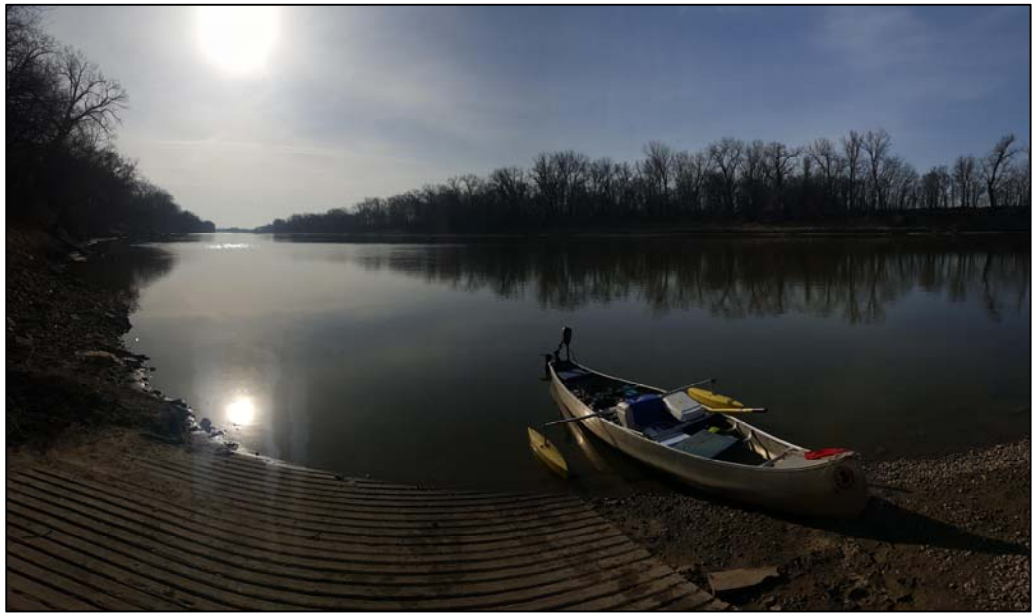
Finding the Farmland Nitrogen: How does changing the chemistry and microbes in the Kansas River impact nitrogen removal?



Amy Burgin, Lydia Zeglin, Michelle C. Kelly, Emma Overstreet, and Janaye Hanschu

THE UNIVERSITY OF KANSAS

Kansas State University

Farmland Site Timeline

1954	1972	1993	2001-2	2004-6	2010	2017	
Farmland Industries begins industrial fertilizer production	Farmland acquires NPDES permit to discharge waste to Kansas River	Farmland addresses environmental issues under Consent Order issued by KDHE; begins groundwater pumping	Farmland ceases operations and declares bankruptcy	Farmland Trust funded with $7M to pay for clean up; Shaw Environmental does large-scale site assessment	City of Lawrence acquires property and Trust, as well as legal obligation to remediate the site; plans Venture Park	KDHE allows City of Lawrence "Temporary and Conditional Additional Discharge" permit	31 March 2018 30M gallons of high N water released to Kansas River

Farmland Site prior to City of Lawrence ownership:

All photos from City of Lawrence Presentation to KS Legislature Senate Committee on Utilities report (10 Jan. 2018)

**decades-old high nitrogen water: Only certain types of microbes can survive there

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Archive for Wednesday, August 16, 2017

Cleanup at former Farmland fertilizer plant may cost city millions more than expected

Photo by Nick Krug. Enlarge photo.

The former Farmland site is seen in this aerial photograph on Monday, July 1, 2013.

Email Print Facebook Tweet Comments (14)

By Rochelle Valverde
August 16, 2017

After taking ownership of the former Farmland fertilizer plant several years ago, the city of Lawrence has now found that the contamination cleanup will be more complicated and more costly than originally thought.

City Manager Tom Markus told city commissioners at their meeting Tuesday that the city is preparing to hire an outside contractor to help with the cleanup. At the same time, he said that the trust fund transferred to the city to pay for the remediation of nitrogen-contaminated groundwater is dwindling.

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Archive for Friday, November 10, 2017

State authorizes Lawrence to release up to 30 million gallons of nitrogen-contaminated water into Kansas River

Photo by Nick Krug. Enlarge photo.

The former Farmland site is seen in this aerial photograph on Monday, July 1, 2013.

Email Print Facebook Tweet Comments (20)

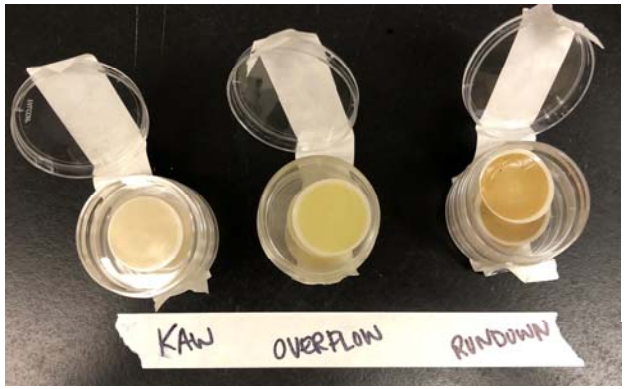
By Rochelle Valverde
November 10, 2017

The state has authorized the City of Lawrence to release millions of gallons of nitrogen-contaminated water from the former Farmland fertilizer plant into the Kansas River.

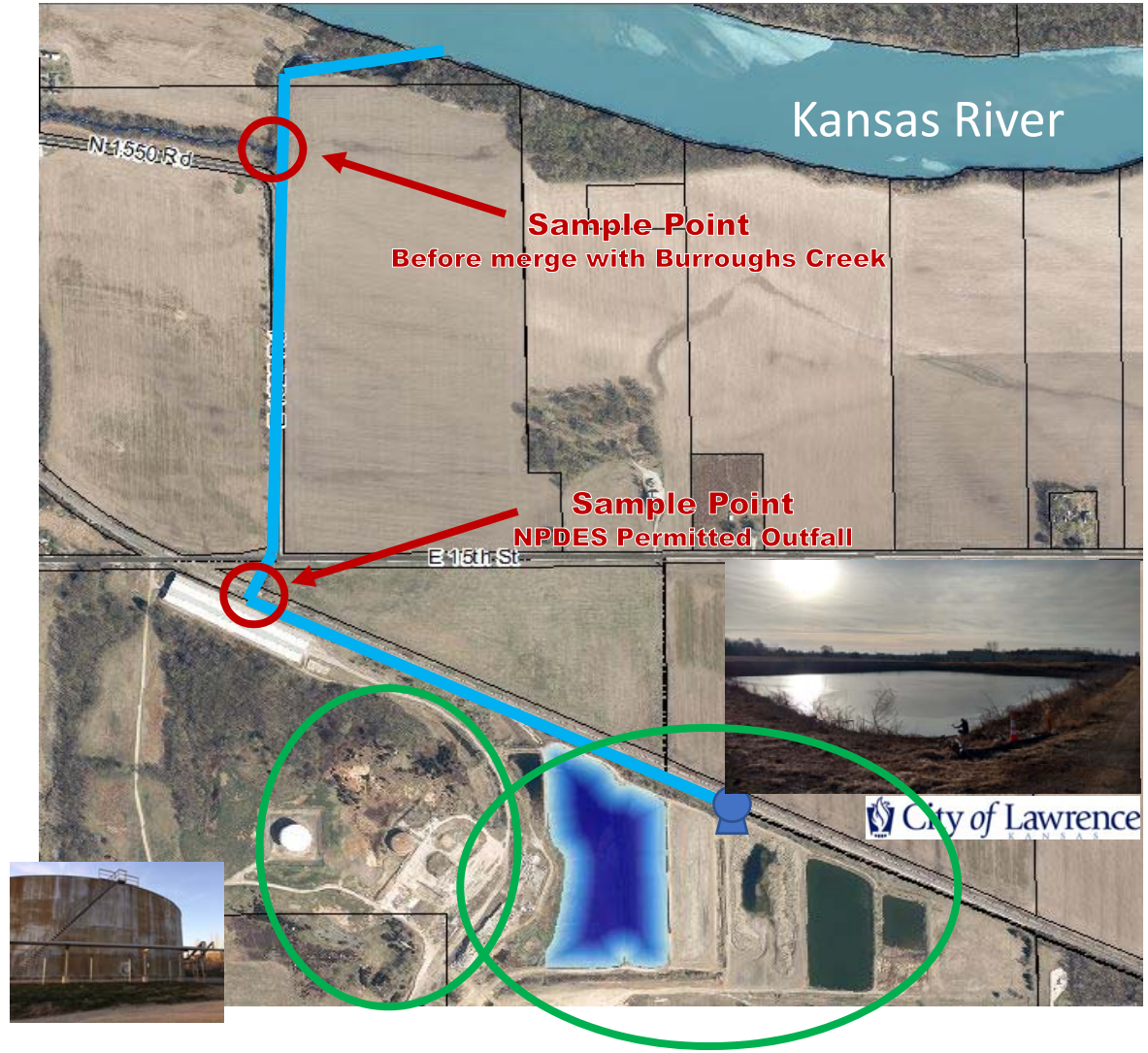
The Kansas Department of Health and Environment authorized the city to release the nitrogen water under certain conditions for the next several months. Nitrogen can be harmful, but KDHE officials said they don't expect any impact because the nitrogen will be heavily diluted.

To relieve the overburdened storage system, save $400K and prevent safety issues from trucking, KDHE allows the City of Lawrence a **temporary and conditional release of the stored water** from the Farmland fertilizer plant to the Kansas River. The City already had a discharge permit, via the National Pollutant Discharge System, to release nitrogen water after heavy rainfall. **Nitrate concentrations were not to exceed 10 milligrams per liter,** due to dilution by the river water, but nitrogen in the river was expected to increase.

Farmland Site Water Release



- Six surface ponds
  - 22M gallons
  - 300 mg/L NH_4^+-N
  - 600 mg/L NO_3^--N**
- Two large tanks
  - 8M gallons
  - 750 mg/L NH_4^+-N
  - 1200 mg/L NO_3^--N
- Kansas River release through NPDES permitted outfall
  - 15 Nov 2017 - 31 March 2018



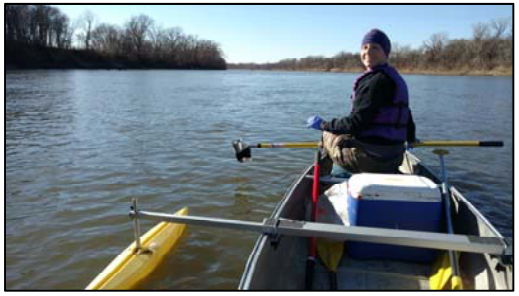
** river water not to exceed 10 mg/L NO_3^--N

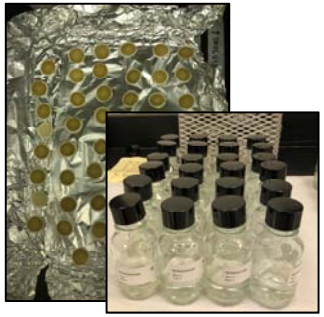
How are we trying to understand this?

<u>Question 1</u>: Did river water nitrogen concentrations go up, and how much?

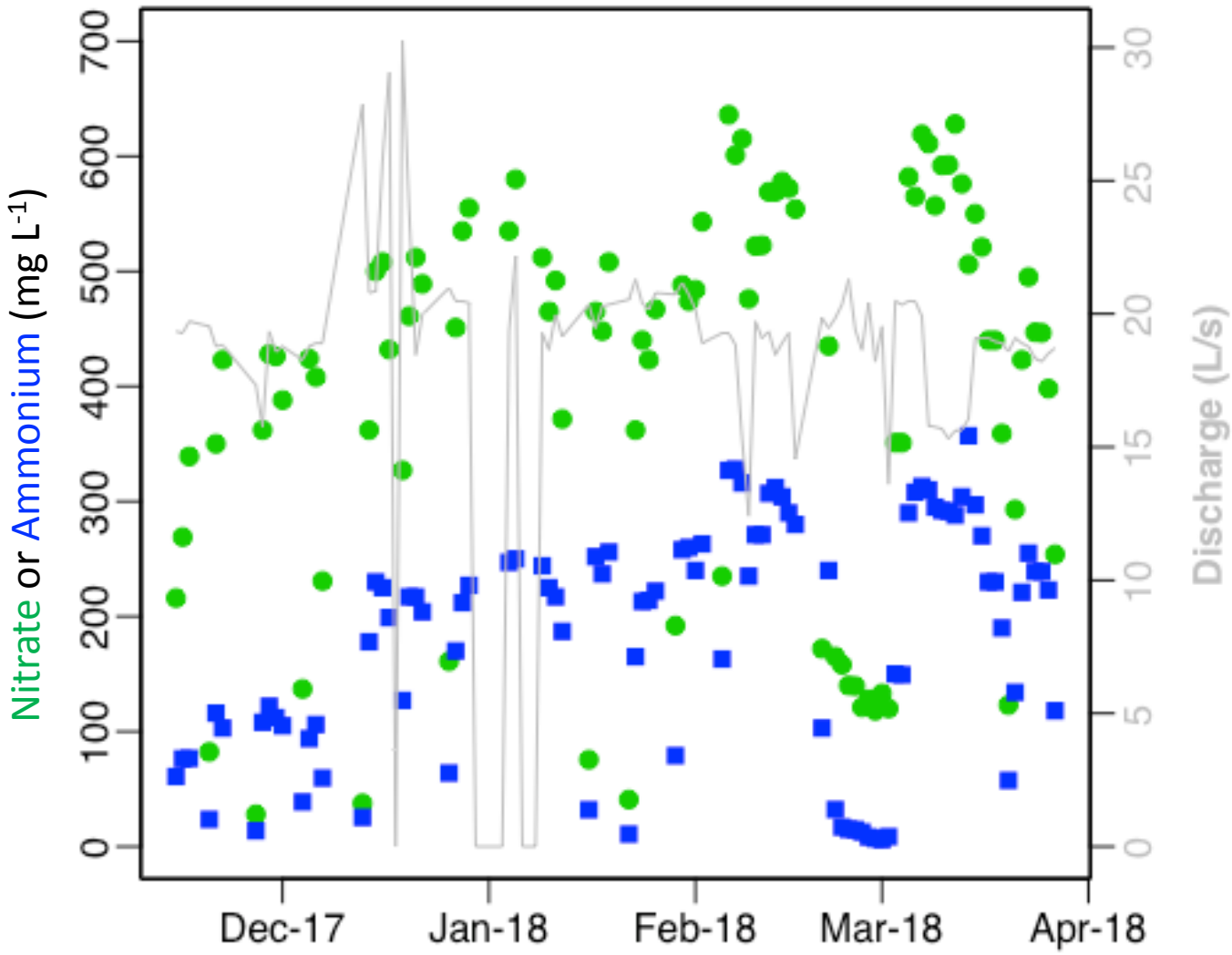
<u>Question 2</u>: Were new bacteria released into the river, and do they affect how fast the nitrogen can be removed?

- Real-time nitrate sensors
- 24-hour sampling to measure N removal
- Bi-monthly floats w/ water chemistry, microbial community and rate assays
- Reciprocal inoculation experiments



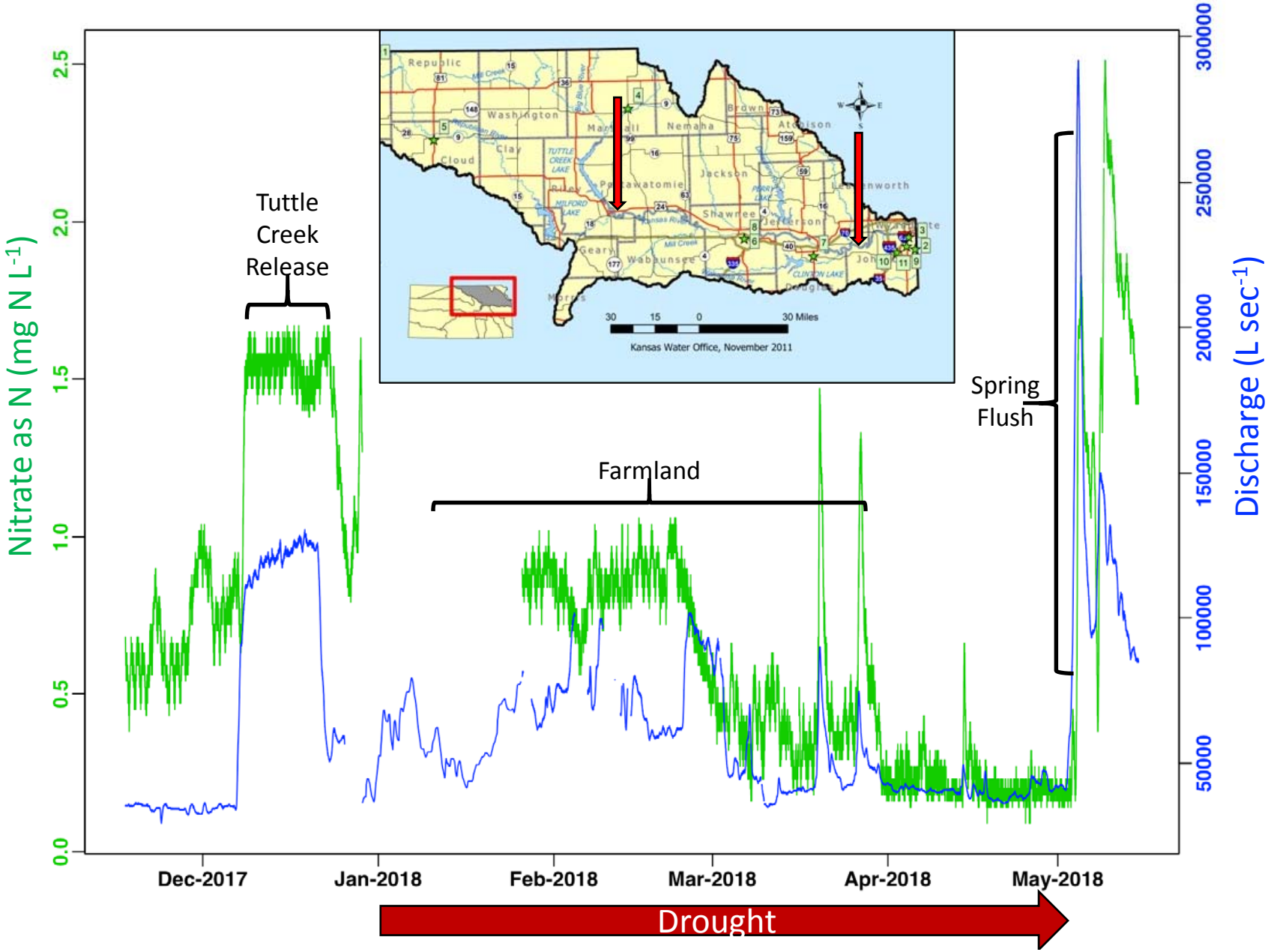


Farmland "Stream" Chemistry

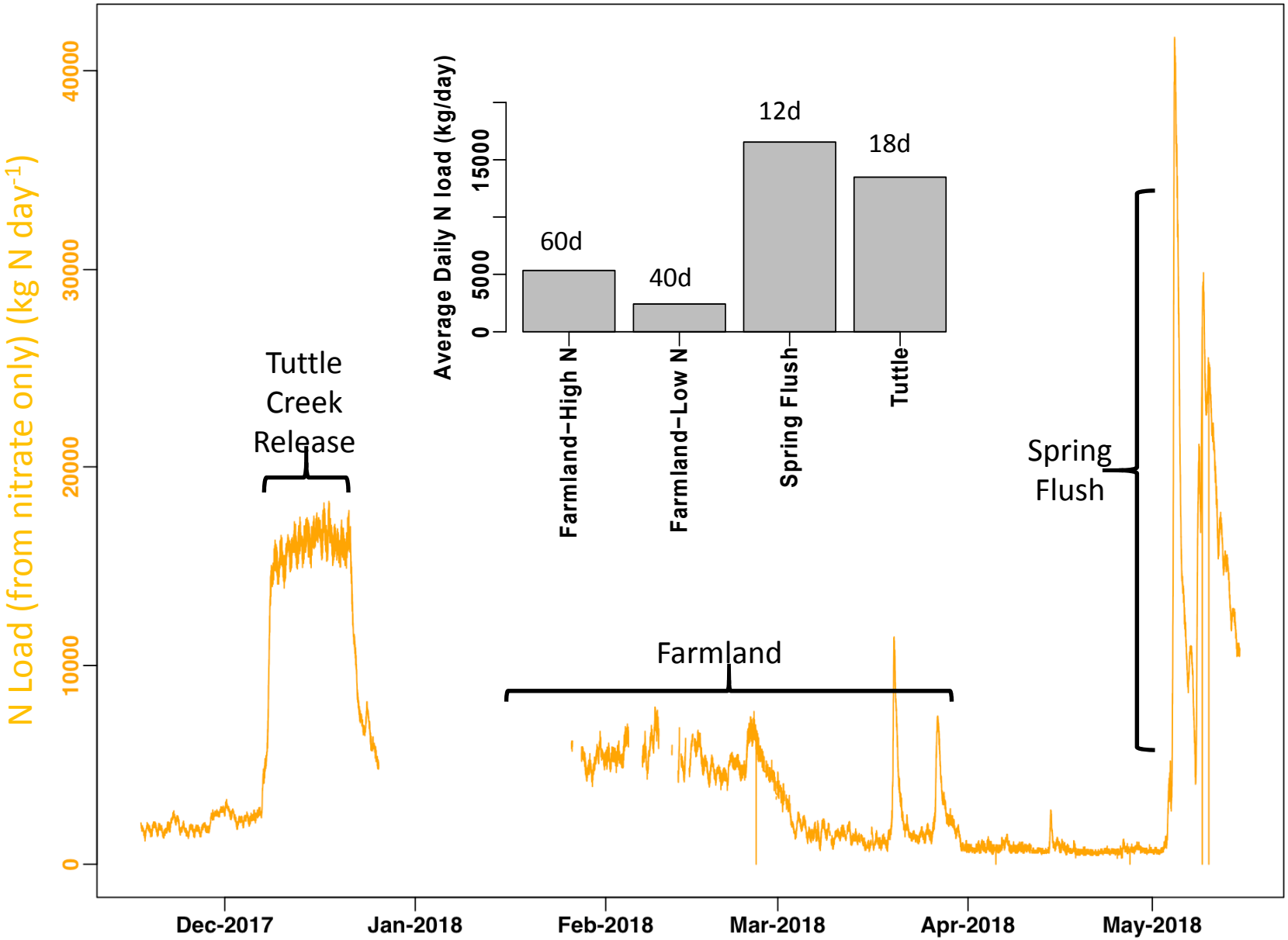


Data provided by the City of Lawrence Water Quality Lab and Utilities Operations

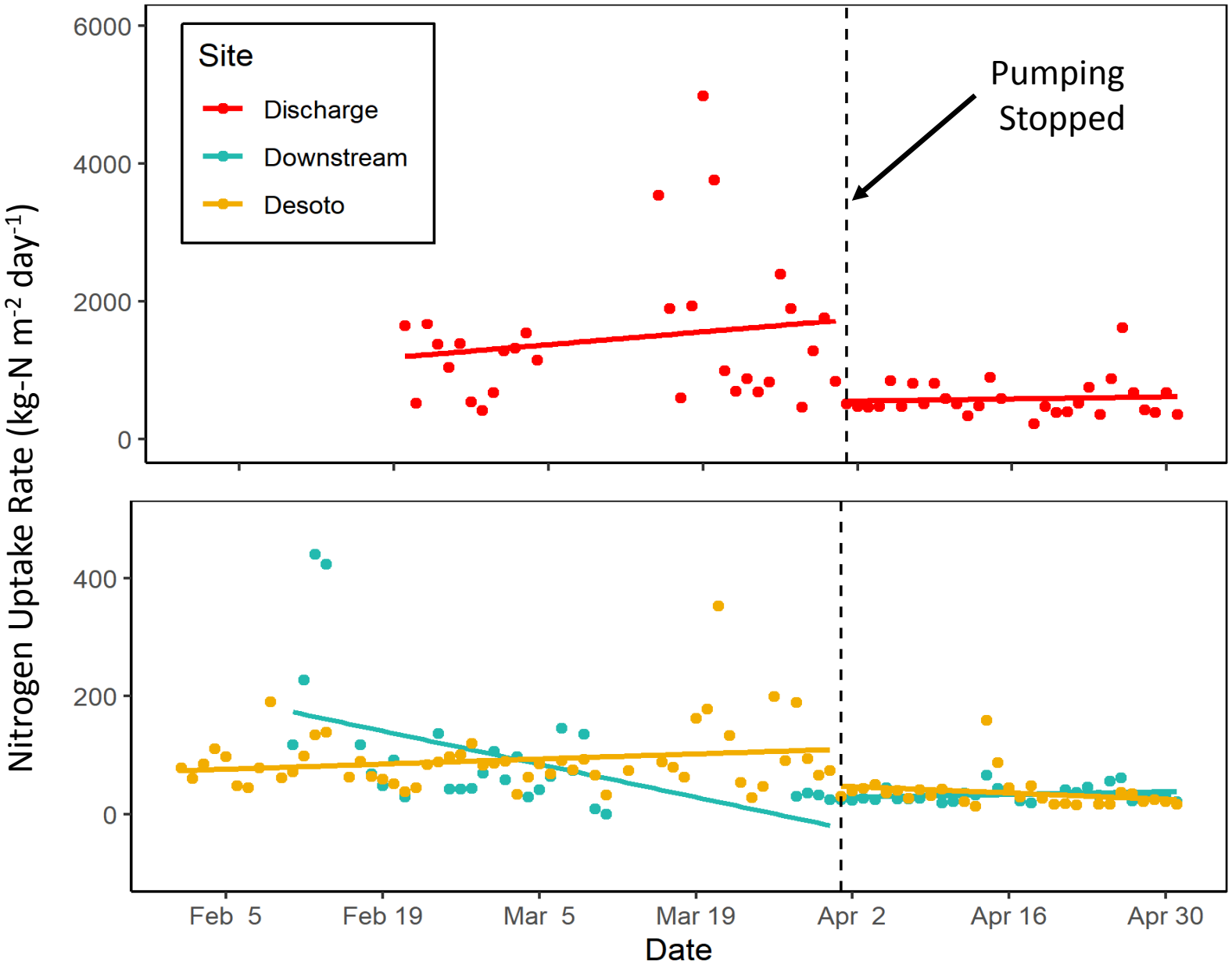
How much did N change in the Kansas River?



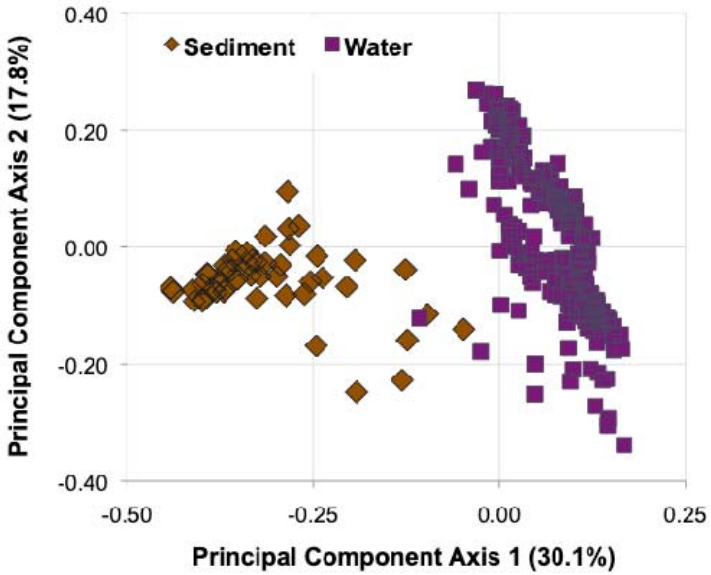
How much did N change in the Kansas River?



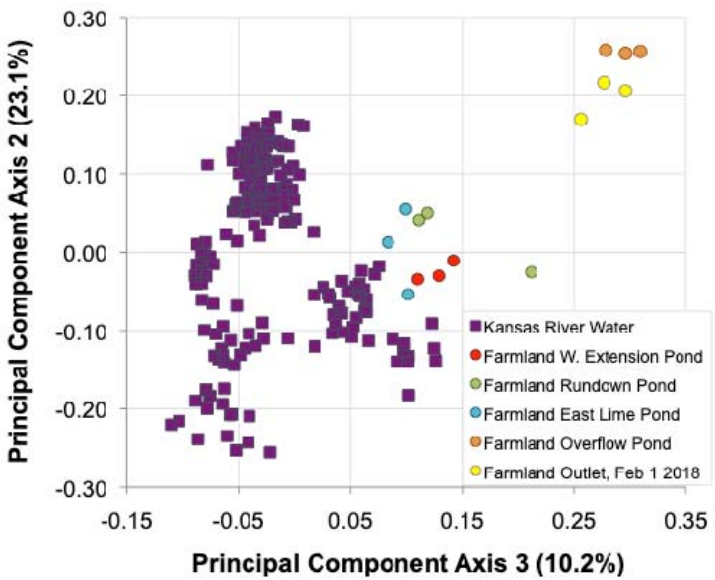
River Nitrogen Removal

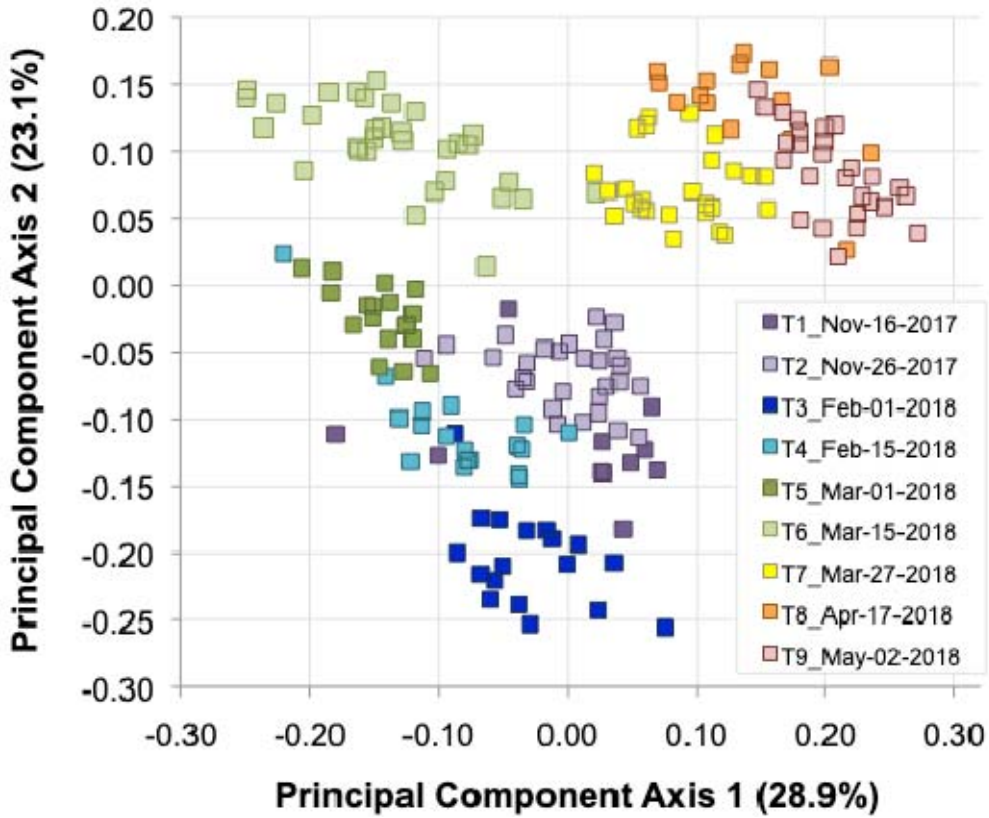


Total bacterial community changes

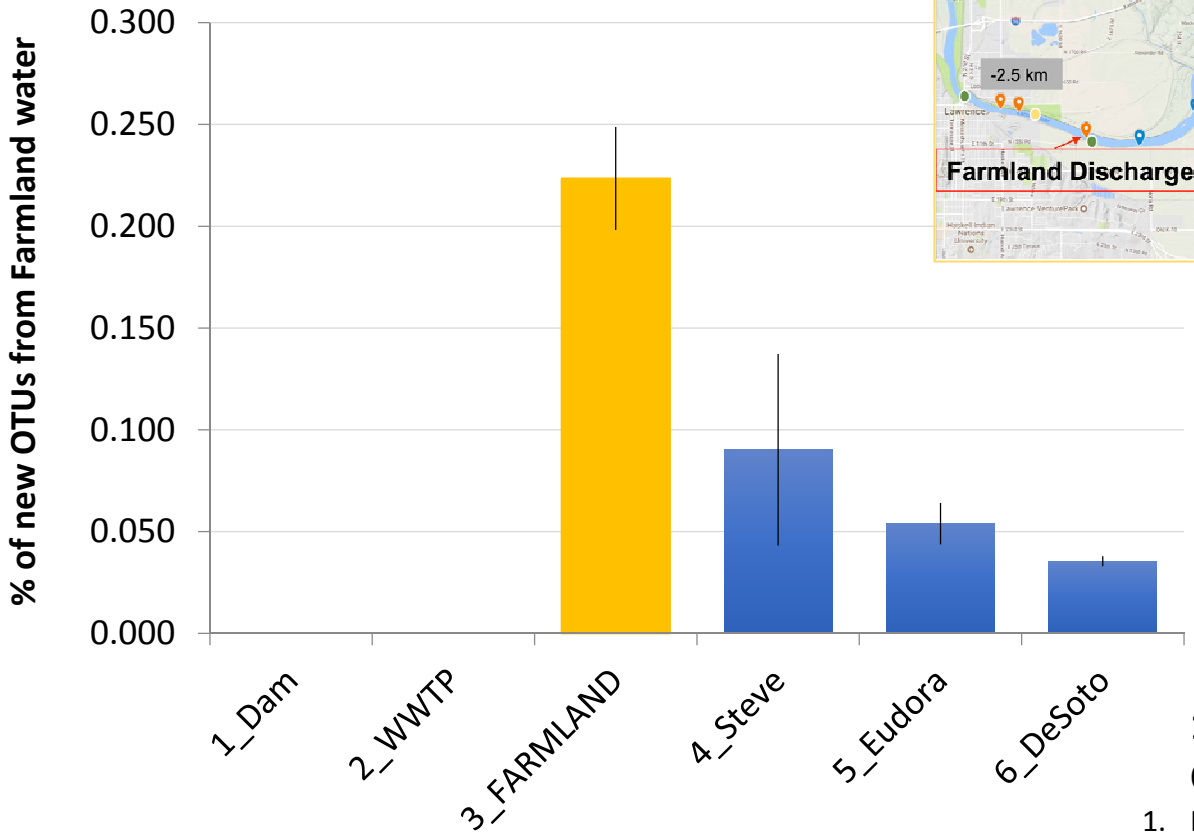


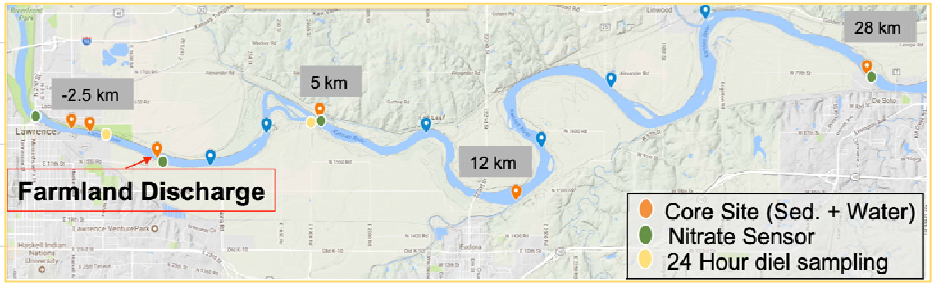
1. Sediment ≠ River water
2. Farmland Ponds ≠ River water
3. River water changes through time





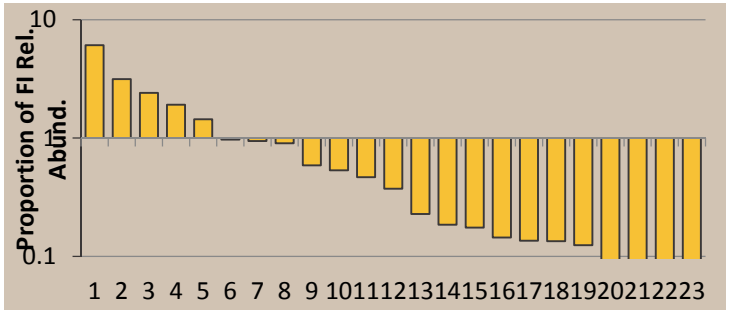
One time point – see signal of input





New bacteria (23) input:
Most (18) don't survive downstream

None are known pathogens



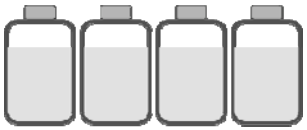
15 March 2018
OTUs in inset:

1. Planctomycetes; Planctomycetia; Pirellulales; Pirellulaceae; *Planctomycete sp.*
2. Planctomycetes; Planctomycetia; Pirellulales; Pirellulaceae;Other
3. Verrucomicrobia; [Pedosphaerae]; [Pedosphaerales]; OPB35
4. Chloroflexi;Other;Other;Other;Other
5. Proteobacteria; Betaproteobacteria; Thiobacterales

23. Chloroflexi; TK10; B07_WMSP1; FFCH4570

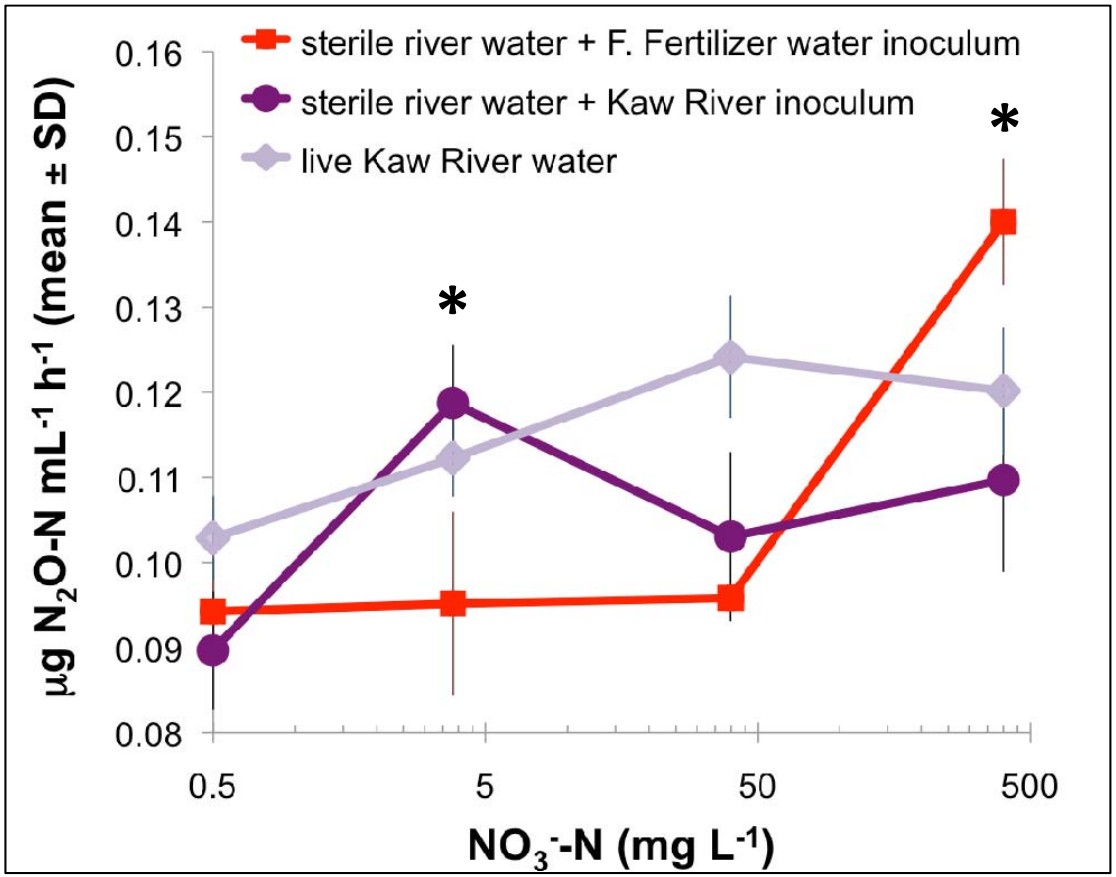
Reciprocal Inoculation activity

Kansas River microbes
living in water ~
0.5 mg/L NO_3^--N



sterile river water
0, +N, ++N, +++N

Farmland input microbes
living in in water ~
400 mg/L NO_3^--N



Different microbes do affect N removal activity

BUT…

Farmland microbes are only faster at super-high nitrogen levels (like they're used to)

***INOCULUM EFFECT**

N=4, alpha=0.05

Take Home Messages

- Farmland provided an unique opportunity to understand how new microbes and high nitrogen change N cycling in a big river
- Farmland inputs changed the chemistry of the river
  - Not out of the realm of other N input events (e.g., Tuttle Creek Release)
  - The Farmland input changed the Kansas River N cycling rates
- The microbial community matters for river N processing
  - Farmland input microbes can be tracked through the river
  - However, river microbes are more likely removing the N
- Good case study of partnering between university scientists, local government, and state agencies

Lydia catching Kaw River microbes at 6AM (hour 21 of 24)

Acknowledgements

University of Kansas
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James Guinnip

University of Nebraska-Lincoln
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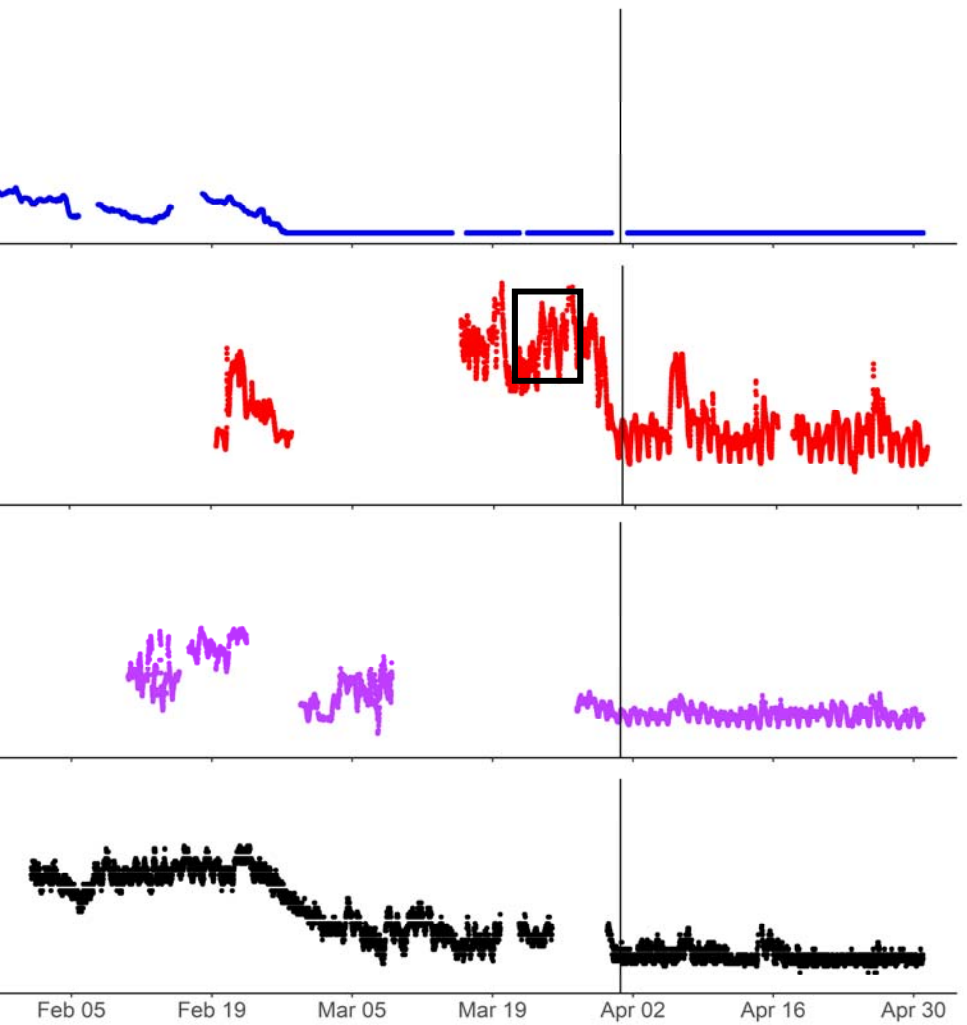
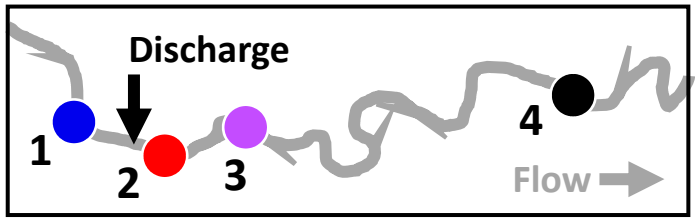
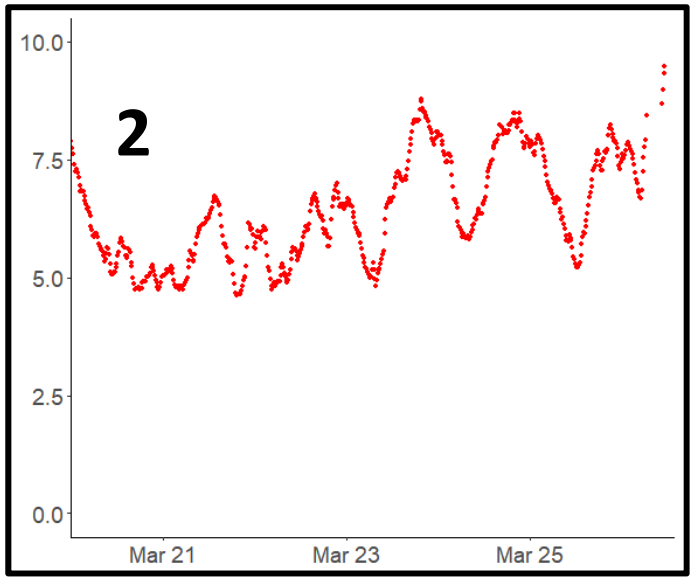
Eric Bloom
Sarah Hill-Nelson and The Bowersock Mills & Power Company
Dawn Buehler, Kansas Riverkeeper
Friends of the Kaw
Sarah Graves and Dave Wagner, City of Lawrence
USGS – Guy Foster, Lawrence
Water One, Johnson Co, KS
Kansas Dept of Health & Environment – Tom Stiles

Funding
NSF DEB RAPID #1822960

$_3^-$ sensors indicate diel concentration swings





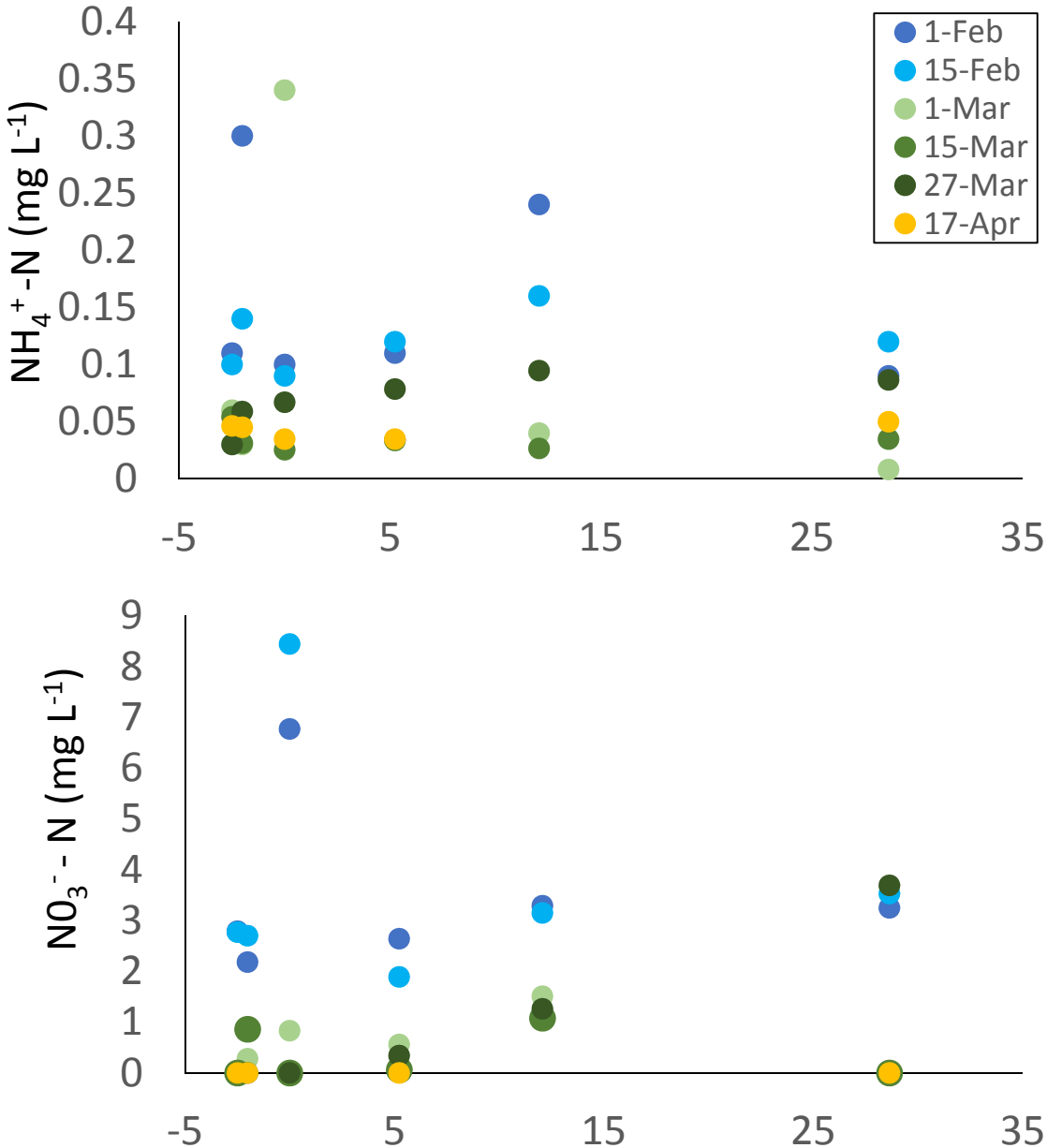


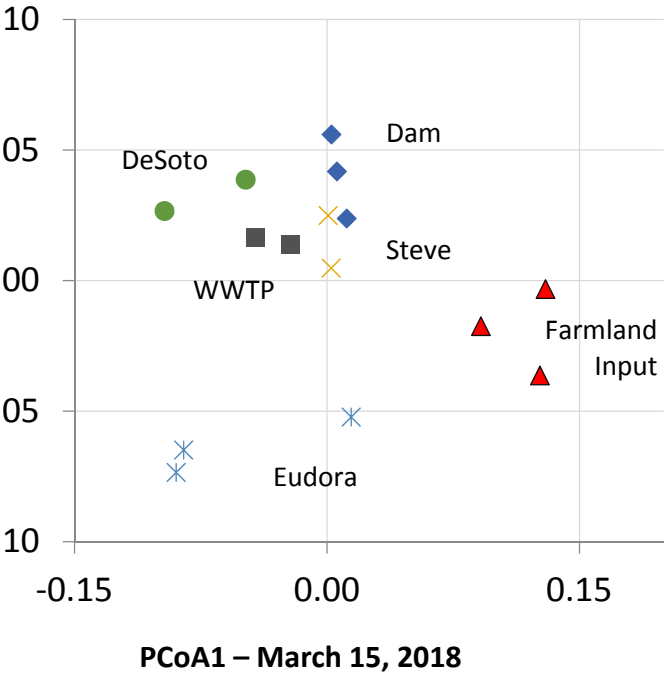
Substantial variation in time and space, tied to riverine N processing

at Grab Sample Chemistry

ner NO_3^- and NH_4^+ in compared to March

Difficult to discern erns in space or time

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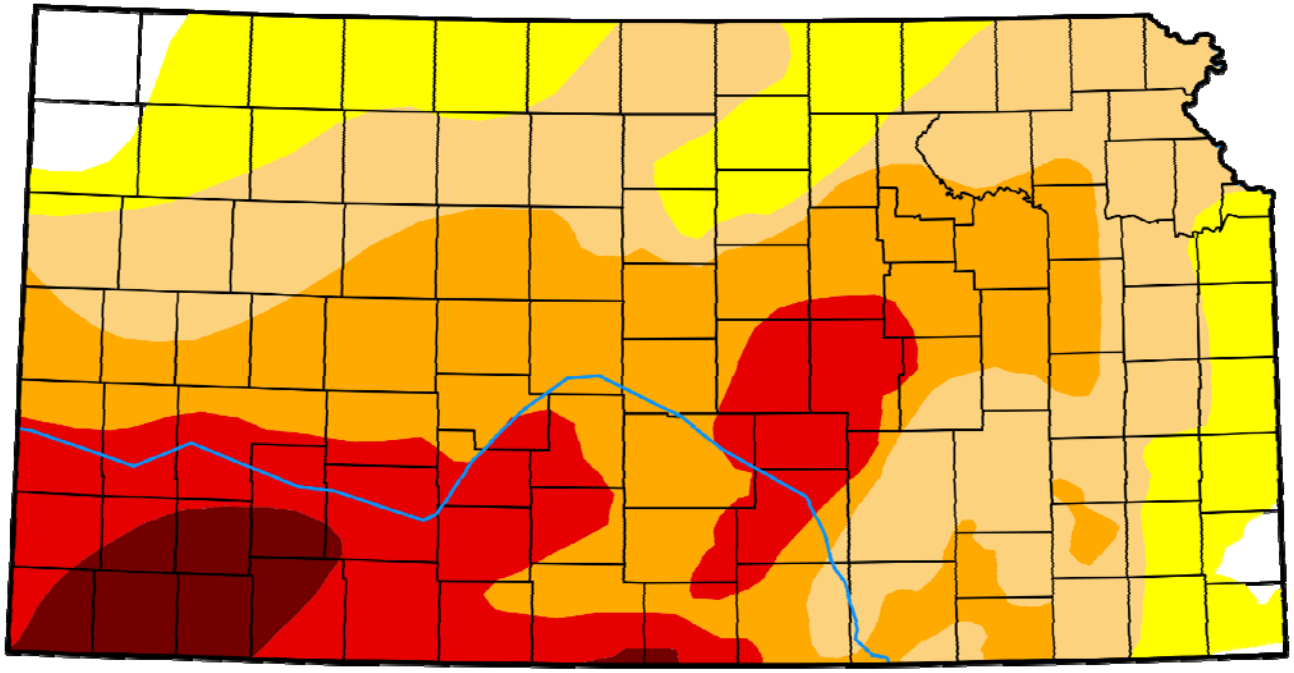
PCoA1 – March 15, 2018

May 17, 2018



The Conditions

- 1. Discharge is to occur over October to April 1 – take advantage of cool temperatures dampening biological response
- 2. Discharge is capped at 0.5 million gallons each day – spread release over at least 60 days
- 3. Discharge only when Kansas River is flowing over 1000 cfs – 3 orders of magnitude dilution
- 4. Weekly (daily) monitoring of pumped discharge to river – volume and concentration
- 5. Plan for long range solution – by February 1
- **Should result in nitrate rise in river of < 1.5 mg/l**

Slide from Tom Stiles, KDHE

site prior to City of Lawrence
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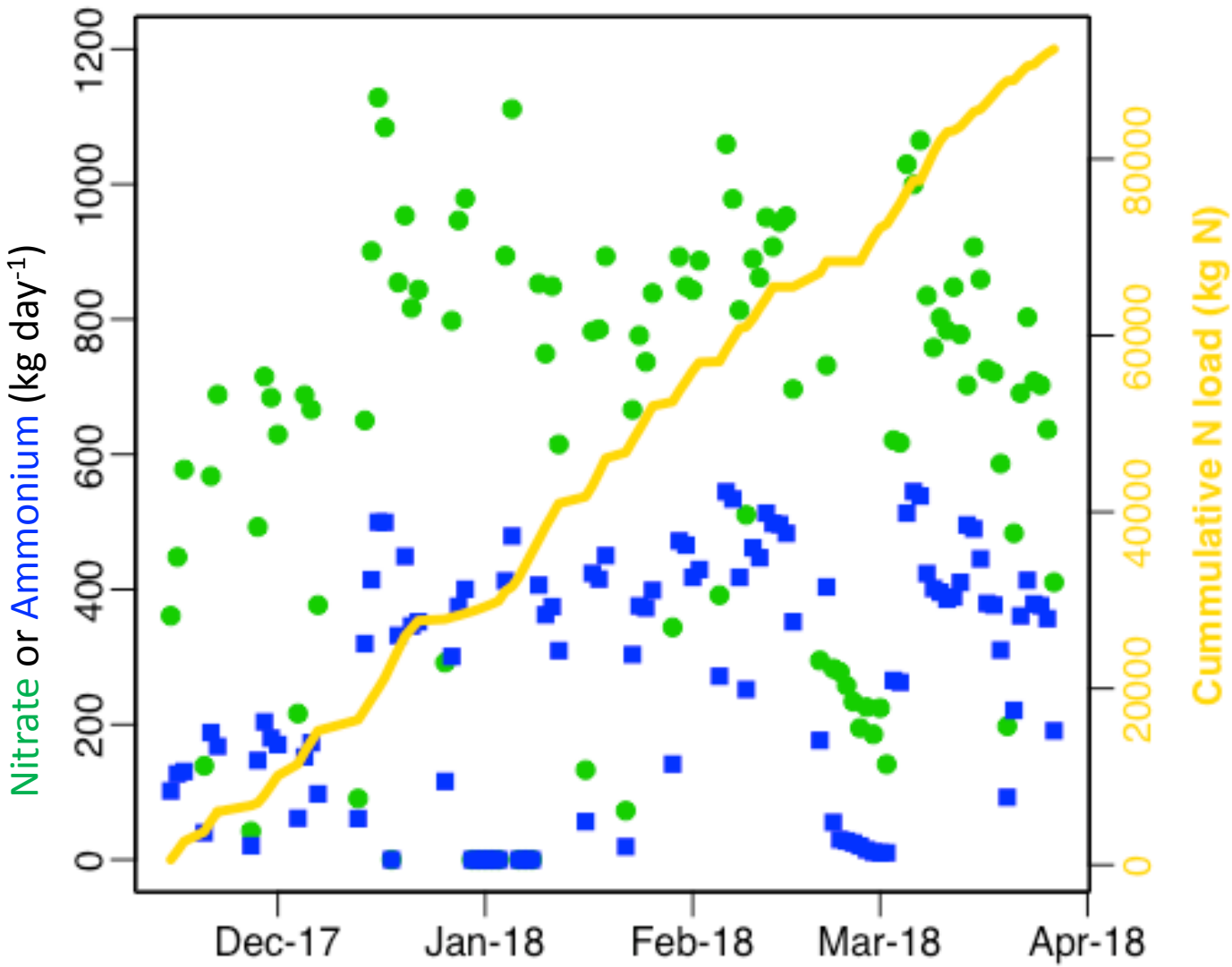
10 Jan. 2018)

Farmland Load to the Kansas River