Big Rock Bacteria Monitoring Project 1999-2008

Final Report

Salt River Watershed Watch
Louisville, Kentucky
December 2008

Acknowledgments

Salt River Watershed Watch recognizes these citizen volunteers who participated as water quality monitors in the project:

- Jean Fenn
- Stephanie Glasford
- Dorothy Gray
- Ken Machtolff
- Trina Palma
- Conrad Selle
- Lynn Schmidt
- Sandy Shroerlucke
- Dan and Anne Siebert
- Jack Still

Bruce Scott coordinated the volunteers, kept records, and prepared this report in addition to monitoring.

In turn, the citizen monitors thank the following people and their organizations for supporting the project:

- Sarah Wolfe and Katie Green, Olmsted Parks Conservancy
- Bud Shardein, Executive Director of the Louisville and Jefferson County Metropolitan Sewer Department
- Beckmar Environmental Laboratory, Louisville, Kentucky
- Judy Petersen, Kentucky Waterways Alliance
- Russ Barnett, Chair of the Steering Committee of Salt River Watershed Watch
- Ken Cooke and Kathy Ward, Water Watch, Kentucky Division of Water

We are grateful to Karen Schaffer, the current Science Coordinator for the SRWW Steering Committee, for her review of this report prior to publication.

We would like to dedicate our report to the late Dr. Jeff Jack who, as a member of the Biology Department of the University of Louisville, advised Salt River Watershed Watch and the Big Rock volunteers on the design of their studies.

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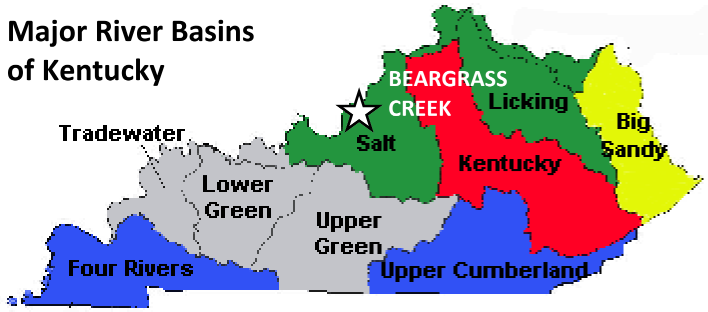
Final Report

For nine years (June 1999– May 2008), citizen volunteers associated with Salt River Watershed Watch monitored bacteria that pollutes "Big Rock," an area in Louisville's Cherokee Park that is used for wading and swimming. This is a final report on the project.

Salt River Watershed Watch

Salt River Watershed Watch (SRWW) is one of eight regional citizen monitoring programs that together span Kentucky's watersheds. SRWW concentrates on the Salt River basin and watersheds of the minor Ohio River tributaries that neighbor it.



Source: Kentucky Division of Water

SRWW and its sister programs are based on the concept of watershed health. In addition to natural conditions such as soils, precipitation, and geology, a stream is affected by human activities on its watershed. A stream is also affected by groundwater flows, especially in areas of karst where underlying bedrock has been dissolved and permits the rapid transport of water (and pollutants) underground.

For the most part, SRWW monitors streams at locations chosen by volunteers. In addition to gathering information about dissolved oxygen, pH, temperature, and flow, volunteers sample for herbicides and pesticides in the spring, bacteria in the summer, and "low-flow" parameters in the fall. SRWW also may authorize volunteer teams to undertake "focus studies," such as the Big Rock study.

Children swimming at Big Rock, 1998. Photo credit: Karen Cairns

Big Rock

Big Rock is a streamside recreational area in Cherokee Park in Louisville, Kentucky. Opened in 1892, the park was laid out along the Middle Fork of Beargrass Creek by its designer, noted American landscape architect Frederick Law Olmsted. The "big rock" itself fell from a cliff above; scouring from floods has created a pool enjoyed by summertime swimmers.

Upstream from the big rock, the level limestone shelves of the stream bottom attract waders of all ages who visit a picnic and play area overlooking the stream. A nearby trailhead demonstrates Best

Management Practices for stormwater. The area is posted with signs warning against contact with the water after storms.

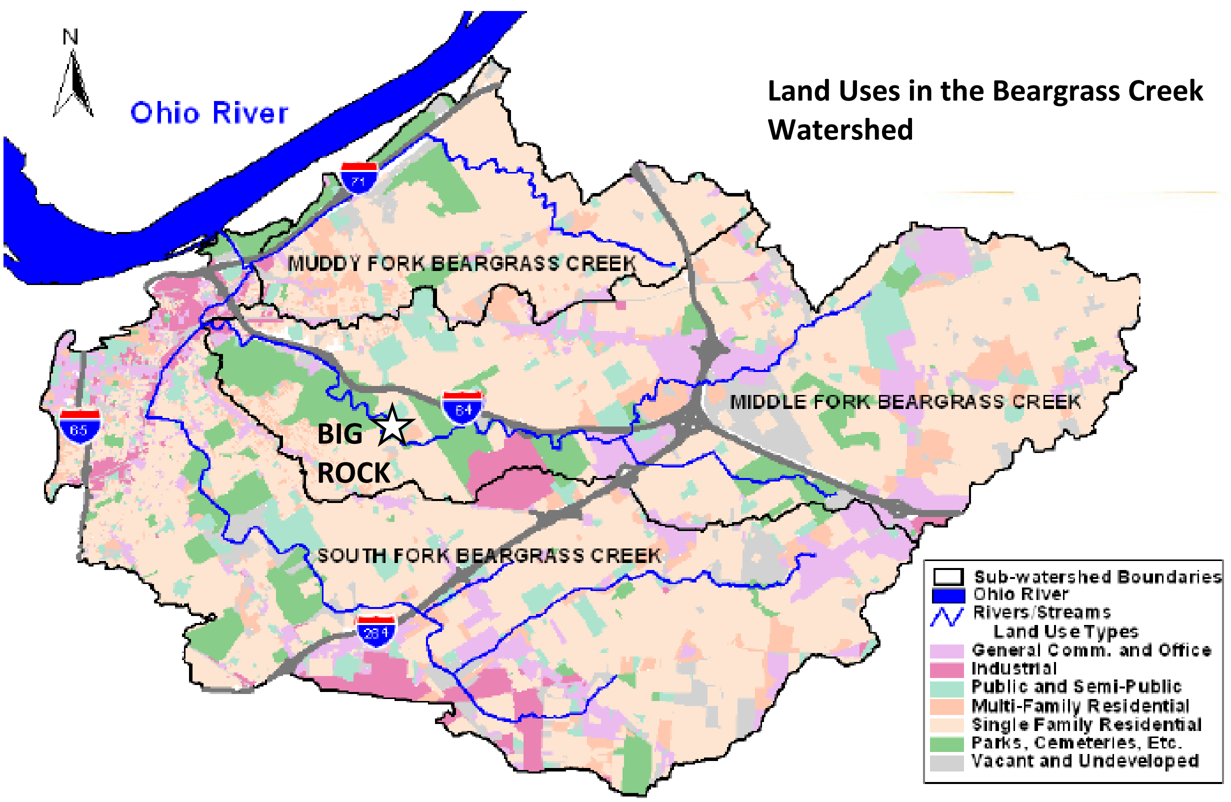
Beargrass Creek

Beargrass Creek lies entirely within Jefferson County, Kentucky. Its political jurisdiction is primarily Metro Louisville, the combined city-county government, but several smaller cities including St. Matthews and Lyndon are other jurisdictions that its streams traverse.

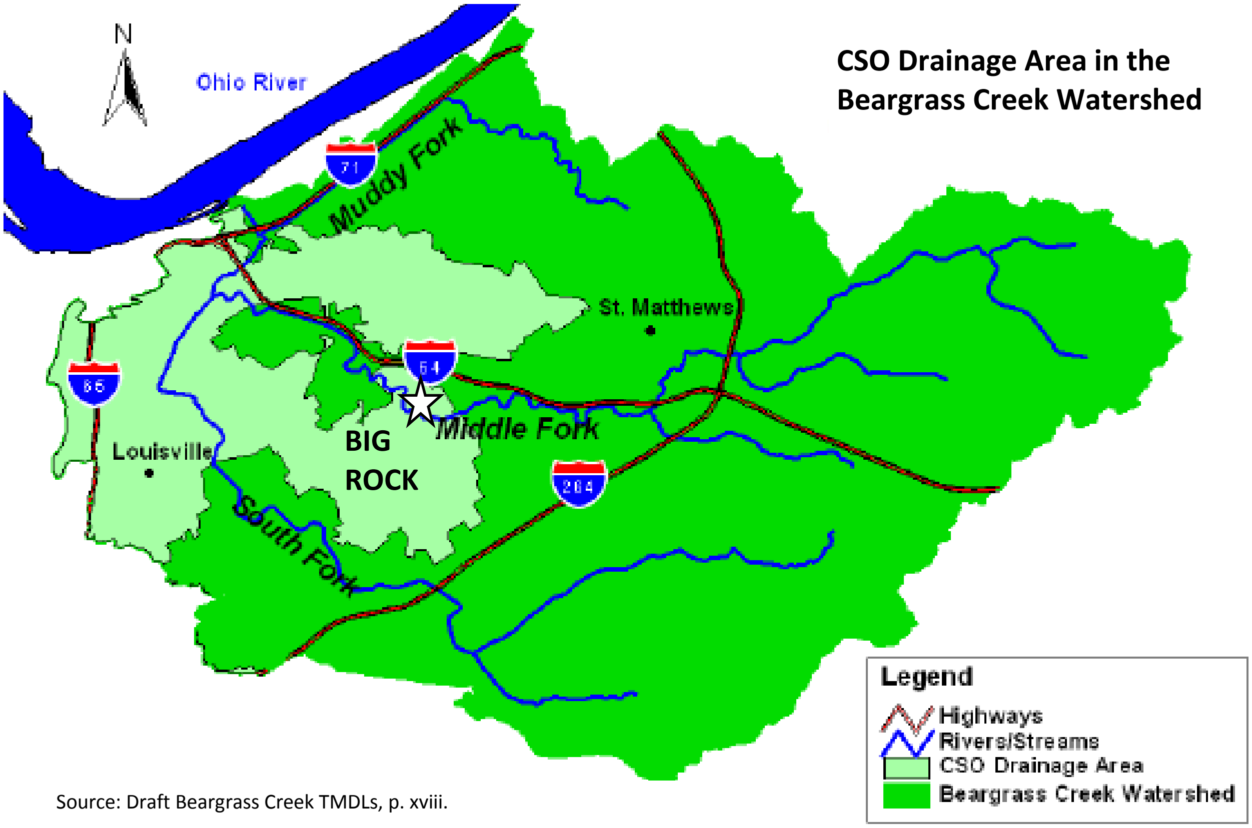
The stream system consists of three major forks: the Muddy Fork (6.9 miles), the Middle Fork (15.8 miles), and the South Fork (13.6 miles). The three forks converge on a channel that formerly flowed across downtown Louisville; the original channel was closed in the 1850s and flow was diverted north through a new channel, called the Main Stem, to the point where it now joins the Ohio River near Eva Bandman Park. The entire watershed of Beargrass Creek covers 60 square miles, and is home to about 200,000 people. (1)

Big Rock is located in the Middle Fork watershed, which drains a surface area of 25 square miles. Land uses are primarily residential (see map, below). Extensive stretches of the stream are bordered by parklands including two of Louisville's historically significant "Olmsted Parks," Seneca and Cherokee, as well as newer parks and greenways developed by the cities of St. Matthews and Lyndon. About ten percent of the watershed is categorized as industrial. (2)

The watershed at and upstream of Big Rock is characterized by karst. Therefore, groundwater is an important consideration in the stream's hydrology.



Source: draft Beargrass Creek TMDLs, p. 11.



Source: Draft Beargrass Creek TMDLs, p. xviii.

One of the biggest challenges facing an urbanizing watershed like Beargrass is the extent of impervious surfaces such as roads, parking lots, and building roofs. Impervious surfaces prevent stormwater from recharging aquifers; furthermore, rainfall is more likely to sweep pollutants, including significant amounts of pathogens, from impervious surfaces to streams without benefit of treatment from a vegetative buffer. The overall imperviousness of the Middle Fork was estimated in 1998 by MSD as 39 percent (3). A more recent study identified several subwatersheds with imperviousness in the range of 10-25 percent, although large areas including the headwaters in the City of Hurstbourne exceeded 25 percent, a threshold value in the literature that indicates that water quality becomes poor if Best Management Practices aren't installed to mitigate the effects of impervious surfaces. (4)

Another major influence on water quality in the Middle Fork of Beargrass Creek is the city's sewer system. Developed areas around Big Rock are within the combined sewer system built previous to World War II that carries both stormwater and sanitary waste (see map, above). During storms, stormwater overwhelms the system and strategically located overflows discharge the excess to the creek so that sewage doesn't back up into homes.

Combined sewer overflow (CSO) volumes in the Middle Fork are dwarfed by the volume of stormwater carrying pathogens that flows off the watershed during storms. A 2008 draft document estimating the Total Maximum Daily Load (TMDL) permissible for pathogens in Beargrass Creek estimated that CSO discharges, themselves consisting of wastewater and stormwater, account for only seventeen percent of the flow of the Middle Fork of Beargrass Creek. (5). The report also identifies aging sewer pipes as sources of pathogens during wet and dry weather. (6) It is important to note that no CSOs are located upstream of Big Rock; in addition, MSD has surveyed stormwater facilities to eliminate sanitary-storm system cross-connections.

Table 1.7 Aggregate Summary of Wastewater and Stormwater Statistics by Sub-basin

SUB-WATERSHED	Area (sqmi)	% Impervious	# Documented SSO Locations	# Documented CSO Locations	# Detention Basins
BEARGRASS					
	1.9	10.3	0	10	0
MIDDLE FORK BEARGRASS CREEK					
	25.0	22.2	132	12	17
MUDDY FORK BEARGRASS CREEK					
	7.5	11.4	15	0	3
SOUTH FORK BEARGRASS CREEK					
	26.4	29.1	110	38	23

Ruling out CSO and SSO contributions, potential sources of elevated pathogens at Big Rock would include:

- Stormwater from impervious surfaces;
- Animal feces from pets and wildlife;
- Failing or poorly sited septic tanks;
- Sanitary sewer overflows; and
- Aging, cracked sanitary sewers.

Water Quality Studies

When the project began, not much data was available about the water quality of the Middle Fork of Beargrass Creek. MSD had intermittently monitored pathogen and other parameters, mostly to assess the functioning of its combined sewer system. Still, the efforts established baseline conditions for further study of the stream's overall health.

In 2003, four years after SRWW's Big Rock project began, MSD established a comprehensive monitoring program in their service area's watersheds. In the Beargrass Creek watershed, five monitoring stations were established to gather data on flow, dissolved oxygen, temperature, and other basic parameters every fifteen minutes. Pathogens are sampled at the sites five times monthly to develop information for regulatory compliance. The diversity of aquatic life-forms, including fish, macro-invertebrates, and algae, are sampled every two years.

MSD's monitoring sites on the Middle Fork are at the intersection of Park and Beals Branch roads in Cherokee Park, downstream from Big Rock, and at Old Cannons Lane and Seneca Park Road, which is upstream. An additional site was established more recently in the lower reach of the Middle Fork where it joins the main stem to assist in the development of the TMDL for pathogens.

A report issued by MSD in 2005 summarized data collected from Beargrass stations in MSD's new monitoring network. The findings for pathogens were not quantified, but displayed in pie charts that show that the percent of samples that did not meet state single-sample standard for primary contact range from approximately 20 percent in the headwaters to about 45 percent in the lowlands. Dissolved oxygen problems were rare in the headwaters but increased to approximately 25 percent of samples in the lowlands. Aquatic life had been measured in two locations: at Old Cannons Lane, where biodiversity was rated “poor,” and at Browns Lane, somewhat upstream, where it was rated “fair.” (7)

Based primarily on data provided by MSD, the Kentucky Division of Water considers the stretch of the Middle Fork of Beargrass Creek where Big Rock is located “impaired” for primary recreation contact due to elevated pathogens. (8)

History of the Project

In its planning meetings in the winter of 1999, the Steering Committee of SRWW identified a monitoring program at Big Rock as a desirable focus study. The committee suggested at least the minimum number of samples required by regulation (9) to characterize the stream’s condition in respect to pathogens.

The regulation governing recreational contact establishes a two-fold standard:

1. A single sample cannot exceed 400 colonies/ 100 ml; *and*
2. A geometric mean of at least five samples in a month cannot exceed 200 colonies/ 100 ml. A geometric mean is the square root of the sum of the squares of the items; it serves to “calm” a wide range of values and usually results in a lower number than an average.

Because of the second standard, five samples per month were ideal. Five volunteers were trained to sample the stream once a month according to a schedule established by the coordinator for the project.

The regulation identifies May through October as the “recreational season” when the standards apply, so monitoring was planned to begin in May, 1999; it actually began in June. That summer was unusual, marked by drought when the standards do not apply, creating a desire for more information; furthermore, volunteer samplers in the project were highly motivated and wanted the sampling to continue. Therefore, the Steering Committee authorized the indefinite continuation of the project.

MSD Biologist Jerry Terhune trains project samplers at the Big Rock picnic pavilion. From left, Conrad Selle, Dorothy Gray, and Trina Palmer.

Turnover among volunteer samplers at the end of the first and second summers required special recruitment and training for citizens from the adjoining neighborhoods who observed sampling activities and volunteered. Two special trainings were provided, in October 1999 and September 2000.

Monitoring results were shared with the community in a variety of ways. Reports on the project were made to SRWW’s annual conferences in 2000, 2003, and 2006. The Friends of Beargrass Creek, now defunct, published results in its quarterly newsletters for the first several years of the project.

At the invitation of the Jefferson County Health Department, a presentation on the results was made in 2002 to the Health Board. A poster developed with support from MSD was displayed at the “Big Rock Jazz Festival” in 2003. The project also received coverage in Louisville’s daily newspaper, the *Courier Journal*.

The project provided a platform for participation by volunteers in planning for the Beargrass Creek watershed. Two volunteers, Kenny Machtolff and Bruce Scott, were members of the Beargrass Creek Watershed Council that met under MSD auspices from 2002 to 2004. One tangible result of the Council's work was the installation in 2005 of a kiosk at Big Rock where the project's results could be posted. The kiosk was a cooperative project among the Council, MSD, Metro Parks, Kentucky Waterways Alliance, and the EPA, which provided matching funds.

The kiosk at Big Rock, where project data and water quality information were posted in cooperation with Metro Parks.

Design of the Study

The hypothesis of the study was that pathogen concentrations in the stream increase during storms. We believed this would occur because of two factors:

- Urban runoff of rainfall during storms is known to have high concentrations of pathogens and
- While there are no combined sewer overflows upstream of the study area, the aging sewers in the area as well as overflows from infiltration into upstream sanitary sewers will also contribute pathogens, again during storms.

In keeping with SRWW's sampling protocols, the study included the collection of these streamside parameters:

- Water temperature in degrees Centigrade;
- Characterization of flow (ponded, low, normal, bank full, flood);
- Characterization of recent rainfall in half-inch ranges;
- Dissolved oxygen in milligrams per liter; and
- pH.

The monitoring site, downstream of the Belknap Bridge and below Big Rock picnic pavilion. This shot is looking east and upstream.

Data for dissolved oxygen and pH were obtained using LaMotte kits. During the visit, streamside data were recorded on a standard SRWW chain of custody form (see Appendix). Samples were collected in accordance with Watershed Watch procedures. (10) Samples with chain of custody forms were transported to Beckmar Environmental Laboratory immediately after sample collection. Beckmar, which is certified by the Kentucky Division of Water to perform bacteria analysis, sent its analysis report with the chain of custody document to the coordinator of the project, who entered the data on a spreadsheet.

Original documents were sent by the coordinator to the Water Watch program of the Kentucky Division of Water in Frankfort, Kentucky, where they are archived.

Results

The tables below show whether monitoring results each month during the recreation season met the two-fold regulatory standard established by the Kentucky Division of Water (summarized in this report on page seven). "OK" means that the two-fold standard was met; "Fail" means that one or both of the standards were not met. (Results for 1999 are not included because the year was marked by drought, when the standards don't apply.)

At Big Rock, Beargrass Creek almost never meets water quality standards for primary contact recreation (swimming); of the 49 months included in the study, the standard was met only during one month, or two percent of the time. However, the stream often met standards for secondary contact (canoeing, wading, fishing but not for consumption); in 21 of the 49 months, or forty percent of the time, secondary contact standards were met.

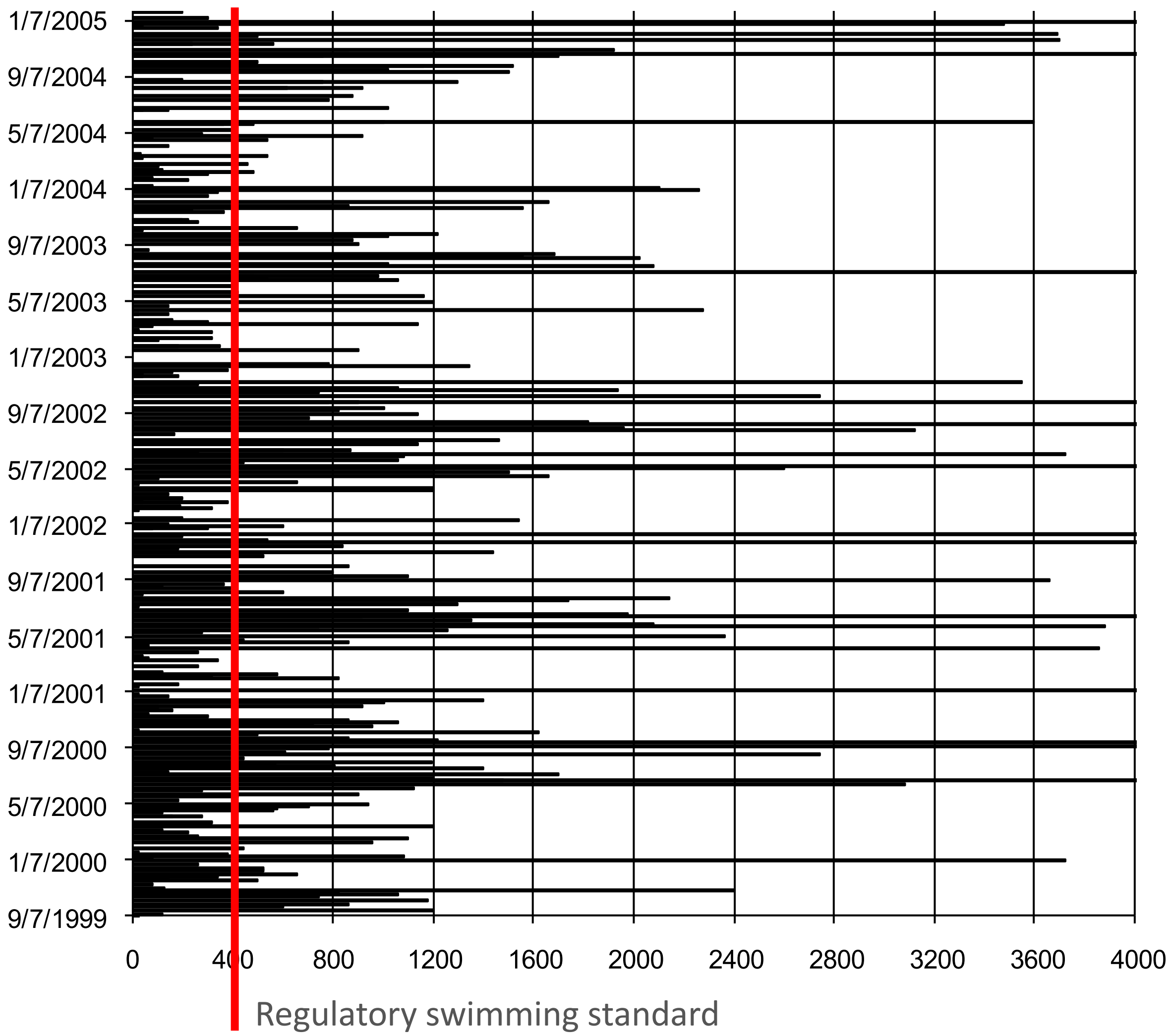
Primary Contact Recreation (Swimming)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
May	Fail	Fail	Fail	Fail	Fail	OK	Fail	Fail	Fail
June	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
July	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
August	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
September	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	
October	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	

Secondary Contact Recreation (Canoeing, Fishing, etc.)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
May	OK	Fail	Fail	OK	Fail	OK	OK	OK	OK
June	Fail	Fail	Fail	OK	OK	Fail	Fail	Fail	
July	OK	Fail	Fail	Fail	OK	OK	Fail	Fail	
August	Fail	OK	Fail	Fail	OK	Fail	OK	Fail	
September	Fail	Fail	Fail	OK	OK	Fail	Fail	Fail	
October	OK	OK	Fail	OK	Fail	OK	OK	Fail	

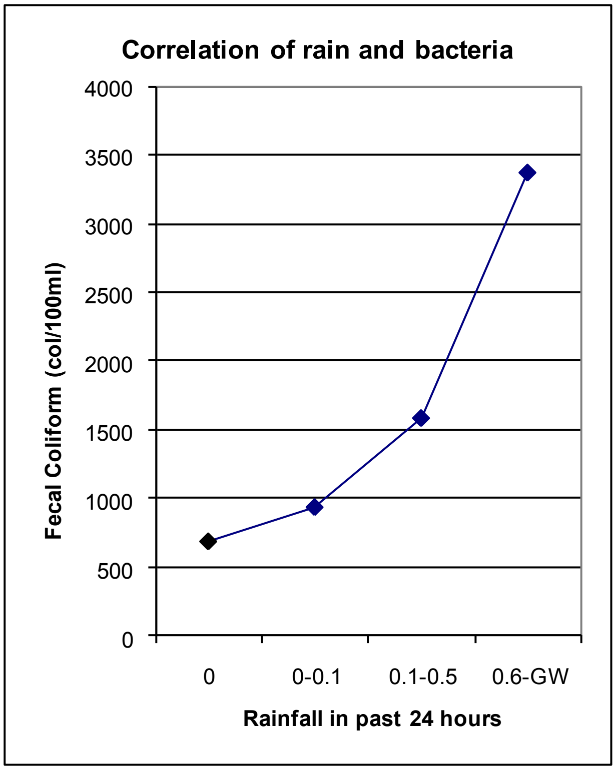
Fecal coliform colonies/ 100 ml, 1999-2004

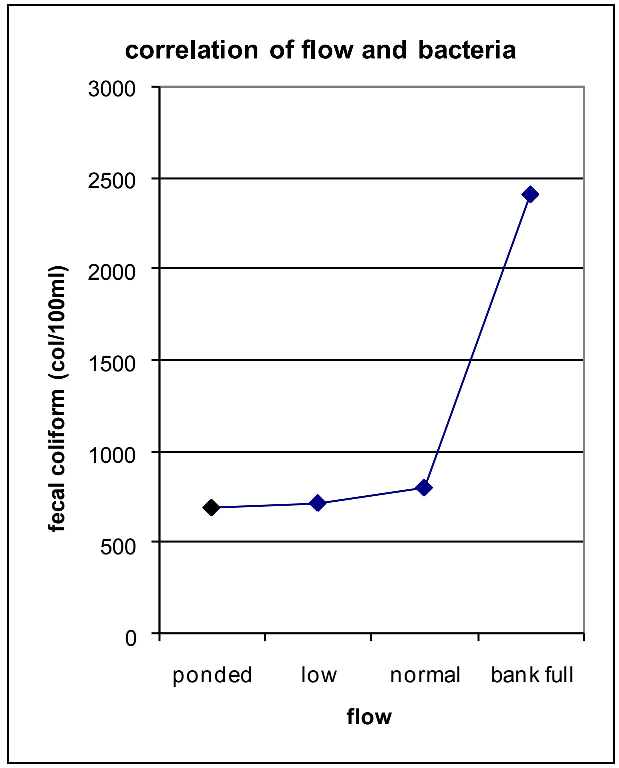


A closer look at the data (chart, above) reveals the nature of the measure we used to measure pathogen pollution in the stream. The chart includes all data from the first six years of the project, and is not limited to the recreation months. To preserve the scale, values exceeding 4000 are cut off.

As can be observed in the chart, pathogen counts vary widely. While variation is certainly due to differences in flow and recent rainfall, limitations on the accuracy of the measure were observed. On eight occasions duplicate samples were taken because of the random nature of the schedules of some volunteers), and the table to the right reveals the range in their values.

date	first value	second value
12/28/01	300	80
6/19/02	600	870
2/27/03	140	320
10/20/04	760	1700
5/31/05	180	40
12/15/06	180	580
2/28/07	100	90
12/19/07	800	440





Analysis of correspondences between average fecal coliform colonies and flow and recent rainfall (N=274). In the chart on the left, rainfall is in inches; “GW” indicates “gullywasher,” a major downpour.

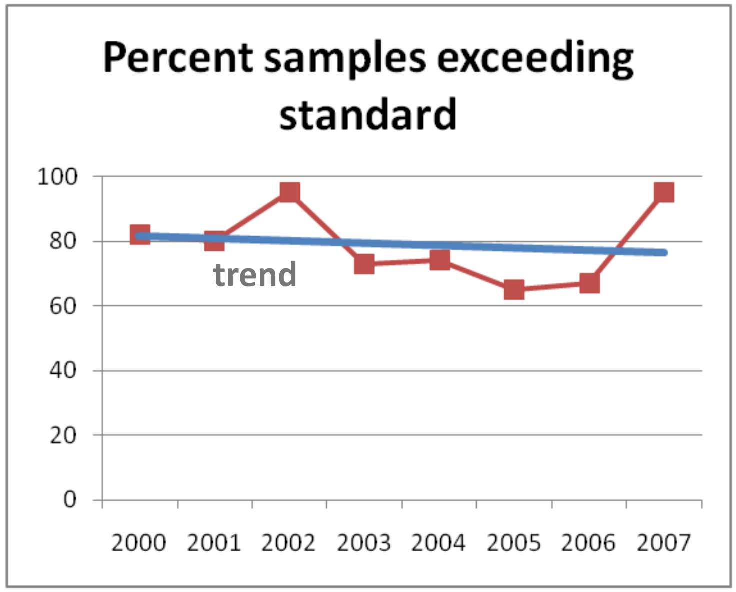
Although values ranged widely, trends emerged that validated our hypothesis when results were aggregated by “recent rainfall” or “flow” (charts, above).

Consistent with our findings about primary contact recreation, the average number of fecal coliform colonies at times of no **recent rainfall** exceeded the single sample standard of 400, but was less than the secondary contact standard of 2000. The secondary contact standard was only exceeded when recent rainfall exceeded 0.5 inches.

A similar finding occurred when the number of fecal coliform colonies was compared to the characterization of **flow**. The secondary contact standard was met, on average, until flow exceeded normal conditions and the banks of the stream were full. (Flood conditions were rarely sampled for safety reasons.)

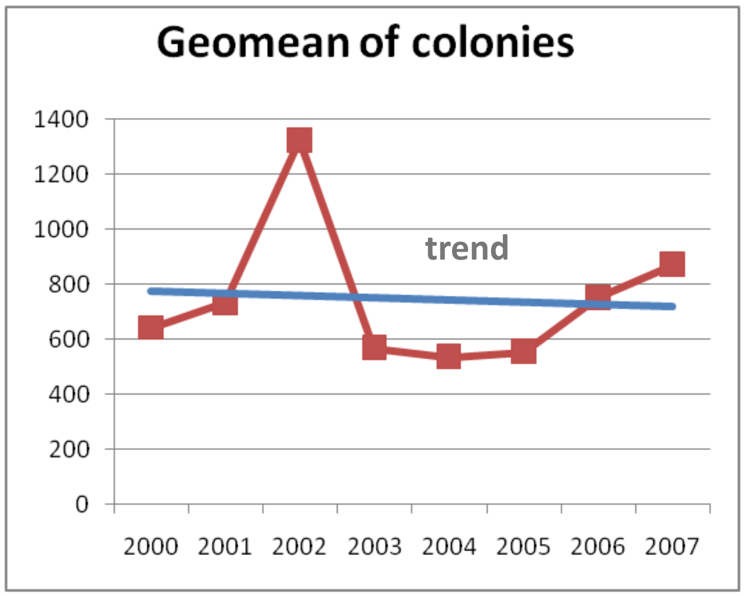
With nine years of weekly data points, it was inevitable to ask the data whether pathogen concentrations were increasing or decreasing over time. MSD had made efforts during the project period to reduce flows from sewer overflows and septic tanks, Metro Parks was reducing mowing along stream banks to help filter stormwater runoff, and various public education campaigns on nonpoint sources like dog droppings had occurred.

By arraying data from 174 data points for low and normal flows over the nine years of the project, a definite trend of improvement appeared in water quality as plotted by the MS Excel program we used (see charts on next page). The trend was apparent when the data was arrayed by percent exceeding the single-sample standard and by geometric means of the data. The year 2002 was an outlier in the data, but did not effect the trend lines when eliminated from the analysis.



Several caveats are necessary when discussing these results.

First, no Quality Assurance Project Plan was developed for the study. Neither duplicate nor blank samples were obtained for quality assurance purposes, although some duplicates were unintentionally generated as noted above and may be useful for quality analysis.



Second, when an average of our data is said to attain a standard, it must be understood that many of the values included in that average grossly exceed it. In a study prepared for the SRWW Annual Conference in January, 2007, a subset of 63 samples were selected where recent rainfall was zero and flow was characterized as normal. The samples had a geometric mean of 349, but ranged between 0 and 6240. Seventy percent (44 of the 63 samples) were below the primary contact single sample standard of 400; however, 21 percent (n = 14) were in the 400-2000 range, and nine percent (n = 6) exceeded the secondary contact single sample standard of 2000.

A final caution is the relationship of fecal coliform colonies to health risk. EPA studies estimate a risk of six additional illnesses per thousand people who have full body contact with water exceeding the state regulatory criteria used by the study. There is no certainty that someone who contacts the water under any circumstances will get sick; at the same time, a person with open wounds or a compromised immune system will be at greater risk than healthy individuals.

Conclusions

Our study's hypothesis was that pathogen concentrations increase during storms. We found that pathogen concentrations increase during wet weather and the higher flows that result.

We also made these findings:

- Standards for primary recreational contact (swimming, full immersion baptism, etc.) are rarely met during normal flow conditions;

- Standards for secondary recreational contact (wading, canoeing, recreational fishing, etc.) are often met during normal flow conditions; and
- The stream always exceeds primary and secondary recreational contact standards for 48 hours following one half inch of rainfall.

In addition, the large amount of data from a single site permitted us to make several preliminary observations about laboratory analysis results:

- Concentrations of fecal coliform in samples taken under similar flow conditions, and even among samples taken within hours of one another, vary widely. To obtain a consistent analytical result, approximately 20 samples taken under similar flow or recent rainfall conditions may be necessary to characterize concentrations of pathogens using fecal coliform analysis; and
- Because concentrations increase rapidly with recent rainfall and the resulting higher flows, flow and recent rainfall are crucial factors in designing studies of pathogen concentrations. A single month of the five-sample regimen, or five samples taken across an entire recreational season, may not adequately characterize pathogen loads.

Recommendations and Next Steps

People's continuing use of Big Rock for primary and secondary recreation indicates the following next steps:

- Results from MSD's pathogen monitoring station upstream of the site at the Old Cannons Lane crossing should be posted at the streamside kiosk used by the project, now that new project data is no longer becoming available.
- MSD should partner with Metro Parks to use the kiosk to educate the public about nonpoint sources of pollution to Beargrass Creek, consistent with its public education requirements under MSD's municipal stormwater (MS4) permit.
- The plans of MSD to reduce CSOs and SSOs through its Consent Decree should be implemented. Because private citizens can reduce the burden on overloaded sewer systems during storms by installing rain gardens, rain barrels, etc., the kiosk may provide an educational resource also for MSD's Consent Decree programming.
- MSD's next municipal stormwater permit should include pathogen reduction strategies with the long-term goal of meeting targets for pathogens in stormwater in the draft TMDL.
- Metro Louisville should educate citizens and implement ordinances that control pet waste.
- Metro Parks and other streamside landowners and land managers should continue to reduce mowing along streams and install native streamside vegetation to intercept runoff and increase infiltration into groundwater, improving dry-weather flows.

References

(1) Kentucky Department for Environmental Protection, "Fecal Coliform TMDLs for Middle Fork, Muddy Fork, and South Fork of Beargrass Creek in Jefferson County, Kentucky," proposed draft, September 2008, p. 1. Online at: www.water.ky.gov/sw/tmdl/TMDLs+Under+Development.htm

(2) *Ibid*., p. 10

(3) Louisville and Jefferson County Metropolitan Sewer District (MSD), "Beargrass Creek Watershed." Online at: www.msdlouky.org/insidemsd/wwwq/watershed/beargrass.htm

(4) MSD, "Beargrass Creek Watershed, A community lifeline in critical condition," pamphlet, 2003.

(5) "Fecal Coliform TMDLs," *op. cit*., p. 45.

(6) *Ibid*., p. 42.

(7) MSD, "Beargrass Creek Watershed, State of the Streams," pamphlet, 2005. Online at: www.beargrasswatershed.org/pdfs/BCW_State_of_the_Streams2005.pdf

(8) Kentucky Division of Water, "Final 2008 Integrated Report on the Conditions of Water Resources in Kentucky," p. 139. Online at: www.water.ky.gov/sw/tmdl/303d.htm

(9) Kentucky Administrative Regulations, 401 KAR 10:031, Surface water standards:

Section 7. Recreational Waters. (1) Primary contact recreation water. The following criteria shall apply to waters designated as primary contact recreation use:

(a) Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli. These limits shall be applicable during the recreation season of May 1 through October 31. Fecal coliform criteria listed in subsection (2)(a) of this section shall apply during the remainder of the year.

(b) pH shall be between six and zero-tenths (6.0) to nine and zero-tenths (9.0) and shall not change more than one and zero-tenths (1.0) pH unit within this range over a period of twenty-four (24) hours.

(2) Secondary contact recreation water. The following criteria shall apply to waters designated for secondary contact recreation use during the entire year:

(a) Fecal coliform content shall not exceed 1,000 colonies per 100 ml as a thirty (30) day geometric mean based on not less than five (5) samples; nor exceed 2,000 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period.

(b) pH shall be between six and zero-tenths (6.0) to nine and zero-tenths (9.0) and shall not change more than one and zero-tenths (1.0) pH unit within this range over a period of twenty-four (24) hours.

(10) Watershed Watch in Kentucky, "Standard Operating Procedures for Grab Sample Collection."Online at http://kywater.net/01-Watershed%20Watch/06_Sampling/2005-QAPP/01-WSW-Sampling-SOP-4.doc

Appendix

Salt River Watershed Watch
Chain of Custody Record
Big Rock Monitoring Program

Sample #	Stream Name	Date	Time
S77	Middle Fork Beargrass Creek		
Watershed	Sampling Location	Sampler Name	Telephone
S39	Big Rock pavilion in Cherokee Park		
County	Description of general water conditions		Supervsng Sampler
Jefferson			Bruce W. Scott
Flow (m/sec)			

Flow Rate	Rain in last 48 hrs?	Water Chemistry				
◊ 0-Dry ◊ 1-Ponded ◊ 2-Low ◊ 3-Normal ◊ 4-Bank full ◊ 5-Flood!	◊ Zero ◊ Less than 0.1 inch ◊ 0.1-0.5 inch ◊ 0.6-1.0 inch ◊ 1.1-1.5 inches ◊ Gullywasher!	O2	pH	Temp	Cndvty	

General comments, questions, concerns, or suggestions:	Sample for analysis:
	Fecal Coliform

When a sample's custody changes, the person relinquishing the sample and the person receiving it must sign below and provide the date and time:

Relinquished by (signature)	Date/Time	Received by (signature)	Date/Time

SAMPLER: Do your best to complete the unshaded parts of the form. This form must accompany your sample to the lab. When delivered, ask the lab to make a copy for you.

LABORATORY: Please mail the original of this form with the fecal coliform result to:
Bruce Scott

Frankfort, KY 40601
Questions or concerns?
Call Bruce at the number up above or
Ken Cooke at Water Watch