American Water Works Association

SUSTAINABLE
Water Management Conference

2018

Developing an Early Warning System for Taste and Odor Episodes on the Missouri River

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2014 Taste & Odor Event

Missouri River Changes May Affect Water Taste & Odor, Water Safety & Quality Not Affected

Recent Snowmelt May Temporarily Alter Water Taste & Odor This Week

(Kansas City, MO)—Kansas City Water Services advises customers that recent warm temperatures and upriver precipitation have changed the characteristics of the Missouri River, which may affect the taste and odor of tap water. These changes are natural and routine occurrences which occur when rain and snow melt increase the amount of clay and silts carried by the Missouri River, the source of Kansas City's drinking water. Other cities located along the Missouri river are also experiencing the same temporary issue.

KCWATER SERVICES

Media Advisory
February 27, 2014

ST. LOUIS POST-DISPATCH March 5, 2014

St. Louis water develops foul taste and smell

ST. LOUIS • The Missouri River is to blame for St. Louis' foul smelling water, officials say.

Curt Skouby, the city's water commissioner, said the odor and taste difference should be gone within a few days. Still, he said, the water is absolutely safe to drink.

Weather has played a role in the changing water throughout the Midwest. Upriver snowmelt and changing temperatures, as well as naturally occurring material in the river, is to blame, officials said.

WRF #4683
Sources and Fate of Taste-and-Odor Causing Compounds in the Missouri River

A Tailored Collaboration Project with:

- St. Louis Department of Public Utilities
- Missouri American Water
- City of Kansas City, MO – Water Services
- Water District #1 of Johnson County, Kansas

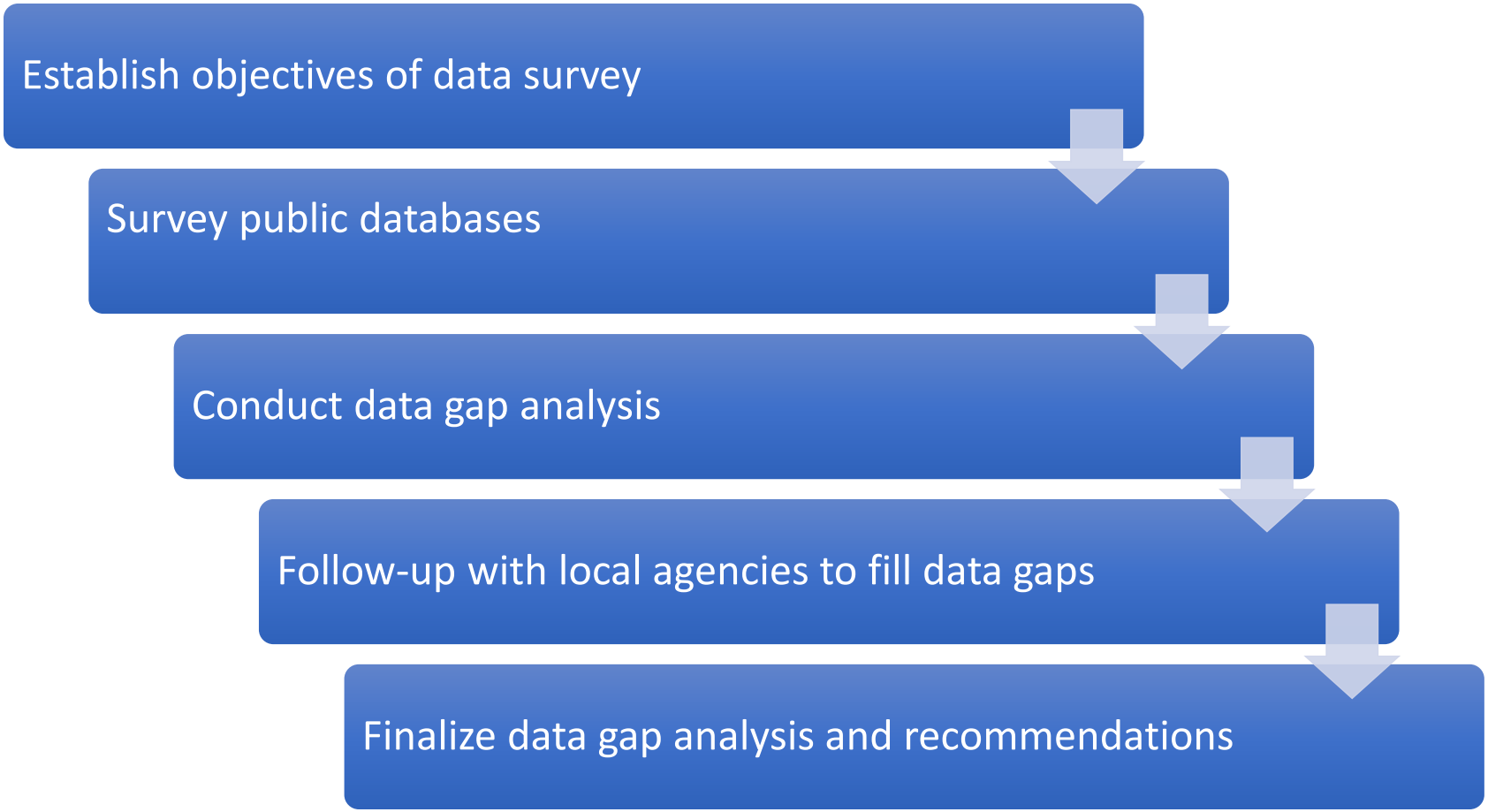
Project Objectives

- Based on the 2014 event, assess the Lower Missouri River watershed for biological and chemical sources of T&O compounds
- Develop the foundation for an early warning monitoring and response program for T&O events in the Lower Missouri River.
  - Predicting/identifying onset of T&O events
  - Analyze fate and transport of the T&O compounds
  - Communication, control and management
- Treatability study
- Investigate remote sensing for T&O identification

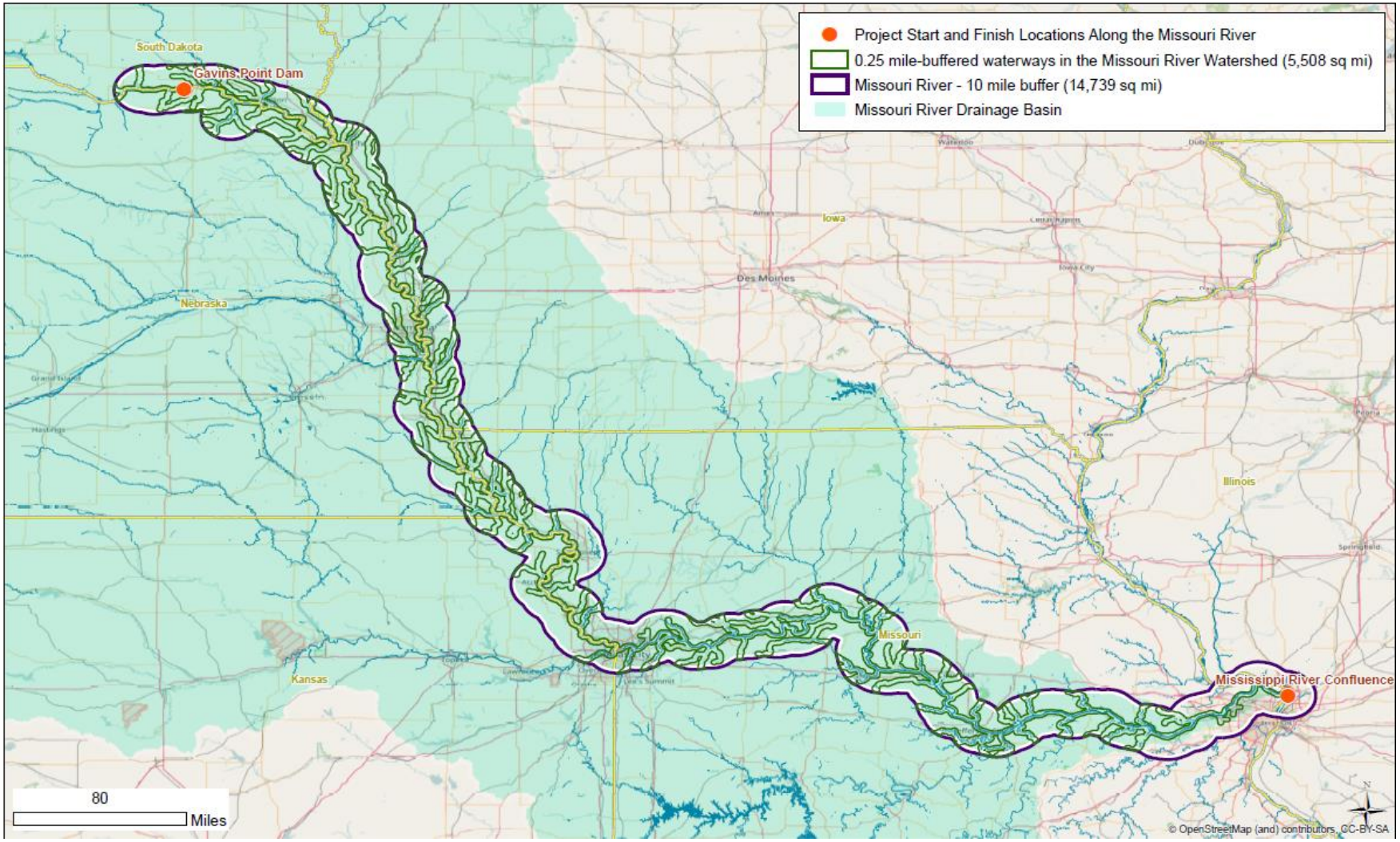
Research Approach

- Review available information and identify data gaps
- Develop recommendations for an early warning system (EWS) to help predict algal blooms and manage T&O events
  - Use hydrologic and flow models as EWS tools
- Treatability study
  - Understand effectiveness of powdered activated carbon (PAC) and ozone in treatment of T&O compounds present in Missouri River water
- Use remote sensing (satellite) data to predict T&O events

Survey of Existing Databases and Data Gap Analysis

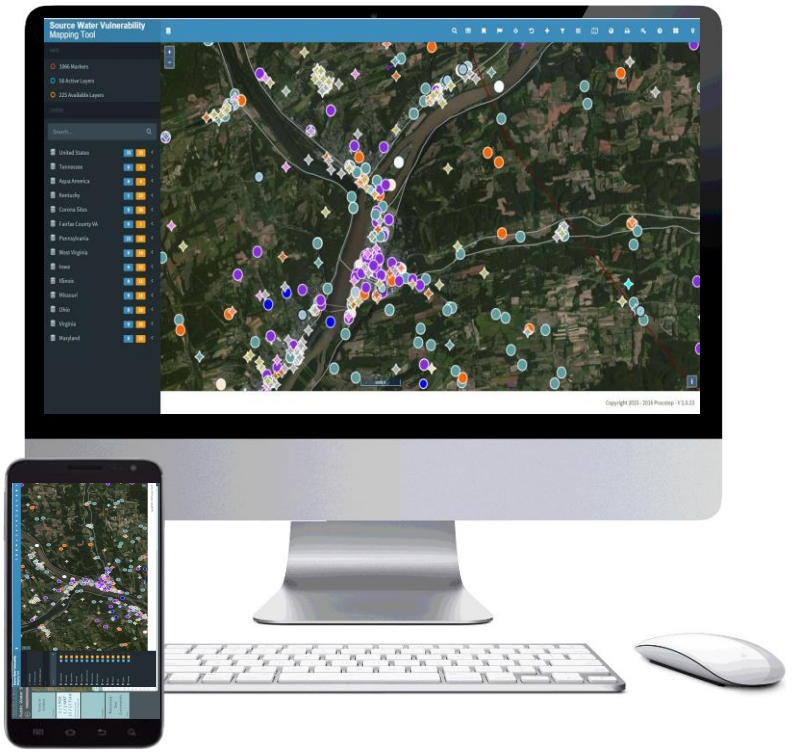


Project Area: Data Review



Data Integration

- Nutrient point/non-point source
- Monitoring
- Land cover & agriculture
- USGS gages
- TMDLs
- Stream network
- Others

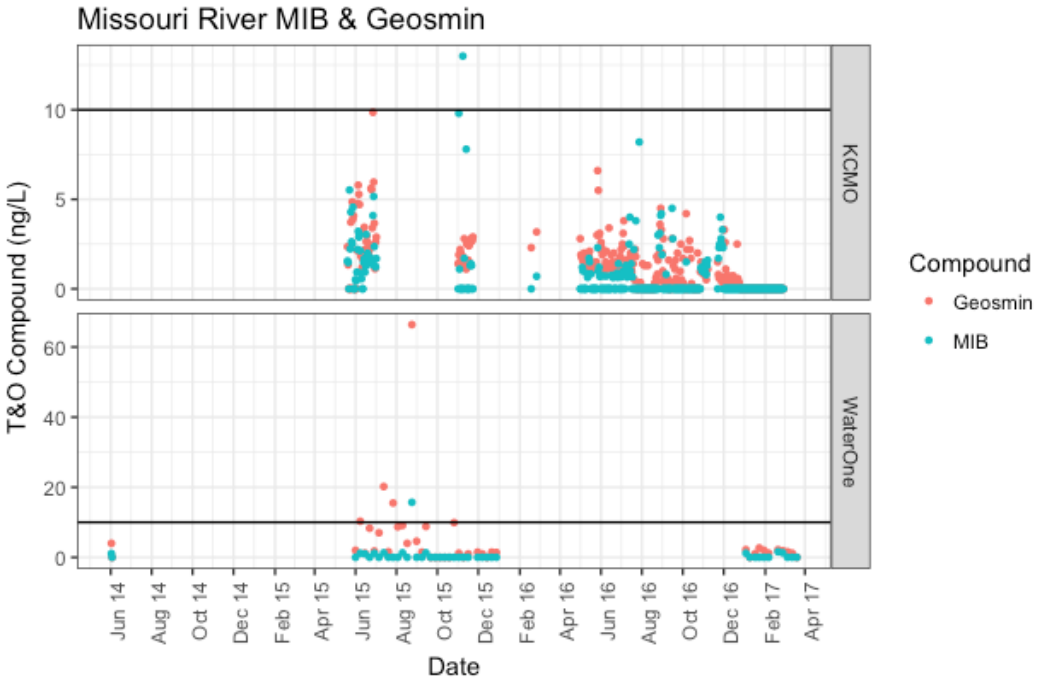


Data from Participating Utilities

	St. Louis	MO AW - North & Central	MO AW - Jefferson City	KCMO	WaterOne
WTP(s)	Howard Bend Chain of Rocks	North & Central	Jefferson City	Kansas City Water Works	Hansen & Wolcott
Source(s)	Missouri R. & Mississippi R.	Missouri R.	Missouri R.	Missouri R. & alluvial wells	Missouri R., Kansas R. & alluvial wells
T&O events/year	1 (FW)	5-6	5-6	3-4	1 (FW)
Log T&O Events	**No**	**No**	**No**	**No**	**No**
Routine T&O Compounds	**No**	**No**	**No**	MIB & Geosmin	MIB & Geosmin
Sensory Analysis	T&O panel & operator assessment	TON & blind test	Blind test & operator assessment	TON & taste assessment (FW)	TON + descriptors
Customer Calls	Yes	Yes	Yes	Yes	Yes
Other T&O Indicators	**No**	**No**	**No**	Algae, UV254	CHL & PC (KS only)
T&O Treatment	PAC	PAC	PAC	PAC & Permanganate	PAC & Permanganate
Defined T&O WQ Goals	No	No	No	In progress (≤ 8 ng/L for MIB or GEOS)	<5 ng/L (FW) & <10 ng/L (SW) for MIB or GEOS

MIB & Geosmin

- Available data indicate that MIB and Geosmin generally low.
- One period of higher results in summer 2015

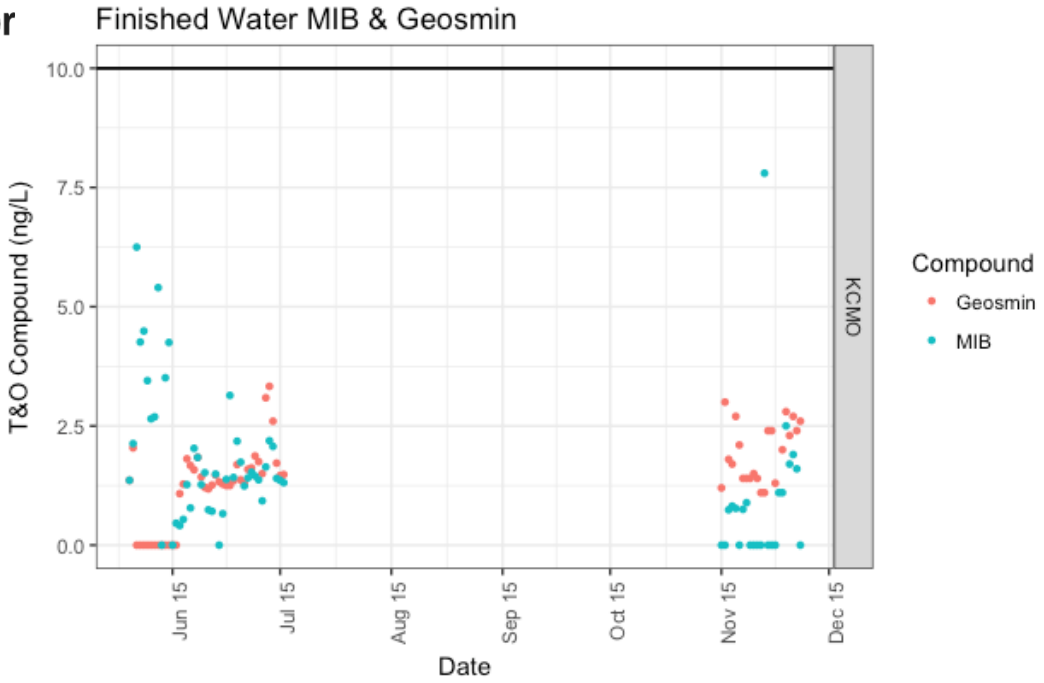


Record snowmelt may change tap water taste & odor

POSTED 5:17 PM, FEBRUARY 26, 2014, BY CHRIS SMITH, *UPDATED AT 05:15PM, FEBRUARY 26, 2014*

February 26, 2014

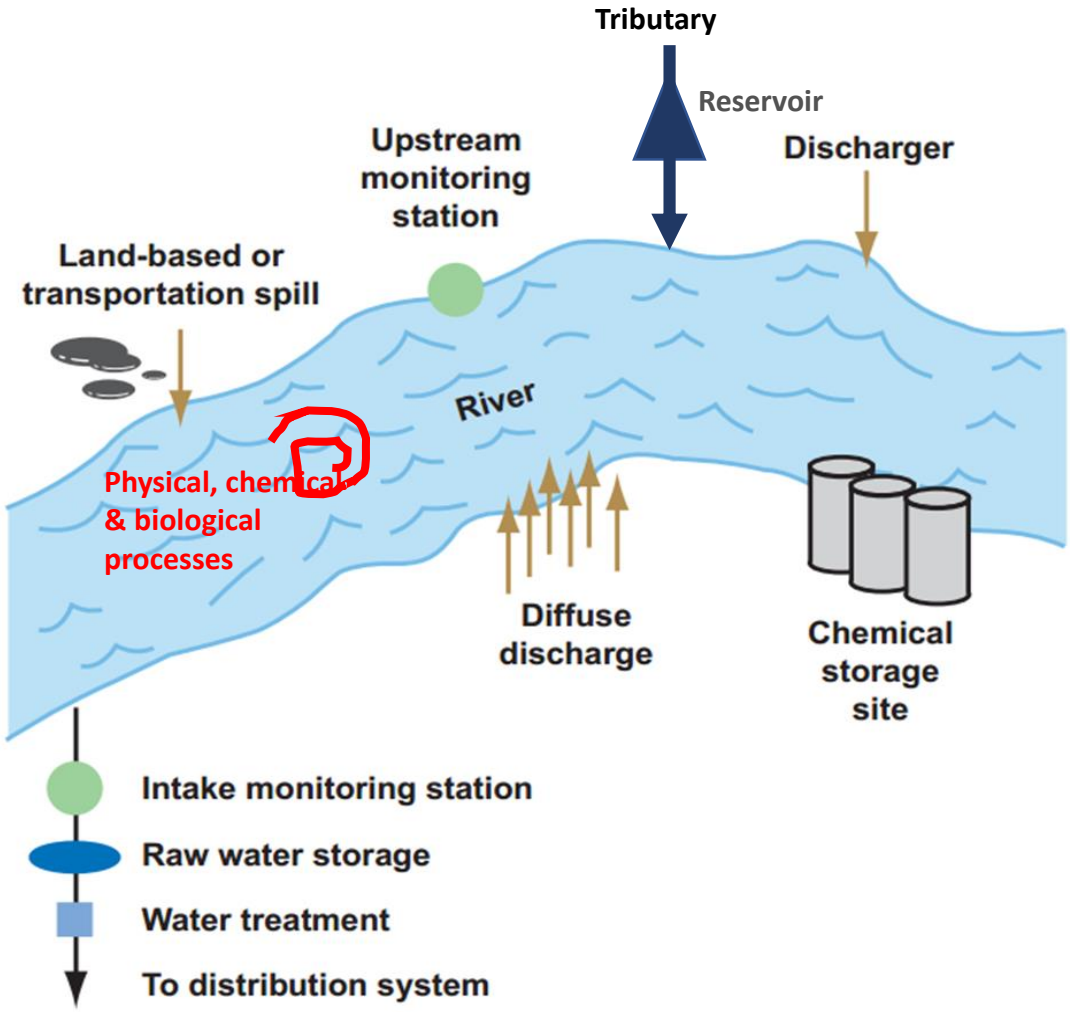
Location	Date	Sample Type	Compound	Result (ng/L)
Central Plant	2/26/14	EFF	2,3,6-Trichloroanisole	ND
Central Plant	2/26/14	EFF	2-Isopropyl-3-methoxypyrazine	ND
Central Plant	2/26/14	EFF	2-Methylisoborneol	ND
Central Plant	2/26/14	EFF	Geosmin	4
Central Plant	2/26/14	RAW	2,3,6-Trichloroanisole	ND
Central Plant	2/26/14	RAW	2-Isopropyl-3-methoxypyrazine	ND
Central Plant	2/26/14	RAW	2-Methylisoborneol	ND
Central Plant	2/26/14	RAW	Geosmin	6



Early Warning System (EWS)

Goal: Reliably and quickly detect and characterize low-probability, high impact contamination events in source water in time to allow an effective local response.

Early Warning System (EWS) Elements



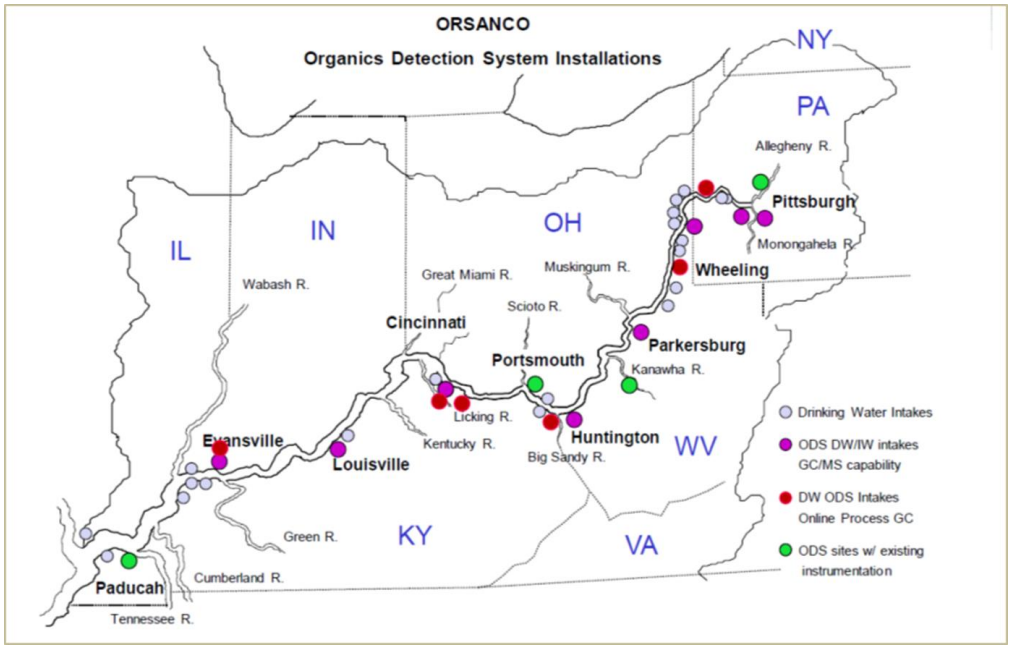
Components of an EWS

- Mechanism for detecting contaminants (monitors, observations)
- Means of characterizing the event (models, sensors, lab analysis)
- Institutional framework for managing the event
- Communication linkages
- Response mechanisms to mitigate impacts

Existing Early Warning Systems

- Example systems
  - ORSANCO (Ohio River)
  - Rhine River (Germany & Netherlands)
  - Metropolitan Water District (Southern California)
  - Central Arizona
- Characteristics
  - Most developed after a major event
  - Utilize permanent dedicated monitors
  - Significant capital and operating costs
  - Centralized coordination & communication
  - Sophisticated river models

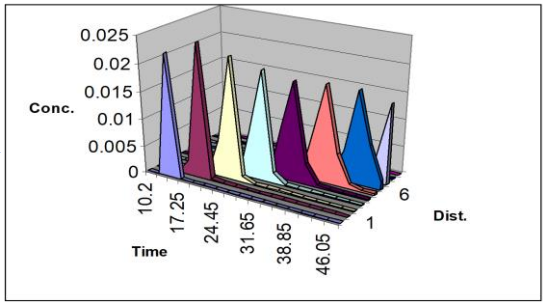
ORSANCO EWS

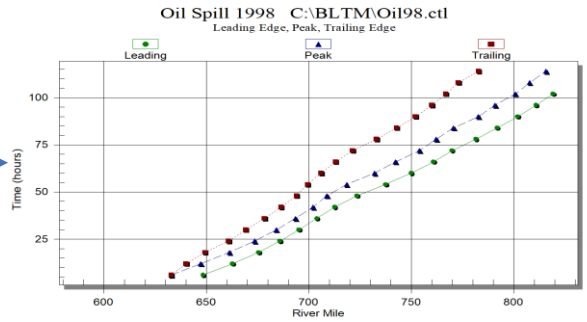


ORSANCO provides coordination & communication linkages

5-day river flow and stage forecasts prepared daily by Corps of Engineers using CASCADE model

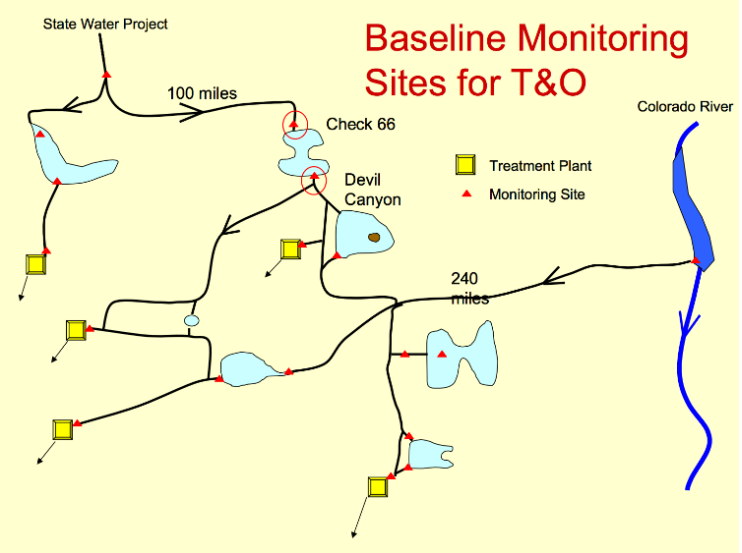
When an event occurs, run BLTM water quality model pre-prepared for Ohio River mainstem.



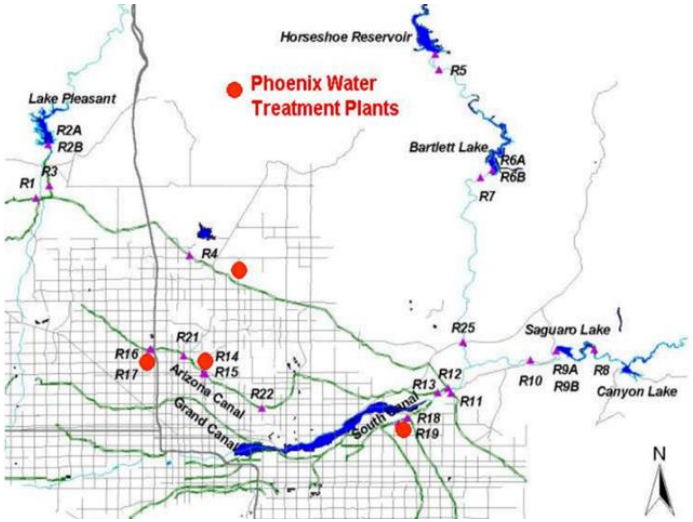


T&O Oriented Early Warning

- Metropolitan Water District
  - Analysis of MIB & Geosmin
  - Early warning monitoring
  - Integrated management approach



- Salt River Project, Central Arizona Project, Phoenix
  - Algae-related issues & effects on drinking water supplies, treatment, and distribution.



Example Existing Early Warning Systems

Name	Location	Institution type	Characteristics
ORSANCO	Ohio River Basin	Interstate Commission	Organic detection system started in 1977. Well funded and staffed organization.
RAIN River Alert Information Network	Western PA & Northern WV	Association	Voluntary organization founded in 2009. Monitoring and early warning. One paid staff member.
EWOCDS Early Warning Organic Compound Detection System	Louisiana Lower Mississippi River	State	Monitoring & modeling. Established in 1986 by State. Recent infusion of State funding.
WV AW	West Virginia	Utility	Monitoring, data management, event detection at 8 treatment plants
Huron to Erie Corridor	Michigan	Local government	Founded in 2006 as partnership. Now funded by State & run by SEMCOG.

EWS Institutional Issues

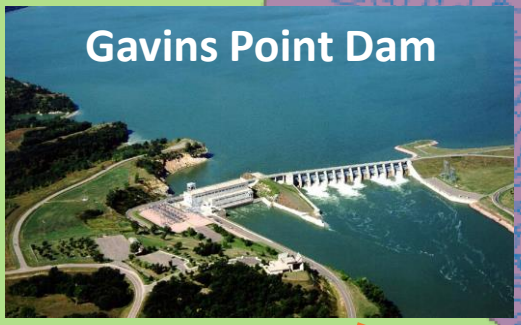
- Legal and administrative structure for the organization
- Resource needs and funding sources
- Responsibilities of participants in the operation of the organization
  - Staffing
  - Employees
  - In-kind contributions
- Representation of stakeholders
- Communication
  - among members
  - with public
  - with governmental agencies

EWS Technical Issues

- Design of monitoring network
  - Use of existing monitors
  - Selection and siting of new monitors
  - What parameters to monitor
- Selection and use of model
- Responsibilities of participants in the operation of the organization
- Communication mechanisms

Proposed EWS for Missouri River

- Smart, low cost, efficient system
- Elements
  - Organization of utilities
  - Minimal staff – rely primarily on in-kind services by utilities
  - Initially rely mostly upon existing monitors
  - Better analysis and record keeping during T&O events
  - Utilize ICWater model for tracking/predicting event
  - More formalized communication among utilities
  - Address both T&O events and other contamination events
  - Coordination with COE, USGS, NOAA, EPA, States, etc.



Minnesota

Nebraska

Kansas

Missouri

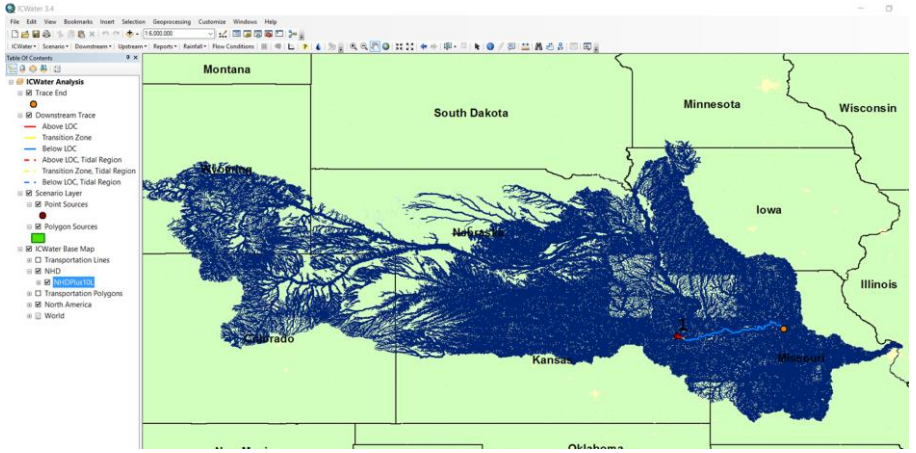
Legend

- Particpating Utility Intakes
- Upstream Utilities
- USGS Gauges

WQ Monitoring Stations

- EPA-R7
- MO DNR
- SD DENR
- USGS-IA
- USGS-MO
- USGS-NE
- USGS-SD

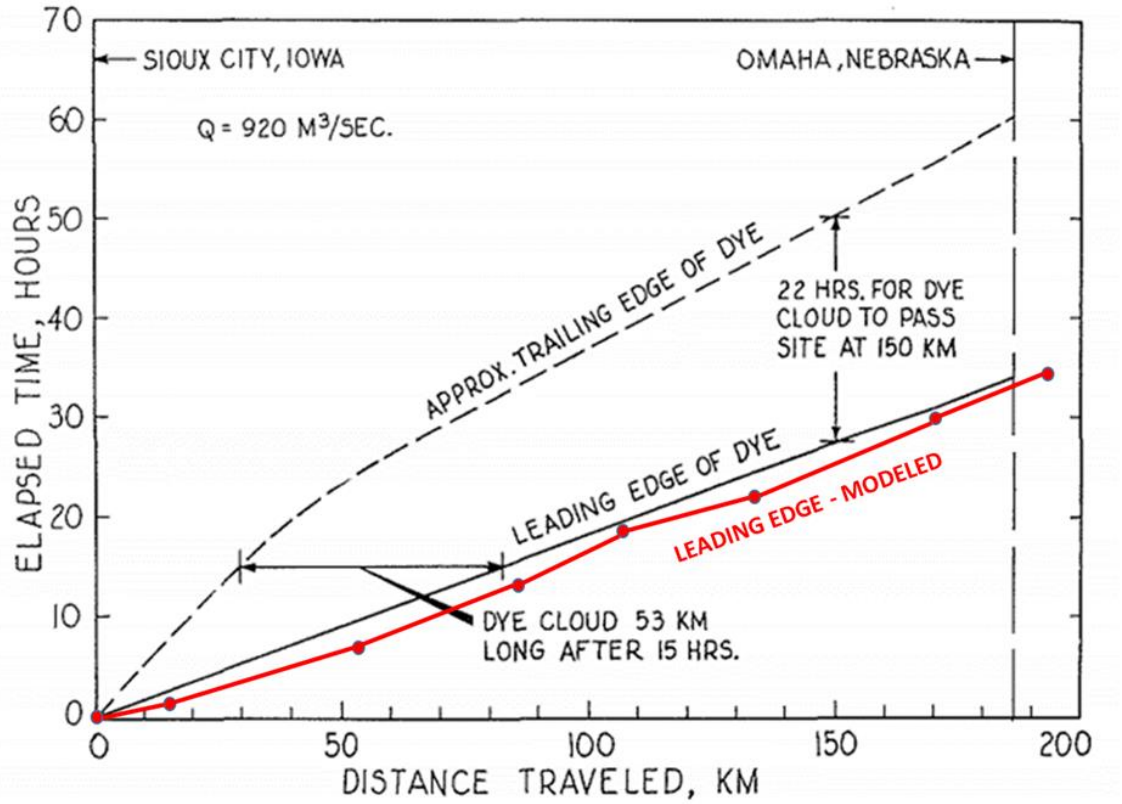
Hydraulic/Water Quality Model



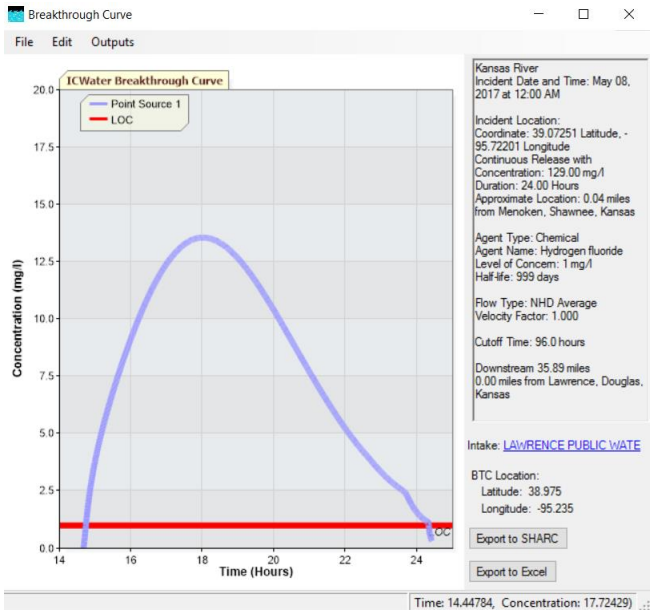
- Existing models surveyed. ICWater selected.
- GIS based tool using National Hydrographic Dataset and flow/velocity data for > 3 million reaches in US
- Distributed by Defense Threat Reduction Agency
- Can be applied with minimal setup and calibration
- Tool for near real-time prediction of contamination spills
- Available at no cost to governmental entities
- Requires basic ArcGIS software ($1500)

Model Calibration

- Needed to adjust model parameters and develop confidence in model
- Very limited data available on Missouri River
- Good match with dye study on 190 km stretch of river
- Additional future calibration is desirable



Model Outputs: Downstream analysis



Contaminant release point

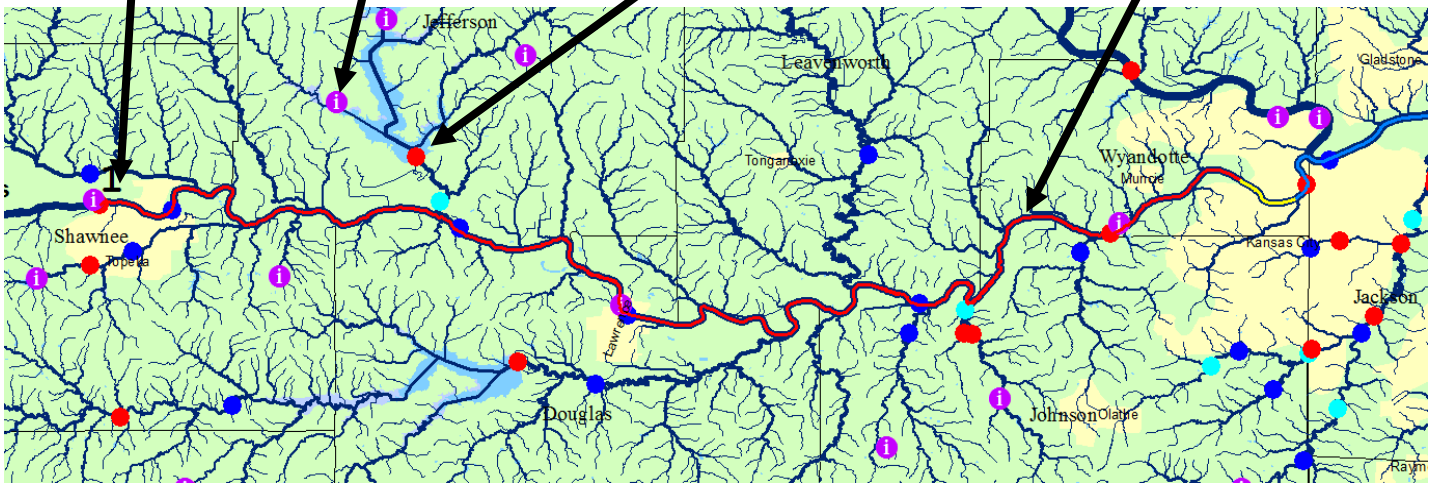
Public water supply intakes

Real-time flow

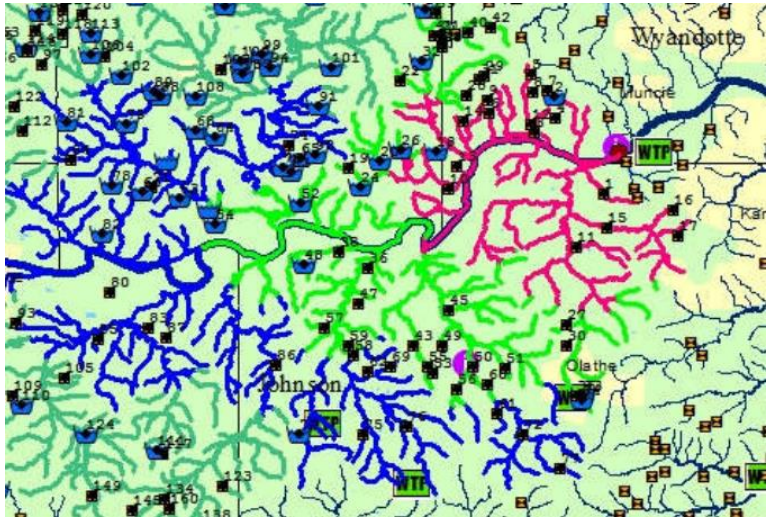
- More than 50% below normal
- 0% to 50% below normal
- 0% to 50% above normal
- More than 50% above normal

Downstream trace

- Above LOC
- Transition Zone
- Below LOC



Upstream Analysis



Dams: National Inventory of Dams

- Flood Control
- Other

Upstream Trace

- 0 to 12.5 miles
- 12.5 to 25 miles
- 25 to 37.5 miles
- 37.5 to 50 miles

Incident Description

Incident Date and Time: June 24, 2017 at 12:00 AM

Incident Location:
Coordinate: 39.05060 Latitude, -94.77961 Longitude

Upstream Trace by Distance
Distance Criteria: 50.0 miles
Number of Intervals: 4

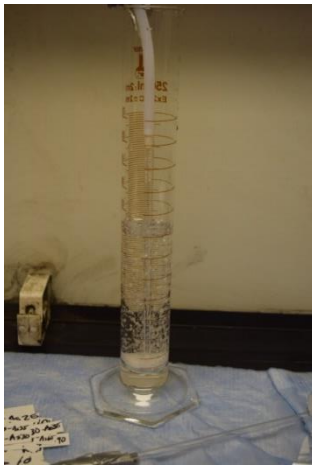
National Inventory of Dams

Index	Name	City	State	Zone	Distance (mi)
1	DEFFENBAUGH INDUSTRIES, INC., HARMON DAM	JOHNSON	KS	0 to 12.5 miles	1.89
2	WALLACE, M.F.	WYANDOTTE	KS	0 to 12.5 miles	3.58
3	LAKE OF THE FOREST INC, DAM NO 1	WYANDOTTE	KS	0 to 12.5 miles	4.38
4	OLSON, D.W.	WYANDOTTE	KS	0 to 12.5 miles	4.70
5	KSNONAME 2993	WYANDOTTE	KS	0 to 12.5 miles	5.25

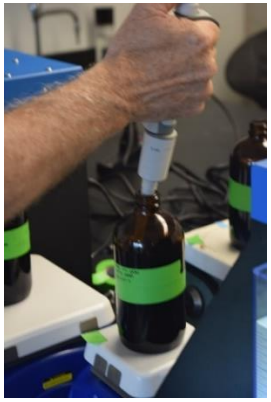
Treatability Study

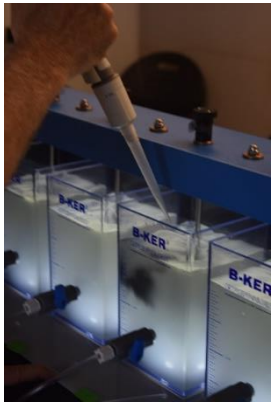
Missouri River Intake

Ozone



PAC Jar Tests





Treatability Study Discovery

- Fate of some potentially important (non-MIB/geosmin) T&O compounds during water treatment is impacted by mechanisms that need to be better understood
    - Affects attempts by utilities to **identify** compounds responsible for T&O events
    - Affects approach by utilities to **control** T&O
    - Affects **analytical approach** to T&O for emerging T&O compounds
    - Points to need to conduct **mechanistic study** of emerging T&O compounds

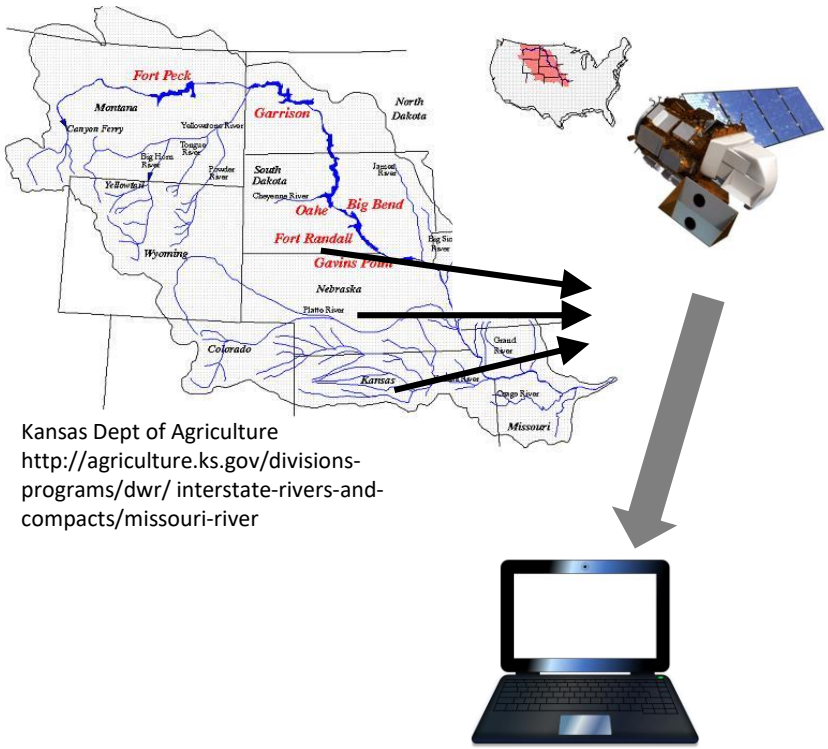
Emerging T&O Compounds

- β-Ionone
- Indole
- Cyclocitral
- Hexanal
- Trans-2-cis-6 nonadienal
- 2,4-Heptadienal

Treatability Study Outcomes

- **Utilities did not successfully respond to a T&O event in 2014 :**
  - no cause identified → increased customers' complaints
  - Common treatment technologies were not effective → increased O&M and customers' complaints
- **Hence, guidance and SOPs are needed!**
- Mechanistic and treatability research provides information to develop guidance; it is not the end unto itself
- The objective here is to:
  - Develop actionable guidance recommendations for utilities for control of T&O
  - Formulate research needs to assist utilities with more comprehensive guidance

Remote Sensing and the T&O EWS



Kansas Dept of Agriculture
http://agriculture.ks.gov/divisions-programs/dwr/ interstate-rivers-and-compacts/missouri-river

- Remote sensing algorithm
  - Intensive sample collection and remote sensing algorithm development
  - Landsat 8 Band 5 reflectance data being used to develop correlations
  - Principle components and partial least squares regression to relate reflectance in all bands to water quality data

Lessons Learned Thus Far

1. Currently, utilities along the Missouri River have very limited information, and do not have any early warning related to T&O events
   - Cause for 2014 event unknown
2. MIB and Geosmin likely not the only significant compounds associated with T&O episodes in the Lower Missouri River
3. Emerging T&O have unique properties that need be better understood
   - Treatability of these compounds with PAC and ozone are dependent on their properties
4. A smart, low cost, efficient early warning system will be proposed for the utilities along the Missouri River
   - Will require regional collaboration/participation from external agencies
5. If successful in the Missouri River basin, T&O early warning systems have great potential for application at other large river and lake watersheds

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