Analyzing the Nutrient Load Dynamics and Metal Partitioning across the Missisquoi Watershed

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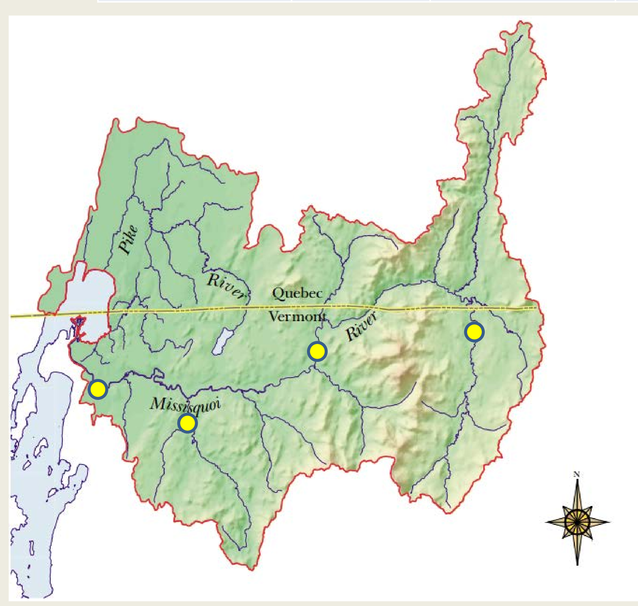
Background

In the Lake Champlain Basin, the Missisquoi River is a critical source of macronutrients and may significantly affect nutrient loading to the lake. This research examines nutrient loads and metals portioning within the Missisquoi watershed during 2012 and 2013 as well as load estimation techniques.

Site	Latitude/ Longitude	Drainage Area	Datum Gage	Station	Threshold
Swanton	44°55'00“ 73°07'44"	850 sq. miles	105 ft. above	4294000	2 m
East Berkshire	44°55'06“ 73°03'20"	18.6 sq. miles	270 ft. above	4293900	2 m
Hungerford Brook	44°57'36“ 72°41'49"	479 sq. miles	402.51 ft. above	4293500	4 m
North Troy	44°58'22" 72°23'09	131 sq. miles	580 ft. above	4293000	3 m

Table 1 (Above): Missisquoi River Site Locations/Information



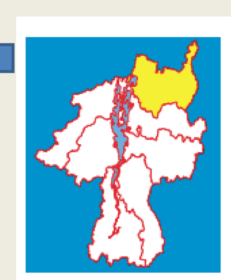
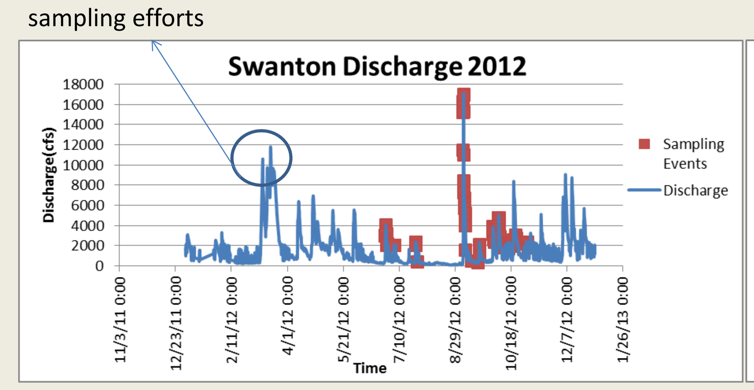
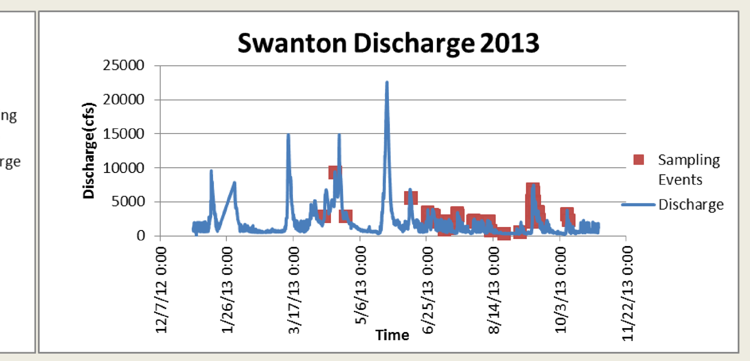


Figure 1(Left): Missisquoi Watershed Map as part of Vermont Watershed. USGS Gauge Station Locations (yellow dots from left to right): Swanton, Hungerford Brook, East Berkshire, North Troy

Annual Loads and Sampling Events

*Insufficient spring sampling efforts





Figures 4&5 (above): Hydrographs for Swanton site with sampling events plotted over hydrograph 2012 and 2013 respectively.

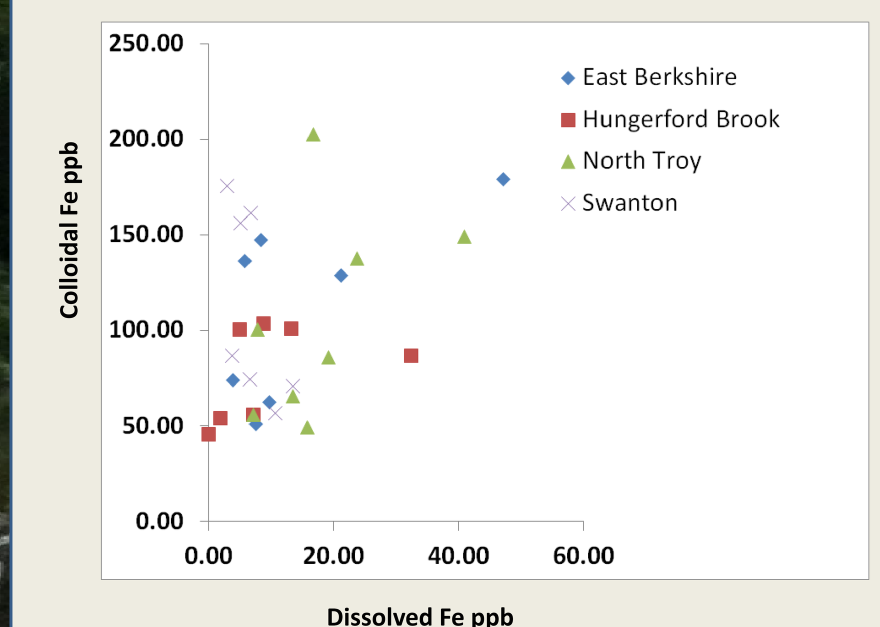
Annual Load Estimations Using Linear Regression Equations		
	2012	2013
Swanton		
TP (kg/year)	$7.32*10^4$	$1.01*10^5$
TN (kg/year)	$1.02*10^6$	$9.13*10^5$
SRP (kg/year)	$2.44*10^4$	$3.48*10^4$
Cumulative Q (cfs)	$4.76*10^{10}$	$4.75*10^{10}$
Hungerford Brook		
TP (kg/year)	[redacted]	$9.04*10^3$
TN (kg/year)		$3.23*10^4$
SRP (kg/year)		$1.76*10^3$
Cumulative Q (cfs)		$4.49*10^8$
East Berkshire		
TP (kg/year)	$5.56*10^3$	$6.80*10^4$
TN (kg/year)	$3.26*10^5$	$4.09*10^5$
SRP (kg/year)	$5.71*10^3$	$4.96*10^3$
Cumulative Q (cfs)	$2.21*10^{10}$	$2.48*10^{10}$
North Troy		
TP (kg/year)	$1.58*10^4$	$1.09*10^5$
TN (kg/year)	$1.38*10^4$	$4.23*10^5$
SRP (kg/year)	[redacted]	$1.87*10^3$
Cumulative Q (cfs)	$8.03*10^9$	$2.03*10^{10}$

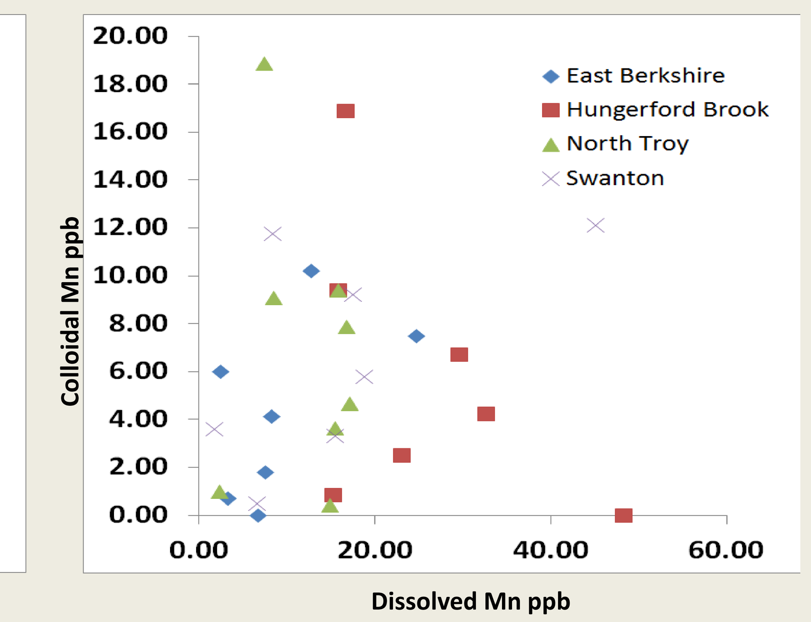
Table 2 (Left): Annual load estimations for each site and nutrient analyzed. North Troy 2012 SRP data was not sufficient. There were also not enough 2012 sampling efforts in Hungerford Brook for sufficient data for model.

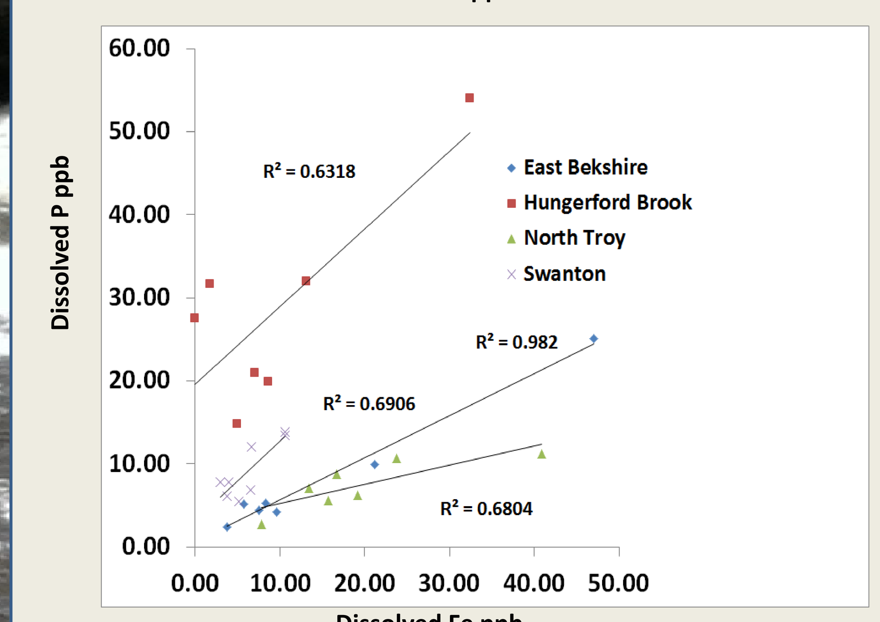
Table 3 (below): Comparison of linear regression model and USGS R Script program for annual load estimations suggests linear regression is a valid assumption for close approximation.

Swanton	TN ($kg*yr^{-1}$)	TP ($kg*yr^{-1}$)	SRP ($kg*yr^{-1}$)
2012 Linear Regr.	$1.02*10^6$	$7.32*10^4$	$2.44*10^4$
2012 USGS R Script	$1.12*10^6$	$1.03*10^5$	$2.52*10^4$
2013 Linear Regr.	$9.13*10^5$	$1.01*10^5$	$3.48*10^4$
2013 USGS R Script	$1.01*10^6$	$1.09*10^5$	$2.08*10^4$

Metal Load Partitioning and P Association







Manganese and Iron are partitioned differently in these rivers, and Fe concentrations are generally higher at all sites.

Fe dominated by the colloidal size class, while Mn has a higher contribution of dissolved phase.

Dissolved P and dissolved Fe appear to be associated suggesting similar geochemical pathways/sources in the watershed. Differs from lake where dissolved Mn and P have higher determination coefficients.

Likely soil and groundwater in the forests, possibly fertilizer/manure in agricultural sites.

Methods

Field Methods:

- Automatic Sampler (ISCO) triggered when river threshold reached.
- ISCO samples and baseline grab samples collected from 4 USGS sites for lab analysis.
- Grab samples for metals analysis

Figure 2- ISCO Automatic Sampler being installed in Missisquoi

Lab Methods:

- TN, TP, SRP analysis performed at Johnson State College
- Metals analysis performed at UVM Rubenstein Ecosystem Lab

Load Estimation Methods:

- Linear regression model developed from Concentration vs. Discharge
- Identify storm events and determine loads from individual storm events.

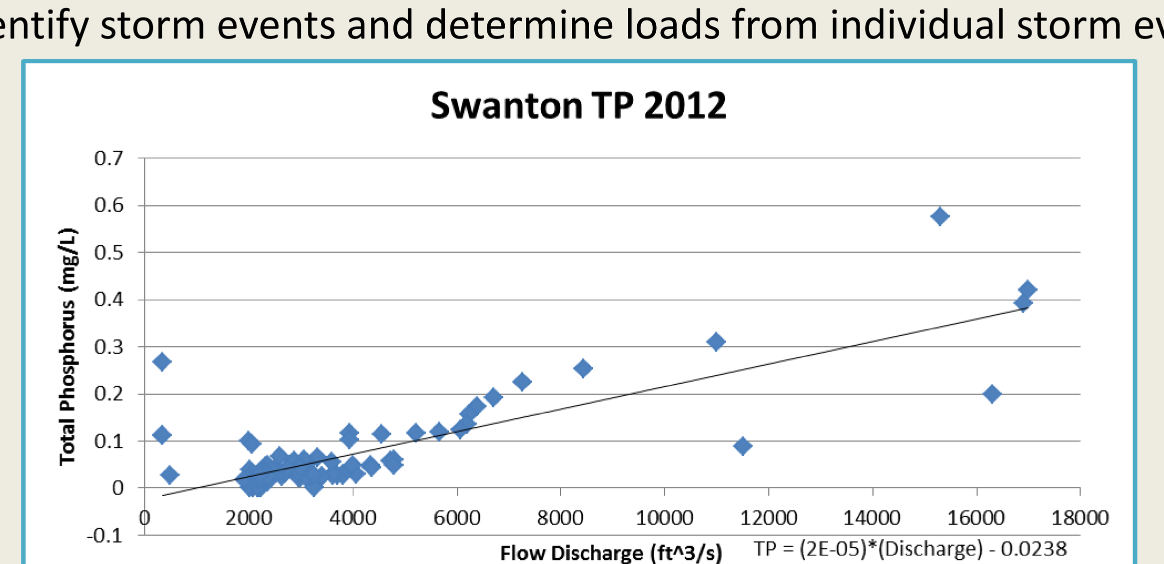
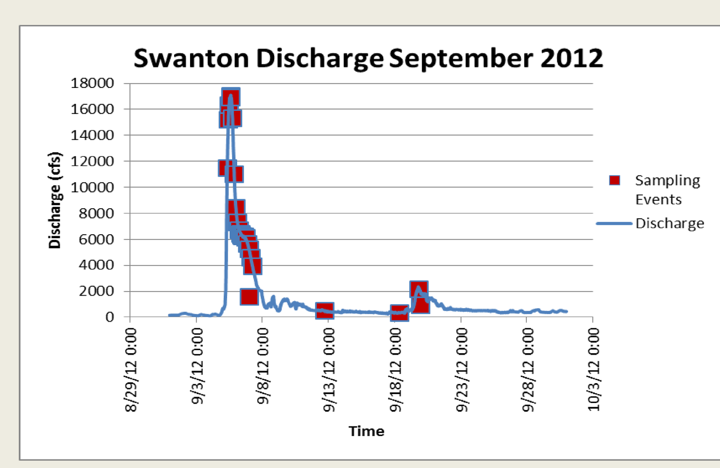
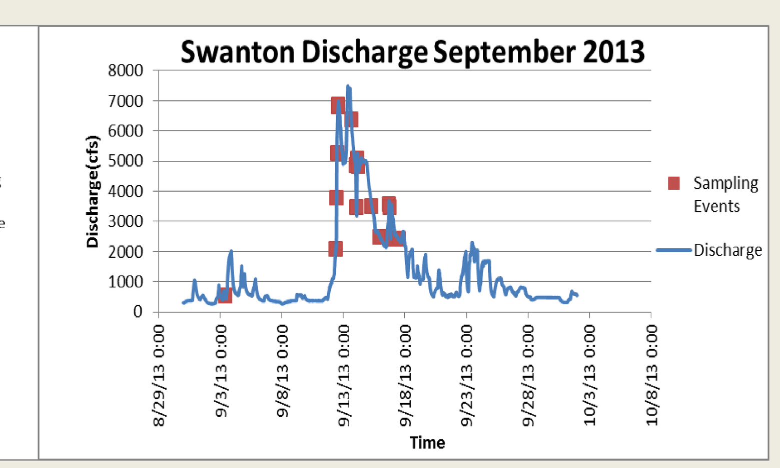


Figure 3- Example of discharge and concentration from Swanton TP 2012 relationship used for load linear regression model

Storm Nutrient Loads





Figures 6&7 (above): Swanton discharge and sampling events highlighting storm events for September 2012 and 2013 respectively. Sampling efforts captured and rise and fall of rivers during storm events.

Date of Storm Event	Nutrient	Storm Flux-Linear Reg.	Percentage of Annual Flux Linear Reg.	Storm Flux-USGS R Script	Percentage of Annual Flux-USGS R Script
9/5/12-9/7/12	TP(kg*storm -1)	$8.27*10^3$	11.1%	$8.26*10^3$	8.0%
	TN(kg*storm -1)	$5.31*10^4$	5.2%	$4.22*10^4$	3.8%
	SRP(kg*storm -1)	$2.47*10^3$	10.1%	$1.38*10^3$	5.4%
	Cumulative Q (cfs)	$1.7*10^9$	3.6%	[redacted]	
9/12/13-9/16/13	TP(kg*storm -1)	$3.59*10^4$	3.4%	$3.88*10^4$	3.6%
	TN(kg*storm -1)	$3.23*10^4$	3.5%	$3.99*10^4$	4.0%
	SRP(kg*storm -1)	$1.18*10^3$	3.7%	$7.66*10^2$	3.7%
	Cumulative Q (cfs)	$3.02*10^8$	0.6%	[redacted]	

Table 4 (Above): Storm fluxes for two storm events from September 2012 and 2013 using linear regression and USGS R Script. Shown as an individual load and as a percentage of the total annual load from Table 2.

Conclusions

Load estimations show a strong relationship between higher discharges and larger loads. A single storm event in September 2013 was responsible for nearly 11% of the total phosphorus flux of the entire year. Hungerford Brook had some of the largest loads, but with only one year of reliable data more research is still needed at that site as well as the agricultural practices near Hungerford Brook. The other Missisquoi sites show similar loads between years with a general trend to higher loads in 2013. These load calculations were done using linear regression models and not accurate as seen in SRP estimations and several outliers at each site. Further load estimation efforts are being made using computer software programs such as R, Loadrunner, and Loadest. When our linear data at Swanton was compared with R Script, the results were similar to the linear regression model suggesting that the linear assumption is useful for approximations and comparative purposes.

The metals analysis showed that iron and manganese are partitioned differently in rivers. Dissolved phosphorus and dissolved iron appear to be associated suggesting similar pathways and sources across the watershed.

It has also been noted a large gap in data is missing during the spring runoff period. Efforts are currently underway in 2014 to capture this critical time period as a continuation of this project in the form of a UVM senior thesis project. This will involve a closer look at the role of spring runoff and more accurate load estimation techniques.

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