SEGMENT ANALYSIS OF SUCKER BROOK

The Location of Sources of Pollution

Part of the Canandaigua Lake Watershed
Located in the City and Town of Canandaigua

Joseph C. Makarewicz and Theodore W. Lewis
Center for Applied Aquatic Science and Aquaculture
Department of Biological Sciences, SUNY Brockport

and

Stephen S. Lewandowski
Ontario County Soil and Water Conservation District

Funded by the Great Lakes Aquatic Habitat Fund
and the Canandaigua Lake Watershed Task Force

December 1999,
Canandaigua, N.Y.

Table of Contents

SUMMARY

1. **Stressed stream analysis or segment analysis was performed on the watershed of Sucker Brook to identify point and non-point sources of pollution**.

~~2.~~**Major sources of nutrients exist within the Sucker Brook watershed.** Although all areas upstream of Site 1 (south of County Road 32) are contributing to the pollution of Sucker Brook and ultimately Canandaigua Lake, the segment of Sucker Brook starting with Site 1 and upstream of Sites 11 and 13 had extraordinary high levels of several pollutants including phosphorus (1,500% higher than Site 8), nitrate, total Kjeldahl nitrogen (2,700% higher than Site 9) and high levels of fecal coliform bacteria. The nature of the losses (high organic nitrogen, high suspended solids, high fecal coliforms, and high nutrients) combined with the land usage primarily in agriculture suggest that animal wastes are either being lost from a manure lagoon and/or poor practices of application on fields is occurring.

~~3.~~**On most of the sampling dates, an increase in phosphorus and total suspended solids (TSS) levels occurred between Sites 3 and 4 on the western border of the City of Canandaigua.** This was particularly evident during the October rain event in which dissolved phosphorus increased by 300% and TSS increased by ~400% from the upstream site. These losses from the watershed may be related to development activities within this segment of Sucker Brook.

4. **Major sources of chloride (deicing salt) exist in the Sucker Brook subwatershed**. Elevated levels of chloride were observed at Site 2 downstream of Routes 5 and 20 and at Sites 6 and 8 in the City of Canandaigua. The elevated levels of chloride are most likely due to high levels of de-icing salt utilized during this time of year on roads.

5. **The Town of Canandaigua Municipal Salt Pile north of Routes 5 and 20 appears to be polluting segments of Sucker Brook and thus Canandaigua Lake**. Although the segment analysis data do not pinpoint this site because of the lack of sampling points in this region, it is likely that the source is the "uncovered" salt storage pile at this location. To increase our confidence on this conclusion, we sampled above and below the salt storage pile. During a non-event period (i.e., no rainfall), salt levels were >1,040% higher immediately downstream of the salt pile compared to an upstream station. During precipitation events, losses of salt originating from the Town of Canandaigua Salt Pile are expected to be much greater. This Salt Pile represents a major source of salt to Sucker Brook and eventually Canandaigua Lake.

~~6.~~**Major sources of fecal coliform bacteria exist in the Sucker Brook subwatershed.** Fecal coliforms are routinely being found during precipitation events in the City limits. The occurrence of coliform bacteria in this stretch of the stream is of concern. Fecal coliform bacteria indicate that sewage from warm-blooded animals is present in the water. The occurrence of fecal coliform bacteria suggests that the material has not been treated and that a potential exists for disease producing pathogens being present in the water. Because this portion of the stream does pass through an area of homes and an elementary school, the potential of contact exists, especially with children. Levels observed suggest that the "General Contact" levels recommended by the Environmental Protection Agency may be exceeded. The historical and 'on-going' monitoring for fecal coliforms at the Parrish Street Site has consistently yielded the highest coliform counts of any tributary in the Canandaigua Lake Watershed.

7. **Sources of nutrients and soil loss varied over the study period due mainly to changing agricultural practices in the upper watershed and urban runoff in the lower potion of the watershed.** The Sucker Brook watershed is dominated by agriculture land usage (53%) in its upper reaches and by suburban and urban development and usage in the lower portion of the watershed.

8. **Sucker Brook serves the Town and City of Canandaigua as a storm water utility as well as a natural stream, and some characteristics of each use can be seen in stretches.** Sucker Brook has been dredged, filled, spilled on, channelized in sections, salted, obstructed, and called upon to accept piped runoff sometimes mixed with sanitary waste.

RECOMMENDATIONS

1. Within the context of the Canandaigua Lake Watershed Management Plan, a remedial action plan should be instituted to remediate the areas of concern in the Sucker Brook watershed identified in this study.

2. Area farmers should be approached in the areas identified as non-point sources of nutrients and their agriculture practices reviewed. Potential problem areas could include over-fertilization of cropland, poor timing of fertilization, poor choice of tillage practices, improper animal waste management, etc. Corrective action is often quite simple and may have dramatic effects in final nutrient loads carried by Sucker Brook to Canandaigua Lake.

3. Further segment analysis of the segment between Sites 3 and 4 is warranted. This should include fecal coliform bacteria analysis and include the first-order stream that runs past the Town of Canandaigua Municipal Salt Pile and the housing development sites within this stretch (e.g., Canandaigua Village Estates). A review of the storm water runoff plan for the appropriate municipalities should be undertaken. Storm water runoff along local highways may contribute a significant amount of nutrients to Sucker Creek.

4. Compared to sixteen subwatersheds in the Canandaigua Lake watershed, Sucker Brook is delivering twice the amount of salt to the lake compared to any other watershed.

   a. A “sensible-use policy” that balances the safety of the motoring public with environmental concerns by maintaining rates of application in the Sucker Brook watershed at or near the average application rate of the entire Canandaigua Lake watershed should be instituted.

   b. The Town of Canandaigua Municipal Salt Pile on Routes 5 and 20 should be covered immediately**.**

5. Site 7 should be monitored through another year. There appears to episodic pollution events. If persistent, a segment analysis above Site 7 to identify sources is warranted.
6. Consideration of enhancement of the City of Canandaigua program for detection of sources of fecal coliforms is suggested. Not only does such a program reduce possible health concerns but also would reduce nutrient inputs to Sucker Brook and thus Canandaigua Lake.
7. Water quality safe-guards such as erosion control and storm water management ordinances, adopted at the municipal level, should be observed, incorporated in specific development plans, and enforced during construction. The Town and City of Canandaigua specifically address erosion control in detail in their land use regulations. The City’s regulations also mandate the management of storm water runoff from developing sites to mitigate water quality and quantity problems.
8. As BMP's are introduced, efforts should be made to carefully monitor their effects. Success in the identification and remediation of an area demonstrates the effectiveness of this program to both the public and the government officials who support this program.
9. A retro-fit of the City’s drop inlet storm sewers is encouraged and the benefits of improved street sweeping should be investigated. Newer models of street sweepers have greater retention of fine particles that not only protect the infrastructure but also improve water quality. More frequent street sweeping would reduce phosphorus and soil loading to Sucker Brook.

INTRODUCTION

Sucker Brook is located in the northwest portion of the Canandaigua Lake watershed, Ontario County, New York (Figs. 1 and 2). The relatively large watershed encompasses 6.9 square miles and flows into Canandaigua Lake at the City of Canandaigua. The Canandaigua Lake Watershed Task Force with the assistance of the Ontario County Planning Department and the Soil and Water Conservation District has monitored Sucker Brook since 1996 in collaboration with the State University of New York at Brockport's Center for Applied Aquatic Science and Aquaculture (CAASA). Monitoring efforts have included the installation of a permanent gauging and sampling station located at Clark Street (Site 9, Figure 3) on the main branch of Sucker Brook. SUNY Brockport has provided analytical services for water quality parameters as well as consulting services on the direction of the monitoring program. Based on two years of monitoring, a priority ranking of watersheds indicated that the Sucker Brook subwatershed was one of the major sources of phosphorus, nitrate, organic nitrogen, chloride and soils to Canandaigua Lake. In fact, Sucker Brook was delivering twice the amount of salt to the lake compared to any other Canandaigua Lake watershed (1, 2). That is, Sucker Brook and the watershed it drained, is a major source of nutrient and soil pollution to Canandaigua Lake. Previous results indicate nutrient loading from Sucker Brook to Canandaigua Lake is high especially during precipitation events (3). Where are the sources of nutrients, soils and salts within the Sucker Brook subwatershed? The next step is to identify the point and non-point sources by stressed stream analysis or segment analysis. With this report, we provide evidence suggesting the location and the intensity of pollution sources in the Sucker Brook watershed.

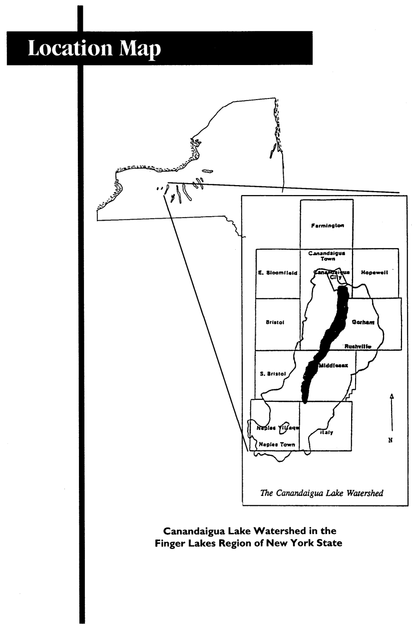
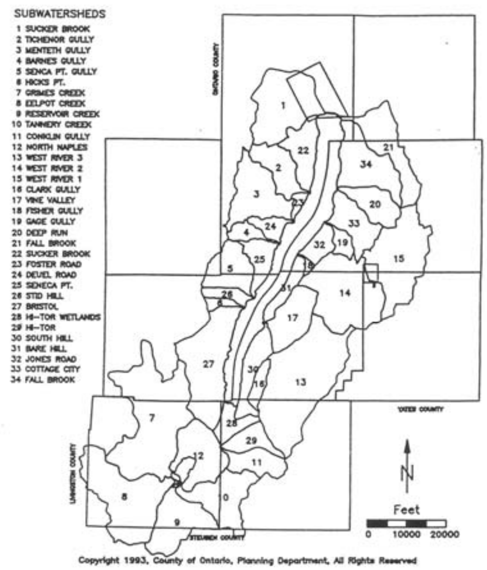


FIG. 1. CANANDAIGUA LAKE

Within an entire lake basin, stressed stream analysis is an approach that identifies impacted sub-watersheds and their associated streams (4, 5, 6). Within a stream, stressed stream analysis is an approach for determining how and where a stream and its ecological community are adversely affected by a pollution source or other disturbances. Stressed stream analysis is an integrative, comprehensive approach for determining the environmental health of a watershed and its constituent streams. It is a technique that identifies the sources, extent, effects and severity of pollution in a watershed. In its fullest use, it combines elements of the sciences of hydrology, limnology, ecology, organismal biology and genetics in an integrated approach to analyze cause and effect relationships in disturbed stream ecosystems.



Canandaigua Lake Watershed - subwatershed boundaries.

FIGURE 2

Within a sub-watershed, the stream(s) is used to monitor the "health" of the watershed. Because nutrients are easily transported by water they can be traced to their source by systematic geographic monitoring of the stream. Stressed stream analysis is a technique that divides the impacted sub-watershed into small distinct geographical units. Samples are taken at the beginning and end of each unit of the stream to determine if a nutrient source occurs within that reach. At this point, the cause and extent of pollution has been identified. If needed, the severity of the pollution within the impacted sub-watershed and or the entire watershed can then be evaluated by spatial analysis of the quantity and quality of biological indicators, such as fish and invertebrates, and by biological examination of structural and functional changes in individual organisms and populations in affected communities. Once identified, sources may be corrected using "Best Management Practices" (BMP).

DEFINITIONS

<u>Coliform bacteria</u>- Short, facultatively anaerobic rods that ferment lactose to produce gas at 35°C. Usually used in bacteriological analysis of water to refer to bacteria that are physiologically similar to the intestinal bacterium *Escherichia coli*, such as *Enterobacter aerogenes.*

Total Coliform analysis- In the bacteriological analysis of water, the type of analysis that does not distinguish among the various bacteria constituting the coliform group but rather gives an estimate that includes the presence of any coliform.

Fecal coliforms- Coliform bacteria such as *Escherichia coli* that are able to grow at 44.5^{o}C and whose normal habitat is the intestinal tract of warm-blooded animals.

Total Phosphorus- A measure of all forms of the element phosphorus. Phosphorus is an element required for plant growth on land or in water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction, of lakes. Phosphorus may enter a watershed in soluble or organic form from several sources including sewage, heavy-duty detergents, fertilizer and agricultural waste. Some forms of phosphorus are more available to and cause more immediate activity in plants.

Soluble Reactive Phosphorus- A measure of the most available and active form of phosphorus.

Nitrates + Nitrites- A measure of the soluble forms of nitrogen used readily by plants for growth. Sources of nitrates in the environment are many and include barnyard waste and fertilizer.

Total Kjeldahl Nitrogen- The Kjeldahl method is a convenient method of analysis for nitrogen but cannot be used for all types of nitrogen compounds. It is, however, a good measure of organic nitrogen, including ammonia. Manure, for example, contains a large amount of organic nitrogen.

Chloride- A measure of the mineral, most commonly found as sodium chloride (NaCl), dissolved in water. NaCl naturally occurs in deep layers of local bedrock. Mined, it is stored and spread as a de-icing agent on roads and other pavements.

Total Suspended Solids - A measure of the loss of soil and other materials suspended in the water from a watershed. Water-borne sediments act as an indicator, facilitator and agent of pollution. As an indicator, they add color to the water. As a facilitator, sediments often carry other pollutants, such as nutrients and toxic substances. As an agent, sediments smother organisms and clog pore spaces used by some species for spawning.

BACKGROUND AND HISTORY

THE WATERSHED

Size and shape:

Sucker Brook is the most northwestern subwatershed of the 174 square mile Canandaigua Lake watershed (Fig. 3). It encompasses 6.9 square miles or 4347 acres in the Town and City of Canandaigua, or 4% of the total watershed. Sucker Brook subwatershed is about 3 miles long and 2 miles wide and drops 332 feet from where the stream originates (1020’ mean sea level) to the lake (688 msl) for an average gradient of 1 % over its whole length (7, 8).

Bedrock and Soil:

Bedrock in the area is relatively flat shale and limestone in beds that dip slowly to the south. Watershed soils are mostly glacial till, dominated by the Honeoye-Lima-Kendaia association whose members are moderately to very well drained. Up to 80% of the association is good to excellent for agricultural use. A clay layer or fragipan at a depth of about 2-3 feet, which holds moisture in the rooting zone, is a significant impediment to the use of the soil for on-site wastewater treatment (9).

FIGURE 3

At the south end of Sucker Brook, the stream flows through large areas of Sloan silt loam and Lakemont silty clay loam, which represent, respectively, alluvial (on land) deposits and lake-laid silts and clays deposited during a post-glacial time when Canandaigua Lake water levels were substantially higher than at present (Fig. 4).

Freshwater Wetlands:

The NYS DEC has mapped 8 freshwater wetlands of greater than 12.4 acres wholly or partly in the Sucker Brook subwatershed. Wetlands CL-1, CL-3, part of CL-5, CL-6, part of CL-7, CG-18, CG-19, and CG-21 are located along stretches of Sucker Brook.

Comparisons of NYS DEC maps and aerial photos of the area indicate alterations of the wetlands, probably through clearing and drainage for agricultural purposes. Some of the normal functions of wetlands in attenuating flows seem to have been lost (10).

Land Use:

Land use was characterized for modeling purposes in 1994, using 1985 aerial photographs. Sucker Brook is 9% forest (391 acres), 17% residential (739 acres), 8% idle (348 acres), 7% commercial/industrial/institutional (304 acres), 53% agricultural (2304 acres), and 3% ponds/wetlands (130 acres). Population of the subwatershed is 6,822 living in 3,085 units. Fifteen active development sites, two SPDES permits, fourteen petroleum and two chemical

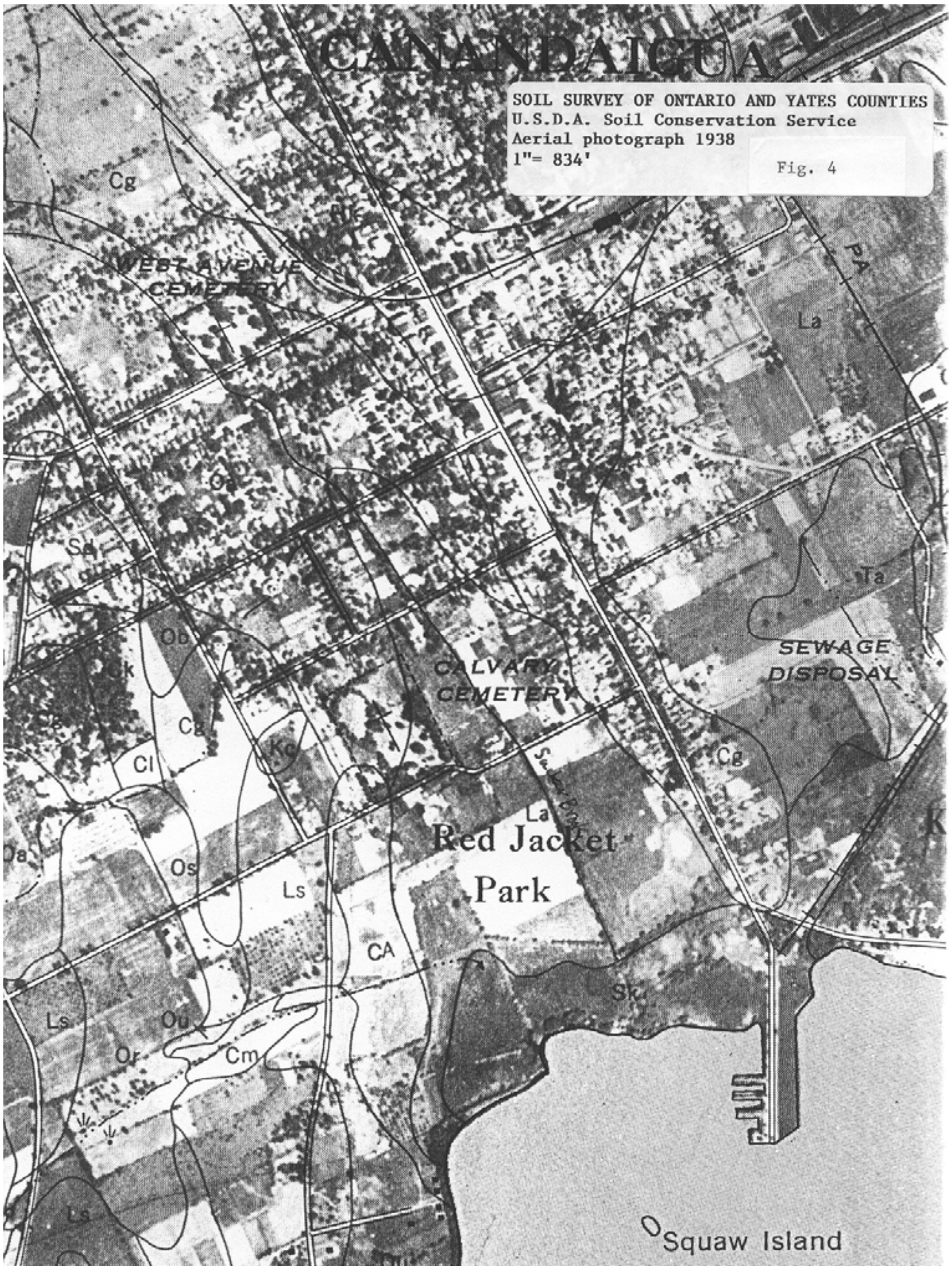


FIGURE 4. SOIL SURVEY

Bulk Storage Facility Permits, and two Inactive Hazardous Waste Sites were detailed in *The State of the Canandaigua Lake Watershed-1994* (7, 11).

Zoning Regulations:

Both the Town and the City of Canandaigua have current comprehensive plans and zoning regulations. In the Town, most of the Sucker Brook subwatershed is zoned Agricultural-Residential-Rural. Large areas north of North Street and along the C.R. 32 corridor are zoned Residential, and a Planned Unit Development is designated between Buffalo Street Extension and West Avenue. A section centering on the North Street/Brickyard road intersection is zoned Industrial.

In the City, the Sucker Brook subwatershed is primarily zoned as some form of Residential, including Residential-Lakefront near the lake. The Commercial districts include restricted, central business, and heavy. The hospital is central to a Health-Related district, and there is a small Manufacturing zone.

THE STREAM

Channel Characteristics:

Sucker Brook flows predominantly north for three miles in the Town of Canandaigua, turns east for one mile, and then flows south for two miles through the City of Canandaigua to the lake. Depending on definitions of "ephemeral" and "intermittent" streams, Sucker Brook is a second or third order stream. There are 19.3 miles of tributary channels included in the subwatershed (7, 8).

SUCKER BROOK

Form and Comparison:

In effect, Sucker Brook reverses its course to drain to Canandaigua Lake. It is mirrored in this movement by Fallbrook on the northeast side of the lake. Both show signs of having been "captured" by the Canandaigua Lake watershed from an earlier, northerly drainage pattern. Unlike Fallbrook, however, Sucker Brook is less linear and more dendritic (leaf-like) in form. The basin's shape influences the time distribution of runoff, and in a dendritic pattern like Sucker Brook's, tributaries feed into the main stream at the same time producing a sudden high peak flow. Three main tributaries come together near North Bloomfield Road to form the main channel, which runs through the City (12, 13).

Gradient:

In 1996, the mile-long segment of Sucker Brook from Parrish Street to Pearl Street in the City was surveyed. The stream gradient fell into three main categories: from Parrish to West Avenue the gradient is 0.3 %; from West Avenue to Gibson Street the gradient is. 0.45 %; and from

Gibson to Pearl Street the gradient is 0.85 %. As might be expected, some deposition of heavier materials (cobbles and stones) is happening at the juncture of the 0.85 and 0.45 gradients (14).

Discharge:

Discharge from the Sucker Brook watershed was continuously measured from 13 April through 23 July, 1996. Average flows were 34,187 cubic meters per day, which can be converted to about 14 cubic feet per second or 9,032,171 gallons per day. Measured flows in Sucker Brook range from less than 5 cfs (cubic feet per second) to more than 300 cfs. From the record of flows, a rating curve relating discharge with stream level has been constructed (Fig. 5).

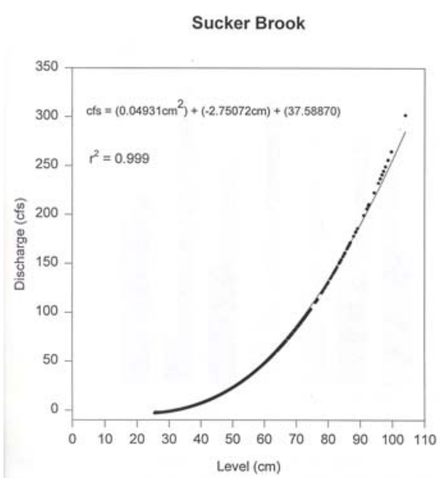


FIGURE 5. RATING CURVE

Responsiveness to Precipitation:

Sucker Brook subwatershed is considered “flashy” or quick to reach a peak on the hydrograph. Explanations include a relatively high percentage of impermeable surfaces in the watershed, direct transport of storm water through the City’s drainage system, and agricultural drainage systems, which limit runoff storage in low spots and wetlands. With a light rainfall, two peaks are discernable on Sucker Brook’s hydrograph, the first marking the almost instantaneous flow of City storm sewers and the second the delayed flow from the larger watershed (3).

Fisheries:

Sucker Brook is named for the White suckers, *Catostomus commersoni*, which spawn in the brook in April and May. When water temperatures and flow are right, they swim upstream from the lake to areas with gravel bottoms and good currents. They have been observed spawning in large numbers at the raceways under the Woodlawn Cemetery bridges. After spawning, the adults return to the lake, and the eggs hatch in 5-10 days.

Though suckers are tolerant of poor environmental conditions, they are also residents of pristine lakes and streams. White suckers may live for 10 years and attain 20 inches in length and 4 pounds in weight. Sucker fry feed on microcrustaceans, rotifers and algae; adults feed on larger crustaceans, insects, snails and clams. They are selective in their diet and can be eaten, especially in the spring, with caution (bones) and pleasure (15).

In the spring of 2000, a Finger Lakes Community College Fish Management class will conduct a survey of Sucker Brook’s waters.

Channel Modifications:

From West Avenue south, Sucker Brook shows signs of channel modification. In natural conditions, the lower gradient stretch of the stream would display deposition and meandering. Instead, the channel is extremely straight. 1938 aerial photographs show a straight stream, probably the product of earlier modifications. Signs of meanders and alternate channels still exist in the vicinity of Bristol, Clark and Parrish Streets, especially in Calvary Cemetery. The overall effect of channel straightening, including removal of deposited materials and diking of banks, would be increased down-cutting of the stream and increased bank instability (12, Fig. 4).

In 1995, the City and Town of Canandaigua cooperatively excavated about one thousand feet of the channel of Sucker Brook north of its intersection with Buffalo Street, in order to improve drainage from a developing area east of the brook and in the northwest corner of the City. All vegetation was cleared from the channel, which was excavated to an elevation below that of the Buffalo Street bridge. No re-vegetation or other treatment of the channel was attempted.

Storm Drain Outfalls:

Sucker Brook serves as an extension of the City’s system of storm drains. In the mile-section surveyed in 1996, thirty-one outfalls, ranging in diameter from four inches to three by five feet, were noted. Some may have been missed. The combined diameter of these thirty-one outfalls would equal a pipe of 47.9 feet (14).

Bridges:

In the City, Sucker Brook passes through a series of bridges. From north to south, the bridges are Buffalo Street (18’ wide), Pearl Street (25’), Elementary School (25’), Gibson Street (21’), West Avenue (22’), Chapin Street (24’), Bristol Street (22’), Clark Street (21’), and Parrish Street (25’). Despite the addition of substantial amounts of storm water through the City’s storm drain system, the channel itself, at least as expressed in its bridges, changes little (14).

Other Modifications to the Stream Ecosystem

History of Dredging and Squaw Island:

In the mid- to late-1950s, a dredge was operated in the area off the mouth of Sucker Brook to allow better access to the lake from a marina west of the City Pier. Other beneficiaries included the Bluebird, a speedboat piloted by Donald Campbell in search of the world water speed record (unsuccessful). Further dredging and channelization was undertaken to enable lake-access for the hotel (now Canandaigua Inn on the Lake) and the development of Holiday Harbor (formerly a marsh immediately west of the Sucker Brook channel). In 1983, the NYS Office of Parks, Recreation and Historic Preservation, after acquisition of what had been the City’s Red Jacket Park, dredged the Sucker Brook channel as far north as the Route 5&20 bypass to develop a State Boat Launch and Marine Park. In 1985, a marina continued dredging north as far as Parrish Street in hopes of gaining water-access to a boat storage facility between Routes 5&20 and Parrish Street (16).

Squaw Island as a Delta:

Squaw Island is a natural 54’ by 120’ island formed of materials deposited during the post-glacial period (c.11,000 years) in the relatively flat and shallow northwestern part of Canandaigua Lake. According to an investigation by Dr. Richard Young of SUNY Geneseo, Squaw Island is formed “on a sand and gravel bar, which was created by the counterclockwise longshore currents interacting with the delta deposits of Sucker Brook…. Sucker Brook delta (now largely destroyed by dredging) would have been historically the logical source for much of the coarser gravel material comprising the bar….”(Fig. 6). Four reasons for the diminishing size of the island were offered, including “periodic dredging, deepening and widening of the mouth and delta area of Sucker Brook” (17).

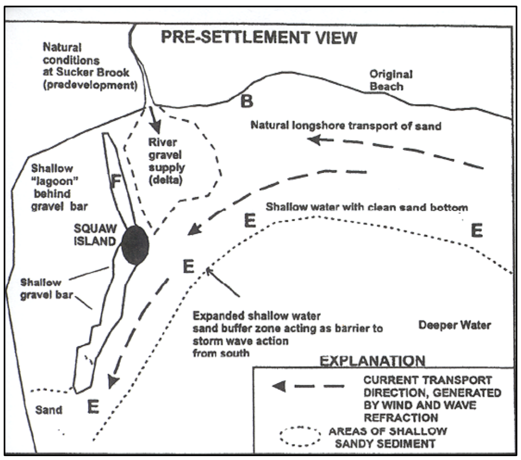


Figure 6. Pr obable prehistoric appearance of northern shoreline of Canandaigua Lake before installation of pier and breakwater structure near B (17).

<u>Flooding</u> <u>of</u> <u>Sucker</u> <u>Brook</u>

Over the years, Sucker Brook has periodically caused local flooding problems. Man-made alterations and obstructions in the stream and the addition of storm water piped from the City’s drainage infrastructure (about two-thirds of the City drains to and through Sucker Brook) have exacerbated flooding problems (16).

Gradient and Deposition:

Sucker Brook exhibits several major gradients within the City of Canandaigua, which influence the ability of the particular stream-reach to detach and transport sediments. When the gradient diminishes, the stream will drop its load of transported sediments, which will further constrict the channel and cause flooding.

Two Kinds of Floods:

Sucker Brook floods during major storms, such as in 1939 and during Hurricane Agnes in 1972, because of insufficient channel capacity. In the City, the primary floodplains, which would have offered flood-relief have been filled and developed. In the case of major storms over the whole Canandaigua Lake watershed, high water conditions in the lake itself can affect water levels in Sucker Brook as far north as Bristol Street.

Sucker Brook floods more commonly due to blockages of ice and debris. These floods coincide with major spring runoff events, which include rainfall, as well as ice and snow melt. The flooding of tributaries to Sucker Brook (many of them now piped and buried) such as Barlow Brook either through excess runoff or blockages was recorded in 1976.

HISTORY OF POLLUTION WITHIN THE WATERSHED

New York State Department of Environmental Conservation Records:

The NYS DEC keeps records of spills reported to its Region 8 office in Avon. Spills reporting is required by law, but if compliance rates associated with SPDES reporting are similar, probably only 50-60% of the total spills are reported.

1986-1992 Period:

A record of spills, sorted by subwatershed, was included in The State of the Canandaigua Lake Watershed-1994. The period of 1986-1992 was covered, and of 129 spills reported in the Canandaigua Lake watershed between 1986 and 1992, 55 (43%) were to Sucker Brook. Of the 55 spills, Canandaigua Wine was responsible for 12 (22%), the NYS Department of Transportation 7 (13%), Mobil Chemical 5 (9%), and the Canandaigua School bus garage and Rochester Gas and Electric spilled twice each. Substances spilled to Sucker Brook include gasoline, fuel, diesel, hydraulic and waste oils, wine wastes, kerosene, epoxy solutions, 1% styrene monome, toluene, MEK, isopentane, and unknown substances (7). According to the *Daily Messenger* newspaper files, significant fish-killing spills occurred in 1973, 1979 (2000 gallons grape juice), 1980 (100 gallons wine), 1981 (unknown quantity of diesel fuel), 1987 (unknown quantities of gasoline, oil, ammonia), and 1992

DEAD FISH – SUCKER BROOK

(unknown quantity silage).

1993-1998 Period:

A study of spills from 1993-1998 has determined that of 144 reported spills located in the Canandaigua Lake watershed, 53 (37%) were to Sucker Brook. Of the 53 spills, Mobil Chemical (later Tenneco Packaging, now Pactiv) was responsible for 10 (19%), Canandaigua Wine 5 (9%), Rochester Gas & Electric 5 (9%), and Canandaigua City Schools (various sites) four times. The rate of spills in the Canandaigua Lake watershed and the ratio in Sucker Brook is very similar between 1986-1992 and 1993-1998, but the responsible parties are changing. Canandaigua Wine has halved its spill-frequency in the later period. Mobil/Tenneco has more than double its frequency of spills in the later period. According to the *Daily Messenger* newspaper files, significant fish-killing spills occurred in 1993 (unknown quantity agricultural waste), and 1997 (unknown quantity boiler cleaner) (16).

Most Frequent Source of Spills:

Overall, Canandaigua Wine has spilled most frequently (17 times) to Sucker Brook in the period 1986-1998. Some of Canandaigua Wine's problems are that its facility has been at the present location many years, is located directly over the eastern branch of Sucker Brook, and handles large quantities of materials that are corrosive and/or oxygen-demanding.

Canandaigua Wine was required in August 1985 to replace old and corroded plumbing in their facility to direct spills away from Sucker Brook and toward the City's sanitary sewers. Canandaigua Wine maintains its own sewage treatment plant to pre-treat waste released to the City's sanitary sewers (7, 16).

Canandaigua Wine's spill record has improved in recent years. Gates on the pipe which conveys Sucker Brook under the facility allow Canandaigua Wine to detain spills and clean them up in-situ, but further light industrial development of the watershed north of Canandaigua Wine may intensify flows through the pipe at times.

Cross-Connections of Storm and Sanitary Sewer:

Many older cities have unintentional cross-connections between their sanitary and storm sewer systems. The City of Canandaigua has an ongoing detection program, and cross-connections are eliminated as detected and/or as included in public works projects. The costs of correction can be very large.

Sanitary Waste- 1985 and 1987:

Cross-connections can also be accidental. Several accidental cross-connections occurred in the City in 1985 and 1987. They were detected first by tests carried out by Canandaigua Lake Pure Waters, Ltd. and the Watershed Inspector, then verified and eliminated by the City. In 1985, an apartment building was detected as improperly connected to an abandoned sanitary sewer emptying into a storm sewer that discharged directly to Sucker Brook. In 1987, utility drilling caused punctures in a sanitary sewer which discharged waste to a storm sewer and Sucker Brook.

De-icing Salt Usage:

There are 46.83 miles of public roads in the Sucker Brook subwatershed. Because of relatively gentle slopes, the roads are not rated as substantial producers of eroded sediment. Sucker Brook has, however, the most roads of any subwatershed and produces some of the saltiest runoff. According to the 1998-99 de-icing salt survey, 1438 tons of salt were used on roads in the Sucker Brook subwatershed. The City used 985 tons (68%) at a rate of 33.6 tons per mile. The Town used 280 tons (20%) at a rate of 24.1 tons per mile. NYS DOT used 173 tons (12%) at a rate of 33.9 tons per mile. All are greater than the 1998-99 average rate of 20.2 tons per mile for the Canandaigua Lake watershed. In addition, the Town of Canandaigua maintains an uncovered salt pile very close to a Sucker Brook tributary (7, 18). Another salt storage site exists in the watershed. The NYDOT Municipal Salt Pile is covered and located on 125 Parrish Street.

Airport Expansion- 1994:

In the summer of 1994, during construction of additional runways at the Canandaigua Airport, an unexpected connection to the Sucker Brook subwatershed was discovered. Turbid water from the construction site was being conveyed to a holding area which contained an existing drop-structure and pipe with an unknown outlet. Samples from Sucker Brook showed 11 mg/l of suspended solids above the pipe's outlet in Sucker Brook at North Bloomfield Road and 2790 mg/l below the outlet. Erosion control practices on the airport property reduced suspended solids loading to normal levels by January, 1995.

HISTORY OF MONITORING

Fecal Coliform - Tributaries:

Canandaigua Lake Watershed Inspectors Roger McDonough and George Barden, employed by the Watershed Commission enabled under State Public Health Law, have conducted a summer testing program for fecal coliform bacteria at about twenty sites in major tributary streams from 1984 to present. One testing station is located at Parrish Street, the southern-most accessible site above the lake's influence. In several instances, when high counts were discovered at Parrish Street such as in 1985 and 1987, other locations in Sucker Brook have been added to the testing regime to discover point sources of discharge.

Large variations in fecal coliform counts occur in the 1984-93 period. For example high readings in 1985 [April 23 (40,000 col/100 mL)), May 7 (183,000), May 30 (2,200), and June 30 (300,000)] are interspersed with lower readings, such as the 30 count on July 24. Fecal coliform tests were also performed at some storm sewer outfalls to Sucker Brook. The outfall at Parrish Street yielded counts of 30,000 on 10/28/86, 30,000 on 6/30/88, 45,000 on 10/27/88 and less than 1 on 4/27/89. Since 1994, fluctuations have moderated somewhat, with the highest recorded as 3740 on June 15, 1998 and 30 as the lowest on April 22, 1997. The fecal coliform testing site at Parrish Street on Sucker Brook has consistently yielded the highest counts of any tributary in the Canandaigua Lake watershed.

Total Coliform – Canandaigua Lake:

Canandaigua Lake Pure Waters, Ltd. began occasional testing of Canandaigua Lake in the early 1970s. Its testing was carried out by students, the Watershed Inspector, and its employee, Scott Sherwood. Good records for a summer in-lake testing program at ten sites exist for the period 1983-present. Some of the sites are in deep, open water, and others are located off the mouth of major tributaries. One of the tributary-related sites is at the mouth of Sucker Brook. Testing in the area is complicated by various stream flows, lake levels, and wind and other mixing effects.

1983-Present:

Between 1983 and 1993, total coliform numbers fluctuated both widely and rapidly. In 1983, in-lake total coliform counts of 9,100 and 43,000 col/100mL were recorded for the respective dates of June 29 and September 6. On September 26, 1984, a count of 3,000 was recorded, and on July 28, 1986, 3,000 coliform colonies were counted. Reports from 1992 and 1993 included numerous instances of colonies too-numerous-to-count. Between these instances of high readings, however, and in some instances only days later or earlier, no coliform colonies were observed. This situation is suggestive of coliform sources associated with precipitation events washing materials into storm drains and /or losses from agricultural facilities.

In the period between 1994 and 1999, there has been much less variation in total coliform abundance from in-lake samples taken off the mouth of Sucker Brook. The recorded highest count was 236 col/100mL on June 29, 1999, and less than one colony was recorded on September 24, 1998.

Overall, in-lake testing site # 1, off the mouth of Sucker Brook, has always displayed counts higher than the open-water sites and usually higher than any other tributary-site (20). Also

Nutrient Testing:

With funds made available from New York State through the Finger Lakes Aquatic Vegetation Management Program, Dr. Bruce Gilman of the Finger Lakes Community College monitored selected tributary streams of Canandaigua Lake between April, 1989 and April, 1996. Generally, two sites on Sucker Brook were tested, an upper (at Buffalo Street) and a lower (at Parrish Street), to distinguish the characteristics of runoff from the upper, more rural segment from characteristics of the lower, more urbanized runoff. During the 1994-6 period, grab samples were tested for total phosphorus, nitrate, ammonia, chloride and for total Kjeldahl nitrogen. Flow measurements were not recorded (21).

CIVIC IMPROVEMENTS IN THE WATERSHED

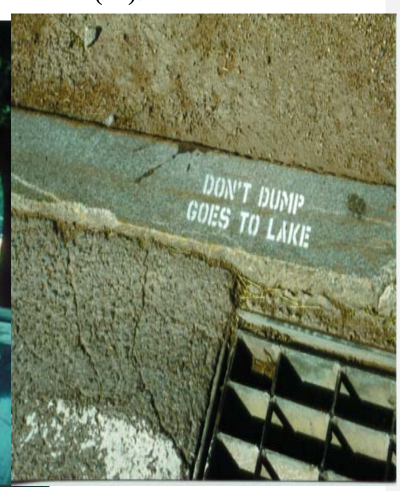
Clean-Up:

Neighbors, individuals and groups of citizens in the City have been concerned with problems in and around Sucker Brook for years. A volunteer clean-up of Sucker Brook scheduled in 1976 proved too large for a small group without power tools. Mayor Roger Avery suggested designating the Sucker Brook corridor as a linear park in 1978. In 1985, as part of a settlement with the City over pollution charges, the Canandaigua Wine Company cleaned the residue of a spill of organic material from much of the length of Sucker Brook.

Storm Drain Stenciling:

Stains on the grates covering the inlets, which allow runoff from the streets to enter the City's system of buried storm drains indicate that substances like antifreeze, used oil and paint have been illegally dumped. Probably citizens mistakenly believed the storm drains connect to the sewage treatment plant. Most connect directly to Sucker Brook. In 1992 and 1997 special projects, Canandaigua Middle School students painted "Do Not Dump- Drains to Lake" on hundreds of drop inlets connected to the City's system of storm drains (16).

THE CREW



THE PRODUCT

Street Sweeping:

The City of Canandaigua owns a street-sweeper and regularly uses it on City streets. The sweeper is an older model, so it probably retains few smaller particles. Recent studies have shown that newer models with greater retention of fine particles not only protect the infrastructure but also improve water quality. Though any use of a sweeper improves the quality of urban runoff, recent studies have also shown that phosphorus loading from urban runoff is significantly diminished by more frequent sweeping (four times rather than once per week).

Channel Repairs:

Sections of Sucker Brook's channel have proved unstable, but the scope and cost of repairs have been beyond the resources available to individual property owners. In 1984, the Senior Citizen Housing Project at 80 Parrish Street applied to the federal government for assistance in repairing a 60-foot stream bank "blow-out" that was progressing toward their foundation. Two hundred and forty tons of stone riprap, with each piece weighing between 750 and 2000 pounds, were placed on a gravel bed re-graded to a 3:1 slope. The standards and specifications followed in this project were intended to solve the blow-out problem by putting a patch in place that would withstand the erosive forces of Sucker Brook at peak flow. In addition, the project was designed to avoid creating further problems on adjacent properties by simply shifting the forces in their direction.

In 1987, the City repaired a deteriorating, vertical wall in Sucker Brook near West Gibson Street. The location of houses in Sucker Brook's floodplain made such repairs necessary as safety of residents would have been imperiled by the wall's failure. The instability of the stream bank of this lower region of Sucker Brook is expected and is a result of the straightening and channelization of this portion of the stream.

Macroinvertebrate Studies and Streambank Improvements:

Sucker Brook on the Canandaigua City School grounds has been used as a training ground for numerous school classes and groups in the techniques of water quality assessment using aquatic macroinvertebrate analysis. The presence or absence of certain aquatic macroinvertebrates (often insects) is a quick indicator of water quality, for preliminary assessments. In 1998, Canandaigua Middle School students carried out assessments and comparisons of Fallbrook and Sucker Brook. Reports presented to the School Board resulted in 1999 streambank plantings on school grounds to enhance the quality of habitat for stream life (16).

SAMPLING AND ANALYTICAL METHODS

Segment analysis was performed on four dates on Sucker Brook (24 January, 22-23 March, 23 April, and 14 October 1999). Sampling locations are shown on Figure 3. Samples were analysed for nitrate, soluble reactive phosphorus, total phosphorus, total Keldahl nitrogen, chloride, total suspended solids, and fecal coliforms. Field sampling was completed by Stephen Lewandowski of the Ontario Soil and Water Conservation District and Robin Evans of the Canandaigua Lake Watershed Task Force.

During the initial stressed stream analysis on 24 January 1999, nine stations were sampled on Sucker Brook (Stations 1 to 9). On the subsequent sampling dates additional samples were taken on specific sub-watersheds that showed particularly high values during the previous sampling efforts. Fifteen stations (Stations 1 to 15) were sampled on the last three dates. All samples were generally taken within 90 minutes. Specific locations of all sampling sites (Fig. 3) are presented in Table 1

All sampling bottles were pre-coded so as to ensure exact identification of the particular sample. All sample bottles were routinely cleaned with phosphate free RBS between sampling dates. Containers were rinsed prior to sample collection with the water being collected. In general, all procedures followed EPA standard methods (22) or Standard Methods for the Analysis of Water and Wastewater (23). Sample water for dissolved nutrient analyses (SRP, nitrate + nitrite) was filtered immediately with 0.45 μm MCI Magna Nylon 66 membrane filters and held at 4^{o}C until analysis. Subsequent analyses were either frozen or analyzed within 24 hours of collection.

Nitrate+Nitrite: Dissolved nitrate+nitrite nitrogen were performed by the automated (Technicon autoanalyser) cadmium reduction method (23).

Soluble Reactive Phosphorus: Sample water was filtered through a 0.45μm membrane filter. The filtrate was analysed for orthophosphate using the automated (Technicon) colorimetric ascorbic acid method (23). The formation of the phosphomolybdeum blue complex was read colorimetrically at 880nm.

Total Phosphorus: The persulfate digestion procedure was used prior to analysis by the automated (Technicon autoanalyser) colorimetric ascorbic acid method (23).

Total Kjeldahl Nitrogen: Analysis was performed using a modification of the Technicon Industrial Method 329-74W/B. The following modifications were made:

- In the sodium salicylate-sodium nitroprusside solution, sodium nitroprusside was increased to 0.4 gm/L.

- The reservoir of the autoanalyser was filled with 2M H_2SO_4 instead of distilled water.
- Other reagents were made fresh prior to analysis.

Chloride: Chloride analysis was performed using the mercuric nitrate method (23).
Total Suspended Solids: APHA (1995) Method 2540D was employed for this analysis.

QUALITY CONTROL

The Water Chemistry Laboratory at SUNY Brockport is certified through the New York State Department of Health's Environmental Laboratory Approval Program (ELAP - # 11439). This program includes bi-annual proficiency audits, annual inspections and good laboratory practices documentation of all samples, reagents and equipment (Table 2).

RESULTS

Chronological Account of Stressed Stream Analysis:

24 January 1999 (Figures 7-12)

The initial sampling event occurred on 24 January 1999 and was characterized as the 'first flush' of the stream after an extended period of little or no flow. The stream was elevated following a light rainfall (0.11 inches of rain measured at the City of Canandaigua Water Treatment Plant). Nine stations were sampled in the Sucker Brook watershed and results are presented in Table 3.

Nitrate (NO_3), total Kjeldahl nitrogen (TKN), total phosphorus (TP) and soluble reactive phosphorus (SRP) levels were high all along the Main Branch (Stations 1, 3, 4, and 9) of the stream. The furthest upstream site at County Road 32 (Site 1) had the highest elevated levels of NO_3, TKN, TP and SRP (Site 1: NO_3 = 8.5 mg N/L, TKN = 1770 µg N/L, TP = 279 µg P/L, SRP = 155 = µg P/L, Table 3) indicating a source of phosphorus and nitrate in the upper reaches of that branch. Based on these results, it was decided that during the next precipitation event several sampling sites on the first order streams would be added to the sampling pattern upstream of Site 1.

Total phosphorus (TP) and soluble reactive phosphorus (SRP) above Site 7 (on the east branch near the Elementary School) also were high, especially for TP where levels reached 1,200 µg/L (Fig. 7). Clearly a source of these nutrients exists above this point on that day.

Sub-watersheds draining tributaries at Sites 2, 5, and 8 did not have excess amount of nutrients and suspended solids. Elevated levels of chloride were observed at Site 2 downstream of Routes 5 and 20 and at Sites 6 and 8 in the City of Canandaigua (Fig. 11). The elevated levels of chloride are most likely due to high levels of de-icing salt utilized during this time of year on roads.

Additional sampling sites were added to subsequent sampling trips to begin to narrow down and identify the sources of the elevated parameters observed on 24 January 1999.

22-23 March 1999 (Figures 7-13)

The 22-23 March 1999 sampling trip encountered similar weather and stream conditions (stream elevated after 0.39 inches of rain) as the first sampling trip with the elimination of the 'first flush' condition. Five additional sites were added in the uppermost reaches of the main stem of Sucker Brook (Sites 10 to 15). Results are presented in Table 4.

As in January, elevated concentrations of TP, SRP, TKN and NO_3 were observed upstream of Site 1 (south of County Road 32). Elevated levels of SRP, TP and TKN between sites 10 and 14 and Sites 11 and 13 on two first order tributaries indicate a significant source of nutrients in these reaches of the stream. Nitrate levels also increased between Sites 1 and 10, 1 and 11 and 1 and 12 on first order streams that converge at Site 1 to form the main stem of Sucker Brook. This entire area south of Site 1 is associated with agriculture. The significant increase in fecal coliforms between Sites 1 and 11 suggest that the increase in organic nitrogen and phosphorus is likely due to improper disposal of organic animal wastes. We believe that rainfall running over the surface of the land is carrying animal wastes into the headwaters of Sucker Brook and eventually into Canandaigua Lake.

As in January, chloride levels were elevated in segments of the stream within the city limits of Canandaigua (Fig. 11). Undoubtedly, this is related to deicing salt usage during this period on roads.

Another source of phosphorus within the Sucker Brook watershed is evident by the increase in both TP and SRP in the segment between Sites 3 and 4 (between County Road 30 and Buffalo

Road)(Figs. 7 and 8). There was also a small increase in fecal coliform from Sites 3 to 9 roughly within the Canandaigua City limits (Fig. 13). The increase in phosphorus and fecal coliforms suggests that a source of fecal contamination exists in this segment of the stream. This may be associated with combined storm sewer flows that apparently exist in the segment and development occurring in this section.

23 April 1999 (Figures 7-13)

A stressed stream analysis was performed on 23 April 1999 encompassing all sites previously sampled. Compared to the previous events sampled, a larger amount of rainfall (0.82 inches of rain) occurred. Tabular results are presented in Table 5.

All the first order tributaries entering the main stem (Sites 9, 6, 4, and 3) of Sucker Brook during the April event had elevated concentrations of TKN, TP and SRP. The increase in TKN, TP and SRP between Sites 1 and 11 (south of County Road 32) suggest, as in previous segment analysis, that a major of source of organic nitrogen and phosphorus occur in this segment – an area in agriculture. Again fecal coliforms levels are very high (over 3000 colonies/100 mL) in portions of this upstream area (Site 10 on Hickox Road, Fig. 13). The nutrient level, the high TKN values, suggestive of high organic nitrogen, and the presence of fecal coliforms, and the fact that similar results were observed during the last precipitation event reinforce the hypothesis that a major source of nutrients exists in this agricultural area. These upstream sites are affecting the entire Sucker Brook, which has been shown by annual monitoring to be one of the major contributors of nutrients into Canandaigua Lake (1). Nitrate levels are also clearly elevated in this entire area (Sites 1, 10, 11, 12, 13, 14, and 15 on Fig. 10). Remediation of this area would reduce nutrient loss from the watershed to Canandaigua Lake.

As in the previous event sampling, an increase in TKN was evident between Sites 3 and 4 (between County Road 30 and Buffalo Road)(Fig. 10). Elevated fecal coliforms were also observed between 7 and 9 within the Canandaigua City limits (Fig. 13). The existence of sewer pipes connected to storm sewers is suggested.

14 October 1999 (Figures 7-13)

The summer of 1999 proved to be very dry and no major precipitation events occurred that generated any major flows of water within the Sucker Brook watershed. The next sampling was during a 1.33-inch rainfall on 14 October 1999. All sites were sampled to confirm sources of pollutants in the Sucker Brook watershed. Since there had not been any major rainfalls in over five months, the potential of loss of materials from the watershed was high. Results are presented in Table 6.

The entire area upstream of Site 1 (south of County Road 32) proved to be a source of nutrients, suspended solids, and fecal coliform bacteria. For example above Sites 10 and 11, TP levels reach as high as 1,781 and 3,196 µg P/L, respectively. TKN in excess of 15,800 µg N/L (15.8 mg N/L) and fecal coliforms levels to numerous to count (>3000 colonies/100mL) were also observed in this area. Relatively high levels of total suspend solids (TSS) and high levels of TP and TKN also suggest that much of the material being lost is as particulate matter being washed off the watershed during this rain event. The levels observed are truly extraordinary high concentrations of these nutrients. For example, phosphorus and total Kjeldahl nitrogen levels are 1,500% and 2,700% higher than the immediate downstream site. A similar result was observed for the sections upstream of Sites 10 and 14, less than 1 mile west of this site.

As on previous sampling dates, the section of stream between Sites 3 and 4 is a source of nutrients being loss to Canandaigua Lake. The increase in TP (232 to 323 µg P/L), SRP (55 to 188 µg P/L) and TSS (33 to 126 mg/L) indicate a source within this reach. As with the previous site, this land is in agricultural use, but also incorporates some areas currently under development.

The section between Sites 4 and 6 within the Canandaigua City limits had high levels in fecal coliforms (mats to 2,460 colonies/ 100 mL)(Fig. 13). In previous events, we have observed a similar increase in fecal coliforms, often accompanied by increases in nutrient levels.

Chloride levels were high during this event in many of the first order tributaries. Since this occurred after the summer, a period of no deicing usage on roads, these results are somewhat surprising and were not observed on other sampling dates. First order streams upstream of Sites 2 (>540 mg/L), 7 (> 80 mg/L) and 1 (variable but as high as 206 mg/L)(Fig. 11) had high levels of chloride.

DISCUSSION

The quality and quantity of runoff from a watershed into a stream is ultimately influenced by people. The amount of runoff is determined by the amount of excess precipitation, that which neither sinks into the ground nor is stored at the surface. Precipitation excess is determined primarily by climate, vegetation, infiltration capacity, surface storage and land use by people (1, 2). Impervious landscapes (e.g., parking lots), removal of wetlands and vegetation in general, storm sewers, blockage of streams by debris, etc., all contribute to rapid rises in stream level and potential flooding. Similarly, land usage contributes to the quality of the water in the stream and ultimately Canandaigua Lake. For example, deicing salt spread on roads is easily dissolved and accumulates in streams raising the concentration of chlorides in water. Another example is the spreading of manure on the land. If done properly, this can be a reasonable practice enriching the soil. If not, the result may be elevated levels fecal coliform bacteria and increased levels of phosphorus and nitrates that cause health concerns or cause eutrophication of down stream systems. Land use practices initiated by people can and do affect stream water quality and stream discharge. If we can identify the sources of pollution, remedial action plans and best management plans can be initiated that mitigate downstream and lake effects.

Major Sources of Chloride (Deicing salt) in the Sucker Brook Subwatershed

Sites 2, 6 and 8 (Fig. 3):

Compared to sixteen subwatersheds in the Canandaigua Lake watershed, Sucker Brook is delivering twice the amount of salt to the lake compared to any other watershed (1). Environmental concerns revolving around elevated levels of deicing salt include: damage to vegetation, affect fish spawning in streams, pollute ground water making well water undrinkable, interfere with the chemical and physical characteristics of Canandaigua Lake, disintegrate pavement and cause metal corrosion. Elevated levels of chloride were observed at Sites 2 downstream of routes 5 and 20 and at Sites 6 and 8 in the City of Canandaigua (City) in January. Similarly, chloride levels were elevated in segments of the stream within the City limits of Canandaigua. The elevated levels of chloride are most likely due to high levels of de-icing salt utilized during this time of year on roads.

According to the 1998-99 de-icing salt survey, 1438 tons of salt were used on roads in the Sucker Brook watershed. The City used 985 tons (68%) at a rate of 33.6 tons per mile. The Town used 280 tons (20%) at a rate of 24.1 tons per mile. NYS DOT used 173 tons (12%) at a rate of 33.9 tons per mile. Application rates in Sucker Brook subwatershed are much greater than the 1998-

99 average rate of 20.2 tons per mile typically used in the Canandaigua Lake watershed.

Segment between Site 3 and 4 and Site 5 (Fig. 3):

On all four sampling dates, chloride levels were elevated at Site 4 compared to the upstream site 3. This suggested a source within this segment. In addition, elevated levels were always observed at Site 5 compared to the down stream sites. This also suggests a source of chloride upstream of Site 5. Located upstream of both sites is the Municipal Salt Pile for the Town of Canandaigua north of Routes 5 and 20. Also, the intersection at Routes 5 and 20 are heavily salted and may also be a source of the chloride observed at Site 5. Although the segment analysis data do not pinpoint this site because of the lack of sampling points in this region, it is likely that the source is the “uncovered” salt storage pile at this location. To increase our confidence on this conclusion, we sampled road culverts on 16 December 1999, just above and below the salt pile. Salt levels were >1,040% higher (862 to 8,970 mg Cl/L) immediately downstream of the salt pile on a day when no rain fell. During a period of precipitation, losses of salt from the Town of Canandaigua Salt Pile would be expected to be higher. This Salt Pile represents a major source of salt to Sucker Brook and eventually Canandaigua Lake.

Sites 1, 2 and 7 in October (Fig. 3):

In October, chloride levels were high during this event on many of the first order tributaries. First order streams upstream of Sites 2 (>540 mg/L), 7 (> 80 mg/L) and 1 (variable but as high as 206 mg/L) possessed elevated levels of chloride. Since this occurred after the summer and thus after a period of no deicing usage on roads, these results are somewhat surprising. This was not observed on other sampling dates. At present, we have no explanation for these high levels at this time of the year. High chloride can be an indicator of deicing salt but may also be an indicator of fecal contamination in that wastewater is often higher in chloride than raw water because chloride passes unchanged through the digestive system (23). Another possible scenario for high chloride during this event is a higher than normal percentage of groundwater making up the entire volume of the stream. This could be due to the drought conditions leading up to this event. There is some support for this idea as public drinking water was brought to this area because of high salt levels in wells.

Best Management Practices:

- A “sensible-use policy” that balances the safety of the motoring public with environmental concerns by maintaining rates of application in the Sucker Brook watershed at or near the average for the entire Canandaigua Lake watershed should be instituted.

- The Town of Canandaigua Municipal Salt Pile on Routes 5 and 20 should be covered immediately**.**

Recommendation:

The occurrence of high levels of chloride should be investigated further during a period where deicing salt is not applied. As pointed out, it is very possible that this is simply a relationship between untreated animal sewage and high chloride levels or ground water high in salt.

Major Sources of Nutrients in Sucker Brook

Upstream of Site 1 (Fig. 3):

The entire area upstream of Site 1 proved to be a source of nutrients, suspended solids, and fecal coliform bacteria. Although all areas upstream of Site 1 are contributing to the pollution of Sucker Brook and ultimately Canandaigua Lake, the segment of Sucker Brook starting with Site 1 and upstream of Sites 11 and 13 had extraordinary high levels of several pollutants. TP levels were in excess of 3,190 µg P/L (3.2 mg P/L); SRP levels were in excess of 1,664 µg P/L (1.7 mg P/L); TKN in excess of 15,800 µg N/L (15.8 mg N/L) and fecal coliforms levels to numerous to count (>3000 colonies/100mL). These are truly extraordinary high levels of these nutrients compared to the entire stream. For example, phosphorus levels at Site 13 are 1,500% higher than Site 8 in the City limits. Similarly, total Kjeldahl nitrogen is 2,700% higher than Site 8 in the City limits.

High levels of total suspended solids (TSS), TP, and TKN also suggest that much of the material being lost is as particulate matter being washed off the watershed during events. The nature of the losses (high organic nitrogen, high suspended solids, high fecal coliforms, and high nutrients) and land generally in agricultural usage suggest that animal wastes are either being lost from a manure lagoon and/or poor practices of manure application on fields is occurring. In fact, there was visual evidence of manure spreading on the field upstream of Site 1 in April and at Site 10 in October. A similar result was observed for the sections upstream of Sites 10 and 14, less than 1 mile west of this site. On all three sampling dates that covered all 15 sites, high losses of nutrients and the existence of fecal coliform bacteria were observed suggesting that this is a persistent problem.

Best Management Practices:

Identified point and non-point sources of nutrients and solids can be remediated using Best

Management Practices (BMP). Whether or not management practices include a reduction of cropland or fertilization, control of water movement can be a means of significantly reducing non-point source pollution. Since water must come in contact with the nutrient source and then be transported to the surface (or subsurface) water body, the nutrients in water bodies are functions of soil fertility and quantities of transporting water. Management practices, which reduce surface runoff have been shown to decrease dramatically the magnitudes of sediment and chemical losses from land areas (24).

Haith (24) and the NYSDEC (25) recommend use of buffer strips of forest or grass between the pollutant source and a stream to intercept the runoff, resulting in removal by deposition or filtering by the vegetative cover. Other cropland management practices include diversions, terraces contour cropping, strip cropping, waterways, minimum and no tillage. Livestock operation controls include barnyard runoff management, manure storage facilities and livestock exclusion from woodlands. They may also include structural devices such as grassed waterways, sediment retention basins, erosion control weirs and animal waste holding tanks. BMP's are designed to reduce sediment and nutrient transport to streams and lakes. They may benefit the farmer in the long term by decreasing fuel and fertilizer costs and by improving soil productivity. With the development of Whole Farm Planning with Canandaigua watershed farmers, a mechanism exists for further education of farmers on issues of public concern. Furthermore, the advent of Concentrated Animal and Feed Operations (CAFO) permits, regulatory control of farms with large numbers of animals may be inevitable.

Section Between Sites 3 and 4 (Fig. 3):

On three out of four sampling dates and an increase in phosphorus levels occurred within this section. An increase in total suspended solids was also observed in this segment on every sampling date. This was particularly evident during the October rain event in which dissolved phosphorus increased by 300% from the upstream site and suspended solids (soil) increased by 380%. A source of phosphorus and total suspended solids exists within this region. Elevated fecal coliforms were also observed in this section on several occasions. Unfortunately, this section of stream has a first order tributary not monitored that drains the area in and around the Town of Canandaigua Municipal Salt Pile. Thus pinpointing sources of nutrient and fecal coliform bacteria pollution is not possible. Construction sites in this section of the stream (e.g., Canandaigua Village Estates) are a likely sources of the elevated levels of nutrients and soil observed in the stream.

Best Management Practices:

Urban and rural management applications include critical area stabilization, shoreline protection and settling basins. Urban area best management practices include leaf collection, street sweeping and infiltration systems. Changes in cropping and soil conservation practices, decreases in impervious services and provision of buffer areas along surface waterways will result in predictable changes in runoff quantities and qualities and hence non-point source pollution (24).

Recommendations:

- The Town and City of Canandaigua specifically address erosion control in detail in their land use regulations. The City's regulations also mandate the management of storm water runoff from developing sites to mitigate water quality and quantity problems. In the City and the Town near the City, large parcels, which were used agriculturally but may have stood idle for decades, are being developed for institutional purposes (civic center, hospital, airport, town hall/garage complex), residential subdivisions (Village Estates, Old Brookside), light industry, and warehouses (Canandaigua Brands, Pactiv). Water quality safe-guards such as erosion control and storm water management ordinances, adopted at the municipal level, should be observed, incorporated in specific development plans, and enforced during construction (25, 26).
- Further segment analysis of this section of Sucker Brook is warranted. This should include fecal coliform bacteria analysis and include the first-order stream that runs up into Town of Canandaigua Municipal Salt Pile.

Upstream of Section 7 (Fig 3):

Phosphorus (TP and SRP) were high (1,196 μg/L) above Site 7 during the January event. High nutrients at this site were not observed during follow-up sampling later in the year. Canandaigua Wine, Inc. is located in this first order tributary and has frequently (17 times) released materials (spills) to Sucker Brook during the period 1986-1998. However, Canandaigua Wine's spill record has improved in recent years. Gates on the pipe, which conveys Sucker Brook under the facility, allow Canandaigua Wine to detain spills and clean them up before lost to the rest of the stream. However, further light industrial development of the watershed north of Canandaigua Wine may intensify flows through the pipe at times and nutrients may be loss before any containment.

Recommendation:

- If high nutrient concentrations of nutrients persist in stream water from this location, it would be useful to target a segment analysis above Site 7.

Major Sources of Fecal Coliforms in the Sucker Brook Subwatershed

Canandaigua City Limits

Elevated fecal coliforms were observed on several occasions within the Canandaigua City limits (between sites 6/7 and 9). Often levels exceeded 2,000 colonies/100 mL. This level is well above the cutoff level for primary contact recreational water (200 colonies/100 mL) and at the level for "General Contact" (2000/100 mL) (27). Although this is not a clear violation of EPA Water Quality Criteria because of the necessity of using a different sampling design, it is clear is that fecal contamination does occur, that it is persistent, and that the existence of sewer pipes connected to storm sewers is probable.

Nevertheless, fecal coliforms are routinely being found during precipitation events in the City limits. The occurrence of coliform bacteria in this stretch of the stream is of concern. Fecal coliform bacteria indicate that sewage from warm-blooded animals is present in the water. The occurrence of fecal coliform bacteria suggest the material has not been treated and that a potential exists for disease producing pathogens being present in the water. Because this portion of the stream does pass through an area of homes and an elementary school, the potential of contact exists, especially with children.

There are several possibilities on the source of the fecal coliforms. Some undoubtedly comes from upstream locations identified above Site 1. However, there is a consistent increase in fecal coliforms in this section of the stream and further downstream as the stream enters the Town and City limits. It is possible, that due to the age of some homes, some homes may still be hooked directly into drains leading into Sucker Brook. Most older cities, such as the City of Canandaigua, have unintentional cross-connections between their sanitary and storm sewer systems. The City does have an ongoing detection program, and cross-connections are eliminated as detected and/or as included in public works projects. From the information provided here, it is clear that fecal pollution is still entering Sucker Brook.

Recommendations:

- Consideration of enhancement of the City of Canandaigua program for detection of sources of fecal coliforms is suggested. Not only does such a program reduce possible health concerns but also would reduce nutrient inputs to Sucker Brook and thus Canandaigua Lake.

LITERATURE CITED

(1) Makarewicz, J.C. and T. W. Lewis. 1999. Nutrient and Sediment Loss from the Watersheds of Canandaigua Lake, January 1997-January 1999, Department of Biological Sciences, SUNY Brockport, Canandaigua, NY: CLWTF. Available from Drake Memorial Library, SUNY Brockport, Brockport, NY.

(2) Makarewicz, J.C. and T.W. Lewis. 1998. Nutrient and Sediment Loss from Watersheds of Canandaigua Lake, January 1997-January 1998, Department of Biological Sciences, SUNY Brockport, Canandaigua, NY: CLWTF, February 1998. Available from Drake Memorial Library, SUNY Brockport, Brockport, NY.

(3) Makarewicz, J.C. and T.W. Lewis. 1996. Spring Nutrient and Sediment Loss from the Sucker Brook Subwatershed of Canandaigua Lake, Department of Biological Sciences, SUNY Brockport, Canandaigua, NY: OCPD and CLWTF. Available from Drake Memorial Library, SUNY Brockport, Brockport, NY.

(4). Makarewicz, J.C. 1993. Stressed Stream Analysis Waterworks. 9:5-12.

(5). Makarewicz, J.C. and T.W. Lewis. 1993. Stress stream analysis of two sub-watersheds of Conesus Lake. Available from Drake Memorial Library, SUNY Brockport, Brockport, NY.

(6). Makarewicz, J.C., T.W. Lewis and R.K. Williams. 1994. Nutrient Loading of Streams entering Sodus Bay and Port Bay, NY. A summary of Port Bay and Sodus Bay tributary monitoring and stressed stream analysis of Glenmark and Wolcott Creeks. Available from Drake Library, SUNY Brockport, Brockport, N.Y.

(7) Ad Hoc Committee. 1994. Canandaigua Lake Watershed Task Force, The State of the Canandaigua Lake Watershed- 1994, Canandaigua, NY: September.

(8) U.S. Department of the Interior 1978. Geological Survey, Maps of Canandaigua and Canandaigua Lake Quadrants.

(9) U.S. Department of Agriculture 1958. Soil Conservation Service, Soil Survey of Ontario and Yates Counties, New York, Washington, DC.

(10) NYS DEC, Freshwater Wetland Maps, Canandaigua and Canandaigua Lake Quadrants, Avon, NY, 1986.

(11) Balyszak, J. 1994. Canandaigua Lake- Nonpoint Source Pollution Information Derived from GWLF Studies, Penn Yan: Yates Co. SWCD.

(12) Morisawa, M. 1968. Streams- Their Dynamics and Morphology, New York, NY: McGraw-Hill.

(13) Rosgen, David L. 1994. A Classification of Natural Rivers, Catena 22, Amersterdam, The Netherlands: Elsevier Science.

(14) Lewandowski, S. and J. Terninko. 1996 Inventory and Survey of Sucker Brook in the City of Canandaigua, NY.

(15) Werner, Robert G. 1980. Freshwater Fishes of New York State, Syracuse, NY: Syracuse University Press.

(16) *Daily Messenger*, assorted articles, 1973-present, 73 Buffalo St., Canandaigua, NY, 14424.

(17) Young, Richard A. 1998. Squaw Island- Geologic Origin and Modification, Geneseo, NY: SUNY, December.

(18) Evans, Robin; assorted Annual Winter De-icing Salt Survey, Canandaigua, NY: CLWTF, 1993-1998.

(19) Barden, G., R. McDonough and S. Sherwood, assorted records of the Canandaigua Lake Watershed Inspector, testing for fecal coliform in Sucker Brook, 1984-present.

(20) Sherwood, S., assorted records in The Lake Reporter, newsletter of Canandaigua Lake Pure Waters, Ltd., in-lake testing for total coliform, Canandaigua, NY, 1983-1999.

(21) Gilman, B. assorted Annual Reports, Examination of Water Resources, Canandaigua, NY: Finger Lakes Community College, 1989-1998.

(22). EPA. 1979. Methods for the Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory. Environmental Protection Agency. Cincinnati, Ohio. EPA-600/4-79-020.

(23). APHA 1998. Standard Methods for the Examination of Waste and Wastewater. American Public Health Association, 20th ed. New York, NY. 1134p.

(24). Haith, D.A. 1975. *In:* Influence of land development and land use patterns on water quality. G.D. Gates and D.A. Haith eds. PB 248071. NTIS.

(25) Morton, W. B. 1985. Stream Corridor Management: A Basic Reference Manual, Albany, NY: NYS DEC.

(26) Morton, W. B. 1992. Reducing the Impacts of Stormwater Runoff from New Development, Albany, NY: NYS DEC.

(27). EPA. 1978. Microbiological Methods for Monitoring the Environment: Water and Wastes. Environmental Protection Agency. EPA-600/8-78-017.

FIGURE 7. Segment analysis: Total phosphorus concentrations at various locations in the Sucker Brook watershed during precipitation events.

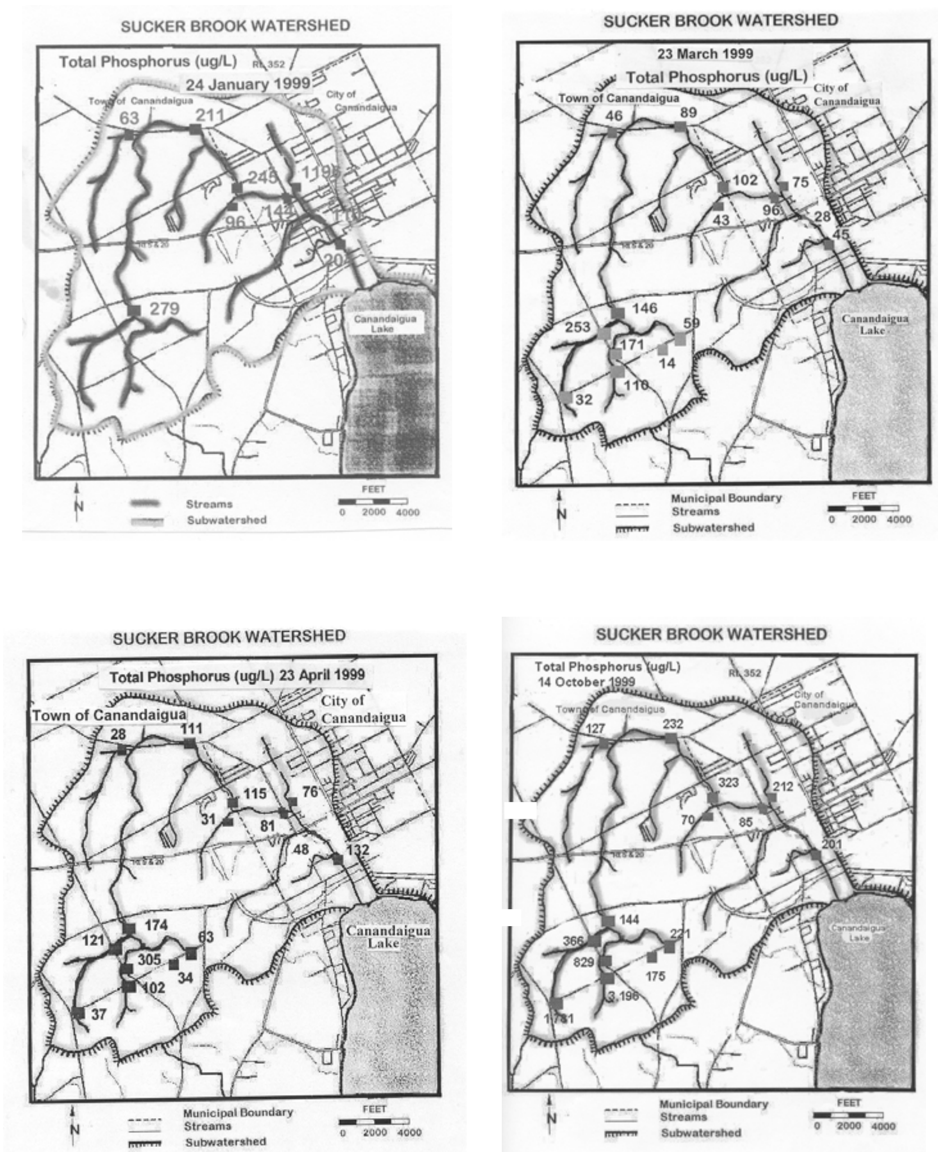


FIGURE 8. Segment analysis: Soluble reactive phosphorus concentrations at various locations of the Sucker Brook watershed during precipitation events.

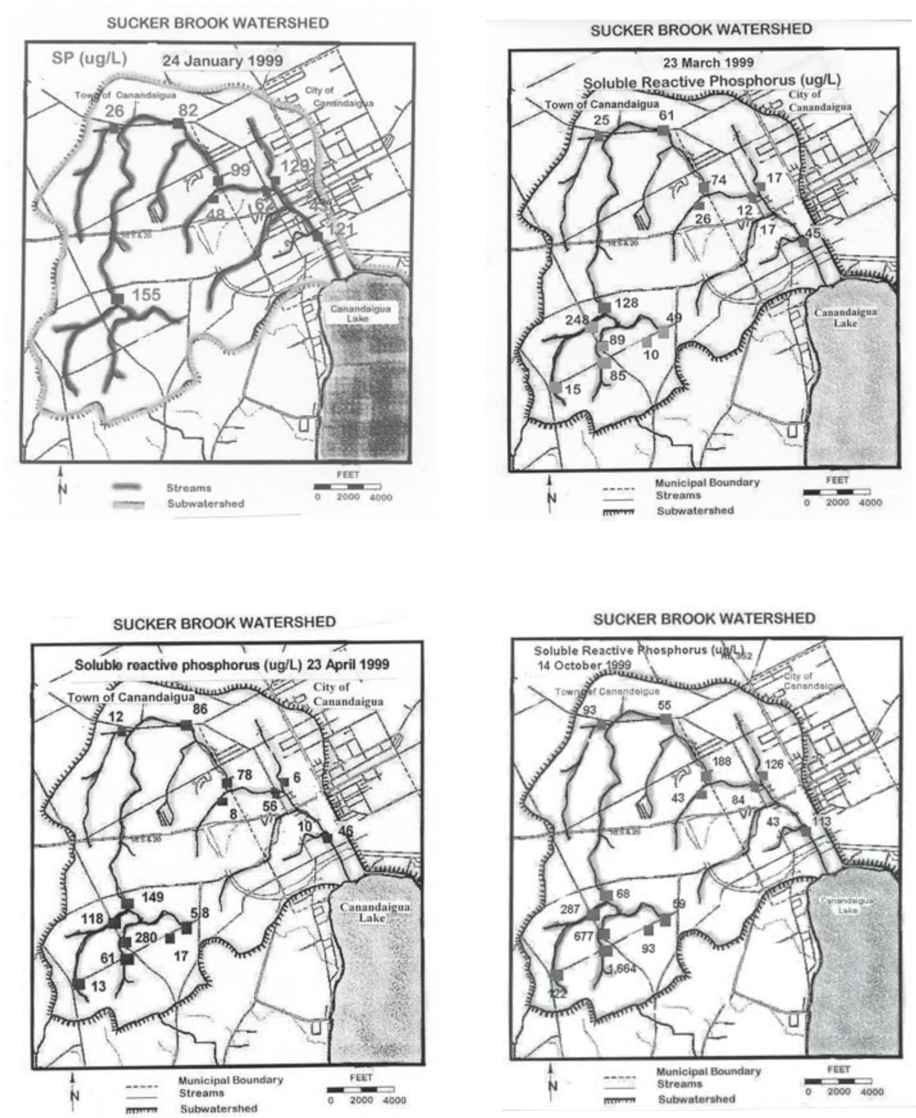


FIGURE 9. Segment analysis: Total Kjeldahl nitrogen concentrations at various locations in the Sucker Brook watershed during events.

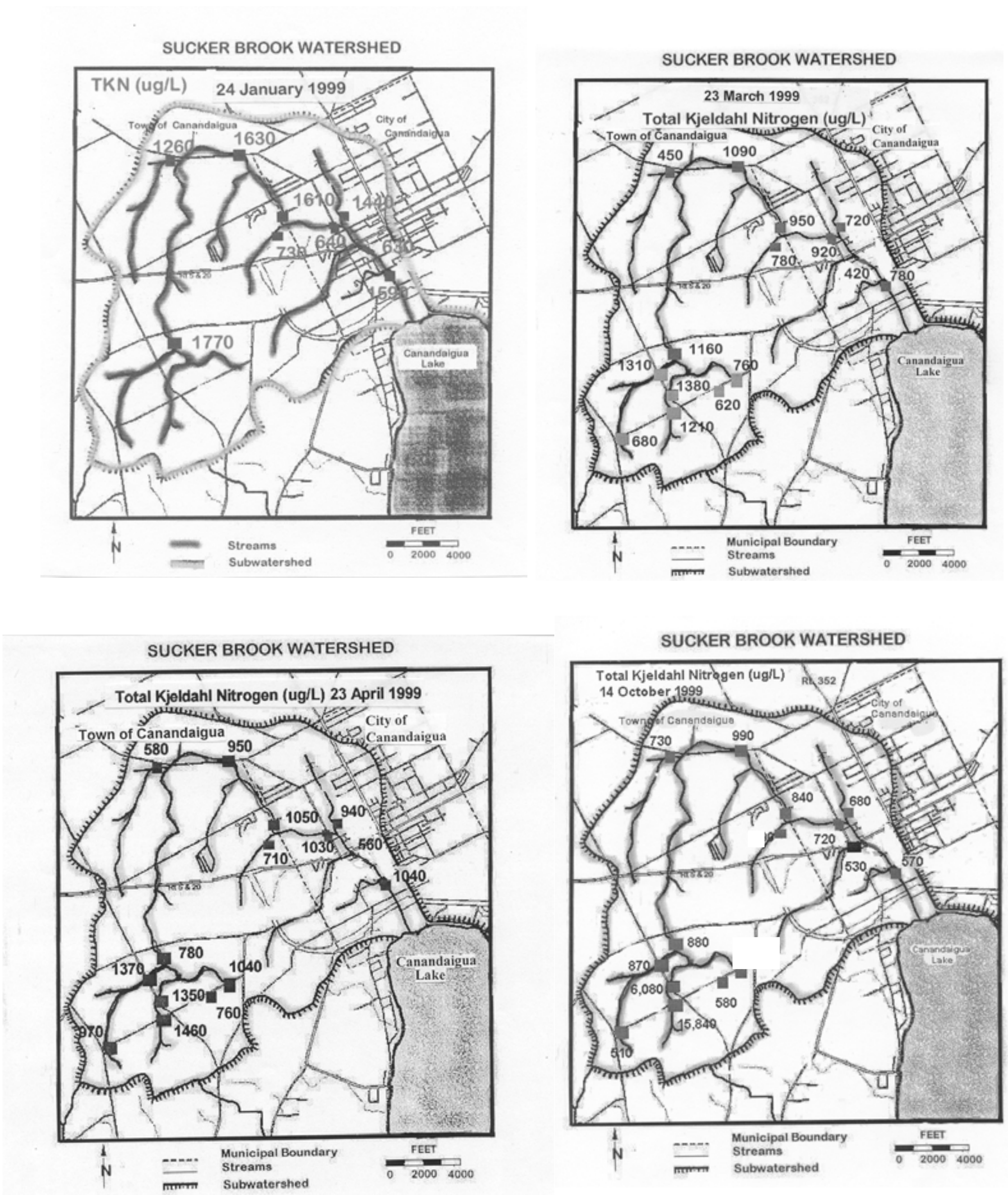


FIGURE 10. Segment analysis: Nitrate concentrations at various locations of the Sucker Brook watershed during events.

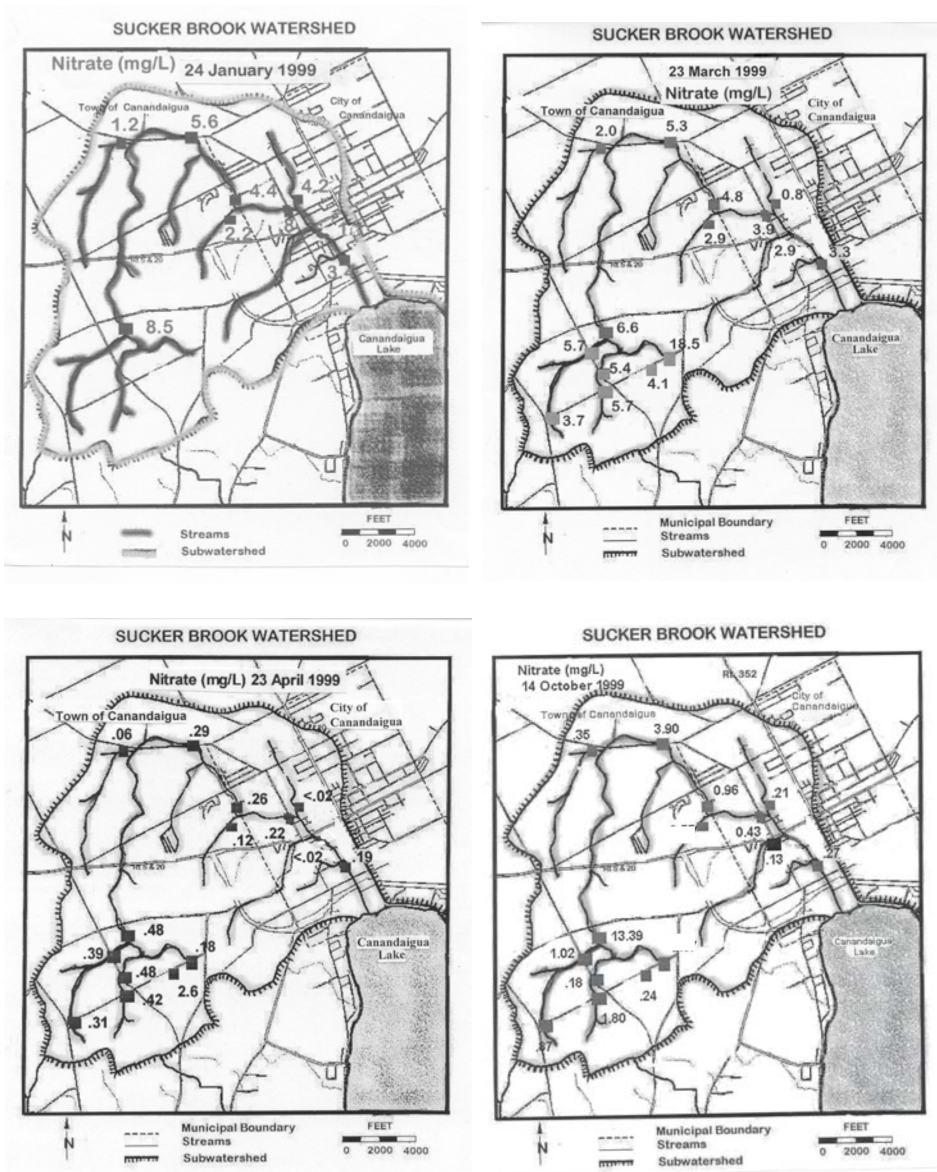


FIGURE 11. Segment analysis: Chloride concentrations at various locations in the Sucker Brook watershed during events.

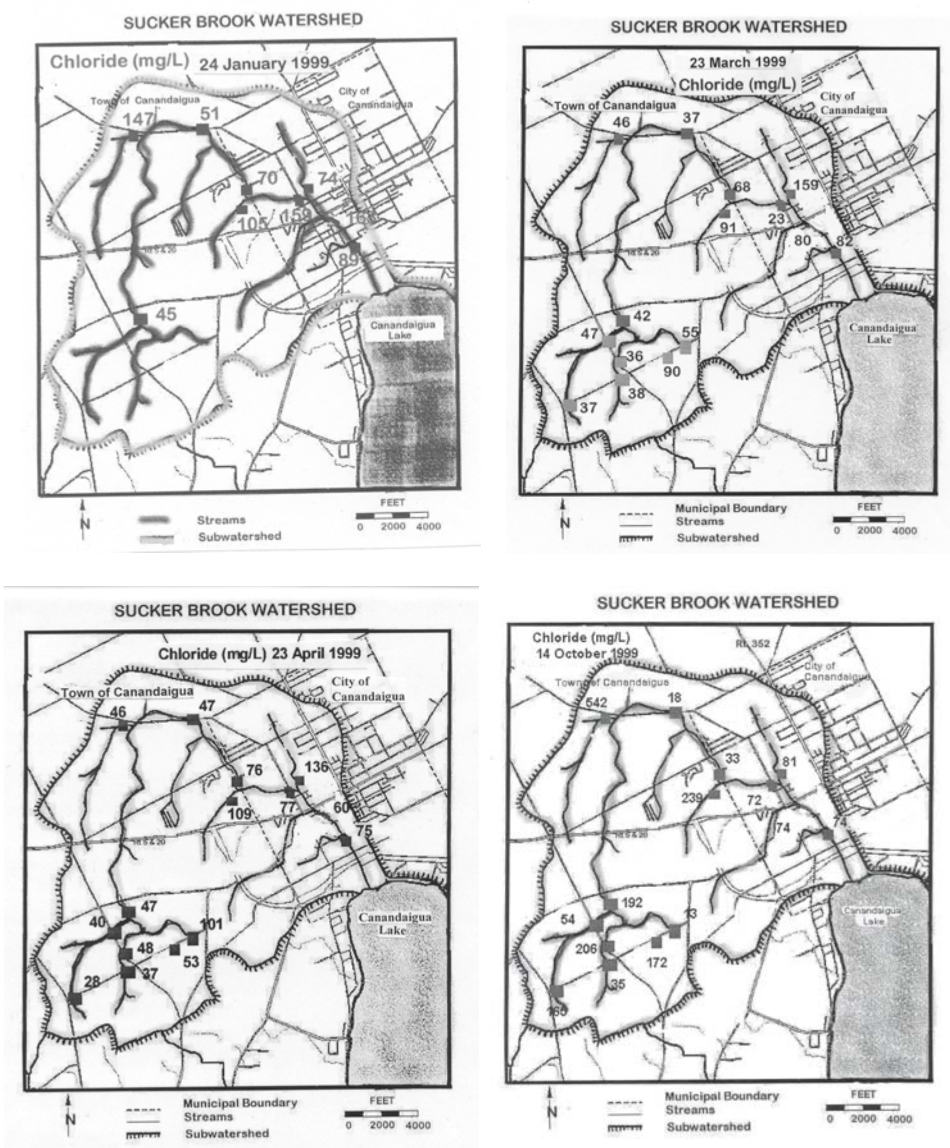


FIGURE 12. Segment analysis: Total suspended solid concentrations at various locations in the Sucker Brook watershed during events.

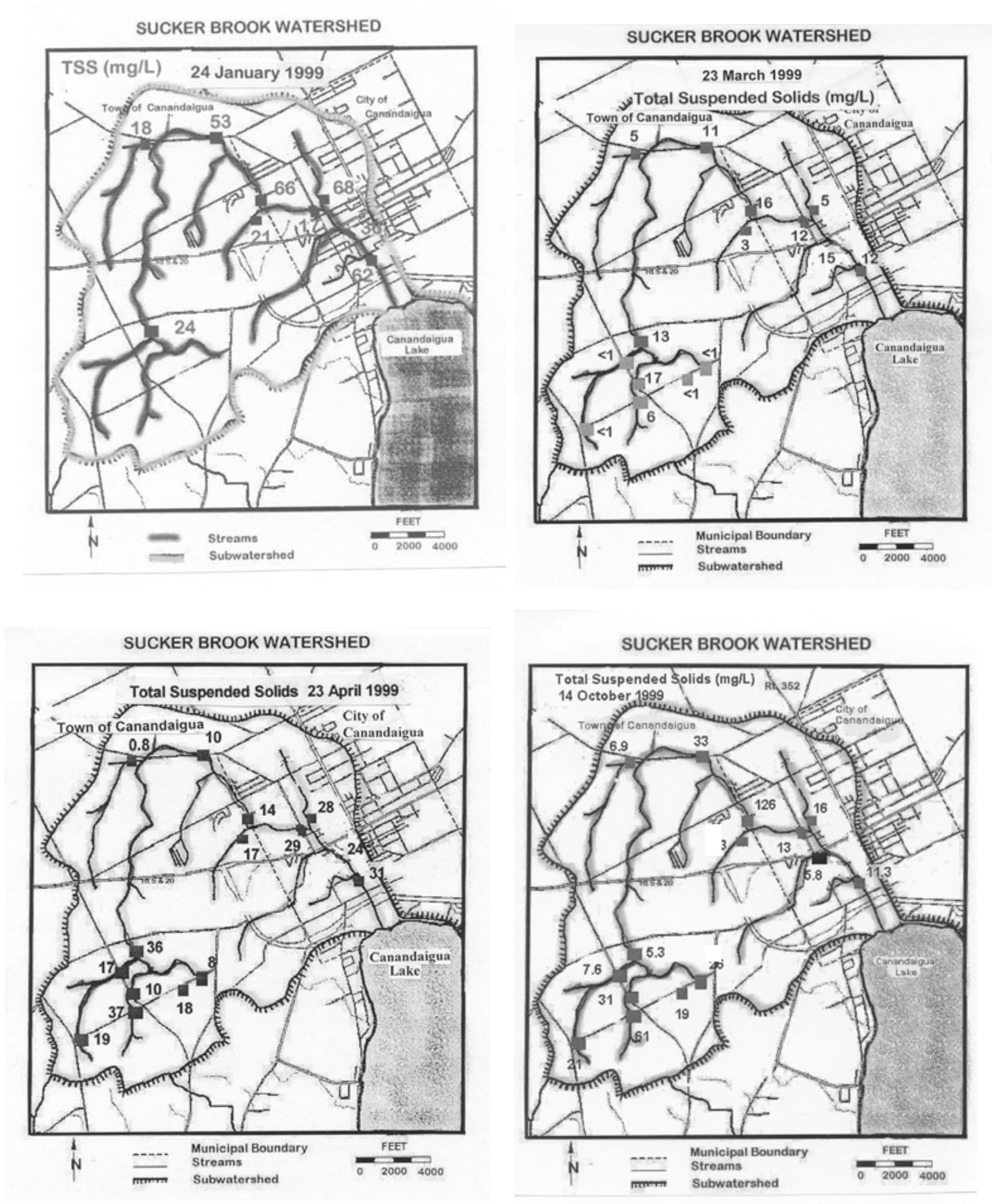


FIGURE 13. Segment analysis: Fecal coliform levels at various locations in the Sucker Brook watershed during events.

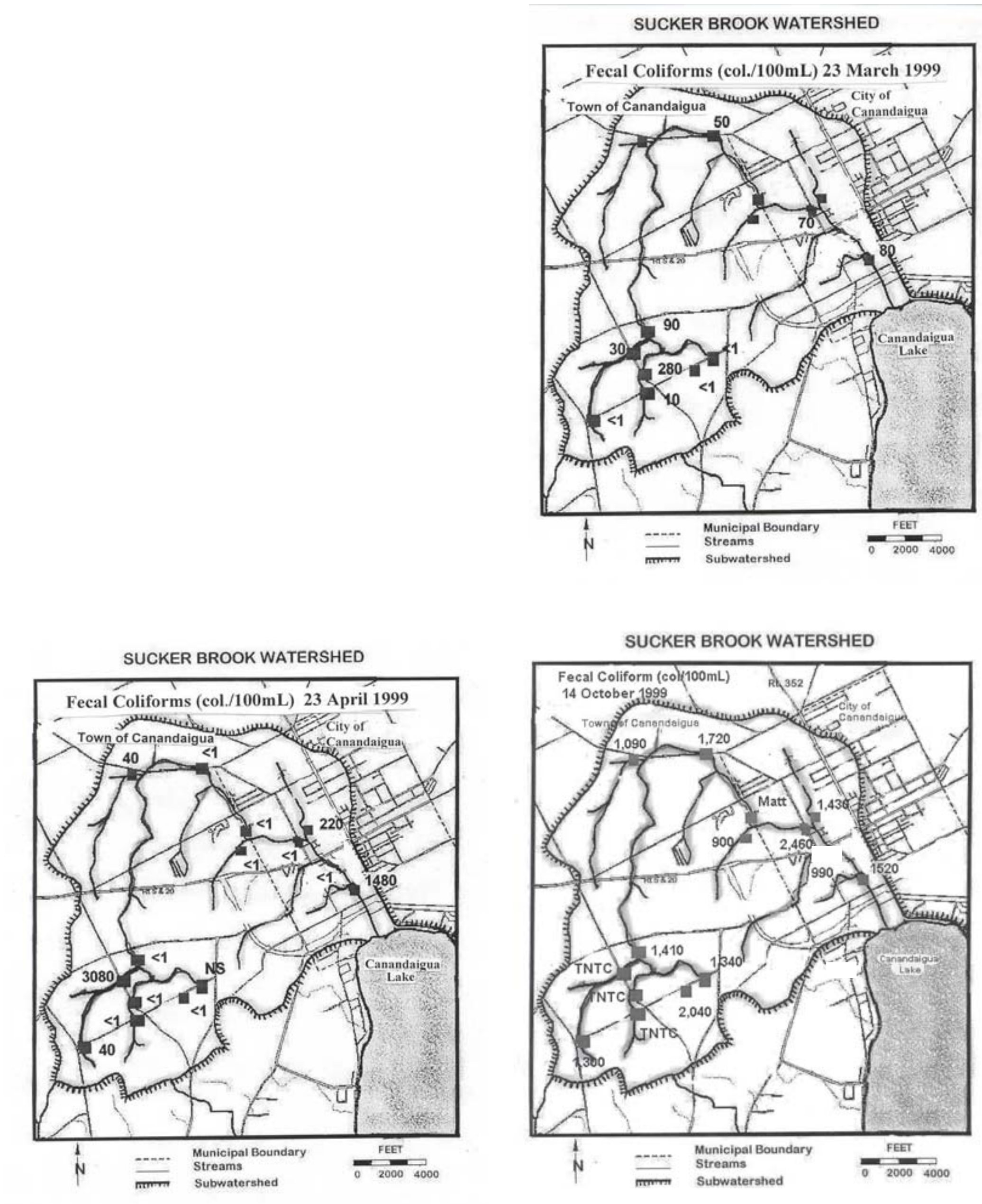


Table 1. Location of sampling sites on Sucker Brook, Canandaigua watershed.

Site Number	Location	
1	South side of County Road 32 – upstream of culvert	
2	North side of Buffalo Street, upstream of culvert	
3	North side of County Road 30, upstream of culvert	
4	South and downstream of Buffalo Street culvert	
5	Behind Woodlawn Cemetery and Baker Park, western branch before junction, no bridge or channel	
6	West branch just upstream of junction with east branch on school grounds, off the entrance to Elementary School near bridge	
7	Same general location as above but the east branch just upstream of junction near bridge	
8	South of West Avenue, downstream of major pipe outflow behind Dobb's Sunoco and bridge	
9	Downstream of Clark Street Bridge at RG & E building, former automated site	
10	Most northern site on Hickok Road at bridge	
11	Most southern site on Hickok Road at bridge	
12	Most eastern first order tributary on Bliss Road east of Hickox Road downstream of culvert	
13	First second order tributary on Bliss Road west of Hickox Road downstream of culvert	
14	Most western first order tributary on Bliss Road west of Hickox Road downstream of culvert	
15	Downstream of culvert on Bliss Road just west of Site 12, drains a wetland	

Table 2. Results of the semi-annual New York State Environmental Laboratory Assurance Program (ELAP Lab # 11439, SUNY Brockport) Non-Potable Water Chemistry Proficiency Test, July 1999. Score Definition: 4 (Highest) = Satisfactory, 3 = Marginal, 2 = Poor, 1 = Unsatisfactory.

Analyte	Mean/Target	Result	Score
Residue			
Solids, Total Suspended	18.3 mg/L	18.2 mg/L	4
Hydrogen Ion (pH)			
Hydrogen Ion (pH)	6.00	5.96	4
Organic Nutrients			
Kjeldahl Nitrogen, Total	14.70 mg/L	15.60 mg/L	4
Phosphorus, Total	1.56 mg/L	1.59 mg/L	4
Total Alkalinity			
Alkalinity	94.60 mg $CaCO_3$/L	98.32 mg $CaCO_3$/L	4
Inorganic Nutrients			
Nitrate (as N)	14.80 mg/L as N	13.33 mg/L as N	4
Orthophosphate (as P)	0.914 mg/L as P	0.920 mg/L as P	4
Minerals			
Chloride	180.0 mg/L	183.2 mg/L	4
Wastewater Metals I and II			
Calcium, Total	20.30 mg/L	19.54 mg/L	4
Magnesium, Total	13.00 mg/L	14.22 mg/L	4
Potassium, Total	5.03 mg/L	5.29 mg/L	4
Sodium, Total	35.70 mg/L	36.68 mg/L	4

Table 3. Water chemistry data for Sucker Brook on 24 January 1999. NO_3+NO_2 = nitrate + nitrite, TP = total phosphorus, SRP = soluble reactive phosphorus, TKN = total kjeldahl nitrogen, TSS = total suspended solids. See Figure 3 for location of stations.

Sites	TP (µg P/L)	NO_2+NO_3 (mg N/L)	Chloride (mg/L)	TSS (mg/L)	TKN (µg N/L)	SRP (µg P/L)
SB1	279	8.49	44.6	24.0	1770	155.0
SB2	63	1.19	147.3	18.0	1260	25.7
SB3	211	5.56	51.1	53.0	1630	82.3
SB4	245	4.44	69.9	65.5	1610	99.5
SB5	96	2.17	104.7	20.7	730	48.1
SB6	144	0.76	158.7	17.3	640	61.7
SB7	1196	4.20	74.4	68.3	1440	129.4
SB8	110	1.09	163.7	36.0	630	43.0
SB9	204	3.68	89.3	62.3	1590	120.8

Table 4. Water chemistry data for Sucker Brook on 22-23 March 1999. NO_3+NO_2 = nitrate + nitrite, TP = total phosphorus, SRP = soluble reactive phosphorus, TKN = total kjeldahl nitrogen, TSS = total suspended solids. NS=No sample. See Figure 3 for location of stations.

	TP (µg P/L)	NO_2+NO_3 (mg N/L)	Chloride (mg/L)	TSS (mg/L)	TKN (µg N/L)	SRP (µg P/L)	Fecal Coliforms (col/100mL)
SB1	145.7	6.58	42.4	12.8	1160	128.2	90
SB2	46.4	2.02	46.0	4.7	450	25.0	NS
SB3	88.6	5.27	36.9	11.1	1090	61.1	50
SB4	102.3	4.80	68.2	16.0	950	73.6	NS
SB5	42.9	2.93	91.3	3.4	780	26.3	NS
SB6	95.5	3.91	23.2	11.7	920	62.1	70
SB7	74.9	0.84	159.1	4.7	720	16.8	NS
SB8	28.3	0.93	80.3	14.7	420	17.4	NS
SB9	45.4	3.35	81.8	12.4	780	45.4	80
SB10	253.0	5.71	47.0	0.6	1310	248.2	30
SB11	170.8	5.42	36.4	17.3	1380	88.7	280
SB12	58.9	18.53	55.1	0.3	760	49.0	<1
SB13	110.3	5.71	37.9	5.9	1210	85.4	10
SB14	32.7	3.68	37.4	<0.1	680	15.1	<1
SB15	14.4	4.07	90.9	0.8	620	10.2	<1

Table 5. Water chemistry data for Sucker Brook on 23 April 1999. NO_3+NO_2 = nitrate + nitrite, TP = total phosphorus, SRP = soluble reactive phosphorus, TKN = total kjeldahl nitrogen, TSS = total suspended solids. NS=No sample. See Figure 3 for location of stations.

	TP (µg P/L)	NO_2+NO_3 (mg N/L)	Chloride (mg/L)	TSS (mg/L)	TKN (µg N/L)	SRP (µg P/L)	Fecal Coliforms (col/100ml)
SB1	173.8	0.48	46.5	35.5	780	149.2	<1
SB2	27.7	0.06	46.0	0.8	580	12.3	40
SB3	110.9	0.29	47.0	10.0	950	86.0	<1
SB4	115.4	0.26	75.8	14.1	1050	77.9	<1
SB5	31.0	0.12	109.1	17.3	710	8.1	<1
SB6	80.5	0.22	77.3	29.2	1030	56.1	<1
SB7	76.0	< 0.02	135.9	27.7	940	5.8	220
SB8	47.9	< 0.02	60.1	24.1	560	10.0	<1
SB9	132.2	0.19	74.7	30.5	1040	45.8	1480
SB10	121.0	0.39	40.4	17.2	1370	117.6	3080
SB11	305.9	0.48	48.0	9.6	1350	280.0	<1
SB12	62.5	0.18	101.0	7.6	1040	5.8	NS
SB13	101.9	0.42	36.7	27.0	1460	60.7	<1
SB14	36.7	0.31	27.8	18.8	970	13.4	40
SB15	34.4	2.63	53.0	18.0	760	16.9	<1

Table 6. Water chemistry data for Sucker Brook on 14 October 1999. NO_3+NO_2 = nitrate + nitrite, TP = total phosphorus, SRP = soluble reactive phosphorus, TKN = total kjeldahl nitrogen, TSS = total suspended solids. NS No Sample. TNTC=To numerous to count. See Figure 3 for location of stations.

	TP (µg P/L)	NO_2+NO_3 (mg N/L)	Chloride (mg/L)	TSS (mg/L)	TKN (µg N/L)	SRP (µg P/L)	Fecal Coliforms (col/100ml)
SB1	143.8	13.39	191.6	5.3	880	67.7	1410
SB2	127.0	0.35	541.9	6.9	730	92.5	1090
SB3	231.8	3.90	17.9	33.1	990	55.2	1720
SB4	323.9	0.96	33.1	126.2	840	187.8	mat growth
SB5	NS	NS	NS	NS	NS	NS	NS
SB6	85.1	0.43	71.6	13.3	720	84.2	2460
SB7	212.3	0.21	81.1	16.0	680	125.9	1430
SB8	69.7	0.13	73.7	5.8	530	42.8	990
SB9	201.1	0.27	73.5	11.3	570	113.2	1520
SB10	365.8	1.02	53.9	7.6	870	287.2	TNTC
SB11	828.5	0.18	206.2	30.9	6080	676.5	TNTC
SB12	220.6	2.57	12.6	26.3	1010	59.4	1340
SB13	3195.5	1.80	34.5	61.2	15840	1663.7	TNTC
SB14	1781.4	0.87	164.7	20.9	510	121.5	1300
SB15	174.5	0.24	171.6	18.6	580	92.5	2040