



WELCOME
TO THE JANUARY EDITION
OF THE 2018 M&R SEMINAR SERIES

BEFORE WE BEGIN

- **SAFETY PRECAUTIONS**
 - PLEASE FOLLOW EXIT SIGN IN CASE OF EMERGENCY EVALUATION
 - AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE
- **PLEASE SILENCE CELL PHONES OR SMART PHONES**
- **QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION**
- **PLEASE FILL EVALUATION FORM**
- **SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE** (www.MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2018 Seminar Series)
- **STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE** (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)

William A. Battaglin

Bill Battaglin is currently a Research Hydrologist for the U. S. Geological Survey in Lakewood, Colorado.

Bill received a B.A. in Geology from the University of Colorado, Boulder, in 1984, and a M. E. in Geological Engineering, from the Colorado School of Mines, in 1992. He has work with various offices of the USGS since 1982. He has helped design and conduct numerous studies investigating the occurrence of pesticides and other contaminants in streams, reservoirs, groundwater, rain, and the air. He is currently working on investigations of the occurrence of contaminants of emerging concern in National Parks, the effects of pesticides on amphibian populations in North America, and the potential effects of contaminant occurrence on the migration of invasive Asian Carp in the Illinois River.

Bill has been an active member of the American Water Resources Association (AWRA) since 1993, serving on several conference committees, the board of directors, State section President in 2009, and National President in 2012. Bill was a founding member of Consortium for Research and Education on Emerging Contaminants and is currently the Treasurer.

Bill enjoys hiking, skiing, camping, ultimate, golf and just about anything else that can be enjoyed outdoors.

Differences in Numbers, Concentrations, and Loads of Anthropogenic Bioactive Chemicals (ABCs) in the Illinois Waterway Upstream and Downstream of the Bigheaded Carp Population Front



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Presentation Outline

- Background on Science Questions and Bigheaded Carp stalled population front

- Sites and Methods

- Anthropogenic Bioactive Chemicals and Contaminant Mixtures

- Results by chemical class

- Results for specific chemicals

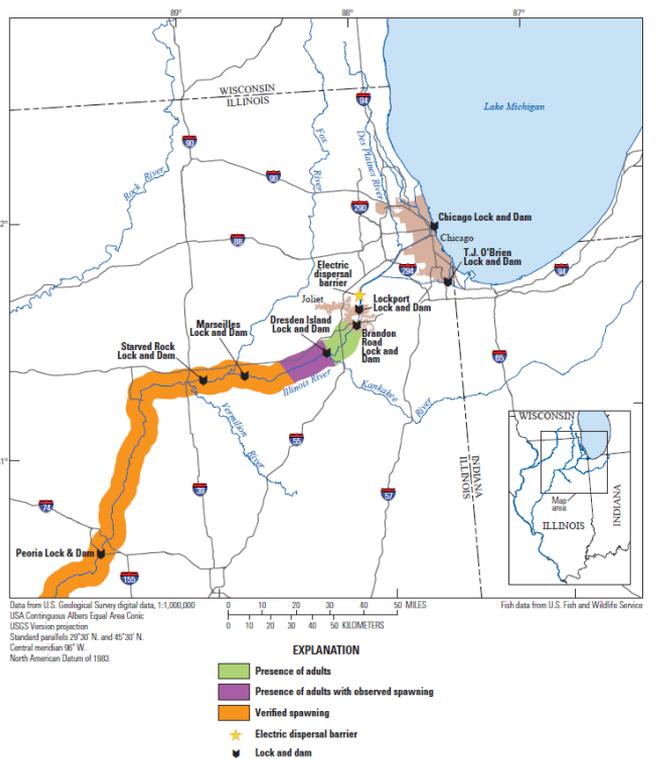
- Results of toxCast “EARs” analysis

This study is supported by the Great Lakes Restoration Initiative, the USGS Toxics Program, the USGS Chemical Mixtures project, and other sources.



Why Bigheaded Carp? Science Questions

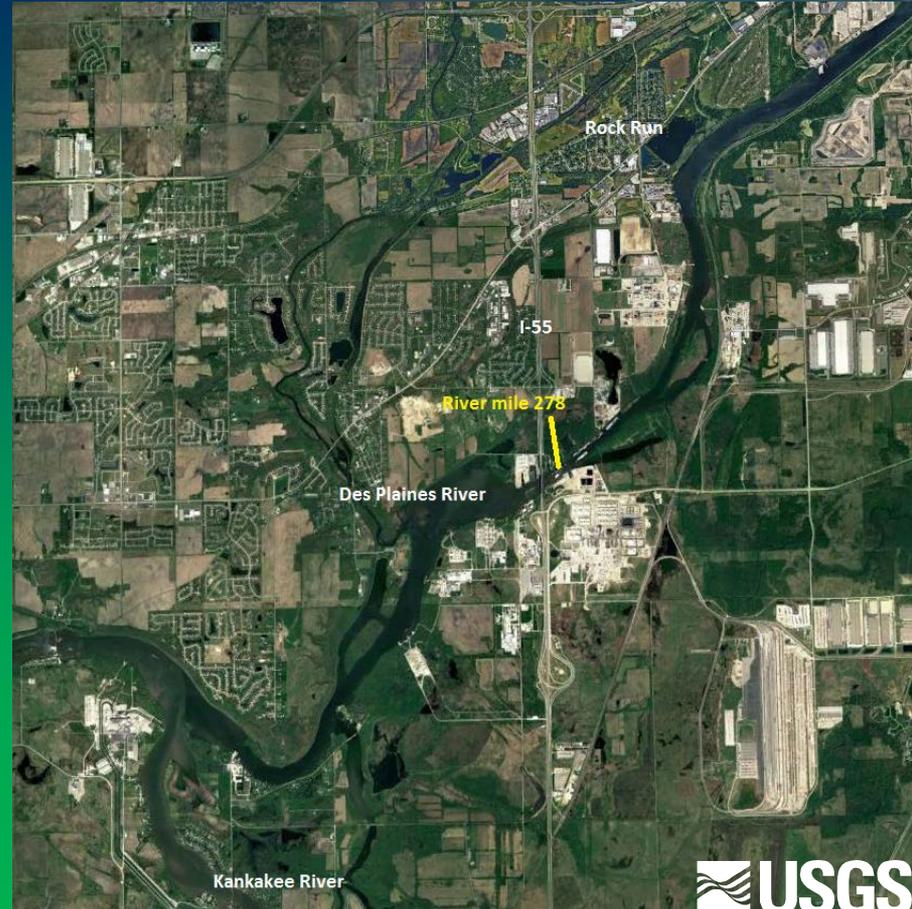
- 🔹 Invasive Bigheaded carp could have serious negative impacts to Great Lakes ecosystem/economy
- 🔹 Poor water quality may be contributing to the stalling of their upstream movement near **River Mile 278**
- 🔹 Is upstream movement limited by hormones, pharmaceuticals, or other contaminants?
- 🔹 What are the sources of contaminants?
- 🔹 Do contaminants persist, degrade or dilute?
- 🔹 What happens to specific chemicals?



Map showing status of carp in the Illinois Waterway

Bigheaded carp-stalled population front

- ❖ Invasive Bigheaded carp population front has been stalled in the general vicinity of RM 278 in the Dresden Island Pool since 2008 or earlier.
- ❖ This reach characterized by sharp changes in water chemistry.
- ❖ Can water chemistry be an environmental factor affecting fish physiology, spawning, behavior, or movement?



Study Methods – 1 Study Sites

Chicago Sanitary and Ship Canal at Lockport, IL – RM 291.1

Most upstream

Des Plaines River below Lock and Dam at Rockdale, IL – RM 285.9

Just upstream of RM 278

Kankakee River at Wilmington, IL

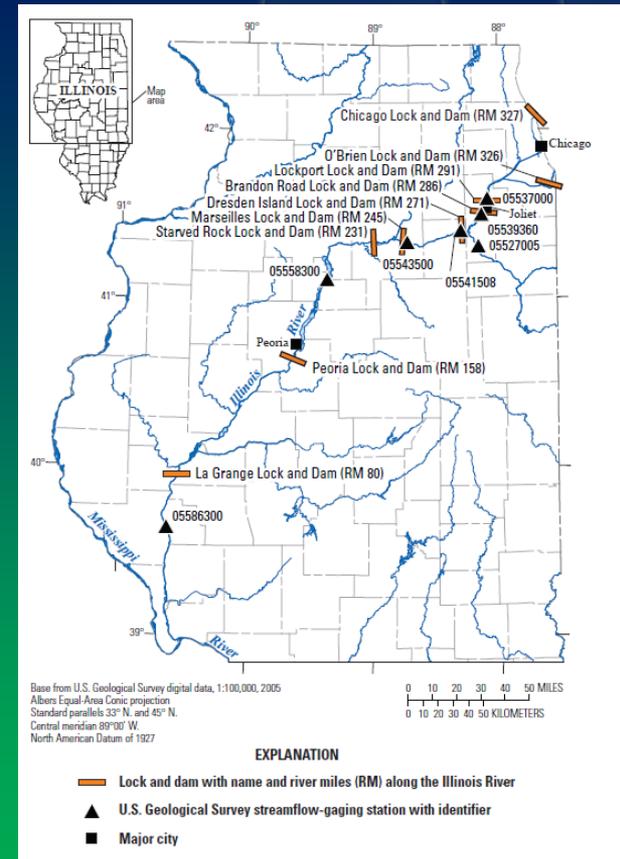
Tributary downstream of RM 278

Illinois River at Minooka, IL – RM 270

Illinois River at Marseilles, IL – RM 243

Illinois River at Henry, IL – RM 195.6

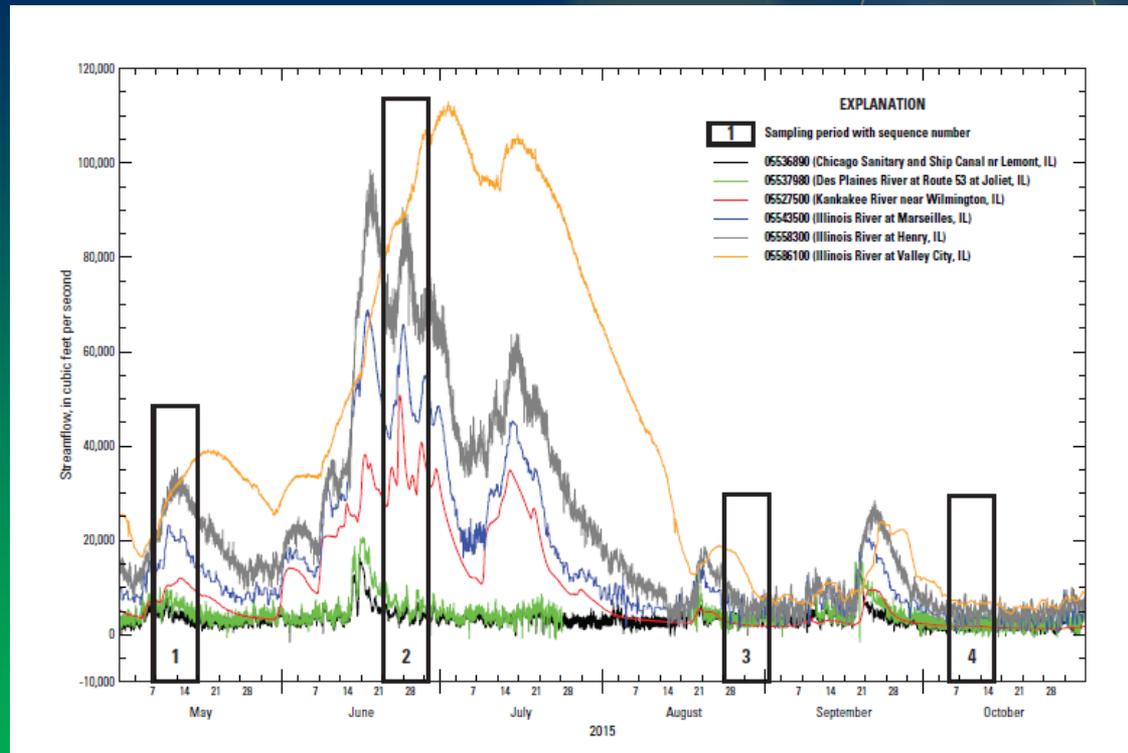
Illinois River at Florence, IL – RM 55.9



Map showing sampling locations and locks and dams

Study Methods – 2 Flow Conditions

- 4 sampling events
- Lagrangian sampling over 5-7 day period
- May, June, August, October
- Higher flows for first 2 events



Graph showing hydrographs from sampling sites and 4 sampling events

Study Methods – 3 Water Quality Sampling

- Sampled using EWI methods from bridges or boats
- Analyzed water for 638 parameters using 4 USGS laboratories:
 - 105 Pharmaceuticals
 - 251 Pesticides
 - 30 Metals
 - 22 Hormones
 - 116 VOCs
 - 55 Wastewater indicators
 - 29 DBPs
 - 9 Nutrients
 - 8 major ions
 - 8 field parameters
 - 5 carboxylic acids



Sampling the Illinois River at Florence, IL

Why worry about ABC in the Illinois? What are ABC?

- 💧 Anthropogenic Bioactive Chemicals (ABC)
 - 💧 includes: drugs, personal care products, pesticides, hormones, industrial chemicals, DBPs
- 💧 Hormones released by animals (humans) and plants.
 - 💧 Many also used by humans as “supplements”
 - 💧 Some hormones used **only** by humans, stock, pets (EE2)
- 💧 A fraction of ABC/hormones end up in water/sediment
- 💧 Some ABC and hormones can:
 - 💧 persist for months or years
 - 💧 affect wildlife at very low concentrations
 - 💧 alter ecosystem functions at low concentrations
 - 💧 move far from their point-of-deposition



Field processing water quality samples

Why worry about low concentrations of some contaminants?



- Is the Paraclesian presumption that “the dose makes the poison” wrong?

- For some ABC/hormones, answer is “yes”

- U-shaped, n-shaped, biphasic responses common for ABC

- In review by Vandenberg et al., 2012 “non-monotonic responses and low-dose effects are remarkably common in studies of natural hormones and EDCs”

- Also states “the timing of exposure is profoundly important to detect low-dose effects of EDCs”

- Mixtures – usually many chemicals - many issues

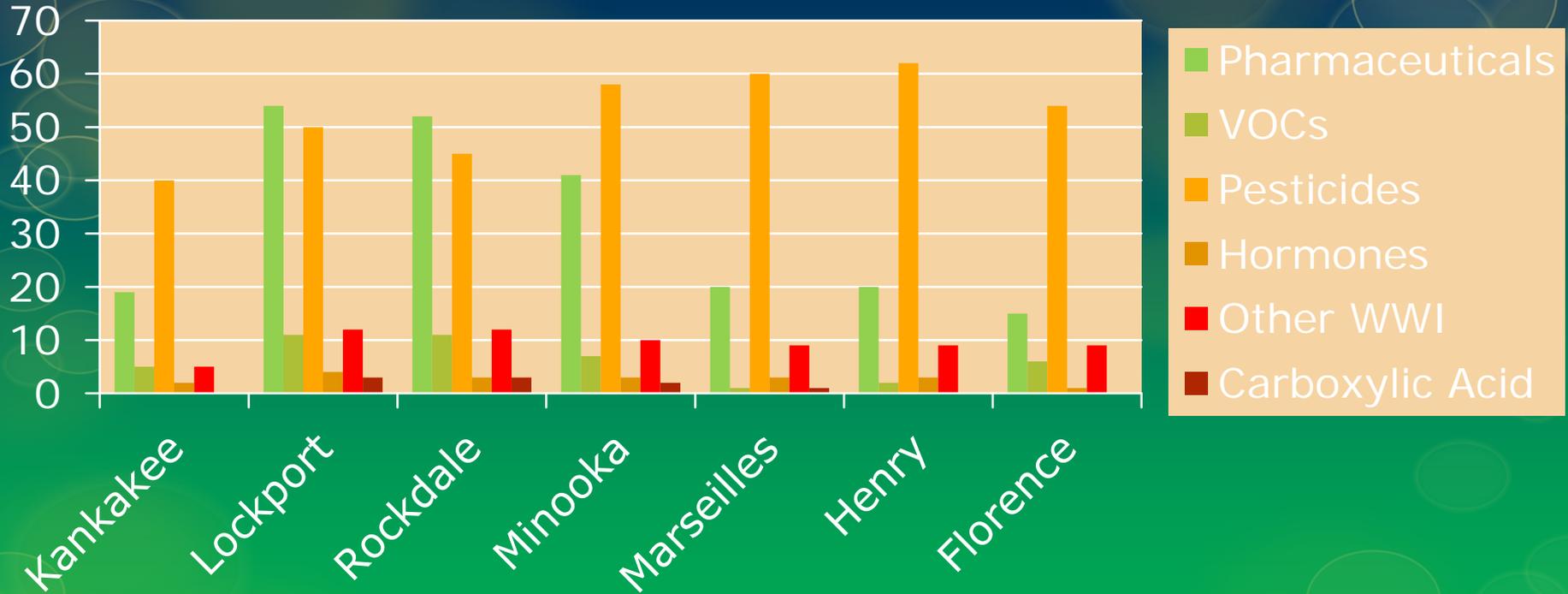
- Combinations of ABC can have effects when individual chemicals do not

- Degradation – persistence controls fate



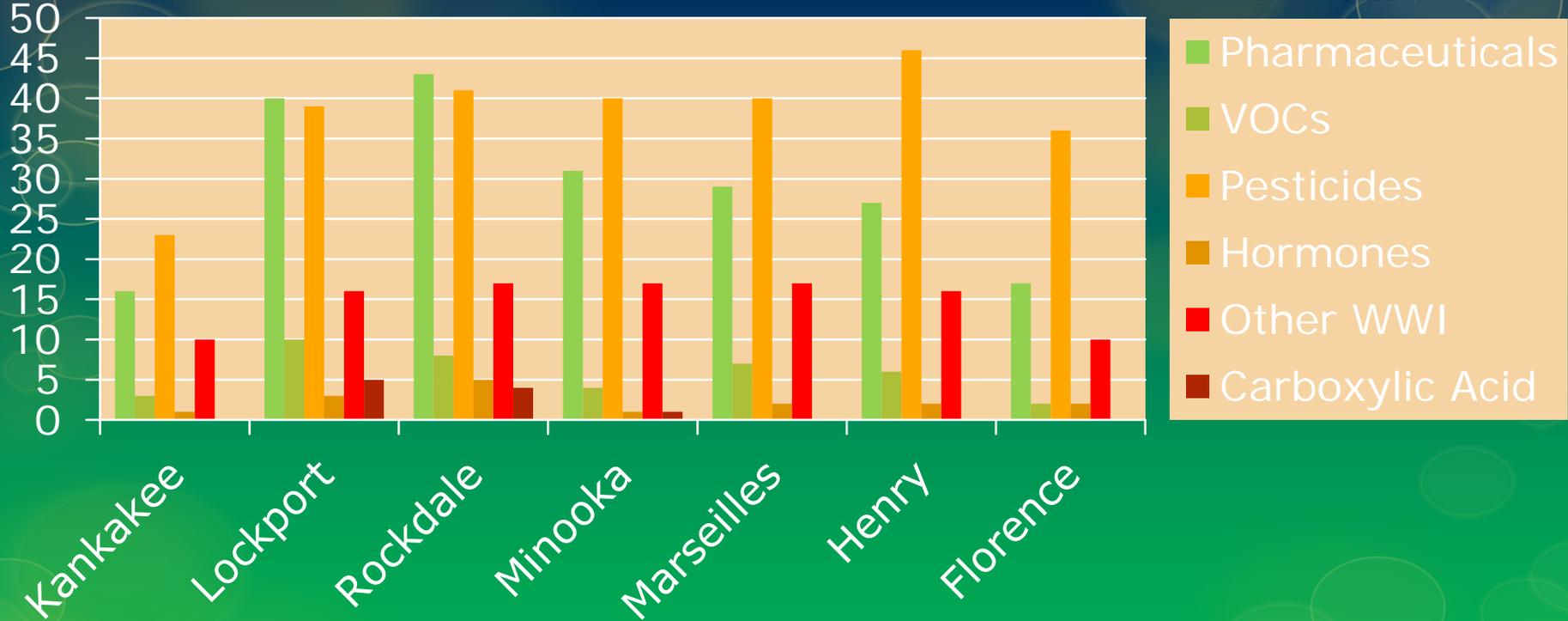
Not a real dead frog

Results 1 – Detections in May



- 💧 Most frequent detections for most classes at Lockport or Rockdale
- 💧 Most frequent detections for pesticides at Henry

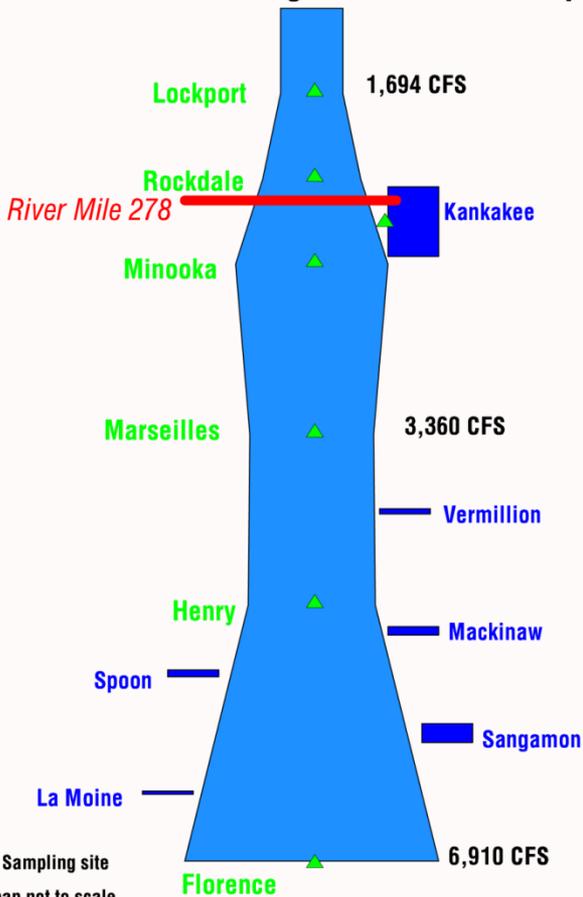
Results 2 – Detections in October



- 💧 Less frequent detections for most classes at most locations
- 💧 Even though streamflow was less
- 💧 More detections of pharmaceuticals downstream

Results 3 – Illinois Waterway Schematic/Streamflow

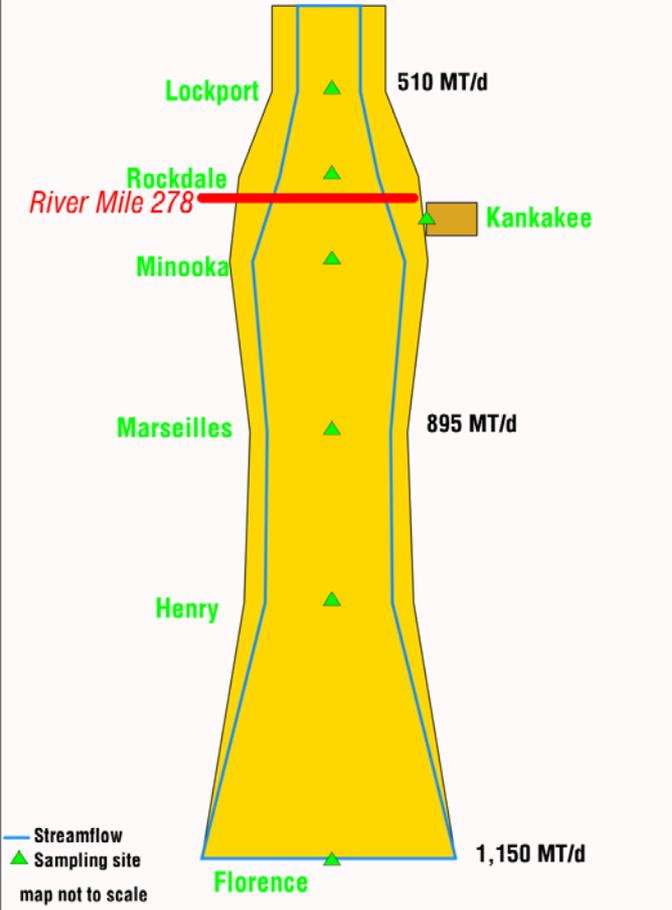
Streamflow During October 2015 Sampling



- Simplified Illinois Waterway schematic
- Flow, flux, concentrations
 - all scaled the same way
- Flow in May - cone shape
- Flow in October – coke bottle
- June – rocket ship
- August – lava lamp
- Flow at Lockport between 5.5 and 45.5% of flow at Florence

Results 4 – Chloride Flux

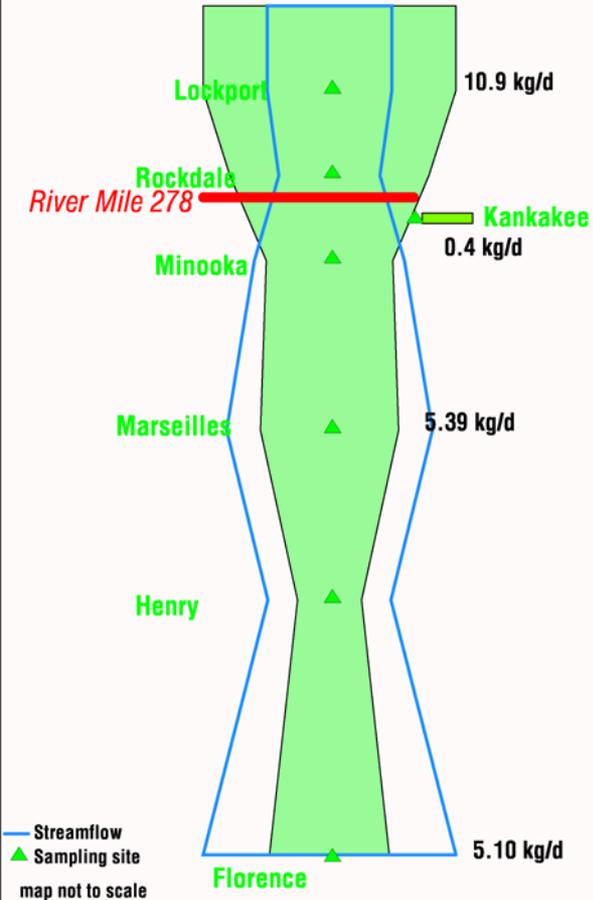
Chloride Flux During October 2015 Sampling



- Plots show chloride flux with streamflow as the blue line
- May results indicate higher relative flux from upper basin
- June results similar to May even though streamflow is 3x greater
- August – more lava lamp like
- October much smaller fluxes
- Flux at Lockport between 33.6% and 67.8% of flux at Florence
- Results confirm Lagrangian sampling

Results 5 – Nutrients Flux

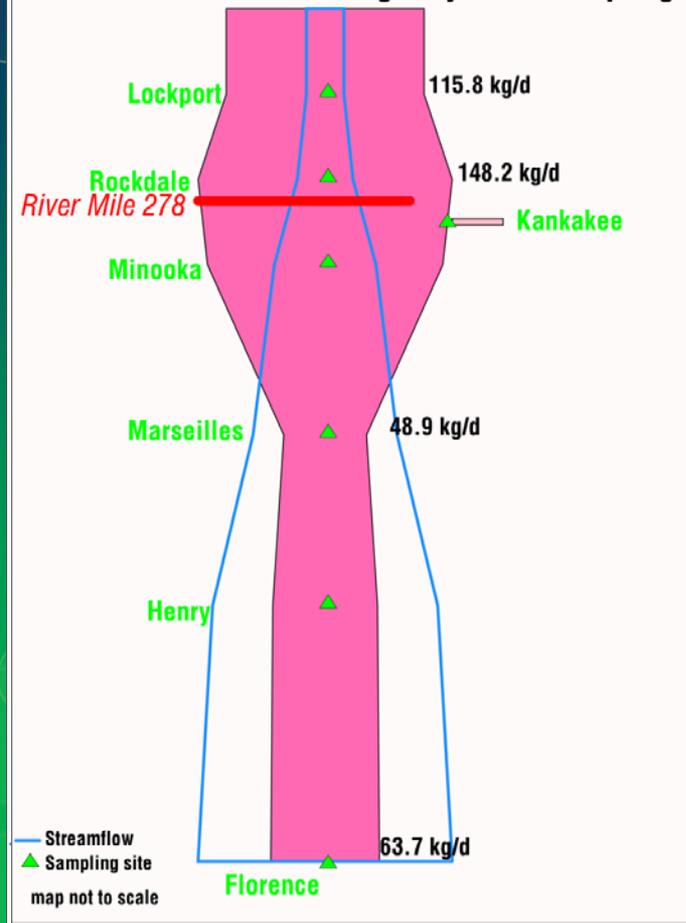
Phosphorus as P Flux During August 2015 Sampling



- Plots show Nitrate as N flux with streamflow as the blue line
- June results indicate conservative transport
- August result show greater influence of upper river inputs – much lower fluxes
- Dissolved Phosphorous as P
- June results show greater influence of upper river inputs
- Even more pronounced in August – with much lower fluxes

Results 6 – VOC, Pesticide, Pharmaceutical Flux

Pharmaceutical Flux During May 2015 Sampling



VOCs flux

- Greatest at Rockdale
- Decreases downstream
- Not conservative
- Flux at Lockport between 109% and 440% of flux at Florence

Pesticide flux

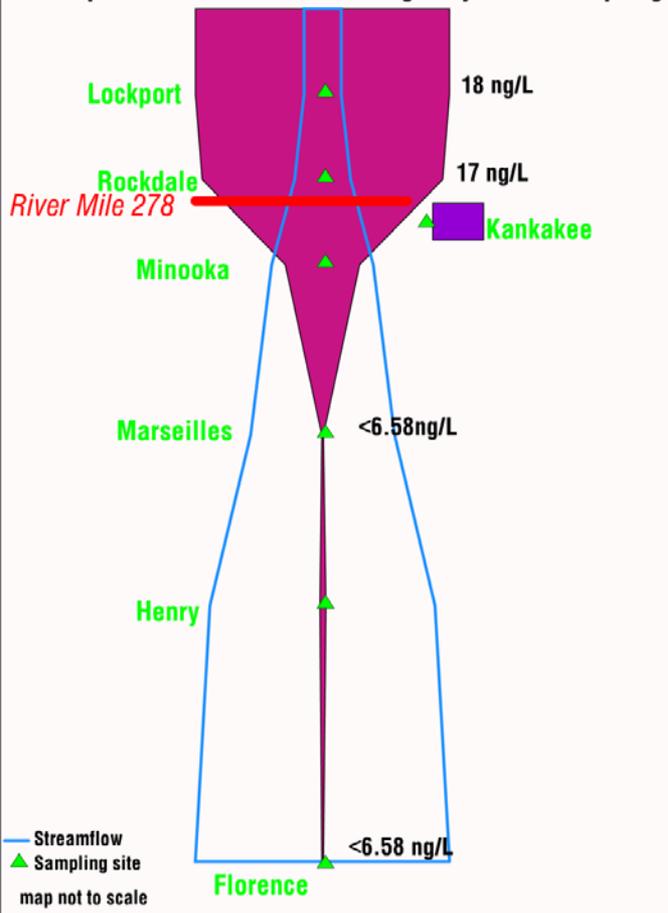
- Greatest at Henry
- Increases downstream
- Flux at Lockport between 3% and 47% of flux at Florence

Pharmaceutical flux

- Greatest at Rockdale
- Decreases downstream
- Not conservative
- Flux at Lockport between 51% and 359% of flux at Florence

Results 7 – Atrazine, Metformin, etc

Citalopram Concentration During May 2015 Sampling



- Atrazine (herbicide) can
 - Disrupt pituitary-ovarian function (Cooper, 2000)
 - Induce gonadal malformation (Hayes, 2006)
- Metformin (diabetes) can
 - Cause intersex and reduced fecundity in fish (Niemuth, 2015)
- Venlafaxine (antidepressant) can
 - Adversely affect predator avoidance (Painter, 2009)
- Citalopram (SSRI) can
 - Can bioaccumulate in fish brains (Arnnok, 2017)

High Throughput Screening assays: ToxCast/Tox21

- EPA National Center for Computational Toxicology (NCCT)

- Goal: Tool for assessing chemicals based on potential health or environmental risks

 - Utilizes High Throughput Screening to rapidly and efficiently assess the potential activity of thousands of chemicals

 - Helps prioritize which chemicals in complex mixtures are potential problem

- Current ToxCast database contains

 - > 300 assays with > 1100 endpoints

 - >8000 chemicals

 - Evaluating effects on Cells, proteins, DNA, RNA, mitochondria, receptors, enzymes



ToxCast Exposure Activity Ratios (EARs)

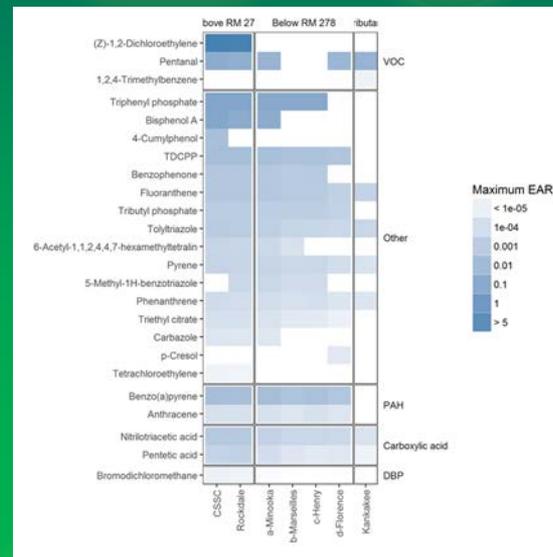
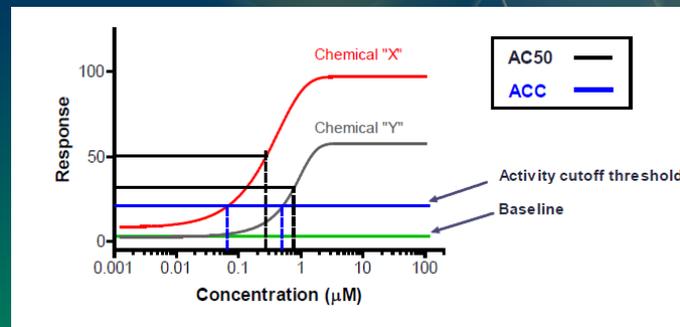
- Incorporates ABC exposure concentration (e.g., measured concentration in water)

- And potential ABC potency ACC (Activity Concentration at Cutoff) from the bioassays in simple ratio

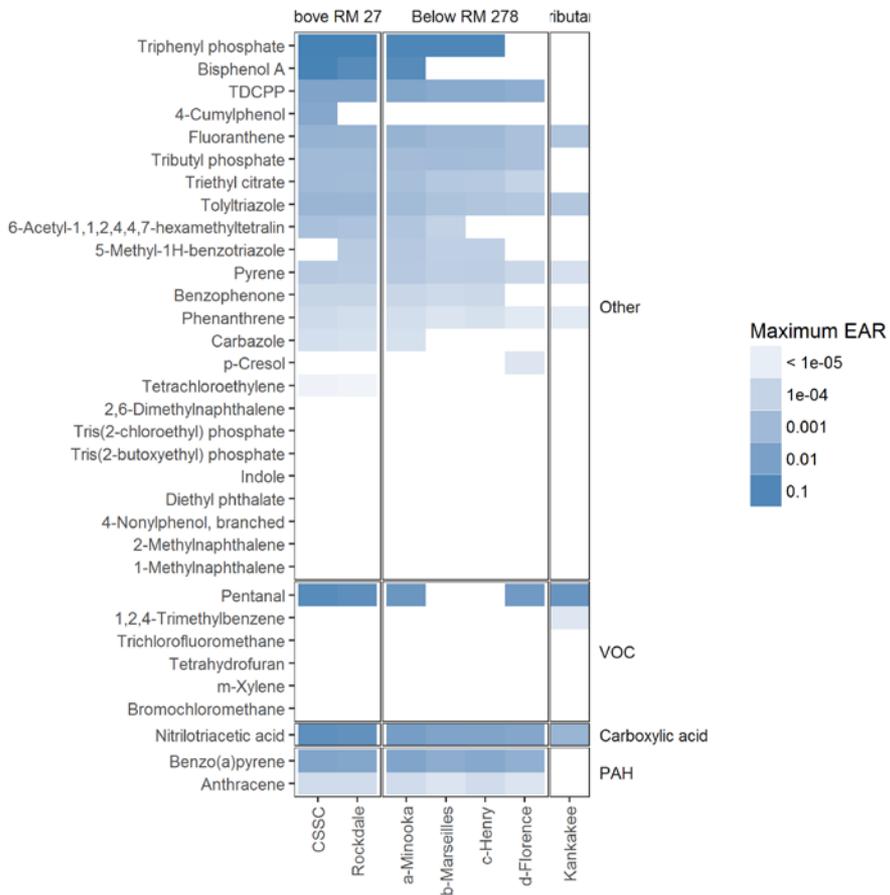
- Results from multiple assays are simplified for analysis

- Strong relations between EARs and Toxicity quotients calculated from water quality guidelines

- Use USGS toxEval R-tool to access ToxCast information and visualize results

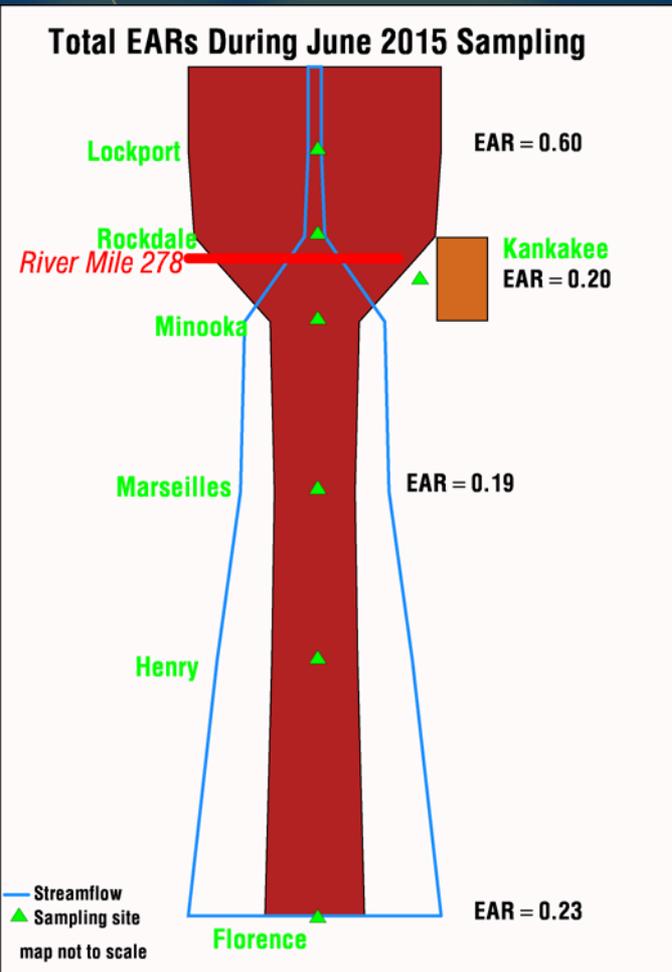


Results 8 - EARs for Round 1 (May) Samples



- Plot shows maximum EARs by ABC class (y-axis) and site (x-axis)
- Looking for ABC that are high above RM 278 or in the tributary, but low or decreasing below RM 278
 - Pesticides high always
 - The other groups show that pattern
- Pesticides – metolachlor, atrazine, 2,4-D
 - Not many are high up and low down
- Pharmaceuticals – Benadryl, metformin
 - Many show occurrence pattern of interest
- Other WWI – triphenyl phosphate, bisphenol A,
 - Several show pattern of interest

Results 9 – Cumulative Exposure Activity Ratios



- Total (sum of) EARs for May Sampling
 - Highest individual EARs – Metolachlor (0.40)
 - Triphenyl phosphate (0.17)
- Kankakee dilutes upper Illinois EARs
- Total EARs for June Sampling
 - Lower totals than for May
 - Highest individual EARs – 4-nonylphenol (0.16)
 - Metolachlor (0.11)

Conclusions and Questions?



Lock and Dam at Rockdale, IL



Illinois River near Minooka, IL

- 💧 We used a Lagrangian sampling strategy to investigate how water quality changes in the Illinois Waterway from Lockport to Florence
- 💧 For most chemical classes fluxes and concentrations decreased in the downstream direction
 - 💧 Pesticides are an exception
- 💧 Several pharmaceuticals showed a pattern of occurrence that suggests a potential for them to be affecting carp spawning or migration
- 💧 We use EPA ToxCast data and the USGS toxEval tool to evaluate the potential effects of mixtures of chemicals and prioritize those chemical for further study.

The questions we are trying to answer

Is water chemistry the primary factor stalling the Bigheaded carp population front ?

Preliminary analysis of water quality data indicate that there are several chemical classes and many ABC that occur in a pattern such that they could be affecting carp spawning or movement upstream, either as individual chemicals or as complex chemical mixtures.



Future Plans

- 💧 Add some tissue analysis (with Cory Suski)
 - 💧 Identify WQ changes post WWTP upgrades
- 💧 Reports with 2015 results
 - 💧 Methods Paper – USGS OFR 2017-1019
 - 💧 Data Release – contact Bill
 - 💧 Journal Article – in preparation

Your Questions?



Lock and Dam at Rockdale, IL



Dam on Kankakee River



Birds hunting in Kankakee River

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