



Gulf Coast Network Water Quality Report

Status of Water Quality of Vicksburg National Military Park

Natural Resource Technical Report NPS/GULN/NRTR—2012/548



ON THE COVER

Durden Creek, April 5, 2009

Photograph by Joe Meiman

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Acronyms and Abbreviations

°C	degrees Celsius
CaCO ₃	calcium carbonate
DO	dissolved oxygen
GULN	Gulf Coast Network
km	kilometer
LNVA	Lower Neches (River) Valley Authority
MDEQ	Mississippi Department of Environmental Quality
mg/l	milligrams per liter
mm	millimeter
MS	Mississippi
n	number of measurements
NPS	National Park Service
NTU	nephelometric turbidity unit
QC	quality control
SOP	standard operating procedures
SpC	specific conductance
SU	standard unit of pH
TCEQ	Texas Commission on Environmental Quality
U.S.C.	United States Code
UADC	Union Avenue, Durden Creek
UAGB	Union Avenue, Glass Bayou
UPMS	Upper Mint Spring Bayou
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VICK	Vicksburg National Military Park
μS/cm	microSiemens per centimeter

Gulf Coast Network Long-Term Water Quality Monitoring

Water quality ranked among the top vital signs and was chosen to be monitored long-term in the eight parks composing the National Park Service's (NPS) Gulf Coast Network (GULN). Water quality monitoring program protocols and standard operating procedures (SOPs) are located in the GULN Vital Signs Monitoring Plan (Segura et al. 2007). The report that follows is a park-specific document that describes the status of water quality knowledge, including a description of the monitoring program, sampling sites, parameters tested, results in graphic form (when available), a brief interpretation of the results, and recommendations of parameters to be measured along with long-term sampling locations and frequency.

Sampling sites were chosen following site visits by GULN hydrologist Joe Meiman in 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 (or where a stream enters or leaves a park) to serve as an integrator of the basin, and should yield characteristics of, and contributions from, the entire watershed. Other near-shore and estuarine sites were chosen with respect to other key park resources such as seagrass beds.

The NPS Water Resources Division requires each network water quality program to monitor four core field parameters: water temperature, pH, specific conductance, and dissolved oxygen. While these key parameters are essential, additional parameters that are tailored to specific parks were chosen to reflect particular water quality issues.

Non-conditional synoptic sampling, where samples are taken regardless of flow and weather conditions on fixed calendar dates, is central to this effort. Basic fixed sampling locations are at integrator sites (locations commonly at tributary confluences or springs, which are representative of water quality issues of individual sub-basins) and indicator sites (locations downstream from either suspected or documented water quality threats, or pristine conditions). It is recognized that in order to best fit with other GULN monitoring activities, some flexibility in site selection is required. This strategy, over the long-term, has proven to yield statistically valid data used to track long-term trends in water quality.

Specific management objectives, past water quality history, biological significance, recreational use, enabling legislation, and field logistics were considered separately for each GULN park in the design of a long-term program. While parameter lists may vary from park to park, and sampling frequency is dictated by extant programs or resource importance, there are several fundamental constants within the GULN program. Namely, all measurements are performed in accordance with SOPs, which are adapted from agencies such as the U.S. Geological Survey (USGS) or the Mississippi Department of Environmental Quality (MDEQ). All contract laboratories are accredited with the National Environmental Laboratory Council. All in-house analyses are performed according to Standard Methods for the Examination of Water and Wastewater (American Public Health Association 2005).

Measureable Objectives

This is a long-term monitoring program. It is not designed to respond to catastrophic or singular water quality events. It is designed to form a comparative database to detect changes in a variety of water quality parameters over time within an individual park or stream. Parks within a

particular ranking category may be cross-comparable, but charting changes in water quality within a particular park is the primary statistical objective for the long-term data. Through a series of Vital Signs Workshops and other meetings with park managers, the water quality monitoring program was devised to meet the management objectives of the GULN parks. These measurable objectives are as follows:

- Provide a backdrop to compare changes in the aquatic biologic community.
- Compare water quality to Texas water quality standards.
- Identify stressors such as land uses and land use change within the watershed.
- Determine potential pollutant sources (non-point source contaminants versus point sources).
- Ascertain impacts to water quality by in-park activities within selected watersheds.
- Determine regional effects of atmospheric contaminants (e.g., acid precipitation).

Hydrologic Introduction to Vicksburg National Military Park

Vicksburg National Military Park (VICK) drains via three small, perennial streams: Mint Spring Bayou, Glass Bayou, and Durden Creek, as well as numerous ephemeral and seasonal streams. Mint Spring and Glass bayous drain into the Yazoo River while Durden Creek flows into Hatcher Bayou, which flows into the Mississippi River. Mint Spring Bayou is divided into the upper and lower reaches by a 10-meter-high (33-foot-high) waterfall over the Mint Spring Formation (limestone of the Oligocene epoch, between 34 and 23 million years ago (Morse 1935) (Figure 1). This waterfall, located adjacent to the Vicksburg National Cemetery, forms a natural impediment to upstream fish movement; only one species of fish — the exotic fathead minnow (*Pimephales promelas*) — exists in Upper Mint Spring Bayou. The lower reach can be adversely affected by the multitude of land and water uses on the Yazoo during times of flooding. All park streams respond immediately to rainfall events; clear base-flow gives way to extremely turbid storm flow as the steeply sloped loess terrain provides ample runoff.

The majority (74 percent) of the 298-hectare (736-acre) Mint Spring Bayou watershed contributing flow to the Upper Mint Spring Bayou monitoring site (UPMS) is contained within the park (Figure 2). The privately owned headwater portion of the watershed (26 percent) consists of low-density residential land use. Conversely, the majority (72 percent) of the 56-hectare (138-acre) Glass Bayou watershed above the Glass Bayou monitoring site (UAGB) lies upstream of the park boundary in residential and low-density commercial uses. Glass Bayou, as it generally cuts through the siege-line ridge along Jackson Road, is somewhat transient to the park. Land use is generally residential. The 91-hectare (225-acre) watershed contributing flow to the Durden Creek monitoring site (UADC) is fully contained within the park.

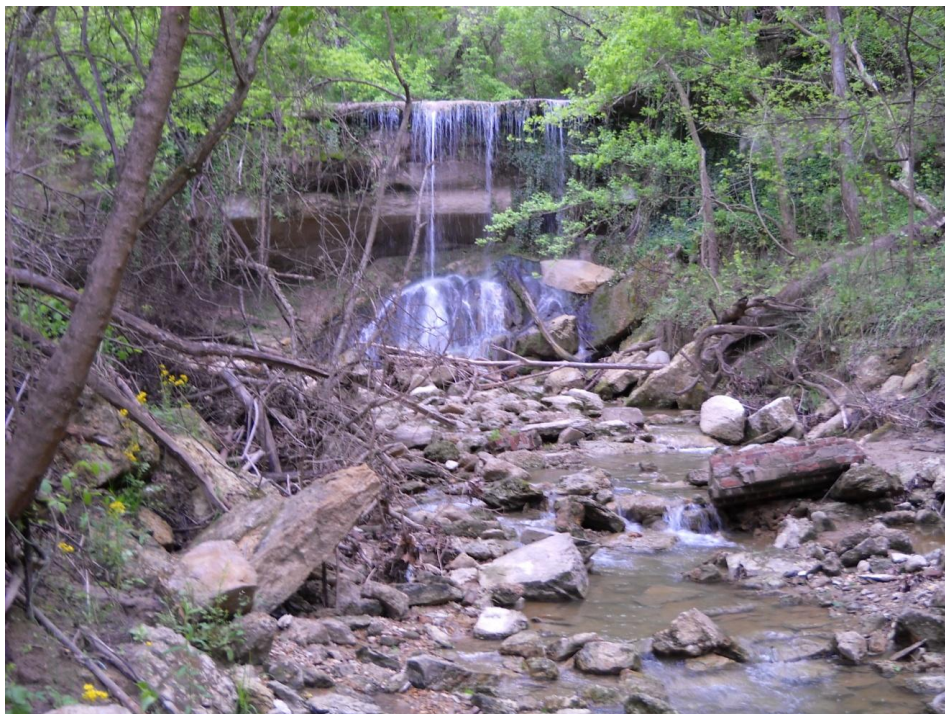


Figure 1. The waterfall dividing Lower and Upper Mint Spring Bayou, April 6, 2009. Photograph by Joe Meiman.

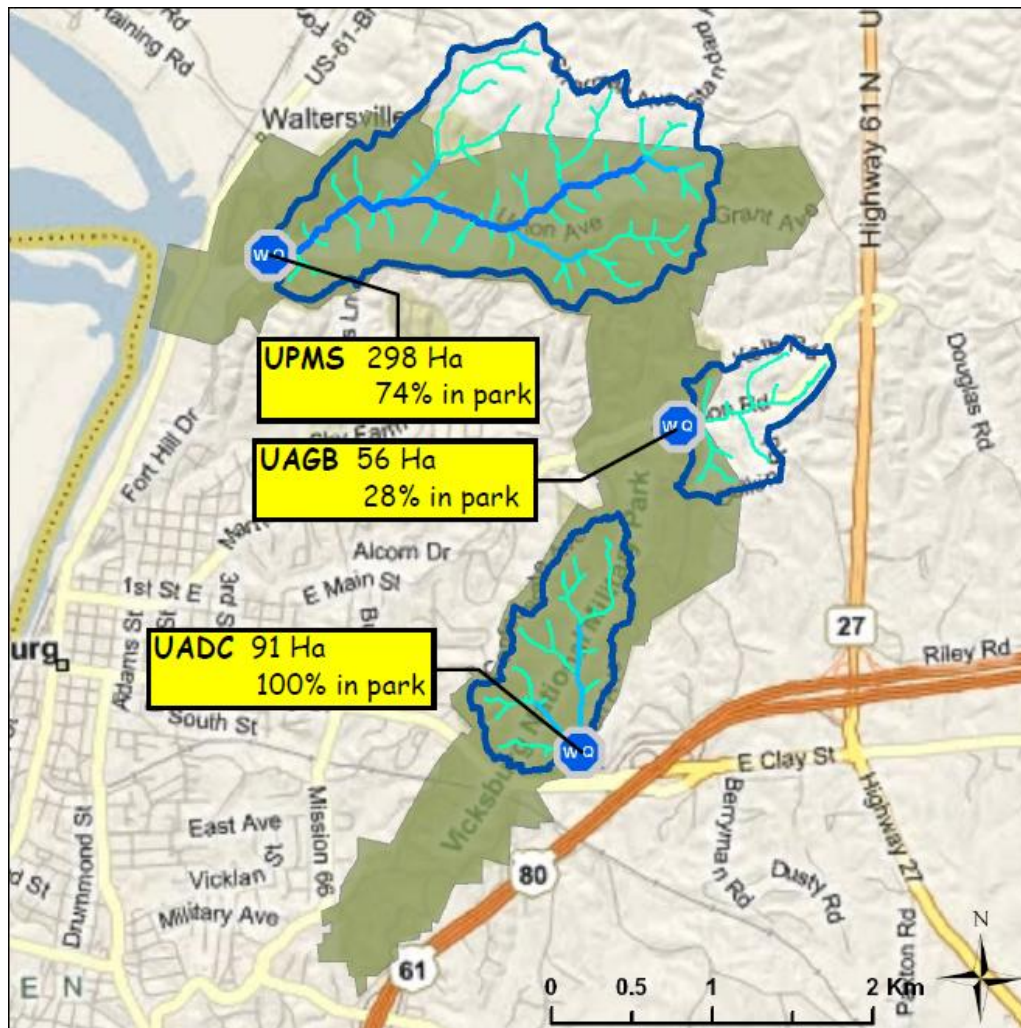


Figure 2. Perennial watersheds of VICK with long-term water quality monitoring stations: UPMS (Upper Mint Spring Bayou), UAGB (Glass Bayou), and UADC (Durden Creek).

Recreational Use and Aquatic Life

Contact recreation, including primary contact (swimming and wading) and secondary contact (fishing and other non-immersion activities), is not promoted in the streams within the park. However, Mint Spring Bayou, immediately above and below the falls, receives several visitors per month wading through its shallow waters (<0.5 m [<1.5 feet]).

The state lists the alligator snapping turtle (*Macrochelys temminckii*) and the Mississippi map turtle (*Graptemys pseudogeographica*) as species of special concern. These species are occasionally found in Mint Spring Bayou, downstream from the falls, where water occasionally backs up from the Yazoo River.

Existing Water Quality Information

Dr. Eric Dibble of Mississippi State University has made dozens of inventory and monitoring rounds at the park between 1996 and 2003. The most-detailed analysis is described in the 1999 Annual Report "Ecological Evaluation of the Streams and Aquatic Communities in Vicksburg National Military Park" (Dibble and Smiley 1999). While most data depict the aquatic biology of

the streams, he and his students have made an effort to sample the basic core water quality measures while composing site habitat descriptions. The three streams were measured at multiple points for water temperature, pH, specific conductance (SpC), dissolved oxygen (DO), turbidity, and flow. Dr. Dibble's water quality data were fully within expected ranges and concordant with those found to this point in the GULN program.

Sampling Sites

Although the park tour road crosses each of the three streams, there are no interpretative signs or public access to the streams, making the water resources of VICK ancillary to the park's mission. They are not labeled on the park map, and with the exception of the Yazoo River, they are not mentioned in the primary interpretative message. Thus, VICK is sampled as a "Tier 3" park with respect to water quality (see <http://www.nature.nps.gov/water/HIS/standards.cfm> for a description of tier ranking of waterbodies). Water quality sampling points at VICK were visited quarterly and an additional Quality Control (QC) sample was collected (Figure 3). Quarterly sampling commenced in August 2007 and continues through the present.

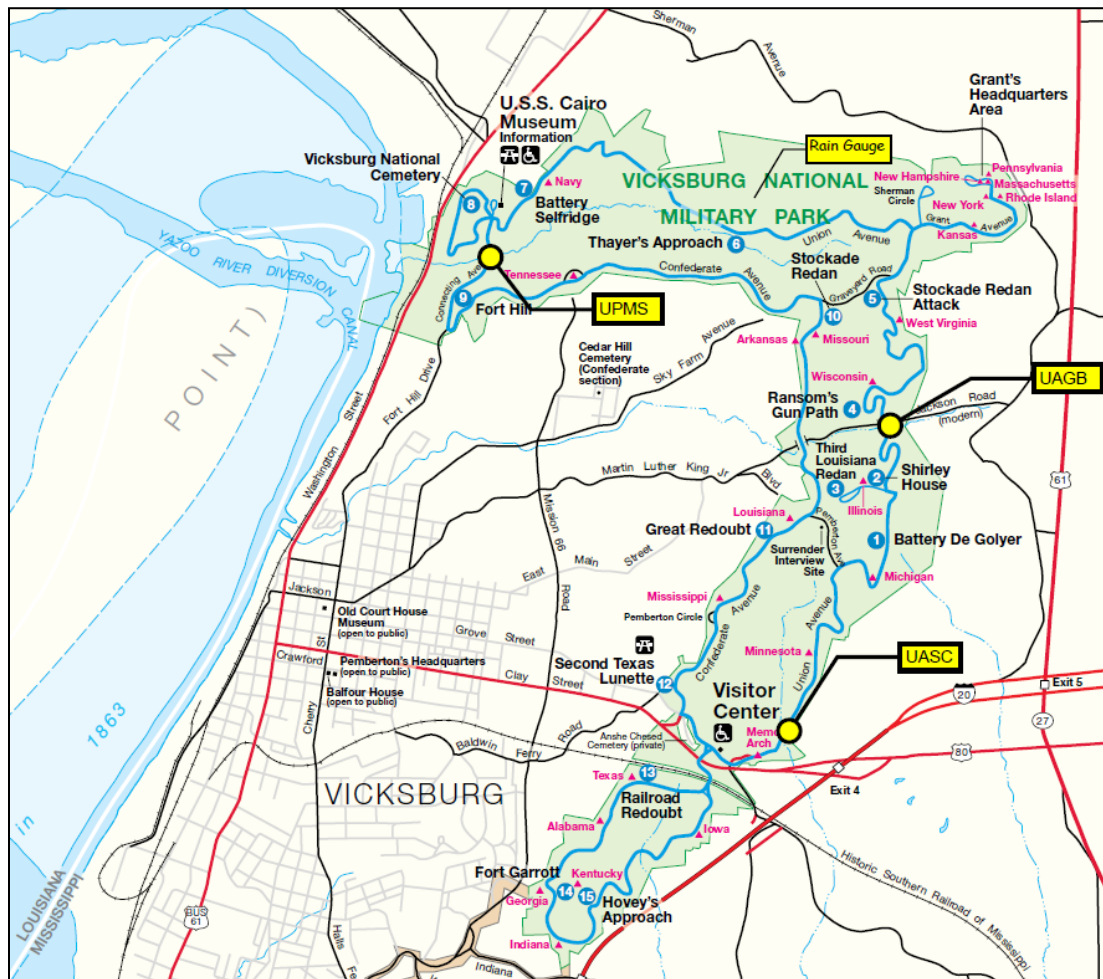


Figure 3. Map of water quality sampling sites at VICK.

Durden Creek (UADC): Durden Creek is sampled where it leaves the park as it crosses under Union Avenue (Figure 4). The watershed upstream of the monitoring station is fully contained within the park and should reflect water quality of undisturbed lands, with the exception of the park's headquarters, visitor center, and maintenance yard, which lies approximately 200 meters (656 feet) upstream of UADC. The site is accessible in all conditions.

Glass Bayou (UAGB): Glass Bayou is sampled where the stream enters the park along Jackson Road as it crosses under Union Avenue (Figure 5). Glass Bayou transects the park for approximately 850 meters (0.5 mile), flowing from light urban and commercial uplands to the Yazoo River in downtown Vicksburg. Site access is moderately easy and safe at all times.

Mint Spring Bayou (UPMS): The upper reaches of Mint Spring Bayou are sampled at the crossing of Connecting Avenue Road, approximately 100 meters (328 feet) above the waterfall, (Figure 6). This location, which is easily and safely accessed in all conditions, is removed from downstream influences of the Yazoo River and thus a better reflection of water quality draining the largely park-managed watershed.



Figure 4. Durden Creek, facing downstream, August 10, 2006.
Note high turbidity in response to brief local shower during the site visit.
Photograph by Joe Meiman.



Figure 5. Glass Bayou adjacent to Jackson Road below Union Avenue, facing downstream, August 10, 2006. Note high turbidity in response to brief local shower during the site visit. Photograph by Joe Meiman.

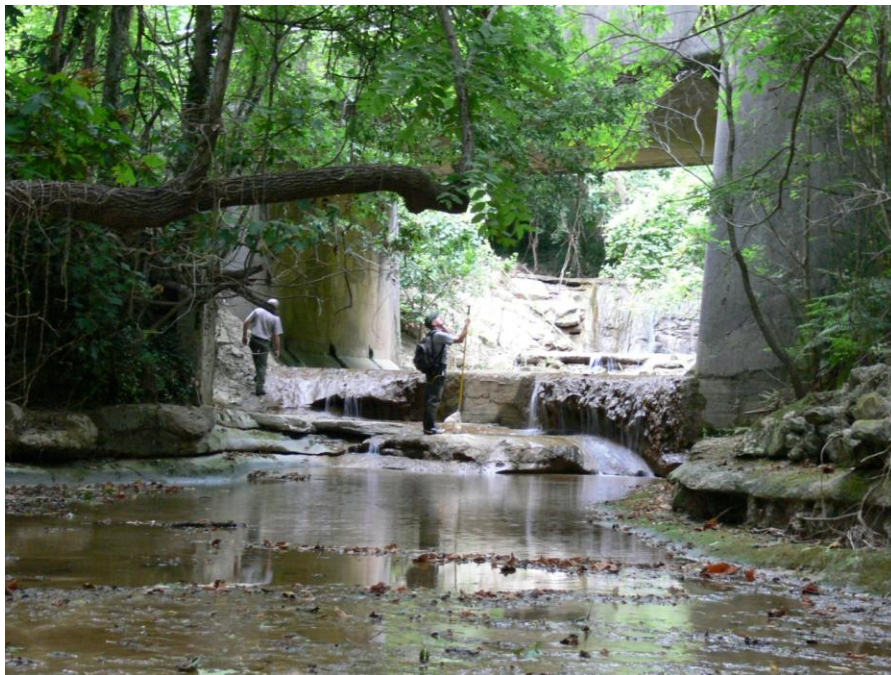


Figure 6. Mint Spring Bayou, facing upstream, below the Connecting Avenue Road Bridge, August 10, 2006. Note the absence of high turbidities seen at the other sites as this site was visited just prior to the rain event. Photograph by Joe Meiman.

Stream Designated Uses and Water Quality Standards

Pursuant to the Federal Pollution Control Act (33 U.S.C. 1251 et seq.), commonly known as the Clean Water Act, states are required to designate uses for their surface waters and adopt criteria to protect those uses. Mississippi waters are classified in to the following uses: public water supply, shellfish harvesting, recreation, fish and wildlife, and ephemeral. No VICK streams were specifically designated by the state, and thus, according to Mississippi law, must at least meet the state's Fish and Wildlife criteria (Table 1). The U.S. Environmental Protection Agency (USEPA), besides mandating these rankings, also directed the states to develop water quality standards for each designated use. By adapting the state standards, we can track park water quality trends within the states, regions, or watersheds. For more information on Mississippi water quality standards, please see:

Mississippi: Mississippi Commission on Environmental Quality, Regulation LW-2, Surface Water and Groundwater Use and Protection, amended January 26, 2006

Table 1. Fish and wildlife water quality standards for parameters measured at VICK.

Parameter	Water Quality Standard
Water temperature	<32.2 °C
Dissolved oxygen	>4.0 mg/l (instantaneous value); >5.0 mg/l (24 hour average)
pH	Between 6.0 and 9.0 SU
Specific conductance	<1,000 µS/cm
Turbidity	<50 NTU above background

Parameters for Water Quality Monitoring

The LNVA (Lower Neches River Valley Authority) and GULN use Texas Commission on Environmental Quality (TCEQ) protocols for all field measures, including sample collection and transport. These protocols can be found in TCEQ (2003) *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue*.

Water Temperature

Measurements of water and air temperature at the field site are essential. Determinations of dissolved oxygen concentrations, specific conductance, 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 human activities. Water temperature was measured in degrees Celsius (°C) using a thermistor thermometer, which 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.

Specific Conductance

Electrical conductance (SpC) is a measure of the capacity of water (or other media) to conduct an electrical current (the inverse of resistance). SpC is a quick and reliable estimation of the dissolved solids in the water, but there is no universal linear relation between total dissolved substances and specific conductance. A dip-cell electrode sensor was used and SpC is measured in microSiemens per centimeter ($\mu\text{S}/\text{cm}$).

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 is therefore an important indicator of the health of a water system. pH is measured using the electrometric measurement method via a hydrogen ion electrode and reported in standard units (SU).

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 depend directly or indirectly on the amount of oxygen present. DO is necessary in aquatic systems for the survival and growth of many aquatic organisms. The GULN uses an amperometric method in which DO concentration is determined with a temperature-compensating, galvanic, membrane-type sensor and measured in milligrams per liter (mg/l).

Turbidity

Turbidity was added to the parameter list for long-term monitoring because of the highly erodible loess soils of the park. 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 with a nephelometer using Standard Method 214 A and reported in nephelometric turbidity units (NTU).

Water Quality Status

Water quality has been sampled through a combination of quarterly sampling (water temperature, SpC, pH, DO, and turbidity), as well as three 1-month-long deployments of multiparameter datasondes that record these parameters, plus water depth, at 15- or 20-minute intervals. From mid-February through March 2008, multiparameter datasondes that record water temperature, depth, SpC, pH, dissolved oxygen, and turbidity every 20 minutes were set at the Durden Creek and Upper Mint Spring Bayou sampling sites. An identical deployment was set through March 2009; however, the Upper Mint Spring Bayou datasonde was lost (either by storm or by theft). Again, datasondes were deployed at Durden and Upper Mint Spring Bayou in early April through mid-May 2010, paired with a tipping-bucket rain gauge in the Upper Mint Spring watershed (Figure 3). The rain gauge totaled increments of 0.1 mm (0.004 inch) at 5-minute intervals. Previous deployments relied on a rain gauge at Vicksburg-Tallulah Regional Airport 17 kilometers (km) (11 miles) west of the park.

While quarterly sampling has not spanned the entire flow continuum (very high or flood flow has not been sampled), the data provide a good description of water quality during the period of record. In addition to quarterly sampling, data were collected upon deployment and retrieval of datasondes. It should be noted that in addition to basic field observations, weather condition, flow condition, air temperature, and precipitation during the week prior to sampling are also recorded. These data are important in interpreting water quality results.

Quarterly Sample Results

Water Temperature

All samples ($n = 53$) were below the state standard of 32.2 °C (Figure 7). Water temperature follows a seasonal pattern. As this data set does not record a flood event, data are representative of base-flow conditions. The streams of VICK are generally supplied by many small seeps and springs found throughout the Cenozoic limestones (Morse 1935) under the steeply rolling loess hills of the park. Groundwater influence, in combination with typical densely vegetated riparian corridors and small watersheds where there is limited atmospheric interaction, may suppress temperatures during summer months.

Specific Conductance

Specific conductance of VICK streams ($n = 53$) is the highest found in the Gulf Coast Network (Figure 8). As the watersheds of VICK are predominantly underlain by Cenozoic limestones, groundwater highly influences stream chemistry. Limestone (CaCO_3) is dissolved by recharge and thus increases the streams' ionic loads (primarily calcium and bicarbonate ions), producing elevated SpC values. These levels are less than the state SpC upper limit and are considered a natural characteristic of VICK waters.

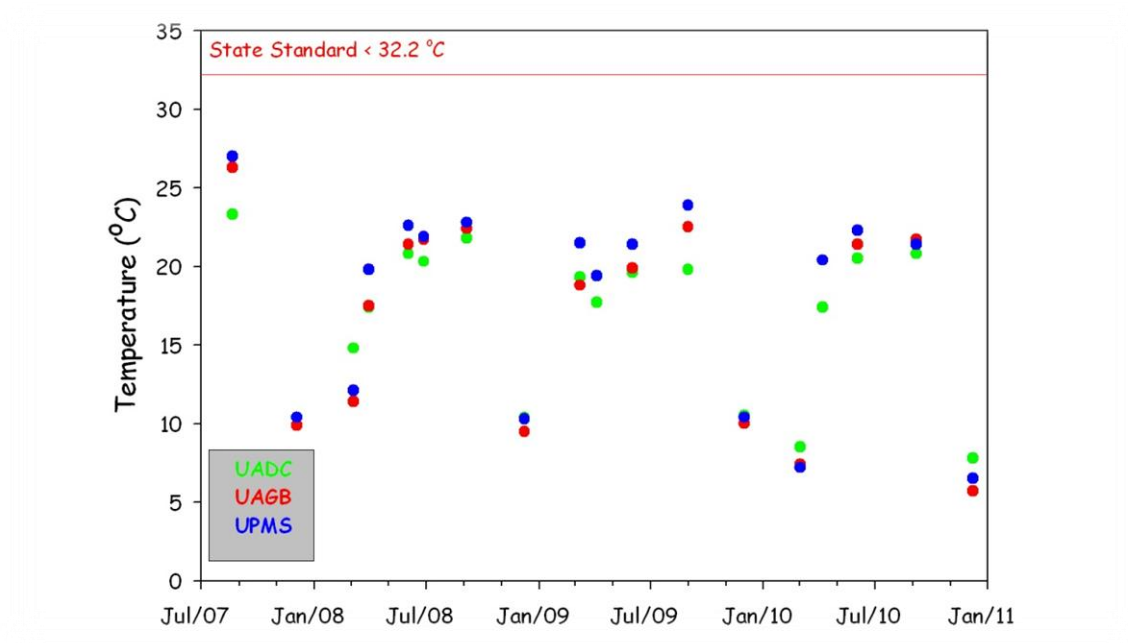


Figure 7. Water temperature at VICK, August 2007 through December 2010 (n = 53).

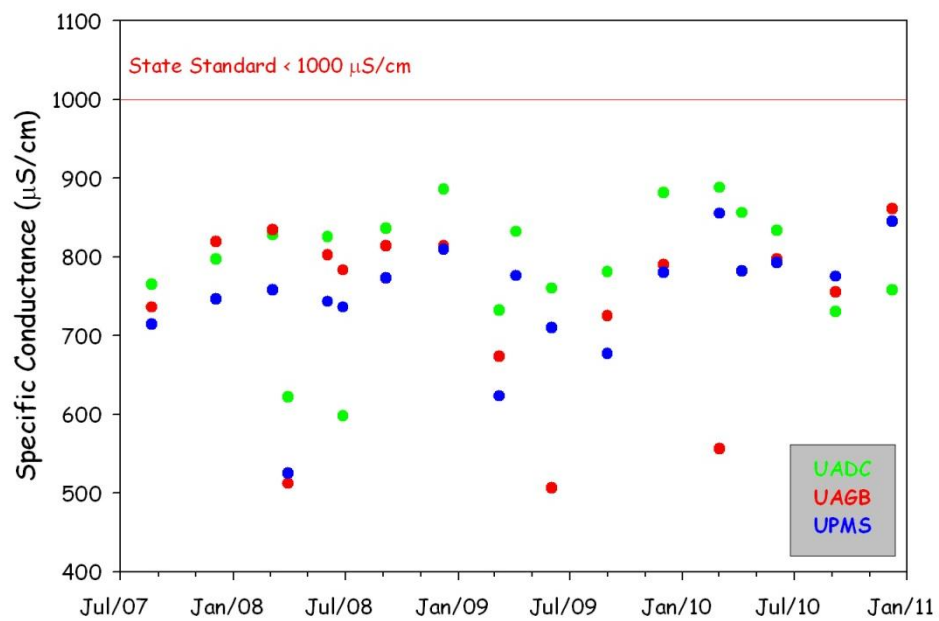


Figure 8. Specific conductance at VICK, August 2007 through December 2010 (n = 53).

pH

Due to the high amounts of dissolved bicarbonate ions found in VICK streams, pH is near-neutral to slightly alkaline (Figure 9). All 53 samples are within state limits, between 6 and 9 standard units. Examination of the nearest National Acid Deposition Program site (50 km east, near Clinton, Mississippi) does not indicate a decline in precipitation pH over this time span. Response of pH is generally independent of atmospheric pH and it is likely that the high buffering capacity of VICK's limestone watersheds influences the pH.

Dissolved Oxygen

Streams of VICK are well aerated as demonstrated by high DO levels (Figure 10). All 47 samples were well above the minimum state standard of 4.0 mg/l for any given instantaneous sample. There is a slight increase in DO during the winter months. This is likely due to diminished demand of oxygen from both chemical and biological processes. DO in Upper Mint Spring (UPMS) is usually slightly higher than Durden Creek (UADC) and Glass Bayou (UAGB), likely the result of its steeper gradient, thus, higher aeration.

Turbidity

The loess soils that drape the steeply rolling hills of Vicksburg are well known for erosion; particle size is dominated by silt (50%–90%; grain size of 0.05–0.002 millimeters [mm]) and clay (5%–50%; grain size <0.002 mm) (McCraw and Autin 1989). Even the slightest of perturbations such as a gentle rainfall is enough to turn a clear stream turbid. Only two of the 53 samples collected at VICK appear to exceed the state standard of 50 NTU above background levels (Figure 11). Background turbidity may be assumed to reflect that of low-flow conditions. Our dataset is representative of low-flow conditions, when the lowest turbidity values would be most likely found. As seen in the continuous data records below, turbidity can routinely exceed 1,000 NTU. It is interesting to note that Durden Creek typically has the highest turbidity, in spite of its entire watershed upstream of the sampling site being contained in the park. It is possible that park operations (equipment washing) or park infrastructure (developed areas) are contributing to the higher turbidity in this stream.

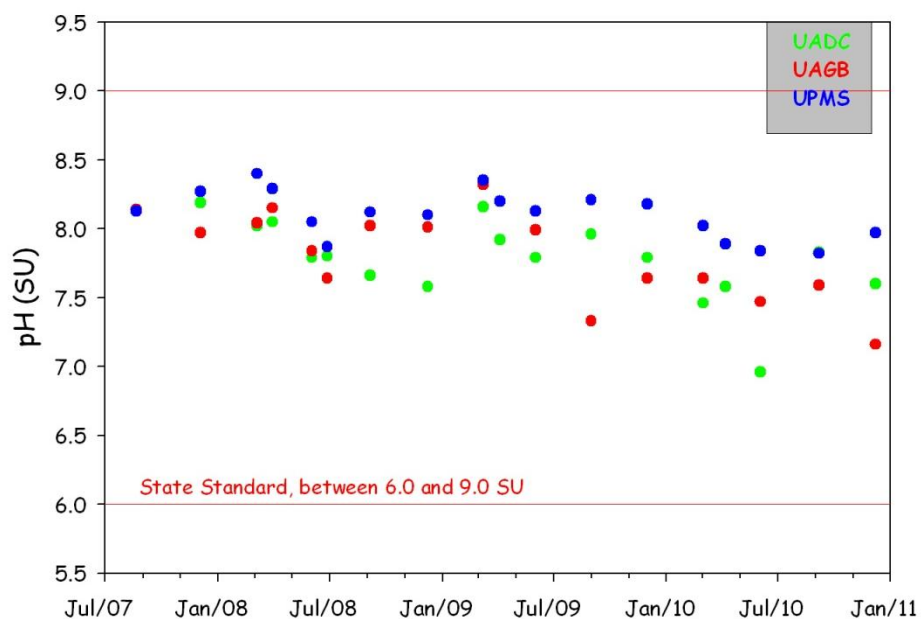


Figure 9. pH at VICK, August 2007 through December 2010 (n = 53).

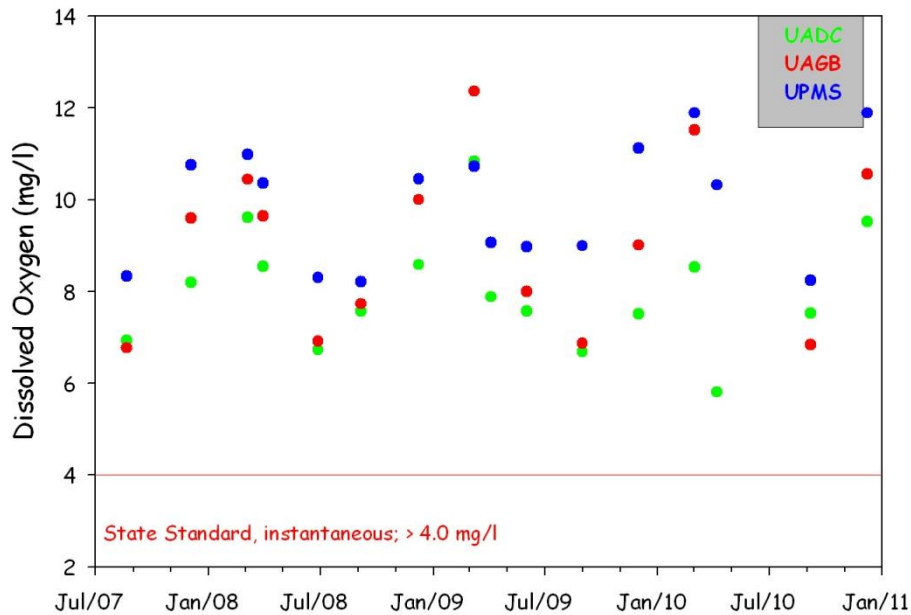


Figure 10. Dissolved Oxygen at VICK, August 2007 through December 2010 (n = 47).

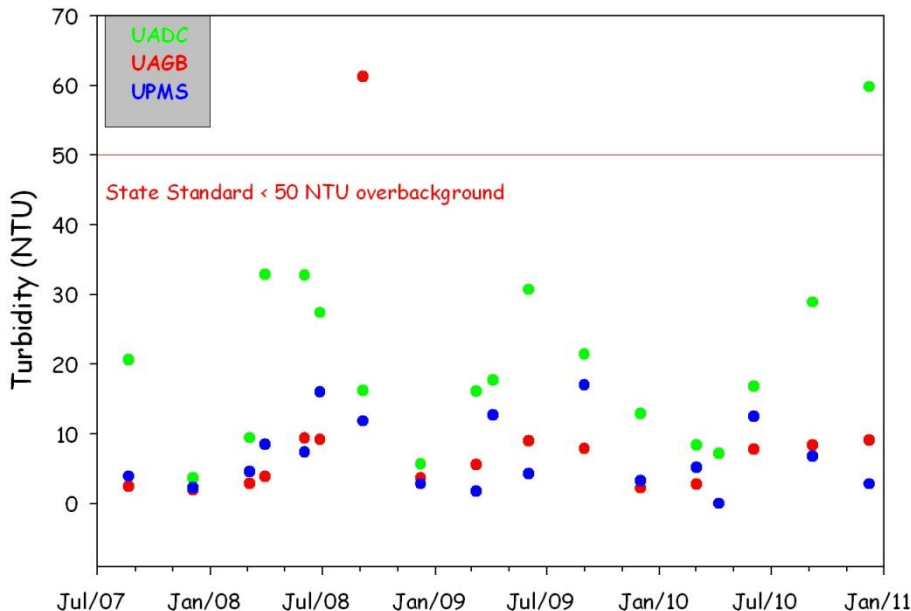


Figure 11. Turbidity at VICK, August 2007 through December 2010 (n = 53).

Continuous Recording Results

Continuous data records during the course of rainfall events are of particular use in determining the maxima or minima of water quality parameters and, as such, routinely describe conditions at the upper end of the flow continuum. From a practical, park-management perspective, these data provide a record of water quality conditions before and after a land-use change — landscape restoration for example. Selected graphs of continuous data demonstrate diurnal and event-driven variations in core water quality parameters. Continuous data also serve to place periodic grab samples in context with diurnal and event fluctuations. For example, a dissolved oxygen reading taken at 0900 hours may be quite different than a reading taken at 1300 due to the oxygen dynamics of a particular stream.

Turbidity is particularly sensitive to rainfall events, as it is an indirect measure of suspended sediment. Determining water quality violations for turbidity is difficult. The state of Mississippi has set a standard that turbidity shall not exceed 50 NTU above “natural conditions.” MDEQ (2007) defines natural conditions as “background water quality conditions due only to non-anthropogenic sources. The criteria herein apply specifically with regard to substances attributed to sources (discharges, nonpoint sources, or instream activities) as opposed to natural phenomena. Waters may naturally have characteristics outside the limits established by these criteria. Therefore, naturally occurring conditions that fail to meet criteria should not be interpreted as violations of these criteria.” Part of this monitoring effort was to establish background conditions.

The park's steep terrain and highly erodible loess soils combine to create a very high potential to transport fine sediments during rainfall events. During low flow, background turbidity of VICK streams was between 0 and 10 NTU (see Figure 11). As flow increases, runoff washes sediment into streams and in-stream sediments are entrained in the higher velocities. Streams change from clear (turbidity <10 NTU) to over 1,000 NTU within a matter of minutes during intense rainfall (Figure 12). Note the upper range of the turbidity sensor is 1,000 NTU. Also of note is that hourly precipitation data used in the 2009 graph was not collected within the individual watersheds or the park but at Vicksburg-Tallulah Regional Airport.

The lack of a proximal rain gage makes it impossible to accurately interpret these data. Some, but not all, rainfall events produce a stage/turbidity response, and likewise, not all stage/turbidity responses are observed in the rainfall record. Just because it rains at the Vicksburg-Tallulah Regional Airport does not mean it rained at Vicksburg Military Park, or vice-versa. The prolonged turbidity event at Durden Creek on March 19, 2009, suggests a rainfall event at the park and not at the airport, for example. The short-lived turbidity spikes at Durden Creek, especially prevalent towards the end of the record, are interesting. Only two appear associated with rainfall events. While it is possible that these are a series of rainfalls not recorded at the airport, it is also possible that a local anthropogenic action is the cause of these spikes as the entire watershed upstream of the sampling site is in the park.

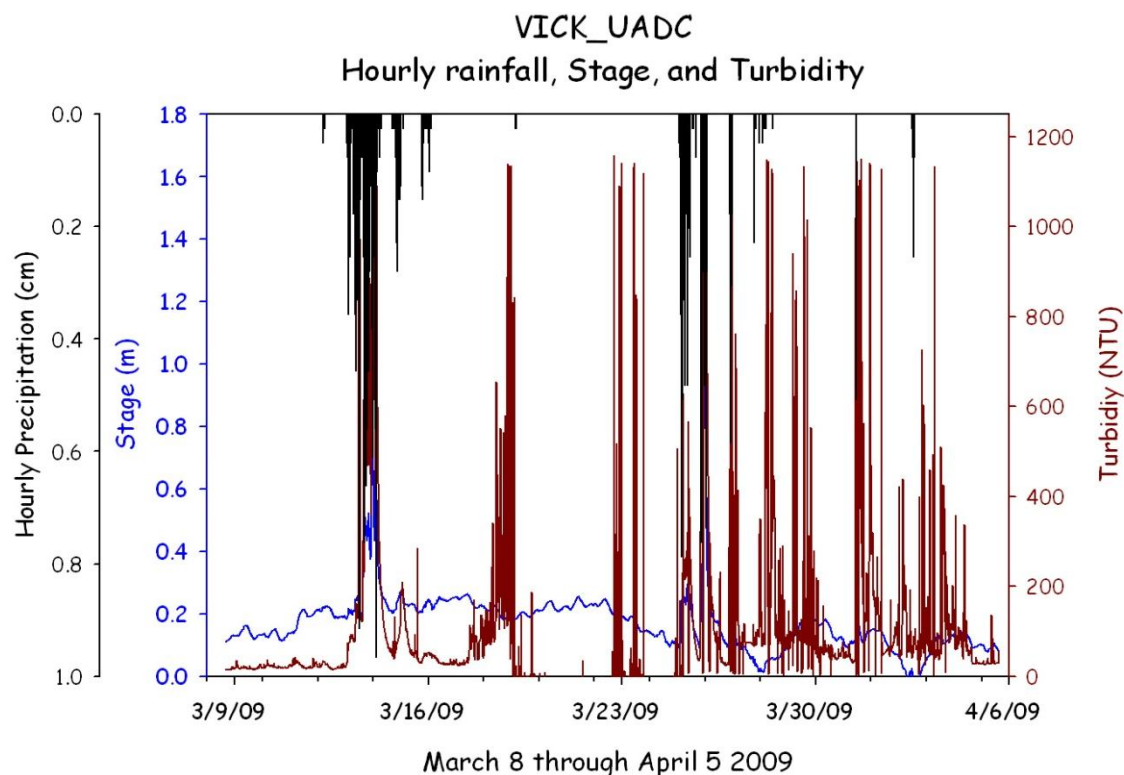


Figure 12. Hourly rainfall, stage, and turbidity at Durden Creek (VICK_UADC), March 8, 2009, through April 5, 2009 (n ~ 2,686).

To eliminate assumptions, a tipping bucket rain gauge was installed in the headwaters of Mint Spring Bayou for the 2010 record. SpC data is overlain with the turbidity and rainfall to denote runoff-producing rainfall events — that is, a sudden drop in SpC marks the arrival of low-conductance rainwaters at the monitoring site (Figure 13). From these data we see that not all rainfall causes runoff and not all turbidity spikes are associated with rainfall. There are two likely sources of non-precipitation turbidity spikes: human or feral pig disturbance. Signs of human traffic, as evident by footprints, is commonly found in Mint Spring Bayou, and feral hogs were known to be within the watershed during this period, both mechanisms capable of muddying the water.

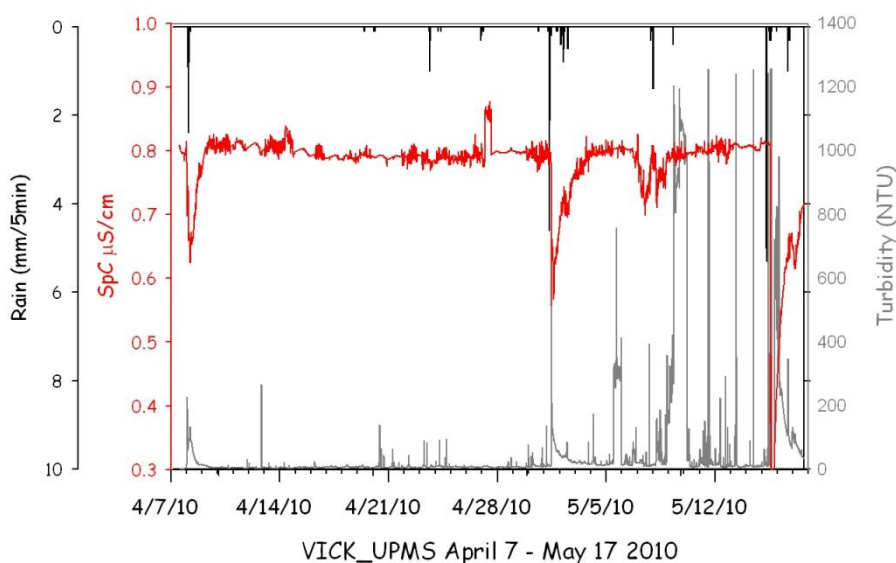


Figure 13. Turbidity and SpC response at Upper Mint Spring Bayou (VICK_UPMS), April 7, 2010, through May 17, 2010 (n ~ 3,858).

Exceedance of surface water quality standards typically occur during rainfall (runoff) events where contaminants are washed into streams, or after a period of drought. Figure 14 shows the continuous records for temperature, SpC, pH, and DO at Upper Mint Spring Bayou during late winter 2008. Each rainfall event is clearly indicated by sudden decline in SpC as longer-residing waters high in dissolved ions are displaced by lower ion-strength waters of the rainfall event. An identical response is seen in pH as the more acidic waters of the rainfall event flush the more alkaline antecedent stream waters. Water temperature and DO rise and fall in diurnal patterns, reflecting surface temperature and biological activity. At no point were state water quality standards exceeded during this period of record.

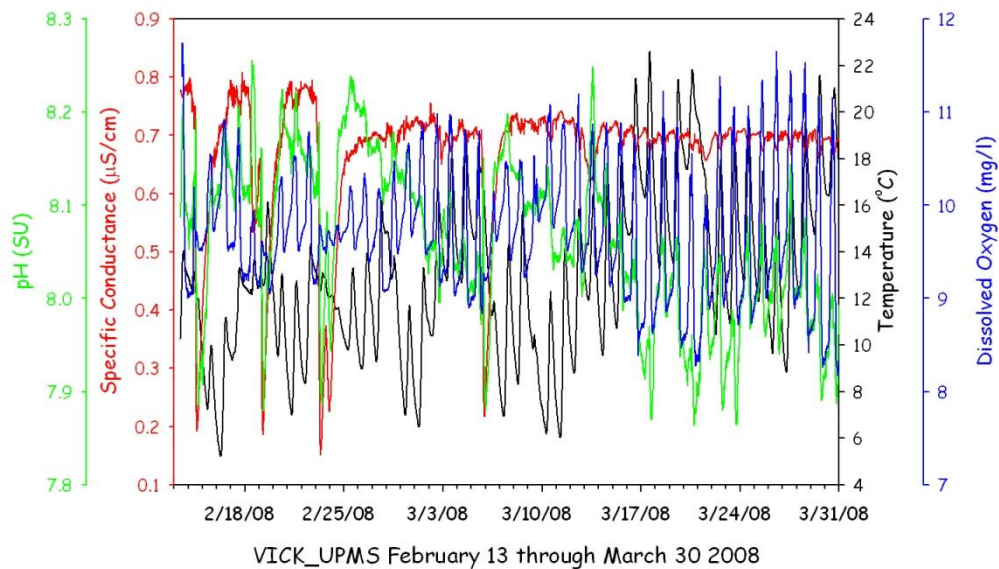


Figure 14. pH, SpC, temperature, and dissolved oxygen response at Upper Mint Spring Bayou (VICK_UPMS), February 13, 2008, through March 30, 2008 (n ~ 4,600).

A slightly different response was observed at Durden Creek during the 2009 datasonde deployment (Figure 15). Each rainfall event caused a very brief increase in SpC. This may be due to the ephemeral tendencies of Durden Creek compared with the other two streams. Ephemeral pools associated with Durden Creek are flushed during rainfall events and long residing waters in the pools are displaced in advance of the lower SpC runoff. This response is identical to that seen in cave streams of Mammoth Cave National Park. The longer water is in contact with rock (in both cases, limestone), the more rock is dissolved and the higher the SpC. Long-residing waters that collect in isolated pools are pushed out on the leading edge of the storm pulse. Like the Mint Spring record, there are no violations of state water quality standards during this period at Durden Creek.

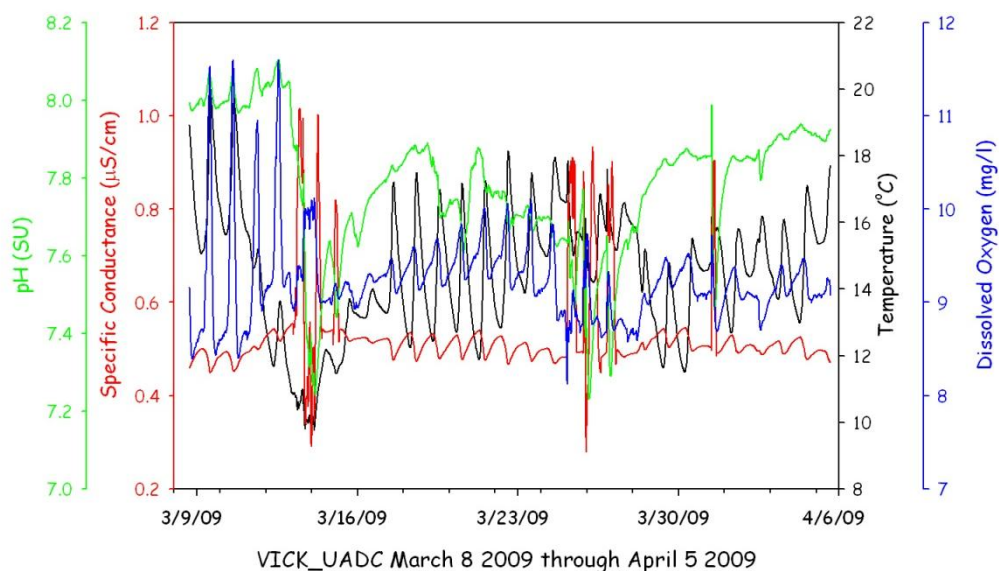


Figure 15. pH, turbidity, temperature, and dissolved oxygen at Durden Creek (VICK_UADC), March 8, 2009, through April 5, 2009 (n ~ 2,686).

Summary

Water quality at Vicksburg National Military Park is good. Quarterly non-conditional synoptic grab sampling and continuous data records have yet to document exceedances of MDEQ surface water quality standards for the Fish and Wildlife designated-use category. Occasional spikes in turbidity that are not linked to rainfall events are most likely caused by park operations, foot traffic, or feral hogs. These spikes are within the natural range of turbidity following a storm event.

The GULN will continue quarterly water quality monitoring at the park in cooperation with park staff. If any questions regarding the hydrology or water quality of the park arise, the GULN hydrologist should be contacted. As a final note, thanks are given to the staff of Vicksburg National Military Park for their support in this monitoring effort and, in particular, to Natural Resources Specialist Virginia DuBow, who performed quarterly monitoring and deployed multiparameter datasondes.

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