



Cumberland Piedmont Network Water Quality Report: Third Serial

Fort Donelson National Military Park



ON THE COVER

Limestone along bank of Hickman Creek Embayment, July 16, 2001

Photograph by: Joe Meiman

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Introduction

This is the third serial 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). The second report (January 2007) updated the status of water quality following the second round of sampling. This report will include those early findings as well as data gathered in fiscal year 2008 and display these results in graphic form (accompanied with a brief interpretation), and concludes with a water quality summary and recommendations. Results from FY 2008 sampling were generated by CUPN Data Manager Brenda Wells.

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, pH, and dissolved oxygen. Samples were also collected for laboratory analysis for bacteria (*Escherichia coli*). An additional sample was collected from one site per round as a quality assurance – quality control provision.

Sampling Sites

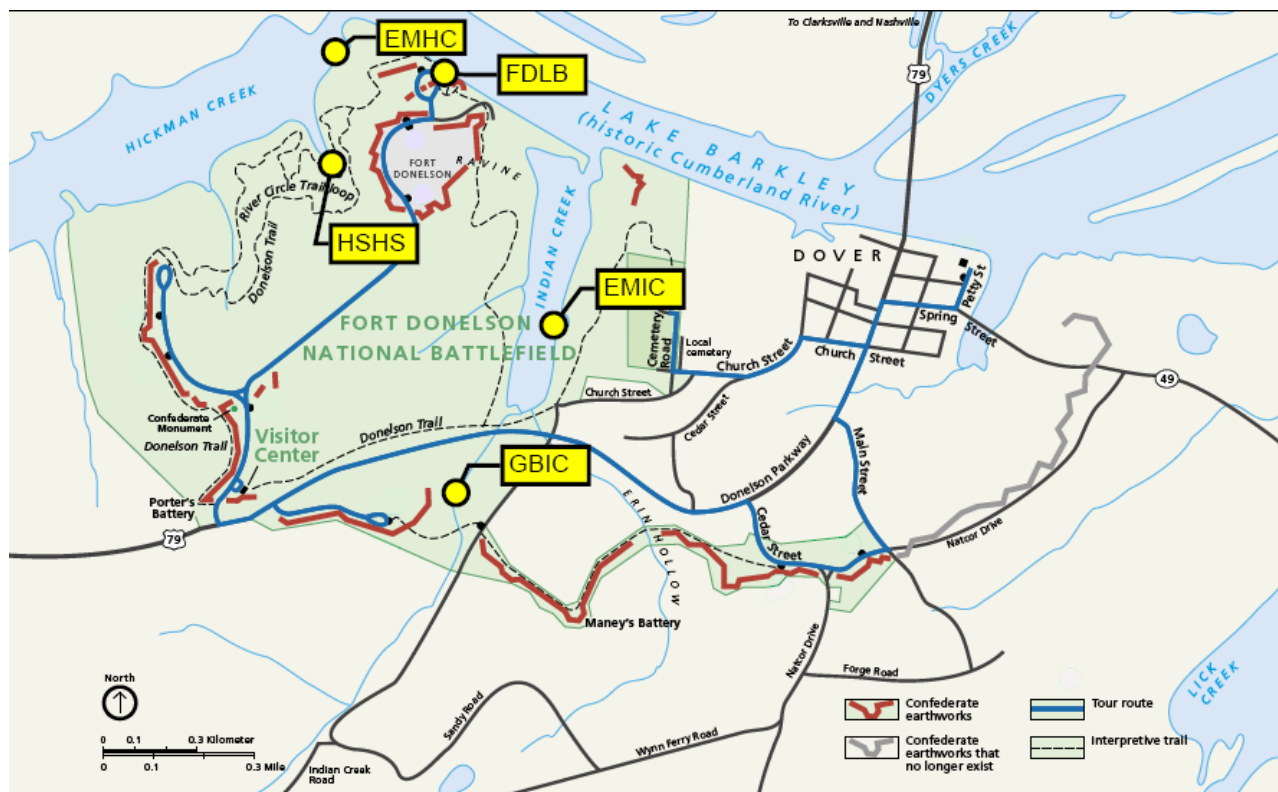


Figure 1. Map of water quality sampling sites at FODO

Description of Sampling Sites

It is important that the reader understand that only two of the three sites are within the boundaries of FODO: Indian Creek east of Grave's Battery, and Hickman Spring. The remaining three sites are sampled just outside the park – defined by the spillway elevation of Lake Barkley Dam. While the park has no jurisdiction over these waters, it makes economic sense to pick up these samples during a visit. Additionally extra samples may provide early warning to water quality problems immediately adjacent to the park.

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 contribute 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’s picnic area. Considerable boat traffic, including barges, traverse 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 US Environmental Protection Agency, 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

Table 1. The table below shows the designated uses for each site. Designated Uses in red font were assigned by the author.

<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	National Park Service Waters Fish & Aquatic Life Irrigation Livestock Watering & Wildlife Recreation
FODO	HSHS	Hickman Spring	TN	National Park Service Waters 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 2005 and August 2006. Following a biennial pause, collection resumed with quarterly sampling from November 2007 through August 2008, for a total of 12 sampling events.

Water quality results are displayed in time series graphs showing all data for each site for a given parameter. The data gaps are caused by the planned one-year pause between sampling series. As the Water Quality Program continues, trends may emerge from these time series graphs.

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.

As mentioned earlier, only two of the five sites are within FODO boundaries. While the NPS cannot be held accountable for water quality violations in waters outside the park, since these sites are directly adjacent to the Park, managers should be knowledgeable of these waters.

Water Temperature

Water temperatures of FODO are considered to be within range to support native aquatic life, although temperature of the adjacent lake does exceed the state limit during the heat of the summer. The moderately compressed temperature range 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.

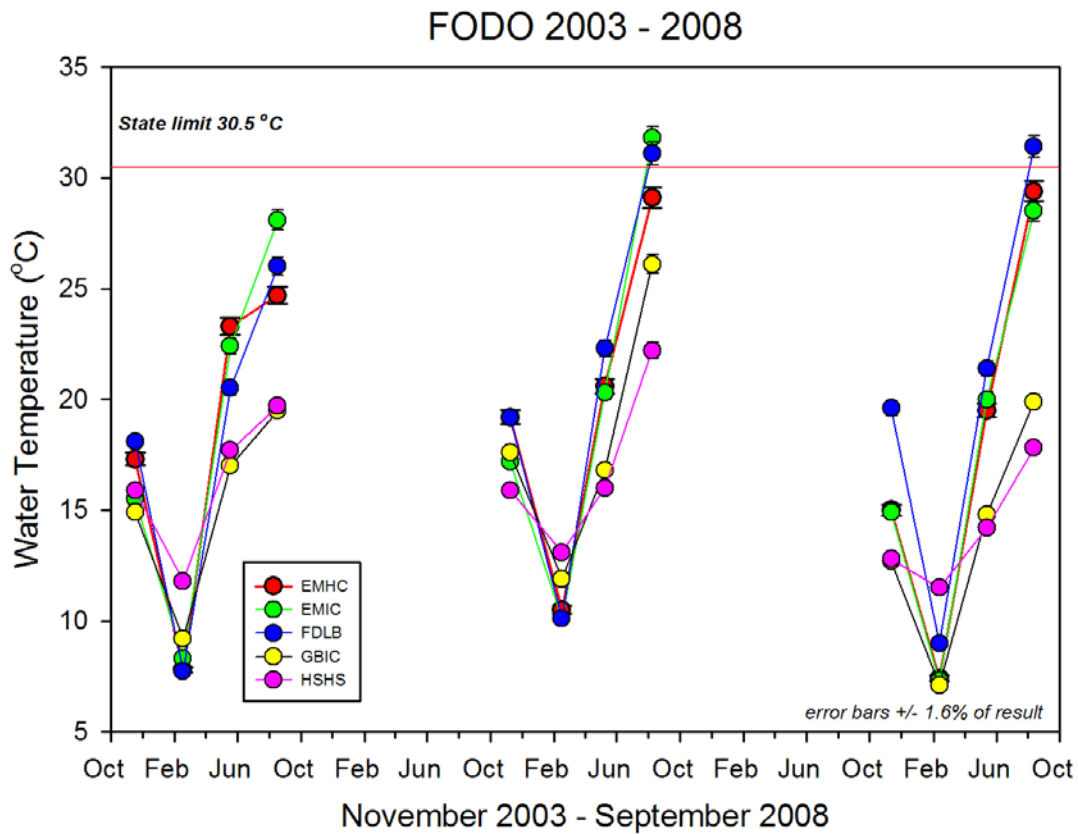


Figure 2. Water Temperatures at FODO

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. It is interesting, but predictable, to see low SpC values during the February sampling round. The area received approximately 3.4 cm of rainfall the week prior to sampling and the resulting quick-flow waters had little time to contact and dissolve bedrock.

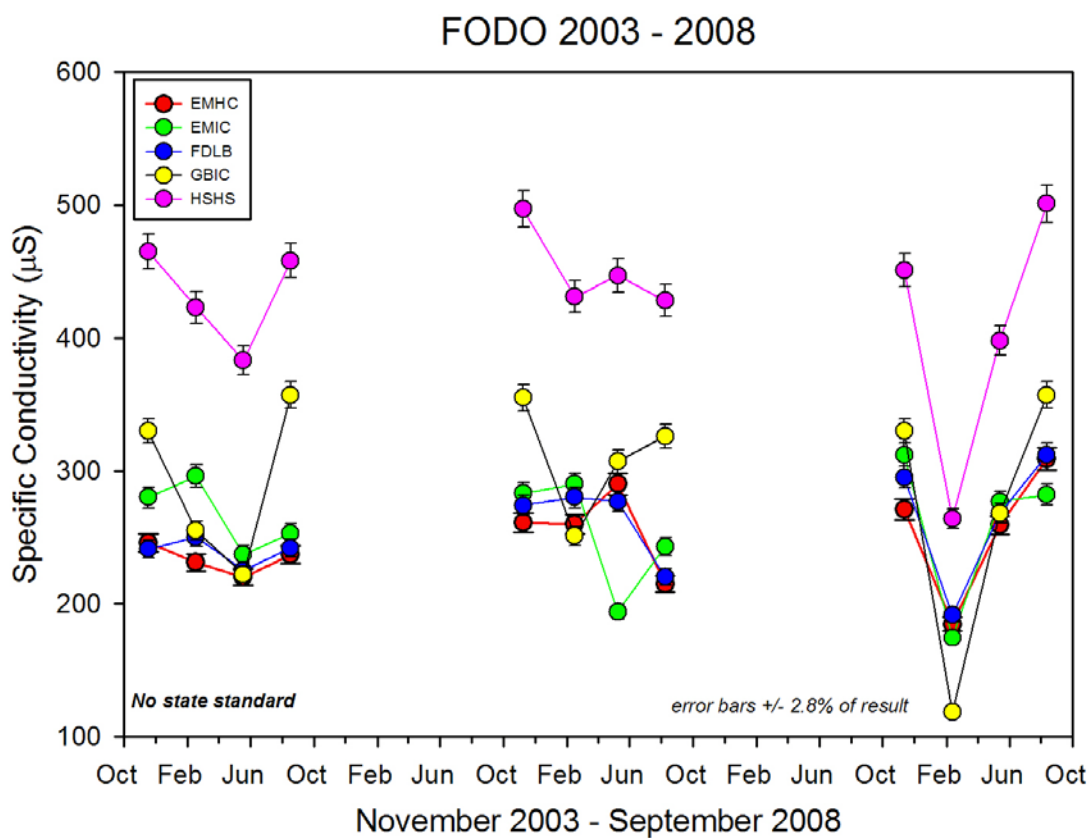


Figure 3. Specific Conductance at FODO

pH

The pH of waters of FODO are near neutral to slightly alkaline. This is common to waters which have 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.

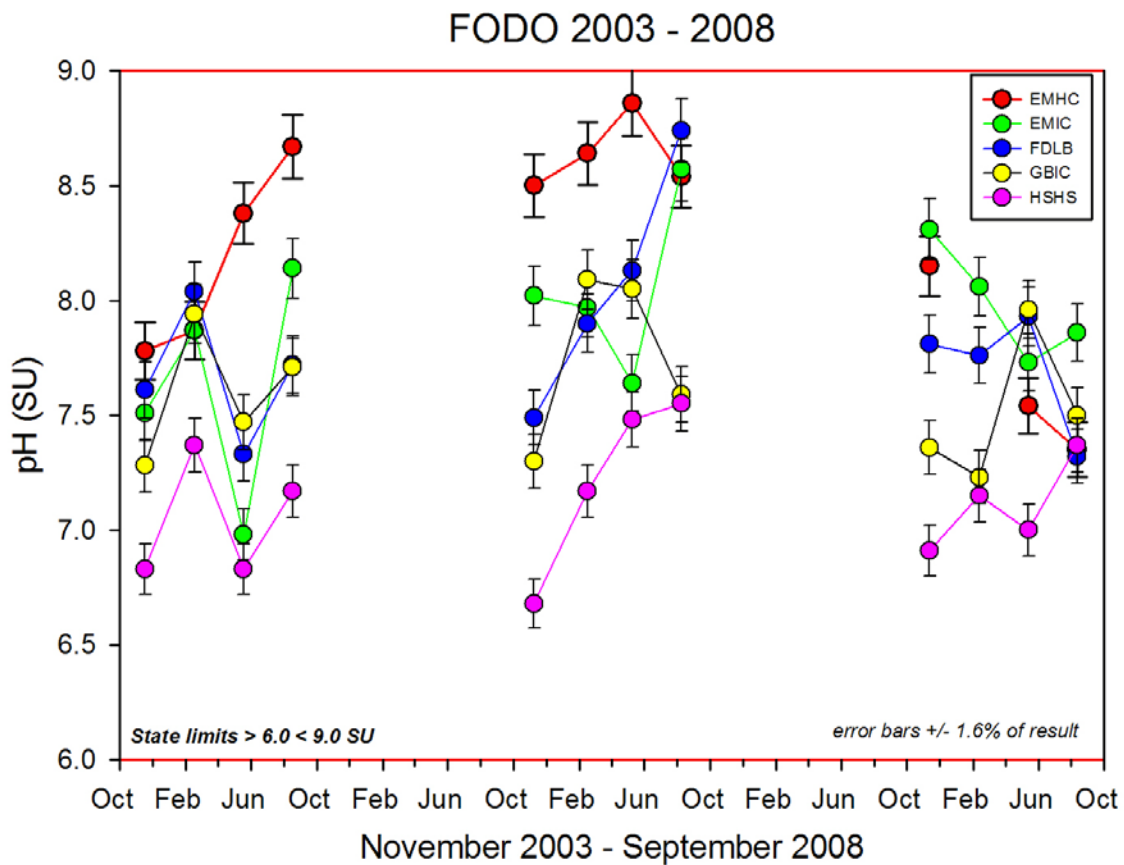


Figure 4. pH at FODO

Dissolved Oxygen

Dissolved oxygen (DO) of the waters in and around FODO range from well-saturated to below the state standard of 5.0 mg/l. One sample during each of the past three sampling years at Hickman Spring has been under this standard. In each case the depressed DO was due to extremely low flow conditions – a mere trickle of water flowing, interstitially in places. These should be considered natural conditions and not in violation of state standards. One sample at EMIC on May 9, 2006 low dissolved oxygen was the result of very low stage in the embayment.

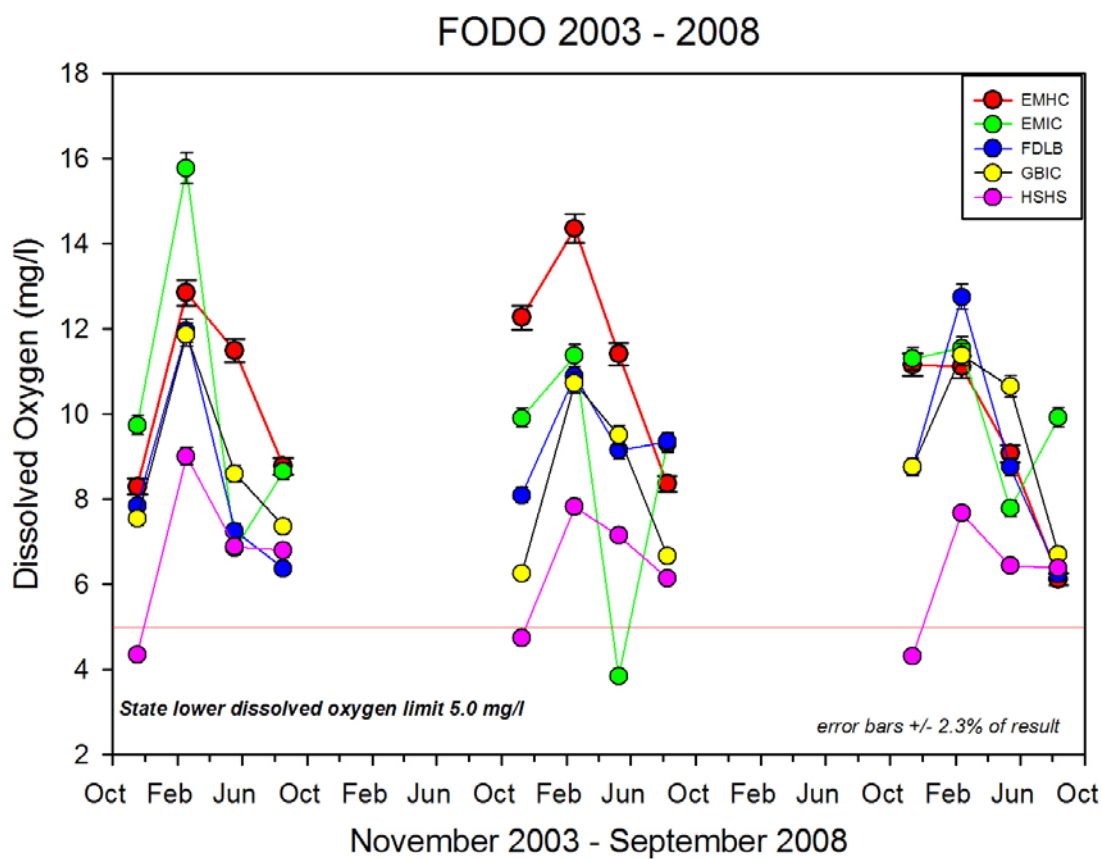


Figure 5. Dissolved Oxygen at FODO

Bacteria

In November 2005 the CUPN began testing for *Escherichia coli* bacteria. This eliminated the highly unreliable fecal coliform analysis and still provides an indicator of overall bacterial load.

The state of Tennessee has provided more restrictive *E. coli* standards for waters on NPS lands. While state recreational contact limits for a single sample is 2,880 colony forming units (CFU)/100 ml, for NPS waters the limit is reduced to 487 CFU/100ml per single sample.

For the most part, *E. coli* levels in park waters are low – with the sole exception of Hickman Spring (HSHS) in November 2005 and February 2008 at Graves Battery (GBIC). The latest sampling series shows elevated *E. coli* in the Embayment of Indian Creek (EMIC). The February 2008 spike was caused by runoff associated with preceding 3.4 cm rainfall.

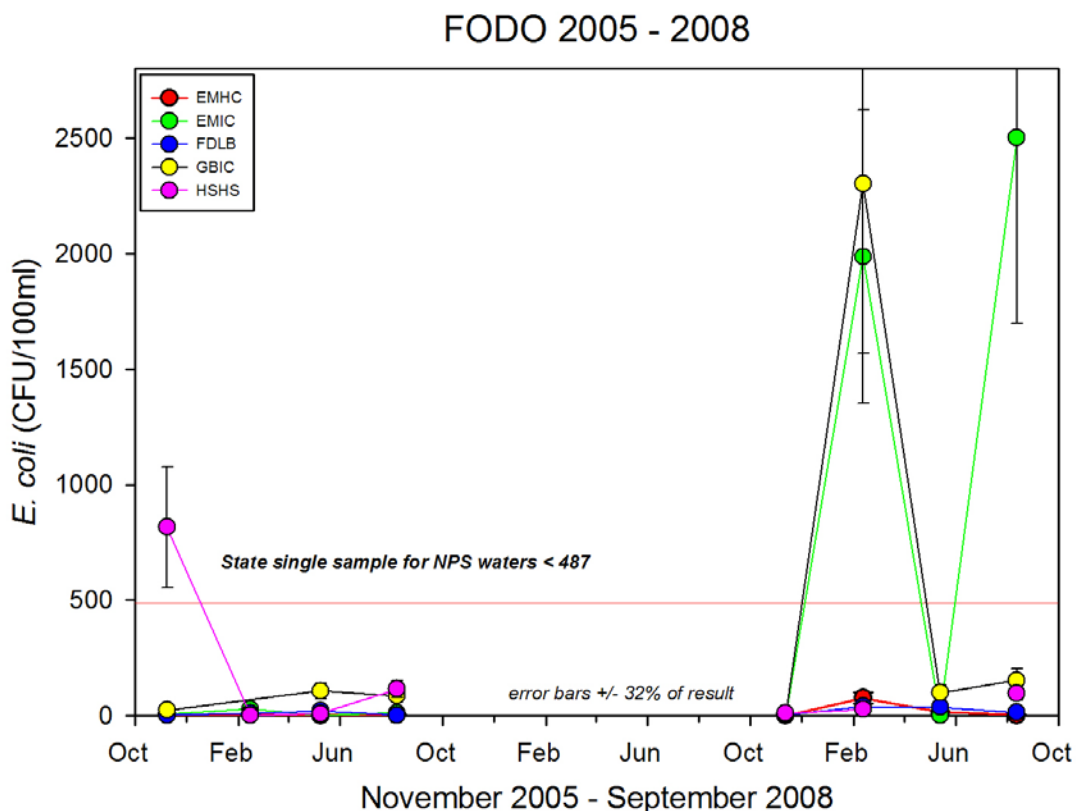


Figure 6. Bacteria at FODO

General Water Quality Status

Water quality at FODO is generally in good condition. There are no obvious trends showing decline in water quality and any exceedences in state standards are caused by antecedent flow conditions. Most notable during the FY 2008 sampling round was the high *E. coli* values at Indian Creek Grave's Battery during February. It is likely that similar spikes – far exceeding the state standard – are common to this stream immediately following rainfall events. That this is the first documented violation is due to sample-frequency (quarterly) rather than a sudden change in upstream land use.

Hickman Spring's dissolved oxygen, on three occasions, 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 as we saw in the February sample at Grave's Battery. The CUPN will resume water quality monitoring at FODO in FY 2010 as scheduled.