

Cumberland Piedmont Network Water Quality Report

February 2005

Stones River National Battlefield

Prepared by Joe Meiman, Mammoth Cave National Park
Advisory Hydrogeologist for the Cumberland Piedmont Network

Based on the field work of Joe Meiman and Katie Seadler,
Mammoth Cave National Park and
Brenda Bacon and Tom Diggs,
Cumberland Piedmont Network

Introduction

Fiscal-Year 2003, a water quality monitoring effort began in the Cumberland Piedmont Network (CUPN). For all intents and purposes, park managers and program directors can think of this work as a water quality inventory, as for many parks in the CUPN, little, if anything, was known regarding water quality. This two-year period also served as a proving-ground for water quality monitoring protocols and logistics. The report that follows is a park-specific document that describes the monitoring sites, parameters tested, results in graphic form, a brief interpretation of the results, and recommendations of parameters to be measured for the long-term.

Sampling sites were chosen following site visits by the Mammoth Cave National Park (MACA) hydrogeologist Joe Meiman, and with consultation with park staff. Some sites were chosen to coincide with past inventories and monitoring efforts. In most cases sites were chosen at the downstream end of a watershed to serve as an integrator of the basin, and should yield characteristics and contributions from the entire watershed.

The NPS Water Resources Division (WRD) requires each Network water quality program to monitor four core field parameters – water temperature, pH, specific conductance, and dissolved oxygen. Any additional parameters of park interest will be considered through the CUPN Vital Signs selection process. As little was known about water quality in most CUPN parks – exceptions being MACA, Little River Canyon National Preserve (LIRI) and Cumberland Gap National Historical Park (CUGA) – a wide net of water quality parameters was cast during the first two years. Furthermore, as much was known about the water quality of these three parks, they were placed near the end of the park rotation allowing full inventories of parks with little data. In addition to the four core parameters, acid neutralizing capacity (ANC) and fecal coliform tests were performed in the field. Samples were taken and analyzed for a variety of ions and constituents at the MACA Water Quality Laboratory and the WATERS Laboratory (a joint venture between MACA and Western Kentucky University WKU). The MACA laboratory moved to the WKU campus in July 2004.

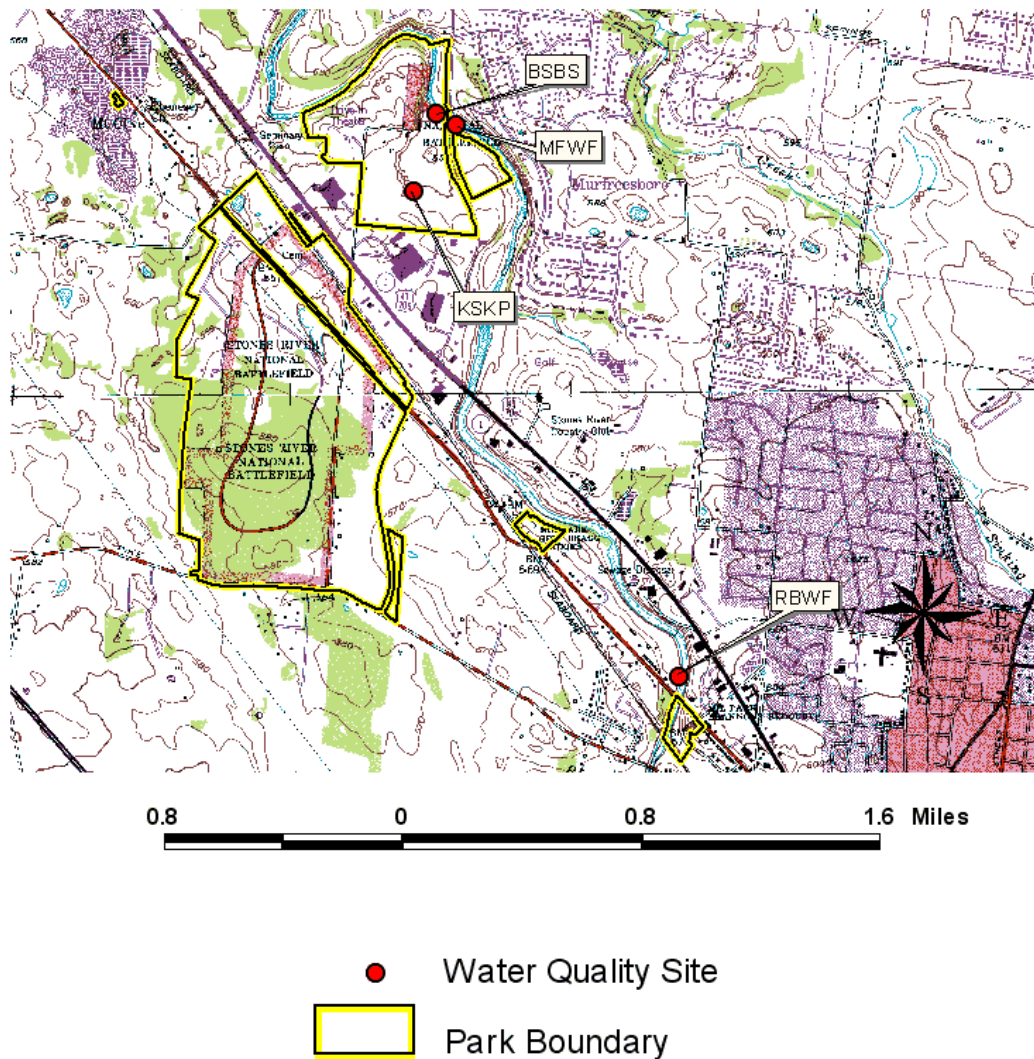
The CUPN Science and Technical Committee (STC) recently reviewed field and laboratory quality and has made their recommendations to the CUPN Board of Directors. Data quality was reviewed based upon the Relative Percent Difference (RPD) between a field sample and its duplicate. In general the STC found the RPD values of the core four parameters to be of acceptable quality (less than 10% duplicate pairs lying outside a +/- 10% RPD tolerance level), although the fecal coliform and ANC tests need attention. Specifically, ANC results were of poor quality below 10 mg/l as CaCO_3 and fecal coliform results were generally poor throughout its entire range. The STC has been tasked with developing new protocols for ANC and fecal coliform.

In addition, the STC reviewed RPD values from laboratory analysis. Overall, eleven of the seventeen lab parameters had greater than 10% of duplicate pairs falling outside a +/- 20% RPD tolerance level. Although data generated from the lab are of questionable quality, they are still of use in a basic inventory of water quality for the park.

Sampling Sites

Below is a map of water quality sampling sites at STRI. During each monthly sampling round each site was visited and an additional Quality Assurance-Quality Control sample was extracted. Monthly sampling commenced in November 2002 and continued until September 2004, for a total of 23 sampling events.

STRI, Water Quality Monitoring Sites



Description of Sampling Sites

The West Fork Stones River has been included on the USEPA 303D list for impaired waters – waters that are not meeting their designated use standards. In the case of the West Fork, the 303D listing is for low Dissolved Oxygen and organic enrichment (nutrients).

The USGS recently completed a one-year study (August 2000 through June 2001) of four quarterly samples. Field measurements include dissolved oxygen, alkalinity, pH, temperature, specific conductivity, turbidity and fecal coliform. Laboratory analysis included a wide range of inorganics (major cations and anions) and organics that comprise a “Level 1” survey. Preliminary results indicate low water quality in several parameters. Dissolved oxygen were below criterion for fish and aquatic life (5.0 mg/l) at both West Fork sites in January 2001 and at King Pond in January and June 2001. Elevated levels of *Escherichia coli* were found in both West Fork sites. One sample exceeded the USEPA single-sample limit of 253 col/100 ml. Arsenic, cadmium, chromium, copper, lead, nickel, selenium, and thallium were detected in key water bodies but did not exceed fish and aquatic life criterion. Chloroform, tetrachloroethylene, trichloroethylene, and cis-1,2-dichloroethylene were also detected in all key park waters except Rebel Yell Cave. Trichloroethylene concentrations at Battlefield Spring (8.9 µg/l) and King Pond (32 µg/l) were found – both exceeded Tennessee State drinking water standards.

West Fork at McFadden's Ford (MFWF): Located on West Fork Stones River, this site represents the focus of most aquatic recreation within the park. Public access is gained by a canoe launch along the Stones River Greenway. West Fork Stones River itself is listed by the State of Tennessee as a 303D water. This location was used by the USGS water quality inventory. Access is easy and safe in all conditions.



Battlefield Spring (BSBS): This small limestone spring is located just downstream (north) of McFadden's Ford. The spring run has been rock-walled many years ago. Battlefield Spring is in part recharged by Kings Pond Spring. This location was used by the USGS water quality inventory. Access is easy and safe in all conditions.



West Fork at Redoubt Brannon (RBWF): Located on West Fork and upstream of McFadden's Ford, the river at Redoubt Brannon is just downstream of the confluence of Lytle Creek, a state 303D listed water (West Fork Stones River itself is listed by the State of Tennessee as a 303D water). This location was used by the USGS water quality inventory. Access is easy and safe in all conditions.



King Pond (KSKP): This small spring-fed farm pond is on the recently acquired land adjacent to (east of) Van Cleve Lane. At this time it is not know what the park's management objectives are regarding this pond, but it was included in the USGS water quality inventory as it is downstream of a large industrial complex. Access is easy and safe in all conditions.



Parameters for Water Quality Inventory

Field Measures

The following text is adapted from the USGS Techniques of Water-Resources Investigations Book 9, Chapters A1-A9 (2001). All equipment specifications and calibration procedures are outlined in this document.

Temperature: Measurements of water and air temperatures at the field site are essential for water-data collection. Determinations of dissolved-oxygen concentrations, conductivity, pH, rate and equilibria of chemical reactions, biological activity, and fluid properties rely on accurate temperature measurements. Accurate water- and air-temperature data are essential to document thermal alterations to the environment caused by natural phenomena and by human activities. A thermistor thermometer is an electrical device made of a solid semiconductor with a large temperature coefficient of resistivity. An electrical signal processor (meter) converts changes in resistance to a readout calibrated in temperature units. Thermistors commonly are incorporated in instruments used for surface-water and groundwater measurements.

Specific Conductance: Electrical conductance is a measure of the capacity of water (or other media) to conduct an electrical current. Basically, Specific Conductance (SPC) is a quick and reliable estimation of the dissolved solids in the water. Electrical conductance of water is a function of the types and quantities of dissolved substances in water, but there is no universal linear relation between total dissolved substances and conductivity. A dip-cell electrode sensor was used.

pH: The pH of an aqueous solution is controlled by interrelated chemical reactions that produce or consume hydrogen ions. Water pH is a useful index of the status of equilibrium reactions in which water participates. The pH of water directly affects physiological functions of plants and animals, and it is, therefore, an important indicator of the health of a water system. The electrometric measurement method uses a hydrogen ion electrode.

Dissolved oxygen: Accurate data on concentrations of dissolved oxygen (DO) in water are essential for documenting changes to the environment caused by natural phenomena and human activities. Sources of DO in water include atmospheric reaeration and photosynthetic activities of aquatic plants. Many chemical and biological reactions in ground water and surface water depend directly or indirectly on the amount of oxygen present. Dissolved oxygen is necessary in aquatic systems for the survival and growth of many aquatic organisms. The most commonly used field method for measuring DO in water is the amperometric method, in which DO concentration is determined with a temperature-compensating instrument or meter that works with a polarographic membrane-type sensor.

ANC: is the acid-neutralizing capacity of solutes plus particulates in an unfiltered water sample, reported in mg/l as CaCO_3 . ANC is equivalent to alkalinity for samples without titratable particulate matter. ANC is basically a measure of buffering capacity – the ability of water to buffer the effects of acid. Waters of low ANC are more susceptible to decreased pH by acid precipitation.

Fecal coliform bacteria: Fecal indicator bacteria are used to assess the quality of water because they are not typically disease-causing, but are correlated to the presence of several waterborne disease-causing organisms (pathogens). The concentration of indicator bacteria (the term "indicator bacteria" is used synonymously with fecal indicator bacteria in this section) is a measure of water safety for body-contact recreation or for consumption. The most widely used indicator bacteria are of the total coliform, fecal coliform, enterococci, and fecal streptococci groups, and *E. coli*. Standard Method 9222D, membrane filtration for fecal coliform was used.

Discharge: The anchor of all water quality data. Discharge data are used to compute the mass flux, or loading, of a particular constituent. Mass flux yields valuable insight as to the mode of contaminant entrainment and transport through the watershed.

Laboratory Measures

Anions: A suite of anions (fluoride, chloride, nitrite, bromide, nitrate, phosphate, and sulfate) was analyzed. Sources of anions are varied – from natural and anthropogenic contribution. Anions such as chloride and bromide are common to oil field brines, and nitrite, nitrate, and phosphate are considered nutrients, and are commonly products of animal wastes. Standard Method 300.1 (ion chromatograph) was used.

Cations: A suite of cations (sodium, potassium, magnesium, and calcium) were analyzed on the ion chromatograph, an unapproved method. Note that all data presented below were a product of the ion chromatograph. Any future cation analysis will be analyzed on a flame atomic adsorption spectrometer using Standard Method 3113. The cation sodium is paired with chloride and may indicate brine contamination. Potassium, magnesium and calcium are usually contributed to the dissolution of rock.

Total Organic Carbon: TOC is a measure of organic carbon in water, including various constituents in various oxidation states. This is a direct and easy measure of organic carbon, including components of biological and chemical oxygen demand. Standard Method 5310 B was used.

Total Suspended Solids: While turbidity measures are a quick and simple estimation of suspended solid loads, it cannot be directly correlated to TSS, which is a true measure of suspended solids due to particle size and color characteristics. Standard Method 2540 E was used.

Chlorophyll-a: Since chlorophyll-containing organisms are the first step in most food chains, the health and /or abundance of these primary producers will have cascading effects to all higher organisms. Therefore, the determination of chlorophyll concentration is one of the key indices in monitoring the health of any natural system. EPA Method 445.0 was used.

Turbidity: Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. Primary contributors to turbidity include clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and microscopic organisms. The measurement is qualitative and cannot be correlated directly as micrograms per liter of suspended solids. Measurements were made in the laboratory with a nephelometer using Standard Method 214 A.

Atrazine: Atrazine, a triazine-class herbicide, represents the most common and durable pesticides used in the United States. They are commonly found after peak applications periods (spring), closely associated with storm pulses (attached to fine particulate matter), and have been found persisting in the water column for six months. The immuno-assay screening technique was used for this analysis.

Stream Designated Uses

As discussed below, each water body sampled within the CUPN has either been assigned a designated use by the state, or, by using the same ranking criteria, by this author. The USEPA, besides mandating these rankings, also directed the states to develop water quality standards for each designated use. We can use these water quality standards as a minimum to track water quality trends in CUPN parks. By adapting the state standards, we can also track park water quality trends within the states, regions, or watersheds. For more information on Tennessee water quality standards, please see:

Tennessee: Rules 1200-4-3-01, Tennessee Department of Environment and Conservation

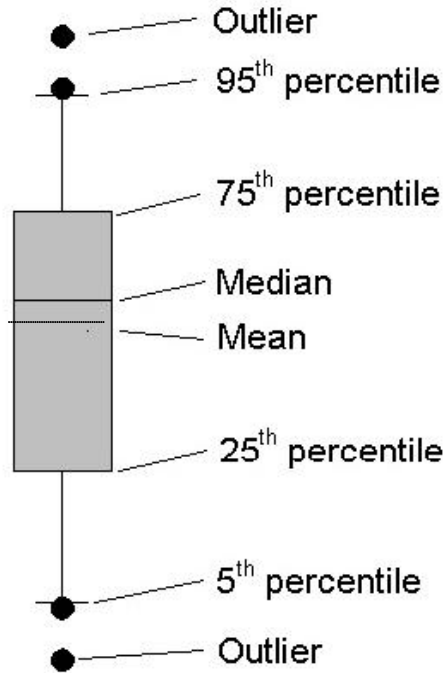
The table below shows that only the two sites on the West Fork are officially listed. The other two sites of STRI were “listed” (those sites in red text) by the author using the same criteria used by the state. If more than one designated use is listed for one waterbody, the highest standard should be used. The West Fork has six different designated uses, and standards for the strictest use should be applied (domestic water supply is more restrictive, for example, than irrigation).

<i>Park</i>	<i>Code</i>	<i>Site</i>	<i>State</i>	<i>Designated Use</i>
STRI	MFWF	West Fork Stones River At McFadden’s Ford	TN	Domestic Water Supply Fish & Aquatic Life Industrial Water Supply Irrigation Livestock Watering & Wildlife Recreation
STRI	BSBS	Battlefield Spring	TN	Fish & Aquatic Life
STRI	RBWF	West Fork Stones River At Redoubt Brannon	TN	Domestic Water Supply Fish & Aquatic Life Industrial Water Supply Irrigation Livestock Watering & Wildlife Recreation
STRI	KSKP	Kings Pond	TN	Fish & Aquatic Life

Most of the water quality parameters included in this inventory are not found in the state water quality standards. This is not to say they are unimportant to park management (a suggested list of parameters for long-term monitoring will conclude this report). If a state designated use water quality exists, it will be mentioned in the data interpretation below.

Results and Interpretation

The following graphs are a composite of 23 consecutive monthly rounds of sampling at STRI. There are represented in the graphs below as box-plots. Here is a key to understanding the structure of a box-plot:



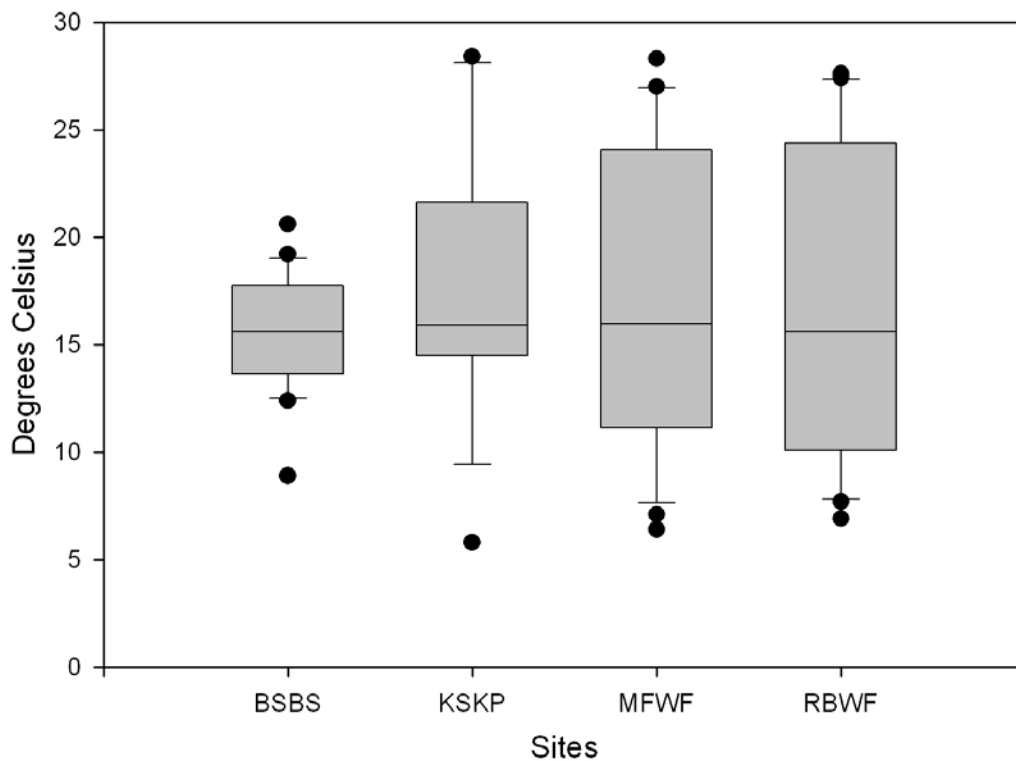
In addition to state water quality standards (where applicable), laboratory “Practical Quantitation Limits” (PQL) will be denoted. The PQL is five times the “Minimum Detection Limit” set by the laboratory. The PQL can be used as a means of determining if a particular parameter is worth monitoring in the future. For example, if samples continually come in well under the PQL value, and there is no known reason to continue that analyte, it would be a candidate to discontinue. The laboratory used the ion chromatograph (unapproved method) for all cation analysis below and did not provide PQL limits. For the cations of calcium, potassium, magnesium, and sodium, PQLs for the flame atomic adsorption method were used. There is also no PQL provided for Chlorophyll-a analysis.

Field Parameters

Water Temperature

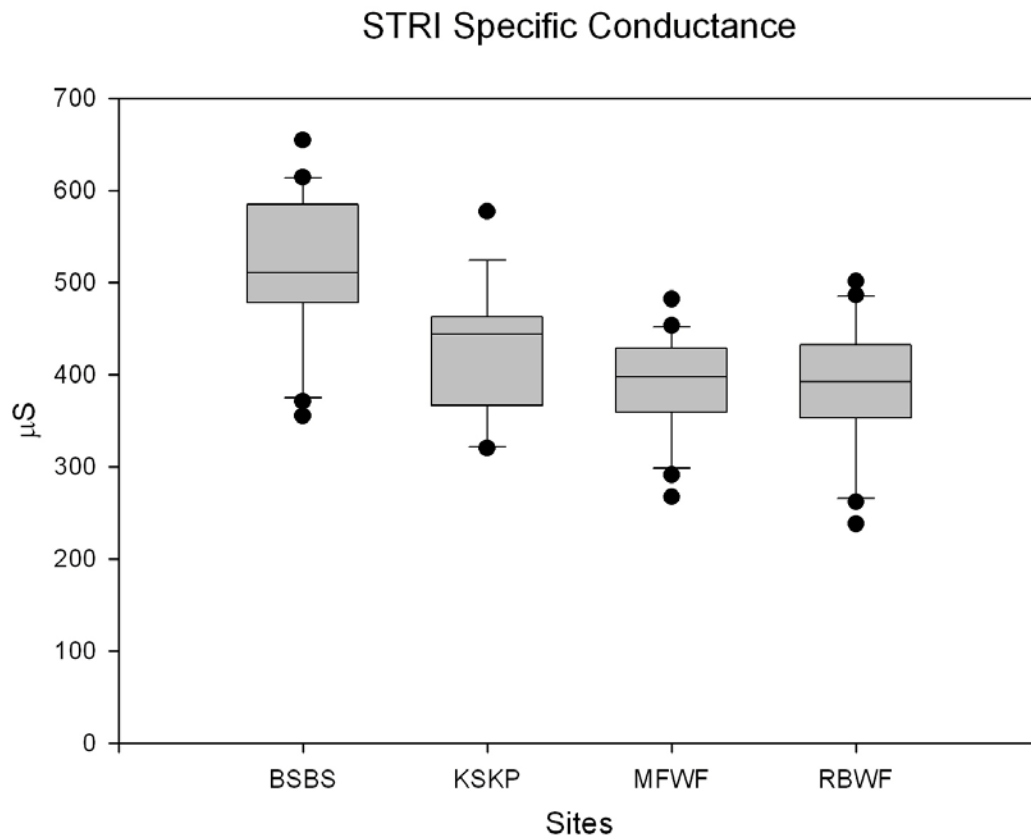
Water temperatures at STRI are considered to be within range to support native aquatic life. The compressed temperature range at Battlefield Spring (BSBS) is a function of longer retention times of groundwater recharging the springs. This is seen to a less extent at Kings Pond Spring (KSKP), which ultimately recharges BSBS. Recharge to KSKP is through a myriad of small solutional openings in the limestone (epikarst) and tend to attenuate temperature. The two sites of the West Fork, McFadden's Ford (MFWF) and Redoubt Brannon (RBWF) display a wide range of temperature reflective of normal seasonal variations.

STRI Water Temperature



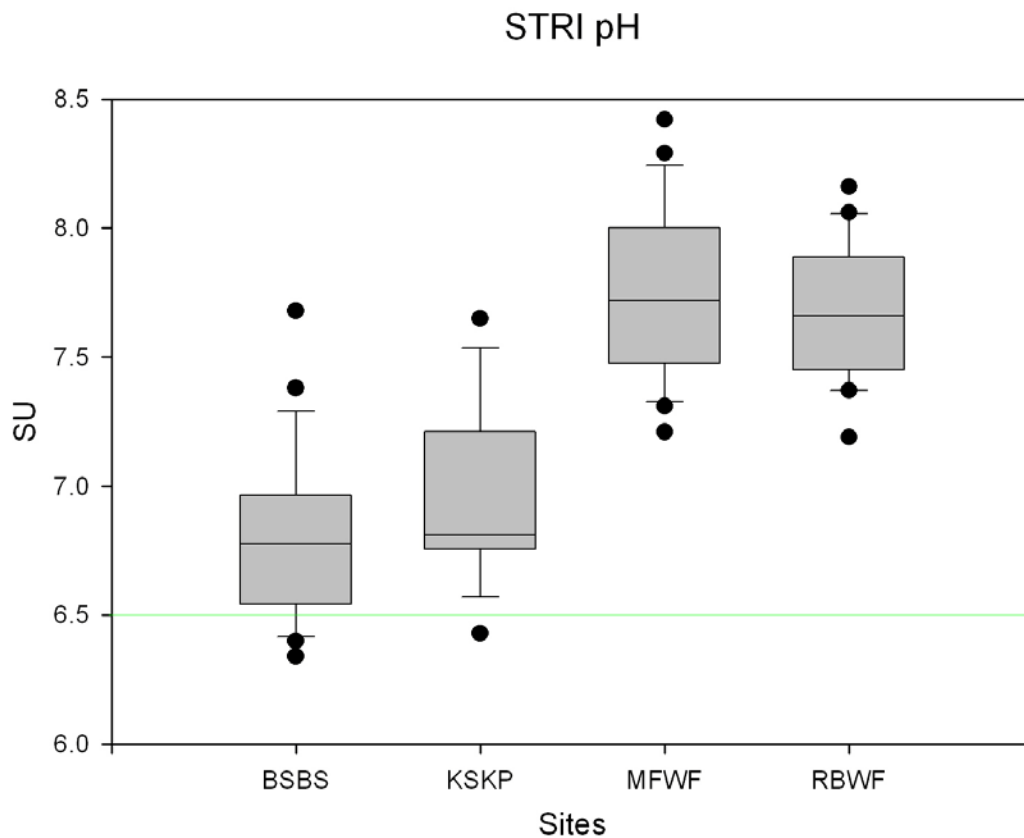
Specific Conductance

The distribution of specific conductance (SPC) of STRI is a function of the amount of time the water is in contact with the limestone. That is, the longer the residence time, the more opportunity to dissolve to rock and increase its load of dissolved solids. BSBS displays the highest SPC values as it is recharged by countless small fissures, and receives flow from KSKP further head-ward in the watershed. The two West fork sites are basically identical as travel times from one site to the next are small, and there are no significant tributaries between them. In general, the points above the 75th percentile are during low-flow periods, and those below the 25th percentile during high flows – each reflective of residence time within the rock.



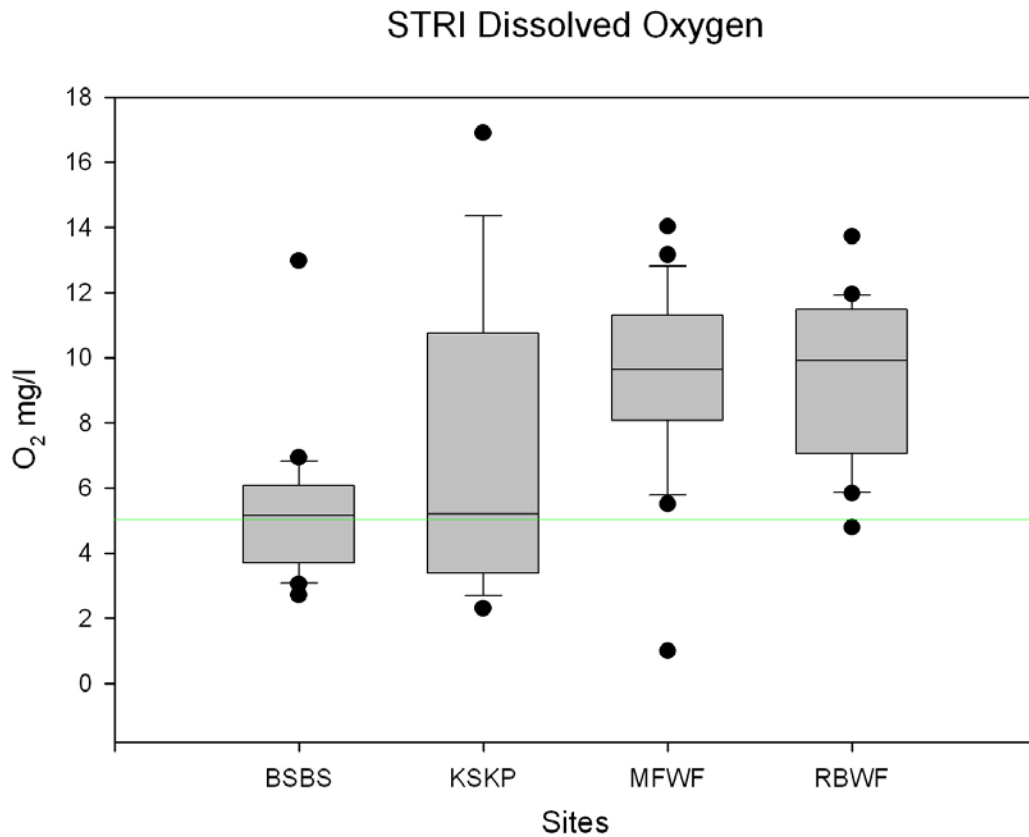
pH

The pH of sites of STRI are generally within the range set by the state for Fish and Aquatic Life, where it must be within 6.5 and 9.0 SU. It is a mystery why the pH values of the two springs are sometimes below the lower pH limit. In nearly every case, karst water should be well buffered, especially if it has been in sufficient contact with limestone. In other karst aquifers, the only time pH values enter the acid range is during flood conditions as surface runoff is quickly flushed through. It is also interesting that the pH of BSBS is typically lower than its contributor, KSKP. A possible explanation may be in that both sites have been found to contain a wide variety of organic compounds (USGS study) and somehow affecting pH. Further investigation is needed to fully explain this issue.



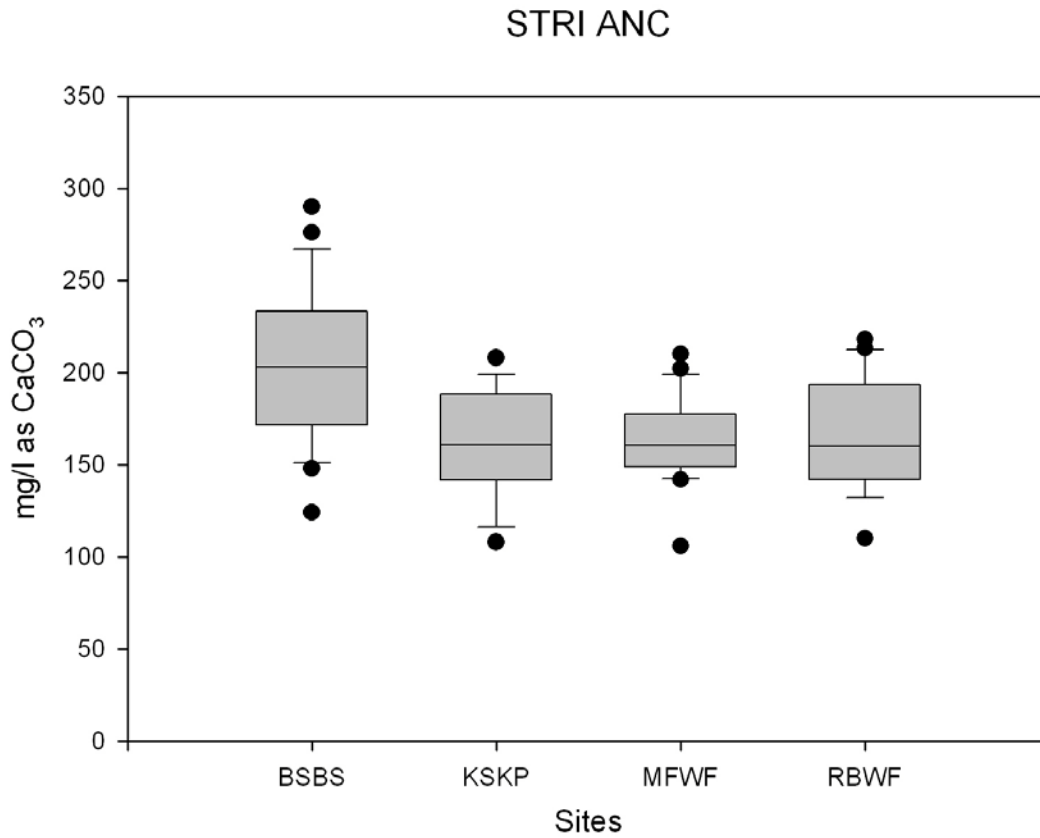
Dissolved Oxygen

Dissolved oxygen is a major concern for the West Fork, as it is on the USEPA 303D for violations of the DO standard. The two sites on the West Fork were found to be above the DO limit for the Aquatic Life and Fish designated use for all but one sampling event. The 95th percentile for both sites does approach the limit. It is curious that both springs commonly have DO concentrations below the standard. In fact, the median values for these springs are at or near the limit. It is not uncommon for springs which are recharged primarily by epikarst (the irregular soil-bedrock interface found underlying many limestone areas) and shallow dolines (sinkholes) to have low DO if the conduits connecting points of recharge and discharge (springs) are of low gradient. That is to say that there are few chances for the groundwater to be well aerated. The low DO concentrations at the spring sites were taken during low or drought conditions when aeration of the groundwater is at its lowest.



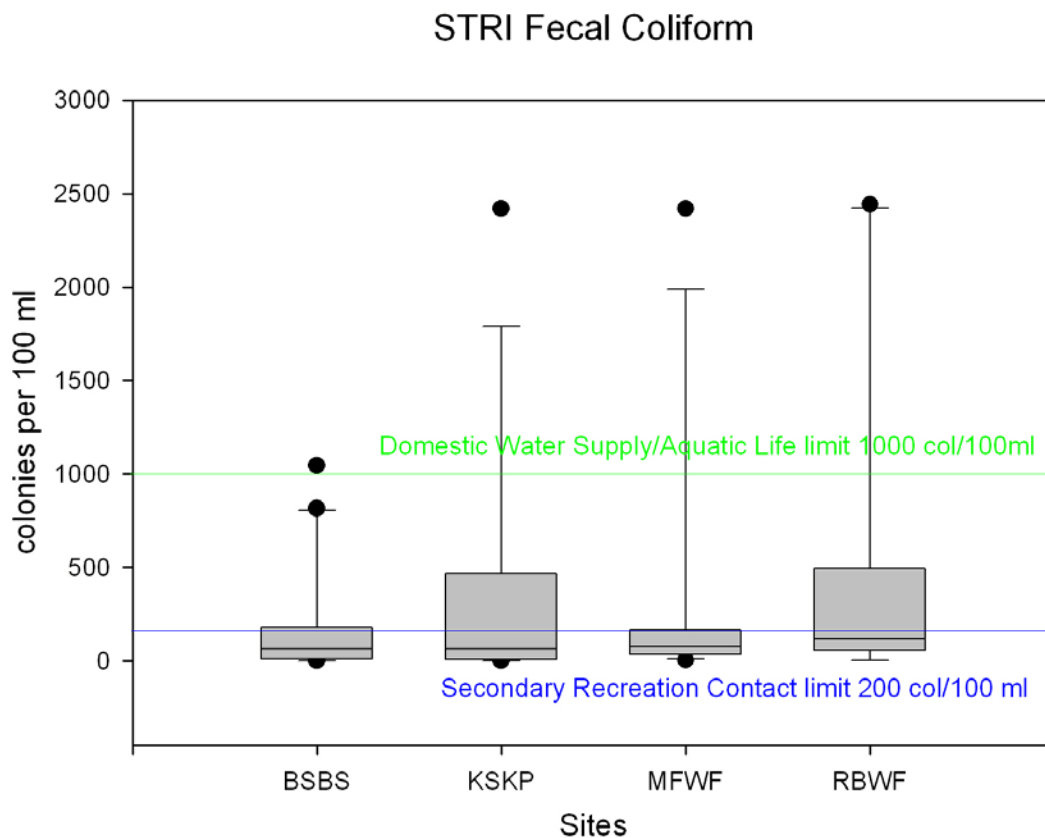
Acid Neutralizing Capacity

A nearly identical signature as was seen with SPC. Acid neutralizing capacity (ANC) of CHCH waters again reflects the amount of time the water is in contact with the limestone as it increases its load of bicarbonate ions. All waters sampled at STRI are well buffered.



Fecal Coliform

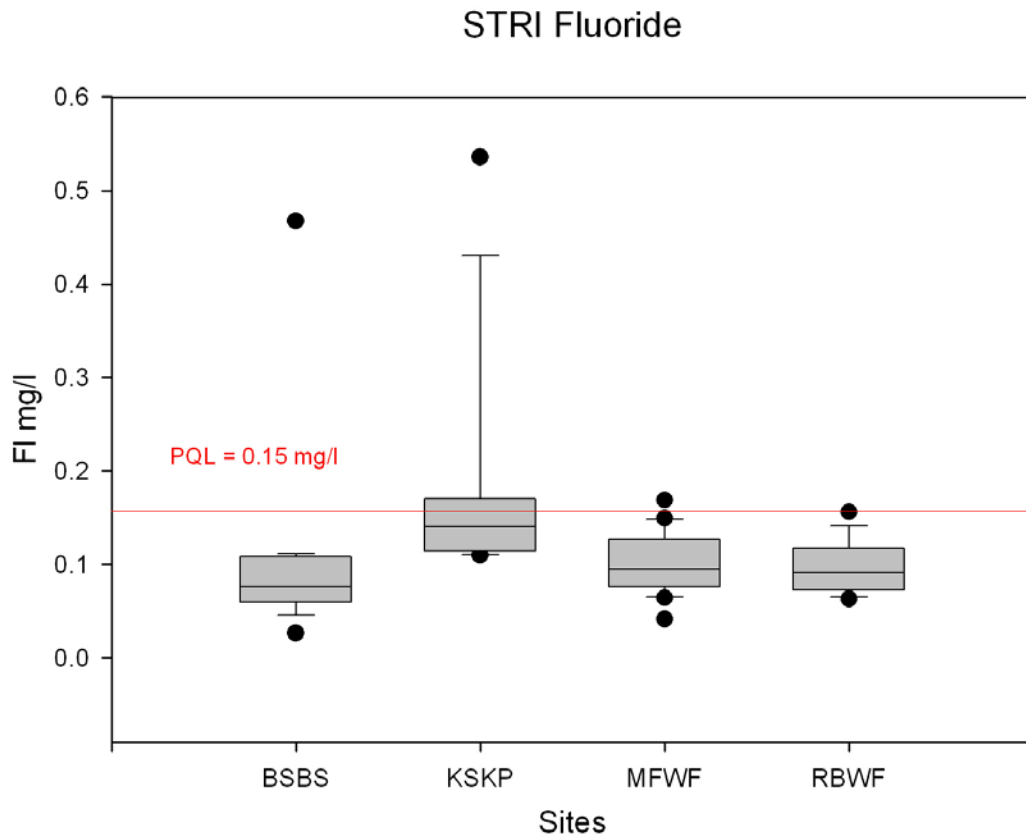
For the most, fecal coliform ranges at STRI run a range of extremely low values during low flow conditions, to very high levels during and following rain events. Higher values are coincidental to high flow, when many non-point source fecal contaminants are washed into streams. In Tennessee, for both Fish and Aquatic Life and Domestic Water Supply, the maximum level is 1000 colonies per 100 ml, while Secondary Recreational Contact is limited to 200 colonies per 100 ml. All standards are based upon a geometric mean of a minimum of 10 samples taken over a period of less than 30 days. What does this mean? While our samples are monthly, they do not strictly apply to the standard, as only one sample was taken in a 30 day period. However, it is safe to say that one could easily collect 10 samples during a five day period (samples must be at least 12 hours apart) to make both West Fork sites out of compliance. Fecal coliform levels were generally lower downstream at the McFadden's Ford site. This is likely due to bacterial die-off from sun light (ultraviolet light).



Laboratory Parameters

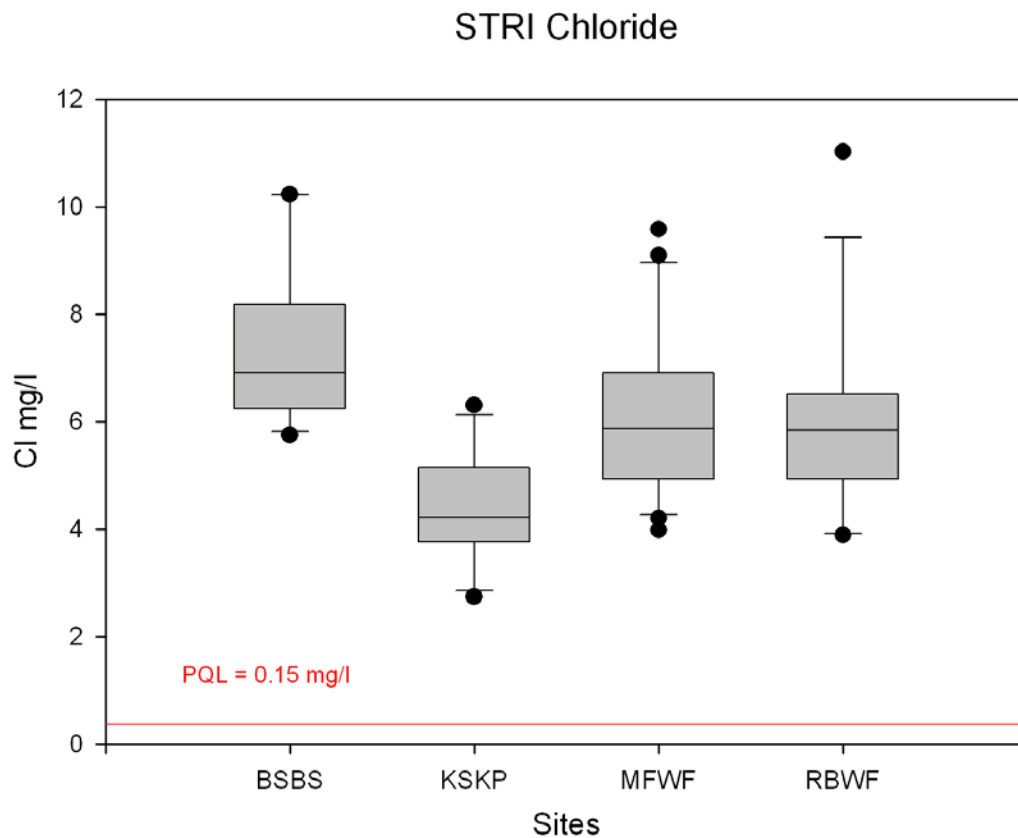
Fluoride

Fluoride concentrations of STRI waters are very low. In all samples, except one sample at Battlefield Spring and a few samples at Kings Pond Spring, concentrations were below the PQL of 0.15 mg/l. There are no state standards for fluoride.



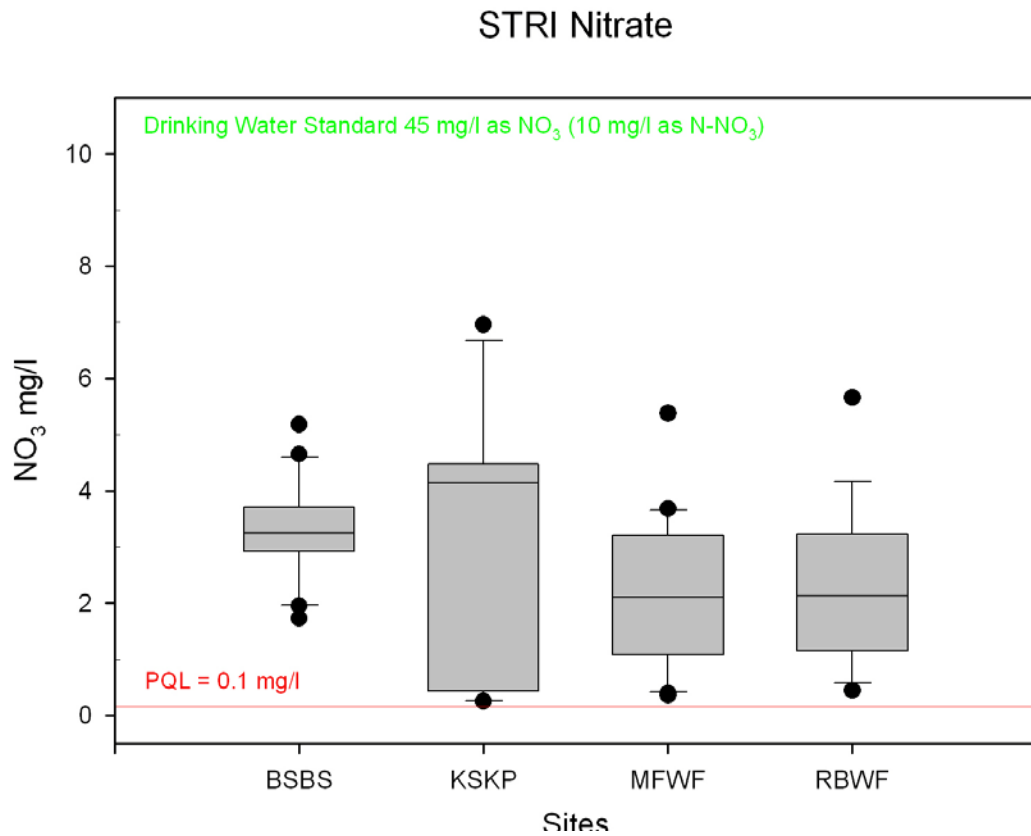
Chloride

While all samples were above the PQL of 0.15 mg/l, no samples exceeded the state standard for chloride, as there is no standard. Even with that in mind, the concentrations of chloride are not very great when compared with other freshwaters. Chloride is found as natural background – concentrations found are typical to that found in many freshwaters.



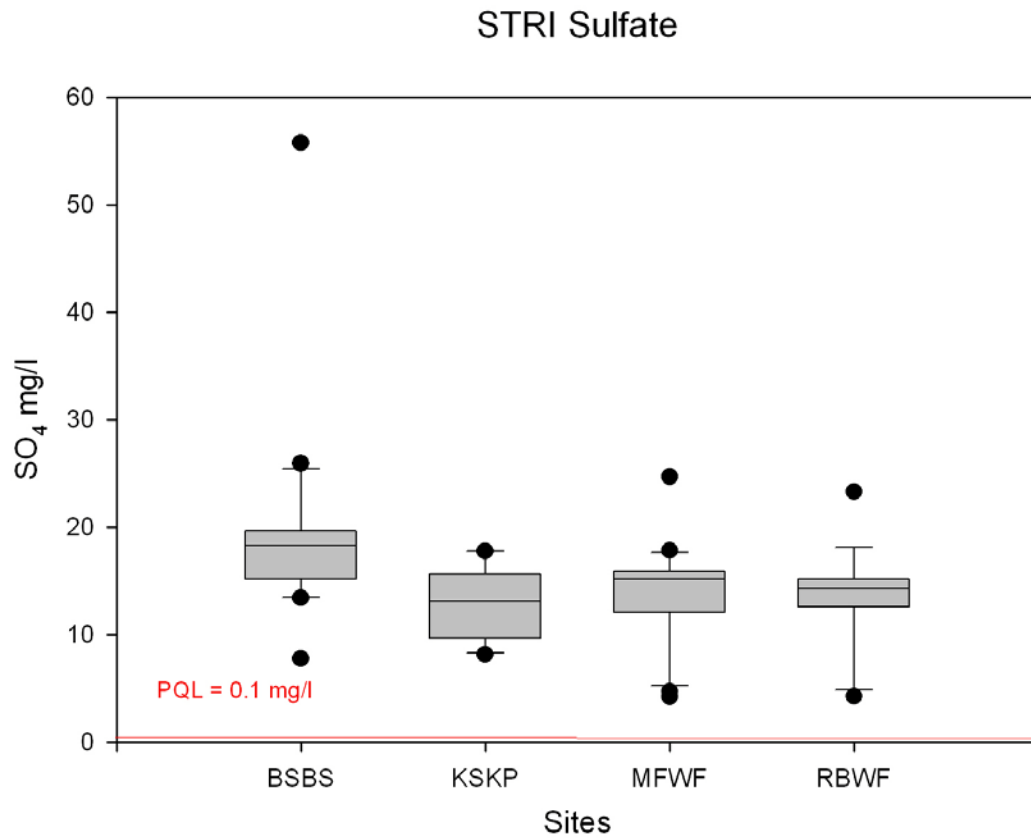
Nitrate

Surprisingly there is no state standard for nitrate in the designated use categories applicable to STRI. For comparison, the general national standard for drinking water is 10 mg/l as commonly expressed as N-NO₃, which translates to 45 mg/l as NO₃ as graphed below. Most sites sampled at STRI were low to moderate in nitrate. As nutrients are a cause of listing on the USEPA 303D list, nitrates should be considered for future monitoring consideration.



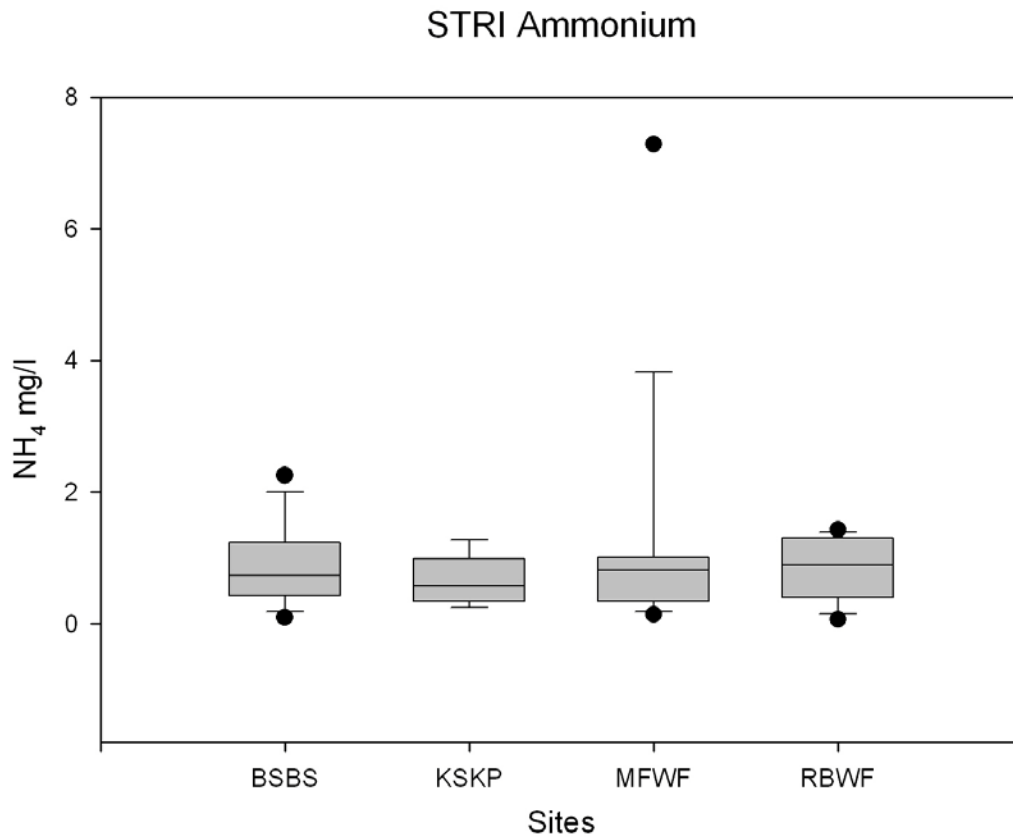
Sulfate

Waters of STRI have moderate sulfate concentrations. With exception of the lone outlier of BSBS, there are no concerns with sulfate concentrations, and even that outlier concentration is not high enough to cause harm to aquatic life. No sulfate standard exists for Tennessee designated use standards for the park's waters.



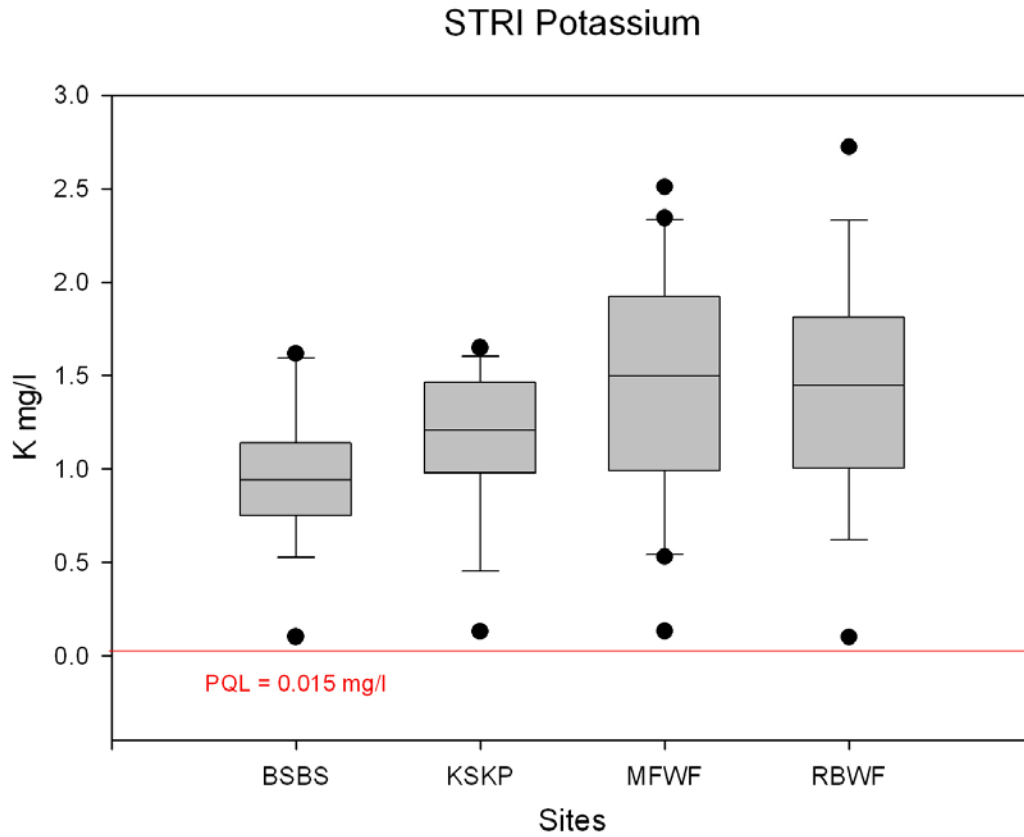
Ammonium

Ammonium levels at all sites are low, with the exception of an outlier or two at McFadden's Ford. It should be noted that the laboratory did not perform ammonium analysis by an approved method. General ammonium reproducibility from the lab is considered unacceptable, and these data are presented in this light and not for management actions or decisions. As dissolved oxygen levels indicate well-aerated stream conditions, there is no reason to believe ammonium values to be of any significant levels – even at the springs where DO readings were sometimes depressed.



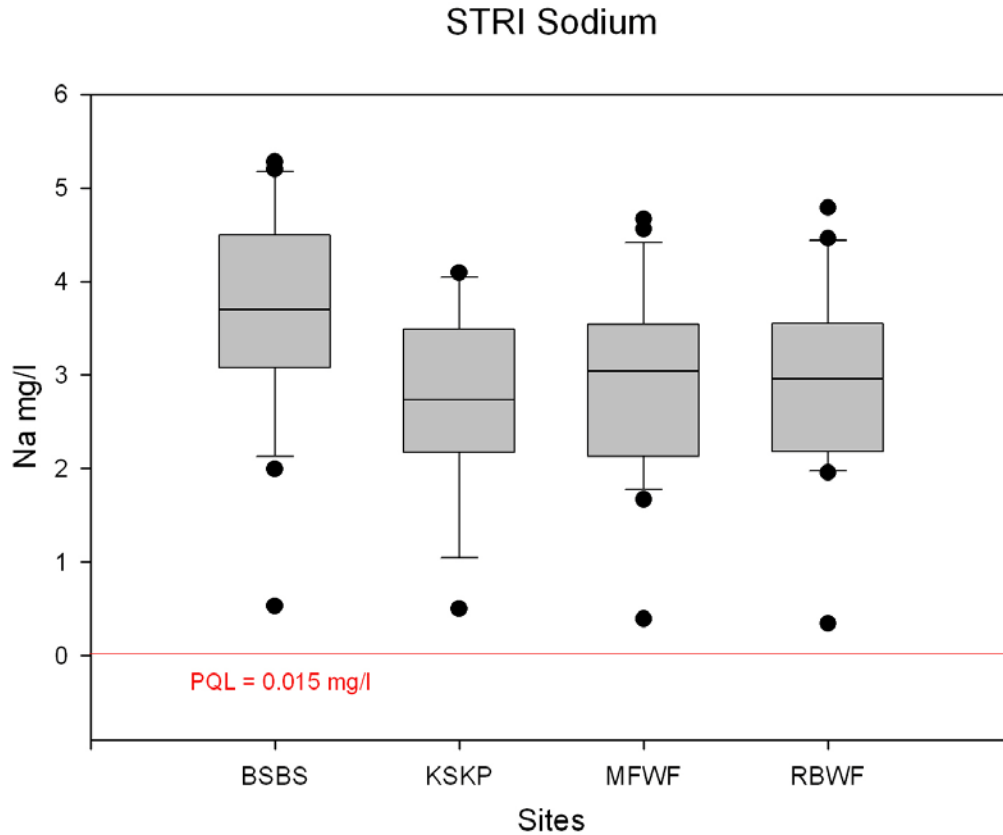
Potassium

Potassium levels of waters monitored at STRI are consistently low. There are no potassium standards for assigned designated uses in Tennessee.



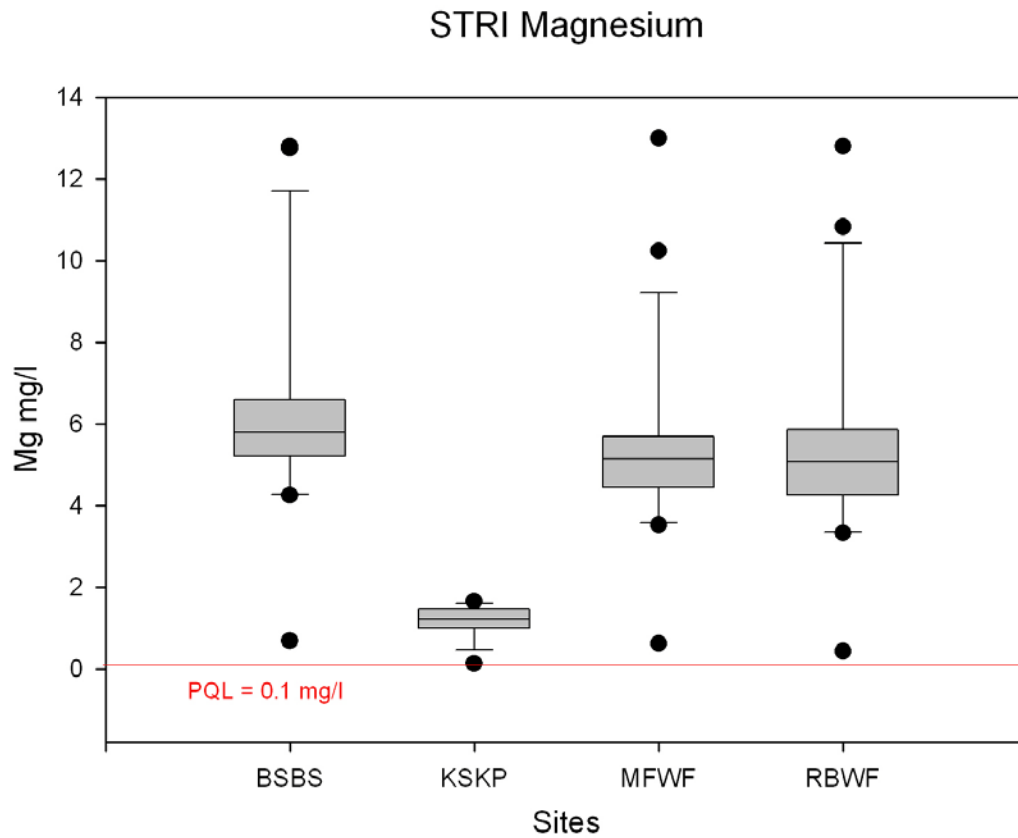
Sodium

The occurrence of sodium approximates that of chloride. These two ions are commonly found in all freshwaters of the world and are primary products of the evaporation of seawater – that is a small amount of NaCl is evaporated along with H₂O and precipitated across the land. This is not the only source of sodium or chloride, as many human-related land uses also liberate these ions. In any case, sodium levels are within normal ranges for waters of STRI, and there is no sodium standard for Tennessee.



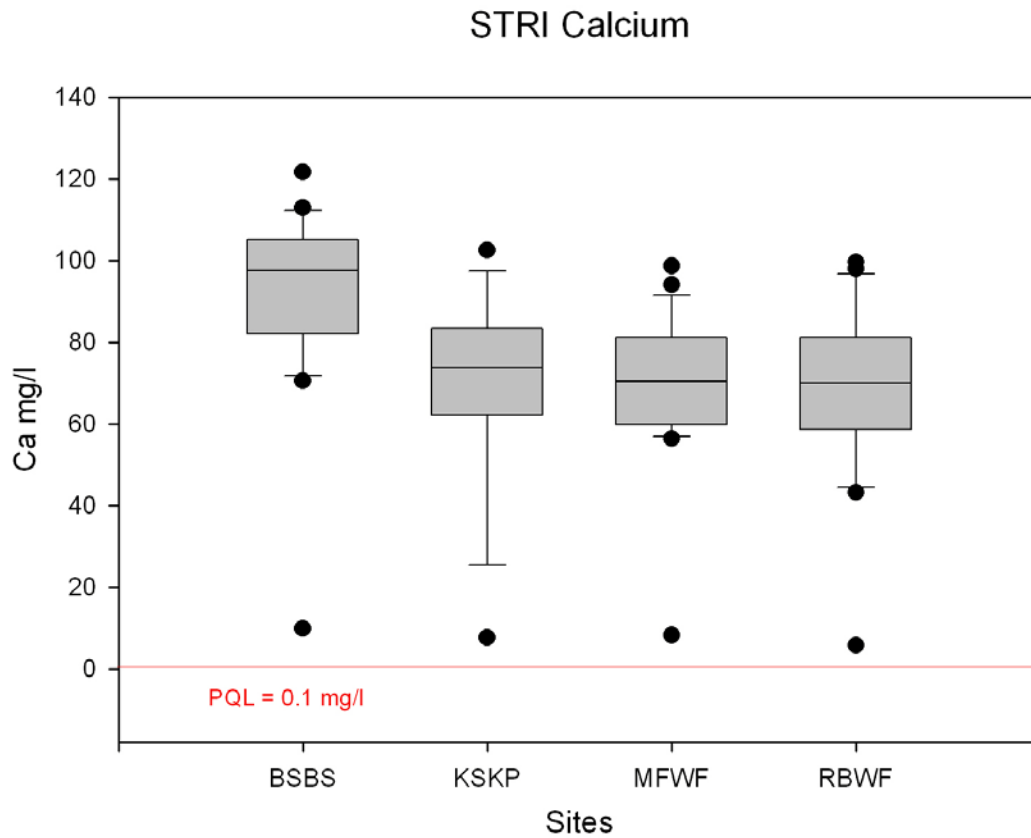
Magnesium

Magnesium levels at STRI are common to that of karst waters as magnesium is common to limestones in the mineral dolomite. It is interesting, from an academic sense, that KSKP is so much lower in magnesium than other sites. This may be just a simple factor of little dolomite within the thin section of carbonates within its watershed. There are no magnesium standards for Tennessee.



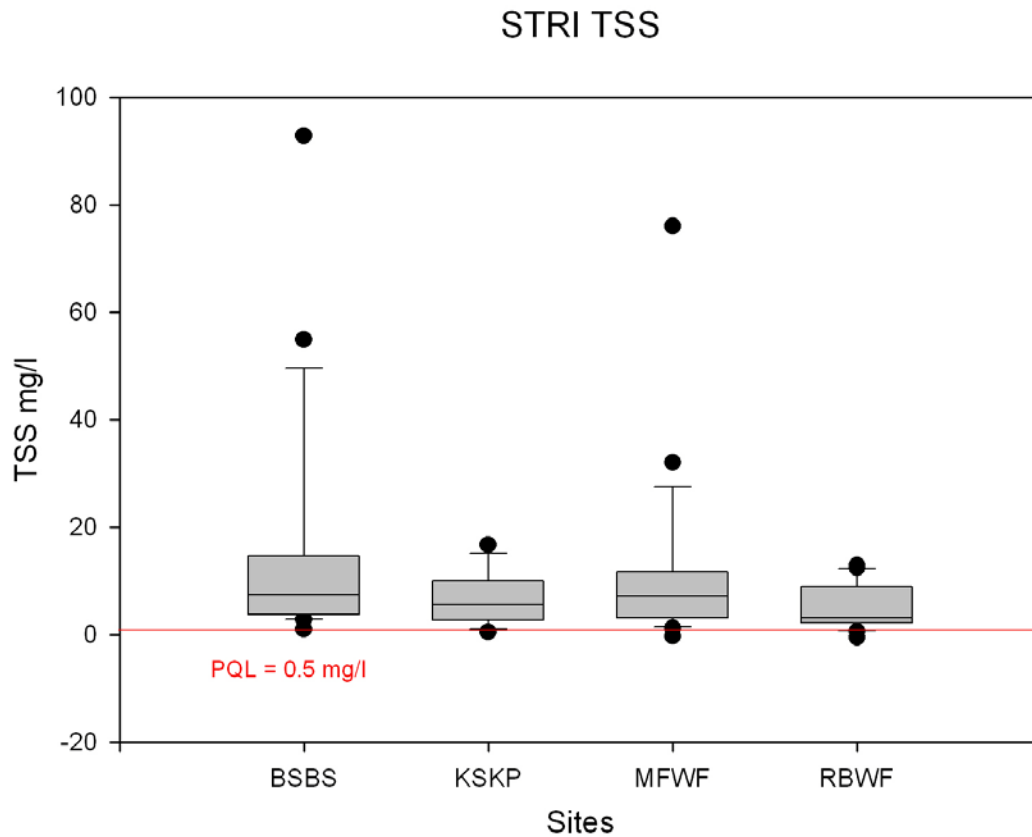
Calcium

Relative concentrations of the calcium ion generally mirror that of magnesium, with exception of Kings Pond Spring, whose calcium levels are now comparable to that found at the other sites. Both divalent cations, calcium and magnesium are often found replacing one another in mineral crystalline matrices. There is no state standard for calcium.



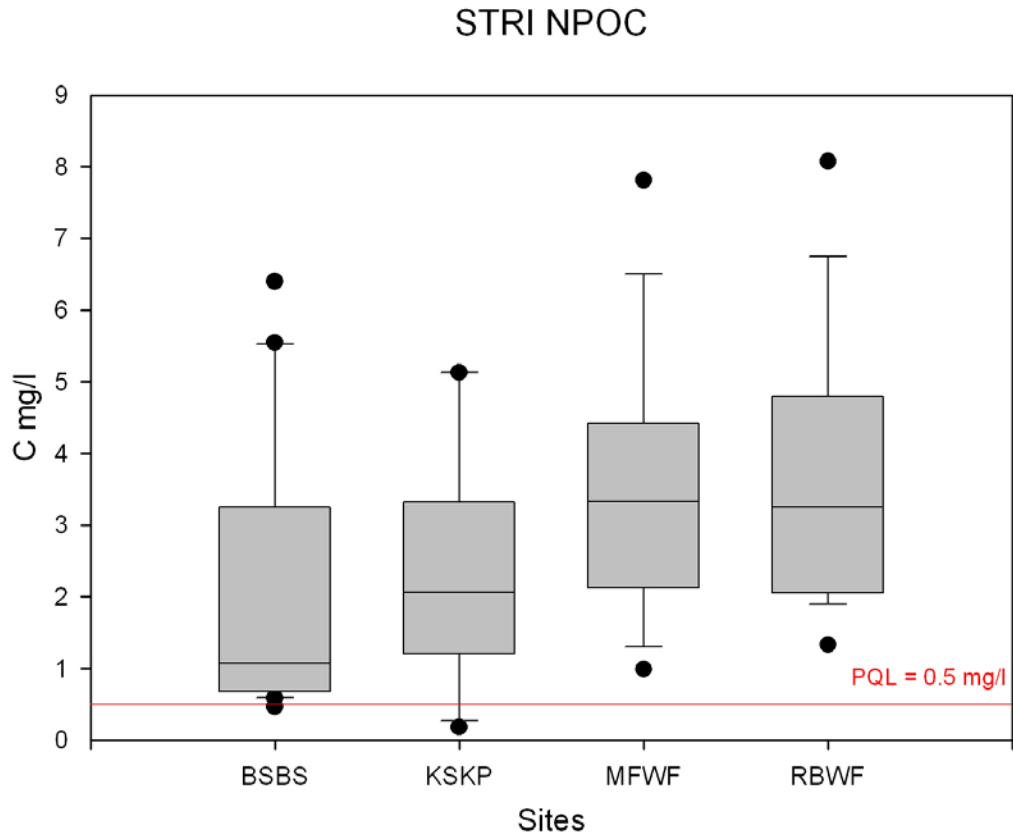
Total Suspended Solids

The laboratory reproducibility for suspended solids was not very good. The lab also reduced solids data into two subsets, fixed and volatile solids. Results are not worth presenting here. There are no state standards for TSS for the appropriate designated use categories.



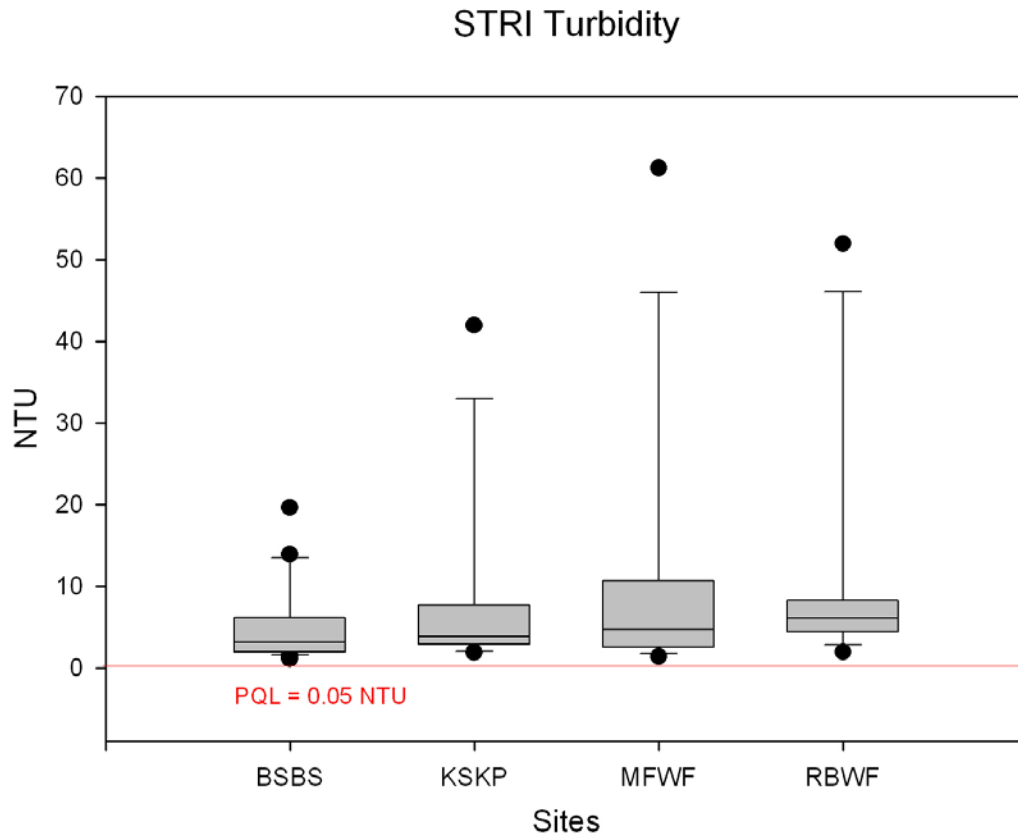
Total Organic Carbon

Total organic carbon, or in the case of most natural waters, non-purgeable organic carbon, is moderate in the waters of STRI. There is no Tennessee standard for TOC.



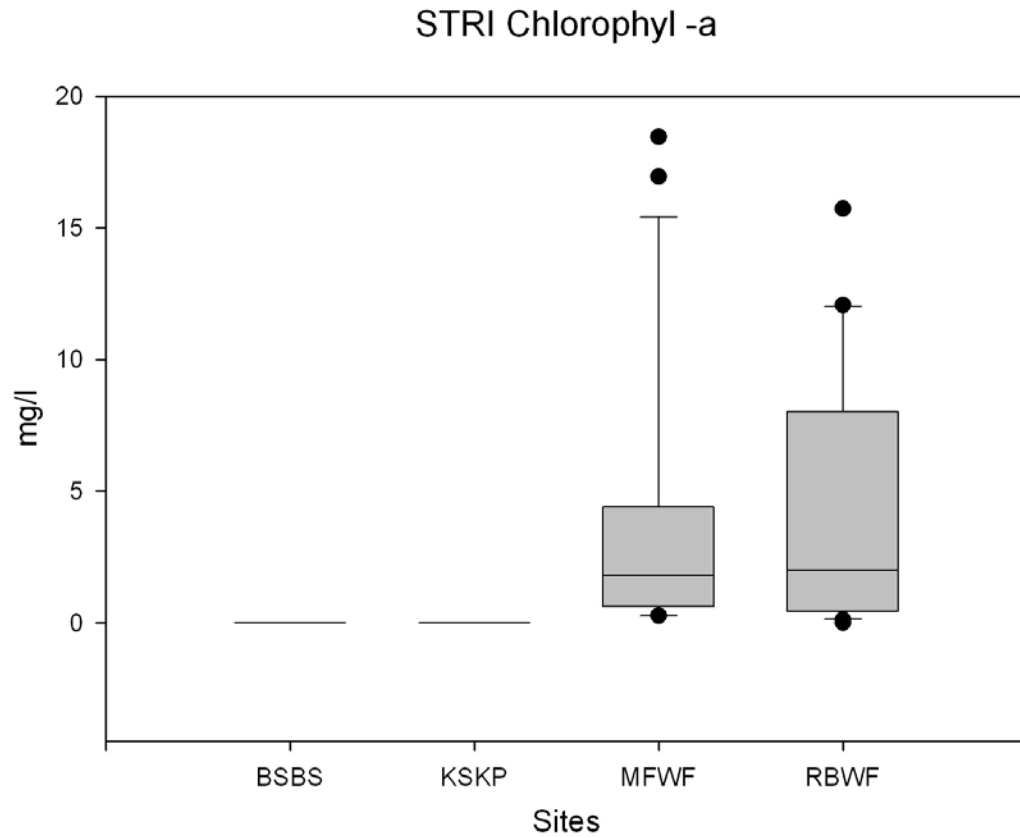
Turbidity

Turbidity is a general measure, or approximation of the amount of suspended material in the water. It is not directly correlative to suspended solids as particle size, shape and color all play a role in the transmission of light through the water column. In general, the higher turbidity values are associated with muddy or turbid waters. In general, waters of STRI were slightly to very turbid. This range is primarily due to sample collection in respect to flood events, as large rainfalls wash particulates into the streams. Turbidity standards are a bit nebulous in Tennessee, which states that turbidity “should not result in visual contrast in a water body due to a man-made activity”.



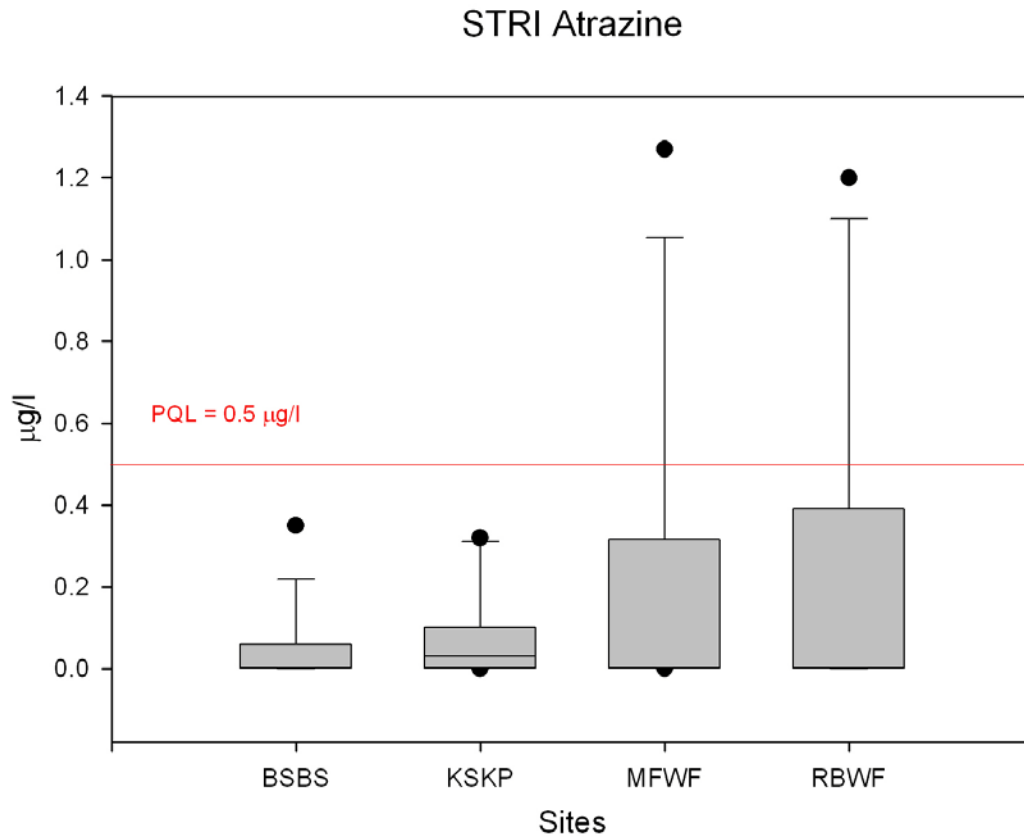
Chlorophyll-a

Chlorophyll-a analysis was only performed at the two West Fork sites, McFadden's Ford and Redoubt Brannon. Data reproducibility at the laboratory was not very good for this analyte, and even these few data points are suspect in terms of quality.



Atrazine

Most atrazine samples were well below the PQL of 0.5 µg/l, and those above this level were limited to the West Fork sites. There are no state standards for atrazine in freshwaters. Some studies have seen a hermaphrodization of amphibians at concentrations of one part per billion. A national drinking water standard of 3.0 µg/l can be used as a general comparison to what was found at STRI.



General Water Quality Status

At first glance, the water quality of the four sites sampled at STRI is fair. It would not be an exaggeration to state that STRI has the most compromised water quality of any park in the CUPN – not surprising as the park is surrounded by large scale development. The West Fork of Stones River is on the USEPA 303D list for low dissolved oxygen and nutrients. Our inventory did not fully support violations in these parameters, although values were close to the limits set by the state of Tennessee.

Dissolved oxygen levels at the two springs were commonly below the 5.0 mg/l limit set by the state. Fecal coliform levels were at times above state limits, but as described above, the sampling schedule (monthly) cannot be used to define a violation. Also as stated above, there is solid reasoning to assume that if a sequence of consecutive samples were taken from the West Fork (at least 10 samples at least 12 hours apart within a 30 day period), these waters would indeed be in violation.

A more insidious water quality issue pertains to the results of the USGS study of 2000-2001. Several organic compounds were found in park waters. The most obvious source of these contaminants is from the industrial sites that are upgradient of park springs. The author suggests consultation with the USGS Nashville office to determine the extent of the contamination with respect to park management objectives.

Future Water Quality Monitoring Recommendations

This inventory of water quality greatly reduces the number of parameters that need long-term monitoring for the Vital Signs program. Possible evidence of nutrient loading (nitrate) was found, although no state-imposed limits were found. Besides fecal coliform (described above), violations were also seen in dissolved oxygen and pH. Nitrite, bromide, and phosphate ions were also analyzed but all samples were found to be below detection limits. It is recommended that the core four field parameters plus nitrate and bacteria should be continued for the long-term. It is likely that the CUPN will adapt a new protocol for bacteria. Rather than use the “membrane filtration” method for fecal coliform, a “most probable number” technique will most likely be used. This technique quantifies both *e. coli* and total coliform bacteria.

Long-Term Monitoring will include:

Water Temperature
Specific Conductivity
pH
Dissolved Oxygen
Nitrate
E. coli and Total Coliform

List of Abbreviations

ANC	Acid Neutralizing Capacity
Br	Bromide
C	Carbon
Ca	Calcium
CaCO ₃	Calcium carbonate
Cl	Chloride
DO	Dissolved Oxygen
Fl	Fluoride
K	Potassium
km	kilometer
l/s	liters per second
MDL	Minimum Detection Limit
Mg	Magnesium
mg/l	milligrams per liter
µg/l	micrograms per liter
NaCl	Sodium Chloride
NH ₄	Ammonium
NO ₃	Nitrate
NTU	Nephelometric Turbidity Unit
PQL	Practical Quantitation Limit
NPOC	Non-purgable Organic Carbon
RPD	Relative Percent Difference
SPC	Specific Conductance
SO ₄	Sulfate
SU	Standard Unit (pH)
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey