



Cumberland Piedmont Network Water Quality Report

Fort Donelson National Military Park



ON THE COVER

Hickman Spring, November 17, 2003

Photograph by: Joe Meiman

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Fort Donelson National Military Park

Joe Meiman
National Park Service
P.O. Box 8
Mammoth Cave, KY 42259

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U.S. Department of the Interior
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Southeast Regional Office
Atlanta, Georgia

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Introduction

This is the second report on water quality of Fort Donelson National Battlefield (FODO) generated by the Cumberland-Piedmont Network (CUPN) Water Quality monitoring Program. The first report, submitted to the park in February 2005, presented the initial results of the water quality inventory, beginning in November 2003 (contact the CUPN office for details on program design). This report will include those early findings as well as data gathered in fiscal year 2006 and display these results in graphic form (accompanied with a brief interpretation), and concludes with a water quality summary and recommendations. Water quality is measured four times per year (quarterly) on alternate years at five sites; Indian Creek near Graves Battery, The Embayment of Indian Creek, the Embayment of Hickman Creek, Hickman Spring, and Lake Barkley (Cumberland River) near the Fort Donelson Overlook. Based upon program requirements and findings of the water quality inventory, a set of parameters were chosen for long-term monitoring; including the field measures of water temperature, specific conductance (SpC), pH, and dissolved oxygen. Samples were also collected for laboratory analysis for bacteria (*E. coli* and total coliform). An additional sample was collected from one site per round as a quality assurance – quality control provision.

Sampling Sites

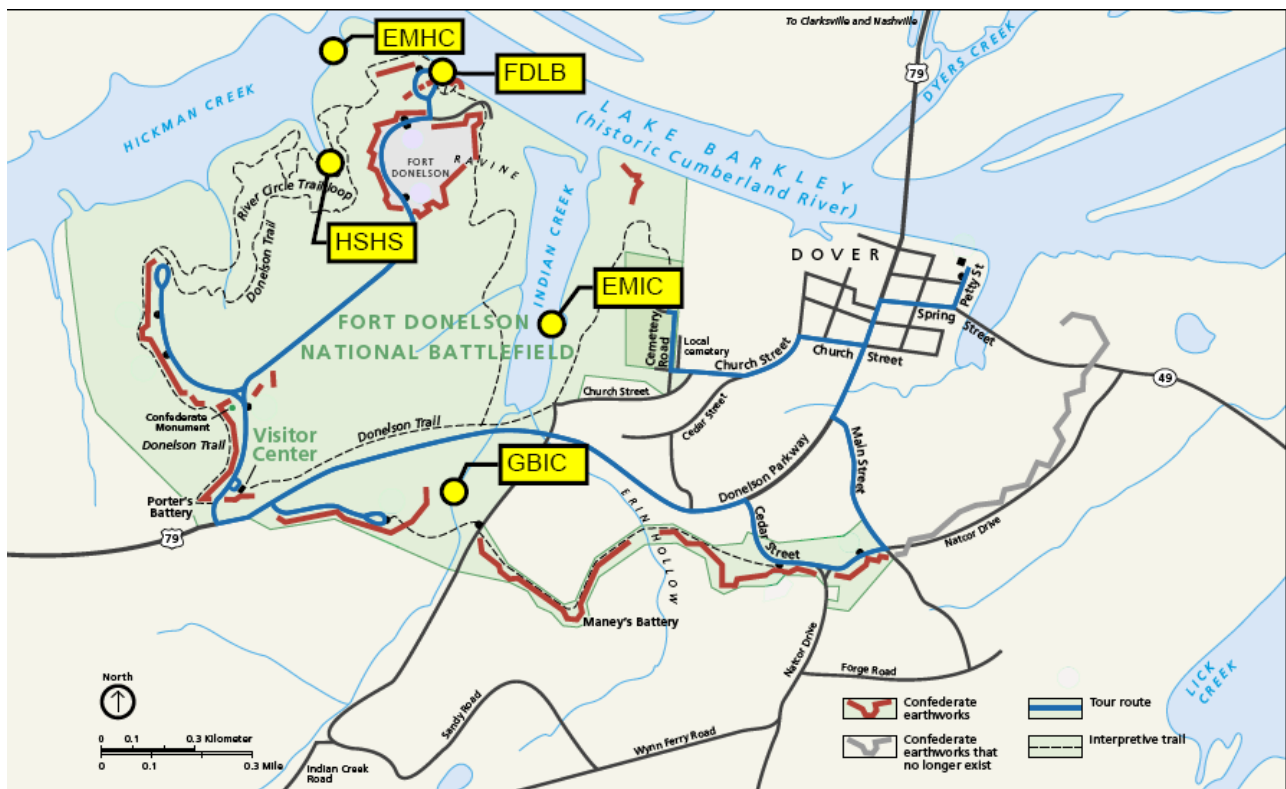


Figure 1. Map of water quality sampling sites at FODO

Description of Sampling Sites

Indian Creek: East of Grave's Battery (GBIC)

This is the best location to monitor Indian Creek within the park. This location has been used for past monitoring efforts. Samples are taken at the footbridge that crosses Indian Creek just east of Grave's Battery.

Hickman Spring (HSHS)

This very small spring is located along the River Circle Trail Loop. This location has been used for past monitoring efforts. Samples are taken at the spring outlet near the footbridge on River Circle Trail Loop.

Hickman Embayment (EMHC)

Although this and the following two sites are technically just beyond the park boundary – defined by a pool elevation that is exceeded about every ten years – they are included as they surround much of the park and greatly contributes to the overall aesthetic value of a park visit, and are cost effective considering the travel to sample. A result of impoundment of Hickman Creek from Lake Barkley (formally the Cumberland River) this site is accessed via the Circle Loop Trail north of Hickman Spring.

Indian Creek Embayment (EMIC)

Like Hickman Bay, Indian Creek Embayment is the result of Lake Barkley impounding this small stream. The site is accessed by the trail leading to the amphitheater on the eastern side of the embayment.

Lake Barkley (FDLB)

This site is located along the main stem of Lake Barley at the overlook of Fort Donelson. Considerable boat traffic, including barges, traverses this section daily. It is accessed along the rip-rap directly upstream of the overlook near the picnic grounds.

Stream Designated Uses

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. New NPS nationwide GPRA goals are now tied to state water quality standards and designated uses. For more information on Tennessee water quality standards, please see:

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

Table 1. The table below shows the designated uses for each site.

<i>Park</i>	<i>Code</i>	<i>Site</i>	<i>State</i>	<i>Designated Use</i>
FODO	EMIC	Embayment, Indian Creek	TN	Fish & Aquatic Life Industrial Water Supply Irrigation Livestock Watering & Wildlife Recreation
FODO	EMHC	Embayment, Hickman Creek	TN	Fish & Aquatic Life Industrial Water Supply Irrigation Livestock Watering & Wildlife Recreation
FODO	FDLB	Lake Barkley at Fort Donelson	TN	Fish & Aquatic Life Industrial Water Supply Irrigation Livestock Watering & Wildlife Recreation
FODO	GBIC	Indian Creek at Grave's Battery	TN	Fish & Aquatic Life Irrigation Livestock Watering & Wildlife Recreation
FODO	HSHS	Hickman Spring	TN	Fish & Aquatic Life Irrigation Livestock Watering & Wildlife Recreation

Results

Quarterly sampling commenced in November 2003 and continued until August 2004. After a one-year hiatus four more rounds were collected between November and August 2006, for a total of eight sampling events.

Water quality results are displayed in time series graphs showing all data for each site for a given parameter. The data gap in the center of the graph is caused by the planned one-year pause in sampling. As the Water Quality Program continues, trends may emerge from these time series graphs. It is anticipated that there will be enough data by the end of the next sampling round (September 2008) for statistical trend analysis.

If state standards exist for a particular parameter they will be displayed. In addition, in a cursory attempt to show an element of data error, each plot is assigned error bars, representing the minimum potential error associated with the measurement.

Water Temperature

Water temperatures of FODO are considered to be within range to support native aquatic life. The moderately compressed temperature ranges at Hickman Spring (HSHS) is a function of long retention times of groundwater recharging the spring. The creek and lake sites display a wider range of temperature are reflective of normal seasonal variations.

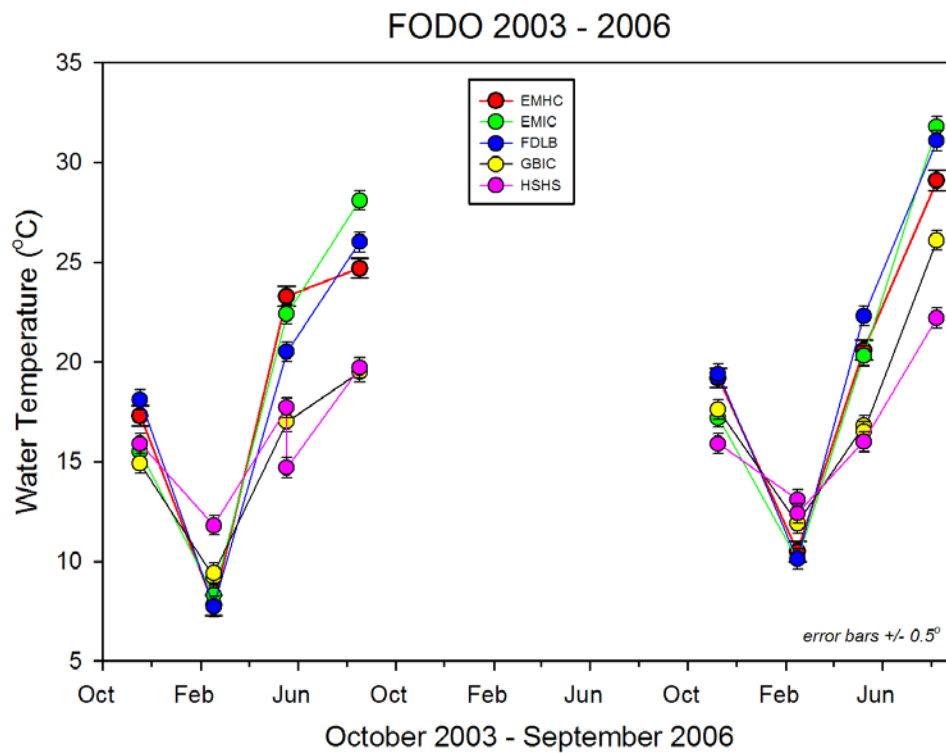


Figure 2. Water Temperatures at FODO

Specific Conductance

The distribution of specific conductance (SpC) of FODO is reflective of the amount of dissolved solids, which is primarily controlled by lithology and residence time. The higher values found at HSHS are the result of karst groundwater being in contact with limestone, thus picking up a larger amount of dissolved ions.

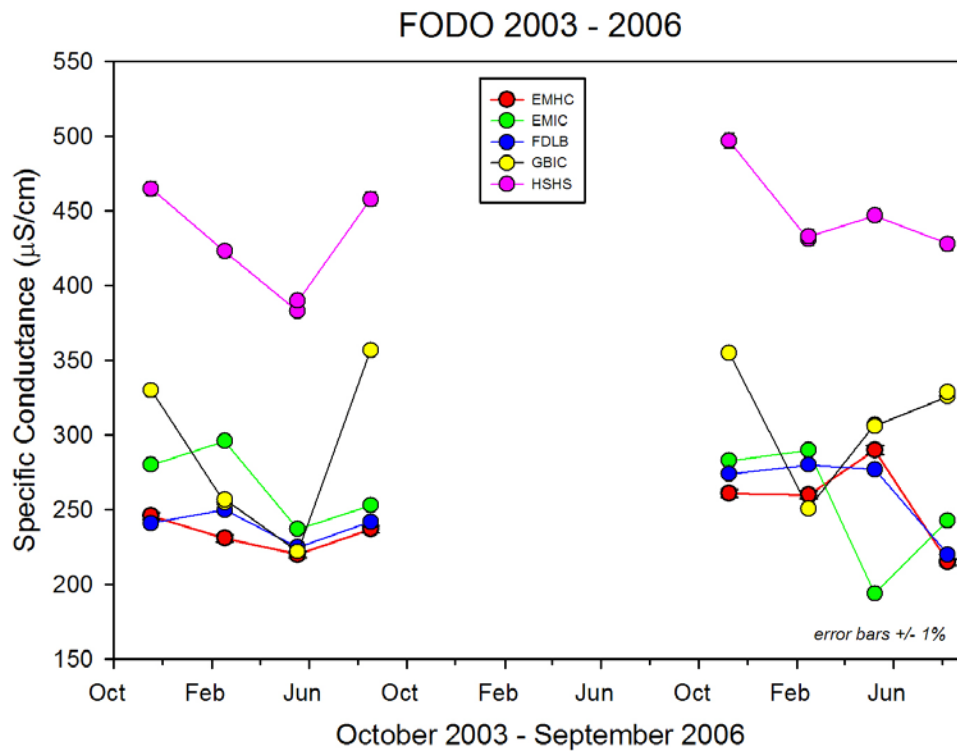


Figure 3. Specific Conductance at FODO

pH

The pH of waters of FODO are near neutral to slightly alkaline. This is common to waters which had been in contact with carbonate strata, as the bicarbonate ion buffers the effects of acid. The acceptable pH range for the designated uses comprises the upper and lower range of the graph, 6.5 to 9.0 SU.

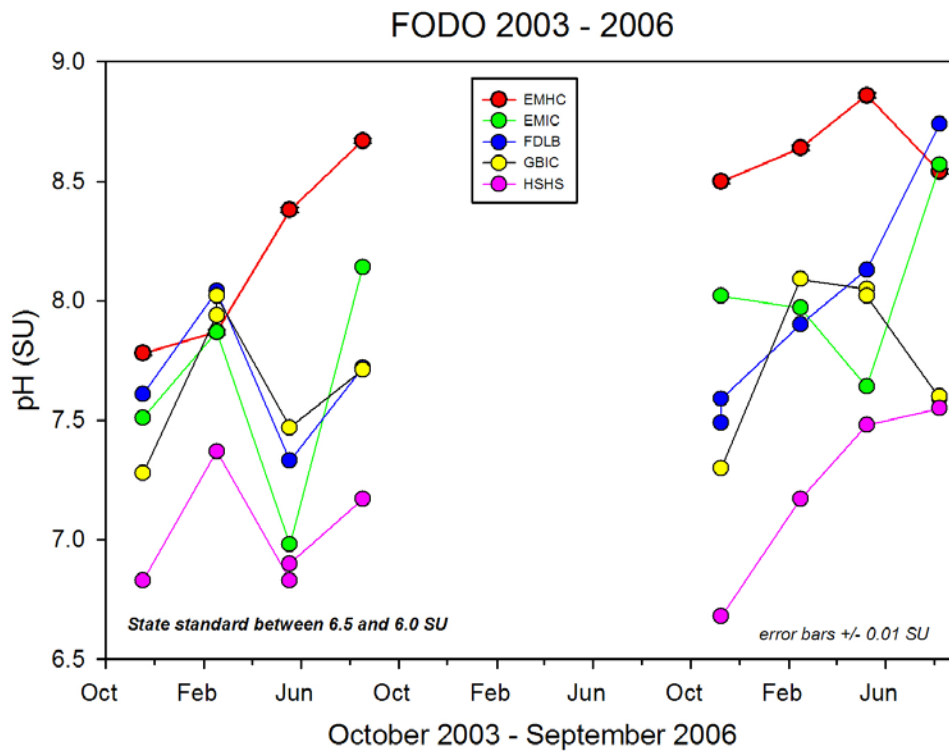


Figure 4. pH levels at FODO

Dissolved Oxygen

All waters monitored at FODO are typically saturated, or at least above the lower limit of 5.0 mg/l for dissolved oxygen (DO), with exception of two samples at Hickman Spring and one in the Embayment of Indian Creek. 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 providing few chances for the groundwater to be well aerated. The May 2006 DO reading at the Embayment of Indian Creek was low (3.8 mg/l). There are a number of explanations ranging from equipment and operator error or simply a temporarily depressed oxygen level. This appears to be a single occurrence as oxygen levels were found to be within the normal range by August.

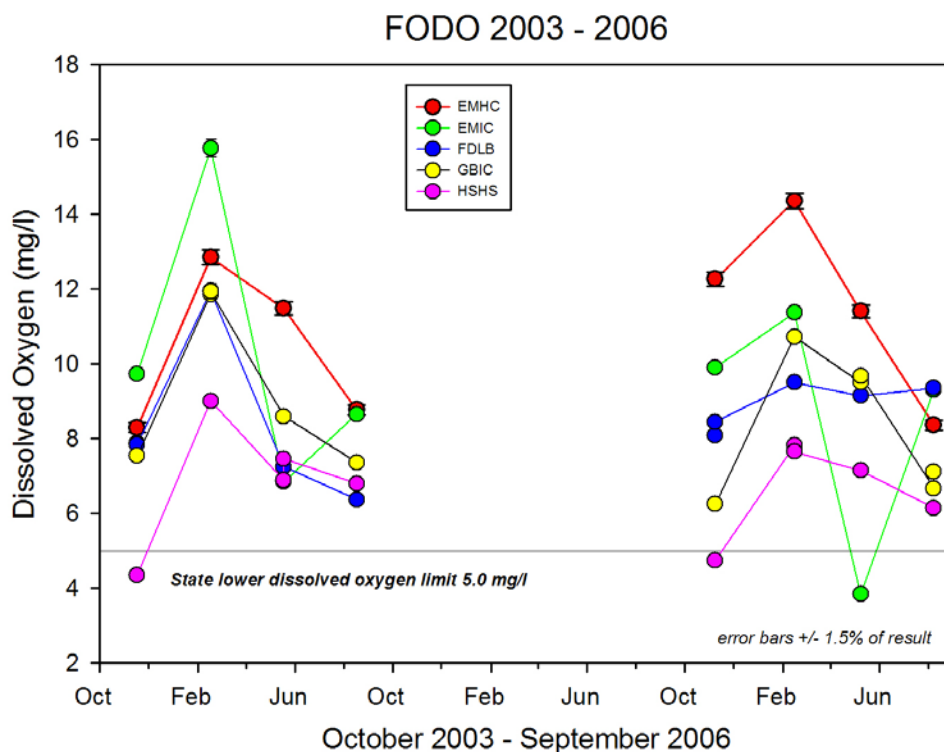


Figure 5. Dissolved Oxygen levels at FODO

Bacteria

Unfortunately the graph below is confusing. Fecal coliform bacteria were measured during the first round of sampling, while total coliform and *Escherichia coli* were used for the second round. All three bacteria are members of the coliform group and are found in the gastrointestinal track of warm-blooded animals; *E. coli* is the most common member of fecal coliform, and fecal coliform a subset of total coliform.

The Tennessee recreational contact standard for *E. coli* is a geometric mean of 630 colonies per 100 ml of not less than 5 samples taken within a 30 day period. No single sample should exceed 2,880 colonies per 100 ml. Earlier fecal coliform data can be compared to a recreational standard of a similar geometric mean of 200 colonies per 100 ml.

We can view these data in a broad-spectrum. There are occasions when bacterial concentrations in park and adjacent waters are elevated. These high counts tend to be associated with rainfall events, which produce runoff. These numbers, as they represent single samples and not a series to produce a geometric mean, are interpreted to be acute, event-related spikes, rather than chronic bacterial contamination.

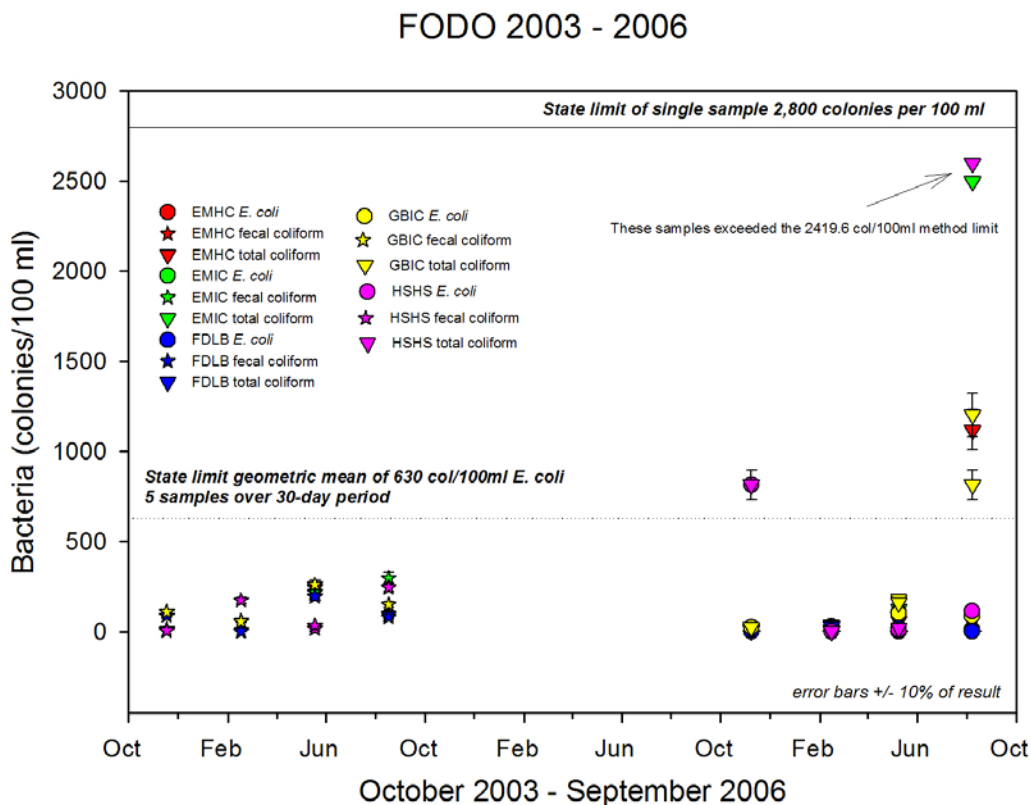


Figure 6. Bacteria levels at FODO

General Water Quality Status

These data show that the water quality of Indian Creek near Graves Battery, Embayment of Hickman Creek, and Lake Barkley at the overlook at Fort Donelson are meeting their designated use. On two occasions (25% of the sample total), dissolved oxygen levels at Hickman Spring were below the state standard of 5.0 mg/l. This is likely a natural condition some springs recharged by diffuse means, such as Hickman Spring, typically have low dissolved oxygen levels. On one occasion the dissolved oxygen of the Embayment of Indian Creek was below 5.0 mg/l.

Bacterial standard attainment is a bit harder to define. The program is not designed to meet the temporal sampling requirements – the geometric mean of five consecutive samples, taken at least 12 hours apart, within a 30-day period. As bacteria in the waters of FODO are likely generated from non-point source (surface runoff), one could easily construct a sampling program to intentionally be above (sampled during or after runoff events) or below (sampled only during low flow times) the standard. One sample at Hickman Spring exceeded the 630 colonies per 100 ml recreational standard, but it is a single sample, and not a series. In any event, at no time was the 2,800 colonies per 100 ml single sample *E. coli* limit exceeded.

Water Quality Designated Use Attainment

Although there was one occurrence where the dissolved oxygen level of the Indian Creek Embayment was below the state standard, this water body is not management by the park.

In addition, while Hickman Spring is certainly within the park and on two occasions its dissolved oxygen was below the state standard of 5.0 mg/l, this condition should be considered natural. According to Tennessee statute 1200-4-3-.05 “*Where naturally formed conditions (e.g., geologic formations) or background water quality conditions are substantial impediments to attainment of the water quality standards, these natural or background conditions shall be taken into consideration in establishing any effluent limitations or restrictions on discharges to such waters.*”

Future Water Quality Monitoring Recommendations

The CUPN is required in accord with the national water quality program to monitor water temperature, specific conductance, pH, and dissolved oxygen. In addition, there is sufficient reason to continue to monitor *Escherichia coli*. Although bacterial levels are generally below state water quality standards, long-term data may serve to alert the park to impending water quality issues.