Real-Time Continuous In-Stream Monitoring to Measure and Estimate Water-Quality Concentrations and Loads

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San Jose, California, May 9, 2006

Why monitor water quality continuously?

- Improves our understanding of hydrology and water quality and can lead to more effective resource management
- Captures seasonal, diurnal, and event-driven fluctuations
- Provides warning for water supply and recreation
- Improves concentration and load estimates with defined uncertainty (8,760 hourly values per year)
- Optimizes the collection of samples

USGS

Types of continuous water-quality monitors

- Electrometric
  - Gage height, temperature, pH, DO, SC
- Electromagnetic spectrum
  - Streamflow, turbidity, chlorophyll, nitrate
- In-stream analyzers (bench chemistries)
  - Nitrate, silicate, phosphorus, chloride, ….
- Labs in field at gage house
  - Aqualab (TCEQ), GC/MS- ORSANCO, etc…

USGS

Improved tools now are available--
In-stream continuous monitors…

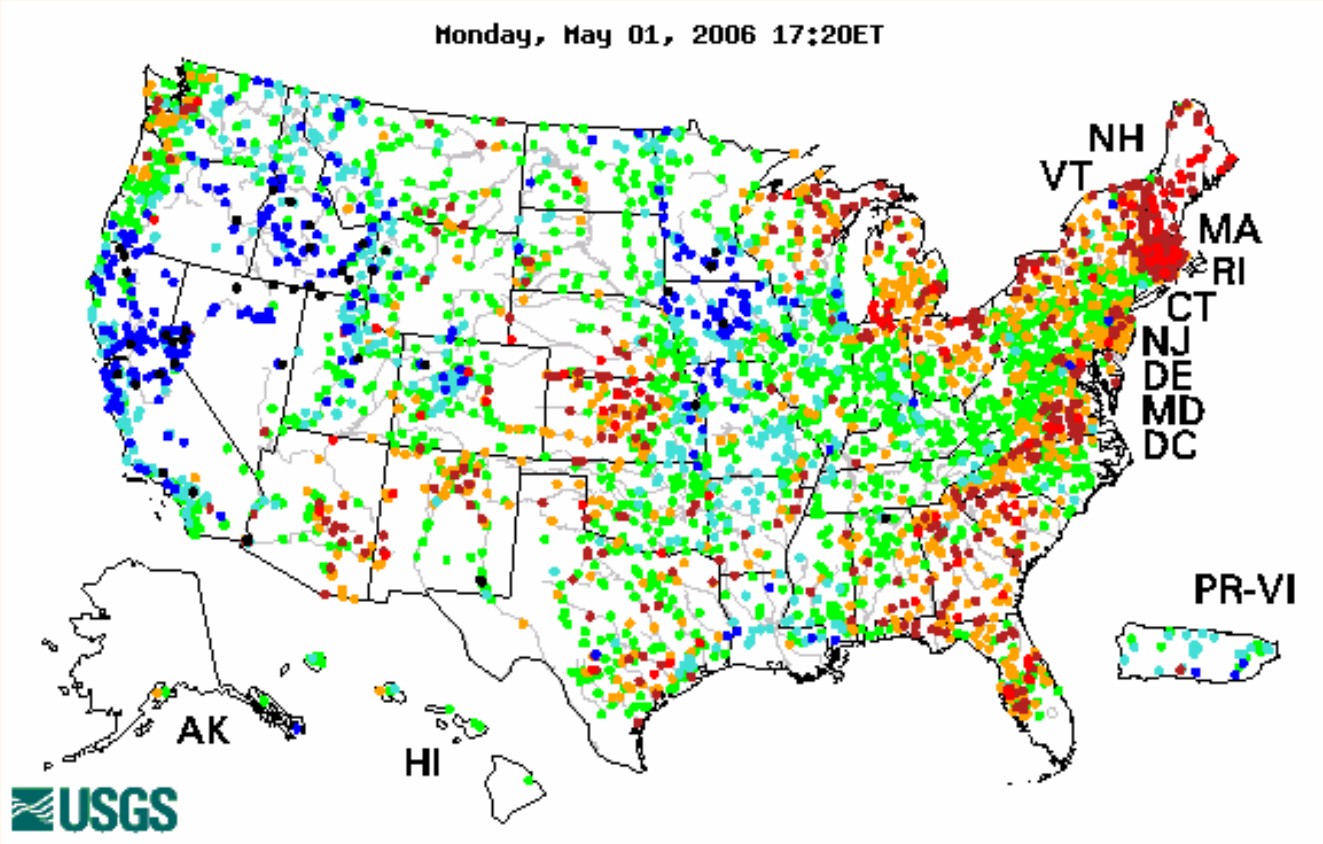
- pH
- Water Temperature
- **Dissolved Oxygen**
- Specific Conductance
- **Turbidity**
- ORP
- Fluorescence
- PAR
- Nitrate, ammonia, etc.
- New gizmos every year

USGS

USGS streamflow network of 7,000+

WaterWatch -- *Current water resources conditions*

Animation of daily streamflow maps for May 2006

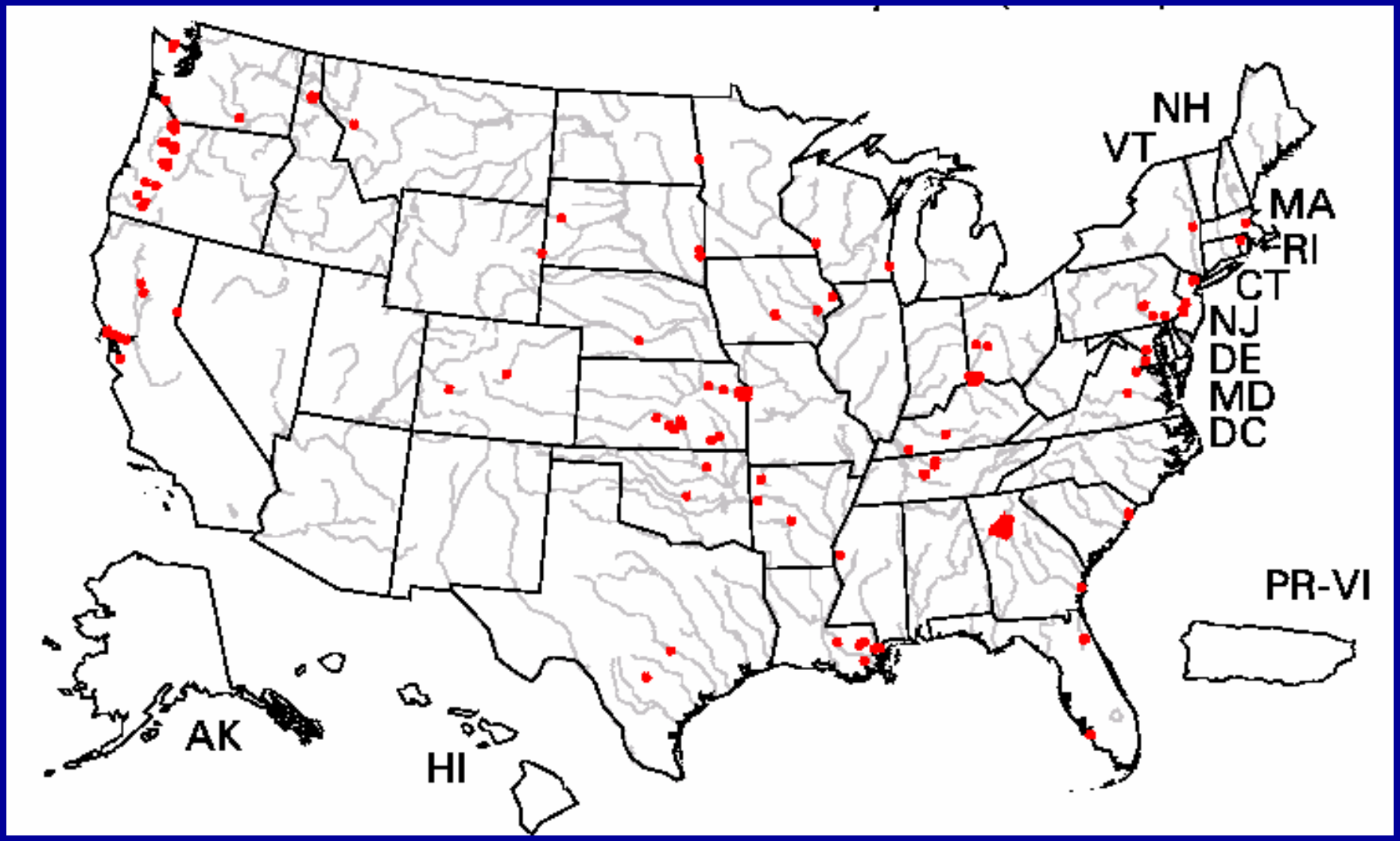


Explanation - Percentile classes						
Low	< 10	10 - 24	25 - 75	76 - 90	> 90	High

USGS

http://water.usgs.gov/waterwatch/

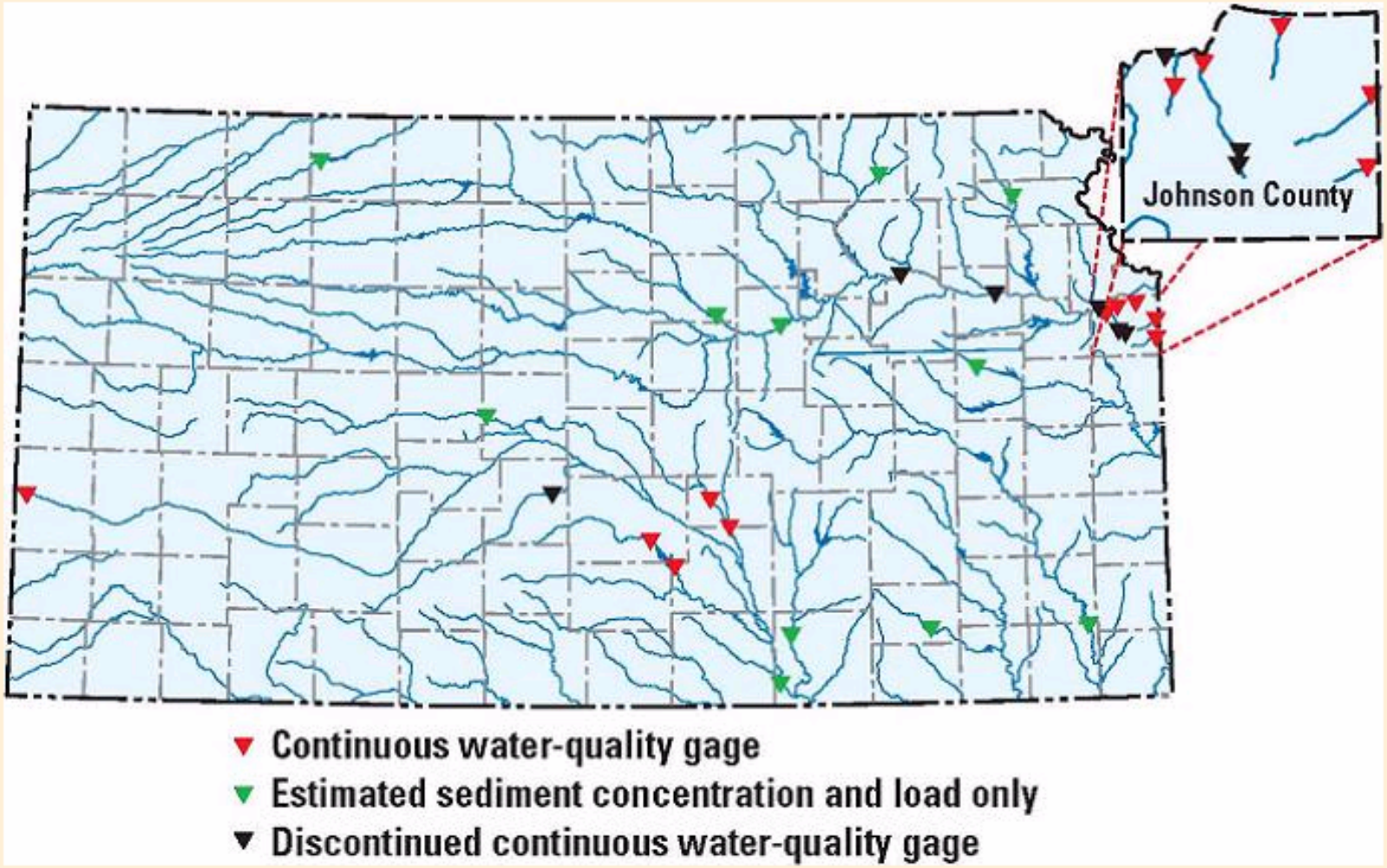
Where is USGS operating continuous "turbidity"?



211 sites. Most sites are in Oregon (34), Georgia (34), Kansas (17), and 10 each in California, Kentucky, and Virginia

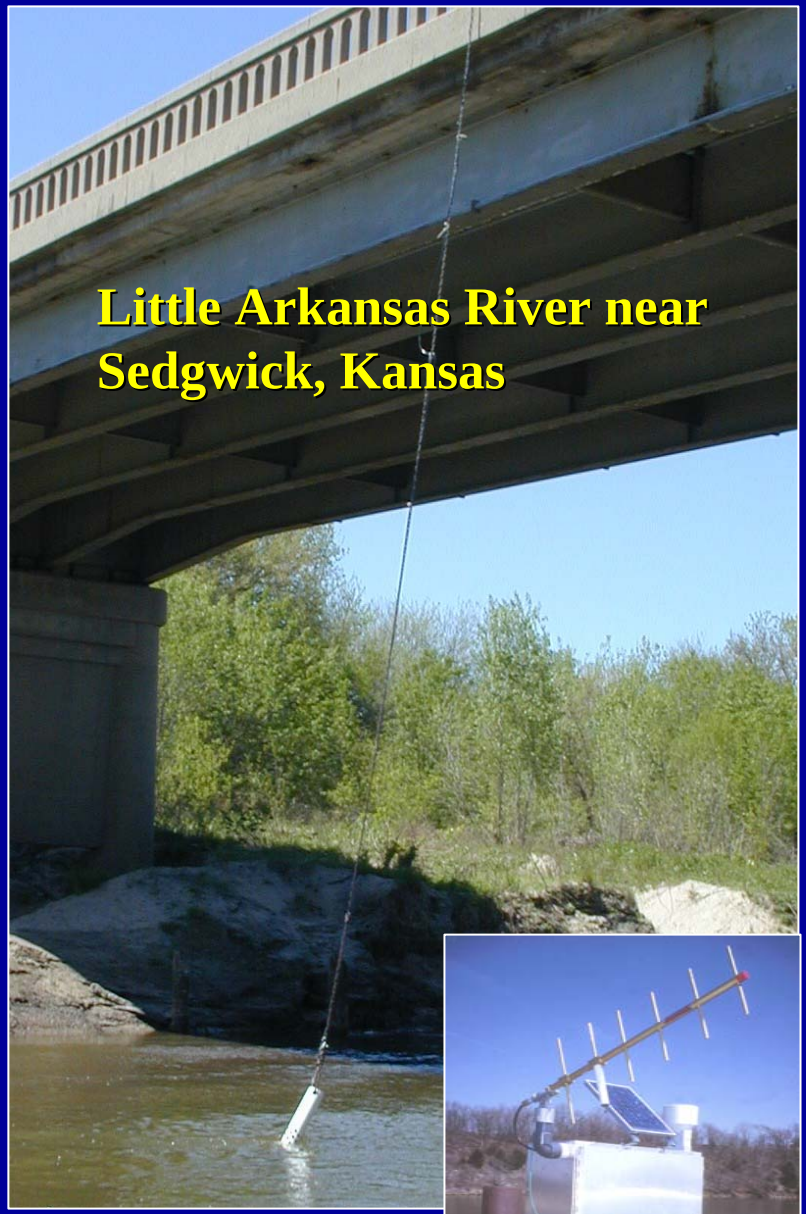
http:// ks.water.usgs.gov/Kansas/rtqw/

Kansas Real-Time Water Quality



USGS

Approach:



- Add water-quality monitors at streamgages and transmit data “real” time
- Collect water samples over the range of hydrologic and chemical conditions
- Develop site-specific regression models using samples and sensor values
- Estimate concentrations and loads
- Publish regression models
- Display estimates, uncertainty, and probability on the Web
- Continued sampling to verify

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

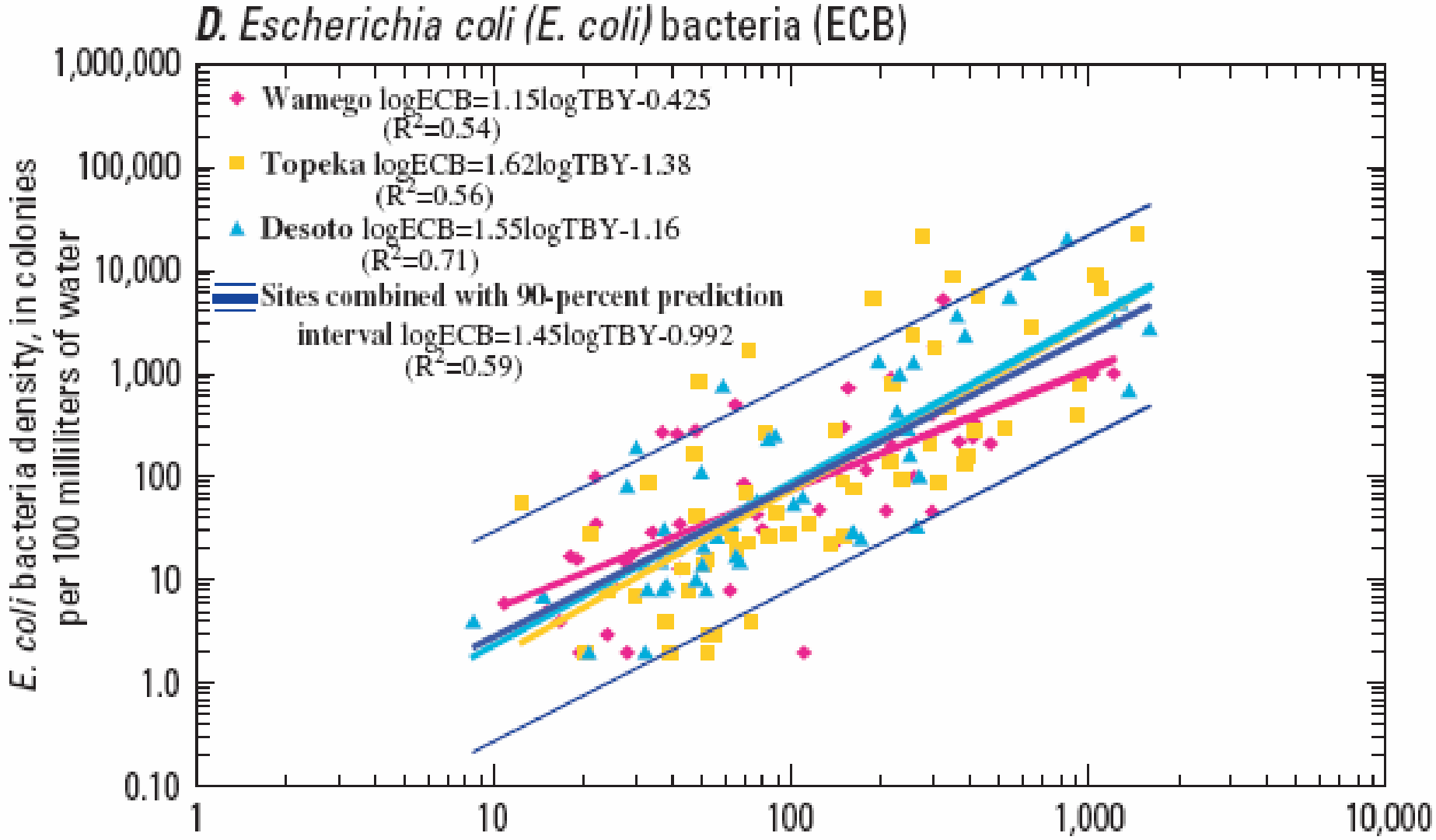
USGS

Directly measured	Estimated
Gage Height/Stage	Streamflow (discharge)
Specific Conductance	Chloride, alkalinity, fluoride, dissolved solids, sodium, sulfate, nitrate, atrazine
Turbidity	Total suspended solids, suspended sediment, fecal coliform, *E. coli*, total nitrogen, total nitrogen, total phosphorus, geosmin

USGS

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

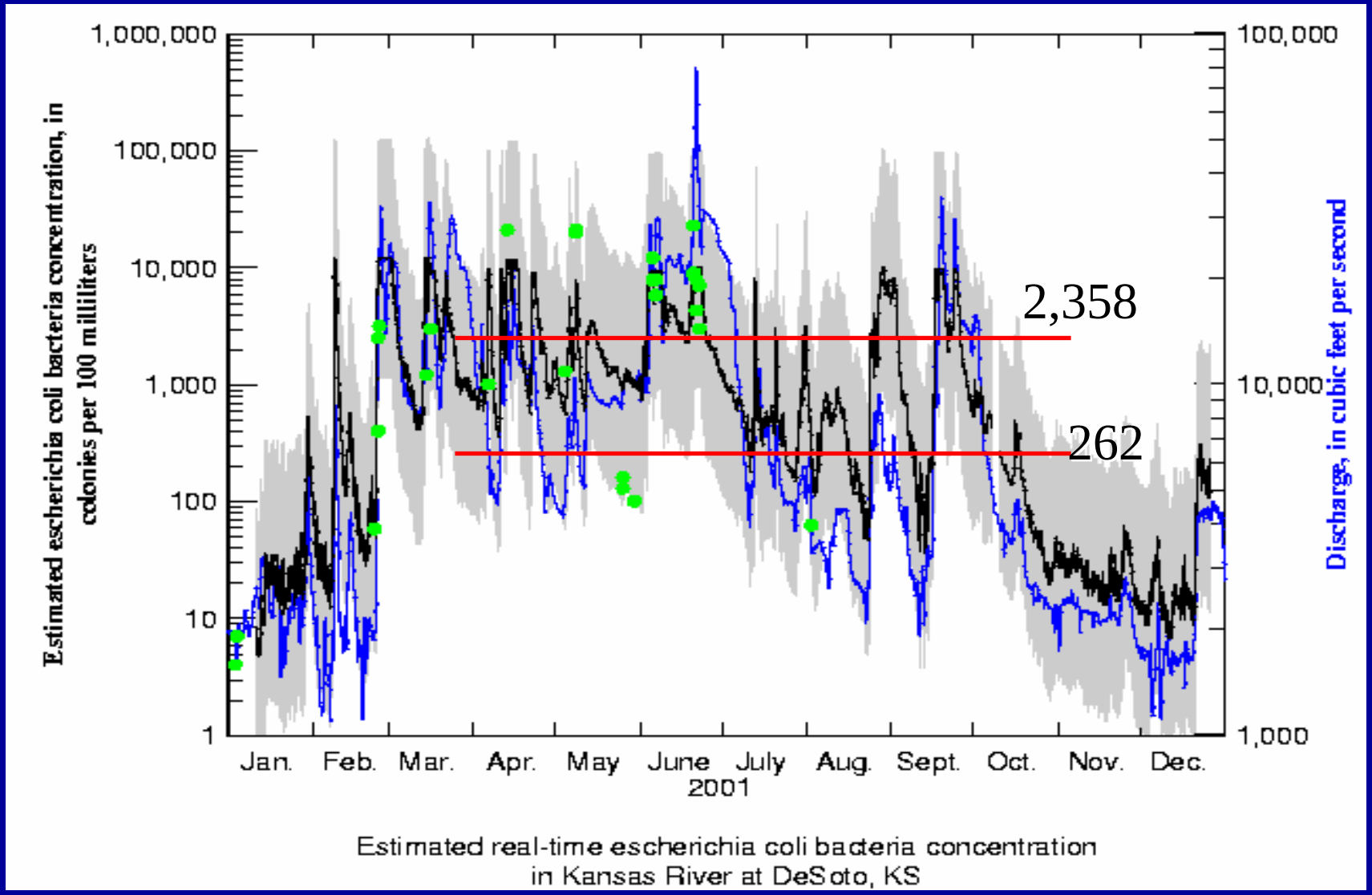
Turbidity estimates *E. Coli* **reliably**



USGS

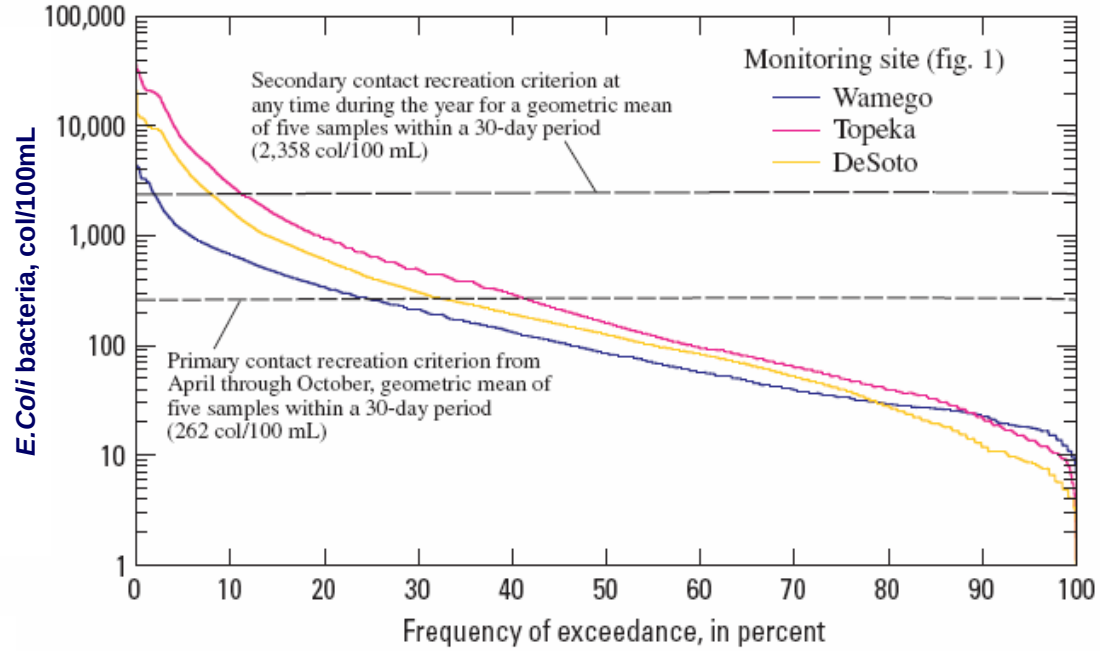
Rasmussen, Ziegler, and Rasmussen, 2005

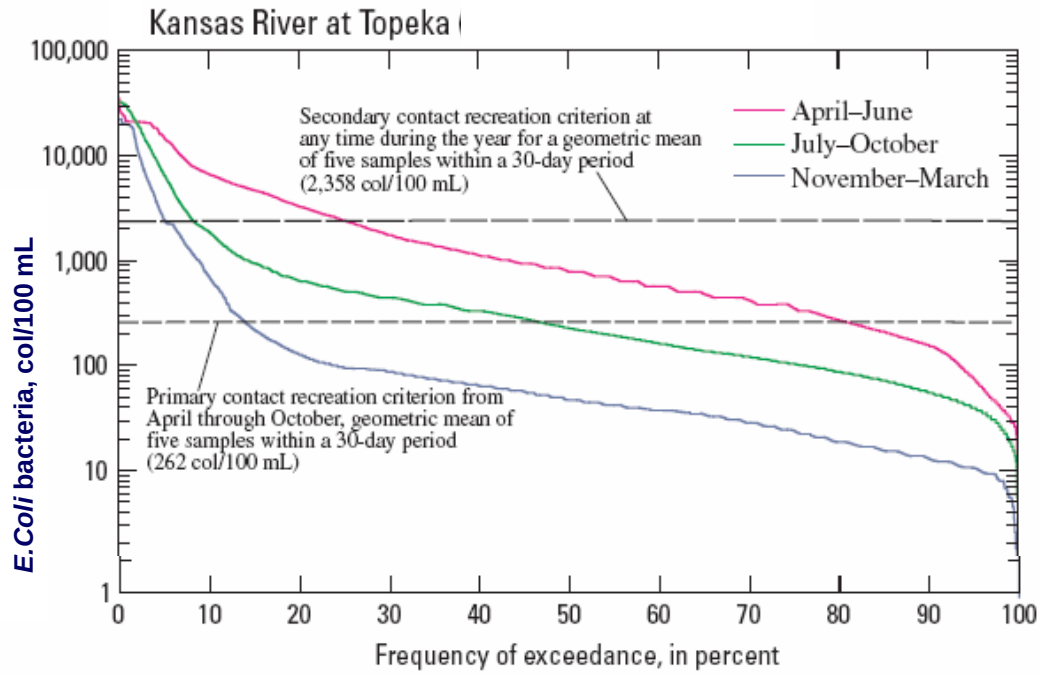
Bacteria frequently exceed water-quality standards



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

***E.Coli* densities generally largest at Topeka.**



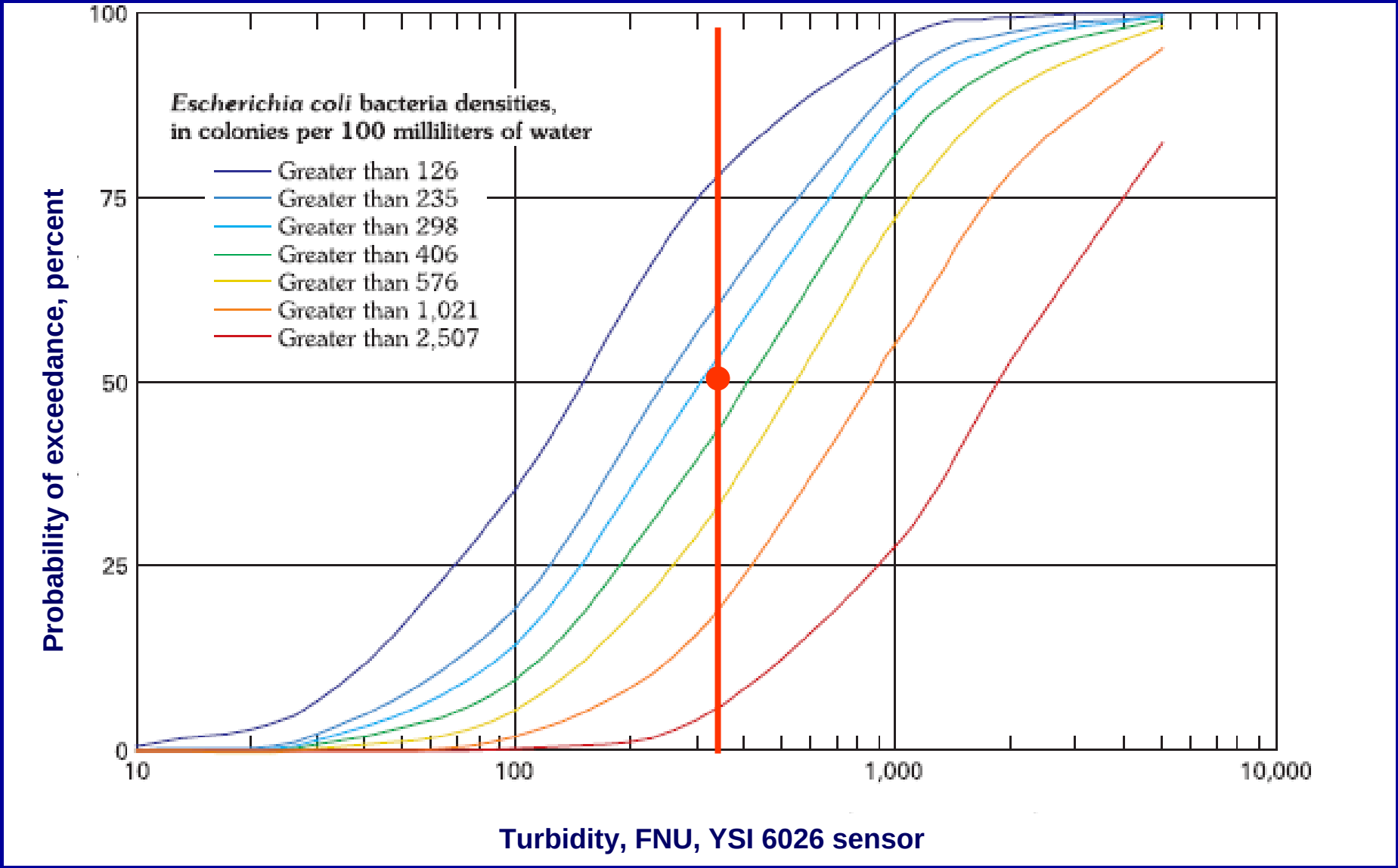


During the spring, the primary contact criterion was exceeded 80% of the time and the secondary contact criterion was exceeded 25% of the time.

USGS

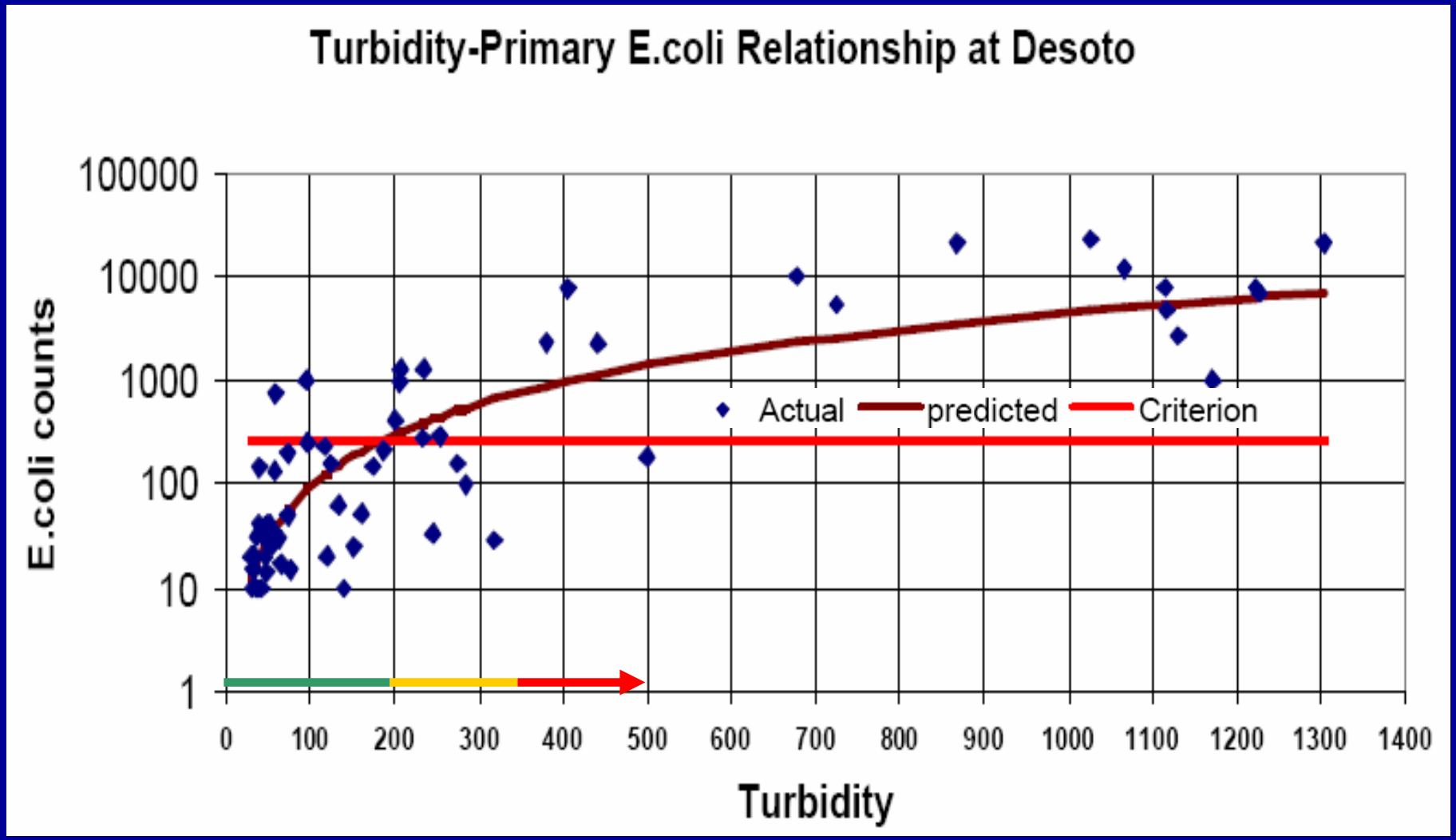
Rasmussen, Ziegler, and Rasmussen 2005

Turbidity to estimate probability of exceeding E. coli criteria



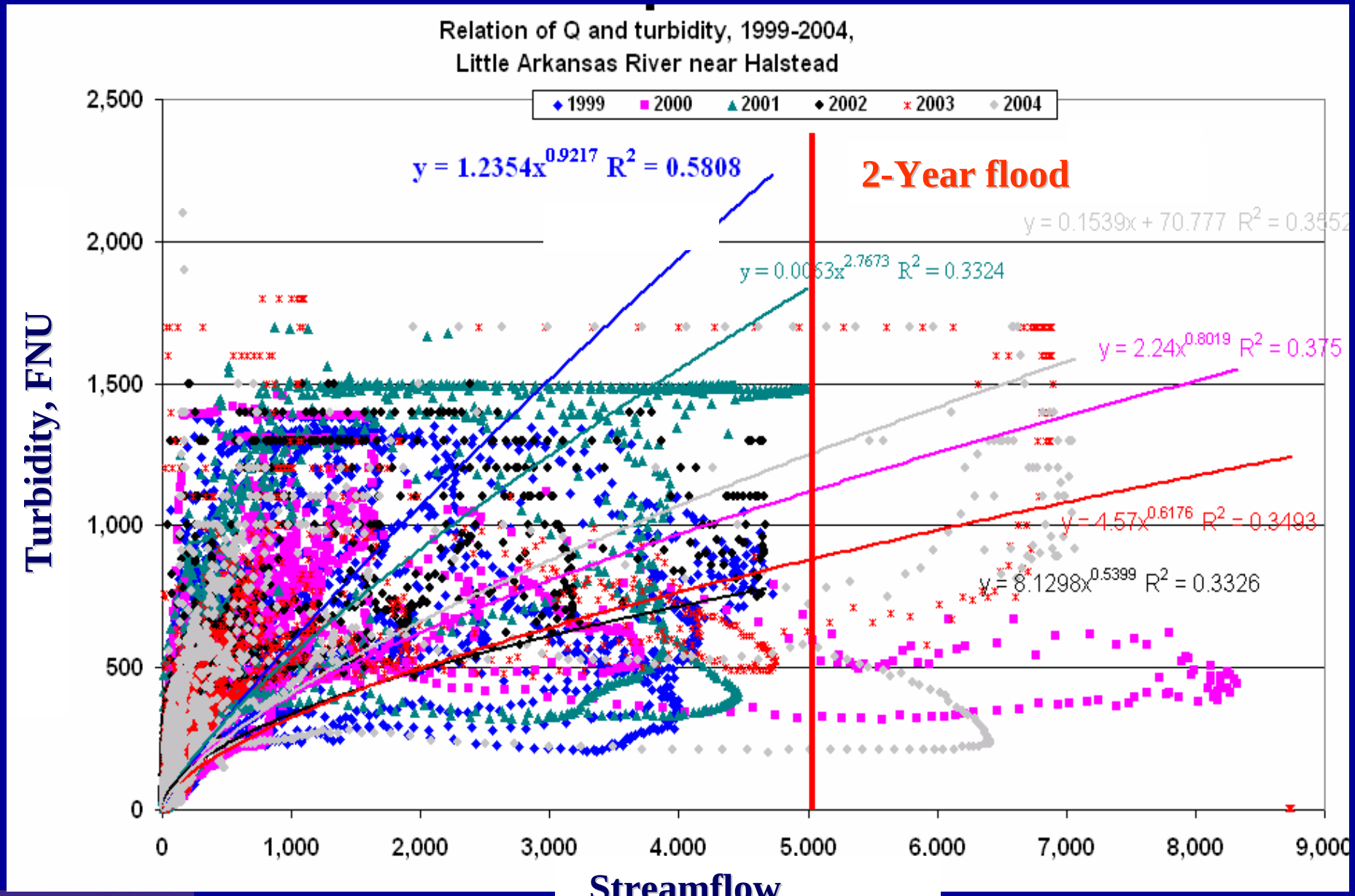
Rasmussen and Ziegler, 2003

Kansas River TMDL incorporates continuous turbidity data. When turbidity > 350 FNU, *E. coli* criteria likely to be exceeded.

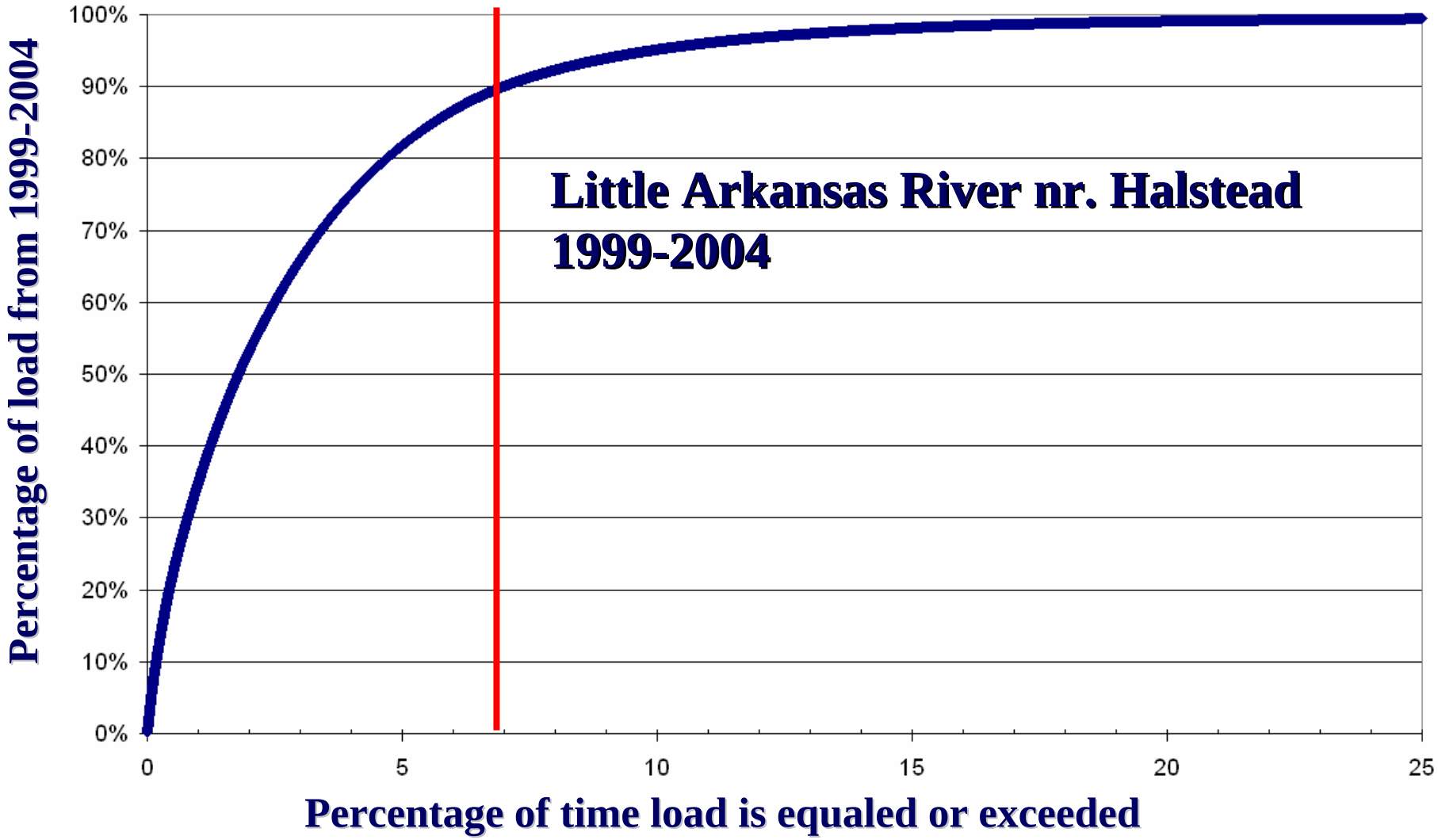


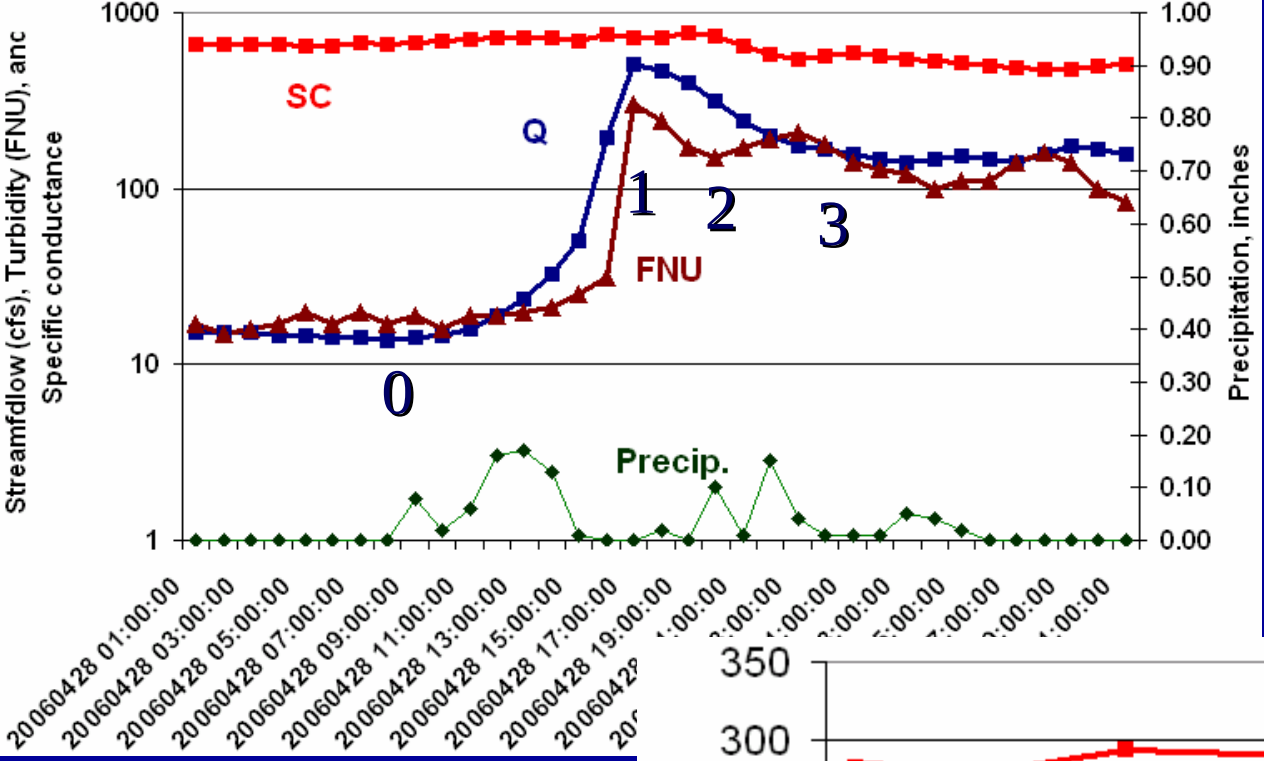
(Figure from KDHE, *E.Coli* Bacteria TMDL for Kansas-Lower Republican Basin, 2005)

Streamflow relation to water quality is complex and variable



90 percent of the load occurs in 7 percent of the time





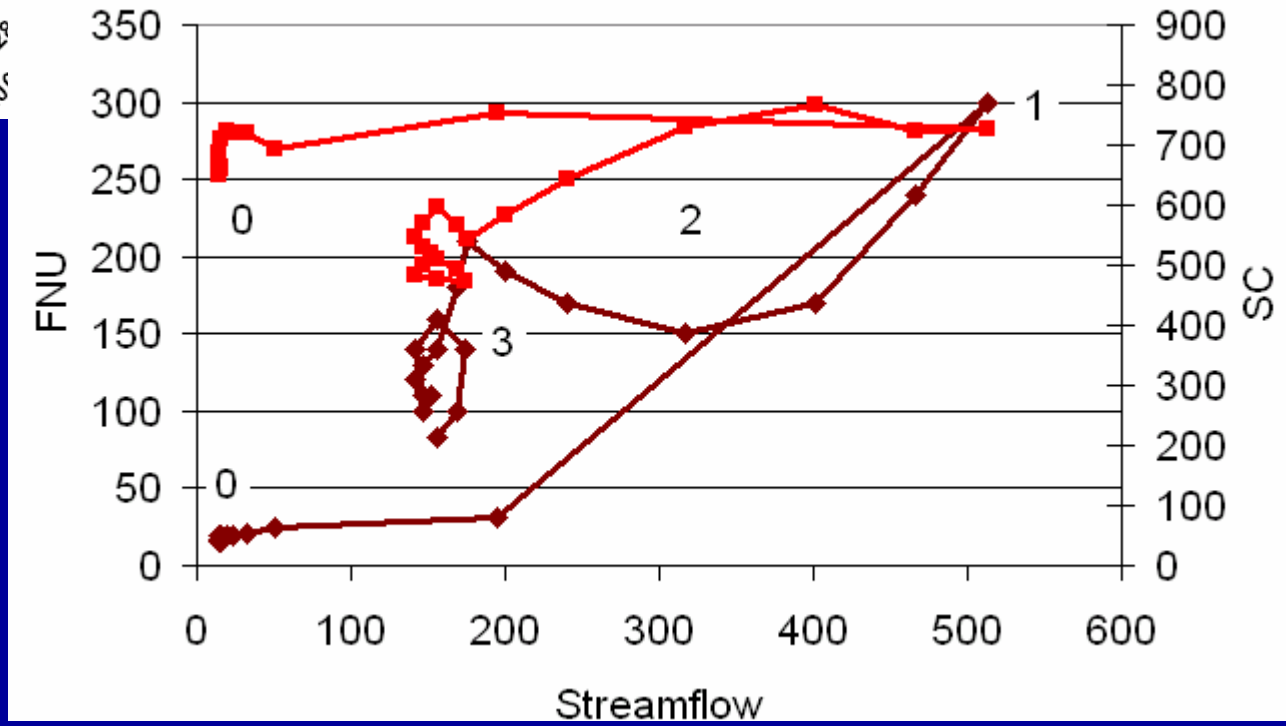
Continuous data is necessary to understand the water-quality response to streamflow

0. Q inc. within 15 min.

1. source limit reached

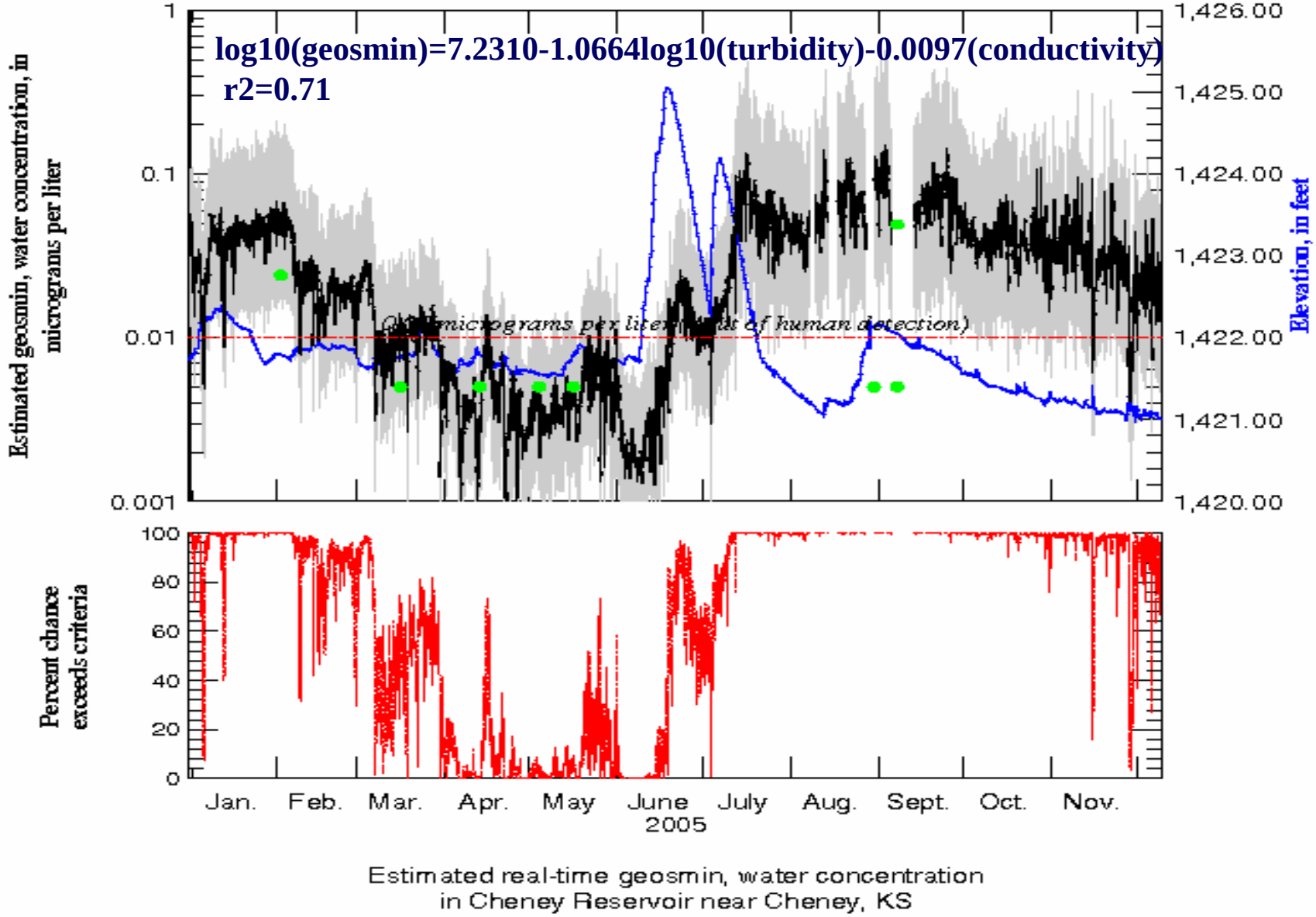
2. new trib or bank collapse source

3. response to precip and new tribs



Mill Creek April 28-29, 2006 hysteresis

Future: Real-time estimation of geosmin in Cheney Reservoir (2005)



http://ks.water.usgs.gov/Kansas/rtqw/sites/07144790/htmls/ytd/p62719_ytd_all_uv.shtml

Benefits of Real Time Water Quality

- Improve our understanding of the hydrology and water quality of streams
- Identify source areas and evaluate trends for NPDES, BMPs and TMDLs
- Provide notification of changes in water-quality conditions for water treatment and recreation in real time
- Comparison to water-quality criteria
- Continuously measure water quality in real time like streamflow
- Better estimate selected constituent concentrations and loads with defined uncertainty
- Optimize timing of sample collection

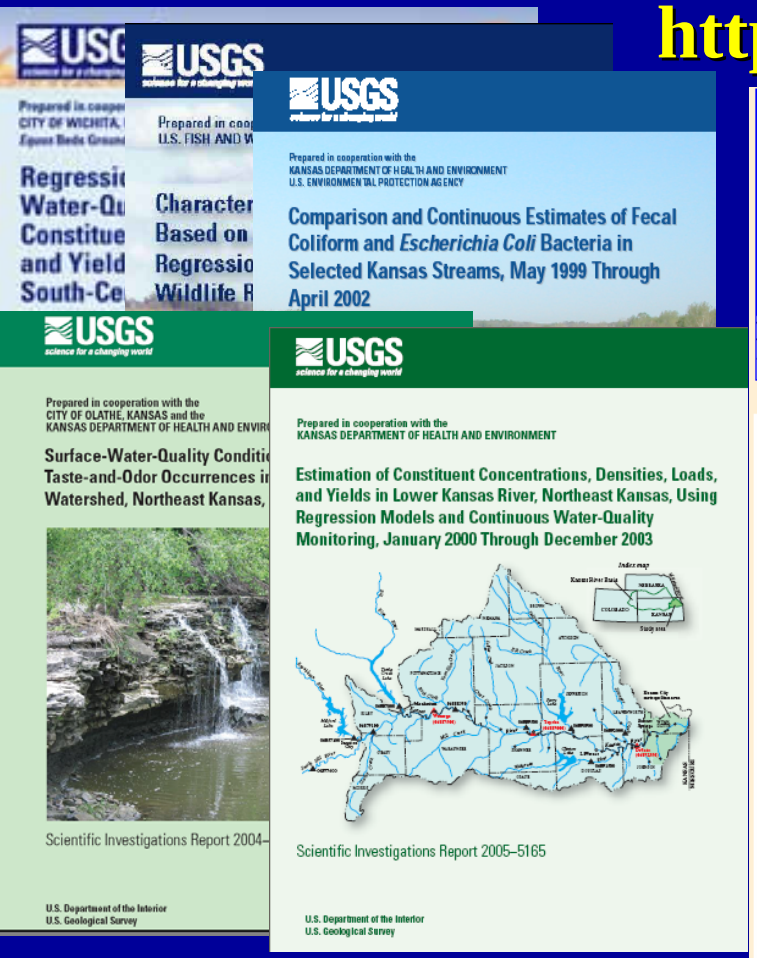
USGS

Future Challenges for Continuous Water Quality

- Detection of water-quality trends and BMPs effectiveness
- More installations nationwide to better understand variability
- Need more direct measurement sensors
- Reduce O&M costs/time
- Ice and shallow water installations
- Continued sampling to document that relations remain representative
- Improve ways to estimate and communicate uncertainty

USGS

Real-time continuous concentrations and loads on the Web—http://ks.water.usgs.gov/Kansas/rtqw/



Select desired options for data display:

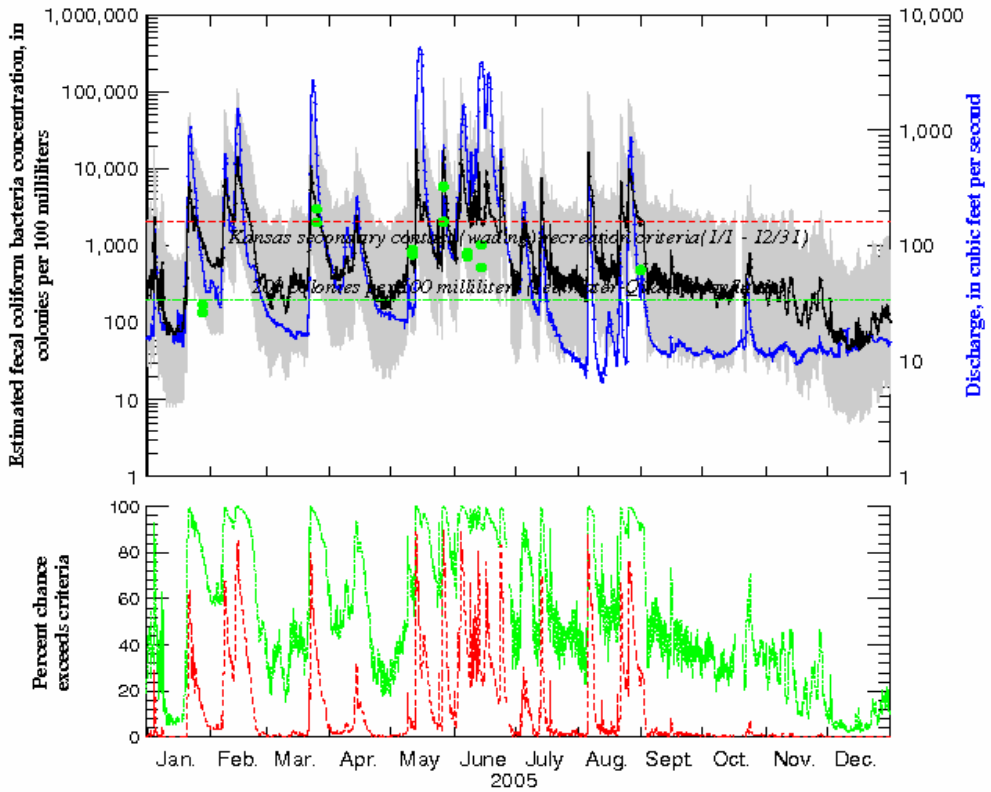
USGS station: 07143672 Little Arkansas River at Highway 50 near Halstead, KS

Parameter: Est. fecal coliform bacteria | Concentration | Hourly | < Go >

Time period: Year 2005 | All | January

Other info: Data Go **Statistics:** Summary Go

Note: Because of daily variation in some parameters, daily data may be better to view for Year-to-date and annual plots.



Estimated real-time fecal coliform bacteria concentration in Little Arkansas River at Highway 50 near Halstead, KS

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