Linking field measurements and numerical modeling to understand fluvial transport processes and nitrate retention in the Suncook River, NH

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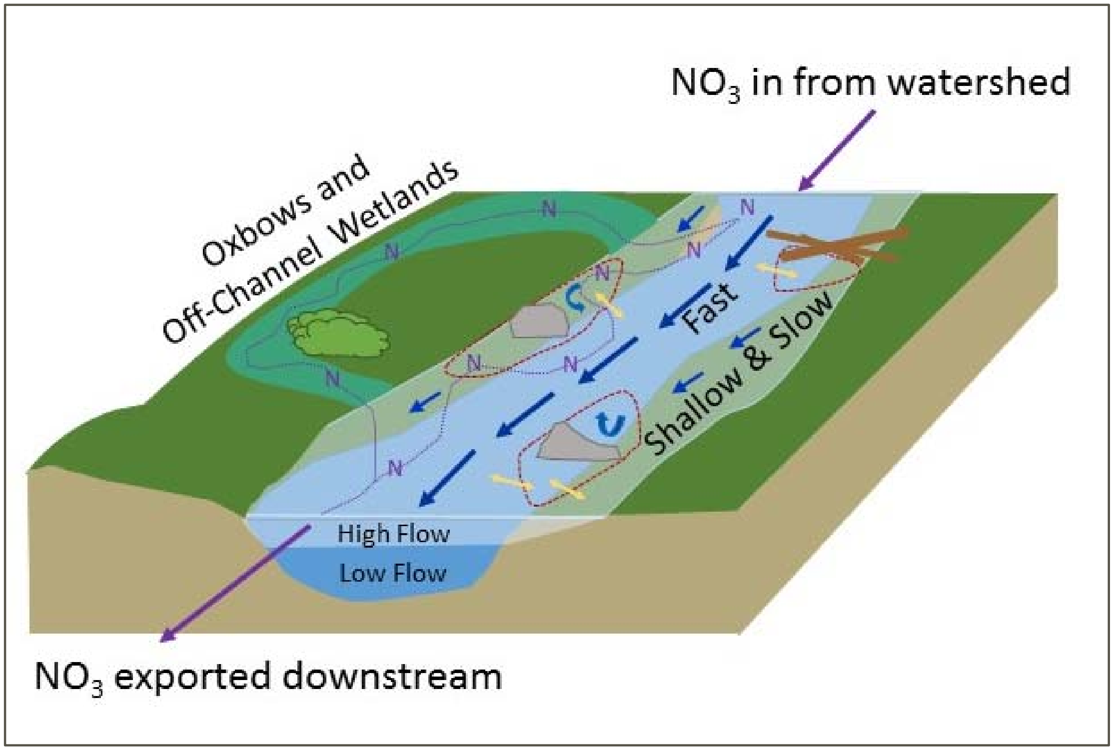
Nitrate Transport and Retention in Rivers

- Rivers can remove up to 80% of nitrogen inputs (Wollheim et al. 2013, WRR 47)
- Hot spots: Locations of increased uptake
- Hot moments: Times of increased uptake due to changes discharge or biogeochemistry



Nitrate Uptake in Rivers

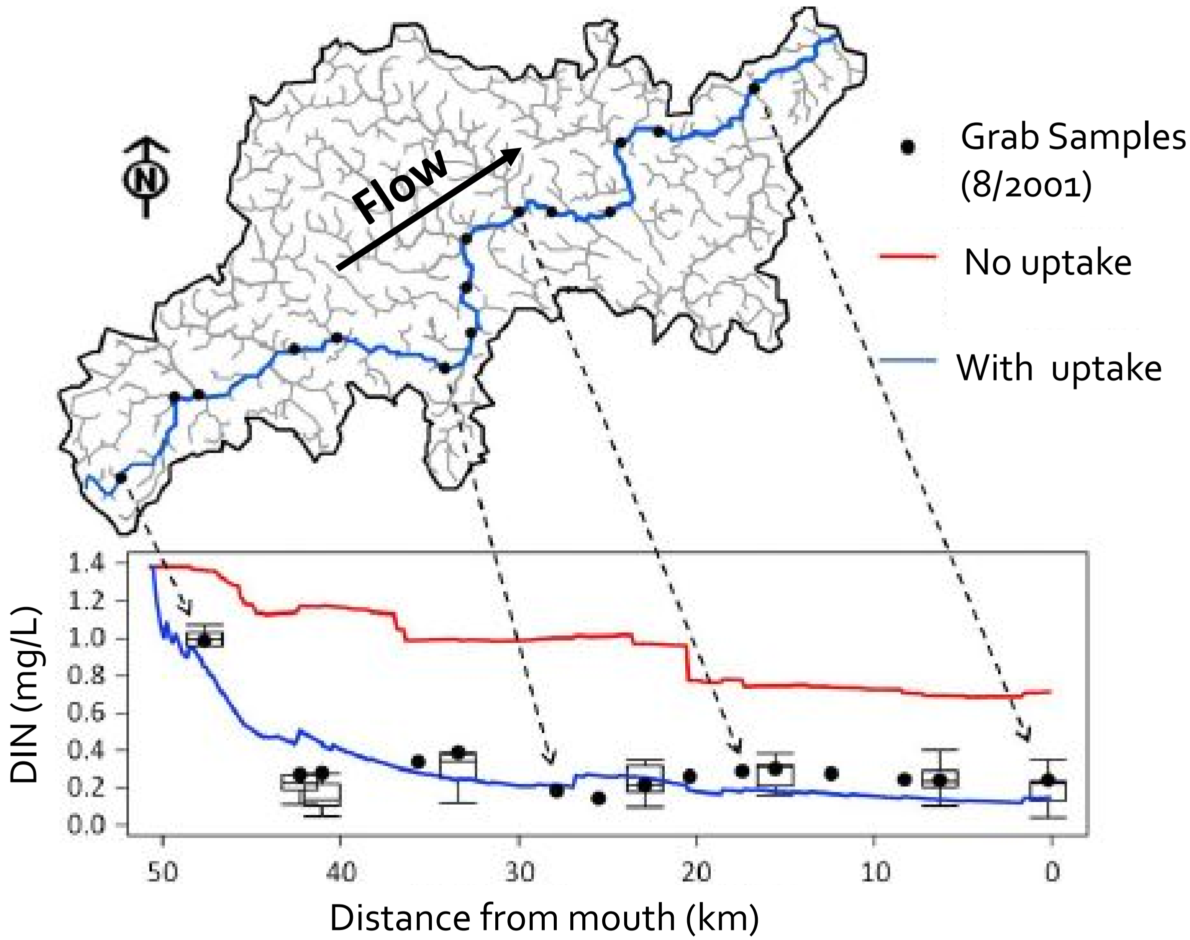
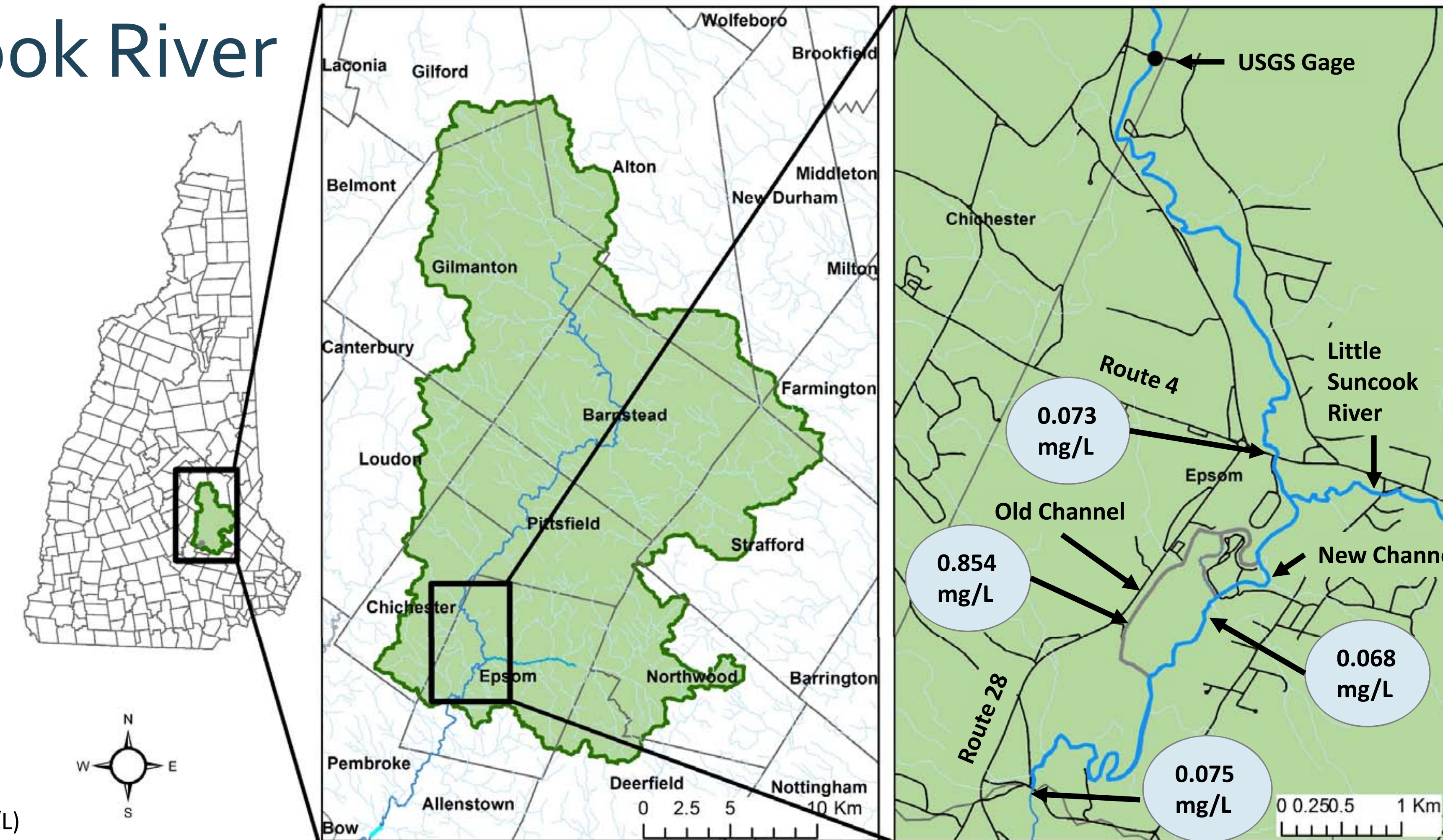


Figure adapted from: Stewart et al. 2011, WRR 47

Suncook River



Nitrate (mg/L)
(Traister. 2007, UNH Dissertation)

Data Source: NH hydrography dataset, NH public roads, and NH political boundaries form NH Granit, http://www.granit.unh.edu/

Suncook River Hydrology

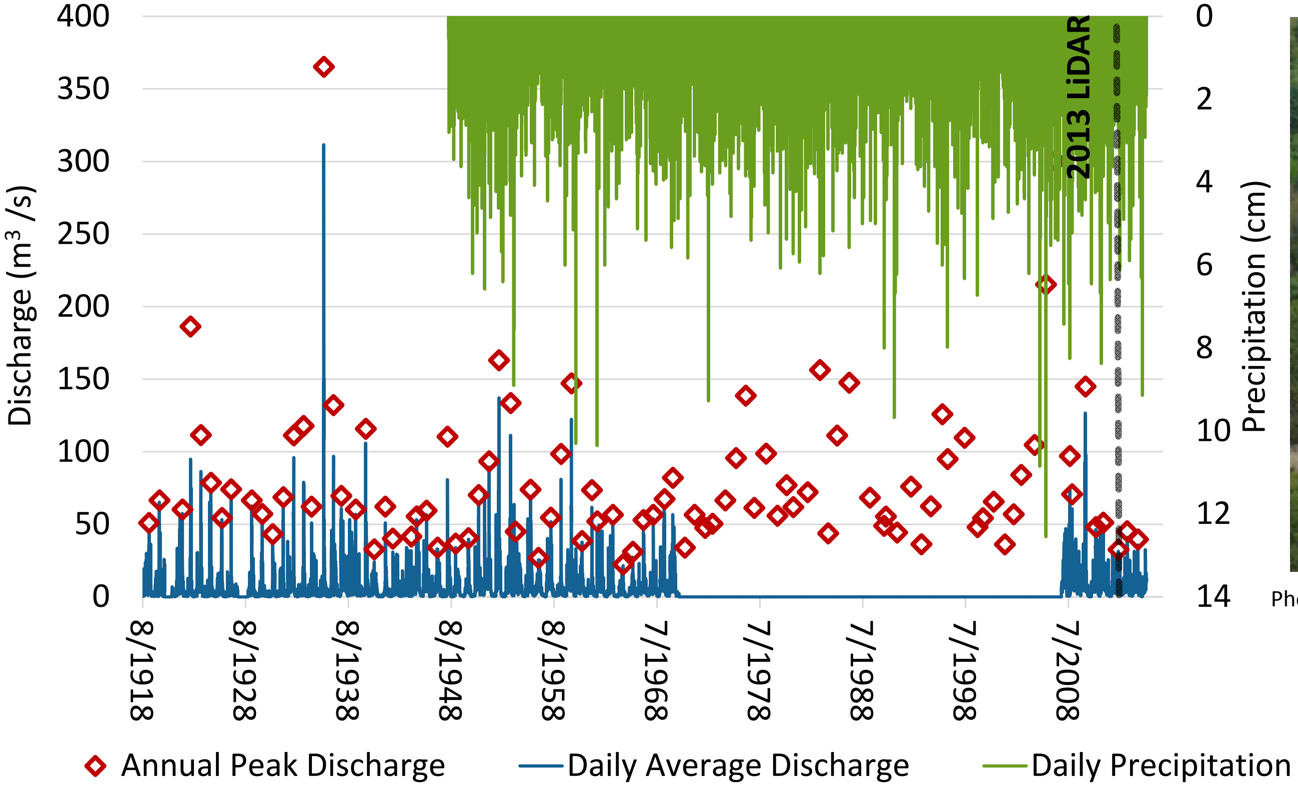
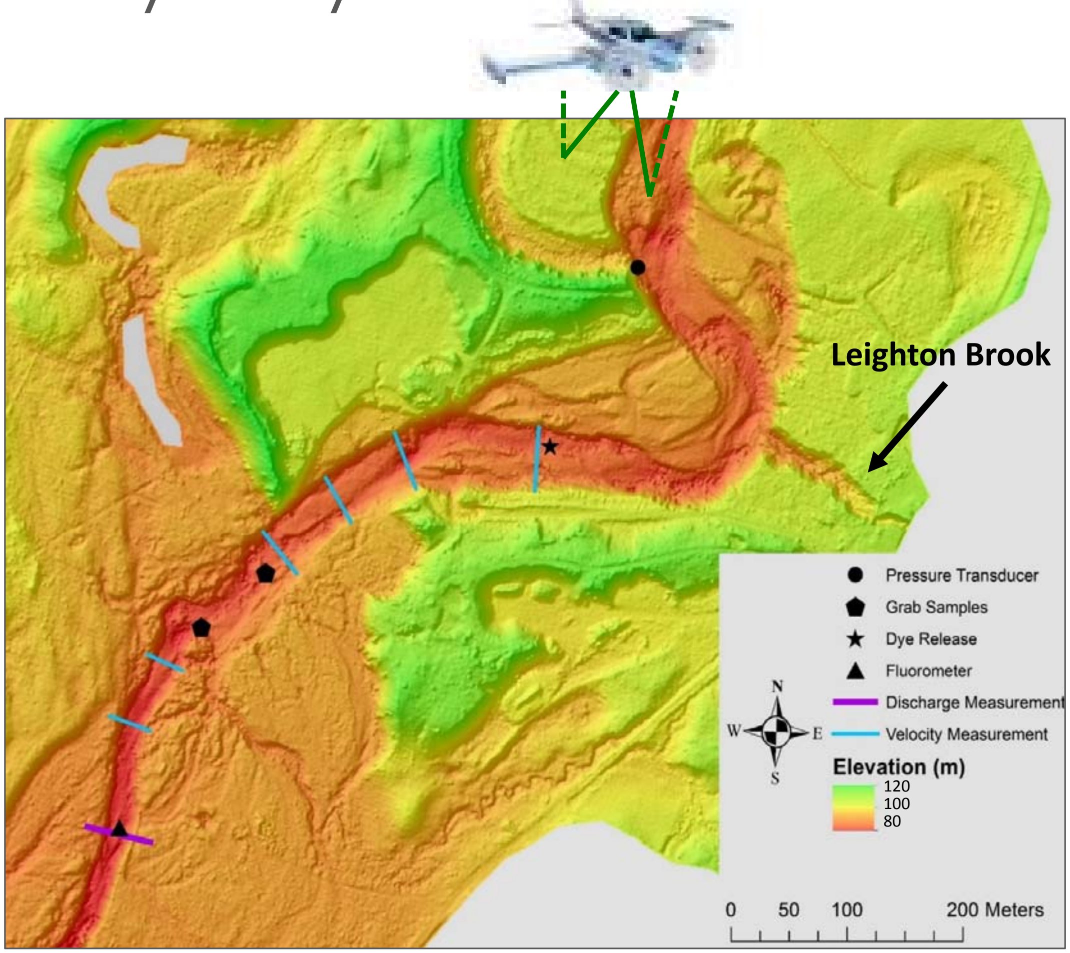


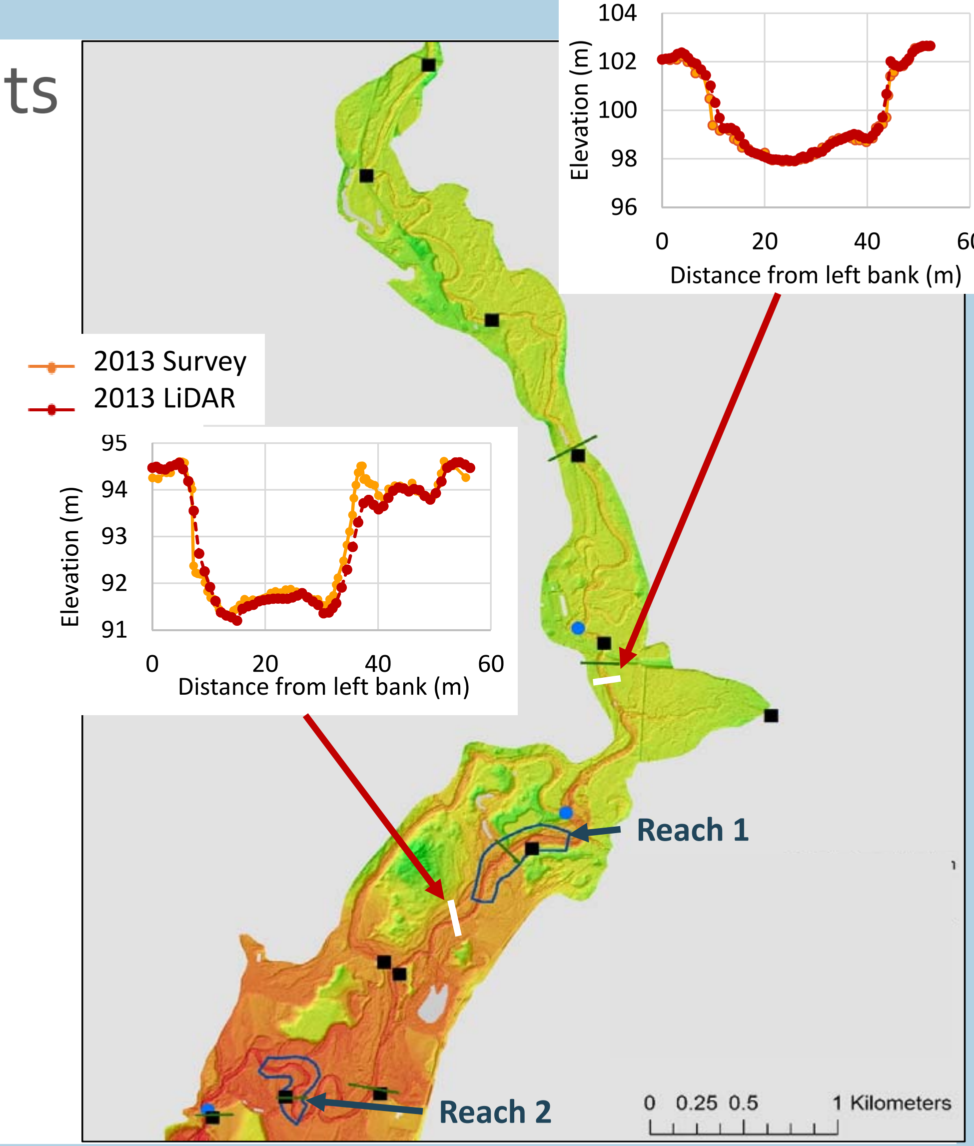
Photo: Stewart Yeaton, http://www.friendsofsuncookriver.org/page11C.htm

Data Sources: Precipitation: NDCD Concord Municipal Airport; Daily average discharge, 1918-1970 and 2008-Present peak flood: USGS streamgage 01089500; 1970-2007 peak flood: Perignon. 2007

Bathymetry and Field Measurements



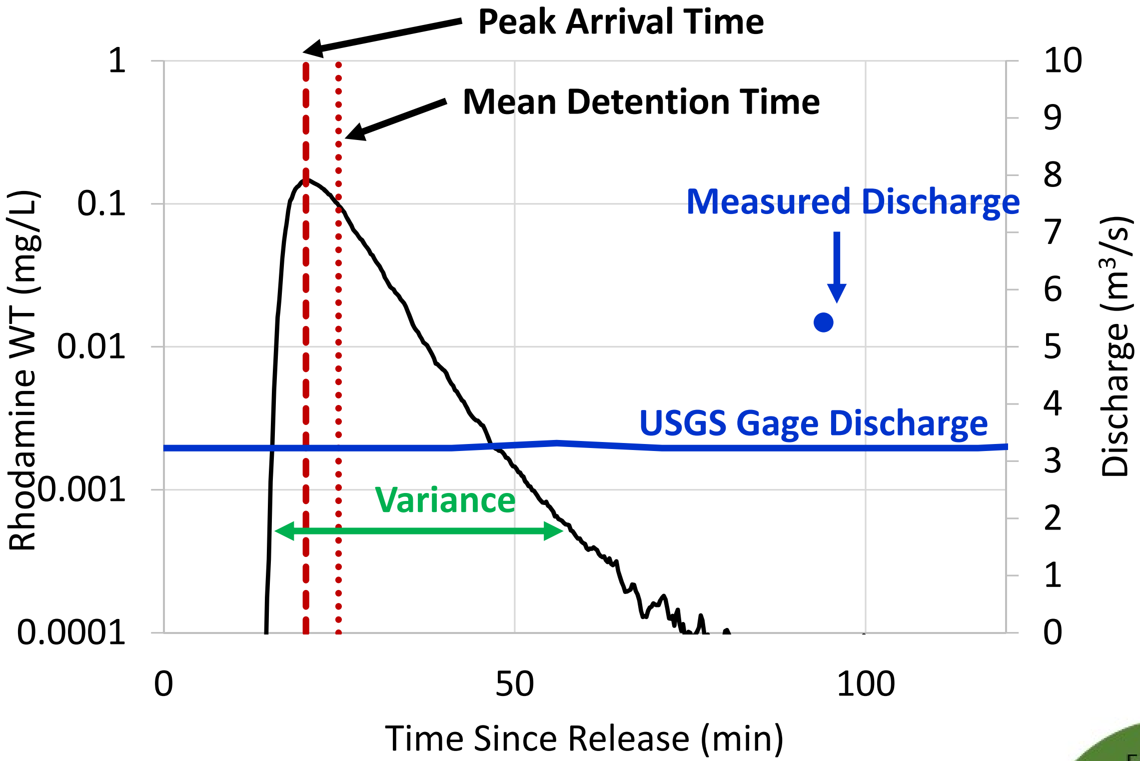
Bathymetry: USGS St. Petersburg and New Hampshire Geological Survey, 2013

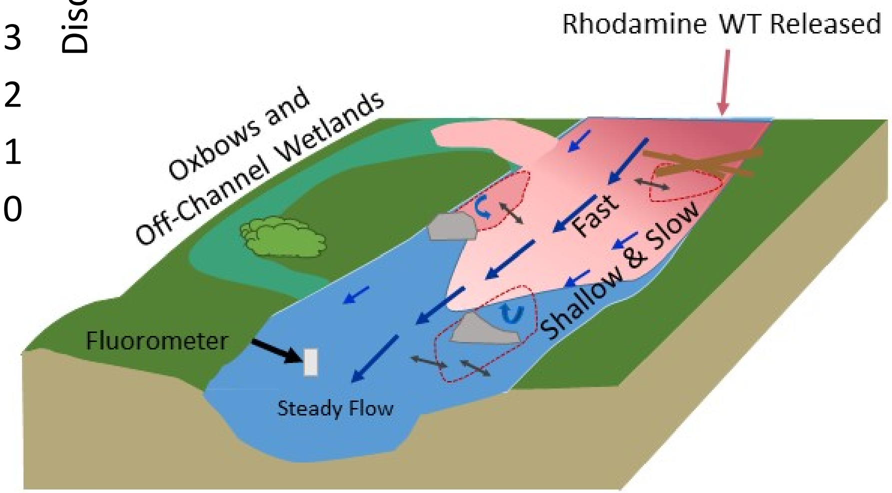


Tracer Studies: Lateral Mixing

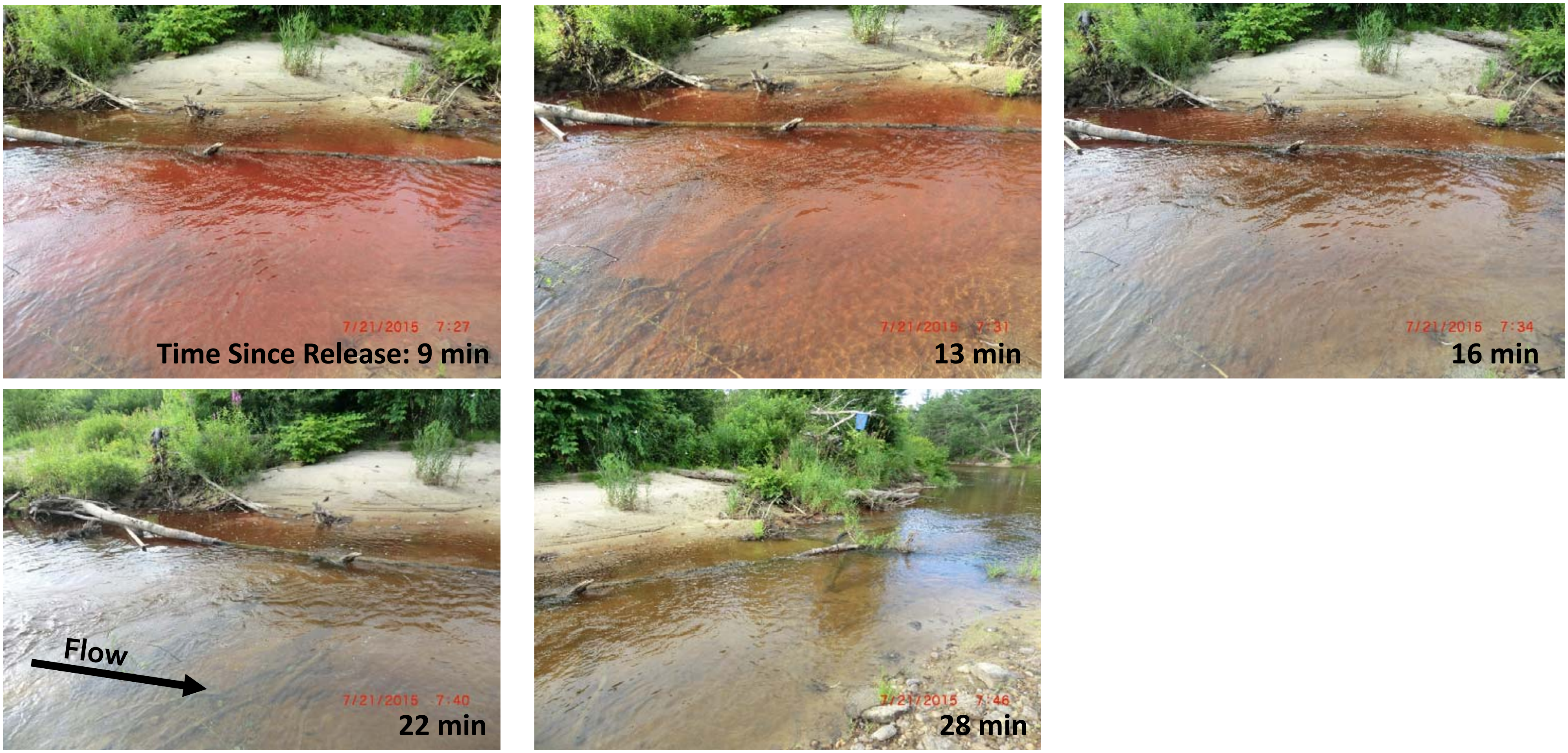
Direction of Flow →

Breakthrough Curve Analysis

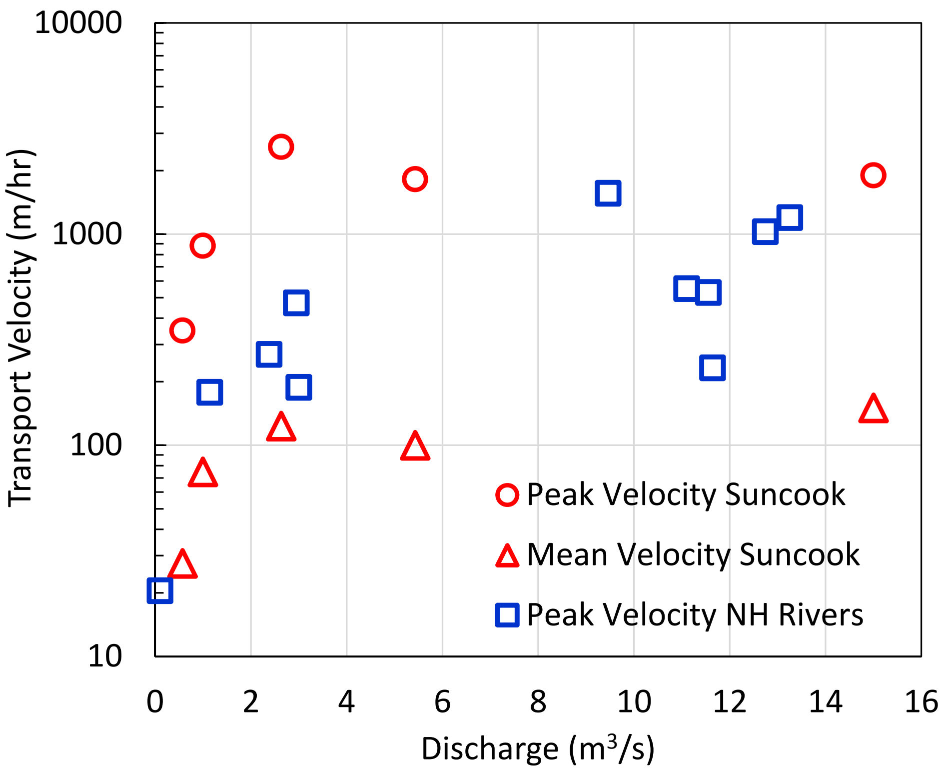


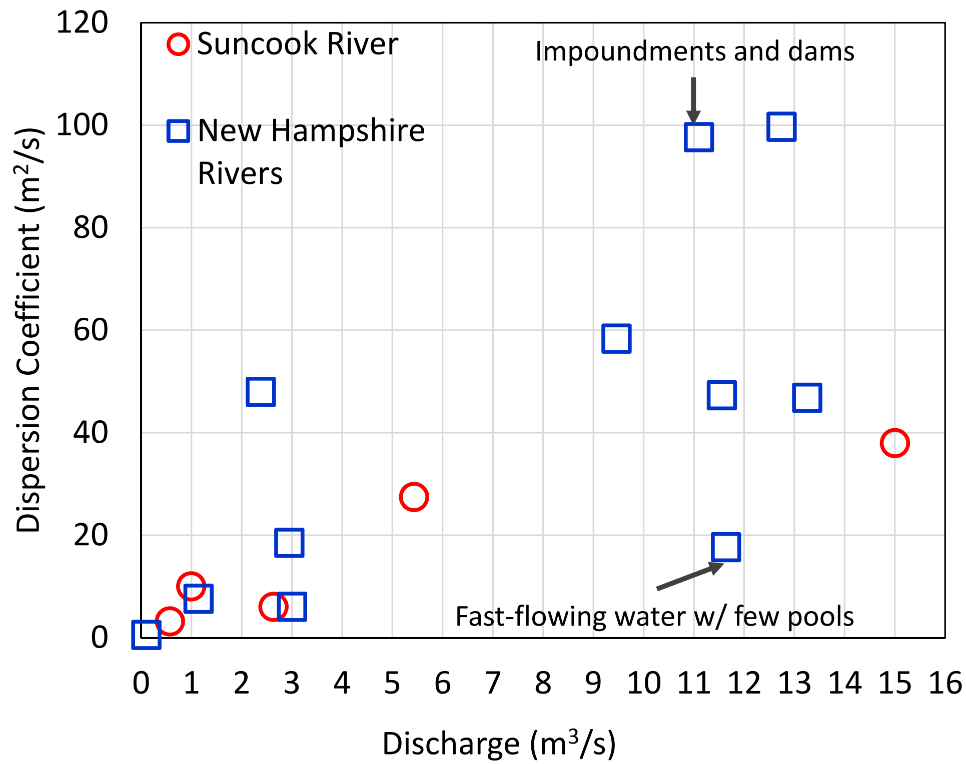


Tracer Studies: Transient Storage



Transport Compared to Other NH Rivers

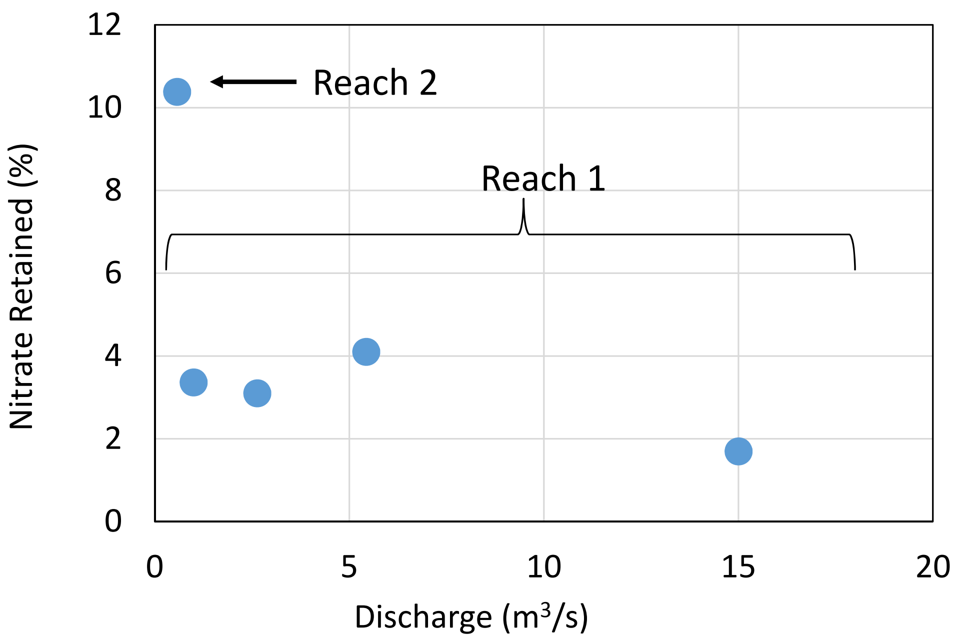




NH River Data: Smith. 2002, USGS

Nitrate Uptake from Field Measurements

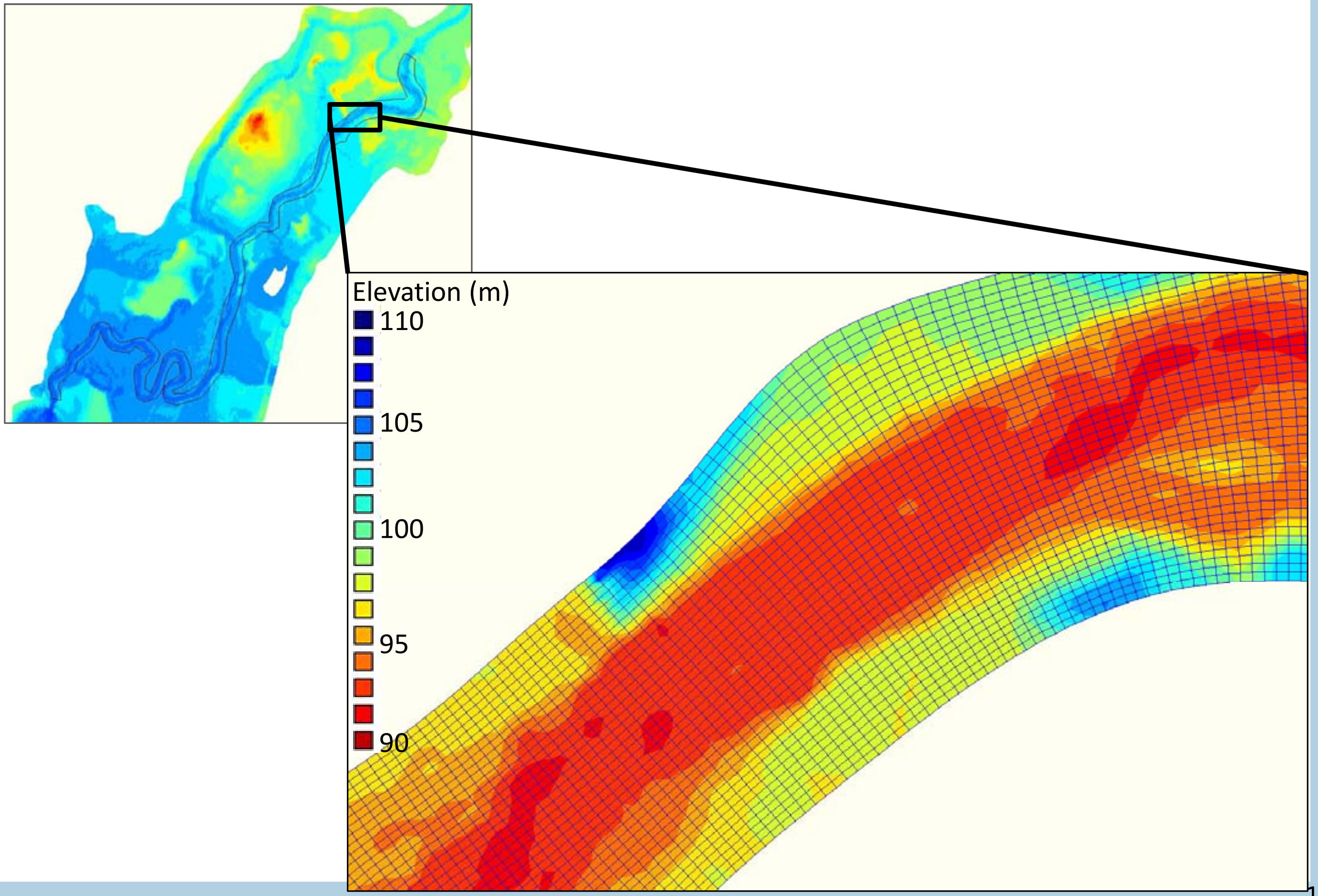
- Use measured breakthrough curves to estimate transport
- Assume spatially uniform uptake rate constant, $k=1.3\ day^{-1}$
 (Wollheim et al. 2014, Biogeochemistry)
- Assume constant nitrate loading



Linking measurements and hydraulic modeling

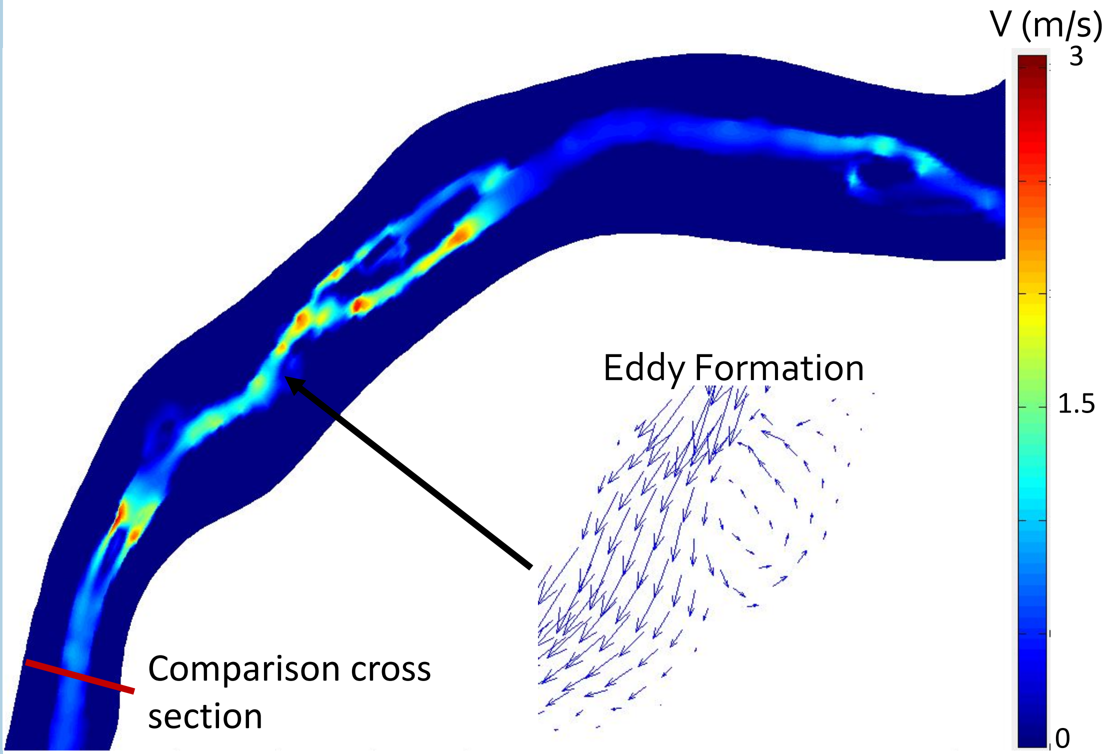
- Hydraulic modeling to explore the effect of nitrate transport on reach-scale retention

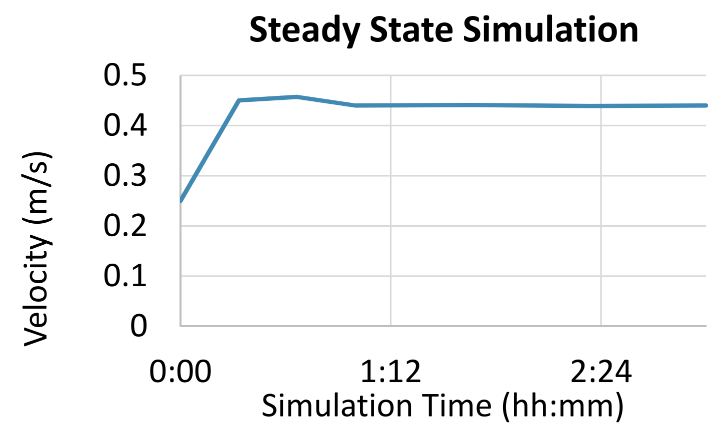
- Delft3D-Flow
  - 2D hydraulic model
  - Shallow water equations
  - Boundary Conditions
  - LiDAR Bathymetry

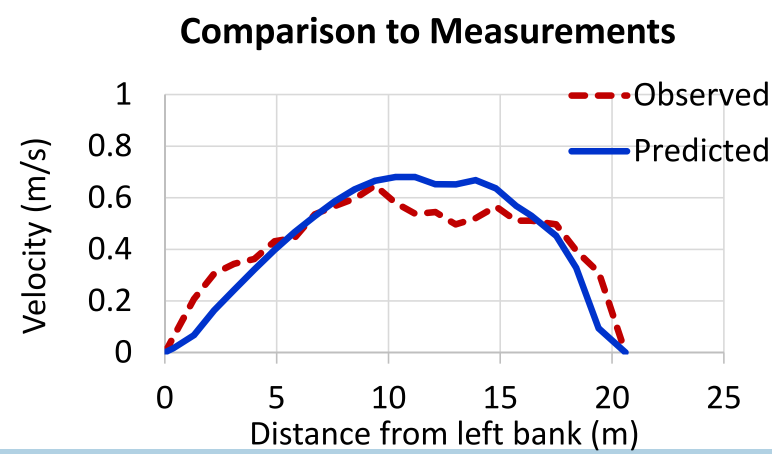


Depth Averaged Velocity

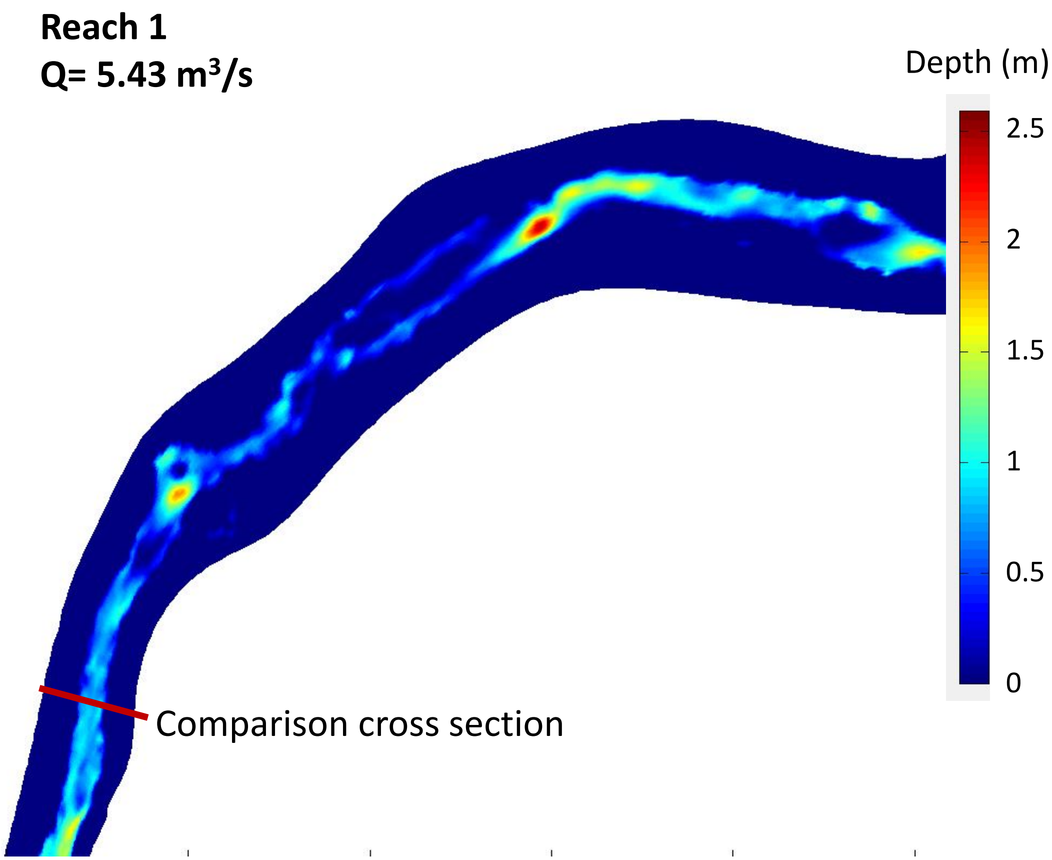
Reach 1
Q= 5.43 m^3/s



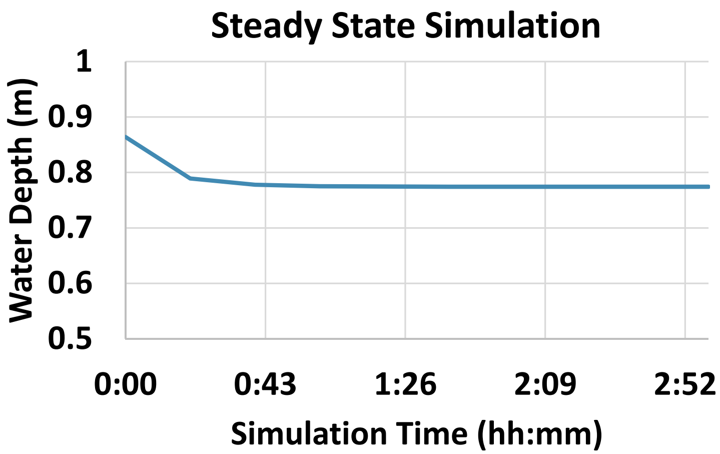




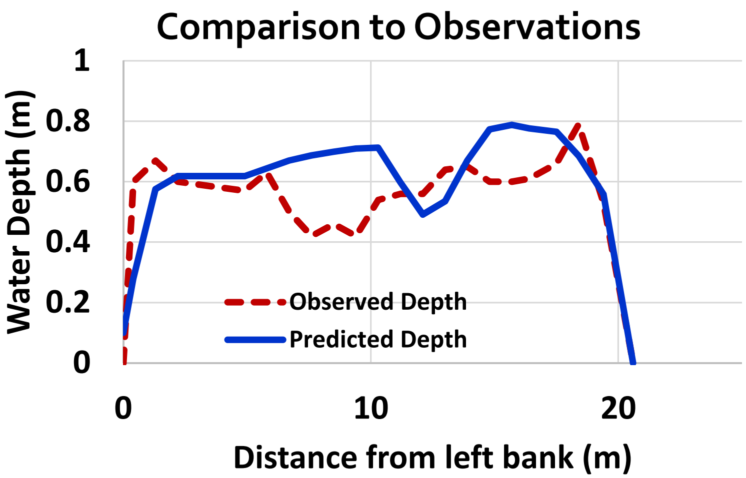
Water Depth



Reach 1
Q= 5.43 m³/s
Depth (m)
2.5
2
1.5
1
0.5
0
Comparison cross section



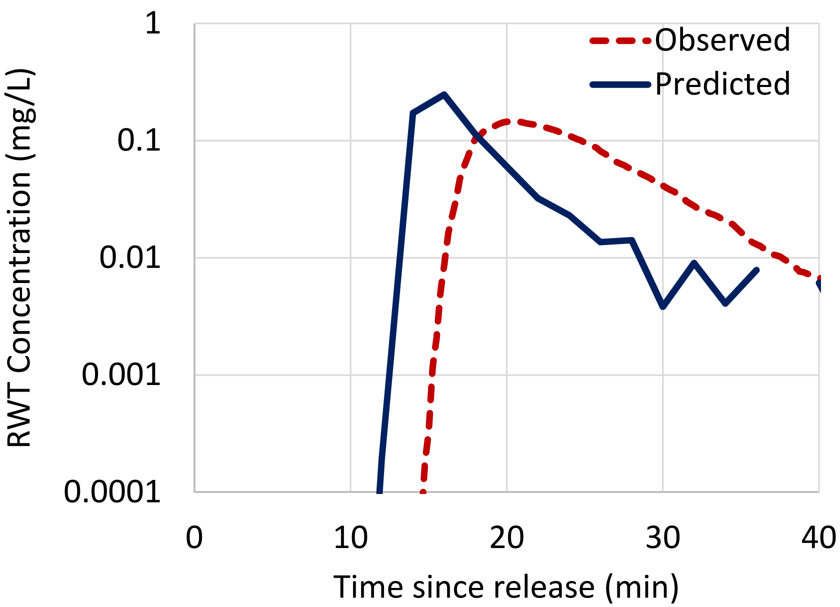
Steady State Simulation
Water Depth (m)
1
0.9
0.8
0.7
0.6
0.5
0:00
0:43
1:26
2:09
2:52
Simulation Time (hh:mm)



Comparison to Observations
Water Depth (m)
1
0.8
0.6
0.4
0.2
0
Observed Depth
Predicted Depth
0
10
20
Distance from left bank (m)

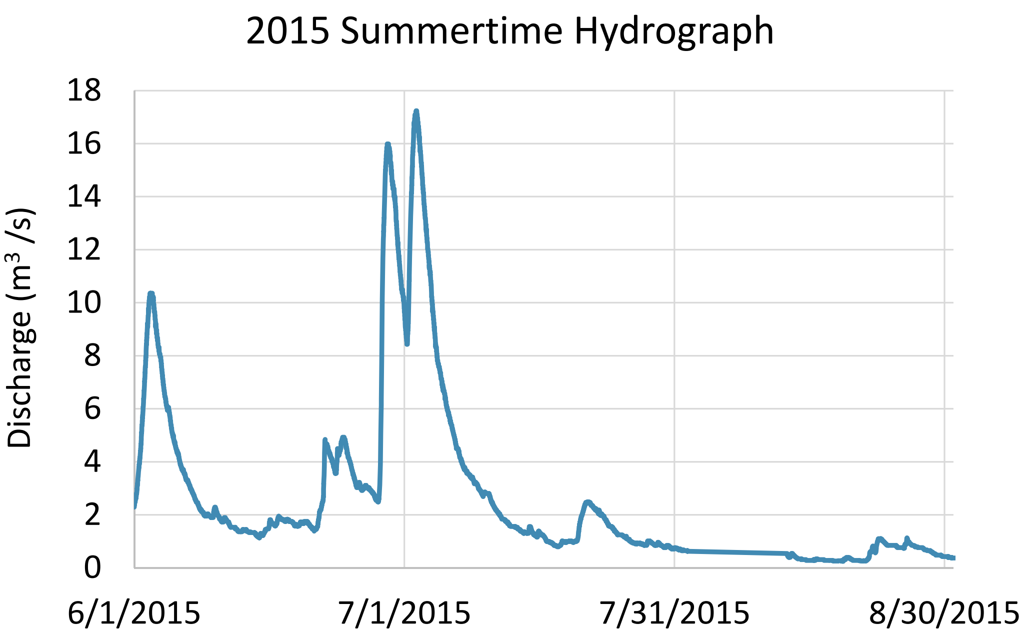
Breakthrough Curves

- Numerically simulate Rhodamine WT instantaneous release.
- Front Arrival Time Difference: 2.75 min
- Peak Arrival Time Difference: 4.25 min



Next Steps

- Simulate nitrate transport at multiple discharges.
- Compare spatially uniform and spatially variable uptake rate constant .
- Assume constant nitrate loading
- Establish relationship between discharge and reach-scale nitrate retention during steady flow conditions.
- Explore nitrate retention during unsteady flow conditions
- Estimate nitrate transport and seasonal averaged retention at the reach scale.



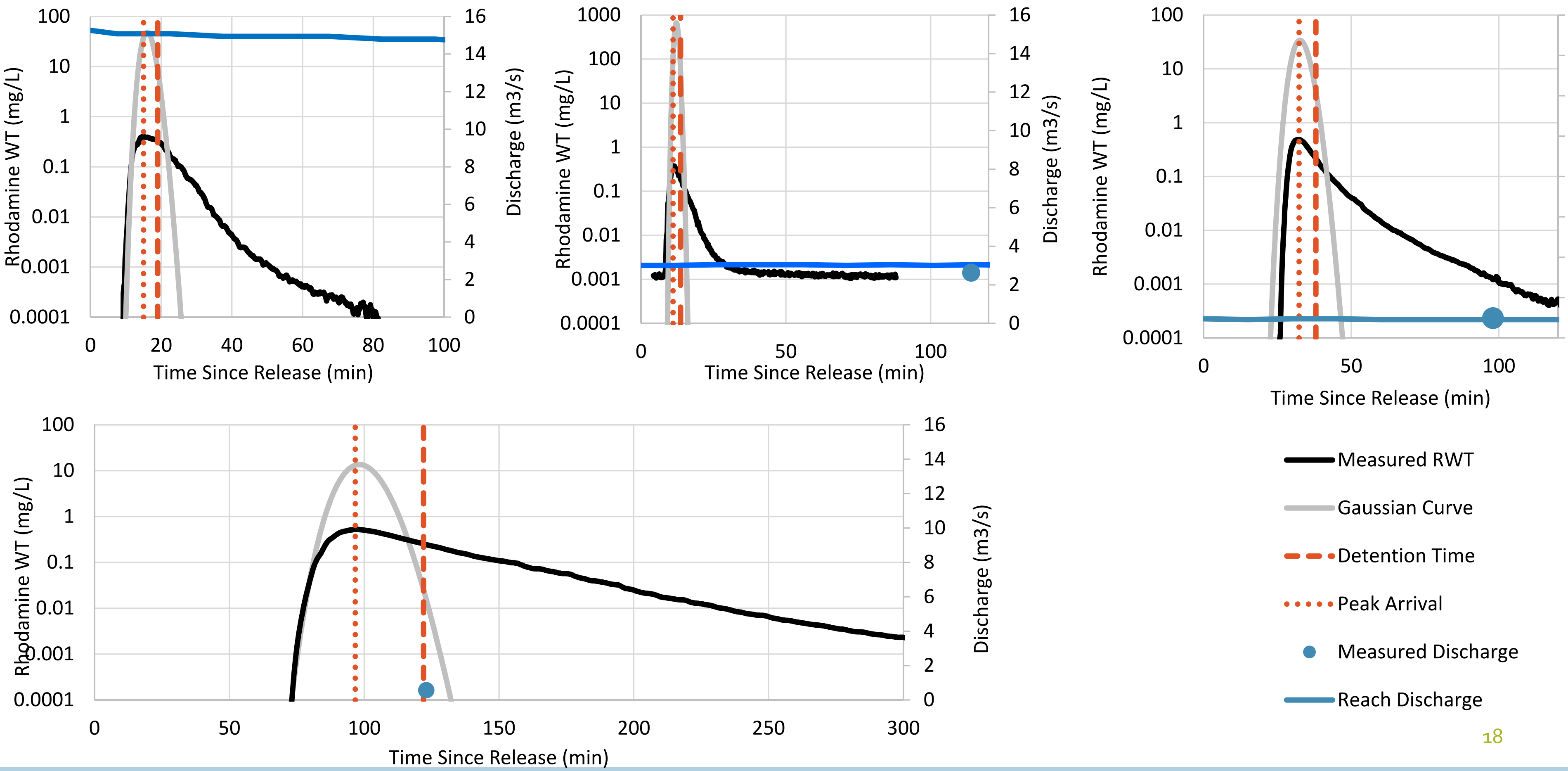
Conclusions

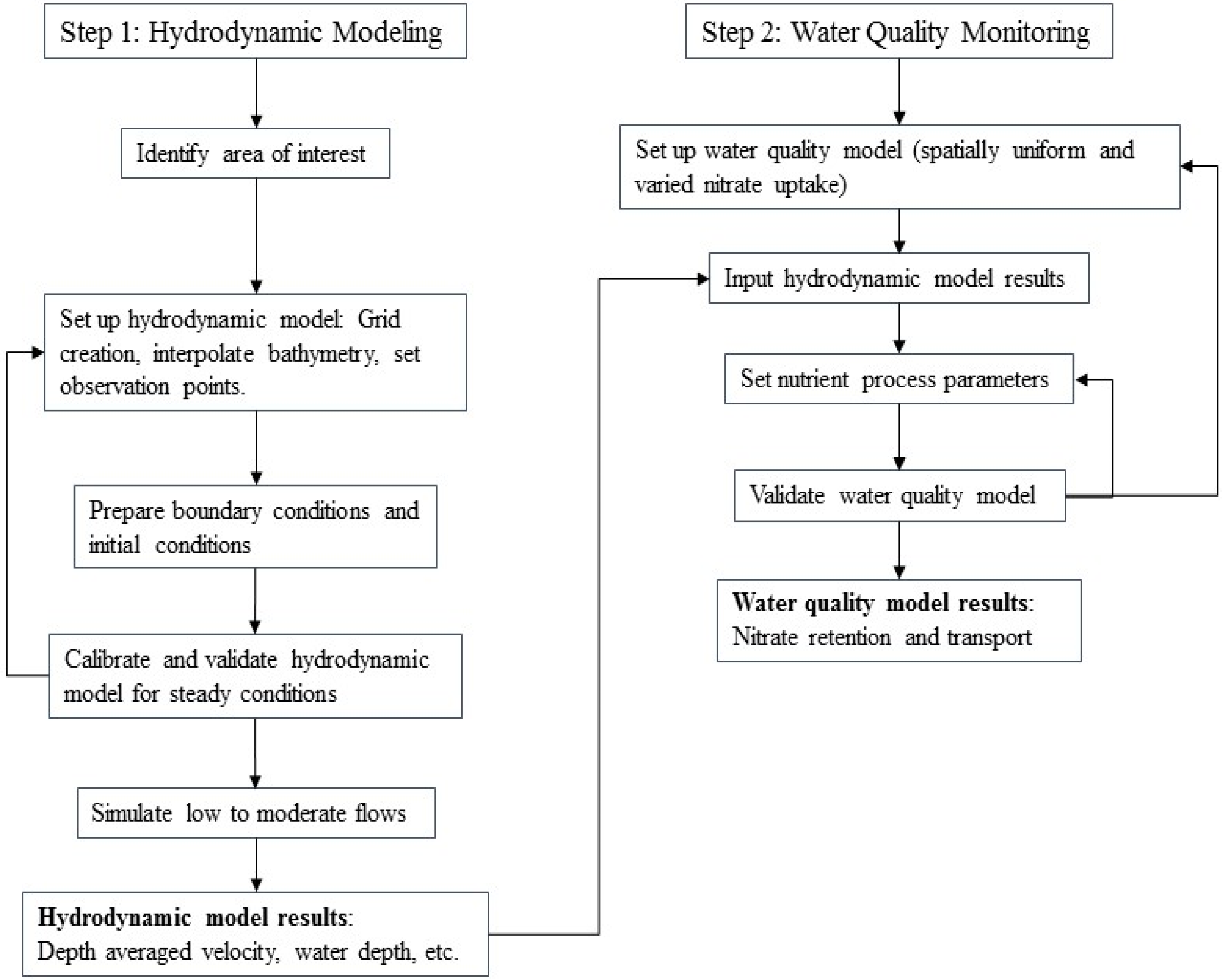
- Nitrate transport and retention may be influenced by geomorphology and discharge levels.
- Hydraulic models can be used to explore the effects of transport on reach-scale retention.

Photo: Low flow tracer study on the Suncook 8/10/15

Thank you! Questions?

Additional Tracer Studies





Step 1: Hydrodynamic Modeling
Identify area of interest
Set up hydrodynamic model: Grid creation, interpolate bathymetry, set observation points.
Prepare boundary conditions and initial conditions
Calibrate and validate hydrodynamic model for steady conditions
Simulate low to moderate flows
Hydrodynamic model results: Depth averaged velocity, water depth, etc.
Step 2: Water Quality Monitoring
Set up water quality model (spatially uniform and varied nitrate uptake)
Input hydrodynamic model results
Set nutrient process parameters
Validate water quality model
Water quality model results: Nitrate retention and transport

Table ##. Summary of USGS gage recorded discharge, measured reach discharge, location, and date, time of tracer release, reach length, mass of tracer released, and fluorometer recording interval for the tracers studies conducted on the Suncook River from July to November 2015.

USGS Gage Discharge (m^3/s)	Reach Discharge (m^3/s)	Location	Date	Time of release	Reach Length (m)	Mass Released (g)	Recording interval (s)	Mass Recovered	Tpeak	2nd moment	
N/A	0.56	DyeDwn	8/10/15	07:20:00	563	774	10				
0.765	1.0	DyeUp	7/31/15	07:45:00	475	273	10				
2.46	2.6	DyeUp	7/21/15	07:19:00	475	266	10				
3.23	5.4	DyeUp	11/13/15	07:49:00	615	452	15				
11.9	15	DyeUp	10/2/15	07:37:30	475	1600	10				