Final Report

LaPlatte Watershed Volunteer Water Quality Monitoring Program – 2004

(Background and Interpretation of Results)

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and
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For the
Water Quality Division
Vermont Department of Environmental Conservation

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EXECUTIVE SUMMARY

As part of its effort to bring up-to-date and monitor the status of the LaPlatte River watershed and its impact on Shelburne Bay, the LaPlatte Watershed Partnership in 2004 initiated a program of water quality sampling which included monthly analyses for *Escherichia coli*, total suspended solids, total nitrogen, nitrate plus nitrite, total phosphorus, and chlorides. Samples were collected from June through November, and were analyzed at the State of Vermont LaRosa Laboratory. The monitoring project was carried out in partnership with the Champlain Water District which determines *E. coli* and enteroccus counts as well as turbidity at times of increasing flow at most of the stations sampled by the LaPlatte Watershed Partnership.

This report of the first year of sampling includes results of analyses carried out by both the LaRosa Laboratory and the laboratory of the Champlain Water District. Data are presented in graphical form and are interpreted and discussed in the context of historical data and related studies, including fluvial geomorphic studies being carried out by the LaPlatte Watershed Partnership.

The LapLatte Watershed Volunteer Water Quality Monitoring Program was initiated to track changes in water quality over time, identify potential problems and progress in improving water quality and protecting the watershed, and to contribute to public understanding of water quality issues. This report includes review and discussion of historical studies of water quality and related subjects, as well as related current data, in order to provide a basis for future analysis and interpretation.

Whereas it is not the intent of the LaPlatte Watershed Volunteer Water Quality Monitoring Program to identify specific polluters or to play a role in regulatory processes or enforcement, the results do point to several areas of concern which deserve attention in subsequent years.

The summer of 2004 was characterized by heavy rains which impacted water quality during the months of June through August. Flows were low during the fall months. The resulting extremes of flow provided an opportunity to compare water quality during heavy and low runoff, and to understand sources of pollutants their behavior under varying conditions in the LaPlatte watershed.

Above all, increasing rainfall resulted in increasing total suspended loadings, and as a result, turbidity. In general, the turbidity measured in NTUs was proportional (and equal) to total suspended solids concentration expressed in mg/l throughout the watershed, although this was not always the case. Vermont stream quality standards include a turbidity standard of 25 NTU for warm water streams, including the LaPlatte River and its tributaries. This standard was exceeded in reaches of the LaPlatte River, McCabe's Brook, and Mud Hollow Brook where the risk of erosion was high at times when the flow was high, as well as specific locations where construction or other activities resulted in high runoff carrying a high silt load. Turbidity did not exceed the standard in the upper reaches of the watershed in Hinesburg, even when rainfall and flows were exceptionally high. It should be noted, however, that of the analyses performed, the mean relative percent differences between samples and duplicates calculated for turbidity were the highest (15.88%) of all the analyses performed, failing to meet targets and indicating relatively high variability. This variability is not, on the other hand, sufficient to alter the above conclusions.

In addition to their intrinsic importance as indicators of erosion, and as they reflect land use and human activities in the watershed, and as they impact on aquatic life in rivers and streams, suspended solids constitute the primary vehicle for the transport of phosphorus within the watershed and into Shelburne Bay. Total phosphorus concentrations increased generally as suspended solids and turbidity increased, but the rate of increase in phosphorus concentration relative to solids concentration decreased with increasing total solids concentration. The relationship was variable, but in general best described logarithmically. Fine clay and silt particles which predominate at low flows and solids concentrations have a high surface to volume ratio and therefore provide more phosphorus adsorption sites relative to their volume and mass than do larger particles which enter the streams and are transported by them at high flows. This explains decreasing phosphorus concentrations relative to suspended solids concentrations and turbidity at higher flows and solids concentrations. Total phosphorus concentrations in relation to flow in the LaPlatte River at Falls Road during 2004 formed an upper boundary for data points representing post-1992 long term monitoring test results.

Total nitrogen concentrations were generally less than 1 mg/l as N. Nitrates and nitrites in general made up a very small proportion of the total nitrogen load. Within the LaPlatte River itself, high concentrations detected upstream decreased steadily until the Hinesburg treatment plant discharge at which point they increased again when effluent was being discharged. In McCabe's Brook, concentrations commonly increased between the two upstream stations, and below the Shelburne treated waste discharge during discharge.

Of interest are molar TN:TP ratios within the watershed. Ratios were predominantly below 20 when suspended solids concentrations were high, suggesting nitrogen limitation, although some investigators feel that ratios are more important in determining composition of periphyton communities than in determining limiting nutrients in riverine systems.

Low ratios as the river discharges into Shelburne Bay could help explain blue-green algal blooms reported in Shelburne Bay, at least at its southern end. Settling of larger solids particles in the bay would be expected to reduce the phosphorus in suspension, and thus increase the TN:TP ratio until phosphorus becomes limiting in deeper water.

Chlorides were included in the LaPlatte sampling program as a non-reactive conservative parameter, but also as an indicator of point source and non-point source waste sources, and of dilution in the river and its tributaries. Results indicated that baseline chloride concentrations in the upstream portions of the watershed were in the neighborhood of 20-30 mg/l. Sewage discharges at Hinesburg and Shelburne constituted the primary point sources of chlorides. When flows were very low, and sewage was not being discharged at Hinesburg, chloride concentrations remained close to baseline throughout the length of the river. Under moderate to high flow conditions when sewage was being discharged, concentrations increased below the point of discharge, but decreased steadily downstream. Under extremely high flow conditions, concentrations decreased to below baseline as a result of dilution with rainwater.

A jump in chloride concentrations observed on a number of occasions in McCabe's Brook as it crossed Route 7 was suggestive of an up-stream source, probably storm runoff from extensive impervious surfaces. The increase in chlorides was at times associated with increases in *E. coli* counts.

Most probable numbers of *E. coli* were determined on samples collected by both volunteer samplers and the Champlain Water District. In general, counts were very high during periods of rainfall, exceeding the State water quality standard of 77/100 ml., and often exceeding 2,419/100 ml., which was the limit of the test on undiluted samples.

The role of storm runoff as a source of *E. coli* is clear. During periods of moderate rainfall, increases in *E. coli* counts were evident below developed areas and pasture land.

Of interest also were enterococcus and *E. coli* results reported by the Champlain Water District and *E. coli*:Enterococcus ratios. *Escherichia coli* counts resembled those reported under the volunteer monitoring program. Although ratios could not be determined on negative samples and samples which exceeded the limits of the test, pairs of real values were available. Comparison of ratios with ratios of fecal coliforms to fecal streptococci typical of animal and human sources of fecal bacteria were generally consistent with predominantly animal sources above the Hinesburg sewage discharge and most tributary streams, and human sources in the LaPlatte River below Leavenworth Road.

Water Quality in the LaPlatte Watershed
Results of Volunteer Water Quality Monitoring, 2004

1. BACKGROUND

1.1 The LaPlatte Watershed

The LaPlatte River arises in Hinesburg, and drains about 53 $mi.^2$ in the towns of Shelburne, Charlotte, Hinesburg, Richmond, Williston, and St. George. Its major tributaries are Patrick Brook (7 $mi.^2$) which flows through Lake Iroquois in Hinesburg, Mud Hollow Brook (8 $mi.^2$) and its tributary Bingham Brook (2.9 $mi.^2$) in Charlotte, and McCabe's Brook (6.2 $mi.^2$) in Charlotte and Shelburne. The River is a valuable resource, particularly in the towns of Hinesburg, Charlotte and Shelburne, where it provides wildlife habitat and corridors, recreation, and is an important feature of the landscape. Its drainage also includes important wetlands, particularly in the lower LaPlatte River and McCabe's Brook area.

The LaPlatte River watershed is the largest sub-basin draining into Shelburne Bay, which in turn is connected at its northern extremity to Burlington Bay and Lake Champlain. The Bay represents an important recreational resource and is the source of water for the Champlain Water District which serves more than 65,000 customers and major corporate entities in the Burlington area. It is listed also by the State of Vermont as impaired water as a result of mercury and PCBs which find their way into game fish and phosphorus which supports the growth of algae and aquatic plants in the Bay and around its margins. These potentially can lead to nuisance conditions, including blooms of toxic blue-green bacteria.

Soils and Land Use/Land Cover. Sub-watersheds draining to individual sampling stations were defined using 10 ft. contour coverages in ArcView (Figure 1). This coverage was employed to determine soil erodability and major land uses in the drainage to each sampling station using SGAT version 2.0 steps 1 to 6 and 11 to 14. The results of this analysis are contained in Tables 1 and 2 and can be helpful in interpreting results of water quality analyses. The results of the analysis are cumulative. Characteristics of individual sub-watersheds can be determined by subtracting upstream from downstream areas and calculating percentages.

Soils. Table 1 includes the land area draining to each sampling station and the areas within those drainage areas covered by water and those with soils characterized as highly erodable, potentially highly erodable, or not highly erodable. Overall, within the LaPlatte watershed excluding McCabe's Brook, between 22% and 40% of soils are classified highly erodable, and between 40% and 73% potentially highly erodable. Between 3.5% and 20% were classified as not highly erodable. The proportions of highly erodable and potentially highly erodable soils were highest in the upper reaches of the LaPlatte River (as high as 96.43% at LP 12), Mud Hollow, Bingham, and Patrick Brooks, and the un-named brook. In contrast, the character of soils in the McCabe's Brook sub-watershed, with the exception of its uppermost station (MB 7), differ in being between only 11% and 18% highly erodable, 48.5% and 53.3% potentially highly erodable, but between 34% and 37% not highly erodable.

Land Use/Land Cover. Table 2 includes the land areas draining to each sampling station and the areas within those drainage areas covered by water and other types of land cover or use. Major land use/land cover classifications were forest (3 categories), pasture, row crops, residential, utilities, and in certain local areas, industrial or commercial. It is noted that there is considerable discrepancy between the areas covered by water in Tables 1 and 2. This discrepancy results in differences between the soils and Lulc coverages employed in the SGAT analysis.

In general, the highest proportions of pasture and row crops are in the Mud Hollow (26-44.65% pasture and 19.6%-27% row crops) and McCabe's Brook (13.6%-30% pasture and 15.3%-18%) watersheds. Overall, within the LaPlatte drainage as a whole, pasture and row crops cover 11% and 22%, and 5.8% and 15.5%, respectively.

Forest land predominates except in the Mud Hollow and McCabe's Brook watersheds, generally decreasing from the upper portions of the watershed to the downstream stations. Thus, about 95% of the LaPlatte drainage is forested at LP 12, but only 37% at LP 01, and 52% at MB 7, but only 23% at MB 1.

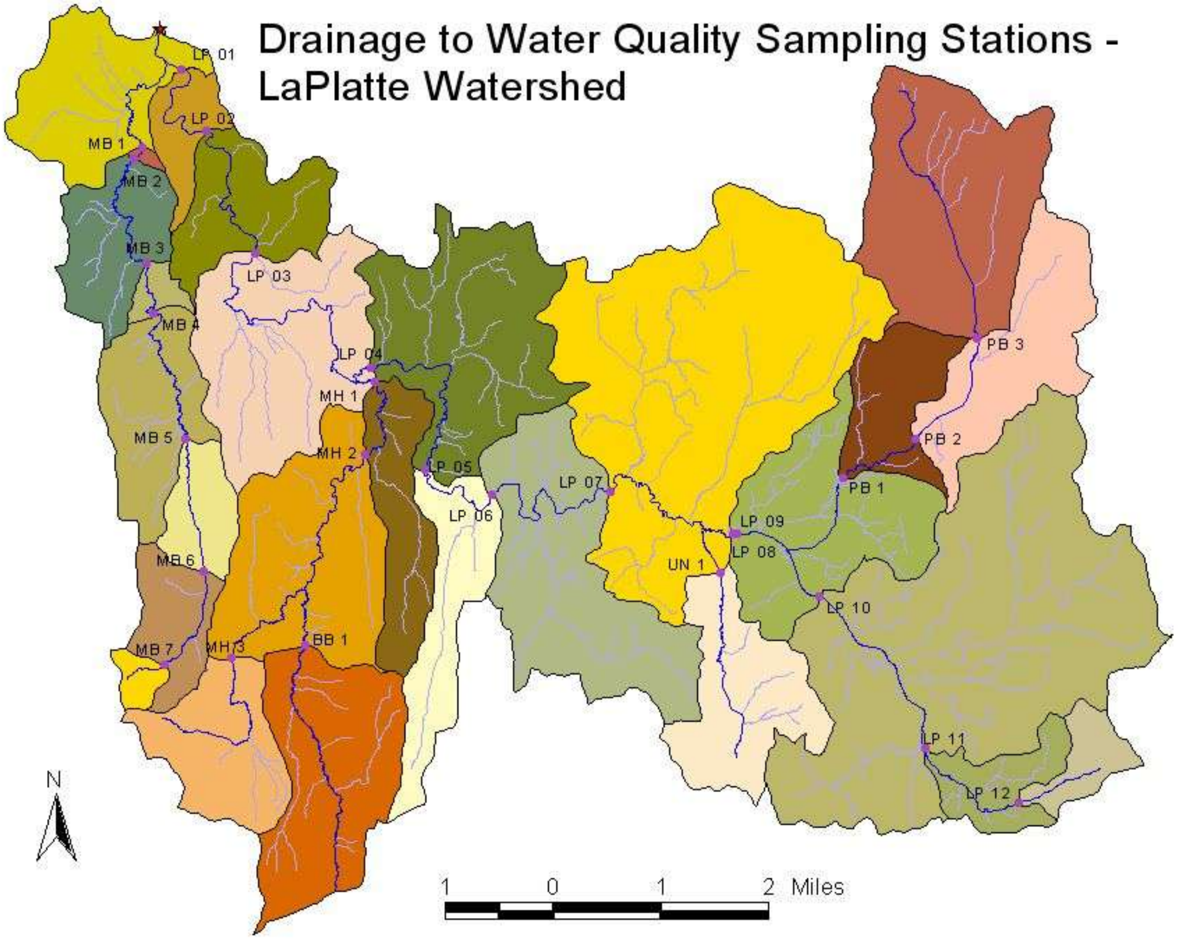
Overall, about 9% of the watershed is considered residential. Particular concentrations of residential use occur in the Patrick Brook watershed draining to PB 2 (15.17%) and PB 1 (19.33%), McCabe's Brook draining to MB 6, and the LaPlatte River drainage to LP 08/09 (13.4%), which includes Patrick Brook, and LP 07 (10.67%).

Wetlands make up about 5% of the LaPlatte River drainage below LP 08/09, but less than 3% above LP 08/09. They constitute a more prominent feature of the landscape draining to UN 1 (15.3%) and the upper Mud Hollow watershed where they constitute over 16% of drainage to MH 3.

Commercial and industrial use together exceed 1.5% only within the McCabe's Brook drainage where it varies from 2.48% at MB 6 to 5.24% at MB 1.

Fluvial geomorphology. With funding from the Town of Shelburne under a Special Environmental Project, the LRP undertook a Phase I fluvial geomorphic assessment of the LaPlatte watershed. Whereas sections of stream defined by water quality sampling locations do not coincide with reach points employed in the geomorphic assessment, it may be in some situations informative to interpret results in the context of the results of the geomorphic assessment. Thus, although it is not the intent here to discuss the results of the Phase I assessment, the results of that study are summarized in Table 3 for reaches of stream defined by water quality sampling stations. Reaches defined in the fluvial geomorphic assessment are shown in Figure 2. Definitions of terms are given in Annex I.

Figure 1



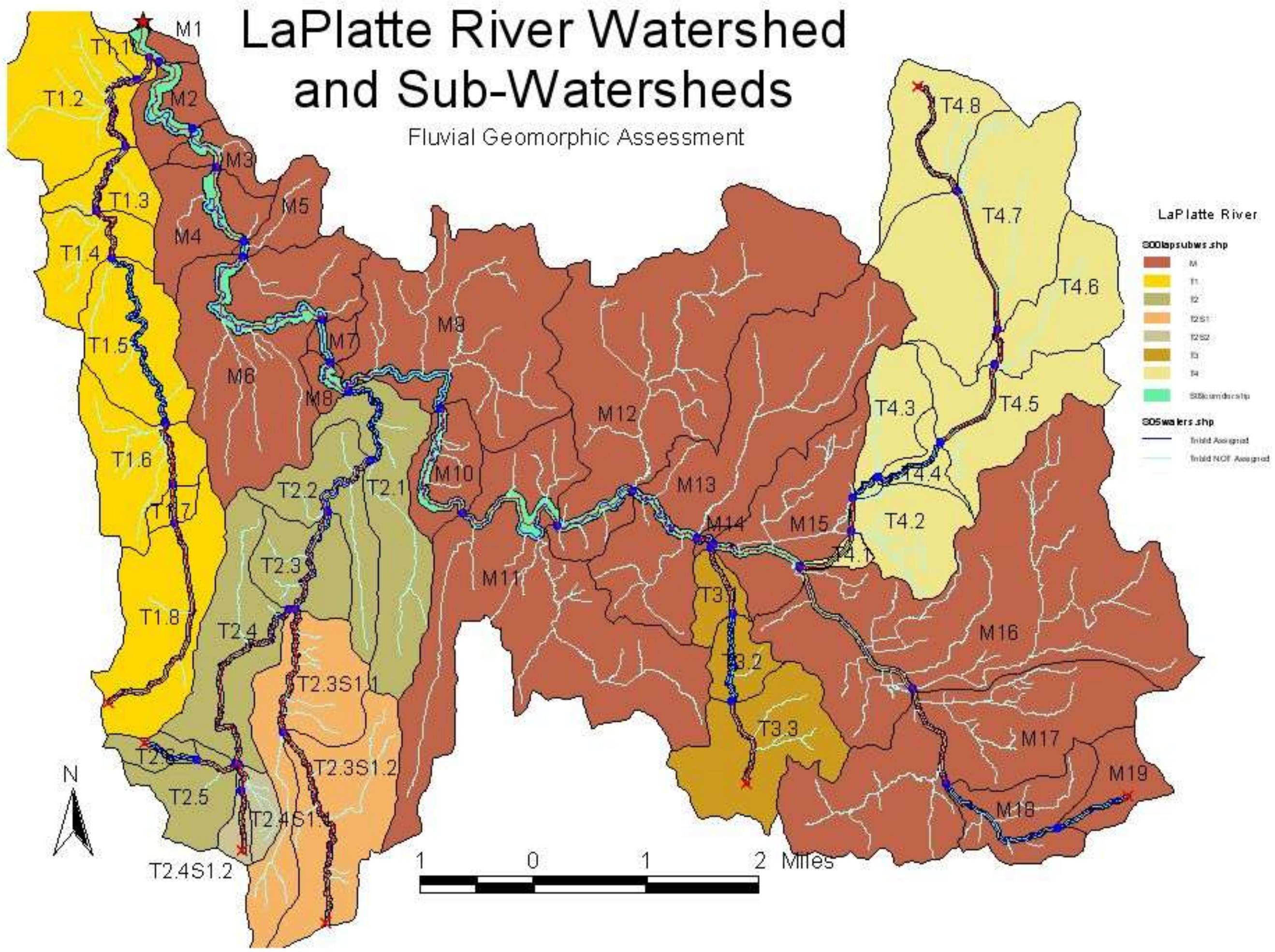
Drainage to Water Quality Sampling Stations -
LaPlatte Watershed
LP 01
LP 02
LP 03
LP 04
LP 05
LP 06
LP 07
LP 08
LP 09
LP 10
LP 11
LP 12
MB 1
MB 2
MB 3
MB 4
MB 5
MB 6
MB 7
MH 1
MH 2
MH 3
BB 1
UN 1
PB 1
PB 2
PB 3
N
1 0 1 2 Miles

Table 1. Erodability of Soils in the LaPlatte Watershed

Sampling Station	Total Drainage Area (sq. mi.)	Water		Highly Erodable Soil		Potentially Highly Erodable Soil		Not Highly Erodable Soil		Not Rated	
		Drainage Area (sq. mi.)	Percent of Drainage Area	Drainage Area (sq. mi.)	Percent of Drainage Area	Drainage Area (sq. mi.)	Percent of Drainage Area	Drainage Area (sq. mi.)	Percent of Drainage Area	Drainage Area (sq. mi.)	Percent of Drainage Area
LP 01	46.36	0.55	1.18	10.39	22.41	25.15	54.26	9.40	20.27	0.78	1.67
LP 02	45.78	0.54	1.18	10.37	22.65	25.07	54.76	8.99	19.64	0.74	1.61
LP 03	44.42	0.54	1.22	10.11	22.76	24.39	54.92	8.61	19.38	0.72	1.61
LP 04	34.00	0.54	1.59	8.81	25.92	17.99	52.90	5.95	17.50	0.71	2.08
LP 05	30.98	0.54	1.74	8.25	26.63	16.16	52.16	5.33	17.20	0.70	2.27
LP 06	29.60	0.53	1.78	8.11	27.39	15.23	51.46	5.19	17.53	0.55	1.85
LP 07	26.51	0.50	1.90	7.56	28.50	13.20	49.78	4.72	17.81	0.53	2.01
LP 08/09	17.69	0.49	2.75	5.51	31.17	8.72	49.29	2.60	14.71	0.37	2.09
LP 10	8.97	0.00	0.05	2.64	29.37	4.78	53.32	1.35	15.03	0.16	1.79
LP 11	1.26	0.00	0.00	0.29	22.78	0.78	62.14	0.18	14.50	0.00	0.23
LP 12	0.50	0.00	0.00	0.14	27.81	0.34	68.62	0.02	3.57	0.00	0.00
MB 1	4.59	0.00	0.02	0.60	13.05	2.23	48.67	1.70	37.02	0.06	1.21
MB 2	4.55	0.00	0.02	0.60	13.16	2.23	49.08	1.66	36.53	0.05	1.17
MB 3	3.34	0.00	0.02	0.37	11.17	1.78	53.33	1.14	34.06	0.05	1.35
MB 4	3.14	0.00	0.02	0.35	11.01	1.68	53.31	1.07	34.18	0.04	1.43
MB 5	1.67	0.00	0.00	0.27	16.04	0.81	48.54	0.59	35.28	0.00	0.14
MB 6	0.99	0.00	0.00	0.19	18.64	0.50	49.88	0.31	31.25	0.00	0.23
MB 7	0.19	0.00	0.00	0.08	39.40	0.08	44.21	0.03	16.39	0.00	0.00
MH 1	7.55	0.00	0.01	0.79	10.52	5.00	66.26	1.75	23.17	0.00	0.05
MH 2	6.33	0.00	0.01	0.58	9.22	4.29	67.69	1.46	23.02	0.00	0.05
MH 3	1.14	0.00	0.00	0.20	17.68	0.66	58.22	0.27	23.78	0.00	0.31
BB 1	2.46	0.00	0.02	0.20	8.08	1.80	73.27	0.46	18.63	0.00	0.00
UN 1	1.77	0.00	0.00	0.62	34.97	0.80	44.98	0.20	11.50	0.15	8.49
PB 1	6.27	0.47	7.52	2.30	36.64	2.80	44.59	0.54	8.64	0.20	3.24
PB 2	5.19	0.47	8.97	2.03	39.03	2.04	39.26	0.51	9.82	0.19	3.73
PB 3	3.25	0.38	11.81	1.11	34.05	1.28	39.48	0.40	12.39	0.09	2.88

[insert EXCEL “Land Use Areas” table 2]

Figure 2



LaPlatte River Watershed
and Sub-Watersheds
Fluvial Geomorphic Assessment
LaPlatte River
M
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
M13
M14
M15
M16
M17
M18
M19
T1.1
T1.2
T1.3
T1.4
T1.5
T1.6
T1.7
T1.8
T2.1
T2.2
T2.3
T2.4
T2.5
T2.6
T2.3S1.1
T2.3S1.2
T2.4S1
T2.4S1.2
T3.1
T3.2
T3.3
T4.1
T4.2
T4.3
T4.4
T4.5
T4.6
T4.7
T4.8
N
1 0 1 2 Miles

Table 3. Summary of Geomorphic Characteristics – LaPlatte Watershed

Sub-Watershed	Geomorphic Reaches	Stream Type	Dominant Adjustment Type	Erodability	Stream Condition	Stream Sensitivity
LP 01-LP 02	M 2, M 1	E, C	Degradation, Degradation	Slight, Slight	Fair, Fair	High, High
LP 02-LP 03	M 3, M 4	C	Degradation, Aggradation	Moderate, Slight	Good, Fair	Medium, High
LP 03-LP 04	M 5-M 8	E, B, C, B	Widening, None, Degradation, Degradation	Slight, Very Severe, Moderate, Very Severe	Fair, Ref., Poor, Good	High, Medium, High, Low
LP 04-LP 05	M 9	B	None	Severe	Good	Medium
LP 05-LP 06	M 9, M 10	C, B	Degradation, None	Moderate, Severe	Fair, Good	High, Medium
LP 06-LP 07	M 11	C	Degradation	Very Severe	Good	Medium
LP 07-LP 08	M 12, M 13	C	Degradation, Aggradation	Slight, Moderate	Good, Fair	Medium, High
LP 08/09-LP 10	M 14-M 16, T 4.1, T 4.2	C, C, E	Aggradation, Planform, None	Slight	Fair, Poor, Good	High, High, Medium
LP 10-LP 11	M 16, M 17	C	Degradation, Aggradation	Slight	Poor, Fair	High
LP 11-LP 12	M 18	B	None	Severe	Good	Medium
LP 12	M 19	A	None	Very Severe	Reference	Low
MB 1/2-MB 3	T 1.3, T 1.4	C, E	Degradation, Degradation	Slight, Slight	Good, Fair	Medium, High
MB 3-MB 4	T 1.5	C	Widening	Severe	Fair	High
MB 4-MB 5	T 1.5	C	Widening	Severe	Fair	High
MB 5-MB 6	T 1.6, T 1.7	C	Degradation, Degradation	Very Severe, Moderate	Fair, Fair	High, Medium
MB 6-MB 7	T 1.8	C	Degradation	Slight	Poor	High
MB 7	T 1.8	C	Degradation	Slight	Poor	High
MH 1-MH 2	T 2.1, T 1.2	C, B	None, Widening	Severe, Severe	Good, Fair	Medium, Medium
MH 2-MH 3	T 2.3, T 2.4	C	Aggradation, None	Moderate, Moderate	Fair, Good	Medium, Medium
MH 3	T 2.4-T 2.6	B, C, C	None, None, Aggradation	Very Severe, Slight, Moderate	Ref., Ref., Fair	Low, Medium, Medium
BB 1	T 2.3 S 1.1, T 2.3 S 1.2	C	Aggradation, Degradation	Slight, Slight	Fair, Fair	High, High
UN 1	T 3.1-T 3.3	C, C, C	Degradation, Degradation, None	Slight, Very Severe, Slight	Fair, Good, Ref.	High, Medium, Medium
PB 1-PB 2	T 4.3, T 4.4	A	Aggradation, Aggradation	Slight, Severe	Poor, Fair	High, Medium
PB 2-PB 3	T 4.5, T 4.6	C	Planform, -	Severe, Slight	Poor, -	High, -
PB 3	T 4.7, T 4.8	C	Degradation, -	Slight, Slight	Fair, -	High, -

In general, the condition of waters within the watershed was fair to good, with portions in poor condition between LP 11 and LP 09, above MB 6, and in Patrick Brook between PB 3 and PB 1. Furthermore, sensitivity was generally medium to high.

It is noted that the report *Lake Champlain Phosphorus TMDL* (Vermont and New York State Departments of Environmental Conservation, *Lake Champlain Phosphorus TMDL*, 2002) calls for long-term research to relate stream geomorphic assessment data to sediment loading expected in each major tributary watershed by measuring sediment loss and phosphorus inputs in selected stream reaches across a variety of conditions.

Impact of change in land use. The watershed has gone through changes which have affected the dynamic of pollution sources. With major improvements in two sewage treatment facilities discharging to the LaPlatte River in Hinesburg and McCabe's Brook in Shelburne during the 1990s, storm runoff from urban/developed areas and farm land increased in relative importance as a source of phosphorus and other nutrients, and constitute a source of sediment load. In addition, while on the one hand, there are fewer farms than there were 20 or 30 years ago, there is a trend towards larger dairy and horse farms, and there is potential for movement towards more concentrated animal feeding operations. Farm plans are changing along McCabe's Brook, and on land draining to the headwaters of Mud Hollow and Bingham Brooks. At the same time, manure is still spread on fields and fertilizer use increases the potential for pollution of surface waters with nutrients and *E. coli*. With the decrease in farming in some areas, urbanization has proceeded, increasing the extent of impervious surfaces. Monitoring of water quality in the LaPlatte watershed during 2004 was intended to contribute to the establishment of a baseline for tracking the dynamic of pollution sources and to the identification of opportunities to improve water quality and to avoiding its further deterioration.

Furthermore, whereas in older housing developments storm runoff was generally carried by grass ditches, roads in newer developments typically are curbed and storm run-off is piped to streams. In some instances, towns such as Shelburne in some locations have replaced grass lined ditches by piped storm drains. This not only encourages increased nutrient discharge to surface waters, but alters the flow regimes in streams. This situation is exacerbated by application of fertilizers and pesticides to lawns. Sediments themselves also transport phosphorus to surface waters impacting directly on phosphorus loadings, as well as damaging fish habitat and adversely affecting other aquatic biota. Future construction in the watershed may also impact on sediment loads reaching the river system and Shelburne Bay.

Few data have been collected since the 1980s to monitor or assess the long term impacts and sustainability of initiatives taken in the 1980s to implement BMPs for the control of nutrients and sediments reaching the waters of the LaPlatte watershed. The LaPlatte Watershed Volunteer Monitoring Program is helping to provide a basis for assessing impacts of fundamental change in land use and management practices, and inform establishment of priorities for improving the condition of the LaPlatte River system and Shelburne Bay.

Point Sources. Two sewage treatment plants discharge within the LaPlatte watershed (See Fig. 7):

Treatment Plant	Capacity (mgd)	Process	Receiving Water Body	Year of Up-Grade	Design Life (yrs)
Hinesburg	0.25	Aerated Lagoons	LaPlatte R.	1990	-
Shelburne Plant No. 2	0.66	Sequencing Batch Reactors	McCabe=s Brook	2001	20

Each of these plants was designed, and is operated, to reduce discharges of phosphorus.

Permitting process. The State of Vermont has established discharge permits for point sources. The emphasis is, and appears to have been from the mid-1970s, on phosphorus loadings to Lake Champlain. The general policy contained in the Vermont Water Quality Standards effective July 2, 2000 states that Atotal phosphorus loadings shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.@ More specifically, in the Lake Champlain watershed it is the policy of the State to accomplish net reductions in phosphorus loadings that are necessary to achieve defined in-lake phosphorus concentrations. In the case of Shelburne Bay, this concentration is 0.014 mg P/l.

Basin-wide phosphorus limits of 0.8 mg P/l applicable to plants treating more than 0.2 mgd were established by the State of Vermont in 1992 (10 V.S.A. '1266a). The statute also requires that there be no significant increase over current loadings. Increases can be incorporated in basin plans or permit limits only when there is a corresponding reduction in loadings from other sources within the watershed of the same lake segment. Aerated lagoons were exempted from the 0.8 mg/l limit.

The 0.8 mg P/l limit is a technology based limit (as opposed to a water quality based limit) established following an analysis of performance and cost data for existing plants which indicated that the limit was readily achievable. Phosphorus limits are contained in a plan for implementing phosphorus total maximum daily loads (TMDLs) for the Lake Champlain Basin (*Lake Champlain Phosphorus TMDL*, *op. cit.*).

Other permitted parameters include BOD_5, total suspended solids, and thermotolerant *Escherichia coli*. Effluent nitrogen is not limited in permits. Permitted discharge limits established for the two treatment plants discharging within the LaPlatte watershed are as follows:

Treatment Plant	Flow (mgd)	Total Phosphorus Conc. (mg/l)	Total Phosphorus Load (lbs/day)	Total Phosphorus Load (kg/day)	5-Day BOD Load (lbs/day) Mo. Mean	5-Day BOD Load (lbs/day) Weekly Mean	E. coli Max. No./100ml	Tot. Suspended Solids Loading (Mo. Mean) (Lbs/day)
Hinesburg	0.25	1.0	2.1	0.95	63	94	77	94
Shelburne Plant No. 2	0.66	0.8	3.0	1.36	113	169	77	113

Point source phosphorus loadings to Shelburne Bay watershed. Point source phosphorus loading to the Shelburne Bay watershed were estimated as early as 1975/1976 when the first studies of Lake Champlain were undertaken to establish the status of the lake and to set guidelines and strategies for its preservation. Point source loadings have declined since the early assessments as a result of improvements in treatment at all four sewage treatment plants discharging to the Bay and its drainage.

Major reductions in point source phosphorus loadings between 1975/76 and 1991 can be attributed to construction and up-grading of all waste treatment plants. Improvements at the Hinesburg waste treatment plant completed in 1991 resulted in a reduction in the loadings to the Bay from about 5,000 kg P to about 700 kg P between 1991 and 1995. A further reduction in the phosphorus loading to the Bay took place following up-grading of the Barttletts Bay plant in 1999, but was compensated by an equivalent increase in the loading from the Hinesburg plant in 2000 following the resumption of full operation of the cheese plant in Hinesburg which discharges to the Hinesburg treatment plant following primary treatment. Based on permitted flows and phosphorus loadings from the four plants, the total annual permitted point source loadings amount to 2,074 kg/year, including 346.8 kg/year from Hinesburg, and 496.4 kg/year from Shelburne Plant No. 2.

It is noteworthy that as a result of improvements at the four treatment plants, the proportion of the total annual phosphorus loading on Shelburne Bay originating from point sources, estimated in 1975/76 to be 60%, declined to about 32% in 1991, and 5.9% in 1995.

Hinesburg waste treatment plant. The Hinesburg sewage treatment plant, first constructed in 1967, consists of four aerated lagoons operated in series and preceded by a comminution step. The plant has been up-graded twice; first in 1988 when the air distribution system was up-graded, and more importantly in 1991 when alum addition was provided prior to the final pond to remove phosphorus. The ponds are of equal size totaling 8 acres and are 12 feet deep. Mean retention time is 32 days. Settleable solids in the influent are removed in the first pond which must be dredged from time to time. Alum floc settles out in the fourth pond and also must be dredged periodically. The effluent from the final pond is discharged directly to the LaPlatte River approximately 17.7 km upstream from its mouth.

During periods of low flow, especially during the hot summer months when flows are reduced and evaporation rates are high, effluent discharge may cease for periods exceeding one month.

- Population and Area Served. The Hinesburg waste treatment plant serves about 300 connections within a service area of slightly more than 2 km^2, primarily within the central town, but including satellite areas to the north adjacent to Geprog=s Park and along Richmond Road, as well as CVU.

  The treatment plant also receives the treated waste from a cheese factory, which currently utilizes slightly more than half of its 20,000 gpd allocation. Following improvements in 1999, the cheese plant increased its production, processing about 1 million pounds of milk annually during the years 1997-1999 to between 25 and 30 million pounds per year after July, 1999. Treatment at the cheese factory includes primary settling and alum flocculation and clarification added in 1993 and 1994.

The town encourages growth in its central area and plans to request an increase in the its permitted discharge flow to 350,000 gpd. Such an increase would have to respect the current 2.1 lbs/day total phosphorus loading, and the permitted concentration of phosphorus in the effluent would have to be reduced accordingly.

- Plant Performance and Discharge. Monthly mean daily discharges from the Hinesburg waste treatment plant vary widely from zero especially during hot, dry months to in excess of 250,000 gpd. Mean monthly discharge during 2004 varied from a high of 230,000 gpd in September to a low of 0 gpd in October.

  Recent historical mean daily phosphorus loading rates have exceeded the permitted limit of 2.1 lbs/day on only one occasion since January, 1996, and have exceeded 1.5 lbs/day on only two occasions since June, 1996. During 2004, the maximum monthly mean daily phosphorus discharge was 0.39 lbs., well below the permitted limit.

  The town=s proposal to request an increase in permitted discharge would require a reduction in the permitted total phosphorus concentration of 0.71 mg/l. Recent historical records indicate that concentrations have exceeded 0.71 mg/l during only four months since production increased at the cheese factory. During 2004, the maximum monthly mean total phosphorus concentration in the effluent was 0.2 mg/l (May, June, August, November).

  A reduction from 4,811 kg phosphorus discharged in 1991 to 185 kg discharged in 1995 was the result of alum precipitation of phosphorus initiated in 1991. This reduction from 12.9 kg P/day to 0.96 kg/day was reflected immediately in an equal reduction in the phosphorus loading to Shelburne Bay from the LaPlatte River (Dept. of Environmental Conservation, 1998).

  The State has established a limit of 45 mg/l for total suspended solids (TSS) in the Hinesburg effluent. Data reported since August, 1999, including 2004, indicate that concentrations fall well below the established limit. The daily maximum total suspended solids concentration during 2004 was 13 mg/l (November).

Fig. 3. Monthly Mean Effluent Total Suspended Solids, Total Kjeldahl Nitrogen, and Total Phosphorus Concentrations, Hinesburg Sewage Treatment Plant - 2004

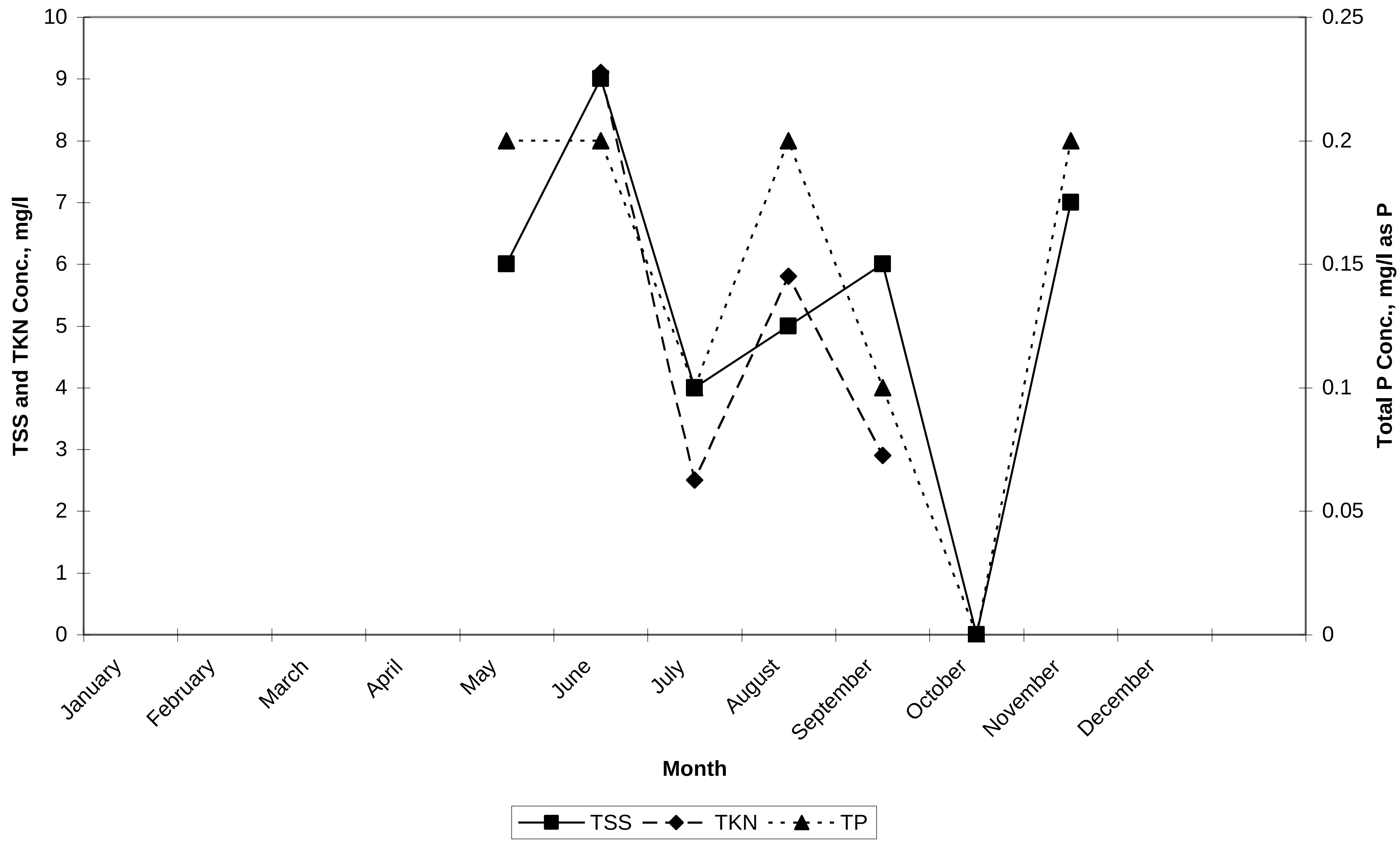
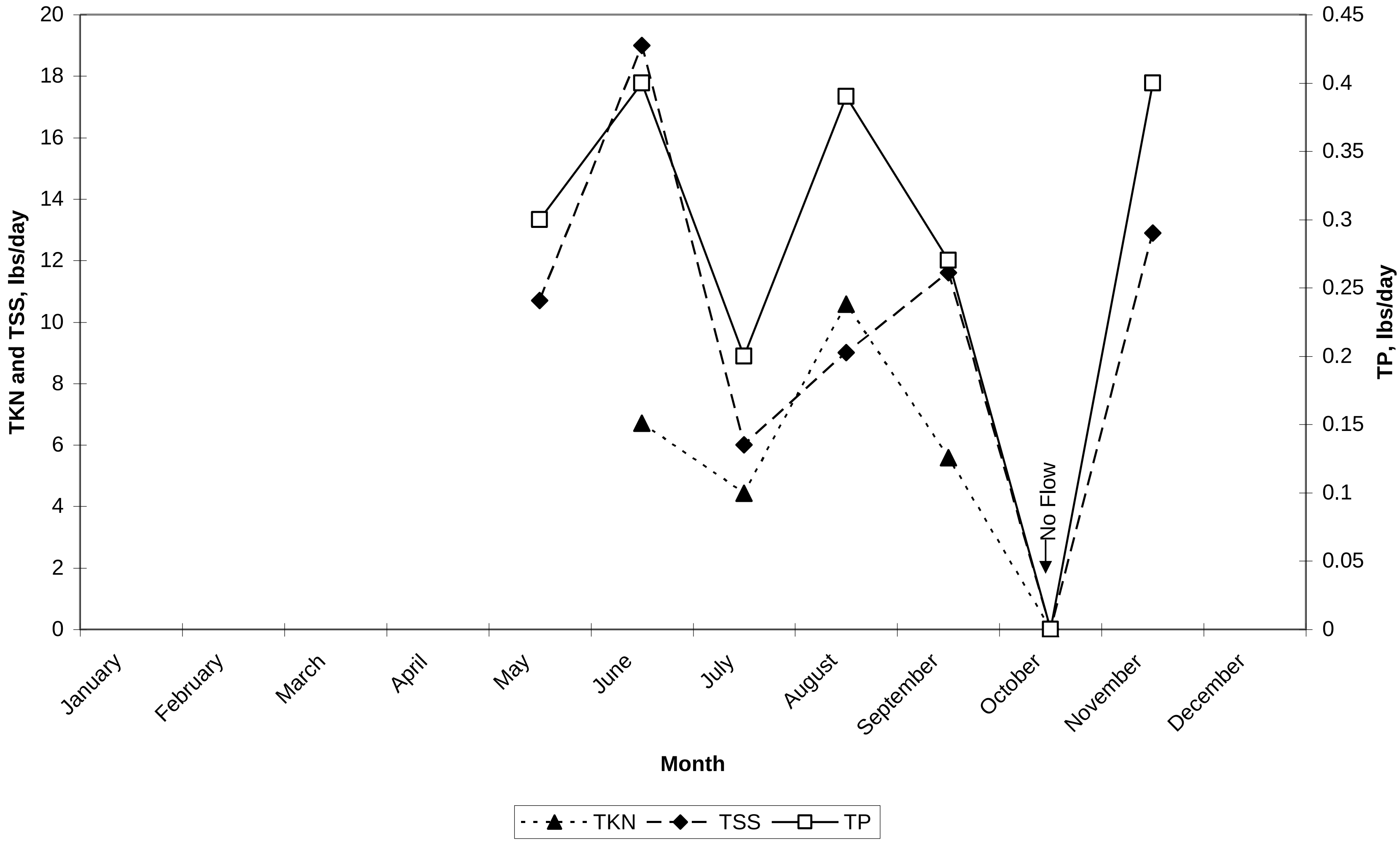


Fig. 4. Monthly Mean Total Suspended Solids, Total Kjeldahl Nitrogen, and Total Phosphorus Loadings, Hinesburg Waste Treatment Plant - 2004



Shelburne Waste Treatment Plant No.2. Shelburne=s waste treatment plant No.2 is located off Harbor Road about 0.8 km west of its intersection with Route 7, and discharges to McCabe's Brook approximately 2.45 km upstream from its confluence with the LaPlatte River and about 3 km upstream from Shelburne Bay.

Until early 2001, Plant No. 2 operated as an activated sludge plant with chlorine disinfection. Renovations completed in early 2001 were carried out to convert the treatment process from activated sludge to sequencing batch reactors with ultraviolet disinfection. The plant is operated on a 6 hour reaction cycle. Alum is added at the reaction stage for phosphorus removal. The plant is currently operated to optimize denitrification. Pre-treatment includes fine rotary screens, aerated grit chamber, and settling. The effluent from the sequencing batch reactors passes through cloth disc filters and UV disinfection step before discharge to Shelburne Bay. Sludge is transferred to Burlington for dewatering and then to the Chittenden County Solid Waste District from whence it is shipped to Quebec for composting. The renovations at the Shelburne plant included dewatering capability, and eventually it is anticipated that sludge will be dewatered before transfer to the Chittenden County Solid Waste District.

- Population and Area Served. Treatment plant No. 2 serves about 1014 connections, about 931 of which are residential customers, and 83 of which are commercial and industrial customers. The plant serves what was originally known as Fire District No. 2 with an area of about 11.9 km^2 extending generally west of Spear Street to the LaPlatte Nature Preserve, and extending from a northern limit at Long Meadow Drive south to the town line. It encompasses the area between Spear Street and Route 7 north of Falls Road and includes the town center, a small area east of Spear Street which includes the Beaver Creek and Maeck Farm developments, and developments to the west of Route 7 south to the town line.

  The plant is operated to take full advantage of the ability of sequencing batch reactors to remove nitrogen.

- Plant Performance and Discharge. Shelburne=s waste treatment plant No. 2 historically has had difficulties meeting permitted discharge requirements for phosphorus and thermotolerant *E. coli*. Flow has always fallen within the discharge limits of 0.66 mgd, although peak months have approached 0.6 mgd in the past. The highest monthly mean flow during 2004 was 0.414 mgd. *Escherichia coli* limits were met on all but one sample in 2004, reaching 210/100 ml. on February 4.

  Monthly mean phosphorus concentrations in the effluent discharging to McCabe=s Brook have reached or exceeded the permitted level of 0.8 mg/l during 12 months between 1996 and 2000,

Fig. 5. Monthly Mean Effluent Total Suspended Solids, Total Kjeldahl Nitrogen, and Total Phosphorus Concentrations, Shelburne Plant No. 2 - 2004

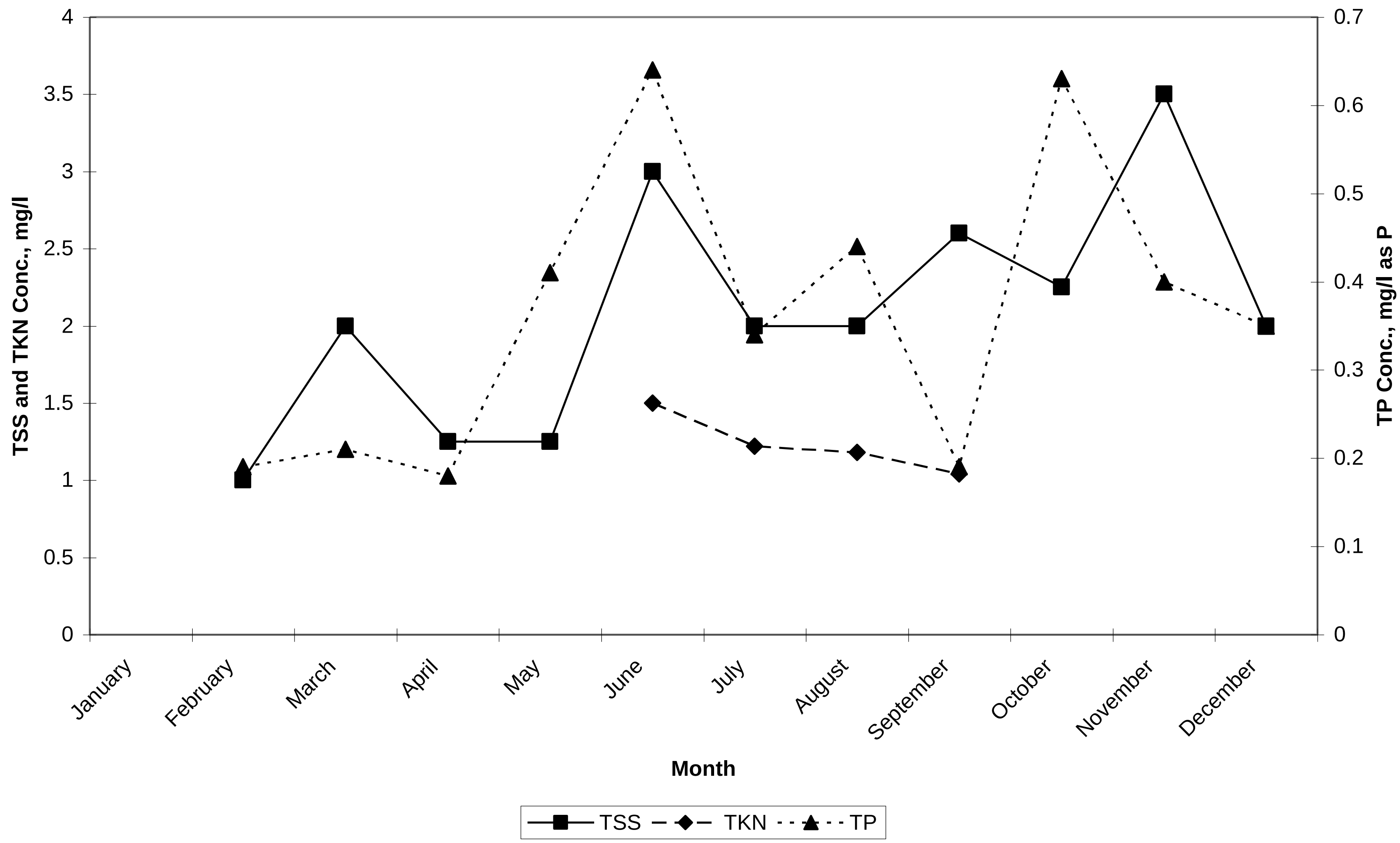
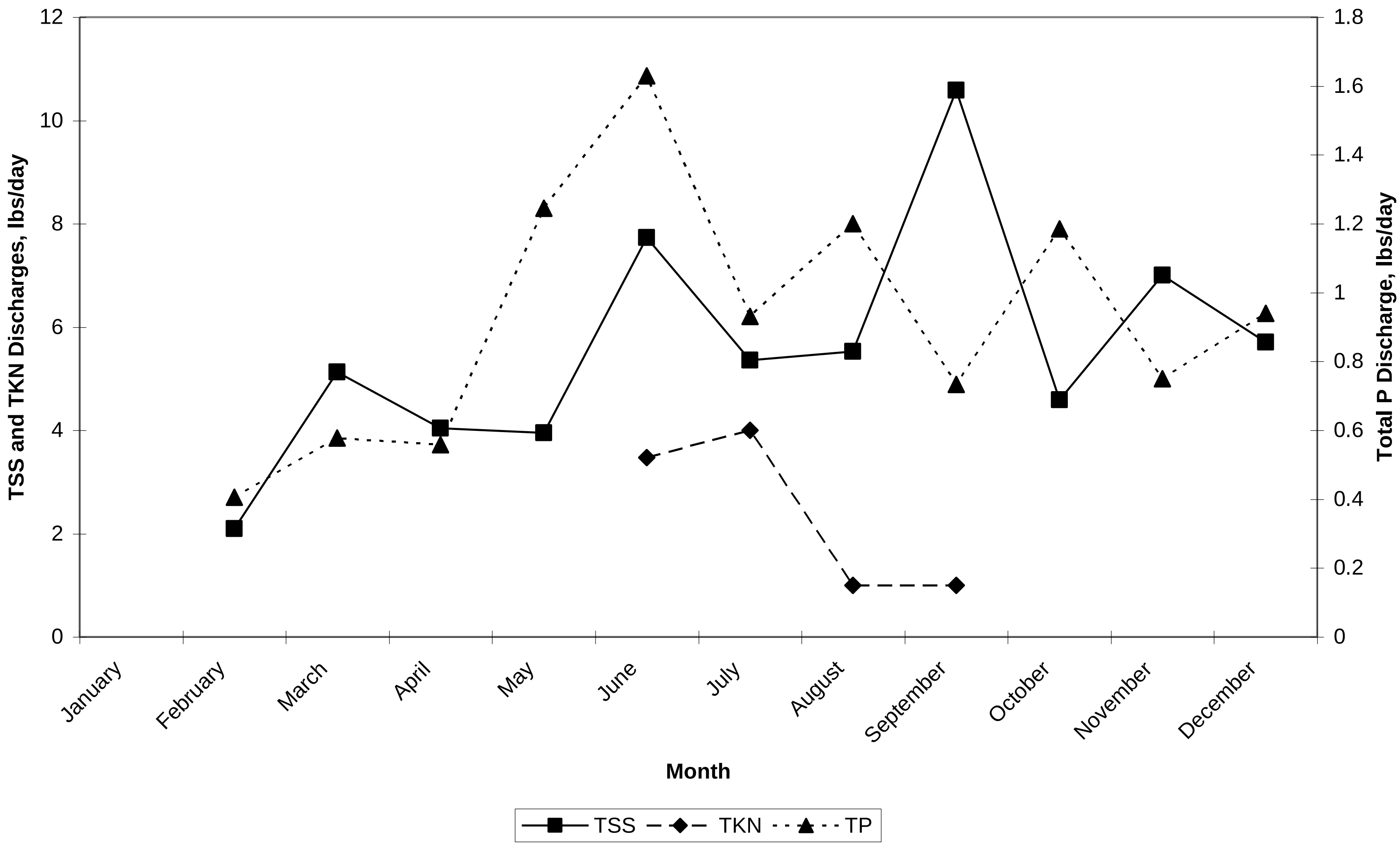


Fig. 6. Monthly Mean Total Suspended Solids, Total Kjeldahl Nitrogen, and Total Phosphorus Loadings, Shelburne Plant No. 2 - 2004



although monthly mean phosphorus loadings have exceeded the limit of 3.0 lbs/day during only three months in 1997 and 1998. During 2004, the maximum monthly mean total phosphorus concentration exceeded 0.6 mg/l in June and October, but did not reach the limit of 0.8 mg/l; the monthly mean total phosphorus loading reached a maximum of only 1.63 lbs/day during June.

Monthly mean total suspended solids loadings historically have fallen well below the permitted level of 113 lbs/day, although they far exceeded that limit in September, 1998. During 2004, the maximum monthly daily loading was 10.6 lbs, discharged in September.

The maximum total Kjeldahl nitrogen loadings during 2004 were 3.47 and 4 lbs/day reported in June and July. The monthly mean maximum concentration of total Kjeldahl nitrogen was 1.5 mg/l reported in August June, 2004.

Toxicity Studies. As part of its requirements under the State of Vermont permitting process, the town of Shelburne is required to undertake toxicity tests on the effluent from waste treatment plant No. 2. These tests are conducted using a control consisting of stream water from McCabe's Brook obtained at Harbor Road. Toxicity tests are conducted using fathead minnows (*Pimephales promelas*) and the cladoceran, *Ceriodaphnia dubia*. During 2004, toxicity tests were conducted in February and again in November. Survival tests employing *Ceriodaphnia dubia* yielded no suggestion of toxicity on either occasion. Similarly, there was no indication of toxicity in survival tests employing *Pimephales promelas* undertaken in February. Results of tests on the effluent and effluent diluted 1:2 with stream water conducted in November employing *Pimephales promelas* revealed no sign of toxicity. It was of particular interest, however, that survival of *Pimephales promelas* in the McCabe's Brook control and dilutions consisting of 93.75% and 75% McCabe's Brook water diluted with 6.25% and 25% effluent, respectively, did not reach an acceptable (80%) level.

Relation to State needs. The 2004 Vermont 303(d) Part A list of impaired waters in need of TMDL includes two sections of the LaPlatte watershed which fail to meet state water quality standards and which are designated as impaired waters. These are:

- LaPlatte River, Hinesburg to mouth – Fecal coliforms
  - Agricultural runoff
- Mud Hollow Brook, mouth to 3 miles upstream – Fecal coliforms
  - Agricultural runoff, streambank

Shelburne Bay itself was listed as impaired as a result of its failure to meet standards for mercury and PCBs.

Under the State draft 303(d) Part C, nutrients in the LaPlatte River at its mouth are designated as in need of further assessment.

The data collected under the LaPlatte Watershed Volunteer Monitoring Program were intended to add to, and strengthen, the understanding of activities or situations impacting on water quality and education of participants and the community regarding them, as well as opportunities to improve the watershed, Shelburne Bay.

1.2 Collaborative Relationships

The LaPlatte Watershed Volunteer Water Quality Monitoring Program is an integral element in a broad strategic plan drafted by the **LP**, which focuses on citizen participation in, and public education regarding, conservation issues relating to the watershed and Shelburne Bay. These include fluvial geomorphic studies, buffer restoration, stormwater education, management and monitoring, wildlife habitat studies, and control of aquatic nuisance organisms. The minimum control measures proposed by the **Town of Shelburne** to meet its MS4 requirements include specific roles for the LRP through public involvement and participation. The sampling program was undertaken to contribute to an understanding of the sources of bacterial contamination, suspended solids, nutrients, and salts, and help put management requirements and priorities into perspective. The sampling program also complements and extends the scope of a limited sampling initiative implemented by the **CWD** which began in February and extended through October, 2004. The CWD monitoring program included determinations of temperature and testing for *E. coli*, enterococci, turbidity, and possibly particle count, size and distribution at 15 locations in the LaPlatte watershed.

Partners in the LaPlatte Watershed Volunteer Water Quality Monitoring Program included:

- LaPlatte Watershed Partnership
- Champlain Water District
- Town of Shelburne
- Town of Hinesburg
- Town of Charlotte
- Lewis Creek Association
- LaRosa Laboratory, Water Quality Division, Vermont Department of Environmental Conservation

2. PURPOSE AND ANTICIPATED OUTCOMES

The purpose/objectives of the LaPlatte Watershed Volunteer Monitoring Program, actions, and anticipated outcomes/results are provided in Table 4.

Table 4. Purpose and Anticipated Outcomes

Purpose:	Action:	Anticipated Outcomes:
Provision of background information which over time can contribute to the assessment of change within the watershed	Annual reports with distribution to towns and state agencies and follow up by LWP. Incorporation of results into state/national water quality databases	Improved assessment of conditions in the target waters and factors impacting on them
Identification of activities and situations impacting, or potentially impacting, on water quality	Analysis of results, field assessments, follow up with town and state agencies	Establishment of priorities based on sound data and analysis
Contributing to database for assessment of surface waters by the State, town NRCCs, and other organizations	Annual reports with distribution to towns and state agencies and follow up by LWP.	Incorporation of results into state/national water quality databases
Providing data applicable to the assessment of water quality in respect of storm water management and MS4	Submission and discussion of results and findings with Shelburne Select Board and CNRC. Follow up as required	Action to implement improved practices for the management of non-point sources of pollution based on an improved understanding of specific sources and their relative importance/inform optimization of BMPs
Contributing to CWD source water database	Submission of Annual Report to CWD and discussion of results, analysis, and findings	Improved planning for operation of drinking water processes in relation to events affecting the raw water source
Education of participants and the community about water quality and strategies for protection of water quality in the LaPlatte watershed and Shelburne Bay. The educational component will contribute to meeting educational requirements under Shelburne's MS4 program.	Training and participation of volunteers Public meetings Articles in Town newspapers	Enhanced public understanding of issues related to water quality and needs for town management initiatives, as well as improved personal responsibility for implementing improved practices at home

3. MATERIALS AND METHODS

- Sampling station locations

  A network of 28 sampling stations within the LaPlatte watershed was sampled in 2004 by LWP volunteers at locations indicated in Figure 7 (LaPlatte River, 12 stations; McCabe's Brook, 7 stations; Mud Hollow, 3 stations; Bingham Brooks, 1 station; Patrick Brook, 3 stations; and an un-named tributary in Hinesburg, 1 station). Sampling stations were located at bridges or easily accessible sites, but were located to enable assessment of the influence of populated areas, effluent discharges, and different categories of farming practices (See Table 5 for detailed descriptions). They included a station located at the USGS gauging station on the LaPlatte River. Whereas most sampling sites did not coincide precisely with reach breaks established as part of the fluvial geomorphic analysis, they relate closely to important reach breaks (See Figure 2).

  Fifteen sites, of which 13 coincided with the 28 LWP sites (See Figure 7), while constituting an integral part of the proposed sampling program, also comprise a network of stations operated by the CWD, and were sampled during periods of increasing flows as well as during low flow for baseline testing.

- Descriptions of Sampling Points

  Locations and descriptions of LWP and CWD sampling points, as well as locations of reach points defined for the Phase I Fluvial Geomorphic Assessment undertaken by the LWP, are indicated in Figure 2. Detailed descriptions are given in Table 5 (LWP stations) and Table 6 (CWD stations).

- Sampling procedures and training of volunteers

  Samples were collected monthly from June through November, 2004. Sampling of the 15 sites earmarked by the CWD was undertaken during periods of increasing flow between February and October.

  Samples were collected by 20 trained LWP volunteers (See Annex II) and CWD water quality staff according to standard procedures defined in the Quality Assurance Project Plan. Samples were stored on ice in the field and during transport to the laboratory. Bacteriological samples were placed on ice during storage and transport to the laboratory in sealed Ziploc bags to isolate them from contamination by the ice.

Figure 7

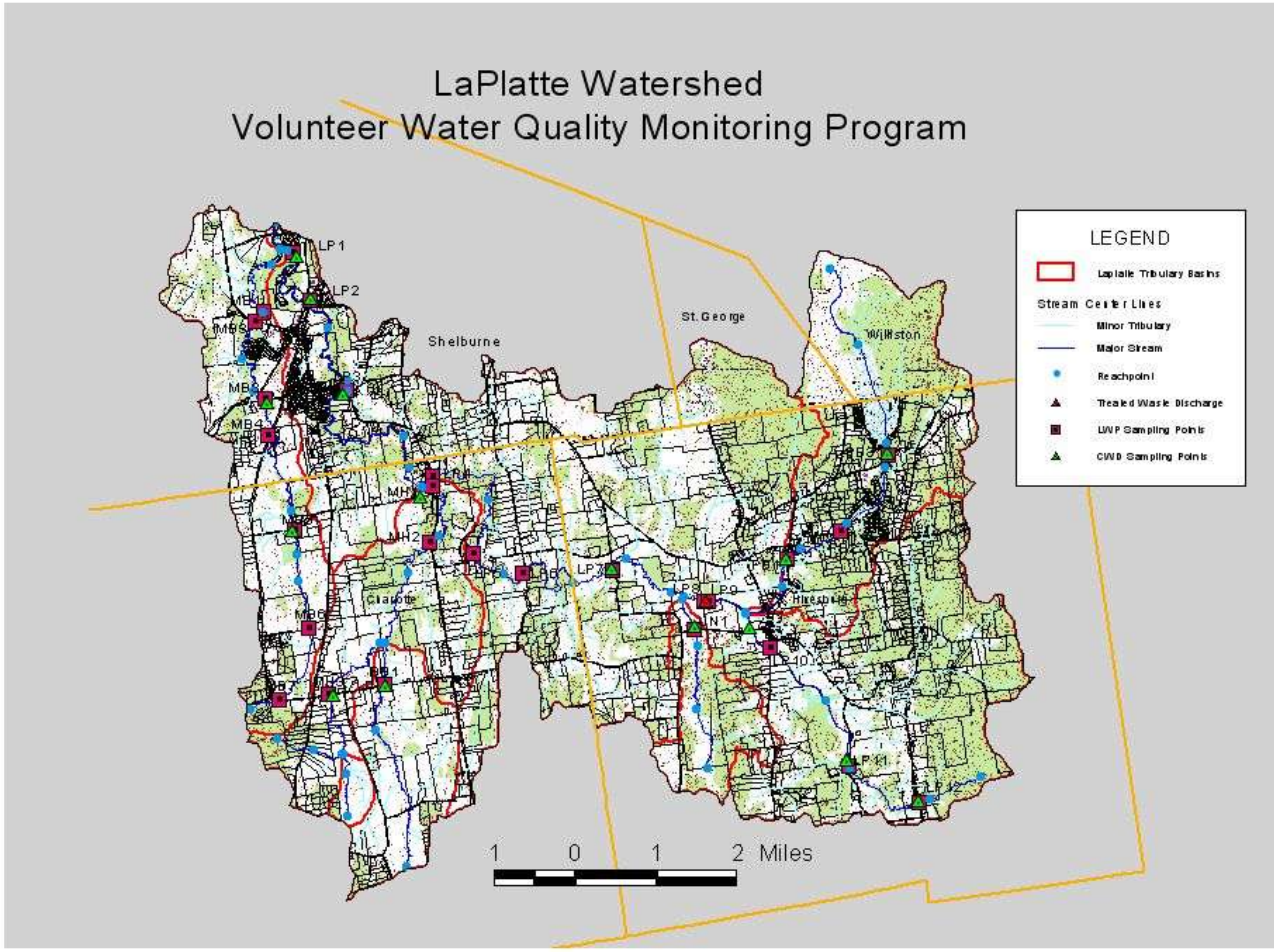

LaPlatte Watershed
Volunteer Water Quality Monitoring Program
LEGEND
Stream Center Lines
Shelburne
St. George
Williston
1 0 1 2 Miles

Table 5. LWP Sampling Station Locations

Station No.	River Mile	Coordinates	Town	Description	Remarks
LP1	LAP 0.55	44.3944972 -73.228786	Shelburne	LaPlatte River, end of walking trail at Yacht Haven Drive.	
LP2 (LR2)	LAP 1.8	44.38707 -73.22515	Shelburne	LaPlatte River, Route 7 bridge north of Shelburne Village. Right bank under bridge.	
LP3 (LR4)	LAP 3.46	44.37022 -73.21577	Shelburne	LaPlatte River, intersection of Thomas and Falls Roads. East (right bank), approximately 30 meters south of Falls Rd. bridge.	Dairy farms drain via tributaries below LP4
LP4	LAP 6.96	44.3550 -73.19382	Charlotte	LaPlatte River, Spear St. bridge (at Gecewicz). Left bank, 3 meters downstream of bridge.	
LP5	LAP 9.19	44.34176 -73.18383	Charlotte	LaPlatte River, Carpenter Rd. bridge. Left bank, 5 meters upstream from bridge.	Dairy farms drain from right bank downstream from LP4b. Bank erosion upstream.
LP6	LAP 10.32	44.33839 -73.17097	Charlotte	LaPlatte River, Dorset St. bridge. Right bank, upstream end of bridge.	
LP7 (LR9)	LAP 12.37	44.33887 -73.14931	Hinesburg	LaPlatte River, Leavenworth Rd. North bridge. Left bank at downstream end of bridge.	
LP8	LAP 14.52	44.33319 -73.12618	Hinesburg	LaPlatte River, 15 meters downstream of Hinesburg sewage treatment plant outfall.	
LP9	LAP 14.54	44.33395 -73.12598	Hinesburg	LaPlatte River, 15 meters upstream of Hinesburg sewage treatment plant outfall.	
LP10 (LR11)	LAP 15.66	44.32524 -73.11015	Hinesburg	LaPlatte River, Silver St. bridge. Right bank, downstream end of bridge.	
LP11 (LR14)	LAP 17.63	44.30492 -73.30492	Hinesburg	LaPlatte River, Gilman Rd. bridge. Left Bank. Downstream discharge from culvert.	Downstream from Cedar Knoll Golf Club
LP12 (LR15)	LAP 18.92	44.29776 -73.07288	Hinesburg	LaPlatte River, Route 116 bridge. Downstream discharge from culvert.	Upstream from Cedar Knoll Golf Club

MB1	LAP 0.34 MB 1.51	44.38423 -73.23695	Shelburne	McCabe's Brook, 15 meters downstream of Shelburne sewage treatment plant #2. East (right) bank.	Intermittent discharge from SBRs. UV disinfection.
MB2	LAP 0.34 MB 1.68	44.38305 -73.23853	Shelburne	McCabe's Brook, Harbor Rd. bridge. Left bank, 15 meters below bridge.	Surface drain channel enters from right bank about half way between the bridge and the sampling point
MB3 (LR3)	LAP 0.34 MB 3.32	44.36892 -73.23586	Shelburne	McCabe's Brook, Bostwick Rd. Bridge. Left bank at downstream discharge from culvert.	
MB4	LAP 0.34 MB 4.00	44.36230 -73.23461	Shelburne	McCabe's Brook, Route 7 bridge. Right bank at upstream end of bridge.	Upstream bank erosion. Vermont Teddy Bear storm drainage pond overflow immediately upstream. Cultivated fields upstream below MB5, west (left) bank.
MB5 (LR5)	LAP 0.34 MB 6.04	44.34582 -73.22868	Charlotte	McCabe's Brook, Lime Kiln Rd. bridge. Downstream discharge from culvert.	Horses upstream, west (left) bank. Nordic Farm upstream.
MB6	LAP 0.34 MB 7.41	44.32802 -73.22493	Charlotte	About __mi. east of the end of Mutton Hill Rd. along old farm road, edge of field. Upstream end of culvert	Hayfield and cultivated fields upstream
MB7	LAP 0.34 MB 8.48	44.31522 -73.23150	Charlotte	McCabe's Brook, Hinesburg-Charlotte Rd.. Upstream end of culvert.	Drainage from Pease Mountain
MH1 (LR6)	LAP 6.64 MH 0.23	44.35353 -73.19340	Charlotte	Mud Hollow Brook, Spear St. Bridge (at Gecewicz). Entrance to culvert at upstream end.	Upstream drainage from cultivated fields.

MH2	LAP 6.64 MH 1.36	44.34373 -73.19449	Charlotte	Mud Hollow Brook, Spear St. Bridge. Downstream discharge from culvert.	Drainage from cultivated fields downstream west (left) bank from MH2.
MH3 (LR7)	LAP 6.64 MH 2.70	44.31632 -73.21956	Charlotte	Mud Hollow Brook, Hinesburg Rd. bridge. Downstream exit from bridge.	
BB1 (LR8)	LAP 6.64 MH 3.47 BB 0.82	44.31789 -73.20571	Charlotte	Bingham Brook, Hinesburg Rd. Bridge. Upstream entrance to culvert. East (right) bank. Near Bingham Brook Farm.	Drainage from cultivated fields upstream east (right) bank.
UN1 (LR10)	LAP 14.09 UN 0.49	44.32844 -73.11427	Hinesburg	Un-named tributary to LaPlatte River, Charlotte-Hinesburg Rd. bridge. Upstream entrance to culvert.	
PB1	LAP 15.09 PB 1.01	44.34115 -73.10594	Hinesburg	Patrick Brook, Mechanicsville Rd. bridge. Right bank, upstream entrance to culvert.	
PB2	LAP 15.09 PB 1.92	44.34556 -73.09268	Hinesburg	Patrick Brook, south of Richmond Rd. bridge. Right bank entrance to discharge weir (raceway) from pond.	Downstream from Sunset Lake and Lower Pond
PB3 (LR13)	LAP 15.09 PB 3.21	44.35973 -73.08067	Hinesburg	Patrick Brook, Pond Brook Rd. bridge. Upstream entrance to culvert.	Downstream from Lake Iroquois, head of Sunset Lake.

Table 6.

Champlain Water District

Water Quality Sampling Stations

CWD STATION NO.	LRP STATION NO.	LONGITUDE	LATITUDE	STREAM	DESRIPTION
LR1	LP 1	-73.22878610	44.39449720	LaPlatte River	Yacht Haven Trail
LR2	LP 2	-73.22508880	44.38700270	LaPlatte River	Route 7
LR3	MB 3	-73.23590000	44.36844330	McCabe's Brook	Bostwick Road
LR4	LP 3	-73.21689720	44.36992500	LaPlatte River	Falls Road
LR5	MB 5	-73.22900550	44.34550000	McCabe's Brook	Lime Kiln Road
LR6	UN 2	-73.19747770	44.35170830	Small Un-named Brook	Lime Kiln Road
LR7	MH 3	-73.21858880	44.31616380	Mud Hollow Brook	Hinesburg Road
LR8	BB 1	-73.20582770	44.31785830	Bingham Brook	Hinesburg Road
LR9	LP 7	-73.14938880	44.33925550	LaPlatte River	Leavenworth Road
LR10	UN 1	-73.12886940	44.32883610	Un-named Brook	Hinesburg-Charlotte Rd.
LR11	LP 9a	-73.11489440	44.32886380	LaPlatte River	Hinesburg-Charlotte Rd.
LR12	PB 1	-73.10607500	44.34123330	Patrick Brook	Mechanicsville Road
LR13	PB 3	-73.08106380	44.36010000	Patrick Brook	Pond Brook Road
LR14	LP 11	-73.09061110	44.30537700	LaPlatte River	Gilman Road
LR15	LP 12	-73.07272770	44.29797770	LaPlatte River	Route 116

- Transport of samples

  Samples were transported to the CWD laboratory or to the LaRosa laboratory by the LWP Project Coordinator and/or CWD staff on the day of collection. Samples were transported on ice and were delivered at the laboratory within 4 hours.

- Sample Analysis

  Parameters determined were selected based on their significance relative to sources and impacts of pollutants. Parameters analyzed by the CWD on the 15 designated stations include temperature, *E. coli*, enterococci, turbidity, and, possibly particle count, size, and distribution. Analyses undertaken under the Volunteer Monitoring Program included the following, and supplemented analyses carried out by the CWD at the 15 designated stations:

Temperature	Nitrate + Nitrite	Turbidity
Total Phosphorus	Chlorides	*E. coli*
Total Nitrogen	Total Suspended Solids	

  All monthly chemical and bacteriological samples collected by LWP volunteers were analyzed at the LaRosa Analytical Laboratory under a Volunteer Water Quality Monitoring Analytical Services Partnership grant from the Water Quality Division, Vermont Department of Environmental Conservation. Analytical methods were standard methods according to **Standard Methods for the Examination of Water and Wastewater (20th Edition)** Edited by Lenore S. Clesceri, Arnold E. Greenberg and Andrew D. Eaton, American Public Health Association, 1998 or EPA Test Methods, April, 2003 as follows:

  - Chloride. Automated Ferricyanide Method (Standard Methods 4500-Cl^- Method E)

    This method measures highly colored ferric thiocyanate formed when thiocyanate liberated from mercuric thiocyanate in the presence of chloride ion reacts with ferric ion. Ferric thiocyanate is measured colorimetrically at 480 nm. The method measures chloride in the range of 1 to 200 mg Cl^-/l.

  - *Escherichia coli*. Enzyme Substrate Test (Standard Methods 9223 Method B)

    In this method, the Colilert test for *E. coli* using the IDEXX Quanti-Tray®/2000 was employed. This is a most probable number (MPN) procedure during which 4-methylumbelliferyl-β-d-glucuronide (MUG) provided as a substrate is metabolized to β-D-glucuronide which fluoresces under UV light. MPNs in the range of <1 to 2014 per 100 ml. were determined from the numbers of fluorescent wells after 24 hrs. incubation at 35° C.

- Nitrate + Nitrite. Automated Cadmium Reduction Method (Standard Methods 4500-NO_3^- Method E)
  In this method, nitrate in the sample is reduced to nitrite in the presence of cadmium by passing through a column of cadmium granules treated with copper sulfate. Nitrite nitrogen is then determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form an azo dye which can be measured colorimetrically at 540 nm.

- Nitrogen, Total. Persulfate Method (Standard Methods 4500-N Method C)

  In this method, all nitrogen compounds are oxidized to NO3- during an alkaline digestion with potassium persulfate. Digestion is followed by determination of nitrate nitrogen by the cadmium reduction method read colorimetrically at 540 nm.

- Phosphorus, Total. Automated Ascorbic Acid Reduction Method (Standard Methods, 4500-P Method F)

  In this method, ammonium molybdate and potassium antimonyl tartrate react with orthophosphate in an acid medium to form an antimony-phosphomolybdate complex which is measured colorimetrically at 650-660 nm or at 880 nm.

- Solids, Total Suspended. Total Suspended Solids Dried at 103-105° C (Standard Methods 2540 Method D)

  In this method, the sample is filtered through a pre-weighed standard glass fiber filter which is dried to constant weight (at least 1 hour) at 103 to 105° C. The total suspended solids concentration is determined from the weight of the residue on the filter and the volume of sample filtered.

- Turbidity. (EPA Method 180.1)

  Turbidity is measured as scattered light at 90° from a tungsten filament lamp at between 2200 and 3000° K. The detector and filter system have a peak response at between 400 and 600 nm. Samples were agitated gently and settled for 1 to 2 minutes to remove heavier particles which make measurement of turbidity difficult.

- Maintenance of data

  Data were transferred from the Project Manager, DEC/DEC to the LRP Project Coordinator as an EXCEL file. Data were organized by the Project Coordinator to facilitate data presentation and interpretation.

- Analysis of results

  Initial data interpretation and draft report preparation were completed by the Project Coordinator and distributed to volunteers, CWD, the WQD/DEC Project Manager, and the DEC Watershed Coordinator for comment. Comments were received by the LRP Project Coordinator and incorporated as considered appropriate.

- Quality assurance

  All data and report files were provided to the QA Coordinator for review and analysis following methodologies specified in the Quality Assurance Project Plan.

- Final Report

  Results have been reviewed and analyzed by the LRP and the CWD in context of land use, potential sources of pollution, potential impacts, and implications. This report has been prepared in a relatively detailed form to provide a basic document to facilitate understanding on the part of the lay reader and to inform continuation of the program in subsequent years. It is being submitted to the WQD, DEC, the town of Shelburne, CWD, Hinesburg, and Charlotte, and will be followed-up with Shelburne on MS4 implications and other interested agencies.

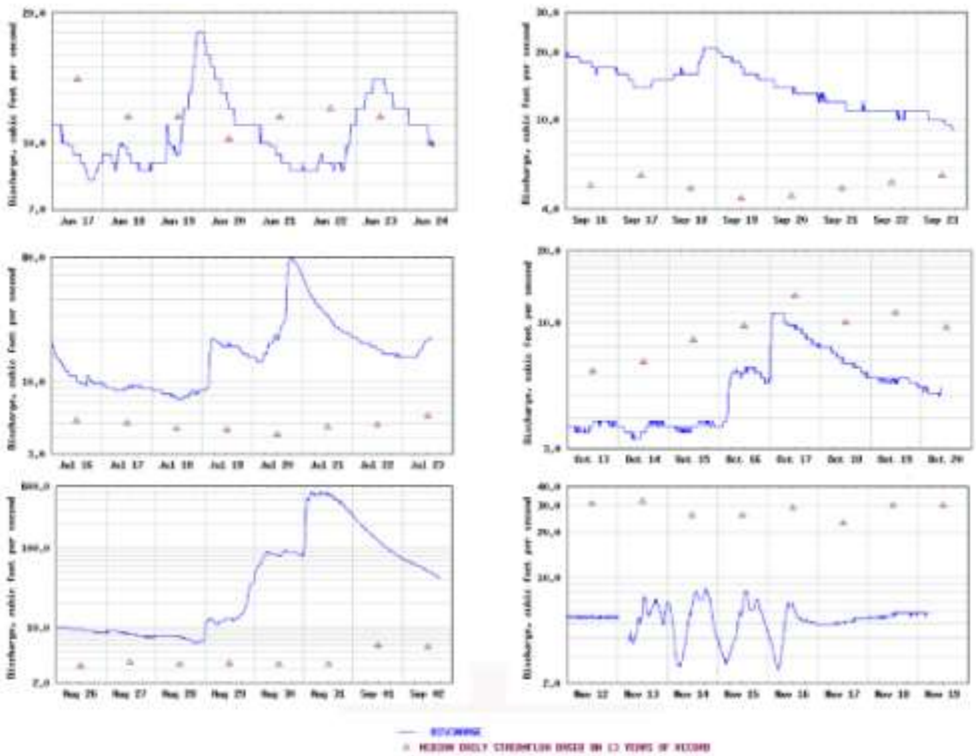
4. RESULTS AND DISCUSSION

4.1 Stream Flow

Stream flows during the summer and early fall months (June through September) reflected a wetter than normal summer. Flows at the USGS glow gauging station located on the LaPlatte River at Shelburne Falls (sampling station LP 3, river mile 3.4) prior to and including sampling dates are provided in Figure 8.

Figure 8

Flows in the LaPlatte River at Shelburne Falls, 2004



Although flows at the gauging station peak later than flows at upstream stations (perhaps after a delay of as much as 12 hours), and rainfall can vary significantly from location to location within the watershed, they do provide an indication of the magnitude of flow (high, medium, or low) and its history at the time of sampling. At the time of sampling, approximate flows and flow histories at the gauging station were as follows:

June 22 — Approximate flow 8.8 cfs. Moderate flow, lower than median flow of 12 cfs for that date. Flow had peaked 2 days earlier following heavy rains. Light to moderate rains had been falling since about 6:00 am and continued through the time of sampling on June 22, following clear weather over the previous 24 hours. This showed up as increased flows at Shelburne Falls in the afternoon and continued through mid-day on June 22.

July 20 — Approximate flow 15 cfs. Moderate flow, but higher than the median flow of about 4 cfs for that date. The flow had increased on July 19 following rains over the previous two days, and began increasing again immediately after sampling was completed, peaking about 12 hours later as a result of heavy rains which had begun around 4:45 am.

August 31 — Approximate flow 500 cfs. Very high flow, exceeding the median of about 3.5 cfs for that date. Rains had begun late on August 28, becoming very heavy on August 29. Sampling on August 31 occurred at the time of peak flow at Shelburne Falls. Rain was heavy at the time of sampling.

September 21 — Approximate flow 11.5 cfs. Moderate flow, but higher than the median flow of about 5 cfs for that date. The weather had been clear for 4 to 5 days, allowing the flow to decline slowly over that period. There was a brief light rain lasting about 10 minutes at about 7:30 am.

October 19 — Approximate flow 6 cfs. Low to moderate flow, lower than the median flow of about 11 cfs for that date. The weather had been clear for the two days prior to October 19, during which the flow had declined steadily from about 11 cfs on October 17.

November 16 — Approximate flow 2.4 cfs. Low flow, lower than the median flow of about 30 cfs for that date. The weather had been clear for a considerable period prior to November 16. The base flow between November 12 and November 18 remained at about 5.5 cfs, but during a very cold period from November 13 through November 16 during which ice was formed on the surface in slow-moving reaches, flows fluctuated from highs of about 7 cfs during the afternoons to lows dropping to less than 3 cfs about 8:00 am each day, apparently reflecting diurnal freezing and thawing of water in the soil and on the ground surface draining to the river.

It is noted that flows and recent flow histories reflect runoff conditions, and at the same time provide dilution. They thus exert a strong influence on water quality, and the latter must be interpreted in the context of flow.

4.2 Temperature

Temperatures were recorded at sampling stations in the lower LaPlatte River (LP 1, LP 2, and LP 3) and lower McCabe's Brook (MB 1, MB 2, MB 3, and MB 4). Temperature affects the rates of chemical reactions and the solubility of oxygen in water. Thus, bacteria survive longer in colder waters, and bacterial action on organic matter in streams takes place at a lower rate. In streams carrying high organic loads during warm weather oxygen may become depleted, especially at night, as a result of reduced solubility on the one hand, and increased metabolic rates on the other.

Stream temperatures observed over the six month sampling period were as follows:

	Lower LaPlatte River	Lower McCabe's Brook
June 22	18.0-21.0°C	15.5-16.6°C
July 20	21.0-23.0°C	19.0-19.5°C
August 31	19.0-19.5°C	19.0°C
September 21	14.0-15.0°C	15.0-17.0°C
October 19	5.5-8.5°C	-
November 16	0°C	0-2.0°C

4.3 Total Suspended Solids

LaPlatte River. Total suspended solids concentrations at the LaPlatte River stations are illustrated in Figures 9 and 9a (NOTE: exceptional total suspended solids concentrations at stations LP 08 and LP 09 omitted from Figure 9a). During low to moderate flows in June, July, September, October, and November concentrations followed a consistent pattern proceeding downstream from station LP 11 to LP 01. This pattern is illustrated by the line representing the mean of observed concentrations during these months (Figure 9a).

In general, concentrations of total suspended solids increased slowly from a mean of 2.6 mg/l at LP 11 to a mean of 10.1 mg/l at LP 08 located below the Hinesburg sewage treatment plant outfall. They then rose dramatically between the outfall and LP 07 located at Leavenworth Road, after which they declined steadily to LP 01. The rises at LP 03 and LP 02 were a consequence of high concentrations observed on July 20 when concentrations increased disproportionately between LP 04 at Spear Street and LP 02 located at Shelburne Road.

Also on July 20, the concentration of solids increased between LP 07 and LP 06 located at the Dorset Street extension. Particularly dramatic, however, was a very large jump in the solids concentration from 5.87 mg/l at LP 10 located in Hinesburg town at Silver Street to 186.4 mg/l above the treatment plant outfall and 243.7 mg/l below the point of discharge (shown in Figure 9, but not in Figure 9a). This increase cannot be explained by erosion in the absence of some severe anthropogenic intervention in this generally highly sensitive reach.

On August 31, during a period of exceptional flow following several days of heavy rainfall, the total suspended solids concentrations increased steadily from 3.43 mg/l at LP 12 where the river flows under Route 116 in Hinesburg to 203.6 mg/l at LP 01.

McCabe's Brook. The picture presented by total suspended solids in McCabe's Brook was less consistent than that in the LaPlatte River, often characterized by a localized high value (Figure 10). But in general, total suspended solids concentrations exhibited a characteristic pattern of low values between the Hinesburg-Charlotte Road (Station MB 7) in Charlotte, and Bostwick Road (Station MB 3) in Shelburne, a rise between Bostwick Road and Falls Road (Station MB 2), and decreasing again between Falls Road and MB 1 below the Shelburne sewage treatment plant outfall. Spikes were observed at Station MB 6 on June 22, September 21, and November 16, at Station MB 3 on July 20, and at Station MB 7 on October 19. Furthermore, concentrations were generally higher at all stations the higher the flows, being highest on August 31 following several days of heavy rains, as well as on July 20. Erodability above MB 6 is considered slight, but stream condition is poor and sensitivity high. The very high concentration at MB 3 on July 20 appears to have been the result of heavy runoff from a construction site on that date.

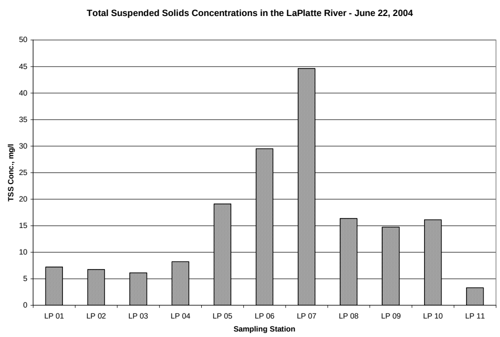
Mud Hollow Watershed. Concentrations of total suspended solids in samples from the Mud Hollow watershed (Figure 11) were subject to considerable variability. In June and July concentrations increased steadily with distance downstream from the Hinesburg-Charlotte Road (Station MH 3) to the Spear Street extension (Station MH 1). However, this pattern was broken on September 21 when the highest concentration was observed at Station MH 2, and on October 19 and November 16 when the concentration at Station MH 3 exceeded that at Station MH 2.

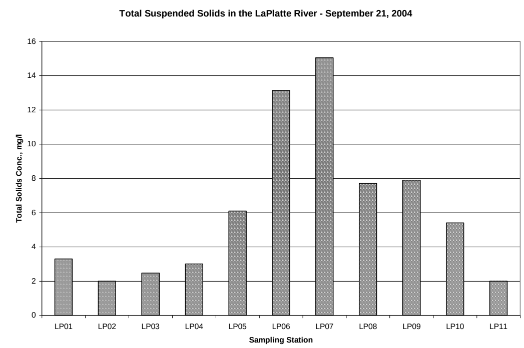
As with other streams, suspended solids concentrations increased during periods of heavy rainfall, being highest on August 31, and moderately high in June and July.

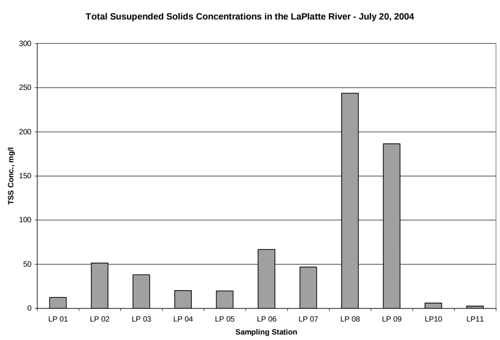
Concentrations in Bingham Brook at the Hinesburg-Charlotte Road on two occasions exceeded concentrations in Mud Hollow Brook itself, but were variable in relation to those in Mud Hollow Brook and in relation to rainfall.

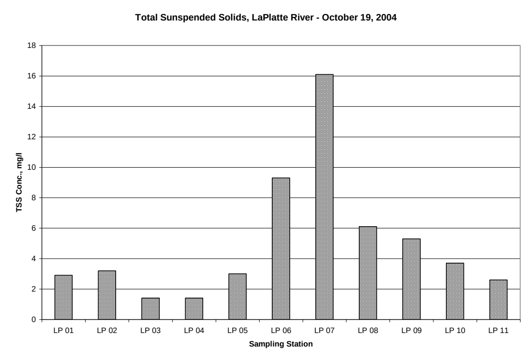
Patrick Brook. Total suspended solids concentrations in Patrick Brook (Figure 12) were consistently highest at the downstream Station PB 1 tending to increase downstream from Station PB 3 to Station PB 2 to Station PB 1, save when the flow was very low on November 16 when the concentration of suspended solids decreased fro station PB 3 to PB 1. Concentrations were generally low, but during moderate and high flows in July and August, increased dramatically between Stations PB 2 at the dam overflow at Richmond Road, and PB 1 at Mechanicsville Road. In contrast to Mud Hollow and McCabe's Brooks, as well as the LaPlatte River, suspended solids concentrations were not highest in August when rainfall and stream flow were greatest.

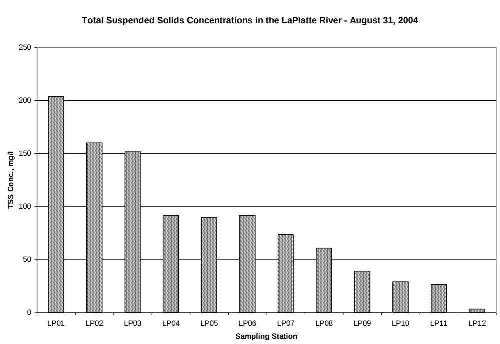
Fig. 9. Total Suspended Solids in the LaPlatte River, 2004











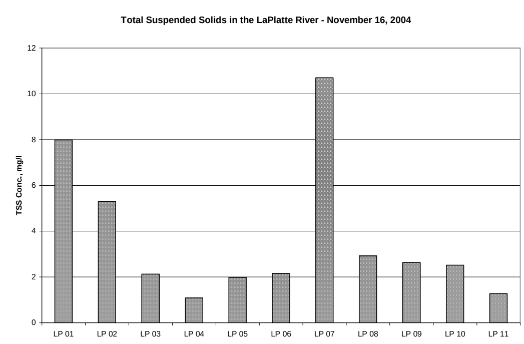


Fig. 9a. Total Suspended Solids in the LaPlatte River, 2004

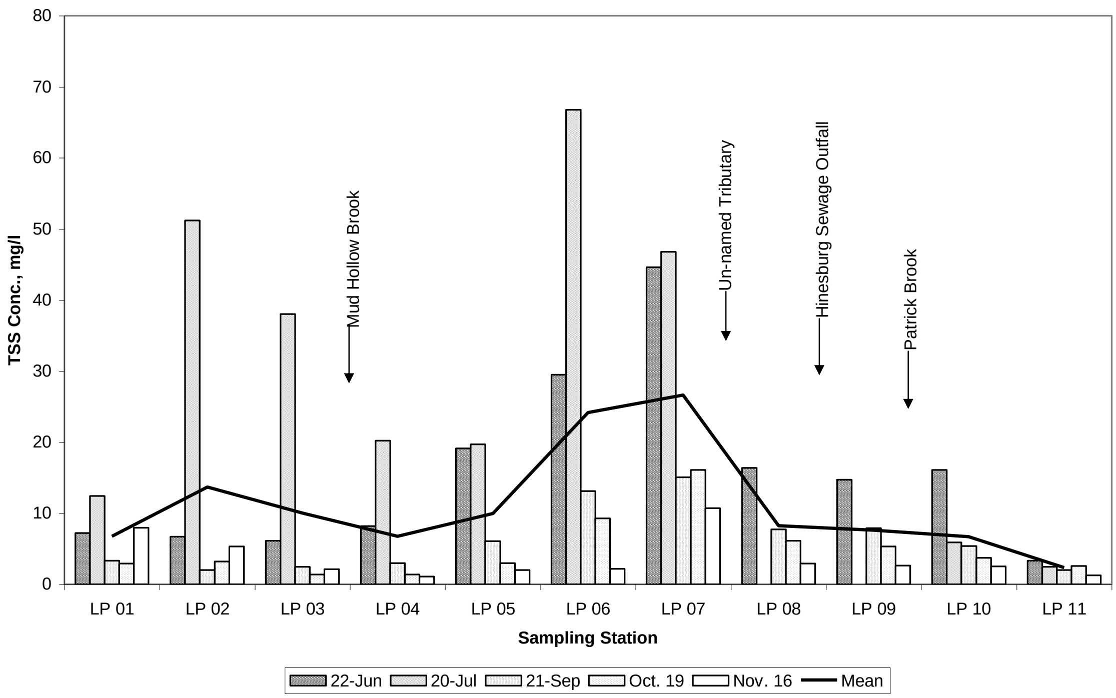


Fig. 10. Total Suspended Solids in McCabe's Brook, 2004

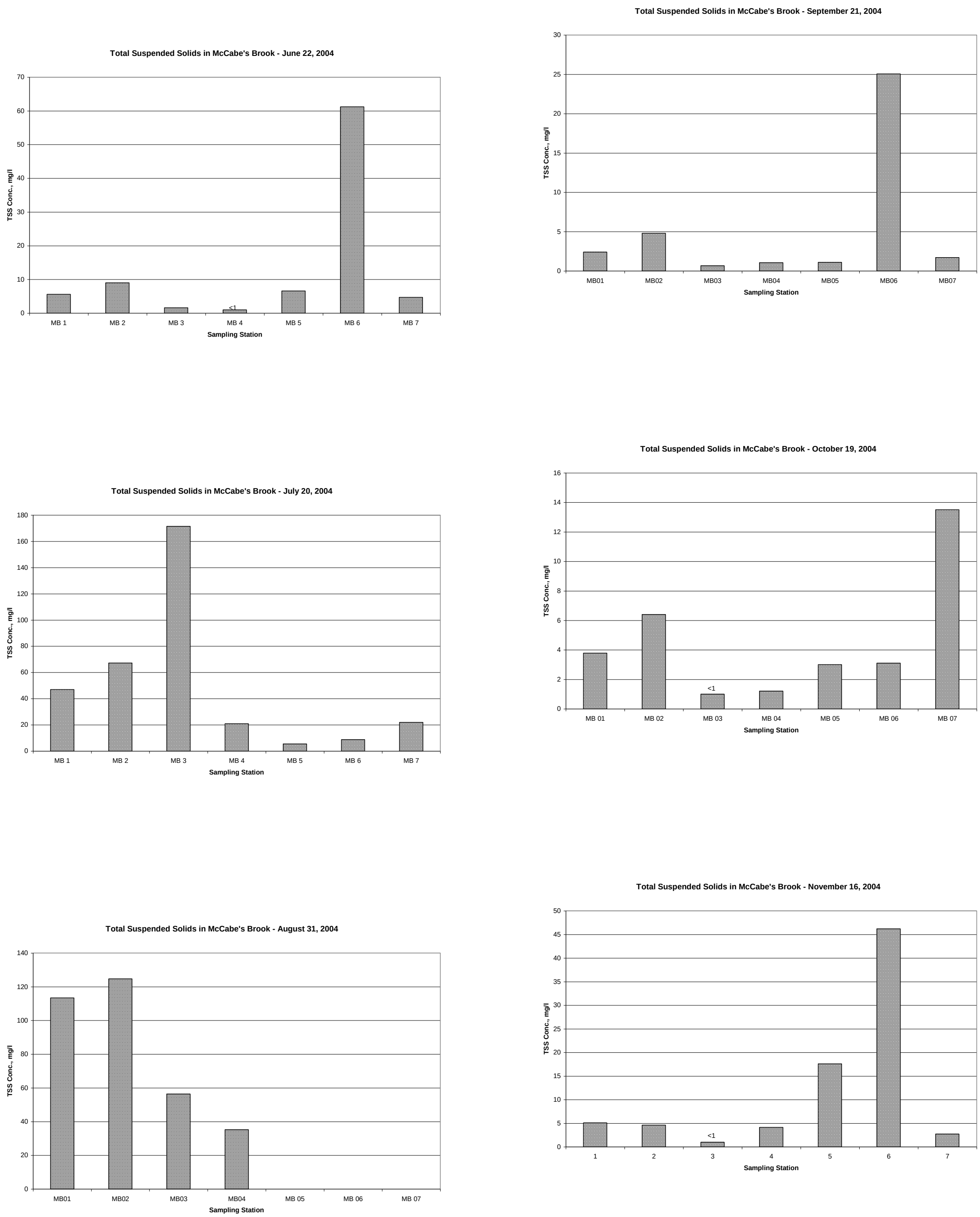
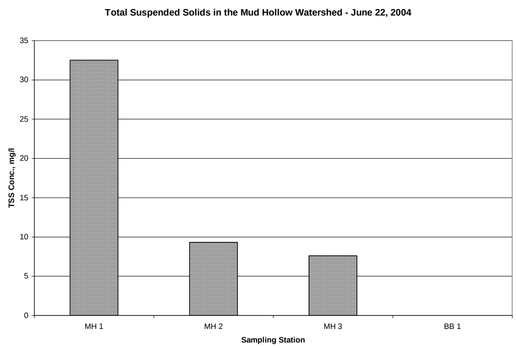
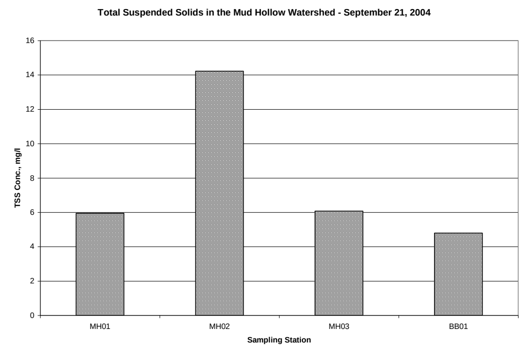
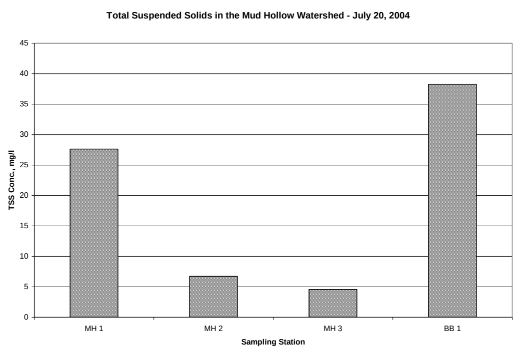
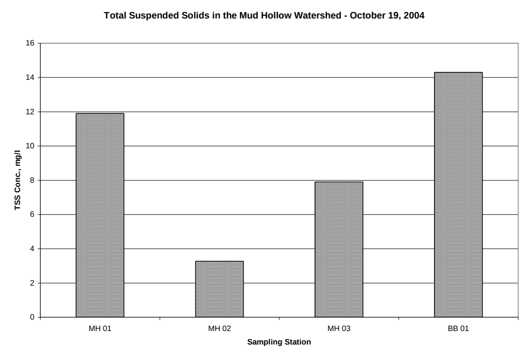


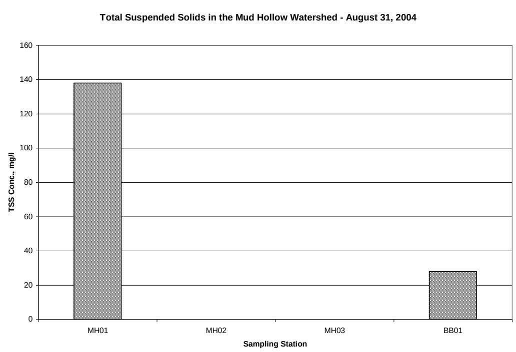
Fig. 11. Total Suspended Solids in the Mud Hollow Watershed, 2004











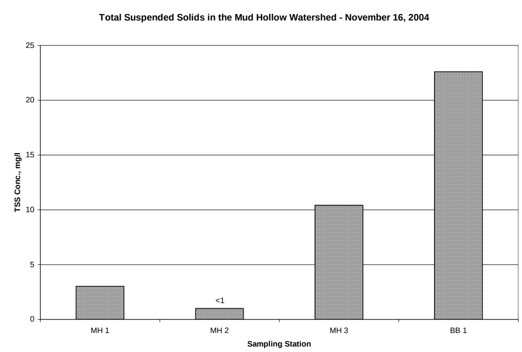
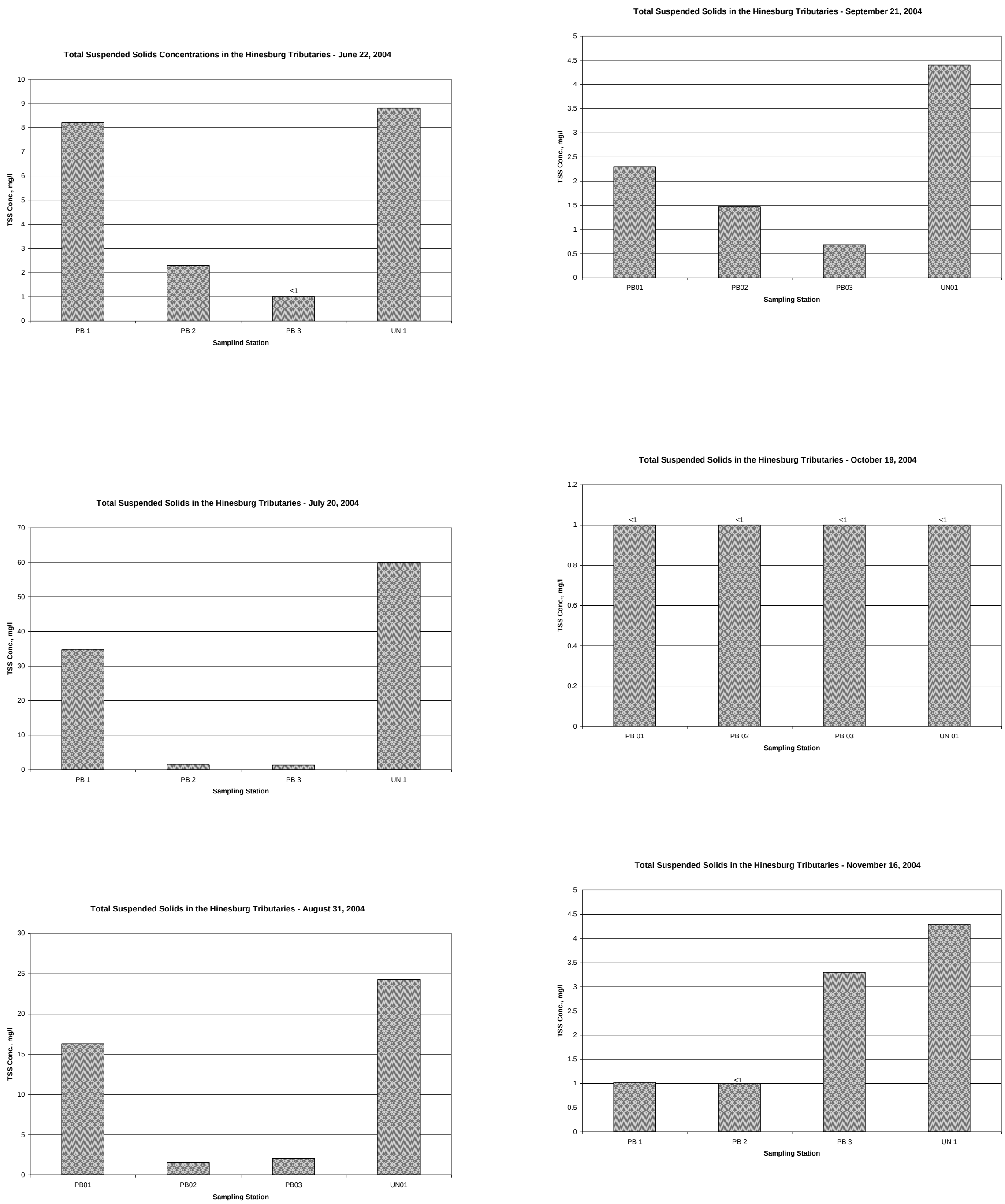


Fig. 12. Total Suspended Solids in the Hinesburg Tributaries, 2004



During low flow in October, concentrations of suspended solids were less than 1 mg/l at all stations.

Un-named Tributary, Hinesburg. Total suspended solids concentrations in the small un-named tributary (Figure 12) flowing from the south in Hinesburg and entering the LaPlatte River downstream from the Hinesburg Sewage Treatment Plant were at all times higher than those detected in Patrick Brook at Mechanicsville Road, but were always lower than those detected in the LaPlatte River at Station LP 08.

As observed with the October samples from Patrick Brook, the concentration of suspended solids concentration on October 19 at Station UN 1 was less than 1 mg/l.

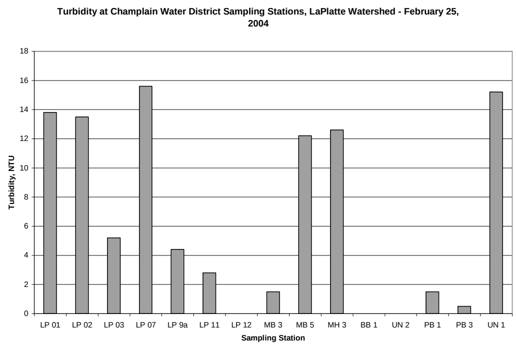
4.4 Turbidity

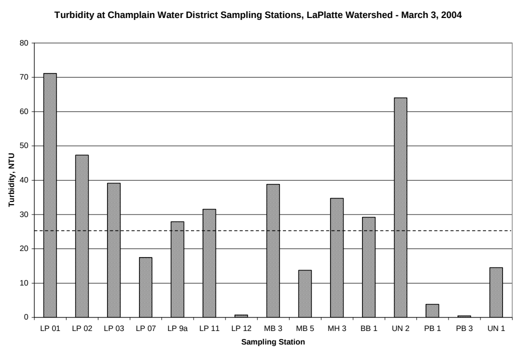
In general, patterns of turbidity throughout the LaPlatte watershed (Figures T-1 to T-4) reflected patterns of total suspended solids concentrations. This is as to be expected since turbidity is caused by fine suspended particulates in the water which are measured gravimetrically as suspended solids. The relationship of turbidity to total suspended solids can be seen more clearly in Figure TS-1, which includes data points for the entire watershed.

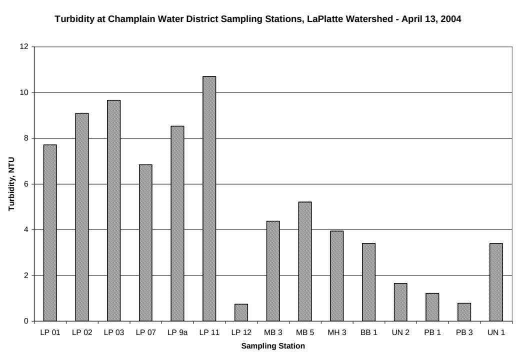
Relationships with CWD Data. In general, turbidity data collected by the CWD (See Figure 13) resembled those collected by the volunteer samplers (Figures 14 through 17). Comparison of analyses of samples collected between February and May is not possible as no samples were collected by the volunteer samplers during those months.

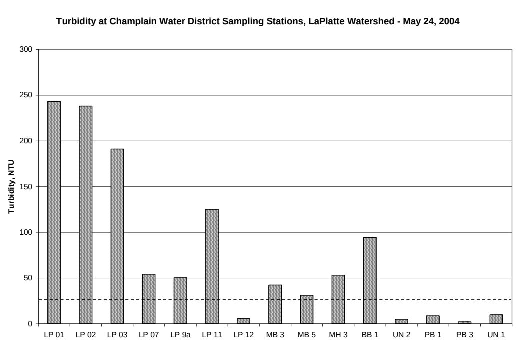
It is instructive first to compare data collected at Falls Road (LP 03) by the CWD on August 30 and September 9 with those collected by the LRP on August 31 and September 25, followed by a comparison of all data collected by CWD and LRP in October and November. The sample collected by CWD was obtained after the flow had been rising for about 12 hours as a result of heavy rains which had been falling for several days, and continued to fall into August 31. Discharge at Falls Road was between 80 and 100 cfs at the time of sampling (See Figure 8). Turbidity was about 35 NTU, not unusual for that location. Heavy rains continued, and when samples were taken by the LP sampling team on August 31, the flow was at its peak of about 500 cfs, and the turbidity had reached 158 NTU, a very high value. When the river was sampled at this point on September 9 by the CWD, the turbidity had decreased, but remained high at 82 NTU. But by September 21 when it was sampled by the LRP team and the flow was low, the turbidity had dropped to about 4 NTU, identical to the value obtained by the CWD on October 13 and the LRP on both October 19 and November 16.

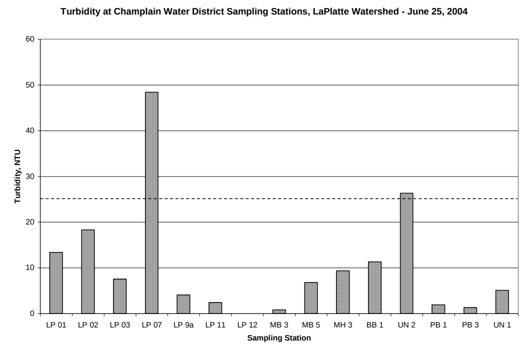
Fig. 13. Turbidity in the LaPlatte Watershed – 2004
Data from the Champlain Water District

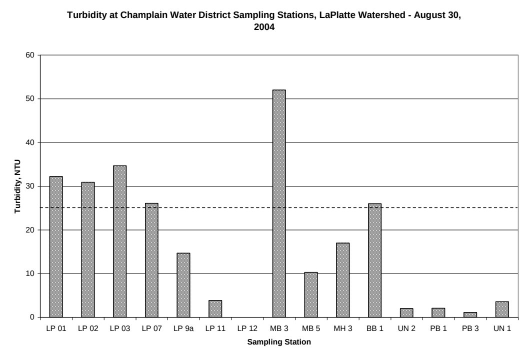


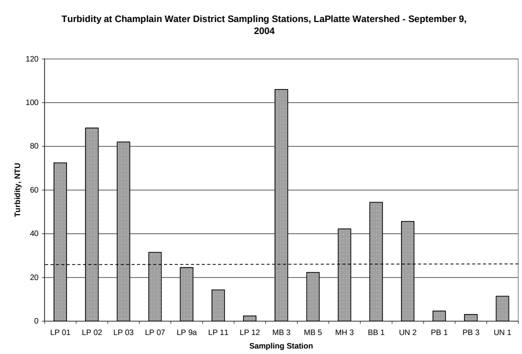












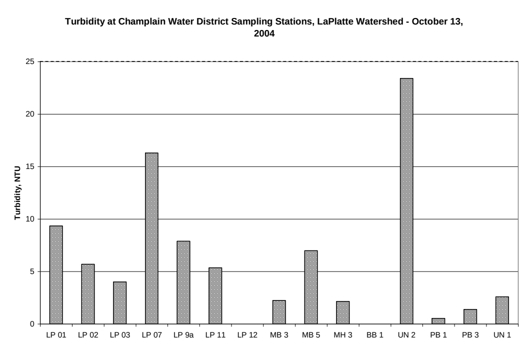
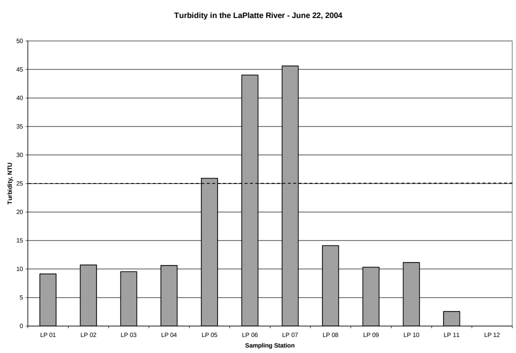
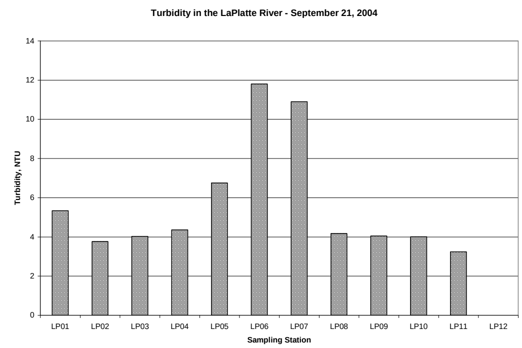
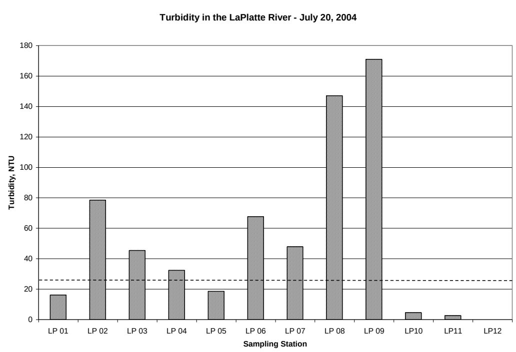
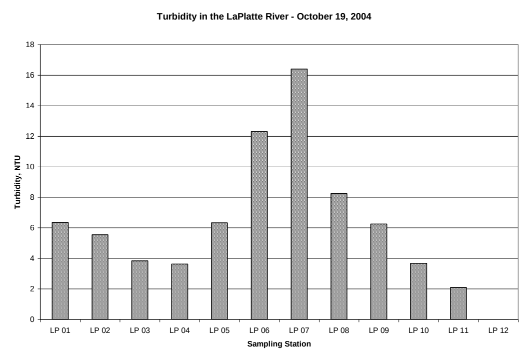


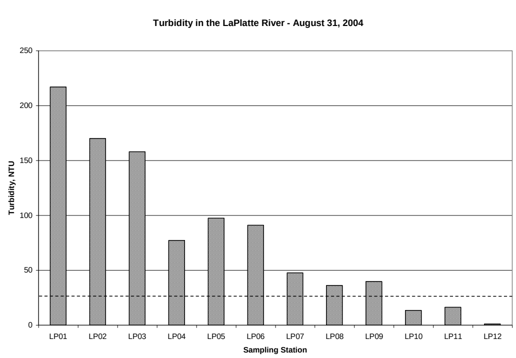
Fig. 14. Turbidity in the LaPlatte River – 2004











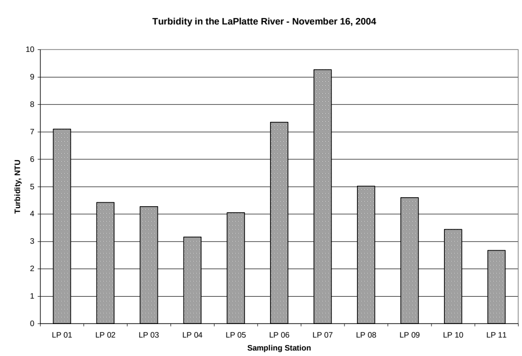


Fig. 15. Turbidity in McCabe's Brook, 2004

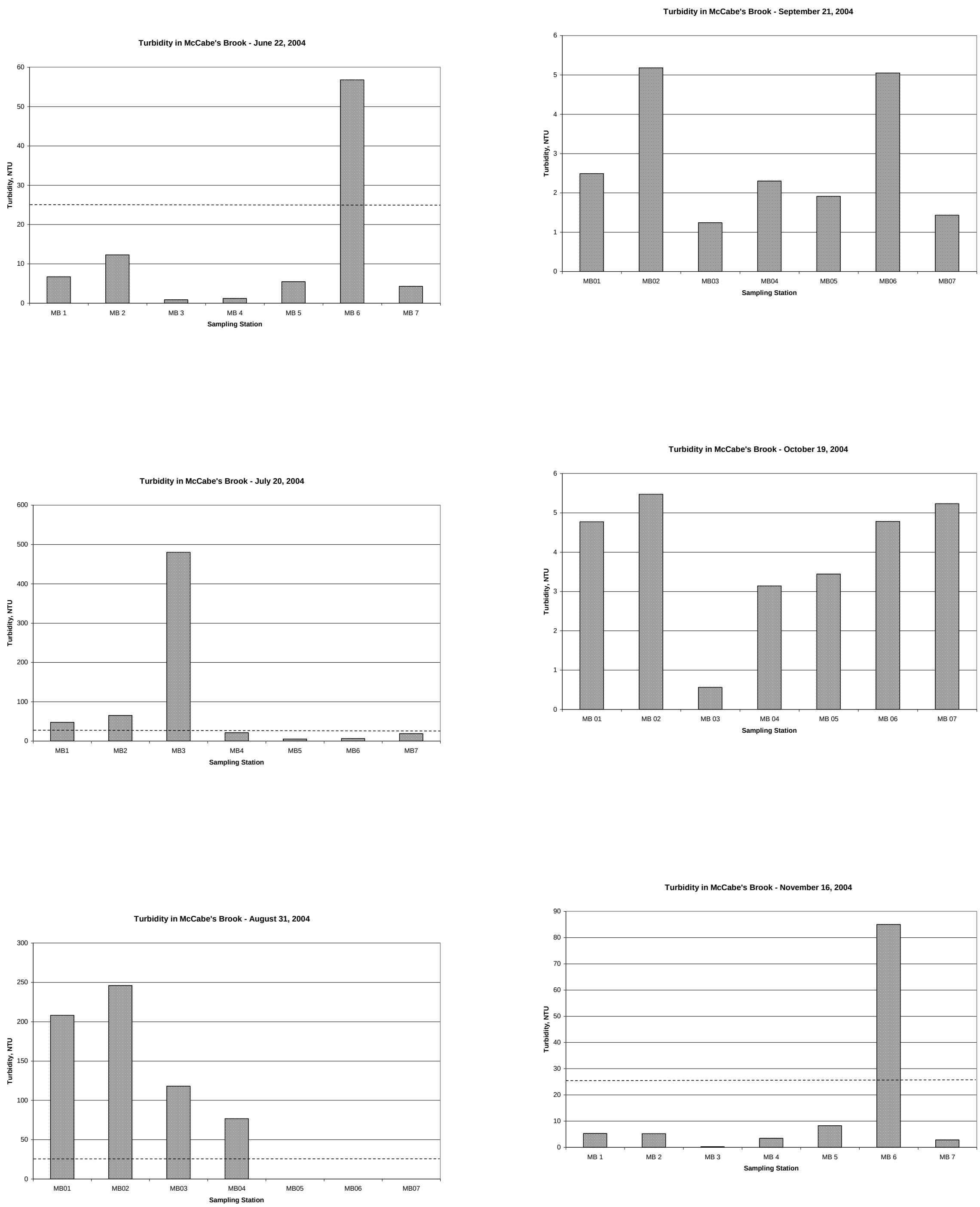


Fig. 16. Turbidity in the Mud Hollow Watershed, 2004

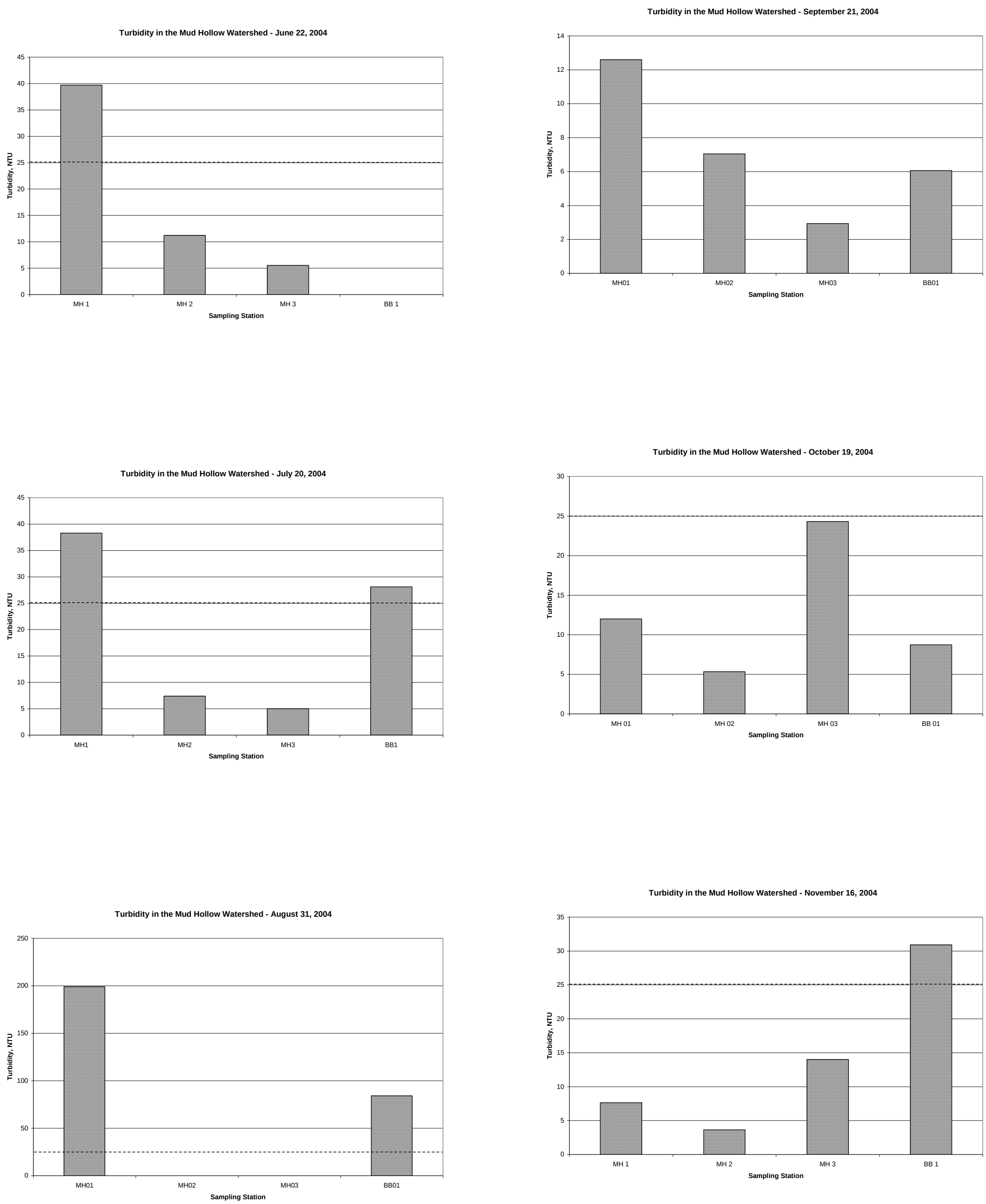
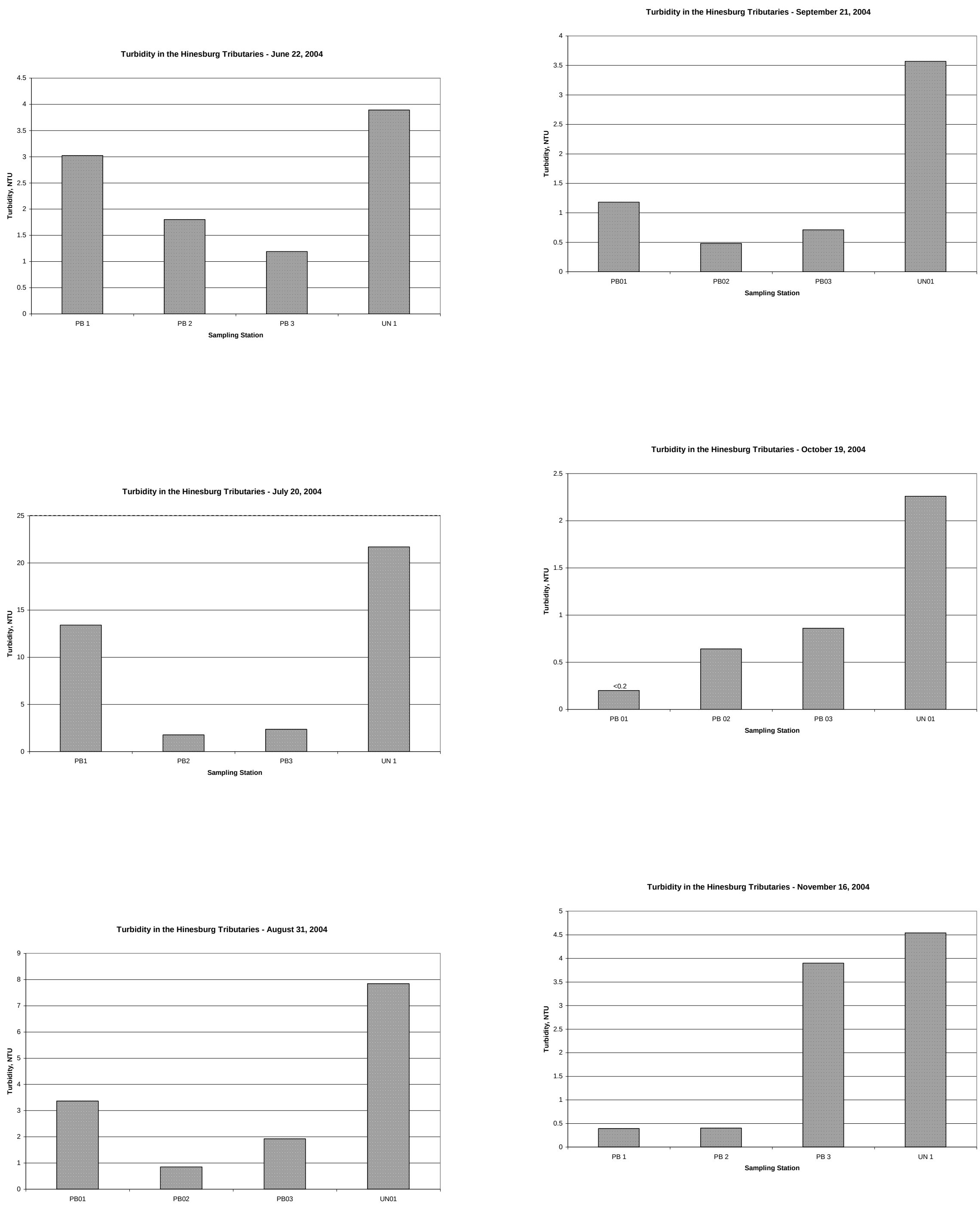


Fig. 17. Turbidity in the Hinesburg Tributaries, 2004



Relation of Turbidity to Total Suspended Solids Concentrations. Overall, the relationship between turbidity and total suspended solids concentrations tends towards a 1:1 relationship (Figure 18). The correlation was demonstrated best on June 22. On other dates, greater scatter occurred. On July 20 and October 19, exceptional values at individual sampling stations (MB 3, LP 08, and LP 09 on July 20; MH 3, BB 1, and MB 7 on October 19) were responsible for much of the variability. On September 21, turbidities and total suspended solids concentrations were low and variable, but generally consistent with the envelopes observed on June 22, August 31, and October 19.

It is important to note that the method for turbidity involved settling for 1 to 2 minutes prior to analysis. This step was introduced during 2004 because large particles associated with high flows interfered with the analysis of turbidity. This explains at least in part high relative percent differences (RPDs) discussed below (see Section 6.2).

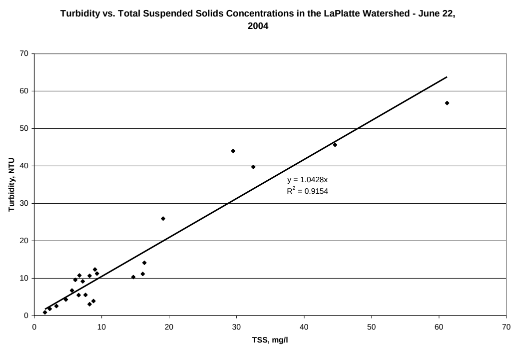
4.5 Nitrogen

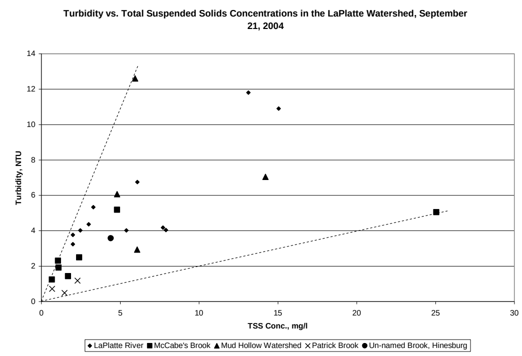
Nitrogen is an essential, and at times, limiting, nutrient required by aquatic plants and algae. With the exception of leguminous plants and certain cyanobacteria which are able to fix atmospheric nitrogen, nitrogen must be derived from the water or sediments.

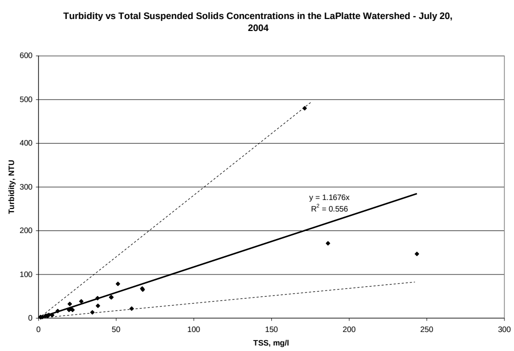
Nitrogen can be present in the water as nitrate, nitrite, ammonium ion, or in the form of dissolved or particulate organic matter. Nitrogen can enter surface waters in the form of nitrate or nitrite with rain, ground water, runoff from urban or agricultural areas, or waste discharges. Similarly, organic nitrogen can enter with runoff from agricultural land, urban areas, or waste discharges, as well as polluted ground water. Ammonium ion, essentially absent from aerated waters, can originate primarily from waste discharges. In the well aerated water of the LaPlatte River and its tributaries at the locations sampled, ammonium ion and nitrite concentrations were probably negligible, and nitrogen was probably present primarily as nitrate ion, measured as $NO_3 + NO_2$, and organic nitrogen, included in the analysis for total nitrogen.

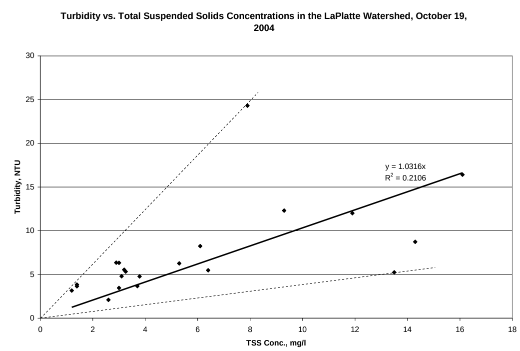
LaPlatte River. In the LaPlatte River itself, total nitrogen concentrations were generally less than 1 mg/l as N. In general, they were high at station LP 11 and then decreased downstream until they increased again below the Hinesburg sewage treatment plant outfall, after which they again decreased with flow downstream until Shelburne Falls (LP 03), after which they either continued to decrease, or more often, to increase slightly to station LP 01. Nitrates constituted a relatively small part of the nitrogen load in the LaPlatte River during the summer and early fall, save at station LP 11 where it made up generally from 60-100% of the total nitrogen present. In the November sample, when runoff and flow were very low, concentrations of nitrates were higher than at other times at all stations and caused an increase in the total nitrogen concentrations at some stations (LP 11, LP 08-LP 04), probably because ground water comprised a major portion of the flow in the river. At the very high flows on August 31, total nitrogen concentrations were high at all LaPlatte River stations.

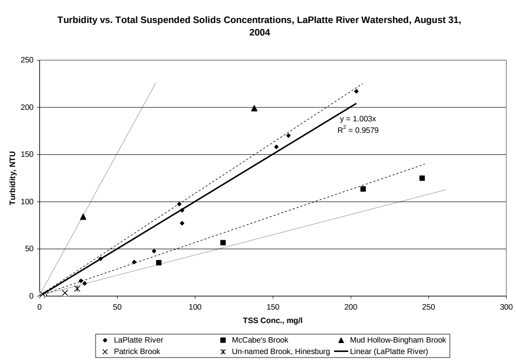
Fig. 18. Turbidity vs. Total Suspended Solids in the LaPlatte Watershed, 2004











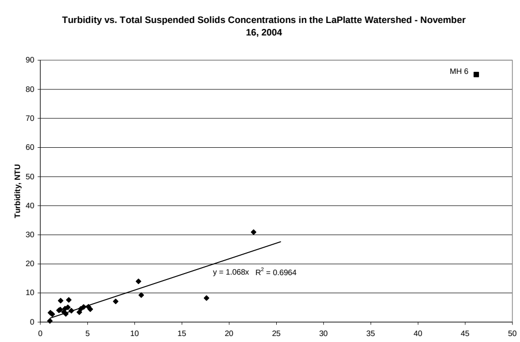
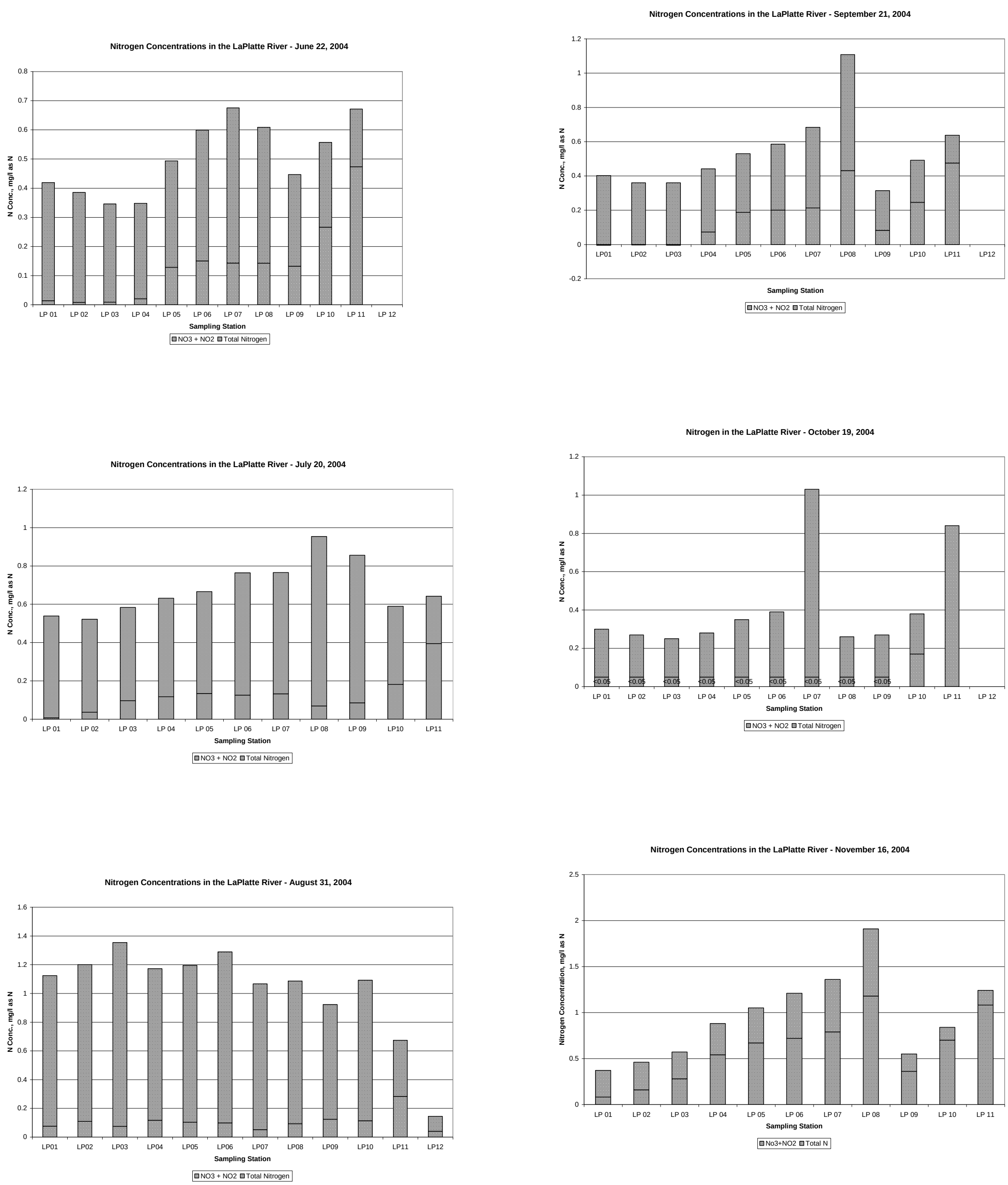


Fig. 19. Nitrogen Concentrations in the LaPlatte River, 2004



McCabe's Brook. Nitrogen concentrations throughout McCabe's Brook (Figure 20) reached generally higher levels than were observed in the LaPlatte River. In general, concentrations of nitrate constituted a minor component of the total nitrogen load. Concentrations increased between MB 7 and MB 6 on each of 5 dates sampled, at times dramatically. Furthermore, on three of six days sampled during discharge (June 22, September 21, and November 16), nitrogen concentrations increased significantly below the Shelburne sewage treatment plant outfall (it is noted that no sample was taken for total nitrogen on July 20). In general, nitrates increased substantially when sewage was flowing.

Mud Hollow Watershed. Nitrogen concentrations in Mud Hollow and Bingham Brooks (Figure 21) tended to be higher in the upper reaches (MH 3 and BB 1), but there was no consistent pattern. Nitrate concentrations were generally very low.

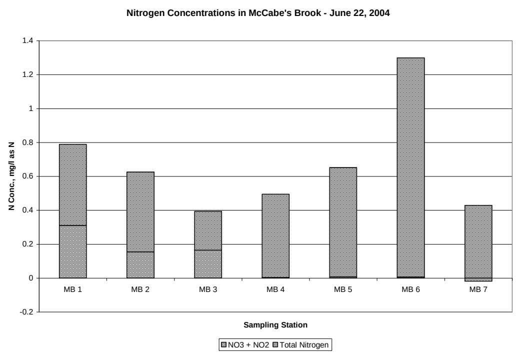
Hinesburg Tributaries. Nitrogen concentrations in the small un-named brook crossing the Hinesburg-Charlotte Road and entering the LaPlatte River below the treatment plant outfall were relatively high on each of the six sampling date (Figure 22). In Patrick Brook, the patterns of nitrogen varied, increasing from the upstream to the downstream station on 3 occasions during the summer months, and decreasing on 3 occasions during the fall months.

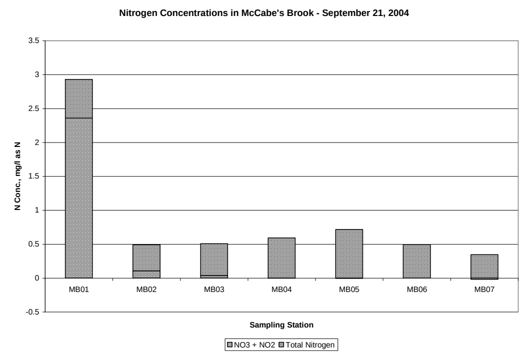
Data available from the monthly samples collected constitute a start towards establishing a baseline of nitrogen relationships in the LaPlatte watershed. In general, organic nitrogen appears to dominate, although in some circumstances nitrate and nitrite predominate, for instance in the LaPlatte River when flow was low in November, at station LP 11 located below a golf course drainage. High total nitrogen concentrations were also associated with treated waste discharges to the LaPlatte River in Hinesburg and McCabe's Brook in Shelburne. Nothing can be concluded about the significance of nitrogen as a potential limiting nutrient from nitrogen data alone in the absence of assay data. The significance of nitrogen, however, can be considered in relation to phosphorus. This is discussed in the section on limiting nutrients below.

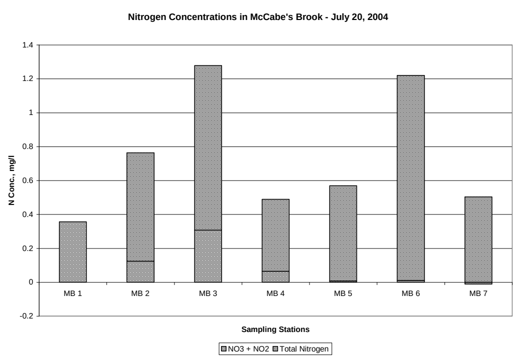
4.6 Phosphorus

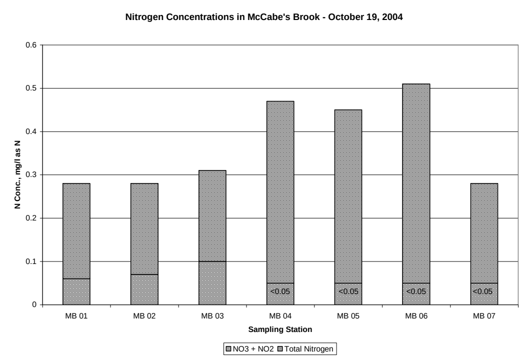
Phosphorus is an important plant nutrient which can reach surface waters from sewage outfalls or with storm runoff from urban areas including lawns and from agricultural lands where they may originate with fertilizers or manure spread on the soil, or with grazing animals. Phosphorus is important as it is a nutrient essential to nuisance plants and algae, and thus contributes to increased production in aquatic habitats. In some situations, production may be limited by the availability of phosphorus, and phosphorus is then considered the limiting nutrient. In such circumstances, any increase in the phosphorus loading may result in an increase in productivity.

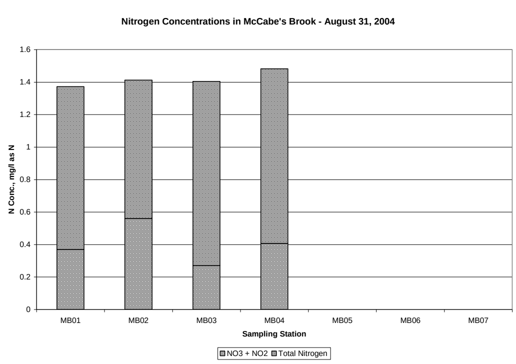
Fig. 20. Nitrogen Concentrations in McCabe's Brook, 2004











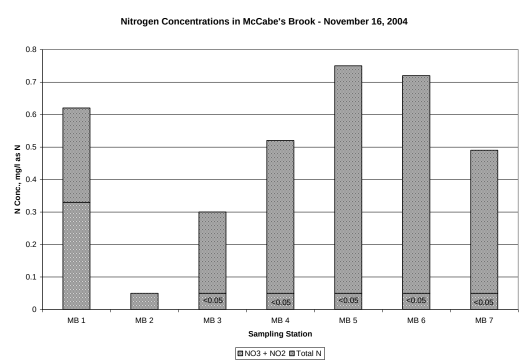
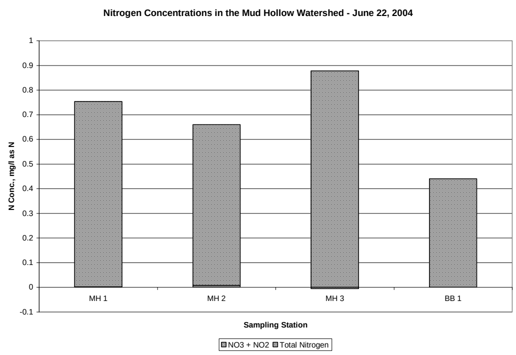
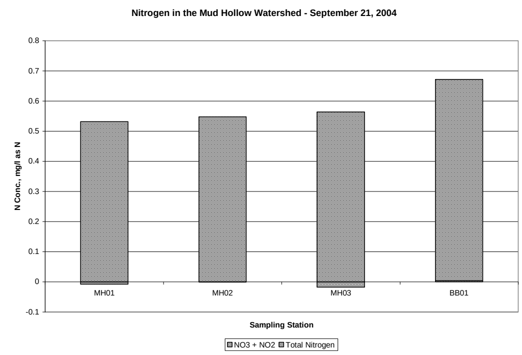
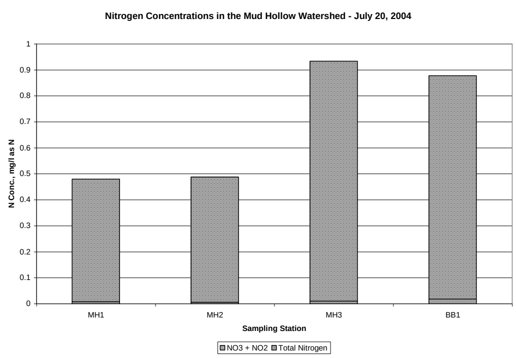
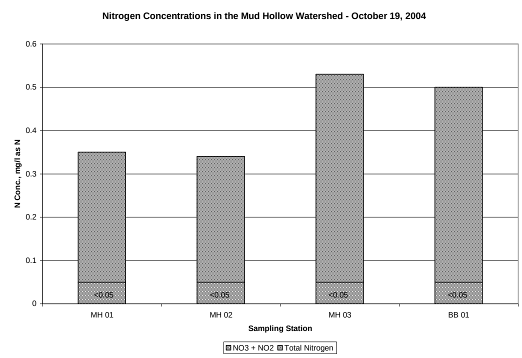


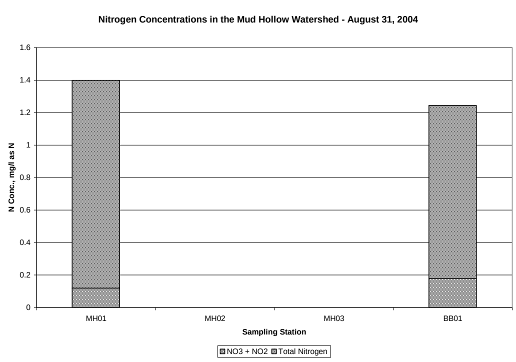
Fig. 21. Nitrogen Concentrations in the Mud Hollow Watershed, 2004











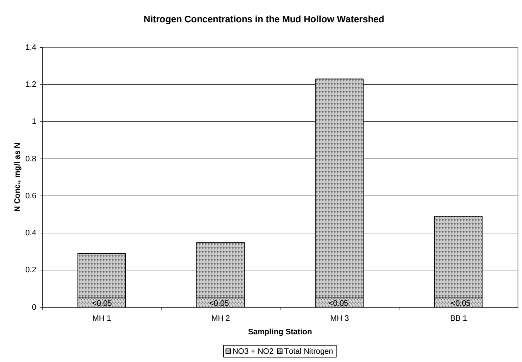
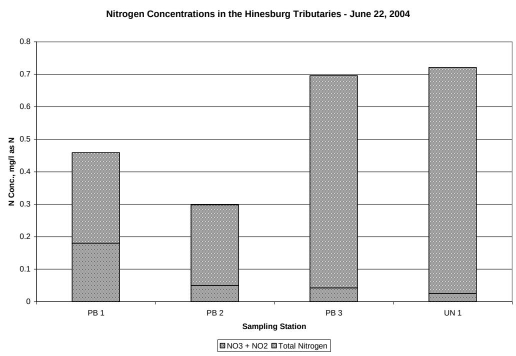
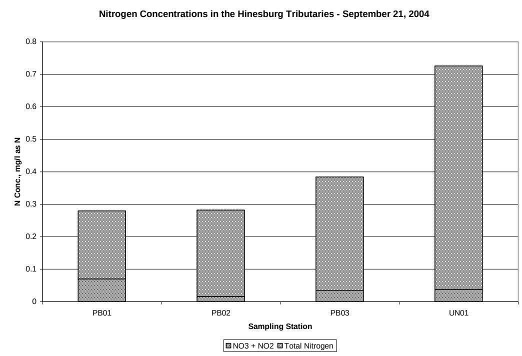
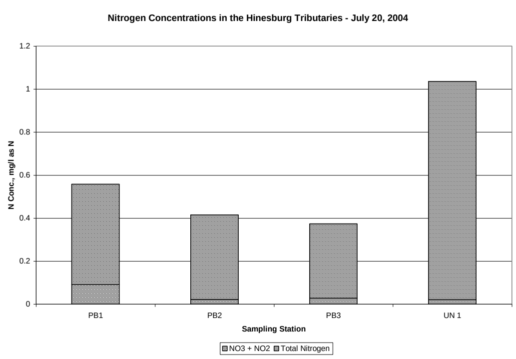
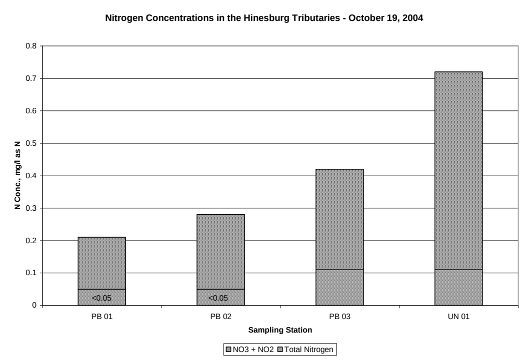


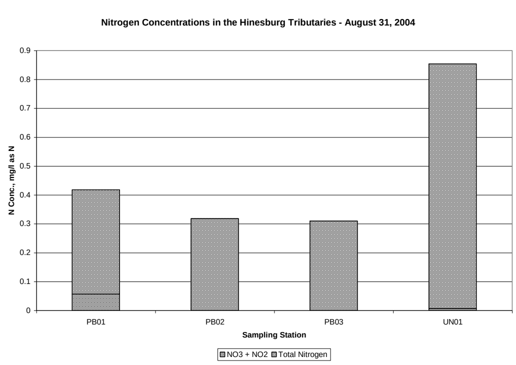
Fig. 22. Nitrogen Concentrations in the Hinesburg Tributaries, 2004

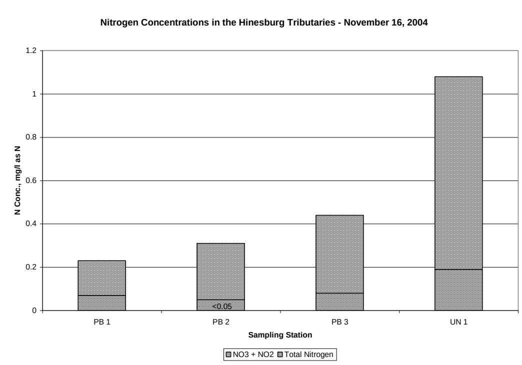












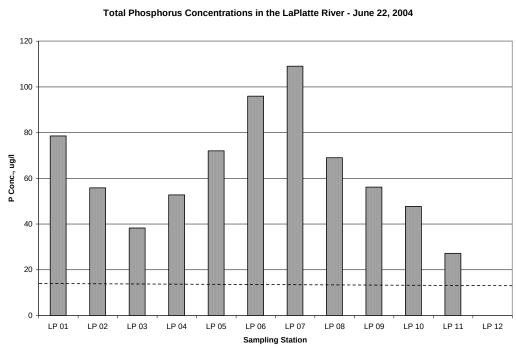
Under aerobic conditions, phosphates form insoluble products with iron or calcium and become associated with soil particles. As a result, there is a relationship between total phosphorus concentrations and concentrations of total suspended solids (TSS) in surface waters.

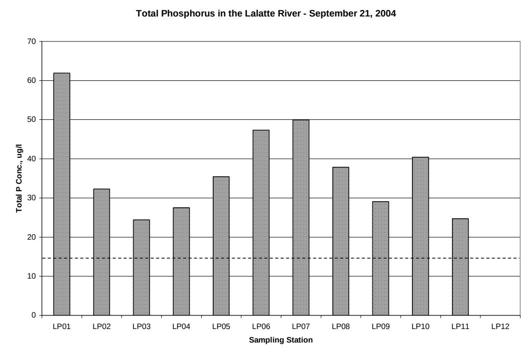
It is generally accepted that phosphorus is the primary nutrient limiting productivity in Lake Champlain and has long been a concern. In a 1976 study by the State of Vermont (K. Little, Nutrient Loadings to Shelburne Bay and St. Albans Bay, Lake Champlain, Vermont, 1975-1976, Vermont Department of Water Resources, 1976), it was estimated that the LaPlatte River itself contributed 24.4% of the total phosphorus loading to Shelburne Bay of 4,053 kg/yr, or 11.1 kg/d. A decade later, Smeltzer (E. Smeltzer, A Summertime Phosphorus Model for Shelburne Bay, Vermont Department of Environmental Conservation, 1988) reported mean phosphorus loadings of 16.98 kg/d during the summer months, and concluded that the LaPlatte River was the most significant source of phosphorus in Shelburne Bay, contributing 62% of the total loading to the bay. In a 1998 status report on the Long-Term Water Quality and Biological Monitoring Project for Lake Champlain (Vermont Department of Environmental Conservation and the New York State Department of Conservation, Long-Term Water Quality and Biological Monitoring Project for Lake Champlain: Cumulative Report for Project Years 1992-1996, 1998), results indicated that total phosphorus concentrations in the river were decreasing significantly. It was concluded that the stream was responding to upstream measures taken in 1992 designed to reduce phosphorus loadings, including upgrades to the Hinesburg sewage treatment plant. This plant, first constructed in 1967, has been up-graded twice, in 1988 and again in 1991. Up-grading of the treatment plant in 1991 was largely responsible for the reduction in the loading to from about 4,811 kg in 1991 to about 186 kg in 1995. This loading decreased to a low of 76 kg. in 1999, but increased to 163 kg. in 2000 following the resumption of full operation of the cheese plant in Hinesburg which discharges to the Hinesburg sewage treatment plant following primary treatment. The cheese plant utilizes about one half of the plant's 20,000 gpd allocation. The Hinesburg sewage treatment plant is currently permitted to discharge up to 0.95 kg/d of phosphorus.

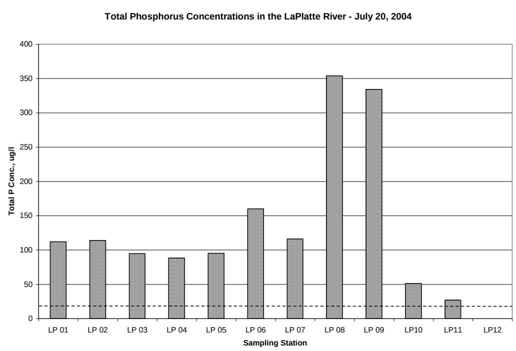
Smeltzer (*op. cit.*), estimated the mean phosphorus loadings of 0.27 kg/d during the summer months from McCabe's Brook, and concluded that McCabe's Brook was not a significant source of phosphorus to Shelburne Bay. Shelburne's Waste Treatment Plant No. 2 is currently permitted to discharge up to 1.35 kg/d of phosphorus.

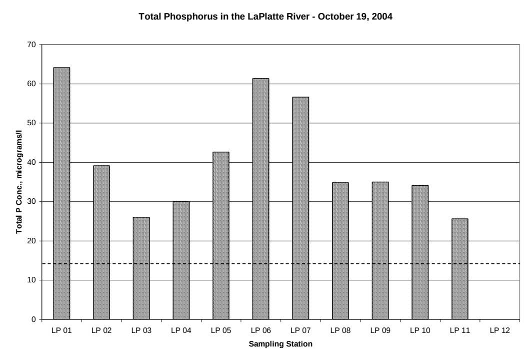
LaPlatte River. Total phosphorus concentrations determined during 2004 in the LaPlatte watershed are presented in Figures 23 to 23a. In the LaPlatte River itself (Figures P-1 and P-2), phosphorus concentrations increased from the upstream station LP 11 to LP 09 located above the discharge from the Hinesburg sewage treatment plant, then continued to increase below the discharge, and continued to increase between LP 08 and Leavenworth Road (LP 07) and Dorset Street (LP 06).

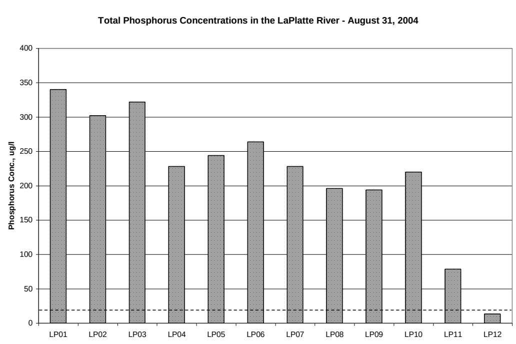
Fig. 23. Total Phosphorus Concentrations in the LaPlatte River, 2004











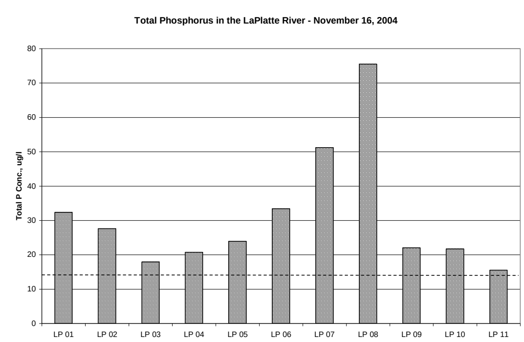
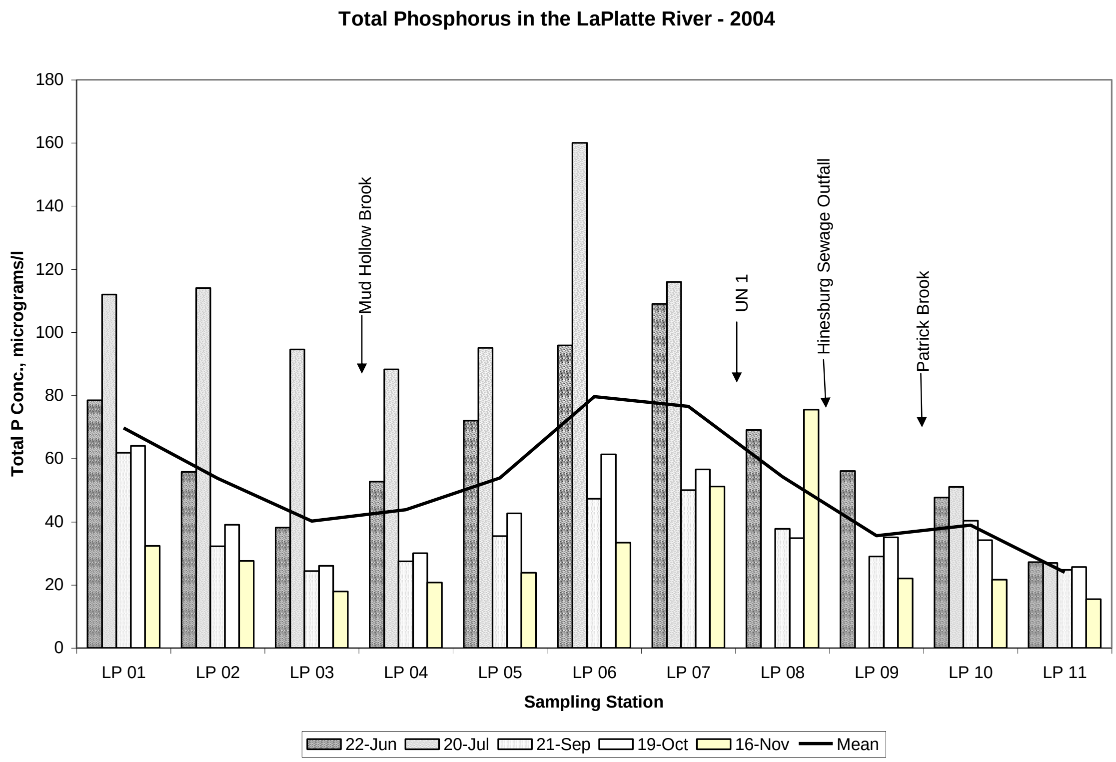


Figure 23a

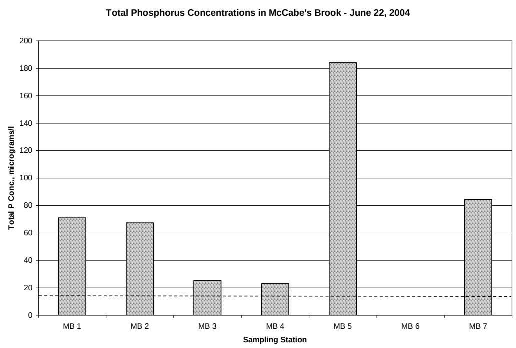


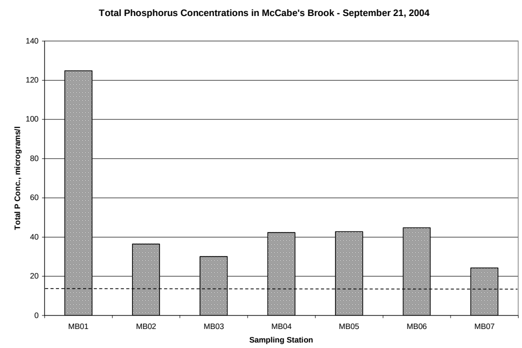
McCabe's Brook. Within McCabe's Brook (Figure 24), total phosphorus concentrations increased below the Shelburne sewage treatment plant outfall (Station MB 1) during discharge as would be anticipated. On July 20, a large jump in the total phosphorus concentration occurred at Station MB 3, apparently as a result of uncontrolled runoff from a construction site. Of further interest, were increases in the total phosphorus concentrations at Station MB 6 (located at the extension of Mutton Hill Road) on June 22, October 19, and November 16. The concentration continued to increase at Station MB 5 on October 19.

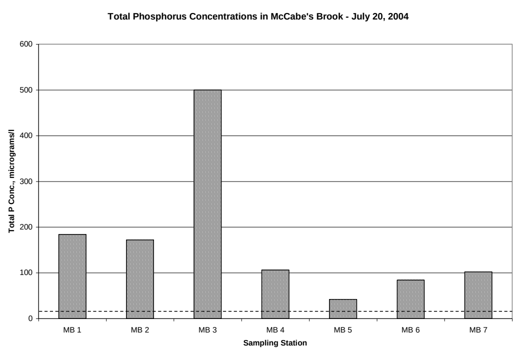
Mud Hollow Watershed. Within Mud Hollow Brook (Figure 25), concentrations were highest at the upstream station, and decreased downstream. Concentrations in the Un-named tributary tended to be high.

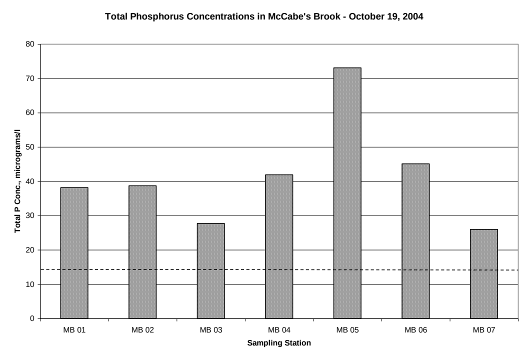
Hinesburg Tributaries. Within Patrick Brook (Figure 26), concentrations were highest at the upstream station PB 3 and decreased with flow downstream. The pattern during the summer months is not clear as data for the downstream station are not available for June

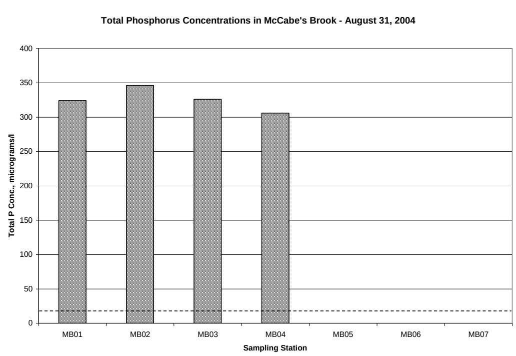
Fig. 24. Total Phosphorus Concentrations in McCabe's Brook, 2004











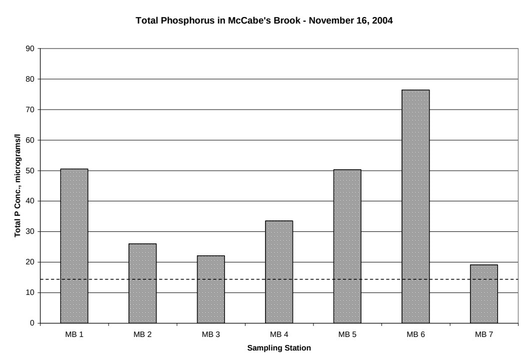
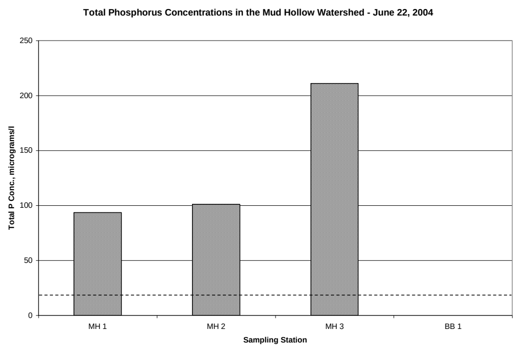
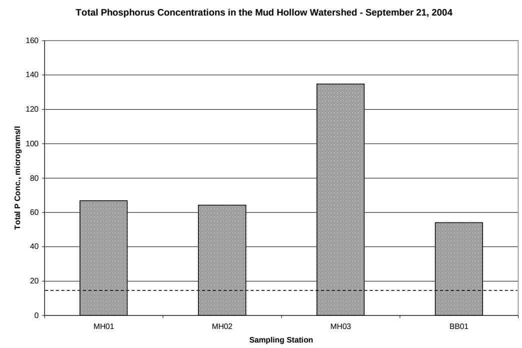
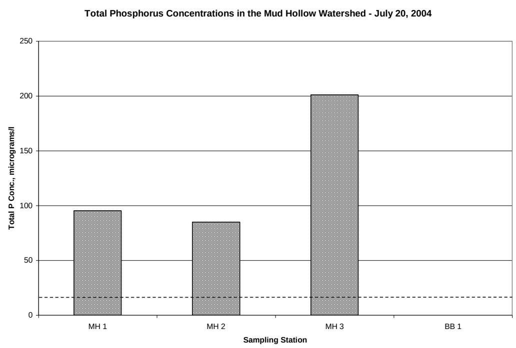
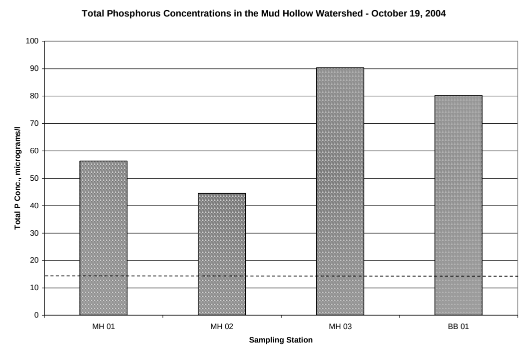


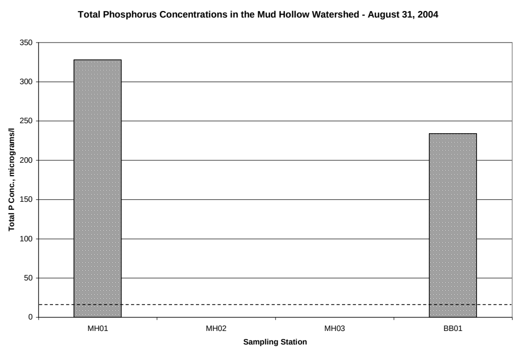
Fig. 25. Total Phosphorus Concentrations in the Mud Hollow Watershed, 2004











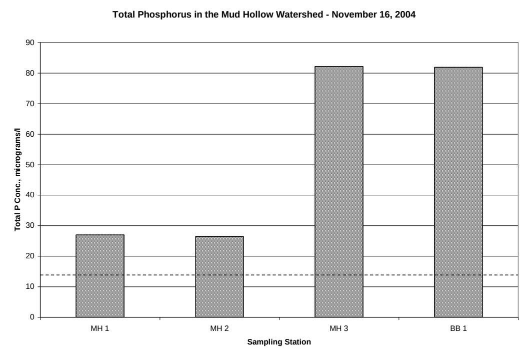
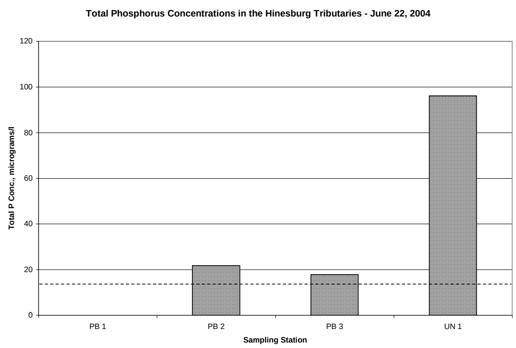
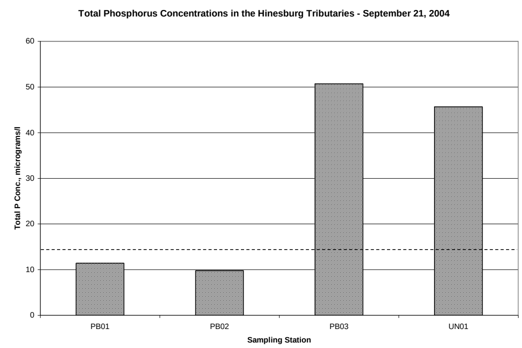
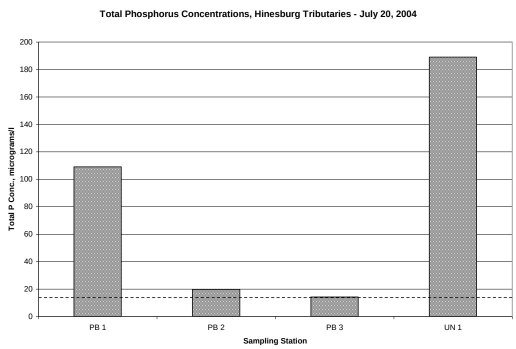
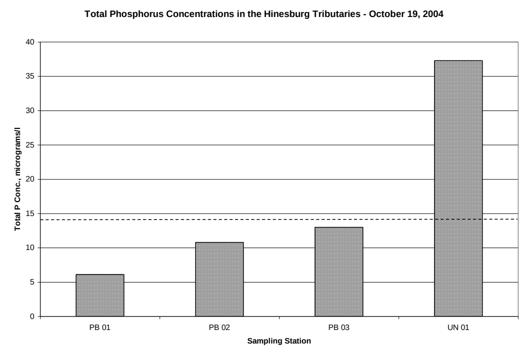


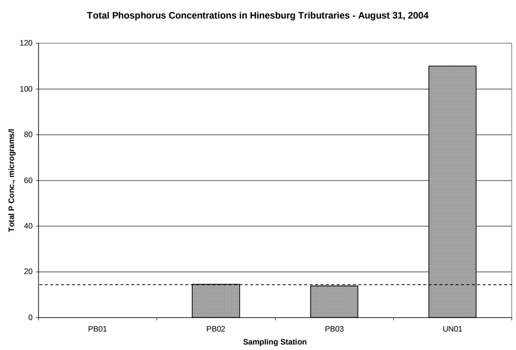
Fig. 26. Total Phosphorus Concentrations in the Hinesburg Tributaries, 2004

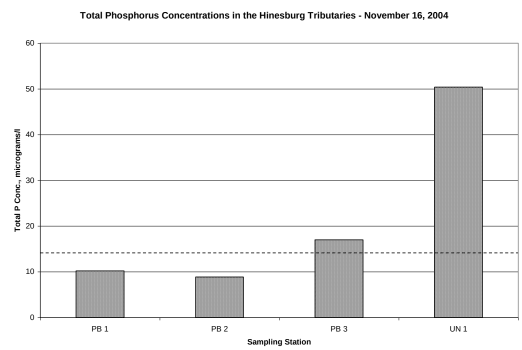












and August; in July the concentrations rose at the downstream station, probably as a result of runoff in the more populated area between PB 2 and PB 1.

Relationship between Phosphorus and Solids. Orthophosphate reacts with sites on the surface of soil particles. As a result, phosphorus associated with soil particles, or applied to it as fertilizer or manure, is carried into surface waters with runoff following rain events. It stands to reason, therefore, that total phosphorus concentrations in streams should increase as TSS concentrations increase, and that the higher the flow rate in streams, and thus their capacity to mobilize sediments, cause erosion, and transport suspended solids, the higher will be the total phosphorus concentration in the stream water. This was indeed the case in the LaPlatte watershed during the summer and fall of 2004, as can be observed readily in Figures 27, 27a, 28, and 28a.

However, it would not necessarily be expected that total phosphorus concentrations would be proportional to concentrations of TSS. At higher flow rates, streams would be expected to transport larger particles having a lower ratio of surface area, and therefore reactive sites, to mass. The effect would be a decreasing ratio with increasing TSS concentrations. This was, in general, the case. However, there was great variation in the relation between total phosphorus concentrations and those of TSS and between total phosphorus concentrations and turbidity. The complexity of, and variation among, the relationships are evident in Figures 27, 27a, 28, and 28a.

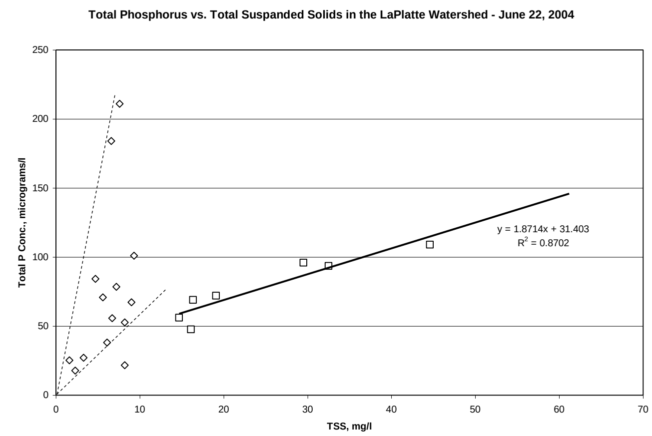
For instance, on June 22, at concentrations of total suspended solids below 15 mg/l, there was no correlation between total phosphorus and TSS, or a very poor correlation at best. At higher TSS concentrations, the relationship is stronger on an arithmetic scale (Fig. 27) than on a log-log scale (Fig. 27a).

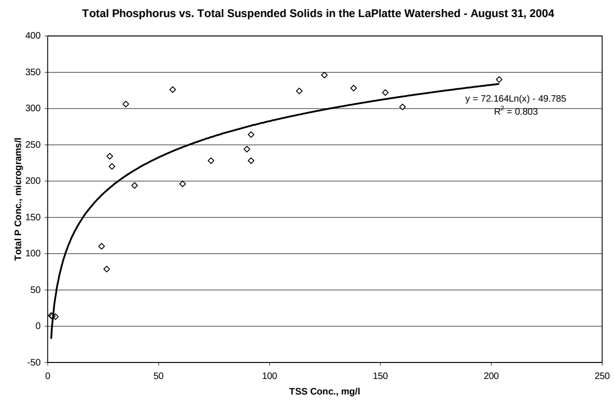
In contrast, a correlation appeared between total phosphorus and turbidity in the low turbidity (<8) range on June 22. This was described best on a log-log scale. At higher turbidities, the relationship was poorer, and could be described slightly better on an arithmetic scale than on a log-log scale. The relationship between total phosphorus and TSS was quite different from that between total phosphorus and turbidity in the high ranges, however.

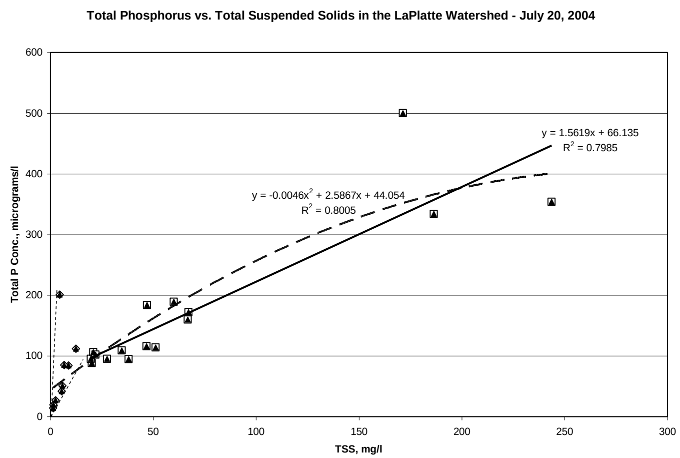
The relationships between total phosphorus and TSS and turbidity emerging on July 20, August 31, and November 16 were very different from those observed on June 22. The correlation between total phosphorus and TSS concentrations and between total phosphorus and turbidity determined on July 20 were best described by polynomial equations (Figs. 28 and 28a), but could be described also by linear relationships on a log-log scale, and, in the case of TSS, by a straight line on an arithmetic scale above 15 mg/l TSS. Furthermore, again on August 31, the relationships between total phosphorus and TSS and turbidity were linear on a log-log scale, although the correlation of the total phosphorus to ln(turbidity) was slightly higher.

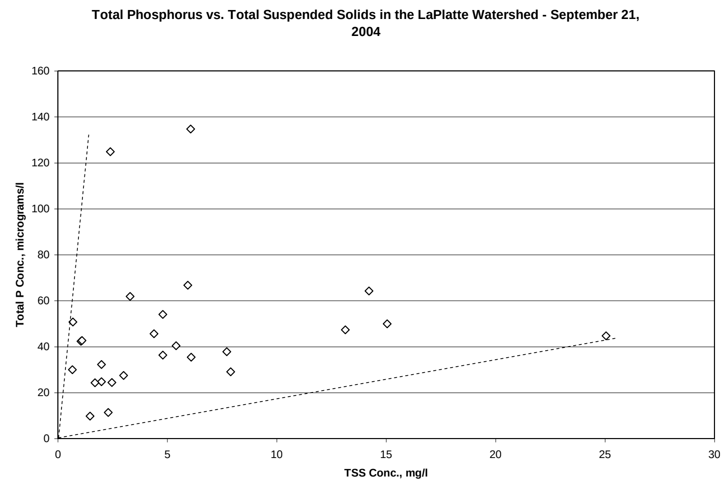
The correlations between total phosphorus and both TSS and turbidity were fair on November 16 when plotted on a log-log scale. The relation between the log(TP) and

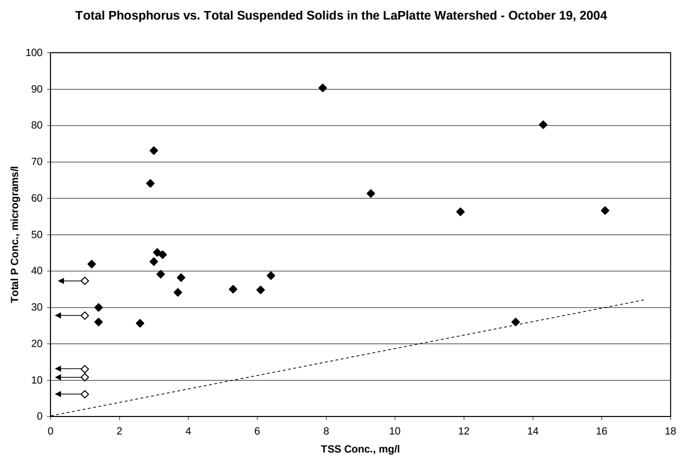
Fig. 27. Relationships between Total Phosphorus and Total Suspended Solids, LaPlatte Watershed, 2004










Total Phosphorus vs. Total Suspended Solids in the LaPlatte Watershed - October 19, 2004
Total P Conc., micrograms/l
TSS Conc., mg/l
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18

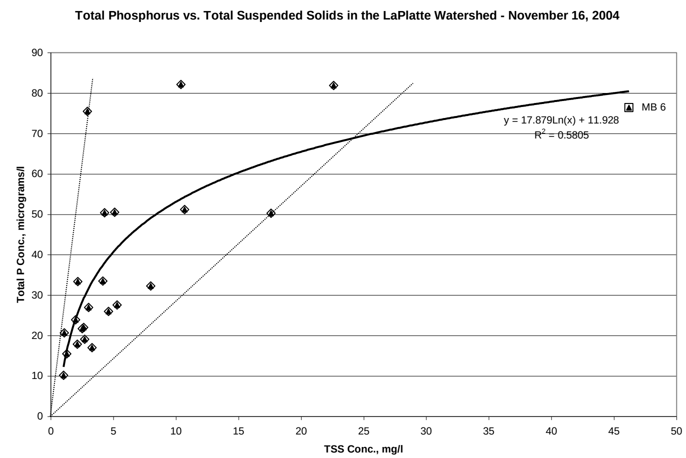
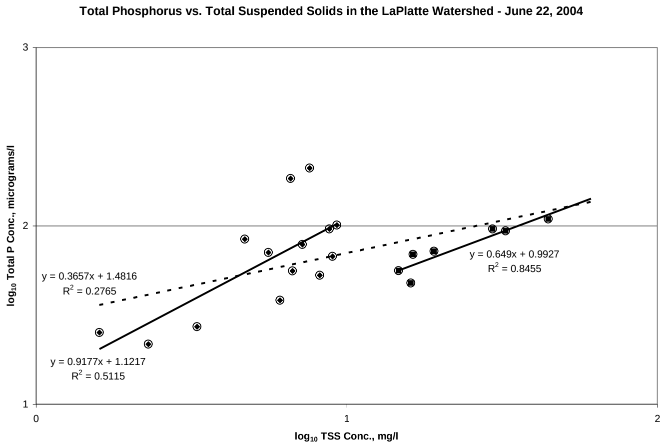
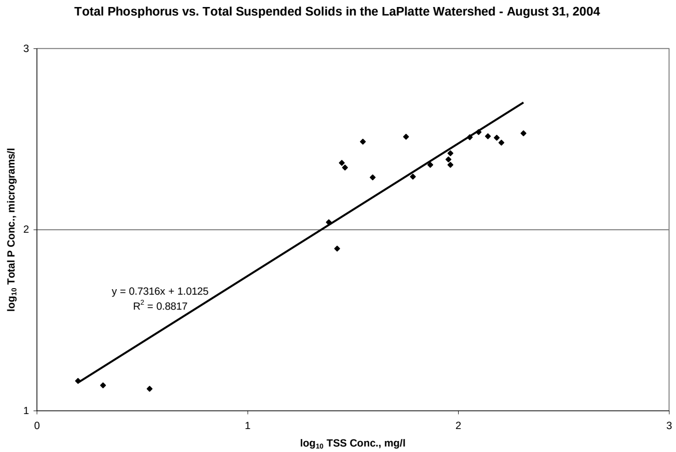
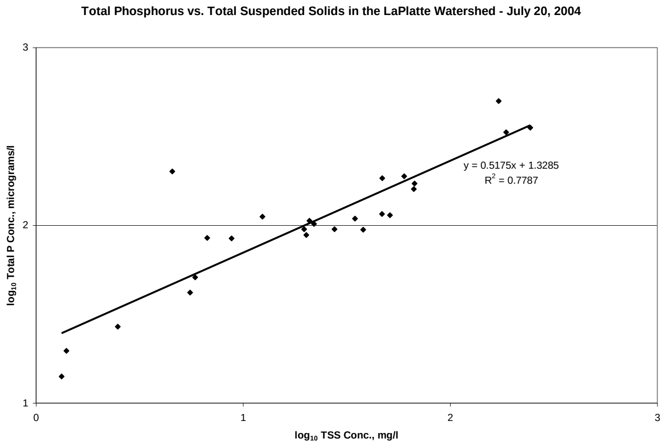
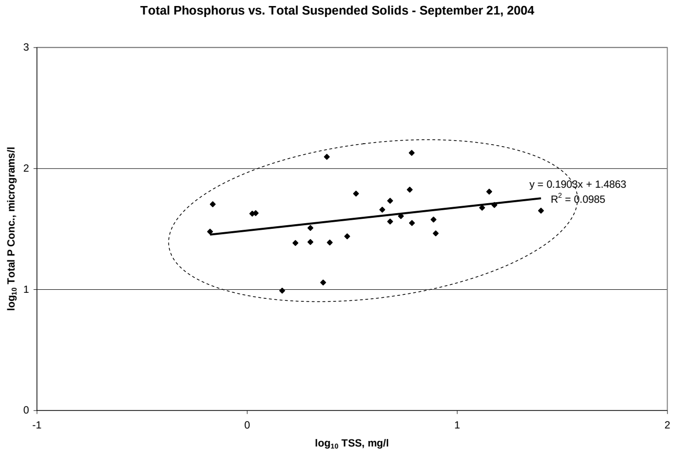

Total Phosphorus vs. Total Suspended Solids in the LaPlatte Watershed - November 16, 2004
MB 6
y = 17.879Ln(x) + 11.928
R2 = 0.5805
Total P Conc., micrograms/l
TSS Conc., mg/l
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
35
40
45
50

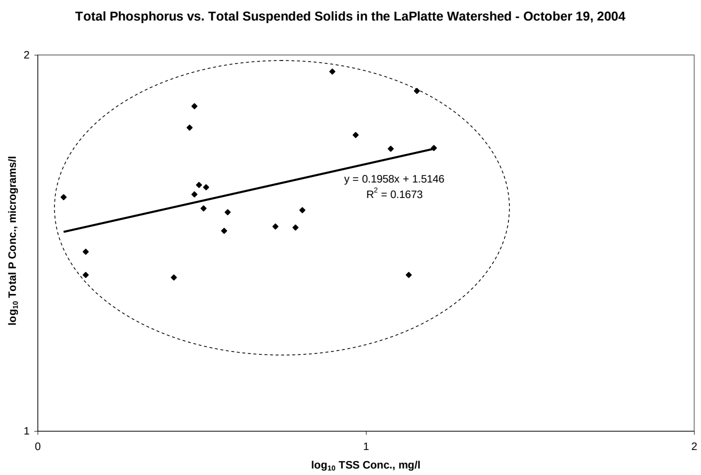
Fig. 27a. Relationships between Total Phosphorus and Total Suspended Solids, LaPlatte Watershed, 2004










Total Phosphorus vs. Total Suspended Solids in the LaPlatte Watershed - October 19, 2004
y = 0.1958x + 1.5146
R2 = 0.1673
log10 Total P Conc., micrograms/l
log10 TSS Conc., mg/l
2
1
0
1
2

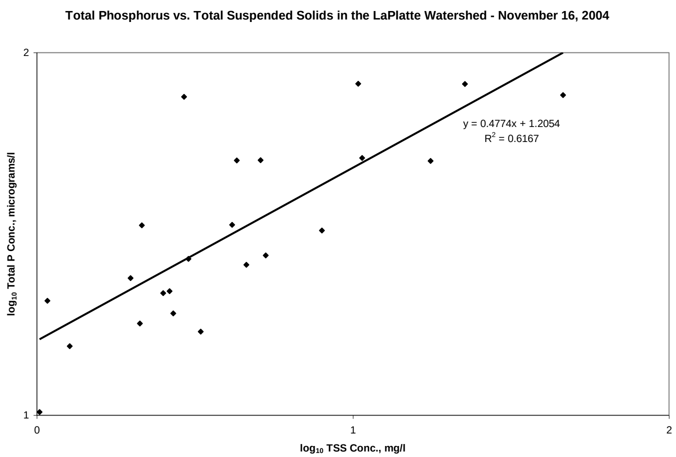
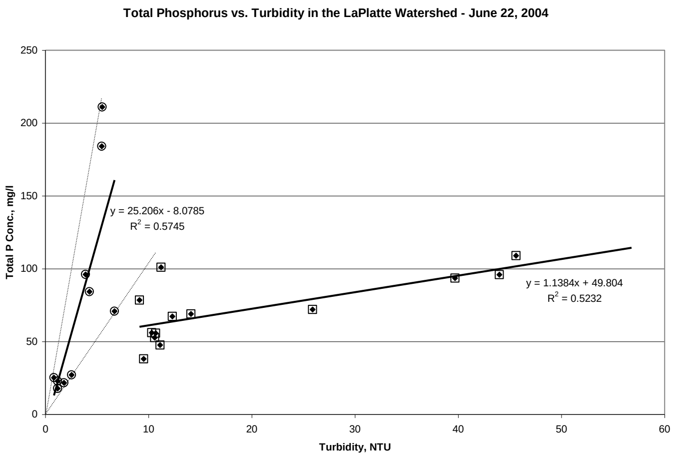
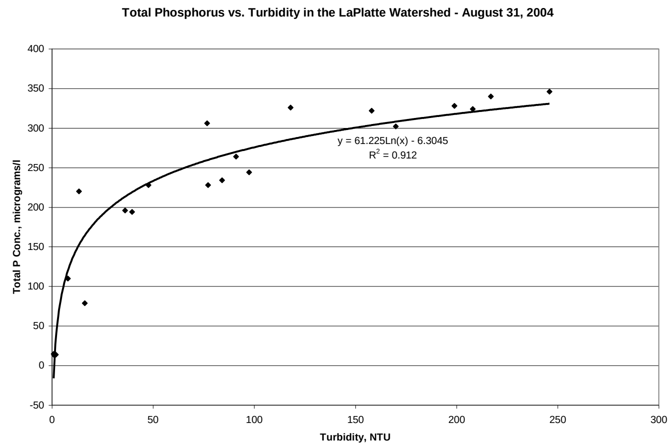
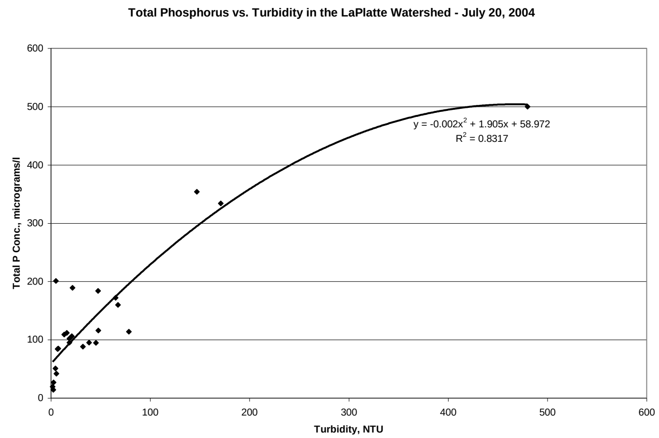
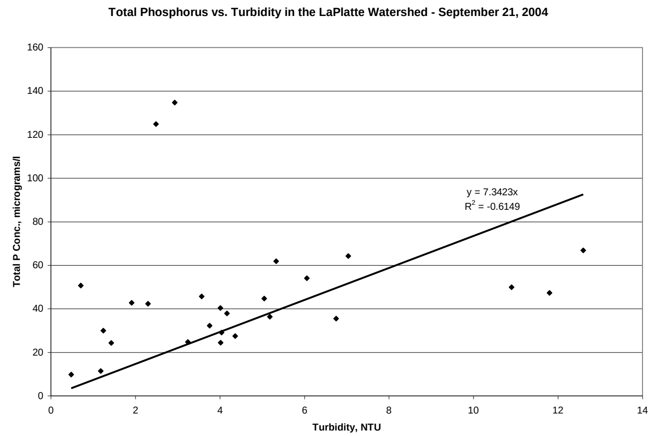

Total Phosphorus vs. Total Suspended Solids in the LaPlatte Watershed - November 16, 2004
y = 0.4774x + 1.2054
R2 = 0.6167
log10 Total P Conc., micrograms/l
log10 TSS Conc., mg/l
2
1
0
1
2

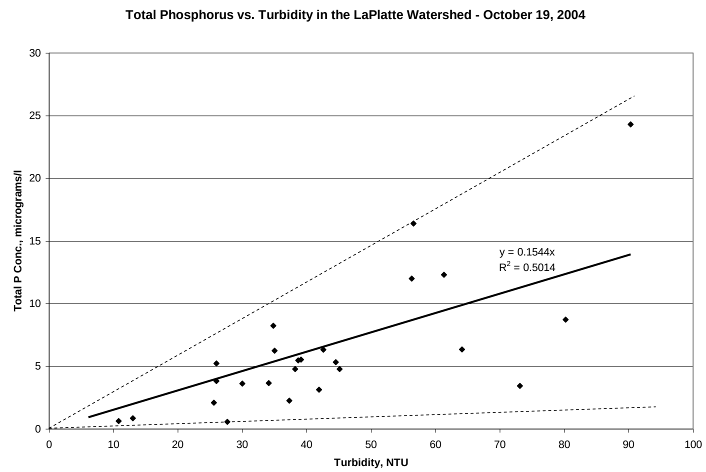
Fig. 28. Relationships between Total Phosphorus and Turbidity, LaPlatte Watershed, 2004










Total Phosphorus vs. Turbidity in the LaPlatte Watershed - October 19, 2004
y = 0.1544x
R2 = 0.5014
Total P Conc., micrograms/l
Turbidity, NTU

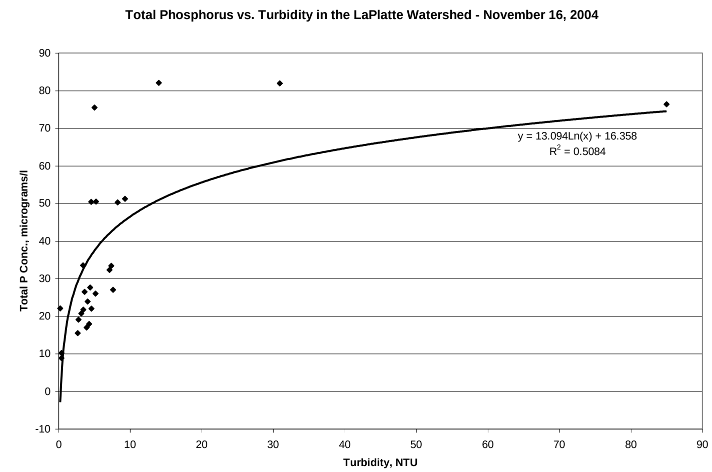
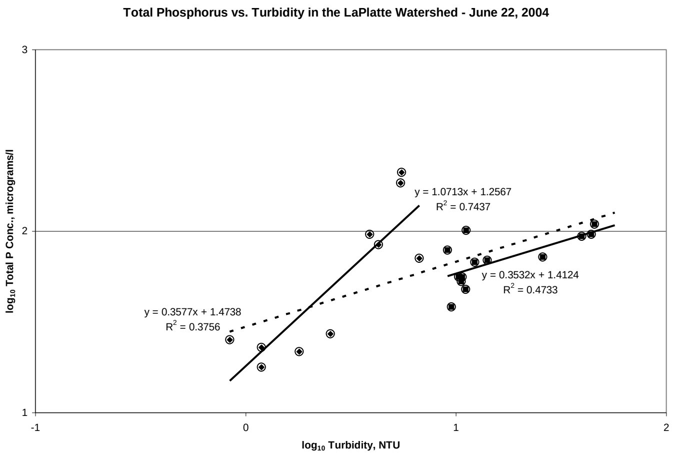
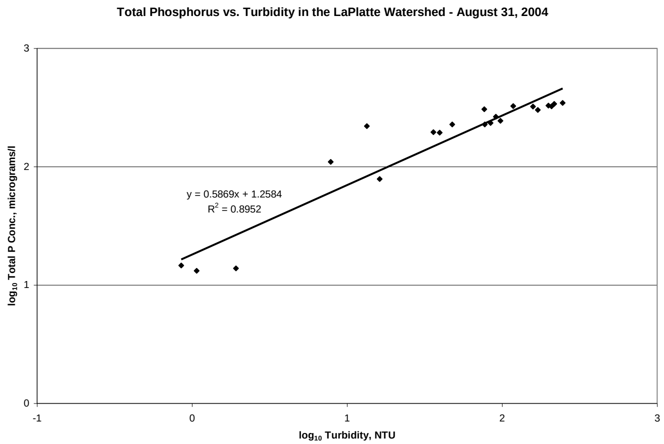
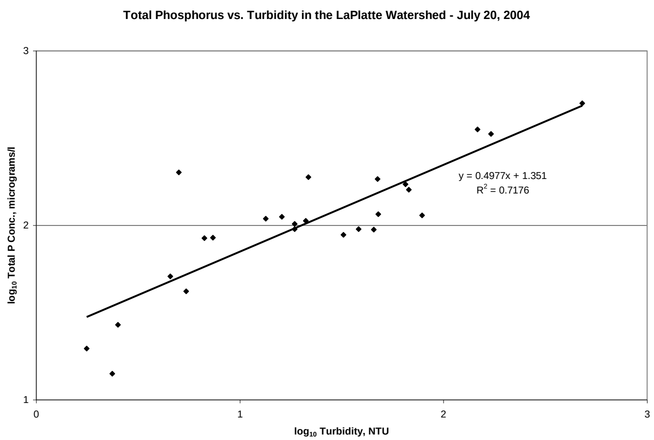
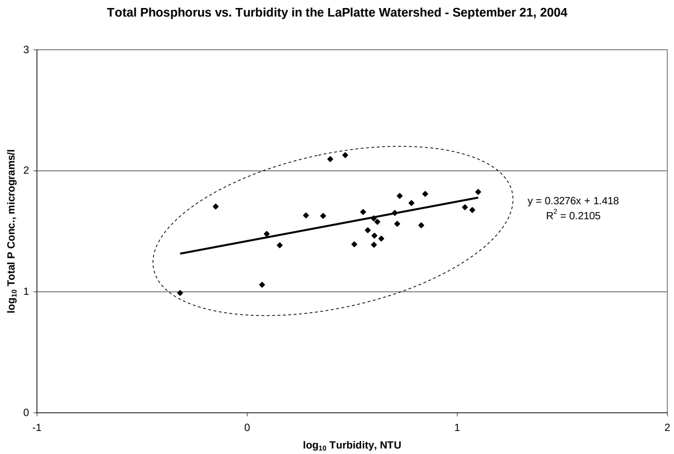

Total Phosphorus vs. Turbidity in the LaPlatte Watershed - November 16, 2004
y = 13.094Ln(x) + 16.358
R2 = 0.5084
Total P Conc., micrograms/l
Turbidity, NTU

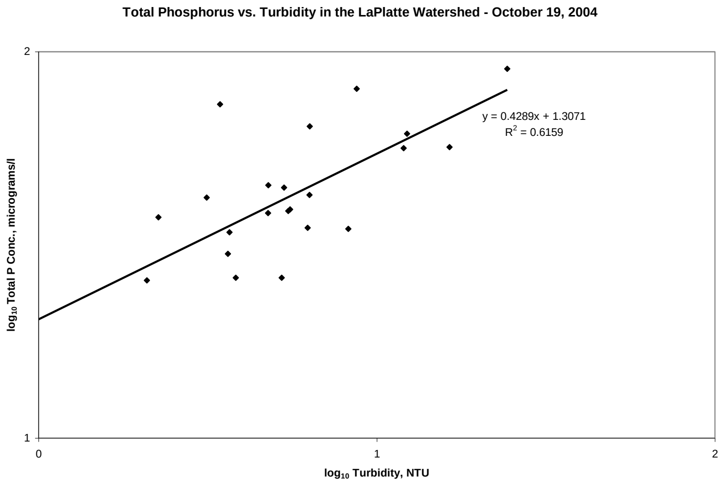
Fig. 28a. Relationships between Total Phosphorus and Turbidity, LaPlatte Watershed, 2004

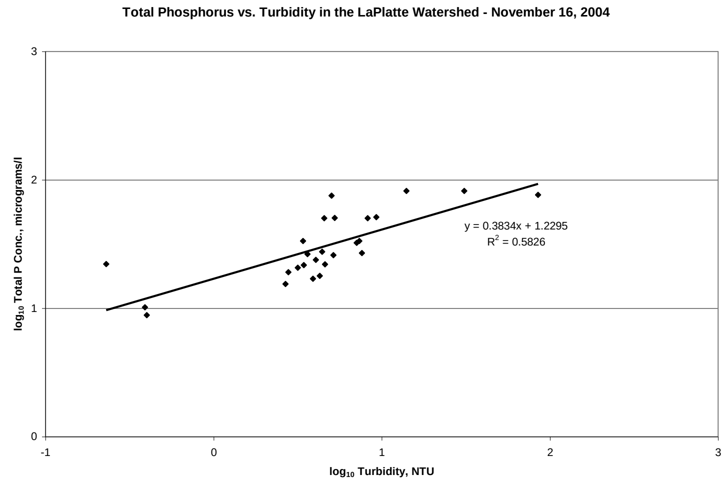









Total Phosphorus vs. Turbidity in the LaPlatte Watershed - October 19, 2004
y = 0.4289x + 1.3071
R2 = 0.6159
log10 Total P Conc., micrograms/l
log10 Turbidity, NTU
0
1
2
1
2


Total Phosphorus vs. Turbidity in the LaPlatte Watershed - November 16, 2004
y = 0.3834x + 1.2295
R2 = 0.5826
log10 Total P Conc., micrograms/l
log10 Turbidity, NTU
-1
0
1
2
3
0
1
2
3

log(turbidity) on October 19 was similar, although there was no correlation between the log(TP) and log(TSS).

The relationships between total phosphorus concentrations and TSS, or its surrogate, turbidity, was highly variable, however, reflecting highly variable flows, local rainfall and runoff conditions, times of flow, and consequently sources and characteristics of solids. Thus, in general, the relationship is not constant from one day to another.

From all of the above, one can conclude that:

1. Total phosphorus concentrations increase in relation to solids concentrations and turbidity.
2. Solids, whether determined directly, or as turbidity, appear to constitute the primary vehicle for transport of phosphorus within the LaPlatte watershed
3. Fine suspended solids particles predominating at low flows carry a greater load of phosphorus relative to the concentrations of solids than do larger particles held in suspension at high flows.
4. The relationship between total phosphorus concentrations and suspended solids concentrations or turbidity is variable, but tends towards linearity on a log-log scale, but can be directly proportional, semi-logarithmic, or non-existent.
5. The relationship between total phosphorus and turbidity appears to be more consistent than that between total phosphorus and TSS. This may have been in part a result of the method employed to determine turbidity which resulted in a reduction in the number of larger more rapidly settling particles.
6. Short of extensive modeling of phosphorus transport within the watershed taking into consideration the distribution of rainfall, runoff, time of flow, land use, erosion sites, fertilizer and manure applications, two additional analyses could provide further insight into the transport of phosphorus in the LaPlatte watershed and help define related issues:

    a. A clearer picture of the role of solids in the transport of phosphorus within the watershed would emerge with the addition of analyses for orthophosphate
    b. Greater insight into the relative roles of large and fine particles in relation to phosphorus transport could be obtained from the addition of analyses of the distribution of particle sizes.

Historical Context. Although individual published historical data are not available, summary data provide a basis for comparison. For instance, the mean of 97 total phosphorus determinations made under the Lake Champlain Diagnostic Feasibility Study (Vermont Department of Environmental Conservation and New York State Department of Environmental Conservation, *A Phosphorus Budget, Model, and Load Reduction Strategy for Lake Champlain: Lake Champlain Diagnostic-Feasibility*

Study Final Report, January, 1997) taken at Falls Road between March, 1990 and February, 1992 (prior to up-grading of the Hinesburg Sewage Treatment Plant) was 253 µg/l (Coefficient of variation = .064). Total phosphorus data collected under the Lake Champlain Long-term Monitoring Program through 2004 include 270 analyses. The mean total phosphorus concentration reported was 187 µg/l (median = 140 µg/l). Minimum and maximum concentrations reported under this program were 16 µg// and 1,110 µg/l, respectively. Results of analyses under the 2002 LaPlatte Watershed Volunteer Monitoring Program were generally consistent with those determined under the Long-term Monitoring Program. During low flows, concentrations varied from about 18 µg/l to about 25 µg/l, consistent with the low concentrations reported under the Long-tem Monitoring Program. During moderate flows in June, July, and September, concentrations varied between 24 µg/l and 90 µg/l, and at a very high flow on August 31, reached about 330 µg/l, in excess of the mean concentration reported under the Long-term Monitoring Program, but less than ⅓ the maximum reported.

On the other hand, a review of long-term monitoring data collected between 1992 and 1996 (Vermont Department of Environmental Conservation and New York State Department of Environmental Conservation, *Long-Term Water Quality and Biological Monitoring Project for Lake Champlain*: *Cumulative Report for Project Years 1992-1996*, March, 1998) examined total phosphorus concentrations in relation to flow (See Figure 29) before and after up-grading of the Hinesburg treatment plant. In spite of considerable scatter, several conclusions are evident. Firstly, total phosphorus concentrations were in general lower after up-grading of the plant. And secondly, prior to up-grading, concentrations tended to decrease with increasing flow as a result of dilution of phosphorus originating from the waste discharge which was the major source of phosphorus entering the river. In contrast, following up-grading, concentrations tended to increase with increasing flow as a result of increasing solids concentrations, now the predominant source of phosphorus.

The relationship between concentrations of total phosphorus determined in 2004 and flow (Figure 29a) define the upper boundary of an envelope encompassing the main body of post-1992 long-term monitoring data points. The steeper regression line suggests an increasing importance of erosion and runoff as sources of phosphorus which should be followed in future monitoring efforts. The relationship of total suspended solids to flow is shown in Figure 29b).

Phosphorus Export. It is useful to consider results of water quality sampling in the context of phosphorus export loadings from the LaPlatte Watershed predicted using the SPARROW (Spatially Referenced Regressions on Watershed Attributes) model developed by the USGS in cooperation with the USEPA and the NEIWPCC. This is a statistical model that uses regression equations to predict total nitrogen and total phosphorus loads from sub-watersheds, or catchments, based on spatially referenced watershed characteristics, including physical characteristics (drainage area, stream flow, time of travel, mean slope, soil permeability, stream density), nutrient sources (waste outfalls, cultivated land, forested land, urban and suburban areas), and nutrient sinks (water bodies and wetlands). Nutrient sources are evaluated as a function of location,

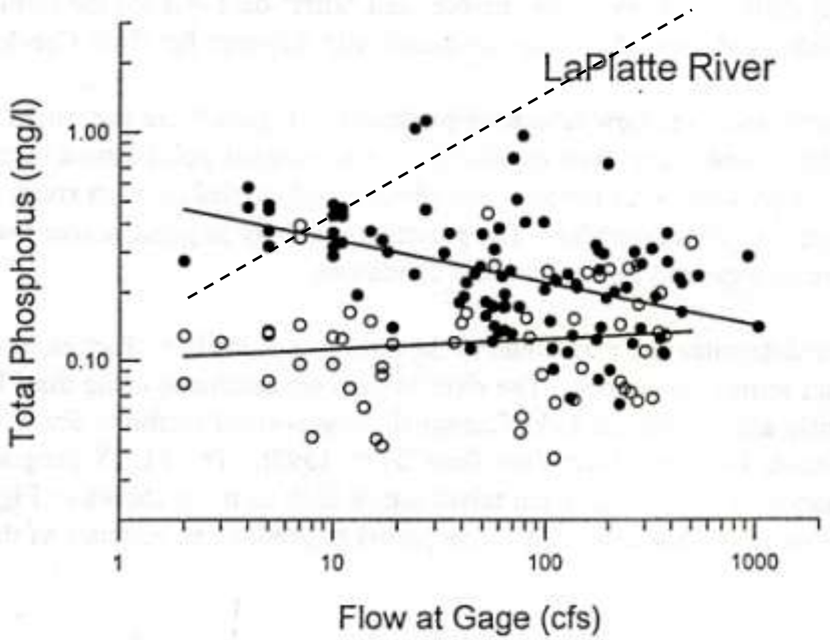


Figure 29. Total Phosphorus Concentration vs. Average Daily Flow in the LaPlatte River at Falls Road. before Hinesburg Treatment Plant improvements (1990-1992, solid circles), and after improvements (1992 – 1996, open circles). *Long-Term Water Quality and Biological Monitoring Project for Lake Champlain. Cumulative Report for Project Years 1992-1996.* Dashed line represents approximate line of best fit for 2004 Volunteer Monitoring data (See Figure 29a).

Figure 29a

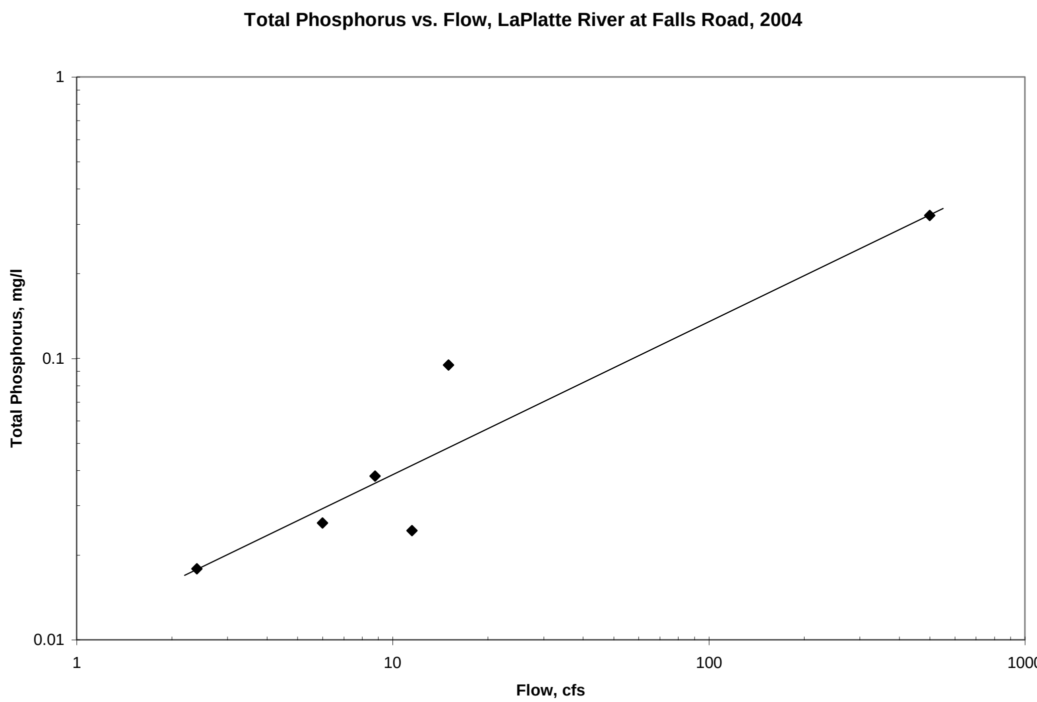
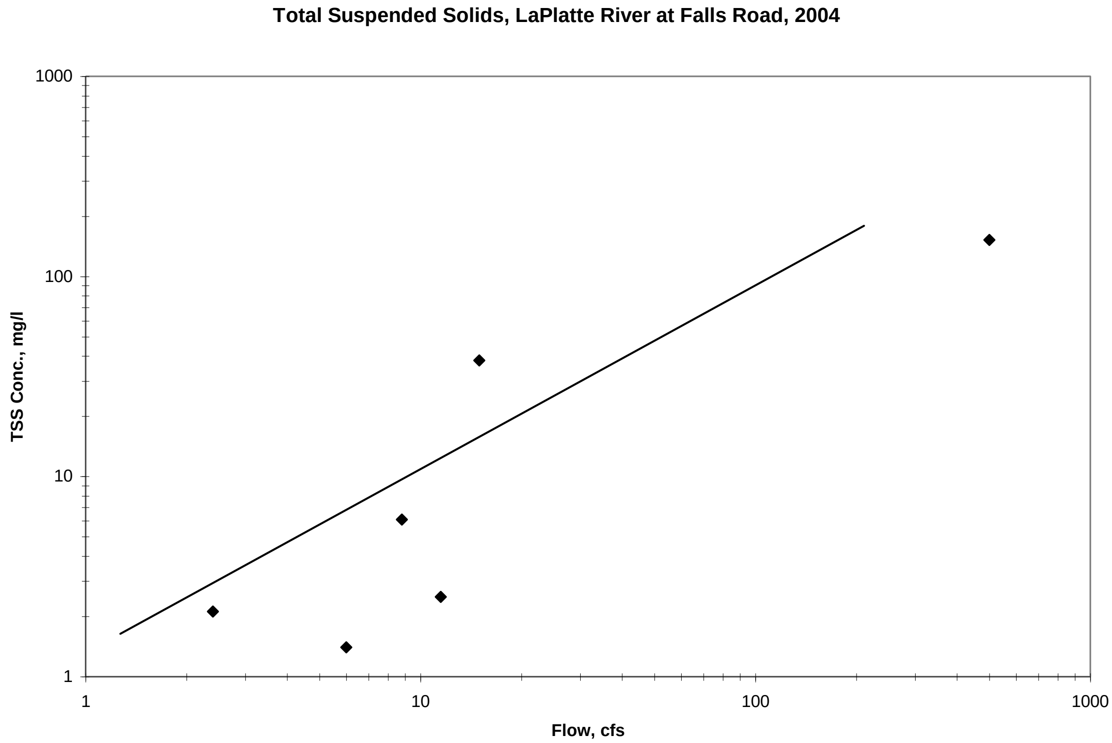


Figure 29b



magnitude, and interaction with watershed characteristics and in-stream processes in water bodies.

The sub-watersheds used in the SPARROW analysis of the LaPlatte watershed are shown in Figures 30a,b, and the results, organized by similar adjacent catchment blocks, are shown in Tables 7 and 8a,b,c (model output results provided by Neil Kamman, Vermont Department of Environmental Conservation). Watershed attributes are provided in Table 7, and export loadings based on three waste discharge scenarios are provided in Tables 8a,b,c and Figures 30a,b.

The input data date from the early 1990s, and in the case of point source treated sewage discharges, consist of data dating from 1992 or earlier. Following up-grading of the Hinesburg treatment plant in 1991, estimated total point source loading to Shelburne Bay was reduced by over 80%. Further reductions were achieved at the Shelburne plant in 2001. Whereas changes in land use may have minor impacts on the results of the SPARROW analysis, the reduced loadings from the sewage treatment plants result in a significant change in loadings within the middle LaPlatte and McCabe's Brook catchments (13562 and 13561, respectively). Table 8a has been adjusted to show point source phosphorus loadings based on permitted discharges (Table 8b), and rough estimates of current discharges (Table 8c). The impact of the adjusted point source loadings on phosphorus export by catchment is illustrated in Figure 30b. The results of the analysis can be interpreted as follows:

Main Stem Patrick Brook (13581, 13583)

P Export Level:- low (<42 kg/km^2)

In spite of moderately steep slopes (9-11%), high permeability (1.7-1.9 in/hr), mostly low stream density, low cultivated area (25-27%), very high forest cover (~60%), and very high water cover (4.57-9.7%) all contribute to reduced sources of P, reduced delivery to the stream system, and effective removal within the catchment area, explaining the low export.

Table 7. Selected Attributes of Catchments

Value	P Export Kg/Km2	Mean Slope Percent	Mean Perm. in/hr	Stream Density	Total Area Sq. Mi.	Barren Percent	Cultivated Percent	Forest Percent	Wetlands Percent	Water Percent	Urban Percent	Suburban Percent
13581	<42	10.887	1.9193	0.000477	1.354143	0.15	25.74	60.84	2.49	4.57	2.18	4.00
13583	<42	9.327	1.704	0.000199	3.913359	0.37	26.74	60.74	1.74	9.71	0.20	0.48
13582	42-<61	15.1972	1.8015	0.000386	0.417328	1.50	45.05	50.21	2.00	0.00	0.08	1.17
13563	42-<61	11.9569	3.0255	0.000198	9.505063	0.59	37.86	58.69	1.26	0.00	0.89	0.65
13580	42-<61	11.8924	1.8507	0.000666	1.754097	0.73	36.13	54.66	1.25	0.00	3.55	2.97
13562	132-192	7.2671	0.7052	0.000255	17.895747	0.47	54.67	37.42	4.82	0.53	0.94	0.99
13572	61-<99	3.8729	0.5997	0.000535	2.894537	0.12	80.76	13.53	5.02	0.04	0.26	0.28
13579	61-<99	5.1059	0.5846	0.000568	2.147795	0.29	69.83	21.49	7.72	0.00	0.42	0.26
13571	42-<61	5.7092	0.5758	0.000794	2.192968	0.19	39.60	41.94	16.59	0.30	0.63	0.74
13561	99-<132	5.9507	0.5639	0.000357	10.863376	0.17	48.88	32.09	11.49	0.08	2.31	3.46

Table 8a. Phosphorus Export from the LaPlatte Watershed based on SPARROW Model Results

	Area	Treated Waste Discharges			Cultivated Land			Forested Land			Urban Areas			Total P Loadings	
Value	Km2	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP
13581	3.51	0.00	0	0.0	31.02	109	73.6	8.55	30	20.3	2.59	9	6.1	42.13	147.75
13583	10.14	0.00	0	0.0	32.24	327	78.6	8.54	87	20.8	0.29	3	0.7	41.03	415.88
13582	1.08	0.00	0	0.0	54.30	59	87.8	7.05	8	11.4	0.52	1	0.8	61.84	66.85
13563	24.66	0.00	0	0.0	45.56	1123	83.7	8.24	203	15.1	0.67	16	1.2	54.43	1,342.06
13580	4.54	0.00	0	0.0	43.55	198	80.3	7.68	35	14.2	3.01	14	5.6	54.21	246.30
13562	46.38	120.75	5601	62.7	65.85	3054	34.2	5.25	244	2.7	0.87	40	0.5	192.71	8,938.05
13572	7.51	0.00	0	0.0	97.17	730	97.9	1.90	14	1.9	0.22	2	0.2	99.29	745.60
13579	5.56	0.00	0	0.0	84.16	468	96.2	3.02	17	3.5	0.28	2	0.3	87.45	486.48
13571	5.68	0.00	0	0.0	47.73	271	88.1	5.89	33	10.9	0.57	3	1.1	54.17	307.71
13561	28.14	66.19	1862	49.9	58.91	1658	44.4	4.51	127	3.4	3.02	85	2.3	132.61	3,731.15
Total	137.19		7,462.89	45.4		7,996.40	48.7		797.19	4.9		174.51	1.1		16,427.82

Table 8b. Phosphorus Export from the LaPlatte Watershed Adjusted to Permitted Discharge Loadings

	Area	Treated Waste Discharges			Cultivated Land			Forested Land			Urban Areas			Total P Loadings	
Value	Km2	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP
13581	3.51	0.00	0	0.0	31.02	109	73.6	8.55	30	20.3	2.59	9	6.1	42.16	147.85
13583	10.14	0.00	0	0.0	32.24	327	78.5	8.54	87	20.8	0.29	3	0.7	41.06	416.16
13582	1.08	0.00	0	0.0	54.30	59	87.8	7.05	8	11.4	0.52	1	0.8	61.87	66.88
13563	24.66	0.00	0	0.0	45.56	1123	83.7	8.24	203	15.1	0.67	16	1.2	54.46	1,342.78
13580	4.54	0.00	0	0.0	43.55	198	80.3	7.68	35	14.2	3.01	14	5.6	54.24	246.44
13562	46.38	7.48	347	9.4	65.85	3054	82.9	5.25	244	6.6	0.87	40	1.1	79.45	3,685.22
13572	7.51	0.00	0	0.0	97.17	730	97.9	1.90	14	1.9	0.22	2	0.2	99.29	745.66
13579	5.56	0.00	0	0.0	84.16	468	96.2	3.02	17	3.5	0.28	2	0.3	87.46	486.55
13571	5.68	0.00	0	0.0	47.73	271	88.1	5.89	33	10.9	0.57	3	1.1	54.20	307.84
13561	28.14	17.64	496	21.0	58.91	1658	70.1	4.51	127	5.4	3.02	85	3.6	84.08	2,365.87
Total	137.19		843.15	8.6		7,996.40	81.5		797.19	8.1		174.51	1.8		9,811.24

Table 8c. Phosphorus Export from the LaPlatte Watershed Adjusted to Estimated Discharge Loadings

	Area	Treated Waste Discharges			Cultivated Land			Forested Land			Urban Areas			Total P Loadings	
Value	Km2	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP	%	kgP/ Km2	KgP
13581	3.51	0.00	0	0.0	31.02	109	73.6	8.55	30	20.3	2.59	9	6.1	42.16	147.85
13583	10.14	0.00	0	0.0	32.24	327	78.5	8.54	87	20.8	0.29	3	0.7	41.06	416.16
13582	1.08	0.00	0	0.0	54.30	59	87.8	7.05	8	11.4	0.52	1	0.8	61.87	66.88
13563	24.66	0.00	0	0.0	45.56	1123	83.7	8.24	203	15.1	0.67	16	1.2	54.46	1,342.78
13580	4.54	0.00	0	0.0	43.55	198	80.3	7.68	35	14.2	3.01	14	5.6	54.24	246.44
13562	46.38	1.12	52	1.5	65.85	3054	90.1	5.25	244	7.2	0.87	40	1.2	73.10	3,390.48
13572	7.51	0.00	0	0.0	97.17	730	97.9	1.90	14	1.9	0.22	2	0.2	99.29	745.66
13579	5.56	0.00	0	0.0	84.16	468	96.2	3.02	17	3.5	0.28	2	0.3	87.46	486.55
13571	5.68	0.00	0	0.0	47.73	271	88.1	5.89	33	10.9	0.57	3	1.1	54.20	307.84
13561	28.14	5.29	149	7.4	58.91	1658	82.1	4.51	127	6.3	3.02	85	4.2	71.74	2,018.39
Total	137.19		200.93	2.2		7,996.40	87.2		797.19	8.7		174.51	1.9		9,169.03

Fig. 30a. Phosphorus Export Projections LaPlatte Watershed

(Projections using SPARROW model)

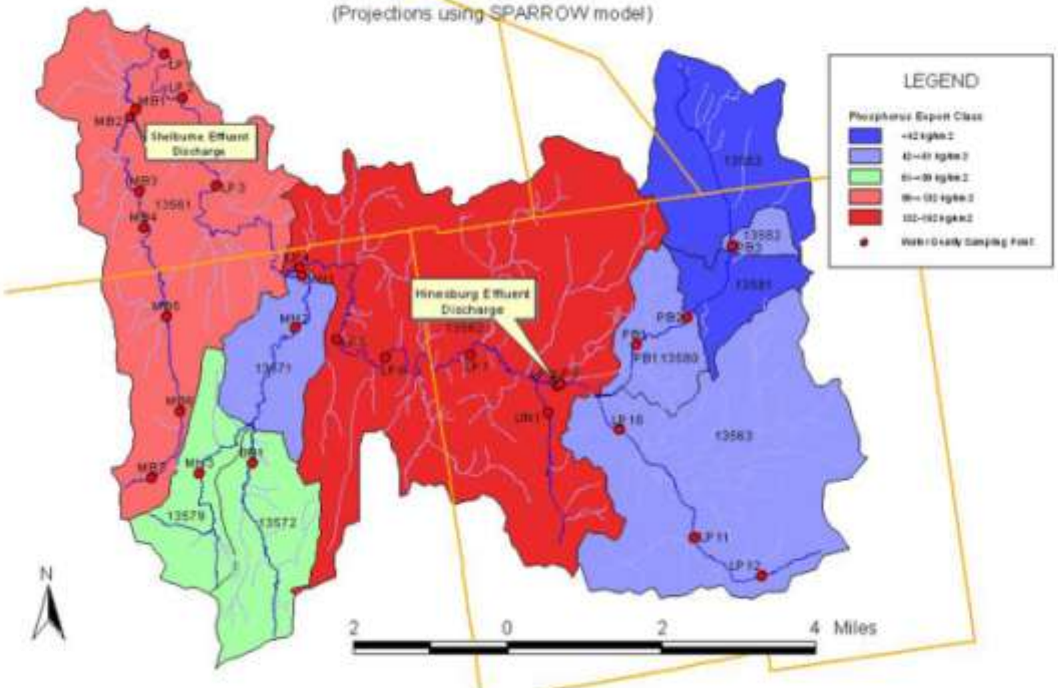
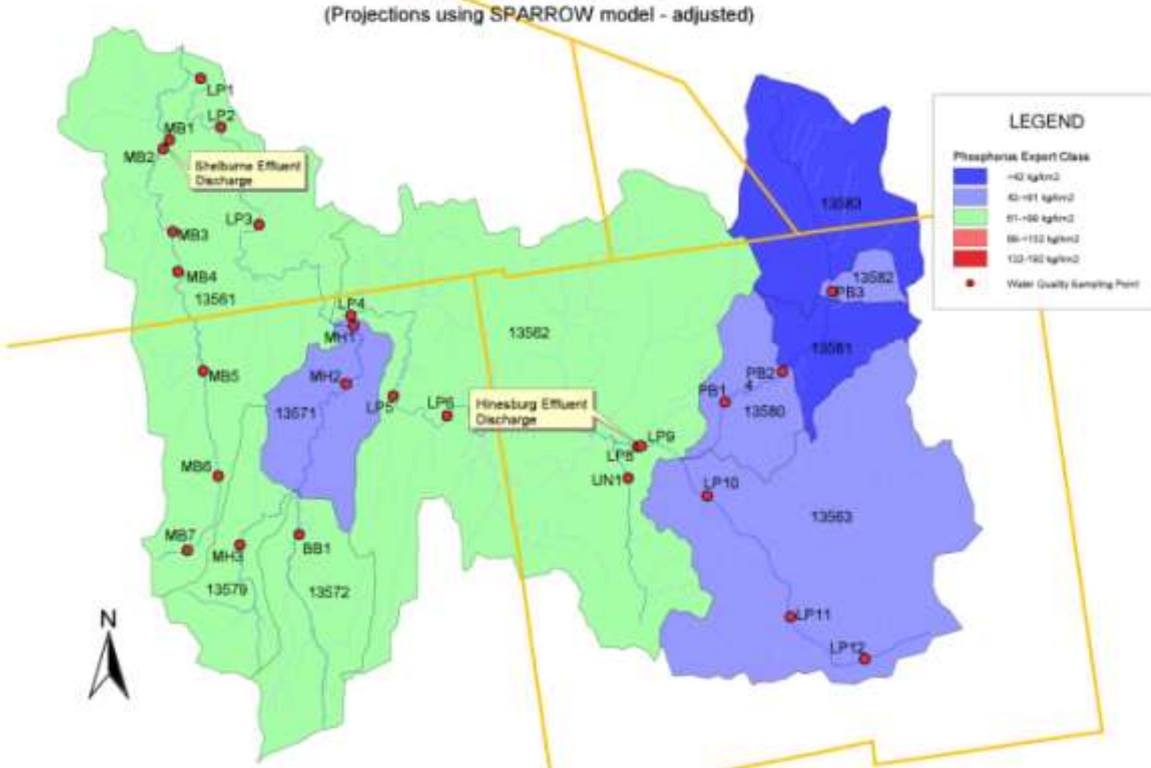


Fig. 30b. Phosphorus Export Projections LaPlatte Watershed

(Projections using SPARROW model - adjusted)



Eastern Tributaries Patrick Brook (13582)

P Export Level:- low-moderate (42-<61 kg/km^2)

Whereas permeability is high (1.8 in/hr) and stream density is moderate, steep slopes (15%) can bringing runoff more rapidly to water courses, somewhat larger cultivated areas (45%) and lower forested areas (50%), together with the absence water bodies which act as sinks, results in slightly higher export than in the Main Stem of Patrick Brook.

Upper LaPlatte River-Lower Patrick Brook (13563, 13580)

P Export Level:- low-moderate (42-<61 kg/km^2)

Mean slope, stream density, and forested area (54.6-58.7%) are similar to Main Stem Patrick Brook, but permeability is very high, reducing runoff. The increase in P export appears to be the result primarily of greater cultivated area (36-38%).

Middle LaPlatte River (13562)

P Export Level:- SPARROW run, very high (132-192 kg/km^2)
Permitted/current estimate, moderate (61-99 kg/km2)

Physical characteristics are moderately favorable to runoff reaching the river; low-moderate slope (7.27%), low permeability (0.7 in/hr), but low stream density (0.000255). Using inputs employed in running the SPARROW model, moderately high coverage by cultivated areas (54.67%), moderate forest coverage (37.42%), together with low-moderate wetland coverage (4.82%) and low water body area (0.53%), but especially the Hinesburg sewage discharge, explain the very high export of phosphorus from the Middle LaPlatte River catchment. When the loadings from the Hinesburg waste treatment plant were adjusted to permitted and estimated current loadings, cultivated land increased in relative and absolute importance.

Upper Mud Hollow-Bingham Brooks (13572,13579)

P Export Level:- moderate (61-<99 kg/km^2)

This catchment, characterized by low mean slopes (3.9-5.1%), but low permeability (0.57-0.59 in/hr) and high stream density (0.00054-0.00057), included the highest cultivated cover (69.8-80.8%), and the lowest forest cover (13.5-21.5%) of all the LaPlatte River catchments, yet with only moderate wetland coverage (5-7.7%), produced only moderate export levels.

Lower Mud Hollow Brook (13571)

P Export Level:- low-moderate (42-<61 kg/km^2)

The physical characteristics of the Lower Mud Hollow catchment were similar to those of the Upper Mud Hollow-Bingham Brook catchment; mean slope, 5.7%; mean permeability, 0.58 in/hr; stream density, 0.000794. A lower cultivated area (39%), a higher forest cover (42%), and very high wetland coverage (16.6%) explain its lower P export level.

Lower LaPlatte-McCabe's Brook (13561)

P Export Level:- SPARROW run, high-moderate (99-<132 kg/km^2)
Permitted/current estimate, moderate (61-99 kg/km2)

The mean slope (5.95%) and mean permeability (0.56 in/hr) were similar to the mean slope and permeability throughout the Mud Hollow and Bingham Brook watersheds; the stream density was lower (0.000357), suggesting that runoff characteristics are roughly similar. The cultivated portion of the Lower LaPlatte-McCabe's Brook catchment (49%) was greater than that in the Lower Mud Hollow catchment, and the forest cover (32%) and wetland coverage (11.5%) were lower. But of particular importance using inputs employed in running the SPARROW model, was the discharge of treated sewage outfall to McCabe's Brook, explaining, along with a higher percentage of urban (2.3%) and suburban (3.46%) area, its higher P export level. When the loadings from the Shelburne waste treatment plant were adjusted to permitted and estimated current loadings, cultivated land increased in relative and absolute importance.

Overall, the SPARROW model predicted a total phosphorus loading of 16.4 metric tons per year from the LaPlatte watershed. This loading by itself far exceeds the total estimated phosphorus export of 11.8 metric tons to Shelburne Bay from all sources (Lake Champlain Basin Atlas, http://www.anr.state.vt.us/champ/Atlas/PDFmaps/is_pload.pdf). Changing the point source inputs to catchments 13562 and 13561 reduced the total loadings to 9.8 metric tons based on permitted discharges, and 9.17 metric tons based on rough estimates of current discharges from the Hinesburg and Shelburne sewage treatment plants. These reductions resulted in a dramatic change in the relative importance of phosphorus sources. Waste discharge loadings constituting 45% of the total loading employed during the application of the model, dropped to 8.6% and 2.2%, respectively, when permitted and estimated current discharge loadings were used. Under these scenarios, the present day role of "cultivated land," representing 81.5% and 87.2% of the total loadings, respectively.

Implications for Shelburne Bay. These observations may affect phosphorus loadings and how they impact on Lake Champlain. For instance, the larger solids particles, which are associated with higher flows and higher solids loads, settle to the bottom when they enter Shelburne Bay. They thus contribute to phosphorus in the near shore area of the mouth of the river and may support primarily aquatic weeds in the littoral zone. Dissolved phosphorus and phosphorus associated with fine particles do not immediately settle to the bottom and are available to support open water algal populations.

The State of Vermont has established water quality criteria for Lake Champlain of 0.010 mg/l in the main lake, and 0.014 mg/l within the euphotic zone in Shelburne and Burlington Bays. These values are consistent with observations of other lakes worldwide. For instance, phosphorus deficient growth is often considered to occur when total phosphorus concentrations are <0.5µmoles/l (0.0155 mg/l) (S.J. Guildford and R.E. Hecky, Limnol. Oceanogr. *45*, 2000, 1213-1223). Phosphorus concentrations in all water samples from the LaPlatte watershed tested during the summer and fall of 2004 exceeded 0.5 µmoles/l and the State water quality criterion (0.014

mg/l), most by a wide margin, individual values exceeding by a factor of >20 times the standard. Phosphorus concentrations at station LP 01, located at river mile 0.55, varied from a low of 32.3 mg/l to a high of 340 mg/l, and those from station MB 1, 1.85 miles above the outlet to Shelburne Bay, from a low of 38.2 mg/l to a high of 324 mg/l.

4.7 Limiting Nutrients

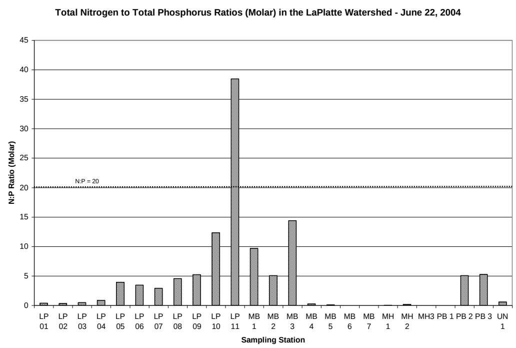
The concept of limiting nutrients has long been central to efforts to control productivity and the development of nuisance conditions in water bodies. Whereas a number of trace elements have been shown to limit the growth of algae and rooted aquatic plants in various special situations, nitrogen and phosphorus are the major requirements for growth, and either may limit growth. A sense of this may be limiting in lakes and the ocean can be derived from the molar ratio of TN:TP. In general, it has been found that when the TN:TP ratio is <20, nitrogen limits growth, and when the ratio is >50, phosphorus deficient growth occurs. At intermediate ratios, either nitrogen or phosphorus may limit growth (S.J. Guildford and R.E. Hecky *op. cit.*).

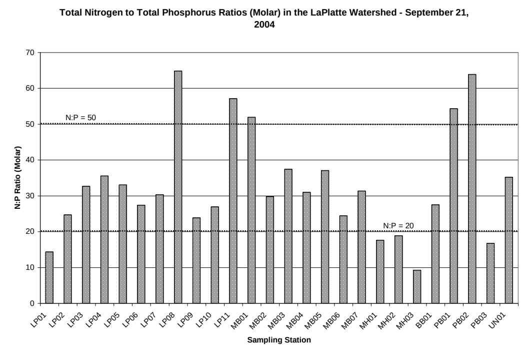
It is noted, however, that Levine *et al.* (J. Great Lakes Res., 23, 1997, 131-148), based on work on Lake Champlain warned that although TN:TP ratios were always indicative of severe phosphorus limitation in the lake (68:1 to 139:1), phosphorus sufficiency was suggested by physiological indicators and mixed phosphorus and nitrogen limitation growth assays. These authors found that phosphorus alone was not limiting at all times, and concluded that while on the one hand, phosphorus was an important factor limiting growth of phytoplankton in Lake Champlain, phosphorus deficiency was not consistent, nitrogen apparently also played an important role. At times addition of phosphorus yielded very little increase in the biomass of phytoplankton until nitrogen limitation was induced, and increased nitrogen loadings in the absence of reductions in phosphorus loadings could lead to increased productivity. In many of her experiments using *Selenastrum capricornatum* as a test organism, growth was always greater when nitrogen and phosphorus were added in combination than when phosphorus was added alone.

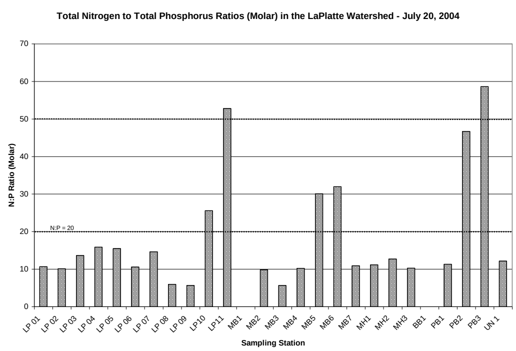
TN:TP ratios calculated for all sampling stations in the LaPlatte watershed are shown in Figure 31. It is difficult to draw specific conclusions with regard to these ratios. In general, however, within the river system, the higher ratios are associated with the upper reaches of the watershed in Hinesburg (un-named tributary, Patrick Brook, and the headwaters of the LaPlatte River itself). Except for samples taken on September 21 and November 16, ratios were predominantly less than 20. This reflects the effect of suspended solids which contribute to the phosphorus loading.

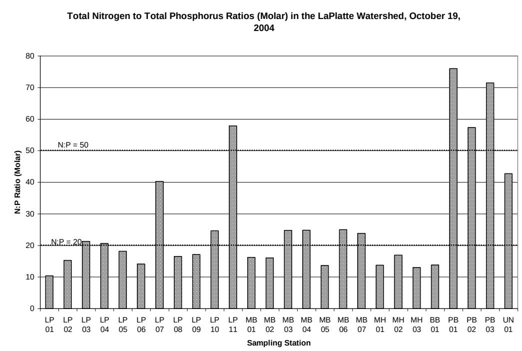
Of greater significance in terms of impact on Shelburne Bay, ratios in 5 of 6 samples taken at LP 01 were well below 20, suggesting nitrogen limitation as the river discharges into the bay. Similarly, ratios in 3 of 5 samples taken at station MB 1 were under 20, although in one sample the ratio exceeded 50. These figures should be viewed in terms of what happens when the river discharges into the bay. At times of high flow when concentrations of total suspended solids and turbidity are high, settling takes place, reducing the total phosphorus associated with particles and the TN:TP ratio can be expected to increase dramatically, increasing the importance of phosphorus as a limiting nutrient.

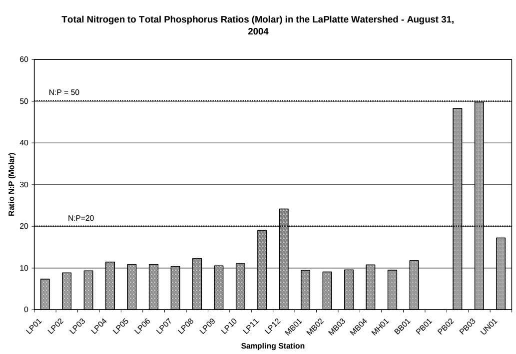
Fig. 31. Total Nitrogen to Total Phosphorus Ratios (Molar) in the LaPlatte Watershed, 2004

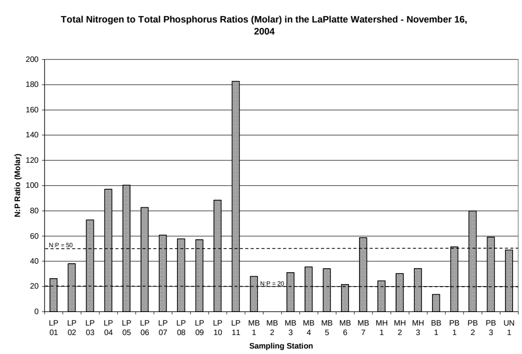












It is often considered that the N:P ratio plays a role in determining the presence or absence of nitrogen fixing blue green bacteria. The low TN:TP ratios in the discharge from the LaPlatte River thus might suggest a reason for blooms of blue green bacteria, including toxic blooms, in the littoral zone of Shelburne Bay which according to reports in the press, have resulted in the death of dogs. However, the situation may be more complex. For instance, an exceptional bloom of *Aphanizomenon ovalisporum* in Lake Kinneret in 1994 derived most of its nitrogen from dissolved organic nitrogen rather than from nitrogen fixation.

In contrast to open water bodies, work on artificial streams fed stream water (R.S. Stelzerand and G.A. Lamberti, Limnol. Oceanogr. *46*, 2001, 356-367) indicated that the structure of the periphyton community is more sensitive to the N:P ratio as well as total nutrient concentrations than is periphyton biomass.

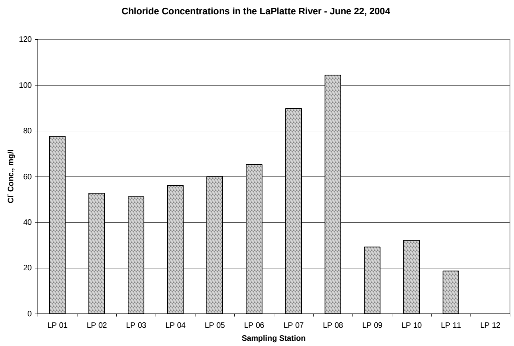
4.8 Chlorides

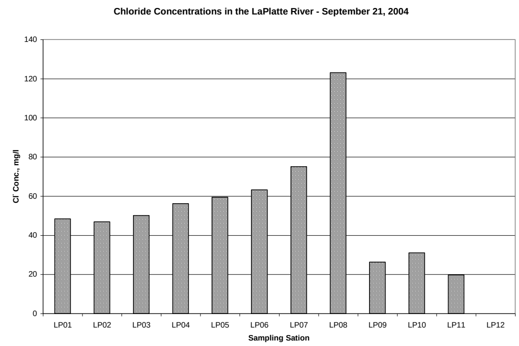
Chloride is a non-reactive, biologically inactive, conservative ion, in contrast to nitrate ion, phosphate ion, or organic compounds containing nitrogen or phosphorus, which are non-conservative in nature. This means that chloride ion is not affected by chemical interactions as is phosphate, nor is it affected by biological interactions, as are nitrogen and phosphorus. It can enter surface waters with industrial or domestic wastewater, runoff from salted roads, salt storage areas, or groundwater exposed to deposits or storage or waste dumps.

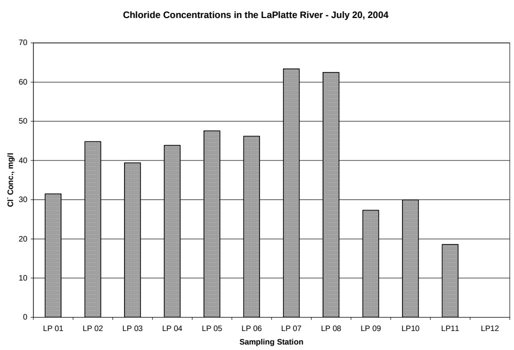
In the 1988 study commissioned by the Vermont Department of Environmental Conservation (*op. cit*.) examined chloride loadings from the LaPlatte River (including McCabe's Brook) into Shelburne Bay. Smeltzer (*op. cit.*) reported chloride loads of 2,570 kg/d during the mid-summer months. He concluded that the LaPlatte River was the most significant source of chloride reaching Shelburne Bay, contributing 72% of the total load.

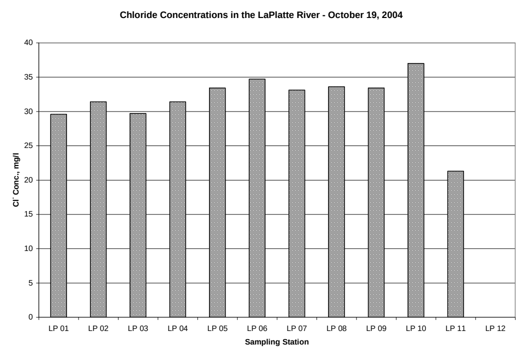
LaPlatte River. The data obtained during the 2004 sampling season (Figure 32) provide the start of a baseline for the watershed, but also clearly highlight the major point sources of wastes and the effects of dilution. Thus, the effect of the Hinesburg sewage treatment plant outfall is clear on 5 of 6 sampling dates, increasing from a baseline of between 20 and 30 mg/l above the outfall to between 40 and 220 mg/l below the outfall. At times, there was an increase at station LP 05. The effect of dilution was also evident in the levels of chloride concentrations, especially below the outfall. For instance, when flows were highest on August 31, concentrations were lowest. When flows were lowest on November 16, concentrations were highest. Concentrations tended to halve between LP 08 and LP 01. The behavior of chloride throughout the LaPlatte River on October 19 differed, and it appeared that there was no discharge from the Hinesburg Sewage Treatment Plant. The concentrations over the length of the river when flow was very low appear to be representative of the baseline concentration (30 mg/l) for the watershed.

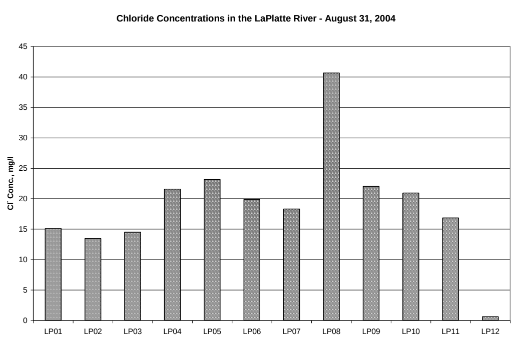
Fig 32. Chloride Concentrations in the LaPlatte River, 2004

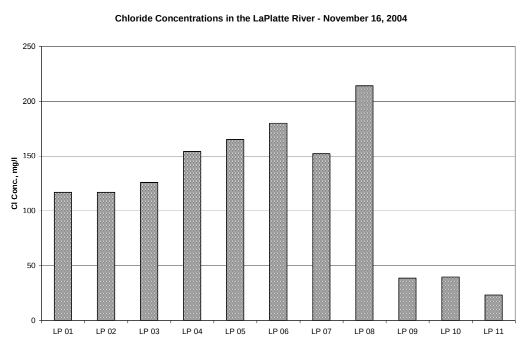












McCabe's Brook. The picture presented by the results of sampling of McCabe's Brook (Figure 33) suggest a baseline chloride concentration of between 10 and 25 mg/l in the upper reaches above Lime Kiln Road (MB 5), but often increasing abruptly between Lime Kiln Road and Route 7 (MB 4). On 4 occasions, the increase exceeded that apparent as a result of sewage discharge between MB 2 and MB 1. In addition, a (generally) slight increase was evident at station MB 6 (Mutton Hill Road extension). In particular, the increase in the chloride concentrations at MB 4 suggests that one or more significant sources exist in this reach of the brook. Several possible sources exist in the drainage to this section of the brook including drainage from cow pastures both south and north of Lime Kiln Road, and from the large impervious area comprising the Vermont Teddy Bear complex. The absence of concurrent increases in total suspended solids, turbidity, and total phosphorus suggest that the increases were attributable to runoff from the impervious areas. *Escherichia coli* did increase during moderate flows in June and July (See next section). A similar effect of the Shelburne sewage treatment plant outfall was evident at station MB 1 during the discharge of sewage.

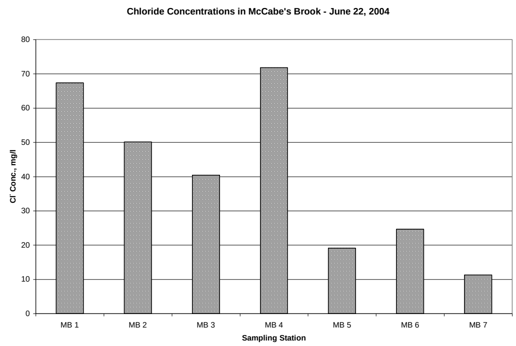
Mud Hollow Watershed. Chloride concentrations in the Mud Hollow watershed (Figure 34) were at all times low. In general, concentrations at MH 3 (Hinesburg-Charlotte Road) were higher than elsewhere in the watershed, but at no times exceptional (>25 mg/l).

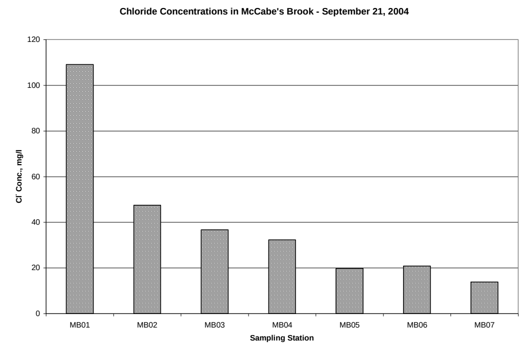
Hinesburg Tributaries. Chloride concentrations in the un-named Hinesburg tributary (Figure 35) were at all times low, lower than in Patrick Brook. Whereas concentrations increased from PB 3 downstream to PB 1, they never exceeded 32 mg/l.

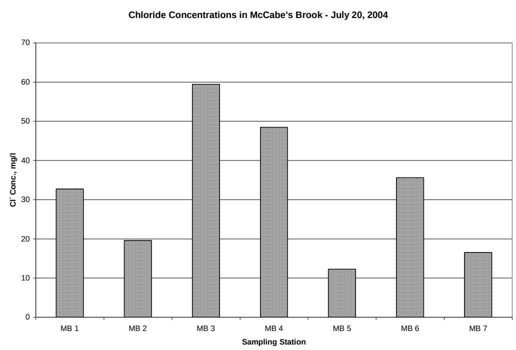
Discussion. The data suggest that natural baseline concentrations of chlorides were between 20 and 30 mg/l throughout the LaPlatte watershed. Increases with downstream flow were associated with sewage discharges in Hinesburg and Shelburne and with runoff at specific identifiable locations. Over other reaches, concentrations diminished with flow. At very high flow, the chloride concentration was reduced at all locations as a result of dilution.

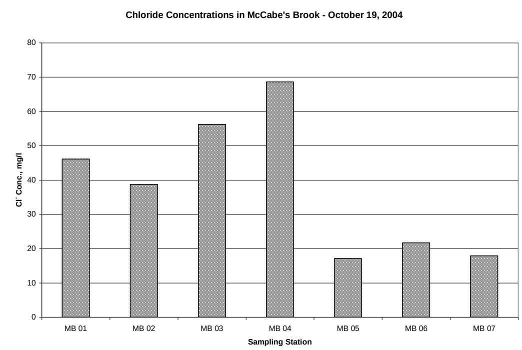
Historical Context. Comparison with published historical data is possible only at Falls Road in Shelburne (Station LP 03). The mean of 97 chloride analyses carried out between March, 1990 and February, 1992 (before up-grading of the Hinesburg Waste Treatment Plant) under the Lake Champlain Diagnostic Feasibility Study (*op. cit.*) was 27.0 mg/l (coefficient of variation 0.04). The mean of 238 analyses carried out under the Lake Champlain Long-Term Monitoring Program through 2004 was 31.8 mg/l (median = 23.05 mg/l), with a minimum concentration of 5.1 mg/l, and a maximum of 180 mg/l. The comparable concentrations determined under the Volunteer Monitoring Program during the summer and fall of 2004 were a minimum of 14.5 mg/l at a very high flow rate on August 30, a maximum of 126 mg/l at very low flow on November 16, and values ranging from 30 to 50 mg/l at moderate discharge rates. These results tend to suggest a rise in chloride concentrations over time, and Volunteer Monitoring data should be considered in the context of all data from the Long-Term Monitoring Program.

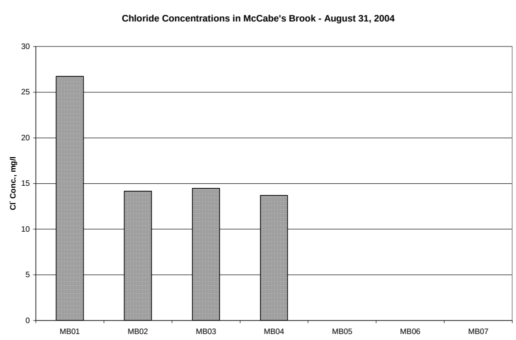
Fig. 33. Chloride Concentrations in McCabe's Brook, 2004











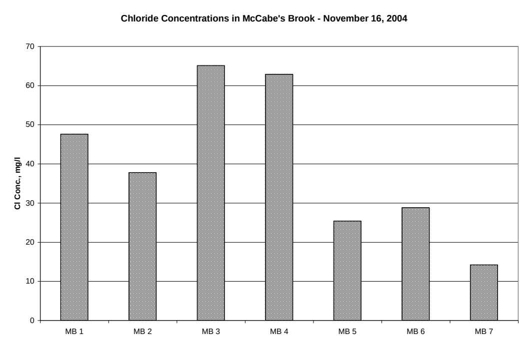
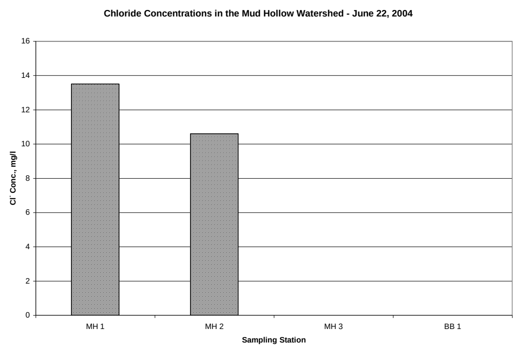
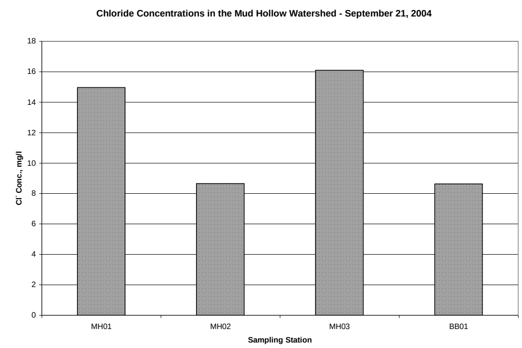
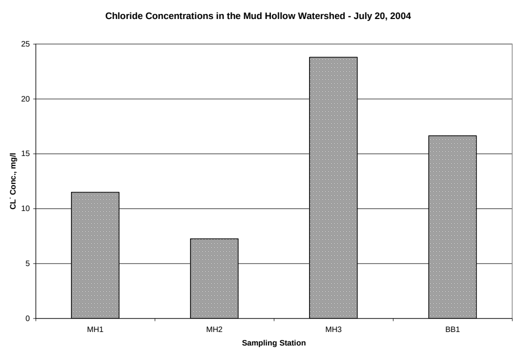
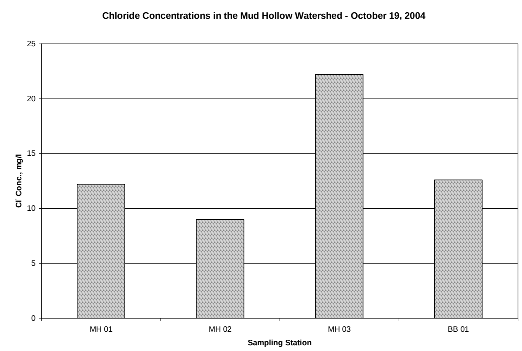


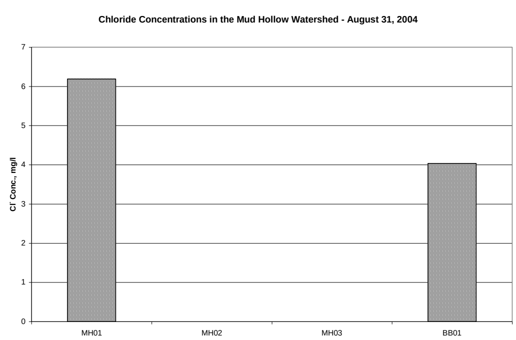
Fig. 34. Chloride Concentrations in the Mud Hollow Watershed, 2004











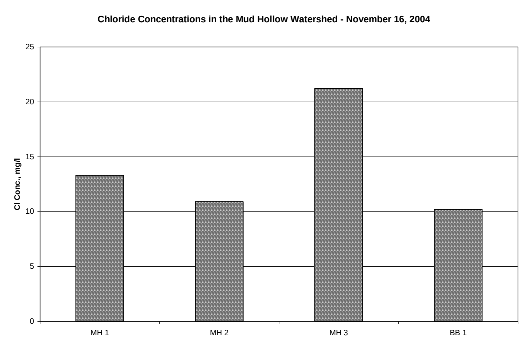
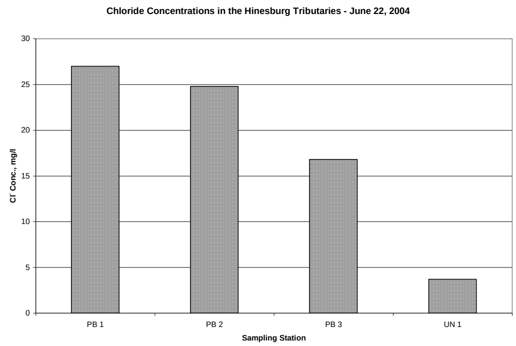
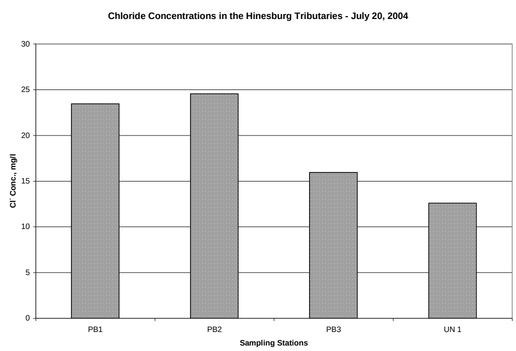
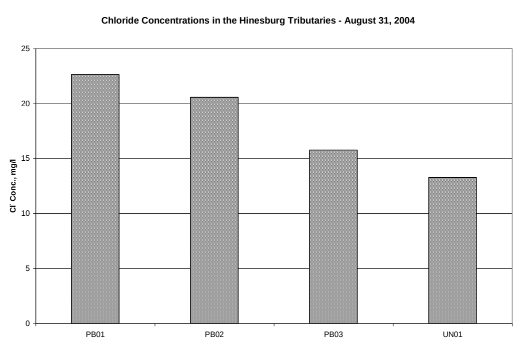
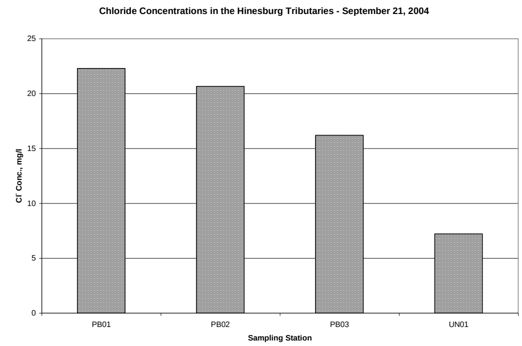


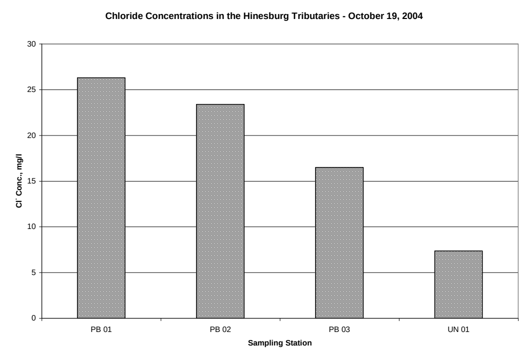
Fig. 35. Chloride Concentrations in the Hinesburg Tributaries, 2004

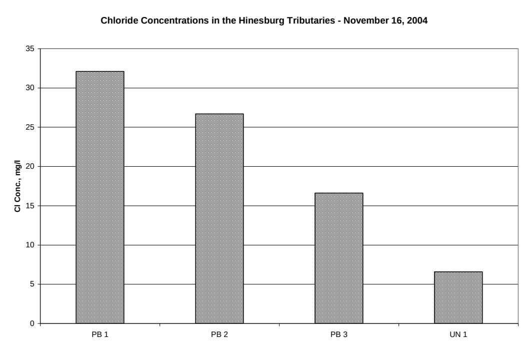












4.9 *Escherichia coli*

Escherichia coli is a member of the *Enterobacteriaceae* which occurs characteristically in the intestinal tracts of warm blooded animals, but does not occur characteristically in the natural environment independently of fecal contamination. The species itself is a normal and harmless inhabitant of the intestinal tract, although certain strains, such as *E. coli* O157:H7, and more recently *E. coli* O104:H21, are known to be enterotoxigenic and to cause *Shigella*-like disease. Most probable numbers, based on the presence or absence of growth in multiple replications of serial dilutions of sample were determined on samples obtained in the LaPlatte watershed during 2004.

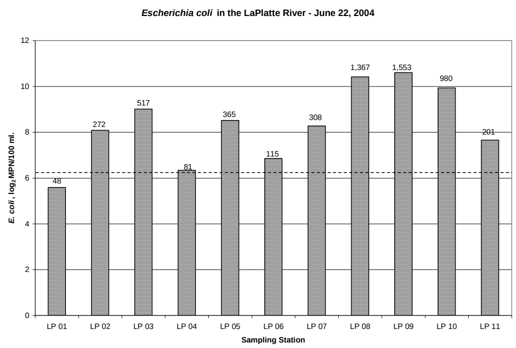
LaPlatte River. In general, *E. coli* counts (Figure 36) were high during periods of high rainfall and runoff. Counts in the LaPlatte River tended to increase as the river flowed from station LP 11 to a high below the sewage treatment plant outfall, save in October when the plant was not discharging to the river, and during very low flow in October and November. They continued to increase to station LP 05 located at Carpenter Road. At moderate flows counts then tended to decrease to station LP 4 located at Spear Street, after which they increased at Shelburne Falls and then fell with flow downstream. The pattern was not consistent, however, and on at least one occasion, counts increased slightly between Shelburne Falls and LP 01. What is striking is the increase in counts with rainfall as flows increased to very high rates on August 31 when counts in all samples between LP 10 and LP 01 were equal to, or greater than 2,419/100 ml., and in all samples save at LP 01 in June, counts exceeded the State standard of 77/100 ml. At the lowest flows in October, and particularly in November, counts were lower, and exceeded the State standard in only a few instances.

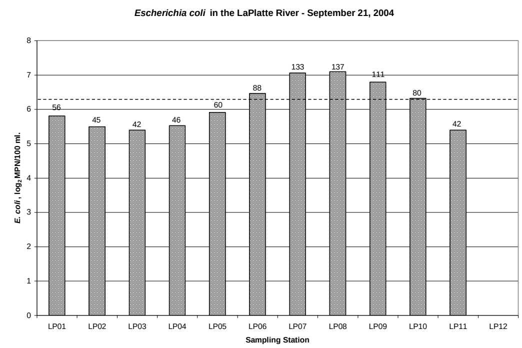
McCabe's Brook. Counts in McCabe's Brook (Figure 37) tended in increase at stations MB 5 and/or MB 4 when rainfall was moderate to high, and tended to increase at MB 2, and to increase further at MB 1 when the Shelburne sewage treatment plant was discharging to the stream. As in the LaPlatte River, counts equaled or exceeded 2,419/100 ml. below MB 4 when the flow was moderate to high.

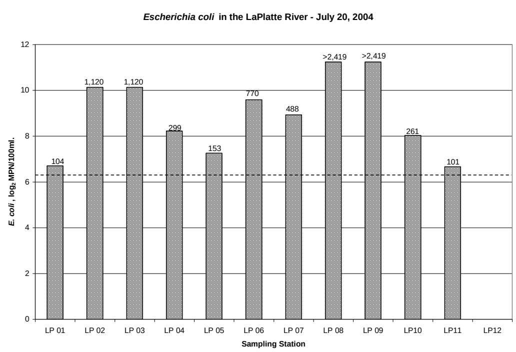
Mud Hollow Watershed. During moderate to low flows, counts of *E. coli* in Mud Hollow Brook (Figure 38) were highest at the upstream station (MH 3) located at the Hinesburg-Charlotte Road, and decreased downstream. Save during very low flows in October and November, all samples taken in the watershed exceeded the State standard.

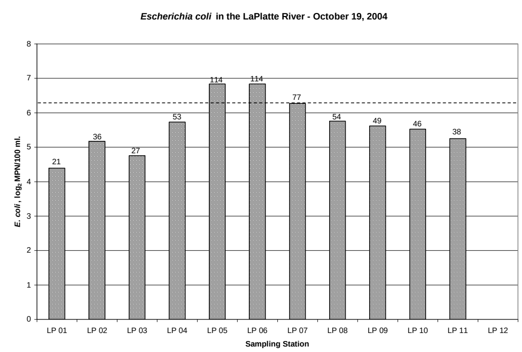
Hinesburg Tributaries. Counts in the un-named Hinesburg tributary were higher than in Patrick Brook during moderate to high flows (Figure 39). In Patrick Brook, counts tended to increase with flow during moderate flows when runoff was more significant, but to decrease during very low flows when runoff was insignificant. Counts exceeded the State standard at PB 1 during moderate flows in June and July, but not in the fall months.

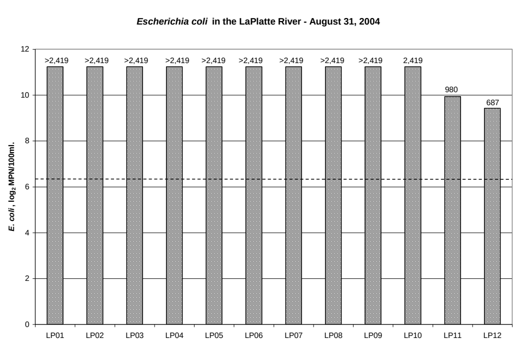
Fig. 36. *Escherichia coli* Counts in the LaPlatte River, 2004











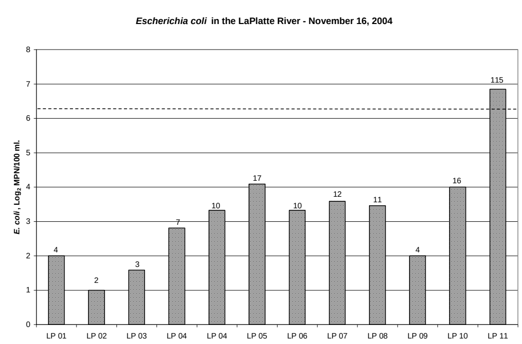
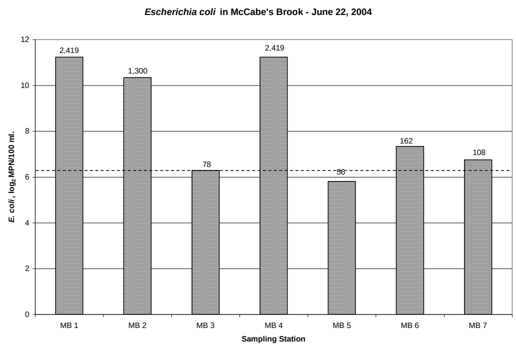
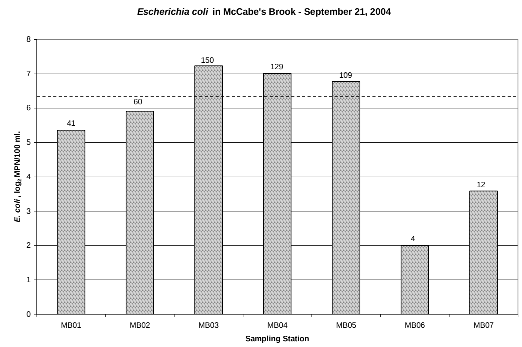
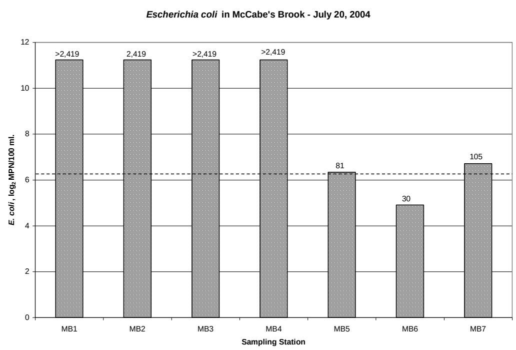
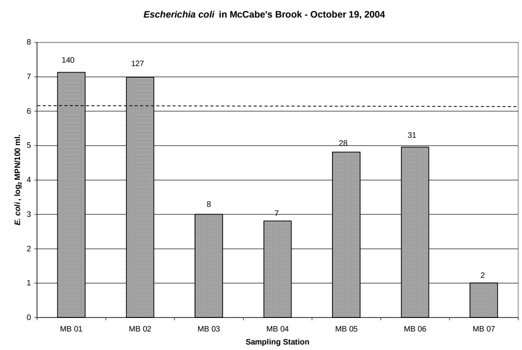


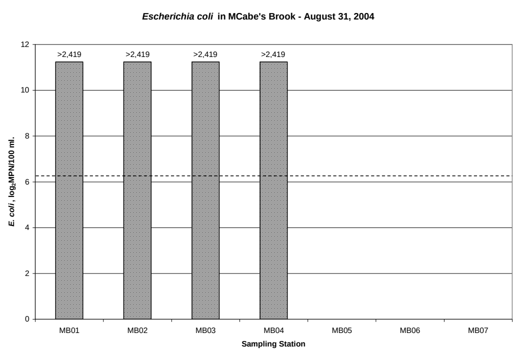
Fig. 37. *Escherichia coli* Counts in McCabe's Brook, 2004











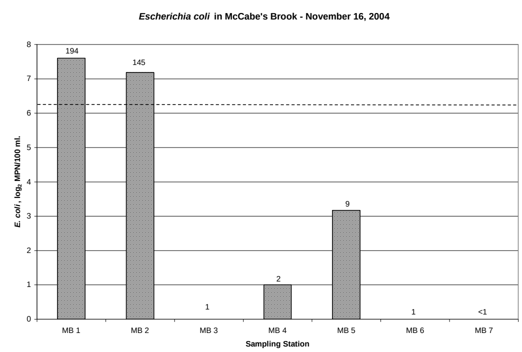
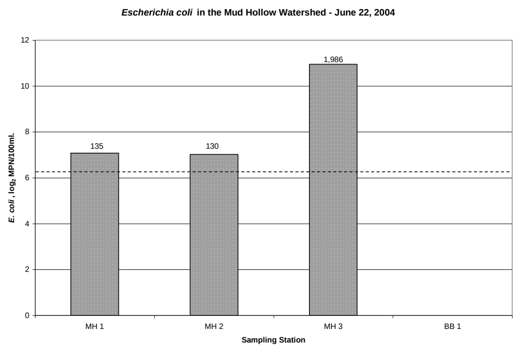
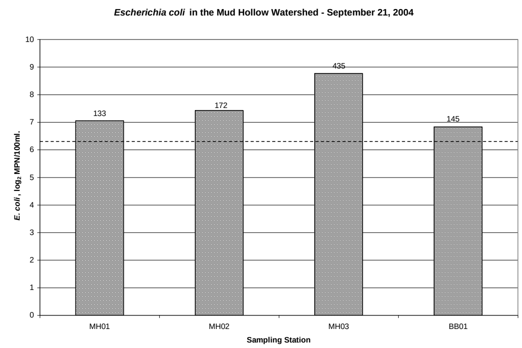
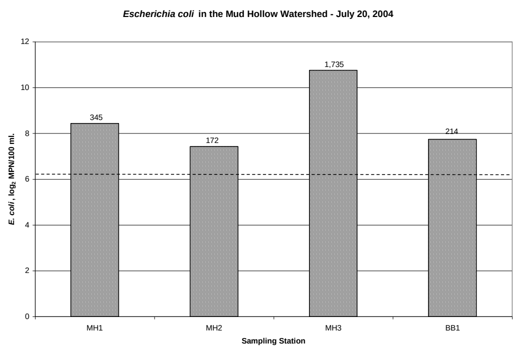
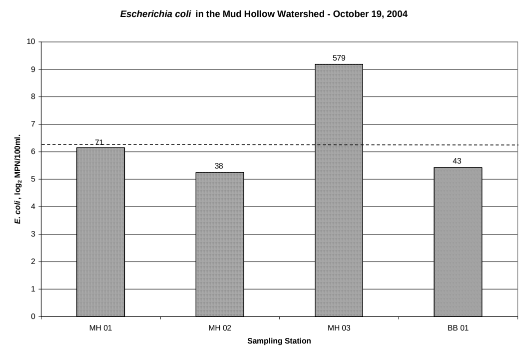


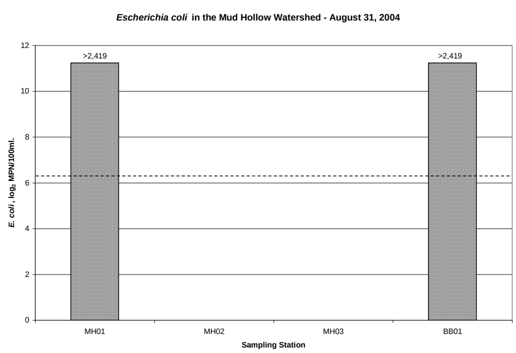
Fig. 38. *Escherichia coli* Counts in the Mud Hollow Watershed, 2004











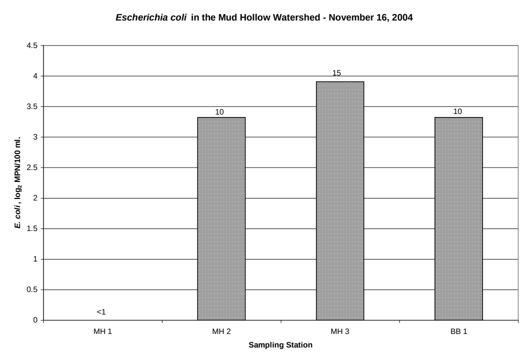
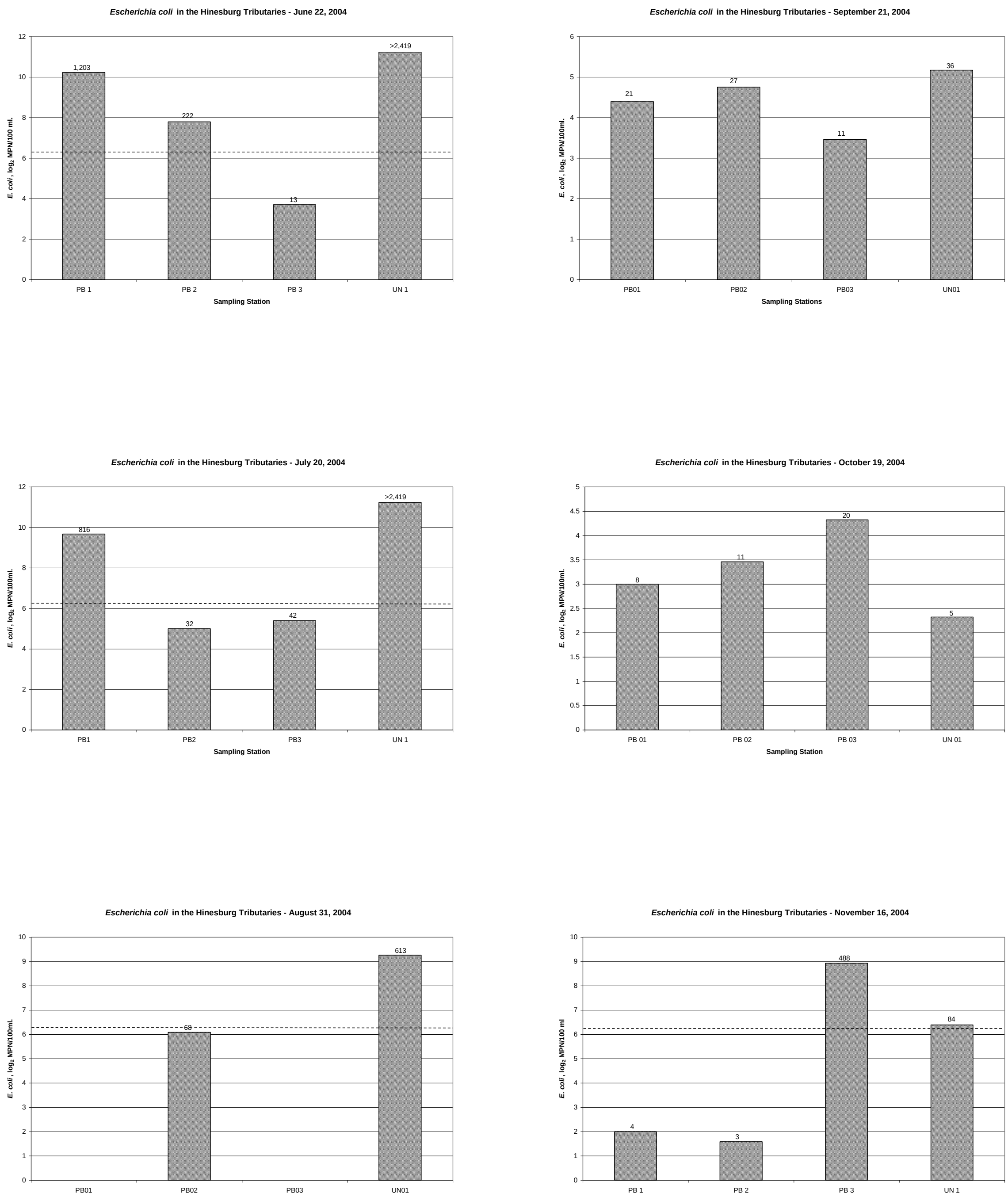


Fig. 39. *Escherichia coli* Counts in the Hinesburg Tributaries, 2004



CWD Data. Counts of *E. coli* determined by the CWD (Figure 40) were entirely consistent with those determined under the Volunteer Monitoring Program. They also extend the coverage by providing monthly data to the period February through May, and supplement the LRP data for June through November.

The CWD results, as did the LRP results, consistently far exceeded State Water Quality Standards during periods when flow was moderate to high in March through September, frequently exceeding 2,419 per 100 ml. during these months.

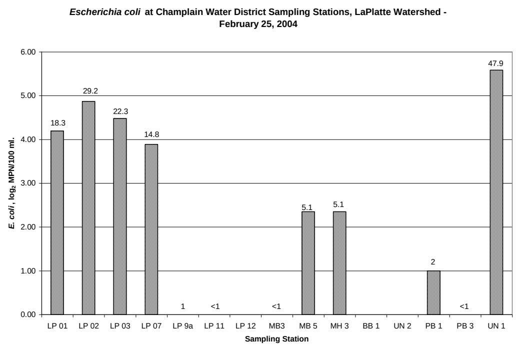
It is interesting to follow the counts in the LaPlatte River beginning with the CWD sample taken during heavy rains discussed above under the section on Turbidity. At the time of sampling, the river had been rising for about 12 hours. Counts of *E. coli* were high, but at Falls Road (LP 03) the count was still within the range of the MPN procedure (1,553 per 100 ml.). Counts above the town of Hinesburg were still relatively low, but in and below the town, were very high.

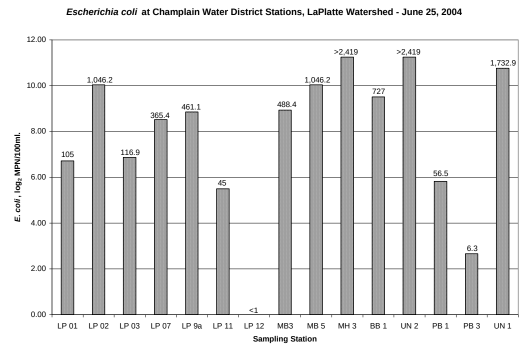
Samples were taken the following day (August 31) by the LRP volunteer samplers. The flow at Falls Road (LP 03) had increased from between 80 and 100 cfs on August 30, to a peak of about 500 cfs at the time of sampling on August 31. Counts at all LaPlatte River stations in a below Hinesburg exceeded the limit of the MPN procedure, and counts at the upstream stations LP 12 and LP 11 were high. On September 9, counts determined by the CWD still exceeded 2,419 per 100 ml., and were still high at LP 12 and LP 11. By September 21 counts determined on samples collected by LRP volunteers had declined, and were generally below the State Standard of 77 per 100 ml. (42 per 100 ml. at Falls Road). Counts remained low, decreasing steadily to 34 per 100 ml. on October 13 (CWD), 27 per 100 ml. on October 19 (LRP), and 3 per 100 ml. on November 16 (LRP). This pattern mirrors that of turbidity discussed above.

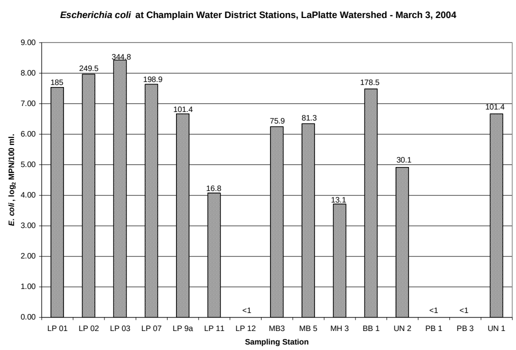
Samples collected by the CWD were tested also for Enterococci. Although numbers of *E. coli* would be expected to exceed those of Enterococci in human wastes (Fecal Coliform:Fecal Streptococcus ~4.4 in human feces, ~4.3-8.6 in sewage: after E.E. Geldreich, *Sanitary Significance of Fecal Coliforms in the Environment*, Federal Water Pollution Control Administration, Publication WP-20-3, 1966), numbers of Enterococci in animal feces may be expected to exceed numbers of fecal coliforms (FC:FS ratios vary from about 0.2 for cows to about 0.4 for pigs and sheep). The result was that counts of Enterococci exceeded the limit of the MPN procedure even more often than did those of *E. coli*.

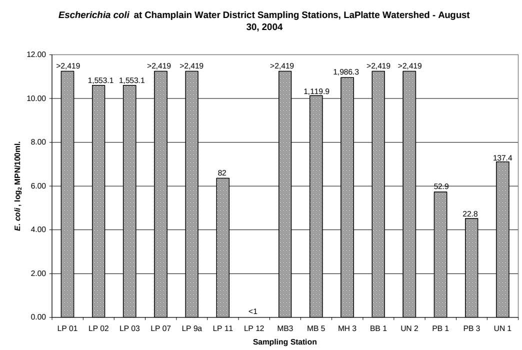
FC:FS ratios in stream waters may be subject to distortion, for instance, if die-off rates or survival in water and sediments differ. However, *E. coli*:Enterococcus ratios were determined for all samples for which real, i.e., no > or < values, counts of both *E. coli* and Enterococci were available. Whereas the availability of pairs of real values was spotty, and ratios were undoubtedly subject to considerable variation, results obtained on February 25, and especially on April 13, June 25, and October 13, are consistent with a predominance of animal pollution throughout most of the watershed above the Hinesburg Sewage Treatment Plant and most and most tributary streams, and human sources from LP 07 (Leavenworth Road) to LP 01.

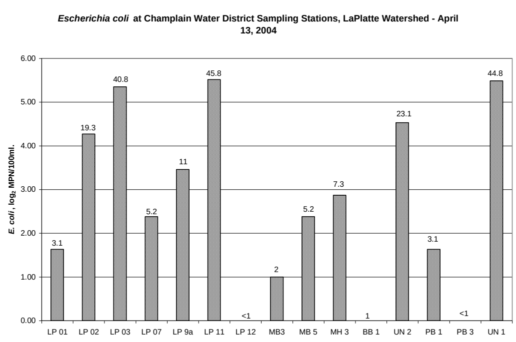
Fig. 40. *Escherichia coli* in the LaPlatte Watershed – 2004
Data from the Champlain Water District

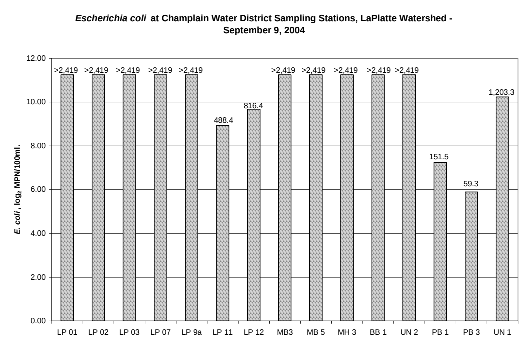


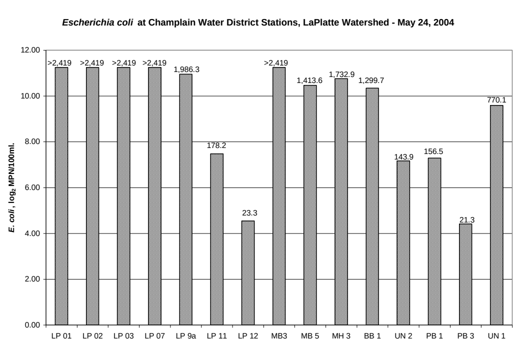












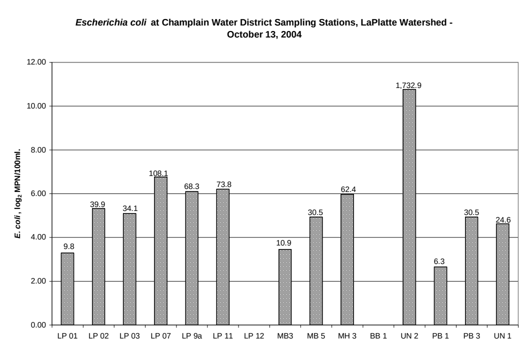
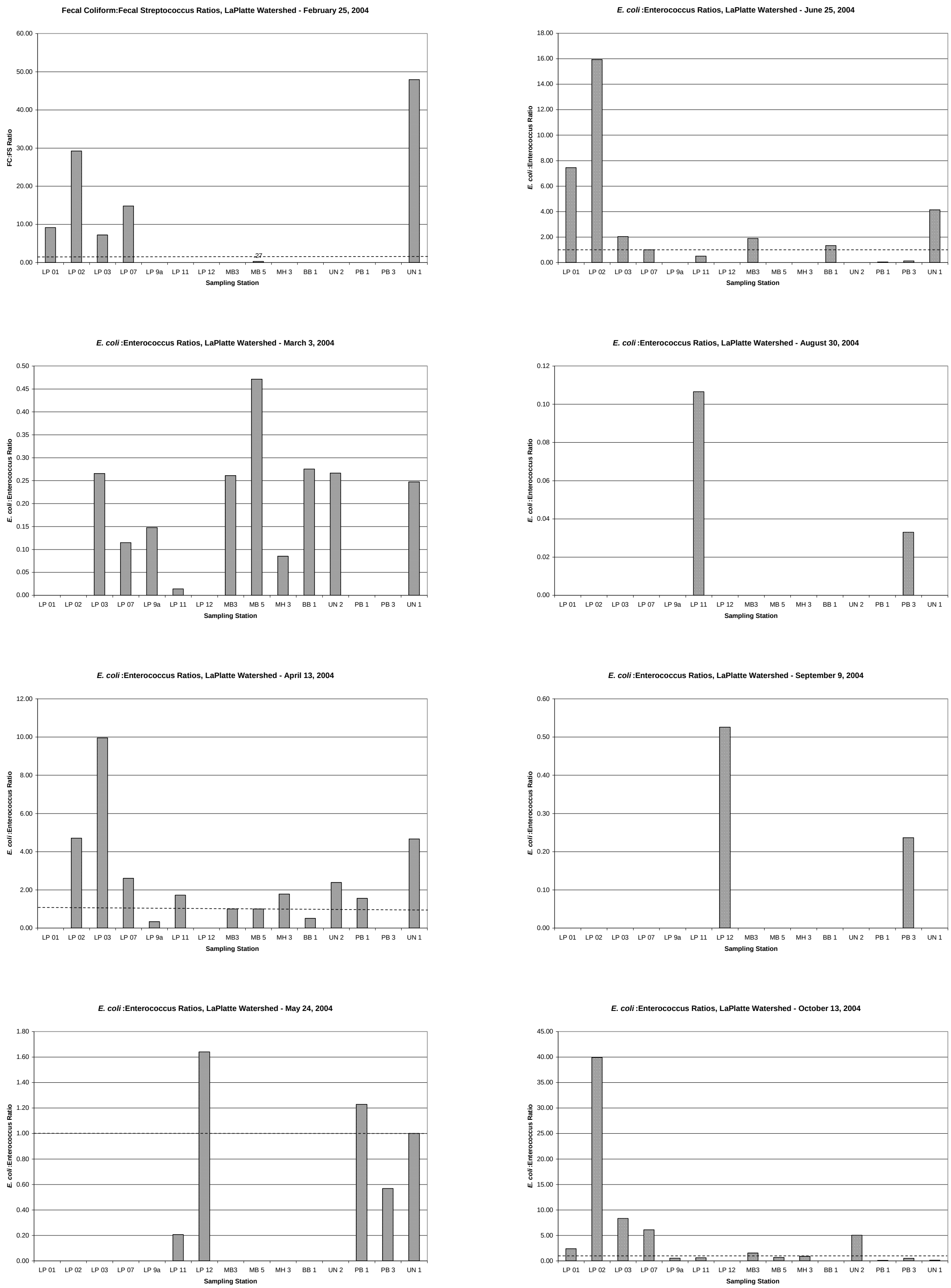


Fig. 41. *E. coli*:Enterococcus Ratios in the LaPlatte Watershed – 2004 Data from the Champlain Water District



5. QUALITY ASSURANCE

5.1 Training

Initial activities undertaken to provide a public forum on water quality and the LaPlatte Watershed Volunteer Water Quality initiative, and to assure understanding of, and adherence to, sampling protocols included the following:

- Initial training session attended by the Project Coordinator in Waterbury
- Water Quality Forum sponsored by the LaPlatte Watershed Partnership, Hinesburg Town Library, May 25. Presentations on water quality in the LaPlatte River and Shelburne Bay by Don Meals and by Mike Barsotti.
- Initial training of volunteers, Shelburne Town Offices, June 15. 15 volunteers present. Coordinated by the Project Coordinator and the Water Quality Director, CWD. Discussion of program objectives, water quality parameters, sampling schedule and procedures, sampling station locations, organization of sampling teams, maintenance of records, and quality assurance
- Field training: Charlotte, June 14 (5 volunteers); Shelburne, June 17 (4 volunteers); Hinesburg, June 18 (10 volunteers). Review of material discussed during the initial training session and detailed discussion, demonstrations, and practice of sampling techniques and labeling. All volunteers participated in field training
- Follow-up of sampling. Following each sampling date, the Project Coordinator communicated with all volunteers, distributing or providing links to data, providing graphs and brief interpretations of results, highlighting areas/results of interest, clarifying procedures as well as discussing problems identified during review of field data sheets and data
- Interim Review Meeting with volunteers, September 13. Discussion of results received to date, problems and constraints, protocols, and improvement of procedures.
- Site visits with sampling teams. The Project Coordinator participated in sampling as a team member in Shelburne and made site visits with Shelburne's second sampling team. Site visits by the QA Coordinator were not possible. This was a major constraint to the implementation of the QA protocol. Careful review of field data and lab sample sheets followed by communications with samplers was an important follow-up action which made up for the lack of site visits, but could not substitute fully for them. In future, efforts should be made to increase the number of volunteers in order to free up the Project Coordinator to carry out this function.

5.2 Data Review

Data management and analysis were carried out by the Project Coordinator. Data entry in the field and office were reviewed for accuracy through direct checks and checks of outlying data. Recorded and manipulated data and analyses were also reviewed for accuracy by the QA Coordinator.

5.3 Completeness of Sampling

The LaPlatte Watershed Volunteer Monitoring Program 27 stations, but water was flowing at station LP 12, the station located farthest up-stream on the LaPlatte River, only in August. As a result, the maximum number of stations available for sampling was 157, of which 151 (96.18%) were sampled, well in excess of the 80% target (See Table 9). For individual analyses, samples were obtained from 95 ± 1% of the total number possible (157). On only one date was it not possible to sample all stations. On August 31, all members of one group were out of town. On that same date, one station was inaccessible as a result of the high flow and consequent flooding.

5.4 Number of Duplicates

The QA Protocol calls for a duplicate sample for every 10th sample. In general, this target was met: 9.93% - 10.74% for all analyses save *E. coli*. In the case of *E. coli* analyses, the frequency of duplicates was one for every 15 samples. The primary reason for the lower number of *E. coli* duplicates was confusion about their collection, resulting in collection of single 250 ml. samples, rather than the required 250 ml. duplicate plus a second 100 ml. sample. This will be clarified in a continuation of the Project.

Table 9. Completeness of Sampling and Field Duplicates

			Number of Samples						
	No. of Stations with Flow	**No. of Stations Sampled**	**TSS**	**Turbidity**	**Total N**	**NO3 + NO2**	**Total P**	**Chlorides**	***E. coli***
Month									
June	26	25	25	25	25	25	24	25	25
July	26	26	26	26	25	26	25	26	26
August	27	22	22	22	22	20	21	22	20
September	26	26	26	26	26	26	26	26	26
October	26	26	26	26	26	26	26	26	26
November	26	26	26	26	25	26	26	26	26
Total Number	157	151	151	151	149	149	148	151	149
Percent	-	96.18	96.18	96.18	94.90	94.90	94.27	96.18	94.90
Target Percent	-		≥80%	≥80%	≥80%	≥80%	≥80%	≥80%	≥80%
Number of Duplicates			16	15	16	16	15	15	10
Percent of Total			10.60	9.93	10.74	10.74	10.14	9.93	6.71
Target Percent			10%	10%	10%	10%	10%	10%	10%

5.5 Mean Relative Percent Differences

The QA Protocol sets precision targets (mean relative percent differences, MRPDs) for each of the parameters analyzed. These are given in Table 10. Targets were met for all parameters save turbidity which exceeded the target by 50% (15.88% vs. 10% target). Such variability could be explained if fine sediments were stirred up during sampling.

Table 10. Summary of Mean Relative Percent Differences

Parameter	Target Precision	Mean RPD
Total Suspended Solids	≤ 10%	9.34%
Turbidity	≤ 10%	15.88%
Total Nitrogen	≤ 15%	14.83%
NO3 + NO2	≤ 11%	2.33%
Total Phosphorus	≤ 15%	7.00%
Chloride	≤ 10%	2.13%
E. coli	≤100%	*

Targets for total suspended solids and total nitrogen (10% and 15%, respectively) were closely approximated (9.34% and 14.83%, respectively). Those for NO_3 + NO_2, total phosphorus, and chloride were met comfortably (from 20% to 50% of target). Even so, relative percent differences (RPDs) for individual samples and field duplicates varied considerably, at times exceeding substantially the target percentage. For turbidity, the highest RPD was 53.6%, and 10 of 15 RPDs exceeded the 10% MRPD target. RPDs for 5 of 16 total suspended solids sample-duplicate pairs exceeded the 10% MRPD target, the highest of which was 29.4%. Whereas only 3 of 16 RPDs for total nitrogen exceeded the 15% MRPD target, the highest was 102.9%. In contrast, RPDs for NO3 + NO2, total phosphorus, and chloride were low, and only 1 (for total phosphorus) exceeded its target MRPD.

The determination of individual field RPDs for *E. coli* was constrained by the number of samples which equaled or exceeded the maximum limit for the MPN procedure (3 of 10 samples-duplicate pairs) and were recorded as either 2,419 or >2,419 per 100 ml. Whereas both the sample and the duplicate might be ≥2,419 per 100 ml., such counts cannot be taken as equal, and cannot be compared. Of the 10 pairs of samples and field duplicates which could be compared, all were under the 100% MRPD target, and the maximum RPD was 43.0%, well below the 100% target.

6. SUMMARY AND CONCLUSIONS

6.1 Potential Hot Spots

LaPlatte River – At Route 116 (LP 12)

There was no flow at station LP 12 near the source of the LaPlatte River, save during a period of extremely high rainfall, although the summer was an unusually wet one. Local experience has been that there is usually flow at this location during summers. Thus, the observations during the summer of 2004 can be considered unusual and warrant follow-up investigation.

LaPlatte River – Between Silver Street (LP 10) and STP Outfall (LP 09)

On July 20 there were observed very high total suspended solids, turbidity, and total phosphorus concentrations, and *E. coli* counts at station LP 09. These were accompanied by a moderate jump in the total nitrogen, concentration, but no change in chloride concentration.

LaPlatte River – Between LP 09 (above STP) and LP 08 (below STP)

Typically there were increases in total nitrogen, nitrate and nitrite, and total phosphorus, and *E. coli*, below the Hinesburg treated sewage outfall when the plant was discharging. At times, the jump in the nitrogen concentration was large. The jump in the chloride concentration was significant when sewage was being discharged.

LaPlatte River – Between the STP (LP 08) and Leavenworth Road (LP 07)

Typically concentrations of total suspended solids, turbidity, and total phosphorus increased significantly between the treatment plant outfall and Leavenworth road, at times accompanied by an increase in the total nitrogen concentrations, and in the *E. coli* counts when sewage was not flowing, but little or no increase in the chloride concentration, indicating that the increases were not caused by the sewage discharge.

LaPlatte River – Between LP 03 (Shelburne Falls) and LP 01

Whereas changes in water quality between Shelburne Falls and the downstream LaPlatte River station, a mostly undeveloped portion of the river, there was a general increase in concentrations of total suspended solids, turbidity, and total phosphorus, with a slight increase in total nitrogen in 3 samples and a slight decrease in 3 samples. Overall, the TN:TP ratio decreased between the two stations. The behavior of *E. coli* populations was variable.

McCabe's Brook – Between the Hinesburg-Charlotte Road (MB 7) and Mutton Hill Road (MB 6)

On 3 occasions there was a significant jump in the concentrations of total suspended solids reflected in the turbidity measurements, accompanied by jumps in both the total nitrogen and total phosphorus concentrations at times. At other times nitrogen, phosphorus, or both increased within this reach. Chloride concentrations tended to increase somewhat in all samples tested. The behavior of *E. coli* was variable.

McCabe's Brook – Between Mutton Hill Road (MB 6) and Lime Kiln Road (MB 5)

On 2 occasions, in June and October, total phosphorus concentrations increased unaccompanied by increases in the total suspended solids, chlorides, or *E. coli*, although the *E. coli* count did increase significantly in the September sample.

McCabe's Brook – Between Lime Kiln Road (MB 5) and Route 7 (MB 4)

There occurred consistently an increase in the chloride concentrations between stations MB 5 and MB 4 unaccompanied by increases in the concentrations of solids, turbidity, total nitrogen, or total phosphorus, suggesting an impact of runoff from extensive impervious areas. In June and July, these increases in chlorides were accompanied by significant increases in the *E. coli* counts.

McCabe's Brook – Between Route 7 (MB 4) and Bostwick Road (MB 3)

On one occasion, July 20, there was a large jump in the concentrations of total suspended solids and turbidity, as well as total nitrogen and nitrates plus nitrites, total phosphorus, and a moderate increase in the chloride concentration. This was probably attributable to heavy runoff observed at a construction site draining into the stream within this reach.

McCabe's Brook – Between Bostwick Road (MB 3) and Harbor Road (MB 2)

There was often a jump in the concentrations of total suspended solids and turbidity between Bostwick Road and Harbor Road upstream from the Shelburne sewage treatment plant outfall accompanied by an increase in the total phosphorus concentration, and on several occasions (June 22, October 19, and November 16), by an increase in the *E. coli* counts.

McCabe's Brook – Below the Shelburne sewage treatment plant outfall (MB 1)

Concentrations of total nitrogen, nitrates plus nitrites, and total phosphorus increased below the Shelburne sewage treatment plant outfall when the plant was discharging treated waste. These increases were accompanied by increases in the chloride concentrations, as would be expected. Minor increases in the *E. coli* concentrations observed on several occasions were not significant.

Mud Hollow Brook – Hinesburg-Charlotte Road (MH 3)

Generally characterized by the highest chloride, total nitrogen, total phosphorus concentrations and *E. coli* counts, but not total suspended solids.

Patrick Brook – Between Pond Brook Road (PB 3) and Mechanicsville Road (PB 1)

Characterized by increases in total suspended solids and turbidity at moderate to high flows accompanied by increases in total nitrogen and total phosphorus concentrations, possibly in part as a result of runoff from lawns. Total nitrogen decreased, however, at low flow. Chlorides increased at on all sampling dates, possibly as a result of leachate from septic tanks.

6.2 Relation to Vermont State Water Quality Criteria

Turbidity – 25 NTU

With the exception of periods of very high flow and specific situations, the State turbidity standard was generally met within the LaPlatte watershed. Within the LaPlatte River itself, turbidity increased typically between stations LP 08 and LP 07 (Leavenworth Road), on three occasions exceeding the standard. On one occasion, the turbidity increased dramatically above the Hinesburg sewage treatment plant outfall, to about 170 NTU, greatly exceeding the standard. During exceptionally high flow on August 31, turbidity increased steadily throughout the length of the river, exceeding the standard between LP 09 (45 NTU) and LP 01 (220 NTU).

In McCabe's Brook, jumps in turbidity at Mutton Hill Road extension (MB 6) exceeded the standard on two occasions. On July 20, a jump in turbidity exceeding the standard occurred at MB 3, apparently primarily affected by runoff from a construction site, and continued to influence turbidity downstream. During exceptional flows on August 31, turbidity far exceeded the standard at all stations sampled.

Within the Mud Hollow watershed, the standard was exceeded at the downstream station MH 1 during the summer months only. It was exceeded by a small margin in Bingham Brook in July and November, and by a significant amount during high flow on August 31.

On no occasion was the standard exceeded in the Hinesburg tributaries.

A note concerning the determination of turbidity is called for. As indicated above in Section 4.4, the methodology included gentle agitation followed by settling for 1 to 2 minutes prior to determining turbidity. This was necessary when flows and total suspended solids concentrations were high as larger particles were found to settle out during the process of reading results (C. Russo, personal communication). The uncertainties introduced by this procedure could argue against comparison of turbidity measurements determined in this way against a standard. It is likely that this is important only when the flow is very high and the turbidity is significantly higher than the standard. The appropriateness and validity of the turbidity standard for streams should be assessed in view of the difficulties encountered in making turbidity measurements.

Nitrates – Not to exceed 5.0 mg/l as N at flows exceeding low median monthly flows

In no samples within the LaPlatte watershed did nitrate concentrations approach 5.0 mg/l as N. On the other hand, at the point of discharge into Shelburne Bay, the TN:TP ratio was at most times less than 20, suggesting that nitrogen (not nitrate ion alone) was probably the limiting nutrient.

Phosphorus – Total phosphorus loadings shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses

If it is assumed that total phosphorus concentrations in excess of 0.5 μmoles/l (0.01555 mg/l), or the Vermont State standard of 0.014 mg/l for Shelburne Bay contributed to eutrophication in the bay, then all samples save some in Patrick Brook can be taken to have exceeded the phosphorus standard.

Although TN:TP ratios suggested nitrogen deficiency as the LaPlatte River discharges into Shelburne Bay, as phosphorus associated with heavier suspended solids settles out, the ratio may be expected to shift in the direction of phosphorus deficiency.

Escherichia coli – MPN less than or equal to 77 per 100 ml.

Counts of *E. coli* throughout the LaPlatte watershed were largely related to runoff and discharges of sewage. Thus, within the LaPlatte River itself, counts exceeded the State standard during moderate to high flows during the summer months, frequently exceeding 2,419/100 ml. during high flows, although counts in the discharge from the river into Shelburne bay in general appeared to meet the standard.

Similarly, counts in McCabe's Brook increased with runoff and discharge of sewage. At moderate to high flows in the summer, counts below MB 4 were high, often exceeding the State standard. Furthermore, during discharge of sewage, counts exceeded the standard above and below the outfall.

Within the Mud Hollow watershed, counts consistently exceeded the standard during the summer and early fall months, but during low flows in October and November, counts exceeded the standard only at station MH 3 in October.

In the Hinesburg tributaries, the standard was exceeded to the greatest extent in the un-named tributary, but also in the lower Patrick Brook during moderate runoff in June and July, as well as in the upper Patrick Brook during very low flow.

7. RECOMMENDATIONS

1. Several corrections to recorded data and procedural and formatting adjustments are recommended as follows:

    a. The date for the October, 2004 samples should be corrected in the DEC records. The October samples were taken on October 19, not on October 10. The source of this error was procedural, resulting from pre-labeling with the date the labels were printed and failure to record the hand corrections to labels made in the field.

    b. It would assist analysis of data if i) station numbers and locations appeared in two separate columns in the EXCEL worksheets supplied by the DEC, and ii) station numbers between 1 and 9 were recorded as 01, 02,….09, for example LP 01, LP 02 etc.

    c. The EXCEL worksheet format should be standardized and established from the first sample date and not altered during the season. This year column labels and orders changed and new columns were inserted. This made running analysis of data more complicated, and therefore more subject to errors.

2. Undertake field investigations and assessments along selected reaches identified during 2004. These include:

    i. LP 12
    ii. LP 10 to LP 09
    iii. LP 08 to LP 07, extend to LP 05
    iv. MB 7 to MB 6
    v. MB 6 to MB 5
    vi. MB 4 to MB 3

3. Initiate 2005 sampling as early as possible (April) in order to record data during early spring runoff.

4. Make available to the public through public presentation as well as articles in the Shelburne, Charlotte, and Hinesburg newspapers to explain and inform the public on results and their implications. This will fulfill in part LP's role in Shelburne's MS4 program.

5. The relationship between concentrations of total suspended solids determined in 2004 and flow (Figure __) define the upper boundary of an envelope encompassing the main body of post-1992 long-term monitoring data points. The steeper regression line suggests an increasing importance of erosion and runoff as sources of phosphorus which should be followed in future monitoring efforts.

6. To enhance the value of *E. coli* data during high flows, and particularly of Enterococci, serious consideration should be given to including appropriate dilutions at these times.

7. Build future analysis and interpretation of results on 2004 analysis and interpretations.

ANNEXES

ANNEX I

Fluvial Geomorphology Definitions

Stream Type – General Characteristics

A – Entrenched, low sinuosity (<1.2), low width:depth ratio (<12)

B – Moderately entrenched, moderate sinuosity (<1.2), moderate width:depth ratio (>12)

C – Slightly entrenched, high sinuosity (>1.2), moderate to high width:depth ratio (>12)

E – Slightly entrenched, very high sinuosity (>1.5), very low width:depth ratio (<12)

Adjustment Processes

Degrading - Downward erosion of stream bed via a head-cutting process

Aggrading - Excessive sediment build-up on streambed and bars

Widening - Erosion of both banks leading to an over-widening stream bed

Planform - Rapid and/or irregular meander movement and pattern

Stream Sensitivity

Low - Stream type and condition not very sensitive to change, future reach and watershed modifications unlikely, not subject to head-cutting from downstream reaches

Moderate - Stream type and condition may be sensitive to change, future reach and watershed modifications likely, or may be subject to head-cutting from downstream reaches

High - Stream type and condition very sensitive to change, future reach and watershed modifications likely, or subject to head-cutting from downstream reaches

Reach Condition

Reference - No significant channel or floodplain modifications, and adjacent forested riparian buffer, i.e., near natural condition

Good - Undergoing only minor adjustments or has substantially adjusted to previous modifications

Fair - Fully in adjustment, may be experiencing or heading towards major and rapid changes as a result of recent floodplain and channel modifications, land cover changes, and/or loss of riparian buffer. Channels undergoing incision, widening, or rapid lateral movement

Poor - Entrenched reach, or one that is severely over-widened and aggrading. Braiding with mid-channel bars

ANNEX II

LaPlatte Volunteer Water Quality Monitoring Teams

1. **Shelburne - Lower LaPlatte Team**

Bill Hoadley, Team Leader	985-5736	bhoadley@together.net
Judy Puck	985-4143	
Logan Puck	985-4143	puckl@dickinson.edu

2. **Shelburne - Lower McCabe Team**

Dick Reid	985-2871	rfreidsr@aol.com
Lucy Blanton	985-5267	lblanton@sover.net

3. **Charlotte - Upper McCabe-Mud Hollow Team**

Dave Hill, Team Leader	425-5354	dhill@gmavt.net
Sue Smith	425-2732	vt5116@juno.com
Lisa Kiley		poatsie@excite.com

4. **Charlotte - Lower Mud Hollow-Bingham Team**

John Quinney, Team Leader	425-3773	johnq@gmavt.net
Nell Fraser/Rob Fraser	425-7098	nfraser@sover.net

5. **Charlotte-Hinesburg - Mid-LaPlatte Team**

Ed Sengle, Team Leader	482-3917	esengle@gmavt.net
Beth Sengle	482-3917	

6. **Hinesburg - TP Team**

Pat Mainer, Team Leader	482-3134	mainers@gmavt.net
Ray/Mike Mainer	482-3134	

7. **Hinesburg - Upper LaPlatte Team**

Lisa Godfrey, Team Leader	598-7252	merichi@yahoo.com
Sue Mead	482-3834	gfrisch13@hotmail.com
Jonathan Trefry	482-2690	trefryj@att.net

8. **Hinesburg - Patrick Team**

Andrea Morgante, Team Leader	482-5120	morgante@gmavt.net
Chuck Reiss	482-3295	vbrreiss@gmavt.net
Michael Brownbridge	482-3548	michael.brownbridge@uvm.edu