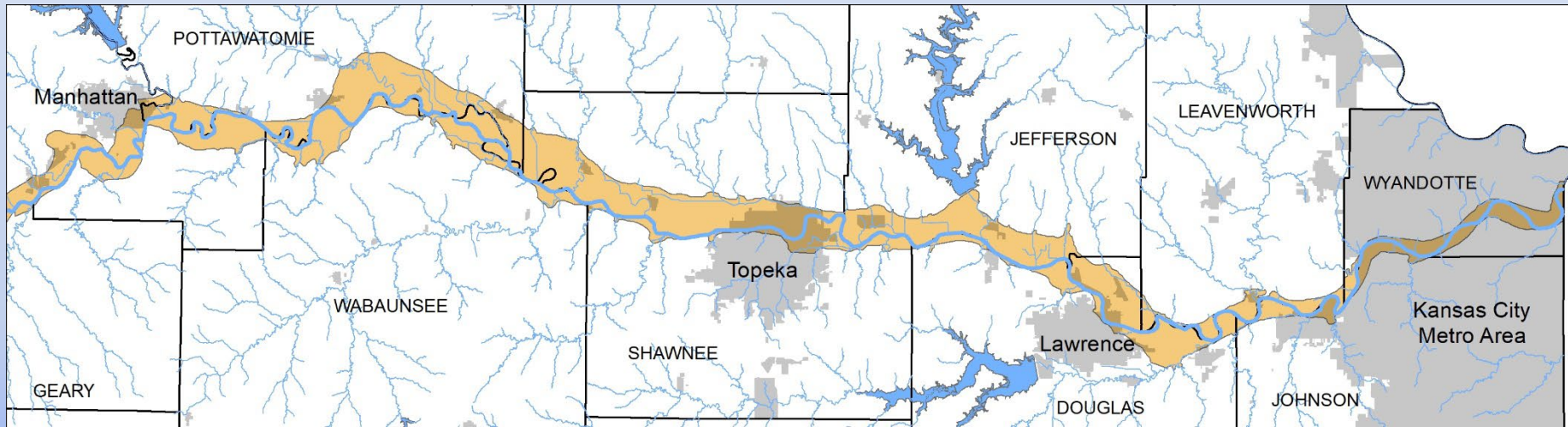


Sources and Variations in Bromide in Kansas River Water



Don Whitemore
Smoky Hill-Saline Regional Advisory Committee
Lawrence, Kansas, February 14, 2023

BROMIDE IN DRINKING WATER ISSUE

Formation of disinfectant byproducts that are of generally greater health concern than chlorine byproducts:

- **Disinfectant chlorine can oxidize dissolved bromide to a form which then can brominate organics in water to produce trihalomethanes, haloacetonitriles, and haloacetic acids.**
- **Disinfectant ozone can oxidize dissolved bromide to bromate. Drinking water standard for bromate is 10 µg/L (0.010 mg/L).**

KANSAS RIVER WATER QUALITY GROUP

Coordinated by the Kansas Water Office

Participants include:

**Water supply systems using Kansas River water
(WaterOne, Manhattan, Topeka, Lawrence, De Soto,
Olathe)**

State agencies (KWO, KDHE, KGS)

Federal agency (USGS)

Non-governmental agencies (FOK, TNC)

Companies (Evergy, B&V)

University (KU)

BROMIDE SOURCES IN WATER SUPPLIES

Natural sources:

- Leaching of plant material, soils, rocks
- Saltwater intrusion from subsurface formations
- Seawater intrusion along coasts

Anthropogenic sources:

- Oil and gas production brine
- Coal-fired power plant wastewater
- Dissolved mined salt for road deicing and water softening
- Remnant bromide from bromide compounds used for controlling pests and as an additive in leaded gasoline

Evapotranspiration of water increases concentration

Solute exclusion by ice formation increases concentration

BROMIDE IN WATER

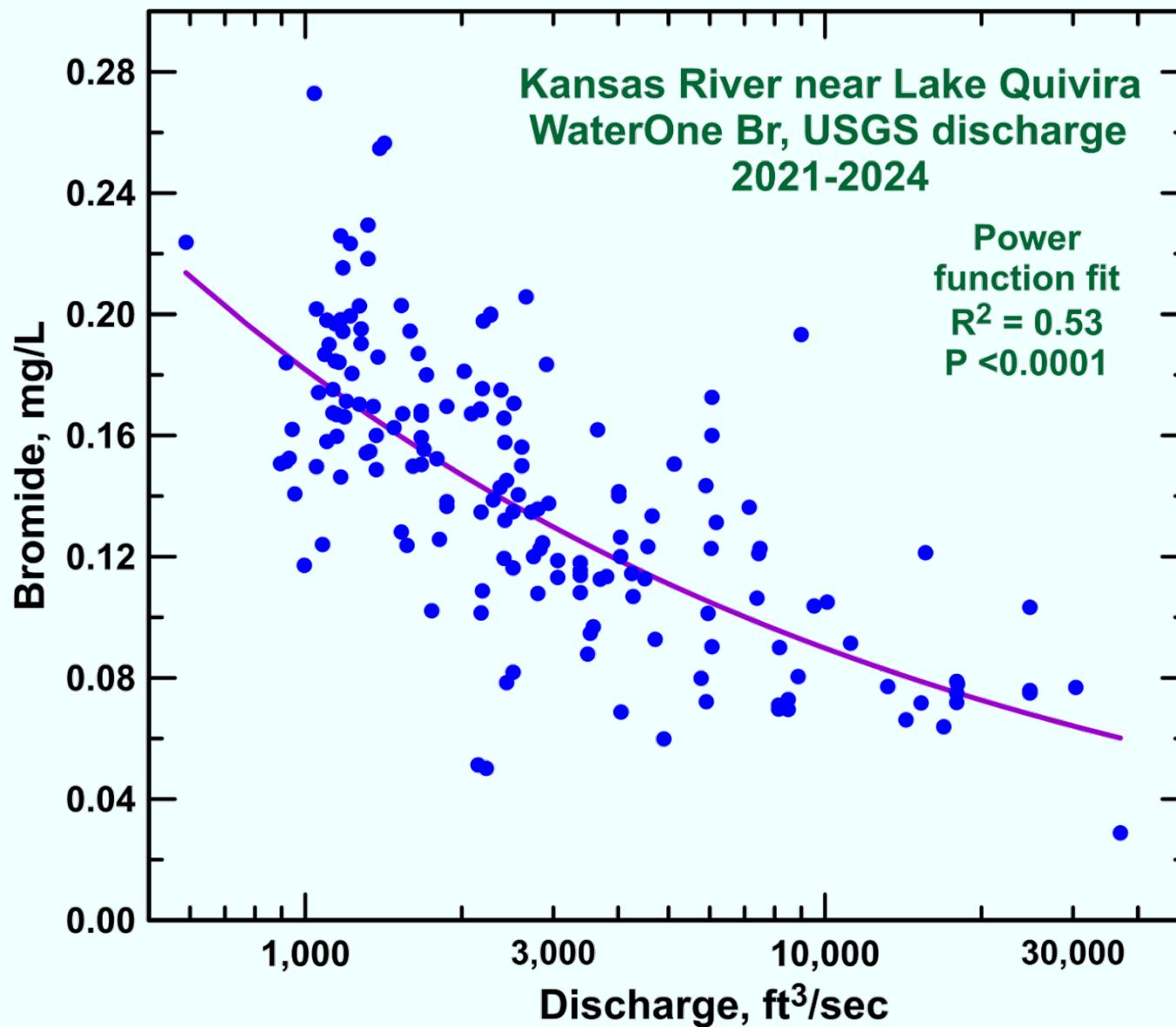
Bromide concentration range in freshwater to saltwater:
0.001 – 0.1 mg/L (1 - 100 µg/L), usually <0.05 mg/L (<50 µg/L)
Up to over 6,000 mg/L in formation brines and salt lakes

Bromide/chloride mass ratio ranges widely:

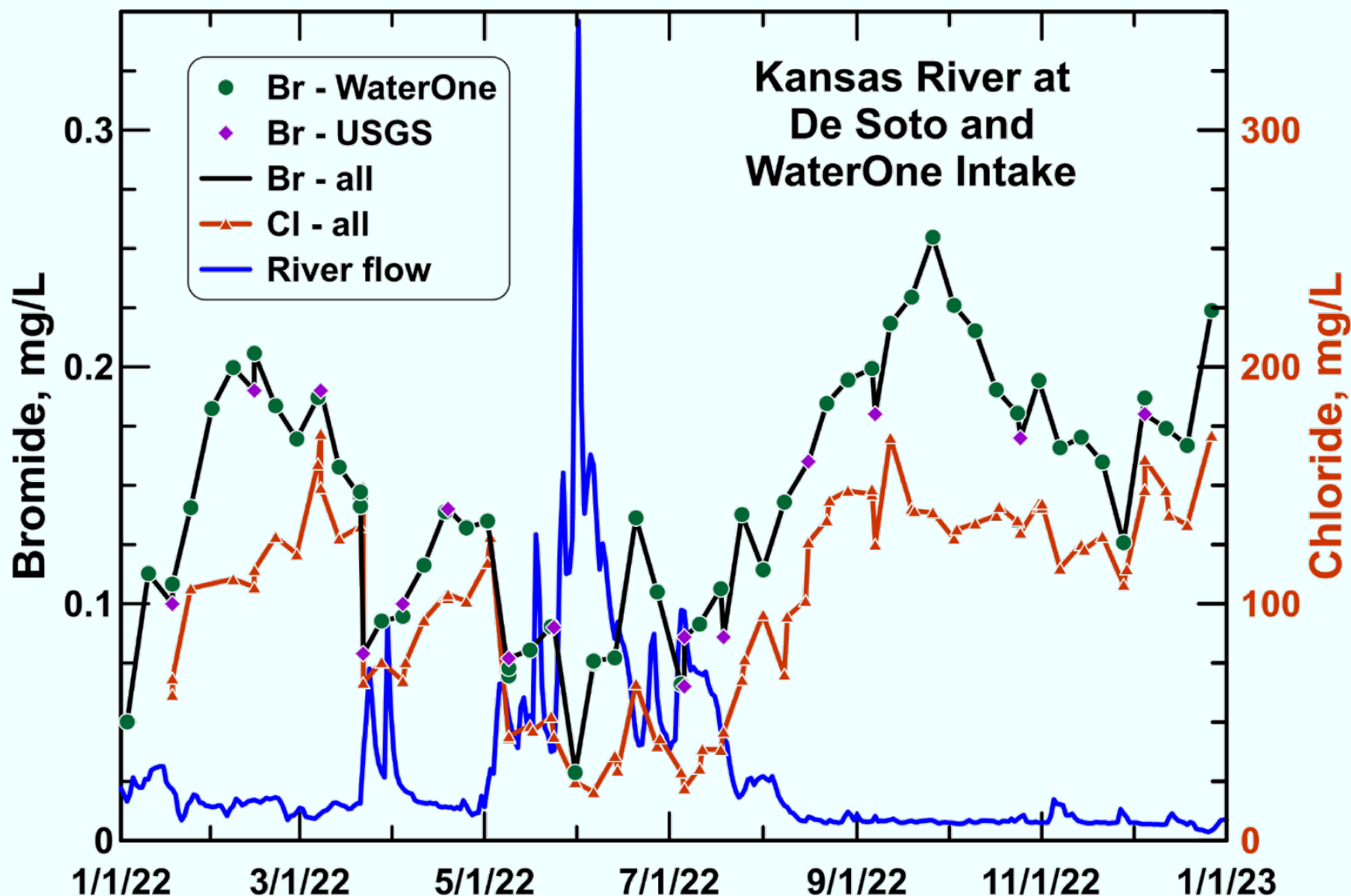
Water Type	General range	
	Cl, mg/L	Br/Cl x 10,000
Precipitation	0.1 - 100	20 - 3000
Fresh surface water and groundwater	0.1 - 100	3 - 1000
Average seawater	19,400	34.7
Salt dissolution brine	10,000 - 250,000	0.6 - 5
Oil and gas formation brine	<10,000 - 270,000	5 - 400



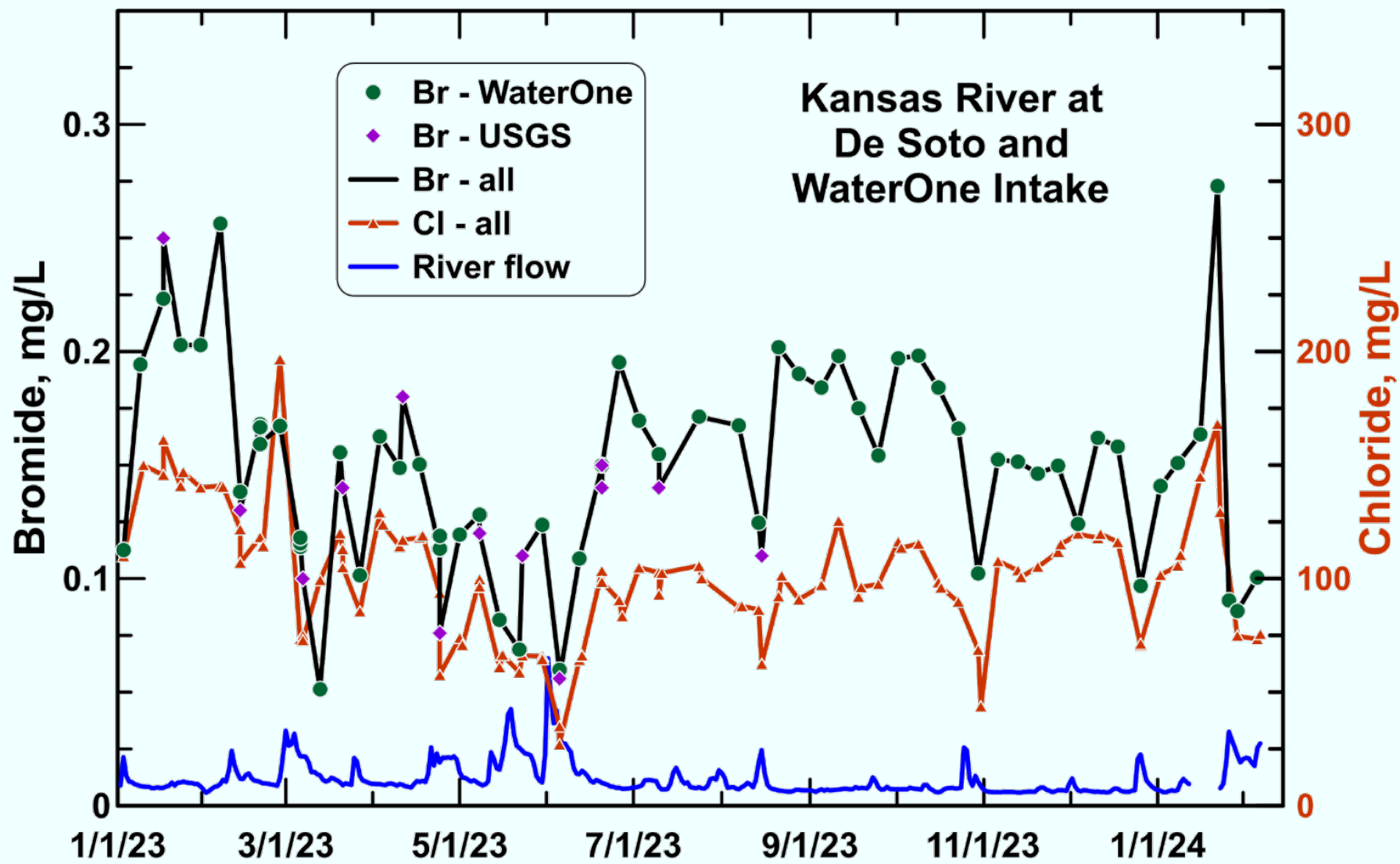
Bromide Concentration versus Discharge in Kansas River



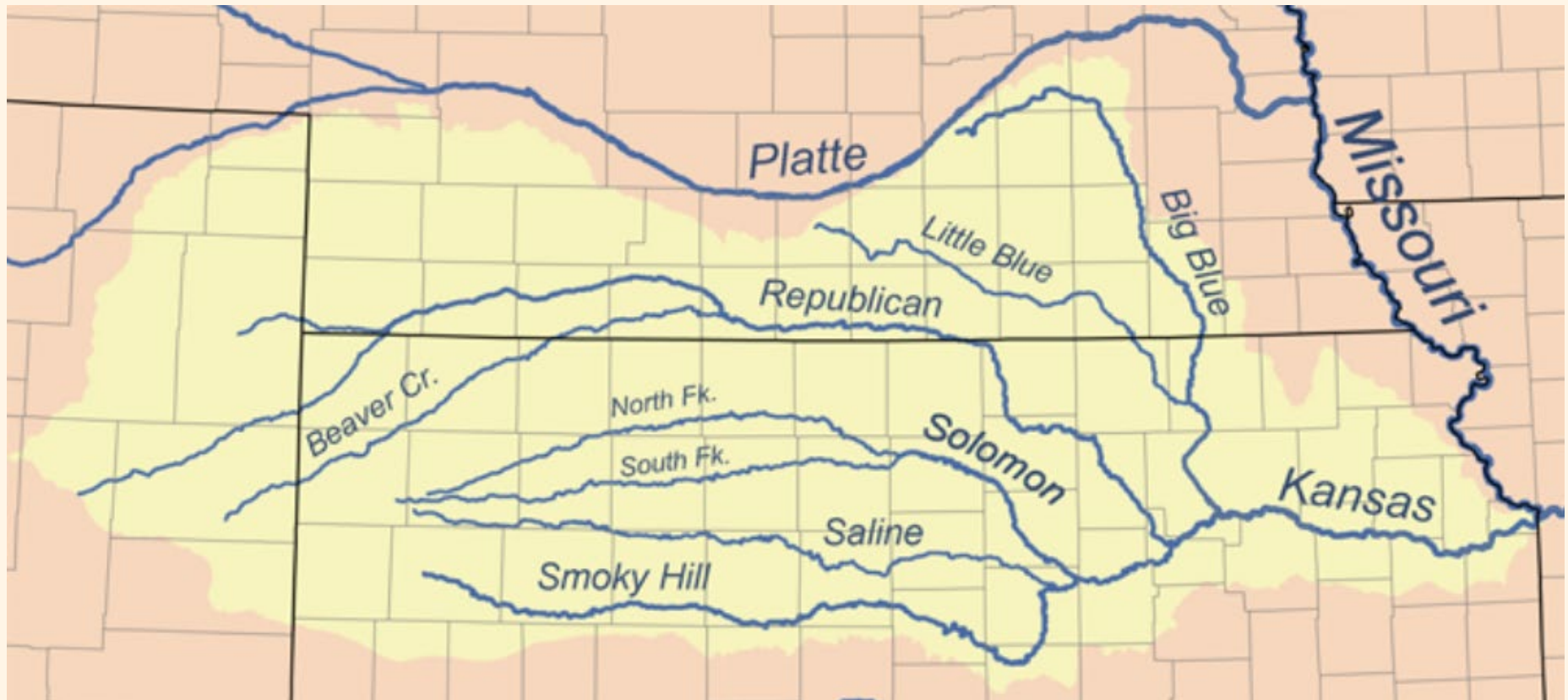
Bromide, Chloride, and Discharge in Kansas River 2022



Bromide, Chloride, and Discharge in Kansas River 2023-2024

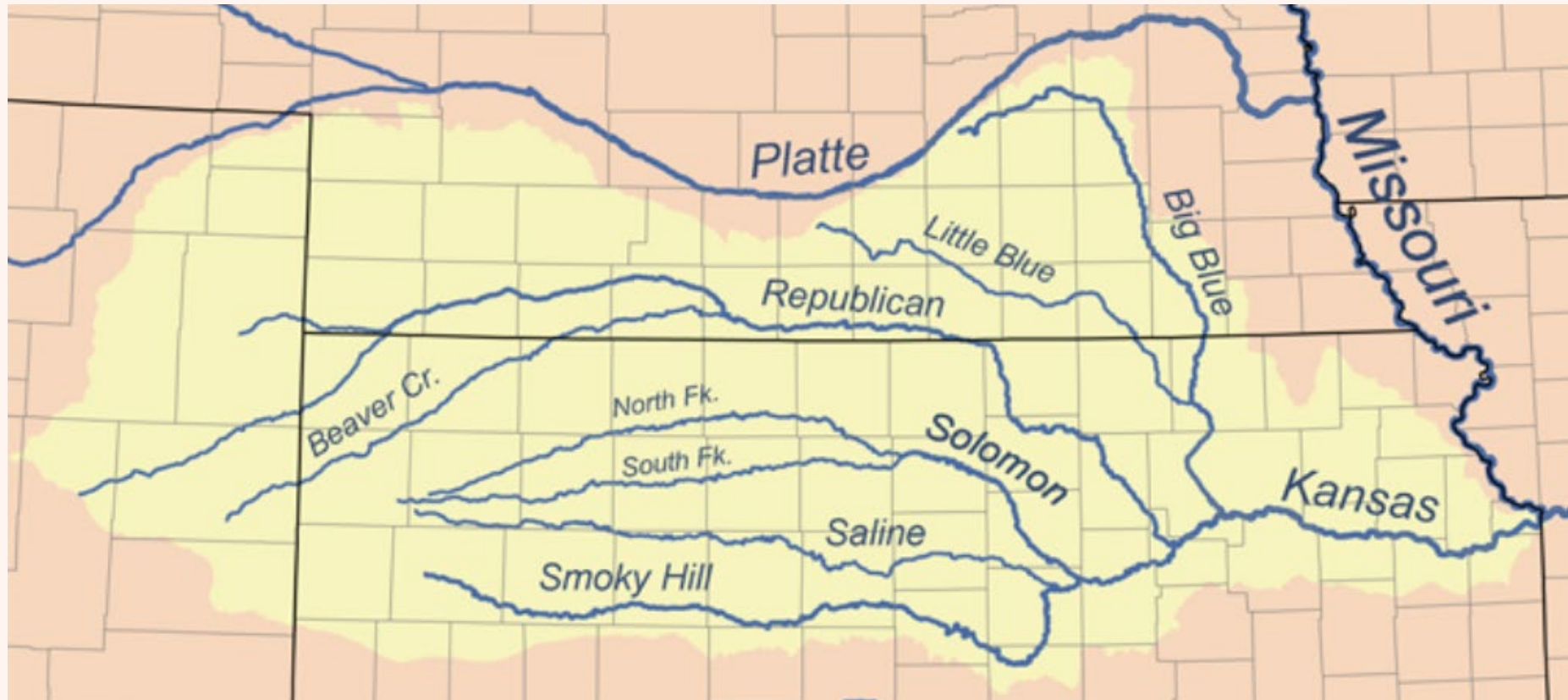


KANSAS RIVER WATERSHED



Major Tributaries to Kansas River
Smoky Hill River (Solomon and Saline river tributaries)
Republican River
Big Blue River (Little Blue River tributary)

KANSAS RIVER WATERSHED



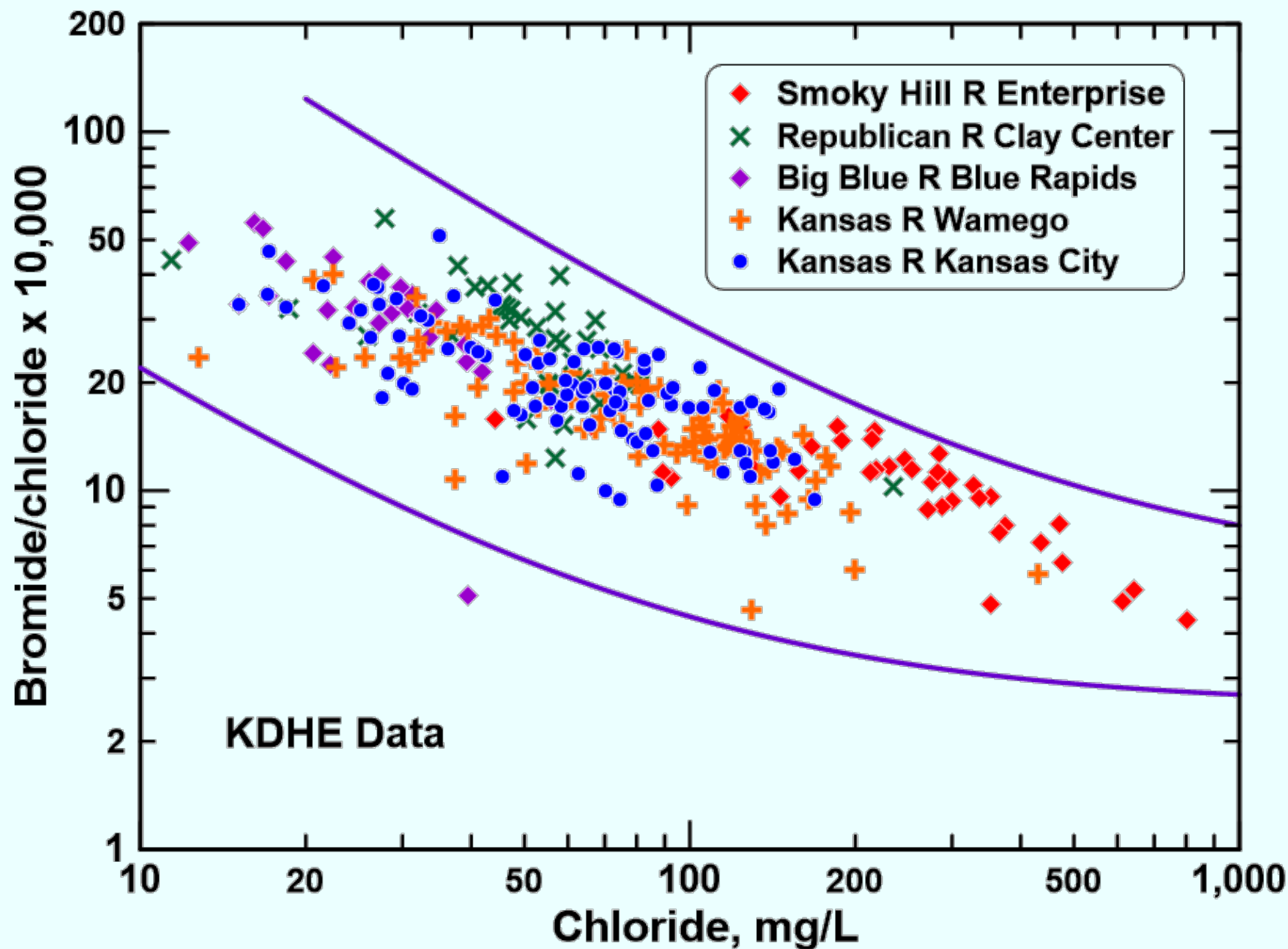
Natural saline water or saltwater intrusion

Permian saltwater to Smoky Hill and Solomon rivers

Dakota saltwater to Solomon, Saline, Smoky Hill, Republican rivers

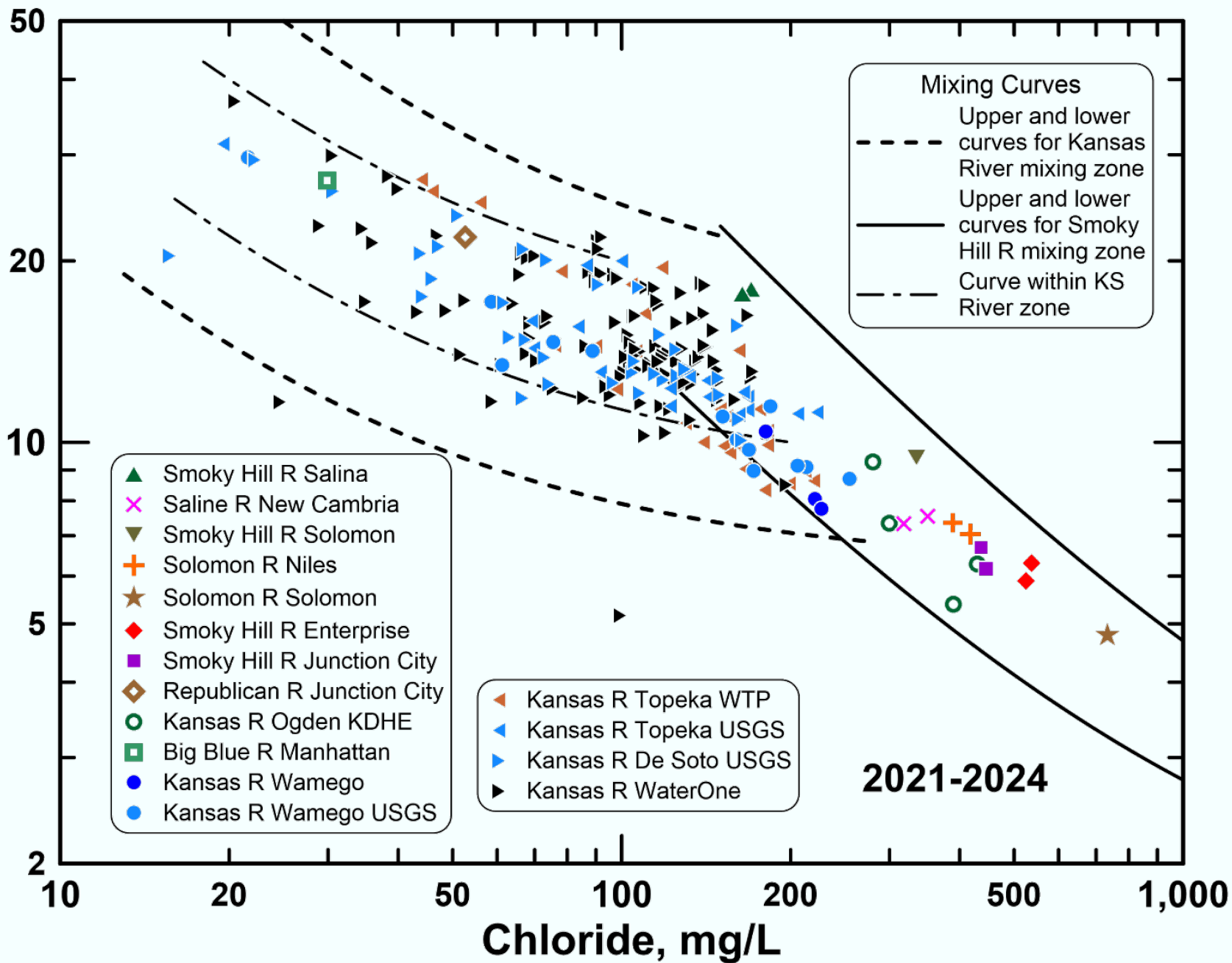
Saline formation water from Paleozoic bedrock

Oil-field brine contamination to Smoky Hill and Saline rivers



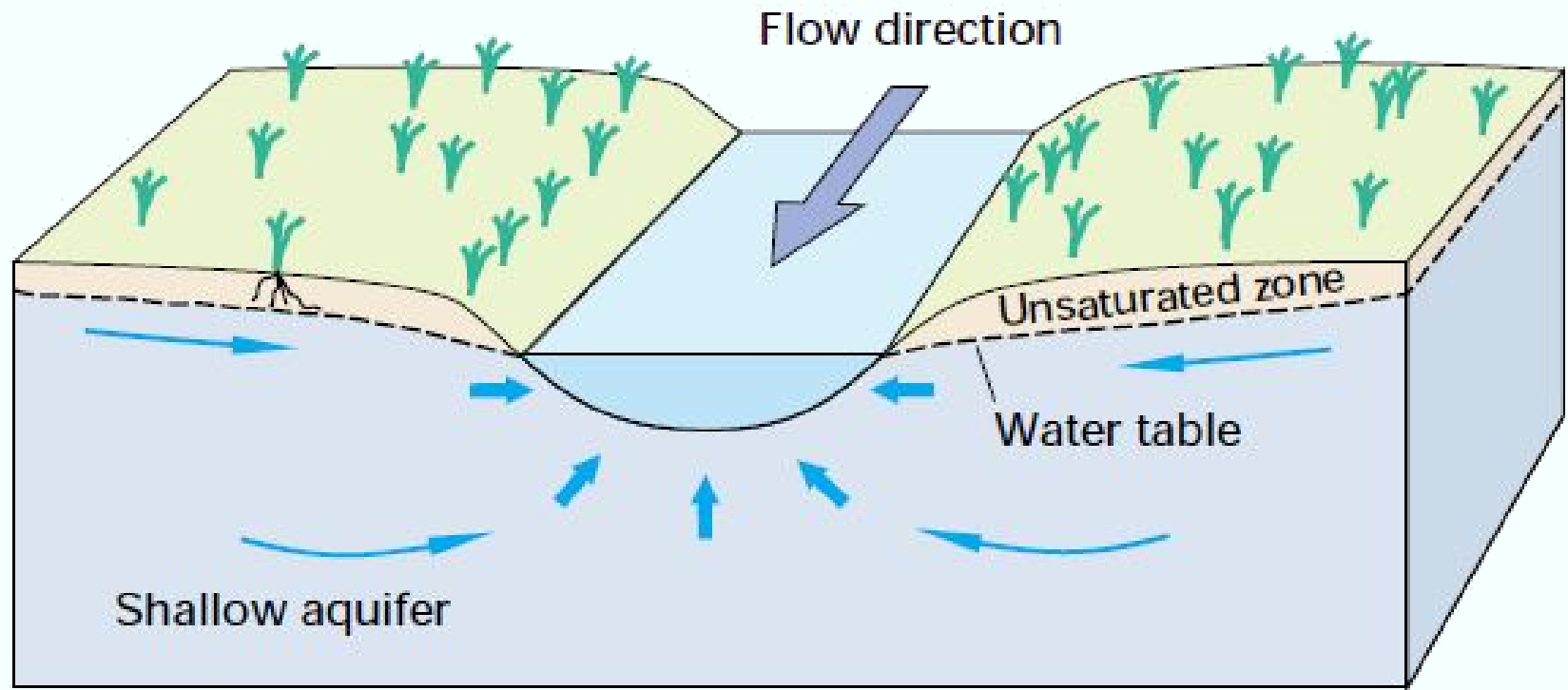


Bromide/chloride x 10,000

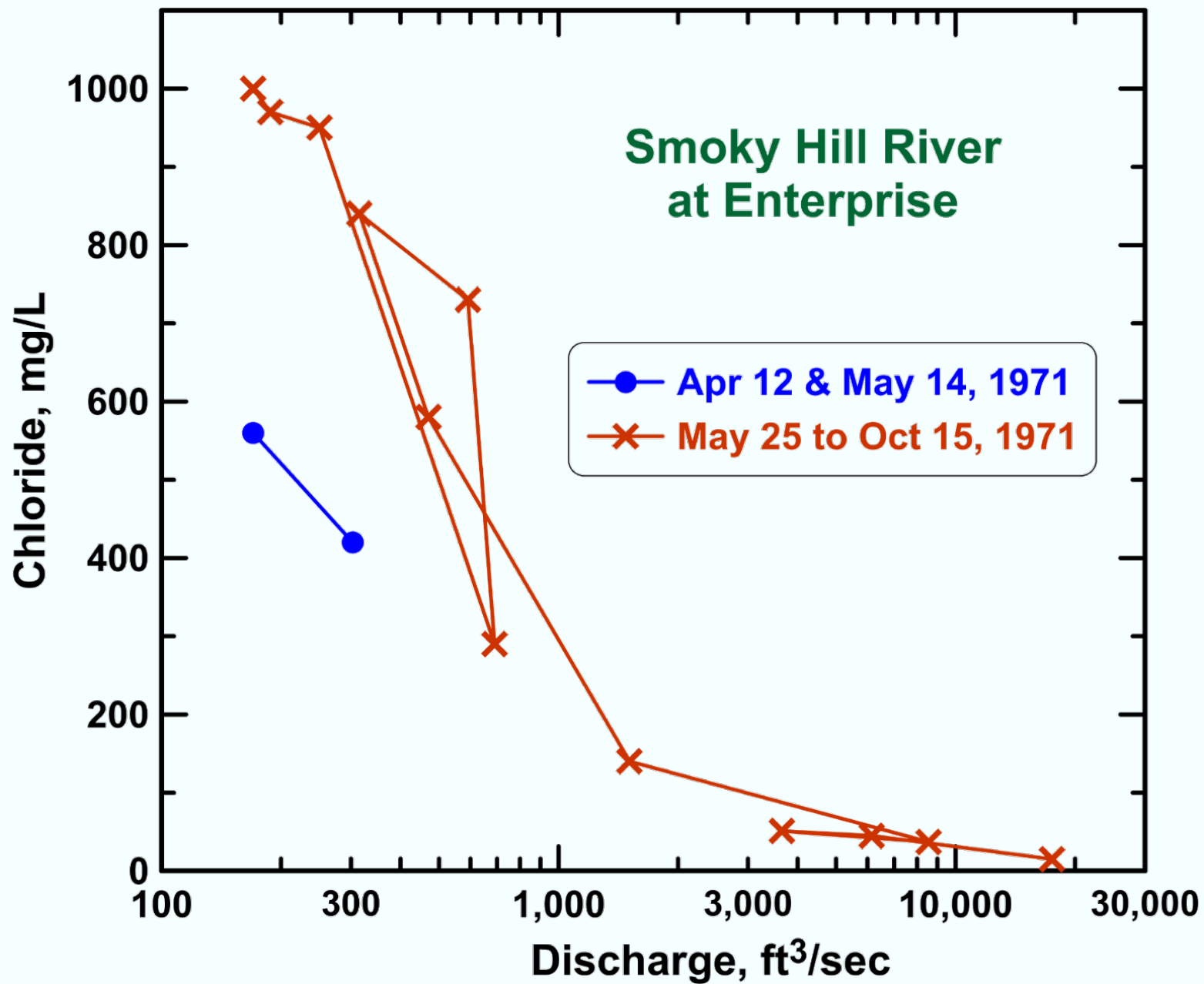


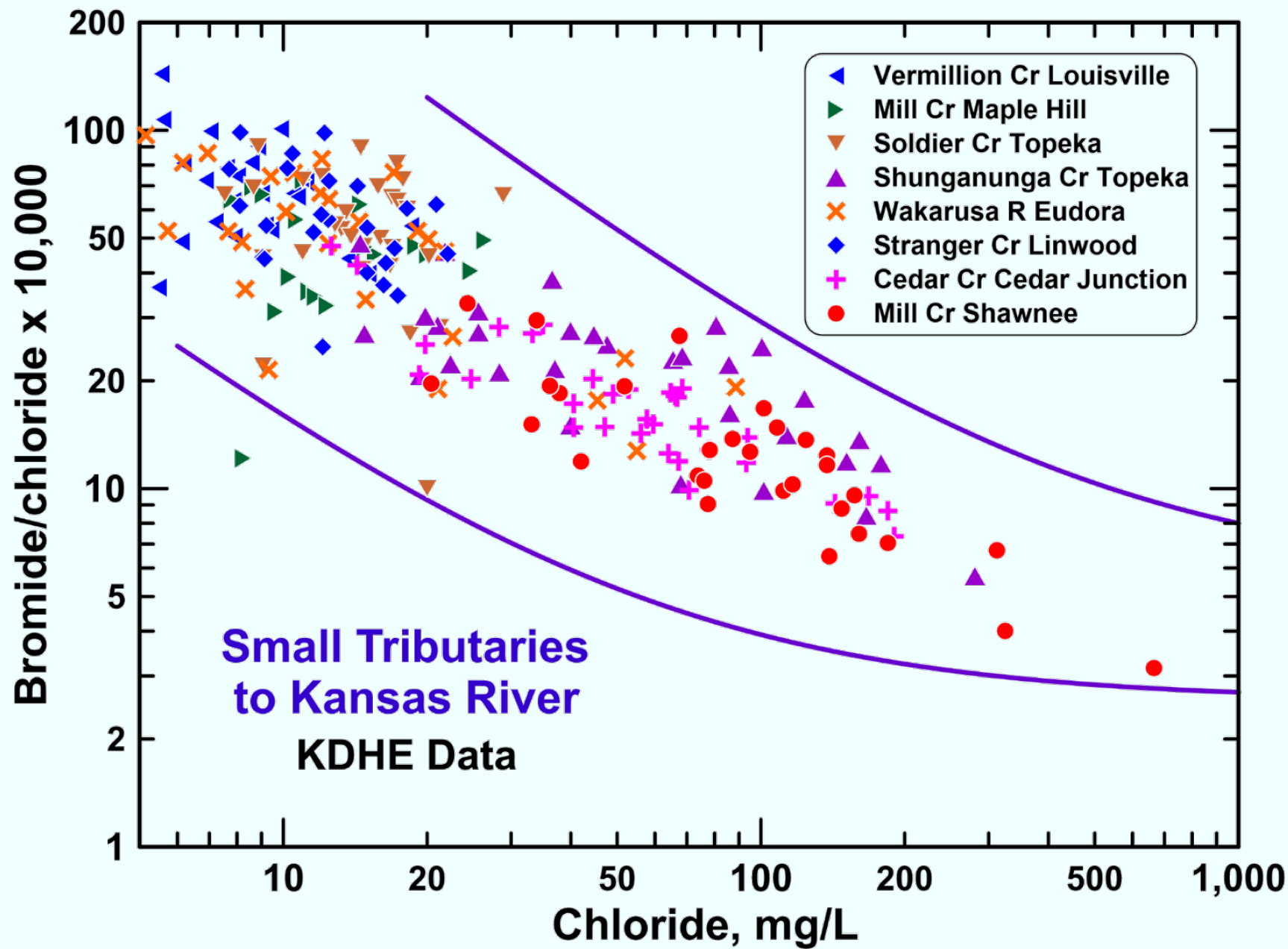


GAINING STREAM

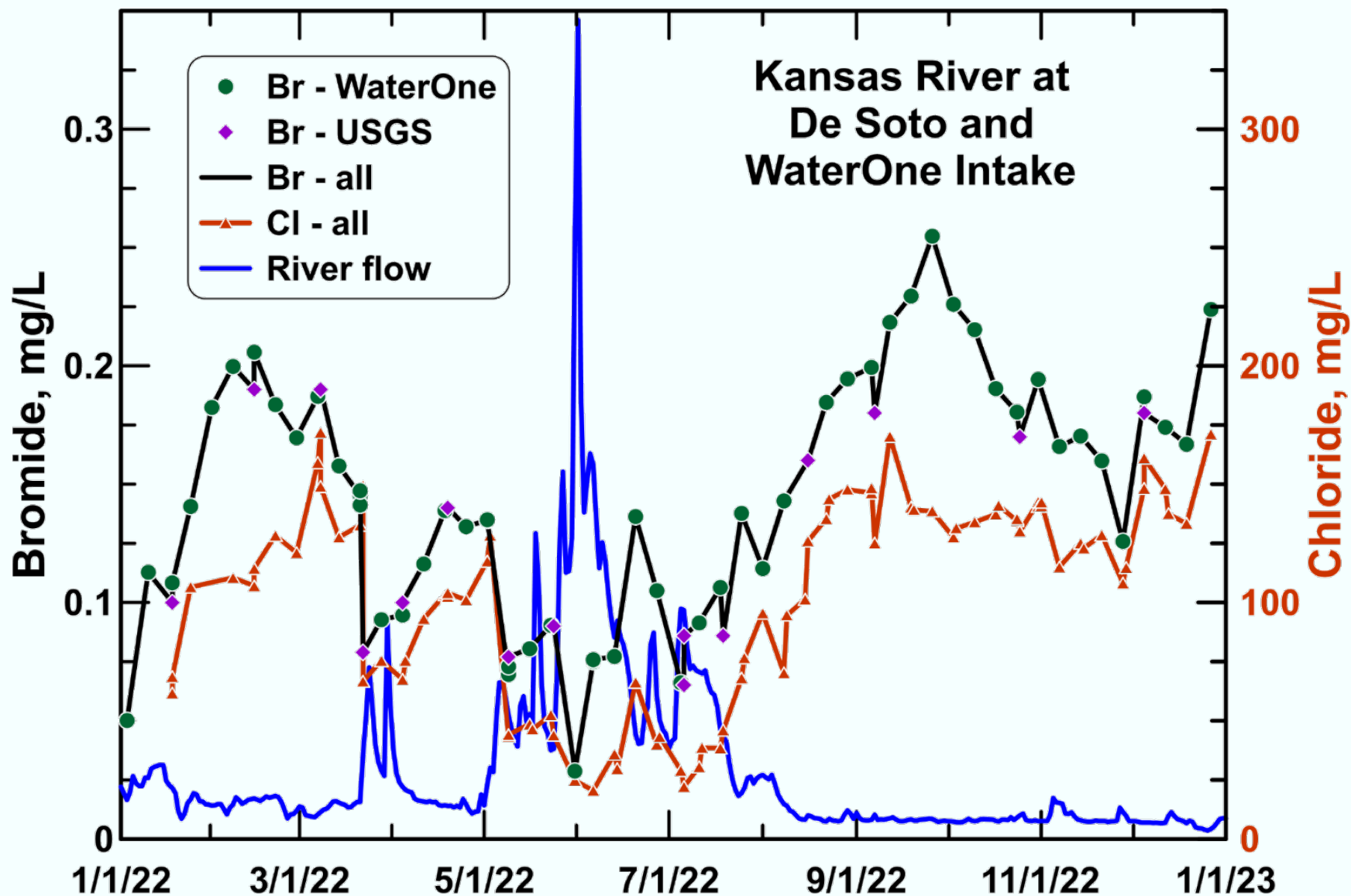


From U.S. Geological Survey, Circular 1139, 1998

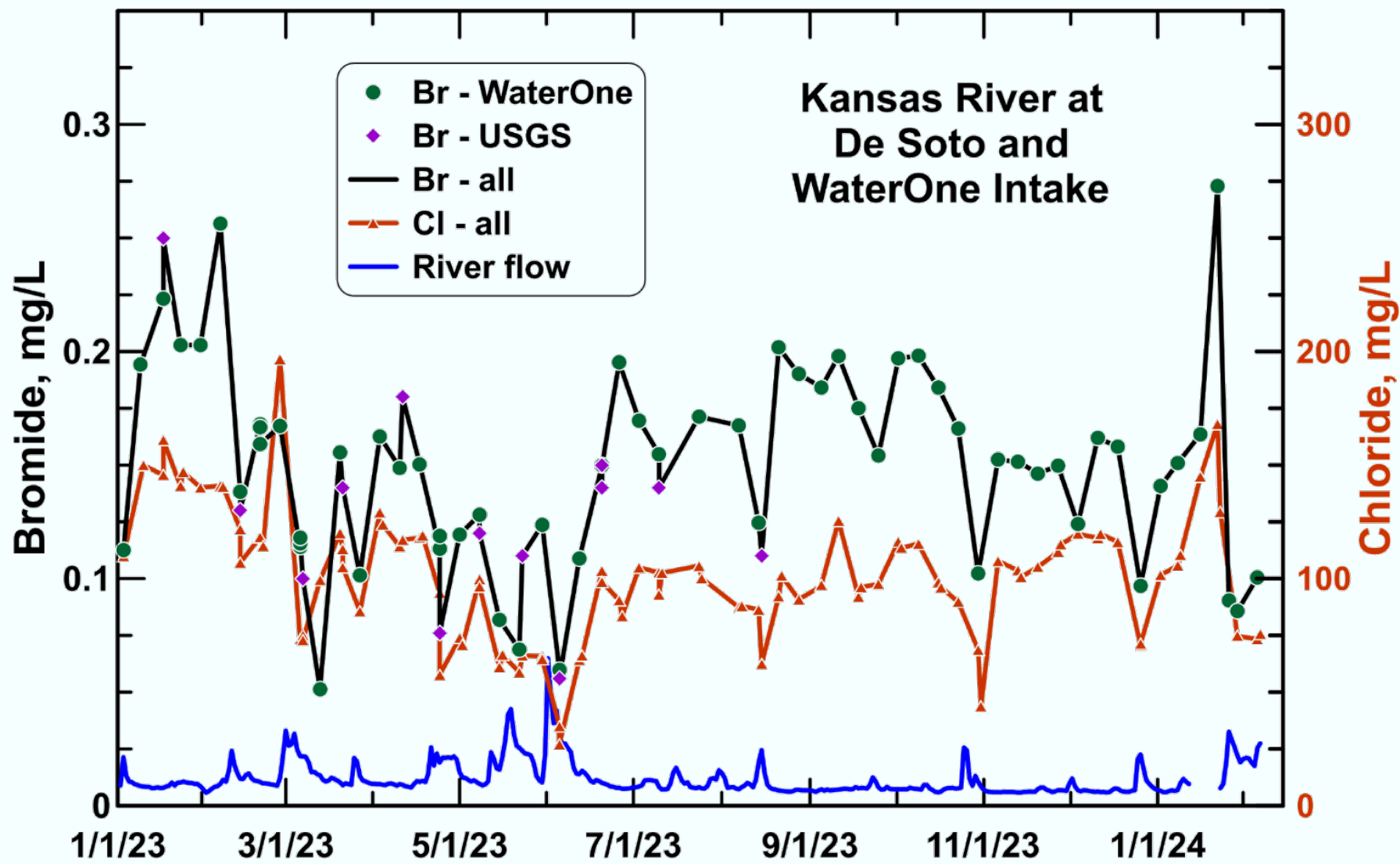




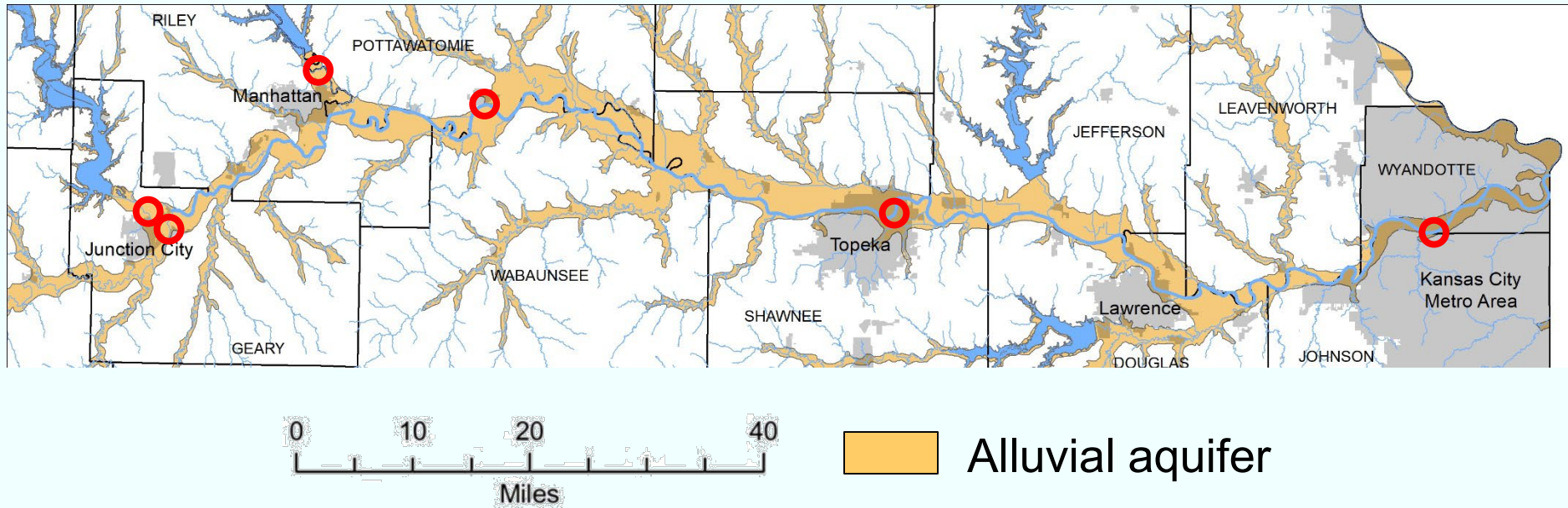
Bromide, Chloride, and Discharge in Kansas River 2022



Bromide, Chloride, and Discharge in Kansas River 2023-2024



RIVER WATER SAMPLING SITES



**Smoky Hill River near Junction City and Kansas River at Wamego
December 2, and Kansas River near Lake Quivira December 6, 2021**

**Republican River near Junction City, Big Blue River near Manhattan,
and Kansas River at Wamego March 3, and Kansas River at Topeka
and near Lake Quivira March 7, 2022**

BROMIDE LOAD CONTRIBUTIONS TO KANSAS RIVER

December 2-6, 2021

River	Br mg/L	Flow ft ³ /sec	Br load g/sec	Load % of KS R. nr Lake Quivira
Smoky Hill River at Junction City	0.292	422	3.50	56.3
Republican & Big Blue rivers + (Wamego minus Junction City load)				(16.9)
Kansas River at Wamego	0.178	902	4.55	73.2
Kansas River nr Lake Quivira (Lake Quivira minus Wamego load)	0.160	1370	6.21	(26.8)

March 3-7, 2022

River	Br mg/L	Flow ft ³ /sec	Br load g/sec	Load % of KS R. nr Lake Quivira
Smoky Hill River + (Wamego minus Republican and Big Blue rivers)				(47.1)
Republican River nr Junction City	0.116	87.8	0.29	3.0
Big Blue River nr Manhattan	0.081	416	0.96	10.0
Kansas R at Wamego	0.188	1080	5.76	60.1
Kansas River at Topeka	0.193	1565	8.57	89.4
Kansas R. nr L. Quivira (load diff.)	0.187	1810	9.58	(10.6)

MANAGEMENT OF BROMIDE ISSUE

- **Mix Kansas River water with other water sources**
WaterOne mixes with Missouri River water
- **Predict conditions with higher bromide concentration**
Determine flow mixtures from tributaries to Kansas River using bromide load variations in different watersheds, river flow, and flow travel time
Determine special conditions such as ice formation
Use monitored specific conductance and conductance-bromide relationship at upstream USGS gaging stations and chemical travel time in river from USGS studies
- **Control of contamination with high bromide input to rivers and tributaries**

CONCLUSIONS

- Major bromide sources in rivers in Kansas are from natural saltwater intrusion, oil-field brine, deicing and water-softener salt (and other wastewater sources?).
- Estimated contributions to bromide loads in the Kansas River near Lake Quivira during low flow:
 - Smoky Hill River watershed ~50%
 - Republican and Big Blue rivers combined ~10-16%
 - Small tributaries to Kansas River ~25-40%
- Management of bromide in the Kansas River could be difficult (control of bromide contamination sources).
- High bromide concentration in the Kansas River could be predicted from upstream monitored specific conductance and chemical travel time in river, and special conditions such as ice formation.

QUESTIONS ?

