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Nutrient Attenuation under Natural Conditions in Agricultural Drainage Ditches

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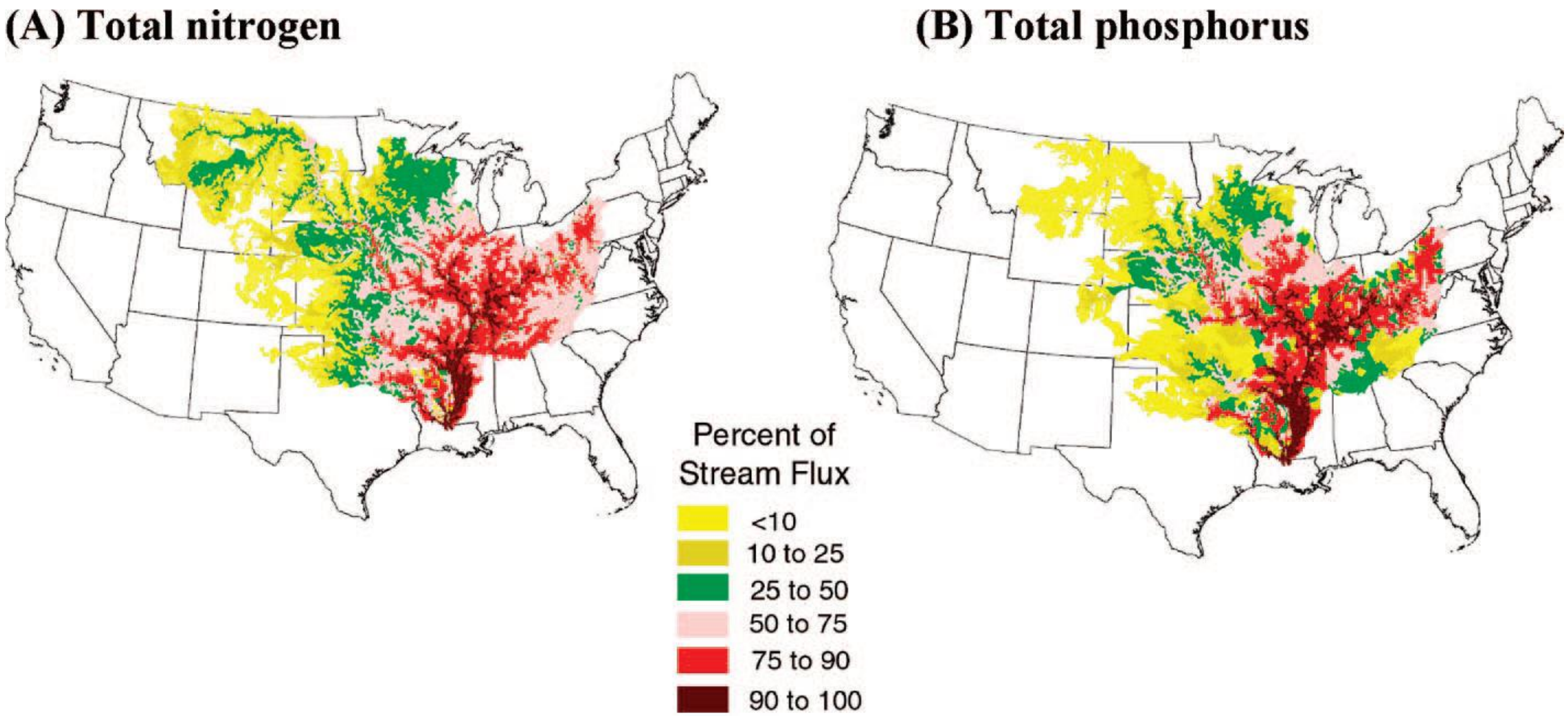
Purdue Ecohydrology Research Group

Background and Motivation



(Adapted from Alexander et al., 2008)

- Over 51 million acres are subject to surface and subsurface drainage systems in the Midwest (Sharpley et al., 2007. JSWC 62(4)).

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Background and Motivation

- Tile-fed drainage ditches in the Midwest have been reportedly associated with the pollution of downstream waters.
- However, the ability of sediments to retain nutrients upstream and downstream from tile outlets, is not clear.
- Effects of tile inputs on the magnitude and transport of nutrients in drainage ditches are still not well understood.

Marshall Ditch, 2008

Tile drain outlet

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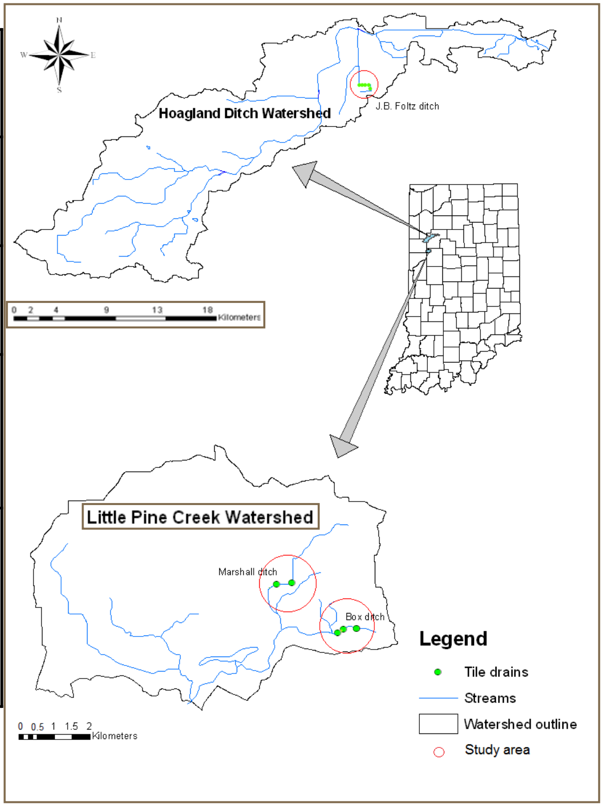
Objectives and Study Sites

- Evaluate effects of tile effluents on nutrient uptake in drainage ditches.
- Examine sediment-water interactions in drainage ditches.

	Box and Marshall Ditches	J.B. Foltz Ditch
Watershed area	53.0 km²	182 km²
Location	W. Lfytt, IN	Reynolds, IN
Area drained by ditch	8 km²	8 km²
Land use	agriculture (90%) low residential (10%)	agriculture (9%) low residential (7%)



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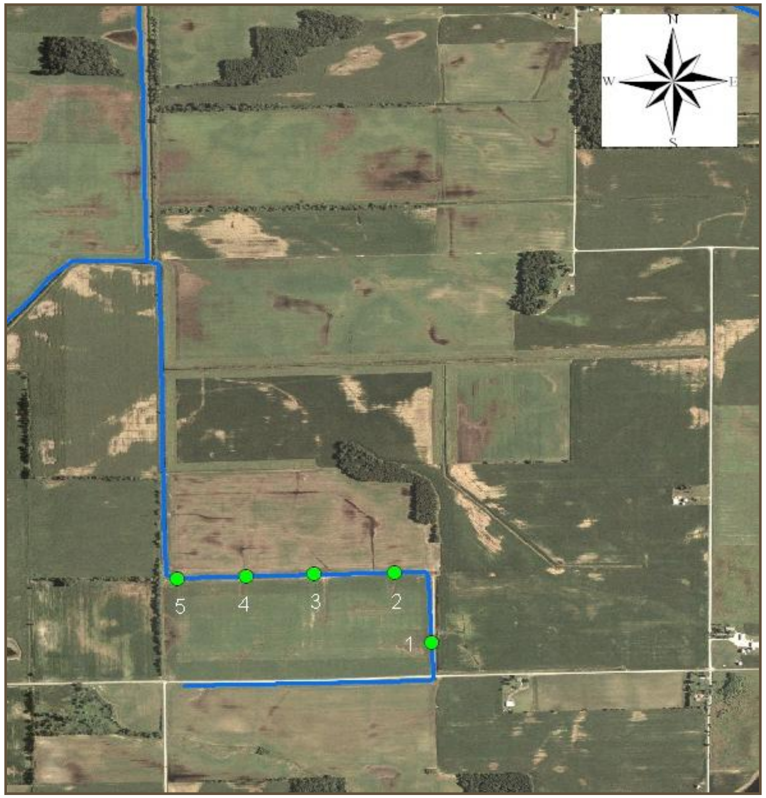
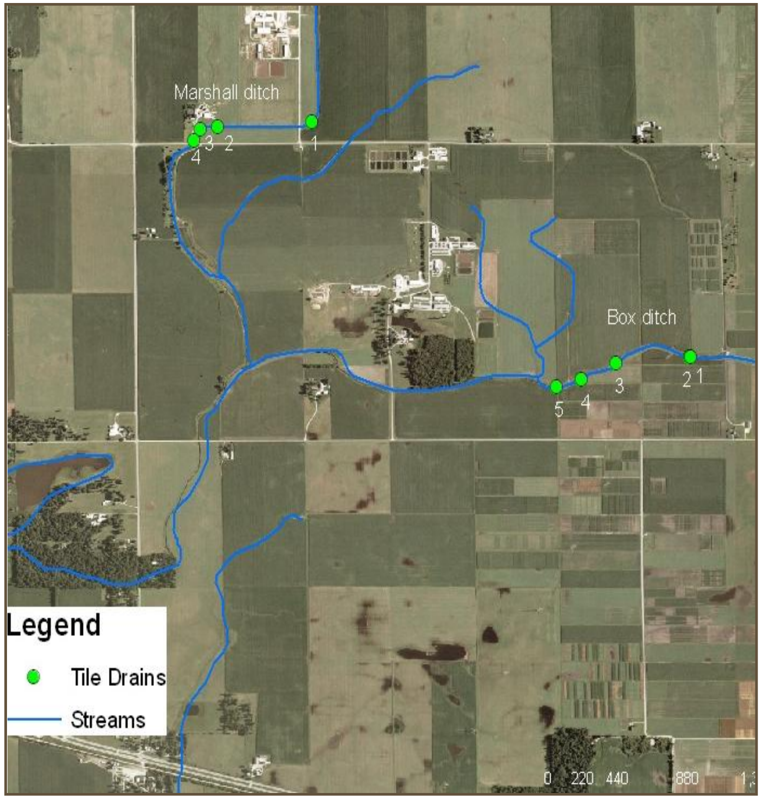
Selected Tile Outlets

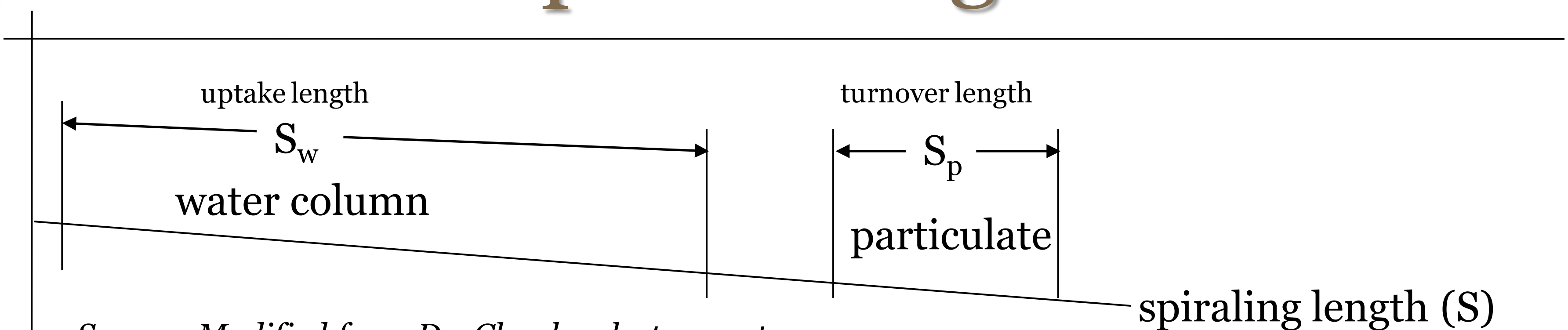


J.B. Foltz Ditch study reach = 1 km



Box Ditch and Marshall Ditch study reach = 1/2 km each

Uptake Length



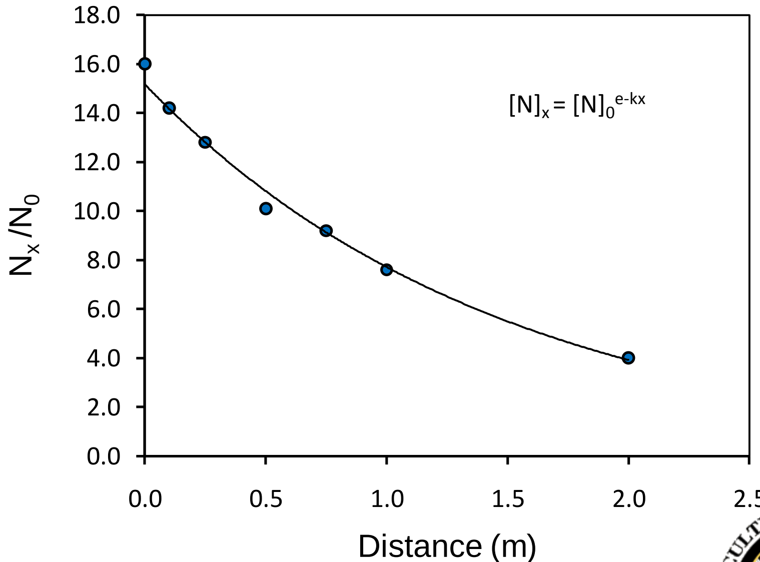
Source: Modified from Dr. Chaubey lecture notes, Spring 2008

- Net uptake length for P and NO3-N:

$$S_{net} = \sum \frac{S_{net(i)} * x_i}{x_{total}}$$

- Mass transfer coefficient:

$$V_f = \frac{v * h}{S_{net}}$$



Sediment-Water Interactions

- EPCo is the concentration at which the net exchange rate of P between sediments and the water column is negligible (Klotz, 1988).
  - If P > sediment EPCo => sediments act as a sink of P.
  - If P < sediment EPCo => sediments act as a source of P.

- PSI is a measurement of the ability of sediments to absorb P and was determined with 2 mg/L of additional P (Bache and Williams, 1971).

- Ex-P/ Ex-N is the amount of easily available P/N for release into the water column and was determined with 1M of $MgCl_2$ /2M of KCl.

Methodology

- Two types of ditch water samples were collected (3x each) in low, mid-range and high flow regimes from Feb to Jul 2008.
  - Soluble P (SP)
  - Ammonia (NH_3-N)
  - Nitrate + nitrite (NO_3-N)
  - Total phosphorus (TP)
  - Total nitrogen (TN)
- Quarterly sediments were collected 5m upstream and downstream from selected tile outlet from Jul 2007 to Jul 2008.

Water sampling

Sediment sampling

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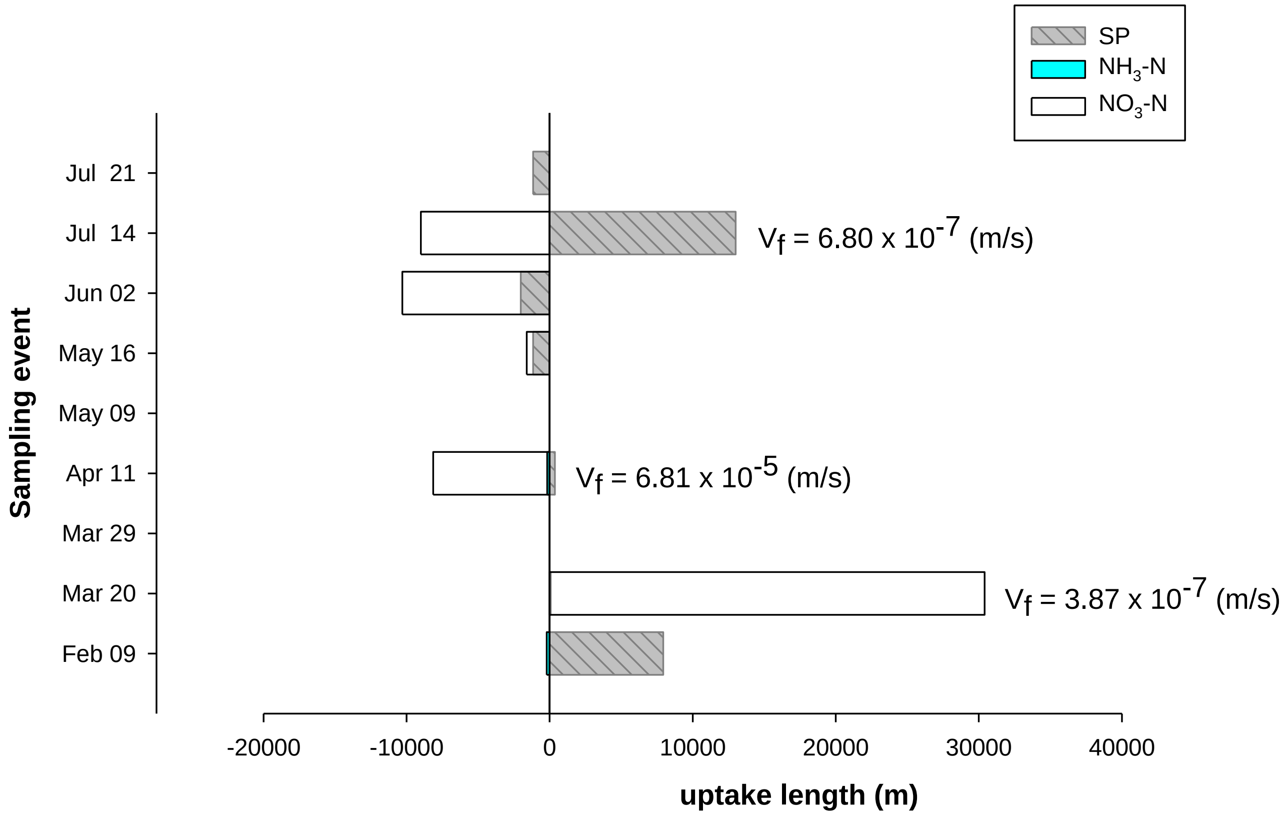
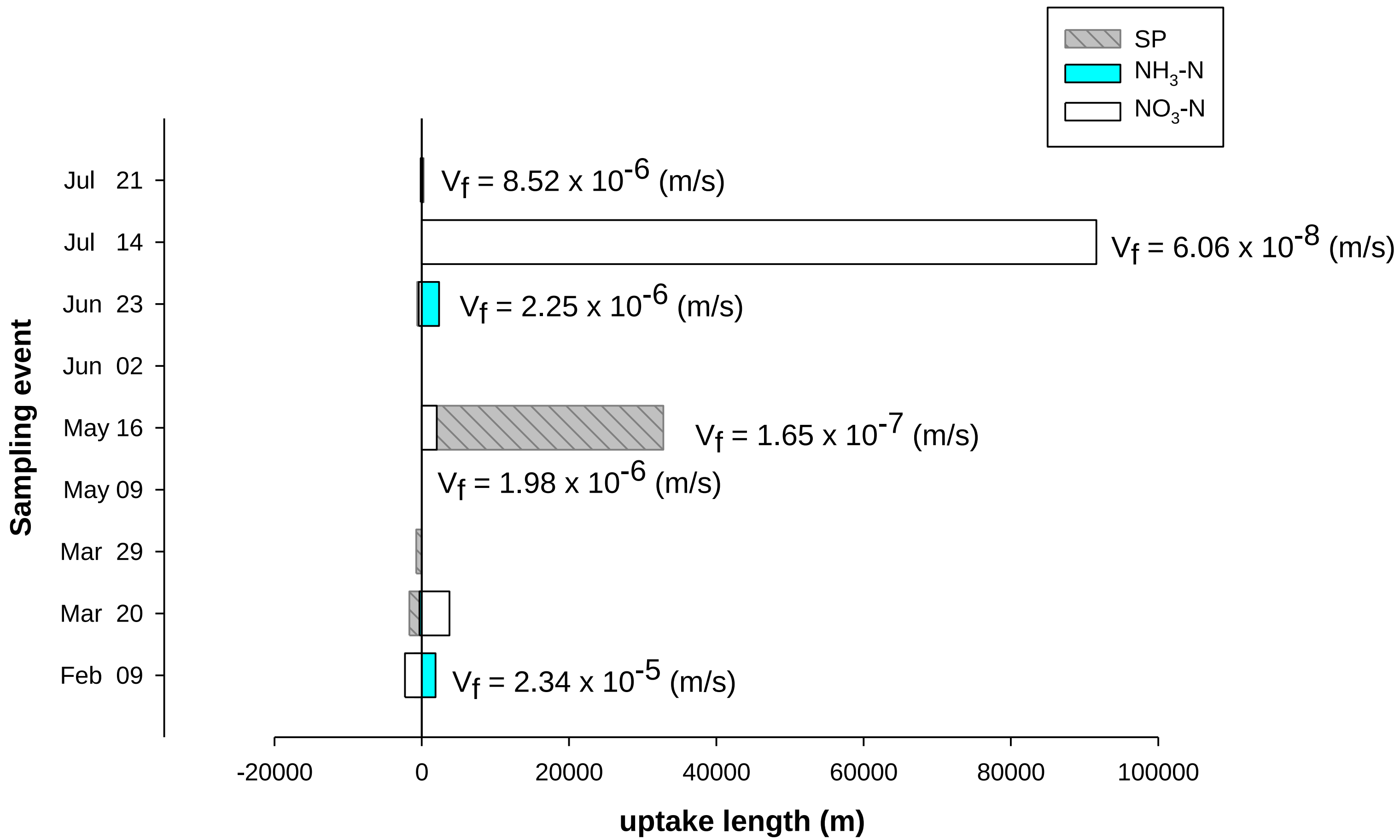
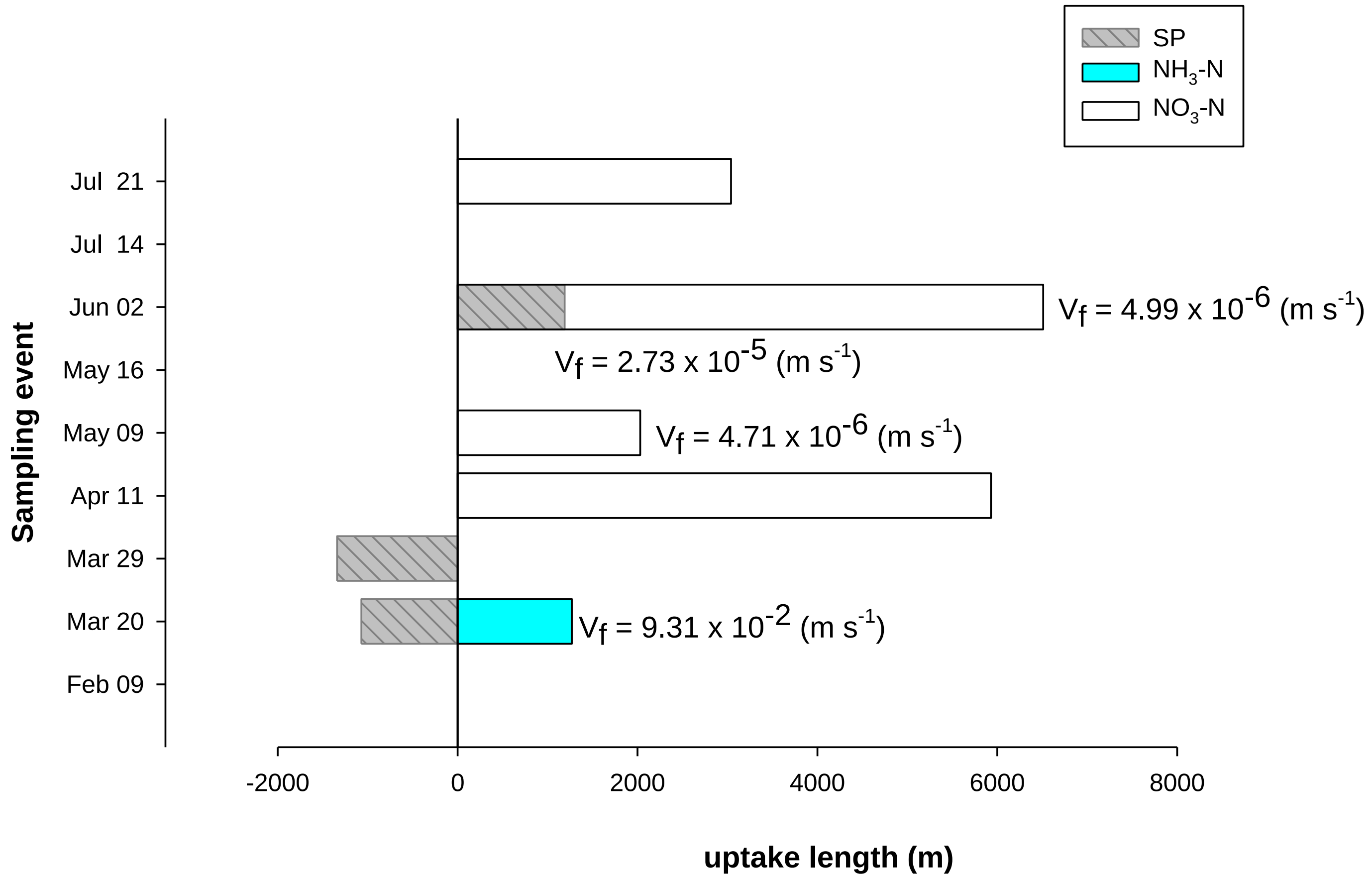
Uptake Length in Box Ditch



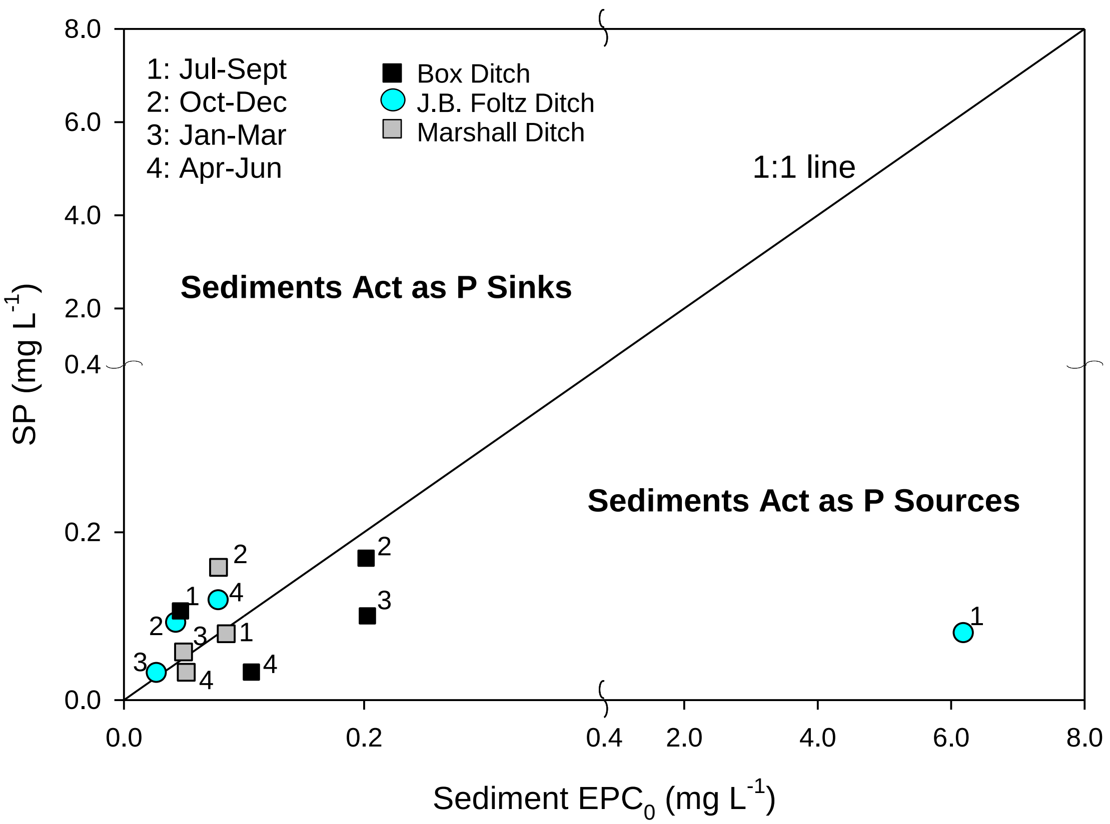
Uptake Length in JB Foltz Ditch



Uptake Length in Marshall Ditch



Sediment-Water Interactions



Sediment-Water Interactions

	Box Ditch		J.B. Foltz Ditch		Marshall Ditch	
	Ex-P	**Ex-N**	**Ex-P**	**Ex-N**	**Ex-P**	**Ex-N**
Jul-Sep	1.51	231.0*	2.34	825.7*	1.51*	70.1
Oct-Dec	5.98*	20.24	3.16	439.1	1.85*	138.4*
Jan-Mar	5.38*	88.6*	1.98	812.4*	1.49	22.1
Apr-Jun	1.81	33.7	2.09	215.4	1.39	104.3*
p-value	*< 0.05*	*< 0.04*	----	*< 0.0001*	*< 0.0001*	*< 0.02*

- * Higher values
- PSI: No significant variation between upstream and downstream sediments.

Concluding Remarks

- No particular trend in nutrient concentrations along the study reaches or based on various flow regimes.
- Retention of NH_3-N > P > NO_3-N.
- Tile drains acted as a point source for nutrients, especially for NO_3-N.
- Sediments in the three ditches acted as a sink or a source of P, or were in equilibrium with the ditch water column P concentration.
- Mean EPC_0, Ex-P, PSI, and Ex-N varied spatially and seasonally.
- Sediments were not sensitive to inputs from tile drains.
- Uptake lengths were long indicating that these ditches were rich in nutrients and may influence downstream waters.