Missisquoi River Basin Association

Water Quality Monitoring Program

Summary of Results 2005-2010

Submitted for the Missisquoi River Basin Association
2839 VT Route 105, East Berkshire, VT 05447
by Jeremy Deeds and Shana Stewart
to the Vermont Department of Environmental Conservation
103 S. Main Street, 10N, Waterbury, VT 05671-0408

Missisquoi River Basin Overview:

The Missisquoi River runs across the northwestern part of Vermont and into southern Quebec. The river begins in Lowell and flows approximately 80 miles into the Missisquoi Bay. The Missisquoi River watershed is comprised of forests, agricultural land, and some urban and suburban developments. At 25%, agriculture is the dominant *non-forested* land use land cover. The water quality in Missisquoi Bay is at risk due to the enrichment of nutrients from the watershed and the toxic algae blooms that result. The Missisquoi River watershed is currently the focus of several monitoring and restoration efforts to identify nutrient sources and minimize nutrient input to the river and bay.

Program Overview:

The Missisquoi River Basin Association (MRBA) is a non-profit organization focused on the restoration of the Missisquoi River and its tributaries. The Water Quality Monitoring program is a volunteer-run sampling program that takes place each summer throughout the basin. Through partnership with the Vermont Department of Environmental Conservation LaRosa Analytical Services Partnership Program, the MRBA has access to the State of Vermont's analytical laboratory to process and analyze the water samples taken in the field.

The goal of the monitoring project is multifaceted. This volunteer program allows community members to learn about the environment of the Missisquoi River Basin, about conservation and restoration of the environment, and how to take water quality samples and interpret the results. In addition, the program collects valuable data that may eventually aid in the determination of specific problem areas at which to focus restoration efforts.

Methods:

Trained citizen volunteers collected water samples biweekly at between 19 and 21 sites depending on the year. These sites were located throughout the Missisquoi River Basin, along the mainstem of the Missisquoi River and its tributaries. Refer to Table 1 for a list of sample sites and their corresponding sample years. Figures 1-3 show the location of each site labeled by their corresponding identifying code.

Table 1: List of mainstem and tributary sample sites with identifying code and sampling years

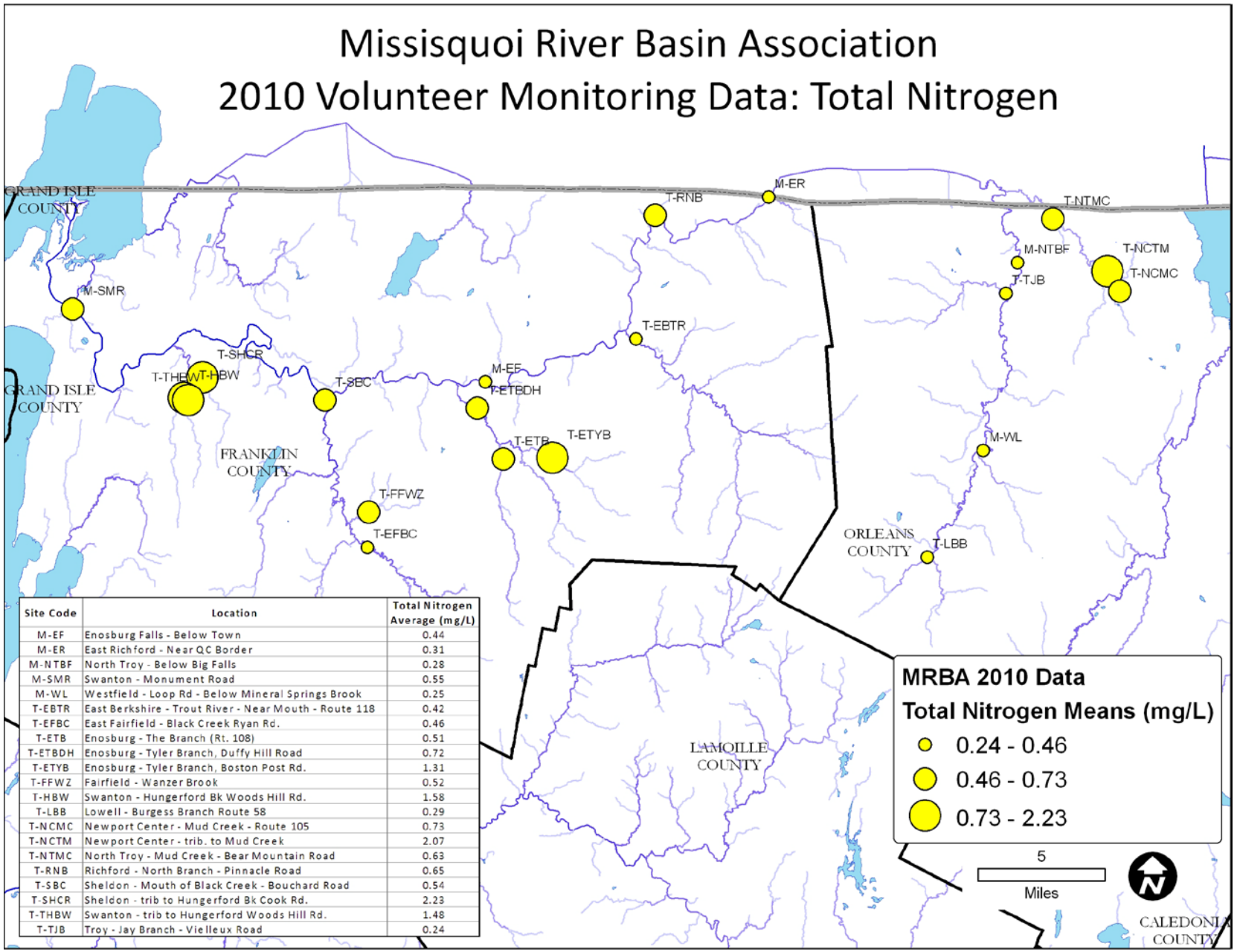
Mainstem Sites	Code	Years
Westfield - Loop Rd - Below Mineral Springs Brook	M-WL	2005, 2006, 2007, 2008, 2009, 2010
Troy - Citizens Dam	M-TCD	2005, 2006, 2007
North Troy - Below Big Falls	M-NTBF	2005, 2006, 2007, 2008, 2009, 2010
East Richford - Near QC Border	M-ER	2005, 2006, 2007, 2008, 2009, 2010
Richford – below town, Davis Park	M-RDP	2005
Richford - Below North Branch Marvin Rd	M-RM	2006, 2007
East Berkshire - Below Trout River	M-EB	2005, 2006, 2007
Enosburg Falls - Lawyers Landing	M-ELL	2005
Enosburg Falls - Below Town	M-EF	2005, 2006, 2007, 2008, 2009, 2010
N.Sheldon - Above Black Creek - Kane Road	M-NS	2005, 2006, 2007
Sheldon Junction - Bridge	M-SJ	2005
Highgate - Dam at Highgate Falls	M-HD	2005, 2006, 2007
Swanton – above town Johns Bridge	M-SJB	2005
Swanton - Marble Mill - Below Dam	M-SMM	2005
Swanton - Monument Road	M-SMR	2005, 2006, 2007, 2008, 2009, 2010

Tributary Sites	Code	Years
Lowell - Burgess Branch Route 58	T-LBB	2005, 2006, 2007, 2008, 2009, 2010
Troy - Jay Branch - Vielleux Road	T-TJB	2006, 2007, 2008, 2009, 2010
Newport Center - Mud Creek - Route 105	T-NCMC	2006, 2007, 2008, 2009, 2010
Newport Center – trib. to Mud Creek	T-NCTM	2008, 2009, 2010
North Troy - Mud Creek - Bear Mountain Road	T-NTMC	2005, 2006, 2007, 2008, 2009, 2010
Richford - North Branch - Pinnacle Road	T-RNB	2006, 2007, 2008, 2009, 2010
East Berkshire - Trout River - Near Mouth - Route 118	T-EBTR	2005, 2006, 2007, 2008, 2009, 2010
Enosburgh - Tyler Branch, Duffy Hill Road	T-ETBDH	2006, 2007, 2008, 2009, 2010
Enosburgh – Tyler Branch, Boston Post Rd.	T-ETYB	2008, 2009, 2010
Enosburgh – below Tyler Branch	T-EBTB	2005
Enosburgh – The Branch (Rt. 108)	T-ETB	2008, 2009, 2010
East Fairfield - Black Creek Ryan Rd.	T-EFBC	2007, 2008, 2009, 2010
Fairfield – Wanzer Brook	T-FFWZ	2008, 2009, 2010
Sheldon - Mouth of Black Creek - Bouchard Road	T-SBC	2005, 2006, 2007, 2008, 2009, 2010
Highgate - Hungerford Brook Route 207	T-HHB	2006, 2007
Sheldon – trib to Hungerford Bk Cook Rd.	T-SHCR	2008, 2009, 2010
Swanton – trib to Hungerford Woods Hill Rd.	T-THBW	2008, 2009, 2010
Swanton – Hungerford Bk Woods Hill Rd.	T-HBW	2008, 2009, 2010

Volunteers received training in accordance with the Quality Assurance Project Plan for taking grab samples for total phosphorus, total nitrogen, total suspended solids, and turbidity. Samples were kept cold during transport and storage before analysis. Samplers also completed a field data sheet at each site noting not only who took the sample, and where and when the sample was taken, but also parameters such as flow and weather observations. The US Environmental Protection Agency provided portable conductivity meters for volunteers to measure the conductivity at each site. The results were also recorded on the data sheet. In order to interpret the results from the state laboratory it was necessary to organize and manage the data using Microsoft® Access© and Microsoft® Excel©, which allowed for further geographic analysis in ESRI® ArcGIS©.

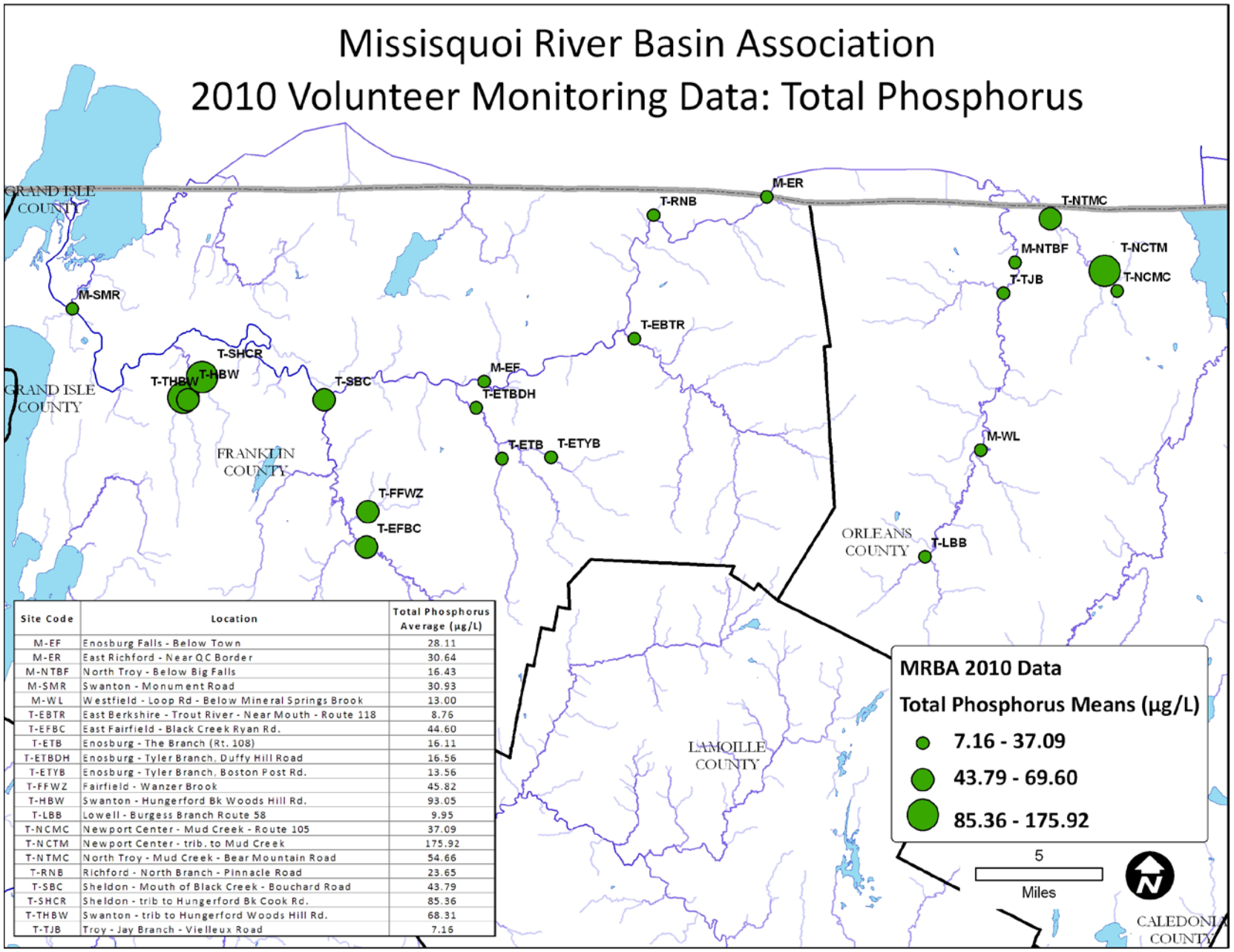
Results and Discussion:

Figures 1-3 shows sampling location and results of the three water quality parameters measured. Each figure shows the results for total nitrogen, total phosphorus, and turbidity respectively. The graphs represent mean values for all parameters at each site ± standard error of the mean.



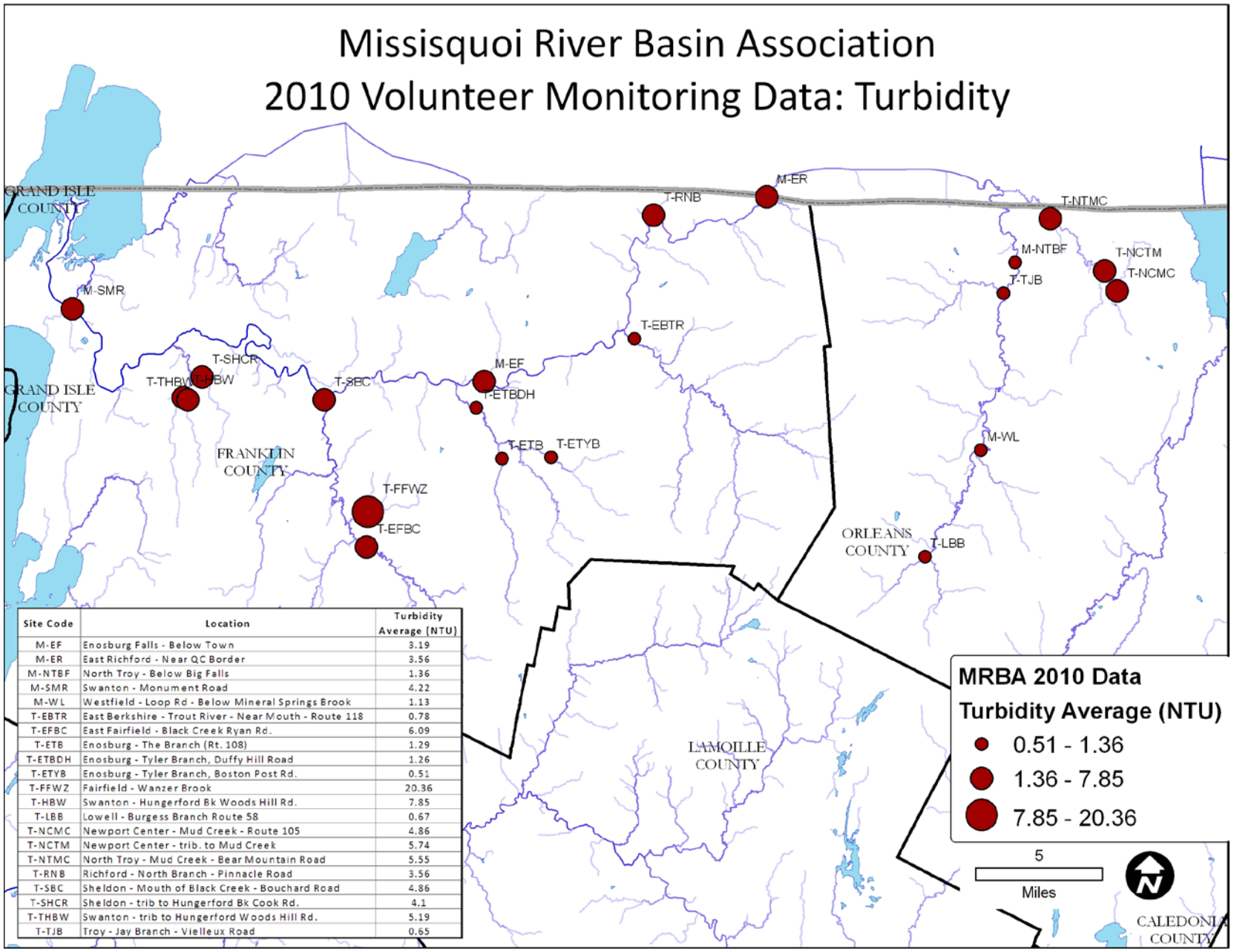
Site Code	Location	Total Nitrogen Average (mg/L)
M-EF	Enosburg Falls - Below Town	0.44
M-ER	East Richford - Near QC Border	0.31
M-NTBF	North Troy - Below Big Falls	0.28
M-SMR	Swanton - Monument Road	0.55
M-WL	Westfield - Loop Rd - Below Mineral Springs Brook	0.25
T-EBTR	East Berkshire - Trout River - Near Mouth - Route 118	0.42
T-EFBC	East Fairfield - Black Creek Ryan Rd.	0.46
T-ETB	Enosburg - The Branch (Rt. 108)	0.51
T-ETBDH	Enosburg - Tyler Branch, Duffy Hill Road	0.72
T-ETYB	Enosburg - Tyler Branch, Boston Post Rd.	1.31
T-FFWZ	Fairfield - Wanzer Brook	0.52
T-HBW	Swanton - Hungerford Bk Woods Hill Rd.	1.58
T-LBB	Lowell - Burgess Branch Route 58	0.29
T-NCMC	Newport Center - Mud Creek - Route 105	0.73
T-NCTM	Newport Center - trib. to Mud Creek	2.07
T-NTMC	North Troy - Mud Creek - Bear Mountain Road	0.63
T-RNB	Richford - North Branch - Pinnacle Road	0.65
T-SBC	Sheldon - Mouth of Black Creek - Bouchard Road	0.54
T-SHCR	Sheldon - trib to Hungerford Bk Cook Rd.	2.23
T-THBW	Swanton - trib to Hungerford Woods Hill Rd.	1.48
T-TJB	Troy - Jay Branch - Vielleux Road	0.24

Figure 1: 2010 total nitrogen averages (mg/L).



Site Code	Location	Total Phosphorus Average (µg/L)
M-EF	Enosburg Falls - Below Town	28.11
M-ER	East Richford - Near QC Border	30.64
M-NTBF	North Troy - Below Big Falls	16.43
M-SMR	Swanton - Monument Road	30.93
M-WL	Westfield - Loop Rd - Below Mineral Springs Brook	13.00
T-EBTR	East Berkshire - Trout River - Near Mouth - Route 118	8.76
T-EFBC	East Fairfield - Black Creek Ryan Rd.	44.60
T-ETB	Enosburg - The Branch (Rt. 108)	16.11
T-ETBDH	Enosburg - Tyler Branch, Duffy Hill Road	16.56
T-ETYB	Enosburg - Tyler Branch, Boston Post Rd.	13.56
T-FFWZ	Fairfield - Wanzer Brook	45.82
T-HBW	Swanton - Hungerford Bk Woods Hill Rd.	93.05
T-LBB	Lowell - Burgess Branch Route 58	9.95
T-NCMC	Newport Center - Mud Creek - Route 105	37.09
T-NCTM	Newport Center - trib. to Mud Creek	175.92
T-NTMC	North Troy - Mud Creek - Bear Mountain Road	54.66
T-RNB	Richford - North Branch - Pinnacle Road	23.65
T-SBC	Sheldon - Mouth of Black Creek - Bouchard Road	43.79
T-SHCR	Sheldon - trib to Hungerford Bk Cook Rd.	85.36
T-THBW	Swanton - trib to Hungerford Woods Hill Rd.	68.31
T-TJB	Troy - Jay Branch - Vielleux Road	7.16

Figure 2: 2010 total phosphorus averages (µg/L).



Site Code	Location	Turbidity Average (NTU)
M-EF	Enosburg Falls - Below Town	3.19
M-ER	East Richford - Near QC Border	3.56
M-NTBF	North Troy - Below Big Falls	1.36
M-SMR	Swanton - Monument Road	4.22
M-WL	Westfield - Loop Rd - Below Mineral Springs Brook	1.13
T-EBTR	East Berkshire - Trout River - Near Mouth - Route 118	0.78
T-EFBC	East Fairfield - Black Creek Ryan Rd.	6.09
T-ETB	Enosburg - The Branch (Rt. 108)	1.29
T-ETBDH	Enosburg - Tyler Branch, Duffy Hill Road	1.26
T-ETYB	Enosburg - Tyler Branch, Boston Post Rd.	0.51
T-FFWZ	Fairfield - Wanzer Brook	20.36
T-HBW	Swanton - Hungerford Bk Woods Hill Rd.	7.85
T-LBB	Lowell - Burgess Branch Route 58	0.67
T-NCMC	Newport Center - Mud Creek - Route 105	4.86
T-NCTM	Newport Center - trib. to Mud Creek	5.74
T-NTMC	North Troy - Mud Creek - Bear Mountain Road	5.55
T-RNB	Richford - North Branch - Pinnacle Road	3.56
T-SBC	Sheldon - Mouth of Black Creek - Bouchard Road	4.86
T-SHCR	Sheldon - trib to Hungerford Bk Cook Rd.	4.1
T-THBW	Swanton - trib to Hungerford Woods Hill Rd.	5.19
T-TJB	Troy - Jay Branch - Vielleux Road	0.65

Figure 3: 2010 turbidity averages (NTU).

In 2010, three tributary systems stood out for elevated levels of nutrients (nitrogen and phosphorus) in the Missisquoi River watershed: Mud Creek, Tyler Branch and Hungerford Brook (see Figures 1 & 2). The Missisquoi watershed is approximately 25% agricultural and is the largest contributor of phosphorus to Lake Champlain among the all the lake's contributing watersheds (Troy et al., 2007). The nutrient loads from these three tributaries suggest that much of this phosphorus in the Missisquoi River originates in these three areas of the watershed. Phosphorus and nitrogen concentrations in the mainstem Missisquoi were found to be lower than the average concentrations in these tributaries.

The Vermont Water Quality Standards set a limit of 25 µg/L phosphorus in the Missisquoi Bay of Lake Champlain (State of Vermont, 2008). Only nine of the 20 sites sampled in 2010 met this criterion (T-TJB, T-EBTR, T-LBB, M-WL, T-ETYB, T-ETB, M-NTBF, T-ETBDH, and T-RNB). The lowest average concentration was found at site T-TJB (7.16 ±0.58 µg/L) and the site with the highest average concentration was T-NCTM (175.92 ±54.98 µg/L). Site M-SMR, where the sample is taken at the mouth of the river before it flows into Missisquoi Bay, had an average phosphorus concentration of 30.93 (±3.66) µg/L in 2010. The individual samples taken from this site varied from 14. 1 µg/L (September 22, 2010) to 45.8 µg/L (July 14, 2010).

There is no state water quality standard for total nitrogen (only for Nitrates), so comparing the nitrogen data discussed here to established criteria is not possible.

Eighteen of the 20 sites sampled in 2010 had a relatively low mean turbidity value of 3.00 (± 0.60) NTU. However, Wanzer Brook (a tributary of Black Creek) had highly elevated values; 20.35 NTU in 2010, nearly three times greater than the next highest value (7.85; Swanton – Hungerford Brook, Woods Hill Rd.). In fact, this is the only site that exceeds the turbidity standard for either cold water fisheries (10 NTU) or warm water fisheries (25 NTU) in the Missisquoi watershed (State of Vermont, 2008). This elevated value is due to the sample from September 22, 2010, which resulted in a turbidity value of 185 NTU; the second highest reading from this site in 2010 was 6.65 NTU (July 14, 2010), which falls below the turbidity standards for both cold and warm water fisheries. This datum is likely an anomaly and may be excluded from future analyses unless continued monitoring records similar high levels. It is possible that stream restoration work in Wanzer Brook, ongoing in 2010, may have affected the turbidity data from the September 22nd sampling event.

Figures 4-6 show the overall averages of all samples taken in the five year period from June 1, 2005 until October 20, 2010. The graphs represent mean values for all parameters at each site ± standard error of the mean. Data from 2005-2008 are grouped together, while data from 2009 and 2010 are separate in order to observe trends in the data from the last two years. These figures show that, for many sites, water quality may be improving. The sites M-NTBF, T-ETBDH, T-NCMC, T-NTMC, T-RNB, T-SHCR, T-THBW and T-TJB all show patterns of decreasing phosphorous concentrations over this time period (although, T-SHCR – tributary to Hungerford Brook, Cook Road – showed an increase in average nitrogen concentration from 2009 to 2010). Notably, many of these sites are from the three tributary systems noted above as having the highest phosphorus concentrations in 2010: Mud Creek, Tyler Branch and Hungerford Brook. A large number of sites have either stayed relatively constant in nutrient concentrations in the past 5 years or have increased only slightly. For turbidity, T-EFBC, E-ETBDH, T-HBW, T-NCMC, T-NCTM, T-NTMC, T-RNB, T-SBC, T-THBW and T-TJB all showed

lower mean values in 2010 than they had in previous years. Statistical analyses would be necessary to determine if these reductions are significant.

The area of the watershed with the lowest mean values for phosphorus, nitrogen and turbidity (T-LBB, M-WL, T-TJB, and M-NTBF) is the upper portion of the Missisquoi River, before it flows into Canada. None of these sites exceed the 25 µg/L phosphorus criterion for Missisquoi Bay (State of Vermont, 2008). These data suggest that this portion of the Missisquoi watershed is highly intact and supports very good water quality.

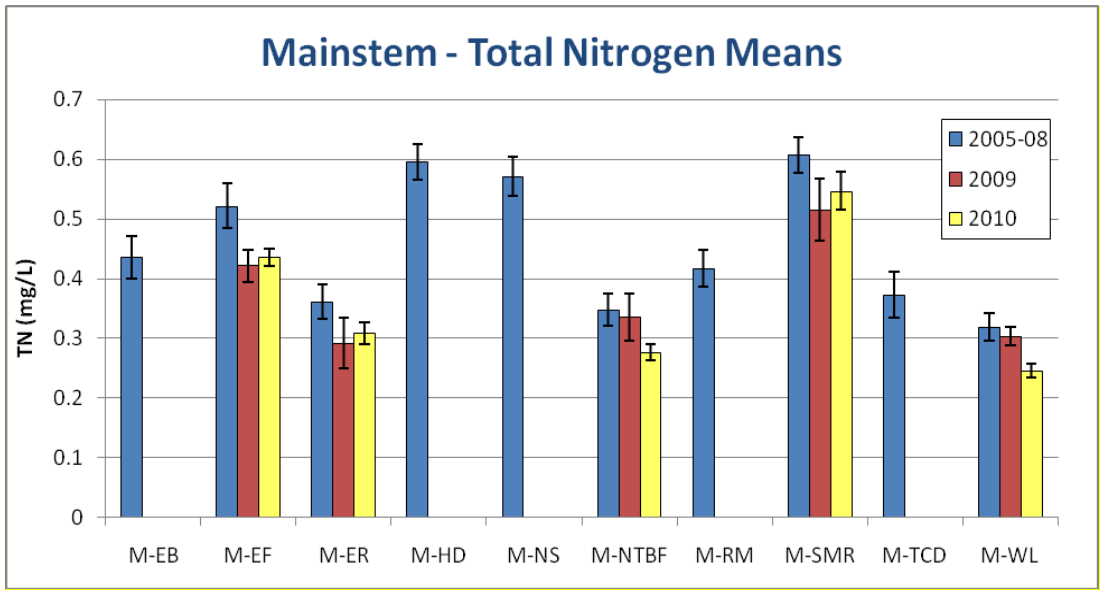


Figure 4a: Mainstem Missisquoi River averages for total nitrogen concentration in mg/L (± standard error), from 2005 to 2010.

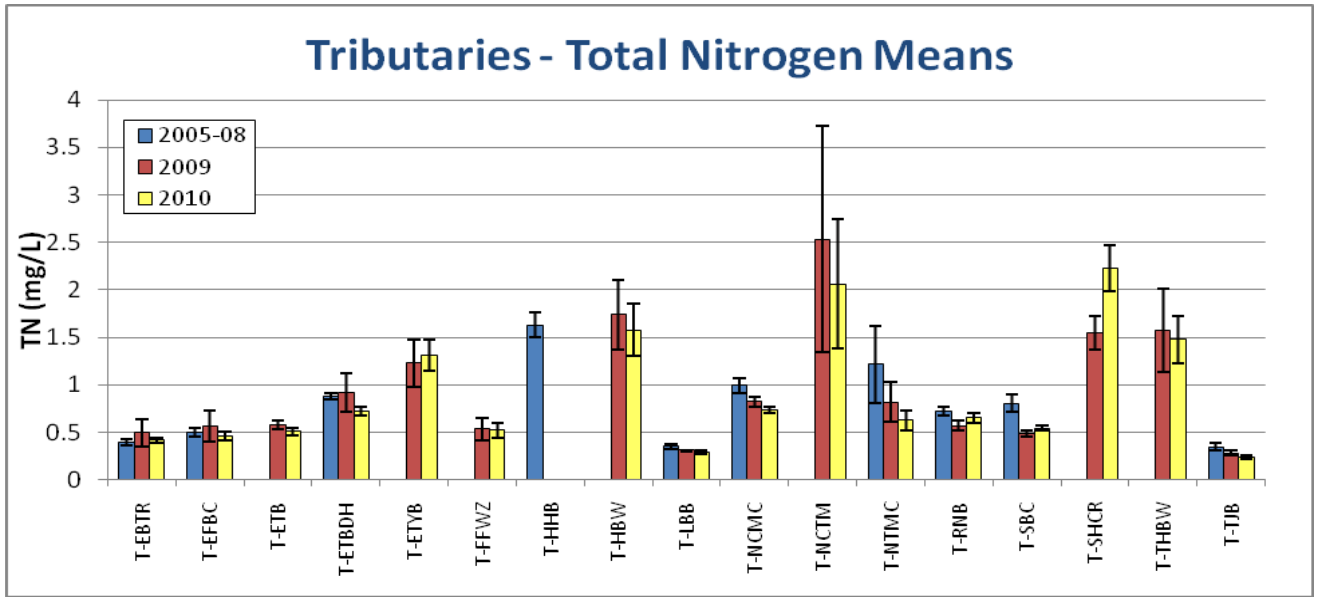


Figure 4b: Missisquoi River Tributary averages for total nitrogen concentration in mg/L (± standard error), from 2005 to 2010.

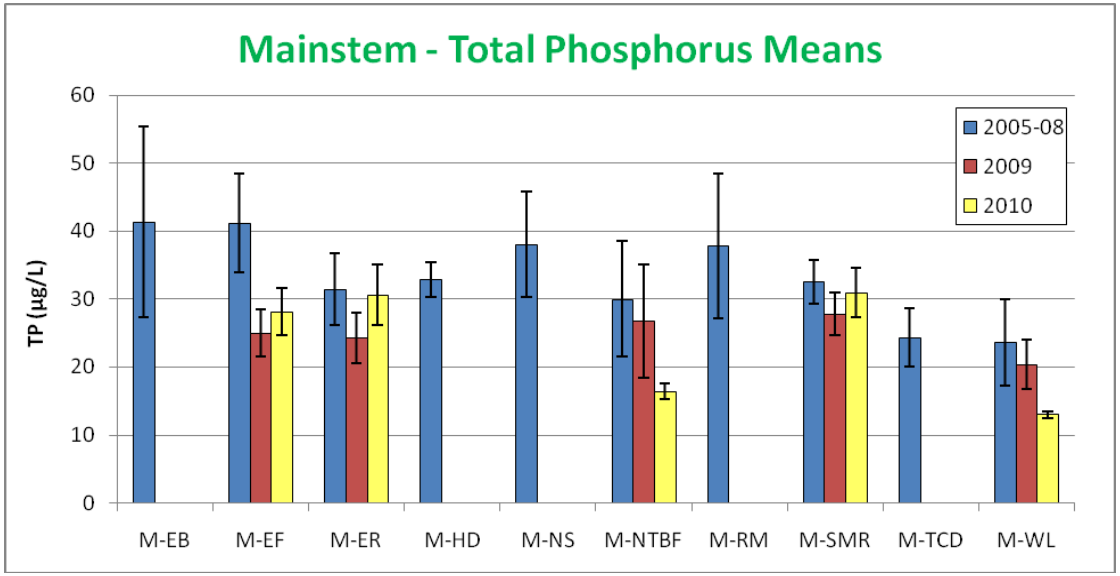


Figure 5a: Mainstem Missisquoi River averages for total phosphorus concentration in µg/L (± standard error), from 2005 to 2010.

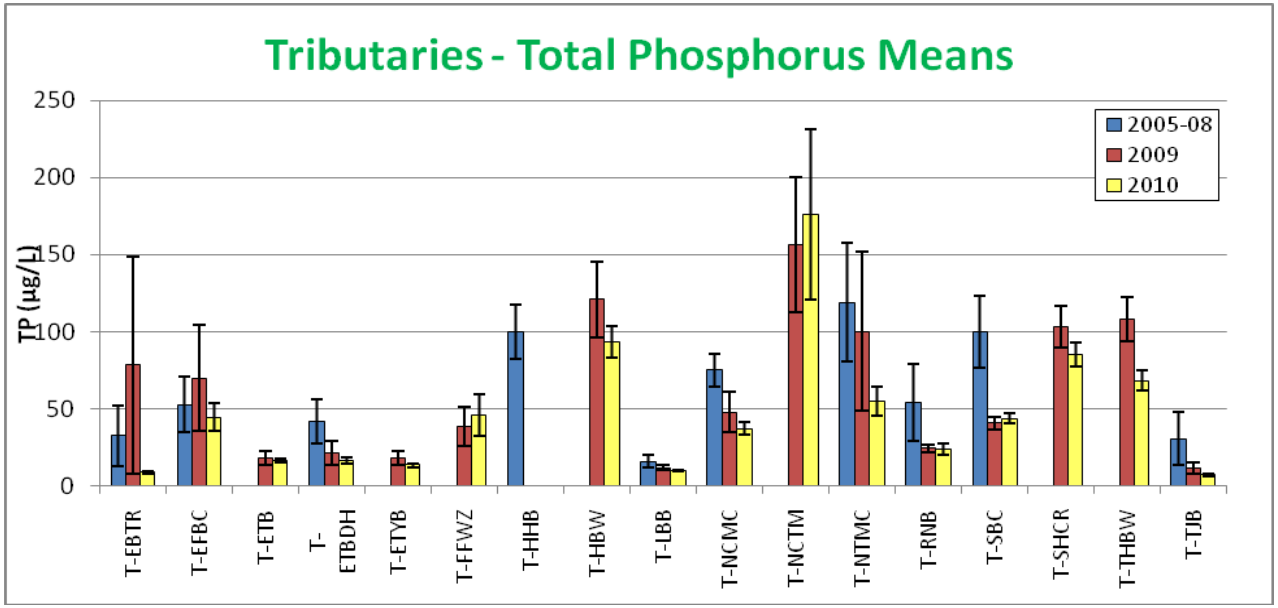


Figure 5b: Missisquoi River Tributary averages for total phosphorus concentration in µg/L (± standard error), from 2005 to 2010.

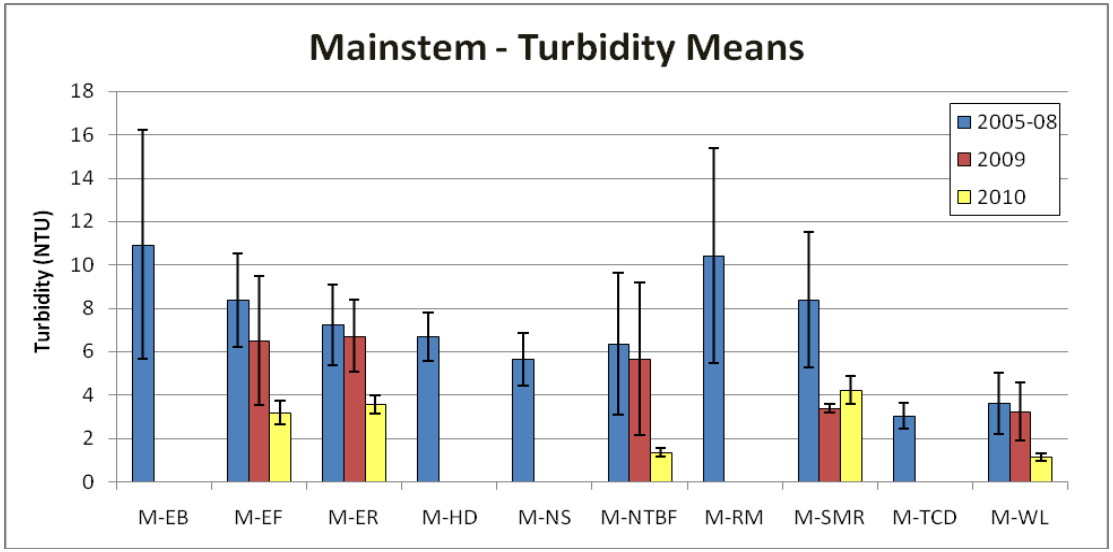


Figure 6a: Mainstem Missisquoi River averages for turbidity in NTU (± standard error), from 2005 to 2010.

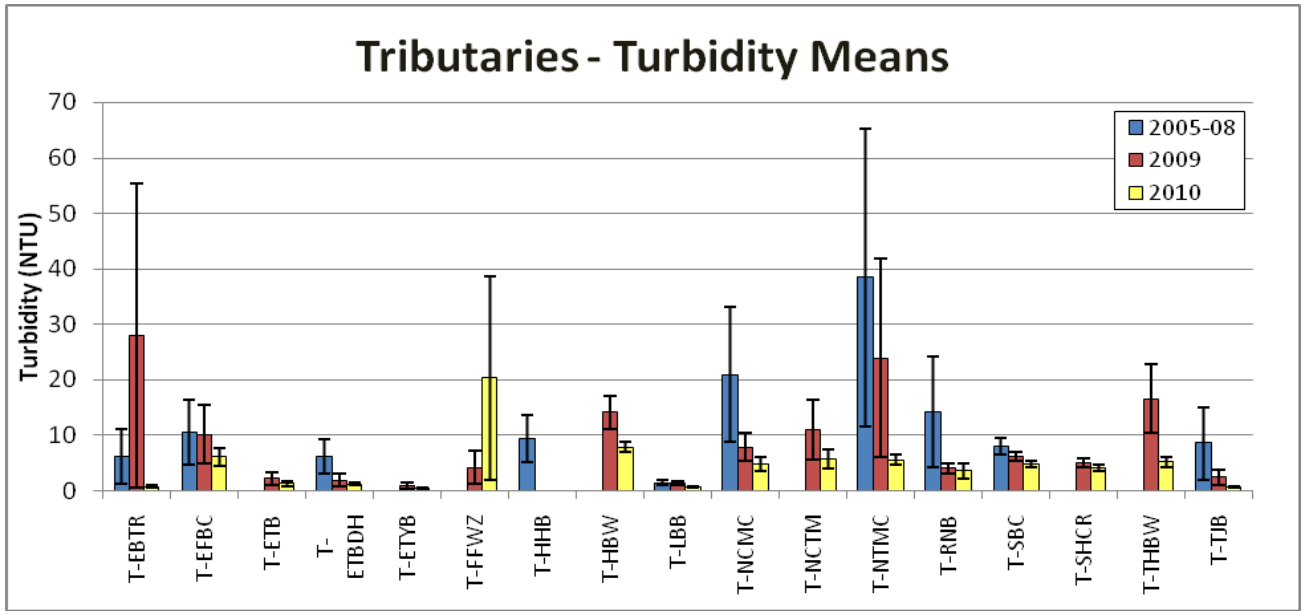


Figure 6b: Missisquoi River Tributary averages for turbidity in NTU (± standard error), from 2005 to 2010.

Correlations between 2010 Data:

The graphs below (Figures 7a-c) show the relationships between the water quality variables measured in 2010. Turbidity does not appear to be correlated with either total nitrogen or total phosphorous. This indicates that the turbidity is likely caused by factors other than those which are contributung high nutrient inputs to the waterways. Nitrogen and phosphorus appear to be related to one another, indicating that these two nutrients may be coming from the same source.

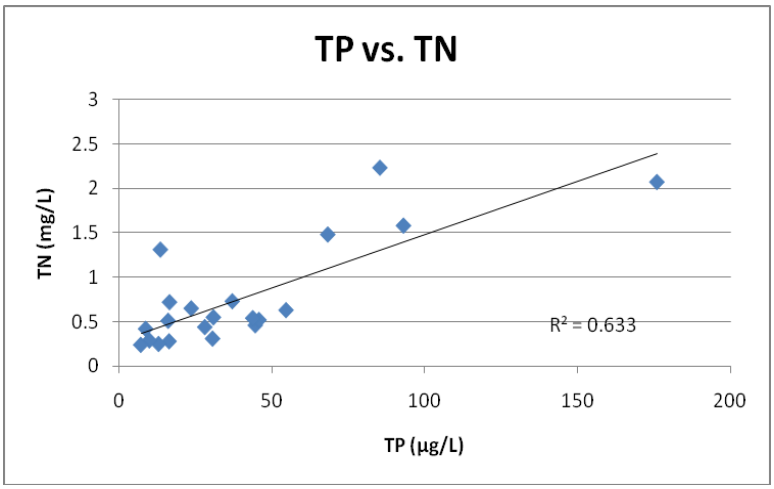


Figure 7a: Relationships between water quality variables (phosphorus and nitrogen).

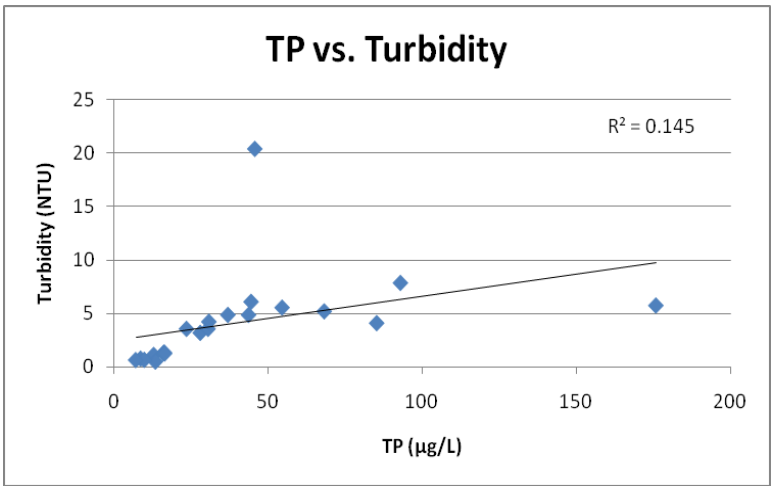


Figure 7b: Relationships between water quality variables (phosphorus and turbidity).

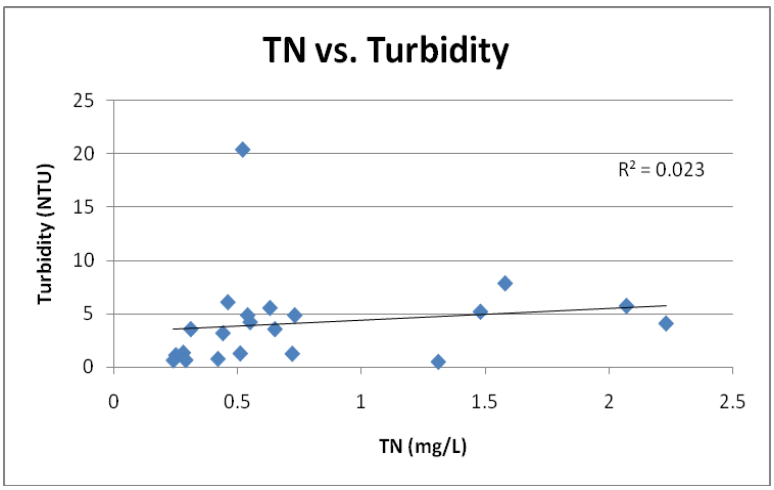


Figure 7c: Relationships between water quality variables (nitrogen and turbidity).

Conclusions:

The MRBA sampling program has proven to be a great success over the past six years. With over two dozen volunteers sampling every two weeks throughout the summer, many samples have been collected and analyzed. The data have been very useful for targeting sites in need of water quality improvement projects due to high concentrations of nutrients and sediment. Some of these projects are already underway in the Missisquoi River Basin. The MRBA Water Quality Monitoring Program, in partnership with the Vermont DEC, hopes to continue in 2011 with a new tributary site to further refine the water quality information in the Missisquoi River Watershed.

References:

Troy, A., D. Wang, D. Capen, J. O'Neil-Dunne and S. MacFaden. 2007. Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading Lake Champlain Basin Program. Lake Champlain Basin Program, Grand Isle, VT.

Vermont Water Quality Standards; Vt. Code R. 12 004 052; State of Vermont Natural Resources Board, Water Resources Panel. Effective January 1, 2008. http://www.nrb.state.vt.us/wrp/rules.htm