Integrated Monitoring of Stream Quality in an Urbanizing Kansas County

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http://ks.water.usgs.gov/Kansas/studies/qw/jocol

National Water Quality Monitoring Conference, May 20, 2008

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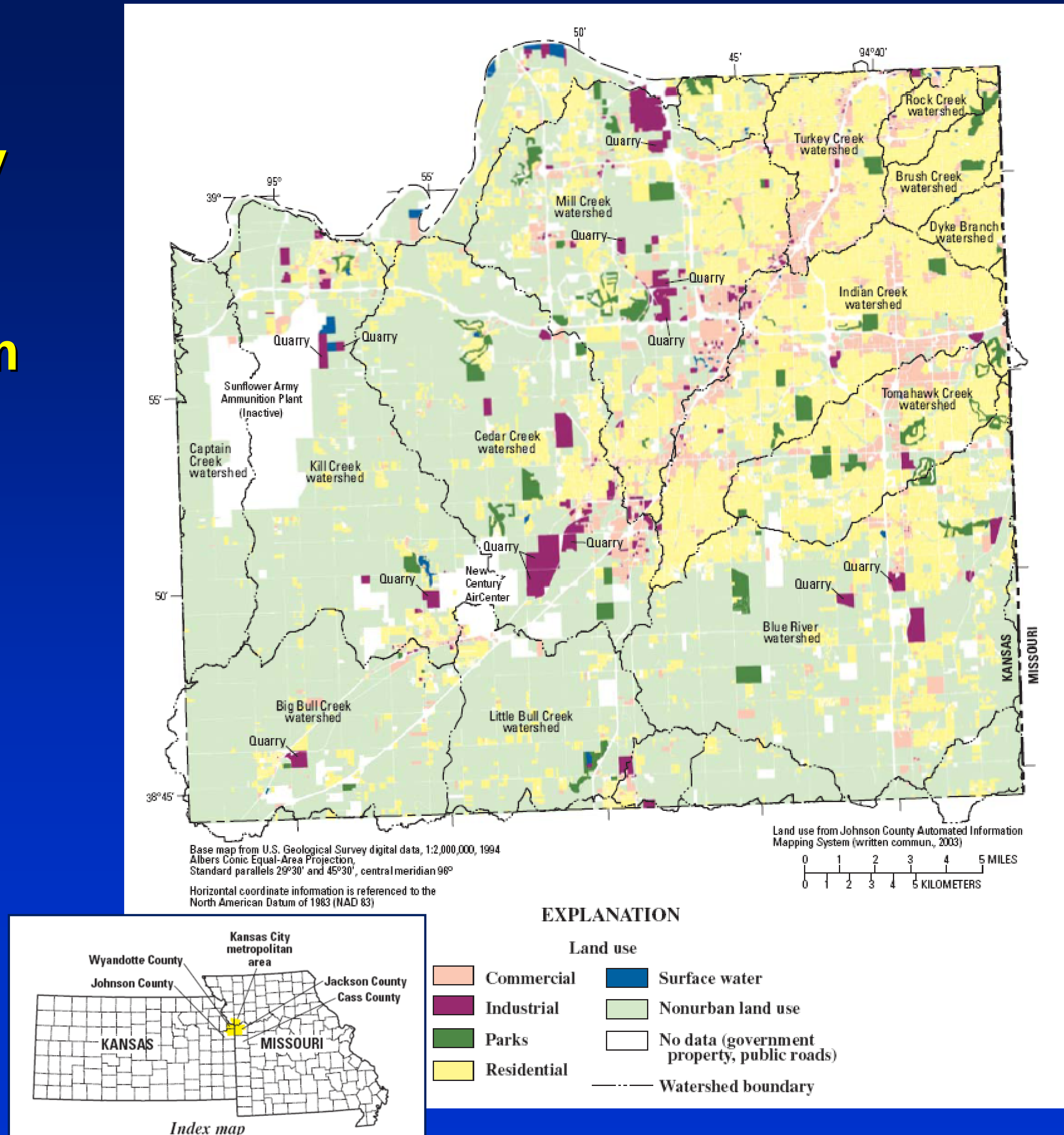
Johnson County Stormwater Management

Population growth in Johnson County leads to increasing interest in stream quality

- Human and environmental health
- Drinking water supply
- Recreation
- Aesthetic value
- State and federal regulations



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Most water-quality impairments in Johnson County are related to excessive bacteria, nutrients, and sediment

Impairments (303d listings) and associated watersheds

Biological	Mill
Chloride	Mill
Chlordane	Blue, Mill
Dissolved oxygen	Blue
Fecal coliform bacteria	Blue, Cedar, Indian, Kill, Mill
Nitrates	Cedar, Indian
Nutrients	Blue, Mill
Sediment impact	Mill
Eutrophication	Lakes - Gardner City, Hillsdale, Olathe and Cedar

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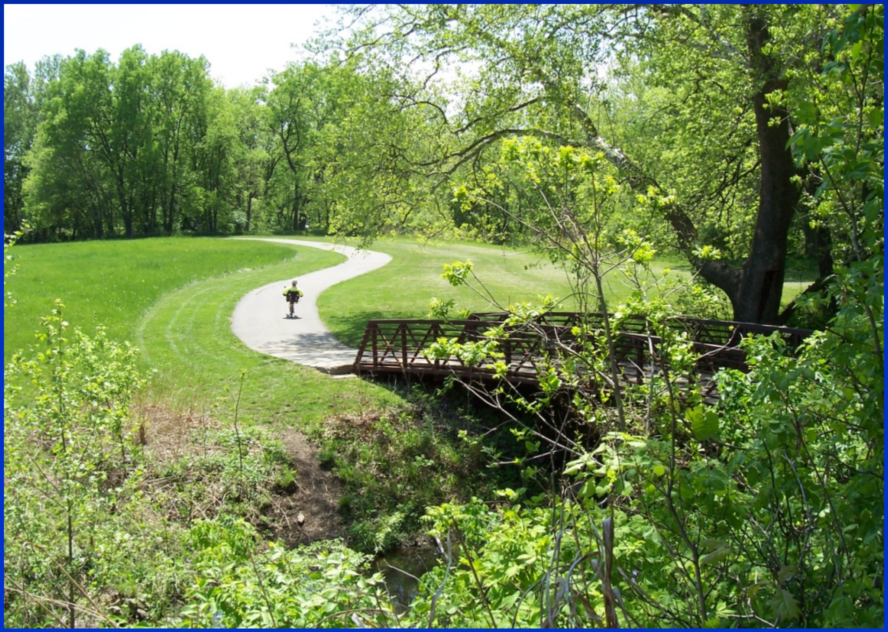
Cooperative water-quality studies between USGS and the Johnson County Stormwater Management Program, 2002-07

Objectives:

- Characterize water-quality of Johnson County streams and determine baseline (current) conditions
- Identify contaminant and sediment source areas
- Estimate contaminant concentrations and loads
- Evaluate effects of urbanization on water quality
- Monitor changes in water quality
- Provide information for developing effective water-quality management plans
- Help meet requirements of the Clean Water Act



Mill Creek near
Shawnee Mission Park

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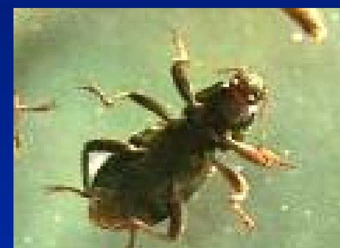
Overall study approach

I. Water and sediment sampling to identify contaminant sources

II. Biological assessment to describe biological conditions

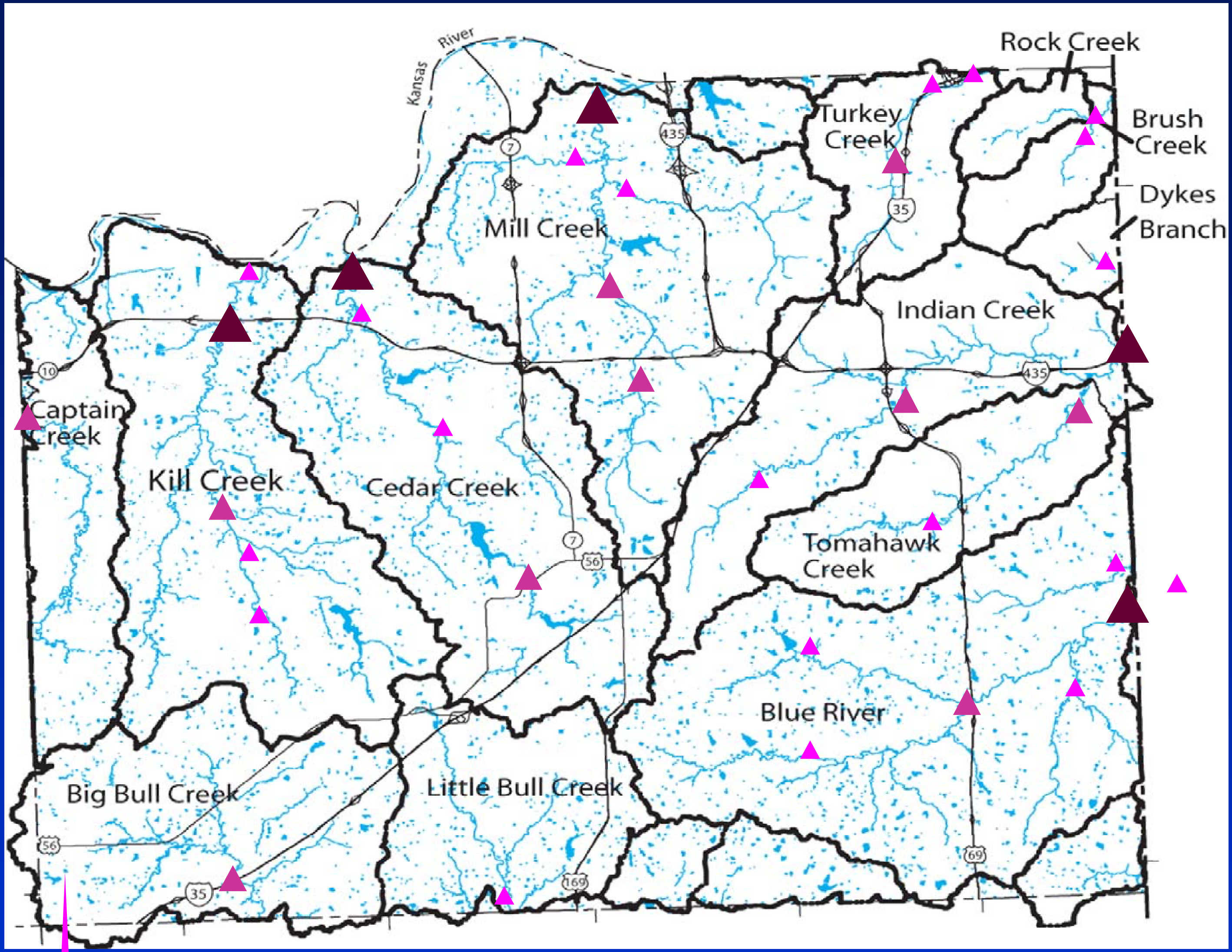


Riffle beetle

Stonefly

III. Continuous water-quality monitoring to estimate chemical concentrations and loads

Sampling sites



Water samples

Water, sediment, biological samples

Continuous monitoring, water, sediment, biological samples

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I. Identifying contaminant sources, 2002-04

1. Evaluated baseflow water-quality conditions - collected 2 synoptic base-flow samples from about 45 stream sites (Nov 2002, July 2003)

2. Examined effects of stormwater – collected several stormflow samples at 6 sites

3. Evaluated combined (base- and stormflow) effects on streams – collected streambed-sediment samples at 15 sites

4. Evaluated point and nonpoint sources of water-quality contamination as related to land use

5. Measured streamflow, suspended sediment, dissolved solids and major ions, nutrients, indicator bacteria, pesticides, wastewater compounds, pharmaceuticals

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Base flow - point sources

- WWTF discharges were the largest source of streamflow during base-flow conditions at sites downstream from WWTFs
- WWTF discharges were a source of elevated concentrations of dissolved solids/major ions, nutrients, and wastewater and pharmaceutical compounds
- WWTF discharges decreased suspended sediment and bacteria concentrations
- Secondary treatment processes affected wastewater and pharmaceutical compound concentrations

Wastewater treatment facility (WWTF)

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Storm flow - nonpoint sources

- Urban areas had increased bacteria and wastewater compounds (upstream from WWTFs)
- Some wastewater compounds had substantial nonpoint sources
- Road salt caused largest dissolved solids/major ions in winter, urban samples
- Sediment, nutrients, and indicator bacteria had large nonpoint sources
- Pesticides were largest in spring, rural stormflow samples

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II. Biological assessment, 2003-04

1. Defined current biological conditions of Johnson County streams
2. Described relations between macroinvertebrates and land use, water and stream quality
3. Evaluated effects of urbanization on macroinvertebrate communities
4. Compared conditions in Johnson County sites to downstream sites in Missouri
5. Compared stream conditions to State biological criteria

Sampled 15 stream sites in Johnson County in early spring of 2003 and 2004

Also evaluated published data from 7 additional sites, 1 in Johnson County and 6 in Missouri

Available land use and water- and streambed-sediment quality data also evaluated

Mayfly (Ephemeroptera)

Stoneflies (Plecoptera)

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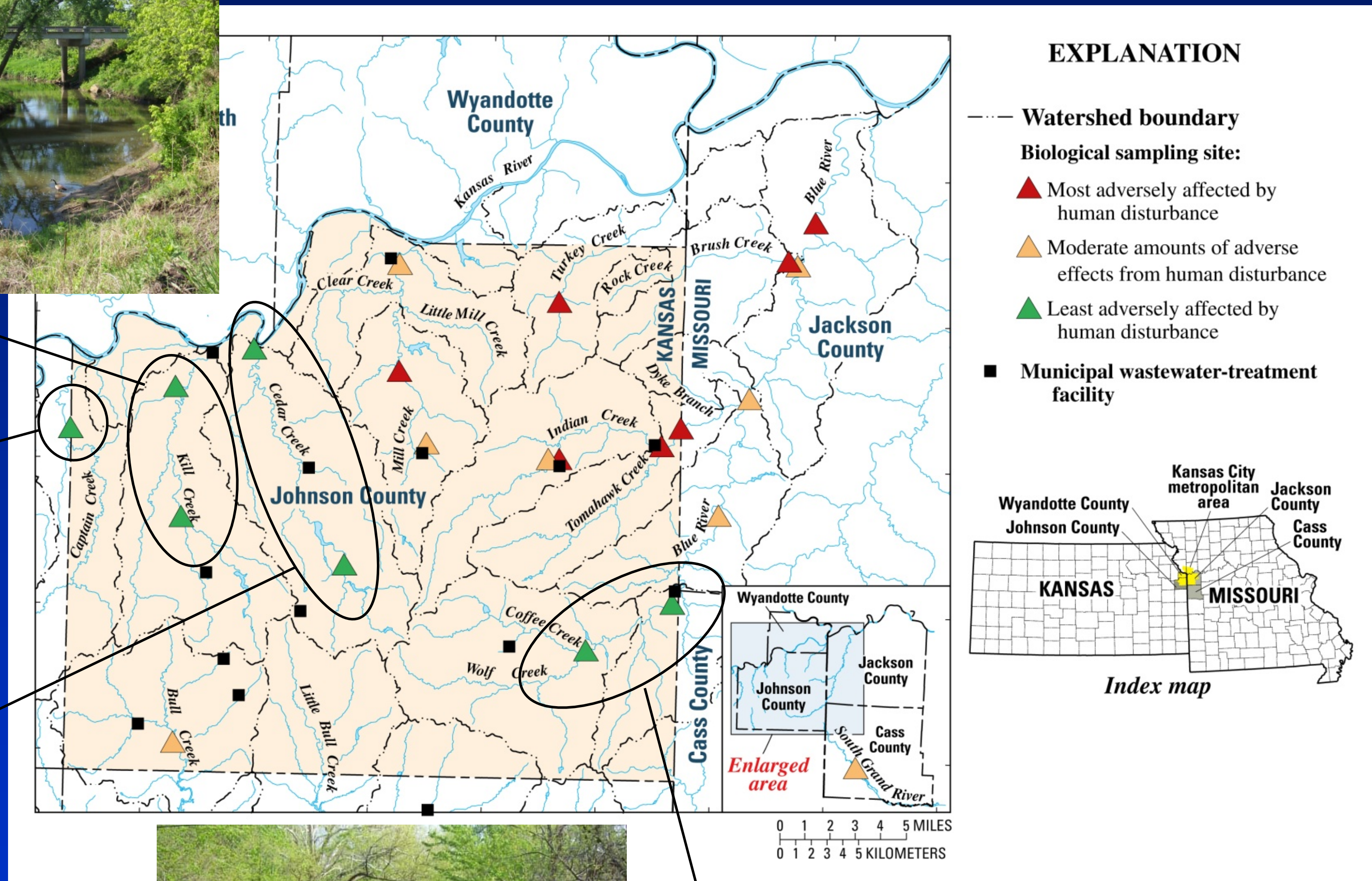
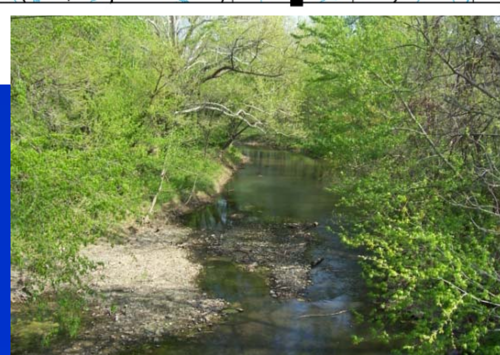
Rural sites consistently scored among those least impacted.

Kill Creek sites

Captain Creek

Cedar Creek sites



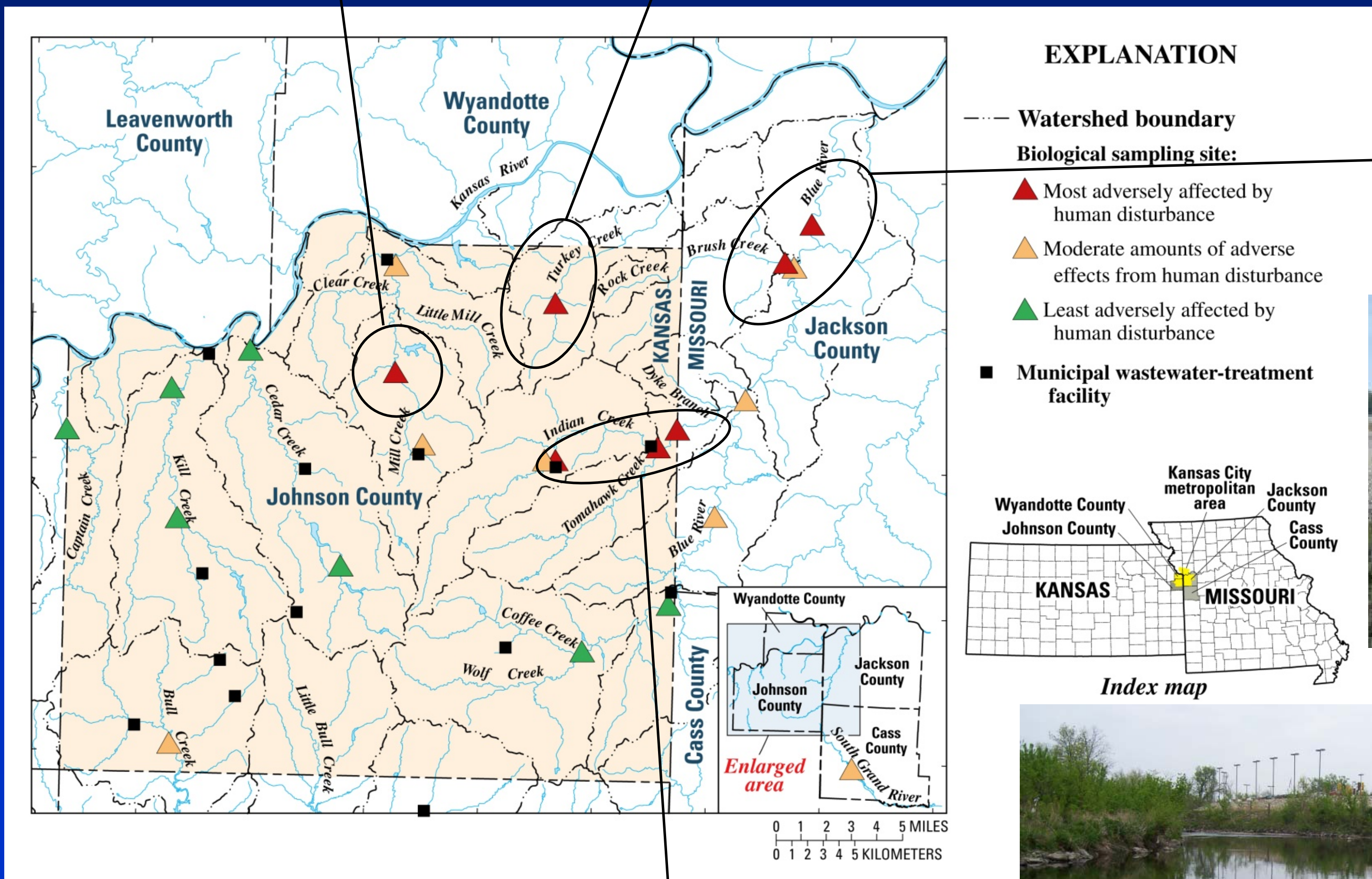


Upstream Blue River sites

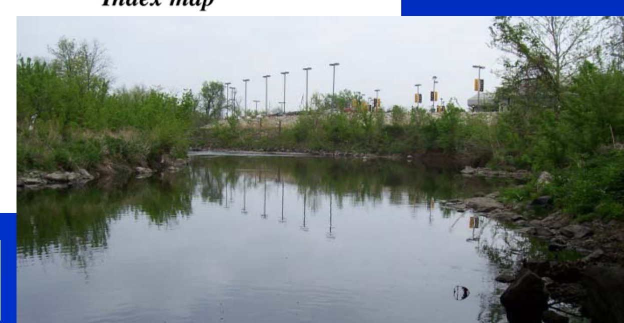
Sites downstream from urban areas and wastewater facilities consistently scored among those most impacted.

Mill Creek at 87th

Turkey Creek



Downstream Blue River sites



Indian and Tomahawk Creek sites

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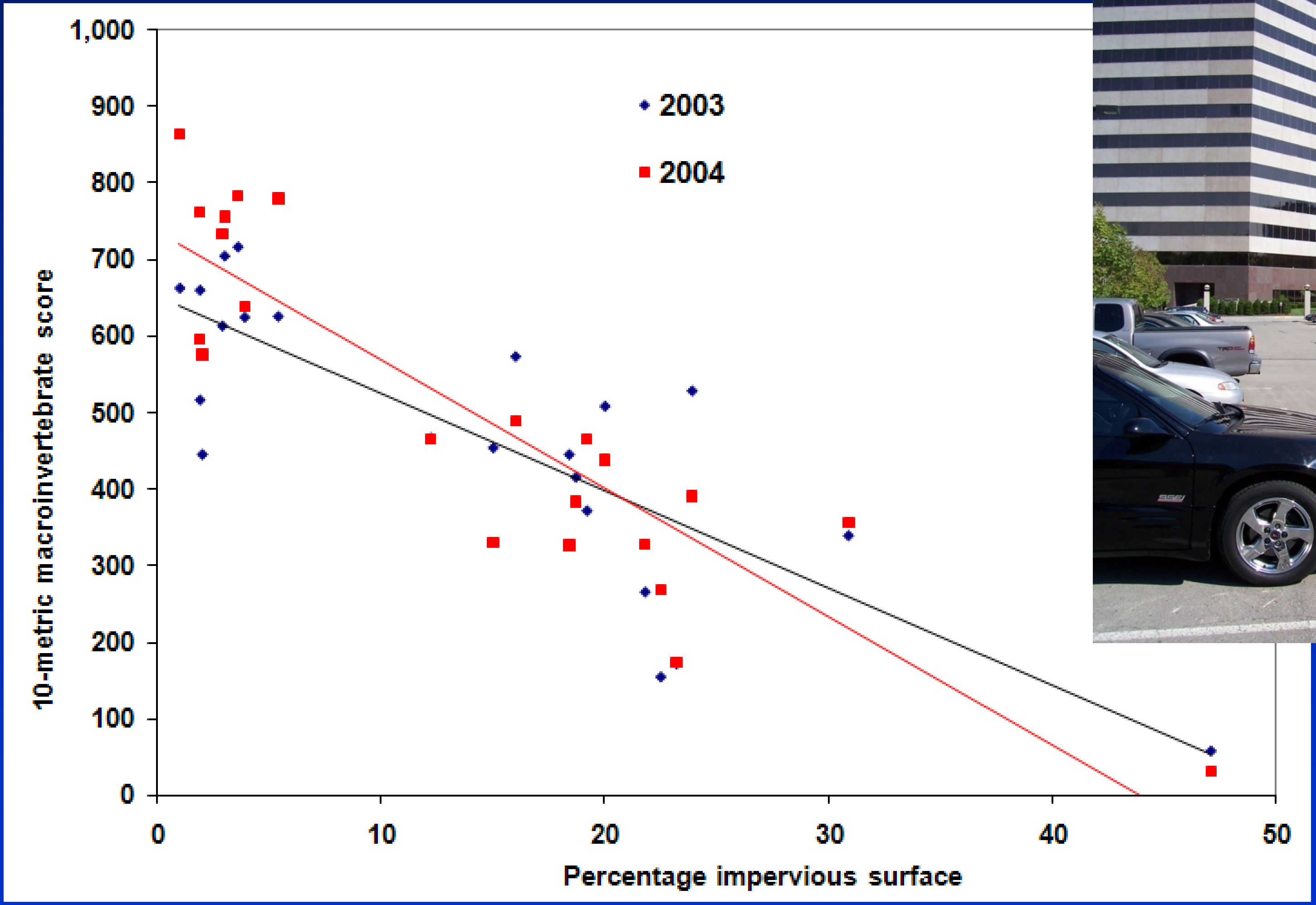
Generally, as urban land use (percent impervious surface and wastewater) upstream from the sampling sites increased, biological quality decreased.



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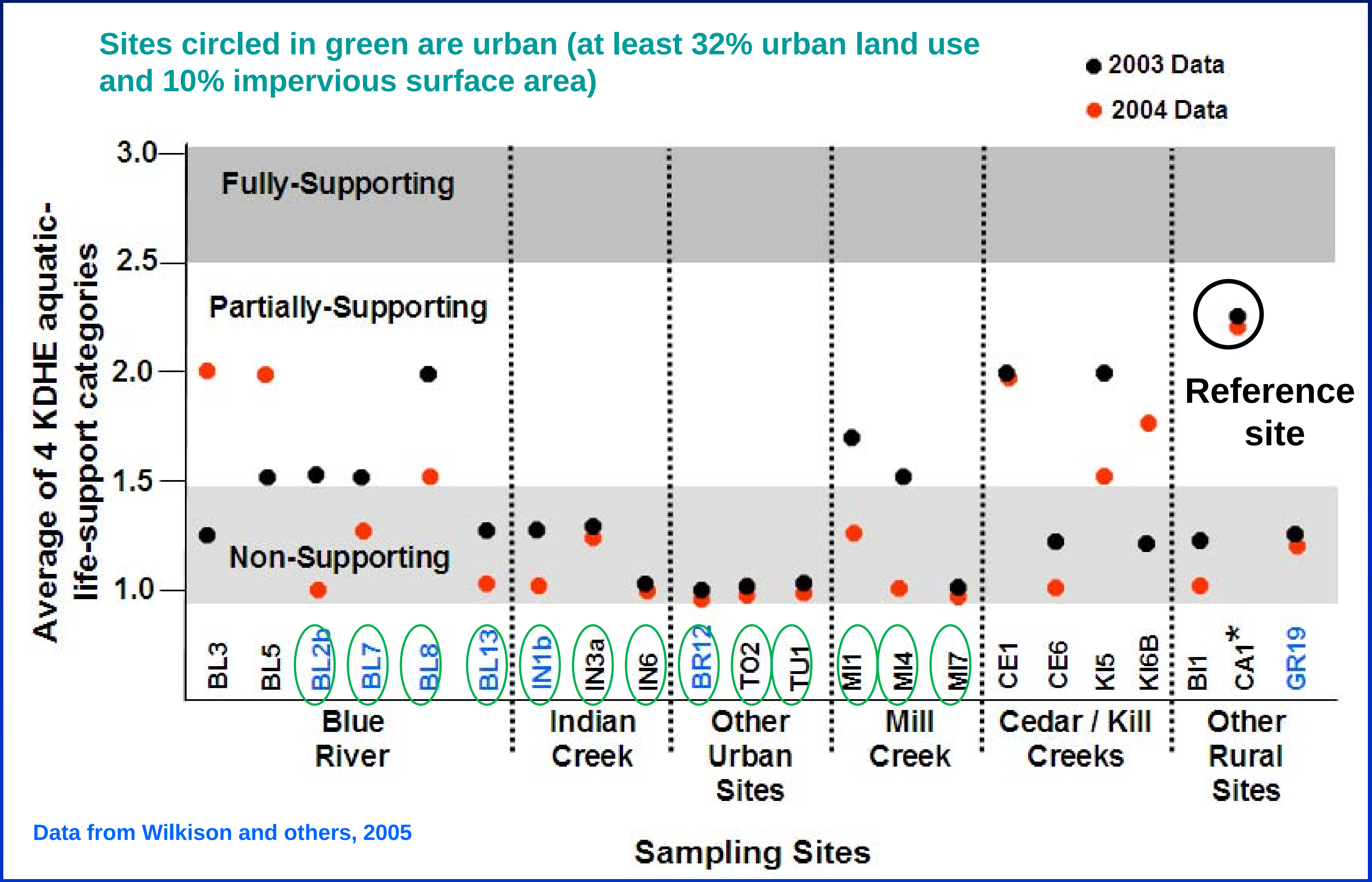
No sites, including the reference site, met State criteria for full support of aquatic life.



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Environmental variables that were significantly correlated with adversely affected biological conditions included:

Land use

- Percent impervious surface
- Percent urban land use
- Percent agricultural land use

Water quality

- Total nitrogen, total phosphorus
- Total concentration of organic wastewater compounds

Streambed-sediment quality

- PAHs
- Nonylphenol diethoxylate
- Fecal coliform

Green indicates variables that were most frequently correlated with different metrics

Photos from http://photogallery.nrcs.usda.gov

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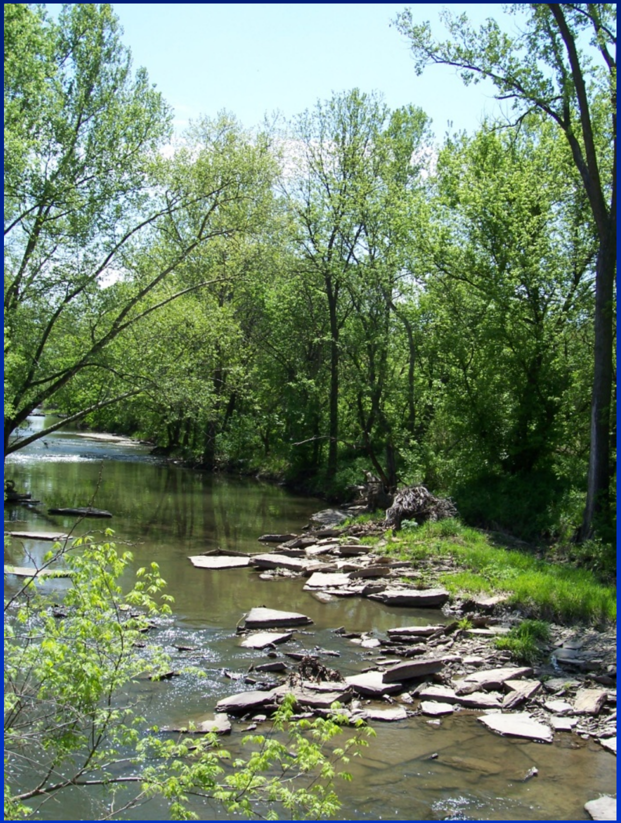
III. Continuous water-quality monitoring, 2002-07



- Quantified and evaluated concentration and load fluctuations during changing streamflow and seasonal conditions
- Evaluated water quality relative to land use and basin characteristics and compared major watersheds
- Assessed conditions relative to water-quality standards, TMDLs, and NPDES requirements
- Established baseline information for evaluating long-term trends and effectiveness of implemented BMPs

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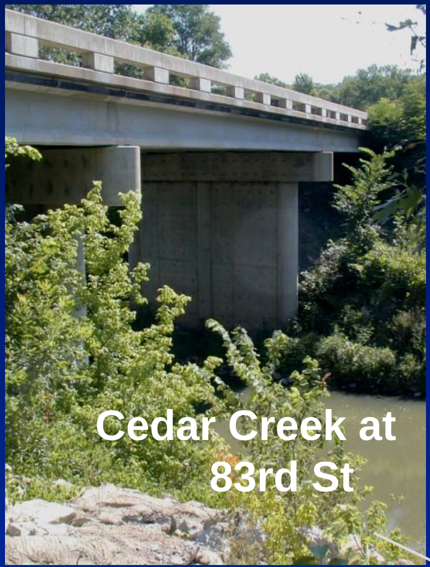
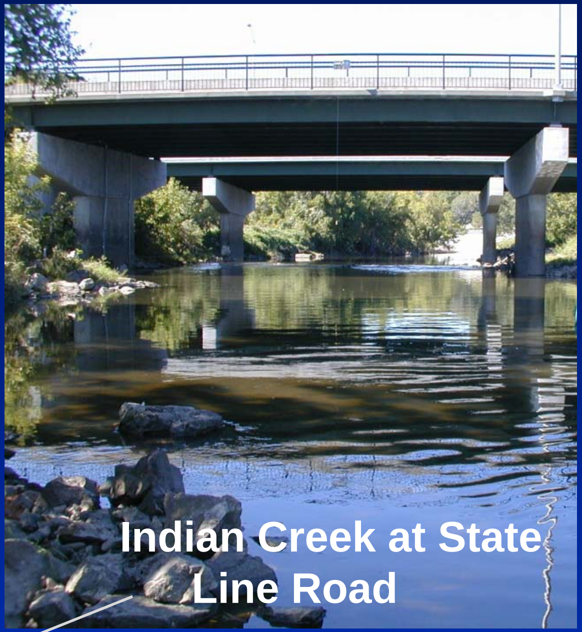
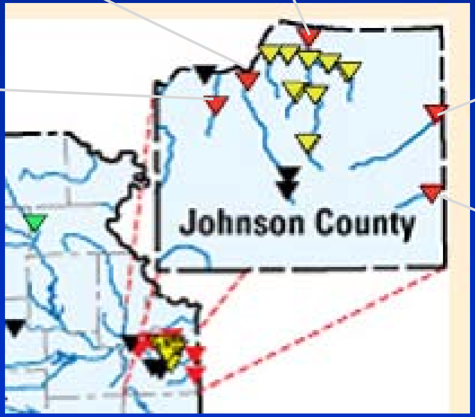
Monitoring sites







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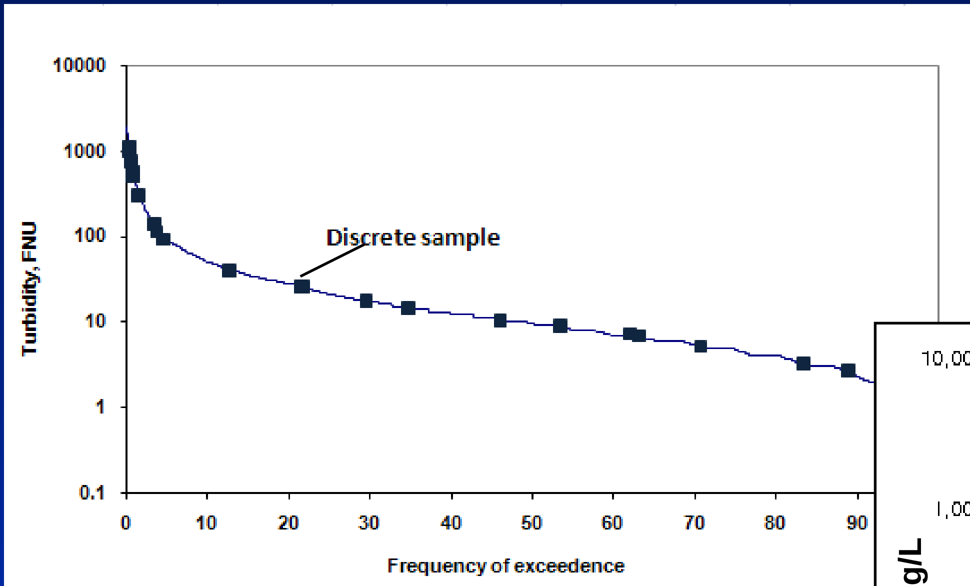
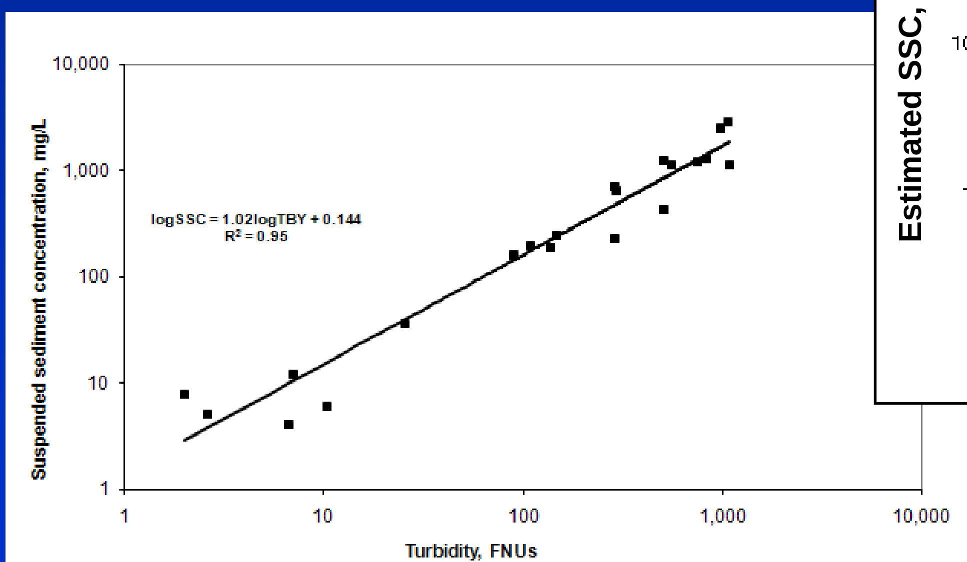
http://ks.water.usgs.gov/Kansas/rtqw/

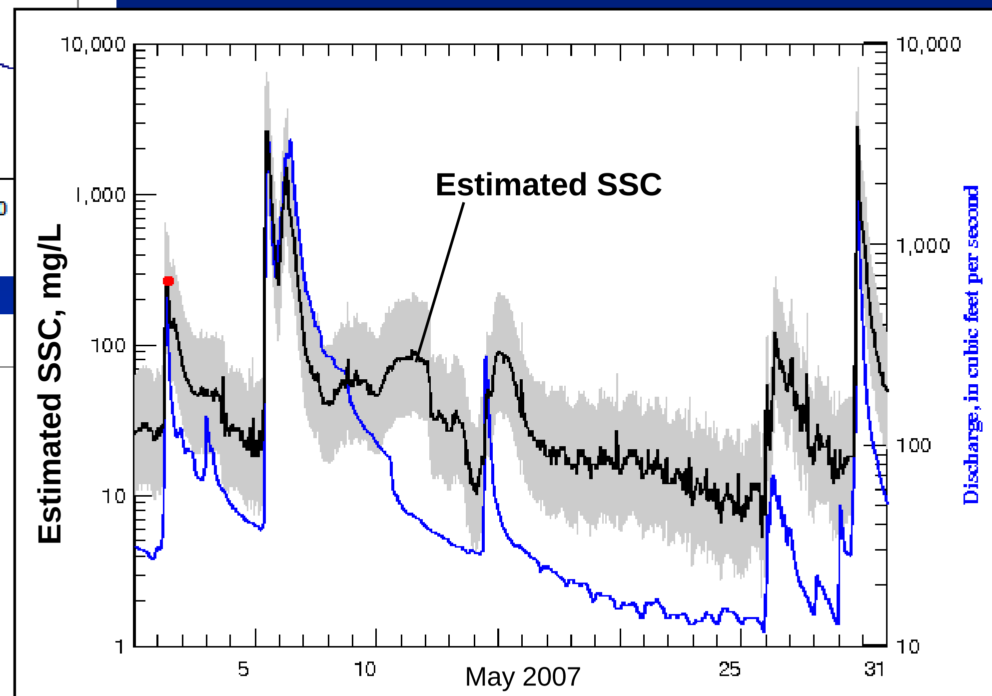
Approach

1. Continuously measure in-stream Q, SC, pH, temp, turbidity, and DO at downstream location in 5 watersheds
2. Collect discrete water samples throughout range of conditions and analyze for sediment, nutrients, bacteria, major ions
3. Develop regression models for sediment, nutrients, bacteria, major ions
4. Provide continuous estimates of concentration and load based on in-stream measurements and regression models

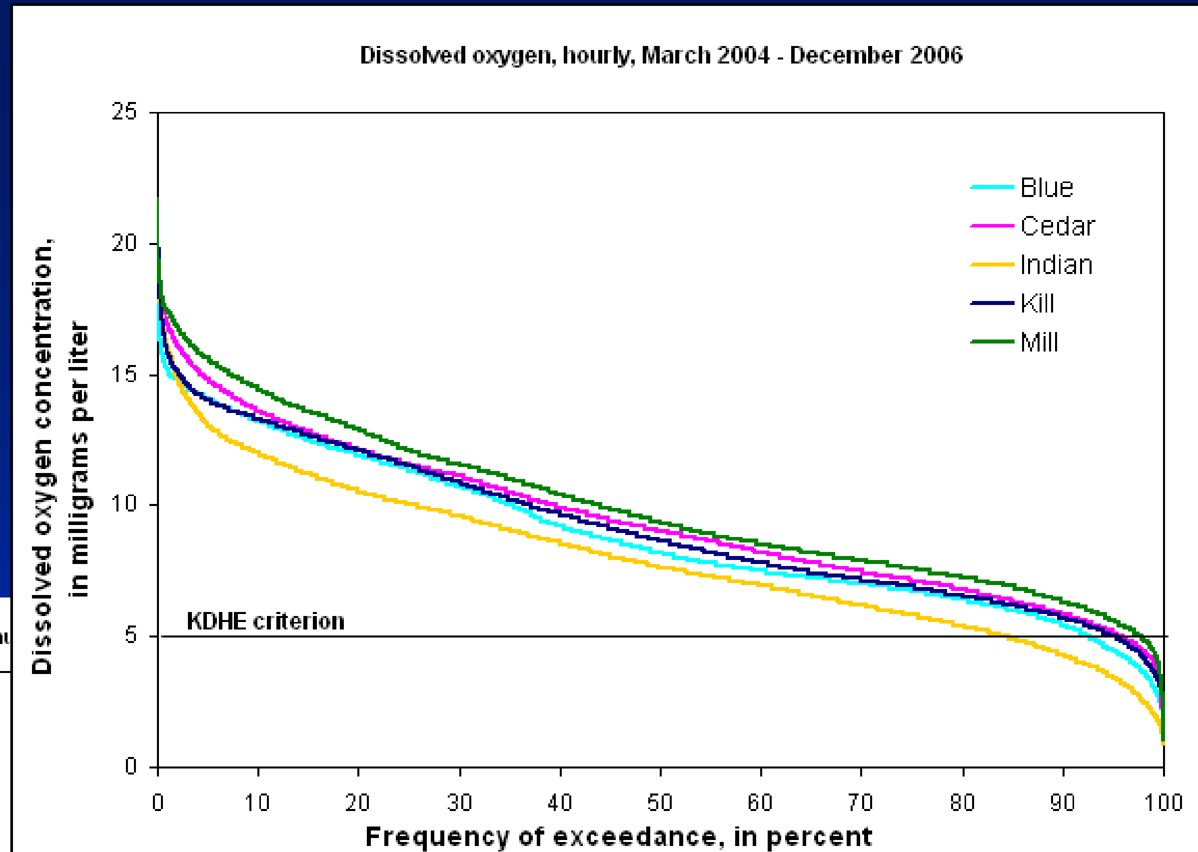
Example: Estimated suspended sediment concentration (SSC), Mill Creek

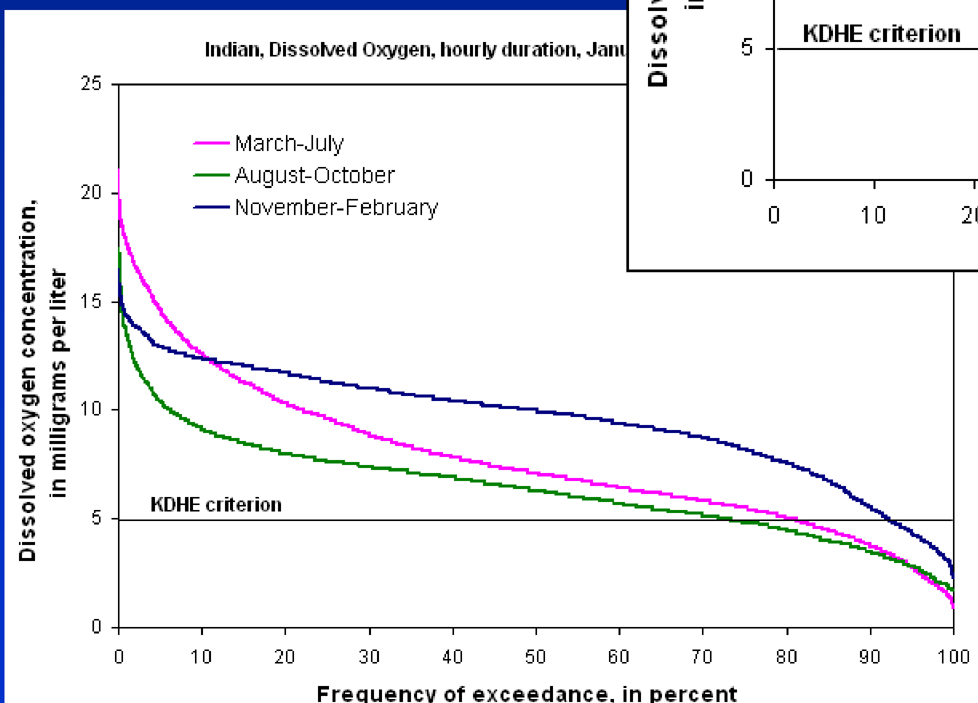






Dissolved oxygen was less than State criterion less than 5% of the time at all sites except Blue (8%) and Indian (15%).





During August-October, dissolved oxygen at Indian Creek was less than State criterion 30% of the time.

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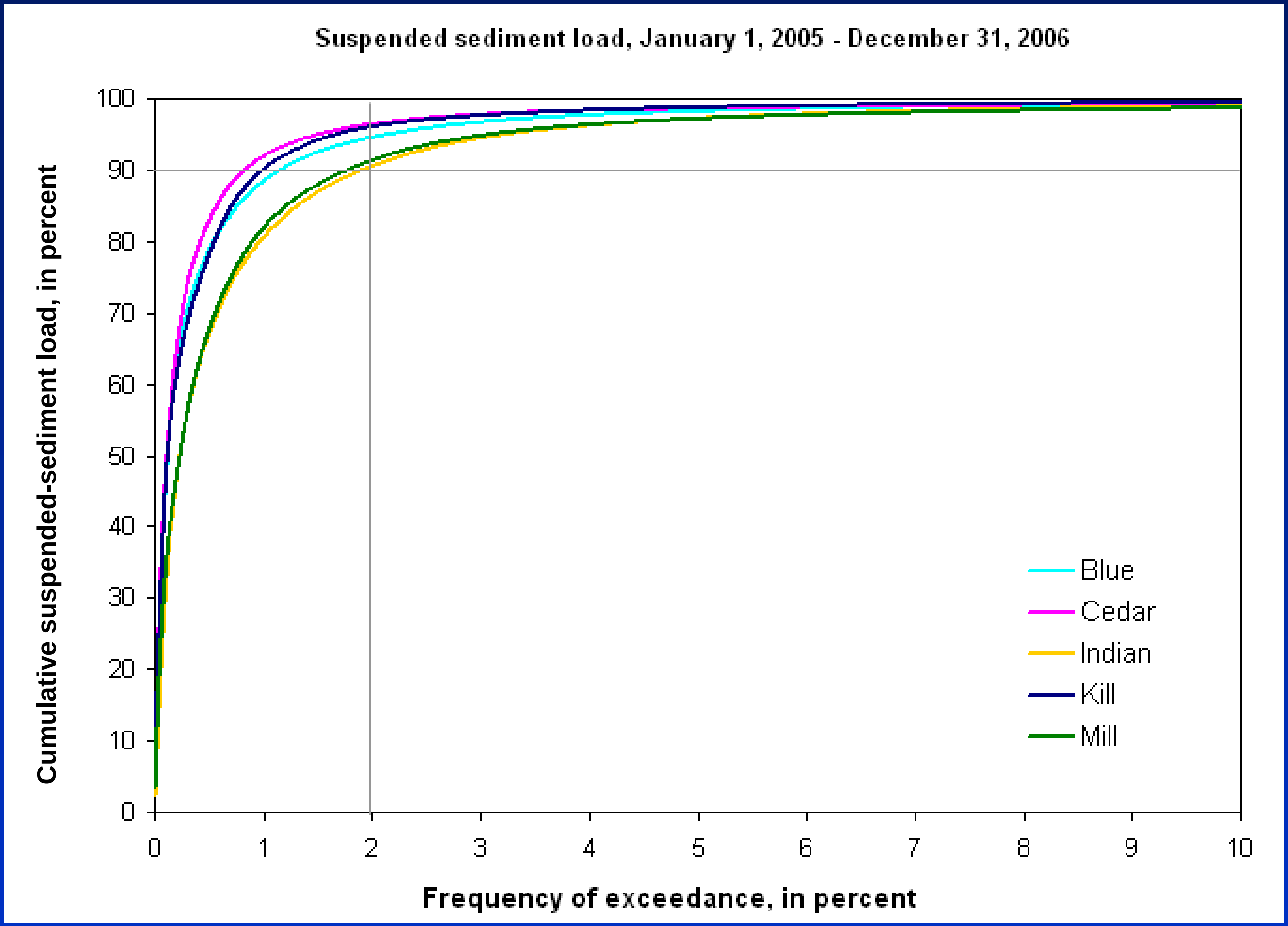
In 2005-06, 90% or more of the total suspended sediment load occurred in less than 2 percent of the time at all 5 sites.



-Continuous monitoring is necessary to capture extreme conditions when most of the load occurs.
-Management practices reducing sediment also reduce sediment-associated contaminants.

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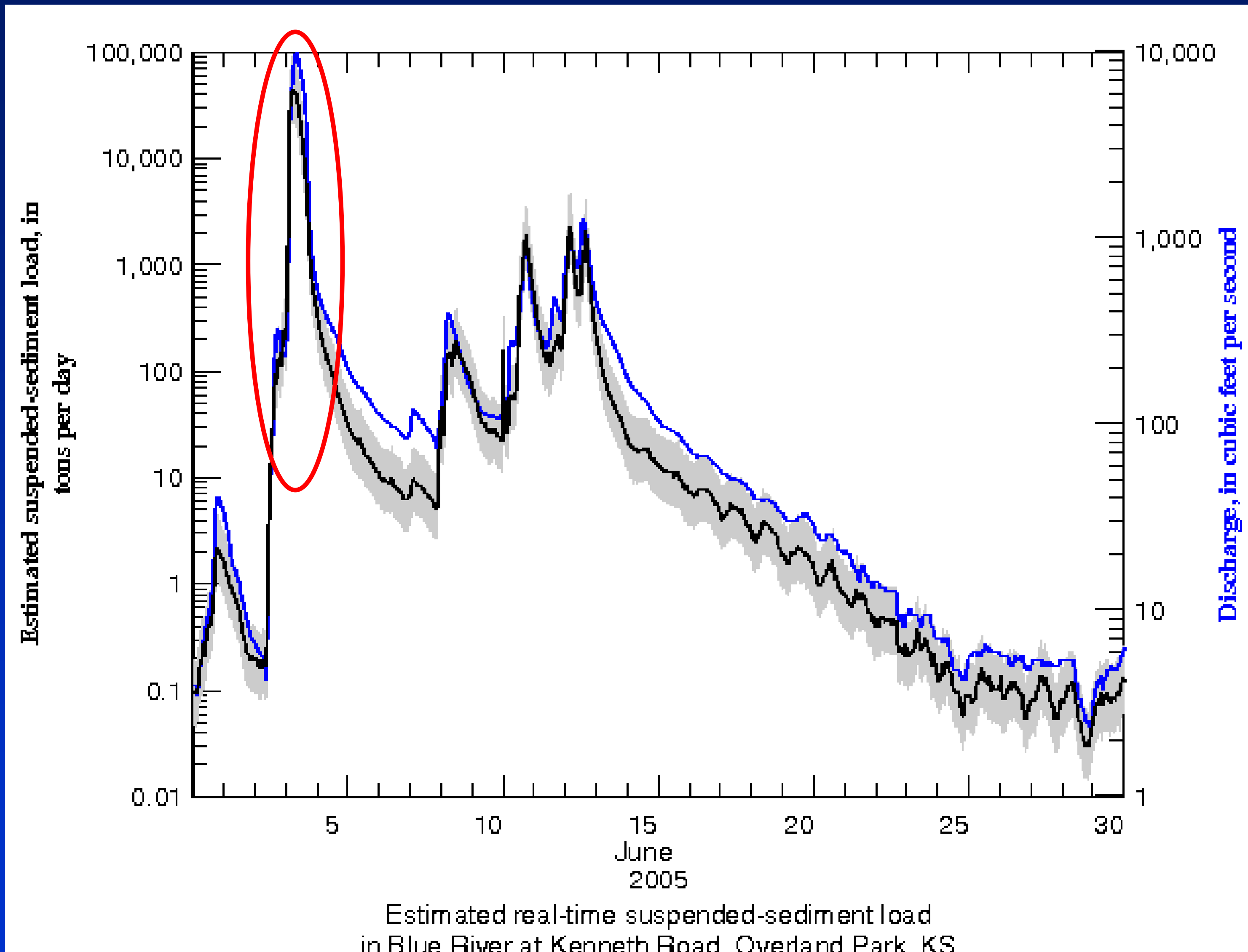
During a 3-day storm runoff period in June 2005, over 50% of the total annual sediment load occurred in the Blue River.



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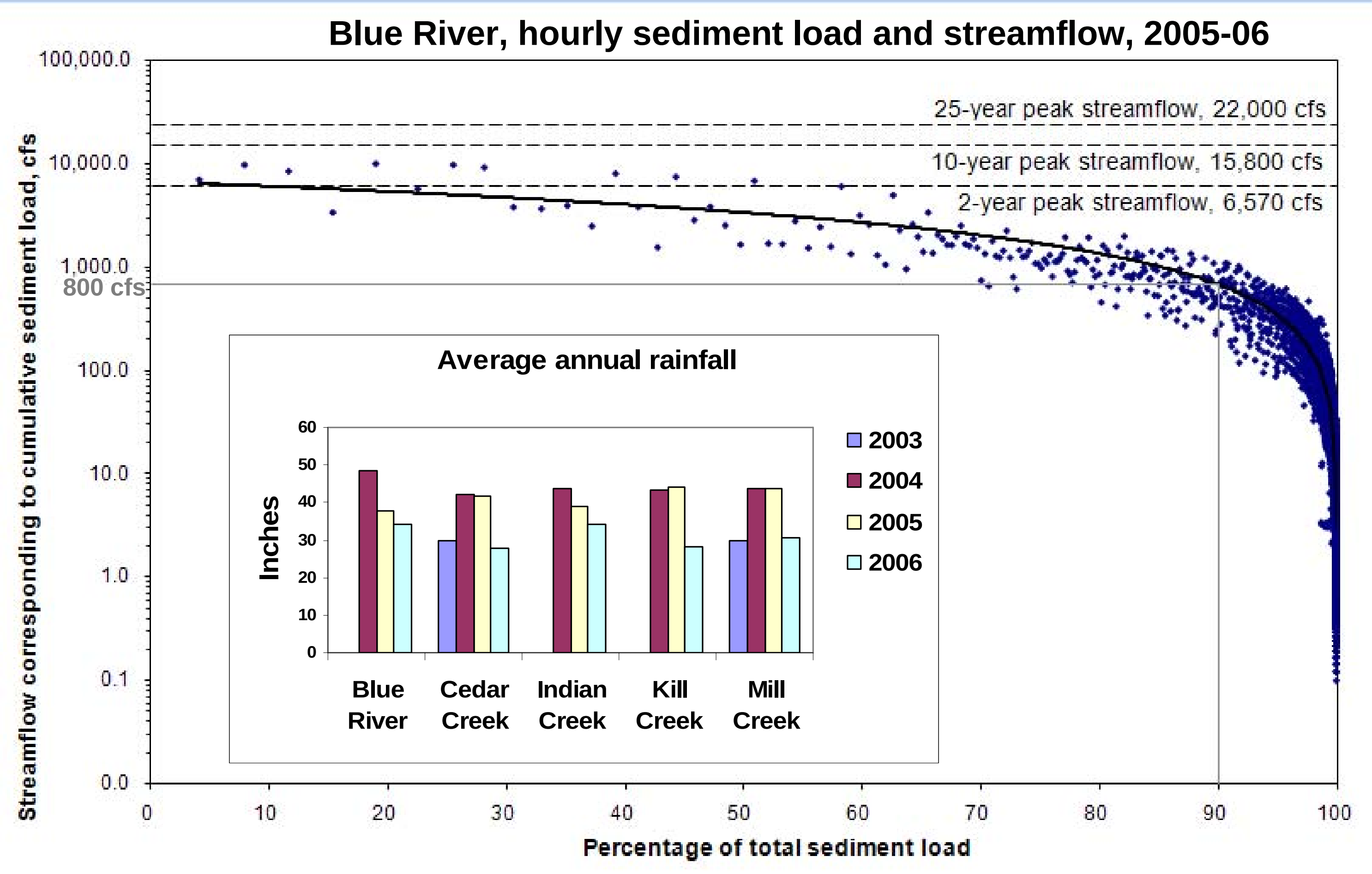
Most water contaminants in both urban and agricultural streams originate from nonpoint sources during storms. Therefore, rainfall and resulting runoff have substantial effect on water quality.



- 90% of the load occurred at streamflow larger than about 800 cfs
- Have barely exceeded 2-yr flood at all sites since monitoring started. Larger floods expected to carry larger percentage of total load.

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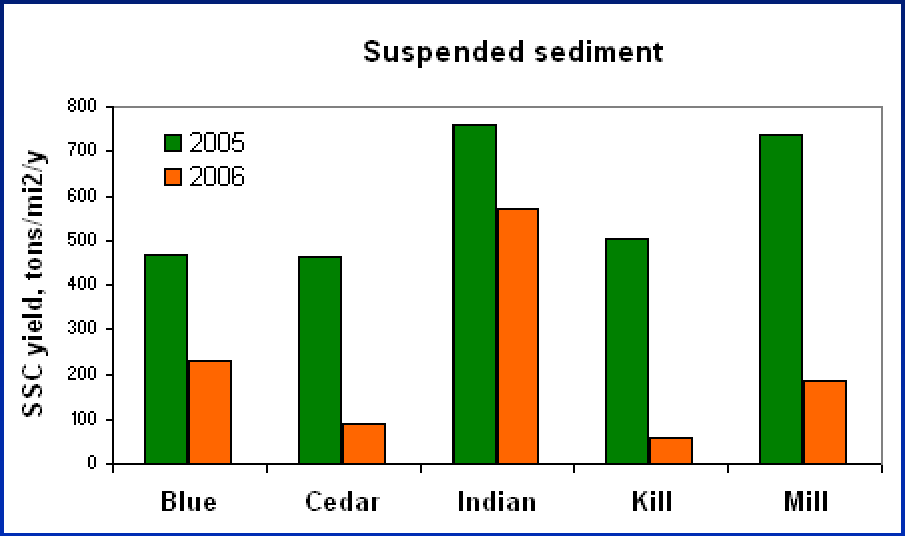
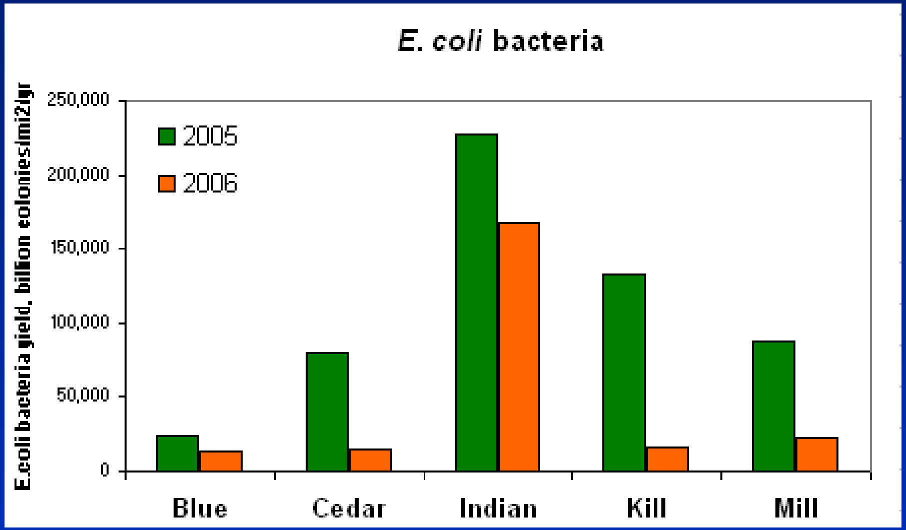
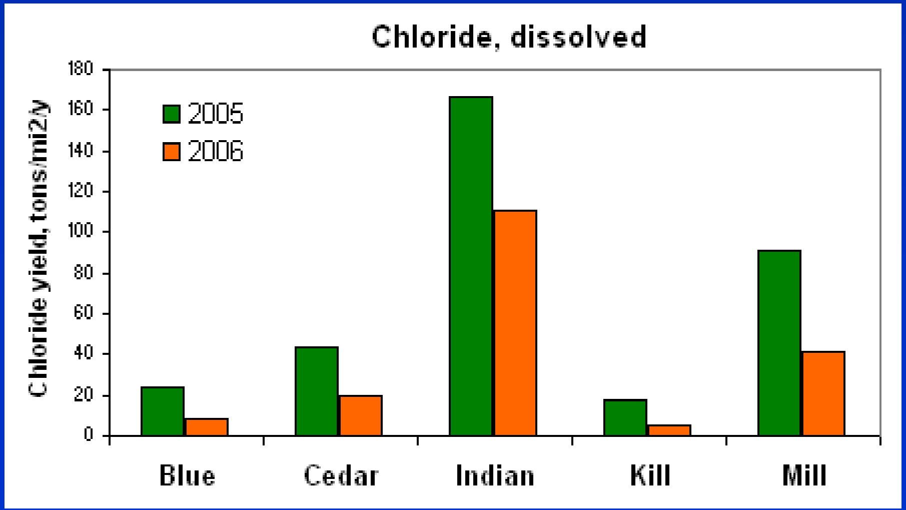
Annual yields for sediment, bacteria, major ions, and some nutrients were larger in 2005 than 2006 because of differences in streamflow. The differences were much larger at the least urban site (Kill, 5x larger) than the most urban site (Indian, 25% larger).

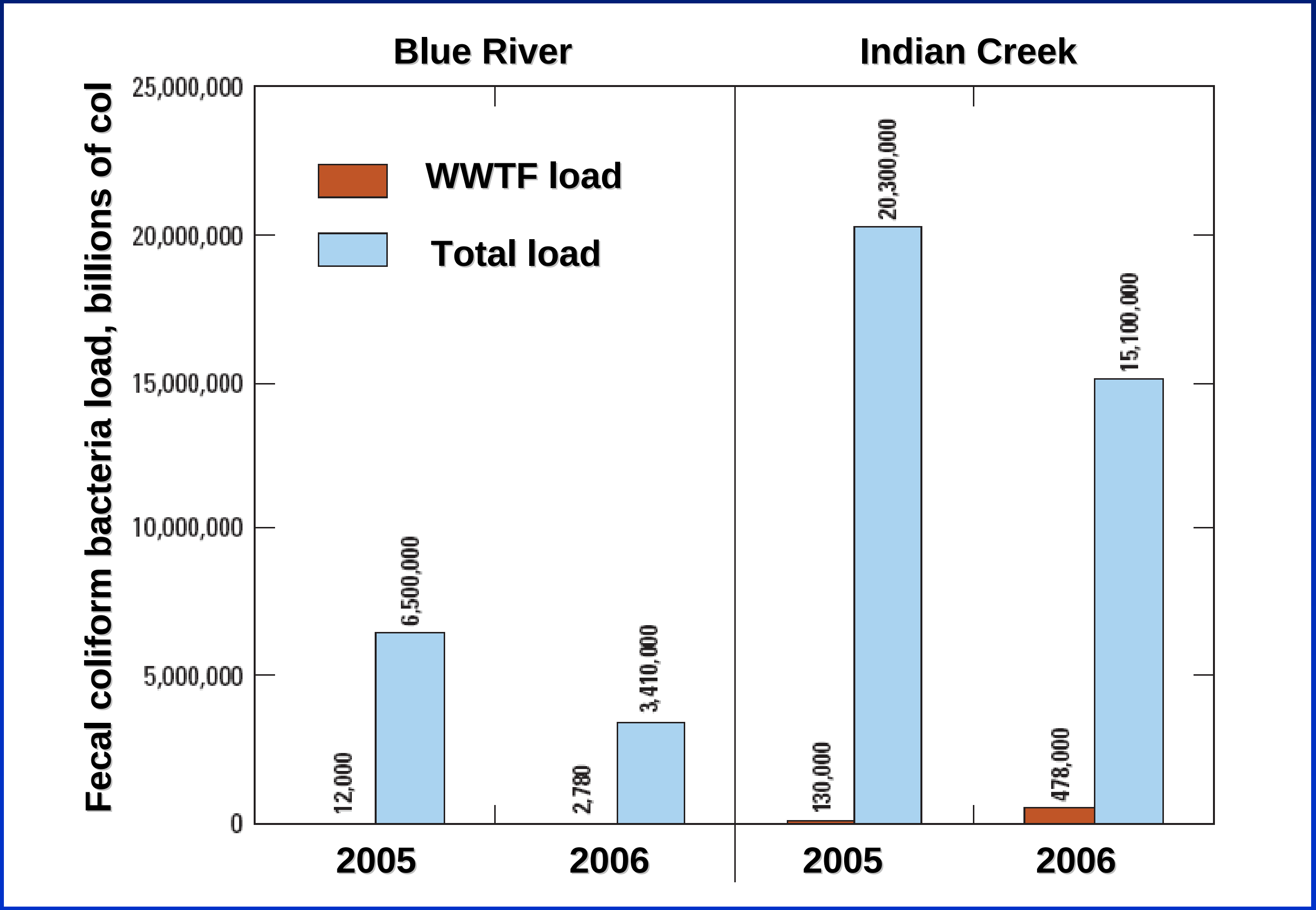




Sediment yields in urban watersheds (Indian, Mill) generally were larger than in nonurban watersheds.



At least 97 percent of the annual fecal coliform bacteria load in the Blue River and Indian Creek in 2005 and 2006 originated from stormwater runoff.



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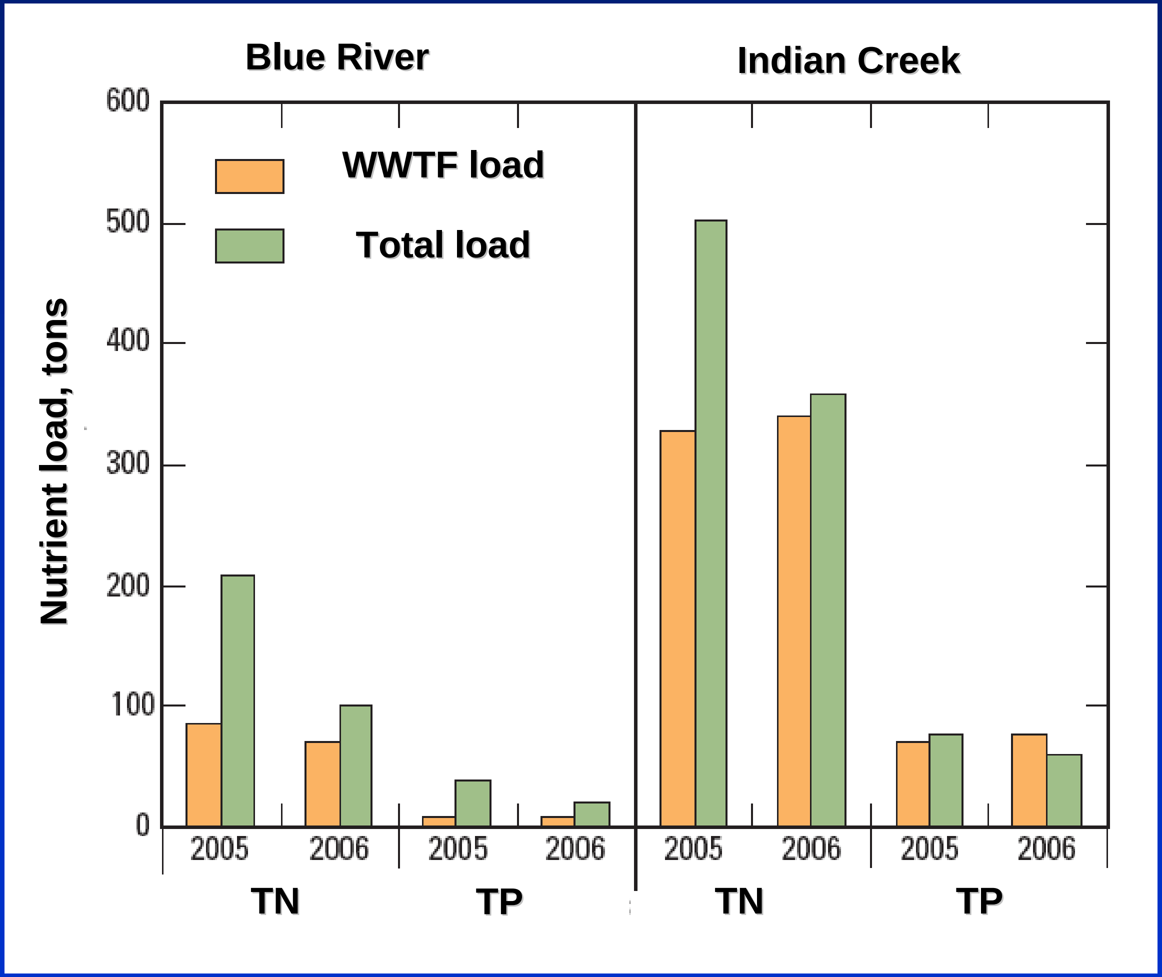
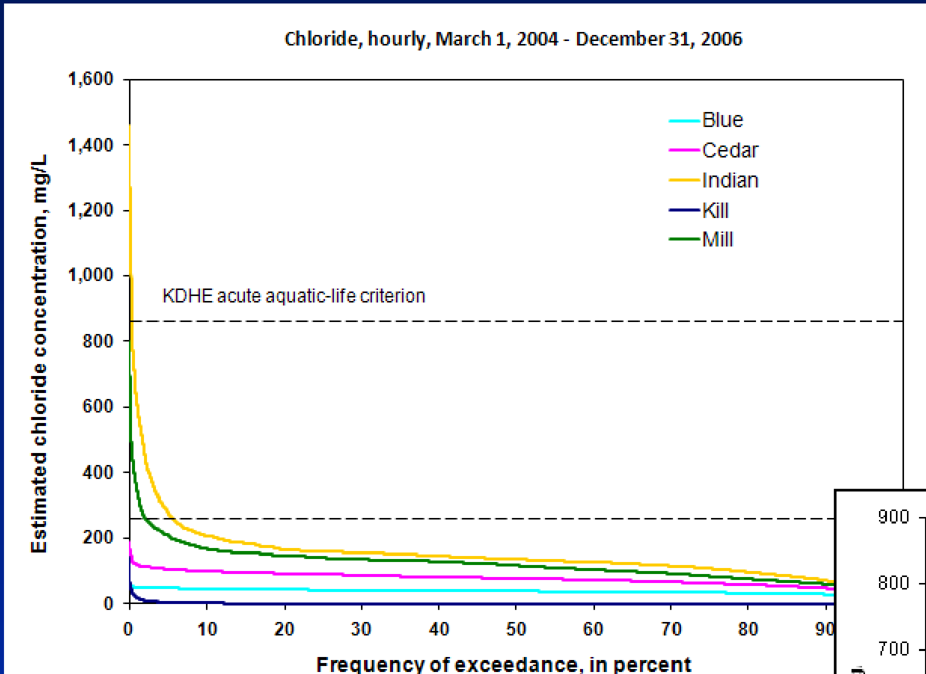
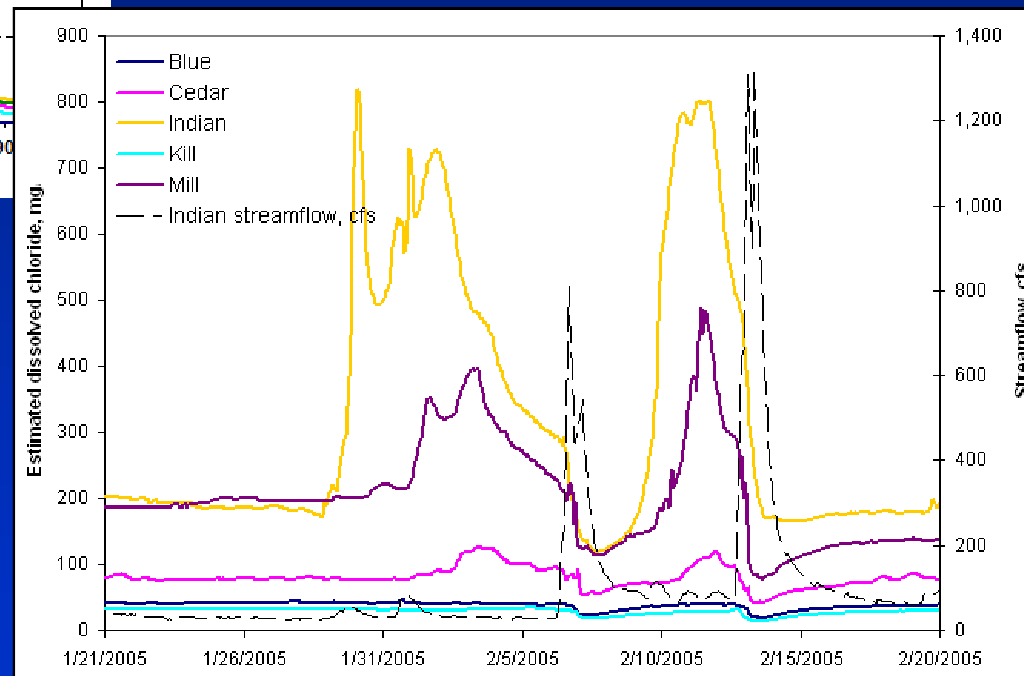
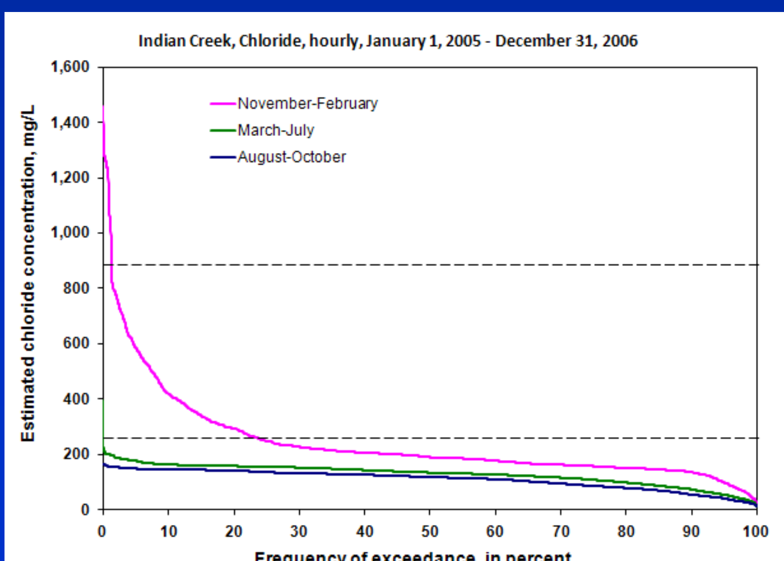
At least one-third of the total nitrogen load and less than one-third of the total phosphorus load in the Blue River originated from wastewater. At least two-thirds of the nutrient load in Indian Creek originated from wastewater.





About 10% of the time during 2005-06, chloride concentrations in Indian and Mill Creeks increased as a result of runoff from road salt application.





Urban sites had larger chloride concentrations year round.

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Current monitoring activities

1. Biological monitoring every 2 years (last sampled in March 2007)

   - Macroinvertebrates, habitat, water, and sediment samples at 20 sites

   - Periphyton (algae) at 10 sites
2. Continue monitor operation at Blue, Indian, and Mill sites and display estimated data on web
3. Mill Creek watershed sediment sources study
4. Monitoring upstream and downstream from wastewater treatment plants – Blue River, Indian Creek

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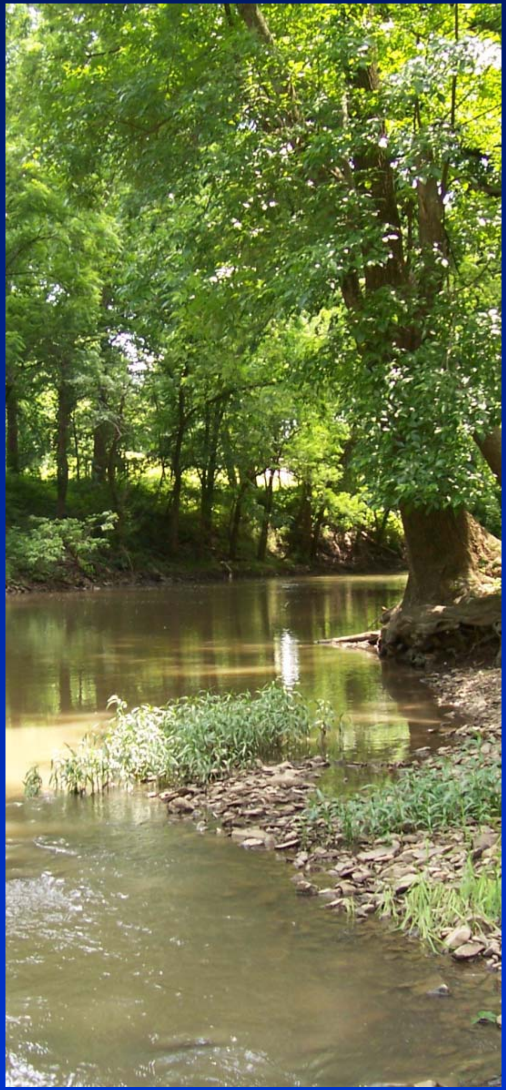
Publications



Lee, C.J., Mau, D.P., and Rasmussen, T.J., 2005, Effects of point and nonpoint sources on water quality and relation to land use in Johnson County, northeastern Kansas, October 2002 through June 2004: U.S. Geological Survey Scientific Investigations Report 2005-5144, 104 p.

Poulton, B.P., Rasmussen, T.J., and Lee, C.J., 2007, Assessment of biological conditions at selected stream sites in Johnson County, Kansas, and Cass and Jackson Counties, Missouri, 2003 and 2004: U.S. Geological Survey Scientific Investigations Report 2007-5108, 68 p.

Rasmussen, T.J., Lee, C.J., and Ziegler, A.C., 2008, Estimation of constituent concentrations, loads, and yields in streams of Johnson County, northeast Kansas, using continuous water-quality monitoring and regression models, October 2002 through December 2006: U.S. Geological Survey Scientific Investigations Report 2008-5014, 104 p.

Wilkison, D.H., Armstrong, D.J., Brown, R.E., Poulton, B.C., Cahill, J.D., and Zaugg, S.D., 2005, Water-quality and biologic data for the Blue River Basin, Kansas City Metropolitan area, Missouri and Kansas, October 2000 to October 2004: U.S. Geological Survey Data Series 127, 170 p.

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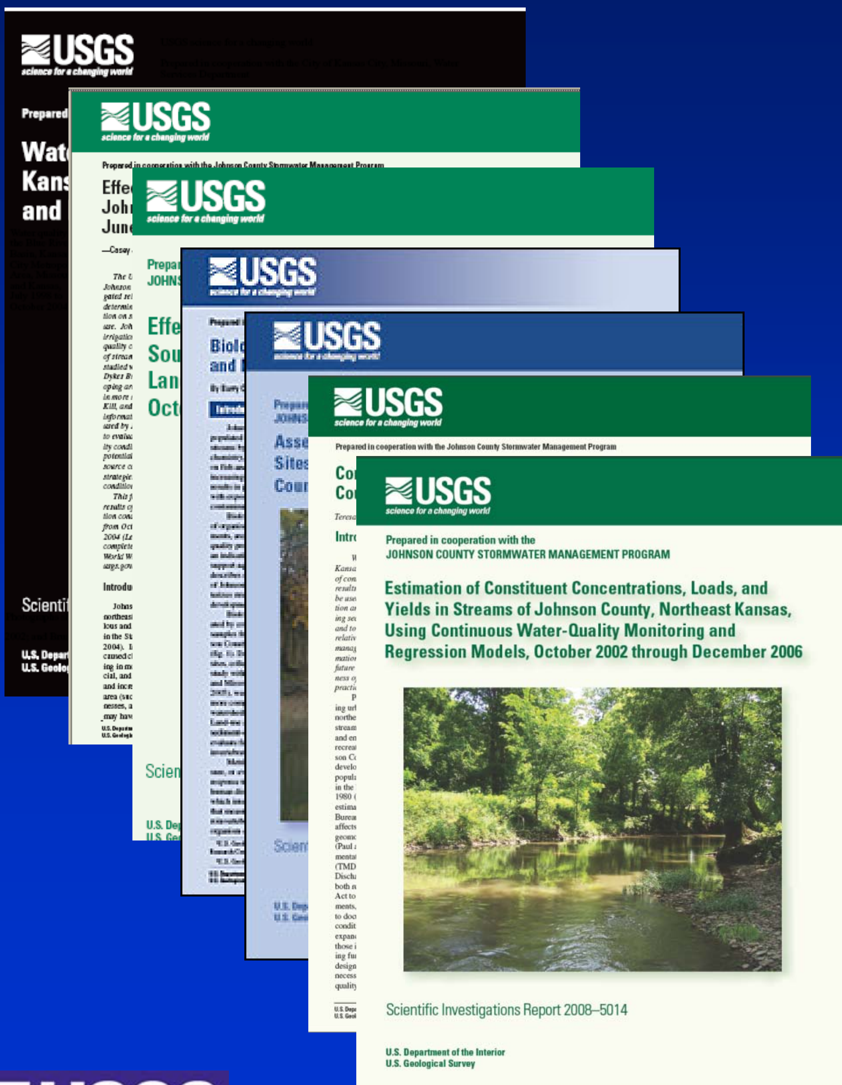
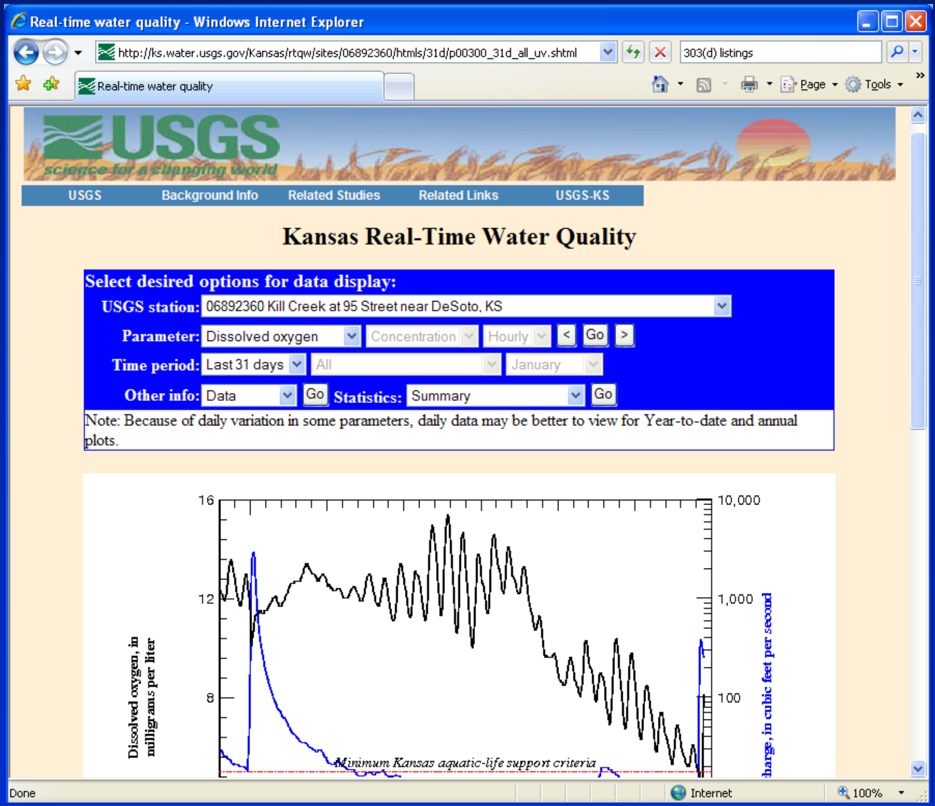
For more information

http://ks.water.usgs.gov/Kansas/studies/qw/joco
http://ks.water.usgs.gov/Kansas/rtqw/





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