Mar 17th, 3:15 PM

Session 2D: Pathogen Transport

Kentucky Water Resources Research Institute, University of Kentucky

ASSESSMENT OF NONPOINT SOURCE IMPACTS ON GROUNDWATER QUALITY IN SOUTH ELKHORN CREEK BASIN, CENTRAL KENTUCKY

Robert J. Blair, Jolene M. Blanset, Joseph A. Ray and James S. Webb
Kentucky Division of Water
14 Reilly Road, Frankfort, KY 40601
(502) 564-3410; robert.blair@ky.gov

As part of statewide efforts to characterize ambient groundwater and nonpoint source impacts, the Kentucky Division of Water sampled twenty-two springs in the South Elkhorn Creek watershed in central Kentucky. The project began in January 2004 and is funded with a Clean Water Act §319(h) Nonpoint Source Pollution grant.

Surface water in South Elkhorn Creek has been impacted by flow and habitat alterations, nutrient enrichment, heavy metals including lead and copper, low dissolved oxygen, pathogens, and organic compounds associated with agricultural and urban run-off. Portions of the watershed have been listed as impaired and do not support all or some of their designated uses (KDOW 305b report, 2000). The focus of this project was to assess groundwater quality and its contribution to surface water quality.

The South Elkhorn Creek watershed covers approximately 179 mi^2 in portions of Fayette, Jessamine, Woodford, Scott and Franklin Counties. The watershed lies completely within the Inner Bluegrass Physiographic Region of Kentucky. The area is underlain by Ordovician limestone and shale with moderately to well-developed karst. Land cover in the study area is predominantly agricultural (71%), forest (14%) and urban/residential (13%).

While some historical groundwater quality data are available this study has significantly increased our knowledge. A total of 168 samples were collected from 22 springs, including two springs that had been part of our Ambient Groundwater Monitoring Network since its inception in 1995. Groundwater quality in the study area is degraded by pathogens and nutrients. Specifically, Eschericia Coli (*E*. Coli) was detected in all study area springs and 98% of samples. Nutrients found to be problematic are Nitrate-N, Orthophosphate-P and Total Phosphorus. These data will be evaluated to determine whether these springs are meeting water quality standards.

Many of these karst groundwater basins ultimately draining to the South Fork of Elkhorn Creek have previously been mapped by dye-tracing; additional tracer tests were conducted for this study. Previous authors identified 90 unique subsurface flow paths and delineated a total of 18 karst groundwater basins interconnected with the South Elkhorn Creek watershed. Tracer tests conducted for this study revealed 12 new subsurface flow paths and allowed the delineation of two additional karst groundwater basins. Comparison of dye-trace data to the USGS 11- and 14-digit Hydrologic Unit Code (HUC) boundaries indicates that 43% of mapped karst groundwater basins deviate from boundaries based on topographic divides.

NOTES

KARST GROUNDWATER INFILTRATION OF THE SANITARY SEWER WITHIN THE BEARGRASS CREEK WATERSHED, JEFFERSON COUNTY, KENTUCKY

Joseph A. Ray, Robert J. Blair, and James S. Webb
Kentucky Division of Water
14 Reilly Road, Frankfort, Kentucky 40601
(502)564-3410; joe.ray@ky.gov

Karst groundwater mapping and water-quality sampling of 30 karst springs in the Beargrass Creek watershed has been conducted since 2004, funded primarily by a Clean Water Act §319(h) Nonpoint Source Pollution grant. This work increased the inventoried karst springs in the watershed from 9 to 48, several of which included attendant spring houses dating from the late 1700's. Karst development mainly occurs in the Devonian Sellersburg & Jeffersonville Limestones and the Silurian Louisville Limestone. Although karst landforms are subdued and depth of development is relatively shallow, occasional cover-collapse sinkholes 3-5 m deep have occurred, usually triggered by stormwater erosion. This study has discovered significant inter-relationships between karst groundwater flow in this watershed with the sanitary, storm, and combined sewers, providing insight for Metropolitan Sewer District (MSD) in addressing Combined Sewer Overflows (CSO's) and Sanitary Sewer Overflows (SSO's).

Localized conduit flow can be efficient and rapid. Traced groundwater flow routes are generally less than 2 km in length, with the greatest flow velocity exceeding 1.4 km/d. These tests have helped map 16 spring basins, only one of which had been previously identified. As might be expected in this urban watershed, several karst springs have been channelized with concrete storm-drains or metal culverts, including five CSO's.

Tracer tests in two basins demonstrated that dyes infiltrated the sanitary sewer, revealing that significant base flow was locally being diverted from Beargrass Creek. This abstraction occurs by infiltration of an aging leaky infrastructure as well as intentionally engineered diversion of groundwater runoff. This combined extraction may impact the stream's water quality by limiting potential dilution of urban and agricultural pollutant load.

Sewer Infiltration: An unnamed southern tributary of Middle Fork of Beargrass Creek, east of I-264, runs dry during low flow conditions, even though it is fed by at least three minor springs. Tracer dyes injected at stream swallets draining into bedrock along Hurstbourne Country Club were repeatedly lost until the sanitary sewer paralleling the tributary was monitored. The dye was quickly detected in the sewer, which apparently captures the entire base flow for this 6 km-long sub-basin. South of I-64, un-recovered dye injections at two losing points of Weicher Creek were explained when a replication was detected in less than two hours in a sewer main adjacent to the stream. The base flow of this 4.5 km-long sub-basin is likewise captured from the Middle Fork of Beargrass Creek. Two un-recovered dye injections into separate sinkholes in the City of St. Matthews may have also infiltrated the sanitary sewer at unknown locations.

Bowling Boulevard Spring, the second largest spring in the study area, with an estimated basin of 4.2 km^2, fails to maintain flow during very dry periods. The most obvious explanation is loss of base flow into the sanitary sewer. Sewer abstraction of karst groundwater in the Beargrass is facilitated by shallow conduit flow routes and older sewer infrastructure. Likewise, intersection and diversion of natural flow routes into storm-water drains is suspected at Nunnlea Spring due to construction of Hurstbourne Parkway. Channelization of groundwater through two outfalls by construction of I-64 has been demonstrated over a path of at least 0.5 km. Although Brown Cemetery Spring appears to have been diminished by this storm-water channelization, the intercepted groundwater does discharge to Beargrass Creek.

Intentionally engineered diversion of karst groundwater into the sanitary sewer was verified along Brownsboro Road. Tracer dye injected into spring flow (1.5 L/s) entering a storm drain was not detected at the logical down-valley discharge point at CSO 154 along Mellwood Avenue. This non-recovery supported MSD maps which indicated that this storm drain contributed flow to the sewage treatment plant. Because of this single diversion, Edwards Pond Branch below CSO 154, which is contaminated by frequent sewer bypasses, fails to receive at least 130 m^3/d of flushing by groundwater discharge. Observations suggest that groundwater runoff from the entire 2.8 km^2 watershed at the west end of Brownsboro Road may be diverted into the sewer system, depriving the surface stream of base flow (not to mention overloading of the treatment system).

Sewer Leakage: If groundwater leaks into a sanitary sewer, sewage may exit during peak flow. Sewer overflow into the groundwater system has been demonstrated north of the I-264/US 31-E interchange, near the historic Farmington Homestead Spring. During high-water conditions, dye introduced into the sanitary sewer near Bardstown Road was detected in the basement sump of a home 230 m to the east.

Also, Spring Station Spring west of St. Matthews appears to be impacted by an ongoing sewer leak at an unknown location. Evidence includes high background levels of fluorescent dyes common to sewage and occasional sewer gas at the spring conduit. During the summer of 2007, the spring was consistently high in bacteria. On May 15, Spring Station Spring exceeded 19 other springs sampled, at 24,196 and 9,804 colonies per 100 ml of total coliform and e-coli, respectively. The lowest of six samples collected at the spring were 7,850 and 1,100 colonies per 100 ml of total coliform and e-coli, respectively.

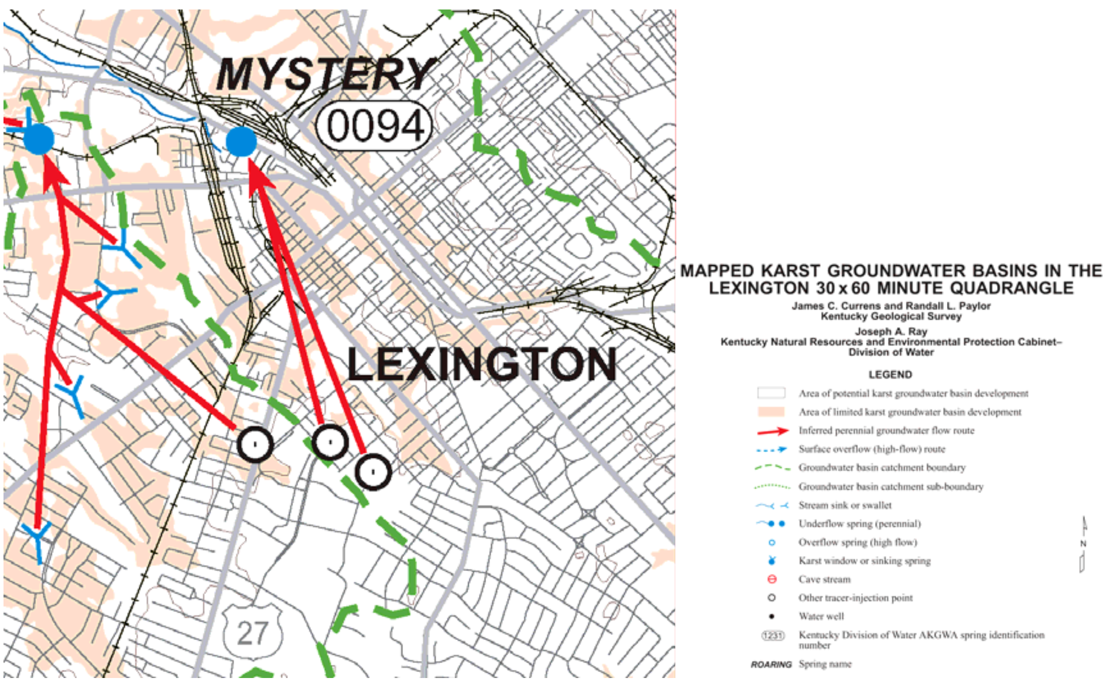
Dye-trace evidence from this study provides independent confirmation that the sanitary-sewer infrastructure in eastern Louisville requires repairs and re-engineering to limit diversion of groundwater and stream base flow, and to reduce sewer leakage and chronic by-passes. This study also demonstrates that karst development within the Beargrass Creek watershed is an integral component of its hydrology. These data further validate the high hydrogeologic sensitivity rating attributed to the Sellersburg & Jeffersonville Limestones and the Louisville Limestone by the Division of Water (1994).

ILLICIT DISCHARGE INTO TOWN BRANCH IN LEXINGTON, KENTUCKY

Charles Martin, P.E. and Rod Chervus, P.E.
Lexington Fayette Urban County Government
Water and Air Quality
301 Lisle Industrial Ave
Lexington, Kentucky 40511
859-425-2400
chmartin@lfucg.com
rchervus@lfucg.com

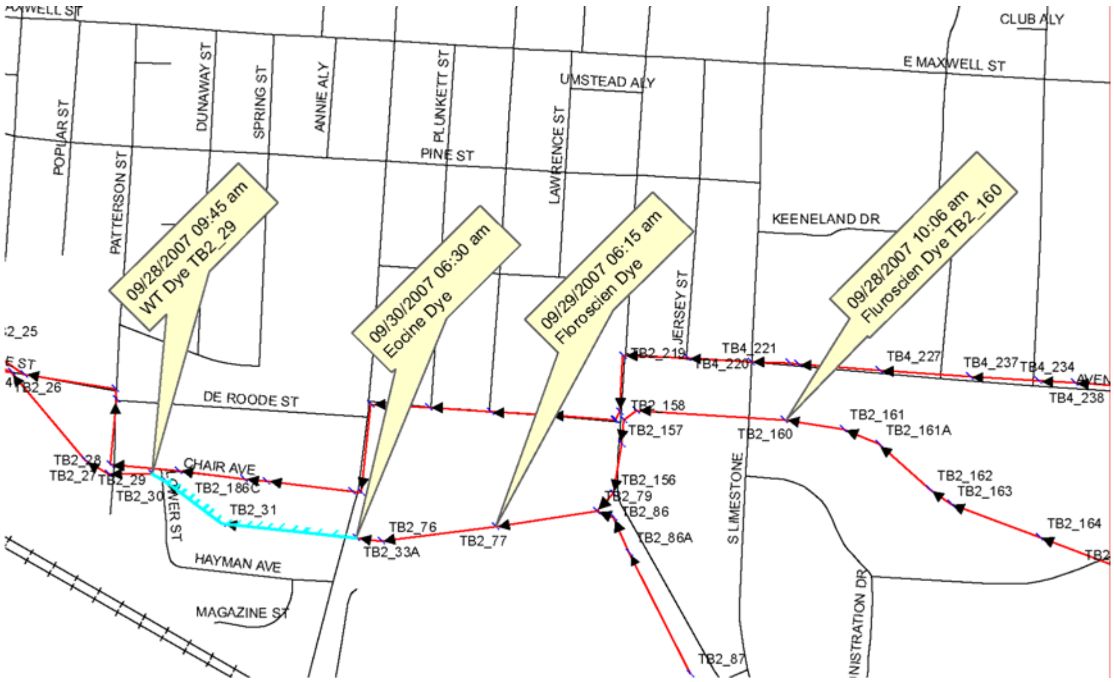
Richard Walker, P.E., and Jim Buckles, P.E., BCEE (Corresponding Author)
Tetra Tech, Inc.
800 Corporate Drive, Suite 800
Lexington, Kentucky 40503
859-223-8000
richard.walker@tetratech.com
jim.buckles@tetratech.com

In September 2007, a suspicious contaminant, believed to be untreated sewage, was detected in Town Branch Creek approximately 1,200 feet upstream of the Manchester Road stream crossing near Ferrell's Car Care. The contaminant below the stream waterline was a gray color and contained a strong hydrogen sulfide odor. A few days after detection of the discharge, LFUCG, Tetra Tech, and the Kentucky Division of Water (KYDOW) Groundwater Branch collaborated to conduct a hydrogeologic documentation review and several dye trace studies. The hydrogeologic documentation revealed that the discharge point along Town Branch Creek was Mystery Spring, part of an extensive karst groundwater basin (see below).



The two dashed lines delimit the Mystery Spring Basin. Though karst topography is difficult to map exactly, all of the observed data validates these boundaries. Water does not flow between water basins; any dye injected into pipelines within the two dashed lines could later be detected at the Mystery Spring discharge point. Any dye injected into pipelines on either side of the bounded area could later be detected at other discharge points, but could not be detected at Mystery Spring.   Any pipeline rupture that discharged contaminant at the Mystery Spring location must therefore be contained within the Mystery Spring Basin. In this way, the hydrogeologic study proved extremely valuable in limiting the area of the possible locations of the source of the contaminant.

The dye traces revealed the location of the release to be between Chair Avenue and South Limestone. Dye traces further narrowed the field of possible locations to some point between TB2_28 and TB2_33A (see below).



While these investigative studies were being conducted, LFUCG took action to treat the illicit contaminant from the spring by capturing the water with a concrete structure and pumping it to the LFUCG collection system for treatment at the Town Branch wastewater treatment plant. A coffer dam was constructed around the spring to isolate the contaminated discharge and the spring water was pumped into the 36” line located near the spring’s discharge point.

Once the dye traces had narrowed the search, LFUCG mobilized to the area where the failure was believed to be and began investigation of this section of pipeline with television equipment. The leak in the sewer was found and rehabilitation of this section of line was accomplished using cured-in-place pipe **(**CIPP**)** technology that sealed the leak and stopped the migration of untreated sewage into the underlying karst aquifer.

ASSESSMENT OF WATER QUALITY TRENDS IN THE UPPER FORKS OF THE KENTUCKY RIVER BASIN: FOCUS ON PATHOGEN IMPAIRMENT

Chandramouli V and Lindell Ormsbee
Kentucky Water Resources Research Institute
233 Mining and Mineral Resources Building
University of Kentucky, Lexington, KY 40506
Email: chand@engr.uky.edu Phone: 859 257 8005.
Email: lormsbee@engr.uky.edu Phone: 859 257 6329

This project consisted of analyzing existing water quality data for streams in the Upper Forks of Kentucky River Basin, with a particular focus on pathogen trends (Figure 1). According to the most recent 303(d) list of Kentucky waters, the majority of streams assessed in the Upper Forks of Kentucky River Basin are impaired for primary recreational contact as a result of pathogens. The state pathogen standard for primary contact recreation is expressed in a dual form which specifies that the 30-day geometric mean of fecal coliform counts not exceed 200 colonies per 100 mL (on a minimum of five samples) and not more than 20 percent of samples should exceed 400 colonies per 100 mL (KAR, 2002).

Historical monitoring data were utilized to assess fecal coliform concentrations and to evaluate the level of success of previous and ongoing projects in the basin. These projects are being funded and implemented through Section 319(h) of the EPA Clean Water Act, Eastern Kentucky PRIDE, the USCOE 531 wastewater program, and the Kentucky Wastewater Program to reduce the level of pathogens in the basin. The assessment utilized historic monitoring data obtained from four different sources: 1) the Kentucky Division of Water (KYDOW) ambient water quality network, 2) the KYDOW focused sampling network, 3) the Kentucky Watershed Watch network, and 4) the University of Kentucky monitoring network. The evaluation involved the analysis of the combined data sets using standard statistical measures to assess pathogen trends and project impacts. Land use patterns were documented to help identify likely pathogen sources, and areas of best management practices (BMP) implementation were examined for correlation with any water quality improvements. Statistical analysis was conducted using data sets to infer changes in the mean concentrations of fecal coliform over two monitoring periods. Standard statistical techniques F test, Student T test and Satterthwaite's Two Sample T test were used for this analysis. Decreases in fecal coliform concentrations were noted for several individual sampling sites throughout the basin and for the aggregated data from the entire basin considered together (Figure 2).

References:

Gilbert, R. O., 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold Company Inc, New York.

KAR, 2002. Kentucky Administrative Regulations. Title 401, Chapter 5:031.

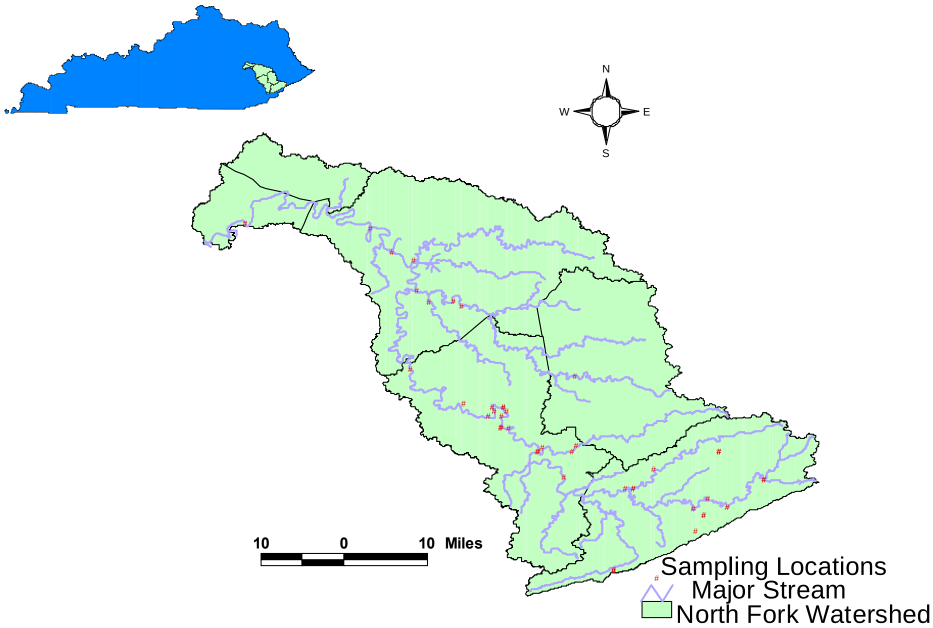


Figure 1. North Fork Watershed – Considered Sampling Station Locations

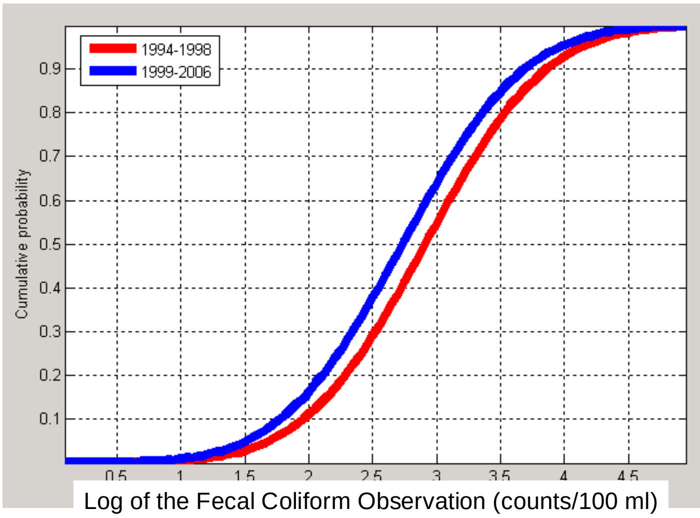


Figure 2. Cumulative Probability Distribution Plot indicating improvement in the System (Watershed based analysis)