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University of California, Davis

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Development of Stream Bacteria Transport Model for SWAT

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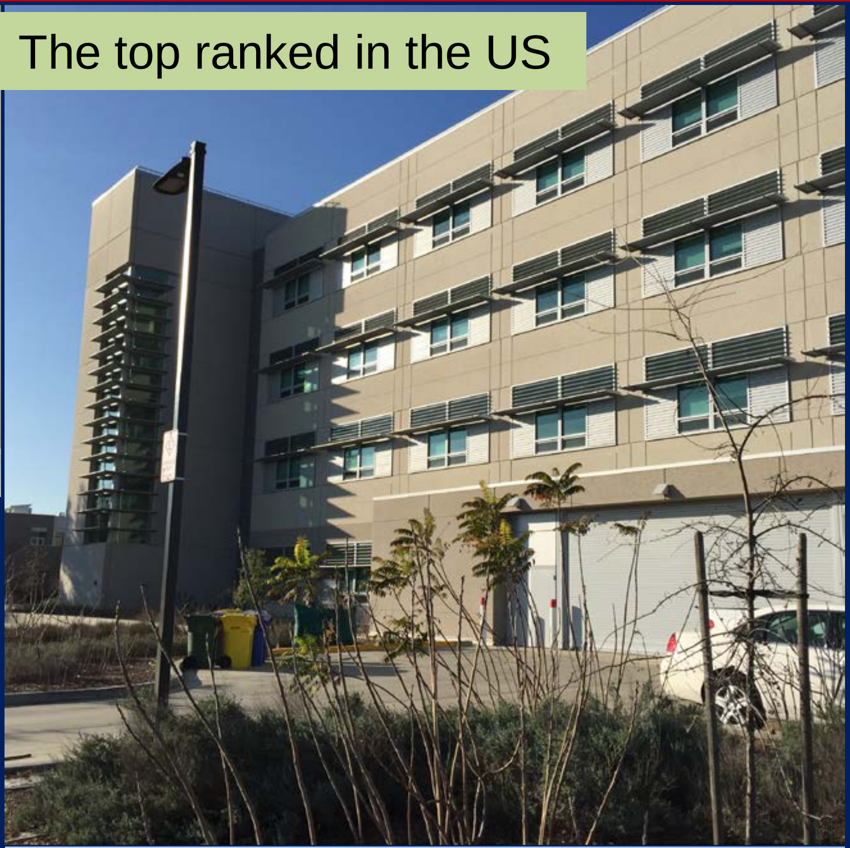
Drs Michelle Soupir, and Chris Rehmann

Iowa State University, Ames, Iowa

International Soil and Water Assessment Tool Conference
Beijing Normal University, China
July 27- 29, 2016

Brief Introduction – UC Vet Med School

The top ranked in the US



My research - water/bacteria/waste

Dairy farm

Dairy lagoon

Manure application

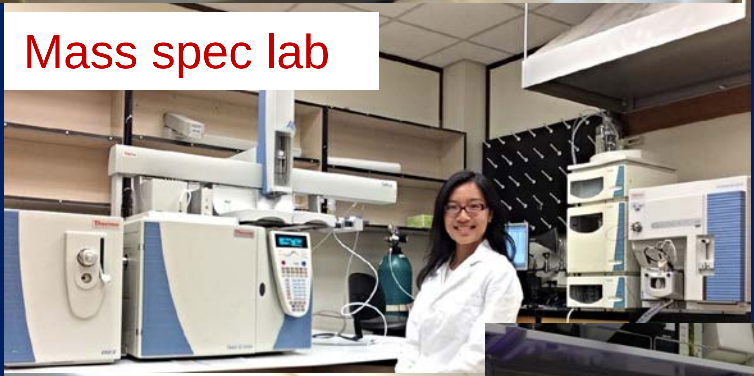
Yosemite National Park – Merced river

Water sampling

My lab research- microbiology/mass spec

Pathogen testing

Pathogen lab



Mass spec lab

Wet lab work

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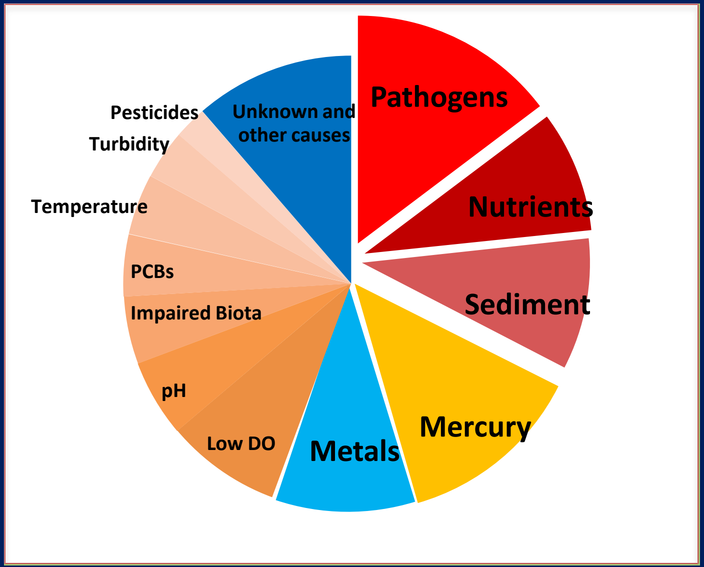
Bacteria Contamination-Why an issue?

- Pathogen contamination is the leading cause of impairments.



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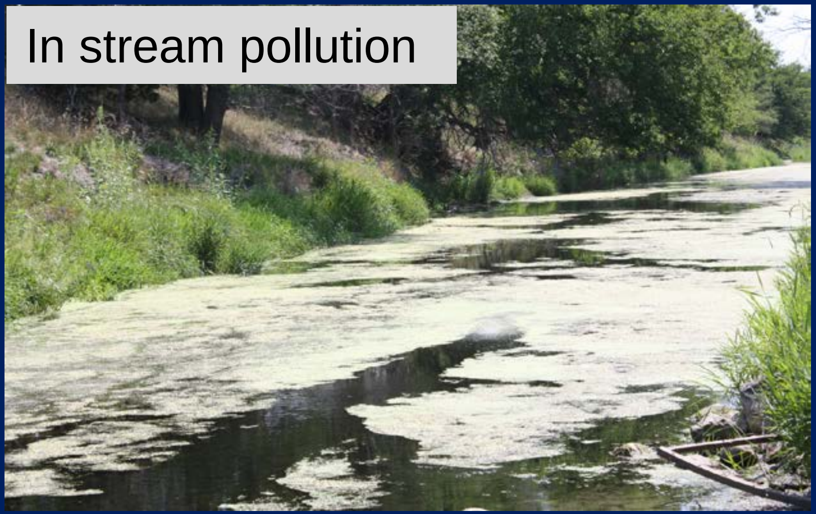
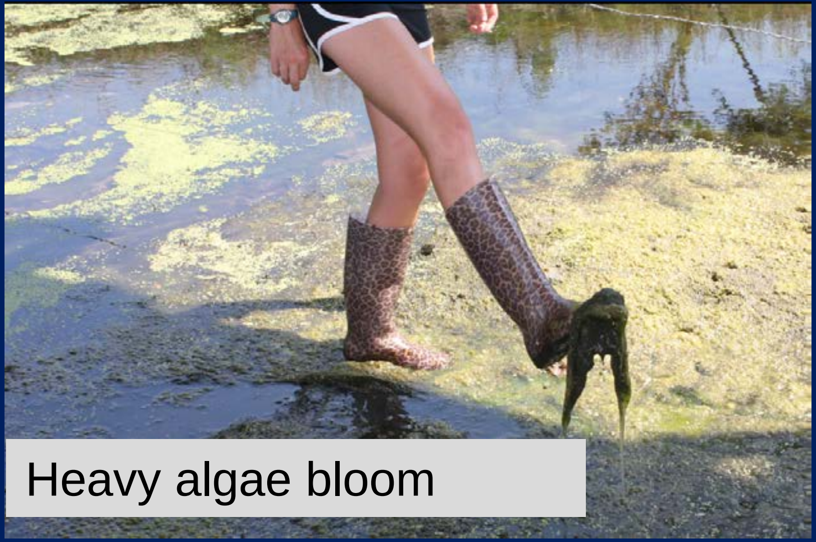
In-stream contamination – Iowa work


In stream pollution


Stream sampling in Iowa


Heavy algae bloom


Dead fish in streams

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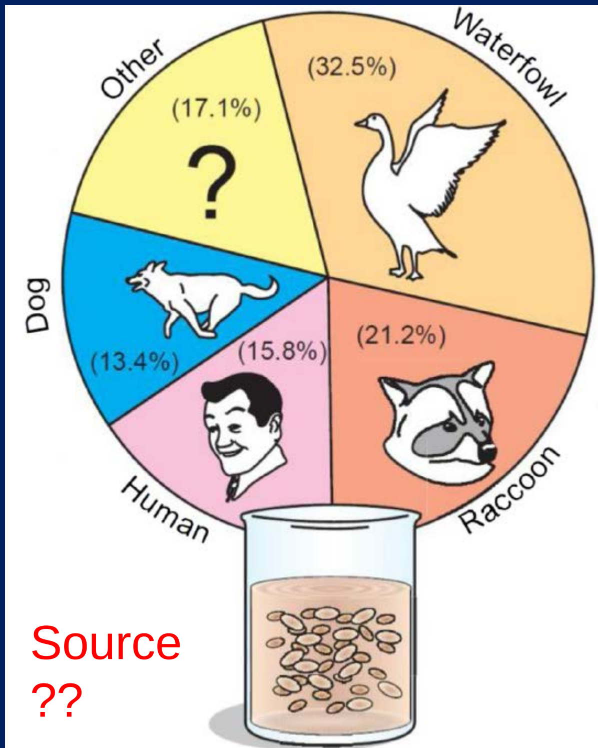
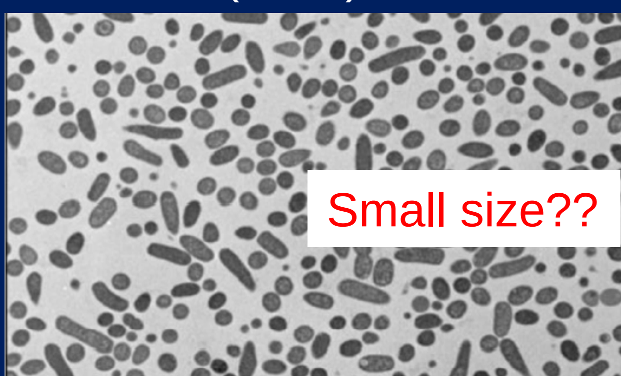
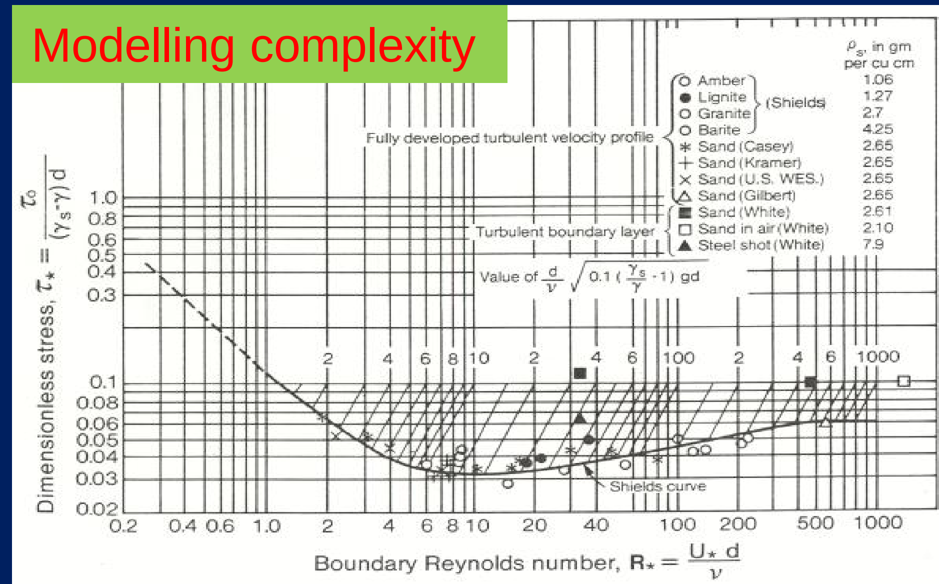
Challenges in bacteria transport modeling

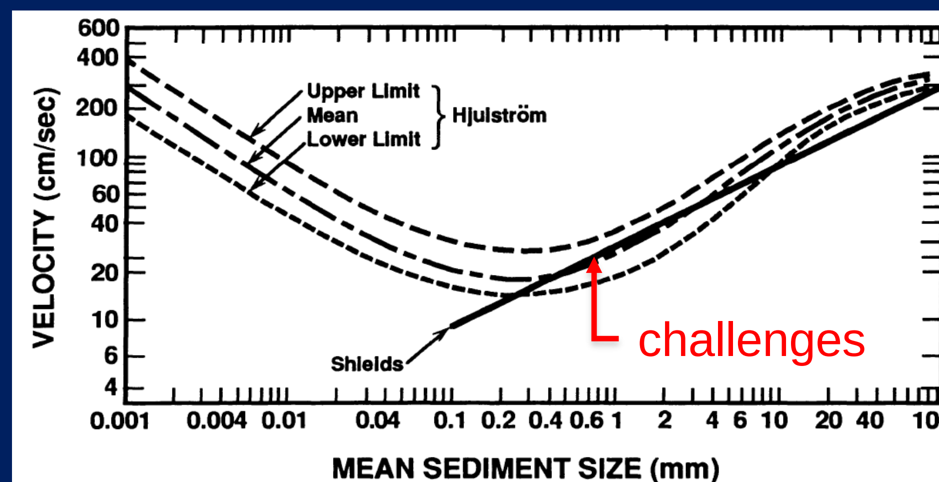


Malakoff (2002)



Pandey et al. (2014)





Issue: poor performance for small sizes < 0.002 mm
Solution: need for new empirical approaches

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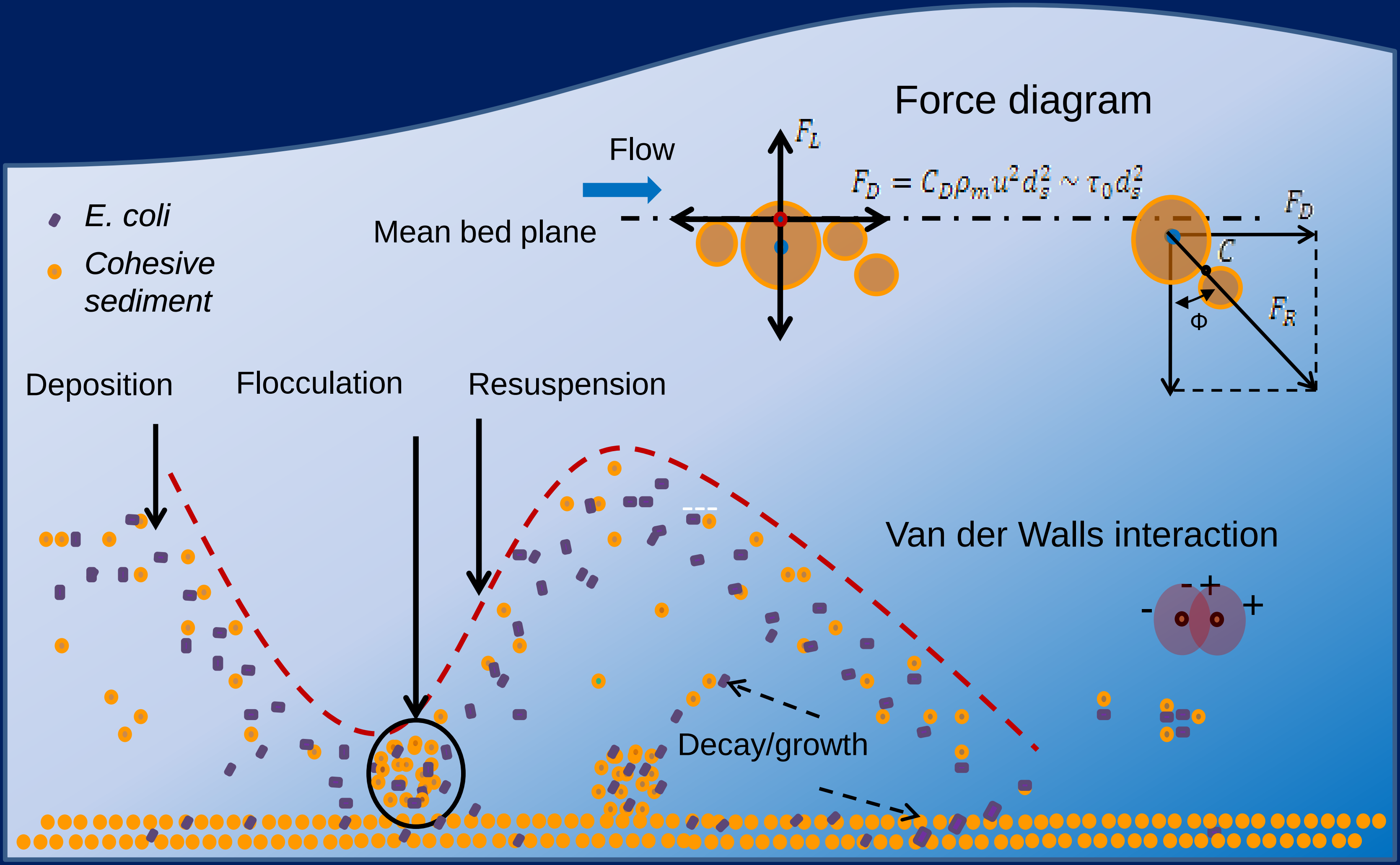
Conceptual bacteria dynamics in streams



Bacteria modelling-new empirical formula

New approach

$$\tau_c = \frac{C_2(F_c+F_g)}{C_1 d^2} \rightarrow \tau_c = \left(1+\frac{ae^{bp}}{d^2}\right)\tau_{cn}$$

$C_1 = \pi\rho_w C_d/8C$ $C_2 = constant$ $F_g = gravitational\ force$ $F_c = cohesive\ force$

$\tau_c = critical\ shear\ stress\ at\ cohesive\ and\ gravitational\ forces$

$$E = 10^{-4}\left(\frac{\tau-\tau_{cn}}{\tau_c-\tau_{cn}}\right)^n$$ and $\tau_{cn} = 414 \cdot d$; d= particle size

Semi - empirical approach

Shields parameter — Cohesive parameter

$\emptyset = Repose\ angle$

$$\frac{\tau_{cs}}{g(\rho_{sf}-\rho)d} = \frac{\alpha_3 \tan\phi}{(\alpha_1+\alpha_2\tan\phi)} + \frac{F_c\tan\phi/(\alpha_1+\alpha_2\tan\phi)}{g(\rho_{sf}-\rho)d^3}$$

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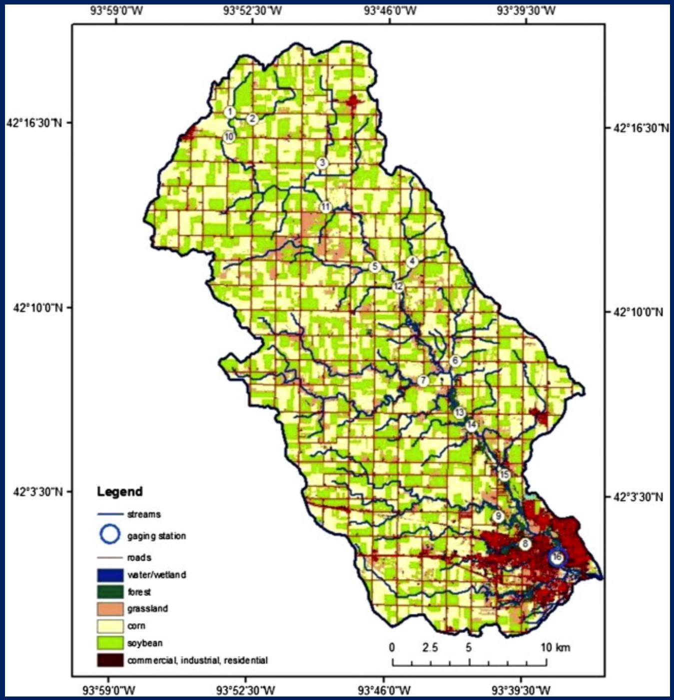
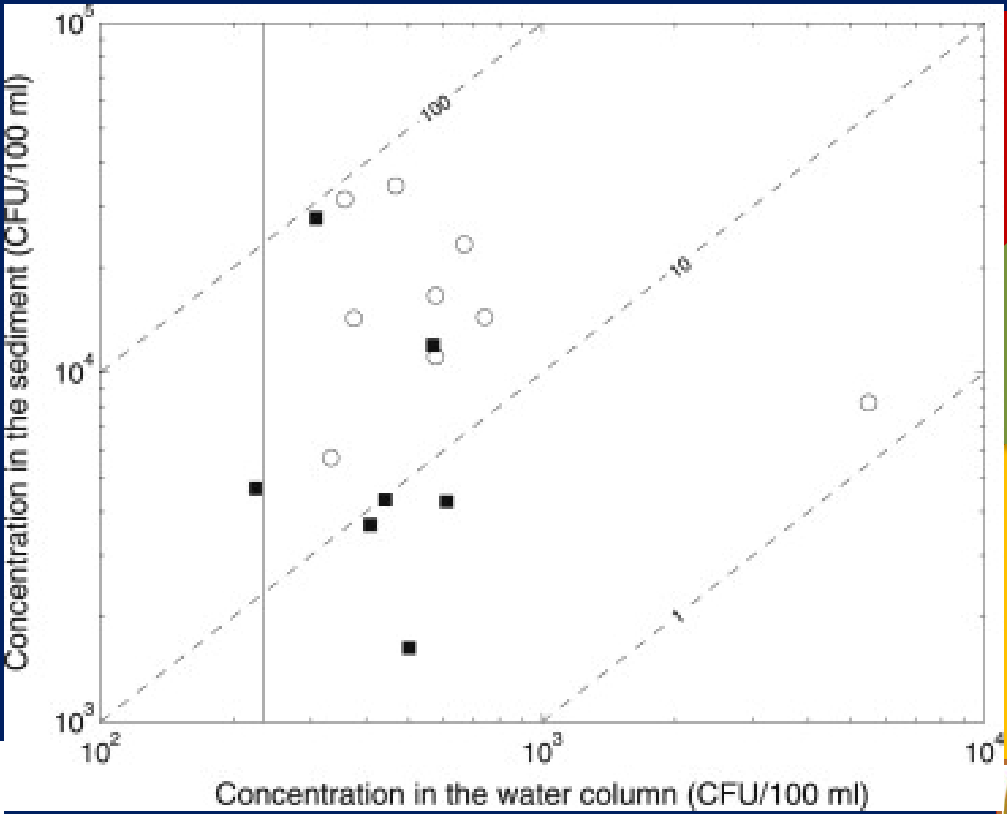
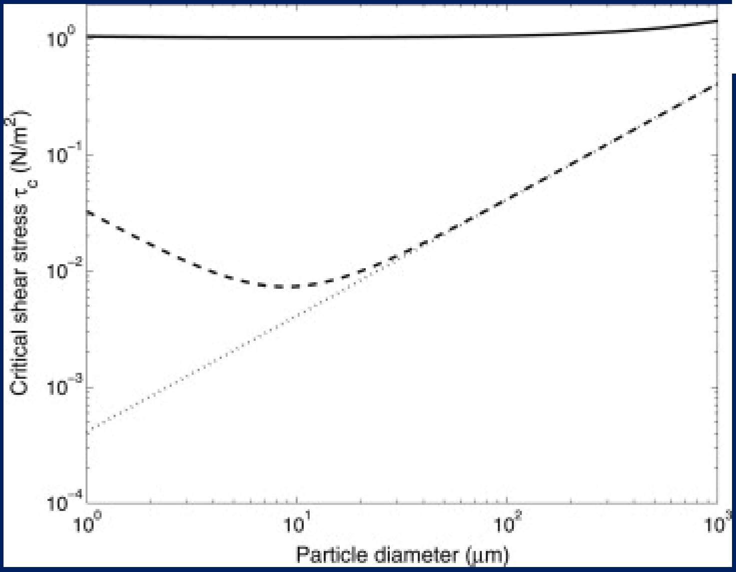
Bacteria modelling – 1. Resuspension in stream







ELSEVIER

Water Research

Volume 46, Issue 1, 1 January 2012, Pages 115–126

A model for predicting resuspension of *Escherichia coli* from streambed sediments

Pramod K. Pandey[a], Michelle L. Soupir[a], Chris R. Rehmann[b]

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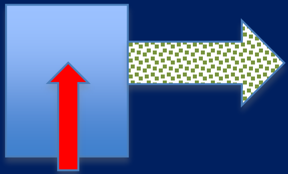
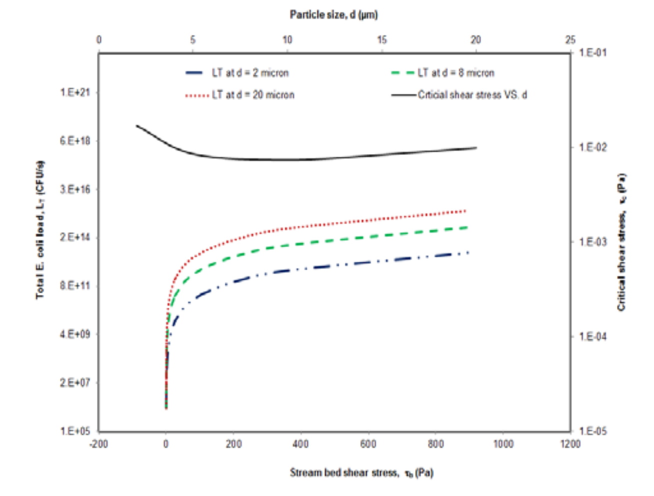
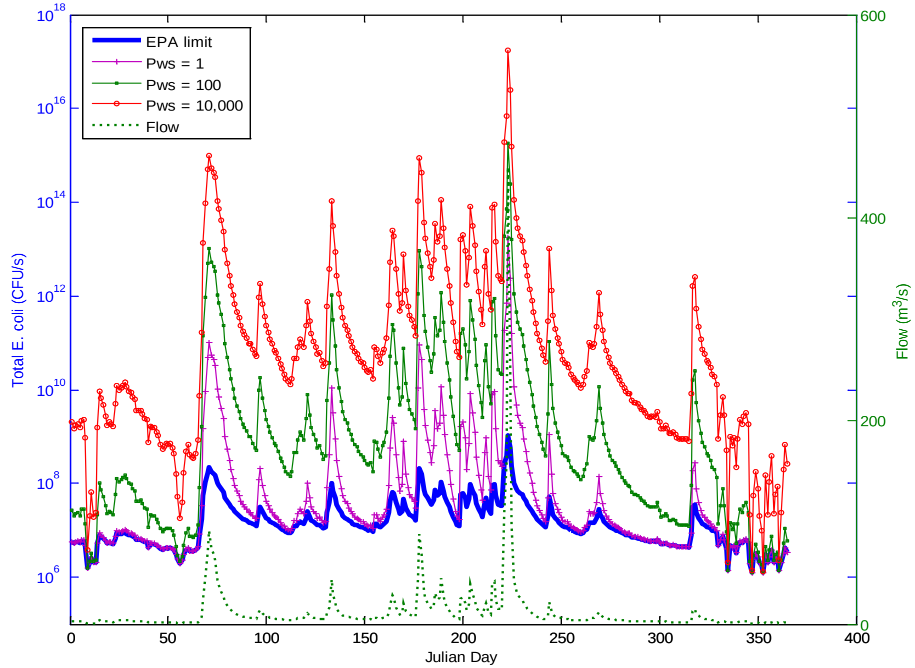
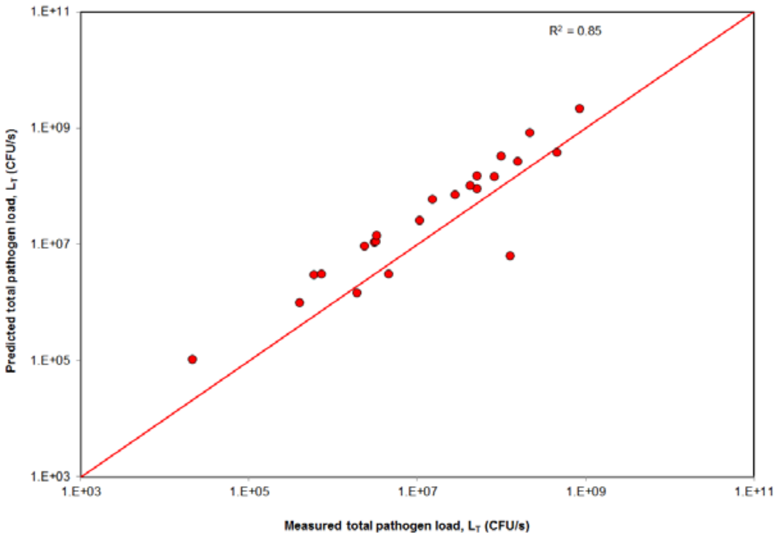
Bacteria modelling- 2. Pathogen Load









Technical Paper

Assessing the Impacts of *E. coli* Laden Streambed Sediment on *E. coli* Loads over a Range of Flows and Sediment Characteristics†

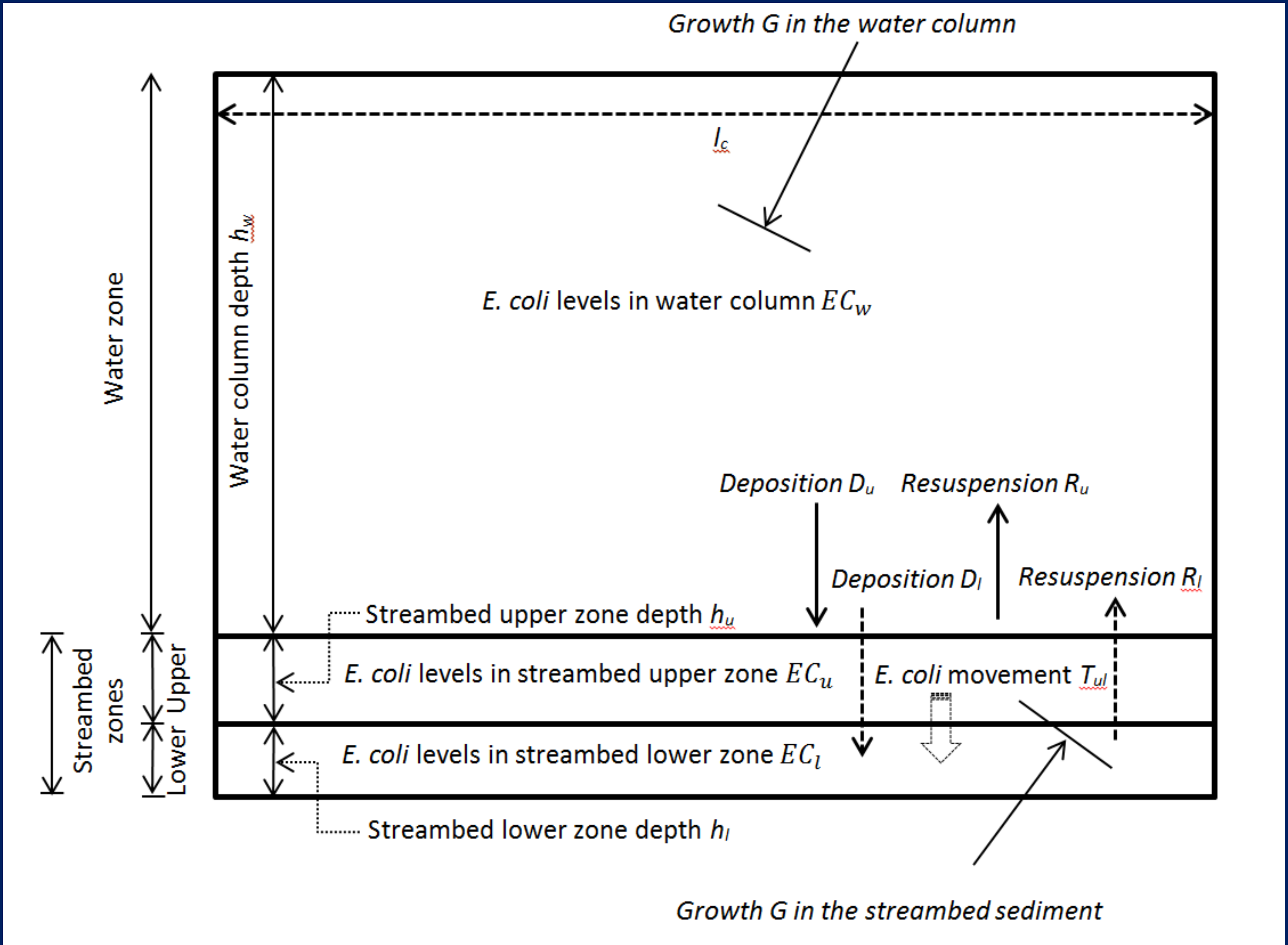
Pramod K. Pandey Postdoctoral scholar
and Michelle L. Soupir Assistant Professor

Version of Record online: 21 JUN 2013
DOI: 10.1111/jawr.12079

Issue

JAWRA Journal of the American Water Resources Association
Volume 49, Issue 6, pages 1261–1269, December 2013

Bacteria modelling- 3. SWAT model



Bacteria (*E. coli*) monitoring in stream

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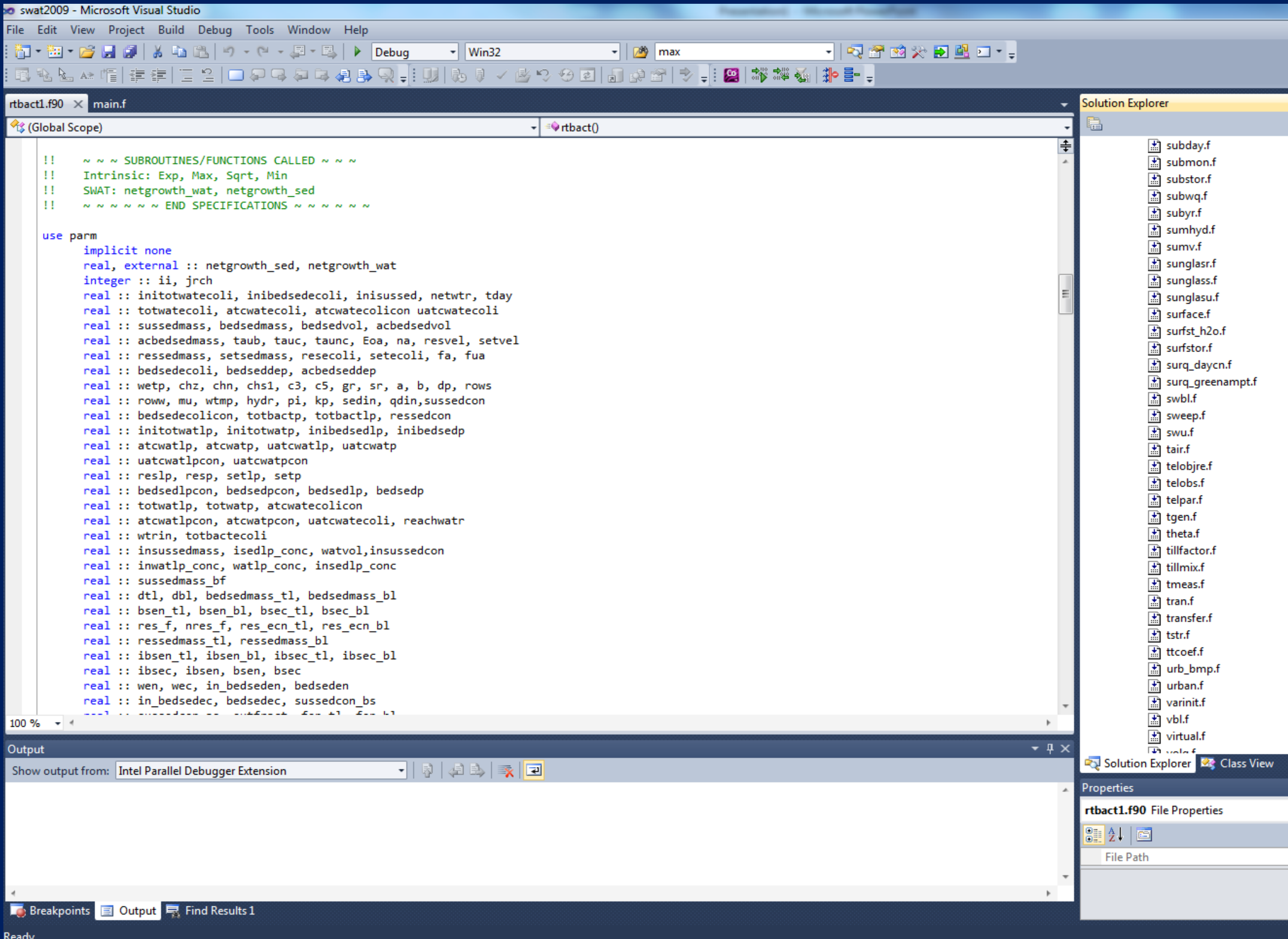
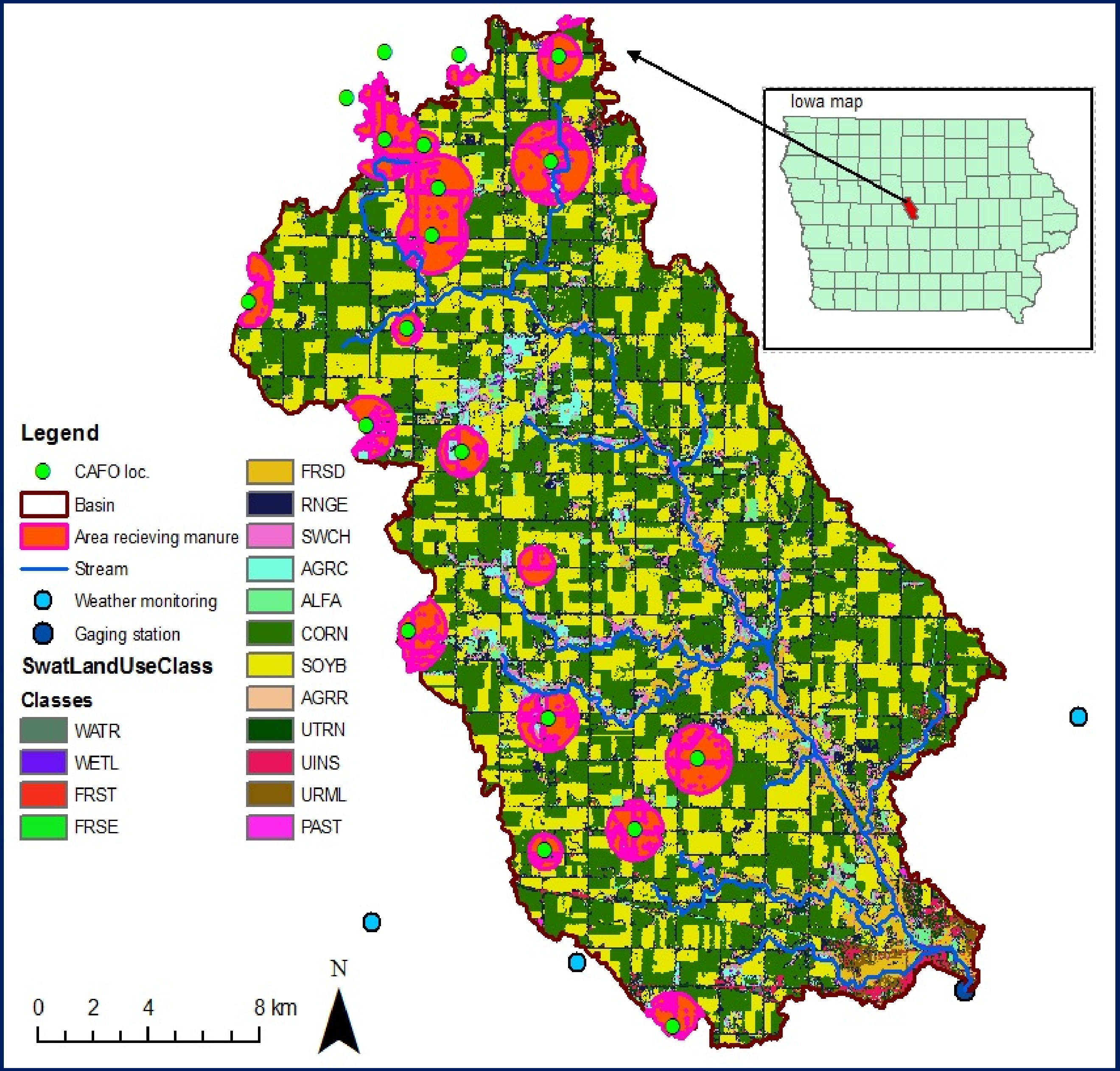
Subroutines for SWAT bacteria transport



My background/experience in programming of ROTO model did help; challenges were in GIS interphase

SWAT setup - Bacteria modeling



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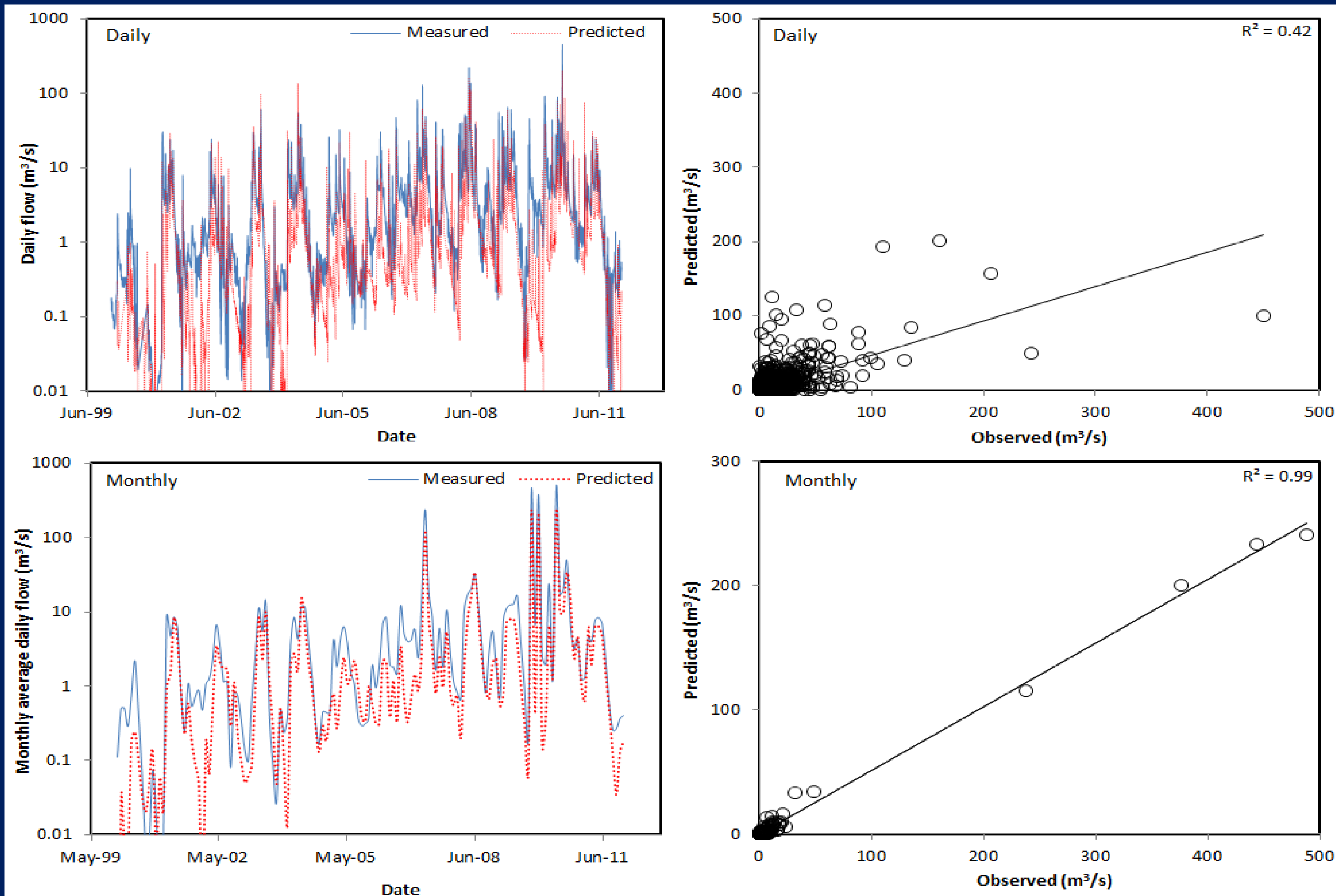
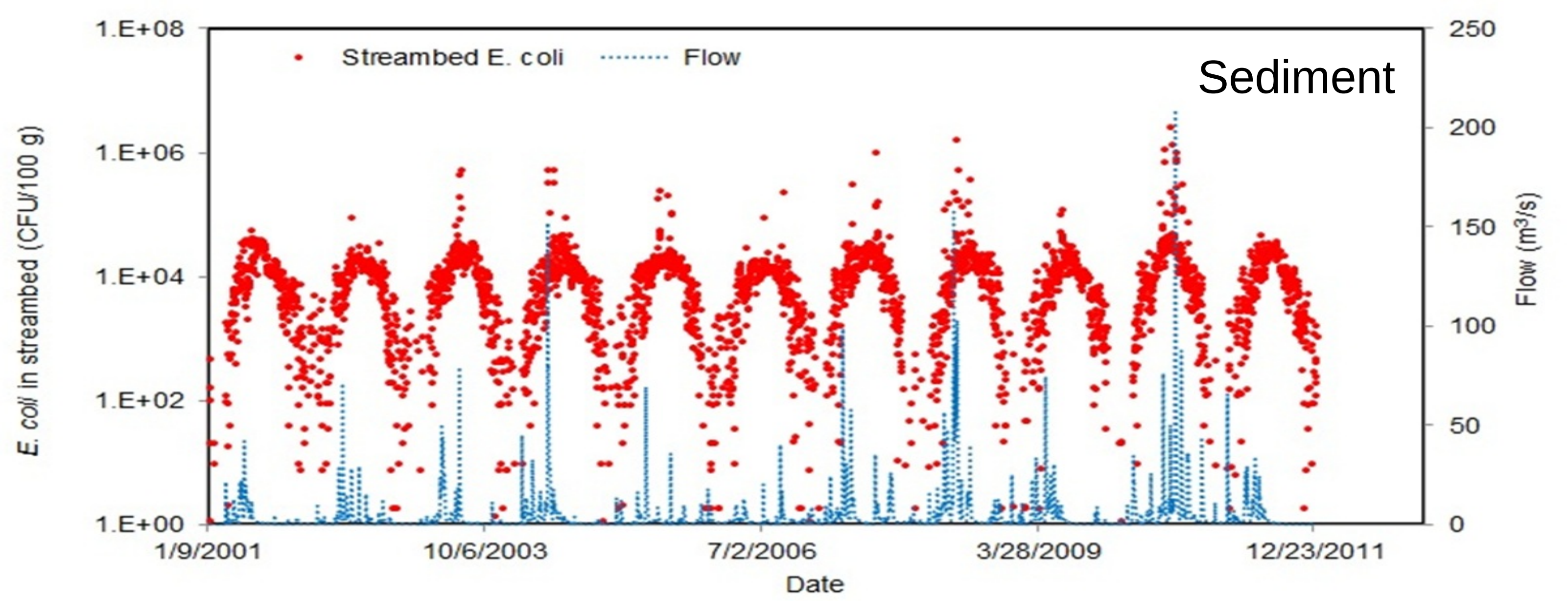
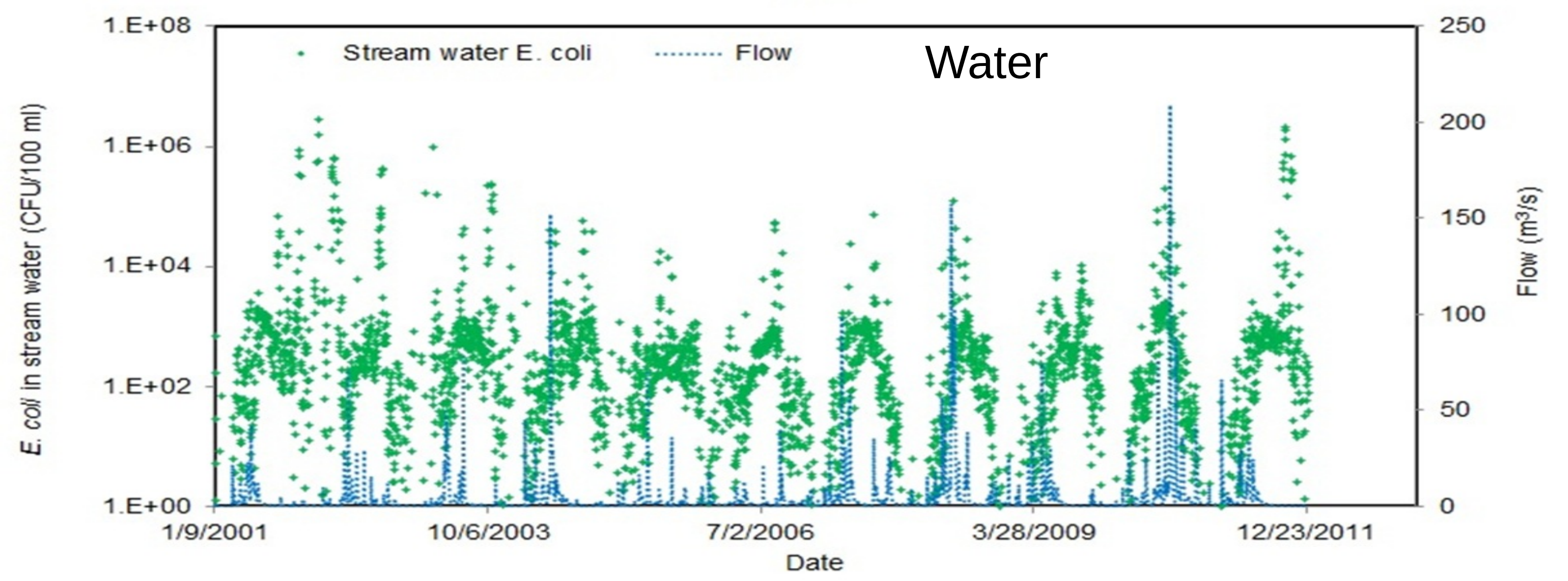
SWAT in-stream flow (observ./pred.)

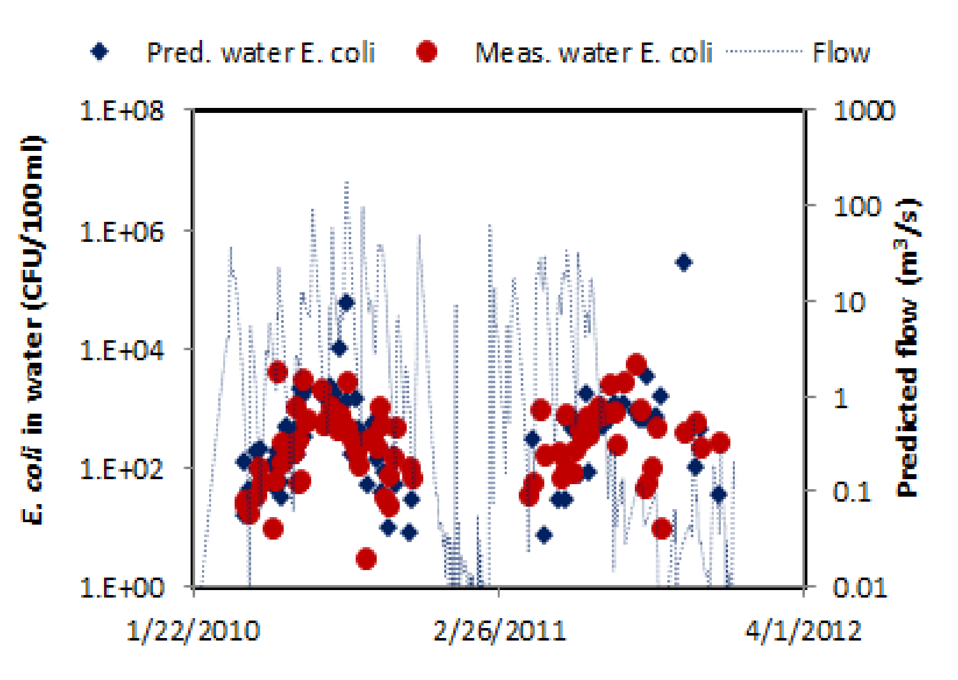


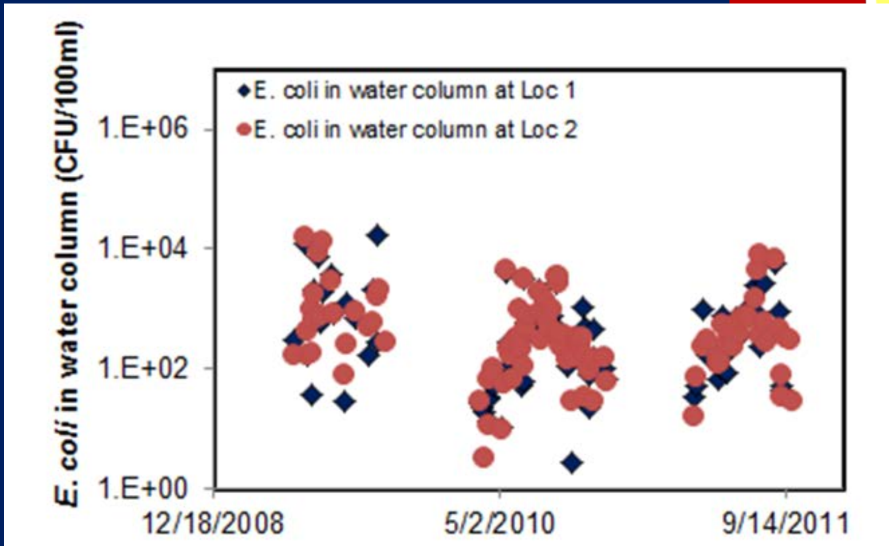
SWAT bacteria predictions

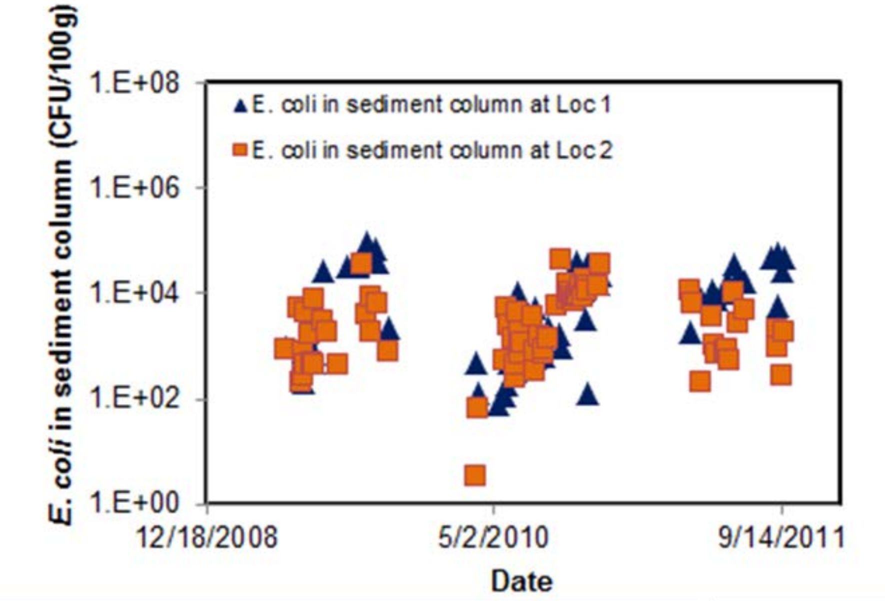




Pathogen modelling in stream







Bacteria field work – relatively expensive

Technical Paper

Predicting Streambed Sediment and Water Column *Escherichia coli* Levels at Watershed Scale†

Pramod K. Pandey Assistant Specialist[1], Michelle L. Soupir Associate Professor[2], Charles D. Ikenberry Graduate Student[2] and Chris R. Rehmann Professor[3]

Version of Record online: 18 DEC 2015

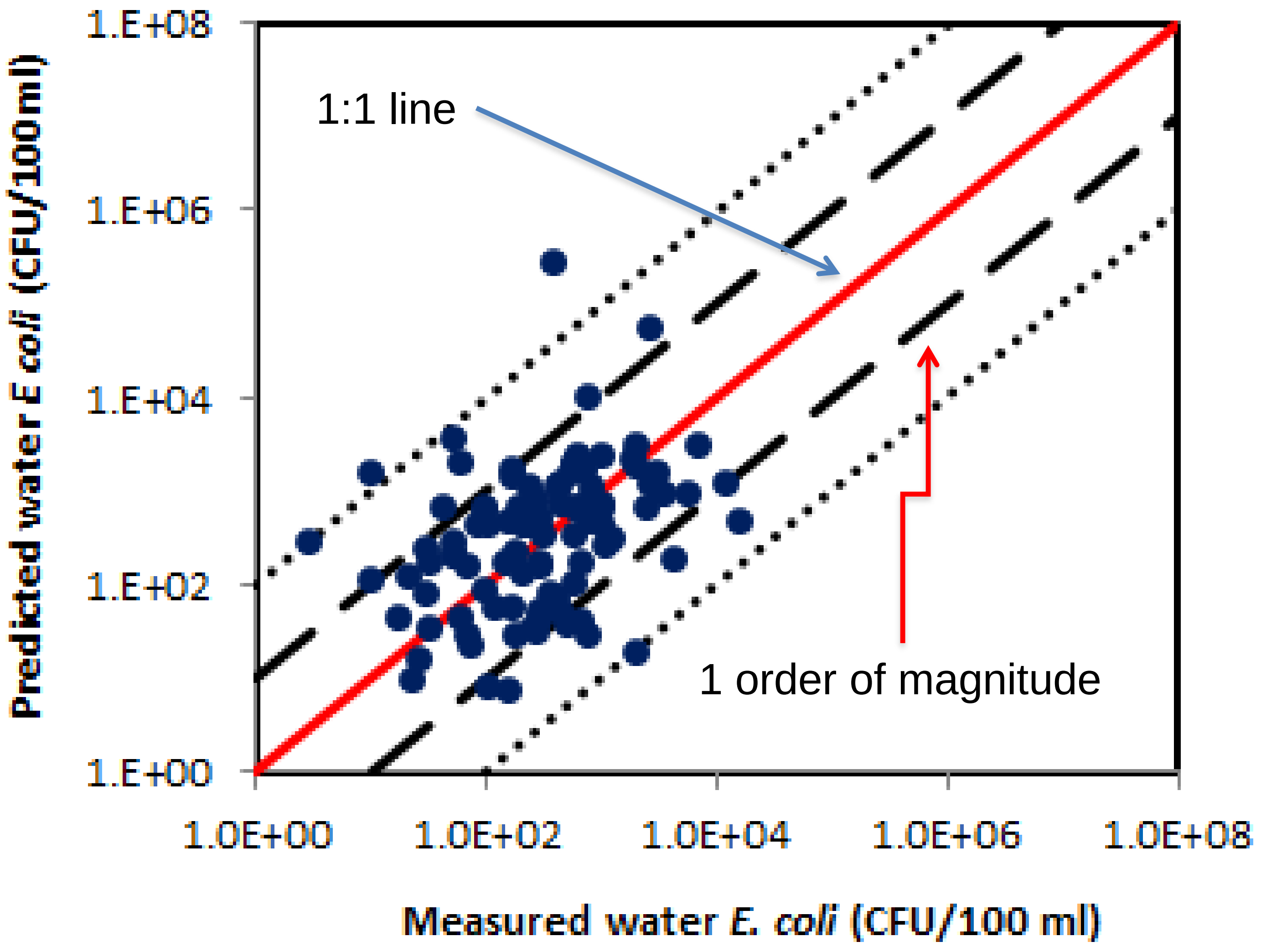
DOI: 10.1111/1752-1688.12372

Issue

JAWRA Journal of the American Water Resources Association

Volume 52, Issue 1, pages 184–197, February 2016

SWAT bacteria predictions and observations (predictability estimation)



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Conclusions of this bacteria modelling

- Modified SWAT model can improve the estimation of bacteria transport at watershed scale.
- This will be the first model to understand bacteria dynamics in streambed sediment (not found reported yet)
- This model predicts pathogen concentrations in the sediment bed as well as in water column simultaneously.
- The predictions were verified in the Squaw Creek Watershed, Iowa; and approximately 82% of the water column predictions and 62% of the streambed sediment bacteria predictions fall within 1 order of magnitude of bacteria measured data.

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Acknowledgments

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- National Science Foundation (NSF)
- Environmental Protection Agency (EPA)

Thank you

Question please ??

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