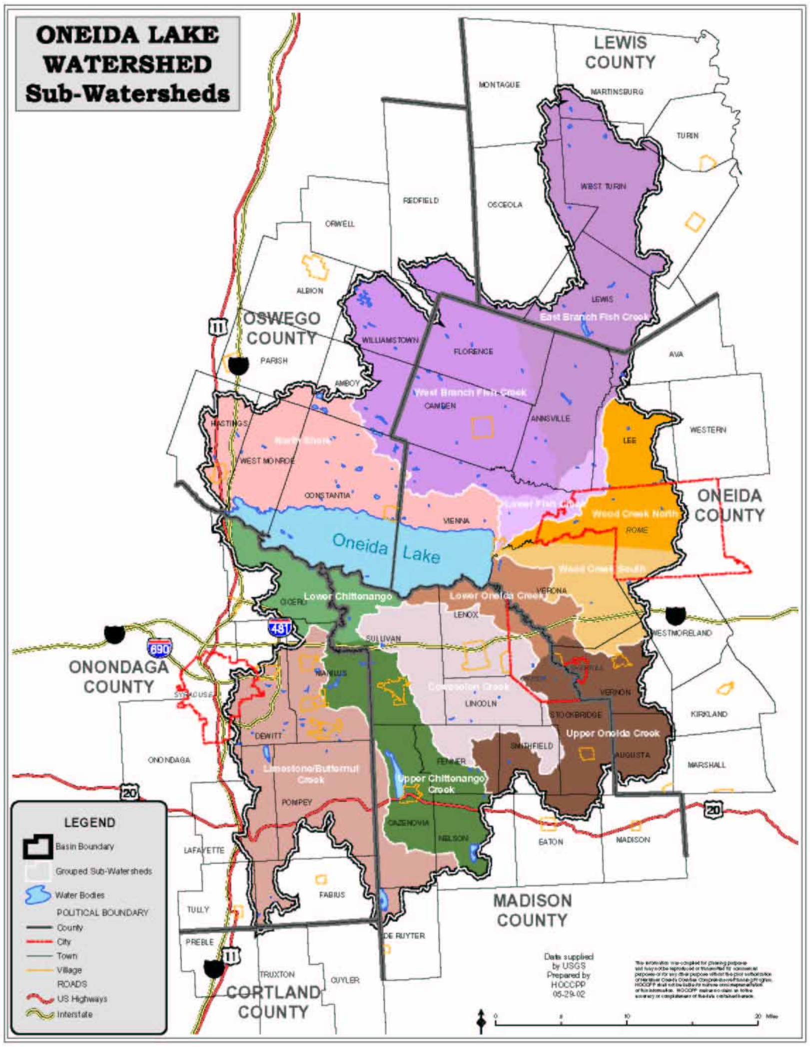
Nutrients and Suspended Solid Losses from Oneida Lake Tributaries, 2002-2003:

Butternut, Big Bay, Chittenango, Canaseraga, Cowaselon, Fish, Limestone, Oneida, Scriba and Wood Creeks



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Summary

1. The purpose of this study was to determine the relative importance of losses of soil and nutrients from major tributaries draining subwatersheds of Oneida Lake. Stream discharge and concentration of nitrate, total phosphorus, chloride, total suspended solids, and total Kjeldahl nitrogen were measured and converted into the amount of material lost from the subwatersheds during events and non-events.

2. In the past year of tributary monitoring, we have established the importance of meteorological events to the loss of nutrients and material from subwatersheds into Oneida Lake. In addition and based on the amount of nutrients and materials lost from subwatersheds, we have identified subwatersheds as candidates for stressed stream analysis. This process identifies sources of nutrients and soil lost from a subwatershed.

3. For the 12 sampling dates, the average highest non-event (3,179,226 m^3/day) and event (6,826,121 m^3/day) flows were observed at Fish Creek.

4. Non-event losses of nutrients from the watersheds were generally low compared to event losses on a per day basis; that is, losses from the watersheds were greatest during hydrometeorological events. Generally, daily losses from the watersheds during events were three to 20 times the baseline losses for total suspended solids (soils), total phosphorus and total Kjeldahl nitrogen.

5. Considering daily areal loading, Oneida Creek delivered more phosphorus (9.1 g P/ha/day) to downstream habitats than any other watershed during events. Three creeks, Cowaselon, Chittenango and Little Bay Creeks delivered over 24 g P/ha/day to Oneida Lake. Total phosphorus loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events (r^2= 0.95). This suggests that the phosphorus in the particulate form (soil) was being washed off the landscape or eroded from stream banks.

6. In general, soil erosion was one of the major sources of nutrient loss from watersheds and was positively correlated with total phosphorus and TKN loss the Oneida Lake watershed. Out of eleven subwatersheds monitored, several watersheds were losing suspended materials at higher rates when normalized by watershed area. Chittenango Creek (6,061g/ha/day), Cowaselon (4,500 g/ha/day), Oneida Creek (4,365 g/ha/day), Limestone (3,528 g/ha/day) and Fish Creek (3,395 g/ha/day) had the greatest loss of suspended matter form the watershed. Using the Oneida Creek subwatershed as an example, about 215 tons of soil per storm event day was washed into the lake. Other high losses were from Fish Creek (199 tons/day) and Chittenango Creek (143 tons). In contrast, Scriba Creek was delivering ~57 pounds daily of suspended matter during non-events of soil.

7. Of the eleven subwatersheds studied, the five subwatersheds contributing the largest amount of nitrate to downstream habitats during events in descending order were:

Cowaselon and Butternut Creeks (53 g/ha/day each), Oneida Creek (46 g/ha/day), and Limestone and Chittenango Creeks (39 g/ha/day each).

8. Of the eleven subwatersheds studied, the five subwatersheds contributing the largest amount of chloride, a component of de-icing salt, to downstream habitats during events in descending order were: Butternut Creek (2,554 g/ha/day), closely followed by Chittenango (2,467 g/ha/day) and Limestone (1,875 g/ha/day) and Big Bay Creeks 1,800 g/ha/day).

9. Of the eleven subwatersheds studied, the five subwatersheds contributing the largest amount of total Kjeldahl nitrogen, to downstream habitats during events in descending order were: Cowaselon Creek (46 g N/ha/day), Fish Creek (46 g N/ha/day), Chittenango Creek (43 g N/ha/day), Big Bay Creek (39 g N/ha/day) and Oneida Creek (36 g N/ha/day). As total phosphorus, total Kjeldahl nitrogen loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events (r^2= 0.85). This suggests that organic nitrogen is being washed off the landscape and may be associated with land use. Over 40% of the land is in some form of agriculture in Madison and Oneida Creeks.

10. Comparison of the rate of nutrient loss from Oneida Lake subwatersheds to watersheds with various land uses in western and central New York is instructive. Non-event phosphorus loss from Oneida Lakes tributaries were similar to other watersheds in western and central New York irregardless of land use. However, during rain events, loss of phosphorus from some Oneida Lake subwatersheds were relatively high. For example, event losses of phosphorus from Oneida Creek (9.1 g P/ha/d), Little Bay Creek (8.8 g P/ha/d), Chittenango Creek (7.6 g P/ha/ d) and Cowaselon Creek (7.4 g P/ha/d), all subwatersheds of Oneida Lake, were substantially higher than event losses from most subwatersheds of Canandaigua Lake and Sandy Pond. Canandaigua Lake is an unproductive, oligotrophic lake possessing high water clarity.

11. The analysis performed in this study were combined with monitoring on five Oswego County north shore Oneida Lake tributaries (Little Bay Creek, Threemile Creek, Dakins Creek, Crandall Creek and Black Creek, Makarewicz and Lewis 2003) to provide a better basin-wide evaluation of losses of nutrients and materials (i.e., soils) from 16 subwatersheds of Oneida Lake and for establishing a priority list of impacted watersheds that could be targeted for remediation and restoration. Since phosphorus is generally considered to be the limiting nutrient of phytoplankton growth in freshwater lakes and soil loss is the likely vector of this loss, four watersheds are suggested as potential targets for stressed stream analysis: Oneida Creek, Cowaselon, Chittenango and Little Bay Creek. These subwatersheds also had high losses of total suspended solids, total phosphorus and total Kjeldahl nitrogen.

12. Stressed stream analysis or segment analysis is a technique that identifies the sources of pollutants within a watershed by subdividing the impacted watershed into small distinct geographical units. Samples are taken at the beginning and end of each stream unit to determine if a nutrient (or other contaminant) source occurs within that reach. We have found this technique very useful in identifying point and non-point sources that are not always obvious. Identified sources can then be targeted for remediation and best management practices.

13. Little Bay Creek also had significantly higher areal losses of chloride than any other subwatershed. Consideration should be given to determining if these losses are anthropogenic losses (de-icing salt usage, improper storage).

Introduction

The Central New York Regional Planning and Development Board organized the Oneida Lake and Watershed Task Force, which is an alliance of agencies, organizations, elected officials, and citizens interested in the protection of water resources in the Oneida Lake Watershed. The 2002 Oneida Lake and Tributary Monitoring Program sponsored by the Task Force is a continuation and an expansion of the monitoring program that took place in the southern region tributaries from 1999 to 2000 (See Makarewicz and Lewis, 2000). Phase I of the 2002 program involved sampling at the base of the primary tributaries flowing into Oneida Lake (including Big Bay, Scriba, East Branch of Fish, Lower Fish, Wood, Oneida, Cowaselon, Canaseraga, Chittenango, Limestone, and Butternut Creeks). By addition of the major tributaries of the north shore to the monitoring strategy, the relative importance of these northern subwatersheds compared to south shore tributaries is evaluated allowing a prioritization of the subwatersheds in terms of nutrient and suspended solids (soil) loss to the lake from tributaries. That is, the monitoring program goal is to document nutrient and sediment loading to the lake and to prioritize the streams according to problem severity allowing direction on potential restoration and protection initiatives in affected subwatersheds.

Closely related to this effort is the 2002 Oswego County North Shore Subwatershed Monitoring Program. This program is an extension of the Oneida Lake Watershed Monitoring Program using identical procedures and methodology to monitor an additional five tributaries (Little Bay Creek, Threemile Creek, Dakins Creek, Crandall Creek and Black Creek) during approximately the same time period (January to December 2002) as the CNYRPB monitoring project. These additional five tributaries are discussed and have been prioritized in combination with the eleven tributaries reported on this study.

Phase II of the tributary monitoring program, scheduled for 2003-4, will involve segment analysis. Stressed stream analysis or segment analysis is a technique that identifies the sources of pollutants within a watershed by subdividing the impacted watershed into small distinct geographical units (Makarewicz and Lewis, 1999). Samples are taken at the beginning and end of each stream unit to determine if a nutrient (or other contaminant) source occurs within that reach. Identified sources can then be targeted for remediation and best management practices. Stressed stream analysis, scheduled for 2003 – 2004, will involve further analyses on the two highest priority streams, as identified during the 2002 sampling period, to further identify pollution sources.

In summary, the goal of this report is to provide:

- An interpretive summary of chemistry trends for each subwatershed sampled in the Oneida Lake watershed;
- A prioritization of the tributaries, based on nutrient and soil loss; and
- A comparison between nutrient and soil loss from Oneida Lake subwatersheds to other central New York watersheds with different land use practices.

Background

An excellent review of the several water quality monitoring programs implemented in the past decade of Oneida Lake is provided in the "Oneida Lake State of the Lake and Watershed Report" (OLSLWR 2003). Examples of regional watershed monitoring programs include the NYS DEC (the Rotating Intensive Basin Studies), Project Watershed CNY, and the Central New York Regional Planning and Development Board. In addition, several counties throughout the Oneida Lake watershed have conducted additional tributary monitoring and the United States Geological Survey (USGS) has monitored tributary flow rates. Much of the biological and ecological research of the Oneida Lake basin is focused at the Cornell Biological Field Station at Schackleton Point (OLSLWR 2003). "The Limnology of Oneida Lake: An interim Report" (Greeson and Meyers, 1969) provides historical water quality date for Oneida Lake.

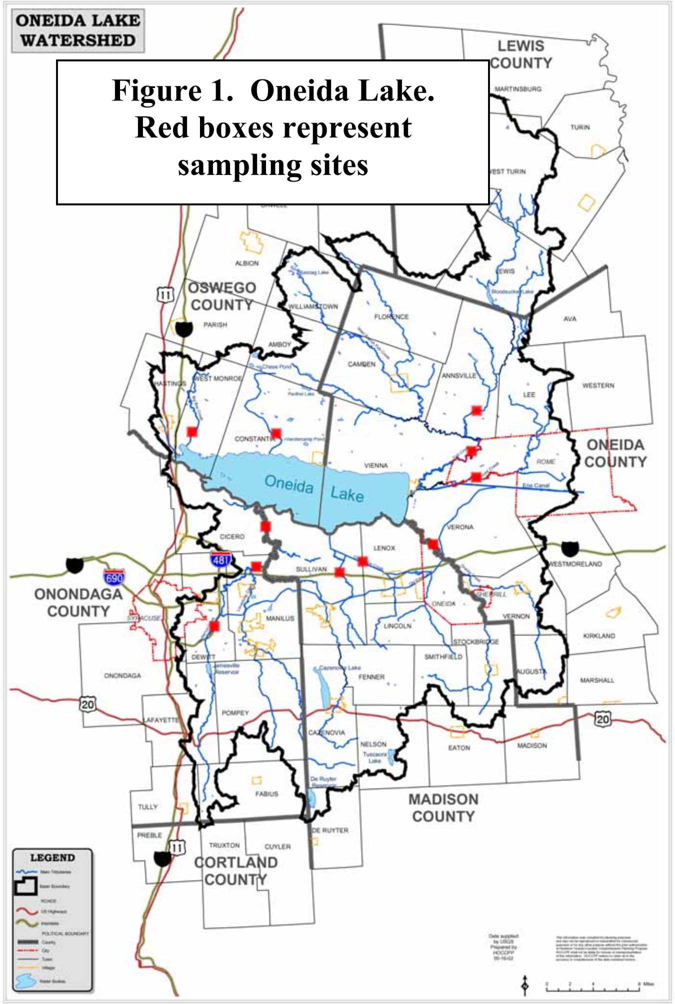
Figure 1. Oneida Lake. Red boxes represent sampling sites

The Oneida Lake Watershed

(Adapted from Oneida Lake State of the Lake and Watershed Report)

(OLSLWR 2003)

The Oneida Lake watershed covers 872,722 acres (about 1,363 square miles) of land area. Approximately 9.7 percent of the watershed lies within Lewis County, 23.8 percent in Madison County, 34.7 percent in Oneida County, 14.9 percent in Onondaga County, 16.8 percent in Oswego County, and less than one percent in Cortland County. The Oneida Lake watershed is composed of seven primary subwatersheds that drain groundwater and surface water from a six county region directly to the Lake.

The Subwatersheds

CHITTENANGO CREEK SUBWATERSHED (Figure 1 and Cover Page)

The headwaters of Chittenango Creek are located in the Madison County Town of Nelson at the Erieville Reservoir (also known as Tuscarora Lake). The stream flows north for 50 linear miles before draining into Cicero Swamp and eventually into Oneida Lake at Bridgeport (OLSLWR 2003). Chittenango Creek forms the border between Madison and Onondaga Counties for its lower 18 miles. The remaining portion flows entirely within Madison County. The main stream and its principal tributaries, Limestone and Butternut Creeks, drain approximately equal areas. These two tributaries, located mainly in Onondaga County, flow north and join Chittenango Creek north of the New York State Thruway, approximately 11.7 miles south of Oneida Lake. The Old Erie Canal flows east to west through the Chittenango Creek subwatershed. Cazenovia Lake is also located in this subwatershed, adjacent to the Village of Cazenovia. Agriculture is a primary land use, with approximately 60 operating farms in the Madison County portion alone. Thirty-seven of these farms are dairy operations. There are also several cash grain and beef operations, with at least one sheep farm and two pig farms. The Villages of Chittenango and Cazenovia are located on Chittenango Creek. According to the "Oneida Lake State of the Lake and Watershed Report" (OLSLWR 2003), Chittenango Creek contributes approximately 18 percent of the total surface water inflow to Oneida Lake.

COWASELON CREEK SUBWATERSHED (Figure 1 and Cover Page)

The Cowaselon Creek subwatershed is contained entirely within the borders of Madison County. The tributaries that flow into Cowaselon Creek originate in the Appalachian Uplands in the central part of the county, flow to the north, and join the main creek after descending the escarpment that separates the Appalachian Upland Region from the low-lying Lake Plain Region. The watershed topography ranges from rolling to steeply sloping in the upland portion of the watershed to relatively flat in the lower watershed areas. Main tributaries within the Cowaselon Creek subwatershed include Clockville Creek, Canastota Creek, and Canaseraga Creek. The Old Erie Canal flows east to west through this subwatershed. Cowaselon Creek enters Oneida Lake at Lakeport.

Cowaselon Creek drains approximately 70,601 acres. Approximately 40 percent of this area is used for intensive agricultural production (OLSLWR 2003). An estimated 59 dairy farms and several beef and sheep farms are found in the watershed. Approximately 29 percent of the watershed is forested. Most of the woodland is comprised of farm wood lots. Population in this subwatershed is concentrated in the Villages of Canastota and Wampsville, as well as along the Oneida Lake shoreline. Land uses in this subwatershed are changing. Population is growing, public sewer and water services are expanding, and abandoned mucklands are being converted back to wetlands. Discharge from Cowaselon and Canaseraga Creeks contributes approximately five percent of the total surface water inflow to Oneida Lake.

FISH CREEK SUBWATERSHED (Figure 1 and Cover Page)

The Fish Creek subwatershed, encompassing approximately 338,500 acres, is located within the Tug Hill Uplands and Lake Plain Regions. Fish Creek is divided into the East Branch, West Branch, and Lower Fish Creek, and spans portions of Lewis, Oneida, and Oswego Counties.

WEST BRANCH FISH CREEK/LOWER FISH CREEK SUBWATERSHED (Fig. 1 and Cover Page)

The West Branch of Fish Creek drains approximately 131,000 acres and flows in a southeast direction from the Tug Hill Uplands. It flows from an area near Williamstown and Redfield in Oswego County, through Camden and McConnelsville, and then joins the East Branch of Fish Creek in Oneida County. The headwaters of the West Branch of Fish Creek are in Oswego County. Flow rates increase as the creek water travels over the steeper gradients of the Tug Hill Uplands down to the lower Lake Plain Region. The East and West Branch of Fish Creek join near Blossvale to form Lower Fish Creek that flows south and west, entering Oneida Lake near Sylvan Beach. The West Branch of Fish Creek contributes approximately 21 percent of the total surface water inflow to Oneida Lake.

Land cover in the West Branch and Lower Fish Creek subwatershed is primarily forest and farmland, but urban and wetland areas are also present. The watershed contains a variety of agricultural operations including dairy, beef, cash crops, sheep and horse farms. The Village of Camden is located along the West Branch of Fish Creek. Population and development is also concentrated in the Lower Fish Creek area including the Oneida Lake shoreline, Village of Sylvan Beach, and City of Rome.

EAST BRANCH FISH CREEK SUBWATERSHED (Figure 1 and Cover Page)

The East Branch of Fish Creek begins in Lewis County and drains 189 square miles (121,000 acres) and is free flowing except at the Tagasoke Reservoir. The creek flows southward through the Tug Hill Upland Region and through limestone and shale bluffs below the Tagasoke Reservoir. The subwatershed contains numerous wetlands, especially in the headwaters in Lewis County. It also encompasses one of the least developed areas within the Oneida Lake watershed with private forests comprising a large portion of the upper subwatershed. The East and West Branches join near Blossvale to form Lower Fish Creek that flows in a southwesterly direction until it enters Oneida Lake at Sylvan Beach. The water supplies for the Cities of Rome and Oneida are located in the East Branch of

Fish Creek. The East Branch of Fish Creek contributes approximately 23 percent of the total surface water inflow to Oneida Lake.

LIMESTONE/BUTTERNUT CREEK SUBWATERSHED (Figure 1 and Cover Page)

Limestone Creek originates at DeRuyter Reservoir in Madison County, while the headwaters of Butternut Creek are located south of the Onondaga County line in Cortland County. Butternut Creek flows north through the Jamesville Reservoir and under an Erie Canal aqueduct in the Town of Dewitt. At Fayetteville, before the confluence of Limestone and Butternut Creeks, a structure diverts flow from Limestone to the Old Erie Canal in order to maintain adequate water supply to the Barge Canal. Butternut joins the north flowing Limestone Creek approximately 1.5 miles north of the Village of Minoa in Onondaga County. Within less than a mile, the stream then joins Chittenango Creek in the northern portion of the Town of Manlius and flows into Oneida Lake six miles farther north near Bridgeport. The remains of several dams interrupt the flow of Limestone Creek in Onondaga County.

DeRuyter Reservoir is a one-square mile storage basin that was built in 1863 to supply water to the Old Erie Canal. It is fed by an artificially diverted tributary of the Middle Branch of Tioughnioga Creek that increases water flow to the Limestone/Butternut Creek subwatershed. Jamesville Reservoir is located on Butternut Creek and was built as a feeder to the Barge Canal. Homes are located on the shorelines and recreational opportunities are plentiful in both reservoirs. Jamesville Reservoir is maintained at or near the spillway level during the summer for recreational purposes. As a result, there is little flood control storage left to alleviate summer flood events. Butternut Creek has a total drainage area at the mouth of approximately 42,600 acres.

The upper portion of the Limestone/Butternut Creek subwatershed is characterized by rural and forested land, and pollution loading is primarily attributed to agricultural and small residential sources. The lower subwatershed is dominated by urban/suburban influences from the City of Syracuse, the Towns of Dewitt and Manlius, and the Villages of East Syracuse, Manlius, Fayetteville, and Minoa. There is approximately 6.8 percent impervious cover in the Limestone/Butternut Creek subwatershed; the Town of Dewitt constitutes 49 percent of that impervious area.

ONEIDA CREEK SUBWATERSHED (Figure 1 and Cover Page)

Oneida Creek originates in Peterboro Swamp, located in the Town of Smithfield, in the Appalachian Upland in central Madison County. It flows to the southeast into the Stockbridge Valley, where it eventually turns northward. Once the Creek reaches the Lake Plain Region, it meanders and is characterized by oxbow formations. Oneida Creek empties into Oneida Lake at South Bay. South of the City of Oneida, the stream begins to form the border of Oneida and Madison Counties. The delineation between the upper and lower reaches of the stream is the Middle Road Bridge, located just south of Route 5. Sconondoa Creek, a tributary of Oneida Creek, originates in Oneida County and flows north and west until it joins Oneida Creek near the City of Oneida. The Old Erie Canal flows in a southwesterly direction through this subwatershed. Oneida Creek contributes seven percent of the total surface water inflow to Oneida Lake.

The Stockbridge Valley is characterized by very steep sides and high stream gradients, resulting in elevated rates of stream bank and farm field erosion. Population and development are concentrated in the Cities of Sherrill and Oneida, and Villages of Vernon, Oneida Castle, and Munnsville. Besides the more populated cities and villages in the Oneida Creek subwatershed, rural areas outside of cities and villages have grown as people take advantage of low taxes, high quality of life, and inexpensive land. This migration to rural areas has resulted in the conversion of lands that were previously agricultural or forested.

About 40 percent of the land area in the Oneida Creek subwatershed is used for intensive agricultural production. Approximately 93 farms are located here, including 34 dairy farms. There are also several cash grain operations, as well as beef and sheep operations. About 38 percent of the watershed is forested - primarily wooded swamps on the plains and forest regions on the steep sides of Stockbridge Valley.

ONEIDA LAKE NORTH SHORE SUBWATERSHED (Figure and Cover Page)

The Oneida Lake North Shore subwatershed is composed of Big Bay Creek, Scriba Creek, and many ponds and smaller south-flowing tributaries that drain directly into Oneida Lake. Discharge from Scriba Creek contributes approximately four percent of the total surface water inflow to the lake. The NYS DEC Oneida Lake Fish Cultural Station is located near the Scriba Creek outlet. The Villages of Central Square and Cleveland are located in the Oneida Lake North Shore subwatershed. In addition to these two villages, population is also clustered along the Oneida Lake shoreline where seasonal camps are increasingly being converted to permanent homes. Most of the subwatershed is privately owned woodland dominated by hardwoods.

WOOD CREEK SUBWATERSHED (Figure 1 and Cover Page)

Wood Creek flows west through the Lake Plain Region in Oneida County, through the City of Rome and Town of Verona where it empties into the canal and eventually makes its way to Oneida Lake at the Village of Sylvan Beach. Wood Creek contributes approximately six percent of the total surface water inflow to Oneida Lake. Canada Creek is a main tributary to Wood Creek.

The Wood Creek subwatershed is generally characterized by 26 percent cropland, 14 percent pastureland, 46 percent woodland, 7 percent urban land, and 7 percent wetland/wildlife. According to the Priority Area Assessment Report for the Oneida Oswego Seneca and Genesee Rivers Basin, Oneida County, New York (1996), 91 farms are located in the Wood Creek subwatershed. Approximately 70 percent of the farms in this area are dairy farms, but beef, cash crop, sheep and horse farms are also present.

Wood Creek also runs through the Rome Sand Plains, where highly erosive stream banks contribute to sediment loading in the watershed. Canada Creek is the other major water body within the Wood Creek North subwatershed. It flows through heavily farmed areas and the Oneida SWCD has documented problems of stream bank erosion, sedimentation, and agricultural runoff.

WOOD CREEK SOUTH SUBWATERSHED (Figure 1 and Cover Page)

The Wood Creek South subwatershed encompasses a total of 36,900 acres. Approximately 18 percent of the total land area is cropland and 19 percent is pastureland. The subwatershed also has 2,100 acres of highly erodible land that contributes sediment and nutrients to the creek. The subwatershed has 54 agricultural producers, of which 40 are dairy farms. Manure spreading and storage for these dairy farms during the winter months result in saturation of the soils in the spring and runoff problems for Wood Creek. The soils in the Wood Creek South subwatershed have moderate problems with contaminants, organic matter, and nutrient imbalances. Wood Creek transports a high volume of water, especially during the spring thaw. The surface water in the basin is moderately impacted by direct animal access, manure spreading and storage, and runoff from urban areas.

Project Organization and Task Responsibilities

This sampling program is a partnership between Central New York Regional Planning and Development Board, NYS Department of Environmental Conservation, SUNY Brockport, Cornell Biological Field Station, and agencies in the four counties that border Oneida Lake (Onondaga County Health Department, Madison County Planning Department, Oneida County SWCD, and Oswego County SWCD).

Anne Saltman – Project Manager, CNY RPDB (Central New York Regional Planning and Development Board), Responsible for communications and agency coordination
Dr. Joseph Makarewicz – Quality Control Officer, SUNY Brockport,
    Responsible for overall project management
Dr. Ed Mills – Director of the Cornell Biological Field Station and
    Chairman of the Technical Committee
Russell Nemecek – Onondaga County contact
    Responsible for sampling in Onondaga County
Scott Ingmire – Madison County contact
    Responsible for Madison County sampling
Jo-Anne Faulkner – Oneida County contact
    Responsible for Oneida County sampling
John DeHollander – Oswego County contact
    Responsible for Oswego County sampling
Dave Prichard, Technical Manager, Life Science Laboratories
    Responsible for laboratory procedures

Definitions

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.

Nitrate + Nitrite- 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.

Dissolved Oxygen– A measure of the amount of oxygen in the water. To support most sport fishes oxygen levels in excess of 4 to 5 mg/L is required.

pH– A measure of the hydrogen ion concentration and indirectly the acidity of water. A pH of seven is neutral. Much of the rainfall in central New York has a pH of 4 to 5 and is acidic.

Specific Conductance– The ability of water to conduct an electrical current. The greater the amount of dissolved substances in water, the greater the ability of the water to conduct electricity. Thus water with a high specific conductance would have a higher amount of dissolved substances than water with a low specific conductance.

Turbidity- A measure of particles, organic or inorganic, found in the water.

Methods

Site Locations

Selection by the Technical Committee members and each of the four County sampling teams of sampling sites for the 2002-monitoring program was based on safety and proximity to Oneida Lake. The eleven sites are located at the base of the primary tributaries flowing into the Lake but are situated far enough upstream to avoid any back-flow influences from the Lake (Figure 1). Sites were chosen at roads where bridges, pipes or culverts are present to allow better measurements of cross-sectional areas of the stream bed necessary for discharge measurements. The “East Branch of Fish Creek” represents the eastern portion of the Fish Creek subwatershed, while the “Fish Creek” location encompasses the entire Fish Creek subwatershed. The sites in the southern watershed region were the same as those selected during 1999-2000 sampling season in order to maintain consistency.

Sites sampled by Onondaga County

1. Limestone Creek (LS2 site from the 1999-2000 monitoring program)
2. Butternut Creek (BN1 site from the 1999-2000 monitoring program)
3. Chittenango Creek (CH2 site from the 1999-2000 monitoring program)

Sites sampled by Madison County

1. Cowaselon Creek (CW1 site from the 1999-2000 monitoring program)
2. Canaseraga Creek (CN1 site from the 1999-2000 monitoring program)
3. Oneida Creek (Swallow Road)

Sites sampled by Oneida County

1. Fish Creek – Represents the entire subwatershed (at the Rt. 49 bridge, below the east and west branches)
2. East Branch of Fish Creek (Main Street, Taberg)
3. Wood Creek (at the Rt. 49 bridge)

Sites sampled by Oswego County

1. Scriba Creek
2. Big Bay Creek

Sampling Dates

Twelve sets of samples were taken over the course of a twelve-month period – six "event" sampling sessions and six "non-event" (baseline) sampling sessions. "Non-event" sampling sessions were scheduled to represent temporal flow and loading variability. Non-event Sampling Days were as follows:

May 9, 2002
June 13, 2002
August 7, 2002
September 12, 2002
April 1, 2003
April 22, 2003

Event Sampling Days – Actual dates of sampling were determined by the occurrence of a substantial rainfall or snowmelt. All "event" samples were taken on the same day and within a three-hour time period in all four counties. An "event" was defined as a period of heavy precipitation or significant snowmelt that results in a substantial increase in the volume of water flowing down a tributary. An "event" was characterized by water levels that rose at least 1" (2.54cm) in depth within 30 minutes. Other considerations in declaring an event (EPA Stormwater Permit Manual) were:

- Rainfall must total more than 0.1 inches.
- At least 72 hours must have elapsed from the previous storm event. This allowed time for pollutants to collect on the drainage surfaces prior to the current event.

Event sampling days were as follows:

May 14, 2002
June 17, 2002
September 28, 2002
October 17, 2002
March 18, 2003
May 13, 2003

Water Sampling: Since these streams being sampled are small and shallow (generally less than a foot in depth), the kinetic energy of the flow of water is sufficient to mix the water column entirely. Thus one water sample was collected per stream for each sampling date. Water samples were placed in pre-cleaned polyethylene bottles provided by LSL, Inc. of Syracuse N.Y. Analysis for chloride, soluble reactive phosphorus, total phosphorus, total Kjeldahl nitrogen, nitrate and total suspended solids were performed by LSL, Inc according to Standard Procedures and preservation techniques (Tables 1 and 2). Field equipment requirements included a HydroLab allowing measurement of temperature and dissolved oxygen.

Stream Velocity: Stream velocity was measured at equally spaced locations in either a culvert or cement channel of a bridge under a road with a Gurley flow meter (Chow 1964). Two sizes were used – a pygmy version for shallow, slower waters and the standard larger Price meter for deeper, higher velocity waters. In high water, deployment of the standard meter was by a cable and weight system lowered from a bridge. All meters were plugged into a digital computer that calculates the velocity. All flow meters were calibrated at the factory prior to the beginning of the study. The number of velocity readings taken varied with the width of the stream. They varied from a high of 17 at Fish and Chittenango Creeks to a low of 3 at Big Bay Creek.

Stream Height and Cross-Sectional Area: Stream depth was measured as the difference between the vertical height of the culvert/bridge opening and the distance between the stream surface and upper portion of the culvert/bridge. Stream cross-sectional area for various stream heights was calculated by planimetry after measuring the cross-sectional dimensions of each stream monitored.

Discharge: Discharge was calculated using standard USGS protocol following Measurement and Computation of Streamflow by Rantz *et al*. (1982). In general, the area-velocity method was used where cross-sectional area and velocity were physically measured during each sampling trip across the width of the streambed.

Watershed Area: Subwatershed areas were estimated from USGS topographic maps.

Nutrient Loading: Daily nutrient and soil loss from the watershed were calculated by multiplying the discharge on the day of the sample by the concentration of the nutrient or solids from the appropriate water sample.

Consistency In Sampling:

To ensure consistent sampling procedures, representatives from the Central New York Regional Planning & Development Board (CNY RPDB), the Cornell Field Station, SUNY Brockport, Onondaga Community College, Life Science Laboratories, the Department of Environmental Conservation, and four County agencies (Onondaga County Health Department, Madison County Planning Department, Oneida County SWCD, and Oswego County SWCD) met at the Cornell Field Station for a training session. The training session was conducted by J. Makarewicz and T. Lewis from SUNY Brockport and was followed by a review of the equipment, sampling handling and storage, and field sampling procedures on Chittenango Creek. Members of the sampling team visited each site at least one time to evaluate the suitability of the site and to collect measurements. Each participant worked with the flow probes and HydroLabs.

Sample Handling and Custody Requirements:

Chain of custody forms were signed by the sampling personnel upon release of the samples and were signed by the individual accepting samples for the laboratory.

Quality Assurance

LSL. Inc is a NELAC certified laboratory. In general, the quality assurance data indicated that laboratory analyses were adequate (Table 3). As indicated on Table 3, several minor quality issues were identified. However, they were either rectified or explained. They did not affect the overall quality of the data nor do they effect the interpretation of the data. To ensure analytical quality control, the following were completed.

Method Blanks were performed at a frequency of one per batch of samples per matrix type per sample extraction or preparation test method. The results of these samples were used to determine batch acceptance. Method blank detections, ten times the reporting limit, required repeat analysis of the associated batch.

Laboratory Control Samples were analyzed at a minimum of 1 per batch of 20 or fewer samples per matrix type per sample extraction or preparation method except for analytes for which spiking solutions were not available (e. g. total suspended solids). The results of these samples are used to determine batch acceptance.

Matrix Spikes (MS) were performed at a frequency of one in 20 samples per matrix type per sample extraction or preparation method except for analytes for which spiking solutions are not available, such as, total suspended solids. The sample(s) selected for spiking were rotated among each creek so that various matrix problems would be noted and/or addressed. Poor performance in a matrix spike generally indicated a problem with the sample composition, and not the laboratory analysis, and was reported to assist in data assessment. The analyst did repeat batch processing due to poor matrix spike recovery.

Laboratory Duplicates were analyzed at a minimum of 1 in 20 samples per matrix type per sample extraction or test method. The selected sample(s) were rotated among received samples so that various matrix problems would be noted and/or addressed.

Results
Concentration of Analytes

Dissolved Oxygen (Table 4):

Dissolved oxygen concentrations were high and more than adequate to support aquatic biota at all sites on all sampling dates. Generally, baseline and event oxygen concentrations were within 1 mg/L of each other. For example, oxygen concentrations in Butternut Creek were essentially the same between baseline flow (mean = 10.56 mg/L) than during event flows (mean = 10.49 mg/L). The largest difference between event and baseline flow oxygen levels was observed in Cowaselon Creek. Baseline concentrations were 1.18 mg/L higher than event concentrations (7.60 m/L).

Specific Conductance (Table 4):

Specific conductance, which reflects the amount of total dissolved solids in water, varied significantly between subwatersheds and within a watershed between an event and a nonevent. For example, specific conductance of Canaseraga and Cowaselon Creeks (~600 to 800 mS/cm) was an order of magnitude higher than Scriba Creek (~60 to 95 mS/cm). Where measured, specific conductance was always higher during baseline conditions than during events. The lower specific conductance observed during events indicated a dilution effect during periods of high flow.

pH (Table 4):

Although the Oneida Lake area received acid precipitation (pH<5.5), the tributaries draining the watersheds were not affected by acid precipitation. In general, pH for all tributaries was above neutrality being in the 7 to 8.5 range. Except for Fish Creek, where a small but insignificant increase occurred (<.02 pH unit), pH of all creeks decreased slightly (<0.7 pH units) during events reflecting the acid nature of the rainfall in this region.

Chloride (Table 4):

The average baseline or nonevent concentration of chloride ranged from a low of 5.6 mg/L at the East Branch of Fish Creek to a high of 68.7 at Limestone. For all sampling sites, except Butternut Creek, the average event concentration was always lower than the average baseline concentration for a given stream. This was somewhat a surprising result. In western and central

New York, chloride (and sodium) concentrations are generally higher during baseline flow than storm events in the winter and spring than during the summer and fall (e.g., Makarewicz and Lewis 1998a, 1998b).

Total Phosphorus (Table 4):

Phosphorus is an element required for plant growth whether on land or in the 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 stream from the watershed as a result of sewage disposal, heavy fertilizer use for lawns or agriculture, and through erosion of soil. Watersheds that have streams with high phosphorus concentrations are potentially the cause of increased phytoplankton and macrophyte (weed) production in lakes. Oneida Creek had the highest event concentration (250 µg/L) followed closely by Cowaselon Creek (155 µg/L). As in the previous study of the south shore tributaries (Makarewicz and Lewis 2000), high levels of total phosphorus were observed during baseline flows in Oneida Creek 1999 (107 µg P/L). The lowest concentrations of total phosphorus were observed during baseline flows at the East Branch of Fish (9 µg/L) and Butternut (7 µg/L) Creeks.

Total phosphorus concentrations increased in all 11 monitoring sites during runoff events. This suggests that phosphorus was being lost from the watershed as particulate matter, probably from soil erosion. Except for Scriba Creek, the increase in total phosphorus concentration was generally greater than 80% from non-events to events.

Total Suspended Solids (Table 4):

Total suspended solid concentrations in stream water generally reflect the amount of suspended materials (e.g., soils) being lost from a watershed. The average total suspended solids concentration in Oneida Lake tributaries varied significantly between subwatersheds and within a watershed between an event and a nonevent. Average total suspended solids concentrations increased significantly in all tributaries during events. The increased volume of water flowing over the landscape during an event washed and carried surficial material increasing the amount of suspended materials in the water. This result is typical of tributaries draining urban and agricultural watersheds. The percent increase in TSS from baseline to event conditions was often substantial. They were as follows: Oneida Creek (847%, 10.3 to 97.5 mg/L), Scriba Creek (505%, 2.0 to 12.1 mg/L), Cowaselon Creek (398%, 14.8 to 73.7 mg/L), East Branch of Fish Creek (365%, 2 to 5.6 mg/L), Fish Creek (335%, 4.8 to 20.9 mg/L), Canaseraga Creek (322%, 15.2 to 64.2 mg/L), Limestone Creek (282%; 16.3 to 62.2 mg/L), Wood Creek (277%, 5.3 to 20.0 mg/L), Butternut Creek (193%, 4.5 to 13.2 mg/L), Big Bay Creek (178%, 8.8 to 24.5 mg/L) and Chittenango Creek (128%, 14.9 to 33.9 mg/L). These results indicated that large amounts of soil were lost from the watershed during events.

Nitrogen – Nitrate and Total Kjeldahl Nitrogen (TKN) (Table 4):

Nitrate is found in fertilizer, while total Kjeldahl (TKN) nitrogen represents the organic nitrogen plus ammonia present. Organic nitrogen would occur from sources such as sewage and animal manure, while nitrate is often a major component of fertilizer and is lost from sewage treatment plants. Unlike most of the south shore tributaries of Oneida Lake, all the north shore tributaries (Wood, Scriba, Fish and East Branch of Fish Creek) experienced a decrease in nitrate concentration during events. Similar to the 1999 study on the south shore tributaries (Makarewicz and Lewis 2000), Limestone and Chittenango Creeks also had a decrease in nitrate concentration during events. As in 1999-2002, all the other south shore tributaries experienced an increase in nitrate of <50%.

TKN increased slightly (<100%) in all tributaries during storm events, except Wood Creek and East Branch of Fish Creek. As in the 1999-2000 study, Cowaselon experienced a large increase (86%) in TKN concentration during events (520 µg/L to 970 µg/l). TKN concentrations also increased 112% during events in Oneida Creek.

Watershed Loss of Materials and Nutrients

Although concentration of analytes provides useful information, the actual quantified loss of nutrients or materials from a watershed or loading is a better measurement of a watershed's impact to a downstream system. The loading estimate is a better indicator because it considers the volume of water being lost from a watershed, in addition to the concentration of the nutrient in that water. For example, a stream with a high concentration of a nutrient but a low discharge will have less of an impact on downstream systems than a stream with high discharge and a moderate concentration of a nutrient. Tables 5 and 6 present the average event and nonevent loss of total phosphorus, total Kjeldahl nitrogen, nitrate, total suspended solids and chloride.

The current sampling scheme provides a “snapshot” for an instant in time. We have twelve snapshots (i.e., sample dates) or instances in time where samples were taken. Because flow or discharge was not monitored continuously, time trend analysis within the study period or into the future is not possible. However, prioritization of subwatersheds based on the amount of nutrients and materials lost from a subwatershed was possible and has been done below. It should be noted that these rankings might change if more sampling dates were added to the database. From a statistical point of view, confidence in these results would increase with more sampling dates. Direct comparisons of watersheds using areal losses (loss per watershed area) were used in this report (Figure 3), although non-weighted nutrient losses were also presented in Figure 2. By calculating the loss per unit area of watershed, we normalized the results so that subwatersheds of different areas could be effectively compared. Each bar graph in Figure 3 represents the nutrient or material losses from a tributary and its associated watershed normalized by the size of the watershed. A watershed with a high loss of nutrients per unit area compared to another would suggest that a non-point or point source of nutrients existed in this watershed. Also by considering areal loading, prioritization or ranking of watersheds for remedial action is possible.

Discharge (Table 5)

For the twelve sampling dates, the average highest baseline (3.2 million m^3/day) and event (6.8 million m^3/day) discharge were observed at Fish Creek (Figure 2). The lowest flows were observed at Scriba (baseline: 102,598 m^3/day, event: 382,807 m^3/day) and Canaseraga Creeks (baseline: 150,934 m^3/day, event: 399,001 m^3/day). Scriba (273%), Oneida (253%), and Wood Creek experienced the largest increase in discharge during events while Butternut (107%) and Fish Creek (115%) experienced the smallest increase in discharge from non-event conditions.

Phosphorus (Tables 5 and 6):

The loss of total phosphorus during events from the Oneida Lake subwatersheds was always higher than baseline losses. Non-event losses from each subwatershed were variable (0.2 to 1.4 g/ha/day), but not as variable as event losses (1.6 to 9.1 g/ha/day). Considering daily areal loading (Table 6), Oneida Creek delivered more phosphorus (9.1 g P/ha/day) to downstream habitats than any other watershed during events (Fig. 5). Chittenango (7.6 g P/ha) and Cowaselon Creek (7.4 g P/ha) also had relatively high event losses of total phosphorus relative to other Oneida Lake subwatersheds. Total phosphorus loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events ($r^2 = 0.95$). This suggests that the phosphorus in the particulate form (soil) was being washed off the landscape or eroded from stream banks.

By considering the total loading of a subwatershed (not normalized by area of the subwatershed) (Table 5), we have a better sense of the amounts of phosphorus being delivered into Oneida Lake by a subwatershed. For example, Oneida Creek, which also had the highest areal loading to Oneida Lake, was delivering 409.6 kg P/day (904 lbs) of phosphorus per storm event day.

Nitrate (Tables 5 and 6)

Nitrate is a measure of the soluble forms of nitrogen that are used readily by plants for growth. Figure 3 depicts annual event and non-event losses of nitrate from the watersheds. Of the eleven subwatersheds studied, the five subwatersheds contributing the largest amount of nitrate to downstream habitats during events in descending order were: Cowaselon and Butternut Creeks (53 g/ha/day each), Oneida Creek (46 g/ha/day), and Limestone and Chittenango Creeks (39 g/ha/day each).

Total Kjeldahl Nitrogen (Tables 5 and 6)

Total Kjeldahl nitrogen (TKN) is a measure of the organic nitrogen loss from the subwatershed. For example, cow manure would contain a large amount of organic nitrogen. Concentrations of TKN were higher in events than during non-events suggesting that organic material was being swept off the subwatershed during precipitation. In descending order, the greatest areal loss of total Kjeldahl nitrogen from the subwatershed to downstream systems occurred in descending order were: Cowaselon Creek (46 g N/ha/day), Fish Creek (46 g N/ha/day), Chittenango Creek (43 g N/ha/day), Big Bay Creek (39 g N/ha/day) and Oneida Creek (36 g N/ha/day)(Figure 3). Makarewicz and Lewis (2000) also reported high losses of organic nitrogen from Cowaselon and Oneida Creeks in 1999. Cowaselon, Oneida, Fish and Chittenango Creeks have sewage treatment plants in their subwatersheds. Malfunctioning “on site wastewater treatment plants” (e.g., septic systems) also can contribute organic nitrogen to a tributary.

These losses may be associated with land use. Over 40% of the land is in some form of agriculture in Madison and Oneida Creeks. Similarly, the Chittenango Creek subwatershed was heavily used in agriculture with over 60 farms in operation. Land use in the Big Bay and Scriba Creeks subwatersheds was not available. As total phosphorus, total Kjeldahl nitrogen loading was highly correlated with total suspended solid loss from Oneida Lake subwatersheds during events (r^2= 0.85). This suggests that nitrogen, in the particulate from, was being washed off the landscape. These losses would suggest a source of nitrogen such as cow manure. Many of the farms in the Oneida Creek (34) and Cowaselon (59) subwatersheds are dairy farms.

Total Suspended Solids (Tables 5 and 6)

The loss of suspended solids is a measurement of the loss of soil and other materials suspended in the water from a watershed and can be used as a measure of soil erosion. Stream bank erosion can be a major source of soil loss. In general, soil erosion is one of the major sources of nutrient loss from watersheds and was positively correlated with total phosphorus and TKN loss in the eleven Oneida Lake tributaries. Several subwatersheds were losing suspended materials at higher levels per unit area of subwatershed compared to other subwatersheds (Figure 3). Chittenango Creek (6,061g/ha/day), Cowaselon (4,500 g/ha/day), Oneida Creek (4,365 g/ha/day), Limestone (3,528 g/ha/day) and Fish Creek (3,395 g/ha/day) had the greatest loss of suspended matter form the subwatershed (Table 6). Similarly, the 1999 study of Makarewicz and Lewis (2000) identified Cowaselon Creek, Limestone Creek, Canaseraga Creek and Oneida Creek as the major south shore tributaries with the highest loss of suspended materials from the watershed.

Another way of gauging the impact of a subwatershed is to consider the total loading from the subwatershed - that is, not normalizing the data for area. Large amounts of suspended materials, most likely soil, were being lost from the subwatershed. Using the Oneida Creek subwatershed as an example, about 215 tons of soil per storm event day was washed into the lake. Other high losses were from Fish Creek (199 tons/day) and Chittenango Creek (143 tons)(Table 5). In contrast, Scriba Creek was delivering ~57 pounds daily of suspended matter during non-events of soil.

A 1995 report indicated that stream bank erosion along Oneida Creek generated the largest amount of sediment (OCSWCD 1995**)**. In fact, the Stockbridge Valley of Oneida Creek is characterized by steep sides and high stream gradients. But stream bank erosion may not be the only cause. Three of the five subwatersheds identified as losing high amounts of soil are located in Madison (Cowaselon and Chittenango Creeks) and Oneida Counties (Oneida Creek). Of the 316 farms listed in State of the Lake Report (OLSLWR 2003), 262 occur in the Madison and Oneida Counties (Table 7). The majority of these farms are dairies located within Madison and Oneida Counties. In Madison and Oneida Counties, farming accounts for approximately 44 and 26 percent of the land use in the county. An estimated 59 dairy farms and several beef and sheep farms are found in Cowaselon Creek subwatershed, while ~76 dairy farms exist in the Oneida Creek subwatershed. In Madison and Oneida Counties, farming accounts for ~44 and 26%, respectively, of the land use (Table 8).

Chloride (Tables 5 and 6)

Chloride is a component of deicing salt. Unlike the other chemical analytes discussed where the highest concentration often occurred during hydrometeorologic events, concentrations of chloride were often highest during non-events (Table 2). Because discharge was considered during the calculation of loading, loss of salt during events was greater than during baseline flows. Of the twelve subwatershed studied, losses of chloride from sub-watersehds in descending order were: Butternut Creek (2,554 g/ha/day), closely followed by Chittenango (2,467 g/ha/day) and Limestone (1,875 g/ha/day) and Big Bay Creeks 1,800 g/ha/day). Surprisingly, losses from the Butternut and Chittenango Creek subwatershed were high during both events and non-events. For example, 2.1 pounds/acre/day of chloride were lost during events, and 1.4 pounds/acre/day were lost during non-events in Chittenango Creek (Table 6).

Discussion

The water quality of a lake is directly influenced by land use practices in the lake's watershed. As precipitation falls on the landscape, it washes or carries materials, such as soil, cow manure, nutrients, pesticides, etc. from the land surface into nearby streams and eventually into Oneida

Lake influencing water quality (Makarewicz and Lewis, 2000). Land usage that includes agriculture and urban living have a greater potential to deliver nutrients and soil to a lake than a forested watershed. Maintenance of a lake's water quality is achieved by protecting the lake's watershed. Remediation of watersheds will serve to improve tributary and lake water quality. More importantly, remediation will serve to protect and improve fish spawning and nursery areas of sport fishes utilizing tributaries and wetlands and other wildlife, increase tourism and the economy by providing better recreational opportunities and, in general, improve the quality of life.

Freshwater resources have historically played an instrumental role in community development and economic sustainability. Oneida Lake is not an exception. The Oneida Lake region provides numerous recreational attractions, outstanding fishing, aesthetic appeal, and economic opportunities for thousands of people (CNYRPDB 2000). This recreational usage and economic value are predicated on the availability of high quality water resources and angling opportunities in Oneida Lake and its tributaries. Needless to say, agriculture also has a major economic impact in the Oneida Lake watershed. Loss of important agriculture resources, such as soil and nutrients, from a watershed is of concern to the landowner, to the Soil and Water Conservation District, and eventually to lake residents because of the potential impact they have on lake water quality and fishery resources. Remediation and protection of soil and water resources depend largely on the identification of both the cause and effect of elements likely to reduce their economic and social value.

The analysis performed in this study and in two other studies of Oneida Lake subwatersheds (Makarewicz and Lewis 2000, Makarewicz and Lewis 2003) provided a basis for evaluating losses of nutrients and materials (i.e., soils) from 16 subwatersheds of Oneida Lake and for establishing a priority list of impacted subwatersheds that could be targeted for remediation and restoration. Included in this evaluation and prioritization are data from several small creeks monitored by Oswego County Soil and Water Conservation District (Makarewicz and Lewis 2000). Chemical analysis, discharge methodology and loading calculations were the same in this study thus allowing a comparison. Although both studies did not completely overlap seasonally, they were done in roughly the same 18-month period.

Other limitations of the monitoring design existed. A total of 12 seasonal samples (6 baseline and 6 event samples) were taken from the eleven tributaries of Oneida Lake and a comparable number of samples from the Oswego Soil and Water Conservation District Study. The database was not large. At any given instance we measured discharge and nutrient levels – but this varied each minute of each day. It might have rained only on one end of the lake but not on the other. We also did not sample all events because of budget limitations. Thus the estimates we have are a good measure of loading for each "snap shot" at an instance in time but not of an annual loading value. These "daily estimates" of loading are improved as a greater number of samples are taken. If more samples were taken or if continuous monitoring of stream discharge were possible, the estimate of loss of nutrients would improve. Nevertheless, the data set as a whole unit is useful in providing an estimate on which subwatersheds were delivering more materials and nutrients to Oneida Lake.

Comparison to Other Watersheds

Comparisons to subwatersheds with various land uses in western and central New York suggest that phosphorus loss from some Oneida Lake subwatersheds were relatively high compared to subwatersheds known to have low losses (Table 9). For example, event losses of phosphorus from Oneida Creek (9.1 g P/ha/d), Little Bay Creek (8.8 g P/ha/d), Chittenango Creek (7.6 g P/ha/d) and Cowaselon Creek (7.4 g P/ha/d), all subwatersheds of Oneida Lake, were substantially higher than event losses from most subwatersheds of Canandaigua Lake and Sandy Pond (Table 9). Canandaigua Lake is an unproductive, oligotrophic lake possessing high water clarity. Similarly, average annual daily losses from Sheldon Creek (27.4 g P/ha/d), a subwatershed of Lake Neatahwanta that drains muckland, were substantially higher than any of the Oneida Lake subwatersheds studied (Makarewicz and Lewis, 1998a). These Oneida Lake and Lake Neatahwanta tributaries with high losses of phosphorus were either in agriculture or had sewage treatment plants located within the subwatershed. These comparisons between subwatersheds suggest that losses of nutrients of some Oneida Lake subwatersheds are above natural levels when compared to other subwatersheds with Oneida Lake and to watersheds in central and western New York.

In What Oneida Lake Subwatersheds Are Losses of Nutrients and Soil High?

A review of Figure 4 identifies several subwatersheds that on areal basis were consistently delivering greater amounts of nutrients and suspended matter than other subwatersheds. For example, Chittenango, Cowaselon, Oneida, Limestone and Fish Creek were clearly losing more suspended matter than other subwatersheds. A similar visual inspection for total phosphorus and total Kjeldhal nitrogen revealed that a similar set of subwatersheds were losing nutrients. These were Oneida, Cowaselon, Chittenango, Limestone and Fish Creeks. Little Bay Creek is an addition to the list as total phosphorus and total Kjeldhal nitrogen losses were comparatively high. Since phosphorus is generally considered to be the limiting nutrient of phytoplankton growth in freshwater lakes and soil loss is the likely vector of this loss, four subwatersheds are suggested as potential targets for stressed stream analysis: Oneida Creek, Cowaselon, Chittenango and Little Bay Creek. These subwatersheds also had high losses of total suspended solids, total phosphorus and total Kjeldahl nitrogen. Also, Little Bay Creek also had significantly higher areal losses of chloride than any other subwatershed. Consideration should be given to identifying sources if these are anthropogenic losses (de-icing salt usage, improper storage). Stressed stream analysis or segment analysis is a technique that identifies the sources of pollutants within a subwatershed by subdividing the impacted subwatershed into small distinct geographical units. Samples are taken at the beginning and end of each stream unit to determine if a nutrient (or other contaminant) source occurs within that reach (Makarewicz 1993).

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Table 1. Analytical methodology employed by LSL, Inc. RL=Reporting Limit

Analyte	Method	Volume/Container	Preservative	Holding Time*	RL
Chloride	EPA 300	250ml plastic	cool 4°C	28 days	0.04 mg/l
Nitrate/nitrite	EPA 353.1	250ml plastic	cool 4°C	48 hours	0.02 mg/l
TKN	EPA 351.2	250ml plastic	H_2SO_4, cool 4°C	28 days	0.002 mg/l
TSS	EPA 160.2	250ml plastic	cool 4°C	7 days	4 mg/l
Total Phosphorus	EPA 365.3	250ml plastic	cool 4°C	28 days	0.002 mg/l

*From time of collection.

Table 2. Quality assurance acceptable Limits for nonpoint water samples. LCS=Laboratory Control Samples, RPD=Replicate Percent Deviation, MS=Matrix Spike.

Analyte	Method	LCS - % Rec.	Duplicate RPD	MS - % Recovery
Chloride	EPA 300	+/- 10%	<20%	no limit
Nitrate/nitrite	EPA 353.1	+/- 10%	<20%	no limit
TKN	EPA 351.2	+/- 10%	<20%	no limit
TSS	EPA 160.2	NA	<20%	no limit
Total Phosphorus	EPA 365.3	+/- 10%	<20%	no limit

Table 3. Quality Control Data for Oneida Lake sample provided by LSL, Inc. LCS = Laboratory Control Standard; %R = Percent Recovery; RPD = Relative Percent Deviation.

5/09/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike %R	Matrix Duplicate RPD
Phosphorus	<0.002	106.1	90-110	108	1.1
TKN	<0.1	64	55-91*	73	2
Nitrate/Nitrite	<0.02	100	90-110	98	1
TSS	<4	NA	NA	NA	<1
Chloride	<1	96	90-110	85	<1

5/14/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	95.4	90-110	108	<1
TKN	<0.1	61	55-91*	60	9
Nitrate/Nitrite	<0.02	99	90-110	77	<1
TSS	<4	NA	NA	NA	17
Chloride	<1	96	90-110	88	<1

6/13/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	101	90-110	103	3.2
TKN	<0.1	120 [3]	55-91*	95	<1
Nitrate/Nitrite	<0.02	97	90-110	83	19
TSS	<4	NA	NA	NA	<1
Chloride	<1	96	90-110	90	<1

6/17/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	101	90-110	102	1.8
TKN	<0.1	Not Available[1]	55-91*	90	<1
Nitrate/Nitrite	<0.02	97	90-110	84	13
TSS	<4	NA	NA	NA	39
Chloride	<1	96	90-110	95	<1

Table 3 (continued). Quality Control Data for Oneida Lake sample provided by LSL, Inc. LCS = Laboratory Control Standard; %R = Percent Recovery; RPD = Relative Percent Deviation.

8/8/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	96	90-110	123	5.1
TKN	<0.1	88	55-91*	69	14
Nitrate/Nitrite	<0.02	103	90-110	98	26
TSS	<4	NA	NA	NA	51 ^{2}
Chloride	<1	94	90-110	100	<1

9/16/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	105	90-110	92	<1
TKN	<0.1	66	55-91*	70	<1
Nitrate/Nitrite	<0.02	99	90-110	88	9
TSS	<4	NA	NA	NA	<1
Chloride	<1	96	90-110	99	2

9/28/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	0.002	106	90-110	92	<1
TKN	<0.1	52	55-91*	70	14
Nitrate/Nitrite	<0.02	93	90-110	88	23^2
TSS	<4	NA	NA	NA	NA
Chloride	<1	95	90-110	99	1

10/17/2002	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	0.002	109	90-110	96	1.7
TKN	<0.1	85	55-91*	64	2
Nitrate/Nitrite	<0.02	95	90-110	129	19
TSS	<4	NA	NA	NA	<1
Chloride	<1	98	90-110	98	<1

Table 3 (Continued). Quality Control Data for Oneida Lake sample provided by LSL, Inc. LCS = Laboratory Control Standard; %R = Percent Recovery; RPD = Relative Percent Deviation.

3/18/2003	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	91	90-110	110	1.4
TKN	<0.1	69	55-91*	72	12
Nitrate/Nitrite	<0.02	103	90-110	85	4
TSS	<4	NA	NA	NA	<1
Chloride	<1	94	90-110	89	<1
4/1/2003	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	94	90-110	100	2.6
TKN	<0.1	63	55-91*	69	35[4]
Nitrate/Nitrite	<0.02	100	90-110	95	4
TSS	<4	NA	NA	NA	<1
Chloride	<1	97	90-110	84	<1

4/22/2003	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	100	90-110	100	2.7
TKN	<0.1	76	55-91*	74	10
Nitrate/Nitrite	<0.02	101	90-110	97	<1
TSS	<4	NA	NA	NA	<1
Chloride	<1	95	90-110	85	<1

5/13/2003	Method Blank (mg/L)	LCS Recovery %	LCS Control Limits %	Matrix Spike (%R)	Matrix Duplicate (RPD)
Phosphorus	<0.002	100	90-110	100	<1
TKN	<0.1	67	55-91*	66	5.5
Nitrate/Nitrite	<0.02	102	90-110	85	2.2
TSS	<4	NA	NA	NA	15
Chloride	<1	91	90-110	84	<1

*The TKN LCS control limits provided in the QAPP referred to the continuing calibration standard acceptable limits. Actual LCS acceptable control limits are based on historical LCS recovery data.

[1] Results are not available for this sample due to a laboratory accident. MS and MSD results are within the acceptable range.

[2] A duplicate analysis of this result was found to be slightly beyond statistical control limits.

[3] Outside of established control limits. MS recovery within acceptable range.

[4] The result of a duplicate analysis of this sample was 0.1 mg/L.

Table 4. Average concentrations in selected Oneida Lake tributaries during events and nonevents. B+E refers to the average for hydrometerological events and baseline (nonevents) conditions. Mean = average concentration, S.E. = standard error, TP = total phosphorus, TKN = total Kjeldahl nitrogen, TSS = total suspended solids, Temp. = water temperature, DO = dissolved oxygen, Turb. = Turbidity, SC = specific conductance, N.D. = no data available.

Creek		TP (mg/l)		Nitrate (mg/l)		TKN (mg/l)		Chloride (mg/l)		TSS (mg/l)		Temp (°F)		DO (mg/l)		pH		Turb (NTU)		SC mS/cm	
		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Big Bay Creek	Baseline	0.038	0.006	0.13	0.03	0.32	0.03	23.8	3.59	8.8	1.2	56.3	5.1	8.42	1.06	7.23	0.21	8.2	2.3	234.7	36.7
	Event	0.064	0.006	0.20	0.07	0.51	0.06	22.0	5.84	24.5	7.2	50.2	4.3	8.90	0.65	6.96	0.19	19.2	3.4	184.8	26.1
	B+E	0.051	0.006	0.17	0.04	0.41	0.04	22.9	3.28	16.7	4.2	53.2	3.3	8.66	0.60	7.09	0.14	13.7	2.6	209.7	22.7
Scriba Creek	Baseline	0.023	0.006	0.12	0.02	0.29	0.03	7.6	0.58	2.0	0.0	57.2	5.5	9.32	0.88	7.13	0.29	6.3	5.4	95.4	14.7
	Event	0.031	0.006	0.09	0.03	0.53	0.06	6.6	0.57	12.1	5.5	50.1	4.2	9.74	0.77	6.81	0.22	29.7	23.1	66.3	16.6
	B+E	0.027	0.004	0.10	0.02	0.41	0.05	7.1	0.42	7.0	3.0	53.7	3.5	9.53	0.56	6.97	0.18	18.0	11.8	80.9	11.4
Oneida Creek	Baseline	0.107	0.028	0.97	0.18	0.41	0.06	33.2	2.26	10.3	4.1	56.9	4.9	7.62	0.99	8.56	0.16	14.1	5.3	653.4	127.9
	Event	0.250	0.099	1.03	0.17	0.87	0.16	23.2	2.26	97.5	31.5	51.1	3.9	7.73	1.06	8.45	0.18	158.3	53.2	504.8	53.7
	B+E	0.178	0.053	1.00	0.12	0.64	0.11	28.2	2.14	53.9	20.0	54.0	3.1	7.67	0.69	8.51	0.12	71.8	30.7	594.0	80.2
Canaseraga Creek	Baseline	0.039	0.008	1.04	0.12	0.41	0.09	31.3	2.95	15.2	5.2	54.2	4.4	7.99	1.01	8.49	0.16	22.9	6.1	783.5	152.5
	Event	0.115	0.031	0.90	0.13	0.65	0.08	22.3	2.91	64.2	12.6	50.4	3.3	7.85	1.07	8.38	0.19	102.0	27.0	599.0	86.6
	B+E	0.077	0.019	0.97	0.09	0.53	0.07	26.8	2.40	39.7	9.8	52.3	2.7	7.92	0.70	8.43	0.12	54.5	16.6	709.7	98.3
Cowaselon Creek	Baseline	0.051	0.008	0.89	0.20	0.52	0.16	33.3	2.16	14.8	5.3	55.4	4.7	8.78	1.05	8.47	0.17	22.5	7.1	799.3	156.1
	Event	0.155	0.031	1.00	0.12	0.97	0.10	30.2	3.12	73.7	17.1	50.8	3.2	7.60	0.99	8.23	0.22	109.3	22.4	606.4	70.4
	B+E	0.103	0.022	0.95	0.11	0.74	0.11	31.8	1.87	44.3	12.3	53.1	2.8	8.19	0.71	8.35	0.14	57.2	16.9	722.1	98.9
Butternut Creek	Baseline	0.007	0.001	0.68	0.11	0.15	0.03	45.7	2.72	4.5	1.3	47.9	7.5	10.56	0.64	8.07	0.06	N.D.	N.D.	N.D.	N.D.
	Event	0.032	0.012	0.75	0.12	0.24	0.04	46.7	4.67	13.2	7.7	39.0	8.9	10.49	0.84	7.97	0.21	N.D.	N.D.	N.D.	N.D.
	B+E	0.020	0.007	0.71	0.08	0.20	0.03	46.2	2.58	8.8	4.0	43.4	5.7	10.53	0.50	8.02	0.11	N.D.	N.D.	N.D.	N.D.
Limestone Creek	Baseline	0.051	0.013	1.50	0.35	0.41	0.07	68.7	6.59	16.3	4.1	47.5	7.3	10.06	0.76	7.90	0.05	N.D.	N.D.	N.D.	N.D.
	Event	0.106	0.017	0.96	0.18	0.43	0.04	43.2	3.77	62.2	11.6	36.9	8.3	10.38	0.75	7.75	0.14	N.D.	N.D.	N.D.	N.D.
	B+E	0.078	0.013	1.23	0.20	0.42	0.04	55.9	5.28	39.2	9.1	42.2	5.5	10.22	0.51	7.82	0.07	N.D.	N.D.	N.D.	N.D.
Chittenango Creek	Baseline	0.044	0.005	0.74	0.06	0.33	0.03	56.2	5.56	14.9	3.3	50.3	7.8	10.14	0.74	7.96	0.05	N.D.	N.D.	N.D.	N.D.
	Event	0.075	0.015	0.63	0.13	0.44	0.08	37.1	8.31	33.9	10.0	37.9	8.8	9.43	0.68	7.49	0.17	N.D.	N.D.	N.D.	N.D.
	B+E	0.059	0.009	0.69	0.07	0.39	0.04	46.7	5.57	24.4	5.8	44.1	5.9	9.79	0.49	7.73	0.11	N.D.	N.D.	N.D.	N.D.
Wood Creek	Baseline	0.026	0.003	0.98	0.10	0.52	0.13	24.7	2.28	5.3	1.8	55.4	4.7	6.96	0.90	8.41	0.11	N.D.	N.D.	N.D.	N.D.
	Event	0.051	0.006	0.39	0.07	0.45	0.02	22.5	5.20	20.0	3.1	50.7	3.7	7.77	1.06	7.95	0.19	N.D.	N.D.	N.D.	N.D.
	B+E	0.038	0.005	0.69	0.11	0.48	0.06	23.6	2.73	12.7	2.8	53.1	2.9	7.36	0.67	8.18	0.12	N.D.	N.D.	N.D.	N.D.
Fish Creek	Baseline	0.019	0.003	0.27	0.02	0.33	0.07	5.9	1.04	4.8	1.6	55.5	5.4	7.63	0.98	8.07	0.25	N.D.	N.D.	N.D.	N.D.
	Event	0.031	0.003	0.21	0.06	0.36	0.06	4.4	0.52	20.9	5.4	50.2	4.3	8.47	1.06	8.09	0.22	N.D.	N.D.	N.D.	N.D.
	B+E	0.025	0.003	0.24	0.03	0.34	0.04	5.2	0.60	12.8	3.6	52.8	3.4	8.05	0.70	8.08	0.16	N.D.	N.D.	N.D.	N.D.
East Branch Fish	Baseline	0.009	0.001	0.35	0.11	0.35	0.09	5.6	2.88	2.0	0.0	54.6	5.4	8.18	1.27	8.32	0.29	N.D.	N.D.	N.D.	N.D.
	Event	0.017	0.001	0.17	0.05	0.31	0.03	4.8	2.24	9.3	2.0	50.4	4.1	9.18	1.43	8.27	0.24	N.D.	N.D.	N.D.	N.D.
	B+E	0.013	0.001	0.26	0.06	0.33	0.05	5.2	1.75	5.6	1.4	52.5	3.3	8.68	0.93	8.30	0.18	N.D.	N.D.	N.D.	N.D.

Table 5. Event and non-event nutrient and suspended solids losses (kg/day) from subwatersheds of Oneida Lake.
TP = Total Phosphorus; TKN = Total Kjeldahl Nitrogen; TSS = Total Suspended Solids, Cl=chlorides

Subwatersheds	Discharge (m^3/d)		TP (kg/day)		Nitrate (kg/day)		TSS (kg/day)		TKN (kg/day)		Cl (kg
	Event	Non-Event	Event	Non-Event	Event	Non-Event	Event	Non-Event	Event	Non-Event	Event
Big Bay	433,372	194,505	27.2	8.1	76	22	10,000	1,946	216	64	10,040
Scriba	382,807	102,598	13.0	2.0	38	11	6,864	205	218	26	2,350
Oneida	2,013,254	570,815	409.5	42.3	2,077	705	195,574	9,891	1,621	211	44,396
Canaseraga	399,001	150,934	39.2	4.6	337	176	23,548	1,935	260	53	8,696
Cowaselon	696,856	298,363	104.9	17.3	748	308	63,620	6,726	644	161	18,591
Butternut	1,266,141	611,987	45.9	4.2	1,069	476	31,605	4,028	305	99	51,390
Limestone	1,178,640	387,810	116.7	12.4	1,017	434	92,225	8,950	559	145	49,009
Chittenango	2,745,274	1,212,320	234.6	46.8	1,429	947	130,119	23,740	1,490	379	89,787
Wood Creek	1,171,080	314,510	56.1	9.1	358	253	22,910	2,879	534	124	20,705
Fish Creek	6,826,121	3,179,226	226.8	52.3	1,103	901	179,843	22,134	2,436	794	26,521
E. Branch Fish Crk.	5,167,051	1,880,733	91.5	15.3	678	517	57,175	3,761	1,712	534	16,924

Table 6. Average event and non-event areal nutrient and suspended solids losses from subwatersheds
TP = Total Phosphorus; TKN = Total Kjeldahl Nitrogen; TSS = Total Suspended Solids

Subwatershed	Discharge (m^3/d)		TP (g/ha/day)		Nitrate (g/ha/day)		TSS (g/ha/day)		TKN (g/ha/day)		Cl^- (g/ha/day)	
	Event	Non-Event	Event	Non-Event	Event	Non-Event	Event	Non-Event	Event	Non-Event	Event	Non-Event
Big Bay	433,372	194,505	4.9	1.4	14	3.9	1,792	349	39	11	1,800	638
Scriba	382,807	102,598	1.6	0.2	5	1.4	850	25	27	3	291	87
Oneida	2,013,254	570,815	9.1	0.9	46	15.7	4,365	221	36	5	991	384
Canaseraga	399,001	150,934	3.8	0.4	32	16.9	2,263	186	25	5	836	433
Cowaselon	696,856	298,363	7.4	1.2	53	21.8	4,500	476	46	11	1,315	649
Butternut	1,266,141	611,987	2.3	0.2	53	23.7	1,571	200	15	5	2,554	1,318
Limestone	1,178,640	387,810	4.5	0.5	39	16.6	3,528	342	21	6	1,875	870
Chittenango	2,745,274	1,212,320	7.6	1.4	39	27.4	6,061	687	43	11	2,467	1,658
Wood Creek	1,171,080	314,510	2.2	0.3	14	9.7	881	111	21	5	796	274
Fish Creek	6,826,121	3,179,226	4.3	1.0	21	17.0	3,395	418	46	15	501	257
E. Branch Fish	5,167,051	1,880,733	1.9	0.3	14	10.6	1,171	77	35	11	347	116

Table 7. Farms in the Oneida Lake Watershed (OLSLWR 2003)

County	*Farms (#)*
Cortland	0
Lewis	0
Madison	169
Oneida	93
Onondaga	43
Oswego	11
Total	316

Table 8. Percent Agricultural Land Use in the Oneida Lake Watershed

County	*Agriculture*
Lewis	4%
Madison	44%
Oneida	26%
Onondaga	23%
Oswego	5%

Source: Prepared by Herkimer - Oneida Counties Comprehensive Planning Program with data from the NYS Office of Real Property Services.

Note: Percentages are based on the number of acres classified as agricultural.

Table 9. Comparison of average daily event and non-event phosphorus loading of Sandy pond tributaries with tributaries of Oneida Lake, Lake Neatahwanta and Canandaigua Lake.

Subbasin or Creek	**Watershed**	**Land Use**	**Total Phosphorus Loading (g P/ha/d)**	
			Daily	**Average**
			Non-event	**Event**
			2002-2003	
Big Bay Creek	Oneida Lake		1.4	4.9
Chittenango Creek	Oneida Lake	Agriculture	1.4	7.6
Limestone Creek	Oneida Lake		0.5	4.5
Butternut Creek	Oneida Lake	Urban?	0.2	2.3
Cowaselon Creek	Oneida Lake	Agriculture, STP	1.2	7.4
Fish Creek	Oneida Lake		1.0	4.3
East Branch Fish	Oneida Lake		0.3	1.9
Wood Creek	Oneida Lake		0.3	2.2
Canaseraga Creek	Oneida Lake		0.4	3.8
Scriba Creek	Oneida Lake		0.2	1.6
Oneida Creek	Oneida Lake	Agriculture, STP	0.9	9.1
			2002	
Little Bay Creek	Oneida Lake		0.6	8.8
Threemile Creek	Oneida Lake		0.3	2.8
Dakins Creek	Oneida Lake		0.2	1.3
Crandell Creek	Oneida Lake		0.4	0.8
Black Creek	Oneida Lake		0.2	1.3
			1999-2002	
Little Sandy Creek	Sandy Pond		0.3	2.9
Blind Creek	Sandy Pond		0.1	1.9
Mud Creek	Sandy Pond		0.4	1.9
Lindsey Creek	Sandy Pond		0.5	1.3
Skinner Creek	Sandy Pond		0.5	2.1
			1997-1999	
T1 Fallbrook	Canandaigua Lake		0.79	2.58
T2 Deep Run	Canandaigua Lake		0.37	2.45
T3 Gauge Gully	Canandaigua Lake		0.10	0.86
T4 Fisher Gully	Canandaigua Lake		0.07	0.22
T6 Lower Vine Valley	Canandaigua Lake		0.37	2.00
T8 Lower West River	Canandaigua Lake		2.72	1.33
T9 Clark Gully	Canandaigua Lake		0.14	1.11
T10 Parish Gully	Canandaigua Lake		0.16	3.70
T11 Upper Naples Creek	Canandaigua Lake		0.16	3.48
T13 Cooks Point	Canandaigua Lake		0.50	24.54
T14 Hicks Point	Canandaigua Lake		0.15	5.44
T15 Seneca Point Gully	Canandaigua Lake		0.20	1.11
T16 Barnes Gully	Canandaigua Lake		0.08	2.06
T17 Menteth	Canandaigua Lake		0.03	1.15
T18 Tichenor Gully	Canandaigua Lake		0.30	3.58
TSB - Sucker Brook - grabs	Canandaigua Lake		0.09	1.95
T24 Tannery Creek	Canandaigua Lake		0.05	0.92
T25 Eelpot Creek	Canandaigua Lake		0.10	1.94
T26 Reservoir Creek	Canandaigua Lake		0.12	10.8

Oneida Lake and Canandaigua Lake data are from Makarewicz and Lewis (2000a, 1998c) Oneida and Canandaigua Lake data represents the daily average for events and nonevents.

Figure 2. Event and non-event nutrient and suspended solids losses from subwatersheds of Oneida Lake. BBC = Big Bay Creek; SC = Scriba Creek; OC = Oneida Creek; CaC = Canaseraga Creek; CoC = Cowaselon Creek; BC = Butternut Creek; LC = Limestone Creek; ChC = Chittenango Creek; WC = Wood Creek; FC = Fish Creek; EFC = East Branch Fish Creek

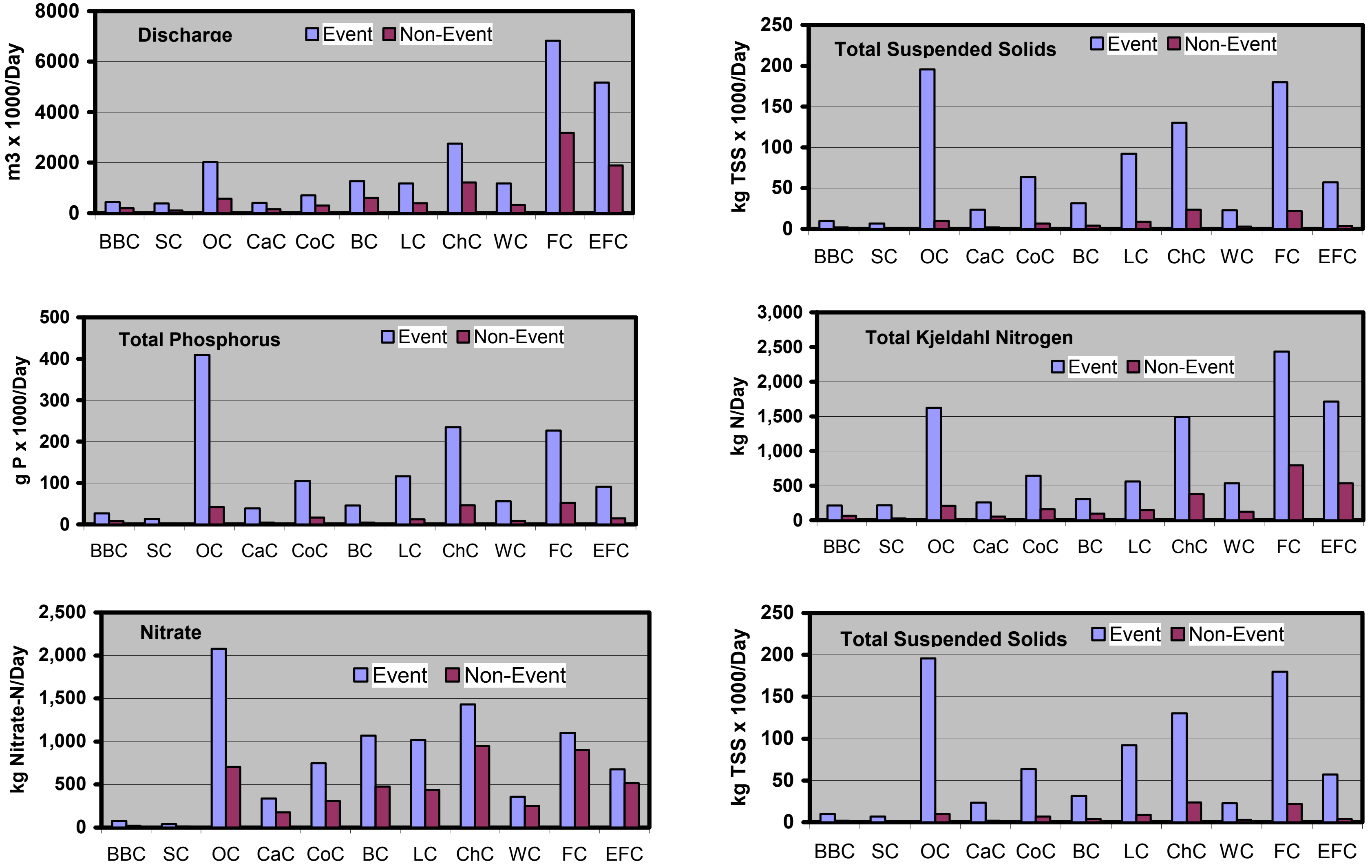
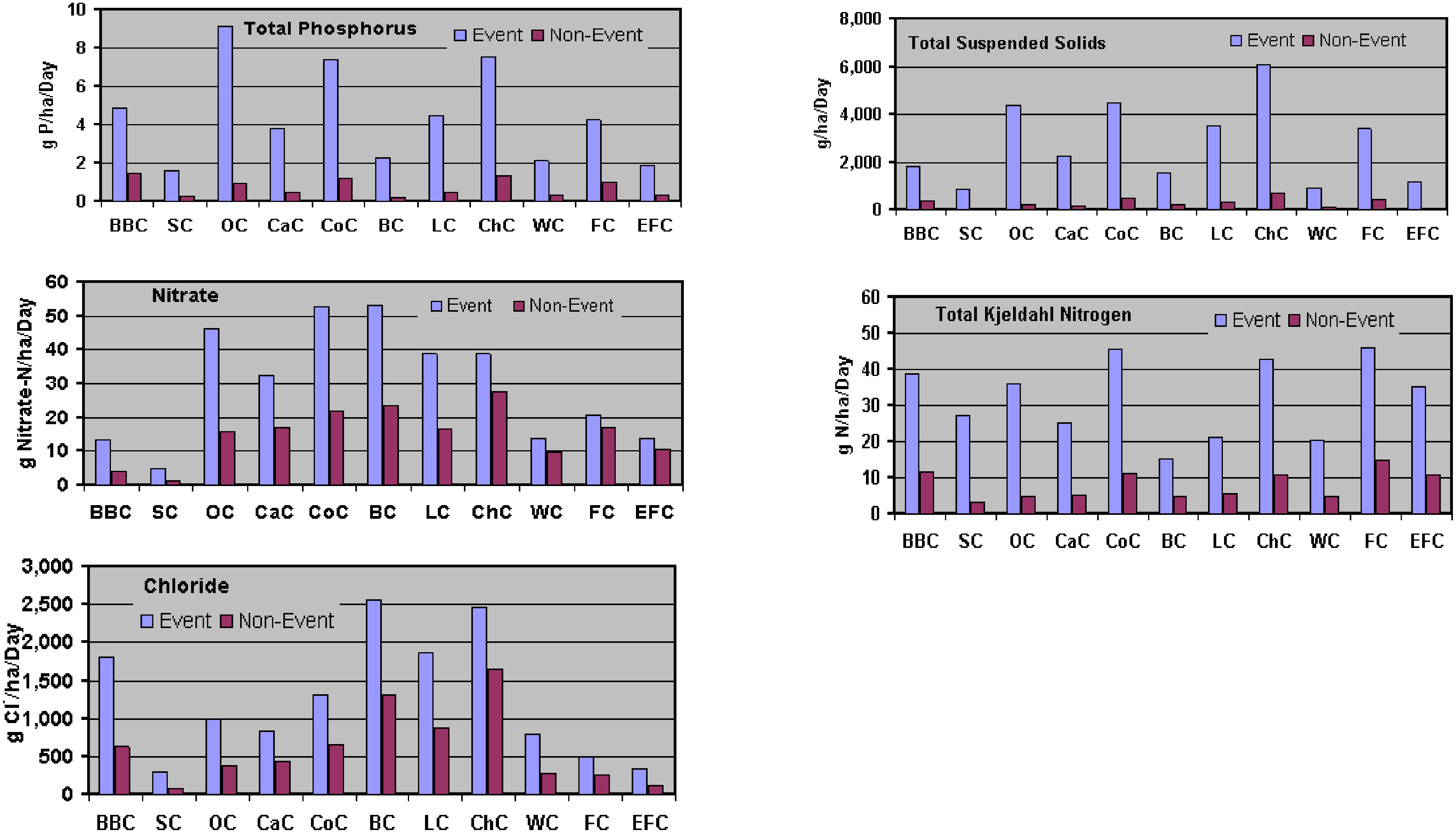


Figure 3. Event and non-event areal nutrient and suspended solids losses from subwatersheds of Oneida Lake. TP = Total Phosphorus; TKN = Total Kjeldahl Nitrogen; TSS = Total Suspended Solids; BBC = Big Bay Creek; SC = Scriba Creek; OC = Oneida Creek; CaC = Canaseraga Creek; CoC = Cowaselon Creek; BC = Butternut Creek; LC = Limestone Creek; ChC = Chittenango Creek; WC = Wood Creek; FC = Fish Creek; EFC = East Branch Fish Creek.



Fig

Figure 4. Event and non-event areal nutrient and suspended solids losses from subwatersheds of Oneida Lake.
BBC = Big Bay Creek; SC = Scriba Creek; OC = Oneida Creek; CaC = Canaseraga Creek; CoC = Cowaselon Creek;
BC = Butternut Creek; LC = Limestone Creek; ChC = Chittenango Creek; WC = Wood Creek; FC = Fish Creek;
EFC = East Branch Fish Creek; LBC = Little Bay Creek; TMC = Three Mile Creek; DC = Dakins Creek; CrC = Crandall Creek;
BlC = Black Creek

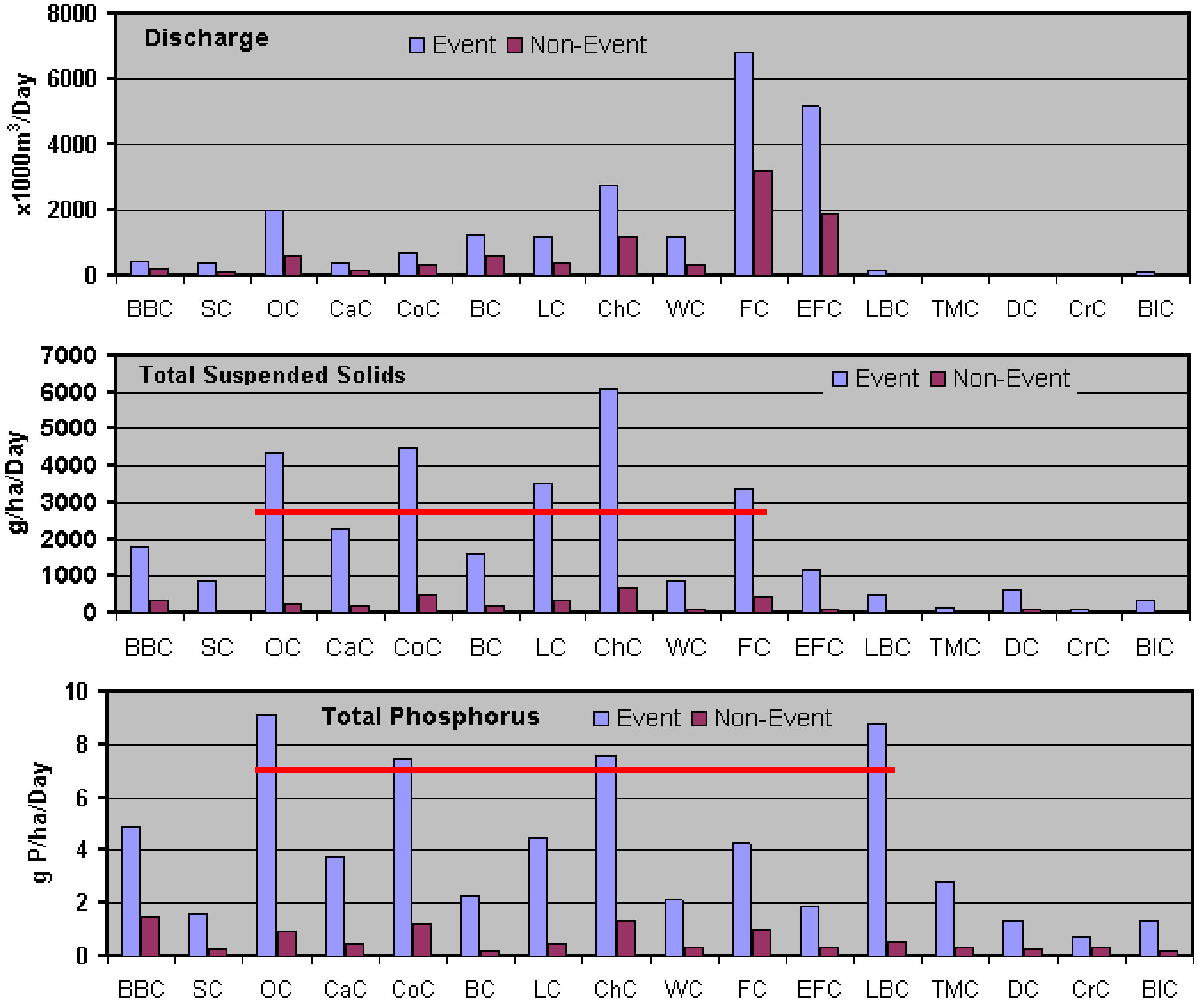
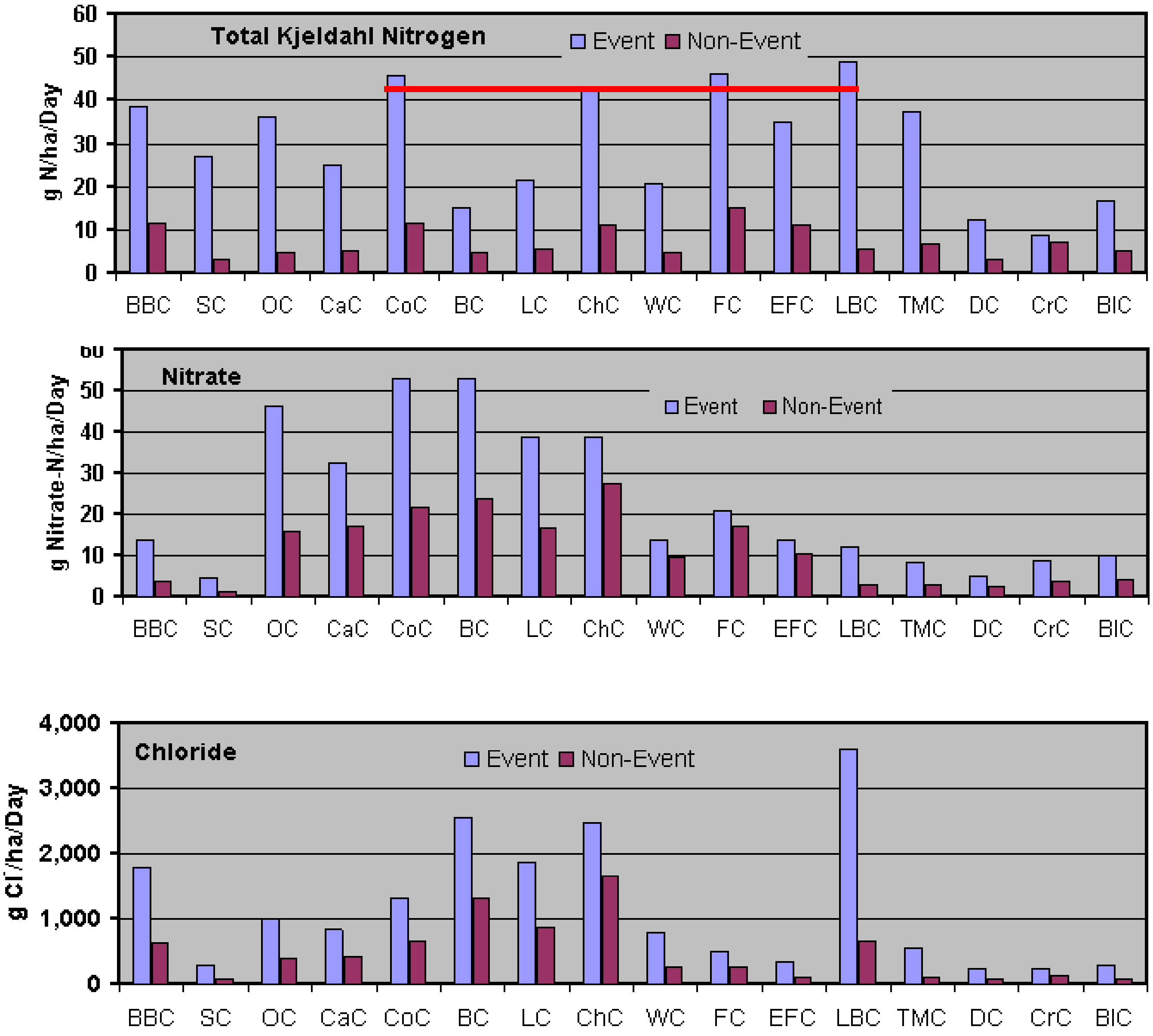


Figure 4 (continued).



Appendix 1. Event and non-event nutrient and suspended solids losses from subwatersheds of Oneida Lake. TP = Total Phosphorus; TKN = Total Kjeldahl Nitrogen; TSS = Total Suspended Solids; Avg. Vel. = Average Velocity

BIG BAY CREEK (43°17’08N; 76°05’29W) Watershed Area: 5579 ha

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	0.63	400,361	36	4	20,418	216	4,404
6/17/02	0.56	374,855	25	32	12,370	270	5,248
9/28/02	0.40	239,364	17	72	7,660	134	4,309
10/17/02	0.49	231,062	12	79	462	83	5,314
3/18/03	0.48	567,449	25	227	9,647	199	28,372
5/13/03	0.64	787,141	49	41	9,446	394	12,594
Average	0.53	433,372	27	76	10,000	216	10,040
S.E.	0.04	86,835	5	32	2,652	44	3,884

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/9/02	0.81	406,869	20	41	5,696	179	7,324
6/12/02	0.17	58,130	3	15	552	22	1,337
8/8/02	0.14	37,939	2	5	322	9	1,480
9/12/02	0.14	39,243	1	2	275	11	1,099
4/1/03	0.54	426,786	17	37	3,841	98	5,975
4/23/03	0.43	198,062	6	32	990	65	4,159
Average	0.37	194,505	8	22	1,946	64	3,562
S.E.	0.11	74,450	3	7	930	27	1,091

SCRIBA CREEK (43°15’22N; 76°00’11W) Watershed Area: 8074 ha

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	0.71	736,990	39	7	27,269	413	3,611
6/17/02	0.93	222,722	6	8	1,782	167	1,225
9/28/02	0.55	91,350	2	10	183	42	676
10/17/02	0.48	46,674	1	6	93	14	392
3/18/02	0.97	778,111	12	179	4,280	459	5,836
5/13/03	1.19	420,992	17	19	7,578	215	2,358
Average	0.81	382,807	13	38	6,864	218	2,350
S.E.	0.11	129,965	6	28	4,242	76	849

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/9/02	0.55	237,737	5	21	475	59	1,593
6/12/02	0.40	105,342	2	19	211	34	758
8/8/02	0.11	16,179	0	1	32	5	160
9/12/02	0.13	25,181	1	4	50	9	217
4/1/03	1.18	156,406	2	14	313	28	923
4/23/03	0.56	74,745	1	7	149	23	546
Average	0.49	102,598	2	11	205	26	699
S.E.	0.16	34,353	1	3	69	8	216

Appendix1 (Continued).

ONEIDA CREEK @ Swallow Road (43°08’23.09"N; 75°42’26.59"W) **Watershed Area: 44807 ha**

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	1.11	3,375,504	371	2,667	273,416	1,992	50,633
6/17/02	0.46	1,509,161	137	845	42,257	1,177	28,674
9/28/02	0.40	1,397,241	475	1,397	108,985	1,160	43,314
10/17/02	0.57	1,183,692	829	1,776	248,575	1,894	28,409
3/18/03	0.96	2,744,460	521	4,391	466,558	2,552	68,612
5/13/03	0.82	1,869,463	123	1,383	33,650	953	46,737
Average	0.72	2,013,254	410	2,077	195,574	1,621	44,396
S.E.	0.12	352,743	108	525	68,197	254	6,150

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/9/02	0.51	962,220	73	962	20,207	395	24,056
6/13/02	0.19	563,345	79	558	6,197	361	18,590
8/7/02	0.04	35,079	8	13	70	16	1,228
9/12/02	0.05	56,600	7	33	113	18	2,377
4/1/03	0.68	1,324,822	72	1,987	31,796	291	41,069
4/22/03	0.32	482,825	16	676	966	188	15,933
Average	0.30	570,815	42	705	9,891	211	17,209
S.E.	0.11	206,636	14	298	5,390	68	6,042

CANASERAGA CREEK @ Tag Road (43°05’54.02"N; 75°51' 01.74"W) **Watershed Area: 10407 ha**

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	1.46	428,611	31	270	25,717	223	6,001
6/17/02	0.88	608,347	37	517	23,117	493	12,167
9/28/02	0.68	436,211	41	288	26,173	262	13,959
10/17/02	0.71	207,608	52	311	18,477	137	6,021
3/18/03	1.76	339,460	54	316	37,341	306	5,431
5/13/03	0.99	373,766	19	318	10,465	142	8,597
Average	1.08	399,001	39	337	23,548	260	8,696
S.E.	0.18	53,821	5	37	3,646	54	1,470

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/9/02	0.79	96,134	4	106	2,884	37	2,211
6/13/02	0.42	97,079	5	92	3,009	58	2,718
8/7/02	0.40	98,393	6	84	197	74	3,444
9/12/02	0.33	68,097	4	43	885	18	2,928
4/1/03	0.94	321,920	6	418	4,185	80	8,370
4/22/03	0.69	223,982	3	314	448	47	7,391
Average	0.59	150,934	5	176	1,935	53	4,510
S.E.	0.10	40,865	1	62	670	9	1,085

Appendix1 (Continued). COWASELON CREEK @ Gee Road (43°07'2.86"N; 75°49' 50.95"W) **Watershed Area: 14138 ha**

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
EVENTS							
5/14/02	0.78	1,195,930	144	801	90,891	1,316	22,723
6/17/02	0.79	427,034	47	367	16,227	598	10,676
9/28/02	0.36	152,239	20	167	13,702	135	5,328
10/17/02	0.48	258,964	78	285	19,940	225	9,841
3/18/03	0.94	1,645,979	296	2,469	230,437	1,185	44,441
5/13/03	0.51	500,987	45	396	10,521	406	18,537
Average	0.64	696,856	105	748	63,620	644	18,591
S.E.	0.09	241,484	42	355	35,608	203	5,775
NON-EVENTS							
5/9/02	0.68	656,044	51	459	20,993	440	17,057
6/13/02	0.41	156,071	12	156	3,902	187	4,682
8/7/02	0.18	70,232	2	52	140	35	2,599
9/12/02	0.12	32,112	1	4	193	4	1,317
4/1/03	0.76	668,684	31	869	14,711	241	22,735
4/22/03	0.40	207,038	7	311	414	60	6,625
Average	0.43	298,363	17	308	6,726	161	9,169
S.E.	0.10	117,841	8	132	3,657	67	3,548

BUTTERNUT CREEK @ Route 481 (43°0.743'N; 76°4.481'W) **Watershed Area: 20122 ha**

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
EVENTS							
5/14/02	1.08	2,246,110	27	1,146	26,953	427	71,876
6/17/02	0.59	911,186	13	419	6,378	346	34,625
9/28/02	0.12	108,284	2	55	541	18	6,605
10/17/02	0.13	154,022	11	143	308	48	9,087
3/18/03	1.28	3,001,944	210	3,602	153,099	841	132,086
5/13/03	0.73	1,175,298	13	1,046	2,351	153	54,064
Average	0.65	1,266,141	46	1,069	31,605	305	51,390
S.E.	0.20	472,054	33	539	24,644	126	19,161
NON-EVENTS							
5/9/02	0.69	1,155,737	5	763	10,402	266	42,762
6/13/02	0.41	528,818	4	238	1,058	11	21,153
8/8/02	0.14	135,843	1	69	272	26	7,064
9/12/02	0.13	114,068	1	51	513	15	5,019
4/1/03	0.85	1,536,519	13	1,537	11,524	246	72,216
4/22/03	0.20	200,937	1	201	402	32	10,851
Average	0.40	611,987	4	476	4,028	99	26,511
S.E.	0.13	245,013	2	237	2,200	50	10,750

Appendix1 (Continued). LIMESTONE CREEK @ Kirkville Road; (48°5.301'N; 75°59.607'W) Watershed Area: 26138 ha

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	0.52	2,573,389	201	1,364	208,445	1,081	77,202
6/17/02	0.26	888,033	62	577	39,961	346	45,290
9/28/02	0.25	243,305	24	414	8,272	88	12,165
10/17/02	0.25	163,777	28	136	9,663	62	5,405
3/18/03	0.32	2,213,030	310	2,877	243,433	1,372	108,438
5/13/03	0.24	990,305	75	733	43,573	406	45,554
Average	0.31	1,178,640	117	1,017	92,225	559	49,009
S.E.	0.04	409,878	47	408	42,947	221	15,928

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/9/02	0.35	495,457	16	401	13,377	362	25,764
6/13/02	0.21	329,859	17	290	7,587	148	19,792
8/8/02	0.21	112,515	6	225	788	39	9,901
9/12/02	0.21	24,286	3	73	121	10	2,161
4/1/03	0.24	1,143,054	24	1,372	29,719	240	64,011
4/22/03	0.10	221,692	9	244	2,106	73	14,853
Average	0.22	387,810	12	434	8,950	145	22,747
S.E.	0.03	165,416	3	192	4,634	55	8,891

CHITTENANGO CREEK @ Route 31 (43°9.295'N; 75°58.294'W) Watershed Area: 34543 ha

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	1.42	6,350,021	552	1,905	374,651	3,810	177,801
6/17/02	0.95	3,649,635	212	1,606	113,139	1,642	120,438
9/28/02	0.26	481,782	38	530	6,263	92	27,943
10/17/02	0.32	646,324	11	297	2,908	129	32,316
3/18/03	0.86	3,428,692	446	3,223	226,294	2,194	174,863
5/13/03	0.65	1,915,191	149	1,015	57,456	1,073	5,363
Average	0.74	2,745,274	235	1,429	130,119	1,490	89,787
S.E.	0.18	903,644	90	437	59,480	574	31,717

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/9/02	0.58	1,711,378	87	1,181	41,073	770	70,166
6/13/02	0.40	1,049,740	54	588	20,995	336	53,537
8/8/02	0.19	295,574	13	207	4,138	92	20,690
9/12/02	0.12	133,559	8	85	267	44	10,017
4/1/03	0.92	3,540,395	103	3,080	70,808	850	159,318
4/22/03	0.23	543,275	17	538	5,161	185	29,880
Average	0.41	1,212,320	47	947	23,740	379	57,268
S.E.	0.12	521,127	17	454	11,260	142	22,297

Appendix1 (Continued). WOOD CREEK @ Route 49 (43°13’20.09"N; 75°35’36.25"W) Watershed Area: 26011 ha

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	0.65	2,614,154	99	444	36,598	1,150	20,652
6/17/02	0.43	439,875	18	194	6,598	202	6,598
9/28/02	0.41	509,351	25	234	11,206	214	14,262
10/17/02	0.48	793,193	64	333	9,518	293	21,416
3/18/03	0.46	824,947	35	536	25,573	437	35,473
5/13/03	0.63	1,844,958	94	406	47,969	904	25,829
Average	0.51	1,171,080	56	358	22,910	534	20,705
S.E.	0.04	354,576	14	53	6,843	163	4,022

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/10/02	0.40	798,503	30	511	9,582	351	15,172
6/13/02	0.36	266,770	7	221	1,200	211	5,602
8/6/02	0.06	8,994	0.2	12	18	9	207
9/12/02	0.08	13,675	0.3	14	27	5	342
4/1/03	0.45	646,603	14	575	6,143	129	16,165
4/22/03	0.28	152,513	3	183	305	41	5,338
Average	0.27	314,510	9	253	2,879	124	7,138
S.E.	0.07	136,247	5	99	1,647	56	2,863

FISH CREEK @ 49 (43°14’25.85"N; 75°37’57.58"W) Watershed Area: 52980 ha

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	0.95	15,667,013	627	1,723	626,681	6,580	50,134
6/17/02	0.42	2,750,748	55	385	20,631	1,430	11,003
9/28/02	0.58	5,025,266	176	854	175,884	2,513	21,609
10/17/02	0.46	3,385,289	118	677	47,394	1,016	16,926
3/18/03	0.40	3,459,762	97	1,695	48,437	623	23,180
5/13/03	0.84	10,668,651	288	1,280	160,030	2,454	36,273
Average	0.61	6,826,121	227	1,103	179,843	2,436	26,521
S.E.	0.09	2,128,770	86	226	93,136	885	5,833

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/10/02	0.41	3,313,764	73	696	18,226	1,160	16,569
6/13/02	0.41	2,246,490	22	517	4,493	1,348	9,885
8/6/02	0.05	186,220	6	50	372	65	1,825
9/12/02	0.05	241,887	5	60	484	80	2,032
4/1/03	0.61	6,256,533	113	2,377	75,078	813	28,154
4/22/03	0.68	6,830,461	96	1,708	34,152	1,298	23,224
Average	0.37	3,179,226	52	901	22,134	794	13,615
S.E.	0.11	1,172,966	19	385	11,855	241	4,470

Appendix1 (Continued). EAST BRANCH FISH CREEK in Taberg (43°18’7.38"N; 75°37’5.66"W) **Watershed Area: 48840 ha**

EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/14/02	3.00	14,095,322	254	1,550	197,335	5,497	35,238
6/17/02	1.38	1,054,577	12	104	2,109	232	2,636
9/28/02	1.77	4,493,264	85	494	29,206	1,618	11,233
10/17/02	1.29	2,854,122	57	400	42,812	799	8,562
3/18/03	1.14	1,774,791	34	781	17,748	710	28,397
5/13/03	2.23	6,730,228	108	740	53,842	1,413	15,480
Average	1.80	5,167,051	92	678	57,175	1,712	16,924
S.E.	0.29	1,969,611	35	201	29,001	784	5,084

NON-EVENTS

Date	Avg. Vel. (m/s)	Discharge (m^3/d)	TP (kg/d)	Nitrate (kg/d)	TSS (kg/d)	TKN (kg/d)	Chloride (kg/d)
5/10/02	1.22	2,098,887	17	294	4,198	1,175	5,877
6/13/02	1.09	1,098,021	9	132	2,196	681	2,965
8/6/02	0.38	312,559	4	97	625	131	1,031
9/12/02	0.27	331,188	3	275	662	70	6,624
4/1/03	1.39	2,726,011	17	1,172	5,452	300	7,088
4/22/03	2.06	4,717,730	42	1,132	9,435	849	10,379
Average	1.07	1,880,733	15	517	3,761	534	5,661
S.E.	0.27	690,013	6	203	1,380	179	1,341

Appendix 2. Event and non-event areal nutrient and suspended solids losses from subwatersheds of Oneida Lake. TP = Total Phosphorus; TKN = Total Kjeldahl Nitrogen; TSS = Total Suspended Solids

BIG BAY CREEK (43°17’08N; 76°05’29W) **Watershed Area: 5579 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	400,361	6.4	0.7	3660	39	789
6/17/02	374,855	4.5	5.8	2217	48	941
9/28/02	239,364	3.0	12.9	1373	24	772
10/17/02	231,062	2.2	14.1	83	15	952
3/18/03	567,449	4.5	40.7	1729	36	5085
5/13/03	787,141	8.7	7.3	1693	71	2257
Average	433,372	4.9	13.6	1,792	39	1,800
S.E.	86,835	1.0	5.8	475	8	696

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/9/02	406,869	3.6	7.3	1021	32	1313
6/12/02	58,130	0.5	2.6	99	4	240
8/8/02	37,939	0.3	1.0	58	2	265
9/12/02	39,243	0.1	0.4	49	2	197
4/1/03	426,786	3.1	6.7	688	18	1071
4/23/03	198,062	1.1	5.7	177	12	745
Average	194,505	1.4	3.9	349	11	638
S.E.	74,450	0.6	1.2	167	5	195

SCRIBA CREEK (43°15’22N; 76°00’11W) **Watershed Area: 8074 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	736,990	4.8	0.9	3378	51	447
6/17/02	222,722	0.8	1.0	221	21	152
9/28/02	91,350	0.3	1.2	23	5	84
10/17/02	46,674	0.1	0.7	12	2	49
3/18/02	778,111	1.5	22.2	530	57	723
5/13/03	420,992	2.1	2.4	939	27	292
Average	382,807	1.6	4.7	850	27	291
S.E.	129,965	0.7	3.5	525	9	105

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/9/02	237,737	0.6	2.6	59	7	197
6/12/02	105,342	0.3	2.3	26	4	94
8/8/02	16,179	0.0	0.2	4	1	20
9/12/02	25,181	0.2	0.5	6	1	27
4/1/03	156,406	0.3	1.7	39	3	114
4/23/03	74,745	0.2	0.9	19	3	68
Average	102,598	0.2	1.4	25	3	87
S.E.	34,353	0.1	0.4	9	1	27

Appendix 2. (Continued). ONEIDA CREEK @ Swallow Road (43°08’23.09"N; 75°42’26.59"W) Watershed Area: 44807 ha

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	3,375,504	8.3	59.5	6102	44	1130
6/17/02	1,509,161	3.1	18.9	943	26	640
9/28/02	1,397,241	10.6	31.2	2432	26	967
10/17/02	1,183,692	18.5	39.6	5548	42	634
3/18/03	2,744,460	11.6	98.0	10413	57	1531
5/13/03	1,869,463	2.8	30.9	751	21	1043
Average	2,013,254	9.1	46.3	4,365	36	991
S.E.	352,743	2.4	11.7	1,522	6	137

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/9/02	962,220	1.6	21.5	451	9	537
6/13/02	563,345	1.8	12.4	138	8	415
8/7/02	35,079	0.2	0.3	2	0.4	27
9/12/02	56,600	0.2	0.7	3	0.4	53
4/1/03	1,324,822	1.6	44.4	710	7	917
4/22/03	482,825	0.4	15.1	22	4	356
Average	570,815	0.9	15.7	221	5	384
S.E.	206,636	0.3	6.6	120	2	135

CANASERAGA CREEK @ Tag Road (43°05’54.02"N; 75°51' 01.74"W) Watershed Area: 10407 ha

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	428,611	3.0	25.9	2471	21	577
6/17/02	608,347	3.6	49.7	2221	47	1169
9/28/02	436,211	4.0	27.7	2515	25	1341
10/17/02	207,608	5.0	29.9	1776	13	579
3/18/03	339,460	5.2	30.3	3588	29	522
5/13/03	373,766	1.9	30.5	1006	14	826
Average	399,001	3.8	32.3	2,263	25	836
S.E.	53,821	0.5	3.5	350	5	141

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/9/02	96,134	0.4	10.2	277.1	4	212
6/13/02	97,079	0.4	8.9	289.2	6	261
8/7/02	98,393	0.6	8.0	18.9	7	331
9/12/02	68,097	0.4	4.1	85.1	2	281
4/1/03	321,920	0.6	40.2	402.1	8	804
4/22/03	223,982	0.3	30.1	43.0	5	710
Average	150,934	0.4	16.9	186	5	433
S.E.	40,865	0.1	6.0	64	1	104

Appendix 2 (continued). COWASELON CREEK @ Gee Road (43°07'2.86"N; 75°49' 50.95"W) **Watershed Area: 14138 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	1,195,930	10.2	56.7	6428	93	1607
6/17/02	427,034	3.3	26.0	1148	42	755
9/28/02	152,239	1.4	11.8	969	10	377
10/17/02	258,964	5.5	20.1	1410	16	696
3/18/03	1,645,979	21.0	174.6	16298	84	3143
5/13/03	500,987	3.2	28.0	744	29	1311
Average	696,856	7.4	52.9	4,500	46	1,315
S.E.	241,484	3.0	25.1	2,518	14	408

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/9/02	656,044	3.6	32.5	1485	31	1206
6/13/02	156,071	0.8	11.0	276	13	331
8/7/02	70,232	0.2	3.7	10	2	184
9/12/02	32,112	0.1	0.2	14	0	93
4/1/03	668,684	2.2	61.5	1040	17	1608
4/22/03	207,038	0.5	22.0	29	4	469
Average	298,363	1.2	21.8	476	11	649
S.E.	117,841	0.6	9.3	259	5	251

BUTTERNUT CREEK @ Route 481 (43°0.743'N; 76°4.481'W) **Watershed Area: 20122 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	2,246,110	1.3	56.9	1340	21	3572
6/17/02	911,186	0.6	20.8	317	17	1721
9/28/02	108,284	0.1	2.7	27	1	328
10/17/02	154,022	0.5	7.1	15	2	452
3/18/03	3,001,944	10.4	179.0	7609	42	6564
5/13/03	1,175,298	0.6	52.0	117	8	2687
Average	1,266,141	2.3	53.1	1,571	15	2,554
S.E.	472,054	1.6	26.8	1,225	6	952

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/9/02	1,155,737	0.2	37.9	517	13	2125
6/13/02	528,818	0.2	11.8	53	1	1051
8/8/02	135,843	0.0	3.4	14	1	351
9/12/02	114,068	0.1	2.6	26	1	249
4/1/03	1,536,519	0.6	76.4	573	12	3589
4/22/03	200,937	0.1	10.0	20	2	539
Average	611,987	0.2	23.7	200	5	1,318
S.E.	245,013	0.1	11.8	109	2	534

Appendix 2 (continued). LIMESTONE CREEK @ Kirkville Road; (48°5.301’N; 75°59.607’W) **Watershed Area: 26138 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	2,573,389	7.7	52.2	7975	41	2954
6/17/02	888,033	2.4	22.1	1529	13	1733
9/28/02	243,305	0.9	15.8	316	3	465
10/17/02	163,777	1.1	5.2	370	2	207
3/18/03	2,213,030	11.9	110.1	9313	52	4149
5/13/03	990,305	2.9	28.0	1667	16	1743
Average	1,178,640	4.5	38.9	3,528	21	1,875
S.E.	409,878	1.8	15.6	1,643	8	609

NON-EVENTS

5/9/02	495,457	0.6	15.4	511.8	13.8	985.7
6/13/02	329,859	0.7	11.1	290.3	5.7	757.2
8/8/02	112,515	0.2	8.6	30.1	1.5	378.8
9/12/02	24,286	0.1	2.8	4.6	0.4	82.7
4/1/03	1,143,054	0.9	52.5	1137.0	9.2	2448.9
4/22/03	221,692	0.3	9.3	80.6	2.8	568.3
Average	387,810	0.5	16.6	342	6	870
S.E.	165,416	0.1	7.4	177	2	340

CHITTENANGO CREEK @ Route 31 (43°9.295’N; 75°58.294’W) **Watershed Area: 34543 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	6,350,021	16.0	55.1	10846	110	5147
6/17/02	3,649,635	6.1	46.5	3275	48	3487
9/28/02	481,782	5.7	0.2	13947	1	15
10/17/02	646,324	0.3	8.6	84	4	936
3/18/03	3,428,692	12.9	93.3	6551	64	5062
5/13/03	1,915,191	4.3	29.4	1663	31	155
Average	2,745,274	7.6	38.8	6,061	43	2,467
S.E.	903,644	2.4	13.9	2,222	17	977

NON-EVENTS

5/9/02	1,711,378	2.5	34.2	1189	22	2031
6/13/02	1,049,740	1.5	17.0	608	10	1550
8/8/02	295,574	0.4	6.0	120	3	599
9/12/02	133,559	0.2	2.5	8	1	290
4/1/03	3,540,395	3.0	89.2	2050	25	4612
4/22/03	543,275	0.5	15.6	149	5	865
Average	1,212,320	1.4	27.4	687	11	1,658
S.E.	521,127	0.5	13.2	326	4	645

Appendix 2 (continued). WOOD CREEK @ Route 49 (43°13’20.09"N; 75°35’36.25"W) Watershed Area: 26011 ha

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	2,614,154	3.8	17.1	1407	44	794
6/17/02	439,875	0.7	7.4	254	8	254
9/28/02	509,351	1.0	9.0	431	8	548
10/17/02	793,193	2.5	12.8	366	11	823
3/18/03	824,947	1.4	20.6	983	17	1364
5/13/03	1,844,958	3.6	15.6	1844	35	993
Average	1,171,080	2.2	13.8	881	21	796
S.E.	354,576	0.6	2.0	263	6	155

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/10/02	798,503	1.2	19.6	368	14	583
6/13/02	266,770	0.3	8.5	46	8	215
8/6/02	8,994	0.0	0.4	1	0.3	8
9/12/02	13,675	0.0	0.5	1	0.2	13
4/1/03	646,603	0.5	22.1	236	5	621
4/22/03	152,513	0.1	7.0	12	2	205
Average	314,510	0.3	9.7	111	5	274
S.E.	136,247	0.2	3.8	63	2	110

FISH CREEK @ 49 (43°14’25.85"N; 75°37’57.58"W) Watershed Area: 52980 ha

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	15,667,013	11.8	32.5	11829	124	946
6/17/02	2,750,748	1.0	7.3	389	27	208
9/28/02	5,025,266	3.3	16.1	3320	47	408
10/17/02	3,385,289	2.2	12.8	895	19	319
3/18/03	3,459,762	1.8	32.0	914	12	438
5/13/03	10,668,651	5.4	24.2	3021	46	685
Average	6,826,121	4.3	20.8	3,395	46	501
S.E.	2,128,770	1.6	4.3	1,758	17	110

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/10/02	3,313,764	1.4	13.1	344	22	313
6/13/02	2,246,490	0.4	9.8	85	25	187
8/6/02	186,220	0.1	0.9	7	1	34
9/12/02	241,887	0.1	1.1	9	2	38
4/1/03	6,256,533	2.1	44.9	1417	15	531
4/22/03	6,830,461	1.8	32.2	645	24	438
Average	3,179,226	1.0	17.0	418	15	257
S.E.	1,172,966	0.4	7.3	224	5	84

Appendix 2 (continued). EAST BRANCH FISH CREEK in Taberg (43°18’7.38"N; 75°37’5.66"W) **Watershed Area: 48840 ha**

EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/14/02	14,095,322	5.2	31.7	4040	113	722
6/17/02	1,054,577	0.2	2.1	43	5	54
9/28/02	4,493,264	1.7	10.1	598	33	230
10/17/02	2,854,122	1.2	8.2	877	16	175
3/18/03	1,774,791	0.7	16.0	363	15	581
5/13/03	6,730,228	2.2	15.2	1102	29	317
Average	5,167,051	1.9	13.9	1,171	35	347
S.E.	1,969,611	0.7	4.1	594	16	104

NON-EVENTS

Date	Discharge (m^3/d)	TP (g/ha/d)	Nitrate (g/ha/d)	TSS (g/ha/d)	TKN (g/ha/d)	Chloride (g/ha/d)
5/10/02	2,098,887	0.3	6.0	86	24	120
6/13/02	1,098,021	0.2	2.7	45	14	61
8/6/02	312,559	0.1	2.0	13	3	21
9/12/02	331,188	0.1	5.6	14	1	136
4/1/03	2,726,011	0.3	24.0	112	6	145
4/22/03	4,717,730	0.9	23.2	193	17	213
Average	1,880,733	0.3	10.6	77	11	116
S.E.	690,013	0.1	4.2	28	4	27