New River Gorge National River
Bluestone National Scenic River
Gauley River National Recreation Area

National Park Service
U.S. Department of the Interior

Water Quality Monitoring Program 2007-2008
New River Gorge National River
Bluestone National Scenic River
Gauley River National Recreation Area

Jesse M. Purvis

September 2009

New River Gorge National River was established by Public Law (PL) 95-625 on November 10, 1978. The park was created to conserve and interpret outstanding natural values and objects, and to preserve an important segment of the New River as a free-flowing stream for the benefit and enjoyment of present and future generations.

Gauley River National Recreation Area was established on October 26, 1988 by PL 100-534. The park was created to protect and preserve scenic, recreational, geological, and fish and wildlife resources of the Gauley River and its tributary, the Meadow River.

The legislation that established Gauley River National Recreation Area also made boundary adjustments to New River Gorge National River, and amended the Wild and Scenic Rivers Act (16 USC 1274(a)), to designate Bluestone National Scenic River. This designation was made to protect and enhance the natural, scenic, cultural and recreational values of a free-flowing segment of the Bluestone River for the benefit and enjoyment of present and future generations.

Water Quality Monitoring for New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area in 2007 and 2008

Jesse M. Purvis

United States Department of the Interior
National Park Service
Glen Jean, West Virginia

September 2009

The use of trade or product names in this report is for identification purposes only and does not constitute or imply endorsement by the U. S. Government.

For additional information please contact:
National Park Service
New River Gorge National River
P. O. Box 246
104 Main Street
Glen Jean, WV 25846
304-465-0505
www.nps.gov/neri

EXECUTIVE SUMMARY

This report presents the results of baseline water quality monitoring for New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area during 2007 and 2008. Baseline monitoring is designed to produce a long-term estimate of average conditions.

The three river-based West Virginia units of the National Park System (parks) provide some of the most popular water-based recreation in the eastern United States. New River Gorge National River supports the best warm water fishery in West Virginia.

Appalachia's a long history of impoverishment today is reflected in infrastructure that is often inadequate. Sewage treatment is absent or woefully substandard in many areas, including the vicinity of the three parks. Early water quality surveys in the area of the three parks identified fecal pollution from inadequate sewage treatment as the most significant issue. To address this the National Park Service began a water quality monitoring program to determine the extent of the problem as it might affect park resources.

This report describes the continuing results of this program. The National Park Service uses this data to inform the public, regulators and decision makers of the extent of sewage-related water quality problems surrounding the three parks. This effort has led to a better informed public, and the commitment of effort and funding that are working towards improving local water quality.

For more information about the water quality monitoring program, or other park aquatic resource issues, please contact the author at 304-465-0508.

ACKNOWLEDGEMENTS

Access or assistance was provided by the United States Army Corps of Engineers (Bluestone Dam); United States Geological Survey (West Virginia Water Science Center); West Virginia Department of Environmental Protection; ACE Adventure Center, CSX Corporation, the Nuttall Estate, the Terreo family, and Dennis Richmond.

Completing this report benefited from many specialists, interns, and volunteers at New River Gorge National River. Andy Steel produced the maps. Field and laboratory work was accomplished by Lisa Wilson and Kathy Oney. Lisa Wilson's assistance was crucial in making the final version accurate. Any mistakes which remain are solely the fault of the author.

Cover photograph by Karen Vandersall.

Additional thanks are extended to staff from other Divisions at New River Gorge National River and other individuals whom we may have neglected to mention.

CONTENTS

Introduction and Methods
- Water Quality Monitoring Program 1
- The 2007-2008 Effort 3

Results 7
- Bluestone National Scenic River 11
- New River Gorge National River 17
- Gauley River National Recreation Area 43

Discussion
- Program Changes in 2007 49
- Madam Creek 50
- Arbuckle Creek 51
- Keeney Creek 53

Literature Cited 55

This page intentionally left blank

INTRODUCTION and METHODS

WATER QUALITY MONITORING PROGRAM

This report summarizes baseline water quality monitoring efforts by the National Park Service (NPS) in Bluestone National Scenic River (BNSR), New River Gorge National River (NRGNR) and Gauley River National Recreation Area (GRNRA) in 2007 and 2008. This work continues an effort focusing on fecal coliform bacteria, an indicator of sewage pollution, that began in 1980. The history of NPS water quality monitoring for the three parks is summarized in a previous report (Wilson and Purvis 2003).

Fecal coliform bacteria live in the lower gut of warm-blooded animals and are excreted with the feces. Fecal coliforms are not necessarily pathogenic (disease-causing). However, other microorganisms that are pathogenic also live in the lower gut and are also excreted with the feces. Fecal coliforms are relatively easy to detect, and thus serve as an indicator of fecal pollution, and hence potential pathogenic conditions related to sewage pollution. Fecal coliforms are the basis for the West Virginia standard for primary contact recreational waters. This standard is that fecal coliforms not exceed 200 per 100 milliliters (200 FC/100ml) of water (West Virginia Water Resources Board 1998). This standard is based on the geometric mean (a kind of average) of at least five samples a month. Alternately, waters should not exceed 400 FC/100ml in more than 10% of samples taken in a month.

The study area is described in previous reports (e.g. Wilson *et al*. 2006). New River Gorge National River is part of the Kanawha-New River watershed (Fig. 1). The New River begins in the North Carolina Blue Ridge Mountains and flows generally north for 250 miles through Virginia and West Virginia. The Bluestone and Greenbrier Rivers, the two major tributaries to the New River, both enter within a few miles of each other near Hinton, West Virginia. The New River joins the Gauley River at Gauley Bridge, West Virginia to form the Kanawha River. The Kanawha River flows northwest to the Ohio River at Point Pleasant, West Virginia.

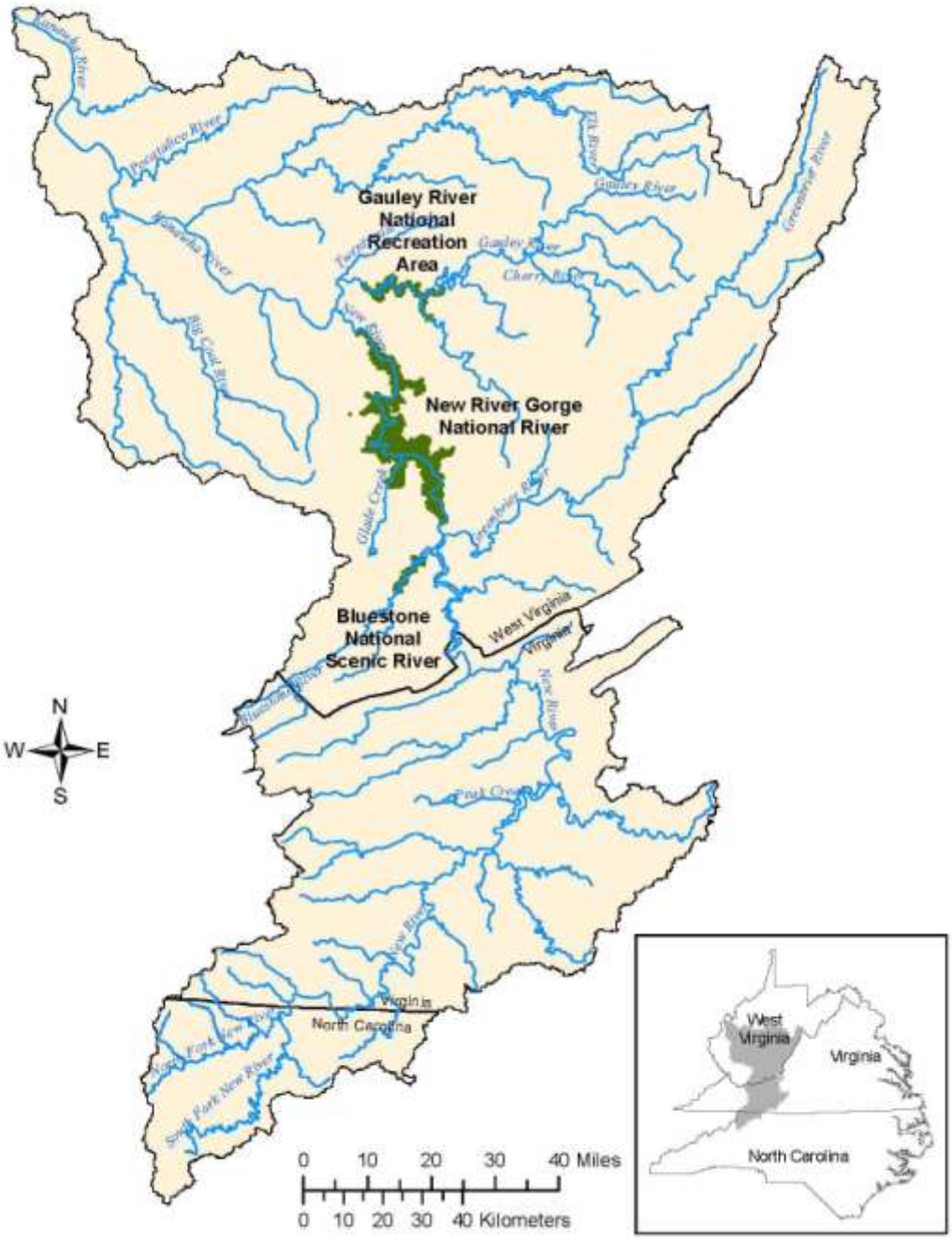

Figure 1. Location of Bluestone National Scenic River, New River Gorge National River, and Gauley River National Recreation Area in Kanawha-New River watershed.

New River Gorge National River includes 53 miles of New River, beginning at Hinton and ending near Fayetteville. Bluestone National Scenic River includes the lower 10.5 miles of Bluestone River between Bluestone and Pipestem State Parks. Gauley River National Recreation Area begins just below Summersville Dam near Summersville, West Virginia, and ends near the community of Swiss, West Virginia. This park includes 25 miles of the Gauley River, and the lower 5.5 miles of the Meadow River.

Several reports summarize earlier water quality monitoring efforts (West Virginia Department of Natural Resources 1988, 1989; Wood 1990a, b, c; Schmidt and Hebner 1991; Hebner 1991; Sullivan 1993a, b; Gibson 1993; Purvis and Wilson 1999; Wilson and Purvis 2000, 2003, Wilson *et al*. 2006, Purvis and Wilson 2007).

THE 2007-2008 EFFORT

Examination of previous data indicated that many streams were well sampled, but others were poorly sampled. To fill in these data gaps, beginning in 2007 we added 12 New River tributaries to our monitoring program. In order to add these streams, monitoring in some well sampled streams was temporarily suspended.

Data were collected at 5 sites in BNSR (Figure 2), 25 sites in NRGNR (Figure 3), and 5 sites in GRNRA (Figure 4). Within NRGNR, three sites were on New River and 22 were on tributaries. For BNSR three sites were on Bluestone River and two were on tributaries. For GRNRA, three sites were on Gauley River, one was on Meadow River, and the other was on a smaller tributary of Gauley River.

Water samples were collected between May and October and analyzed for fecal coliform bacteria by NPS staff at the NPS Water Quality Laboratory at park headquarters according to standard methods (e.g. Bordner *et al*. 1978, American Public Health Association 1992). Details on these routines are described in an earlier report (Wilson *et al*. 2006).

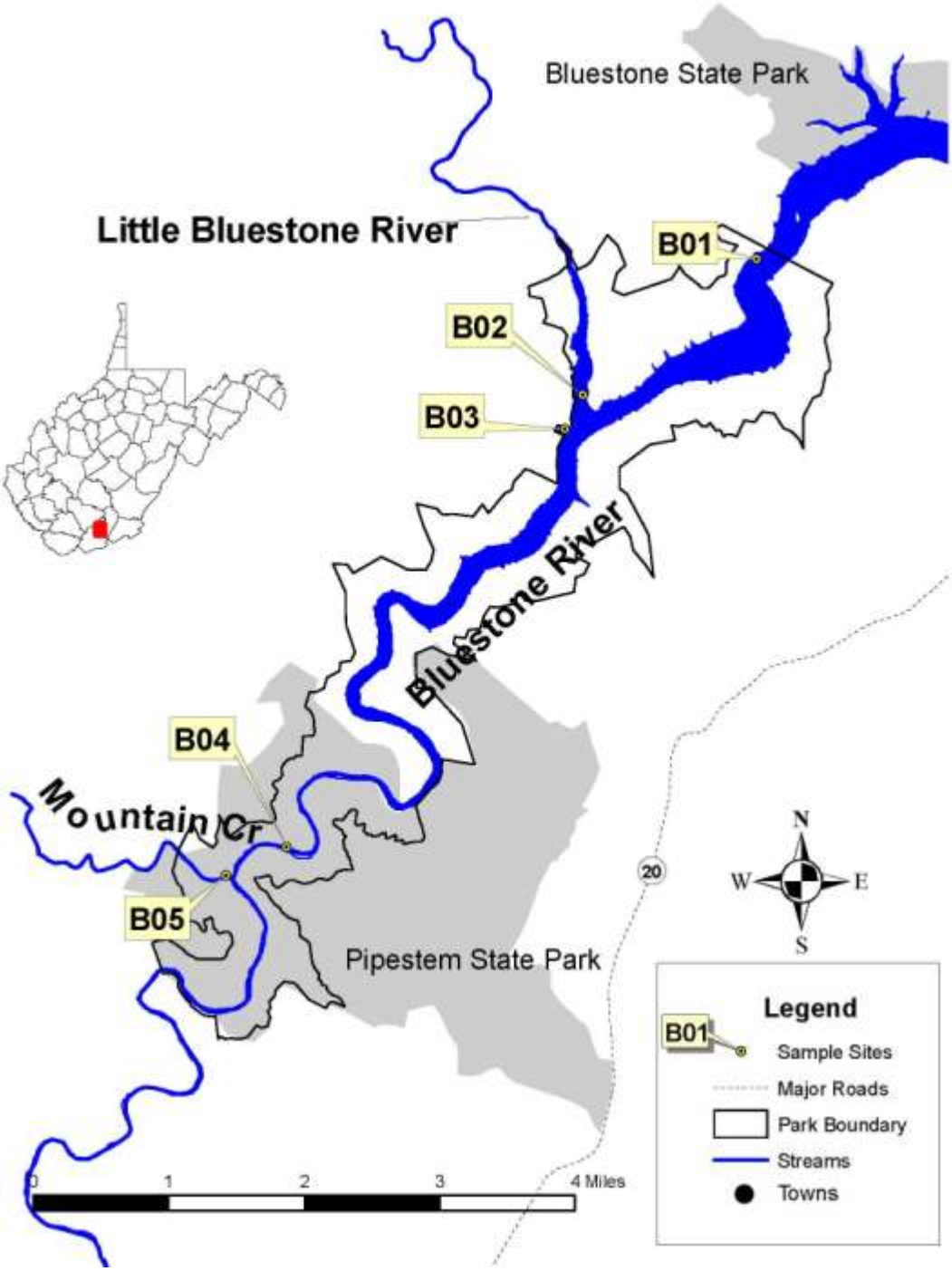

Figure 2. Bluestone National Scenic River water quality monitoring sites.

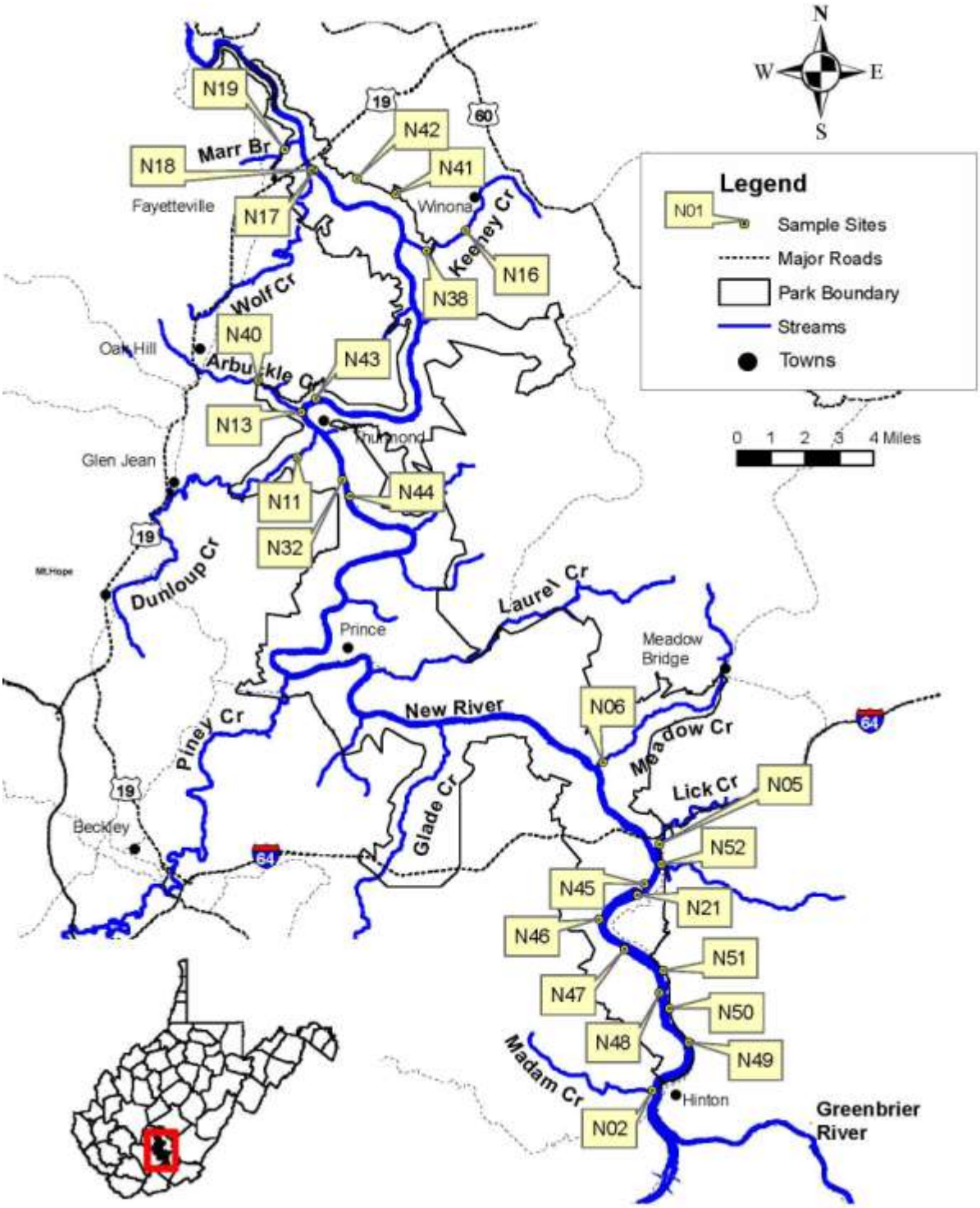

Figure 3. New River Gorge National River water quality monitoring sites.

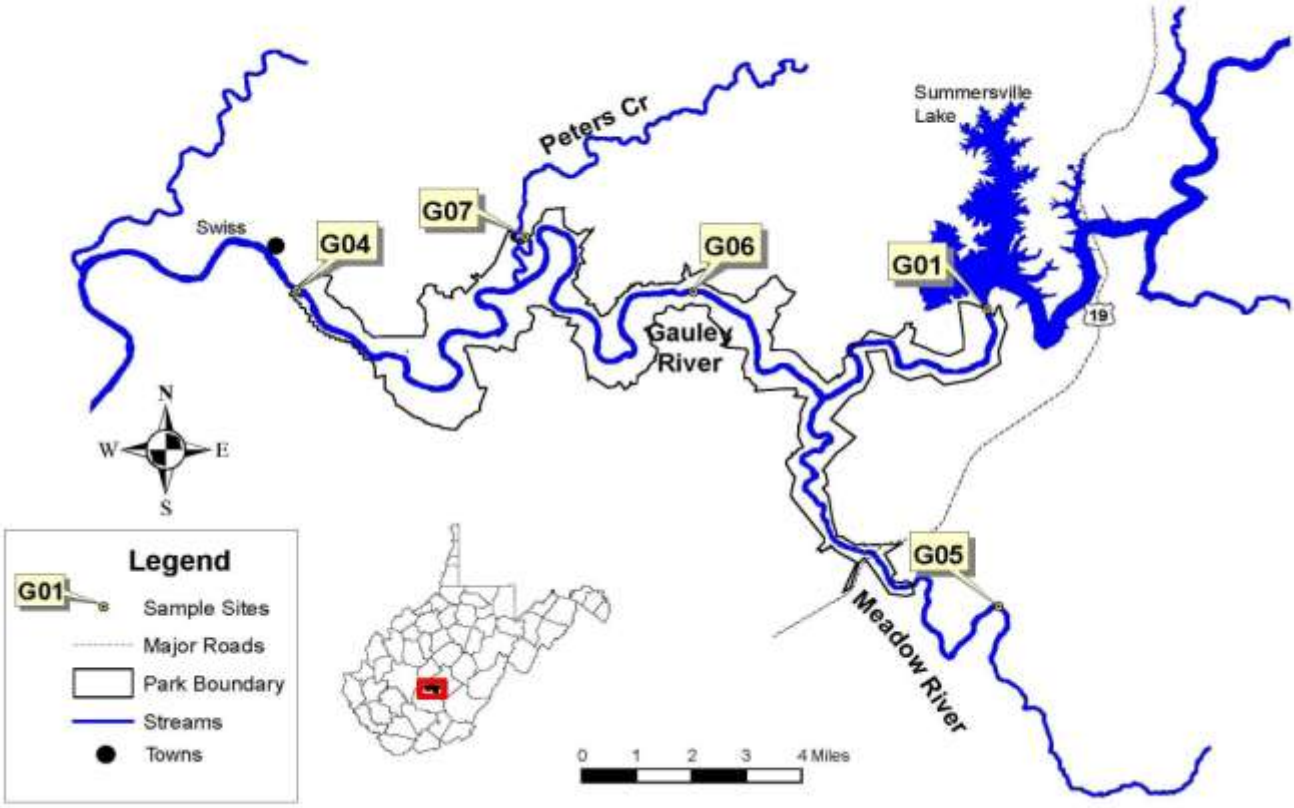

Figure 4. Gauley River National Recreation Area water quality monitoring sites.

RESULTS

This section is organized in a downstream direction. Information on Bluestone National Scenic River is presented first, followed by New River Gorge National River and Gauley River National Recreation Area. Results are also presented in downstream direction within each park, except that mainstem information is presented first, followed by information from the tributary streams.

One page is provided for the results from each sampling site. At the top of the page is the site name, followed by a unique site number. These are the same numbers used in Figures 2-4. Underneath the names is a color-coded box containing a quick summary noting the frequency that the site exceeded 200 fecal coliforms per 100 milliliters of water (the West Virginia fecal coliform standard for contact recreation), both in the period covered by this report, and since monitoring began at the site.

These sites do not exceed the West Virginia standard more than 10% of the time, either historically or in 2007-2008.
These sites exceed the West Virginia standard more than 10% of the time but no more than 25% of the time, either historically or in 2007-2008.
These sites exceed the West Virginia standard more than 25% of the time, either historically or in 2007-2008.
These sites were recently added to the monitoring program, so reliable estimates of their water quality are not yet available.

Following the boxes is a brief description of the sample location, and its relation to other sampling locations and U. S. Geological Survey (USGS) stream gages. These gages include (with their full title and USGS number):

- Pipestem (Bluestone River near Pipestem; 03179000),
- Greenbrier (Greenbrier River at Hilldale; 0318400),
- Hinton (New River at Hinton; 03184500),
- Thurmond (New River at Thurmond; 03185400),

- Summersville Dam (Gauley River below Summersville Dam; 03189600),
- Belva (Gauley River above Belva; 03192000), and
- Meadow River (Meadow River near Mount Lookout; 03190400).

Stream gage data is published annually by the USGS. The 2007 data is available at http://wdr.water.usgs.gov/wy2007/search.jsp and the 2008 data is available at http://wdr.water.usgs.gov/wy2008/search.jsp.

A short paragraph describes the range and average values of fecal coliform bacteria density during 2007-2008. Three averages – the (arithmetic) mean, the geometric mean and the median – are used to describe the data. The (arithmetic) mean is the average with which most readers will be familiar. It is calculated by adding the values for all the samples and dividing by the number of samples. The geometric mean is often used in cases where one or a few samples have a much greater value than most of the other samples. Such extreme values often occur in fecal coliform data, so the geometric mean is used in the appropriate West Virginia standard to determine whether or not a site is in compliance with water quality regulations. Geometric means are calculated by taking the logarithm of each value, adding these logarithms, dividing the total by the number of samples, and then taking the anti-logarithm of this result. The median of a set of samples is the value with an equal number of values greater than it and less than it. The median may be a more useful average when the sample size is small and the sampled population is not normally distributed (*i.e.* does not produce the traditional bell-shaped curve).

The different averages can give quite different results. For example, if five samples produced values of 10, 12, 18, 20, and 540, then the arithmetic mean would be 120, the geometric mean 29.7 and the median 18. For some sample sets, the averages can be very close. For example, if the sample set is 10, 12, 14, 18 and 20, then the mean would be 14.8, the median 14, and the geometric mean 14.3. For data sets with an even number of samples, the median is calculated by taking the arithmetic mean of the two samples closest to the middle. For example, if the sample data are 10, 12, 14, 16, 18, and 20, the median would be 15 (arithmetic mean of 14 and 16).

A bar graph shows fecal coliform bacteria densities for each sample. Blue bars indicate samples with bacteria density up to 200 FC/100ml, yellow bars indicate samples with bacteria density greater than 200 but not more than 400 FC/100ml, and red bars indicate samples with bacteria density greater than 400 FC/100ml. The sample fecal coliform bacteria density value is noted above each bar. Note that some graphs have a logarithmic axis for FC/100ml because of the range of values encountered.

This page intentionally left blank

BLUESTONE NATIONAL SCENIC RIVER

BLUESTONE RIVER MAINSTEM

Bluestone River below Mountain Creek, site B04

None of the 5 (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 5).

Since 1991, 17 of 101 (17%) samples exceeded 200 FC/100 ml.

This site is on river left, upstream of Mountain Creek Lodge at Pipestem State Park. The site is about one-half mile upstream of the Pipestem gage. Mountain Creek (see site B05) enters the Bluestone River about 0.7 miles upstream from this site, and an intermittent stream enters the Bluestone River about 0.4 miles upstream.

In 2008 fecal coliform bacteria density ranged from 24 to 151 FC/100ml (mean 52, geometric mean 38, median 26).

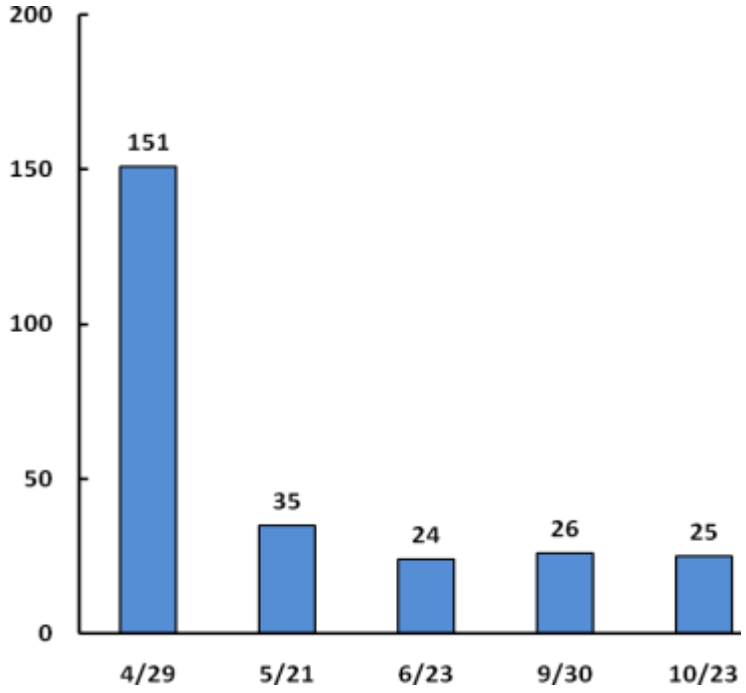

Figure 5. Fecal coliform bacteria density (FC/100ml) at Bluestone River below Mountain Creek (B04) site during 2008.

Bluestone River above Little Bluestone River, site B03

One of the five (20%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 6).

Since 1991, 10 of 90 (11%) samples exceeded 200 FC/100 ml.

This site is on river left upstream of the confluence of the Bluestone and Little Bluestone Rivers. The site is about 5.4 miles downstream of the Pipestem gage and 5.9 miles downstream of the Bluestone River below Mountain Creek site (B04). Twelve tributaries (2 perennial and 10 intermittent) enter the Bluestone River between the Pipestem gage and this site.

In 2008 fecal coliform bacteria density ranged from 4 to 380 FC/100 ml (mean 92, geometric mean 29, median 26).

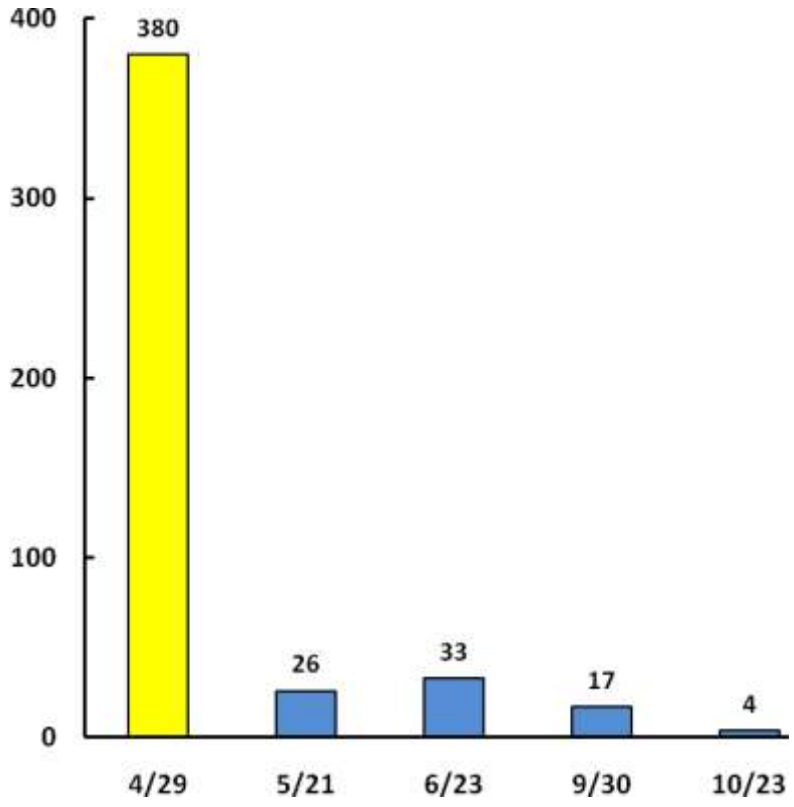

Figure 6. Fecal coliform bacteria density (FC/100ml) at Bluestone River above Little Bluestone River (B03) site during 2008.

Bluestone River above Mouth, site B01

One of the four (25%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 7).

Since 1991, 18 of 105 (17%) samples exceeded 200 FC/100 ml.

This site is upstream of Bluestone State Park on river left off the Bluestone Turnpike Trail. The site is about 7.5 miles downstream of the Pipestem gage, 8.0 miles downstream of the Bluestone River below Mountain Creek site (B04), and 2.1 miles downstream of the Bluestone River above Little Bluestone River site (B03). Twenty tributaries (3 perennial and 17 intermittent) enter the Bluestone River between the Pipestem gage and this site.

In 2008 fecal coliform bacteria density ranged from 5 to 317 FC/100 ml (mean 90, geometric mean 26, median 18).

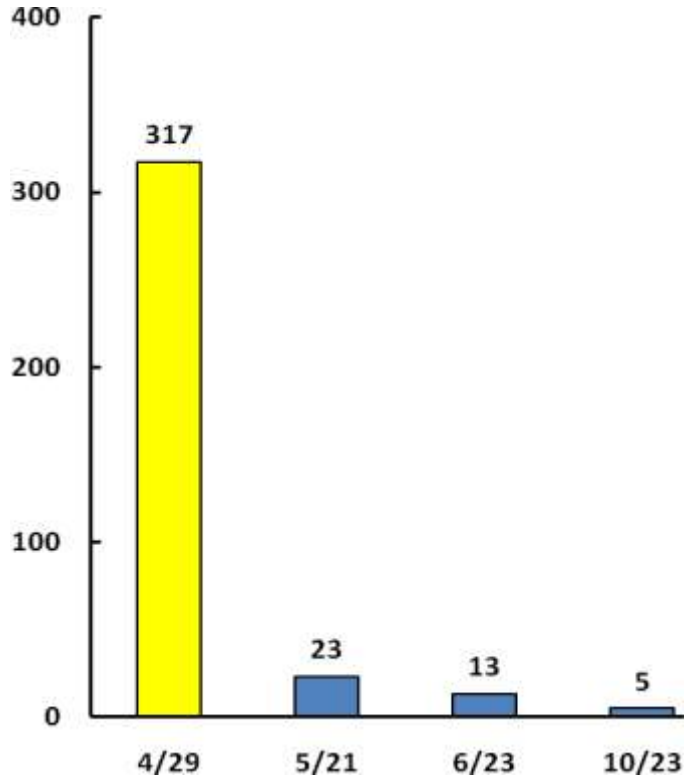

Figure 7. Fecal coliform bacteria density (FC/100ml) at Bluestone River above Mouth (B01) site during 2008.

BLUESTONE RIVER TRIBUTARIES

Mountain Creek, site B05

None of the five (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 8).

Since 1991, 12 of 94 (13%) samples exceeded 200 FC/100 ml.

The site is on stream left, near the mouth of the creek in Pipestem State Park. The site is about 0.7 miles upstream of site B04, Bluestone River below Mountain Creek. Mountain Creek enters Bluestone River 1.2 miles upstream of the Pipestem gage.

In 2008 fecal coliform bacteria density ranged from 3 to 130 FC/100 ml (mean 55, geometric mean 25, median 35).

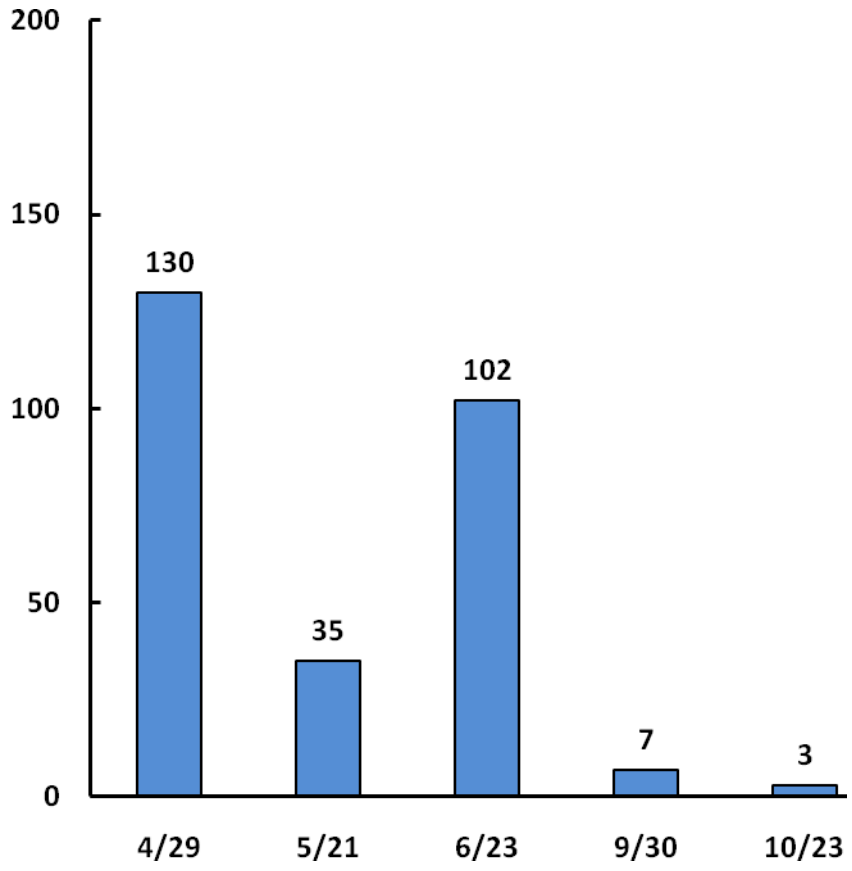

Figure 8. Fecal coliform bacteria density (FC/100ml) at Mountain Creek (B05) site during 2008.

Little Bluestone River, site B02

None of the five (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 9).

Since 1991, 14 of 105 (13%) samples exceeded 200 FC/100 ml.

The site is on river right near the mouth of the stream. The Little Bluestone River enters Bluestone River about 5.4 miles downstream of the Pipestem gage and 2.1 miles upstream of the Bluestone River above Mouth site (B01).

In 2008 fecal coliform bacteria density ranged from 5 to 111 FC/100 ml (mean 42, geometric mean 19, median 9).

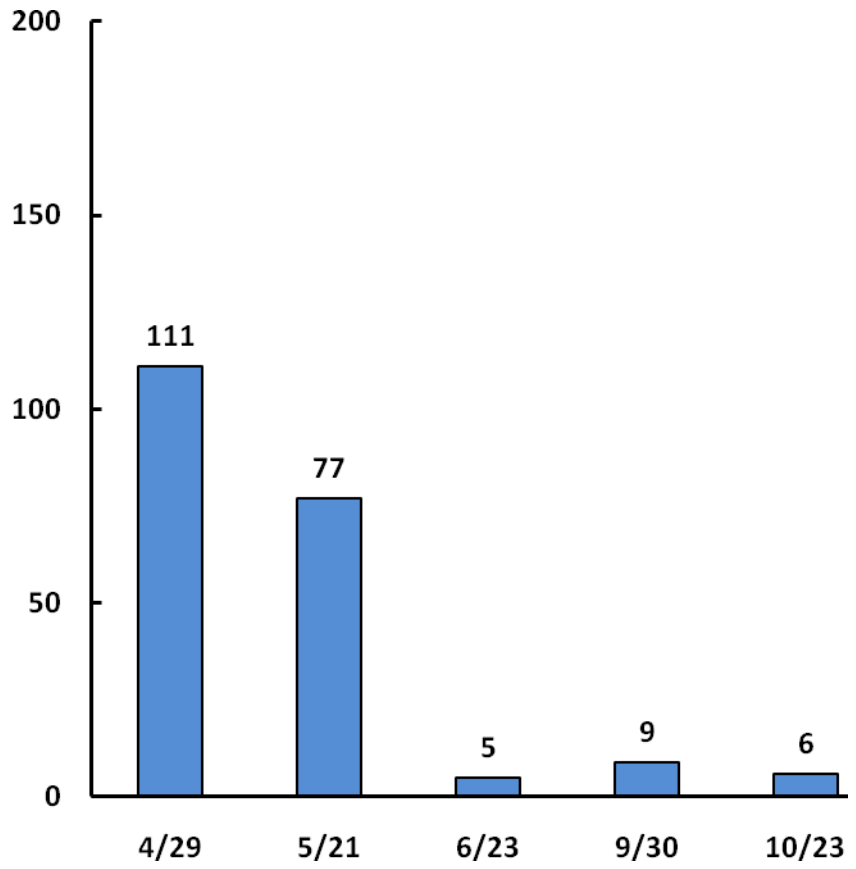

Figure 9. Fecal coliform bacteria density (FC/100ml) at Little Bluestone River (B02) site during 2008.

This page intentionally left blank

NEW RIVER GORGE NATIONAL RIVER

NEW RIVER MAINSTEM

New River below Sandstone Falls, site N21

None of the eleven samples (0%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 10).

Since 1993, 12 of 112 samples (11%) have exceeded 200 FC/100 ml.

This site is on river left below the main falls at the end of the boardwalk at the NPS Sandstone Falls day-use area off State Route 26 (River Road). The site is about 8.0 miles downstream of the Hinton gage and 28.4 miles upstream of the Thurmond gage. There are 25 tributaries (11 perennial and 14 intermittent) between the Hinton gage and this site.

In 2007 and 2008 fecal coliform bacteria density ranged from 13 to 114 FC/100 ml (mean 33, geometric mean 27, median 25).

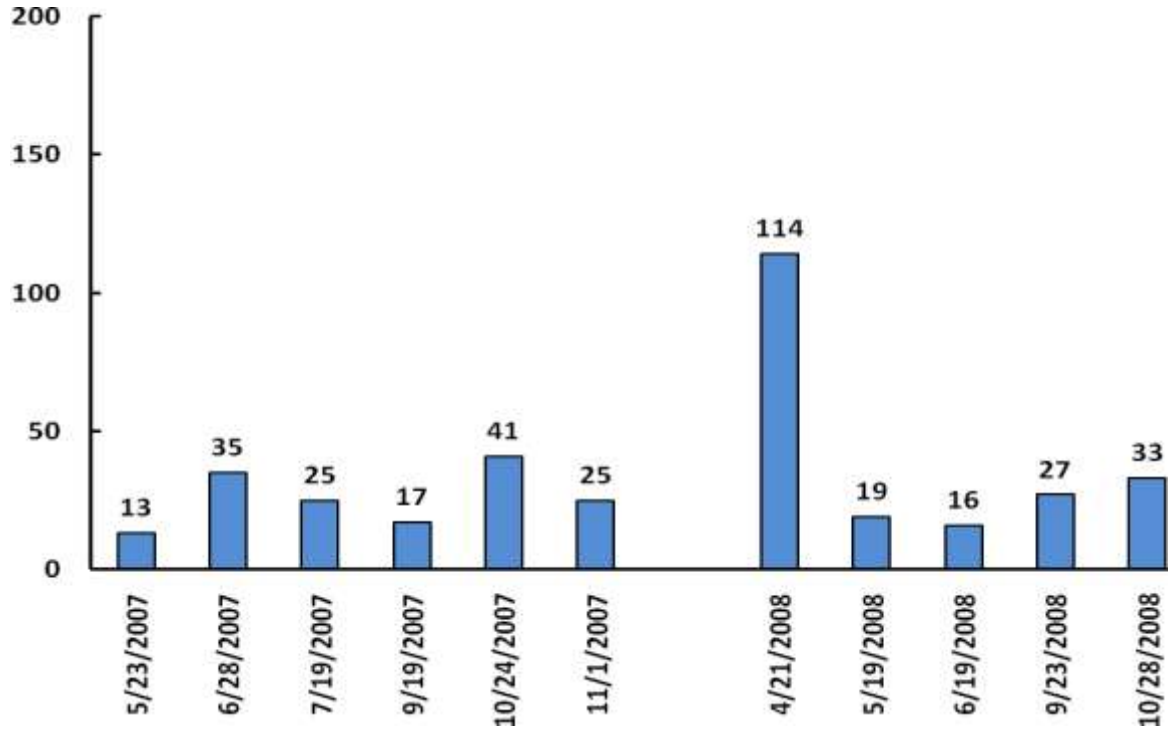

Figure 10. Fecal coliform bacteria density (FC/100ml) at New River below Sandstone Falls (N21) site during 2007-2008.

New River at Stonecliff, site N32

One of the 10 samples (10%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 11).

This site is on river left at the NPS Stonecliff River access. This site is about 1.5 miles upstream of the Thurmond gage and 34.8 miles downstream of the Hinton gage. There are 33 perennial and 34 intermittent tributaries between the Hinton gage and this site. Dunloup Creek, Mollys Creek and two intermittent tributaries enter New River between this site and the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 2 to 345 FC/100 ml (mean 53, geometric mean 10, median 6).

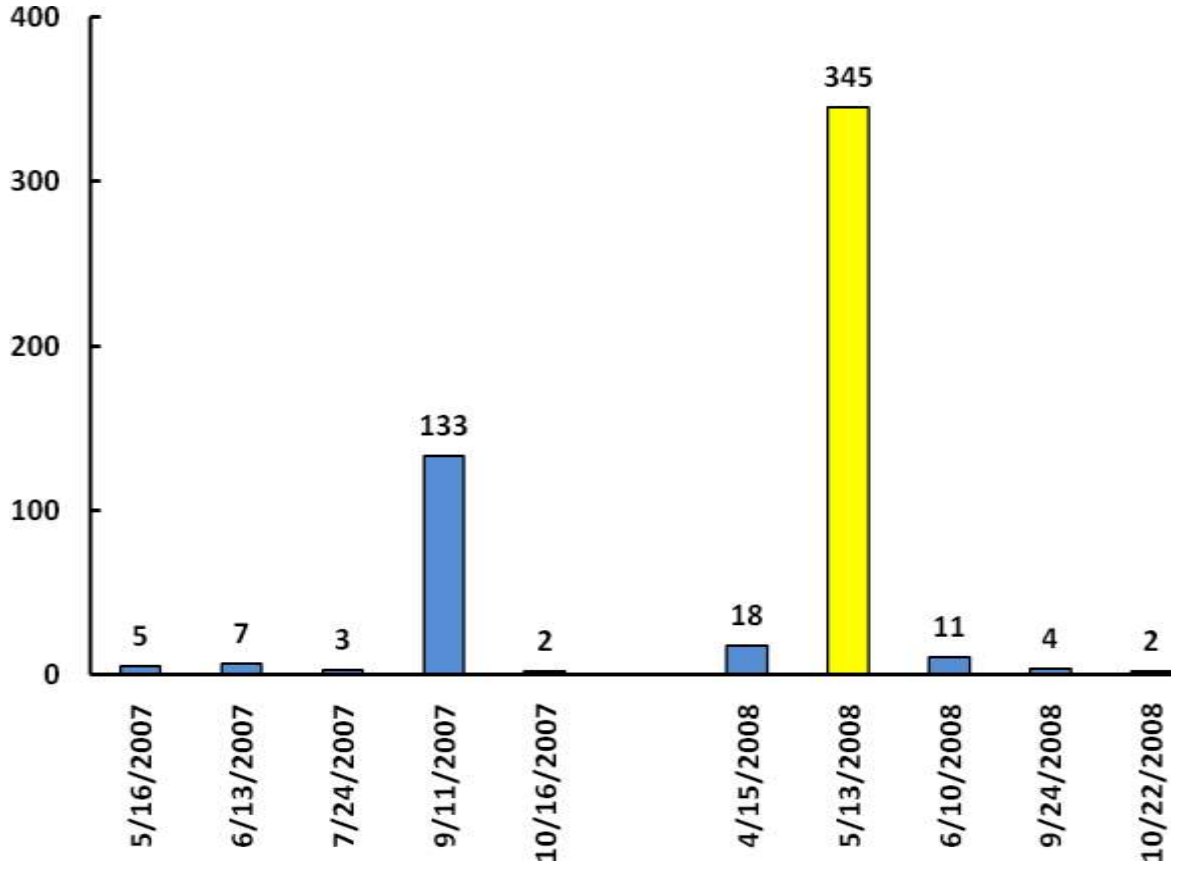

Figure 11. Fecal coliform bacteria density (FC/100ml) at New River at Stonecliff (N32) site during 2007-2008.

New River above Wolf Creek, site N17

None of the 11 samples (0%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 12).

Since 1990, 16 of 141 samples (11%) have exceeded 200 FC/100 ml.

This site is on river left upstream of the mouth of Wolf Creek. It is about 50 miles downstream of the Hinton gage and 13.6 miles downstream of the Thurmond gage. Eighteen tributaries (13 perennial and 5 intermittent) enter New River between the Thurmond gage and this site.

In 2007 and 2008 fecal coliform bacteria density ranged from 2 to 143 FC/100 ml (mean 34, geometric mean 15, median 16).

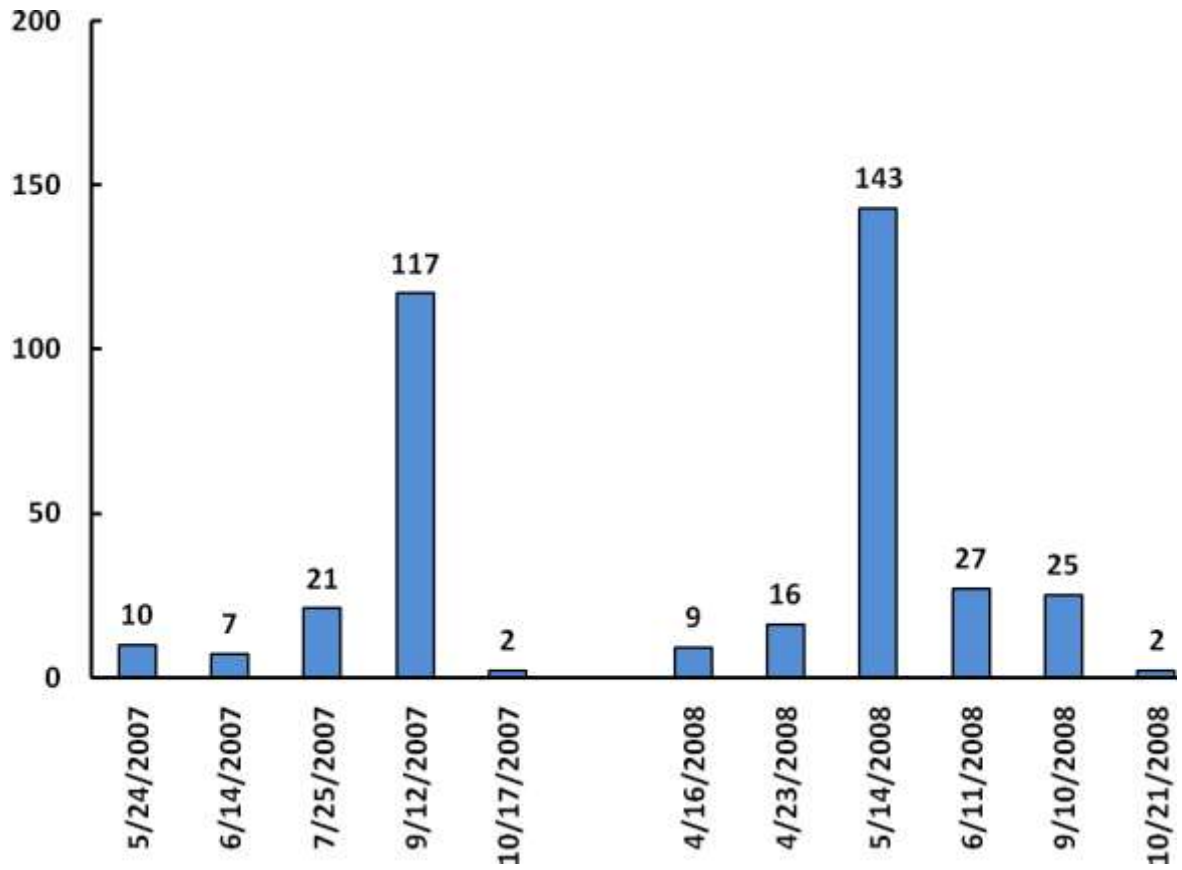

Figure 12. Fecal coliform bacteria density (FC/100ml) at New River above Wolf Creek (N17) site during 2007-2008.

NEW RIVER TRIBUTARIES

Madam Creek, site N02

Four of the 11 (36%) samples collected in 2007 and 2008 exceeded 200 FC/100 ml and for the first time in our monitoring history, none (0%) of the samples exceeded 400 FC/100ml (Fig. 13).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 118 of 132 samples (89%) exceeded 200 FC/100 ml.

This site is on stream left near the mouth of the creek, just downstream of the State Route 26 bridge across the creek. Madam Creek enters New River about 0.2 miles downstream of the Hinton gage and 36.2 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 2 to 382 FC/100 ml (mean 126, geometric mean 63, median 80).

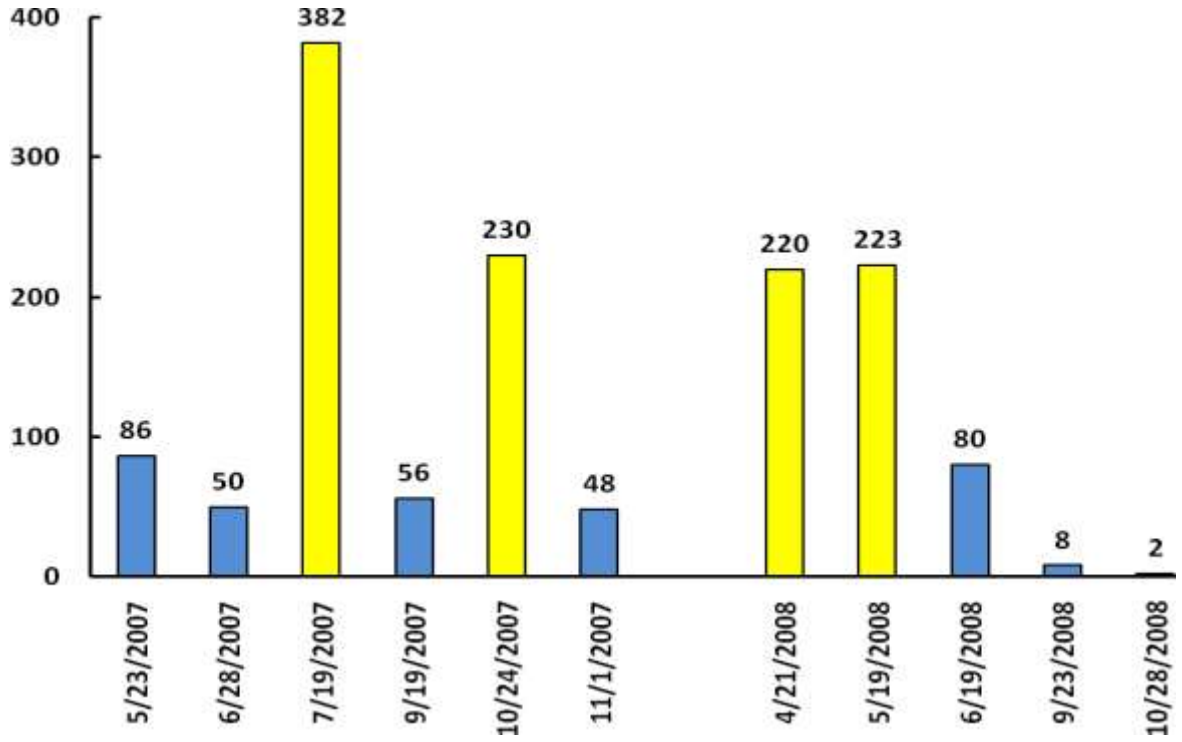

Figure 13. Fecal coliform bacteria density (FC/100ml) at Madam Creek (N02) site during 2007-2008.

Tug Creek, site N49

Nine of the 10 (90%) sample dates anlyzed in 2007 and 2008 exceeded 200 FC/100 ml and six (60%) exceeded 400 FC/100ml (Fig. 14).

Although a new site, the frequency and magnitude of fecal coliform pollution points to the conclusion that water quality at this site is unsatisfactory for contact recreation.

This site is stream left downstream of the railroad tracks and State Route 20. Tug Creek enters New River about 2.1 miles downstream of the Hinton gage and 34.3 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 30 to 5160 FC/100 ml (mean 1200, geometric mean 516, median 470).

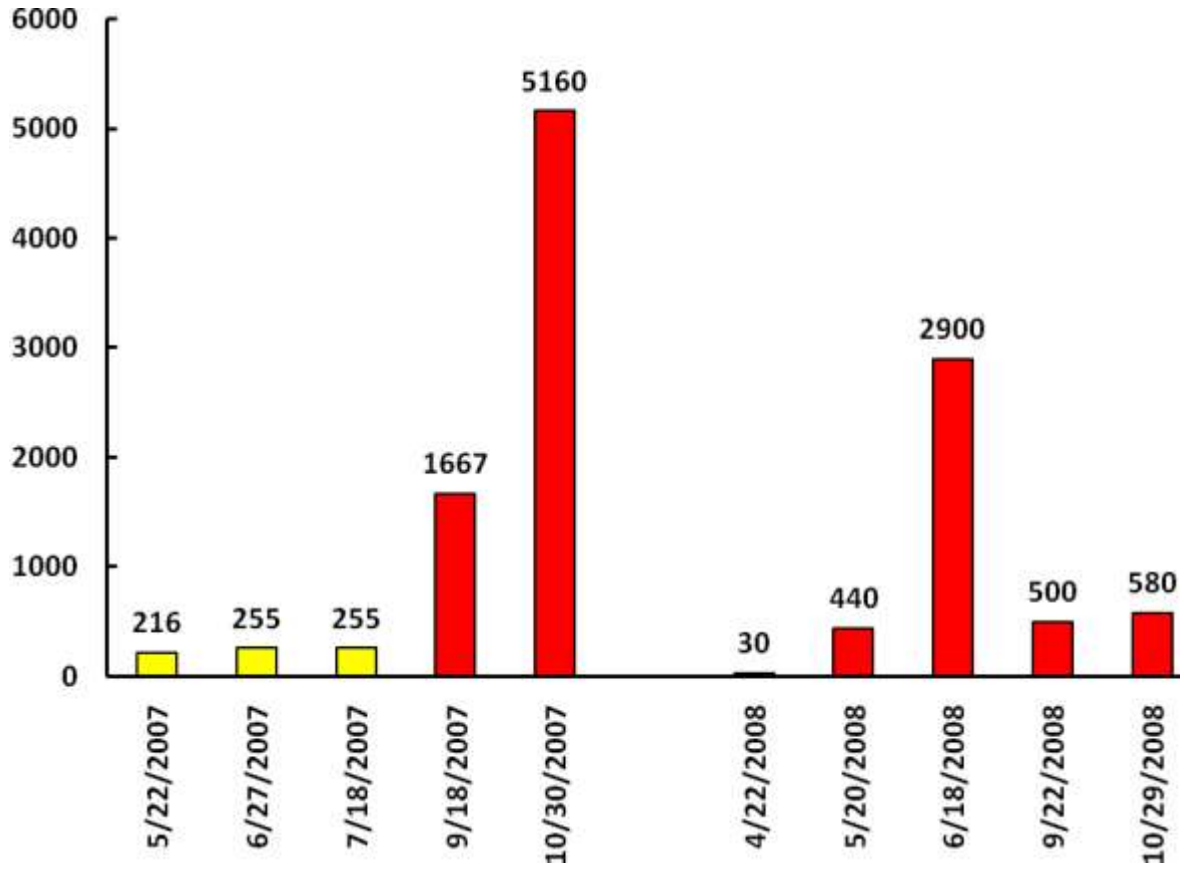

Figure 14. Fecal coliform bacteria density (FC/100ml) at Tug Creek (N49) site during 2007-2008.

Brooks Branch, site N50

Six of the 10 samples (60%) collected in 2007 and 2008 exceeded 200 FC/100 ml and four (40%) exceeded 400FC/100ml (Fig. 15).

Although a new site, the frequency and magnitude of fecal coliform pollution points to the conclusion that water quality at this site is unsatisfactory for contact recreation.

This site is on stream left downstream of the State Route 20 bridge but upstream of the railroad bridge. Brooks Branch enters New River about 3.5 miles downstream of the Hinton gage and 32.9 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 15 to 3150 FC/100 ml (mean 840, geometric mean 253, median 279).

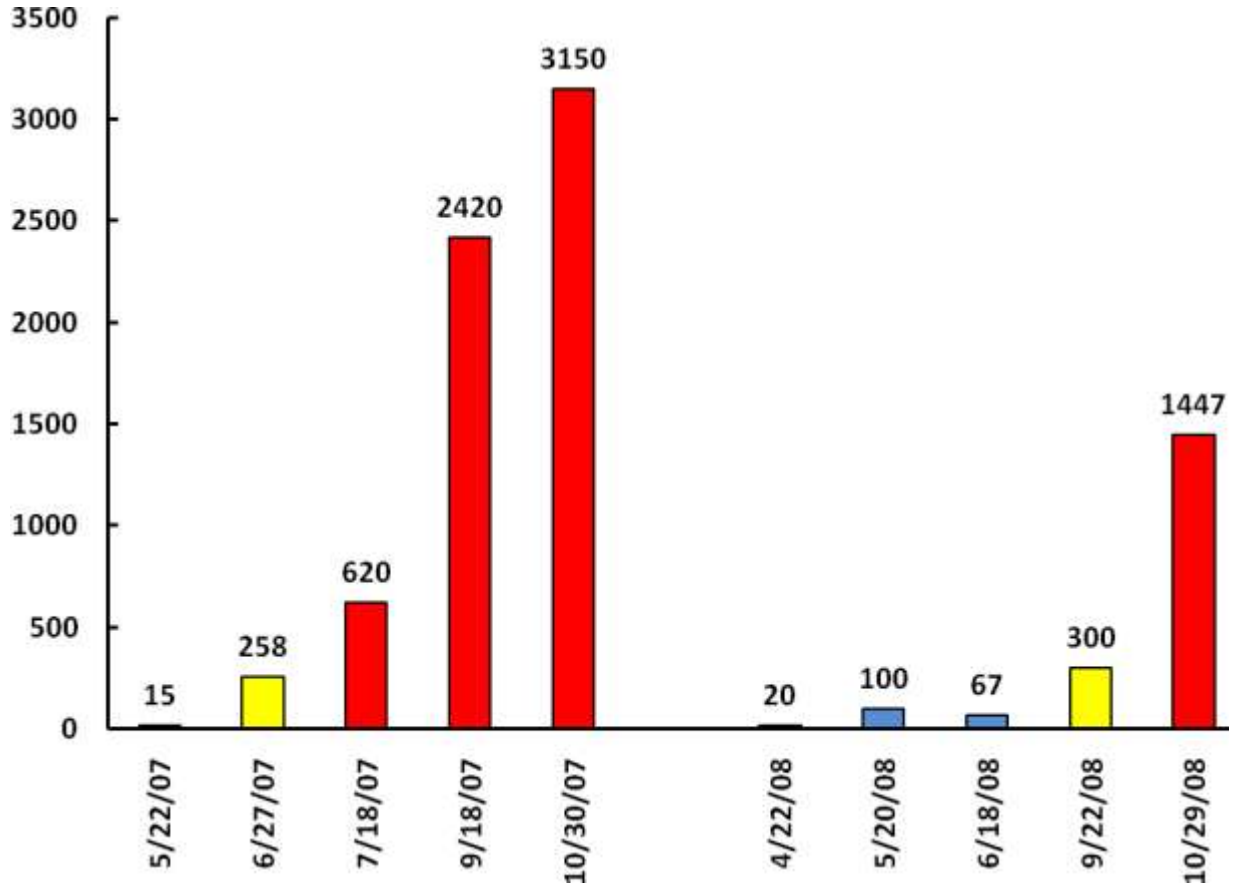

Figure 15. Fecal coliform bacteria density (FC/100ml) at Brooks Branch (N50) site during 2007-2008.

Big Branch, site N48

One of the six samples (17%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 16).

This site is on stream left just upstream of a culvert crossing State Route 26. Big Branch enters New River about 3.9 miles downstream of the Hinton gage and 32.5 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 2 to 250 FC/100 ml (mean 91, geometric mean 41, median 68.5). In spite of its name, this stream is rather small, and dries up in the summer.

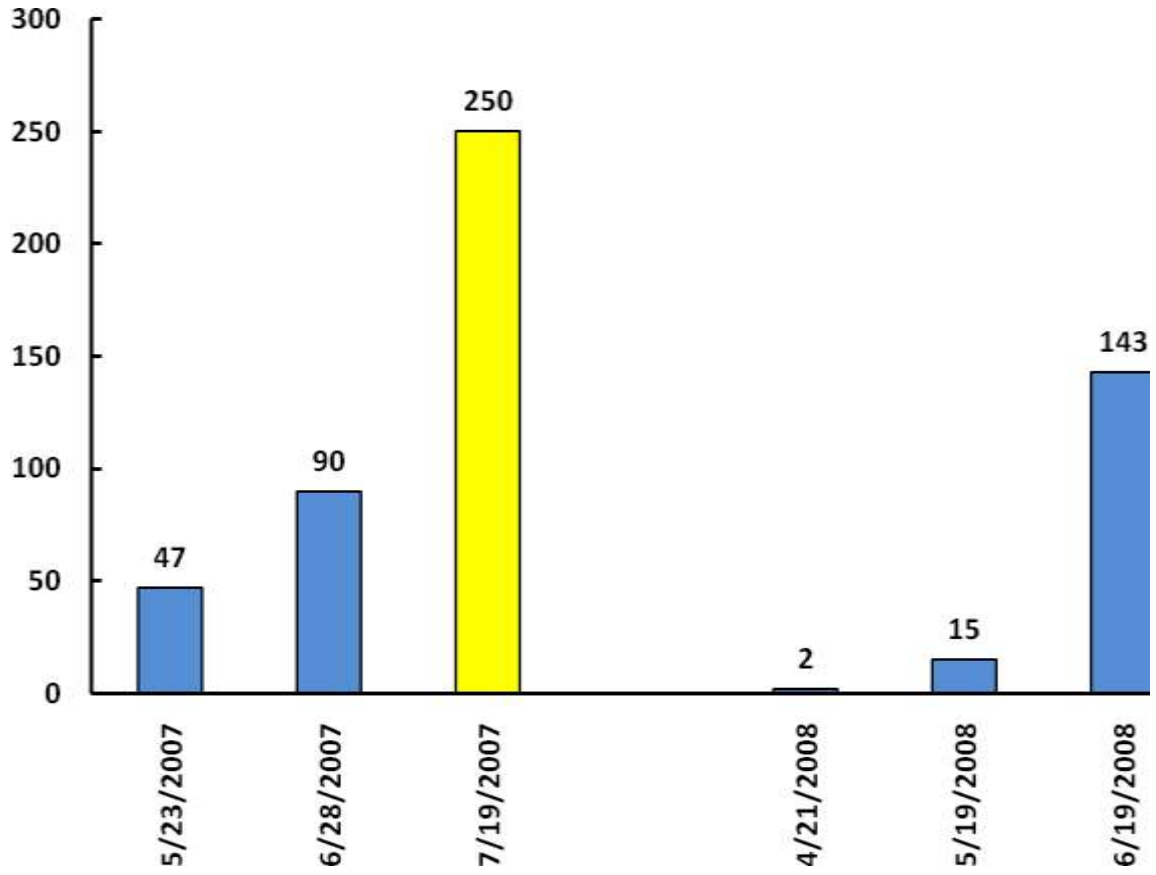

Figure 16. Fecal coliform bacteria density (FC/100ml) at Big Branch (N48) site during 2007-2008.

Owens Branch, site N51

Three of the eight samples (37.5%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 17).

This site is on stream left downstream of State Route 20 and just downstream of the railroad tracks near Camp Brookside. Owens Branch enters New River about 4.6 miles downstream of the Hinton gage and 31.8 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 20 to 400 FC/100 ml (mean 146, geometric mean 106, median 94.5). This small stream was dry during late summer of 2008.

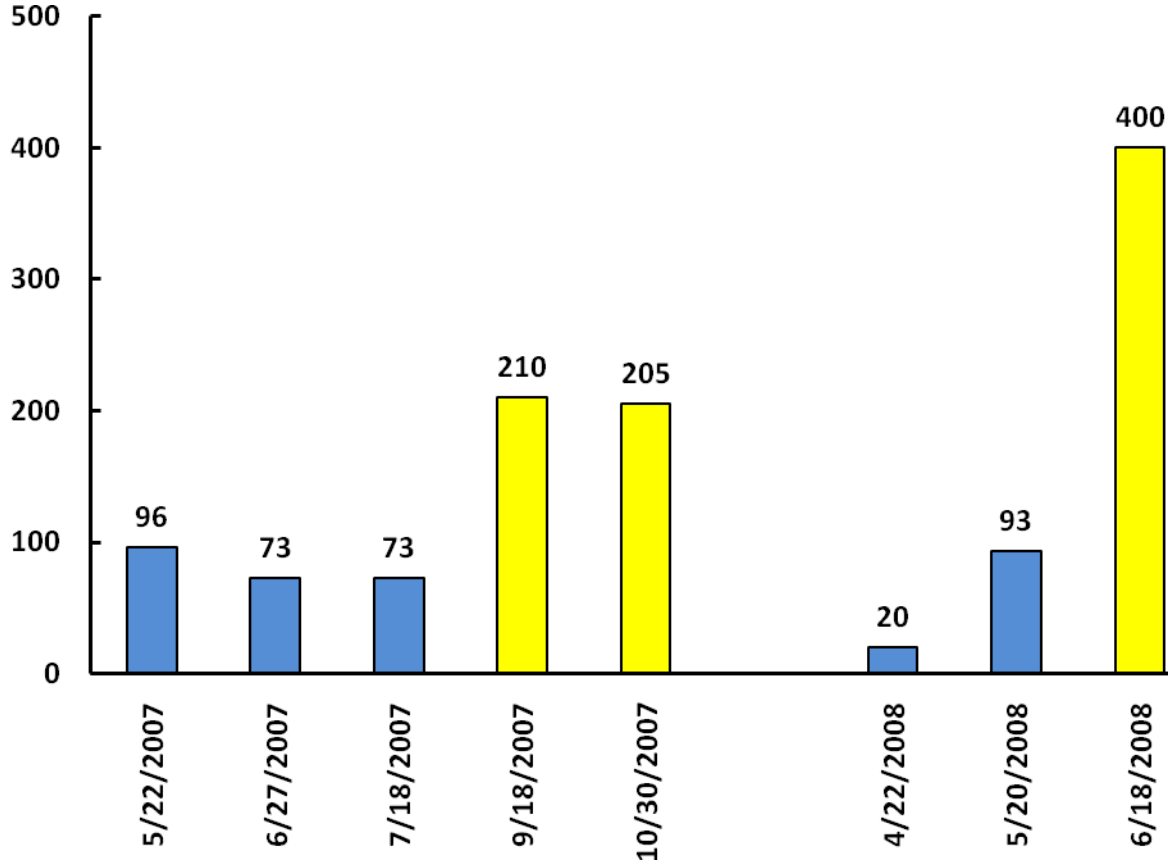

Figure 17. Fecal coliform bacteria density (FC/100ml) at Owens Branch (N51) site during 2007-2008.

Kates Branch, site N47

One of the nine samples (11%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 18).

This site is on stream right near the mouth, downstream of State Route 26. Kates Branch enters New River about 5.7 miles downstream of the Hinton gage and 30.8 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 9 to 301 FC/100 ml (mean 67, geometric mean 40, median 31). This stream was dry during the September 23, 2008 sampling.

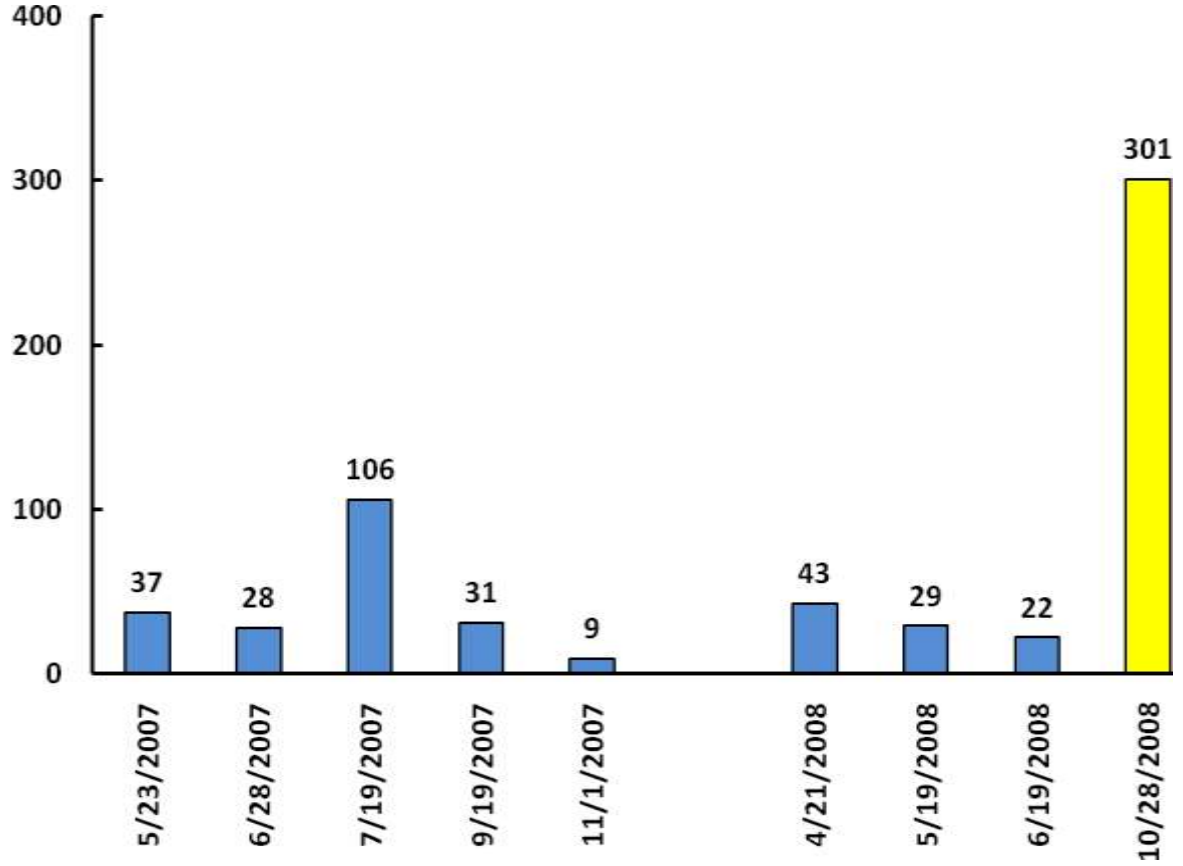

Figure 18. Fecal coliform bacteria density (FC/100ml) at Kates Branch (N47) site during 2007-2008.

Fall Branch, site N46

None of the ten samples (0%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 19).

This site is on stream right just upstream of State Route 26. Fall Branch enters New River about 6.9 miles downstream of the Hinton gage and 29.6 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 4 to 114 FC/100 ml (mean 24, geometric mean 15, median 13.5).

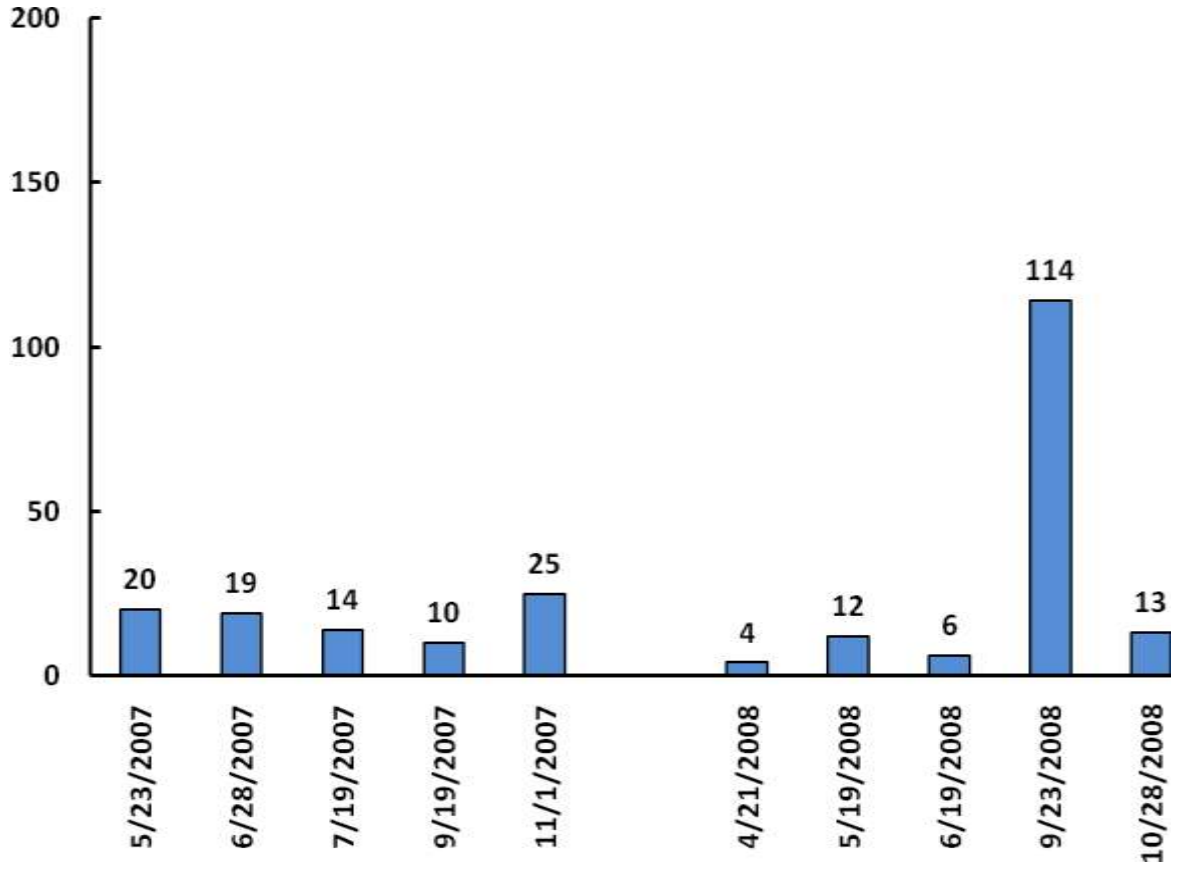

Figure 19. Fecal coliform bacteria density (FC/100ml) at Fall Branch (N46) site during 2007-2008.

Sandstone Falls Creek, site N45

Two of the five samples (40%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 20).

This stream was not named on any map, so we assigned it a name based on its location along the lower end of Irish Mountain Road where it ends at State Route 26 just downstream of Sandstone Falls. The site is on stream left downstream of State Route 26. This stream enters New River about 8.7 miles downstream of the Hinton gage and 27.8 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 15 to 390 FC/100 ml (mean 154, geometric mean 78, median 125). This small stream dried up in the summer of each year.

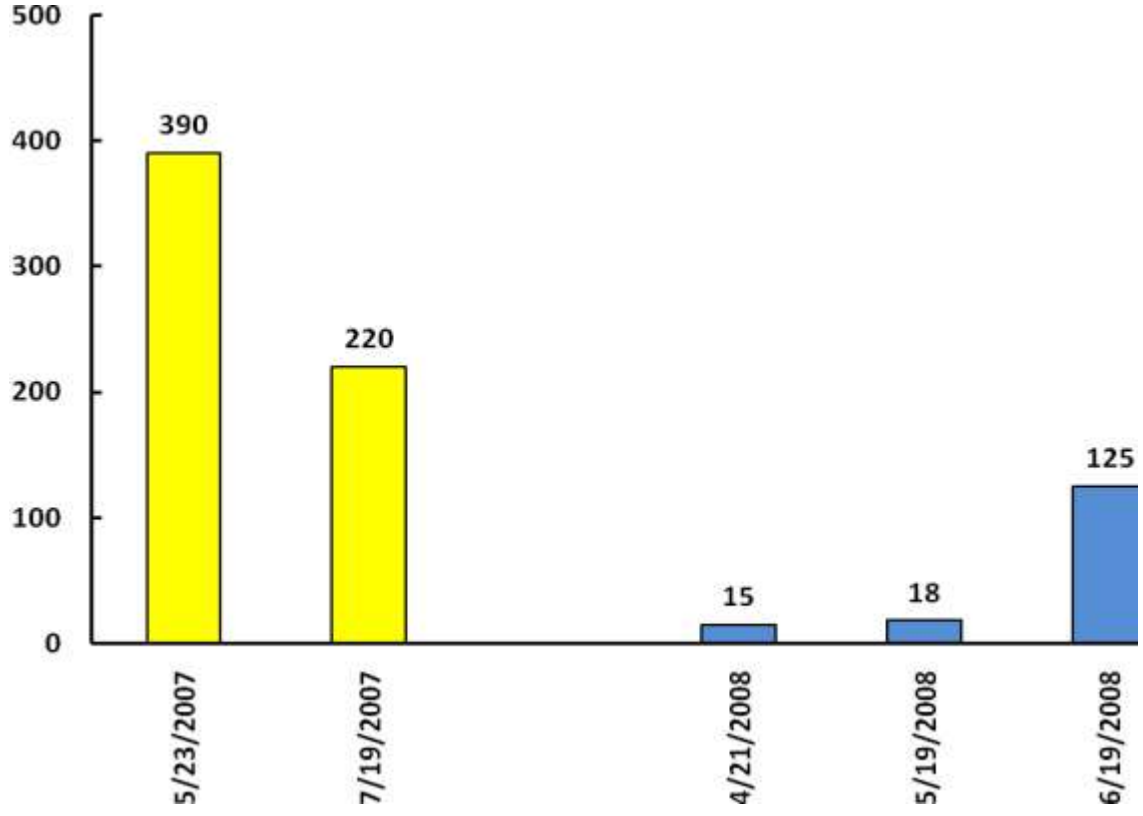

Figure 20. Fecal coliform bacteria density (FC/100ml) at Sandstone Falls Creek (N45) site during 2007-2008.

Laurel Creek near Sandstone, site N52

One of the ten samples (10%) collected in 2007 and 2008 exceeded both 200 and 400 FC/100 ml (Fig. 21).

This site is on stream right upstream of the State Route 20 highway bridge. Access is through Richmond's Campground in the community of Sandstone. This Laurel Creek enters New River about 9.2 miles downstream of the Hinton gage and 27.3 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 6 to 456 FC/100 ml (mean 78, geometric mean 36, median 32).

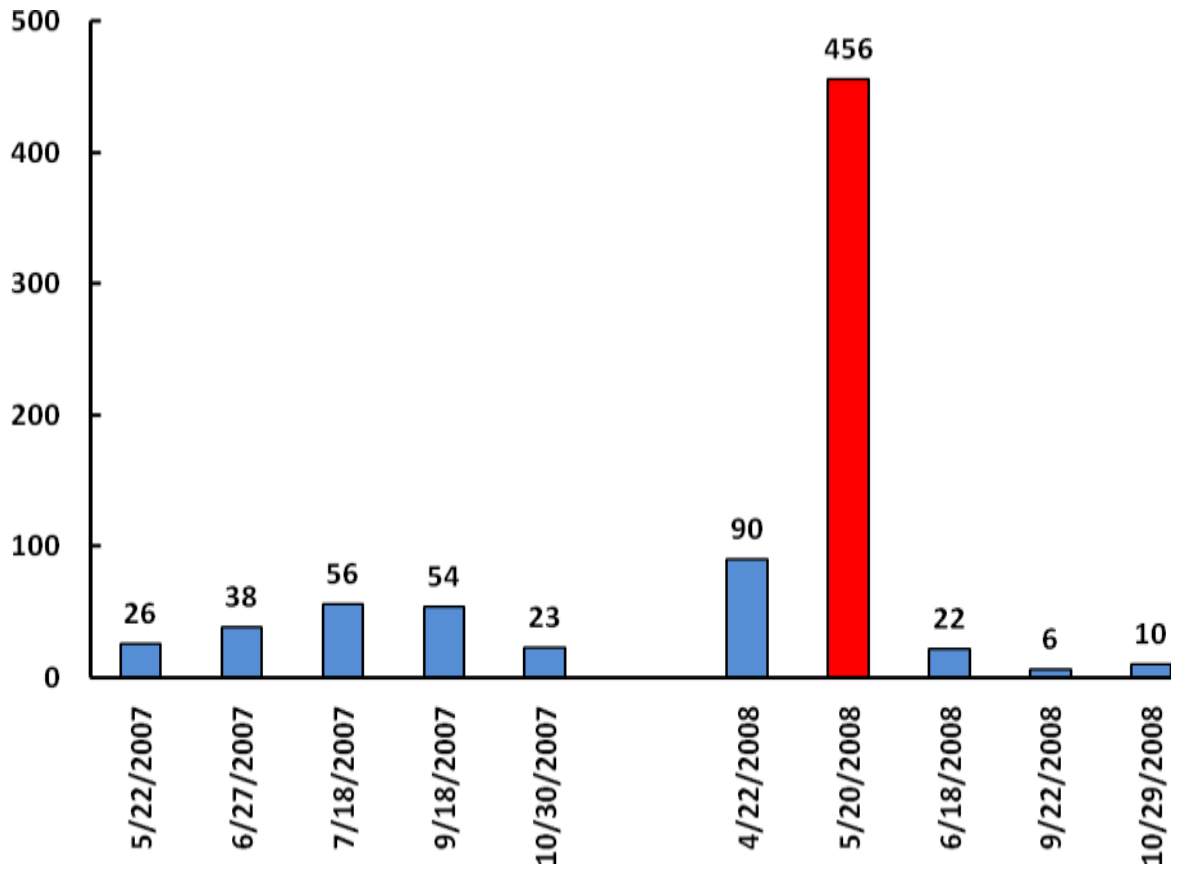

Figure 21. Fecal coliform bacteria density (FC/100ml) at Laurel Creek near Sandstone (N52) site during 2007-2008.

Lick Creek, site N05

Three of the 11 (27%) samples collected in 2007 and 2008 exceeded 200 FC/100 ml and one (9%) exceeded 400 FC/100ml (Fig. 22).

Since 1990, 26 of 143 samples (18%) exceeded 200 FC/100 ml.

This site is on stream right near the mouth of the stream, just downstream of a CSX railroad bridge. Lick Creek enters New River about 9.4 miles downstream of the Hinton gage and 27.0 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 14 to 463 FC/100 ml (mean 144, geometric mean 89, median 85).

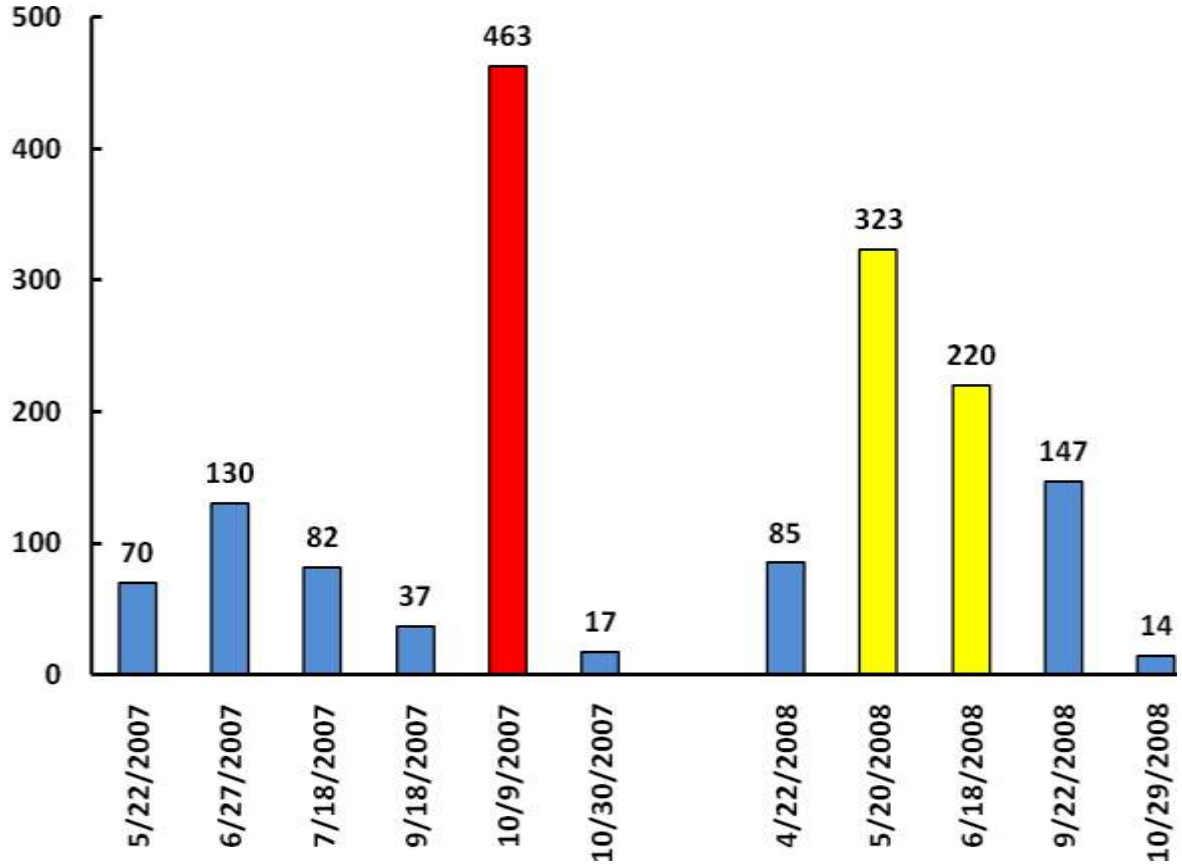

Figure 22. Fecal coliform bacteria density (FC/100ml) at Lick Creek (N05) site during 2007-2008.

Meadow Creek, site N06

One of the 11 (9%) samples collected in 2007 and 2008 exceeded 200 FC/100 ml and 400 FC/100ml (Fig. 23).

Since 1990, 28 of 143 (20%) samples exceeded 200 FC/100 ml.

This site is on stream left, near the mouth, and beneath the County Road 7 bridge just north of the community of Meadow Creek. Meadow Creek enters New River about 12.5 miles downstream of the Hinton gage and 23.9 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform density ranged from 5 to 233 FC/100 ml (mean 64, geometric mean 38, median 50).

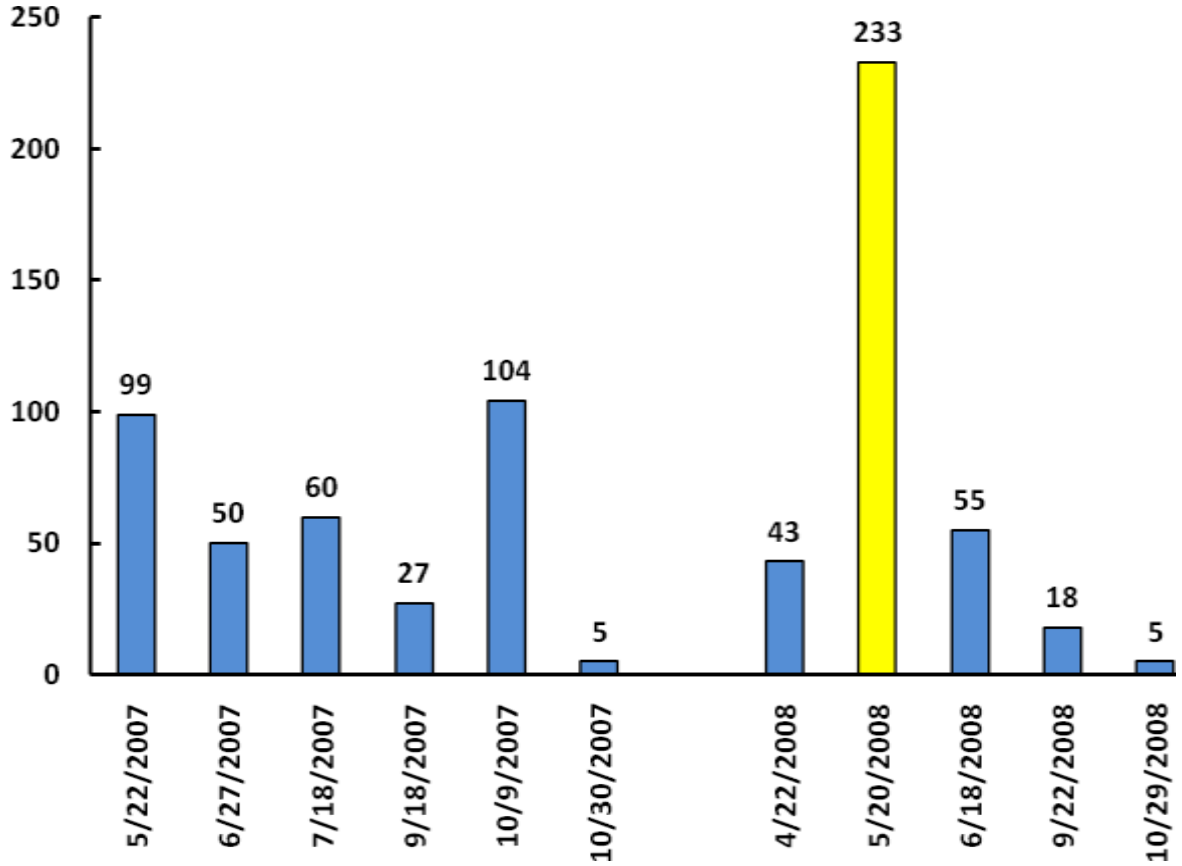

Figure 23. Fecal coliform bacteria density (FC/100ml) at Meadow Creek (N06) site during 2007-2008.

Todd Creek, site N44

One of the seven sample dates (14%) collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 24).

This stream is not named on any map. We chose a name based on a sign indicating "Todd Beach" near its confluence with New River. The site is on stream left near the mouth, and is downstream of McKendree Road (County Road 25) and the railroad tracks. Todd Creek enters New River about 34.3 miles downstream of the Hinton gage and 2.1 miles upstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 0 to 7850 FC/100ml (mean 1125, geometric mean 5, median 1). For the April 15 2008 sample the fecal coliform density was changed from 0 to 0.1 to allow calculation of a geometric mean. Note use of a logarithmic scale in Fig. 24. This stream tends to dry in late summer.

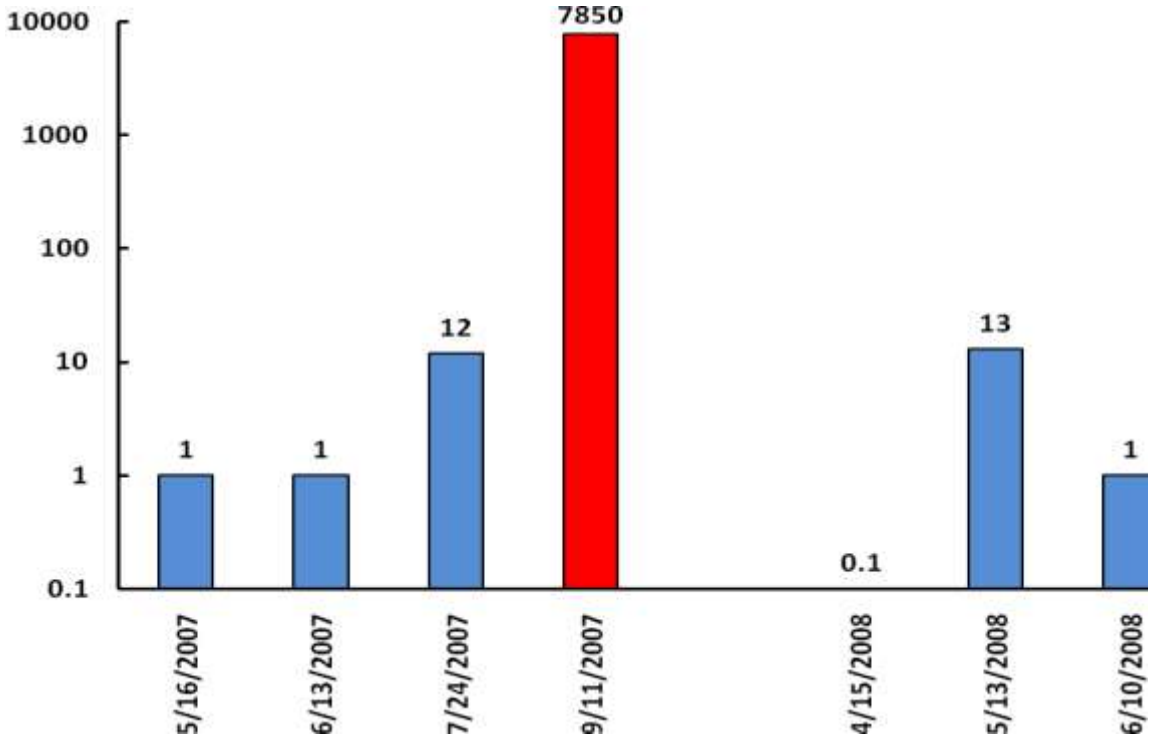

Figure 24. Fecal coliform bacteria density (FC/100ml) at Todd Creek (N44) site during 2007-2008.

Dunloup Creek, site N11

One of the 10 (10%) samples taken in 2007 and 2008 exceeded 200 FC/100 ml but none (0%) exceeded 400 FC/100ml (Fig. 25).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 69 of 152 (45%) samples exceeded 200 FC/100 ml.

This site is on stream left, just downstream of the County Route 25 bridge near the NPS Thurmond-Minden Trailhead parking area. Dunloup Creek enters New River about 36.5 miles downstream of the Hinton gage and 0.1 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 5 to 290 FC/100 ml (mean 87, geometric mean 43, median 67).

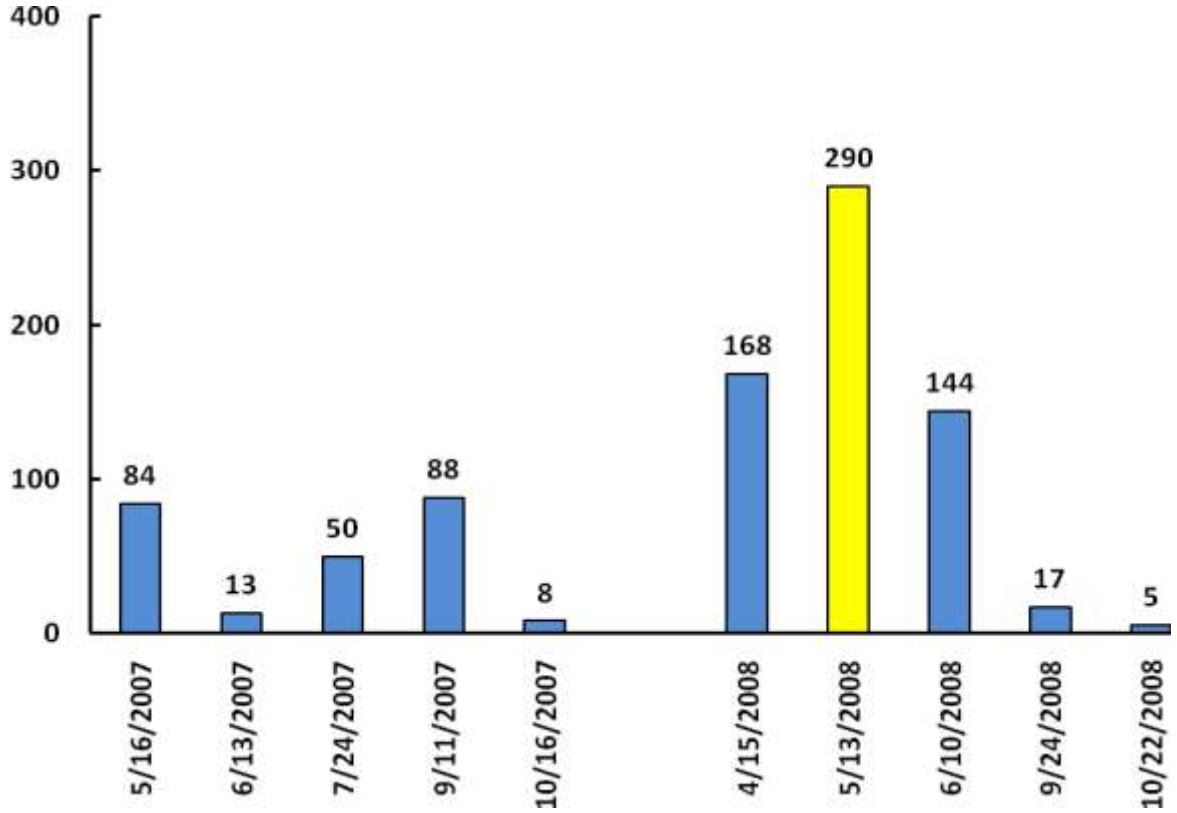

Figure 25. Fecal coliform bacteria density (FC/100ml) at Dunloup Creek (N11) site during 2007-2008.

Arbuckle Creek at Minden, site N40

Five of the 10 (50%) samples collected in 2007 and 2008 exceeded 200 FC/100 ml and three (30%) exceeded 400 FC/100ml (Fig. 26).

Since 2004, 14 of 22 samples (64%) have exceeded 200 FC/100ml.

This site is near the Minden end of the Thurmond-Minden trail. The site is sampled on stream left upstream of the trailhead access parking lot culvert. A USGS staff gage is located at the site. The site is about 1.7 miles upstream of Arbuckle Creek at mouth (N13). Arbuckle Creek enters New River about 37.2 miles downstream of the Hinton gage and 0.8 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 50 to 135,000 FC/100 ml (mean 27,568, geometric mean 716, median 200). Note use of a logarithmic scale in Fig. 26.

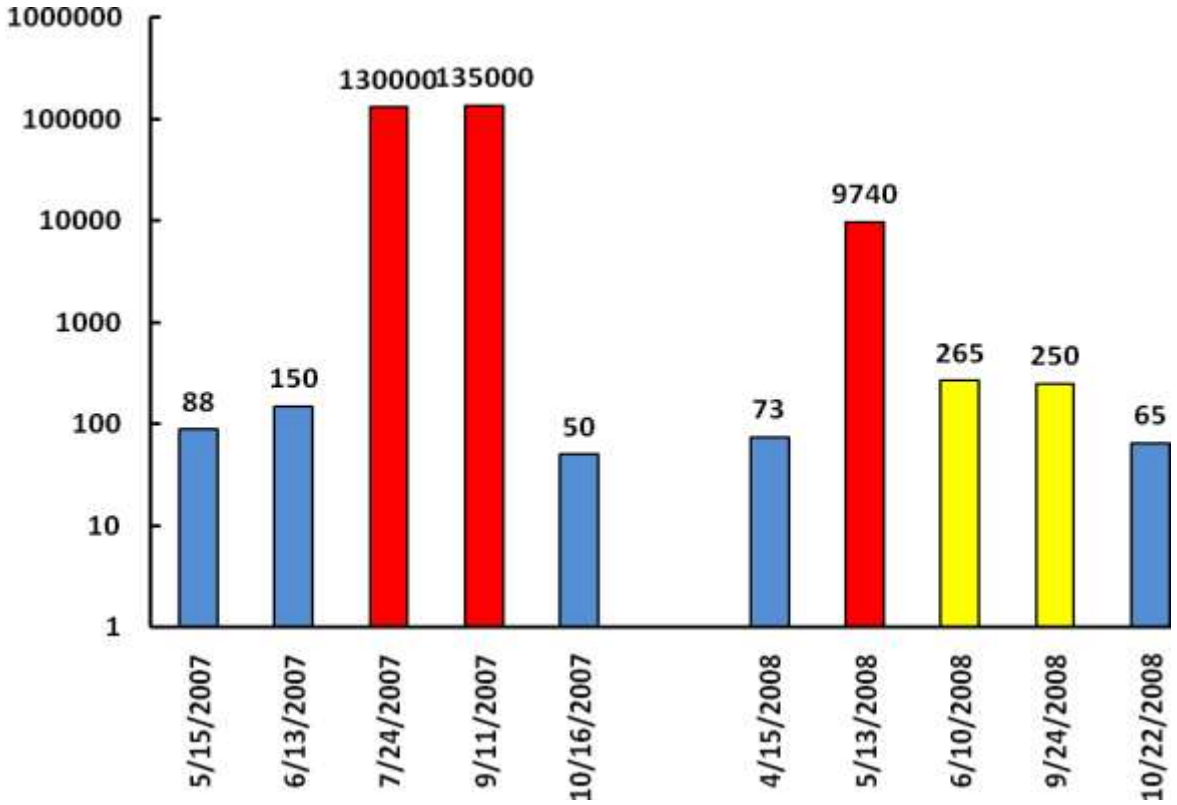

Figure 26. Fecal coliform bacteria density (FC/100ml) for Arbuckle Creek at Minden (N40) site during 2007-2008.

Arbuckle Creek at mouth, site N13

Six of the 10 (60%) samples collected in 2007 and 2008 exceeded 200 FC/100 ml and four (40%) exceeded 400 FC/100ml (Fig. 27).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 80 of 138 samples (58%) have exceeded 200 FC/100 ml.

This site is located on stream left, just downstream of the National Park Service Thurmond-Minden Trail bridge that crosses the creek near its mouth. It is about 1.7 miles downstream of Arbuckle Creek at Minden (N40).

In 2007 and 2008 fecal coliform bacteria density ranged from 7 to 25,000 FC/100 ml (mean 3326, geometric mean 274, median 332.5). Note use of a logarithmic scale in Fig. 27.

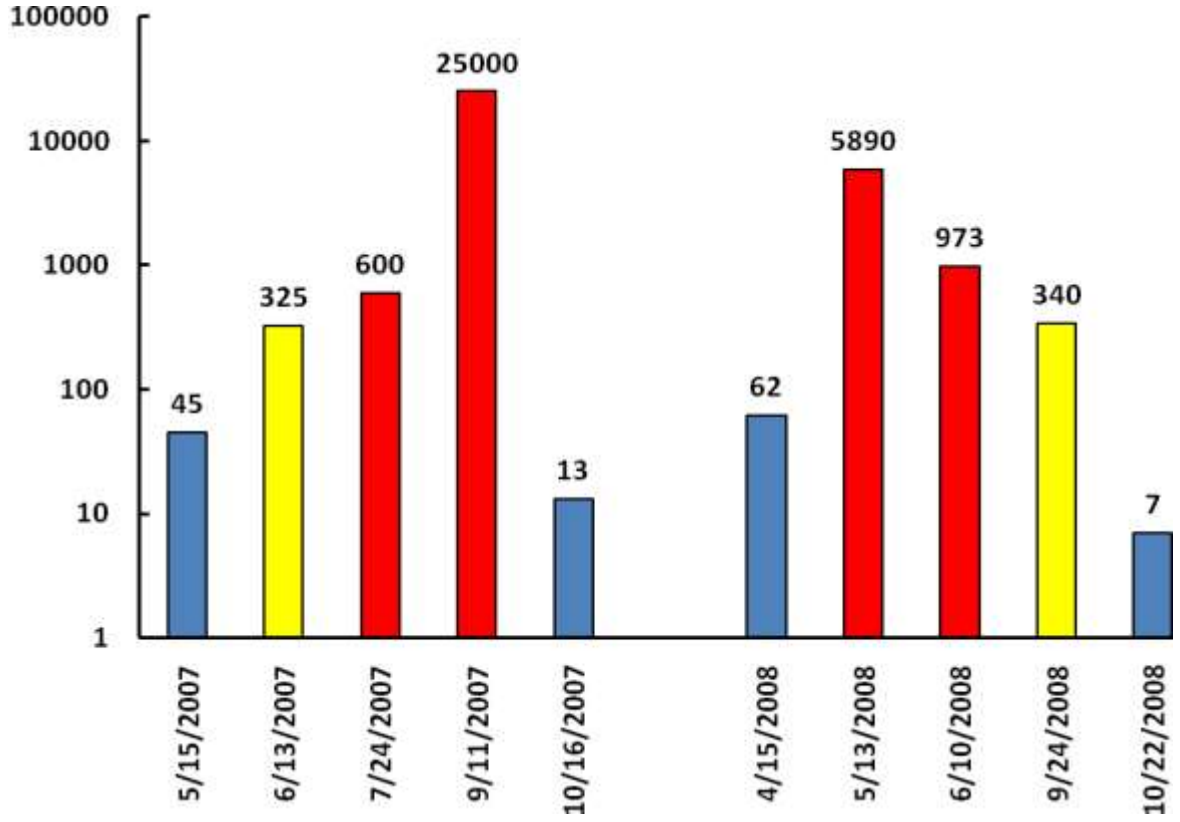

Figure 27. Fecal coliform bacteria density (FC/100ml) at Arbuckle Creek (N13) site during 2007-2008.

Rush Run, site N43

One of the 10 samples (10%) collected in 2007 and 2008 exceeded both 200 and 400 FC/100 ml (Fig. 28).

Rush Run is accessed from the Brooklyn-Southside Junction Trail about 0.7 miles from Arbuckle Creek at mouth (N13). The site is on stream left just downstream of the trail bridge. Rush Run enters New River about 37.7 miles downstream of the Hinton gage and 1.3 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 0 to 18,400 FC/100ml (mean 1855, geometric mean 13, median 9.5). For the April 15, 2008 sample, fecal coliform density was changed from 0 to 0.1 to allow calculation of a geometric mean. Note use of a logarithmic scale in Fig. 28.

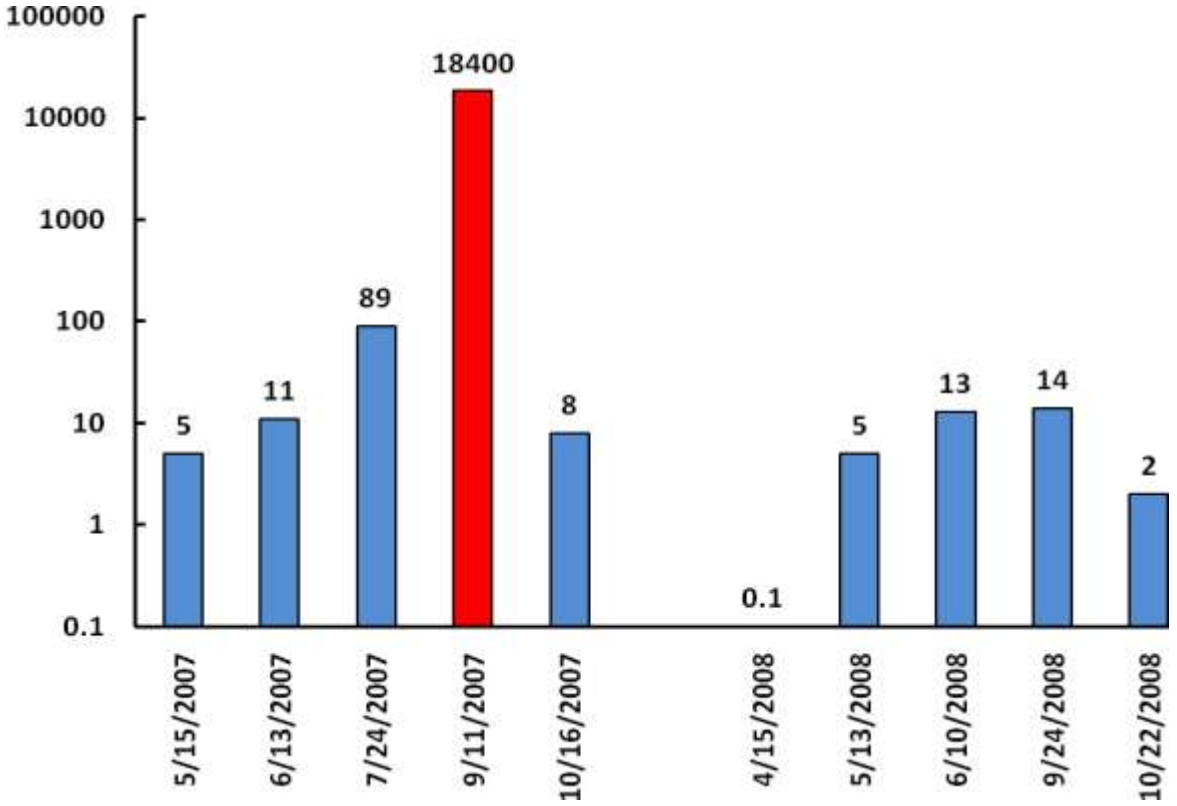

Figure 28. Fecal coliform bacteria density (FC/100ml) at Rush Run (N43) site during 2007-2008.

Keeney Creek at Winona, site N16

The one sample (100%) sample collected in 2007 exceeded both 200 FC/100 ml and 400 FC/100ml (1330 FC/100ml).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 124 of 130 samples (95%) have exceeded 200 FC/100 ml.

This site is on stream left, just downstream of a bridge across the creek in the lower end of the community of Winona. This site is 1.1 miles upstream from the Keeney Creek below Winona (N38) site. Keeney Creek enters New River about 46.1 miles downstream of the Hinton gage and 9.7 miles downstream of the Thurmond gage.

Only one sample was collected during the period covered by this report (1330 FC/100ml on June 11, 2008. This sample was collected because access to the downstream site (N38) was blocked. The National Park Service has discontinued regular monitoring of this site since we now have a site downstream within the park boundary.

Keeney Creek below Winona, site N38

Four of nine (44%) samples collected in 2007 and 2008 exceeded 200 FC/100ml, but none (0%) exceeded 400 FC/100ml (Fig. 29).

Since monitoring began in 2003, 10 of the 30 (33%) samples exceeded 200 FC/100ml.

This site is inside the National Park Service boundary about 1.1 miles downstream from the community of Winona. It is located on stream left, just downstream of the third bridge downstream from Winona on County Route 85 (Keeney Creek Road). Prior to September 10, 2008 this site was located upstream of the bridge, but falling rocks dictated a slight change in site location.

In 2007 and 2008 fecal coliform bacteria density ranged from 0 to 320 FC/100 ml (mean 143, geometric mean 33, median 113). For the October 21, 2008 sample, the fecal coliform density was changed from 0 to 0.1 to allow calculation of a geometric mean.

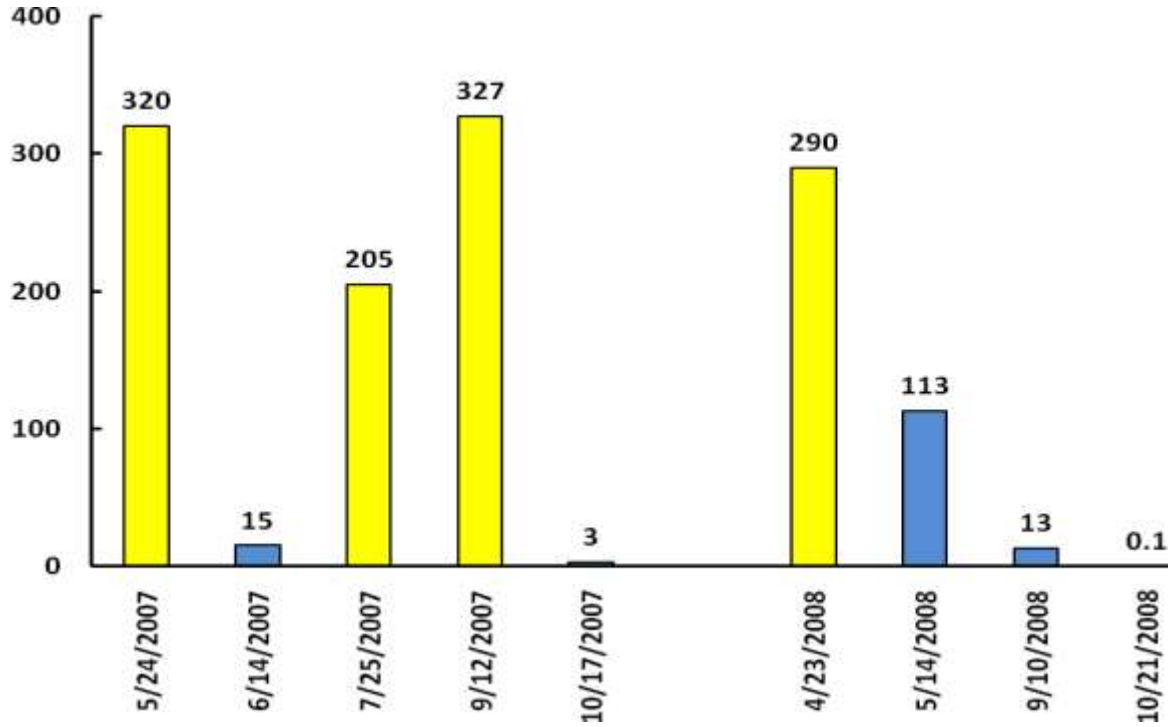

Figure 29. Fecal coliform bacteria density (FC/100ml) at Keeney Creek below Winona (N38) site during 2007-2008.

Short Creek, site N41

Three of the eight samples (37.5%) collected in 2007 and 2008 exceeded 200 FC/100 ml and one (12.5%) exceeded 400 FC/100ml (Fig. 30).

This site, on private land, is on stream right about 0.5 miles above the mouth of Short Creek. Short Creek enters New River about 47.1 miles downstream of the Hinton gage and 10.7 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 5 to 401 FC/100ml (mean 168, geometric mean 98, median 125). Short Creek tends to go dry during late summer.

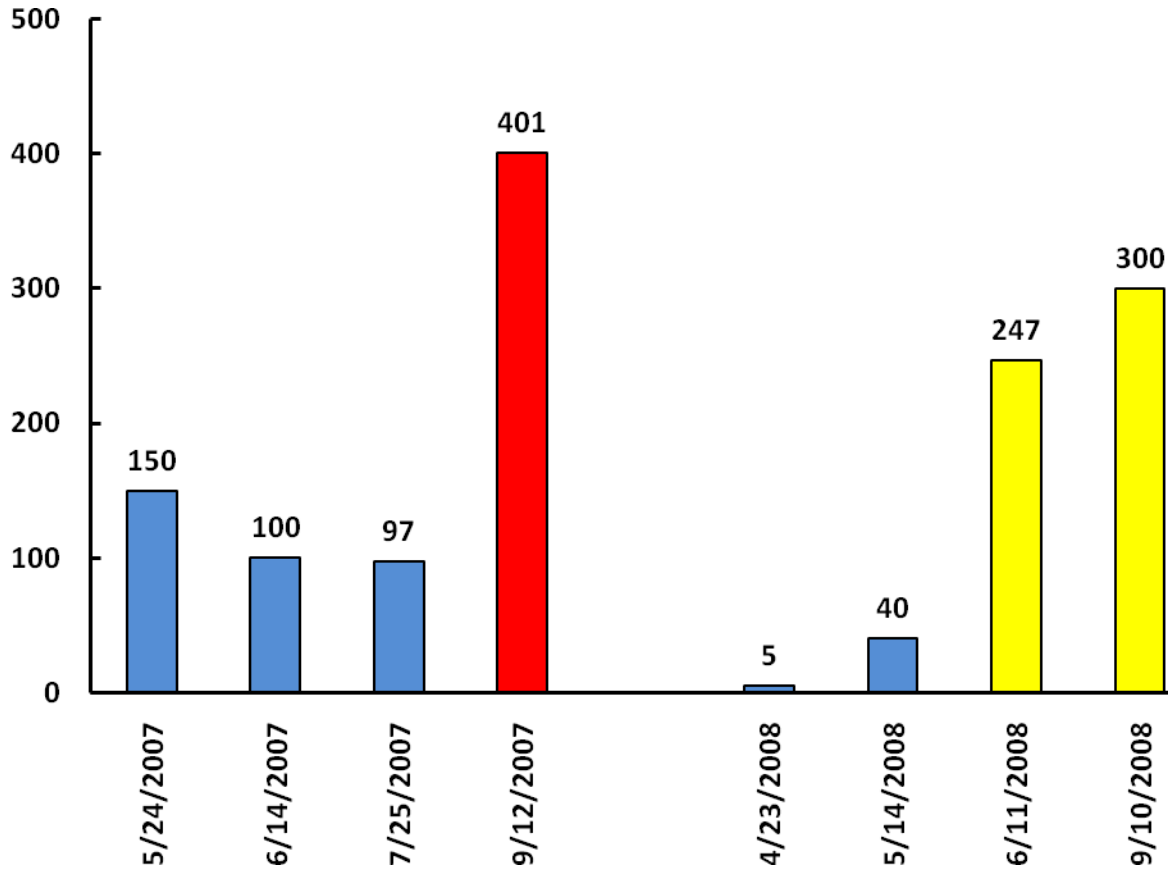

Figure 30. Fecal coliform bacteria density (FC/100ml) at Short Creek (N41) site during 2007-2008.

Fern Creek, site N42

Three of the 10 samples (30%) collected in 2007 and 2008 exceeded 200 FC/100ml and one (10%) exceeded 400FC/100ml (Fig. 31).

This site is just downstream of the County Road 82 bridge across the stream, and is about 0.9 miles upstream of the mouth. Fern Creek enters New River about 49.1 miles downstream of the Hinton gage and 12.7 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 1 to 412 FC/100ml (mean 104, geometric mean 20, median 12.5).

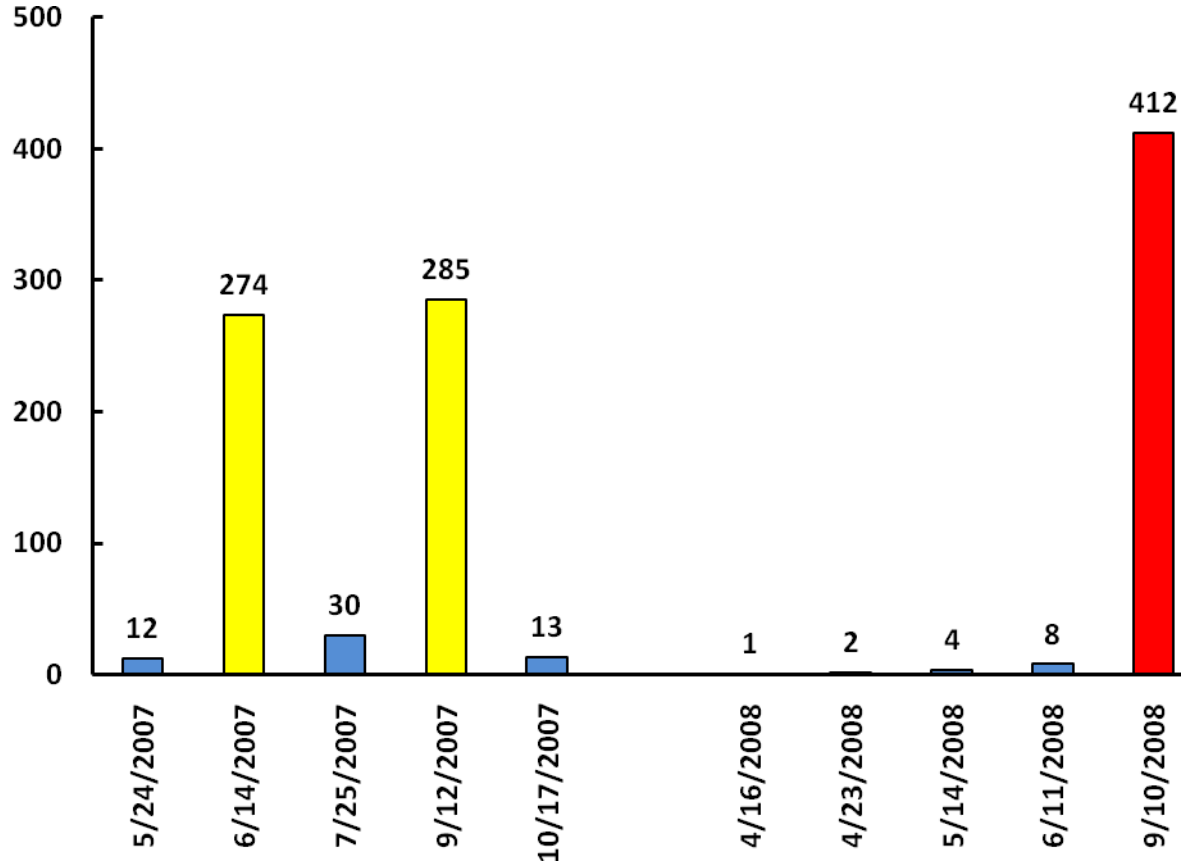

Figure 31. Fecal coliform bacteria density (FC/100ml) at Fern Creek (N42) site during 2007-2008.

Wolf Creek, site N18

One of the 11 (9%) samples collected in 2007 and 2008 exceeded 200 FC/100 ml (Fig. 32).

Since 1990, 32 of 141 samples (23%) have exceeded 200 FC/100 ml.

This site is located on stream right, just downstream of the bridge for the upper Fayette Station parking area. Wolf Creek enters New River about 50.1 miles downstream of the Hinton gage and 13.7 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 1 to 310 FC/100 ml (mean 50, geometric mean 12, median 14).

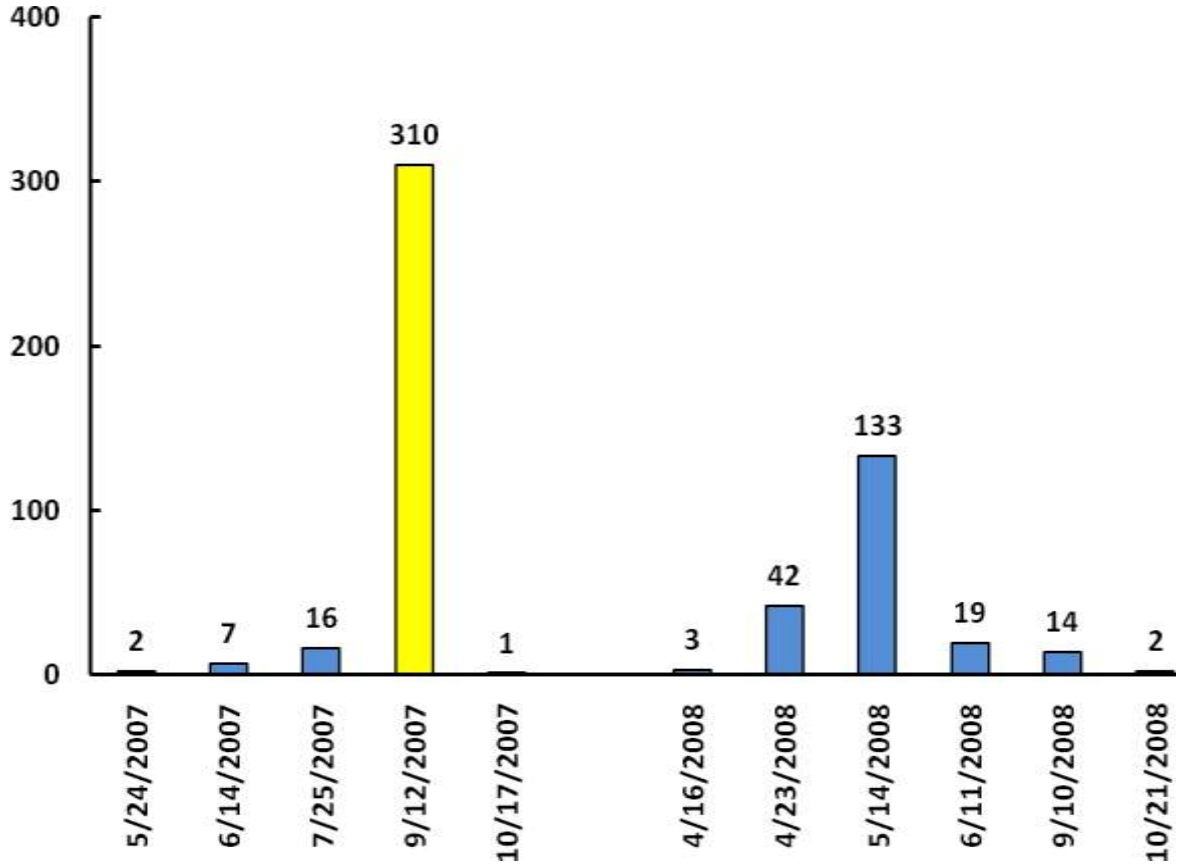

Figure 32. Fecal coliform bacteria density (FC/100ml) at Wolf Creek (N18) site during 2007-2008.

Marr Branch, site N19

Four of the 11 (36%) sample dates in 2007 and 2008 exceeded 200 FC/100 ml and three (27%) dates exceeded 400 FC/100 ml (Fig. 33).

Water quality at this site is unsatisfactory for contact recreation. Since 1990, 89 of 139 (64%) samples have exceeded 200 FC/100 ml.

This site is on stream right just off Fayette Station Road (County Route 82) below the former Rivers Inc. complex. Marr Branch enters New River 50.9 miles downstream of the Hinton gage and 14.5 miles downstream of the Thurmond gage.

In 2007 and 2008 fecal coliform bacteria density ranged from 16 to 2350 FC/100 ml (mean 549, geometric mean 145, median 98). Note the use of a logarithmic vertical axis in Fig. 33.

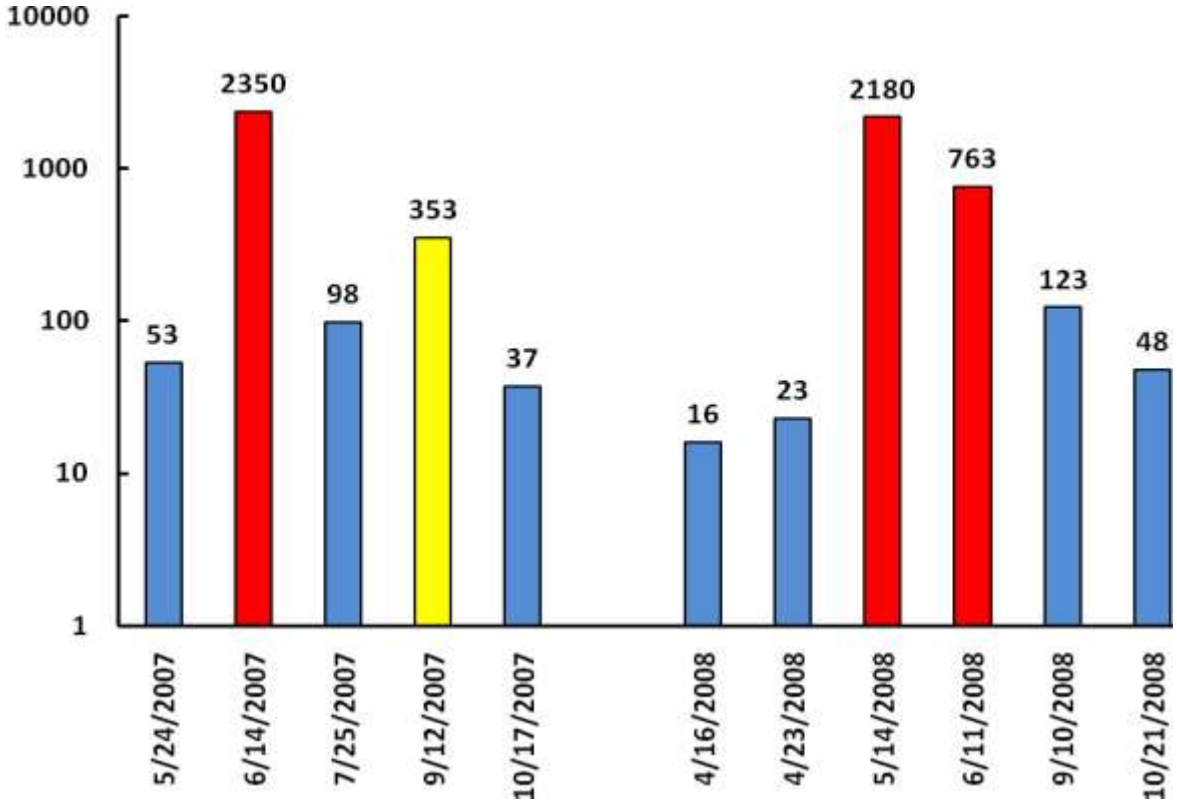

Figure 33. Fecal coliform bacteria density (FC/100ml) at Marr Branch (N19) site during 2007-2008.

This page intentionally left blank

GAULEY RIVER NATIONAL RECREATION AREA

GAULEY RIVER MAINSTEM

Gauley River below Summersville Dam, site G01

None of the seven (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 34).

Since 1991, 5 of 130 samples (4%) have exceeded 200 FC/100 ml.

This site is on river right just below Summersville Dam, about 600 feet upstream of the Summersville Dam gage. No streams enter Gauley River between the site and the gage.

In 2008 fecal coliform bacteria density ranged from 0 to 21 FC/100 ml (mean 4, geometric mean 1, median 1). For the samples collected on 30 April and 8 September, density was changed from 0 to 0.1 to allow calculation of a geometric mean.

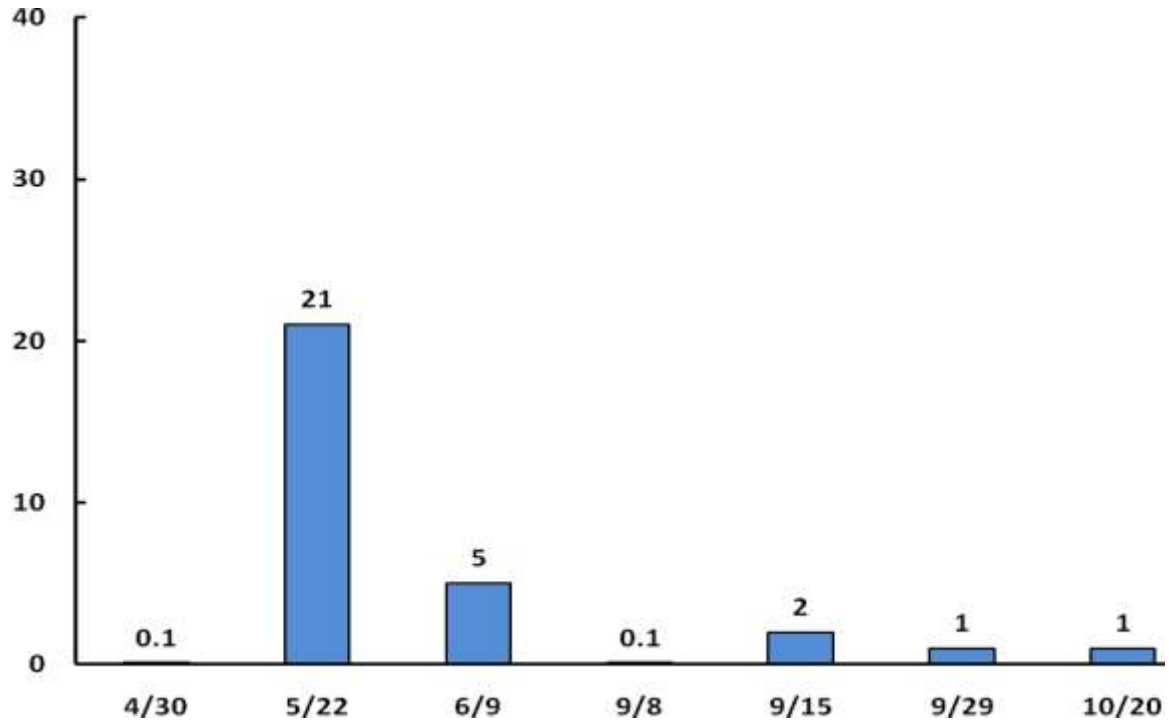

Figure 35. Fecal coliform bacteria density (FC/100ml) for Gauley River below Summersville Dam (site G01) during 2008.

Gauley River above Mason Branch, site G06

None of the seven (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 35).

Since 1996, 6 of 66 samples (10%) have exceeded 200 FC/100 ml.

The sampling site is on river right upstream of a Gauley River access at the mouth of Mason Branch, and is about 8.6 miles downstream of the Summersville Dam gage. Ten tributaries (six perennial and four intermittent) enter Gauley River between the gage and this site.

In 2008 fecal coliform bacteria density ranged from 4 to 50 FC/100 ml (mean 15, geometric mean 10, median 6).

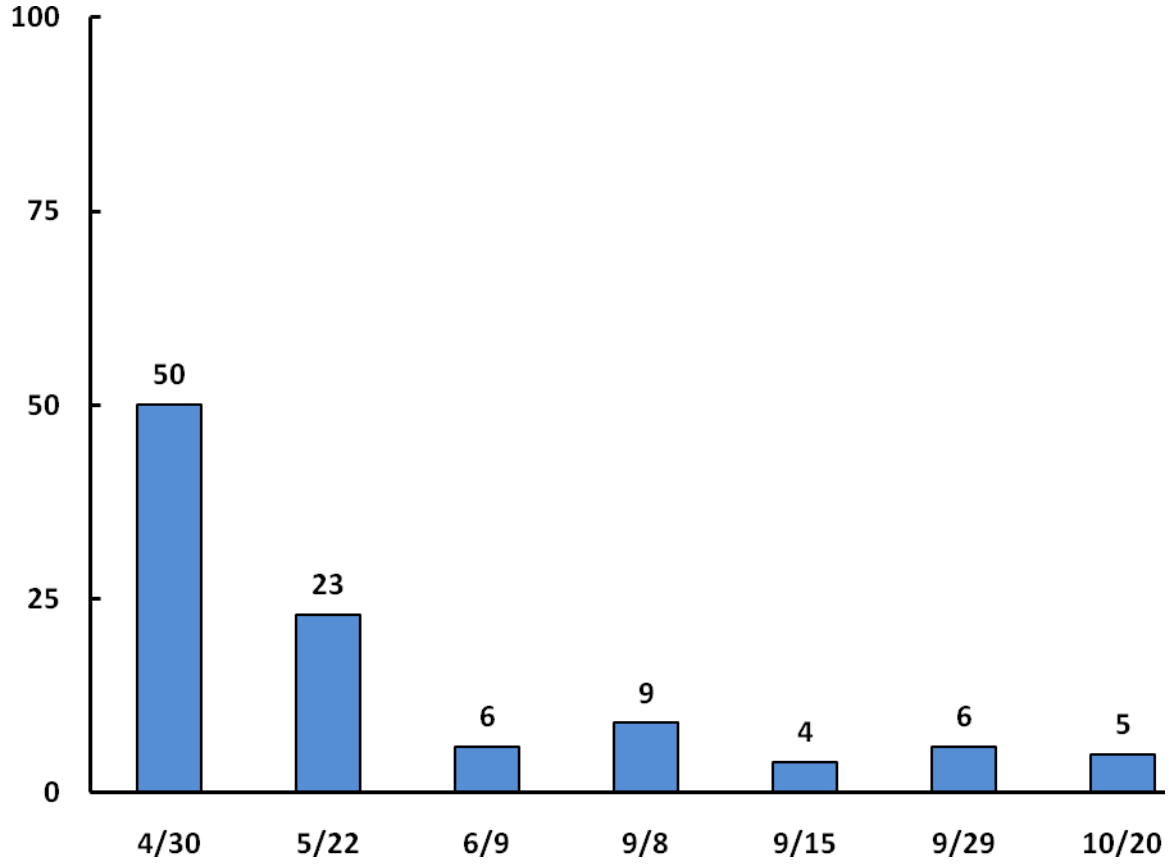

Figure 36. Fecal coliform bacteria density (FC/100ml) for Gauley River above Mason Branch (site G06) during 2008.

Gauley River above Swiss, site G04

None of the seven (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 36).

Since 1991, 7 of 127 samples (6%) have exceeded 200 FC/100 ml.

The sampling site is on river right, upstream of the community of Swiss and just upstream from the mouth of Laurel Creek. The site is about 14.1 miles downstream from the Summersville Dam gage. There are 44 tributaries (17 perennial and 27 intermittent) between the gage and the site.

In 2008 fecal coliform bacteria density ranged from 4 to 31 FC/100 ml (mean 11, geometric mean 8, median 6).

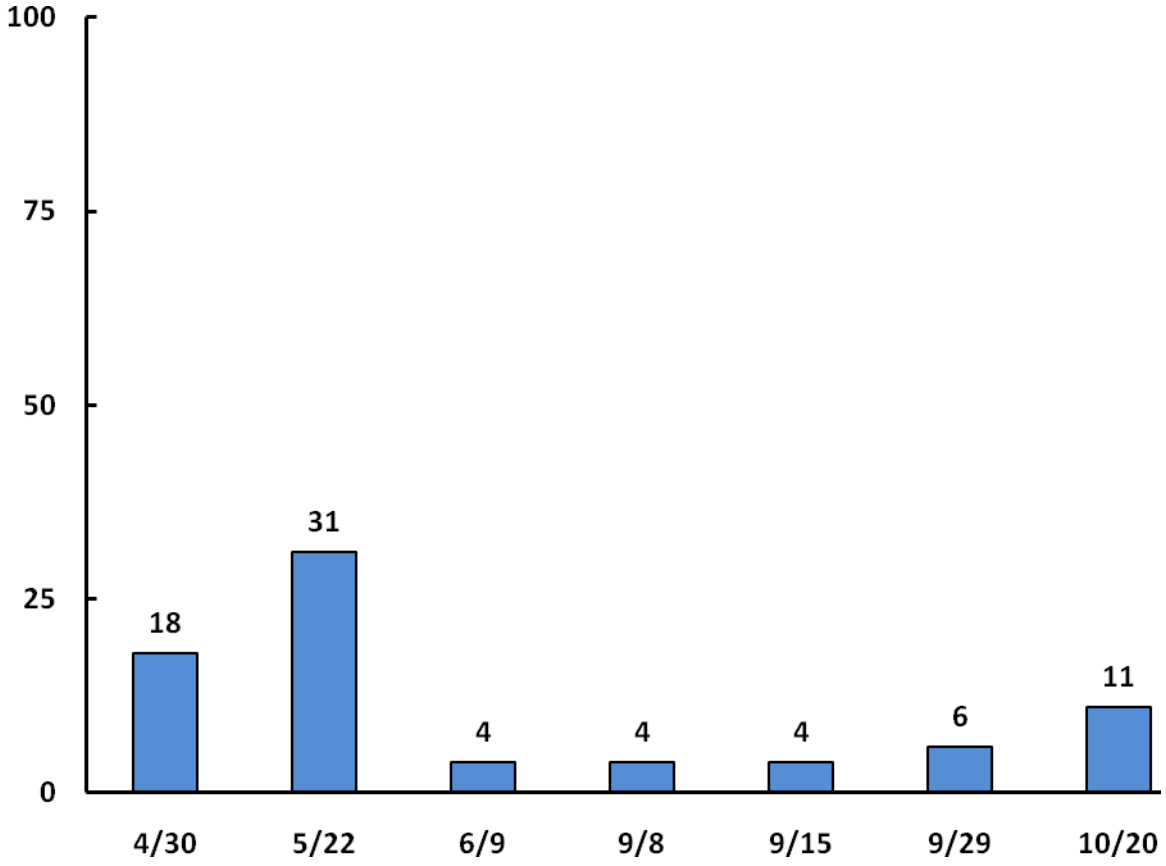

Figure 37. Fecal coliform bacteria density (FC/100ml) for Gauley River above Swiss (site G04) during 2008.

GAULEY RIVER TRIBUTARIES

Meadow River, site G05

One of the seven (14%) samples collected in 2008 exceeded both 200 FC/100 ml and 400 FC/100 ml (Fig. 37).

Since 1991, 12 of 104 samples (12%) have exceeded 200 FC/100 ml.

This site, outside GRNRA, is on river right upstream of Anglins Creek and the Wilderness Public Service District water treatment plant. It is about 8.9 miles upstream of the Meadow River gage. Fourteen tributaries (11 perennial and 3 intermittent) enter Meadow River between this site and the gage. Meadow River enters Gauley River about 4.9 miles downstream of the Summersville Dam gage.

In 2008 fecal coliform bacteria density ranged from 2 to 440 FC/100 ml (mean 79, geometric mean 12, median 44).

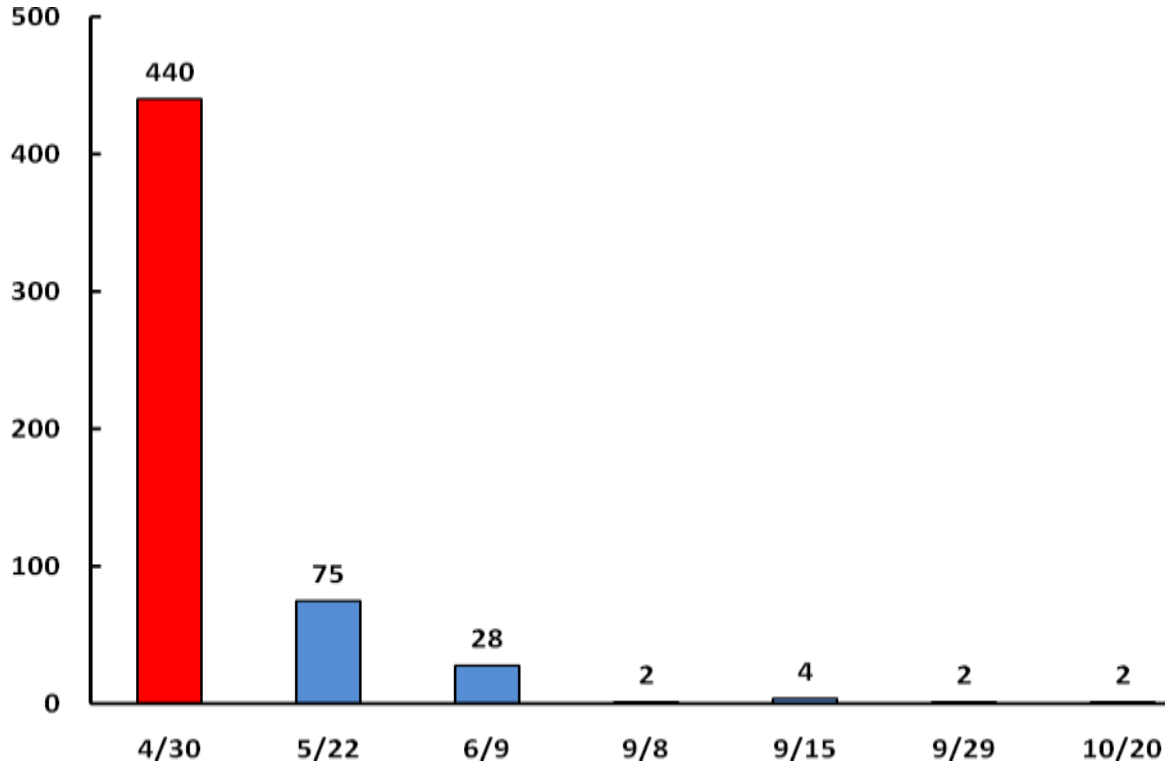

Figure 38. Fecal coliform bacteria density (FC/100ml) for Meadow River (site G05) during 2008.

Peters Creek at ford, site G07

None of the seven (0%) samples collected in 2008 exceeded 200 FC/100 ml (Fig. 38).

Since 1996, 20 of 69 samples (29%) have exceeded 200 FC/100 ml.

The sampling site is on stream left about 1.5 miles upstream from the mouth of the creek. Peters Creek enters Gauley River about 6.5 miles downstream from the Summersville Dam gage. Four wheel drive enthusiasts are typical visitors to the sample site, while anglers, campers and boaters are typical visitors at the mouth of Peters Creek.

In 2008 fecal coliform bacteria density ranged from 28 to 138 FC/100 ml (mean 86, geometric mean 76, median 91).

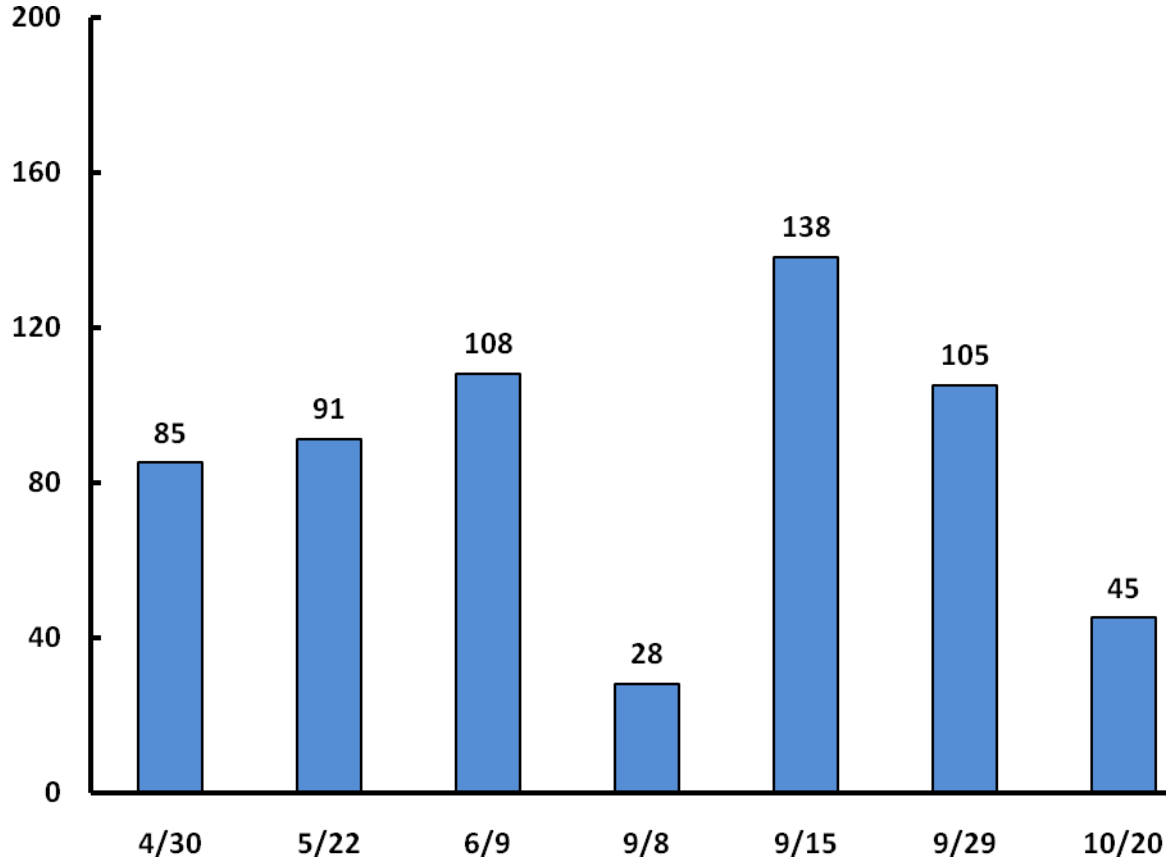

Figure 39. Fecal coliform bacteria density (FC/100ml) for Peters Creek at ford (site G07) during 2008.

This page intentionally left blank

DISCUSSION

Program Changes in 2007

Mapping of our existing data showed a number of streams that were not being monitored. To get a better geographic perspective of local water quality, in 2007 we added 14 previously unmonitored sites to our monitoring program. The new sites were all in New River Gorge National River. One was a mainstem site; New River at Stonecliff (N32). This site was sampled previously in evaluating impacts of the 2001 floods (see Resource Assessment Team 2001) and as part of storm-event monitoring program that will be reported on separately. The other thirteen sites were tributaries: Tug Creek (N49), Brooks Branch (N50), Big Branch (N48), Owens Branch (N51), Kates Branch (N47), Fall Branch (N46), Sandstone Falls Creek (N45), Laurel Creek near Sandstone (N52), Todd Creek (N44), Arbuckle Creek at Minden (N40), Rush Run (N43), Short Creek (N41) and Fern Creek (N42).

To add these sites without increasing staff or costs, a number of sites judged to have sufficient long-term data, mostly with records of good water quality, were temporarily dropped from the monitoring program. As a sufficient knowledge base accumulates about water quality in these newly added streams, we will again reevaluate our monitoring program.

While there are generally too few samples to make definitive statements about the new sites, some trends are emerging. Water quality seems to be acceptable for the New River at Stonecliff (N32), Kates Branch (N47) and Fall Branch (N46). Water quality is apparently unacceptable for Tug Creek (N49), Brooks Branch (N50) and Arbuckle Creek at Minden (N40).

Early data for the other nine new sites raise water quality concerns. Some sites mostly had low fecal coliform bacteria densities, but one of the samples was high. For example, Todd Creek (N44) had six samples no greater than 13 FC/100ml, but one sample of 7850 FC/100ml. Similarly, 90% of the Rush Run (N43) samples were no greater than 89 FC/100ml, but one sample was 18,400 FC/100ml.

Madam Creek

There has been a marked improvement in water quality at this site. Through 2004, 108 out of 115 samples (94%) exceeded 200 FC/100ml. Not only was the frequency high, but the magnitude was also high. Between 1995 and 2004, 73 of 79 samples (92%) exceeded 400 FC/100ml, with 58 samples (73%) exceeding 1000 FC/100ml. Each of those years had a sample with a bacteria density greater than 9,000 FC/100 ml. Perhaps the only reason that 1998 did not have a value so great was that we only collected two samples that year. The maximum density we recorded over this time span was 37,600 FC/100ml.

From 2004 through 2007, only eight of 22 samples (36%) exceeded 200 FC/100ml, and only two samples (9%) exceeded 400 FC/100ml, with a maximum bacteria density of 600 FC/100ml. In fact, 2007 and 2008 were the only two years in our monitoring history that has not seen a value greater than 400 FC/100ml in Madam Creek.

The dramatic improvement in Madam Creek water quality must be attributed to the extension of a sewer line across the New River to serve residences in this area. The City of Hinton is to be commended for this effort that demonstrates the concern about water quality in a community that has the New River as its lifeblood.

Arbuckle Creek

Like Madam Creek, Arbuckle Creek has a long history of awful water quality. For the site near the mouth (N13), over half of the samples collected since 1990 exceeded the West Virginia standard for contact recreation. What is more appalling is the magnitude of these exceedances. Eleven of the samples have been 25,000 FC/100ml or greater, including a maximum value of 250,000 FC/100ml.
In 2004 we began sampling a new site, Arbuckle Creek at Minden (N40), on the same days we sampled the old site, Arbuckle Creek (N13) located near the mouth of the stream. Between 2004 and 2008 we analyzed 22 samples at each site (Fig. 40).

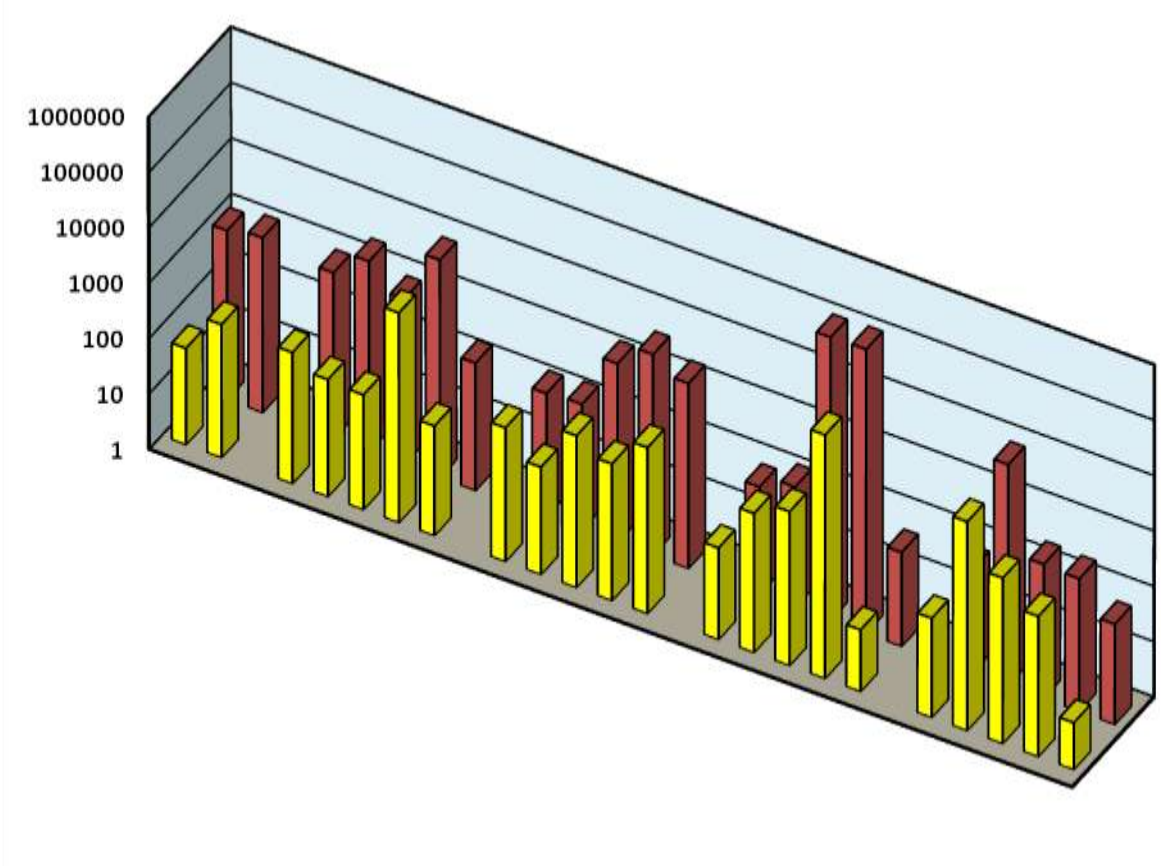

Figure 40. Fecal coliform bacteria density (FC/100ml on vertical axis) for Arbuckle Creek near mouth (N13 – yellow) and Arbuckle Creek at Minden (N40 - red) from 2004 through 2008.

For the lower site (N13), 16 of the samples (73%) exceeded 200 FC/100ml, eight (36%) exceeded 400 FC/100ml, three (14%) exceeded

1000 FC/100ml, one (5%) exceeded 10,000 FC/100ml, and none exceeded 100,000 FC/100ml. For this site the mean was 1928 FC/100ml, the geometric mean was 267 FC/100ml and the median was 256.5 FC/100ml. The minimum value we noted was 7 FC/100ml and the greatest value was 25,000 FC/100ml.

For the upper site (N40), 17 of the samples (77%) exceeded 200 FC/100ml, 13 (59%) exceeded 400 FC/100ml, 11 (50%) exceeded 1000 FC/100ml, and two (9%) exceeded both 10,000 and 100,000 FC/100ml. For this site the mean was 13,645 FC/100ml, the geometric mean was 911 FC/100ml and the median was 990 FC/100ml. The minimum value we noted was 50 FC/100ml, and the maximum was 135,000 FC/100ml.

Even though the frequency of exceeding 200 FC/100ml is similar between the two sites, it is clear that the magnitude of exceedances is greater at the upper site (N40). The upper site is just at the park boundary, and therefore closer to residences, businesses, and sewage treatment plants in the Arbuckle Creek watershed, while the lower site (N13) is nearly two miles downstream.

There are two sewage treatment plants, operating under separate management entities, discharging into Arbuckle Creek. High levels of fecal coliform bacteria in Arbuckle Creek are probably due to faulty sewer system collection lines, plant facilities, and/or plant operations (including bypasses during storm events). Discussions have been underway to possibly consolidate operation of the two plants under one responsible management entity. It is hoped that such action will result in improved sanitary conditions in Arbuckle Creek.

Keeney Creek

Keeney Creek is yet another stream with a long history of water quality problems. From 1990 through 2008, 124 out of 130 baseline samples (95%) analyzed for Keeney Creek at Winona (N16) exceeded 200 FC/100ml. Including storm event samples collected in 2002 and 2003, 162 out of 170 samples (95%) for this site exceeded 200 FC/100ml, 146 (86%) exceeded 400 FC/10ml), 110 (65%) exceeded 1000 FC/100ml, 13 (8%) exceeded 10,000 FC/100ml, and none exceeded 100,000 FC/100ml.

Completion of a road down Keeney Creek below Winona allowed us to sample inside the park beginning in 2003 (Keeney Creek below Winona – N38). For N38, only 10 of 30 samples (33%) exceeded 200 FC/100ml and only two (7%) exceeded 400FC/100ml. The maximum density at N38 was 1500 FC/100ml, found on the first sampling date (9 April 2003) for this site. The only other value greater than 400FC/100ml for this site was on 12 June 2006 when we counted 500FC/100ml.

Clearly there is a decrease in fecal coliform bacteria density as Keeney Creek flows downstream away from Winona. This was first described in an earlier report (Wilson *et al*. 2006), and continued monitoring supports this assertion. The National Park Service believes that this downstream dynamics of fecal coliform bacteria in high gradient streams warrants future research.

About the same time we began sampling Keeney Creek below Winona, Fayette County began taking a serious look at how to address the lack of sanitary wastewater disposal in the Winona area. Unlike Arbuckle Creek, no sewage treatment plants serve the Keeney Creek watershed. Our data, providing a vivid description of the fecal pollution in the Winona area, was instrumental in Fayette County's movement on this problem.

To support these efforts, we began sampling Keeney Creek above Winona (N00; sampled from 2003-2006 – see Wilson *et al*. 2006, Purvis and Wilson 2007) to further describe fecal bacteria dynamics in Keeney Creek. Some concerns had been voiced that the upstream communities of Lookout and Divide, plus some agricultural use, might also be a part of the problem. Indeed, we found that for N00, 9 of 20 samples (45%) exceeded 200 FC/100 ml and 4 exceeded 400 FC/100ml, with a maximum density of 4670 FC/100ml.

Hopefully the county will soon be able to obtain funding to address the wastewater issues along Keeney Creek, and water quality and the quality of life in these areas will be improved. The National Park Service will continue to be a partner with Fayette County and other stakeholders to support these efforts.

LITERATURE CITED

American Public Health Association. 1992. Standard methods for the examination of water and wastewater, 18th Ed. American Public Health Association, Washington, DC.

Bordner, R., J. A. Winter and P. V. Scarpino (editors). 1978. Microbiological methods for monitoring the environment, water and wastes. EPA-600/8-78-017, U. S. Environmental Protection Agency, Cincinnati, OH.

Gibson, S. 1993. Winter fecal coliform bacteria study, New River Gorge Nation River, Bluestone National Scenic River, Gauley River National Recreation Area. New River Gorge National River, Glen Jean, WV.

Hebner, S. W. 1991. New River Gorge National River fecal coliform study, April - September 1987. New River Gorge National River, Glen Jean, WV.

Purvis, J. M. and L. Wilson. 1999. Hydrologic influences on fecal coliform bacteria in a tributary to New River Gorge National River. Pages 24-31 *In* Proceedings New River Symposium, April 15-16, 1999, Boone, North Carolina. National Park Service, Glen Jean, WV.

Purvis, J.M. and L. Wilson. 2007. Water quality monitoring program 2004-2006, New River Gorge National River, Bluestone National Scenic River, Gauley River National Recreation Area. National Park Service, Glen Jean, WV.

Resource Assessment Team. 2001. New River Gorge floods – 2001, emergency rehabilitation plan. National Park Service, Glen Jean, WV.

Schmidt, D. and S. Hebner. 1991. New River Gorge National River fecal coliform study April – September 1990. New River Gorge National River, Glen Jean, WV.

Sullivan, R. J. 1993a. New River Gorge National River water quality monitoring program, April – September 1992. New River Gorge

National River, Glen Jean, WV.

Sullivan, R. J. 1993b. New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area water quality monitoring program 1993. New River Gorge National River, Glen Jean, WV.

West Virginia Department of Natural Resources. 1988. New River Gorge National River: fecal coliform study, April-September, 1987. Division of Water Resources, Monitoring Branch, Charleston, WV.

West Virginia Department of Natural Resources. 1989. New River Gorge National River: fecal coliform study, April-September, 1987-1988. Division of Water Resources, Monitoring Branch, Charleston, WV.

West Virginia Water Resources Board. 1998. Title 46, Legislative Rules, Series 1, Requirements Governing Water Quality Standards. West Virginia Water Resources Board, Charleston, WV.

Wilson, L. and J. Purvis. 2000. Water quality monitoring program 1994-1997, New River Gorge National River, Bluestone National Scenic River and Gauley River National Recreation Area. National Park Service, Glen Jean, WV.

Wilson, L. and J. M. Purvis 2003. Water quality monitoring program 1998-2000, New River Gorge National River, Bluestone National Scenic River, Gauley River National Recreation Area. National Park Service, Glen Jean, WV.

Wilson, L., K. Vandersall and J.M. Purvis. 2006. Water quality monitoring program 2001-2003, New River Gorge National River, Bluestone National Scenic River, Gauley River National Recreation Area. National Park Service, Glen Jean, WV.

Wood, D. M. 1990a. New River Gorge National River water studies summary 1980 – 1986. West Virginia Division of Natural Resources, Charleston, WV.

Wood, D. M. 1990b. New River Gorge National River water quality study 1989. West Virginia Division of Natural Resources, Charleston, WV.

Wood, D. M. 1990c. New River Gorge National River water quality study 1990. West Virginia Division of Natural Resources, Charleston, WV.

This page intentionally left blank