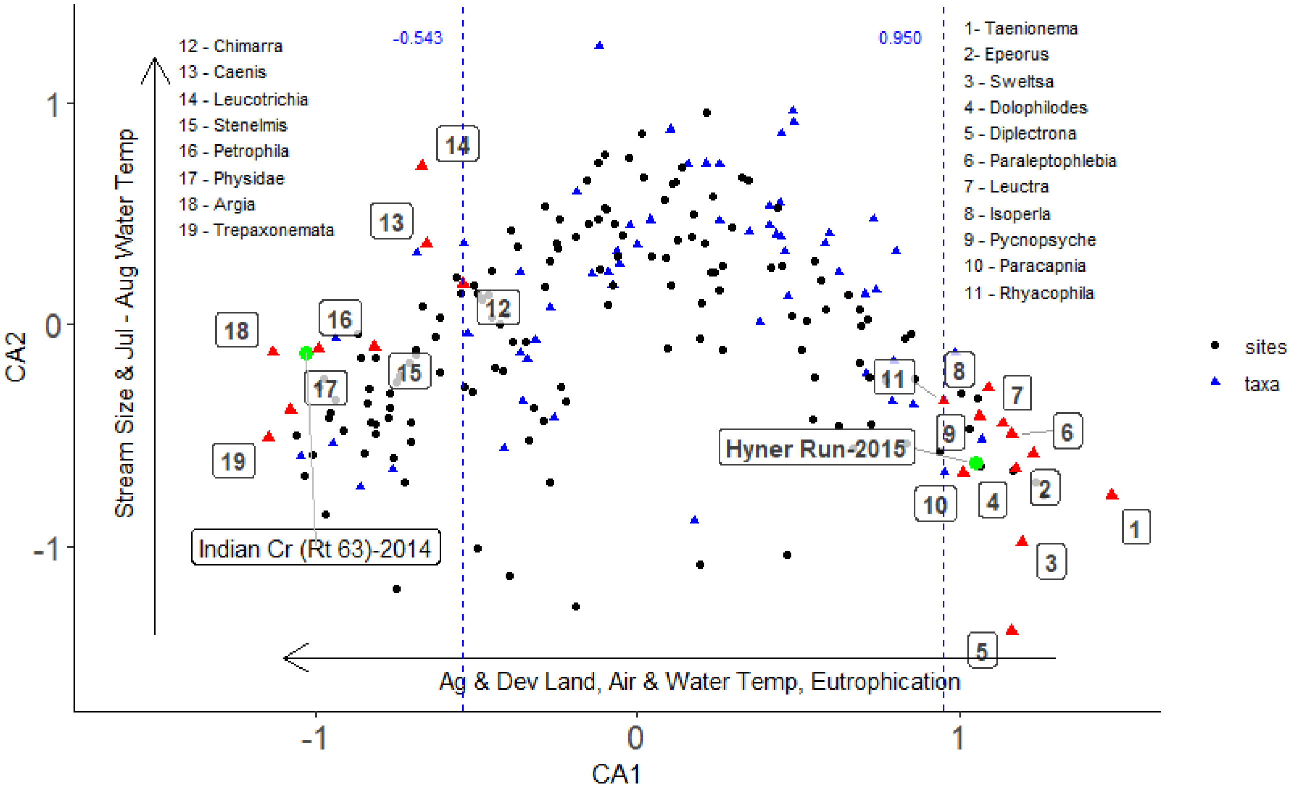


Figure 5.1a. Biplot of sample and taxa CA axis 2 vs. CA axis 1 scores.

Spearman correlation analysis revealed a gradient along CA axis 1, where CA axis 1 scores decrease with increasing percent agriculture and developed land cover, air and water temperature, and eutrophication stress (Figure 5.1a). Moderate to strong Spearman correlation values ($|r_s| \geq 0.60$) were observed between sample CA axis 1 scores and several variables associated with stream eutrophication including: percent agriculture and developed land, modeled mean annual watershed TP and TN loading rates, annual mean instream concentrations of TP, TN, and secondary nutrients

(Ca and Mg expressed as total hardness), air and water temperature, and p75DailyRange_WX and p25DailyMin_WX values. Spearman correlation values of sample CA axis 1 and CA axis 2 scores and selected environmental factors are summarized in Table 5.1b.

In addition to the CA axis 1 eutrophication gradient discussed above, a strong macroinvertebrate community structure and composition gradient was also observed along CA axis 1(Figure 5.1a). For example, the majority (53.0%) of the macroinvertebrate individuals collected at Hyner Run in 2015 (CA axis 1 score = 1.050) consisted of taxa with a CA axis 1 score ≥ 0.950). In contrast to Hyner Run, the majority (57.3%) of the macroinvertebrate individuals collected at Indian Cr (Rt 63) in 2014 (CA axis 1 score = -1.030) consisted of taxa with a CA axis 1 score ≤ -0.543). Macroinvertebrate taxa collected at Hyner Run in 2015 with a CA axis 1 score ≥ 0.950 are numbered 1-11 in Figure 5.1a and macroinvertebrate taxa collected at Indian Cr (Rt 63) in 2014 with a taxa CA axis 1 score ≤ -0.543 are numbered 12-19 in Figure 5.1a.

Table 5.1b. Spearman correlation values of sample CA axis 1 and CA axis 2 scores vs. selected environmental factors.

Parameter	CA Axis 1 Score		CA Axis 2 Score	
CA Axis 2 Score	0.20			
Forest %	0.81	****	0.18	
Ag+Devel %	-0.81	****	-0.22	
Spec Cond umhos/cm	-0.85	****	-0.30	
Hard mg/L	-0.78	***	-0.26	
Alk mg/L	-0.70	***	-0.17	
Carbonate %	-0.28		0.03	
Channel Slope %	0.59		-0.27	
AirTemp MeanAnnual C	-0.73	***	-0.08	
Elev Station ft	0.63	**	-0.09	
Latitude	0.55	*	-0.01	
Longitude	-0.27		0.09	
TP kg/ha	-0.71	***	-0.10	
TN kg/ha	-0.67	**	-0.06	
TP mg/L	-0.77	***	-0.25	
TN mg/L	-0.74	***	-0.25	
p75DailyRange_WX Apr	-0.84	****	-0.06	
p75DailyRange_WX MayOct Mean	-0.75	***	0.10	
p75DailyRange_WX JunSep Mean	-0.70	***	0.21	
p75DailyRange_WX JulAug Mean	-0.64	**	0.20	
p25DailyMin_WX Apr	0.76	***	0.15	
p25DailyMin_WX MayOct Mean	0.69	**	0.10	
p25DailyMin_WX JunSep Mean	0.66	**	0.06	
p25DailyMin_WX JulAug Mean	0.60	**	0.06	
p75DailyMax_TW Apr	-0.66	**	0.11	
p75DailyMax_TW MayOct Mean	-0.80	****	-0.01	
p75DailyMax_TW JunSep Mean	-0.63	**	0.35	
p75DailyMax_TW JulAug Mean	-0.44		0.49	*
DrainageArea mi2	-0.11		0.46	*
StreamOrder	-0.10		0.48	*
Bankfull Width ft	-0.06		0.50	*
Bankfull Depth ft	-0.08		0.49	*

[1] |ρ| ≥ 0.80 ****

[2] |ρ| = 0.70-0.79 ***

[3] |ρ| = 0.60-0.69 **

[4] |ρ| = 0.45-0.59 *

CA axis 2 scores were most closely related to stream size and July-August water temperature (Figure 5.1a). Figure 5.1a reveals the arch effect that is a common artifact of CA analysis which can hinder the interpretation of CA axis 2 scores. While investigating the arch effect, a detrended correspondence analysis (DCA) was run on the dataset and DCA results did not enhance interpretation of CA axis scores.

5.2 Eutrophication Tolerance Index (ETI) Score

In addition to CA axis 1 scores, sample eutrophication tolerance index (ETI) scores were used as a second biological response variable. A sample's ETI score reflects the overall tolerance of its benthic macroinvertebrate community to stressful eutrophication conditions (i.e., elevated p75DailyRange_WX and depressed p25DailyMin_WX values). The ETI is a relative abundance-weighted tolerance index value calculated in a manner similar to the commonly used Hilsenhoff Biotic Index (Hilsenhoff 1977) using the following equation:

$$\text{Sample ETI Score} = \frac{\Sigma n_i \ x \ a_i}{N} \qquad \text{Equation 5.2a}$$

Where, *n* is the number of individuals of taxon *i*, *a* is the eutrophication tolerance value (ETV) of taxon *i*, and *N* is the total number of individuals in the sample with an ETV.

Taxon ETVs were derived from continuously monitored DO %Sat data and specifically reflect the taxa's tolerance for elevated DailyRange_WX and depressed DailyMin_WX conditions. Separate values were calculated for DO %Sat DailyRange_WX tolerance (DORT) and DO %Sat DailyMin_WX tolerance (DOMT) and the average of the two tolerance values was used as the taxon ETV in Equation 5.2a. Taxon ETVs were calculated using the multi-step process described below with monthly p75DailyRange_WX values used to generate DORT values and monthly p25DailyMin_WX values used to generate DOMT values. This process consisted of the following steps:

Step 1

Sample DO %Sat values were used in conjunction with macroinvertebrate taxa presence/absence data to construct monthly logistic distribution curves of the DO %Sat conditions associated with the occurrence of each taxa in the dataset. Rare taxa (observed in <5% of the samples) were removed, resulting in the construction of logistic distribution curves for a total of 77 macroinvertebrate taxa. Two parameters of each monthly logistic curve (location and scale) were used to quantify a taxon's tolerance to elevated DailyRange_WX and depressed DailyMin_WX conditions using Equation 5.2b and Equation 5.2c in accordance with the Gaussian response curve approach described in ter Braak (1996).

Tolerance to elevated DailyRange_WX = Location + 2 x Scale Equation 5.2b
Tolerance to depressed DailyMin_WX = Location – 2 x Scale Equation 5.2c

Logistic curve location and scale values were generated using the elogis function in the EnvStats package in R (Millard 2013). Examples of how monthly logistic curve location and scale values were used to quantify taxa tolerance to elevated DailyRange_WX and depressed DailyMin_WX conditions are provided in Figure 5.2a.

Step 2

Percentile rank values were generated for each monthly taxon tolerance to elevated DailyRange_WX value and each monthly taxon tolerance to depressed DailyMin_WX value derived from logistic curves in Step 1. This process ranked each taxon on a scale of 0.00 to 1.00 with regard to their degree of tolerance for each of the DO %Sat parameters relative to the other 76 taxa included in the ETI dataset. This process was conducted for each month (April-October) generating seven monthly percentile rank values for tolerance to elevated DailyRange_WX and seven monthly percentile rank values for tolerance to depressed DailyMin_WX for each taxon.

Step 3

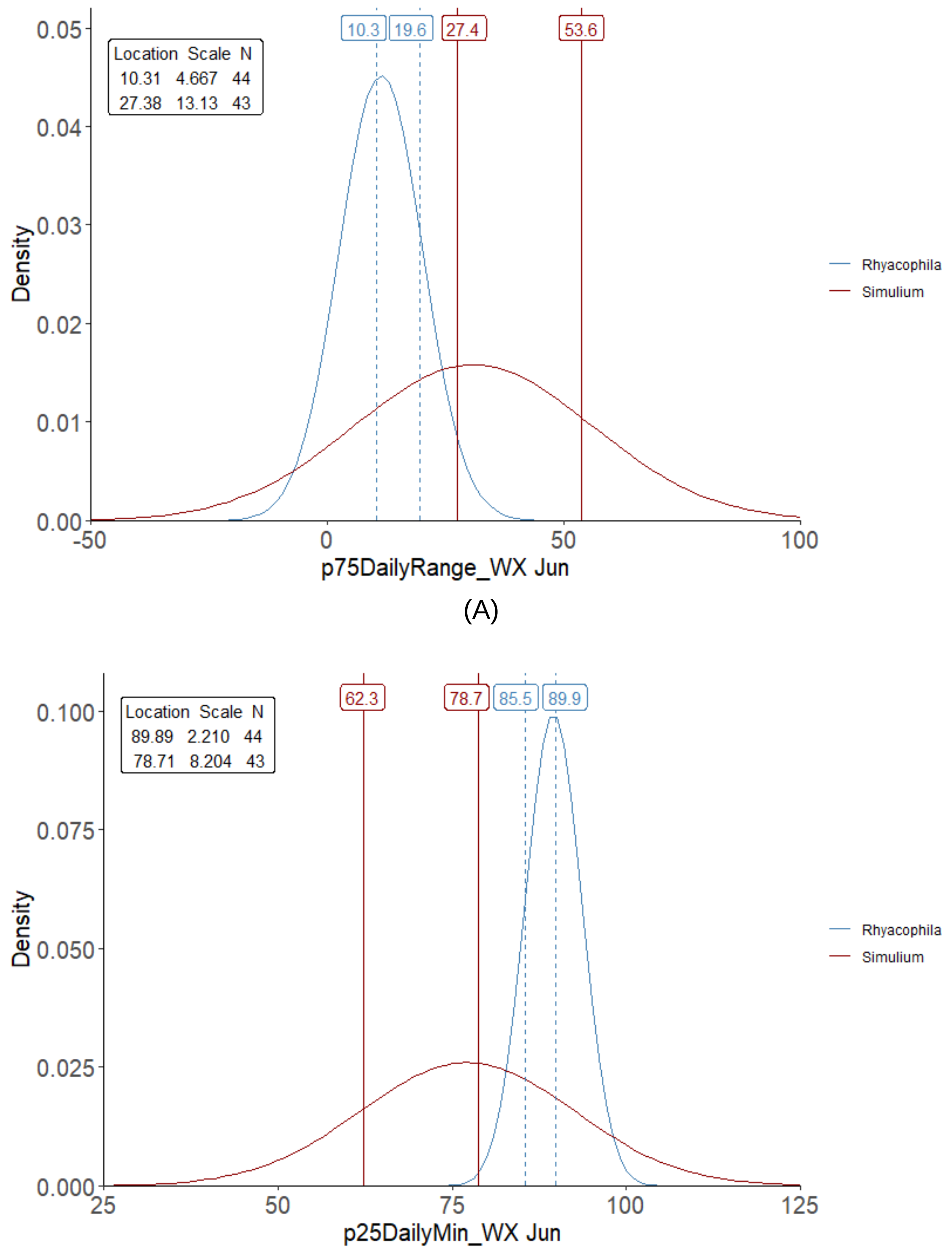
For each taxon, the median of the seven monthly percentile rank values for each of the two DO %Sat parameters was used as the taxon’s tolerance for that DO %Sat parameter, resulting in a single value for tolerance to elevated DailyRange_WX and a single value for tolerance to depressed DailyMin_WX for each of the 77 taxa.

Step 4

For each of the two DO %Sat parameters, percentile rank values were calculated for the tolerance values generated for each of the 77 taxa in Step 3. This resulted in each taxon being ranked on a scale of 0.00 to 1.00 with regard to their degree of tolerance for each of the two DO %Sat parameters relative to the other 76 taxa included in the ETI dataset.

Step 5

For each of the two DO %Sat parameters, the taxa percentile rank values generated in Step 4 were converted to a scale of 1-10 and used as DORT (tolerance to elevated DailyRange_WX) and DOMT (tolerance to depressed DailyMin_WX) values.



(A)

(B)

Figure 5.2a. Graphic examples of how monthly logistic curves were used to generate taxa tolerance values for elevated DailyRange_WX conditions (A) and depressed DailyMin_WX conditions (B) for *Rhyacophila* and *Simulium* in the month of June (*Rhyacophila* tolerance to elevated DailyRange_WX = 10.31 + (2 x 4.67) = 19.65 and tolerance to depressed DailyMin_WX = 89.89 - (2 x 2.21) = 85.47).

Step 6

The mean of taxa DORT and DOMT values (rounded to the closest whole number) were used as the value representing the taxa's overall tolerance to eutrophication (ETV). Taxa ETV, DORT-values, and DOMT-values are summarized in Table 5.2a.

Spearman correlation analysis revealed strong relationships between macroinvertebrate taxa CA axis 1 scores and taxa ETVs ($\rho = -0.90$) and between sample CA axis 1 scores and sample ETI scores and ($\rho = -0.97$) (Figure 5.2b). Strong Spearman correlation values were also observed between sample PCA axis 1 scores and sample CA axis 1 and ETI scores (Figure 5.2c). Ultimately, sample PCA axis 1, CA axis 1, and ETI scores were all strongly correlated ($|\rho| \geq 0.80$) with sample macroinvertebrate IBI scores (Figure 5.2d).

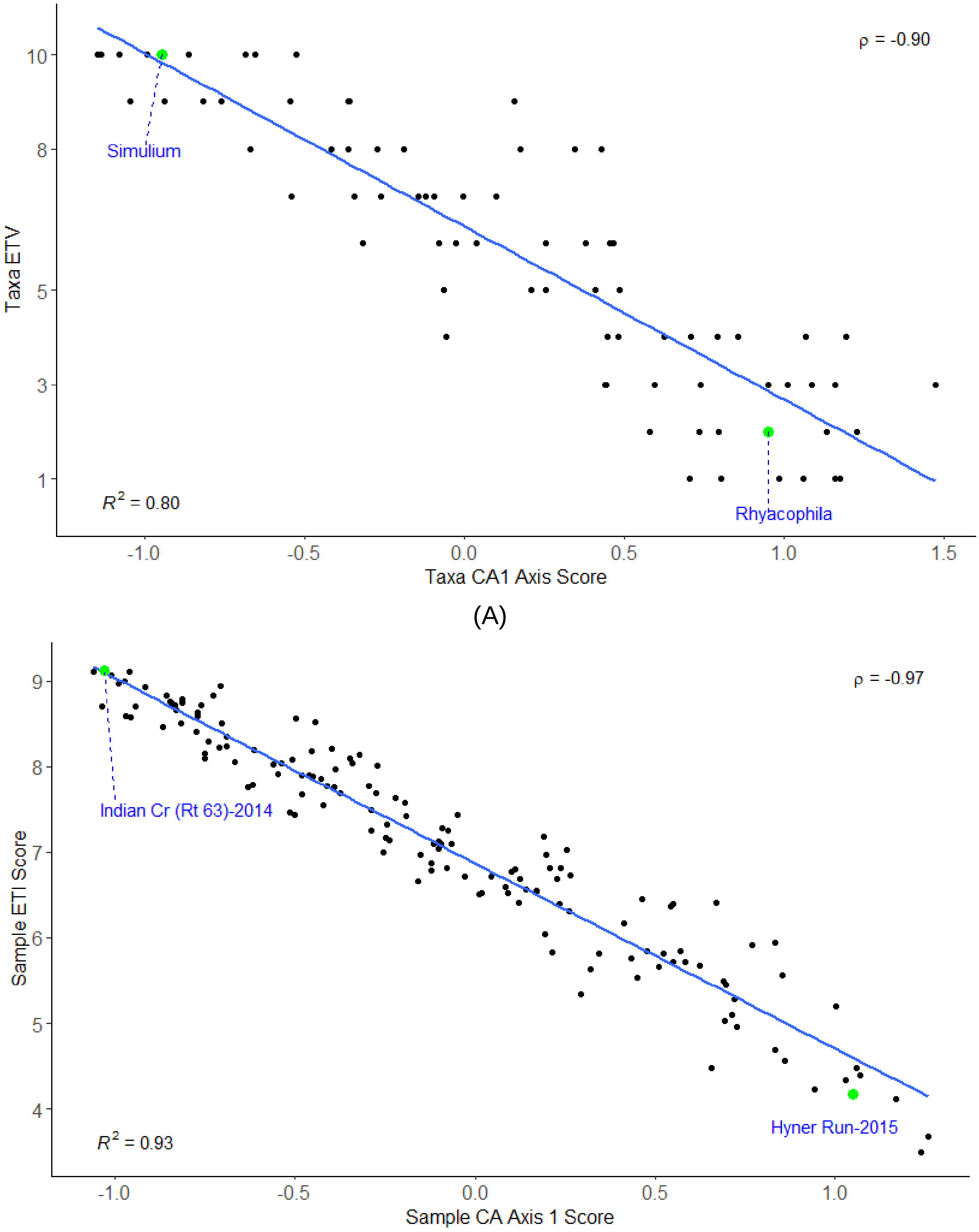
Spearman correlation results also revealed moderate to strong relationships ($|\rho| \geq 0.60$) between sample ETI scores and several variables associated with stream eutrophication. These relationships mirrored those observed between sample CA axis 1 scores discussed above in Section 5.1. Spearman correlation values of sample CA axis 1, ETI, and PCA axis 1 scores vs. selected environmental factors are summarized in Table 5.2b. Calibration and ancillary sample biological data are summarized in Appendix D.

Table 5.2a. Taxon eutrophication tolerance (ETV), DORT, and DOMT values.

Order	Family	Taxa	ETV	DORT DOMT Mean	DORT Value	DOMT Value
Ephemeroptera	Baetidae	*Acentrella*	3	3	3	3
		Diphetor	3	3	2	4
		Baetis	8	8	8	8
		Acerpenna	9	9	9	9
	Caenidae	*Caenis*	10	10	10	10
	Ephemerellidae	*Eurylophella*	3	3	3	3
		Teloganopsis	5	4.5	5	4
		Ephemerella	6	5.5	6	5
		Serratella	7	6.5	8	5
	Heptageniidae	*Epeorus*	2	2	2	2
		Maccaffertium	6	6	6	6
		Leucrocuta	8	7.5	8	7
		Stenacron	8	7.5	7	8
	Isonychiidae	*Isonychia*	7	6.5	7	6
	Leptophlebiidae	*Paraleptophlebia*	3	2.5	3	2
Plecoptera	Capniidae	*Paracapnia*	3	2.5	1	4
		Allocapnia	5	5	5	5
	Chloroperlidae	*Alloperla*	1	1	1	1
		Sweltsa	4	3.5	2	5
	Leuctridae	*Leuctra*	2	1.5	1	2
	Nemouridae	*Prostoia*	2	2	2	2
	Perlidae	*Paragnetina*	1	1	1	1
		Acroneuria	3	3	3	3
		Agnetina	6	6	6	6
	Perlodidae	*Isoperla*	3	3	3	3
	Taeniopterygidae	*Taenionema*	3	2.5	3	2
		Strophopteryx	5	4.5	4	5
		Taeniopteryx	5	5	5	5
Trichoptera	Apataniidae	*Apatania*	4	3.5	4	3
	Brachycentridae	*Brachycentrus*	4	4	4	4
	Glossosomatidae	*Glossosoma*	4	3.5	4	3
	Hydropsychidae	*Diplectrona*	1	1	1	1
		Ceratopsyche	7	6.5	6	7
		Cheumatopsyche	8	8	8	8
		Hydropsyche	8	8	8	8
	Hydroptilidae	*Hydroptila*	6	5.5	5	6
		Leucotrichia	8	8	9	7
	Lepidostomatidae	*Lepidostoma*	4	3.5	4	3
	Limnephilidae	*Pycnopsyche*	1	1	1	1
	Odontoceridae	*Psilotreta*	8	7.5	8	7
	Philopotamidae	*Dolophilodes*	1	1	1	1
		Chimarra	9	8.5	8	9
	Polycentropodidae	*Polycentropus*	6	6	5	7
	Rhyacophilidae	*Rhyacophila*	2	1.5	2	1
	Thremmatidae	*Neophylax*	5	5	5	5

Table 5.2a (*Continued*). Taxa ETV, DORT-values, and DOMT-values.

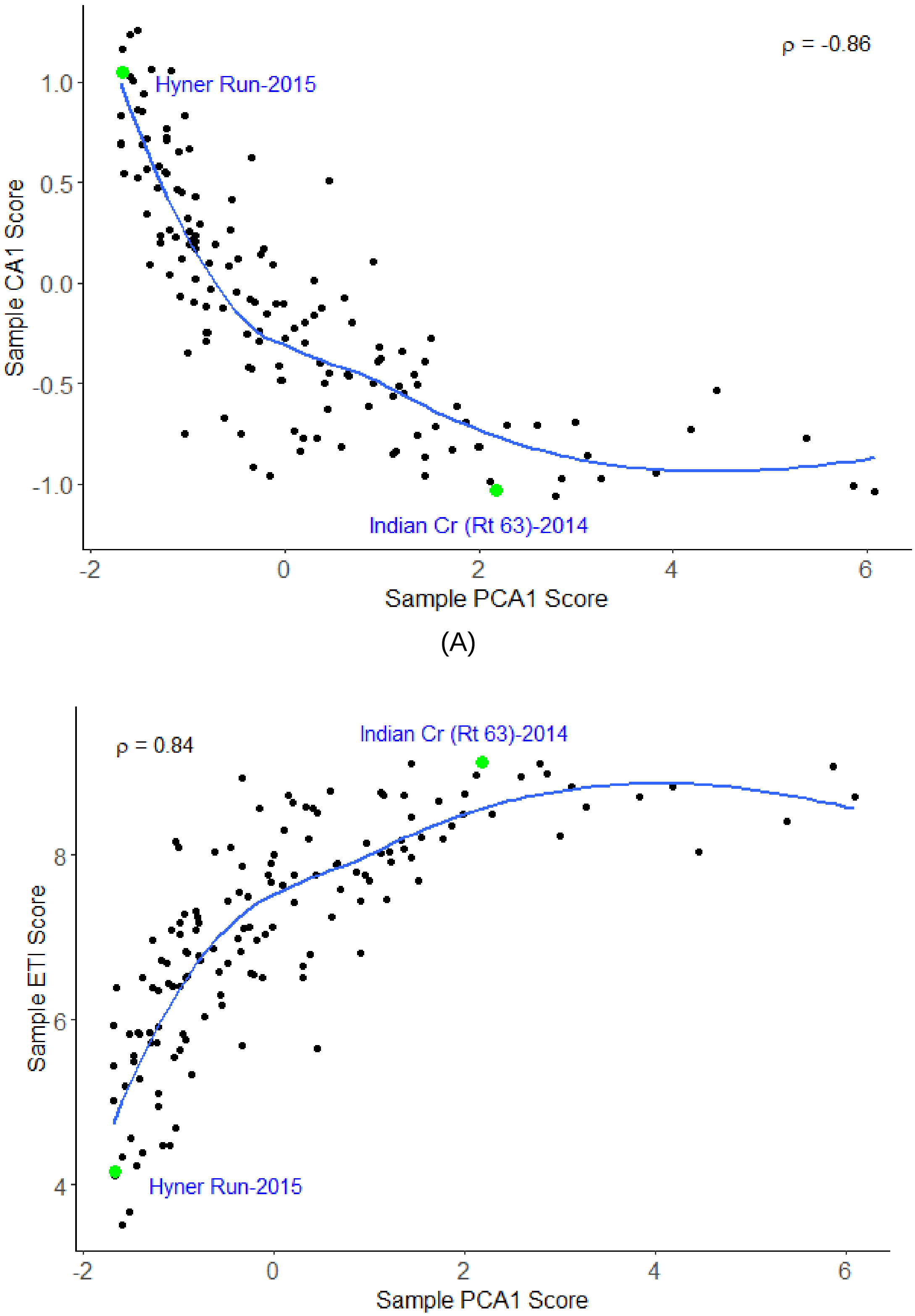
Order	Family	Taxa	ETV	DORT DOMT Mean	DORT Value	DOMT Value
Odonata	Coenagrionidae	*Argia*	10	10.0	10	10
	Gomphidae	*Lanthus*	1	1.0	1	1
Megaloptera	Corydalidae	*Nigronia*	3	2.5	3	2
		Corydalus	7	6.5	7	6
	Sialidae	*Sialis*	6	5.5	6	5
Lepidoptera	Crambidae	*Petrophila*	10	9.5	10	9
Coleoptera	Elmidae	*Oulimnius*	4	3.5	4	3
		Promoresia	4	3.5	4	3
		Optioservus	7	7.0	7	7
		Stenelmis	9	9.0	9	9
		Dubiraphia	10	9.5	9	10
	Psephenidae	*Psephenus*	9	8.5	9	8
Diptera	Athericidae	*Atherix*	2	2.0	2	2
	Chironomidae	*Chironomidae*	9	8.5	8	9
	Empididae	*Hemerodromia*	7	7.0	7	7
	Limoniinae	*Hexatoma*	4	3.5	3	4
		Antocha	6	6.0	6	6
	Pediciidae	*Dicranota*	2	2.0	2	2
	Simuliidae	*Prosimulium*	4	3.5	3	4
		Simulium	10	9.5	9	10
	Tipulidae	*Tipula*	7	7.0	5	9
Amphipoda	Crangonyctidae	*Crangonyx*	9	9.0	9	9
	Gammaridae	*Gammarus*	9	8.5	9	8
Gastropoda	Ancylidae	*Ancylidae*	7	7.0	7	7
	Corbiculidae	*Corbiculidae*	9	9.0	9	9
	Physidae	*Physidae*	10	10.0	10	10
	Sphaeriidae	*Sphaeriidae*	10	9.5	9	10
Hydracarina		*Hydracarina*	6	6.0	6	6
Isopoda	Asellidae	*Caecidotea*	10	9.5	9	10
Nematoda		*Nematoda*	5	5.0	6	4
Oligochaeta		*Oligochaeta*	8	7.5	7	8
Trepaxonemata		*Trepaxonemata*	10	10.0	10	10



(A)

(B)

Figure 5.2b. Biplot of taxa eutrophication tolerance value (ETV) vs. taxa CA axis 1 score (A) and sample eutrophication tolerance index (ETI) score vs. sample CA axis 1 score.



(A)

(B)

Figure 5.2c. Biplot of sample PCA axis 1 scores and sample CA axis 1 scores vs. PCA axis 1 scores (A) and sample ETI scores vs. PCA axis 1 scores (B).

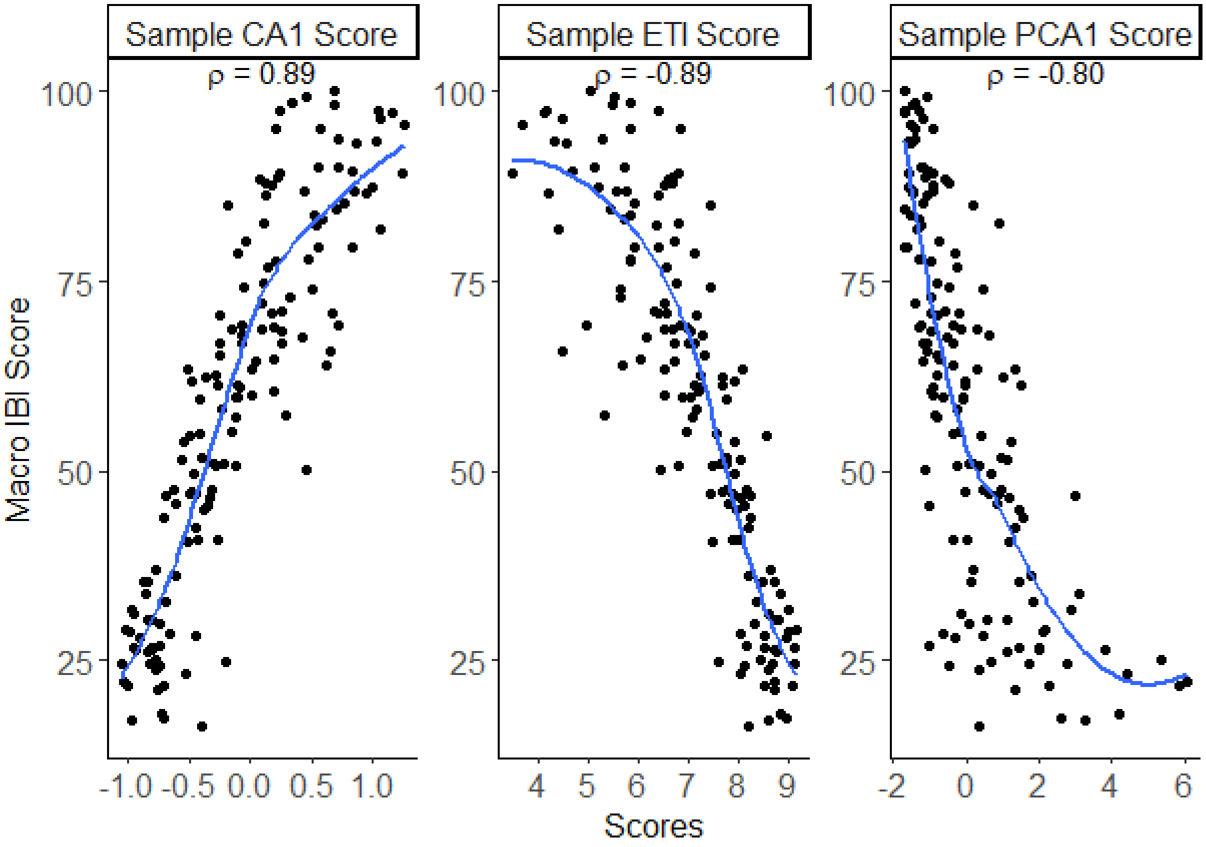


Figure 5.2d. Biplot of macroinvertebrate IBI score vs. sample CA axis 1 score (left panel), eutrophication tolerance index (ETI) score (middle panel), and PCA axis 1 score (right panel).

Table 5.2b. Spearman correlation values of sample CA axis 1, ETI, and PCA axis 1 scores vs. selected environmental factors.

Parameter	CA Axis 1 Score		ETI Score		PCA Axis 1 Score	
ETI Score	-0.97	****				
PCA1 Score	-0.86	****	0.84	****		
Forest %	0.81	****	-0.75	***	-0.76	***
Ag+Devel %	-0.81	****	0.76	***	0.78	***
Spec Cond umhos/cm	-0.85	****	0.8	****	0.8	****
Hard mg/L	-0.78	***	0.73	***	0.76	***
Alk mg/L	-0.7	***	0.67	**	0.73	***
Carbonate %	-0.28		0.26		0.34	
Channel Slope %	0.59	*	-0.55	*	-0.58	*
AirTemp MeanAnnual C	-0.73	***	0.67	**	0.62	**
Elev Station ft	0.63	**	-0.57	*	-0.54	*
Latitude	0.55	*	-0.48	*	-0.47	*
Longitude	-0.27		0.24		0.21	
TP kg/ha	-0.71	***	0.69	**	0.76	***
TN kg/ha	-0.67	**	0.64	**	0.69	**
TP mg/L	-0.77	***	0.75	***	0.84	****
TN mg/L	-0.74	***	0.72	***	0.79	***
p75DailyRange_WX Apr	-0.84	****	0.8	****	0.92	****
p75DailyRange_WX MayOct Mean	-0.75	***	0.73	***	0.86	****
p75DailyRange_WX JunSep Mean	-0.7	***	0.66	**	0.81	****
p75DailyRange_WX JulAug Mean	-0.64	**	0.62	**	0.78	***
p25DailyMin_WX Apr	0.76	***	-0.71	***	-0.87	****
p25DailyMin_WX MayOct Mean	0.69	**	-0.67	**	-0.85	****
p25DailyMin_WX JunSep Mean	0.66	**	-0.66	**	-0.84	****
p25DailyMin_WX JulAug Mean	0.6	**	-0.61	**	-0.79	***
p75DailyMax_TW Apr	-0.66	**	0.59	*	0.68	**
p75DailyMax_TW MayOct Mean	-0.8	****	0.78	***	0.76	***
p75DailyMax_TW JunSep Mean	-0.63	**	0.59	*	0.66	**
p75DailyMax_TW JulAug Mean	-0.44		0.38		0.48	*
DrainageArea mi2	-0.11		0.06		0.1	
StreamOrder	-0.1		0.06		0.09	
Bankfull Width ft	-0.06		0.02		0.05	
Bankfull Depth ft	-0.08		0.03		0.06	

[1] |ρ| ≥ 0.80 ****
[2] |ρ| = 0.70–0.79 ***
[3] |ρ| = 0.60–0.69 **
[4] |ρ| = 0.45–0.59 *

6. MODEL VALIDATION

The USEPA conceptual model diagram for stream dissolved oxygen shown in Figure 2a graphically links interacting stressors (nutrients) and proximate stressors (dissolved oxygen characteristics) to some form of biological response. In the development of the ECM, the annual mean instream concentrations of TP and TN were identified as interacting stressors, p75DailyRange_WX and p25DailyMin_WX values as proximate stressors, and macroinvertebrate CA axis 1 and ETI scores as biological response variables. As a means of testing the appropriateness of the stressor and response variables used in the development of the ECM, the Akaike Information Criterion (AIC) results were used to evaluate the effectiveness of the stressor and response variables used.

AIC results, generated using the AICcmodavg package in R (Mazerolle 2020), were used to identify the multiple linear regression models that explained the greatest amount of variation in the biological response variables (CA axis 1 and ETI scores) using the fewest possible predictor variables (interacting and proximate stressors). A total of 22 models were analyzed, one model for each relevant potential combination of sample period, PA eutrophication region, stream type, and biological response variable. All models were generated using annual mean TP, annual mean TN, monthly p75DailyRange_WX values, and monthly p25DailyMin_WX z-score values as predictor variables. Separate models were run for each of the biological response variables (CA axis 1 and ETI scores).

Both proximate stressors (monthly p75DailyRange_WX and p25DailyMin_WX values) were identified as important variables in the AIC best-fit models in 18 out of 22 models analyzed (Table 6a). The AIC best-fit models that did not include both proximate stressor variables were the April models for PA eutrophication region A streams and the May and October models for streams with a drainage area <38.6 mi^2 in PA eutrophication region A. Since the dataset did not show a reasonably strong linkage between both proximate stressor variables and the biological response variables in these streams during these sample periods, these streams are excluded from the ECM during these sample periods.

Table 6a. Akaike Information Criterion (AIC) results with predictor variables included in best-fit models identified with (✓).

Model Predictor Variables (z-score)	Sample Period	Stream Type	Model Response Variable	Predictor Variables Included in AIC Best-Fit Models			
				p75 Daily Range WX	p25 Daily Min WX	TP	TN
p75 Daily Range WX	April	PA Eutro Reg- A	CA 1	✓			
p25 Daily Min WX			ETI	✓			
TP Annual Mean		PA Eutro Reg- B	CA 1	✓	✓	✓	✓
TN Annual Mean			ETI	✓	✓	✓	✓
	May & Oct	<38.6 mi2 - A	CA 1	✓			
			ETI	✓			
		<38.6 mi2 - B	CA 1	✓	✓	✓	✓
			ETI	✓	✓	✓	✓
		38.6-500 mi2	CA 1	✓	✓	✓	✓
			ETI	✓	✓	✓	✓
	Jun & Sep	<38.6 mi2 - A	CA 1	✓	✓		
			ETI	✓	✓	✓	✓
		<38.6 mi2 - B	CA 1	✓	✓	✓	✓
			ETI	✓	✓	✓	✓
		38.6-500 mi2	CA 1	✓	✓	✓	✓
			ETI	✓	✓	✓	✓
	Jul & Aug	<38.6 mi2 - A	CA 1	✓	✓	✓	
			ETI	✓	✓	✓	✓
		<38.6 mi2 - B	CA 1	✓	✓	✓	✓
			ETI	✓	✓	✓	✓
		38.6-500 mi2	CA 1	✓	✓	✓	✓
			ETI	✓	✓	✓	✓

Apart from PA eutrophication region A streams in April and <38.6 mi^2-A streams in May and October, AIC results confirm the linkages implied in the USEPA conceptual model diagram for stream DO (Figure 2a) using the selected suite of proximate stressor and response variables. Overall, AIC results, in conjunction with the pairwise adonis results discussed in Section 4.2, indicate the selected suite of stressor and response variables and the process used to delineate samples into stream types and stream type-specific eutrophication stress classes effectively categorized samples across the eutrophication gradient of the dataset, and confirm the linkages implied in the conceptual model (Figure 2a).

It’s recognized that eutrophication is a stream ecosystem process that leads to several potential stressor-response pathways (e.g., alteration of food resources, alteration of physical habitat structure, production of algal toxins, etc.) in addition to the ecosystem metabolism (P and ER) stressor-response pathway used in the development of the ECM. The ecosystem metabolism stressor-response pathway was focused on for several reasons:

1. Theoretical linkage of DO with nutrients, aquatic community structure, and stream ecosystem processes as shown in USEPA's conceptual model diagram for DO (Figure 2a)
2. The large amount of continuously monitored DO data available, and
3. The strength of the relationships observed in the calibration dataset between DO %Sat values and macroinvertebrate community response variables (CA axis 1 and ETI scores)

Regarding the strength of the relationships observed in the dataset between DO %Sat values and macroinvertebrate community response variables, Spearman correlation results were used to confirm the appropriateness of using monthly p75DailyRange_WX and p25DailyMin_WX values as proximate stressors. Spearman correlation values ranged from |0.50| to |0.76| and all correlations were significant at p=0.000 (Table 6b). Spearman correlation values, the AIC results discussed above, and the pairwise adonis results discussed in Section 4.2, indicate the selected suite of eutrophication stressor and biological response variables, and the process used to delineate samples into stream types and stream type-specific eutrophication stress classes, effectively categorized samples across the eutrophication gradient of the dataset, and confirm the linkages implied in the conceptual model (Figure 2a).

Table 6b. Spearman correlation results between DO %Sat values and macroinvertebrate community response variables.

Sample Period	Stream Type	Biological Response Variable	p75 Daily Range WX		p25 Daily Minimum WX	
			r_s	p	r_s	p
April	<38.6 mi2-B	CA Axis 1 Score	-0.76	0	0.76	0
		ETI Score	0.73	0	-0.73	0
	38.6-500 mi2-B	CA Axis 1 Score	-0.66	0	0.59	0
		ETI Score	0.66	0	-0.62	0
May & October	<38.6 mi2-B	CA Axis 1 Score	-0.6	0	0.65	0
		ETI Score	0.55	0	-0.62	0
	38.6-500 mi2	CA Axis 1 Score	-0.63	0	0.59	0
		ETI Score	0.66	0	-0.59	0
June & September	<38.6 mi2-A	CA Axis 1 Score	-0.7	0	0.6	0
		ETI Score	0.69	0	-0.5	0
	<38.6 mi2-B	CA Axis 1 Score	-0.6	0	0.61	0
		ETI Score	0.52	0	-0.59	0
	38.6-500 mi2	CA Axis 1 Score	-0.59	0	0.55	0
		ETI Score	0.64	0	-0.63	0
Jul & Aug	<38.6 mi2-A	CA Axis 1 Score	-0.75	0	0.62	0
		ETI Score	0.72	0	-0.52	0
	<38.6 mi2-B	CA Axis 1 Score	-0.57	0	0.63	0
		ETI Score	0.51	0	-0.6	0
	38.6-500 mi2	CA Axis 1 Score	-0.53	0	0.5	0
		ETI Score	0.59	0	-0.58	0

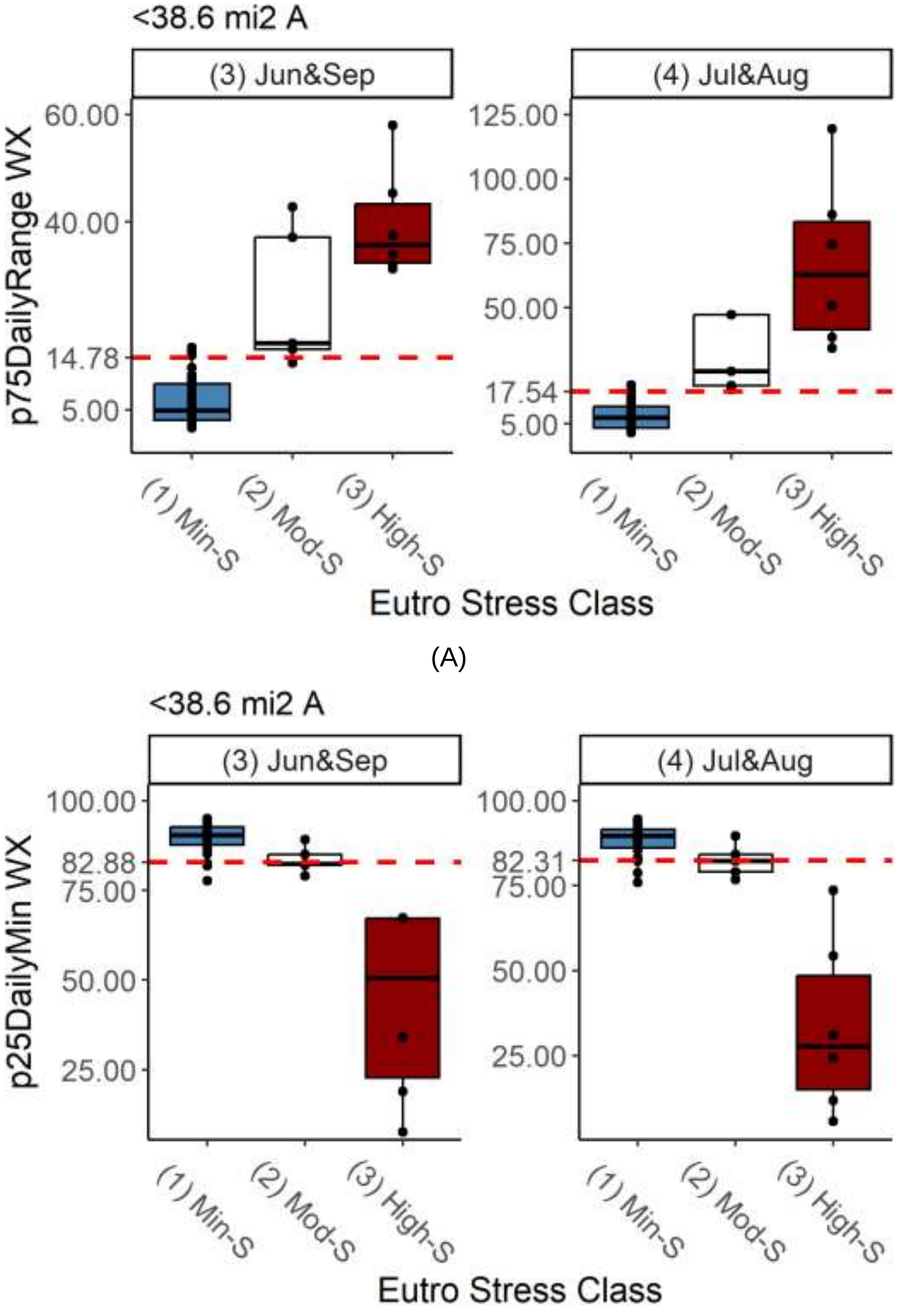
7. EUTROPHICATION CAUSE DECISION

In the ECM, eutrophication is identified as a cause of impairment in ALU or Special Protection Use impaired streams when both proximate stressors (monthly p75DailyRange_WX and p25DailyMin_WX) fail to meet the appropriate sample period-specific benchmarks in the same month. This requirement is designed to assure that nutrient enrichment has simultaneously elevated rates of both primary production (autotrophy) and ecosystem respiration to the point where stream DO characteristics have been substantially altered and thus, aquatic life (benthic macroinvertebrate community) has been negatively impacted by the process of eutrophication. In contrast to failing to meet both benchmarks in the same month, an impaired stream impacted by excessive amounts of organic matter from allochthonous sources (heterotrophy) may have excessively low p25DailyMin_WX values in the absence of elevated p75DailyRange_WX, suggesting organic enrichment/low DO may be a cause of impairment as opposed to the process of eutrophication.

Proximate stressor benchmarks were identified based on the daily DO %Sat characteristics of samples classified as minimally stressed by eutrophication (Min-S samples, Section 4.2). Benchmark values for streams with a drainage area <38.6 mi^2 in eutrophication region A were based on the 5th and 95th percentile values of Min-S samples. Benchmark values for streams with a drainage area <38.6 mi^2 in eutrophication region B and streams with a drainage area between 38.6 and 500 mi^2 statewide, were based on the 10th and 90th percentile values of Min-S samples. The use of different percentile values in the development of benchmarks (95th vs. 90th percentiles) reflects the differences observed in the degree of eutrophication stress of supporting samples between PA eutrophication regions and among stream types discussed in Section 4.2 and shown in Figure 4.2a. Proximate stressor benchmark values are summarized in Table 7a and shown graphically in Figures 7a-e.

Table 7a. Summary table of proximate stressor benchmarks.

Proximate Stressor	Stream Type	April	May & October	June & September	July & August
p75 Daily Range WX	<38.6 mi^2 - A	N/A	N/A	14.78	17.54
	<38.6 mi^2 - B	29.84	26.26	27.42	34.91
	38.6-500 mi^2 - A	N/A	30.21	42.64	52.61
	38.6-500 mi^2 - B	29.84	30.21	42.64	52.61
p25 Daily Min WX	<38.6 mi^2 - A	N/A	N/A	82.88	82.31
	<38.6 mi^2 - B	87.15	83.87	80.07	80.36
	38.6-500 mi^2 - A	N/A	81.82	77.82	74.86
	38.6-500 mi^2 - B	87.15	81.82	77.82	74.86



(A)

(B)

Figure 7a. June through September p75DailyRange_WX (A) and p25DailyMin_WX (B) benchmark values for stream type <38.6 mi^2-A samples.

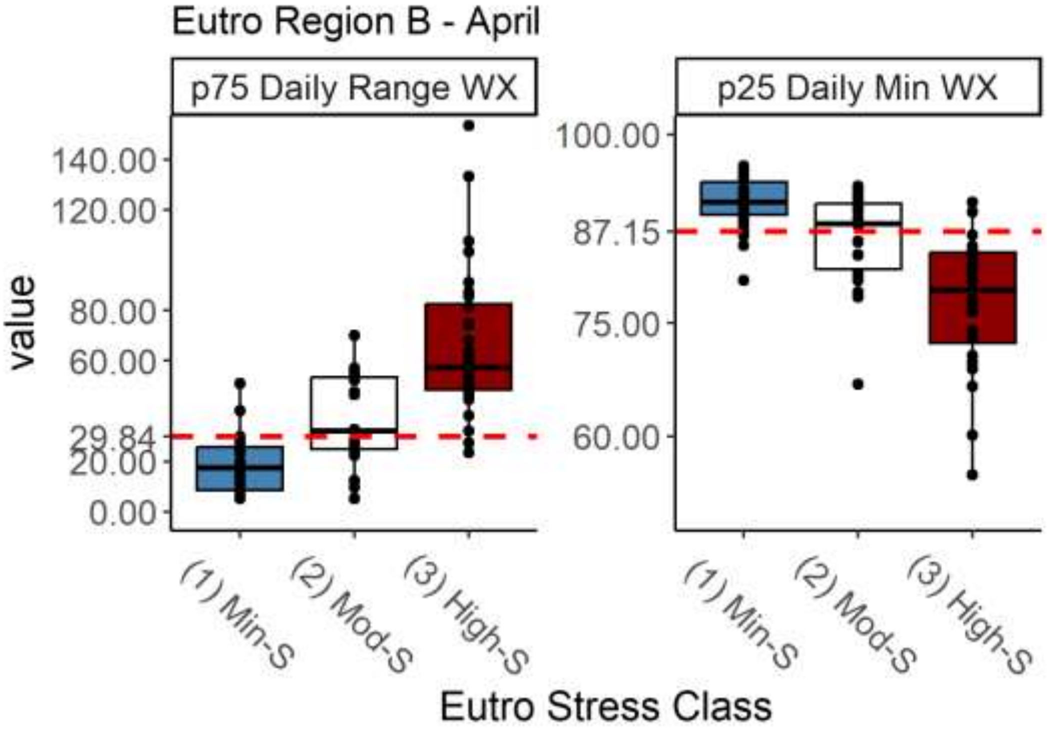
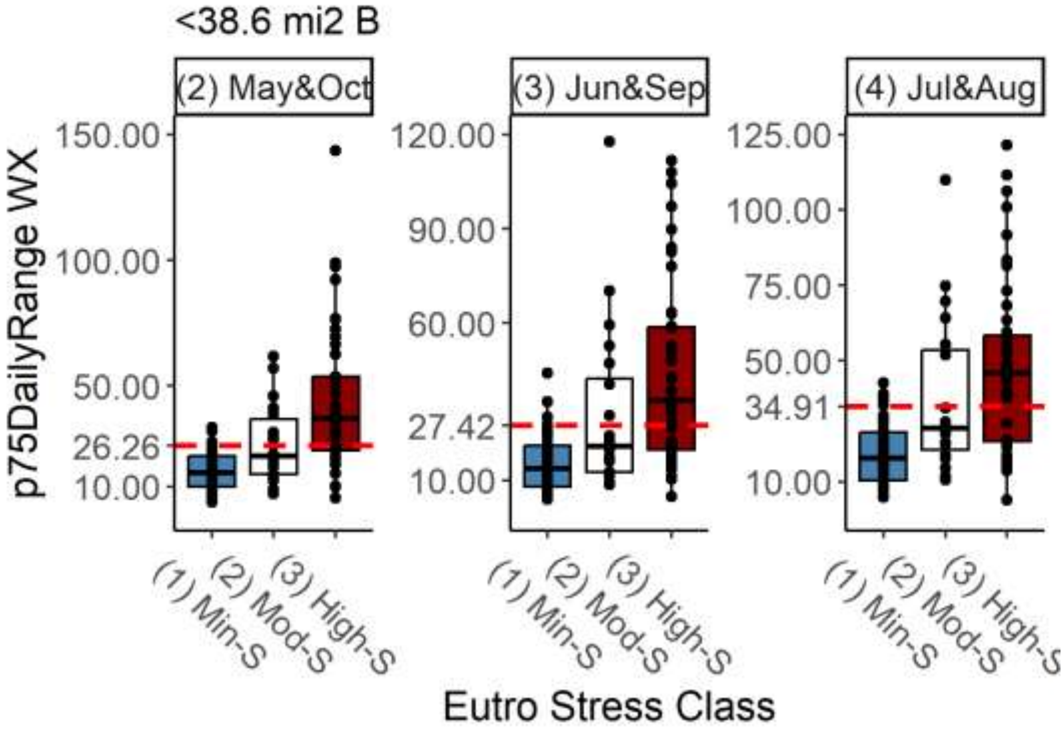
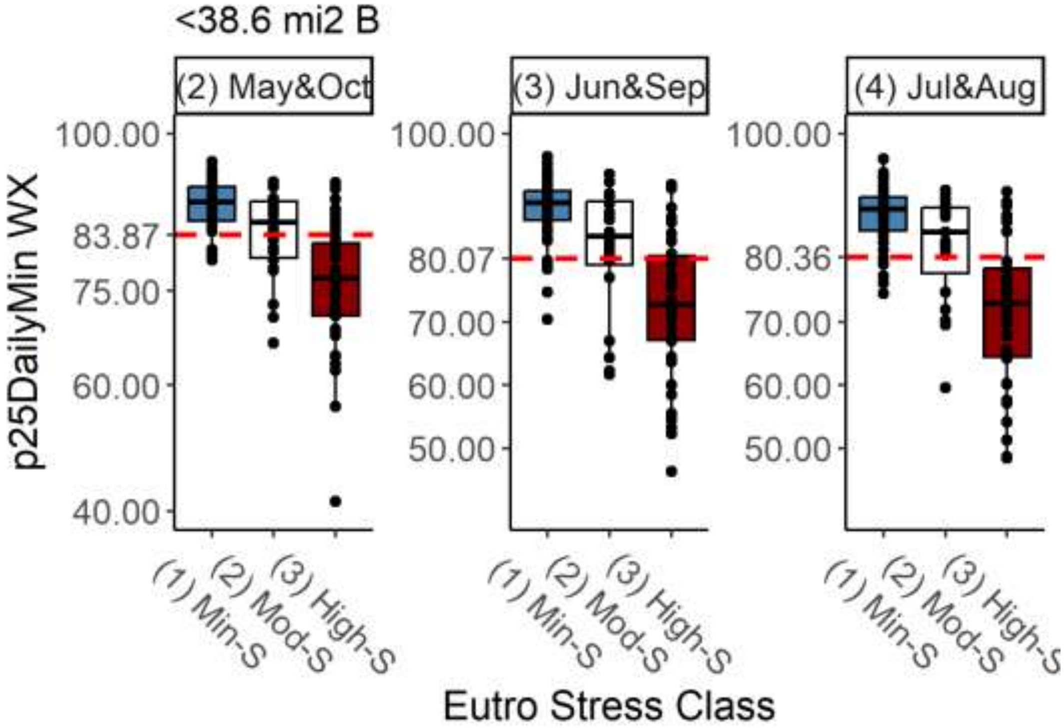


Figure 7b. April p75DailyRange_WX and p25DailyMin_WX benchmark values for PA eutrophication region B samples.

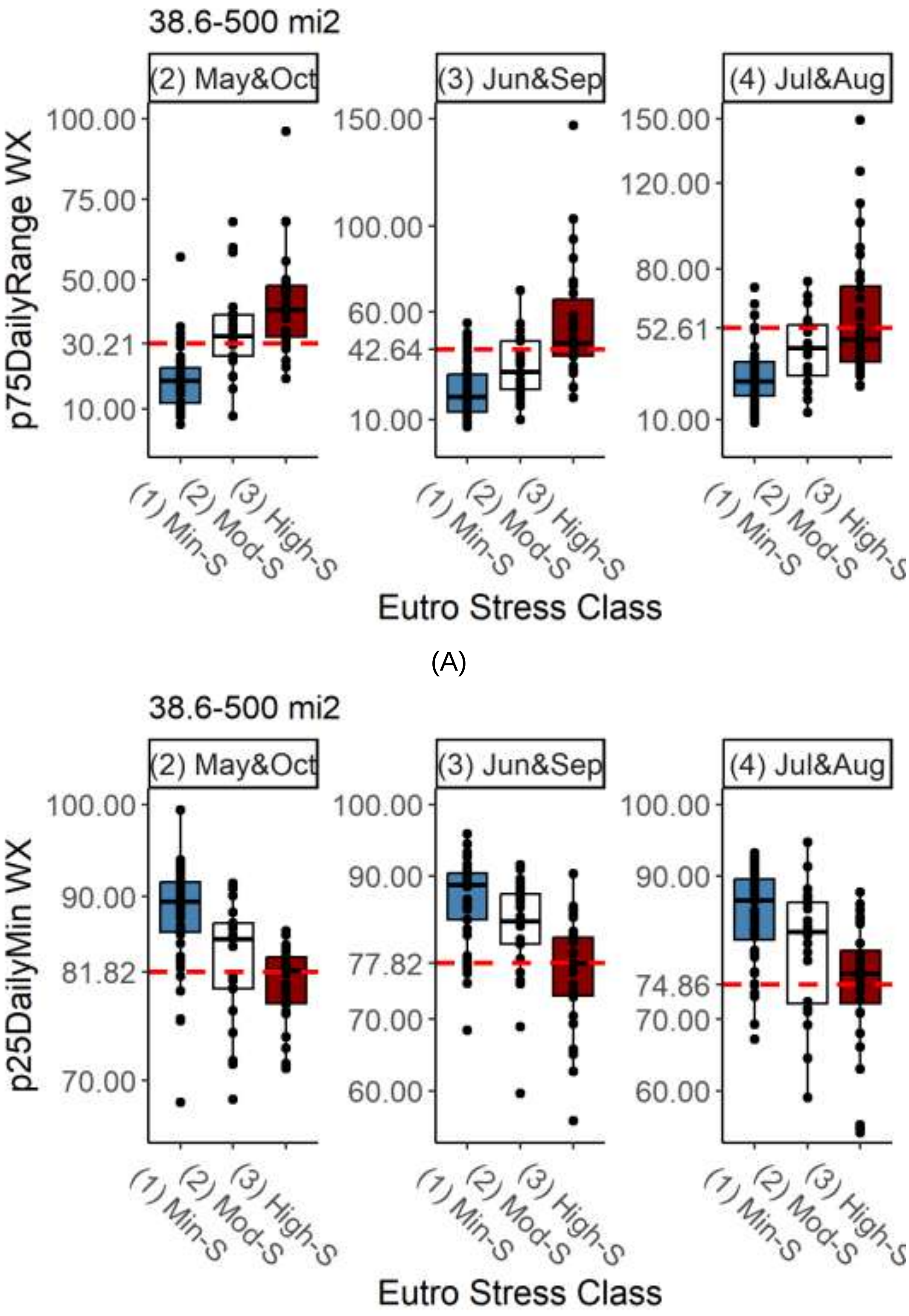


(A)



(B)

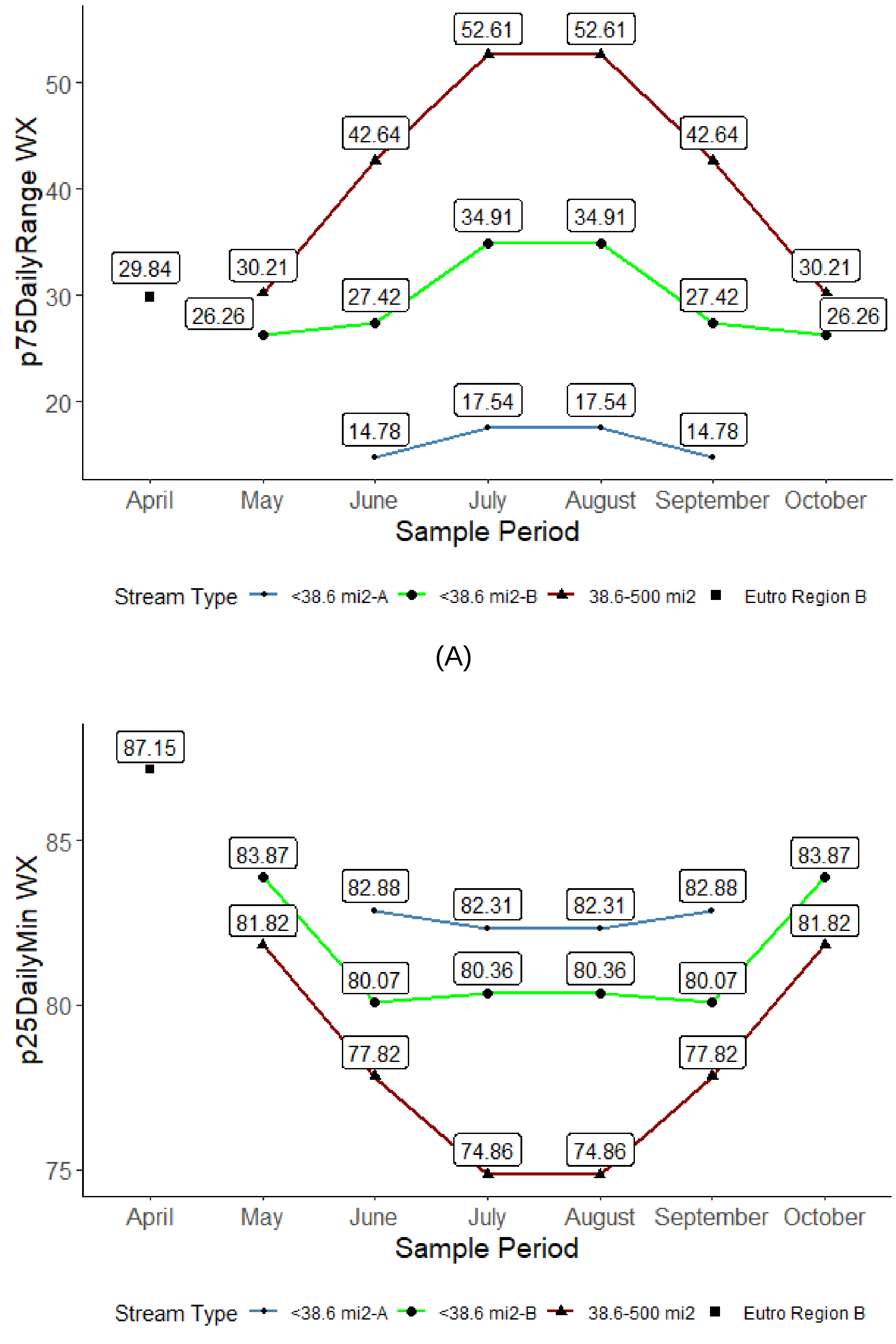
Figure 7c. May through October p75DailyRange_WX (A) and p25DailyMin_WX (B) benchmark values for stream type <38.6 mi^2-B samples.



(A)

(B)

Figure 7d. May through October p75DailyRange_WX (A) and p25DailyMin_WX (B) benchmark values for stream type 38.6-500 mi^2 samples.



(A)

(B)

Figure 7e. p75DailyRange_WX (A) and p25DailyMin_WX (B) benchmark values by stream type. Applying the proximate stressor benchmark values shown in Table 7a to the dataset provides a means for categorizing individual months of data into one of the following monthly ECM status categories:

ECM Status 1	Both proximate stressor benchmarks supported (primary productivity and ecosystem respiration rates comparable to benchmarks)
ECM Status 2	The p25DailyMin_WX proximate stressor benchmark supported, but the p75DailyRange_WX proximate stressor benchmark not supported (elevated primary productivity rate)
ECM Status 3	The p75DailyRange_WX proximate stressor benchmark supported, but the p25DailyMin_WX proximate stressor benchmark not supported (elevated ecosystem respiration rate)
ECM Status 4	Both proximate stressor benchmarks simultaneously not supported in the same month, eutrophication is identified as a cause of impairment in an ALU or Special Protection Use impaired waterway (elevated primary productivity and ecosystem respiration rates)

Calibration and ancillary sample monthly ECM status information is summarized in Appendix E.

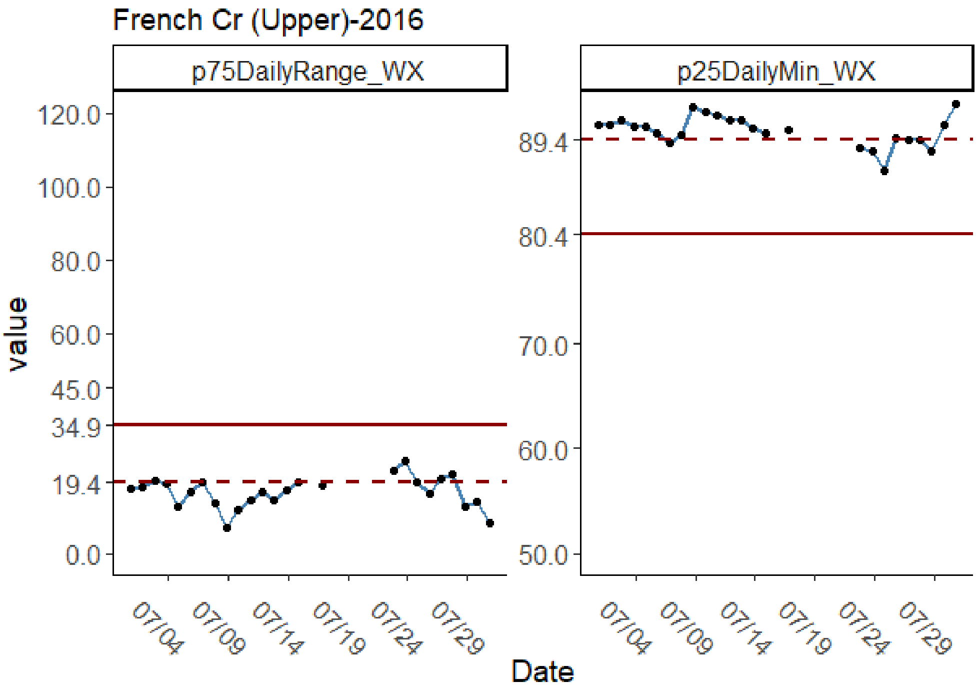
Shown below are graphic examples of the four monthly ECM status categories described above. The examples consist of data collected in July of various years at four different <38.6 mi^2-B stations. The first example is of ECM Status 1 data from French Creek (Upper) in July of 2016. ECM Status 1 data support both the p75DailyRange_WX benchmark value of a maximum of 34.91 and the p25DailyMin_WX benchmark value of a minimum of 80.36, indicating no eutrophication signal detected in that month (Figure 7f (A)).

The second example is of ECM Status 2 data from Pickering Creek in July of 2016. ECM Status 2 data exceed the p75DailyRange_WX benchmark value of a maximum of 34.91 but support the p25DailyMin_WX benchmark value of a minimum of 80.36. ECM Status 2 data indicate elevated primary productivity rates but ecosystem respiration rates comparable to benchmark values, indicative of a weak eutrophication signal that is not strong enough to indicate eutrophication as a cause of impairment in that month (Figure 7f (B)).

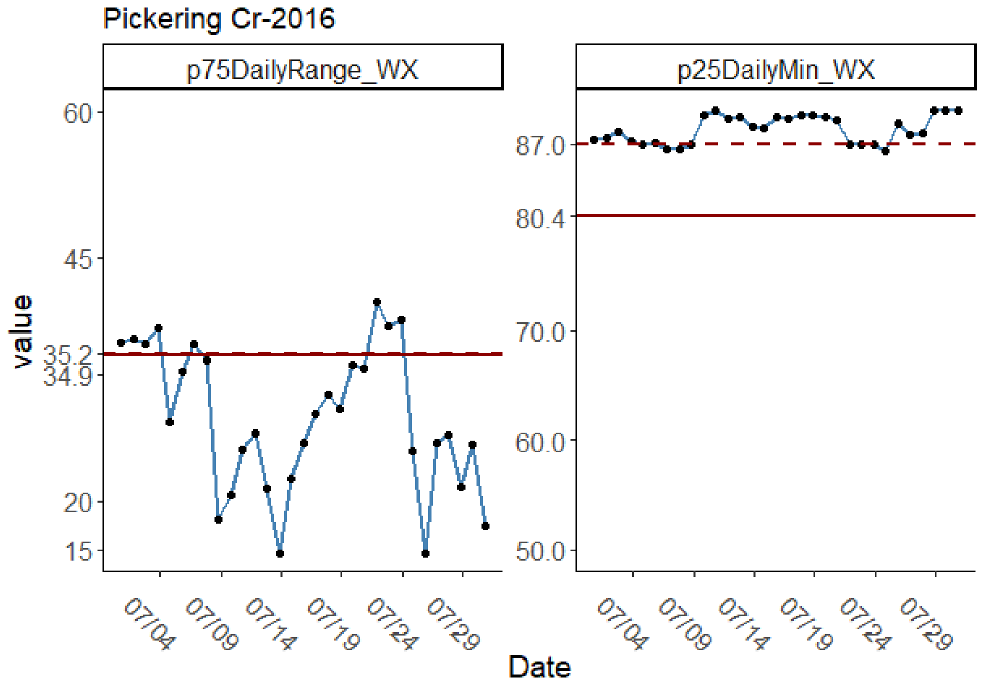
The third example is of ECM Status 3 data from Chiques Creek (Mill) in July of 2017. ECM Status 3 data support the p75DailyRange_WX benchmark value of a maximum of 34.91, but not the p25DailyMin_WX benchmark value of a minimum of 80.36. ECM Status 3 data indicate primary productivity rates comparable to benchmark values, but elevated ecosystem respiration rates indicative of low DO conditions that are not driven by photosynthesis/eutrophication in that month (Figure 7g (A)).

The fourth example is of ECM Status 4 data from Tinicum Creek in July of 2016. ECM Status 4 data fail to support both the p75DailyRange_WX benchmark value of a maximum of 34.91 and the p25DailyMin_WX benchmark value of a minimum of 80.36. ECM Status 4 data indicate elevated primary productivity and ecosystem respiration rates, indicative of eutrophication as a cause of impairment in an ALU or Special Protection Use impaired waterway (Figure 7g (B)).

The ECM is designed for use in streams with a benthic macroinvertebrate community that does not support the ALU or Special Protection Use. In this method, eutrophication is identified as a cause of impairment when both proximate stressors (monthly p75DailyRange_WX and p25DailyMin_WX) fail to meet the appropriate stream type, sample period-specific benchmarks in the same month. Of the four monthly ECM status categories described above and illustrated in Figures 7f and 7g, only ECM Status 4 data (Tinicum Creek, Figure 7g (B)) would indicate eutrophication as a cause of impairment in an ALU or Special Protection Use impaired waterway (Figure 7h). July daily DO %Sat values from the four ECM status examples are shown in Figure 7i. The ECM is summarized in the schematic diagram shown in Figure 7j.

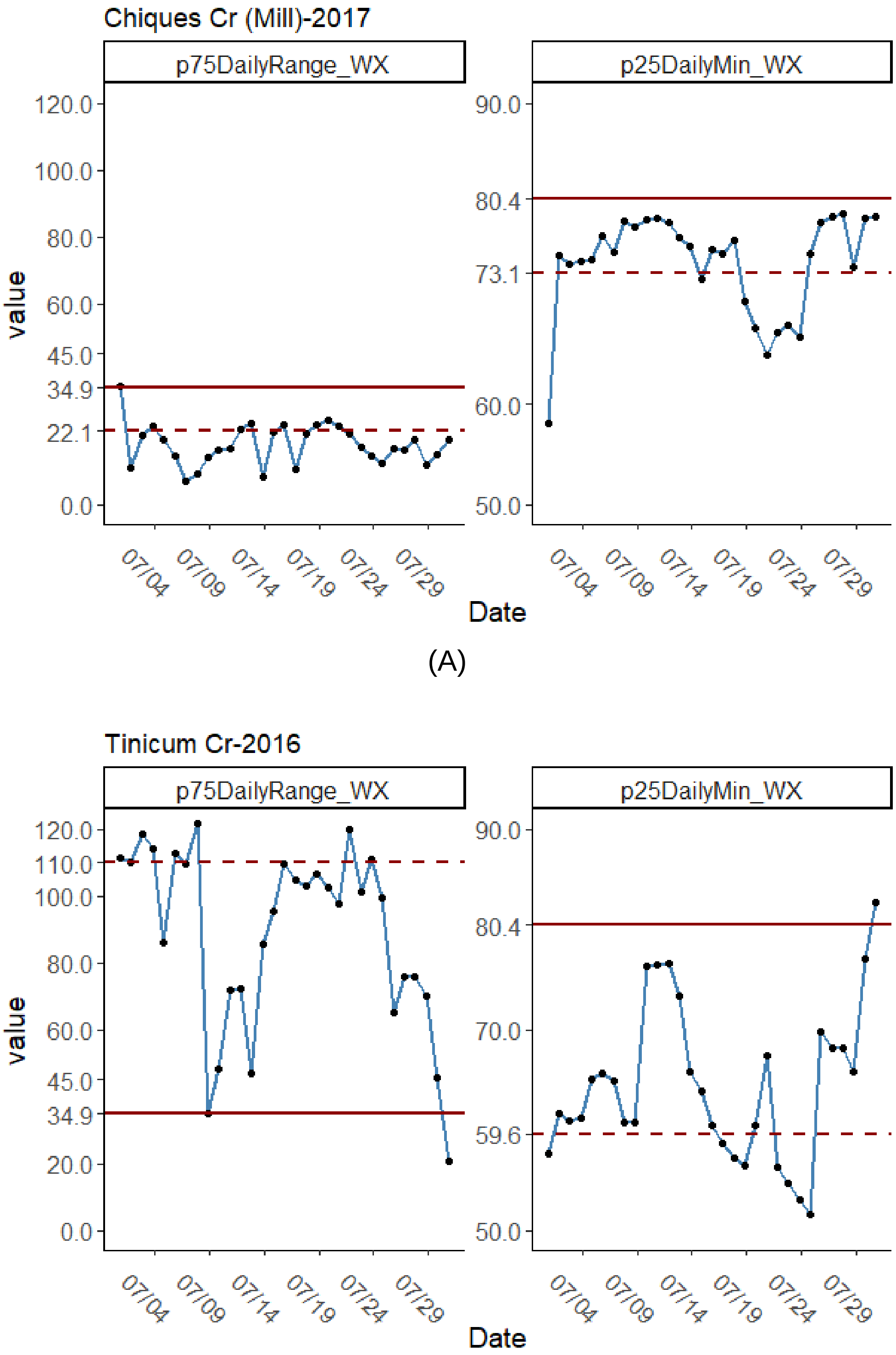


(A)



(B)

Figure 7f. Graphic representation of daily values (dots) and monthly p75 and p25 values (dashed lines) of (A) ECM Status 1 data from French Creek (Upper) in July of 2016 and (B) ECM Status 2 data from Pickering Creek in July of 2016. Solid horizontal lines represent benchmark values.



(A)

(B)

Figure 7g. Graphic representation of daily values (dots) and monthly values (dashed lines) of (A) ECM Status 3 data from Chiques Creek (Mill) in July of 2017 and (B) ECM Status 4 data from Tinicum Creek in July of 2016. Solid horizontal lines represent benchmark values.

Figure 7h. Dense periphyton growth at the Tinicum Creek, ECM Status 4 in July 2016 (Photo: A. Everett).

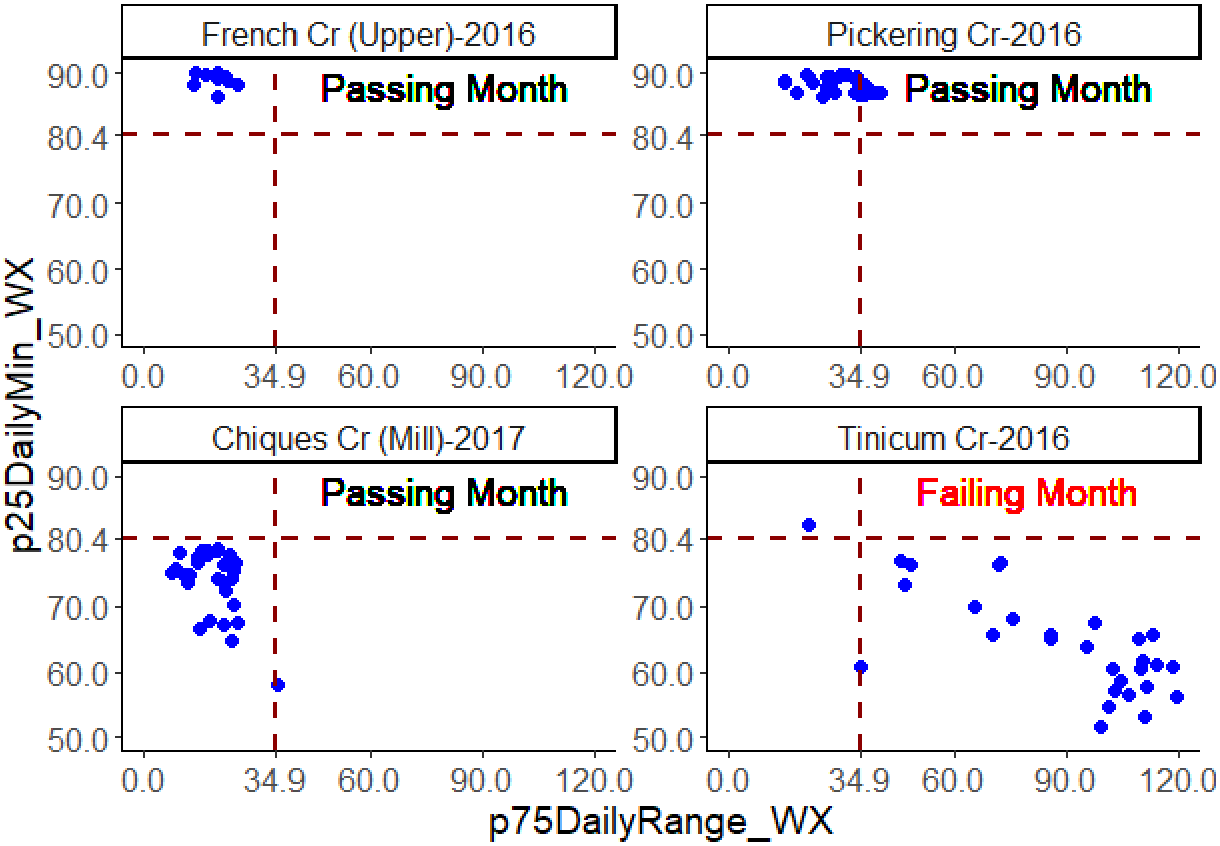


Figure 7i. Graphic representation of July daily values showing examples of four monthly ECM status categories: ECM Status 1 (upper left panel), ECM Status 2 (upper right panel), ECM Status 3 (lower left panel), and ECM Status 4 (lower right panel). Dashed lines represent benchmark values.

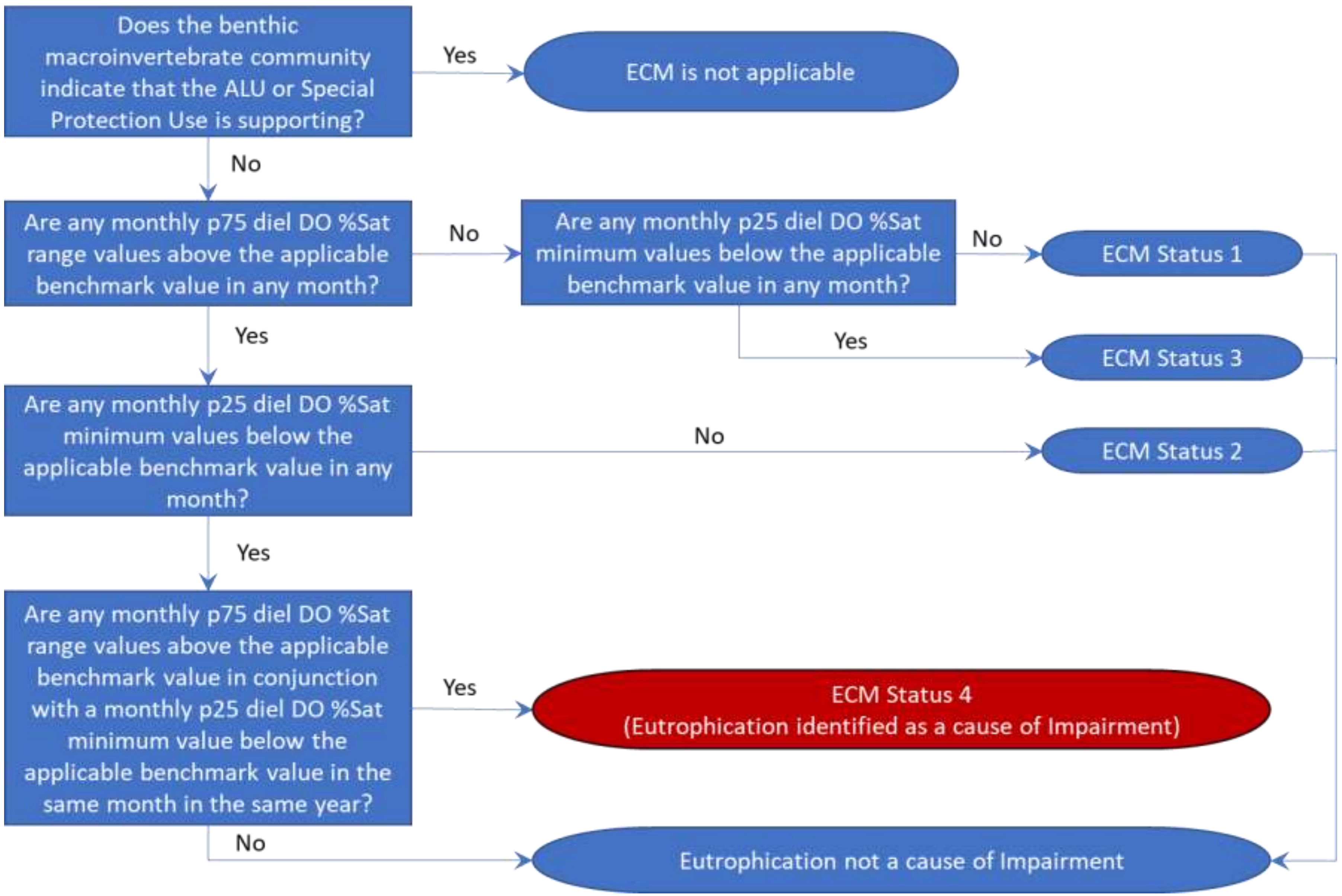


Figure 7j. Schematic diagram of the Eutrophication Cause Method (ECM).

8. METHOD PERFORMANCE, MINIMUM DATA COLLECTION REQUIREMENTS, AND POTENTIAL ADDITIONAL USES OF ETI SCORES AND ECM BENCHMARK VALUES

The overall performance of the ECM was evaluated based on how effectively ECM results discriminated between the eutrophication stressor, biological response, and the support status of calibration samples. Discrimination efficiency (DE) values were calculated for these characteristics between supporting samples with all months of data categorized as ECM Status 1 (primary productivity and ecosystem respiration rates comparable to benchmarks) vs. non-supporting samples with at least one month of data categorized as ECM Status 4 (elevated primary productivity and ecosystem respiration rates) (see Figure 8a for example DE calculations).

Figures 8b through 8d show clear discrimination between eutrophication stressor and macroinvertebrate community response variables of supporting ECM Status 1 samples vs. non-supporting ECM Status 4 samples. Discrimination efficiency (DE) values ranged from 75.0 to 100.0 with most values ≥82.6. This clear discrimination in the eutrophication stressor and biological response variables used to develop the ECM confirms that ECM results strongly align with the linkages implied in the USEPA conceptual model diagram for stream dissolved oxygen (Figure 2a).

Calibration and ancillary samples were used to evaluate the degree of temporal variability associated with the ECM by comparing method results generated at a given station in different years. Sample pairs ranged from one to three years apart. Results agreed (i.e. no months categorized as ECM Status 4 in both years or at least one month categorized as ECM Status 4 in both years) in 21 of the 26 temporal variability paired-sample comparisons (80.8% agreement).

Calibration and ancillary samples also were used to evaluate the degree of spatial variability associated with the ECM by comparing method results from stations located on the same waterway with similar land cover, during the same year. Method results agreed (i.e. no months categorized as ECM Status 4 at both sample locations or at least one month categorized as ECM Status 4 at both sample locations) in nine of the 11 spatial variability paired-sample comparisons (81.8% agreement).

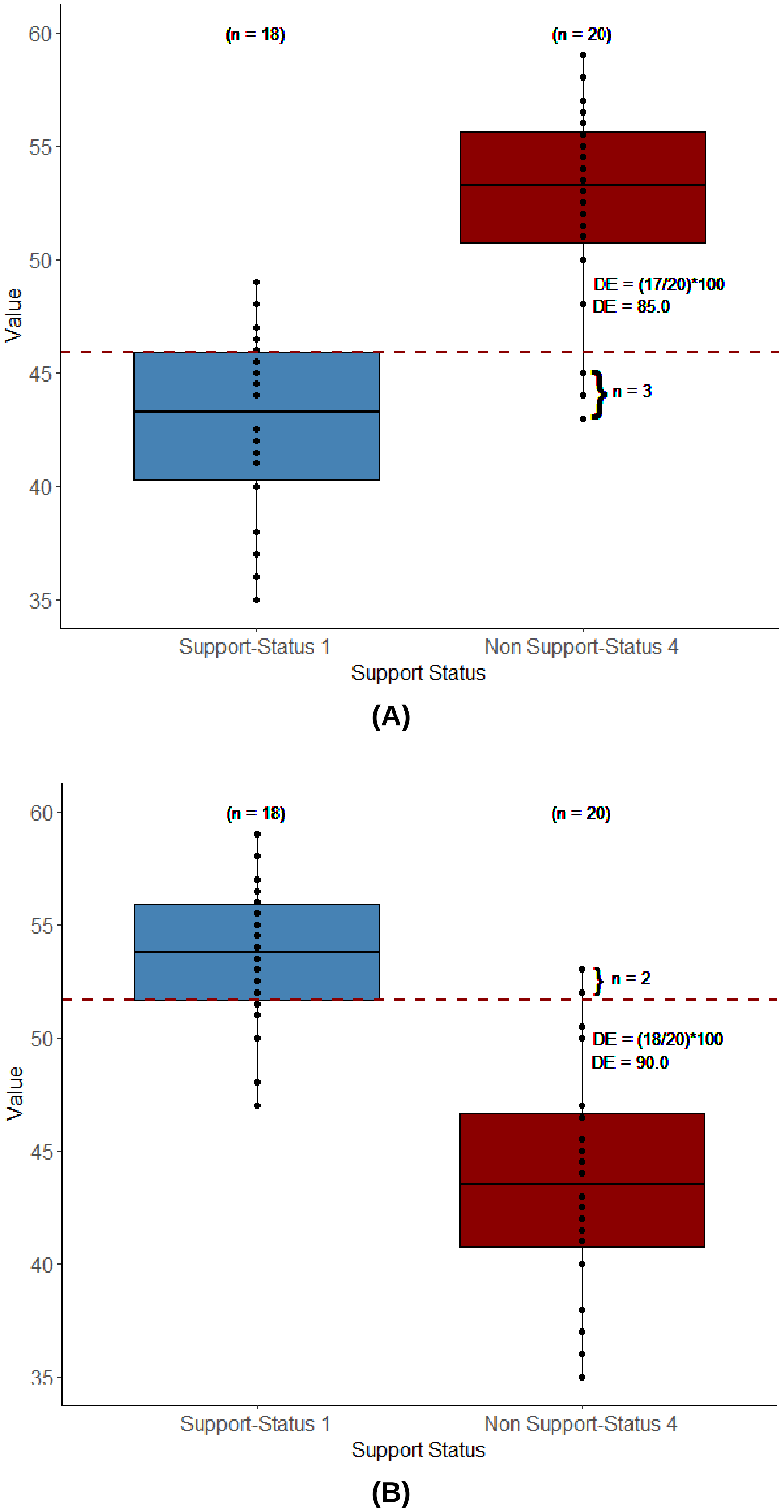
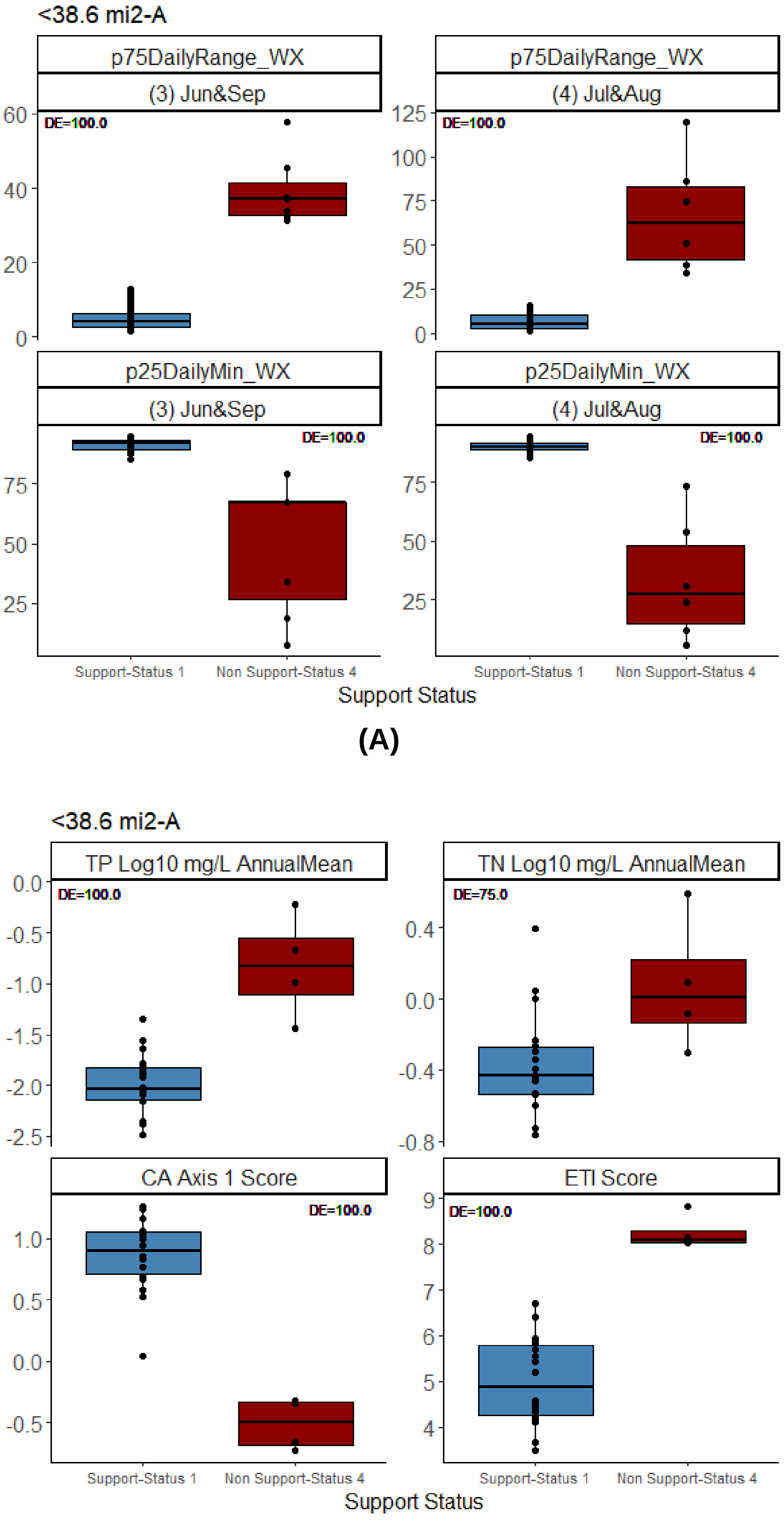


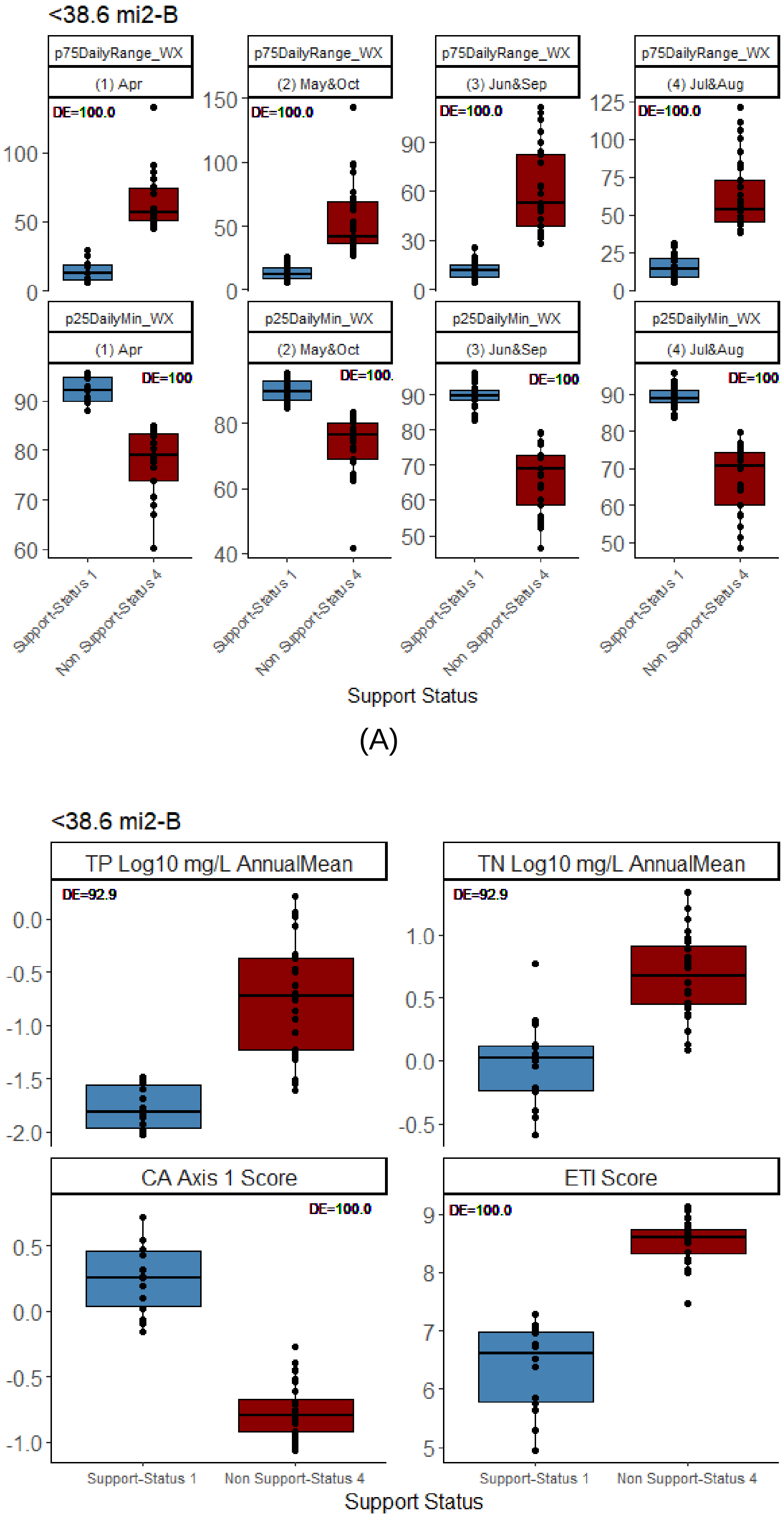
Figure 8a. Example of discrimination efficiency (DE) calculations for parameters with values that increase with increasing eutrophication stress (A) and for parameters with values that decrease with increasing eutrophication stress (B).



(A)

(B)

Figure 8b. Discrimination efficiency (DE) of stream type <38.6 mi^2 – A sample proximate stressor values (A) and interacting stressor and biological response values (B) between supporting ECM Status 1 samples vs. non-supporting ECM Status 4 samples.



(A)

(B)

Figure 8c. Discrimination efficiency (DE) of stream type <38.6 mi^2 – B sample proximate stressor values (A) and interacting stressor and biological response values (B) between supporting ECM Status 1 samples vs. non-supporting ECM Status 4 samples.

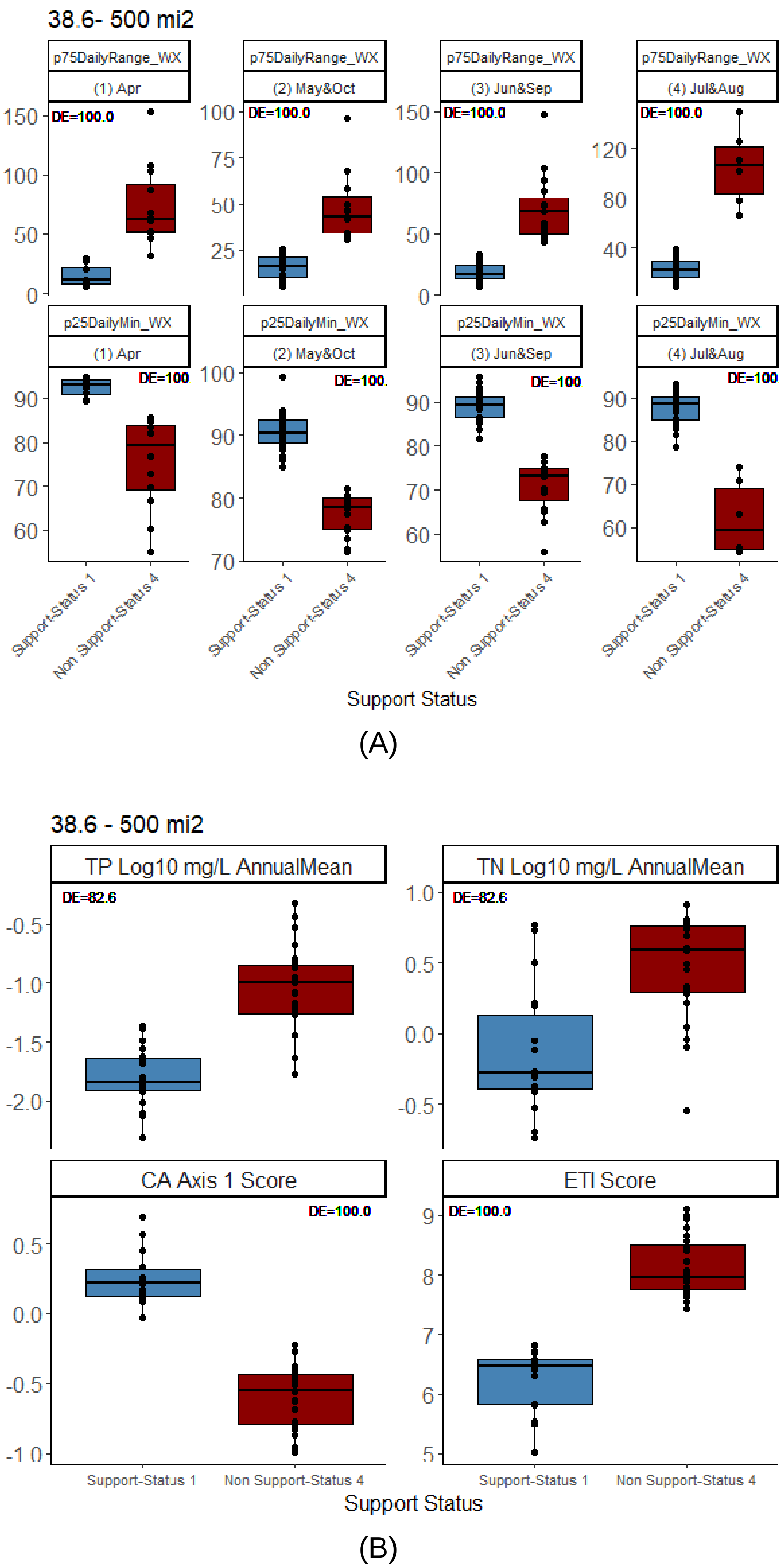


Figure 8d. Discrimination efficiency (DE) of stream type 38.6-500 mi^2 sample proximate stressor values (A) and interacting stressor and biological response values (B) between supporting ECM Status 1 samples vs. non-supporting ECM Status 4 samples.

The average duration of sonde deployment in the calibration dataset used to develop the ECM was 5.9 months. However, the minimum amount of data required to identify eutrophication as a cause of impairment (one month of data categorized as ECM Status 4) could be as little as 14 days of usable data collected within a given calendar month.

In addition to their use in the development of the ECM described above, macroinvertebrate sample ETI scores and stream type, sample period-specific p75DailyRange_WX and p25DailyMin_WX benchmark values also can be used as a screening tool for identifying impaired streams as candidates for implementing the ECM. First, sample ETI scores can be used to categorize impaired streams as having high, moderate, or low potential for eutrophication as a cause of impairment based on the ETI scores shown in Table 8a and in Figure 8e.

Table 8a. Macroinvertebrate sample ETI score ranges for categorizing impaired streams as having high, moderate, or low potential for eutrophication as a cause of impairment.

Stream Type	Low Potential	Moderate Potential	High Potential
<38.6 mi^2 - A	<6.72	6.72 – 8.04	>8.04
<38.6 mi^2 - B	<7.28	7.28 – 8.26	>8.26
38.6 - 500 mi^2	<6.82	6.82 – 7.76	>7.76

Next, after a period of at least 14 days without a substantial scour event, the difference in discrete measurements of late-afternoon and early-morning stream DO %Sat values taken within a period of 24 hours can be compared to the appropriate p75DailyRange_WX benchmark value to determine if the waterway shows signs of elevated primary productivity. Likewise, early-morning discrete measurements of stream DO %Sat can be compared to the appropriate p25DailyMin_WX benchmark, to determine if the waterway is subject to elevated ecosystem respiration rates (Table 8b). This screening process can be used to categorize an impaired stream segment's potential for the implementation of the ECM (Figure 8f).

Late-afternoon and early-morning discrete measurements of stream DO %Sat also may be useful for delineating the upstream and downstream extent of eutrophication impacts in an impaired stream segment in which eutrophication has been identified as a cause of impairment. These discrete measurements of stream DO %Sat taken at various locations on the stream, its tributaries, and potential point and non-point sources of nutrients can be compared to appropriate DO %Sat benchmark values and used to delineate the extent of eutrophication impact.

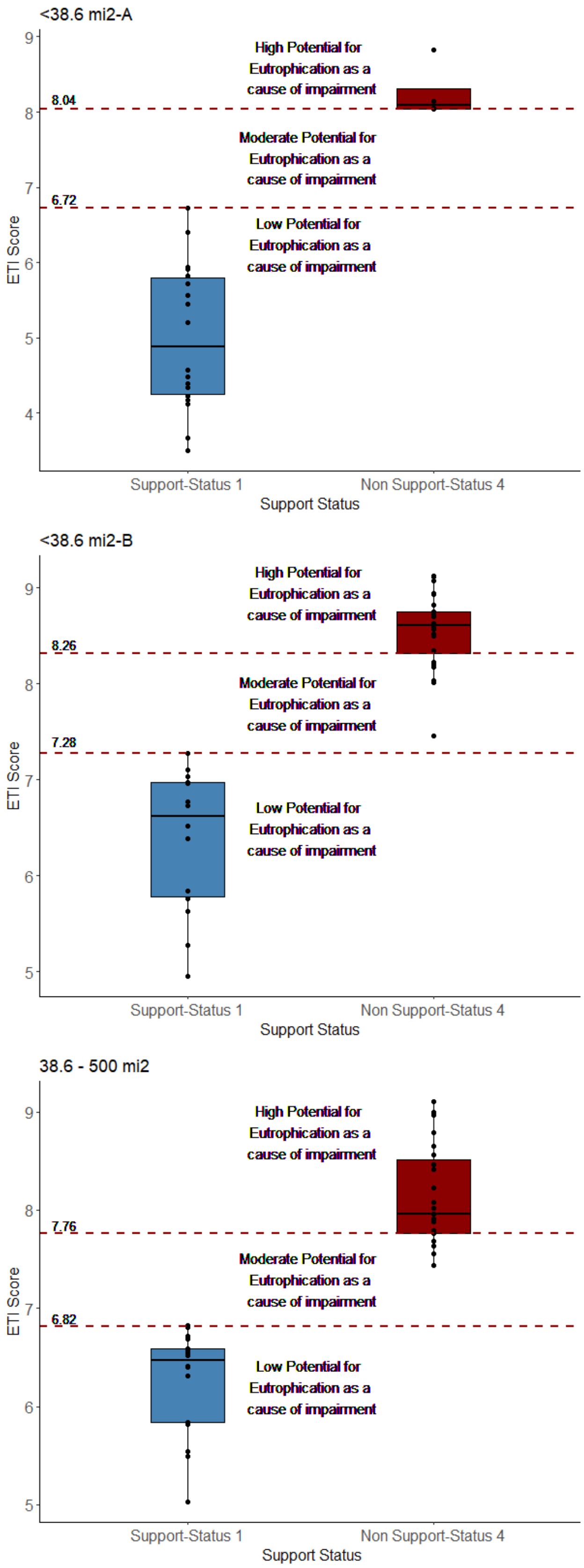


Figure 8e. Macroinvertebrate sample ETI scores for categorizing impaired streams as having high, moderate, or low potential for eutrophication as a cause of impairment and the potential for implementation of the ECM.

Table 8b. Summary table of proximate stressor benchmarks.

Proximate Stressor	**Stream Type**	**April**	**May & October**	**June & September**	**July & August**
p75 Daily Range WX	<38.6 mi^2 - A	N/A	N/A	14.78	17.54
	<38.6 mi^2 - B	29.84	26.26	27.42	34.91
	38.6-500 mi^2 - A	N/A	30.21	42.64	52.61
	38.6-500 mi^2 - B	29.84	30.21	42.64	52.61
p25 Daily Min WX	<38.6 mi^2 - A	N/A	N/A	82.88	82.31
	<38.6 mi^2 - B	87.15	83.87	80.07	80.36
	38.6-500 mi^2 - A	N/A	81.82	77.82	74.86
	38.6-500 mi^2 - B	87.15	81.82	77.82	74.86

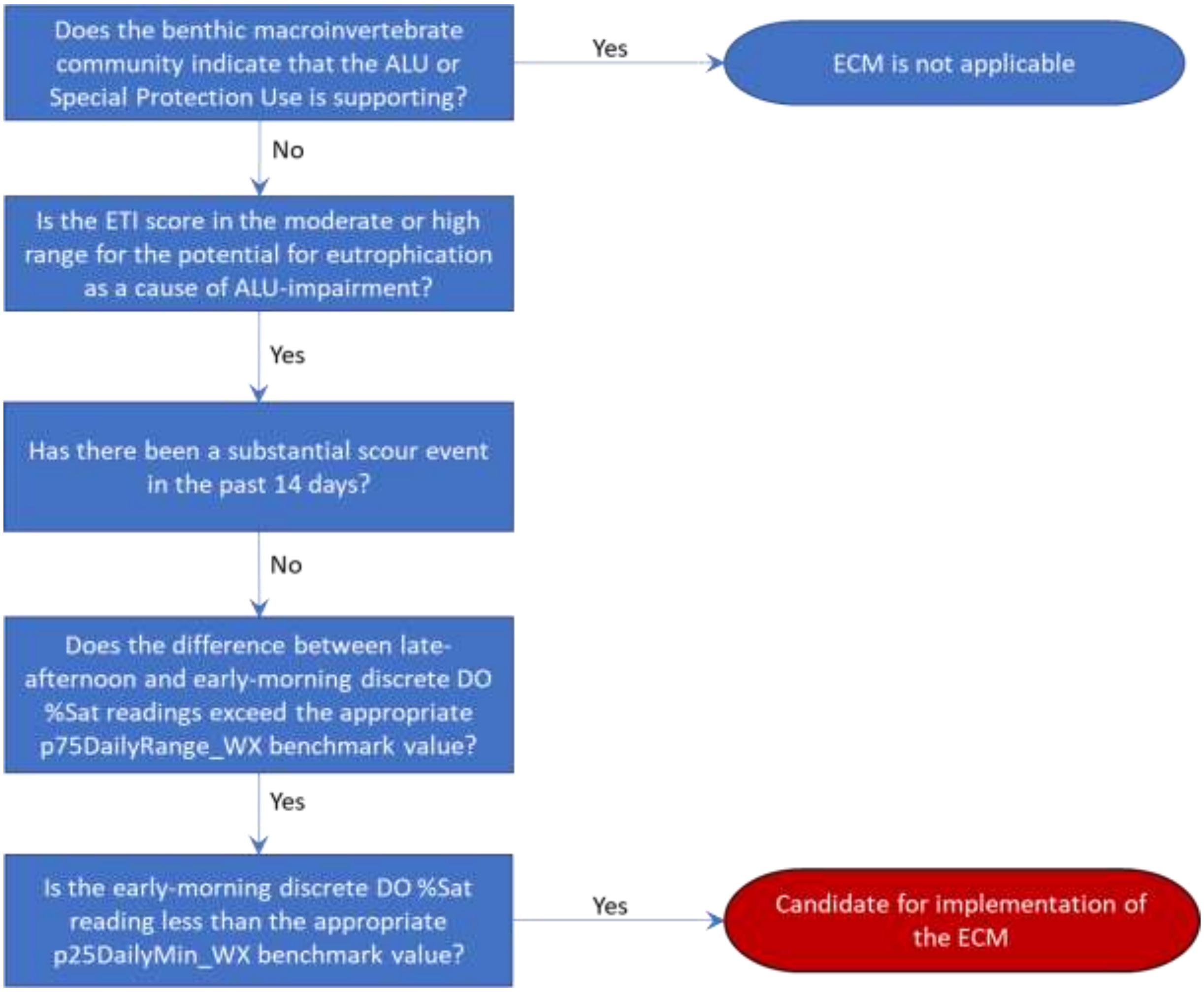


Figure 8f. Schematic diagram of the screening process used to categorize an impaired stream segment’s potential for the implementation of the Eutrophication Cause Method (ECM).

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10. APPENDICES

10.1 Appendix A: Sample Location and General Information

Sample Name	County	Latitude	Longitude	Sample Type	Forest (%)	Agriculture (%)	Developed (%)	Carbonate (%)	TP kg/ha	TN kg/ha	TP mg/L Annual Mean	TN mg/L Annual Mean	Alk mg/L Annual Mean
Allegheny R (Port Allegany)-2015	McKean	41.818611	-78.293056	Cal	72.5	14.8	2.6	0	0.29	2.41	0.048	0.66	20.5
Aughwick Cr-2014	Huntingdon	40.307250	-77.876630	Cal	78.3	15.3	5.8	7	0.48	5.89	0.018	0.50	59.7
Beaver Cr-2018	Bedford	40.147811	-78.389938	Cal	56.6	38.1	5.3	36	0.80	9.12	0.048	3.43	103.4
Beaver Run-2016	Chester	40.157864	-75.671565	Cal	50.1	25.1	9.8	0	0.61	13.27	0.028	1.00	37.9
Bells Run-2016	Lancaster	39.846505	-76.022107	Cal	12.8	79.4	4.8	0	3.18	57.96	0.058	10.56	35.3
Big Elk Cr-2014	Chester	39.731696	-75.850315	Cal	21.8	48.8	24.1	0	1.22	25.27	0.024	5.14	29.9
Big Wapwallopen Cr-2020	Luzerne	41.126114	-75.944987	Cal	65.0	0.5	27.4	0	0.19	2.17	0.010	0.40	16.2
Birch Run-2016	Chester	40.147425	-75.621492	Cal	40.7	33.2	12.6	0	0.84	16.46	0.031	1.07	40.6
Bobs Cr-2018	Bedford	40.226188	-78.565505	Cal	88.8	5.8	5.1	0	0.34	4.87	0.028	1.12	14.6
Brandywine Cr (Chadds)-2015	Chester	39.869722	-75.593611	Cal	29.9	33.0	26.9	8	1.42	21.87	0.150	2.88	65.0
Brodhead Cr-2016	Monroe	41.116549	-75.227370	Cal	80.8	1.0	5.9	0	0.13	1.74	0.013	0.18	11.7
Browns Run-2013	Lycoming	41.342825	-77.398944	Cal	90.0	0.0	0.4	0	0.12	2.20	0.004	0.19	4.6
Buck Run (WQN 627)-2020	McKean	41.640303	-78.684340	Cal	85.5	6.9	2.8	0	0.11	1.69	0.015	0.25	34.3
Buckwa Cr-2020	Carbon	40.822488	-75.523872	Cal	61.9	27.5	9.8	0	0.42	2.74	0.013	1.67	21.4
Buffalo Cr (Rt 849)-2013	Perry	40.482404	-77.174339	Cal	68.8	24.2	6.2	5	0.66	9.36	0.024	1.23	66.9
Buffalo Cr (Rt 849)-2014	Perry	40.482404	-77.174339	Anc	68.8	24.2	6.2	5	0.66	9.36	0.018	1.59	61.6
Buffalo Cr (Strawbridge Rd)-2020	Union	40.986953	-76.935854	Cal	62.5	29.3	6.5	15	0.85	18.10	0.043	1.48	88.7
Burd Run (Brit)-2019	Cumberland	40.061560	-77.514730	Anc	53.3	29.4	17.0	50	0.87	14.05	0.023	3.13	161.3
Burd Run (Twp Park)-2019	Cumberland	40.052960	-77.482830	Cal	66.0	25.4	8.2	37	0.75	13.16	0.023	0.90	38.6
Campbells Run-2015	Allegheny	40.424985	-80.108260	Cal	26.9	0.8	71.5	0	4.02	19.60	0.736	3.94	54.9
Carley Brk-2016	Wayne	41.597608	-75.246112	Cal	55.8	29.9	3.9	0	0.26	1.86	0.018	0.38	29.4
Cherry Run-2016	Armstrong	40.673160	-79.458530	Cal	71.8	19.0	8.8	0	0.40	2.65	0.013	0.54	73.7
Chester Cr (Dar)-2017	Delaware	39.901683	-75.470701	Cal	25.7	8.7	56.8	0	4.41	16.79	0.469	6.68	59.0
Chester Cr (Dil)-2017	Chester	39.929305	-75.532979	Anc	17.7	6.4	67.7	0	6.67	22.21	0.691	8.60	59.2
Chester Cr (Goose)-2014	Chester	39.929890	-75.550066	Cal	16.0	3.3	75.5	0	13.50	23.68	1.153	13.47	56.8
Chillisquaque Cr-2013	Northumberland	40.940827	-76.854667	Cal	26.7	64.2	6.5	7	1.43	11.11	0.050	1.79	77.5
Chillisquaque Cr-2014	Northumberland	40.940827	-76.854667	Anc	26.7	64.2	6.5	7	1.43	11.11	0.062	1.91	78.1
Chiques Cr (FS)-2017	Lancaster	40.172874	-76.389829	Cal	43.0	35.6	14.9	1	2.32	44.51	0.173	3.40	67.9
Chiques Cr (FS)-2018	Lancaster	40.172874	-76.389829	Anc	43.0	35.6	14.9	1	2.32	44.51	0.419	4.62	57.5
Chiques Cr (Mill)-2017	Lancaster	40.142235	-76.408876	Cal	28.4	47.6	19.0	10	2.59	47.75	0.241	4.16	88.6
Chiques Cr (Mill)-2018	Lancaster	40.142235	-76.408876	Anc	28.4	47.6	19.0	10	2.59	47.75	0.316	5.56	80.2
Clover Cr-2018	Blair	40.466247	-78.175372	Cal	51.6	42.5	5.8	72	0.77	17.84	0.044	5.90	176.3
Conestoga R (DnS STP)-2017	Lancaster	40.009680	-76.302800	Cal	24.0	45.2	24.4	46	2.92	36.75	0.300	6.32	168.1
Conestoga R (Rt 23)-2017	Lancaster	40.077560	-76.259300	Cal	25.1	46.9	21.3	43	2.43	33.62	0.100	5.59	165.5
Conodoguinet Cr (Brent)-2016	Cumberland	40.262030	-76.944910	Cal	33.3	47.6	17.4	40	1.23	19.22	0.023	3.13	168.1
Conodoguinet Cr (Smpl Br LD)-2015	Cumberland	40.251628	-77.023948	Cal	34.9	48.7	14.7	38	1.16	19.16	0.023	3.91	168.1

Sample Name	County	Latitude	Longitude	Sample Type	Forest (%)	Agriculture (%)	Developed (%)	Carbonate (%)	TP kg/ha	TN kg/ha	TP mg/L Annual Mean	TN mg/L Annual Mean	Alk mg/L Annual Mean
Cooks Cr-2013	Bucks	40.582838	-75.205219	Anc	38.6	39.8	10.3	35	0.73	4.48	0.012	1.62	91.5
Cooks Cr-2016	Bucks	40.582838	-75.205219	Cal	38.6	39.8	10.3	35	0.73	4.48	0.024	1.62	118.7
Cramer Cr-2019	Wayne	41.676686	-75.309824	Cal	53.3	31.8	5.3	0	0.27	1.88	0.023	0.37	25.3
Crum Cr (Smed)-2018	Delaware	39.918090	-75.359618	Cal	33.8	14.1	44.1	0	0.55	6.58	0.031	1.22	55.9
Crum Cr (W Chest Pk)-2018	Delaware	39.977996	-75.437403	Cal	34.4	22.0	33.9	0	0.64	7.92	0.026	1.75	55.7
Deep Run-2015	Bucks	40.410109	-75.184402	Cal	19.5	50.5	23.9	0	1.64	11.46	0.115	2.38	114.0
Donegal Cr-2015	Lancaster	40.057264	-76.525837	Anc	2.8	71.7	24.2	83	2.93	34.81	0.050	10.06	221.6
Donegal Cr-2017	Lancaster	40.057264	-76.525837	Cal	2.8	71.7	24.2	83	2.93	34.81	0.195	9.41	204.8
Donegal Cr-2018	Lancaster	40.057264	-76.525837	Anc	2.8	71.7	24.2	83	2.93	34.81	0.177	10.26	205.2
Dunbar Cr-2016	Fayette	39.943805	-79.583283	Cal	95.7	1.0	3.2	0	0.12	1.82	0.008	0.29	19.7
E Br Brandywine Cr-2020	Chester	39.968611	-75.673611	Cal	33.2	27.1	27.6	9	1.61	26.20	0.161	4.06	74.4
E Br W Br Conneaut Cr-2018	Crawford	41.803482	-80.465271	Cal	40.7	50.6	3.0	0	0.68	4.27	0.101	1.24	88.9
E Hickory Cr-2020	Forest	41.605017	-79.372937	Cal	92.9	0.8	0.6	0	0.10	2.01	0.016	0.29	13.8
E Licking Cr-2018	Juniata	40.548985	-77.522937	Cal	97.3	0.0	2.7	0	0.44	3.02	0.008	0.46	12.0
E Sandy Cr-2020	Venango	41.317816	-79.726091	Cal	72.8	18.4	5.1	0	0.29	2.64	0.008	0.39	25.6
Fishing Cr (Craley)-2020	York	39.941944	-76.500278	Cal	31.9	47.6	16.3	0	1.55	17.75	0.014	5.86	
Fishing Cr (Goldsboro)-2020	York	40.153333	-76.755556	Cal	37.7	29.8	32.2	0	0.52	7.92	0.039	2.14	
Fishing Cr (Lower)-2016	Clinton	41.075100	-77.478007	Cal	73.2	20.6	6.0	37	0.39	11.59	0.017	2.15	122.0
Fishing Cr (Upper)-2016	Clinton	40.982870	-77.462069	Cal	71.5	21.4	6.8	38	0.34	9.60	0.037	2.82	139.2
Frankstown Br-2014	Blair	40.475854	-78.196094	Anc	65.5	19.6	14.0	27	1.04	17.24	0.127	1.96	105.4
Frankstown Br-2015	Blair	40.475854	-78.196094	Cal	65.5	19.6	14.0	27	1.04	17.24	0.104	1.99	120.4
French Cr (Lower)-2016	Chester	40.151424	-75.601807	Cal	47.3	27.7	12.0	1	0.76	13.26	0.032	0.88	46.4
French Cr (Upper)-2016	Chester	40.170154	-75.724431	Cal	62.5	15.9	7.9	1	0.69	8.74	0.030	0.57	41.3
Genesee Forks-2018	Potter	41.837060	-77.706072	Cal	82.4	9.2	2.8	0	0.26	2.44	0.015	0.68	21.1
Genesee River-2018	Potter	41.939984	-77.810824	Cal	41.7	48.0	5.3	0	0.92	3.95	0.045	2.49	32.6
Goose Cr (Most)-2014	Chester	39.953839	-75.589017	Anc	3.9	1.6	93.7	0	0.62	10.15	0.078	2.85	112.7
Goose Cr (Oak)-2014	Chester	39.942277	-75.572408	Cal	10.8	1.0	86.4	0	21.12	23.47	1.637	16.19	61.9
Grays Run-2013	Lycoming	41.449653	-77.019953	Cal	92.5	0.0	0.6	0	0.11	1.79	0.004	0.29	5.5
Groff Cr-2016	Lancaster	40.114179	-76.203831	Cal	0.1	81.6	17.9	100	3.17	34.81	0.202	8.73	265.0
Hell Run-2016	Lawrence	40.930331	-80.234557	Cal	47.1	38.7	9.0	0	0.64	3.13	0.040	0.75	104.9
Huntington Cr (Lower)-2020	Columbia	41.113481	-76.340818	Cal	62.9	26.6	4.2	0	0.41	5.08	0.021	0.50	15.3
Huntington Cr (Upper)-2020	Luzerne	41.274239	-76.213585	Cal	89.0	5.9	2.4	0	0.12	1.66	0.015	0.34	11.1
Hyner Run-2014	Clinton	41.358845	-77.625531	Anc	95.8	0.1	0.3	0	0.12	2.22	0.005	0.23	9.2
Hyner Run-2015	Clinton	41.358845	-77.625531	Cal	95.8	0.1	0.3	0	0.12	2.22	0.004	0.17	8.0
Hyner Run-2016	Clinton	41.358845	-77.625531	Anc	95.8	0.1	0.3	0	0.12	2.22	0.007	0.21	8.3
Indian Cr (Berg)-2013	Montgomery	40.321122	-75.352315	Anc	1.5	17.0	78.5	0	0.89	8.37	0.094	9.85	69.5

Sample Name	County	Latitude	Longitude	Sample Type	Forest (%)	Agriculture (%)	Developed (%)	Carbonate (%)	TP kg/ha	TN kg/ha	TP mg/L Annual Mean	TN mg/L Annual Mean	Alk mg/L Annual Mean
Indian Cr (Berg)-2014	Montgomery	40.321122	-75.352315	Anc	1.5	17.0	78.5	0	0.89	8.37	0.083	8.88	66.1
Indian Cr (Rt 63)-2013	Montgomery	40.293486	-75.403570	Anc	5.2	37.8	49.9	0	1.18	10.86	0.091	2.20	110.5
Indian Cr (Rt 63)-2014	Montgomery	40.293486	-75.403570	Cal	5.2	37.8	49.9	0	1.18	10.86	0.086	2.64	92.2
Ithan Cr-2017	Delaware	39.998702	-75.350859	Cal	24.9	0.3	73.3	0	0.25	7.18	0.052	1.72	74.5
Jacks Cr-2013	Mifflin	40.612941	-77.531726	Cal	70.1	23.7	5.8	13	0.74	12.37	0.019	0.98	93.9
Jones Mill Run-2019	Somerset	40.003714	-79.242398	Cal	93.4	0.0	6.1	0	0.17	2.18	0.007	1.01	15.5
Kettle Cr-2013	Clinton	41.475833	-77.826111	Anc	86.0	6.2	0.9	0	0.20	2.31	0.009	0.49	12.7
Kettle Cr-2016	Clinton	41.475833	-77.826111	Cal	86.0	6.2	0.9	0	0.20	2.31	0.012	0.40	15.6
Kishacoquillas Cr (Manns)-2014	Mifflin	40.654793	-77.585814	Anc	62.2	30.4	7.2	25	0.89	18.33	0.060	2.71	109.1
Kishacoquillas Cr (Manns)-2015	Mifflin	40.654793	-77.585814	Cal	62.2	30.4	7.2	25	0.89	18.33	0.051	3.44	135.5
Kishacoquillas Cr (Park)-2013	Mifflin	40.618102	-77.559602	Cal	62.1	29.9	7.8	25	0.91	17.31	0.058	2.77	136.3
Kreutz Cr-2020	York	40.014167	-76.548056	Cal	24.7	40.5	30.0	36.83	1.24	14.79	0.076	5.66	
L Beaver Cr-2016	Lancaster	39.970795	-76.165364	Cal	20.3	64.0	12.2	46	3.06	45.62	0.187	7.71	137.6
L Conestoga Cr-2017	Lancaster	39.957770	-76.371300	Cal	7.0	42.4	47.6	90	2.88	36.89	0.112	5.53	193.8
L Juniata R-2014	Huntingdon	40.609696	-78.136734	Anc	74.0	14.1	11.0	22	0.79	16.78	0.098	1.66	84.9
L Juniata R-2015	Huntingdon	40.609696	-78.136734	Cal	74.0	14.1	11.0	22	0.79	16.78	0.054	1.78	98.5
L Mahoning Cr (Lower)-2019	Indiana	40.820403	-78.981961	Cal	68.9	23.2	6.4	0	0.30	2.33	0.014	0.54	32.1
L Mahoning Cr (Upper)-2019	Indiana	40.824674	-78.927038	Cal	67.4	24.7	6.2	0	0.29	2.29	0.016	0.58	42.1
L Swatara Cr-2014	Lebanon	40.408129	-76.474780	Cal	25.6	60.5	12.7	3	1.42	25.53	0.063	6.10	102.8
Lackawaxen R-2019	Wayne	41.478522	-75.183095	Cal	58.6	24.4	6.4	0	0.36	2.21	0.042	0.54	26.8
Laurel Hill Cr (Lower)-2019	Somerset	39.820004	-79.321114	Cal	78.4	15.1	4.9	0	0.32	3.96	0.010	0.77	18.7
Laurel Hill Cr (Upper)-2019	Somerset	39.952746	-79.270921	Anc	75.6	16.7	5.8	0	0.33	5.23	0.011	0.80	19.7
Lick Branch-2020	Luzerne	41.275988	-76.214496	Cal	87.3	2.4	2.1	0	0.07	1.54	0.013	0.36	11.9
Lick Run-2015	Allegheny	40.278111	-79.957136	Cal	22.2	0.7	76.5	0	5.59	32.73	1.063	6.18	125.8
Lost Cr (Upper)-2018	Juniata	40.627465	-77.307804	Cal	89.1	6.3	4.2	0	0.63	9.33	0.009	0.25	12.6
Loyalsock Cr (WQN0408)-2013	Lycoming	41.333402	-76.916114	Cal	78.6	10.6	2.6	0	0.32	2.18	0.005	0.30	21.5
Mahoning Cr (Dam)-2015	Armstrong	40.927500	-79.291389	Cal	66.0	24.1	8.3	0	0.49	2.73	0.015	0.87	46.6
Marsh Cr-2018	Tioga	41.785639	-77.309804	Cal	46.9	40.8	9.6	0	1.44	9.64	0.214	0.83	75.6
Marshall Run-2017	Indiana	40.525630	-79.355668	Cal	75.3	15.5	5.4	0	0.25	2.34	0.015	1.64	127.6
Masthope Cr-2016	Pike	41.553424	-75.084499	Cal	69.1	14.2	3.9	0	0.22	2.17	0.021	0.24	16.0
McGee Run (DnS)-2020	Westmoreland	40.352219	-79.289120	Cal	61.4	17.9	19.9	0	0.30	2.84	0.425	3.65	59.0
McGee Run (UpS)-2020	Westmoreland	40.342052	-79.297435	Anc	65.0	7.4	26.2	0	0.23	2.37	0.040	1.02	78.2
Middle Cr (Adams)-2016	Adams	39.726374	-77.298780	Cal	51.3	35.8	9.9	15	0.71	6.75	0.040	0.59	100.0
Middle Cr (Monroe)-2020	Monroe	40.904758	-75.495509	Cal	68.1	11.9	19.0	0	0.33	2.23	0.010	1.13	11.1
Middle Cr (Wayne)-2019	Wayne	41.480636	-75.201348	Cal	65.8	18.3	4.8	0	0.31	2.04	0.028	0.43	25.9
Mill Cr-2017	Lancaster	40.002490	-76.293100	Cal	9.3	63.5	24.9	92	2.84	41.50	0.214	5.92	218.3

Sample Name	County	Latitude	Longitude	Sample Type	Forest (%)	Agriculture (%)	Developed (%)	Carbonate (%)	TP kg/ha	TN kg/ha	TP mg/L Annual Mean	TN mg/L Annual Mean	Alk mg/L Annual Mean
Mitchell Run-2020	Indiana	40.664412	-79.269261	Cal	86.9	5.7	7.5	0	0.17	2.15	0.014	0.35	37.0
Moyers Mill Run-2016	Snyder	40.810029	-77.177959	Cal	84.7	10.7	4.7	28	1.05	16.67	0.026	1.29	72.7
Muddy Cr-2016	York	39.773500	-76.316423	Cal	31.1	55.3	10.5	0	1.14	16.47	0.013	5.40	32.2
Muddy Run-2016	Lancaster	40.050754	-76.173018	Cal	0.7	88.2	10.3	91	3.06	34.94	0.322	8.99	249.5
N Br Mahatango Cr-2018	Snyder	40.687769	-76.984425	Cal	60.1	32.1	7.0	9	1.27	16.37	0.029	1.35	59.5
N Br Middle Cr-2018	Snyder	40.817132	-77.146232	Cal	58.9	31.1	7.0	16	1.35	14.56	0.033	1.95	44.0
N F Cowanesque-2018	Tioga	41.945200	-77.585600	Cal	44.2	50.3	2.8	0	0.86	4.33	0.061	1.49	56.3
N F Redbank Cr-2019	Jefferson	41.229611	-79.049228	Cal	77.5	15.2	1.9	0	0.18	2.01	0.015	0.51	11.3
Neshaminy Cr-2013	Bucks	40.174289	-74.957711	Cal	20.4	21.5	49.9	2	1.92	12.60	0.068	1.93	78.5
Penns Cr (Pine)-2016	Snyder	40.802310	-76.857770	Cal	65.3	27.3	6.3	22	0.71	15.11	0.023	0.29	103.3
Pennypack Cr (Lower Elkins)-2020	Montgomery	40.118917	-75.070987	Cal	14.1	2.9	79.6	0	3.13	8.43	0.440	5.95	81.3
Pennypack Cr (Upper UMHJSA)-2020	Montgomery	40.159717	-75.106231	Cal	8.0	2.4	87.5	0	0.73	9.62	0.059	1.34	101.2
Perkiomen Cr-2014	Montgomery	40.153433	-75.456060	Cal	32.0	29.5	24.9	1	2.04	17.67	0.058	1.65	75.2
Peters Cr (DnS)-2015	Allegheny	40.283082	-79.946905	Cal	36.4	6.8	54.5	0	1.83	9.29	0.483	4.98	123.0
Peters Cr (Mouth)-2015	Allegheny	40.304071	-79.882152	Anc	37.4	5.6	54.8	0	1.56	7.64	0.628	5.13	103.8
Peters Cr (UpS)-2015	Allegheny	40.271248	-79.969686	Cal	44.7	16.1	36.0	0	0.62	2.47	0.042	0.79	134.0
Pickering Cr-2016	Chester	40.101271	-75.535536	Cal	33.1	29.8	22.7	0	0.85	18.78	0.025	1.26	58.6
Pine Cr (Berks)-2014	Berks	40.408517	-75.736340	Cal	67.9	14.5	5.0	7	0.80	6.99	0.017	0.60	37.7
Piney Fork-2015	Allegheny	40.276787	-79.972603	Cal	30.4	1.5	67.5	0	0.56	4.66	0.870	8.03	121.0
Pohopoco Cr-2020	Carbon	40.889837	-75.529294	Cal	55.4	20.6	22.6	0	0.55	3.87	0.016	1.57	13.5
Porcupine Cr (WQN 466)-2020	Venango	41.439559	-79.545148	Cal	91.1	4.0	1.9	0	0.14	1.98	0.009	0.37	30.2
Princess Run-2020	Monroe	40.852231	-75.440005	Cal	58.9	28.1	12.7	0	0.60	3.15	0.010	2.10	15.4
Quittapahilla Cr-2015	Lebanon	40.342385	-76.561106	Cal	12.3	51.3	35.3	76	2.50	37.57	0.085	6.16	198.0
Raccoon Cr-2013	Perry	40.515981	-77.236449	Cal	79.8	14.9	4.2	9	0.64	10.62	0.021	1.33	58.2
Rairigh Run-2019	Indiana	40.785742	-78.937382	Cal	73.0	20.6	5.7	0	0.22	2.20	0.009	0.55	52.1
Red Clay Cr-2014	Chester	39.816261	-75.691398	Cal	22.1	36.0	34.2	11	1.21	19.75	0.102	5.21	84.6
Ridley Cr (Lower Old Mill)-2018	Delaware	39.894222	-75.387405	Cal	36.6	17.2	38.1	0	2.07	20.29	0.172	2.83	55.5
Ridley Cr (Upper Oke)-2018	Chester	39.968693	-75.484142	Cal	24.5	17.1	47.5	0	1.40	21.11	0.055	2.66	57.2
Rife Run-2015	Lancaster	40.159515	-76.405472	Anc	11.2	69.0	14.9	0	3.25	114.36	0.048	6.61	85.6
Rife Run-2017	Lancaster	40.159515	-76.405472	Cal	11.2	69.0	14.9	0	3.25	114.36	0.136	5.50	79.7
Rife Run-2018	Lancaster	40.159515	-76.405472	Anc	11.2	69.0	14.9	0	3.25	114.36	0.234	8.20	71.8
Rock Run-2014	Lycoming	41.502425	-76.945342	Anc	89.7	2.4	1.4	0	0.16	1.88	0.004	0.32	8.2
Rock Run-2015	Lycoming	41.502425	-76.945342	Cal	89.7	2.4	1.4	0	0.16	1.88	0.003	0.25	6.8
Rock Run-2016	Lycoming	41.502425	-76.945342	Anc	89.7	2.4	1.4	0	0.16	1.88	0.007	0.65	10.8
S F Tenmile Cr-2016	Greene	39.923056	-80.072778	Cal	68.7	20.1	9.2	0	0.56	2.42	0.112	0.91	138.1
Sherman Cr-2013	Perry	40.323325	-77.167721	Cal	69.6	23.9	5.5	11	0.71	14.30	0.064	1.58	58.3

Sample Name	County	Latitude	Longitude	Sample Type	Forest (%)	Agriculture (%)	Developed (%)	Carbonate (%)	TP kg/ha	TN kg/ha	TP mg/L Annual Mean	TN mg/L Annual Mean	Alk mg/L Annual Mean
Sixpenny Cr-2020	Berks	40.235910	-75.792185	Cal	89.3	1.6	4.3	0	0.47	5.33	0.014	0.36	13.4
Skippack Cr (Mainland)-2013	Montgomery	40.253802	-75.356011	Cal	6.5	32.9	57.0	0	2.28	38.99	0.448	21.86	99.1
Skippack Cr (Ridge)-2013	Montgomery	40.172182	-75.430924	Cal	16.4	26.2	50.9	0	1.56	14.92	0.111	3.94	71.9
Slab Cabin Run Kissinger Meadow-2019	Centre	40.789569	-77.833326	Cal	49.0	35.8	15.2	68	0.87	14.68	0.025	2.91	162.6
Slab Cabin Run Shingletown Road-2019	Centre	40.755759	-77.854115	Anc	43.1	42.2	14.7	71	1.18	16.87	0.022	4.08	182.9
Spring Cr-2021	Centre	40.889590	-77.793900	Cal	36.7	35.1	27.7	82.77	0.84	18.42	0.036	3.14	208.7
Spruce Cr-2016	Huntingdon	40.608569	-78.134331	Cal	59.1	35.1	5.8	84	0.62	12.35	0.024	3.19	161.3
Stone Run-2018	Crawford	41.792278	-80.436107	Cal	32.7	55.0	3.1	0	0.72	4.37	0.605	3.95	157.0
Straight Run-2019	Indiana	40.826111	-78.924702	Cal	71.3	20.7	6.4	0	0.27	2.26	0.009	0.40	17.2
Swatara Cr (Harp)-2014	Lebanon	40.402724	-76.577422	Anc	50.0	36.1	11.3	1	1.14	21.29	0.028	2.40	49.2
Swatara Cr (Hersh)-2014	Dauphin	40.288466	-76.675591	Cal	42.2	39.7	15.6	13	1.44	24.49	0.044	3.34	86.1
Tacony Cr-2020	Montgomery	40.065355	-75.102599	Cal	12.5	0.2	86.4	0	0.49	19.40	0.028	2.24	79.5
Thompson Run-2019	Centre	40.809665	-77.836467	Cal	7.7	2.6	89.7	100	0.39	17.63	0.010	3.78	241.7
Three Square Hollow Run-2019	Cumberland	40.159550	-77.489380	Cal	60.8	30.3	7.9	0	0.72	11.86	0.019	1.44	30.6
Tinicum Cr-2016	Bucks	40.470798	-75.136773	Cal	65.8	16.0	9.0	0	0.52	2.77	0.025	0.44	90.7
Tioga R (Carp)-2016	Tioga	41.652943	-77.035328	Anc	78.9	1.9	2.5	0	0.21	2.13	0.007	0.20	6.5
Tioga R (Morris)-2016	Tioga	41.660835	-77.049251	Cal	79.6	1.6	2.4	0	0.21	2.12	0.007	0.20	7.3
Tionesta Cr (WQN 830)-2020	Forest	41.605505	-79.047247	Cal	84.9	2.2	2.5	0	0.19	2.20	0.015	0.29	20.4
Tohickon Cr-2013	Bucks	40.433537	-75.115661	Cal	42.9	27.0	17.2	0	0.96	8.37	0.053	0.79	50.8
Tohickon Cr-2014	Bucks	40.433537	-75.115661	Anc	42.9	27.0	17.2	0	0.96	8.37	0.048	0.85	44.2
Towamencin Cr-2013	Montgomery	40.228853	-75.363999	Cal	9.7	9.0	78.4	0	2.79	6.81	0.239	5.97	81.0
Traverse Cr-2015	Beaver	40.503509	-80.423835	Cal	73.3	17.7	6.7	0	0.23	1.56	0.034	0.70	93.6
Tunungwant Cr (DnS)-2018	McKean	41.992816	-78.624943	Cal	82.9	1.7	6.2	0	0.23	2.60	0.135	1.10	37.5
Tuscarora Cr-2013	Juniata	40.515500	-77.419201	Anc	75.6	19.6	4.1	11	0.72	11.26	0.017	0.80	64.2
Tuscarora Cr-2014	Juniata	40.515500	-77.419201	Cal	75.6	19.6	4.1	11	0.72	11.26	0.017	1.09	73.0
W Br Brandywine Cr (Modena)-2020	Chester	39.961667	-75.801667	Cal	31.3	33.9	25.2	5	1.21	22.11	0.137	3.38	77.4
W Br Brandywine Cr (Wagontown)-2016	Chester	40.021648	-75.847600	Cal	31.7	43.4	14.3	2	1.31	23.79	0.072	2.68	60.5
W Br Caldwell Cr-2018	Warren	41.696780	-79.572352	Cal	73.1	13.6	1.9	0	0.24	2.21	0.012	0.51	21.2
W Br Chester Cr-2017	Delaware	39.884554	-75.487082	Cal	26.9	9.8	55.5	0	1.68	7.47	0.337	3.47	61.0
W Br Lackawaxen R-2019	Wayne	41.633790	-75.343684	Cal	55.2	29.7	4.4	0	0.27	1.90	0.022	0.50	23.9
W Br Octoraro Cr-2016	Lancaster	39.825444	-76.090441	Cal	17.8	71.7	7.4	6	2.72	55.16	0.082	8.28	46.9
Walnut Cr-2013	Erie	42.073889	-80.234722	Anc	32.8	21.3	35.9	0	0.45	3.05	0.018	0.57	126.0
Walnut Cr-2016	Erie	42.073889	-80.234722	Cal	32.8	21.3	35.9	0	0.45	3.05	0.037	0.50	133.8
West Run-2020	McKean	41.652221	-78.839015	Cal	44.2	15.8	33.4	0	0.96	6.90	0.143	1.77	42.4
Willow Run-2018	Juniata	40.404906	-77.627177	Cal	95.1	1.2	3.6	19	0.50	3.86	0.012	0.91	65.7
Wissahickon Cr (Ft Wash)-2013	Montgomery	40.123973	-75.219173	Cal	20.3	5.8	69.2	8	5.59	14.84	0.369	6.46	105.5

10.2 Appendix B: Sample Proximate Stressor Data

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Allegheny R (Port Allegany)-2015	5	25.2	82.3
Allegheny R (Port Allegany)-2015	6	20.4	85.8
Allegheny R (Port Allegany)-2015	7	28.8	82.9
Allegheny R (Port Allegany)-2015	8	36.9	74.7
Allegheny R (Port Allegany)-2015	9	43.6	68.5
Allegheny R (Port Allegany)-2015	10	14.8	88.2
Aughwick Cr-2014	4	25.6	88.7
Aughwick Cr-2014	5	35.4	83.5
Aughwick Cr-2014	7	39.7	73.6
Aughwick Cr-2014	8	43.7	76.6
Aughwick Cr-2014	9	38.4	77.1
Aughwick Cr-2014	10	18.5	76.5
Beaver Cr-2018	4	28.6	85.9
Beaver Cr-2018	5	38.6	79.9
Beaver Cr-2018	6	16.0	79.8
Beaver Cr-2018	7	34.3	81.3
Beaver Cr-2018	8	26.4	80.7
Beaver Cr-2018	10	28.7	87.2
Beaver Run-2016	4	25.7	88.1
Beaver Run-2016	6	9.6	91.3
Beaver Run-2016	8	12.1	89.7
Beaver Run-2016	9	13.2	89.6
Beaver Run-2016	10	11.9	87.2
Bells Run-2016	4	55.4	84.7
Bells Run-2016	5	41.1	83.5
Bells Run-2016	6	52.0	76.5
Bells Run-2016	7	55.9	65.5
Bells Run-2016	8	63.5	64.6
Bells Run-2016	9	50.7	69.1
Bells Run-2016	10	37.4	84.5
Big Elk Cr-2014	6	16.3	89.6
Big Elk Cr-2014	7	34.6	86.2
Big Elk Cr-2014	8	31.5	87.2
Big Elk Cr-2014	9	31.3	86.8
Big Elk Cr-2014	10	30.3	86.5
Big Wapwallopen Cr-2020	4	5.7	92.9
Big Wapwallopen Cr-2020	5	10.3	91.0
Big Wapwallopen Cr-2020	6	8.6	89.0
Big Wapwallopen Cr-2020	7	15.8	87.9
Big Wapwallopen Cr-2020	8	14.0	88.5
Big Wapwallopen Cr-2020	9	11.6	90.2
Big Wapwallopen Cr-2020	10	9.3	88.6
Birch Run-2016	4	17.4	90.8
Birch Run-2016	6	18.1	90.0
Birch Run-2016	7	23.6	88.9
Birch Run-2016	8	21.5	88.8
Birch Run-2016	9	18.6	89.1
Birch Run-2016	10	16.7	87.7
Bobs Cr-2018	4	14.8	91.7
Bobs Cr-2018	5	15.3	89.7
Bobs Cr-2018	6	5.0	91.1
Bobs Cr-2018	7	10.1	90.9
Bobs Cr-2018	8	14.4	92.0
Bobs Cr-2018	9	4.0	93.3
Bobs Cr-2018	10	11.5	93.5
Brandywine Cr (Chadds)-2015	4	38.1	91.0
Brandywine Cr (Chadds)-2015	5	42.9	79.5
Brandywine Cr (Chadds)-2015	6	42.6	81.8
Brandywine Cr (Chadds)-2015	7	46.2	72.6
Brandywine Cr (Chadds)-2015	8	39.0	70.9
Brandywine Cr (Chadds)-2015	9	41.8	80.7
Brandywine Cr (Chadds)-2015	10	24.9	82.7
Brodhead Cr-2016	4	6.6	100.3
Brodhead Cr-2016	5	5.1	99.4
Brodhead Cr-2016	6	8.8	95.9
Brodhead Cr-2016	7	13.0	92.8
Brodhead Cr-2016	8	11.8	93.0
Brodhead Cr-2016	9	13.3	92.9
Brodhead Cr-2016	10	10.6	94.0
Browns Run-2013	4	2.3	94.0
Browns Run-2013	5	2.5	93.2
Browns Run-2013	6	1.7	94.6
Browns Run-2013	10	3.7	84.9
Buck Run (WQN 627)-2020	4	3.2	91.9
Buck Run (WQN 627)-2020	5	4.6	91.9
Buck Run (WQN 627)-2020	6	3.6	90.2
Buck Run (WQN 627)-2020	7	3.2	89.9
Buck Run (WQN 627)-2020	8	2.6	91.6
Buck Run (WQN 627)-2020	9	2.3	92.1
Buck Run (WQN 627)-2020	10	2.6	89.9
Buckwa Cr-2020	4	11.3	94.2
Buckwa Cr-2020	5	25.9	89.7
Buckwa Cr-2020	6	22.1	86.5
Buckwa Cr-2020	7	26.6	84.9
Buckwa Cr-2020	8	20.7	90.6
Buckwa Cr-2020	9	20.2	90.9
Buckwa Cr-2020	10	14.9	88.4
Buffalo Cr (Rt 849)-2013	6	51.2	74.9
Buffalo Cr (Rt 849)-2013	7	74.2	69.2
Buffalo Cr (Rt 849)-2013	8	56.3	71.0
Buffalo Cr (Rt 849)-2013	9	51.5	59.6
Buffalo Cr (Rt 849)-2013	10	29.7	72.1
Buffalo Cr (Rt 849)-2014	7	54.5	77.1
Buffalo Cr (Rt 849)-2014	8	52.8	78.8
Buffalo Cr (Rt 849)-2014	9	47.2	78.9
Buffalo Cr (Rt 849)-2014	10	33.8	81.2
Buffalo Cr (Strawbridge Rd)-2020	4	47.3	78.4
Buffalo Cr (Strawbridge Rd)-2020	5	59.9	77.6
Buffalo Cr (Strawbridge Rd)-2020	6	46.5	75.4
Buffalo Cr (Strawbridge Rd)-2020	7	67.7	64.6
Buffalo Cr (Strawbridge Rd)-2020	8	64.2	59.0
Buffalo Cr (Strawbridge Rd)-2020	9	70.2	68.9
Buffalo Cr (Strawbridge Rd)-2020	10	67.9	68.0
Burd Run (Brit)-2019	6	13.6	77.0
Burd Run (Brit)-2019	7	16.6	73.8
Burd Run (Brit)-2019	8	14.8	76.6
Burd Run (Brit)-2019	9	12.4	78.7
Burd Run (Brit)-2019	10	13.5	74.5
Burd Run (Twp Park)-2019	4	5.1	92.4
Burd Run (Twp Park)-2019	5	3.9	91.5
Burd Run (Twp Park)-2019	6	4.9	84.9
Burd Run (Twp Park)-2019	7	10.2	74.6
Campbells Run-2015	5	5.5	89.5
Campbells Run-2015	6	4.9	88.2
Campbells Run-2015	7	4.0	90.8
Carley Brk-2016	4	17.2	88.4
Carley Brk-2016	5	14.4	87.6
Carley Brk-2016	6	9.8	82.5
Carley Brk-2016	7	11.8	82.3
Carley Brk-2016	8	8.7	86.5
Carley Brk-2016	9	10.4	86.1
Carley Brk-2016	10	10.0	85.0
Cherry Run-2016	4	17.5	90.3
Cherry Run-2016	5	12.4	90.0
Cherry Run-2016	6	35.0	86.0
Cherry Run-2016	7	42.7	82.7
Cherry Run-2016	8	37.1	84.5
Cherry Run-2016	10	12.8	93.0
Chester Cr (Dar)-2017	4	59.2	82.8
Chester Cr (Dar)-2017	5	18.7	87.1
Chester Cr (Dar)-2017	8	23.7	89.1
Chester Cr (Dil)-2017	4	74.7	73.5
Chester Cr (Dil)-2017	5	44.2	74.7
Chester Cr (Dil)-2017	6	44.9	73.3
Chester Cr (Dil)-2017	7	54.5	71.1
Chester Cr (Dil)-2017	8	49.1	72.9
Chester Cr (Goose)-2014	7	47.1	75.3
Chester Cr (Goose)-2014	8	53.3	77.0
Chester Cr (Goose)-2014	9	38.6	79.3
Chester Cr (Goose)-2014	10	38.5	76.9
Chillisquaque Cr-2013	7	58.8	74.9
Chillisquaque Cr-2013	8	37.7	79.6
Chillisquaque Cr-2013	9	25.3	78.9
Chillisquaque Cr-2013	10	31.1	67.6
Chillisquaque Cr-2014	5	43.2	65.1
Chillisquaque Cr-2014	6	43.6	67.0

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Chiques Cr (FS)-2017	4	48.7	78.2
Chiques Cr (FS)-2017	5	33.4	82.5
Chiques Cr (FS)-2017	6	11.3	77.5
Chiques Cr (FS)-2017	7	13.5	79.5
Chiques Cr (FS)-2017	8	21.3	79.5
Chiques Cr (FS)-2017	9	18.4	80.9
Chiques Cr (FS)-2017	10	18.8	80.9
Chiques Cr (FS)-2018	5	28.7	81.9
Chiques Cr (FS)-2018	6	11.4	84.3
Chiques Cr (FS)-2018	7	26.1	80.9
Chiques Cr (FS)-2018	8	13.4	80.5
Chiques Cr (FS)-2018	9	8.0	86.2
Chiques Cr (FS)-2018	10	16.4	87.0
Chiques Cr (Mill)-2017	4	44.6	80.5
Chiques Cr (Mill)-2017	5	42.1	74.7
Chiques Cr (Mill)-2017	6	34.4	64.5
Chiques Cr (Mill)-2017	7	22.1	73.1
Chiques Cr (Mill)-2017	8	29.4	78.3
Chiques Cr (Mill)-2017	9	26.5	73.7
Chiques Cr (Mill)-2017	10	23.4	71.1
Chiques Cr (Mill)-2018	4	57.6	78.2
Chiques Cr (Mill)-2018	5	38.1	76.8
Chiques Cr (Mill)-2018	6	18.9	81.7
Chiques Cr (Mill)-2018	7	26.9	74.6
Chiques Cr (Mill)-2018	8	13.6	80.6
Chiques Cr (Mill)-2018	9	10.3	83.8
Chiques Cr (Mill)-2018	10	31.6	84.2
Clover Cr-2018	5	18.1	86.7
Clover Cr-2018	6	13.6	88.8
Clover Cr-2018	7	28.0	87.1
Clover Cr-2018	8	22.4	88.7
Clover Cr-2018	9	15.3	88.9
Clover Cr-2018	10	24.1	89.9
Conestoga R (DnS STP)-2017	5	31.5	78.2
Conestoga R (DnS STP)-2017	6	48.1	62.7
Conestoga R (DnS STP)-2017	7	41.6	66.1
Conestoga R (DnS STP)-2017	8	31.6	77.5
Conestoga R (DnS STP)-2017	9	31.6	79.3
Conestoga R (DnS STP)-2017	10	19.5	82.5
Conestoga R (Rt 23)-2017	5	41.3	82.5
Conestoga R (Rt 23)-2017	6	72.9	70.5
Conestoga R (Rt 23)-2017	7	57.7	77.3
Conestoga R (Rt 23)-2017	8	35.8	84.3
Conestoga R (Rt 23)-2017	9	40.7	84.2
Conestoga R (Rt 23)-2017	10	33.4	82.1
Conodoguinet Cr (Brent)-2016	8	149.5	54.1
Conodoguinet Cr (Brent)-2016	9	146.9	55.8
Conodoguinet Cr (Brent)-2016	10	96.1	73.5
Conodoguinet Cr (Smpl Br LD)-2015	5	68.1	74.8
Conodoguinet Cr (Smpl Br LD)-2015	6	85.0	73.9
Conodoguinet Cr (Smpl Br LD)-2015	7	90.0	75.5
Conodoguinet Cr (Smpl Br LD)-2015	8	86.7	76.0
Conodoguinet Cr (Smpl Br LD)-2015	9	93.8	73.2
Conodoguinet Cr (Smpl Br LD)-2015	10	55.8	84.3
Cooks Cr-2013	4	34.5	87.5
Cooks Cr-2016	4	30.0	85.3
Cooks Cr-2016	5	27.5	85.3
Cooks Cr-2016	6	44.1	79.8
Cooks Cr-2016	7	29.6	80.2
Cooks Cr-2016	8	26.4	79.2
Cooks Cr-2016	9	29.9	78.4
Cooks Cr-2016	10	32.2	79.9
Cramer Cr-2019	4	3.0	93.5
Cramer Cr-2019	5	4.3	93.9
Cramer Cr-2019	6	4.0	92.7
Cramer Cr-2019	7	4.1	88.7
Cramer Cr-2019	8	3.4	89.7
Cramer Cr-2019	9	4.5	89.1
Cramer Cr-2019	10	6.1	89.9
Crum Cr (Smed)-2018	4	26.8	88.0
Crum Cr (Smed)-2018	5	26.4	72.8
Crum Cr (Smed)-2018	6	23.1	62.3
Crum Cr (Smed)-2018	9	8.6	86.4
Crum Cr (Smed)-2018	10	7.3	81.8
Crum Cr (W Chest Pk)-2018	5	13.8	87.8
Crum Cr (W Chest Pk)-2018	6	17.4	90.1
Crum Cr (W Chest Pk)-2018	7	17.8	88.9
Crum Cr (W Chest Pk)-2018	8	18.8	91.0
Crum Cr (W Chest Pk)-2018	9	11.4	92.3
Crum Cr (W Chest Pk)-2018	10	14.8	92.3
Deep Run-2015	4	91.2	69.0
Deep Run-2015	5	143.5	41.5
Deep Run-2015	6	108.0	58.5
Deep Run-2015	7	100.8	57.6
Deep Run-2015	8	91.7	54.2
Deep Run-2015	9	84.1	53.3
Donegal Cr-2015	5	21.7	73.6
Donegal Cr-2015	6	17.0	82.4
Donegal Cr-2015	7	26.6	83.3
Donegal Cr-2015	8	22.9	81.3
Donegal Cr-2015	9	18.5	84.6
Donegal Cr-2015	10	14.7	87.2
Donegal Cr-2017	4	48.2	85.2
Donegal Cr-2017	5	26.3	83.5
Donegal Cr-2017	6	14.1	85.9
Donegal Cr-2017	7	15.6	87.0
Donegal Cr-2017	8	16.2	88.5
Donegal Cr-2017	9	18.3	84.1
Donegal Cr-2017	10	20.5	76.7
Donegal Cr-2018	5	32.3	81.0
Donegal Cr-2018	6	11.4	90.2
Donegal Cr-2018	7	13.1	89.7
Donegal Cr-2018	8	13.7	91.0
Donegal Cr-2018	9	8.6	89.8
Donegal Cr-2018	10	21.3	90.5
Dunbar Cr-2016	4	2.6	93.5
Dunbar Cr-2016	5	1.9	93.8
Dunbar Cr-2016	6	2.7	92.5
Dunbar Cr-2016	7	6.0	89.1
Dunbar Cr-2016	8	6.7	89.5
Dunbar Cr-2016	9	6.5	87.5
Dunbar Cr-2016	10	4.2	89.2
E Br Brandywine Cr-2020	4	27.3	89.7
E Br Brandywine Cr-2020	5	50.0	84.6
E Br Brandywine Cr-2020	6	39.3	81.5
E Br Brandywine Cr-2020	7	43.7	78.1
E Br Brandywine Cr-2020	8	60.2	76.4
E Br Brandywine Cr-2020	9	43.3	77.8
E Br Brandywine Cr-2020	10	39.4	81.9
E Br W Br Conneaut Cr-2018	4	46.3	84.8
E Br W Br Conneaut Cr-2018	5	43.2	71.5
E Br W Br Conneaut Cr-2018	6	31.2	67.3
E Br W Br Conneaut Cr-2018	7	86.2	31.1
E Br W Br Conneaut Cr-2018	8	74.6	24.3
E Br W Br Conneaut Cr-2018	9	37.5	34.1
E Br W Br Conneaut Cr-2018	10	11.8	78.9
E Hickory Cr-2020	4	4.1	93.6
E Hickory Cr-2020	5	7.4	93.2
E Hickory Cr-2020	6	10.6	86.6
E Hickory Cr-2020	7	17.6	83.4
E Hickory Cr-2020	8	20.0	82.5
E Hickory Cr-2020	9	16.0	85.8
E Hickory Cr-2020	10	9.1	86.6
E Licking Cr-2018	5	5.7	94.6
E Licking Cr-2018	6	3.9	93.8
E Licking Cr-2018	7	5.0	93.6
E Licking Cr-2018	8	4.8	94.6
E Licking Cr-2018	9	2.7	95.0
E Licking Cr-2018	10	3.1	95.2
E Sandy Cr-2020	4	5.2	94.3
E Sandy Cr-2020	5	7.5	93.4
E Sandy Cr-2020	6	14.6	89.7
E Sandy Cr-2020	7	26.0	87.4
E Sandy Cr-2020	8	23.2	88.1
E Sandy Cr-2020	9	19.0	90.2
E Sandy Cr-2020	10	17.3	90.5

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Fishing Cr (Craley)-2020	4	18.5	92.0
Fishing Cr (Craley)-2020	5	18.1	91.7
Fishing Cr (Craley)-2020	6	17.6	90.9
Fishing Cr (Craley)-2020	7	24.7	87.9
Fishing Cr (Craley)-2020	8	30.8	87.8
Fishing Cr (Craley)-2020	9	25.7	88.6
Fishing Cr (Craley)-2020	10	24.1	86.1
Fishing Cr (Goldsboro)-2020	4	52.2	88.3
Fishing Cr (Goldsboro)-2020	5	61.6	81.3
Fishing Cr (Goldsboro)-2020	6	47.3	83.0
Fishing Cr (Goldsboro)-2020	7	69.8	74.8
Fishing Cr (Goldsboro)-2020	8	64.2	82.1
Fishing Cr (Goldsboro)-2020	9	59.4	82.6
Fishing Cr (Goldsboro)-2020	10	45.8	78.2
Fishing Cr (Lower)-2016	4	46.6	85.7
Fishing Cr (Lower)-2016	5	36.1	85.8
Fishing Cr (Lower)-2016	6	37.4	83.5
Fishing Cr (Lower)-2016	8	53.8	79.3
Fishing Cr (Lower)-2016	9	48.1	78.5
Fishing Cr (Lower)-2016	10	41.5	80.1
Fishing Cr (Upper)-2016	4	56.2	81.2
Fishing Cr (Upper)-2016	5	31.5	80.9
Fishing Cr (Upper)-2016	6	41.1	80.5
Fishing Cr (Upper)-2016	7	50.7	71.5
Fishing Cr (Upper)-2016	8	45.3	78.2
Fishing Cr (Upper)-2016	9	38.9	76.5
Fishing Cr (Upper)-2016	10	32.5	71.7
Frankstown Br-2014	9	35.3	84.3
Frankstown Br-2014	10	31.9	82.7
Frankstown Br-2015	4	32.6	89.0
Frankstown Br-2015	5	34.2	80.0
Frankstown Br-2015	6	21.9	83.1
Frankstown Br-2015	9	35.6	85.7
Frankstown Br-2015	10	30.0	85.4
French Cr (Lower)-2016	4	29.8	89.7
French Cr (Lower)-2016	5	20.9	91.9
French Cr (Lower)-2016	6	30.9	89.3
French Cr (Lower)-2016	7	36.5	88.6
French Cr (Lower)-2016	8	34.0	89.4
French Cr (Lower)-2016	9	30.5	88.9
French Cr (Lower)-2016	10	21.2	88.8
French Cr (Upper)-2016	4	29.0	89.9
French Cr (Upper)-2016	6	17.3	90.6
French Cr (Upper)-2016	7	19.4	89.4
French Cr (Upper)-2016	8	20.9	90.0
French Cr (Upper)-2016	9	19.7	86.9
French Cr (Upper)-2016	10	16.7	85.9
Genesee Forks-2018	5	7.3	89.8
Genesee Forks-2018	6	15.1	87.3
Genesee Forks-2018	7	14.4	85.6
Genesee Forks-2018	8	13.2	88.6
Genesee Forks-2018	9	6.7	89.7
Genesee Forks-2018	10	7.3	90.8
Genesee River-2018	5	7.8	90.4
Genesee River-2018	6	10.4	87.7
Genesee River-2018	7	10.8	87.4
Genesee River-2018	8	8.1	90.2
Genesee River-2018	9	5.5	91.2
Genesee River-2018	10	4.2	91.2
Goose Cr (Most)-2014	7	26.0	51.1
Goose Cr (Most)-2014	8	20.7	62.4
Goose Cr (Most)-2014	9	20.2	58.9
Goose Cr (Most)-2014	10	18.5	56.1
Goose Cr (Oak)-2014	6	22.3	72.2
Goose Cr (Oak)-2014	8	29.3	67.8
Goose Cr (Oak)-2014	10	30.0	64.6
Grays Run-2013	5	3.3	96.1
Grays Run-2013	6	3.1	94.7
Grays Run-2013	9	5.3	93.2
Grays Run-2013	10	8.2	88.2
Groff Cr-2016	4	81.3	74.0
Groff Cr-2016	5	50.4	76.2
Groff Cr-2016	6	52.6	69.0
Groff Cr-2016	7	55.8	64.5
Groff Cr-2016	8	73.1	60.3
Groff Cr-2016	9	82.6	52.3
Groff Cr-2016	10	69.5	68.7
Hell Run-2016	5	13.2	80.9
Hell Run-2016	6	3.4	81.7
Hell Run-2016	7	8.3	76.0
Hell Run-2016	8	4.8	78.6
Hell Run-2016	9	5.0	77.6
Hell Run-2016	10	4.0	77.1
Huntington Cr (Lower)-2020	4	8.4	94.8
Huntington Cr (Lower)-2020	5	24.9	89.4
Huntington Cr (Lower)-2020	6	27.1	86.7
Huntington Cr (Lower)-2020	7	31.0	83.3
Huntington Cr (Lower)-2020	8	29.8	82.6
Huntington Cr (Lower)-2020	9	28.2	85.9
Huntington Cr (Lower)-2020	10	19.4	84.9
Huntington Cr (Upper)-2020	4	5.6	92.8
Huntington Cr (Upper)-2020	5	7.0	91.3
Huntington Cr (Upper)-2020	6	7.6	87.6
Huntington Cr (Upper)-2020	7	10.5	85.8
Huntington Cr (Upper)-2020	8	11.4	85.4
Huntington Cr (Upper)-2020	9	11.0	85.2
Huntington Cr (Upper)-2020	10	12.1	75.1
Hyner Run-2014	8	2.9	94.0
Hyner Run-2014	9	3.8	93.3
Hyner Run-2014	10	3.7	92.5
Hyner Run-2015	4	1.7	95.5
Hyner Run-2015	5	4.3	93.6
Hyner Run-2015	6	2.7	92.9
Hyner Run-2015	7	2.6	93.0
Hyner Run-2015	8	3.9	91.7
Hyner Run-2015	9	4.5	91.0
Hyner Run-2015	10	4.0	94.0
Hyner Run-2016	4	3.8	93.3
Hyner Run-2016	5	3.3	93.6
Hyner Run-2016	6	3.2	91.5
Hyner Run-2016	7	4.1	90.0
Hyner Run-2016	8	4.9	88.8
Hyner Run-2016	9	5.4	87.7
Hyner Run-2016	10	3.6	88.9
Indian Cr (Berg)-2013	9	71.6	64.1
Indian Cr (Berg)-2013	10	79.7	62.4
Indian Cr (Berg)-2014	6	47.6	71.1
Indian Cr (Berg)-2014	7	79.8	66.1
Indian Cr (Berg)-2014	10	61.4	70.0
Indian Cr (Rt 63)-2013	5	89.2	60.8
Indian Cr (Rt 63)-2013	7	95.4	70.3
Indian Cr (Rt 63)-2013	8	73.8	75.4
Indian Cr (Rt 63)-2013	9	81.7	73.9
Indian Cr (Rt 63)-2013	10	85.6	75.0
Indian Cr (Rt 63)-2014	5	97.6	76.6
Indian Cr (Rt 63)-2014	6	89.8	72.0
Indian Cr (Rt 63)-2014	7	121.6	57.2
Indian Cr (Rt 63)-2014	8	111.7	64.2
Indian Cr (Rt 63)-2014	9	111.8	60.1
Indian Cr (Rt 63)-2014	10	76.3	72.8
Ithan Cr-2017	4	53.7	79.1
Ithan Cr-2017	5	19.6	83.0
Ithan Cr-2017	6	21.7	80.9
Ithan Cr-2017	7	25.7	82.8
Ithan Cr-2017	8	27.7	84.4
Ithan Cr-2017	9	30.5	84.3
Jacks Cr-2013	5	22.7	86.4
Jacks Cr-2013	6	20.4	86.7
Jacks Cr-2013	7	27.5	86.4
Jacks Cr-2013	8	35.0	82.0
Jacks Cr-2013	9	36.6	78.2
Jacks Cr-2013	10	31.6	79.8

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Jones Mill Run-2019	4	2.8	90.1
Jones Mill Run-2019	5	2.1	90.3
Jones Mill Run-2019	6	1.7	90.3
Jones Mill Run-2019	7	1.6	90.4
Jones Mill Run-2019	8	1.7	90.1
Jones Mill Run-2019	9	1.7	90.3
Jones Mill Run-2019	10	2.0	89.0
Kettle Cr-2013	4	15.3	97.3
Kettle Cr-2013	5	19.9	92.3
Kettle Cr-2013	6	17.5	89.1
Kettle Cr-2013	7	23.8	85.5
Kettle Cr-2013	8	32.3	82.0
Kettle Cr-2013	9	27.7	83.8
Kettle Cr-2013	10	22.4	87.3
Kettle Cr-2016	4	14.0	94.0
Kettle Cr-2016	5	16.3	91.5
Kettle Cr-2016	6	22.5	85.5
Kettle Cr-2016	7	36.8	78.7
Kettle Cr-2016	8	33.2	81.5
Kettle Cr-2016	9	33.0	81.8
Kettle Cr-2016	10	18.6	90.7
Kishacoquillas Cr (Manns)-2014	4	28.6	88.8
Kishacoquillas Cr (Manns)-2014	7	27.6	90.3
Kishacoquillas Cr (Manns)-2014	8	23.1	91.6
Kishacoquillas Cr (Manns)-2014	9	28.8	88.7
Kishacoquillas Cr (Manns)-2015	4	23.2	91.0
Kishacoquillas Cr (Manns)-2015	5	35.7	85.8
Kishacoquillas Cr (Manns)-2015	6	20.4	87.8
Kishacoquillas Cr (Manns)-2015	8	44.0	88.1
Kishacoquillas Cr (Manns)-2015	9	28.3	89.1
Kishacoquillas Cr (Manns)-2015	10	26.5	91.4
Kishacoquillas Cr (Park)-2013	7	50.8	83.8
Kishacoquillas Cr (Park)-2013	8	54.4	81.8
Kishacoquillas Cr (Park)-2013	9	47.3	83.0
Kreutz Cr-2020	4	22.3	93.2
Kreutz Cr-2020	5	14.2	92.1
Kreutz Cr-2020	6	9.2	90.1
Kreutz Cr-2020	7	11.8	88.4
Kreutz Cr-2020	8	10.6	90.5
Kreutz Cr-2020	9	9.3	93.5
Kreutz Cr-2020	10	8.9	91.6
L Beaver Cr-2016	4	54.2	81.5
L Beaver Cr-2016	5	51.2	78.3
L Beaver Cr-2016	6	58.6	72.8
L Beaver Cr-2016	7	47.1	69.8
L Beaver Cr-2016	8	58.1	70.8
L Beaver Cr-2016	9	63.4	69.1
L Beaver Cr-2016	10	53.7	72.0
L Conestoga Cr-2017	4	63.7	81.9
L Conestoga Cr-2017	5	49.3	84.2
L Conestoga Cr-2017	6	45.7	85.3
L Conestoga Cr-2017	7	49.8	83.8
L Conestoga Cr-2017	8	47.4	87.8
L Conestoga Cr-2017	9	42.1	90.3
L Juniata R-2014	10	27.4	85.9
L Juniata R-2015	4	25.6	90.6
L Juniata R-2015	5	38.0	84.6
L Juniata R-2015	6	24.1	87.5
L Juniata R-2015	8	42.4	85.4
L Juniata R-2015	9	32.1	88.3
L Juniata R-2015	10	39.2	87.0
L Mahoning Cr (Lower)-2019	4	5.8	93.9
L Mahoning Cr (Lower)-2019	5	9.7	93.0
L Mahoning Cr (Lower)-2019	6	12.0	92.7
L Mahoning Cr (Lower)-2019	10	10.4	89.6
L Mahoning Cr (Upper)-2019	4	7.3	89.1
L Mahoning Cr (Upper)-2019	5	9.7	92.2
L Mahoning Cr (Upper)-2019	6	11.5	92.3
L Mahoning Cr (Upper)-2019	7	15.9	87.7
L Mahoning Cr (Upper)-2019	8	15.9	85.7
L Mahoning Cr (Upper)-2019	9	12.9	88.8
L Mahoning Cr (Upper)-2019	10	10.5	88.0
L Swatara Cr-2014	6	52.5	79.2
L Swatara Cr-2014	7	71.1	75.3
L Swatara Cr-2014	8	75.2	76.1
L Swatara Cr-2014	9	68.6	74.8
L Swatara Cr-2014	10	45.5	83.3
Lackawaxen R-2019	4	25.0	80.7
Lackawaxen R-2019	6	32.1	86.7
Lackawaxen R-2019	7	35.8	83.7
Lackawaxen R-2019	8	29.9	84.4
Lackawaxen R-2019	9	28.8	86.0
Lackawaxen R-2019	10	22.2	88.6
Laurel Hill Cr (Lower)-2019	4	8.1	89.5
Laurel Hill Cr (Lower)-2019	5	11.6	89.4
Laurel Hill Cr (Lower)-2019	6	15.8	89.2
Laurel Hill Cr (Lower)-2019	7	22.6	86.8
Laurel Hill Cr (Lower)-2019	8	26.0	84.7
Laurel Hill Cr (Lower)-2019	9	26.3	83.9
Laurel Hill Cr (Lower)-2019	10	22.1	86.1
Laurel Hill Cr (Upper)-2019	4	5.8	89.8
Laurel Hill Cr (Upper)-2019	5	6.1	89.8
Laurel Hill Cr (Upper)-2019	6	7.0	90.0
Laurel Hill Cr (Upper)-2019	7	8.4	89.7
Laurel Hill Cr (Upper)-2019	8	10.8	88.0
Laurel Hill Cr (Upper)-2019	9	12.7	87.7
Laurel Hill Cr (Upper)-2019	10	8.7	87.2
Lick Branch-2020	4	2.2	96.7
Lick Branch-2020	5	3.0	96.1
Lick Branch-2020	7	2.5	92.9
Lick Branch-2020	8	2.5	92.2
Lick Branch-2020	9	2.6	94.2
Lick Branch-2020	10	4.0	89.5
Lick Run-2015	5	37.0	81.4
Lick Run-2015	6	15.7	86.7
Lick Run-2015	8	15.7	84.5
Lick Run-2015	9	15.5	83.0
Lick Run-2015	10	15.1	88.0
Lost Cr (Upper)-2018	4	8.9	94.7
Lost Cr (Upper)-2018	5	8.5	94.4
Lost Cr (Upper)-2018	6	4.9	95.2
Lost Cr (Upper)-2018	7	8.5	93.7
Lost Cr (Upper)-2018	8	7.6	96.0
Lost Cr (Upper)-2018	9	4.0	96.4
Lost Cr (Upper)-2018	10	5.2	95.6
Loyalsock Cr (WQN0408)-2013	6	18.5	89.2
Loyalsock Cr (WQN0408)-2013	7	22.4	90.2
Loyalsock Cr (WQN0408)-2013	8	21.1	93.3
Loyalsock Cr (WQN0408)-2013	9	24.6	88.5
Loyalsock Cr (WQN0408)-2013	10	22.8	87.7
Mahoning Cr (Dam)-2015	4	5.1	90.8
Mahoning Cr (Dam)-2015	5	19.8	90.1
Mahoning Cr (Dam)-2015	6	9.8	81.2
Mahoning Cr (Dam)-2015	7	19.3	80.6
Mahoning Cr (Dam)-2015	8	27.4	72.4
Mahoning Cr (Dam)-2015	9	27.7	84.4
Mahoning Cr (Dam)-2015	10	16.3	81.2
Marsh Cr-2018	5	53.3	77.6
Marsh Cr-2018	6	58.0	67.4
Marsh Cr-2018	7	119.4	54.2
Marsh Cr-2018	8	50.8	73.5
Marsh Cr-2018	9	31.9	67.1
Marsh Cr-2018	10	17.2	86.1
Marshall Run-2017	4	14.9	91.2
Marshall Run-2017	5	11.0	90.3
Marshall Run-2017	6	6.8	90.6
Marshall Run-2017	7	7.9	90.1
Marshall Run-2017	8	9.3	89.3
Marshall Run-2017	9	10.7	83.4
Marshall Run-2017	10	11.8	80.9

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Masthope Cr-2016	4	8.3	91.9
Masthope Cr-2016	5	7.2	92.2
Masthope Cr-2016	6	11.5	87.8
Masthope Cr-2016	7	18.0	85.9
Masthope Cr-2016	8	13.2	88.7
Masthope Cr-2016	9	16.6	85.4
Masthope Cr-2016	10	8.3	87.0
McGee Run (DnS)-2020	4	23.4	86.7
McGee Run (DnS)-2020	5	25.6	82.3
McGee Run (DnS)-2020	6	17.2	70.7
McGee Run (DnS)-2020	7	38.9	60.2
McGee Run (DnS)-2020	8	18.5	68.1
McGee Run (DnS)-2020	9	21.0	75.5
McGee Run (DnS)-2020	10	21.4	56.7
McGee Run (UpS)-2020	4	14.9	90.1
McGee Run (UpS)-2020	5	14.3	87.6
McGee Run (UpS)-2020	6	16.5	74.9
McGee Run (UpS)-2020	7	25.8	69.8
McGee Run (UpS)-2020	8	39.2	60.8
McGee Run (UpS)-2020	9	29.6	77.6
McGee Run (UpS)-2020	10	26.0	67.6
Middle Cr (Adams)-2016	4	50.9	80.7
Middle Cr (Adams)-2016	5	41.2	84.8
Middle Cr (Adams)-2016	6	40.6	77.1
Middle Cr (Adams)-2016	7	52.0	69.6
Middle Cr (Adams)-2016	8	55.3	70.3
Middle Cr (Adams)-2016	9	52.7	64.4
Middle Cr (Adams)-2016	10	30.6	70.8
Middle Cr (Monroe)-2020	4	7.7	95.1
Middle Cr (Monroe)-2020	5	9.3	93.3
Middle Cr (Monroe)-2020	6	4.7	91.7
Middle Cr (Monroe)-2020	7	5.4	91.4
Middle Cr (Monroe)-2020	8	5.2	93.1
Middle Cr (Monroe)-2020	9	5.3	94.1
Middle Cr (Monroe)-2020	10	5.3	90.0
Middle Cr (Wayne)-2019	4	6.6	94.2
Middle Cr (Wayne)-2019	6	7.9	94.5
Middle Cr (Wayne)-2019	7	14.7	91.1
Middle Cr (Wayne)-2019	8	11.6	92.1
Middle Cr (Wayne)-2019	9	14.8	91.4
Middle Cr (Wayne)-2019	10	8.7	93.1
Mill Cr-2017	4	61.7	76.8
Mill Cr-2017	5	49.7	71.8
Mill Cr-2017	6	46.5	73.1
Mill Cr-2017	7	36.8	76.2
Mill Cr-2017	8	30.5	79.2
Mill Cr-2017	9	25.0	81.3
Mill Cr-2017	10	28.7	77.3
Mitchell Run-2020	4	12.4	92.2
Mitchell Run-2020	5	12.4	88.7
Mitchell Run-2020	6	12.6	81.7
Moyers Mill Run-2016	4	12.9	95.8
Moyers Mill Run-2016	5	10.7	93.5
Moyers Mill Run-2016	6	7.2	91.5
Moyers Mill Run-2016	7	10.7	88.9
Moyers Mill Run-2016	8	11.4	93.1
Moyers Mill Run-2016	9	12.3	88.5
Moyers Mill Run-2016	10	16.2	86.2
Muddy Cr-2016	4	20.0	92.4
Muddy Cr-2016	5	18.6	92.6
Muddy Cr-2016	7	36.7	88.2
Muddy Cr-2016	8	39.7	88.7
Muddy Cr-2016	10	22.8	90.0
Muddy Run-2016	4	74.4	74.0
Muddy Run-2016	5	99.0	68.6
Muddy Run-2016	6	104.4	55.3
Muddy Run-2016	7	83.3	48.4
Muddy Run-2016	8	106.3	51.3
Muddy Run-2016	9	97.0	55.5
Muddy Run-2016	10	72.6	69.0
N Br Mahatango Cr-2018	4	23.1	90.7
N Br Mahatango Cr-2018	5	33.5	88.0
N Br Mahatango Cr-2018	6	21.7	91.3
N Br Mahatango Cr-2018	7	31.8	87.7
N Br Mahatango Cr-2018	9	14.4	93.0
N Br Mahatango Cr-2018	10	22.4	93.5
N Br Middle Cr-2018	4	19.2	89.8
N Br Middle Cr-2018	5	26.1	87.2
N Br Middle Cr-2018	6	12.6	88.9
N Br Middle Cr-2018	7	22.5	84.4
N Br Middle Cr-2018	8	10.7	88.1
N Br Middle Cr-2018	9	7.7	86.6
N Br Middle Cr-2018	10	9.2	89.1
N F Cowanesque-2018	5	31.9	82.1
N F Cowanesque-2018	8	25.5	82.2
N F Cowanesque-2018	9	16.3	84.9
N F Cowanesque-2018	10	12.4	89.2
N F Redbank Cr-2019	4	6.4	93.2
N F Redbank Cr-2019	5	8.5	92.6
N F Redbank Cr-2019	6	6.5	93.3
N F Redbank Cr-2019	7	10.5	92.7
N F Redbank Cr-2019	8	11.0	91.4
N F Redbank Cr-2019	9	11.4	91.3
N F Redbank Cr-2019	10	8.4	91.6
Neshaminy Cr-2013	4	103.4	69.8
Penns Cr (Pine)-2016	8	125.6	63.0
Penns Cr (Pine)-2016	9	103.5	65.1
Penns Cr (Pine)-2016	10	67.9	78.5
Pennypack Cr (Lower Elkins)-2020	4	45.9	84.3
Pennypack Cr (Lower Elkins)-2020	5	37.1	81.6
Pennypack Cr (Lower Elkins)-2020	6	48.1	76.7
Pennypack Cr (Lower Elkins)-2020	7	81.4	72.1
Pennypack Cr (Lower Elkins)-2020	8	68.3	75.4
Pennypack Cr (Lower Elkins)-2020	9	52.2	80.2
Pennypack Cr (Upper UMHJSA)-2020	5	41.0	62.4
Pennypack Cr (Upper UMHJSA)-2020	6	31.2	46.2
Pennypack Cr (Upper UMHJSA)-2020	7	37.8	48.6
Pennypack Cr (Upper UMHJSA)-2020	8	43.2	57.3
Pennypack Cr (Upper UMHJSA)-2020	9	31.9	54.5
Pennypack Cr (Upper UMHJSA)-2020	10	24.3	64.7
Perkiomen Cr-2014	4	87.4	54.9
Perkiomen Cr-2014	6	72.3	76.5
Perkiomen Cr-2014	7	77.9	70.9
Perkiomen Cr-2014	8	66.4	73.9
Perkiomen Cr-2014	9	58.3	73.4
Perkiomen Cr-2014	10	33.7	80.3
Peters Cr (DnS)-2015	4	52.5	82.0
Peters Cr (DnS)-2015	5	34.2	79.0
Peters Cr (DnS)-2015	6	32.5	79.1
Peters Cr (DnS)-2015	7	42.1	78.5
Peters Cr (DnS)-2015	8	33.6	80.6
Peters Cr (DnS)-2015	9	45.4	74.8
Peters Cr (DnS)-2015	10	29.5	83.5
Peters Cr (Mouth)-2015	8	46.6	73.3
Peters Cr (Mouth)-2015	9	32.4	79.3
Peters Cr (UpS)-2015	4	9.7	91.7
Peters Cr (UpS)-2015	5	14.8	89.6
Peters Cr (UpS)-2015	6	12.6	87.4
Peters Cr (UpS)-2015	7	14.5	89.5
Peters Cr (UpS)-2015	9	20.1	90.4
Peters Cr (UpS)-2015	10	21.2	86.1
Pickering Cr-2016	4	29.0	89.1
Pickering Cr-2016	5	24.3	89.0
Pickering Cr-2016	6	30.1	87.7
Pickering Cr-2016	7	35.2	87.0
Pickering Cr-2016	8	38.9	86.0
Pickering Cr-2016	9	26.4	87.6
Pickering Cr-2016	10	20.7	86.7
Pine Cr (Berks)-2014	7	13.2	91.0
Pine Cr (Berks)-2014	8	15.0	90.5
Pine Cr (Berks)-2014	9	14.4	89.0
Pine Cr (Berks)-2014	10	14.3	84.5

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Piney Fork-2015	4	52.1	76.5
Piney Fork-2015	5	30.6	75.0
Piney Fork-2015	6	16.7	71.0
Piney Fork-2015	8	13.8	71.7
Pohopoco Cr-2020	4	11.3	91.1
Pohopoco Cr-2020	5	17.8	90.4
Pohopoco Cr-2020	6	13.4	88.8
Pohopoco Cr-2020	7	17.8	88.8
Pohopoco Cr-2020	8	16.2	90.3
Pohopoco Cr-2020	9	11.6	92.8
Pohopoco Cr-2020	10	12.2	91.1
Porcupine Cr (WQN 466)-2020	4	2.1	95.2
Porcupine Cr (WQN 466)-2020	5	3.0	95.3
Porcupine Cr (WQN 466)-2020	6	4.6	92.7
Porcupine Cr (WQN 466)-2020	7	8.6	91.2
Porcupine Cr (WQN 466)-2020	8	9.2	90.5
Porcupine Cr (WQN 466)-2020	9	8.2	92.5
Porcupine Cr (WQN 466)-2020	10	6.9	91.3
Princess Run-2020	4	5.6	95.3
Princess Run-2020	5	7.3	94.3
Princess Run-2020	6	7.9	92.1
Princess Run-2020	7	8.7	91.7
Princess Run-2020	8	7.8	92.7
Princess Run-2020	9	9.2	93.6
Princess Run-2020	10	8.5	93.0
Quittapahilla Cr-2015	4	50.6	83.4
Quittapahilla Cr-2015	5	30.5	77.5
Quittapahilla Cr-2015	6	20.1	81.2
Quittapahilla Cr-2015	7	25.4	86.1
Quittapahilla Cr-2015	8	26.1	85.2
Quittapahilla Cr-2015	9	25.2	85.0
Quittapahilla Cr-2015	10	22.9	82.8
Raccoon Cr-2013	5	16.2	92.6
Raccoon Cr-2013	6	12.9	90.7
Raccoon Cr-2013	7	15.6	88.7
Raccoon Cr-2013	8	15.6	86.5
Raccoon Cr-2013	9	15.3	83.3
Raccoon Cr-2013	10	23.0	85.8
Rairigh Run-2019	4	4.1	92.6
Rairigh Run-2019	5	4.2	91.7
Rairigh Run-2019	6	1.8	92.0
Rairigh Run-2019	7	2.1	91.3
Rairigh Run-2019	8	2.8	89.0
Rairigh Run-2019	9	3.1	88.0
Rairigh Run-2019	10	3.8	87.2
Red Clay Cr-2014	5	31.5	89.4
Red Clay Cr-2014	7	29.7	87.2
Red Clay Cr-2014	8	28.0	86.7
Red Clay Cr-2014	9	24.0	86.7
Red Clay Cr-2014	10	22.8	85.8
Ridley Cr (Lower Old Mill)-2018	4	56.9	66.9
Ridley Cr (Lower Old Mill)-2018	5	10.2	86.1
Ridley Cr (Lower Old Mill)-2018	6	13.5	86.0
Ridley Cr (Lower Old Mill)-2018	7	17.2	86.0
Ridley Cr (Lower Old Mill)-2018	8	18.8	88.6
Ridley Cr (Lower Old Mill)-2018	9	10.4	91.3
Ridley Cr (Lower Old Mill)-2018	10	10.0	91.2
Ridley Cr (Upper Oke)-2018	4	70.1	81.6
Ridley Cr (Upper Oke)-2018	5	66.4	77.3
Ridley Cr (Upper Oke)-2018	6	34.0	84.1
Ridley Cr (Upper Oke)-2018	7	45.2	79.7
Ridley Cr (Upper Oke)-2018	8	46.6	86.4
Ridley Cr (Upper Oke)-2018	9	22.6	91.9
Ridley Cr (Upper Oke)-2018	10	19.1	92.3
Rife Run-2015	5	61.6	64.9
Rife Run-2015	6	51.2	70.3
Rife Run-2015	7	46.4	73.7
Rife Run-2015	8	60.5	68.6
Rife Run-2015	9	66.1	66.0
Rife Run-2015	10	46.6	81.1
Rife Run-2017	5	46.7	77.1
Rife Run-2017	6	58.9	67.3
Rife Run-2017	7	52.7	72.8
Rife Run-2017	8	39.6	72.3
Rife Run-2017	9	43.0	72.2
Rife Run-2017	10	36.1	74.3
Rife Run-2018	5	44.4	75.2
Rife Run-2018	6	27.1	81.5
Rife Run-2018	8	28.6	80.0
Rife Run-2018	10	32.6	88.0
Rock Run-2014	6	4.6	93.0
Rock Run-2014	7	6.5	91.6
Rock Run-2014	8	5.4	91.9
Rock Run-2014	9	5.4	94.4
Rock Run-2014	10	4.6	92.6
Rock Run-2015	4	1.8	95.7
Rock Run-2015	5	3.6	94.1
Rock Run-2015	6	4.0	94.3
Rock Run-2015	7	3.7	94.1
Rock Run-2015	8	4.6	92.8
Rock Run-2015	9	6.1	93.0
Rock Run-2015	10	4.1	93.1
Rock Run-2016	4	3.0	94.7
Rock Run-2016	5	3.2	95.0
Rock Run-2016	6	4.7	92.7
Rock Run-2016	7	11.8	89.1
Rock Run-2016	8	9.7	89.5
S F Tenmile Cr-2016	4	68.0	72.9
S F Tenmile Cr-2016	5	42.7	71.3
S F Tenmile Cr-2016	6	42.2	73.6
S F Tenmile Cr-2016	7	46.5	68.0
S F Tenmile Cr-2016	8	32.7	74.6
S F Tenmile Cr-2016	9	52.1	69.4
S F Tenmile Cr-2016	10	38.1	86.3
Sherman Cr-2013	4	24.8	87.2
Sherman Cr-2013	5	26.1	85.9
Sherman Cr-2013	6	46.3	78.4
Sherman Cr-2013	7	71.4	73.2
Sherman Cr-2013	8	52.8	76.4
Sherman Cr-2013	9	54.9	76.4
Sherman Cr-2013	10	57.1	76.7
Sixpenny Cr-2020	4	8.1	89.7
Sixpenny Cr-2020	5	7.0	89.5
Sixpenny Cr-2020	6	4.4	84.4
Sixpenny Cr-2020	7	5.3	83.7
Sixpenny Cr-2020	8	4.8	84.1
Sixpenny Cr-2020	9	5.5	83.0
Skippack Cr (Mainland)-2013	4	133.2	60.1
Skippack Cr (Mainland)-2013	5	92.2	63.3
Skippack Cr (Mainland)-2013	6	78.0	76.0
Skippack Cr (Mainland)-2013	8	59.6	74.3
Skippack Cr (Mainland)-2013	9	63.0	72.0
Skippack Cr (Mainland)-2013	10	76.6	67.9
Skippack Cr (Ridge)-2013	4	107.5	66.6
Slab Cabin Run Kissinger Meadow-2019	4	47.7	83.9
Slab Cabin Run Kissinger Meadow-2019	5	29.6	80.3
Slab Cabin Run Kissinger Meadow-2019	6	34.8	79.1
Slab Cabin Run Kissinger Meadow-2019	7	49.1	73.1
Slab Cabin Run Kissinger Meadow-2019	8	43.8	74.5
Slab Cabin Run Kissinger Meadow-2019	9	52.5	76.6
Slab Cabin Run Kissinger Meadow-2019	10	36.6	77.0
Slab Cabin Run Shingletown Road-2019	7	37.0	78.0
Slab Cabin Run Shingletown Road-2019	8	40.2	75.0
Slab Cabin Run Shingletown Road-2019	9	38.2	74.9
Slab Cabin Run Shingletown Road-2019	10	23.7	78.6
Spring Cr-2021	4	32.0	84.9
Spring Cr-2021	5	45.7	81.6
Spring Cr-2021	6	55.1	77.7
Spring Cr-2021	7	48.1	78.8
Spring Cr-2021	8	52.5	77.1

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
Spruce Cr-2016	4	27.3	89.3
Spruce Cr-2016	5	21.2	86.0
Spruce Cr-2016	6	20.8	90.0
Spruce Cr-2016	7	21.8	89.1
Spruce Cr-2016	8	21.4	88.8
Spruce Cr-2016	9	16.9	91.7
Spruce Cr-2016	10	14.5	90.0
Stone Run-2018	5	47.7	38.2
Stone Run-2018	6	33.9	18.9
Stone Run-2018	7	34.3	11.9
Stone Run-2018	8	38.5	5.7
Stone Run-2018	9	45.3	7.6
Stone Run-2018	10	17.6	63.8
Straight Run-2019	4	2.7	93.2
Straight Run-2019	5	2.6	93.0
Straight Run-2019	6	2.0	92.5
Straight Run-2019	7	2.9	91.7
Straight Run-2019	8	3.4	90.2
Straight Run-2019	9	3.0	89.2
Straight Run-2019	10	3.8	87.0
Swatara Cr (Harp)-2014	5	17.7	87.8
Swatara Cr (Harp)-2014	6	25.2	85.6
Swatara Cr (Harp)-2014	7	32.4	82.2
Swatara Cr (Harp)-2014	8	33.2	82.4
Swatara Cr (Harp)-2014	9	27.5	82.4
Swatara Cr (Harp)-2014	10	15.8	80.4
Swatara Cr (Hersh)-2014	6	16.9	91.0
Swatara Cr (Hersh)-2014	7	23.4	91.3
Swatara Cr (Hersh)-2014	8	13.2	94.7
Swatara Cr (Hersh)-2014	9	19.6	91.5
Swatara Cr (Hersh)-2014	10	7.7	90.9
Tacony Cr-2020	4	57.2	84.1
Tacony Cr-2020	5	62.7	80.2
Tacony Cr-2020	6	28.4	63.7
Tacony Cr-2020	7	52.1	74.4
Tacony Cr-2020	8	46.5	75.5
Tacony Cr-2020	9	42.4	82.9
Tacony Cr-2020	10	31.3	85.2
Thompson Run-2019	4	31.6	88.8
Thompson Run-2019	5	19.3	88.4
Thompson Run-2019	6	19.8	88.9
Thompson Run-2019	7	22.4	88.1
Thompson Run-2019	8	22.7	87.8
Thompson Run-2019	10	17.9	89.7
Three Square Hollow Run-2019	4	12.9	91.9
Three Square Hollow Run-2019	5	15.4	91.3
Three Square Hollow Run-2019	6	14.2	90.6
Three Square Hollow Run-2019	7	20.0	86.2
Three Square Hollow Run-2019	8	22.7	84.7
Three Square Hollow Run-2019	9	27.5	79.1
Three Square Hollow Run-2019	10	18.3	81.5
Tinicum Cr-2016	4	55.3	80.7
Tinicum Cr-2016	5	38.9	78.6
Tinicum Cr-2016	6	117.7	61.7
Tinicum Cr-2016	7	110.0	59.6
Tinicum Cr-2016	8	74.8	72.1
Tinicum Cr-2016	9	70.4	67.0
Tinicum Cr-2016	10	57.0	66.7
Tioga R (Carp)-2016	4	2.5	93.8
Tioga R (Carp)-2016	5	2.2	93.1
Tioga R (Carp)-2016	6	3.9	89.8
Tioga R (Carp)-2016	7	5.3	90.3
Tioga R (Carp)-2016	8	5.1	91.7
Tioga R (Carp)-2016	9	5.0	92.1
Tioga R (Carp)-2016	10	3.4	93.7
Tioga R (Morris)-2016	4	4.4	93.0
Tioga R (Morris)-2016	5	5.2	93.0
Tioga R (Morris)-2016	6	6.9	90.6
Tioga R (Morris)-2016	7	8.6	90.3
Tioga R (Morris)-2016	8	11.3	90.3
Tioga R (Morris)-2016	9	13.2	90.2
Tioga R (Morris)-2016	10	9.0	92.5
Tionesta Cr (WQN 830)-2020	4	9.3	92.2
Tionesta Cr (WQN 830)-2020	5	19.9	89.3
Tionesta Cr (WQN 830)-2020	6	33.5	78.4
Tionesta Cr (WQN 830)-2020	7	52.5	69.3
Tionesta Cr (WQN 830)-2020	8	51.5	67.2
Tionesta Cr (WQN 830)-2020	9	41.1	75.1
Tionesta Cr (WQN 830)-2020	10	22.8	82.9
Tohickon Cr-2013	4	27.4	89.9
Tohickon Cr-2013	5	20.1	87.1
Tohickon Cr-2013	6	39.9	83.2
Tohickon Cr-2013	7	22.6	86.6
Tohickon Cr-2013	9	54.5	83.7
Tohickon Cr-2013	10	58.6	75.2
Tohickon Cr-2014	4	15.5	95.1
Tohickon Cr-2014	5	10.7	93.9
Tohickon Cr-2014	6	24.9	87.7
Tohickon Cr-2014	7	51.2	82.0
Tohickon Cr-2014	8	53.8	77.7
Tohickon Cr-2014	9	52.2	81.0
Tohickon Cr-2014	10	47.9	78.2
Towamencin Cr-2013	4	85.7	77.6
Traverse Cr-2015	8	26.0	76.2
Traverse Cr-2015	9	21.4	70.5
Traverse Cr-2015	10	22.7	80.7
Tunungwant Cr (DnS)-2018	7	110.4	54.7
Tunungwant Cr (DnS)-2018	8	101.8	55.2
Tunungwant Cr (DnS)-2018	9	74.3	65.8
Tunungwant Cr (DnS)-2018	10	47.0	80.5
Tuscarora Cr-2013	4	29.1	81.3
Tuscarora Cr-2013	6	50.4	72.0
Tuscarora Cr-2014	5	29.3	86.8
Tuscarora Cr-2014	6	50.1	82.6
Tuscarora Cr-2014	7	63.8	76.4
Tuscarora Cr-2014	8	58.4	79.4
Tuscarora Cr-2014	9	48.0	77.6
Tuscarora Cr-2014	10	33.3	81.4
W Br Brandywine Cr (Modena)-2020	4	24.5	92.4
W Br Brandywine Cr (Modena)-2020	5	39.4	91.1
W Br Brandywine Cr (Modena)-2020	6	25.2	87.3
W Br Brandywine Cr (Modena)-2020	7	33.6	82.7
W Br Brandywine Cr (Modena)-2020	8	40.2	83.0
W Br Brandywine Cr (Modena)-2020	9	24.4	86.4
W Br Brandywine Cr (Modena)-2020	10	24.9	88.3
W Br Brandywine Cr (Wagontown)-2016	4	40.0	86.6
W Br Brandywine Cr (Wagontown)-2016	5	27.0	88.5
W Br Brandywine Cr (Wagontown)-2016	6	24.4	86.6
W Br Brandywine Cr (Wagontown)-2016	7	36.4	81.5
W Br Brandywine Cr (Wagontown)-2016	8	27.2	77.3
W Br Brandywine Cr (Wagontown)-2016	9	23.8	74.7
W Br Brandywine Cr (Wagontown)-2016	10	15.5	85.0
W Br Caldwell Cr-2018	4	6.7	92.3
W Br Caldwell Cr-2018	5	10.7	89.3
W Br Caldwell Cr-2018	6	9.4	87.3
W Br Caldwell Cr-2018	7	10.8	85.8
W Br Caldwell Cr-2018	8	13.0	87.6
W Br Caldwell Cr-2018	9	9.9	88.1
W Br Caldwell Cr-2018	10	4.4	93.4
W Br Chester Cr-2017	4	74.8	70.7
W Br Chester Cr-2017	6	35.3	67.0
W Br Chester Cr-2017	7	43.5	70.8
W Br Chester Cr-2017	8	44.4	76.6
W Br Lackawaxen R-2019	4	8.5	92.5
W Br Lackawaxen R-2019	5	11.3	91.9
W Br Lackawaxen R-2019	6	13.0	90.4
W Br Lackawaxen R-2019	7	21.4	83.5
W Br Lackawaxen R-2019	8	20.4	85.2
W Br Lackawaxen R-2019	9	19.9	85.3
W Br Lackawaxen R-2019	10	12.2	88.3

Sample_Short_Name	Month	p75DailyRange_WX	p25DailyMin_WX
W Br Octoraro Cr-2016	4	52.2	84.8
W Br Octoraro Cr-2016	5	40.6	85.8
W Br Octoraro Cr-2016	6	35.0	82.3
W Br Octoraro Cr-2016	7	38.3	83.4
W Br Octoraro Cr-2016	8	36.7	83.6
W Br Octoraro Cr-2016	9	32.9	85.7
W Br Octoraro Cr-2016	10	33.1	84.7
Walnut Cr-2013	5	15.4	96.5
Walnut Cr-2013	6	8.4	99.4
Walnut Cr-2013	7	20.4	94.8
Walnut Cr-2013	8	33.7	92.9
Walnut Cr-2013	9	26.2	92.9
Walnut Cr-2013	10	20.6	91.6
Walnut Cr-2016	5	21.5	89.5
Walnut Cr-2016	6	37.2	79.1
Walnut Cr-2016	7	47.3	84.2
Walnut Cr-2016	8	47.4	89.6
Walnut Cr-2016	9	42.8	89.2
Walnut Cr-2016	10	26.1	94.1
West Run-2020	4	7.8	88.7
West Run-2020	5	10.2	87.3
West Run-2020	6	17.3	82.4
West Run-2020	7	19.8	76.8
West Run-2020	8	18.2	79.1
West Run-2020	9	13.7	81.9
West Run-2020	10	12.6	79.9
Willow Run-2018	5	22.1	89.3
Willow Run-2018	6	14.8	89.5
Willow Run-2018	7	23.9	86.8
Willow Run-2018	8	29.5	89.0
Willow Run-2018	9	12.1	88.6
Willow Run-2018	10	21.2	90.4
Wissahickon Cr (Ft Wash)-2013	4	153.6	60.2

10.3 Appendix C: Station Stream Type Designation Information

Station Name	Stream Type 3	PA Eutro Region	Drainage Area (mi2)	Stream Order	Channel Slope TNM/NHD (%)	Station Elev (ft)	Air Temp Mean Annual (C)	Carbonate Geology (%)	EPA Nutrient Ecoregion	Omernik Ecoregion L3	Omernik Ecoregion L4	Physiographic Province	Physiographic Section
Allegheny R (Port Allegany)	(3) 38.6-500 mi2	A	252.0	5	0.05	1458	7.0	0	VIII	62	62d	Appalachian Plateaus	Deep Valleys Section
Aughwick Cr	(3) 38.6-500 mi2	B	307.0	5	0.22	556	10.2	7	XI	67	67b	Ridge and Valley	Appalachian Mountain Section
Beaver Cr	(2) <38.6 mi2-B	B	16.7	4	0.35	1158	9.8	36	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Beaver Run	(2) <38.6 mi2-B	B	4.4	2	1.68	284	11.0	0	IX	64	64c	Piedmont	Piedmont Upland Section
Bells Run	(2) <38.6 mi2-B	B	4.1	2	0.84	297	11.2	0	IX	64	64c	Piedmont	Piedmont Upland Section
Big Elk Cr	(3) 38.6-500 mi2	B	38.8	4	0.23	174	11.2	0	IX	64	64c	Piedmont	Piedmont Upland Section
Big Wapwallopen Cr	(2) <38.6 mi2-B	B	14.7	3	0.62	1138	8.7	0	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
Birch Run	(2) <38.6 mi2-B	B	6.5	3	1.01	203	11.0	0	IX	64	64a	Piedmont	Piedmont Upland Section
Bobs Cr	(1) <38.6 mi2-A	A	30.3	4	0.94	1274	9.1	0	XI	67	67d	Ridge and Valley	Allegheny Front Section
Brandywine Cr (Chadds)	(3) 38.6-500 mi2	B	288.0	6	0.24	151	11.2	8	IX	64	64c	Piedmont	Piedmont Upland Section
Brodhead Cr	(3) 38.6-500 mi2	A	58.1	4	1.02	692	8.0	0	VIII	62	62b	Appalachian Plateaus	Glaciated Low Plateau Section
Browns Run	(1) <38.6 mi2-A	A	5.8	2	4.01	646	8.1	0	VIII	62	62d	Appalachian Plateaus	Deep Valleys Section
Buck Run (WQN 627)	(1) <38.6 mi2-A	A	7.5	3	1.35	1631	6.9	0	VIII	62	62d	Appalachian Plateaus	High Plateau Section
Buckwa Cr	(3) 38.6-500 mi2	B	42.3	5	0.37	440	9.7	0	XI	67	67b	Ridge and Valley	Blue Mountain Section
Buffalo Cr (Rt 849)	(3) 38.6-500 mi2	B	65.0	4	0.08	430	10.4	5	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
Buffalo Cr (Strawbridge Rd)	(3) 38.6-500 mi2	B	110.0	5	0.07	454	9.4	15	XI	67	67a	Ridge and Valley	Susquehanna Lowland Section
Burd Run (Brit)	(2) <38.6 mi2-B	B	18.7	3	0.50	633	10.7	50	XI	67	67a	Ridge and Valley	Great Valley Section
Burd Run (Twp Park)	(2) <38.6 mi2-B	B	14.6	3	0.56	696	10.6	37	XI	67	67a	Ridge and Valley	Great Valley Section
Campbells Run	(2) <38.6 mi2-B	B	2.8	2	1.42	893	10.9	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Carley Brk	(1) <38.6 mi2-A	A	10.6	4	0.46	1084	7.6	0	VII	60	60b	Appalachian Plateaus	Glaciated Low Plateau Section
Cherry Run	(2) <38.6 mi2-B	B	27.0	4	0.26	861	9.9	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Chester Cr (Dar)	(2) <38.6 mi2-B	B	29.6	4	0.30	133	11.7	0	IX	64	64c	Piedmont	Piedmont Upland Section
Chester Cr (Dil)	(2) <38.6 mi2-B	B	19.9	4	0.10	241	11.7	0	IX	64	64c	Piedmont	Piedmont Upland Section
Chester Cr (Goose)	(2) <38.6 mi2-B	B	6.3	2	0.28	252	11.8	0	IX	64	64c	Piedmont	Piedmont Upland Section
Chillisquaque Cr	(3) 38.6-500 mi2	B	112.0	5	0.12	436	9.8	7	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
Chiques Cr (FS)	(2) <38.6 mi2-B	B	22.1	4	0.17	399	11.2	1	IX	64	64d	Piedmont	Piedmont Lowland Section
Chiques Cr (Mill)	(2) <38.6 mi2-B	B	37.2	4	0.17	374	11.3	10	IX	64	64d	Piedmont	Piedmont Lowland Section
Clover Cr	(3) 38.6-500 mi2	B	48.8	4	0.81	849	9.9	72	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Conestoga R (DnS STP)	(3) 38.6-500 mi2	B	331.0	5	0.06	221	11.3	46	IX	64	64d	Piedmont	Piedmont Lowland Section
Conestoga R (Rt 23)	(3) 38.6-500 mi2	B	310.0	5	0.09	257	11.2	43	IX	64	64d	Piedmont	Piedmont Lowland Section
Conodoguinet Cr (Brent)	(3) 38.6-500 mi2	B	498.0	5	0.07	316	11.0	40	XI	67	67b	Ridge and Valley	Great Valley Section
Conodoguinet Cr (Smpl Br LD)	(3) 38.6-500 mi2	B	467.0	5	0.06	354	11.0	38	XI	67	67b	Ridge and Valley	Great Valley Section
Cooks Cr	(2) <38.6 mi2-B	B	29.2	4	0.48	144	10.5	35	VIII	58	58h	Ridge and Valley	Great Valley Section
Cramer Cr	(1) <38.6 mi2-A	A	4.7	2	3.16	1126	7.3	0	VII	60	60b	Appalachian Plateaus	Glaciated Low Plateau Section
Crum Cr (Smed)	(2) <38.6 mi2-B	B	29.4	4	0.14	77	11.9	0	IX	64	64c	Piedmont	Piedmont Upland Section
Crum Cr (W Chest Pk)	(2) <38.6 mi2-B	B	15.3	4	0.71	212	11.6	0	IX	64	64c	Piedmont	Piedmont Upland Section
Deep Run	(2) <38.6 mi2-B	B	6.7	3	0.40	351	10.8	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Donegal Cr	(2) <38.6 mi2-B	B	17.1	3	0.29	254	11.5	83	IX	64	64d	Piedmont	Piedmont Lowland Section
Dunbar Cr	(1) <38.6 mi2-A	A	18.0	4	1.56	1294	9.6	0	XI	69	69a	Appalachian Plateaus	Allegheny Mountain Section
E Br Brandywine Cr	(3) 38.6-500 mi2	B	89.9	5	0.13	200	11.1	9	IX	64	64c	Piedmont	Piedmont Upland Section

Station Name	Stream Type 3	PA Eutro Region	Drainage Area (mi2)	Stream Order	Channel Slope TNM/NHD (%)	Station Elev (ft)	Air Temp Mean Annual (C)	Carbonate Geology (%)	EPA Nutrient Ecoregion	Omernik Ecoregion L3	Omernik Ecoregion L4	Physiographic Province	Physiographic Section
E Br W Br Conneaut Cr	(1) <38.6 mi2-A	A	3.0	2	0.62	1011	8.5	0	VII	61	61b	Appalachian Plateaus	Northwestern Glaciated Plateau Section
E Hickory Cr	(1) <38.6 mi2-A	A	36.7	4	0.69	1144	7.6	0	VIII	62	62d	Appalachian Plateaus	High Plateau Section
E Licking Cr	(1) <38.6 mi2-A	A	22.2	3	0.69	627	10.0	0	XI	67	67c	Ridge and Valley	Appalachian Mountain Section
E Sandy Cr	(3) 38.6-500 mi2	B	94.2	4	0.47	1050	8.4	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Fishing Cr (Craley)	(2) <38.6 mi2-B	B	15.8	3	0.50	391	11.3	0	IX	64	64c	Piedmont	Piedmont Upland Section
Fishing Cr (Goldsboro)	(2) <38.6 mi2-B	B	17.4	4	0.52	307	11.2	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Fishing Cr (Lower)	(3) 38.6-500 mi2	B	137.0	4	0.27	610	8.8	37	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Fishing Cr (Upper)	(3) 38.6-500 mi2	B	53.3	4	0.48	1033	8.4	38	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Frankstown Br	(3) 38.6-500 mi2	B	295.0	6	0.23	823	9.6	27	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
French Cr (Lower)	(3) 38.6-500 mi2	B	59.1	4	0.28	166	10.9	1	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
French Cr (Upper)	(2) <38.6 mi2-B	B	18.8	3	0.19	285	10.8	1	IX	64	64c	Piedmont	Gettysburg-Newark Lowland Section
Genesee Forks	(1) <38.6 mi2-A	A	18.0	3	0.86	1661	7.1	0	VIII	62	62c	Appalachian Plateaus	Deep Valleys Section
Genesee River	(1) <38.6 mi2-A	A	11.6	3	1.26	1794	7.0	0	VIII	62	60e	Appalachian Plateaus	Glaciated High Plateau Section
Goose Cr (Most)	(2) <38.6 mi2-B	B	1.9	2	1.45	393	11.8	0	IX	64	64c	Piedmont	Piedmont Upland Section
Goose Cr (Oak)	(2) <38.6 mi2-B	B	3.3	2	0.42	322	11.8	0	IX	64	64c	Piedmont	Piedmont Upland Section
Grays Run	(1) <38.6 mi2-A	A	16.2	3	1.16	847	7.9	0	VIII	62	62c	Appalachian Plateaus	Deep Valleys Section
Groff Cr	(2) <38.6 mi2-B	B	10.4	2	0.28	294	11.4	100	IX	64	64d	Piedmont	Piedmont Lowland Section
Hell Run	(1) <38.6 mi2-A	A	4.3	2	1.77	1133	9.7	0	VII	61	61c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Huntington Cr (Lower)	(3) 38.6-500 mi2	B	112.0	5	0.41	639	8.9	0	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
Huntington Cr (Upper)	(1) <38.6 mi2-A	A	18.1	3	0.57	898	8.6	0	VII	60	60a	Ridge and Valley	Susquehanna Lowland Section
Hyner Run	(1) <38.6 mi2-A	A	26.6	4	1.32	783	7.8	0	VIII	62	62d	Appalachian Plateaus	Deep Valleys Section
Indian Cr (Berg)	(2) <38.6 mi2-B	B	1.4	2	0.78	344	11.2	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Indian Cr (Rt 63)	(2) <38.6 mi2-B	B	5.7	3	0.33	208	11.3	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Ithan Cr	(2) <38.6 mi2-B	B	7.3	3	0.37	195	12.2	0	IX	64	64c	Piedmont	Piedmont Upland Section
Jacks Cr	(3) 38.6-500 mi2	B	57.1	4	0.31	492	9.9	13	XI	67	67b	Ridge and Valley	Appalachian Mountain Section
Jones Mill Run	(1) <38.6 mi2-A	A	4.8	3	2.15	1995	8.5	0	XI	69	69a	Appalachian Plateaus	Allegheny Mountain Section
Kettle Cr	(3) 38.6-500 mi2	A	137.0	5	0.49	1028	7.4	0	VIII	62	62d	Appalachian Plateaus	Deep Valleys Section
Kishacoquillas Cr (Manns)	(3) 38.6-500 mi2	B	163.0	5	0.47	560	9.8	25	XI	67	67c	Ridge and Valley	Appalachian Mountain Section
Kishacoquillas Cr (Park)	(3) 38.6-500 mi2	B	185.0	5	0.33	479	9.8	25	XI	67	67b	Ridge and Valley	Appalachian Mountain Section
Kreutz Cr	(2) <38.6 mi2-B	B	32.2	3	0.19	261	11.4	36.83	IX	64	64d	Piedmont	Piedmont Lowland Section
L Beaver Cr	(2) <38.6 mi2-B	B	5.3	3	0.30	391	11.4	46	IX	64	64d	Piedmont	Piedmont Lowland Section
L Conestoga Cr	(3) 38.6-500 mi2	B	65.1	4	0.20	189	11.5	90	IX	64	64d	Piedmont	Piedmont Lowland Section
L Juniata R	(3) 38.6-500 mi2	B	224.0	5	0.32	752	9.2	22	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
L Mahoning Cr (Lower)	(3) 38.6-500 mi2	B	50.3	5	0.54	1265	9.1	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
L Mahoning Cr (Upper)	(1) <38.6 mi2-A	A	25.3	4	0.67	1358	9.2	0	XI	69	69b	Appalachian Plateaus	Pittsburgh Low Plateau Section
L Swatara Cr	(3) 38.6-500 mi2	B	99.1	4	0.31	391	10.8	3	XI	67	67b	Ridge and Valley	Great Valley Section
Lackawaxen R	(3) 38.6-500 mi2	A	206.0	5	0.42	877	7.4	0	VIII	62	62b	Appalachian Plateaus	Glaciated Low Plateau Section
Laurel Hill Cr (Lower)	(3) 38.6-500 mi2	A	121.0	5	0.18	1335	8.7	0	XI	69	69b	Appalachian Plateaus	Allegheny Mountain Section
Laurel Hill Cr (Upper)	(3) 38.6-500 mi2	A	69.8	5	0.81	1758	8.5	0	XI	69	69b	Appalachian Plateaus	Allegheny Mountain Section
Lick Branch	(1) <38.6 mi2-A	A	2.3	1	2.95	913	8.5	0	VII	60	60a	Ridge and Valley	Susquehanna Lowland Section

Station Name	Stream Type 3	PA Eutro Region	Drainage Area (mi2)	Stream Order	Channel Slope TNM/NHD (%)	Station Elev (ft)	Air Temp Mean Annual (C)	Carbonate Geology (%)	EPA Nutrient Ecoregion	Omernik Ecoregion L3	Omernik Ecoregion L4	Physiographic Province	Physiographic Section
Lick Run	(2) <38.6 mi2-B	B	8.6	3	0.80	815	11.0	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Lost Cr (Upper)	(2) <38.6 mi2-B	B	11.1	3	0.79	602	10.0	0	XI	67	67a	Ridge and Valley	Susquehanna Lowland Section
Loyalsock Cr (WQN0408)	(3) 38.6-500 mi2	A	436.0	6	0.20	594	7.9	0	VIII	62	62d	Appalachian Plateaus	Deep Valleys Section
Mahoning Cr (Dam)	(3) 38.6-500 mi2	B	344.0	6	0.22	1003	8.9	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Marsh Cr	(1) <38.6 mi2-A	A	25.5	3	0.45	1179	7.5	0	VIII	62	62c	Appalachian Plateaus	Deep Valleys Section
Marshall Run	(2) <38.6 mi2-B	B	2.2	3	1.50	1014	10.5	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Masthope Cr	(1) <38.6 mi2-A	A	24.0	4	0.72	936	7.6	0	VIII	62	62b	Appalachian Plateaus	Glaciated Low Plateau Section
McGee Run (DnS)	(2) <38.6 mi2-B	B	7.3	3	0.27	1086	10.3	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
McGee Run (UpS)	(2) <38.6 mi2-B	B	3.7	3	0.68	1104	10.1	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Middle Cr (Adams)	(2) <38.6 mi2-B	B	23.4	5	0.38	442	11.2	15	IX	64	64b	Piedmont	Gettysburg-Newark Lowland Section
Middle Cr (Monroe)	(2) <38.6 mi2-B	B	18.2	3	0.72	701	9.1	0	XI	67	67b	Ridge and Valley	Blue Mountain Section
Middle Cr (Wayne)	(3) 38.6-500 mi2	A	80.7	4	1.12	942	7.5	0	VIII	62	62b	Appalachian Plateaus	Glaciated Low Plateau Section
Mill Cr	(3) 38.6-500 mi2	B	56.1	4	0.19	237	11.4	92	IX	64	64d	Piedmont	Piedmont Lowland Section
Mitchell Run	(2) <38.6 mi2-B	B	3.0	3	0.72	1016	10.2	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Moyers Mill Run	(2) <38.6 mi2-B	B	4.0	2	0.95	646	10.0	28	XI	67	67a	Ridge and Valley	Susquehanna Lowland Section
Muddy Cr	(3) 38.6-500 mi2	B	133.0	4	0.36	175	11.3	0	IX	64	64c	Piedmont	Piedmont Upland Section
Muddy Run	(2) <38.6 mi2-B	B	8.8	2	0.15	335	11.4	91	IX	64	64d	Piedmont	Piedmont Lowland Section
N Br Mahatango Cr	(2) <38.6 mi2-B	B	29.2	4	0.36	470	10.0	9	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
N Br Middle Cr	(2) <38.6 mi2-B	B	10.1	4	0.26	644	9.7	16	XI	67	67a	Ridge and Valley	Susquehanna Lowland Section
N F Cowanesque	(1) <38.6 mi2-A	A	19.0	3	0.91	1502	7.2	0	VIII	62	62c	Appalachian Plateaus	Glaciated High Plateau Section
N F Redbank Cr	(3) 38.6-500 mi2	A	72.4	4	0.30	1293	8.0	0	VIII	62	62d	Appalachian Plateaus	Pittsburgh Low Plateau Section
Neshaminy Cr	(3) 38.6-500 mi2	B	209.0	5	0.03	46	11.5	2	IX	64	64c	Piedmont	Piedmont Upland Section
Penns Cr (Pine)	(3) 38.6-500 mi2	B	375.0	6	0.04	415	9.2	22	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
Pennypack Cr (Lower Elkins)	(2) <38.6 mi2-B	B	27.6	3	0.22	103	12.0	0	IX	64	64c	Piedmont	Piedmont Upland Section
Pennypack Cr (Upper UMHJSA)	(2) <38.6 mi2-B	B	12.4	3	0.22	182	11.9	0	IX	64	64c	Piedmont	Gettysburg-Newark Lowland Section
Perkiomen Cr	(3) 38.6-500 mi2	B	301.0	6	0.06	82	11.1	1	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Peters Cr (DnS)	(3) 38.6-500 mi2	B	39.1	4	0.33	797	10.9	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Peters Cr (Mouth)	(3) 38.6-500 mi2	B	51.3	4	0.21	732	11.0	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Peters Cr (UpS)	(2) <38.6 mi2-B	B	13.6	3	0.47	829	10.9	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Pickering Cr	(2) <38.6 mi2-B	B	31.0	4	0.56	144	11.2	0	IX	64	64c	Piedmont	Piedmont Upland Section
Pine Cr (Berks)	(2) <38.6 mi2-B	B	9.9	3	0.32	361	10.4	7	VIII	58	58h	Ridge and Valley	Great Valley Section
Piney Fork	(2) <38.6 mi2-B	B	13.5	3	0.87	846	10.9	0	XI	70	70b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Pohopoco Cr	(3) 38.6-500 mi2	B	52.1	4	0.83	636	9.3	0	XI	67	67b	Ridge and Valley	Blue Mountain Section
Porcupine Cr (WQN 466)	(1) <38.6 mi2-A	A	11.6	3	1.62	1067	8.4	0	VIII	62	62d	Appalachian Plateaus	High Plateau Section
Princess Run	(2) <38.6 mi2-B	B	10.0	3	1.82	561	9.6	0	XI	67	67b	Ridge and Valley	Blue Mountain Section
Quittapahilla Cr	(3) 38.6-500 mi2	B	73.4	4	0.13	370	11.0	76	XI	67	67b	Ridge and Valley	Great Valley Section
Raccoon Cr	(2) <38.6 mi2-B	B	11.8	3	0.52	493	10.1	9	XI	67	67a	Ridge and Valley	Susquehanna Lowland Section
Rairigh Run	(1) <38.6 mi2-A	A	3.1	2	1.37	1462	9.1	0	XI	69	69b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Red Clay Cr	(2) <38.6 mi2-B	B	27.6	4	0.79	194	11.6	11	IX	64	64c	Piedmont	Piedmont Upland Section
Ridley Cr (Lower Old Mill)	(2) <38.6 mi2-B	B	32.7	4	0.32	72	12.0	0	IX	64	64c	Piedmont	Piedmont Upland Section

Station Name	Stream Type 3	PA Eutro Region	Drainage Area (mi2)	Stream Order	Channel Slope TNM/NHD (%)	Station Elev (ft)	Air Temp Mean Annual (C)	Carbonate Geology (%)	EPA Nutrient Ecoregion	Omernik Ecoregion L3	Omernik Ecoregion L4	Physiographic Province	Physiographic Section
Ridley Cr (Upper Oke)	(2) <38.6 mi2-B	B	13.7	3	0.16	231	11.6	0	IX	64	64c	Piedmont	Piedmont Upland Section
Rife Run	(2) <38.6 mi2-B	B	5.9	3	0.46	386	11.4	0	IX	64	64d	Piedmont	Piedmont Lowland Section
Rock Run	(1) <38.6 mi2-A	A	28.1	4	1.37	871	8.0	0	VIII	62	62c	Appalachian Plateaus	Deep Valleys Section
S F Tenmile Cr	(3) 38.6-500 mi2	B	181.0	6	0.10	855	10.5	0	XI	70	70b	Appalachian Plateaus	Waynesburg Hills Section
Sherman Cr	(3) 38.6-500 mi2	B	207.0	5	0.13	423	10.5	11	XI	67	67b	Ridge and Valley	Susquehanna Lowland Section
Sixpenny Cr	(2) <38.6 mi2-B	B	1.7	1	2.19	503	10.9	0	IX	64	64b	Piedmont	Gettysburg-Newark Lowland Section
Skippack Cr (Mainland)	(2) <38.6 mi2-B	B	11.6	4	0.22	187	11.3	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Skippack Cr (Ridge)	(3) 38.6-500 mi2	B	53.0	5	0.23	108	11.5	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Slab Cabin Run Kissinger Meadow	(2) <38.6 mi2-B	B	15.4	3	0.56	1024	9.2	68	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Slab Cabin Run Shingletown Road	(2) <38.6 mi2-B	B	6.2	3	0.72	1092	9.3	71	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Spring Cr	(3) 38.6-500 mi2	B	84.2	4	0.46	794	9.2	82.77	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Spruce Cr	(3) 38.6-500 mi2	B	109.0	4	0.67	756	9.6	84	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Stone Run	(1) <38.6 mi2-A	A	1.1	1	0.56	1063	8.5	0	VII	61	61b	Appalachian Plateaus	Northwestern Glaciated Plateau Section
Straight Run	(1) <38.6 mi2-A	A	14.5	4	0.80	1367	8.8	0	XI	69	69b	Appalachian Plateaus	Pittsburgh Low Plateau Section
Swatara Cr (Harp)	(3) 38.6-500 mi2	B	336.0	5	0.07	357	10.5	1	XI	67	67b	Ridge and Valley	Great Valley Section
Swatara Cr (Hersh)	(3) 38.6-500 mi2	B	485.0	5	0.11	321	10.7	13	XI	67	67b	Ridge and Valley	Great Valley Section
Tacony Cr	(2) <38.6 mi2-B	B	13.6	3	0.38	102	12.5	0	IX	64	64c	Piedmont	Piedmont Upland Section
Thompson Run	(2) <38.6 mi2-B	B	3.7	2	1.47	954	9.3	100	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
Three Square Hollow Run	(2) <38.6 mi2-B	B	12.7	4	0.34	508	11.1	0	XI	67	67b	Ridge and Valley	Great Valley Section
Tinicum Cr	(2) <38.6 mi2-B	B	14.5	3	0.80	195	10.8	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Tioga R (Carp)	(3) 38.6-500 mi2	A	49.3	4	0.95	1446	7.5	0	VIII	62	62c	Appalachian Plateaus	Glaciated High Plateau Section
Tioga R (Morris)	(3) 38.6-500 mi2	A	57.5	4	0.77	1395	7.6	0	VIII	62	62c	Appalachian Plateaus	Glaciated High Plateau Section
Tionesta Cr (WQN 830)	(3) 38.6-500 mi2	A	232.0	6	0.13	1255	7.2	0	VIII	62	62d	Appalachian Plateaus	High Plateau Section
Tohickon Cr	(3) 38.6-500 mi2	B	98.0	4	1.07	259	10.7	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Towamencin Cr	(2) <38.6 mi2-B	B	10.1	4	0.27	169	11.4	0	IX	64	64a	Piedmont	Gettysburg-Newark Lowland Section
Traverse Cr	(2) <38.6 mi2-B	B	14.6	4	0.35	916	10.5	0	XI	70	70c	Appalachian Plateaus	Pittsburgh Low Plateau Section
Tunungwant Cr (DnS)	(3) 38.6-500 mi2	A	137.0	5	0.08	1400	7.0	0	VIII	62	62d	Appalachian Plateaus	Deep Valleys Section
Tuscarora Cr	(3) 38.6-500 mi2	B	198.0	5	0.11	424	10.2	11	XI	67	67a	Ridge and Valley	Appalachian Mountain Section
W Br Brandywine Cr (Modena)	(3) 38.6-500 mi2	B	55.4	4	0.16	265	11.0	5	IX	64	64c	Piedmont	Piedmont Upland Section
W Br Brandywine Cr (Wagontown)	(2) <38.6 mi2-B	B	32.0	3	1.20	486	11.0	2	IX	64	64c	Piedmont	Piedmont Upland Section
W Br Caldwell Cr	(1) <38.6 mi2-A	A	19.4	3	0.54	1283	7.9	0	VIII	62	62d	Appalachian Plateaus	High Plateau Section
W Br Chester Cr	(2) <38.6 mi2-B	B	11.5	3	0.37	185	11.8	0	IX	64	64c	Piedmont	Piedmont Upland Section
W Br Lackawaxen R	(3) 38.6-500 mi2	A	53.3	5	0.50	1129	7.1	0	VII	60	60b	Appalachian Plateaus	Glaciated Low Plateau Section
W Br Octoraro Cr	(3) 38.6-500 mi2	B	39.5	3	0.28	287	11.2	6	IX	64	64c	Piedmont	Piedmont Upland Section
Walnut Cr	(1) <38.6 mi2-A	A	37.4	4	0.56	576	8.9	0	VII	83	83a	Central Lowlands	Eastern Lake Section
West Run	(1) <38.6 mi2-A	A	2.8	2	1.16	1723	6.8	0	VIII	62	62d	Appalachian Plateaus	High Plateau Section
Willow Run	(2) <38.6 mi2-B	B	8.3	3	0.50	616	10.3	19	XI	67	67b	Ridge and Valley	Appalachian Mountain Section
Wissahickon Cr (Ft Wash)	(3) 38.6-500 mi2	B	40.6	4	0.34	143	11.9	8	IX	64	64c	Piedmont	Piedmont Lowland Section

10.4 Appendix D: Calibration and Ancillary Sample Biological Data

Sample Name	Sample Type	Support Status	Macro IBI Score	PCA Axis 1 Score	CA Axis 1 Score	ETI Score
Allegheny R (Port Allegany)-2015	Cal	Supporting	67	-0.39	-0.25	7.00
Aughwick Cr-2014	Cal	Supporting	79	-0.32	-0.10	7.10
Beaver Cr-2018	Cal	Not-Supporting	41	-0.01	-0.27	8.01
Beaver Run-2016	Cal	Supporting	73	-0.99	0.32	5.63
Bells Run-2016	Cal	Not-Supporting	33	1.86	-0.69	8.35
Big Elk Cr-2014	Cal	Not-Supporting	47	-0.03	-0.48	7.68
Big Wapwallopen Cr-2020	Cal	Supporting	78	-1.32	0.48	5.85
Birch Run-2016	Cal	Supporting	87	-0.93	0.43	5.76
Bobs Cr-2018	Cal	Supporting	85	-1.21	0.77	5.91
Brandywine Cr (Chadds)-2015	Cal	Not-Supporting	47	0.44	-0.63	7.76
Brodhead Cr-2016	Cal	Supporting	100	-1.69	0.69	5.03
Browns Run-2013	Cal	Supporting	89	-1.60	1.24	3.50
Buck Run (WQN 627)-2020	Cal	Supporting	96	-1.52	1.26	3.67
Buckwa Cr-2020	Cal	Supporting	89	-0.92	0.24	6.81
Buffalo Cr (Rt 849)-2013	Cal	Supporting	68	0.61	-0.07	7.26
Buffalo Cr (Strawbridge Rd)-2020	Cal	Supporting	83	0.90	0.11	6.81
Burd Run (Twp Park)-2019	Cal	Supporting	50	-1.11	0.46	6.45
Campbells Run-2015	Cal	Not-Supporting	25	0.69	-0.20	7.58
Carley Brk-2016	Cal	Supporting	89	-1.03	0.83	4.70
Cherry Run-2016	Cal	Supporting	57	-0.87	0.30	5.34
Chester Cr (Dar)-2017	Cal	Not-Supporting	44	1.55	-0.71	8.22
Chester Cr (Goose)-2014	Cal	Not-Supporting	23	4.45	-0.54	8.04
Chillisquaque Cr-2013	Cal	Supporting	69	0.29	-0.16	6.66
Chiques Cr (FS)-2017	Cal	Not-Supporting	28	0.45	-0.44	8.52
Chiques Cr (Mill)-2017	Cal	Not-Supporting	30	1.14	-0.84	8.73
Clover Cr-2018	Cal	Supporting	69	-0.12	0.09	6.52
Conestoga R (DnS STP)-2017	Cal	Not-Supporting	27	1.44	-0.96	9.11
Conestoga R (Rt 23)-2017	Cal	Not-Supporting	47	0.91	-0.50	7.44
Conodoguinet Cr (Brent)-2016	Cal	Not-Supporting	47	3.00	-0.69	8.23
Conodoguinet Cr (Smpl Br LD)-2015	Cal	Not-Supporting	63	1.36	-0.51	8.08
Cooks Cr-2016	Cal	Supporting	71	-0.22	0.17	6.54
Cramer Cr-2019	Cal	Supporting	87	-1.48	0.85	5.57
Crum Cr (Smed)-2018	Cal	Not-Supporting	28	-0.33	-0.92	8.93
Crum Cr (W Chest Pk)-2018	Cal	Not-Supporting	45	-1.00	-0.35	8.09
Deep Run-2015	Cal	Not-Supporting	34	3.12	-0.86	8.83
Donegal Cr-2017	Cal	Not-Supporting	41	1.18	-0.52	7.46
Dunbar Cr-2016	Cal	Supporting	93	-1.51	0.86	4.57
E Br Brandywine Cr-2020	Cal	Not-Supporting	50	0.66	-0.46	7.90
E Br W Br Conneaut Cr-2018	Cal	Not-Supporting	47	1.20	-0.34	8.04
E Hickory Cr-2020	Cal	Supporting	90	-1.21	0.71	5.10
E Licking Cr-2018	Cal	Supporting	85	-1.69	0.69	5.44
E Sandy Cr-2020	Cal	Supporting	97	-1.28	0.24	6.40
Fishing Cr (Craley)-2020	Cal	Supporting	55	-0.18	-0.15	6.97
Fishing Cr (Goldsboro)-2020	Cal	Supporting	51	0.37	-0.12	6.79
Fishing Cr (Lower)-2016	Cal	Not-Supporting	51	0.09	-0.22	7.63

Sample Name	Sample Type	Support Status	Macro IBI Score	PCA Axis 1 Score	CA Axis 1 Score	ETI Score
Fishing Cr (Upper)-2016	Cal	Supporting	74	0.45	0.51	5.66
Frankstown Br-2015	Cal	Not-Supporting	59	-0.07	-0.41	7.77
French Cr (Lower)-2016	Cal	Supporting	80	-0.77	-0.03	6.72
French Cr (Upper)-2016	Cal	Supporting	60	-0.93	0.02	6.51
Genesee Forks-2018	Cal	Supporting	82	-1.22	0.54	6.36
Genesee River-2018	Cal	Supporting	71	-0.99	0.67	6.41
Goose Cr (Oak)-2014	Cal	Not-Supporting	22	6.09	-1.04	8.70
Grays Run-2013	Cal	Supporting	94	-1.60	1.03	4.34
Groff Cr-2016	Cal	Not-Supporting	25	2.79	-1.06	9.11
Hell Run-2016	Cal	Supporting	65	-0.73	0.20	6.04
Huntington Cr (Lower)-2020	Cal	Supporting	88	-0.92	0.17	6.54
Huntington Cr (Upper)-2020	Cal	Supporting	97	-1.17	1.06	4.48
Hyner Run-2015	Cal	Supporting	97	-1.68	1.05	4.17
Indian Cr (Rt 63)-2014	Cal	Not-Supporting	29	2.19	-1.03	9.13
Ithan Cr-2017	Cal	Not-Supporting	31	-0.15	-0.96	8.57
Jacks Cr-2013	Cal	Supporting	88	-0.49	0.12	6.69
Jones Mill Run-2019	Cal	Supporting	82	-1.38	1.07	4.39
Kettle Cr-2016	Cal	Supporting	95	-0.93	0.21	6.82
Kishacoquillas Cr (Manns)-2015	Cal	Not-Supporting	58	-0.26	-0.24	7.13
Kishacoquillas Cr (Park)-2013	Cal	Not-Supporting	51	0.20	-0.29	7.77
Kreutz Cr-2020	Cal	Not-Supporting	41	-0.34	-0.43	7.86
L Beaver Cr-2016	Cal	Not-Supporting	27	1.99	-0.82	8.50
L Conestoga Cr-2017	Cal	Not-Supporting	46	0.87	-0.62	7.79
L Juniata R-2015	Cal	Not-Supporting	69	-0.36	-0.08	6.82
L Mahoning Cr (Lower)-2019	Cal	Supporting	72	-1.39	0.09	6.52
L Mahoning Cr (Upper)-2019	Cal	Supporting	64	-1.19	0.04	6.72
L Swatara Cr-2014	Cal	Not-Supporting	54	1.22	-0.55	7.91
Lackawaxen R-2019	Cal	Supporting	88	-0.58	0.09	6.59
Laurel Hill Cr (Lower)-2019	Cal	Supporting	78	-0.96	0.21	5.84
Lick Branch-2020	Cal	Supporting	97	-1.67	1.17	4.12
Lick Run-2015	Cal	Not-Supporting	22	2.29	-0.71	8.50
Lost Cr (Upper)-2018	Cal	Supporting	80	-1.66	0.55	6.39
Loyalsock Cr (WQN0408)-2013	Cal	Supporting	86	-1.07	0.12	6.41
Mahoning Cr (Dam)-2015	Cal	Not-Supporting	71	-0.80	-0.25	7.17
Marsh Cr-2018	Cal	Not-Supporting	47	0.97	-0.32	8.14
Marshall Run-2017	Cal	Supporting	61	-0.99	0.19	7.18
Masthope Cr-2016	Cal	Supporting	90	-1.23	0.55	5.72
McGee Run (DnS)-2020	Cal	Not-Supporting	21	1.37	-0.76	8.72
Middle Cr (Adams)-2016	Cal	Supporting	63	0.30	0.01	6.51
Middle Cr (Monroe)-2020	Cal	Supporting	94	-1.42	0.72	5.28
Middle Cr (Wayne)-2019	Cal	Supporting	99	-1.42	0.34	5.82
Mill Cr-2017	Cal	Not-Supporting	35	1.44	-0.87	8.46
Mitchell Run-2020	Cal	Not-Supporting	66	-1.10	0.66	4.48
Moyers Mill Run-2016	Cal	Supporting	67	-1.18	0.26	6.73
Muddy Cr-2016	Cal	Supporting	77	-0.25	0.14	6.56

Sample Name	Sample Type	Support Status	Macro IBI Score	PCA Axis 1 Score	CA Axis 1 Score	ETI Score
Muddy Run-2016	Cal	Not-Supporting	26	3.83	-0.94	8.71
N Br Mahatango Cr-2018	Cal	Supporting	57	-0.82	-0.12	7.09
N Br Middle Cr-2018	Cal	Supporting	75	-0.79	0.10	6.77
N F Cowanesque-2018	Cal	Supporting	68	-0.55	0.42	6.17
N F Redbank Cr-2019	Cal	Supporting	95	-1.43	0.57	5.84
Neshaminy Cr-2013	Cal	Not-Supporting	29	2.11	-0.99	8.97
Penns Cr (Pine)-2016	Cal	Not-Supporting	61	1.51	-0.27	7.69
Pennypack Cr (Lower Elkins)-2020	Cal	Not-Supporting	27	2.00	-0.81	8.75
Pennypack Cr (Upper UMHJSA)-2020	Cal	Not-Supporting	26	1.12	-0.85	8.75
Perkiomen Cr-2014	Cal	Not-Supporting	52	1.12	-0.56	8.02
Peters Cr (DnS)-2015	Cal	Not-Supporting	25	1.72	-0.83	8.65
Peters Cr (UpS)-2015	Cal	Not-Supporting	27	-1.03	-0.75	8.16
Pickering Cr-2016	Cal	Supporting	60	-0.64	-0.12	6.87
Pine Cr (Berks)-2014	Cal	Supporting	67	-1.08	-0.07	7.10
Piney Fork-2015	Cal	Not-Supporting	17	3.27	-0.97	8.59
Pohopoco Cr-2020	Cal	Supporting	99	-1.06	0.45	5.54
Porcupine Cr (WQN 466)-2020	Cal	Supporting	87	-1.57	1.00	5.20
Princess Run-2020	Cal	Supporting	69	-1.28	0.20	6.97
Quittapahilla Cr-2015	Cal	Not-Supporting	30	0.58	-0.81	8.79
Raccoon Cr-2013	Cal	Supporting	61	-0.94	-0.09	7.28
Rairigh Run-2019	Cal	Supporting	87	-1.45	0.94	4.22
Red Clay Cr-2014	Cal	Not-Supporting	30	0.10	-0.74	8.30
Ridley Cr (Lower Old Mill)-2018	Cal	Not-Supporting	35	0.15	-0.83	8.72
Ridley Cr (Upper Oke)-2018	Cal	Not-Supporting	37	0.19	-0.77	8.63
Rife Run-2017	Cal	Not-Supporting	42	1.33	-0.45	8.18
Rock Run-2015	Cal	Supporting	80	-1.69	0.83	5.94
S F Tenmile Cr-2016	Cal	Not-Supporting	47	0.65	-0.45	7.88
Sherman Cr-2013	Cal	Supporting	85	0.21	-0.19	7.42
Sixpenny Cr-2020	Cal	Supporting	69	-1.23	0.72	4.95
Skippack Cr (Mainland)-2013	Cal	Not-Supporting	22	5.86	-1.01	9.07
Skippack Cr (Ridge)-2013	Cal	Not-Supporting	32	2.86	-0.97	9.00
Slab Cabin Run Kissinger Meadow-2019	Cal	Not-Supporting	16	0.36	-0.40	8.21
Spring Cr-2021	Cal	Not-Supporting	55	0.40	-0.50	8.56
Spruce Cr-2016	Cal	Supporting	71	-0.57	0.26	6.31
Stone Run-2018	Cal	Not-Supporting	18	4.18	-0.73	8.83
Straight Run-2019	Cal	Supporting	84	-1.52	0.52	5.82
Swatara Cr (Hersh)-2014	Cal	Not-Supporting	63	-0.81	-0.29	7.25
Tacony Cr-2020	Cal	Not-Supporting	24	0.33	-0.77	8.58
Thompson Run-2019	Cal	Not-Supporting	24	-0.45	-0.75	8.10
Three Square Hollow Run-2019	Cal	Supporting	65	-0.82	-0.24	7.32
Tinicum Cr-2016	Cal	Supporting	52	0.95	-0.39	7.76
Tioga R (Morris)-2016	Cal	Supporting	98	-1.48	0.69	5.49
Tionesta Cr (WQN 830)-2020	Cal	Supporting	74	-0.49	-0.05	7.44
Tohickon Cr-2013	Cal	Not-Supporting	55	-0.37	-0.42	7.55
Towamencin Cr-2013	Cal	Not-Supporting	17	2.60	-0.71	8.95

Sample Name	Sample Type	Support Status	Macro IBI Score	PCA Axis 1 Score	CA Axis 1 Score	ETI Score
Traverse Cr-2015	Cal	Supporting	51	-0.27	-0.29	7.49
Tunungwant Cr (DnS)-2018	Cal	Not-Supporting	45	1.44	-0.39	7.96
Tuscarora Cr-2014	Cal	Supporting	61	-0.01	-0.10	7.13
W Br Brandywine Cr (Modena)-2020	Cal	Not-Supporting	62	-0.04	-0.48	7.90
W Br Brandywine Cr (Wagontown)-2016	Cal	Supporting	60	-0.10	-0.10	7.04
W Br Caldwell Cr-2018	Cal	Supporting	83	-1.30	0.58	5.71
W Br Chester Cr-2017	Cal	Not-Supporting	36	1.77	-0.61	8.20
W Br Lackawaxen R-2019	Cal	Supporting	89	-1.12	0.23	6.69
W Br Octoraro Cr-2016	Cal	Not-Supporting	62	1.00	-0.37	7.69
Walnut Cr-2016	Cal	Not-Supporting	29	-0.62	-0.67	8.05
West Run-2020	Cal	Supporting	64	-0.34	0.62	5.68
Willow Run-2018	Cal	Supporting	68	-0.99	0.26	7.03
Wissahickon Cr (Ft Wash)-2013	Cal	Not-Supporting	25	5.38	-0.77	8.41
Buffalo Cr (Rt 849)-2014	Anc	Supporting	94			6.92
Burd Run (Brit)-2019	Anc	Not-Supporting	31			8.08
Chester Cr (Dil)-2017	Anc	Not-Supporting	30			8.26
Chillisquaque Cr-2014	Anc	Not-Supporting	47			8.08
Chiques Cr (FS)-2018	Anc	Not-Supporting	39			7.72
Chiques Cr (Mill)-2018	Anc	Not-Supporting	41			6.88
Cooks Cr-2013	Anc	Supporting	57			6.76
Donegal Cr-2015	Anc	Not-Supporting	37			8.08
Donegal Cr-2018	Anc	Not-Supporting	36			7.76
Frankstown Br-2014	Anc	Not-Supporting	56			8.22
Goose Cr (Most)-2014	Anc	Not-Supporting	23			8.10
Hyner Run-2014	Anc	Supporting	99			4.12
Hyner Run-2016	Anc	Supporting	97			4.39
Indian Cr (Berg)-2013	Anc	Not-Supporting	18			8.68
Indian Cr (Berg)-2014	Anc	Not-Supporting	21			8.22
Indian Cr (Rt 63)-2013	Anc	Not-Supporting	24			8.99
Kettle Cr-2013	Anc	Supporting	87			6.65
Kishacoquillas Cr (Manns)-2014	Anc	Not-Supporting	49			7.56
L Juniata R-2014	Anc	Not-Supporting	65			6.53
Laurel Hill Cr (Upper)-2019	Anc	Supporting	95			5.82
McGee Run (UpS)-2020	Anc	Not-Supporting	24			8.65
Peters Cr (Mouth)-2015	Anc	Not-Supporting	18			8.72
Rife Run-2015	Anc	Not-Supporting	24			8.83
Rife Run-2018	Anc	Not-Supporting	45			7.81
Rock Run-2014	Anc	Supporting	90			5.36
Rock Run-2016	Anc	Supporting	95			3.64
Slab Cabin Run Shingletown Road-2019	Anc	Not-Supporting	35			8.15
Swatara Cr (Harp)-2014	Anc	Not-Supporting	50			7.61
Tioga R (Carp)-2016	Anc	Supporting	96			5.68
Tohickon Cr-2014	Anc	Not-Supporting	63			8.14
Tuscarora Cr-2013	Anc	Supporting	73			6.63
Walnut Cr-2013	Anc	Not-Supporting	16			8.82

10.5 Appendix E: Calibration and Ancillary Sample ECM Results

Sample Name	% of Months ECM Status 1	% of Months ECM Status 4	Months Evaluated N	Months ECM Status 1 N	Months ECM Status 2 N	Months ECM Status 3 N	Months ECM Status 4 N
Allegheny R (Port Allegany)-2015	66.7	16.7	6	4	0	1	1
Aughwick Cr-2014	33.3	0.0	6	2	1	3	0
Beaver Cr-2018	33.3	16.7	6	2	1	2	1
Beaver Run-2016	100.0	0.0	5	5	0	0	0
Bells Run-2016	0.0	85.7	7	0	1	0	6
Big Elk Cr-2014	80.0	0.0	5	4	1	0	0
Big Wapwallopen Cr-2020	100.0	0.0	7	7	0	0	0
Birch Run-2016	100.0	0.0	6	6	0	0	0
Bobs Cr-2018	100.0	0.0	4	4	0	0	0
Brandywine Cr (Chadds)-2015	42.9	14.3	7	3	1	2	1
Brodhead Cr-2016	100.0	0.0	6	6	0	0	0
Browns Run-2013	100.0	0.0	1	1	0	0	0
Buck Run (WQN 627)-2020	100.0	0.0	4	4	0	0	0
Buckwa Cr-2020	100.0	0.0	7	7	0	0	0
Buffalo Cr (Rt 849)-2013	0.0	80.0	5	0	0	1	4
Buffalo Cr (Rt 849)-2014	0.0	25.0	4	0	3	0	1
Buffalo Cr (Strawbridge Rd)-2020	0.0	100.0	7	0	0	0	7
Burd Run (Brit)-2019	0.0	0.0	5	0	0	5	0
Burd Run (Twp Park)-2019	75.0	0.0	4	3	0	1	0
Campbells Run-2015	100.0	0.0	3	3	0	0	0
Carley Brk-2016	50.0	0.0	4	2	0	2	0
Cherry Run-2016	50.0	0.0	6	3	3	0	0
Chester Cr (Dar)-2017	66.7	33.3	3	2	0	0	1
Chester Cr (Dil)-2017	0.0	100.0	5	0	0	0	5
Chester Cr (Goose)-2014	0.0	100.0	4	0	0	0	4
Chillisquaque Cr-2013	50.0	25.0	4	2	1	0	1
Chillisquaque Cr-2014	0.0	100.0	2	0	0	0	2
Chiques Cr (FS)-2017	14.3	28.6	7	1	0	4	2
Chiques Cr (FS)-2018	83.3	16.7	6	5	0	0	1
Chiques Cr (Mill)-2017	0.0	42.9	7	0	0	4	3
Chiques Cr (Mill)-2018	42.9	28.6	7	3	1	1	2
Clover Cr-2018	100.0	0.0	6	6	0	0	0
Conestoga R (DnS STP)-2017	50.0	33.3	6	3	0	1	2
Conestoga R (Rt 23)-2017	33.3	16.7	6	2	3	0	1
Conodoguinet Cr (Brent)-2016	0.0	100.0	3	0	0	0	3
Conodoguinet Cr (Smpl Br LD)-2015	0.0	50.0	6	0	3	0	3
Cooks Cr-2013	0.0	0.0	1	0	1	0	0
Cooks Cr-2016	0.0	57.1	7	0	1	2	4
Cramer Cr-2019	100.0	0.0	4	4	0	0	0
Crum Cr (Smed)-2018	40.0	20.0	5	2	0	2	1
Crum Cr (W Chest Pk)-2018	100.0	0.0	6	6	0	0	0
Deep Run-2015	0.0	100.0	6	0	0	0	6
Donegal Cr-2015	83.3	0.0	6	5	0	1	0
Donegal Cr-2017	57.1	28.6	7	4	0	1	2
Donegal Cr-2018	83.3	16.7	6	5	0	0	1

Sample Name	% of Months ECM Status 1	% of Months ECM Status 4	Months Evaluated N	Months ECM Status 1 N	Months ECM Status 2 N	Months ECM Status 3 N	Months ECM Status 4 N
Dunbar Cr-2016	100.0	0.0	4	4	0	0	0
E Br Brandywine Cr-2020	42.9	14.3	7	3	3	0	1
E Br W Br Conneaut Cr-2018	0.0	100.0	4	0	0	0	4
E Hickory Cr-2020	25.0	0.0	4	1	3	0	0
E Licking Cr-2018	100.0	0.0	4	4	0	0	0
E Sandy Cr-2020	100.0	0.0	7	7	0	0	0
Fishing Cr (Craley)-2020	100.0	0.0	7	7	0	0	0
Fishing Cr (Goldsboro)-2020	0.0	42.9	7	0	4	0	3
Fishing Cr (Lower)-2016	16.7	33.3	6	1	3	0	2
Fishing Cr (Upper)-2016	28.6	42.9	7	2	0	2	3
Frankstown Br-2014	50.0	0.0	2	1	1	0	0
Frankstown Br-2015	60.0	20.0	5	3	1	0	1
French Cr (Lower)-2016	100.0	0.0	7	7	0	0	0
French Cr (Upper)-2016	100.0	0.0	6	6	0	0	0
Genesee Forks-2018	75.0	0.0	4	3	1	0	0
Genesee River-2018	100.0	0.0	4	4	0	0	0
Goose Cr (Most)-2014	0.0	0.0	4	0	0	4	0
Goose Cr (Oak)-2014	0.0	33.3	3	0	0	2	1
Grays Run-2013	100.0	0.0	2	2	0	0	0
Groff Cr-2016	0.0	100.0	7	0	0	0	7
Hell Run-2016	0.0	0.0	4	0	0	4	0
Huntington Cr (Lower)-2020	100.0	0.0	7	7	0	0	0
Huntington Cr (Upper)-2020	100.0	0.0	4	4	0	0	0
Hyner Run-2014	100.0	0.0	2	2	0	0	0
Hyner Run-2015	100.0	0.0	4	4	0	0	0
Hyner Run-2016	100.0	0.0	4	4	0	0	0
Indian Cr (Berg)-2013	0.0	100.0	2	0	0	0	2
Indian Cr (Berg)-2014	0.0	100.0	3	0	0	0	3
Indian Cr (Rt 63)-2013	0.0	100.0	5	0	0	0	5
Indian Cr (Rt 63)-2014	0.0	100.0	6	0	0	0	6
Ithan Cr-2017	50.0	16.7	6	3	1	1	1
Jacks Cr-2013	83.3	16.7	6	5	0	0	1
Jones Mill Run-2019	100.0	0.0	4	4	0	0	0
Kettle Cr-2013	100.0	0.0	6	6	0	0	0
Kettle Cr-2016	100.0	0.0	6	6	0	0	0
Kishacoquillas Cr (Manns)-2014	100.0	0.0	4	4	0	0	0
Kishacoquillas Cr (Manns)-2015	83.3	0.0	6	5	1	0	0
Kishacoquillas Cr (Park)-2013	33.3	0.0	3	1	2	0	0
Kreutz Cr-2020	100.0	0.0	7	7	0	0	0
L Beaver Cr-2016	0.0	100.0	7	0	0	0	7
L Conestoga Cr-2017	50.0	16.7	6	3	2	0	1
L Juniata R-2014	100.0	0.0	1	1	0	0	0
L Juniata R-2015	66.7	0.0	6	4	2	0	0
L Mahoning Cr (Lower)-2019	100.0	0.0	4	4	0	0	0
L Mahoning Cr (Upper)-2019	100.0	0.0	4	4	0	0	0

Sample Name	% of Months ECM Status 1	% of Months ECM Status 4	Months Evaluated N	Months ECM Status 1 N	Months ECM Status 2 N	Months ECM Status 3 N	Months ECM Status 4 N
L Swatara Cr-2014	0.0	20.0	5	0	4	0	1
Lackawaxen R-2019	100.0	0.0	5	5	0	0	0
Laurel Hill Cr (Lower)-2019	100.0	0.0	6	6	0	0	0
Laurel Hill Cr (Upper)-2019	100.0	0.0	6	6	0	0	0
Lick Branch-2020	100.0	0.0	3	3	0	0	0
Lick Run-2015	80.0	20.0	5	4	0	0	1
Lost Cr (Upper)-2018	100.0	0.0	7	7	0	0	0
Loyalsock Cr (WQN0408)-2013	100.0	0.0	5	5	0	0	0
Mahoning Cr (Dam)-2015	71.4	0.0	7	5	0	2	0
Marsh Cr-2018	0.0	100.0	4	0	0	0	4
Marshall Run-2017	85.7	0.0	7	6	0	1	0
Masthope Cr-2016	50.0	0.0	4	2	2	0	0
McGee Run (DnS)-2020	0.0	14.3	7	0	0	6	1
McGee Run (UpS)-2020	28.6	28.6	7	2	0	3	2
Middle Cr (Adams)-2016	0.0	85.7	7	0	1	0	6
Middle Cr (Monroe)-2020	100.0	0.0	7	7	0	0	0
Middle Cr (Wayne)-2019	100.0	0.0	5	5	0	0	0
Mill Cr-2017	42.9	42.9	7	3	0	1	3
Mitchell Run-2020	100.0	0.0	3	3	0	0	0
Moyers Mill Run-2016	100.0	0.0	7	7	0	0	0
Muddy Cr-2016	100.0	0.0	5	5	0	0	0
Muddy Run-2016	0.0	100.0	7	0	0	0	7
N Br Mahatango Cr-2018	83.3	0.0	6	5	1	0	0
N Br Middle Cr-2018	100.0	0.0	7	7	0	0	0
N F Cowanesque-2018	0.0	50.0	2	0	1	0	1
N F Redbank Cr-2019	100.0	0.0	6	6	0	0	0
Neshaminy Cr-2013	0.0	100.0	1	0	0	0	1
Penns Cr (Pine)-2016	0.0	100.0	3	0	0	0	3
Pennypack Cr (Lower Elkins)-2020	0.0	83.3	6	0	1	0	5
Pennypack Cr (Upper UMHJSA)-2020	0.0	83.3	6	0	0	1	5
Perkiomen Cr-2014	0.0	100.0	6	0	0	0	6
Peters Cr (DnS)-2015	57.1	42.9	7	4	0	0	3
Peters Cr (Mouth)-2015	50.0	0.0	2	1	0	1	0
Peters Cr (UpS)-2015	100.0	0.0	6	6	0	0	0
Pickering Cr-2016	57.1	0.0	7	4	3	0	0
Pine Cr (Berks)-2014	100.0	0.0	4	4	0	0	0
Piney Fork-2015	0.0	50.0	4	0	0	2	2
Pohopoco Cr-2020	100.0	0.0	7	7	0	0	0
Porcupine Cr (WQN 466)-2020	100.0	0.0	4	4	0	0	0
Princess Run-2020	100.0	0.0	7	7	0	0	0
Quittapahilla Cr-2015	71.4	28.6	7	5	0	0	2
Raccoon Cr-2013	100.0	0.0	6	6	0	0	0
Rairigh Run-2019	100.0	0.0	4	4	0	0	0
Red Clay Cr-2014	80.0	0.0	5	4	1	0	0
Ridley Cr (Lower Old Mill)-2018	85.7	14.3	7	6	0	0	1

Sample Name	% of Months ECM Status 1	% of Months ECM Status 4	Months Evaluated N	Months ECM Status 1 N	Months ECM Status 2 N	Months ECM Status 3 N	Months ECM Status 4 N
Ridley Cr (Upper Oke)-2018	28.6	42.9	7	2	2	0	3
Rife Run-2015	0.0	100.0	6	0	0	0	6
Rife Run-2017	0.0	100.0	6	0	0	0	6
Rife Run-2018	25.0	25.0	4	1	1	1	1
Rock Run-2014	100.0	0.0	4	4	0	0	0
Rock Run-2015	100.0	0.0	4	4	0	0	0
Rock Run-2016	100.0	0.0	3	3	0	0	0
S F Tenmile Cr-2016	0.0	42.9	7	0	1	3	3
Sherman Cr-2013	28.6	42.9	7	2	2	0	3
Sixpenny Cr-2020	100.0	0.0	6	6	0	0	0
Skippack Cr (Mainland)-2013	0.0	100.0	6	0	0	0	6
Skippack Cr (Ridge)-2013	0.0	100.0	1	0	0	0	1
Slab Cabin Run Kissinger Meadow-2019	0.0	100.0	7	0	0	0	7
Slab Cabin Run Shingletown Road-2019	0.0	75.0	4	0	0	1	3
Spring Cr-2021	40.0	60.0	5	2	0	0	3
Spruce Cr-2016	100.0	0.0	7	7	0	0	0
Stone Run-2018	0.0	100.0	4	0	0	0	4
Straight Run-2019	100.0	0.0	4	4	0	0	0
Swatara Cr (Harp)-2014	83.3	0.0	6	5	0	1	0
Swatara Cr (Hersh)-2014	100.0	0.0	5	5	0	0	0
Tacony Cr-2020	0.0	71.4	7	0	2	0	5
Thompson Run-2019	83.3	0.0	6	5	1	0	0
Three Square Hollow Run-2019	71.4	14.3	7	5	0	1	1
Tinicum Cr-2016	0.0	100.0	7	0	0	0	7
Tioga R (Carp)-2016	100.0	0.0	6	6	0	0	0
Tioga R (Morris)-2016	100.0	0.0	6	6	0	0	0
Tionesta Cr (WQN 830)-2020	50.0	0.0	6	3	0	3	0
Tohickon Cr-2013	66.7	16.7	6	4	1	0	1
Tohickon Cr-2014	57.1	14.3	7	4	2	0	1
Towamencin Cr-2013	0.0	100.0	1	0	0	0	1
Traverse Cr-2015	0.0	0.0	3	0	0	3	0
Tunungwant Cr (DnS)-2018	0.0	100.0	4	0	0	0	4
Tuscarora Cr-2013	0.0	50.0	2	0	0	1	1
Tuscarora Cr-2014	16.7	33.3	6	1	3	0	2
W Br Brandywine Cr (Modena)-2020	85.7	0.0	7	6	1	0	0
W Br Brandywine Cr (Wagontown)-2016	28.6	14.3	7	2	2	2	1
W Br Caldwell Cr-2018	100.0	0.0	4	4	0	0	0
W Br Chester Cr-2017	0.0	100.0	4	0	0	0	4
W Br Lackawaxen R-2019	100.0	0.0	6	6	0	0	0
W Br Octoraro Cr-2016	57.1	14.3	7	4	2	0	1
Walnut Cr-2013	25.0	0.0	4	1	3	0	0
Walnut Cr-2016	0.0	25.0	4	0	3	0	1
West Run-2020	0.0	75.0	4	0	0	1	3
Willow Run-2018	100.0	0.0	6	6	0	0	0
Wissahickon Cr (Ft Wash)-2013	0.0	100.0	1	0	0	0	1

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