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Continuous Turbidity Monitoring and Regression Analysis to Estimate Total Suspended Solids and Fecal Coliform Bacteria Concentrations and Loads in Real Time

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Problems with Conventional Water-Quality Monitoring

- Limited number of samples are collected annually
- Annual load estimates are based on a small finite number of samples
- Seasonal, diurnal, and event driven fluctuations are nearly always missed
- Costs of manual sampling and analysis

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What is a Surrogate?

- A sensor measurement used to estimate a concentration of a constituent of greater interest
  - Continuous
  - Real time
- Surrogate relations are developed using statistical regression techniques

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Objectives of Continuous Water-Quality Monitoring of Surrogates

- **More accurately estimate constituent concentrations and loads**
- **Provide regulatory agencies & water suppliers information to improve treatment processes and drinking-water quality**
- **Continuously measure turbidity and other water-quality constituents that indicate potential stress to aquatic organisms**
- **Optimize timing of sample collection**

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Continuous Water-Quality Monitoring

- pH
- Water Temperature
- Dissolved Oxygen
- Specific Conductance
- Total Chlorophyll
- **Turbidity**

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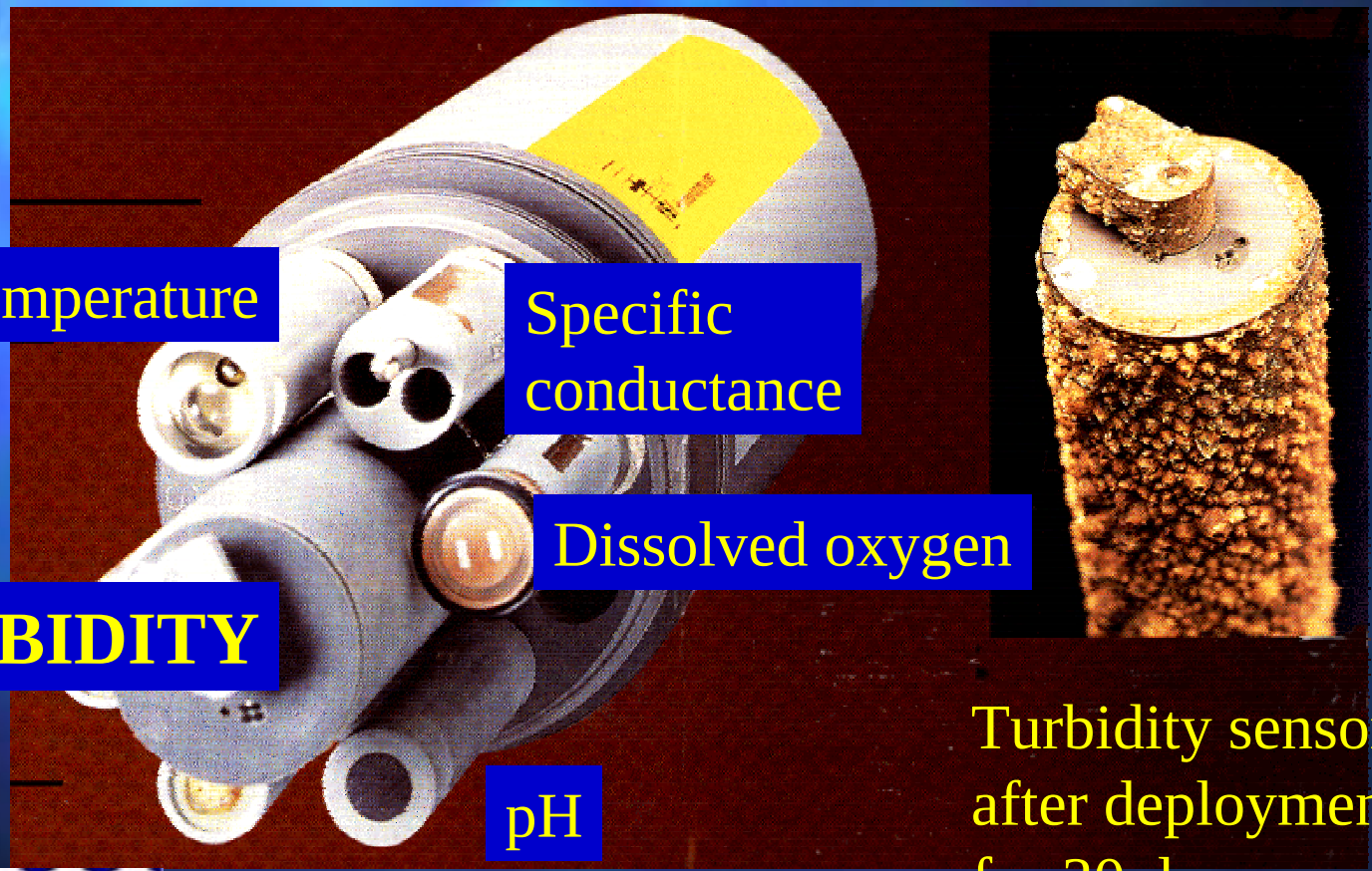
YSI Sonde



Turbidity sensor after deployment for 30 days

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Approach

1. In-stream water-quality monitors installed at USGS gaging stations and real-time data transmitted by DCP
2. Periodic manual samples collected over the range of expected hydrologic conditions
3. Regression equations developed between surrogates (turbidity) and constituents of interest (TSS, FCB, and SSC)
4. Equations used to estimate real-time constituent concentrations and loads

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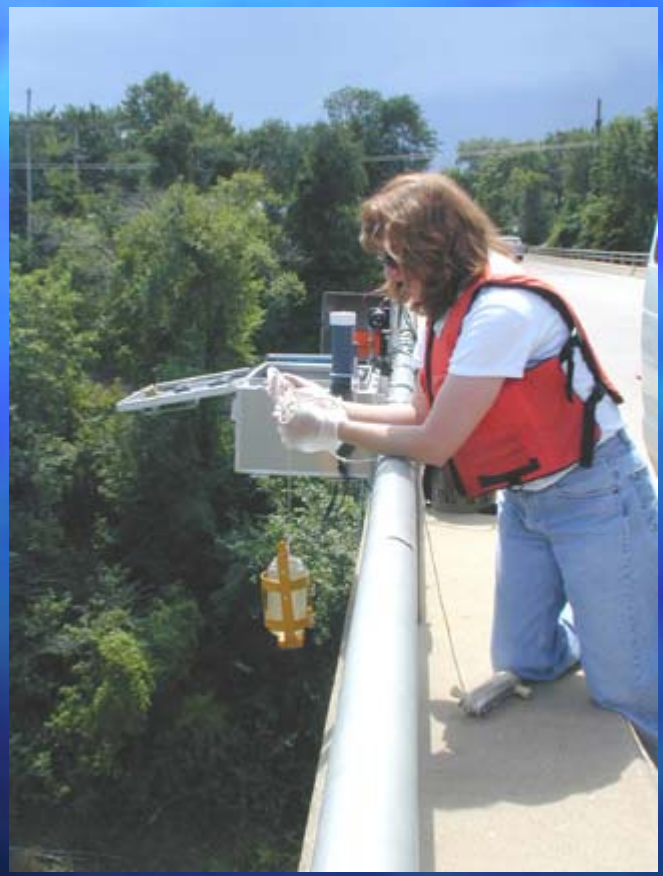
Collection of manual samples



- Collected throughout the range in expected hydrologic conditions
- Analyzed for tss, bacteria, sediment, and other constituents
- Historical data may be used
- Equal width increment (EWI) measurements collected during site visits

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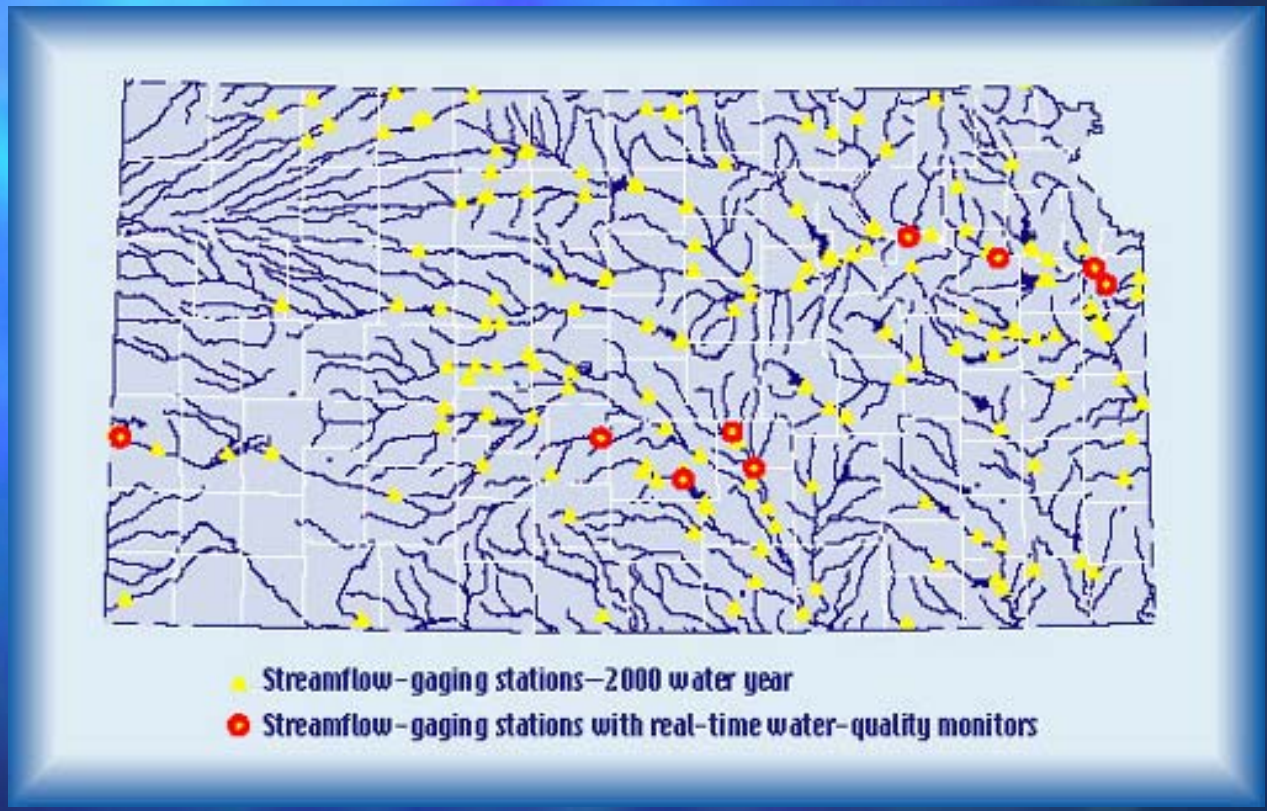
Existing Streamflow-Gaging Stations in Kansas



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Real-Time Water-Quality Studies in Kansas

- **Quivira National Wildlife Refuge**
- **Kansas River Real-Time Alert Network**
- **New Lake Olathe**
- **Equus Beds Ground-Water Recharge Project**

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Quivira National Wildlife Refuge

- U.S. Fish and Wildlife Service and GMD5
- Alert USFWS to high constituent concentrations entering refuge
- T&E species
- Establish TMDLs
- CAFOs

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Kansas River Alert Network

- Kansas Dept. of Health and Environment (KDHE)
- Alert downstream suppliers
- FCB vs. E. Coli
- Monitor TMDLs
- Optimize sample collection frequency

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New Lake Olathe

- City of Olathe
- Determine nutrient loads to urban reservoir
- Taste and odor problems
- Analysis of bottom sediment

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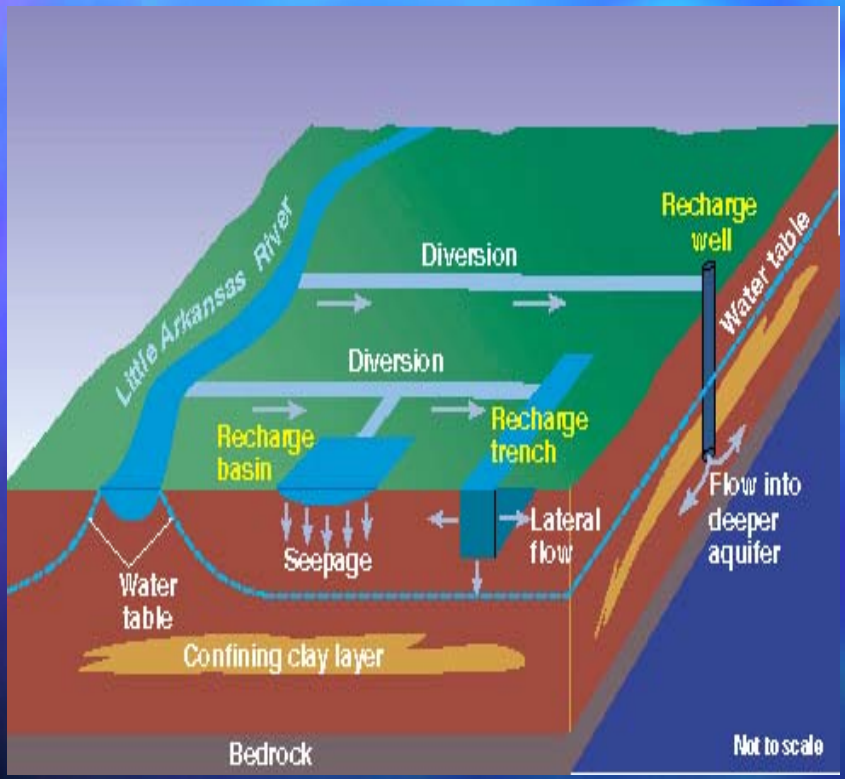
Equus Beds Ground-Water Recharge Project – Little Arkansas River



- City of Wichita
- Increase water supply
- Prevent saltwater intrusion
- Alert project officials to changes in water-quality
- Development of TMDLs

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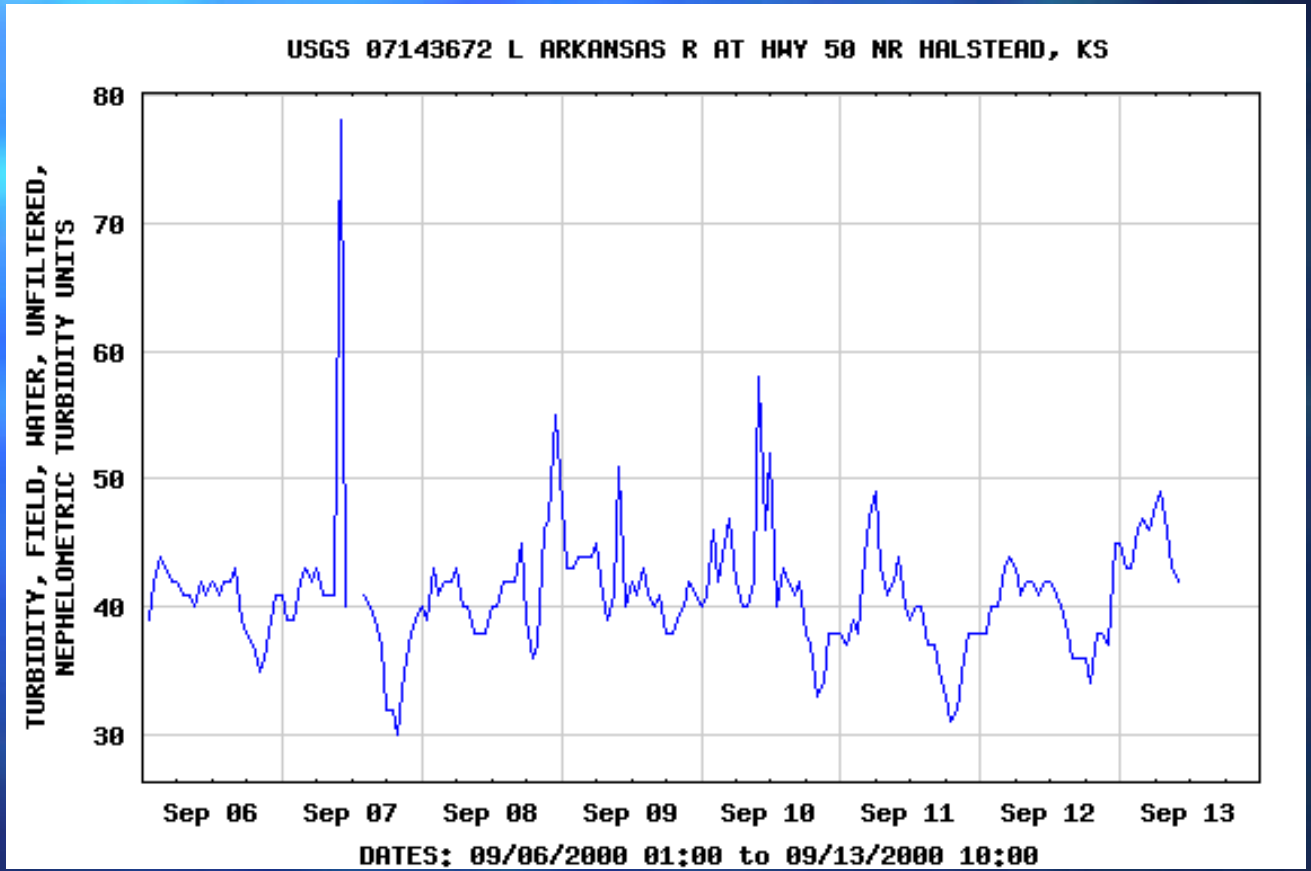
Real-time turbidity



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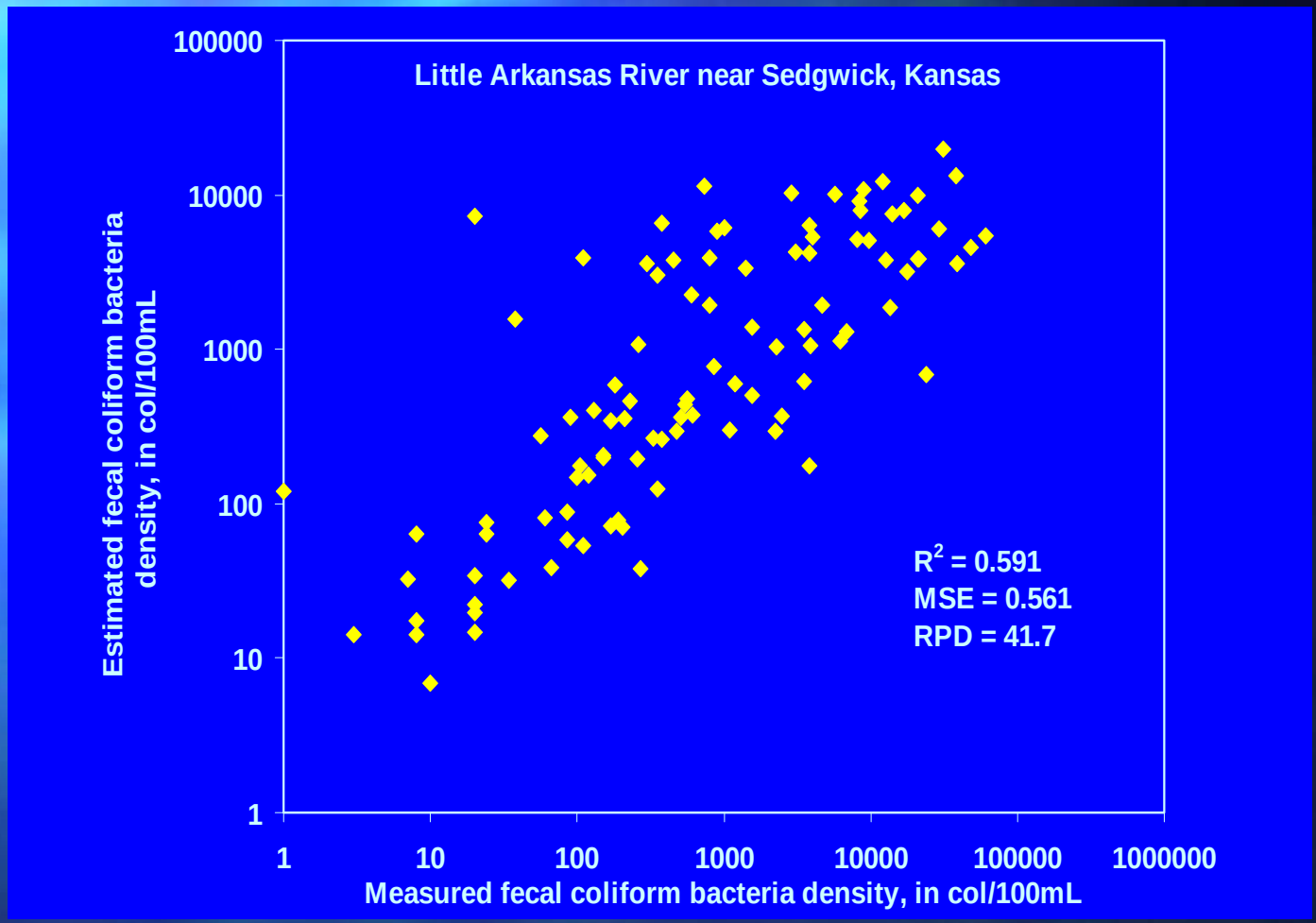
Regression Estimated vs. Measured Bacteria Densities



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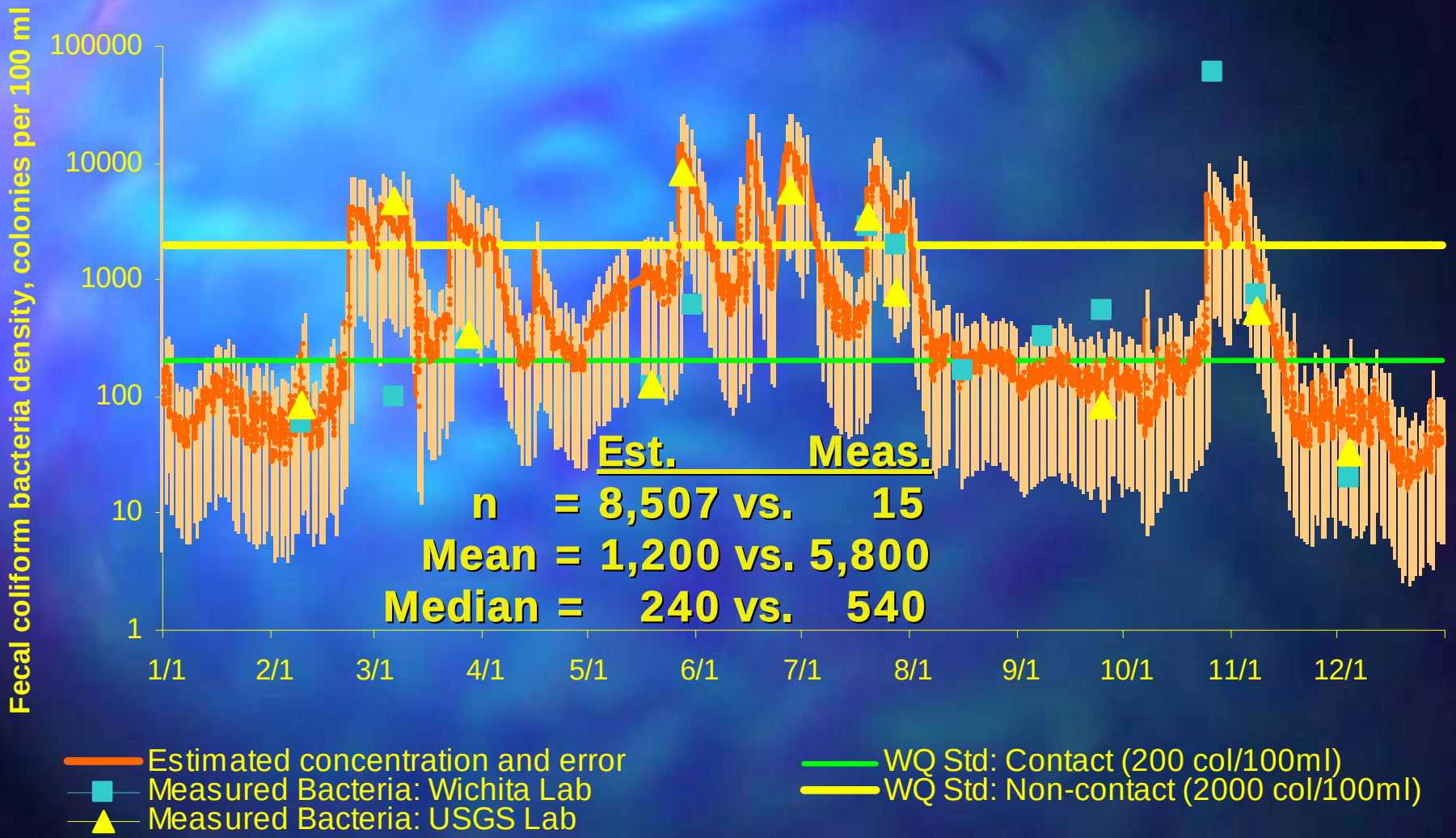
$$\mathrm{Log}_{10}FCB = -0.169\sin(2\pi(D/365)) - 0.300\cos(2\pi(D/365)) + 0.799\log_{10}T + 0.299\log_{10}Q + 0.474$$

Estimated Bacteria Concentrations, 2000



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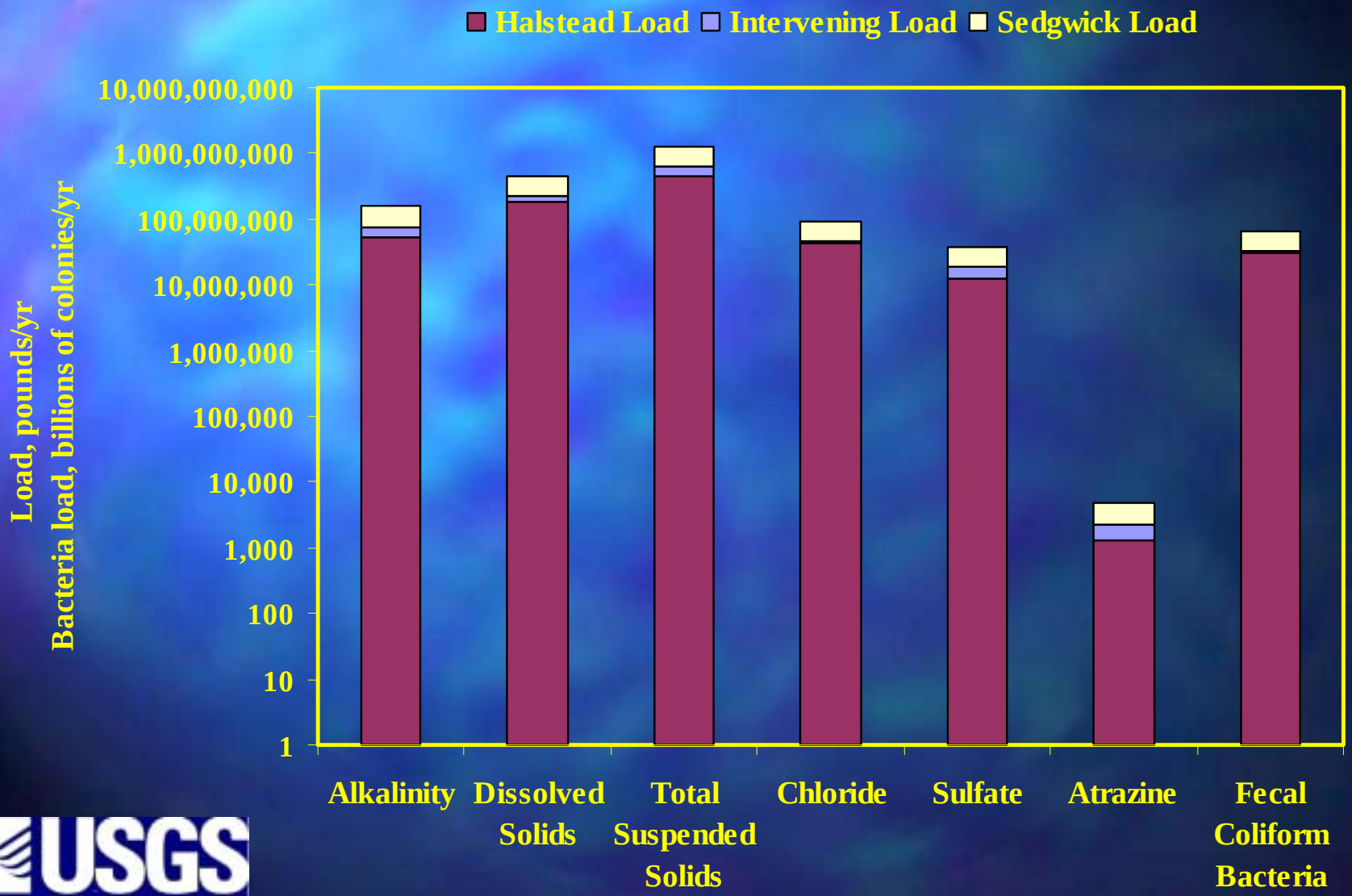
The information is useful to determine contributions within a basin for TMDLs



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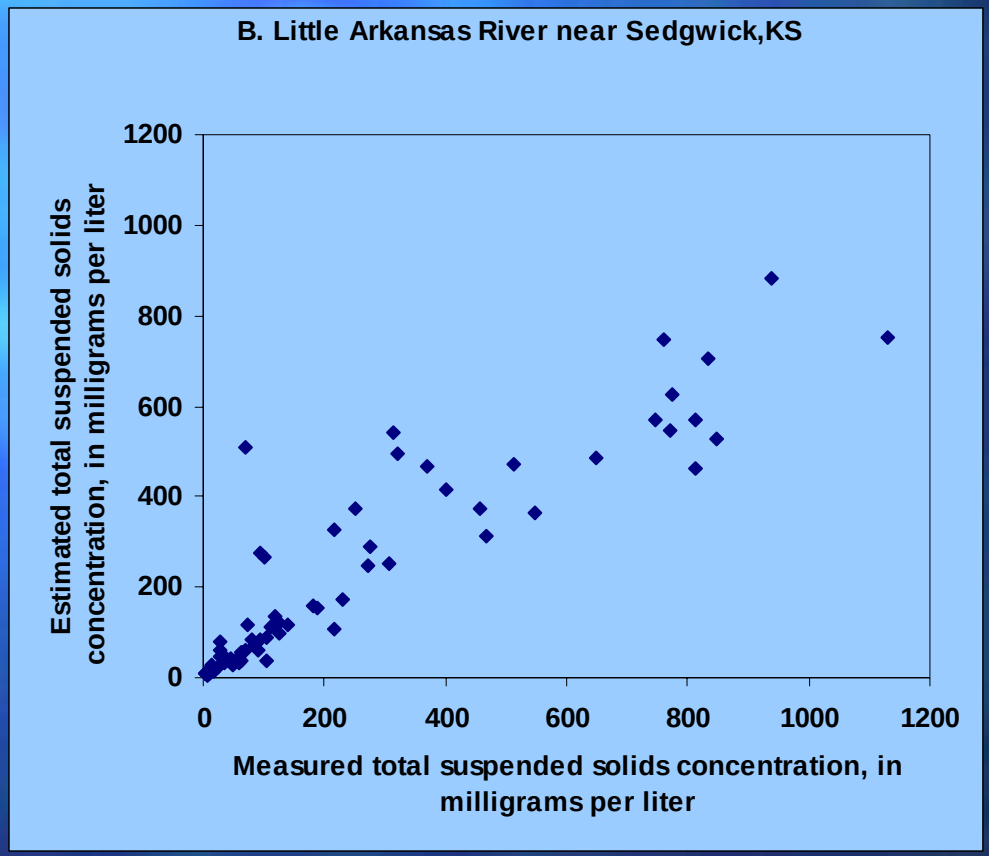
Estimated vs. Measured TSS Concentrations



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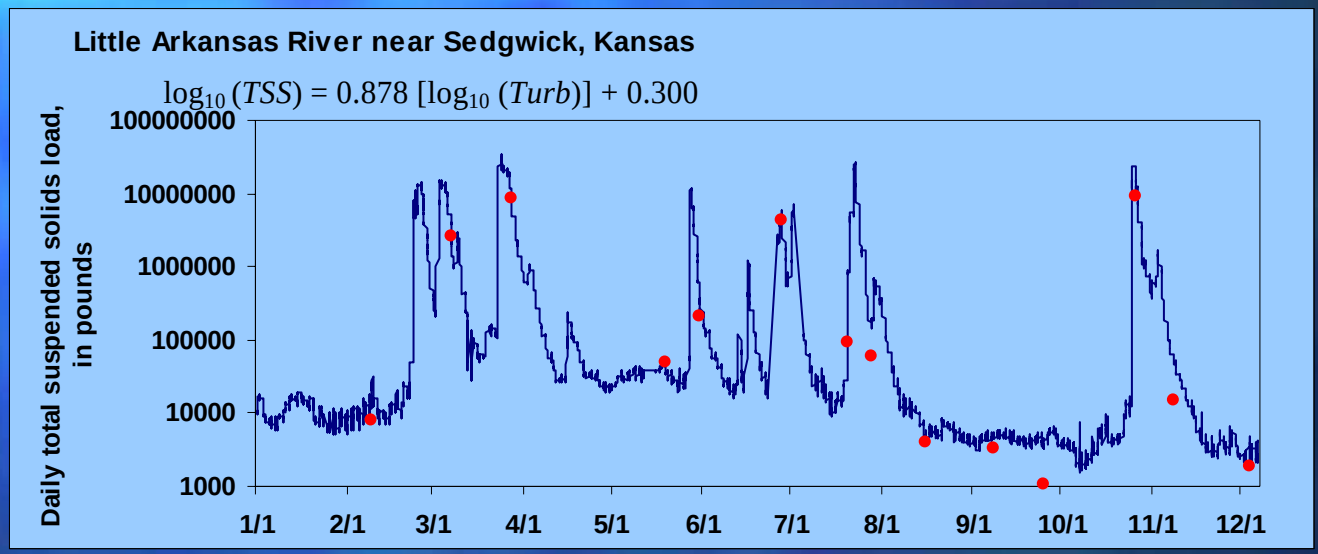
$$\log_{10} TSS = 0.878(Turb) + 0.300$$

Estimated vs. Measured Total Suspended Solids Loads



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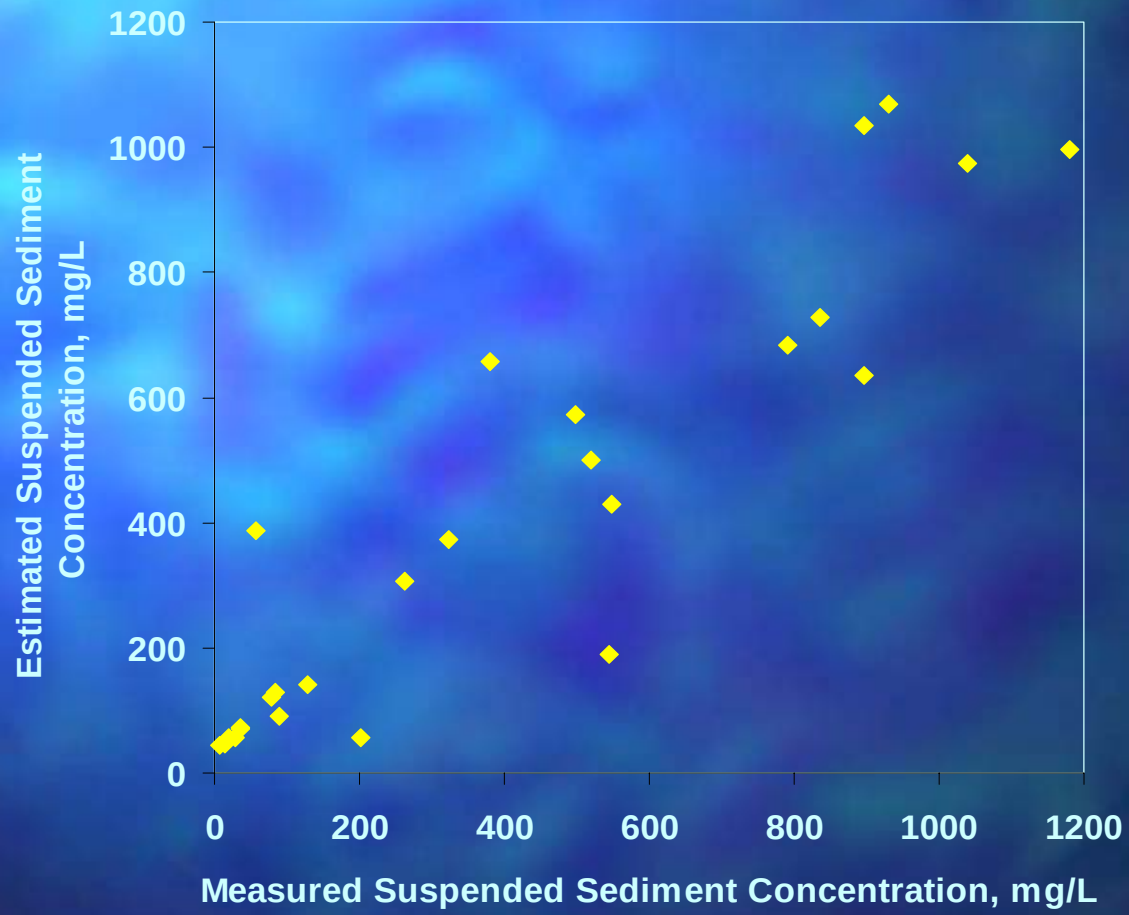
Estimated and Measured Suspended Sediment Concentrations

Little Arkansas River near Sedgwick, Kansas



$R^2 = 0.852$

MSE = 23256

RPD = 14.6

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$$SSC = 0.38Q + 0.790T + 36.4$$

Benefits and Conclusions

- More accurate estimates with continuous data collection
- Approach can be used to determine concentrations and loads and to monitor TMDLs
- Loads can be used to evaluate BMPs
- Approach compliments current activities of our cooperators to optimize sampling
- Infrastructure is already there (existing gaging stations)

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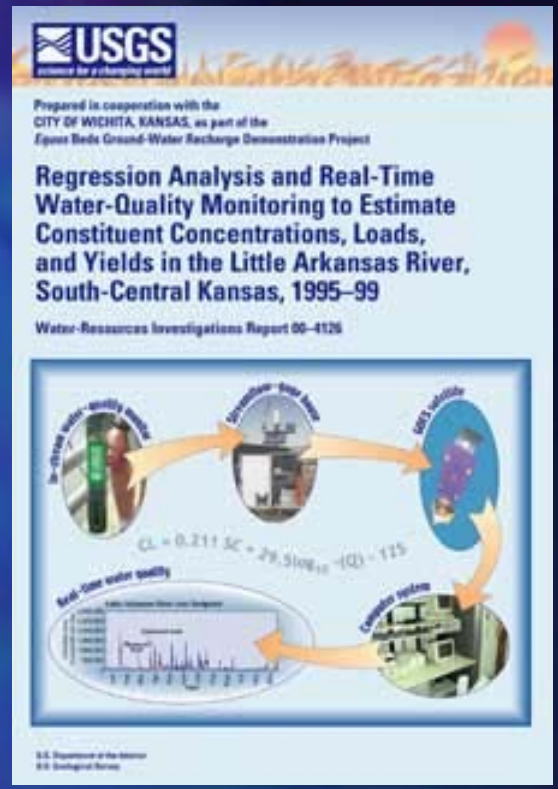
For more information on real-time water quality in Kansas:



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

http://water.usgs.gov/ks/nwis/

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