Grand River Modeling: Water Quality and Land Use

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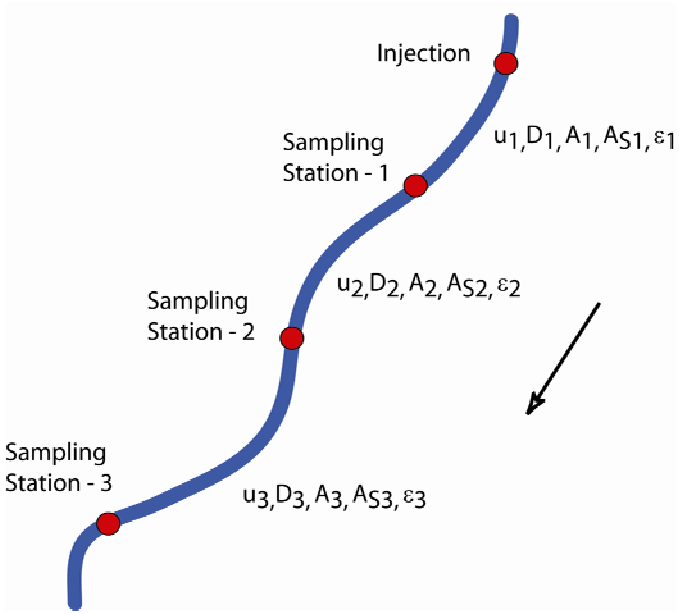
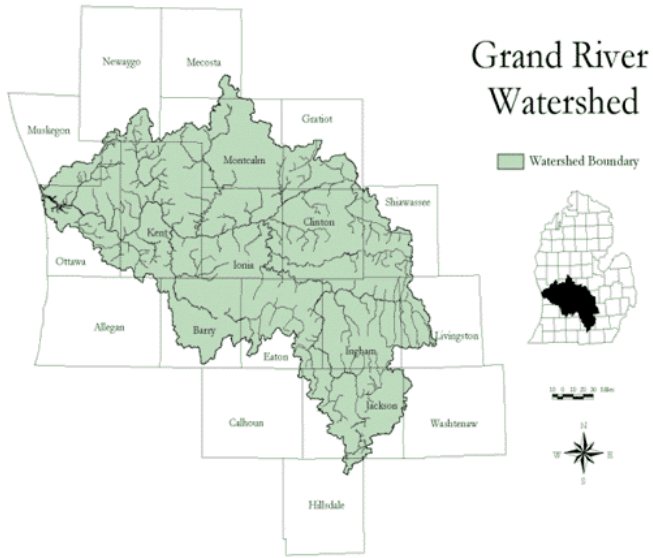
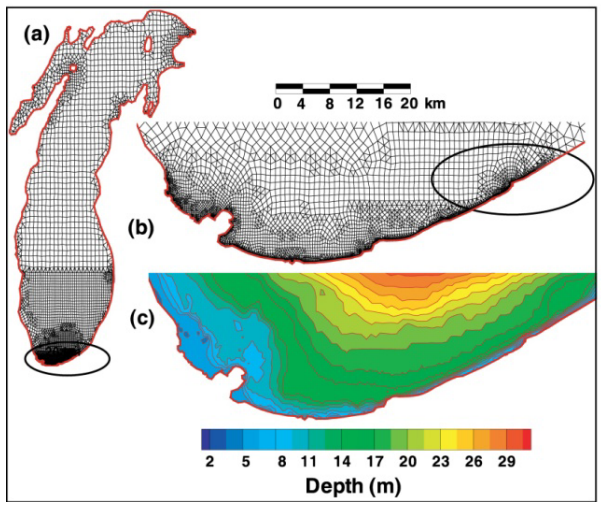
Fate & Transport of Contaminants: In-Stream, Watershed and Near-shore Environments



In-Stream



Watershed



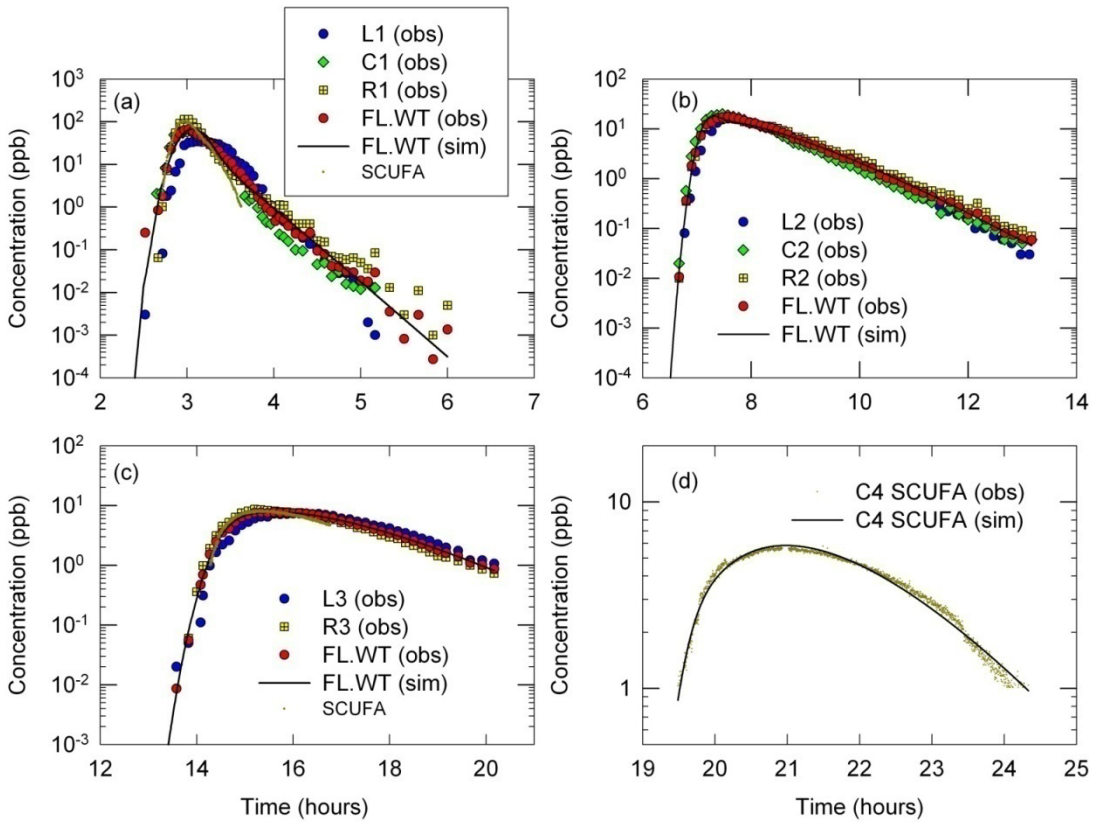
Near-shore Modeling

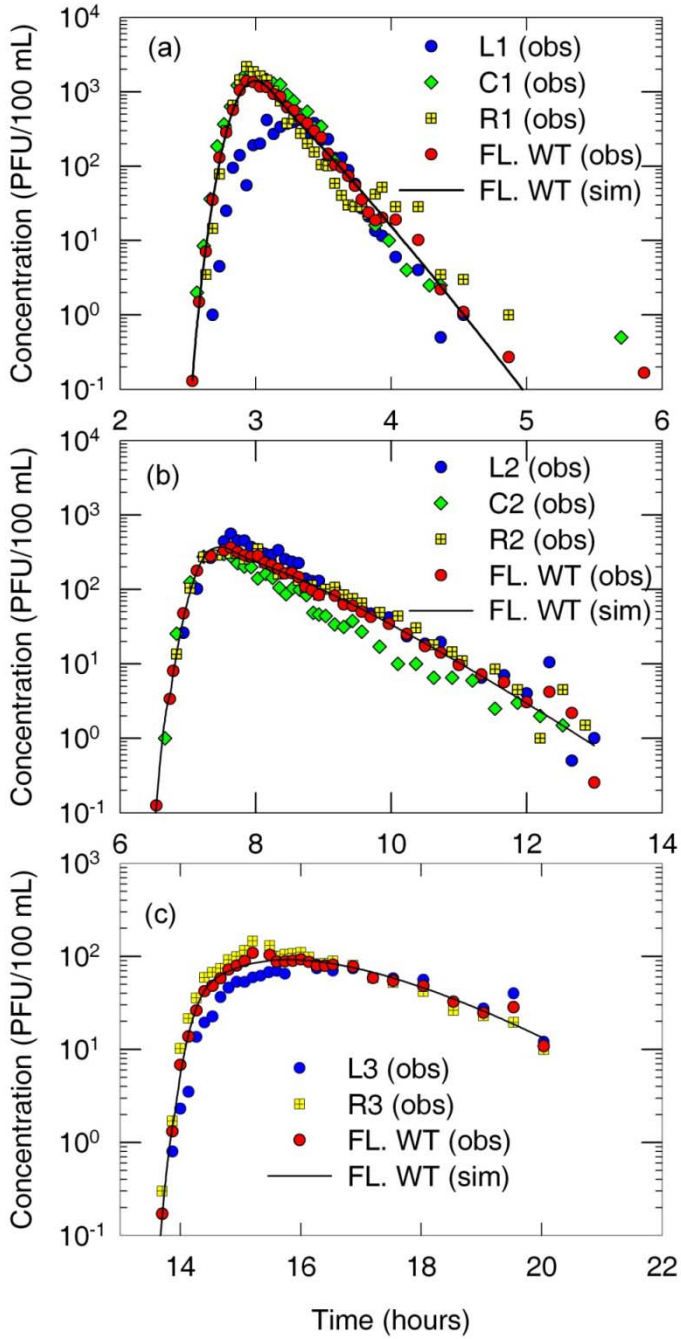
Transport of Chemical & Biological Agents: The Grand River, MI

- What are the major differences in the transport of chemical and biological agents?

Transport of Chemical & Biological Agents in the Grand River

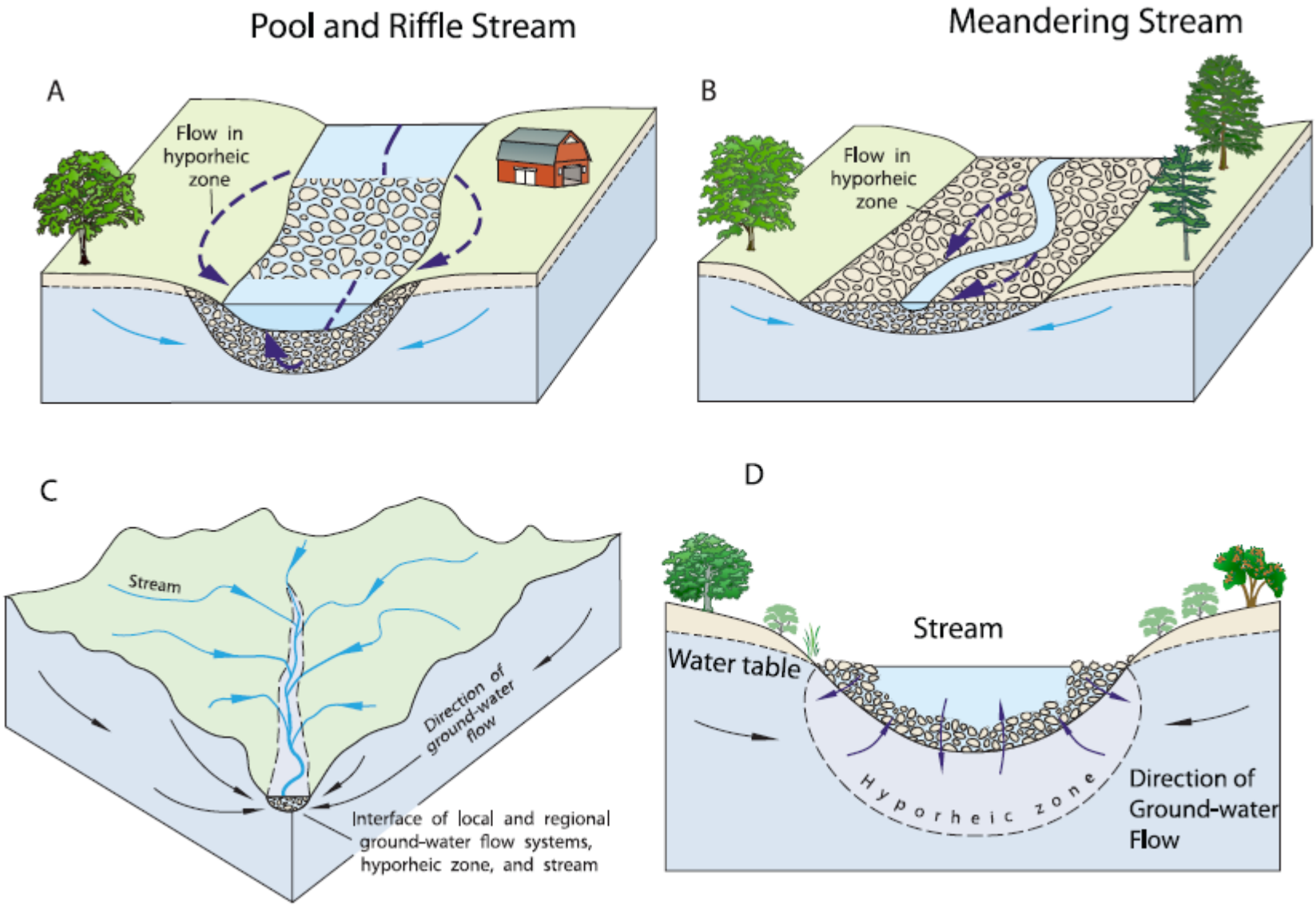
Chemical (Rhodamine WT):





Biological (Virus):

TS = Surface Storage + Hyporheic Retention



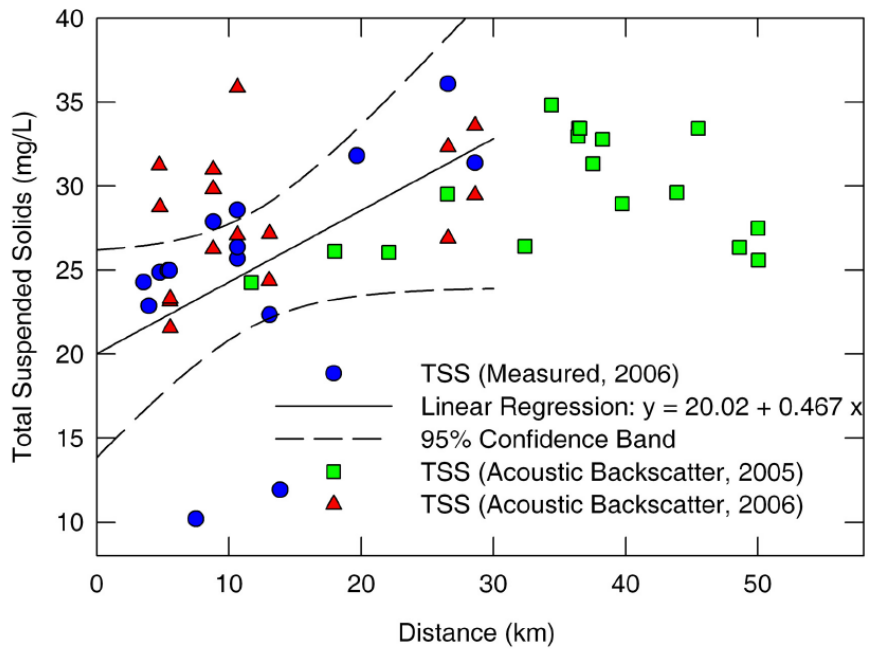
Reach	Urban+ Transportation	Agricultural	Herbaceous+ Park	Forest	Aquatic	Bare Soil
1	52.2%	21.2%	7.1%	16.1%	3.1%	0.2%
2	47.1%	19.0%	9.7%	20.8%	2.7%	0.7%
3	24.0%	45.4%	9.6%	17.8%	2.3%	0.8%
4	8.3%	69.2%	5.3%	14.4%	2.2%	0.5%

Transport of Chemical & Biological Agents in the Grand River

	R-squared	Correlation
Urban (RWT)	0.35	Negative
Agricultural (RWT)	0.14	Positive
Forested (RWT)	0.67	Positive
Urban (P22)	0.86	Negative
Agricultural (P22)	0.65	Positive
Forested (P22)	0.15	Positive

*

Relating Channel Storage to Land Use



* C. Shen, M. Phanikumar, I. Aslam,T. Fong and J. Rose, *Environmental Science & Technol* (in review)

Conclusions:

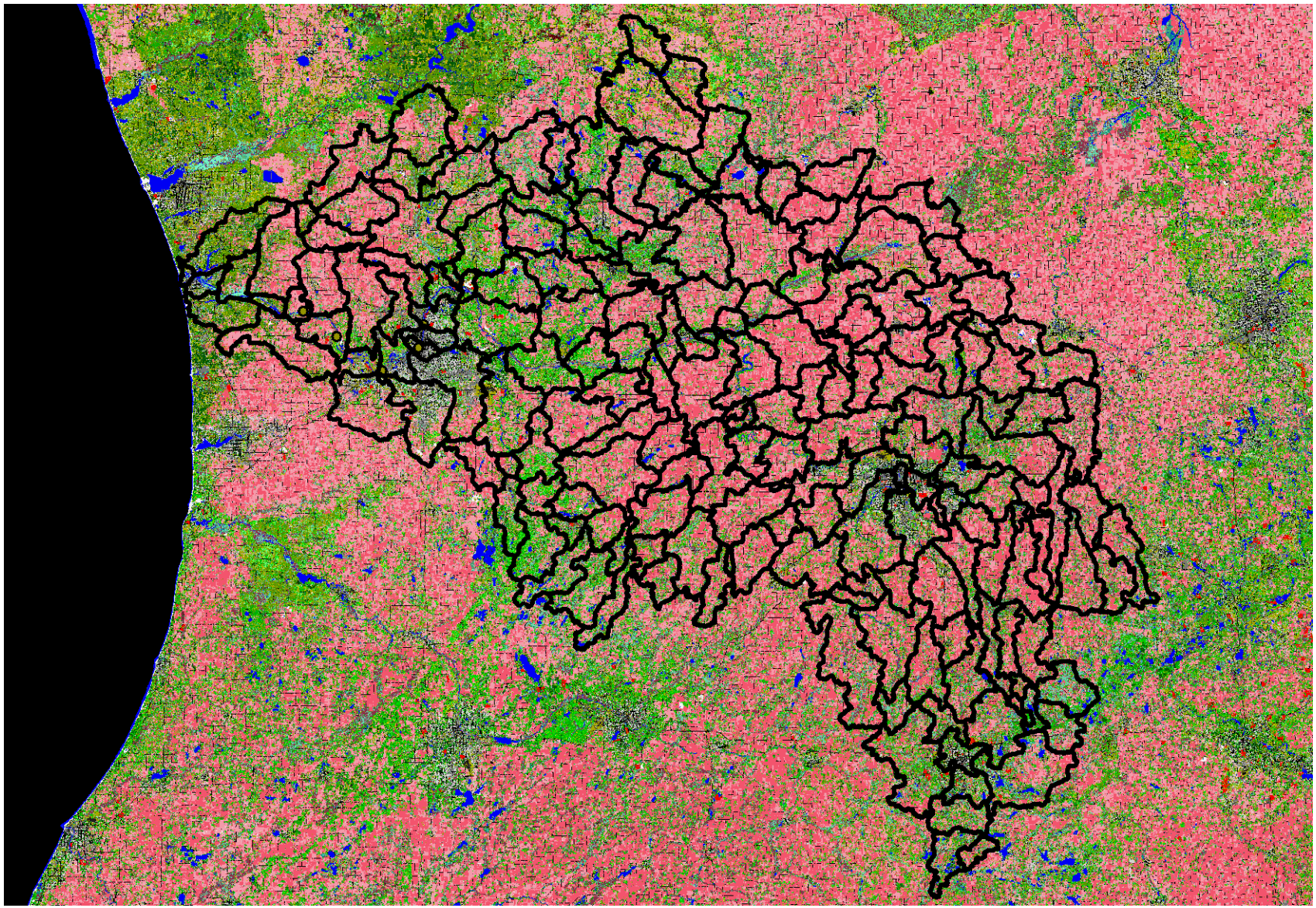
Dissolved versus suspended particulate matter means:

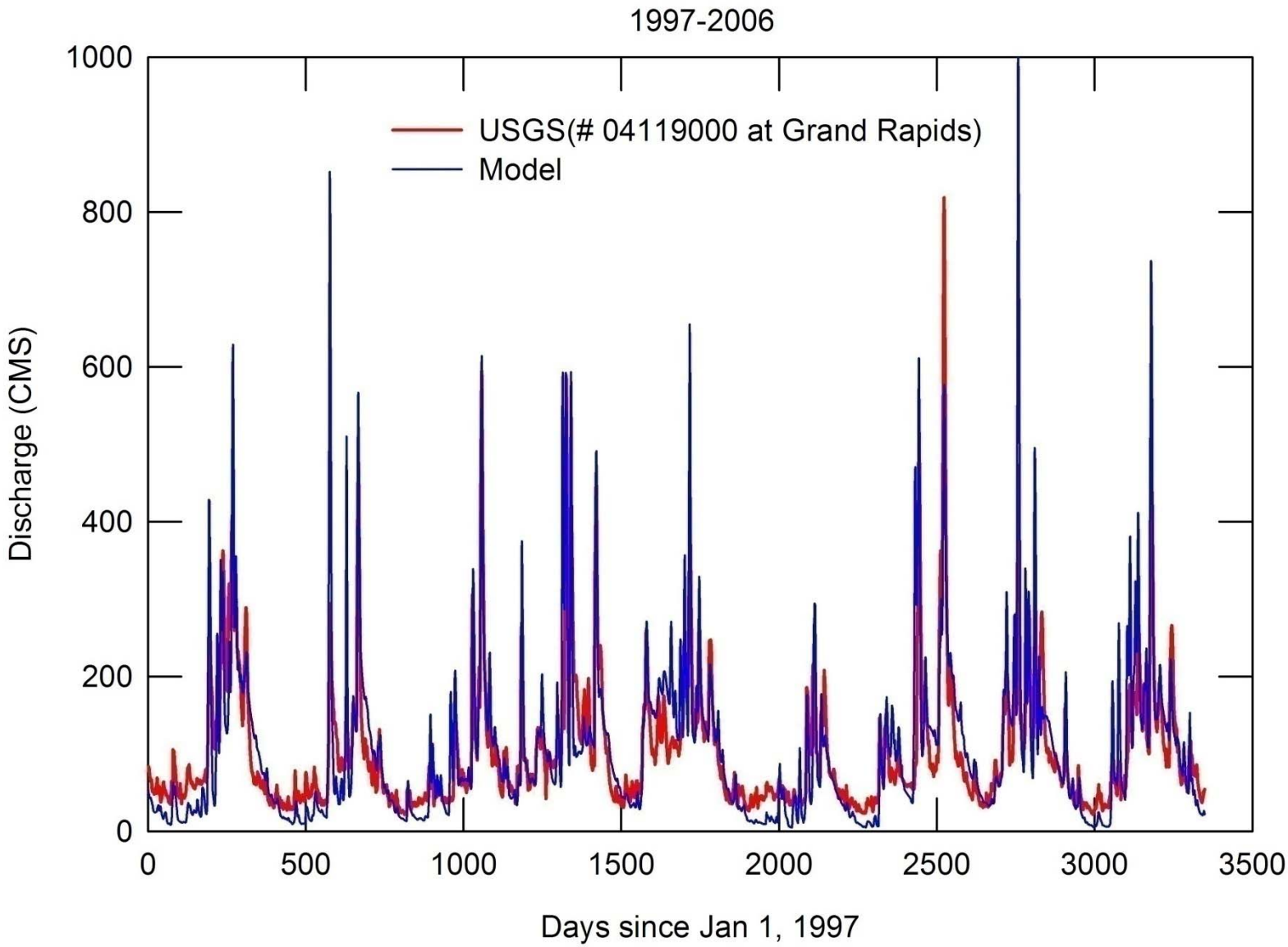
- Potentially different sizes of storage zones
- Different retention times in storage zones
- Losses due to settling
- Resuspension
- Sunlight

Result:

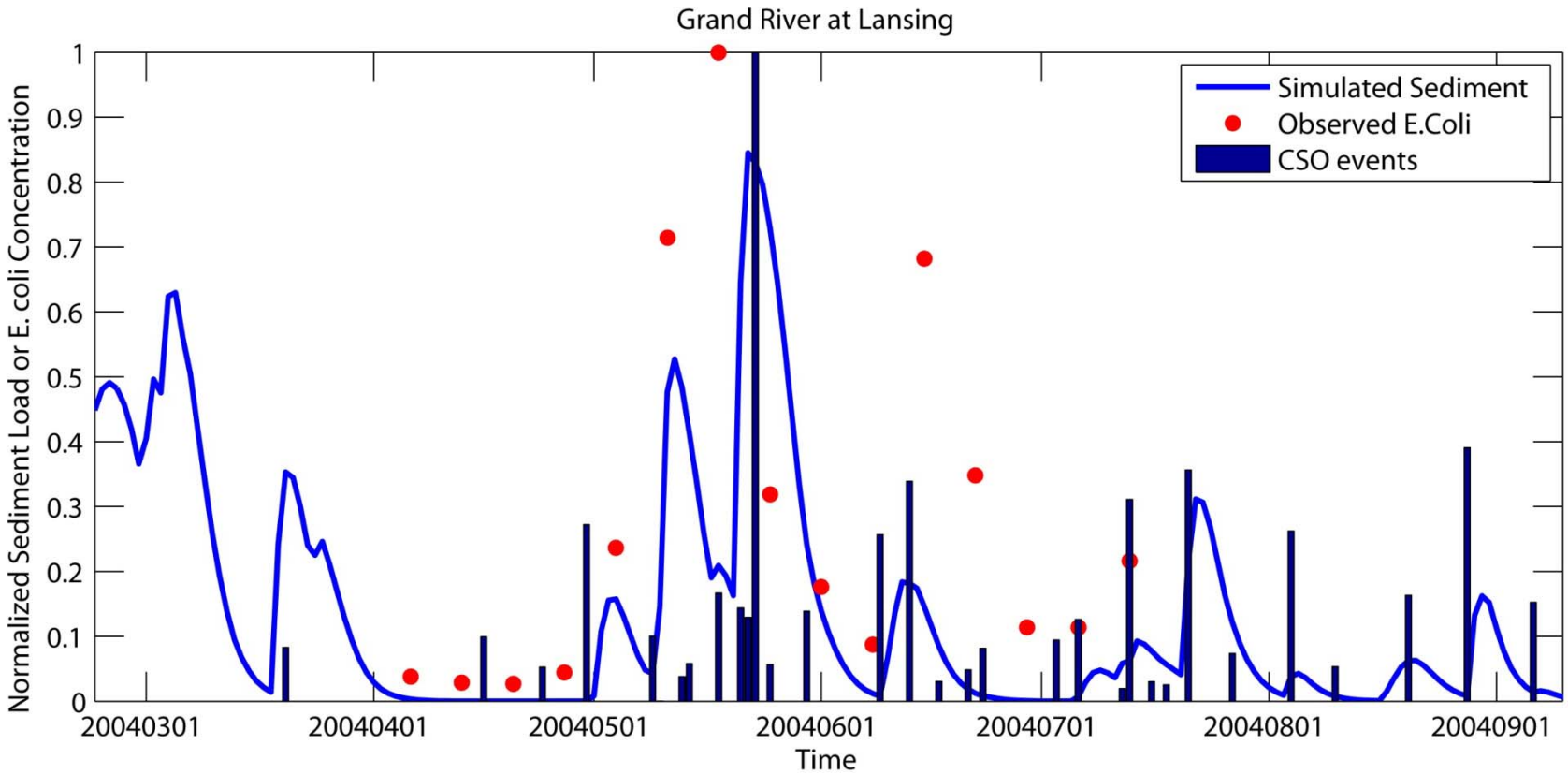
Peaks in breakthrough curves are attenuated, shifted in time or both

The Grand River Watershed




1997-2006
USGS(# 04119000 at Grand Rapids)
Model
Discharge (CMS)
Days since Jan 1, 1997
0
200
400
600
800
1000
0
500
1000
1500
2000
2500
3000
3500

E. Coli and Suspended Sediment



Update

A New Process-Based Watershed Model for Grand River will be ready in Spring 2009:

* Can model both water quantity and water quality issues

Bacterial Fecal Indicators in Water and Sediment of Parks & Beaches

Aim: To determine the quality of surface water in Grand River including contamination in sediments

Sites & Indicators

Eight sites along the Grand River were examined for fecal indicators:

- Fecal coliforms
- *E. Coli*
- enterococci
- C. perfringens
- coliphage

Indicators

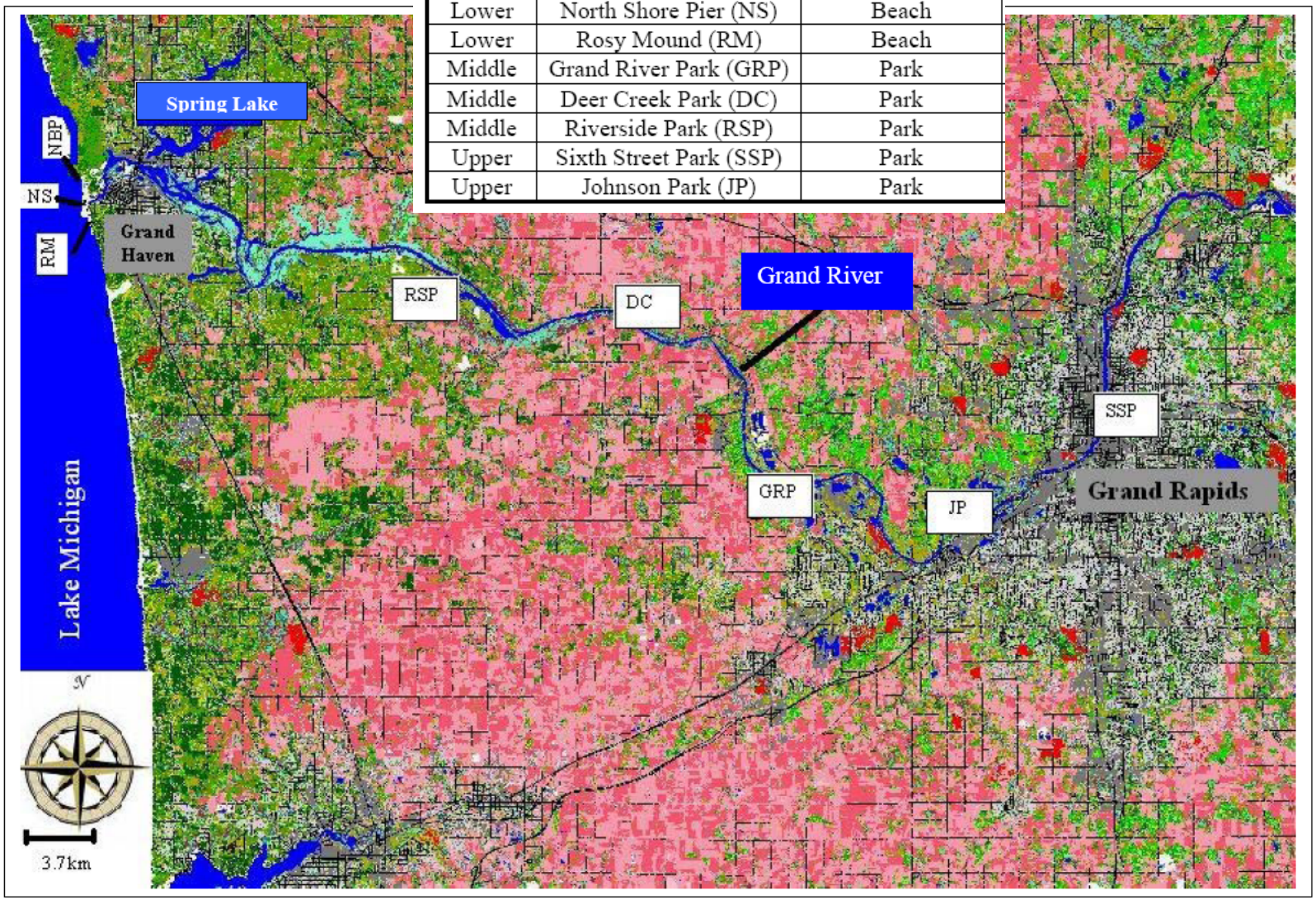
Coliforms live in the digestive tract of warm-blooded animals… indicate the possible presence of other fecal pathogens, disease-causing bacteria

Enterococci are part of the fecal streptococci group; not restricted to humans.

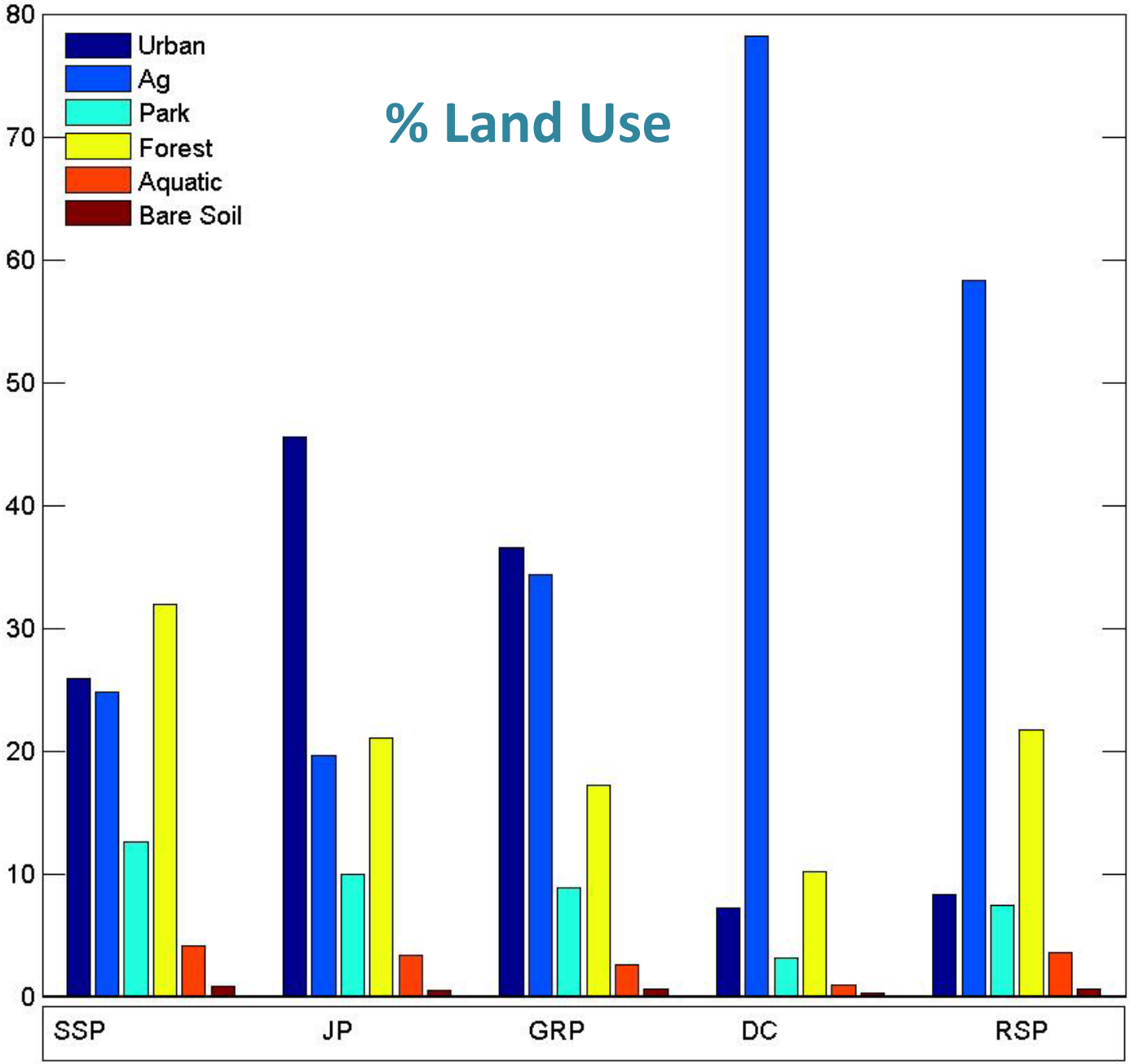
Clostridium perfringens are spore forming bacteria which replicate under anaerobic conditions… an indication of persistent pollution... Due to lower decay rates, *C. perfringens* can persist in the environment significantly longer than enteric pathogens making them good indicators of fecal pollution

Viruses are microscopic nano particles which infect cells of a living organism and cannot replicate on their own. Bacteriophage are virus that infect bacteria, and coliphages are bacteriophages that are specific to the host E. coli. Because coliphages come from fecal material, their presence in water bodies indicates fecal contamination

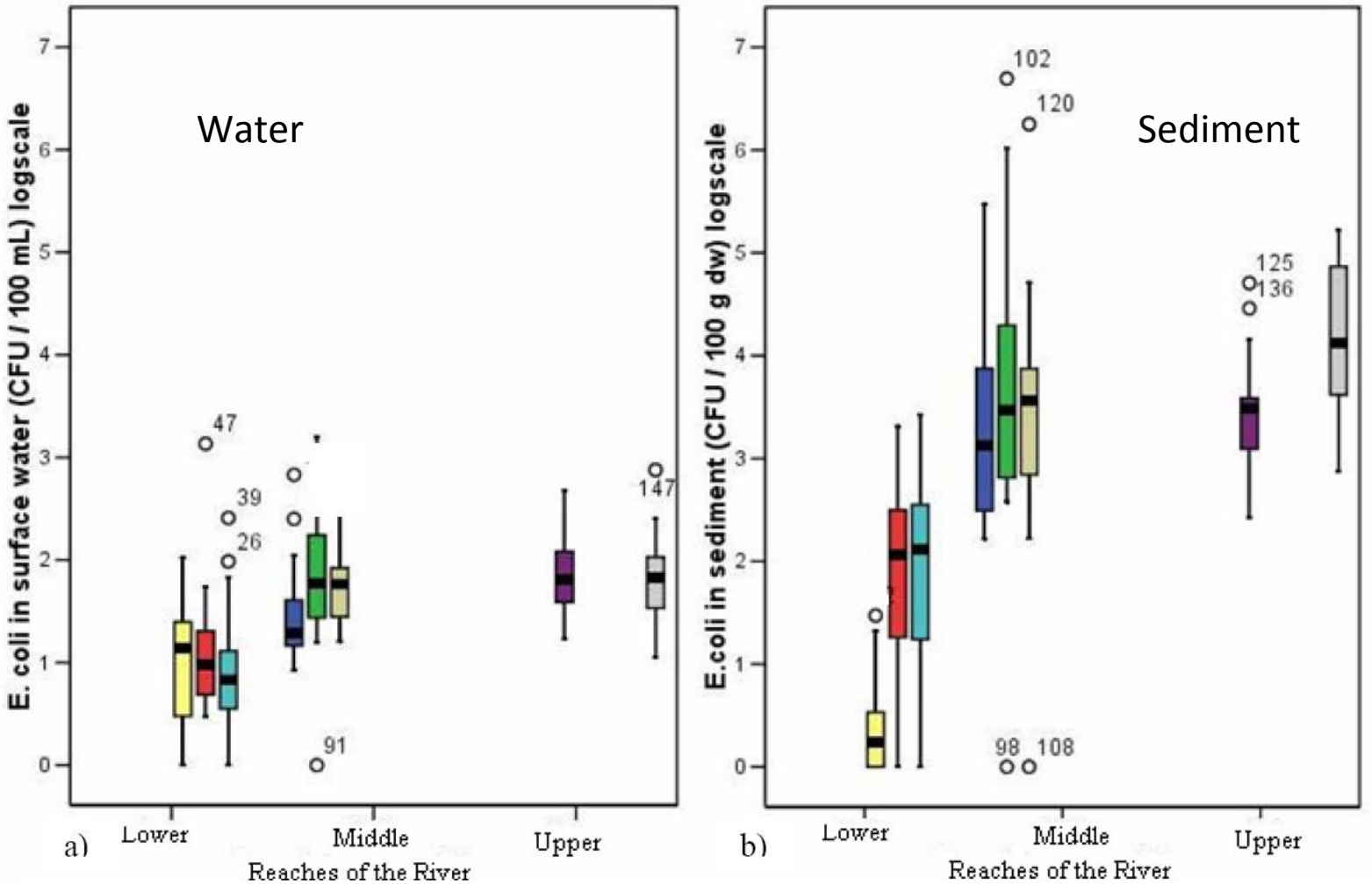
REACH	SITE	PARK OR BEACH
Lower	North Beach Park (NBP)	Beach
Lower	North Shore Pier (NS)	Beach
Lower	Rosy Mound (RM)	Beach
Middle	Grand River Park (GRP)	Park
Middle	Deer Creek Park (DC)	Park
Middle	Riverside Park (RSP)	Park
Upper	Sixth Street Park (SSP)	Park
Upper	Johnson Park (JP)	Park



Map of study sites along the Grand River from Grand Rapids to Lake Michigan.


% Land Use
Urban
Ag
Park
Forest
Aquatic
Bare Soil
80
70
60
50
40
30
20
10
0
SSP
JP
GRP
DC
RSP

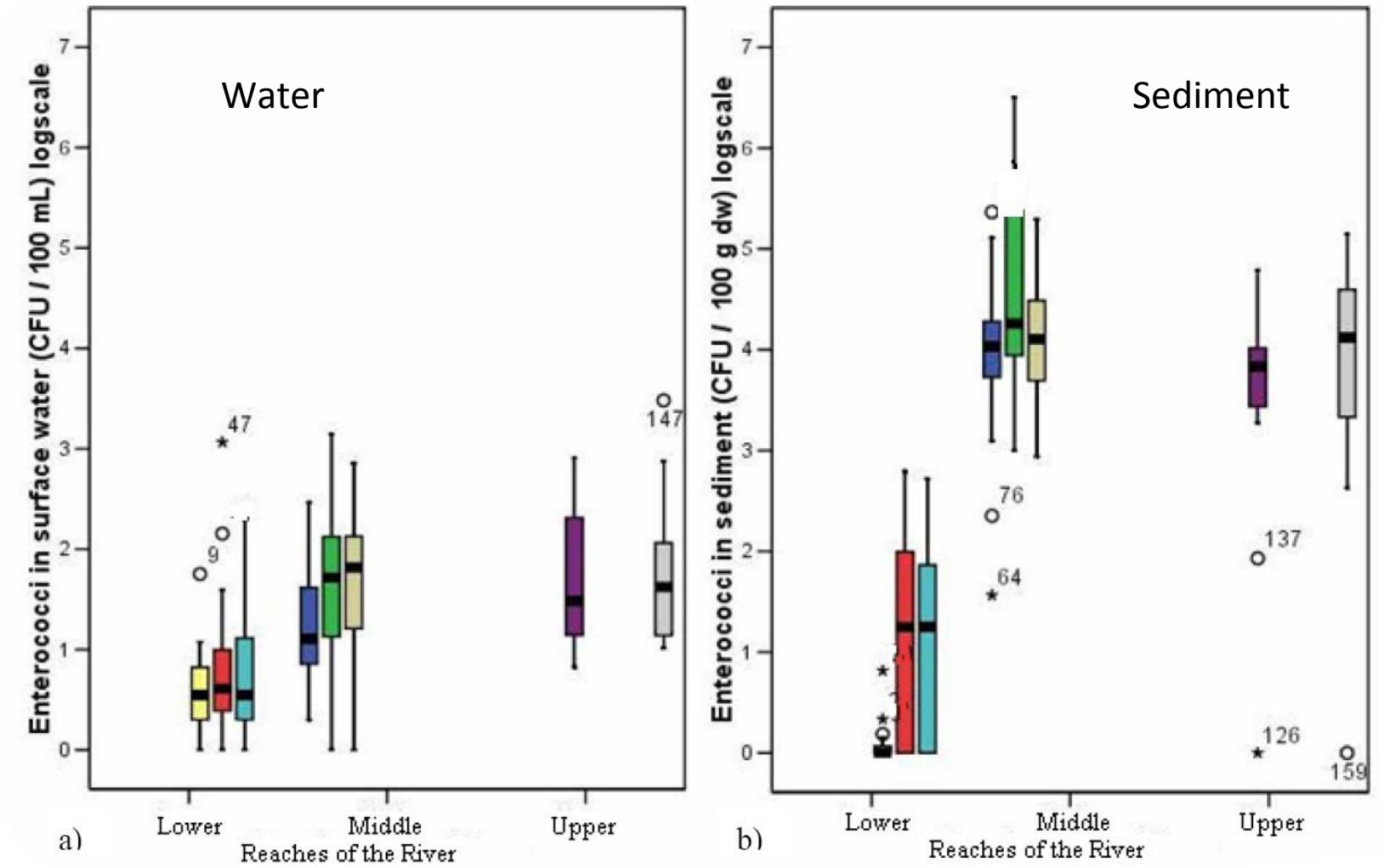
E. Coli



Concentrations of *E. coli* along the Grand River in a) surface water and b)

sediment NBP NS RM RSP DC GRP JP SSP

Enterococci



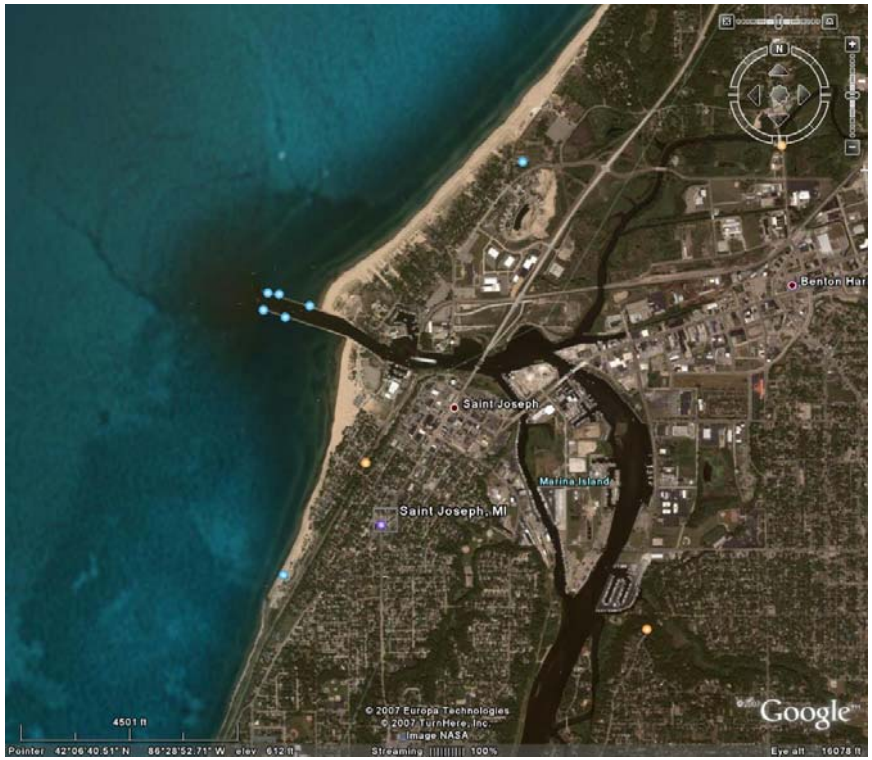
Concentrations of Enterococci along the Grand River in a) surface water and b) sediment

NBP NS RM RSP DC GRP JP SSP

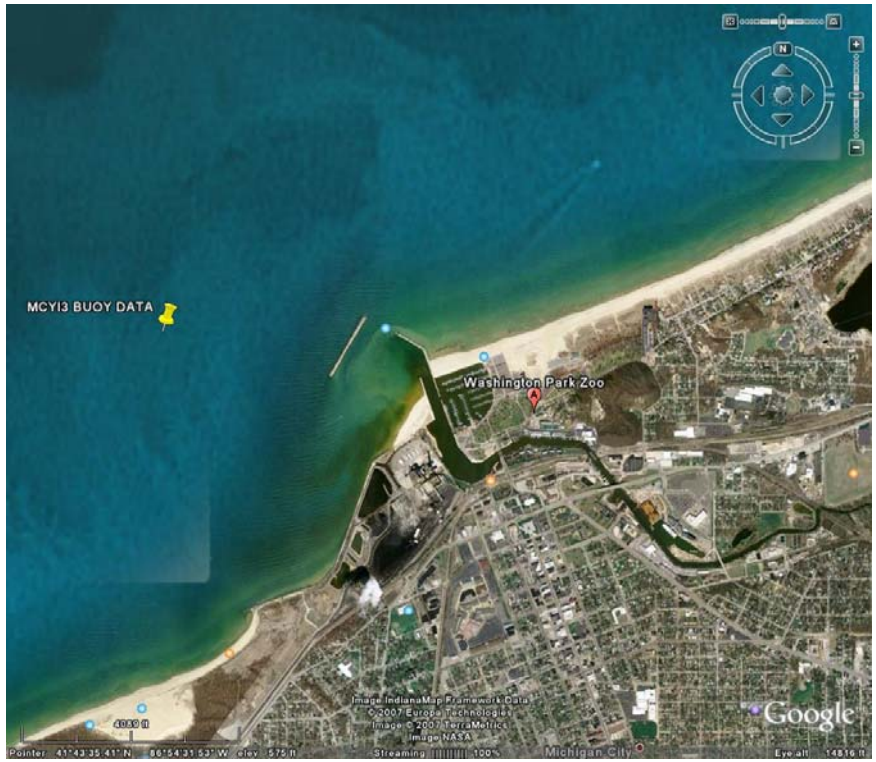
Beach Modeling Update

Biology models have been further refined
Can be applied to any beach

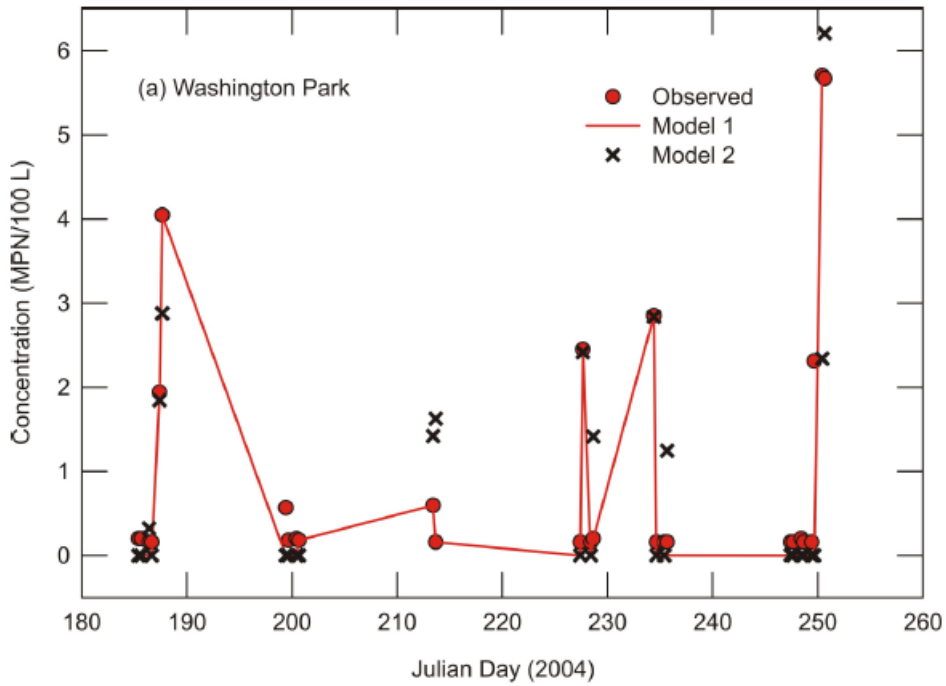
Improved Statistical Models

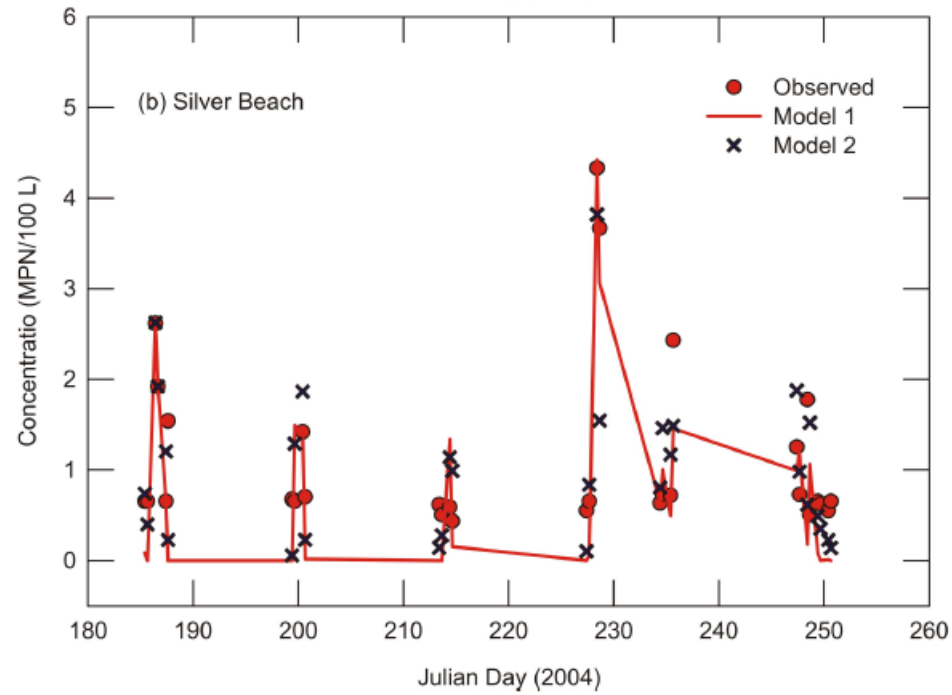


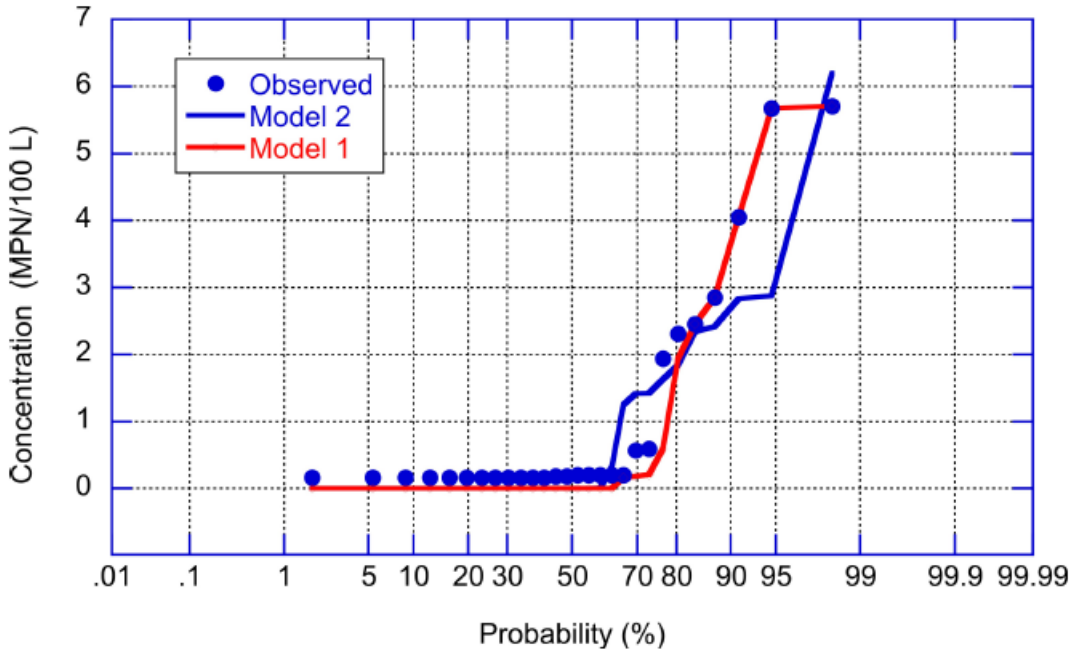
Silver Beach, MI



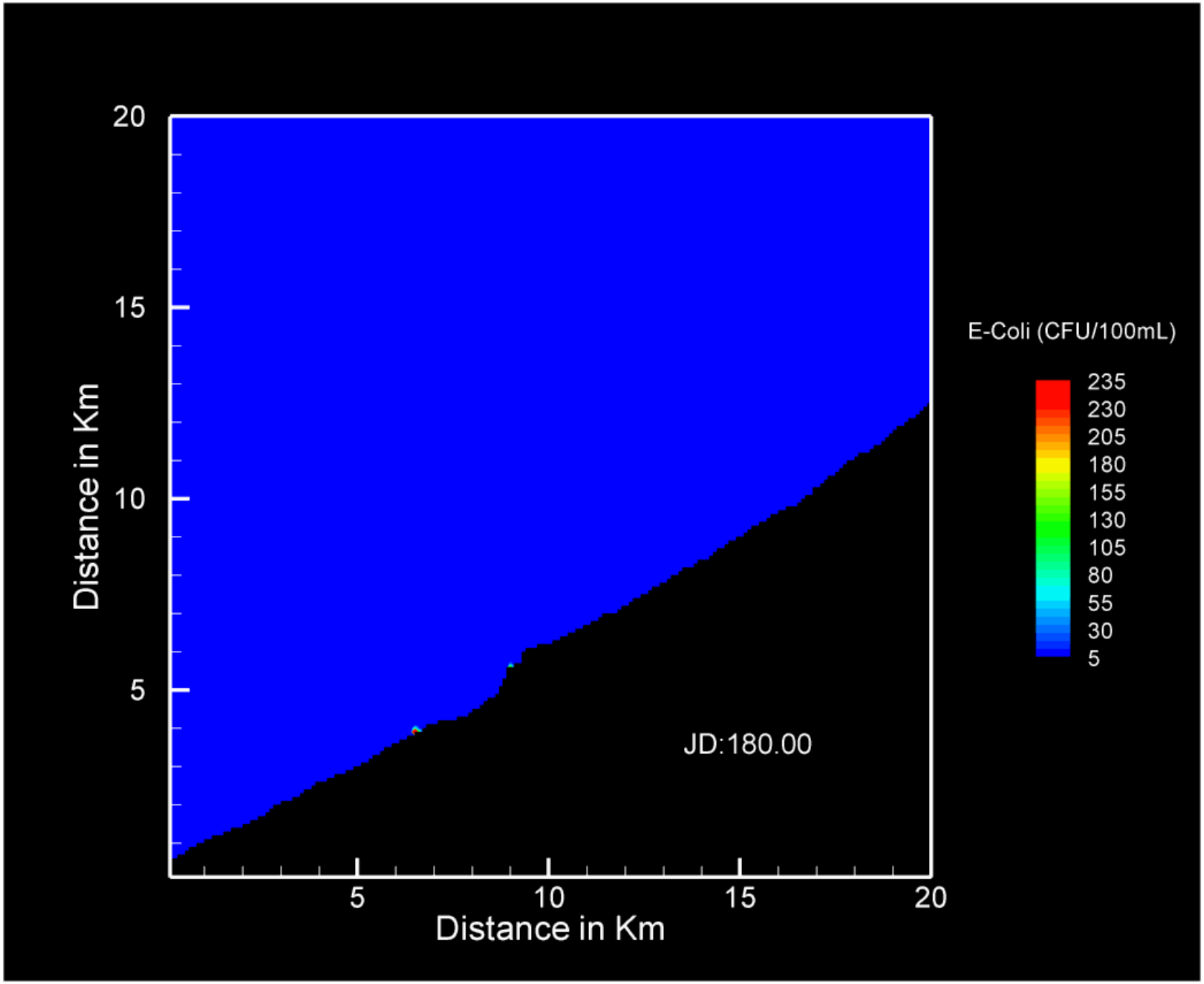
Washington Park, IN


(a) Washington Park
Observed
Model 1
Model 2
Concentration (MPN/100 L)
Julian Day (2004)
0
1
2
3
4
5
6
180
190
200
210
220
230
240
250
260


(b) Silver Beach
Observed
Model 1
Model 2
Concentratio (MPN/100 L)
Julian Day (2004)
0
1
2
3
4
5
6
180
190
200
210
220
230
240
250
260



Silver Beach Model 2	$\log_{10}(y) = \beta_1 + \beta_2\sqrt{P_{24}} + \beta_3 W + \beta_4 N + \beta_5 W\sqrt{P_{24}} + \beta_6 kT + \beta_7 k\log_{10}(I) + \beta_8 k\tau\sqrt{P_{24}}$ $\beta_1 = 0.753,\ \beta_2 = -0.755,\ \beta_3 = -0.144,\ \beta_4 = -0.005,$ $\beta_5 = 0.093,\ \beta_6 = -0.435,\ \beta_7 = 3.494,\ \beta_8 = 0.041$	$R^2 = 0.55$ $AIC = -4.5$


20
15
10
5
Distance in Km
5
10
15
20
Distance in Km
JD:180.00
E-Coli (CFU/100mL)
235
230
205
180
155
130
105
80
55
30
5

Thank you!