Water Quality in the Schoenick Creek Watershed and Long and Schoenick Lakes Shawano County, Wisconsin

Final Report to the DNR
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Executive Summary

Shoenick Creek is a 7 mile stream segment that includes Long and Shoenick Lakes. The source of water to the Creek is precipitation falling within the surface and groundwater watersheds. The surface watershed was delineated using ground surface elevations obtained from a digitial elevation model. The 8,400 acre watershed is the area within which precipitation that becomes runoff drains to Schoenick Creek. Land use and soil within this watershed are important to determining runoff rates, quantities and quality. In the watershed, principal land use is woodland and agriculture. Only 2% of the land in the watershed is residential, although much of that is near surface water.

Stream water quality was measured at five different points in the watershed. Sediment, nutrient and chloride concentrations were measured at those locations under low flow ("baseflow") and higher flow ("event flow") conditions. These measurements provide a snapshot of quality and were compared to stream conditions and watershed contributing areas to better understand the influences on water quality in Schoenick Creek.

Water quality in the streams varied throughout the watershed. All sites had high phosphorus concentrations during runoff conditions. A SWAT model was built to assist in the partitioning of inputs from the sub-watersheds that contribute flow to each sample site. The resulting percentages of phosphorus inputs were Belle Plaine Ave (39%), St. John's Rd (17%), Shoenrock Rd (14%), Long Lake Inflow (10%), Grass Lake Rd (9%), Hunting Rd (8%), Cloverleaf Lakes Rd (3%). The tributary at Grass Lake Road had extremely high concentrations of sediment, phosphorus and nitrogen. Near the Schoenrock Road site the stream was receiving most of the nitrogen inputs from groundwater, which may require implementation of different best management practices than those implemented to reduce runoff concentrations.

Long Lake and Shoenick Lake were examined in detail through profile measurements of oxygen, temperature, pH and conductivity and detailed water quality at specific depths for nutrients and other water quality characteristics. Those results were combined with the historical record of volunteer monitoring in Long Lake. Both lakes appear to be phosphorus limited and eutrophic based on their phosphorus concentrations. These results are likely linked to the large watershed that contributes water to these lakes and their relatively small size in relation to those watersheds. Phosphorus was measured in soil samples collected around Long Lake and all samples ranged from high to excessive. Groundwater flowing into Long Lake was assessed and analyses showed both local and regional land use impacts, however, most samples contained little phosphorus.

Schoenick Creek Watershed citizens were involved in this project from its inception and are committed to improve the conditions in Schoenick Creek. Throughout the project they participated in some of the water quality sampling and took the lead on the soil sampling. The Long Lake Association held several meetings that highlighted improved shoreland management practices and lawn maintenance. Forty-eight citizens attended the final meeting that was held at the Belle Plaine Town Hall to summarize the study results and discuss plans for the future remediation/protection of Schoenick Creek Watershed.

Acknowledgements

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Introduction

Schoenick Creek is a seven mile hardwater, warm-water forage fishery system that discharges to Long Lake, Schoenick Lake, and ultimately the Wolf River. The headwaters of the stream begin in the wetlands just south of State Highway 22. Schoenick Creek flows south through the east end of Long Lake, continues through Schoenick Lake and empties into the Wolf River. It is designated by the Department of Natural Resources as part of the Middle Wolf River Watershed (WR 14). Problems identified in this watershed include animal waste and soil erosion (Project Description for the Water Quality Evaluation of the Schoenick Creek Watershed, 2001).

The Schoenick Creek watershed encompasses just over 13 square miles (8,409 acres) near the southern border of Shawano County and the northern border of Waupaca County. This watershed lies within the Wolf River drainage basin and includes Long and Schoenick Lakes. Schoenick Creek flows into the north-eastern lobe of Long Lake and then almost immediately flows out of the north eastern lobe; this is very unique among drainage lakes. Further downstream it enters the smaller, minimally developed Schoenick Lake. Soil in the watershed is predominantly sand, silt loam, fine sand, fine sandy loam, and loamy sand. Soils directly adjacent to Long Lake are mostly loamy fine sands, loamy sand, and Marky and Cathro mucks.

Long Lake is a warm water 86-acre lake approximately 4,300 feet long and 1,000 feet wide aligned in a general northeast to southwest position. It has a maximum depth of 35 feet with approximately 2.0 miles of shoreline. There is no public access to this water body and the majority of its shoreline is developed, except where Schoenick Creek enters and exits. Aquatic plants and algae are abundant throughout the growing season. They occur in densities that are considered to be a nuisance to some of the property owners. Long Lake is considered to be a warm-water fishery with a common occurrence of northern pike, largemouth bass, and panfish. Little historical water quality data is available for Long Lake but some members of the Long Lake Association perceive there has been an increase in aquatic plants and algae in recent years. Residents of Long Lake have been on a sanitary system since the 1980s. A water quality assessment was completed for the lake in 1993 by IPS Environmental and Analytical Services that recommended continued monitoring and reduction of riparian and nonpoint source inflows. In 1997, Foth and Van Dyke conducted a water quality lake study recommending (1) to conduct a detailed evaluation of inlet and outlet tributary flows to determine flushing trends and identify other sources of inlet flow such as springs, (2) create an ongoing water quality sampling program to determine the effect of improvements on the lake.

Schoenick Lake is a 30-acre hardwater drainage lake with Schoenick Creek as the inlet and outlet. Northern pike, largemouth bass, and panfish comprise the fishery resource. Waterfowl utilize the lake during spring and fall migrations. The lake is classified as very sensitive to phosphorus loading (Class I). Few studies have been conducted in this lake and to our knowledge, historical data do not exist.

Some land use practices may have more impact on the health of an aquatic ecosystem during particular times of the year. Groundwater discharging to the streams can carry dissolved nutrients throughout the year, while spring runoff and large storm events can also deliver slugs of sediment and nutrients to streams and lakes. For example, runoff can carry excessive loads of nutrients from barnyards and sediment and fertilizer from fields during precipitation events or spring melt.

This study included a survey of water quality in the streams, and both lakes to increase the Lake Association's understanding of current conditions and their causes. In addition, near shore soil sampling was conducted by the Long Lake Association to better understand nutrient concentrations near the lake. In this study, a total of five sites in Schoenick Creek and two of its tributaries were monitored for water quality and flow. Samples were collected during low flow conditions (baseflow) in July 2002, and runoff event flow was sampled four times. These are a minimal number of sampling events that do not describe year-to-year variability. In addition, due to budgetary constraints, only single samples were collected during each event. Baseflow measurements were used to estimate groundwater influences on water quality in the stream; while event samples were used to observe how water flowing over the land is affecting water quality in the stream. Stream flow measurements were made at each site and continuously monitored for seven months at two locations.

Baseflow stream flow, in combination with water quality measurements were used to estimate the total amount of nutrients passing each location. This nutrient "yield" is the quantity that moves past each site. The baseflow nutrient yield only accounts for a minor portion of the total amount flowing in the stream, because it does not include nutrients that are delivered from direct runoff during precipitation events. The area of land contributing to the flow at each site was determined by delineating the portion of the watershed ("sub-watershed") that terminates at each location. This information was used to evaluate how land use within each sub-watershed relates to water quality measured at each site and eventually to the overall quality of Schoenick Creek, Long Lake, and Schoenick Lake.

Water quality samples from event flows were tested analyzed for chloride, total suspended solids, soluble reactive and total phosphorus, and several forms of nitrogen. Concentrations of reactive and total phosphorus were found to be well above acceptable limits in lake, stream, and in groundwater samples for reactive phosphorus. Water quality in Schoenick Creek and both Long and Schoenick Lakes appears to be influenced by impacts from local and watershed land use. In the Schoenick Creek watershed, agriculture land use (3,547 acres) and a mixture of woodlands (3,432 acres) dominate; however, open land (693 acres), public utilities (236 acres) and residential (178 acres) are important land uses.

Long term monitoring and follow-up studies should continue to provide a long-term record of changes in Schoenick Creek and its watershed, in addition to Long and Schoenick Lakes. Routine data collection over a period of time can help to sort out year-to-year variability from long term trends. Periodic studies and evaluations will help to evaluate if changes in the watershed are resulting in improvements or negative impacts to water quality in its stream and lake ecosystems and provide a better understanding of functions within the watershed.

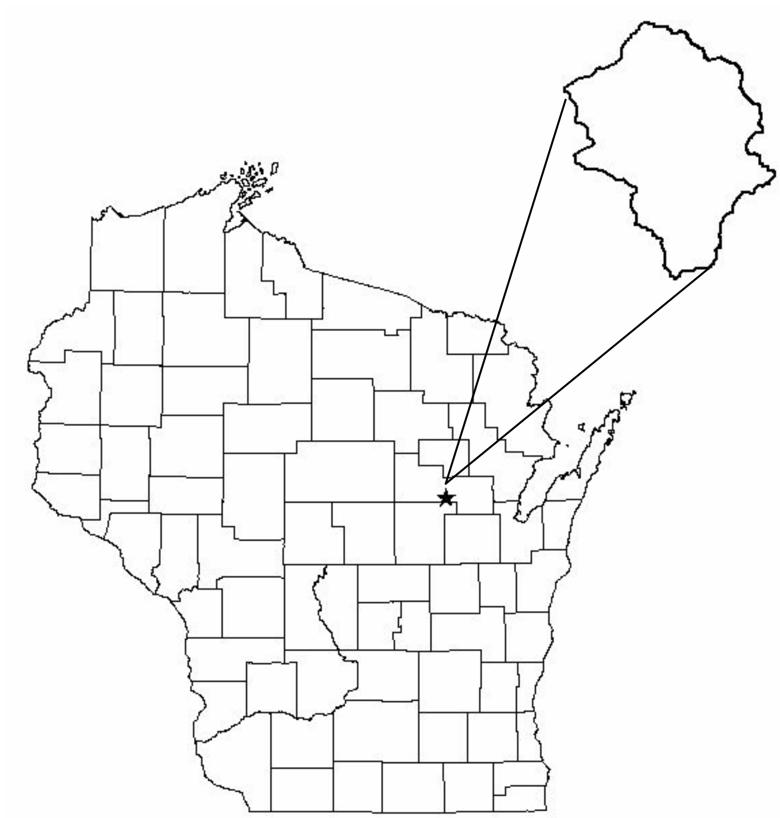


Figure 1. Location of Schoenick Creek Watershed in Shawano County, Wisconsin.

Goals and Objectives

The study was designed to assess current water quality conditions within the Schoenick Creek Watershed in a format that will be understandable to landowners and Shawano County personnel; and to make recommendations for water quality improvement. Objectives of this study included:

- Determine the current quality within the Schoenick Creek Watershed during base flow and event conditions.
- Assess the land use practices within the surface and groundwater watersheds and how they are related to water quality within the Schoenick Creek Watershed.
- Determine the current quality of groundwater entering Long Lake.
- Look at long-term water quality trends within the Schoenick Creek Watershed using current and historic data.
- Provide educational opportunities for the watershed landowners to increase their understanding of the Schoenick Creek Watershed and how their land use decisions may affect water quality in the streams and lakes.
- Provide recommendations to assist with future watershed decisions.
- Create a stakeholder generated plan to improve and protect the Schoenick Creek Watershed.
- Establish a volunteer monitoring program to track changes in water quality as the strategic plan is implemented and to educate citizens on the quality of their water.

This study was a cooperative effort between UWSP Center for Watershed Science and Education, Fox-Wolf Watershed Alliance, Long Lake Homeowners Association, Shawano County Land Conservation Department, and the Wisconsin Department of Natural Resources.

METHODS

WATER QUALITY SAMPLING

Seven sample sites along Schoenick Creek and two of its tributaries were evaluated in this study. Samples were collected during baseflow and event flow conditions over a one year period. Baseflow sampling was conducted during mid-summer when runoff was absent, vegetative cover was near its maximum, and stream flow was relatively low and dominated by groundwater inputs. There were four other sampling periods which were evaluated during event conditions or periods of high flow. The baseflow samples are more representative of groundwater inputs and contributions from the stream channel while event flow samples are more likely to show the impacts of water running off the landscape in addition to the groundwater contributions.

Baseflow samples were collected at all sites between July 30 and 31, 2003, except for the site located at the inflow to Long Lake. A 500 mL polyethylene bottle was used to collect the water sample from each site upstream from a road crossing using the standard grab method. The bottle was submerged in the stream in a downstream direction, the cap was removed allowing it to fill with stream water, and then replaced on the bottle before removing it from the stream. One 60 mL polyethylene bottle was filled with an unfiltered sample and preserved with 1 molar H_2SO_4. The second 60 mL polyethylene bottle was preserved with 1 molar H_2SO_4, and filled with filtered sample. All samples were filtered using an in-line filter cassette connected to a 60 ml plastic syringe. A 0.45 μm membrane filter was used for fine filtering in combination with a 934 / AH fiberglass pre-filter for removing coarse particles. The third bottle was a 500 mL polyethylene bottle that was left unpreserved and unfiltered. After collection, the bottles were immediately placed on ice in a cooler.

Runoff event samples were collected from all sites in June and September 2003, and all sites, except the Long Lake inflow, in October 2002 and March 2003. Runoff event sampling was instituted by use of siphon samplers or grab samples. Figure 2 illustrates the siphon sampler and its components. The siphon sampler used for this study was modified from devices designed by the USGS (USGS Report 13).

The bottle bracket slid onto a regular round pipe or "T" fence post that was inserted approximately 18 inches into the streambed. The siphon samplers were positioned to sample an anticipated rise in the stream from an event. This height varied from site to site depending upon the morphology (size, shape) of the stream and location within watershed. When the water crested above the peak of the lower tube, the river water entered the bottom tube and filled the 500 mL polypropylene sample bottle. The event samples were collected by watershed volunteers, properly preserved and/or filtered and shipped to the state certified Water and Environmental Analysis Lab (WEAL) at the University of Wisconsin-Stevens Point.

After collection, both baseflow and event samples were stored and transported on ice to the WEAL lab. Baseflow samples were analyzed for nitrate + nitrite- N (NO_2 + NO_3), ammonium– N (NH_4 - N), total Kjedahl nitrogen (TKN), total phosphorus (total P), dissolved reactive phosphorus (reactive P), and chloride.

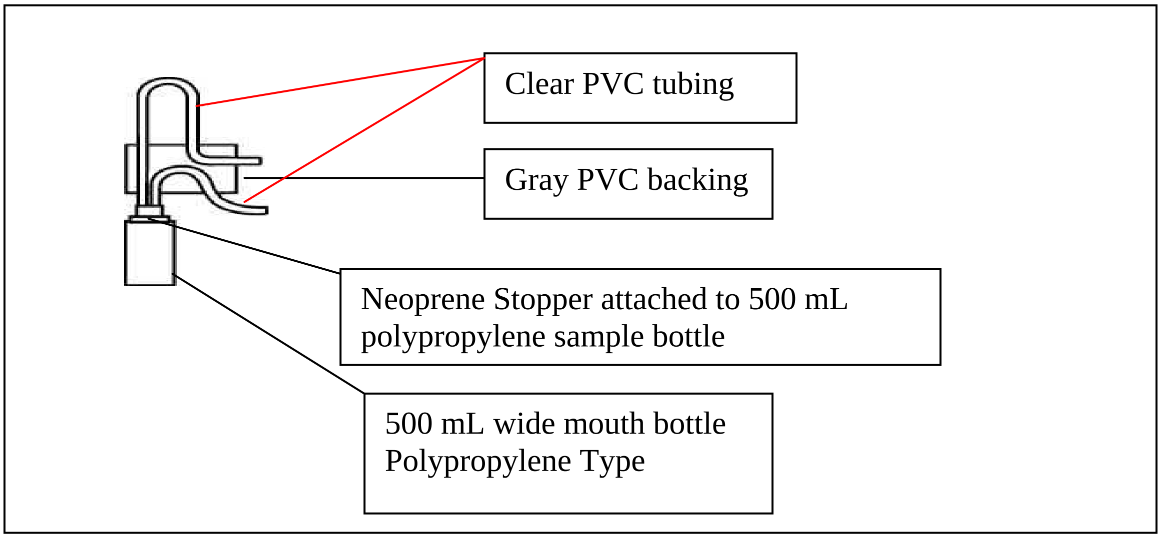


Figure 2. Diagram showing the event flow siphon sampler components

Flow Measurement

Stream discharge was measured at each site periodically throughout the study period and when baseflow water samples were collected. Flow measurements were collected using a Marsh McBirney Model 2000 portable meter stream flow monitor, which measures flow by using an electromagnetic field sensor that estimates velocity by responding to the flow of ions in the water over the sensor as a result of the water's conductivity. The stream width was measured with a 100' tape measure pulled tight using 2 chaining pins, the length was divided into at least 10 equal intervals in order to gather a minimum of 10 measurements across the stream. The Marsh McBirney's electromagnetic sensor was then adjusted to record at 60% of the total stream depth. Total discharge was calculated by determining the discharge of each interval [Discharge= Width (X ft) x Depth (X ft) x Velocity (X $^{ft}/_{sec}$)] and then by summing all calculated discharges together.

Solinst Level logger diver units (pressure transducers) were used to calculate a consistent record of stream flow. The level loggers were established at St. John's Church Road and Cloverleaf Lakes Road and measured the level of water in the stream with a pressure sensor. Data was downloaded onto a computer and the stage height was corrected using data gathered from a level logger measuring barometric pressure at a near by location. Data was then transferred to a Microsoft Excel spreadsheet. The transducers were set to read every half hour unless a two percent change occurred in water depth, in this situation they would record the depth of water every 15 minutes. A rating curve was developed from the measured stream discharges and transducer readings at St. John's Church Road and Cloverleaf Lakes Road.

MID-LAKE WATER QUALITY CHEMISTRY

Mid-lake samples were collected in the deepest areas of both Schoenick and Long Lakes. The deep holes were determined using a bathymetric map and an anchored measuring tape and marked with a Global Positioning System (GPS). Landmarks were used to return to the same location each sampling episode. Both lakes were sampled three times, once in October 2002 and then again in February and April 2003. A 7-foot long PVC column integrator was used to sample the water column in October and April. The sampler collects a vertical sample of the lake water, yielding a composite or integrated sample. During the February sampling period samples were collected at three depths; Long Lake was sampled at 6, 20, and 30 feet deep, and Schoenick Lake was sampled at 4, 22, and 27 feet deep. An alpha bottle was used to acquire the water at these depths.

Prior to sampling temperature, dissolved oxygen, pH, and conductivity were measured in the vertical plane at the deep hole. Readings were taken every two feet from the surface of the water to the lake bottom using a Hydrolab Quanta sonde. This information was used to identify the three strata (epilimnion, metalimnion, and hypolimnion) and the depth at which the samples would be collected in the winter.

A Secchi disc was used to measure water transparency during the October and April sampling periods. The Secchi disc is a simple water assessment tool, an 8-inch diameter weighted disc that is divided into four triangular sections alternating in black and white coloration. The disc was lowered over the downwind, shaded side of the canoe until it just disappeared from sight and then raised until it was just visible. Additional Secchi measurements were made by the Long Lake Association volunteers throughout the growing season.

Samples for analysis were transferred to three different high-density polypropylene bottles, a 500-ml bottle containing unpreserved and unfiltered sample, a 125-ml bottle with H_2SO_4-preserved unfiltered sample, and a 125-ml bottle filtered and H_2SO_4-preserved. Filtering was accomplished by drawing the sample up with a 60-ml syringe and pushing it through a back-to-back 1-micron glass microfiber pre-filter (934-AH) and a 0.45-micron membrane filter. All samples were transported on ice to WEAL. Total phosphorus samples were collected throughout the growing season by Long Lake Association volunteers following self-help protocol. These samples were submitted to the State Lab of Hygiene in Madison.

Analyses followed standard procedures and quality assurance measures. Analyses performed on the mid-lake samples included nitrate and nitrite (NO_2+NO_3-N), ammonium (NH_4-N), Total Kjeldahl Nitrogen (TKN), total phosphorus (TP), reactive phosphorus (RP), and chloride; the October and April mid-lake sampling analyses also included alkalinity, total hardness, calcium hardness, sulfate, potassium, sodium, turbidity, and color.

GROUNDWATER INFLOW/OUTFLOW

During late August 2002 small wells (mini-piezometers) were used to determine the groundwater quality and estimate the rate at which groundwater was entering and leaving Long Lake. To quantify groundwater inflow/outflow the change in hydraulic head between shallow groundwater and the lake was measured. The hydraulic conductivity (Hvorslev, 1951) was measured approximately every 150-200 feet along the shoreline of Long Lake. The physical characteristics of these 62 sites were described, GPS readings were collected, and all sites were identified on a map (Figure 24). Samples for chemical analysis were collected from each of the inflow sites for lab analysis.

The mini-piezometers were constructed of 5-foot polypropylene tubing with a ¼ inch of internal diameter. A nylon-slotted, round-head screw was inserted approximately ¼ inch to ½ inch in the lower end of the tubing to prevent inflow of sediments. Several inches above the bottom, a 1 ½ -inch screen was created with a small diameter needle. A pipette tip was attached to the same end of the well for ease of insertion and a steel rod was inserted into the tube to help penetrate the substrate. A steel tile probe initiated the hole before the well was introduced into the sediment. The tile probe was only used on sites where hard and compact substrate created difficulties when inserting the mini-piezometers.

Mini-piezometers were inserted approximately 2-feet into the lake substrate where the water depth was 18 inches. Once the metal insertion rod was removed, a 60 cc syringe was used to draw the groundwater into the mini-piezometer. The wells were purged by removing up to 180 cc of groundwater or until the water was clear, indicating adequate groundwater flow. If no water could be drawn, the well had to be developed by injecting several full syringes of lake water into the well and then drawing out at least four more. At several locations, development did not establish communication between the mini-piezometer and the groundwater. Those locations were not tested further. At the other locations, once communication was developed and there was clear water in the mini-piezometer, the static head was allowed to reach equilibrium. The height of the groundwater in the well compared to the lake level is called the static head. If the static head was above the level of the lake, then groundwater inflow was occurring at that location. These inflow sites recharge the lake with groundwater. If however, the static head was below the lake level, outflow was occurring, and the lake water was actually returning to the groundwater. If neither inflow nor outflow existed, there was no interaction of groundwater and surface water at that point, which is referred to as no flow.

The permeability of the sediments to the flow of water was determined using the falling head test. This test involved placing an o-ring at 37% of the slug height above the static head (Hvorslev, 1951), then drawing groundwater to the top of the well and timing it as it is allowed to drop to the o-ring. The rate at which it falls is determined by the permeability of the sediments. The average of three time trials of the falling head test was recorded and the mini-piezometer was removed.

The groundwater samples were filtered through an in-line filter cassette containing a glass fiber filter and a 0.45-micron micropore filter. The samples were preserved with H_2SO_4 for analysis of NO_2+NO_3-N, chloride, ammonium-N, and reactive phosphorus in the laboratory. The samples were transported on ice to WEAL. Analytical methods are shown in Table 1.

Table 1. Analytical methods and detection limits for the UWSP Water and Environmental Analysis Lab.

ANALYSES	METHOD	METHOD DETECTION LIMIT
Alkalinity	Titrimetric 2320 B	4 mg/L
Chloride	Automated Ferricyanide 4500 C1 E	0.2 mg/L
Chlorophyll *a*	Spectrometric 10200 H	0.1 mg/L
Conductivity (in lab)	Conductivity Bridge 2510 B	1 umho
Hardness, Calcium	Titrimetric 3500 Ca D	4 mg/L
Hardness, Total	Titrimetric 2340 C	4 mg/L
Nitrogen, Ammonium	Automated Salicylate 4500-NH_3 G	0.01 mg/L
Nitrogen, Nitrate + Nitrite	Automated Cadmium Reduction 4500 NO_3 F	0.021 mg/L
Nitrogen, Total Kjeldahl	Block Digester; Auto Salicylate 4500-NH3 G	0.08 mg/L
Phosphorus, Soluble Reactive	Automated Colorimetric 4500 P F	0.003 mg/L
Phosphorus, Total	Block Digester, Automated 4500 P F	0.012 mg/L
Potassium	ICP 3120 B	270 ug/L
Sodium	ICP 3120 B	0.2 mg/L
Sulfur (SO4)	ICP 3120 B	26 ug/L
Total Suspended Solids	Glass Fiber 103-105C 2540 D	1 mg/L

Results and Discussion

SCHOENICK CREEK WATERSHED SURFACE WATER

The Schoenick Creek watershed is almost entirely in Shawano County with approximately 28 acres in Waupaca County. The watershed size was estimated to account for all of the drainage basins of the sampling sites in this study and subsequently equaled 8,409 acres. The Schoenick Creek watershed was subdivided into seven sub-watersheds; five sample sites were located in Schoenick Creek and two sample sites were located in tributaries of the creek. To best identify the land areas that were contributing water to Schoenick Creek and both Long and Schoenick Lakes sub-watersheds were delineated using a topographic 30 meter digital elevation model provided by the WDNR (Figure 3).

Woodlands and non-irrigated cropland (row crops, forage, pasture, etc.) are abundant throughout the Schoenick Creek watershed, each comprising 3,432 (40.8%) and 3,547 (42.2%) acres, respectively (Tables 2 & 3). Eight other land covers identified within this watershed include pastureland, various types of agriculture, residential land, open water, open land, public utilities, commercial and industrial, and nonmetallic mineral mining, and quarrying. Of the previously mentioned land uses, open land and public utilities comprise the most acreage with 693 (8.2%) and 236 (2.8%) acres of each, respectively. Residential land use is an important land use to consider, and in the watershed of Schoenick Creek comprises 178 acres (2.1%).

Each category of land use can be broken down into more specific types, but for this study the following general groupings were selected to characterize relationships with water quality. “Other Agriculture” represents a number of potential agricultural practices along with dairy product manufacturing. Residential land use includes single and two family structures, farm residences, and accessory residential uses and buildings. “Open Water” consists of man-made ponds, natural ponds, lakes, streams, and creeks. The “Open Land” catagory represents all vacant land that is considered developable (i.e. residential subdivision lots, urban or rural lots), in addition to general recreation parks. “Public Utilities” includes all highways and streets, electric power generation, and transmission and distribution.

Soil within the boundaries of the Schoenick Creek watershed have a number of characteristics that influence the quantity and quality of groundwater and surface water. Soil that is very permeable allows water to move to groundwater rapidly. If contaminants are on the ground surface or in the soil, they can be carried to groundwater as well. Soil that has low permeability tends to have more surface runoff during rain and snowmelt. In both cases, contaminants on the land can move to surface water with surface runoff water. On all soils, changes to the land that reduce water infiltration (e.g., compaction and impervious surfaces) increase the amount of surface runoff. In the watershed there are five primary types of soil. Sandy soil occurs in 48.6% of the watershed, and are deep and well drained with rapid permeability. This rapid permeability allows water and contaminants to easily move to groundwater. Silt loam soil occurs in 30.3% of the watershed and are deep and poorly drained soils with moderate permeability. Many are found on slopes of 0 to 3% where surface runoff from these soils may be lower. Fine sandy soil occur in 12.9% of the watershed; these fine sand soils are deep, somewhat poorly drained, and exhibit rapid permeability with slow runoff. Fine sandy loam soil occurs in 6.9% of the watershed. This soil is well to moderately well-drained with moderate to moderately slow permeability. Loamy sand soils occur in 1.3% of the watershed and are well to excessively drained with rapid permeability.

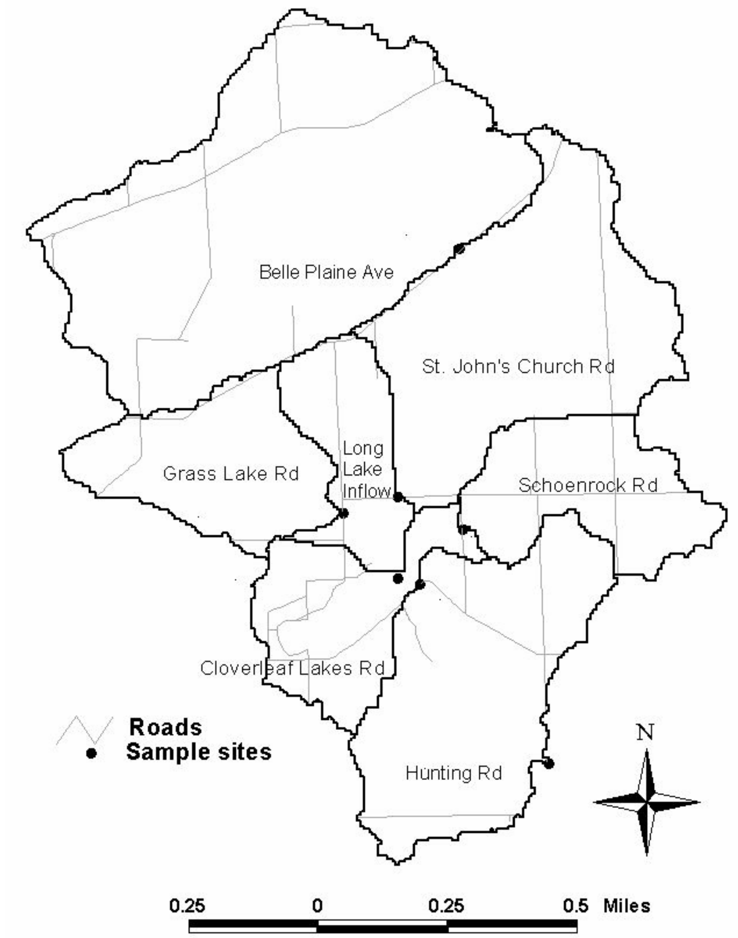


Figure 3. Sub watersheds, roads, and sample sites in the Schoenick Creek Watershed, Shawano, WI.

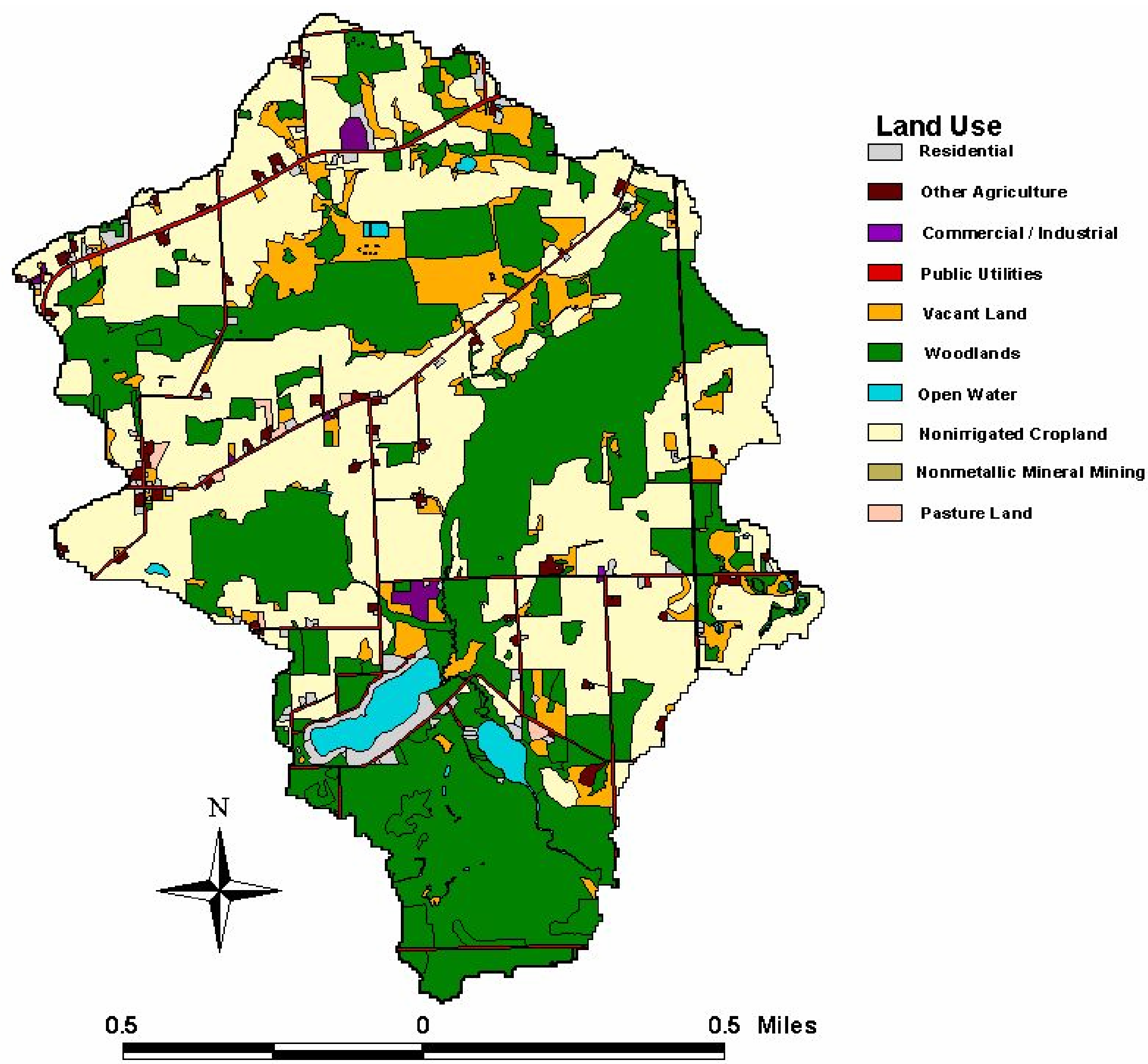


Figure 4. Land use in the Schoenick Creek Watershed.

Table 2. Major land use practices, shown in acres, occurring within the Schoenick Creek Watershed.

Sub-Watershed	Woodlands	Nonirrigated Cropland	Pastureland	Other Agriculture	Residential	Open Water	Vacant Land	Public Utilites	Commercial / Industrial	Nonmetallic Mineral Mining and Quarrying
Belle Plaine Ave	833	1443	17	34	53	13	397	78	17	0
Grass Lake Rd	276	408	4	12	11	4	15	16	1	<.5
St. Johns Church Rd	887	581	0	6	6	1	105	31	0	0
Schoenrock Rd	154	427	0	15	11	6	61	27	2	0
Cloverleaf Lakes Rd	313	99	0	2	73	89	15	30	0	0
Hunting Rd	908	276	5	12	14	45	58	33	0	0
Long Lake Inflow	62	314	<.5	12	10	4	42	20	21	0
Schoenick Creek Watershed	3432	3547	26	94	178	162	693	236	40	<.5

Table 3. Major land use practices, given in percent of acres, occurring within the Schoenick Creek Watershed.

Sub-Watershed	Woodland	Nonirrigated Cropland	Pastureland	Other Agriculture	Residential	Open Water	Vacant Land	Public Utilites	Commercial / Industrial	Nonmetallic Mineral Mining and Quarrying
Belle Plaine Ave	28.9	50.1	0.6	1.2	1.8	0.5	13.8	2.7	0.6	0.0
Grass Lake Rd	36.9	54.6	0.6	1.7	1.5	0.5	2.0	2.2	0.1	<.05
St. Johns Church Rd	54.8	35.9	0.0	0.4	0.4	0.1	6.5	1.9	0.0	0.0
Schoenrock Rd	21.9	60.8	0.0	2.2	1.5	0.8	8.7	3.9	0.3	0.0
Cloverleaf Lakes Rd	50.3	15.9	0.0	0.4	11.8	14.4	2.5	4.8	0.0	0.0
Hunting Rd	67.2	20.4	0.4	0.9	1.1	3.3	4.3	2.5	0.0	0.0
Long Lake Inflow	12.7	64.7	0.1	2.4	2.1	0.8	8.7	4.2	4.4	0.0
Schoenick Creek Watershed	40.8	42.2	0.3	1.1	2.1	1.9	8.2	2.8	0.5	<.05

Site Descriptions/Land Use/Soil and Water Chemistry

This section describes land uses within each sub-watershed along with stream water chemistry associated with the seven sampling sites. Land use practices, soil type, slope of land, and vegetative cover are some of the primary factors that affect the quality of water in a steam. Land cover and land practices vary throughout the year, so water samples were collected in all seasons. Baseflow samples represent the quality of water that is moving to the stream via groundwater flow plus the effects of materials that have moved into the stream during runoff events and have deposited in the stream. Water entering the stream through baseflow is fairly consistent throughout the year. Runoff events occur when materials are carried over land in water to the stream. If there is minimal material, events can actually dilute what is entering the stream via groundwater, but if there is a lot of material in-river concentrations will increase. Understanding how nutrients are moving to a river and the land they are flowing over is imperative when it is desirable to reduce inputs to a river system.

During this study, seven stream sites were sampled and evaluated within the Schoenick Creek Watershed. Belle Plaine Ave., Grass Lake Rd., St. John's Church Rd. Schoenrock Lake Rd., Cloverleaf Lakes Rd., Hunting Rd., and the inflow of Long Lake which was located approximately 50 yards up-stream of the inlet to the lake (Figure 3). Grass Lake and Schoenrock Lake Rds were sites not directly located on Schoenick Creek, but were instead located on two of its unnamed tributaries. Grass Lake Rd. tributary flows into Schoenick Creek from the west while the Schoenrock Lake Rd. tributary enters from the east.

All sites except the Long Lake inflow were sampled on five dates; four during event flow conditions and one during baseflow. The sample site at the inflow to Long Lake was measured three times during event flow conditions. Baseflow samples were collected by UWSP using the grab method and discharge was measured. The event flow samples were collected by volunteers using the grab method and by use of siphon samplers. Continuous flow was measured at St. John's Church Rd and Cloverleaf Lakes Rd from March to October 2003. Both baseflow and event flow samples were lab analyzed for nitrogen, phosphorus, and chloride. Event samples were also analyzed for total suspended solids. Details about these constituents and a discussion of possible sources can be found in the Mid-Lake section of this document.

The results are discussed in several formats beginning with the various chemical measurements in the overall watershed, a site by site description of each watershed and the associated water quality, followed by watershed scale modeling results using BASINS and SWAT.

WATERSHED CHEMISTRY

Chloride (Cl^-)

Chloride moves with water, and reflects the land to water interaction. There are minimal natural sources in Wisconsin and it is not biologically reactive so it makes a good tracer. Chloride was measured at all sample sites during baseflow conditions, and suggests some chloride is entering the stream through groundwater. During event sampling, the amount of chloride usually increased, indicating that chloride also enters the stream from runoff. The exception exists at the Schoenrock Rd site where chloride concentrations were decreasing during event flows demonstrating that surface runoff from this sub-watershed diluted the groundwater chloride concentrations. Samples collected from the Grass Lake Rd site had the highest chloride concentrations for all sampling periods, which includes both baseflow and event flow conditions. High concentrationss of chloride during runoff and baseflow at the Schoenrock Rd site are the result of agricultural fertilizer and/or animal waste linked to the agriculture in the sub-watershed. Chloride concentrations can be correlated with the amount of land in agricultural use in all the sub-watersheds. Increased chloride concentrations during the March sampling may be attributed to road salt runoff in addition to land spread manure on snow.

Total Suspended Solids (TSS)

TSS is a measure of particulate matter in the water samples. Eroding soil, buildup/washoff of sediment on barren land surfaces, or erosion of stream banks are all potential sources of TSS to streams. Differences in TSS between many of the sample sites can be attributed to erosion of exposed soil surfaces near the stream and along the banks of the stream.

In this study, TSS was measured only during event flows. The two tributaries of Schoenick Creek that were sampled had the highest TSS concentrations, these tributaries were sampled off of Grass Lake Rd and Schoenrock Rd. The Grass Lake Rd samples had extremely high concentrations of TSS with a mean of 700 mg/L. The lowest concentrations of TSS for all sites were measured in samples collected at the Hunting Rd site. Here concentrations of TSS never exceeded 5 mg/l. Hunting Rd was the most downstream sampling site in the Schoenick Creek watershed, located after water has flowed through wetlands and both Long and Schoenick Lakes.

Table 4. Baseflow concentrations of nitrogen, phosphorus, and chloride in Schoenick Creek and two of its tributaries, Shawano County, WI, July 2002.

Site Name	Cl^- mg/L	NO_2+NO_3 mg/L	NH^{4+} mg/L	Total N mg/L	Organic N mg/L	Total P ug/L	Reactive P ug/L
Belle Plaine Ave	17	0.1	0.1	2.8	2.7	768	228
Grass Lake Rd	23.5	0.4	0.12	1.7	1.2	218	80
St. John's Church Rd	16.5	0.6	1.32	4.6	2.8	593	184
Schoenrock Rd	23	3.3	0.04	3.9	0.5	102	70
Cloverleaf Lakes Rd	10	0.3	0.05	1.0	0.7	98	54
Hunting Rd	8.5	0.2	0.03	1.0	0.8	80	57

Table 5. Concentrations of chloride and total suspended solids in event flow samples within the Schoenick Creek watershed, Shawano County, Wisconsin. Data from four event periods are summarized. (Three for Long Lake Inflow).

Site	Cl (mg/L)			TSS (mg/L)		
	Min	Max	Mean	Min	Max	Mean
Belle Plaine Ave	17.0	22.5	20.3	3.0	43.0	17.0
Grass Lake Rd	12.0	59.5	26.5	7.0	2120.0	700.3
St. John's Church Rd	11.0	21.0	15.9	4.0	192.0	64.5
Schoenrock Rd	8.0	21.5	12.0	4.0	322.0	131.0
Cloverleaf Lakes Rd	6.5	19.0	11.0	4.0	245.0	127.3
Hunting Rd	6.5	13.5	8.9	2.0	5.0	4.3
Long Lake Inflow	9.5	19.0	14.7	31.0	117.0	85.0

Nitrate (NO_2 + NO_3-N)

In this region, the normal range for concentrations of nitrate in streams and rivers is 0.3 mg/L (EPA, 2000). Some nitrate in streams is expected due to the breakdown of vegetation and biological nitrogen cycling. High concentrations of nitrate entering a stream suggest other sources such as lawn and agricultural fertilizers, livestock waste, and septic systems. Mean values for all sites and samples collected during events, excluding the Long Lake inflow, exceeded 0.3 mg/L. The greatest concentrations of nitrate (max of 9.3 mg/L; mean of 3.4 mg/L) were measured in samples collected from the Grass Lake Rd site. The tributary at St. John's Church Rd and Schoenrock Rd were also much higher than 0.3 mg/L during event flow. The lowest concentrations of nitrate during event flows occurred in samples from the Grass Lake Rd site, and during baseflow from Belle Plaine Ave site. The lowest concentration of nitrate during event flows was 0.01 mg/L from the Grass Lake Road site and during baseflow the lowest nitrate concentration was 0.09 mg/L from the Belle Plaine Ave site. The Schoenrock Rd site had the highest baseflow concentration of nitrate (3.3 mg/L), but the event flow concentrations here were low. This suggests that nitrate from Schoenrock Rd sub-watershed is entering the stream through groundwater, and at Grass Lake Rd they are increased by event runoff.

Ammonium (NH_4^+)

Ammonium within a water body is a concern because it is assimilated by aquatic vegetation and ammonia can be toxic to fish at high concentrations. Ammonium is a form of nitrogen that is more prevalent under low oxygen conditions and/or during breakdown of organic material. Once in the water, it can be converted to nitrate. At most locations, the average concentrations of ammonium were higher during event flow than baseflow. St. John's Church Rd location was the exception; with baseflow concentrations (1.32 mg/L) slightly higher than the average event flow concentrations (0.84 mg/L). Almost all measured baseflow concentrations of ammonium were below 0.3 mg/L, except for the St. John's Church Rd baseflow sample. Ammonium making its way to Schoenick Creek during event conditions is most likely the result of animal waste.

Organic Nitrogen

Organic nitrogen is the amount of nitrogen associated with particulates including soil and organic matter. When organic matter decomposes the organic nitrogen can be converted to ammonia and then later could be converted to nitrate when oxygen is present. During baseflow conditions St. Johns Church Rd and Belle Plaine Ave sites the highest concentrations of organic nitrogen. As would be expected, mean averages for organic nitrogen from samples collected during event flow conditions were greater than baseflow samples for all sites except for St. John's Church Rd and Belle Plaine Avenue. Grass Lake Rd contained the greatest concentrations of organic nitrogen during event flows, which is likely the result of direct runoff from exposed soil and barnyard waste.

Total Nitrogen

Total nitrogen is the sum of inorganic nitrogen plus organic nitrogen. In this region, normal concentrations of total nitrogen should be around 0.54 mg/L (EPA, 2000). Mean concentrations of total nitrogen for all sites in the Schoenick Creek watershed exceeded 0.54 mg/L during both baseflow and event flow conditions. The data collected and shown in Table 6 indicates that during event flow conditions the samples at the Grass Lake Rd site had the highest concentrations of total nitrogen. Samples from the Schoenrock Rd site had the highest concentrations of total nitrogen during baseflow conditions.

Soluble Reactive Phosphorus (SRP)

Soluble reactive phosphorus is a form of phosphorus that passes through a fine filter and is readily available for assimilation by plants and algae. Typically in small streams, much of the soluble reactive phosphorus comes from organic material dropping into the stream and then it is processed and recycled as it "spirals" downstream.

All samples had high concentrations of SRP. Concentrations of SRP generally varied ten-fold during both baseflow and event flow conditions and between sites (Figure 5 and Table 7). Mean concentrations of SRP during event flows were greater than any of the concentrations measured during baseflow. When compared to all other sites, the Grass Lake Rd site had several samples that were had extremely high concentrations of SRP during event flow. However, during baseflow the Belle Plaine Ave sample had the highest concentration of SRP.

Total Phosphorus

Total phosphorus includes both the soluble reactive phosphorus plus the phosphorus in sediment, plant, and animal fragments suspended in water. Primary sources of total phosphorus include animal waste, soil erosion, and runoff from farmland or lawns. The U.S. Environmental Protection Agency suggests that normal total phosphorus concentrations in this region are 33 ug/L. All of the study sites within the Schoenick Creek watershed contained samples well above 33 ug/L during baseflow and event flow conditions. Samples from the Grass Lake Rd site had the highest concentrations of total phosphorus during event flow conditions, while samples from the St. John's Church Rd site had the highest concentrations during baseflow (Figure 6).

Table 6. Concentrations of nitrate, ammonium, organic nitrogen, and total nitrogen in event flow samples within the Schoenick Creek watershed, Shawano County, Wisconsin. Data from four event periods are summarized (3 for Long Lake Inflow).

Site	NO2+NO3 (mg/L)			NH4 (mg/L)			Total N (mg/L)			Organic N (mg/L)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Belle Plaine Ave	0.05	0.2	0.1	0.005	1.85	0.70	2.06	4.96	3.38	1.74	3.19	2.53
Grass Lake Rd	0.01	9.3	3.4	0.005	1.97	0.72	1.70	30.26	15.92	1.65	24.02	11.76
St. John's Church Rd	0.4	1.2	0.7	0.06	1.65	0.84	2.61	5.14	4.14	2.15	2.81	2.59
Schoenrock Rd	0.6	1.7	1.1	0.03	1.41	0.41	2.84	5.81	3.98	1.84	3.02	2.51
Cloverleaf Lakes Rd	0.2	0.8	0.6	0.05	1.52	0.53	2.12	4.94	3.41	1.87	2.65	2.32
Hunting Rd	0.1	0.6	0.3	0.03	1.00	0.15	1.29	3.79	2.01	0.94	2.19	1.35
Long Lake Inflow	0.2	0.3	0.5	0.06	1.72	0.95	1.97	7.06	3.94	1.69	4.30	2.81

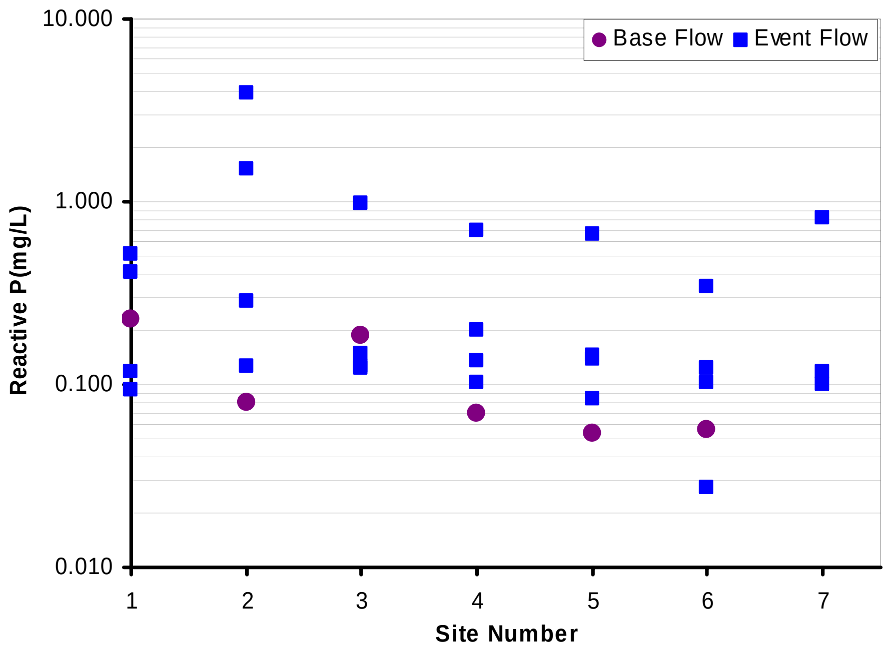


Figure 5. Concentrations of reactive phosphorus measured during baseflow and event flow conditions where site numbers correlate to site names so that site 1-Belle Plaine Ave, 2-Grass Lake Rd, 3-St. John's Church Rd, 4-Schoenrock Rd, 5-Cloverleaf Lakes Rd, Hunting Rd, 7-Long Lake Inflow.

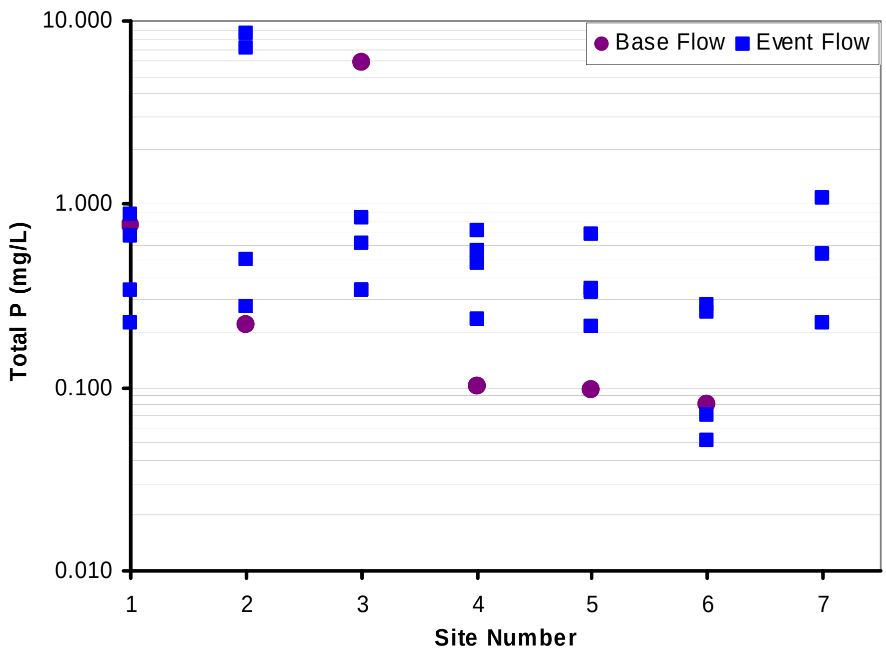


Figure 6. Concentrations of total phosphorus measured during baseflow and event flow conditions where site numbers correlate to site names so that site 1-Belle Plaine Ave, 2-Grass Lake Rd, 3-St. John's Church Rd, 4-Schoenrock Rd, 5-Cloverleaf Lakes Rd, Hunting Rd, 7-Long Lake Inflow.

Table 7. Concentrations of total and reactive phosphorus in event flow samples within the Schoenick Creek watershed, Shawano County, Wisconsin.

Site	n	Total P (ug/L)			Reactive P (ug/L)		
		Min	Max	Mean	Min	Max	Mean
Bell Plaine Ave	4	224	886	531	94	520	286
Grass Lake Rd	4	273	8620	4144	126	3970	1474
St. John's Church Rd	4	340	846	534	120	970	343
Schoenrock Rd	4	234	718	496	103	693	282
Cloverleaf Lakes Rd	4	216	684	394	83	664	257
Hunting Rd	4	51	281	166	27	346	150
Long Lake Inflow	3	225	1070	608	99	816	344

SITE BY SITE SUMMARY

The following section describes each site and summarizes the water quality results for each sub-watershed. The nitrogen and phosphorus results are presented in concentration and estimated yield based on baseflow chemistry and flow measurements. Yield estimates are made by multiplying concentration times the measured flow. These yield estimates do not account for additional flow and inputs during event conditions as continuous flow and analyses were not conducted as part of this study and at many of the sites the total yield would actually be greater because more nutrients potentially enter the stream as runoff increases during event conditions. Phosphorus and nitrogen yield estimates are shown in Table 8 and Figures 7 and 8.

Belle Plaine Avenue

This site is located just upstream of Belle Plaine Ave in Schoenick Creek. At this location the stream flows through an area of wetland, resulting in a poorly defined channel. The water color is brown (tannic) to rusty red with substrate consisting of some gravel and sand but predominantly fine silt. Belle Plaine Ave. is the upper most site in

Table 8. Estimated annual baseflow yield of reactive and total phosphorus, and total nitrogen for Schoenick Creek for each sample site during baseflow conditions during a one year period.

Site Name	Flow (ft3/sec)	Flow (gal/yr)	Reactive P (ug/L)	Reactive P (lbs/yr)	Total P (ug/L)	Total P (lbs/yr)	Total N (mg/L)	Total N (lbs/yr)
Belle Plaine Ave	0.92	216,575,309	228.0	412.1	768.0	1388.0	2.85	5,150.8
Grass Lake Rd	0.05	10,852,358	80.0	7.2	218.0	19.7	1.75	158.5
St. Johns Church	0.29	68,181,116	184.0	104.7	593.0	337.4	4.64	2,640.0
Schoenrock Rd	0.07	17,410,958	70.0	10.2	102.0	14.8	3.89	565.2
Clover leaf Lakes Rd	3.14	741,499,125	54.0	334.1	98.0	606.4	1.02	6,311.5
Long Lake Inflow	1.53	361,643,016	99.0	298.8	225.0	679.0	1.97	5,945.2
Hunting Rd	2.67	629,554,697	57.0	299.5	80.0	420.3	1.02	5,358.6

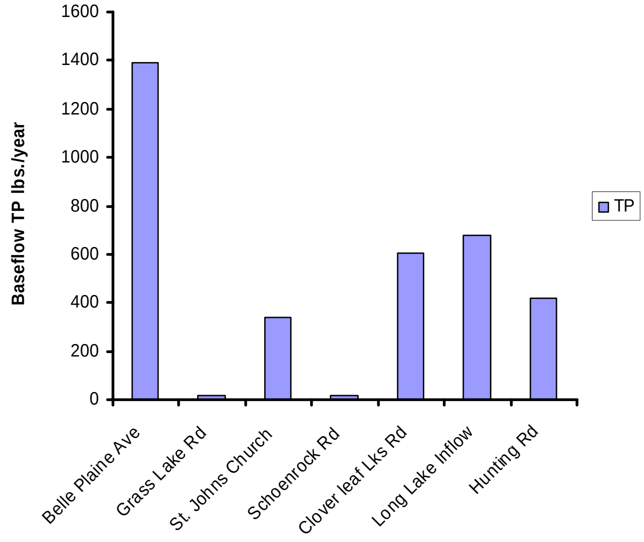


Figure 7. Baseflow yield estimates of total phosphorus for each sub-watershed.

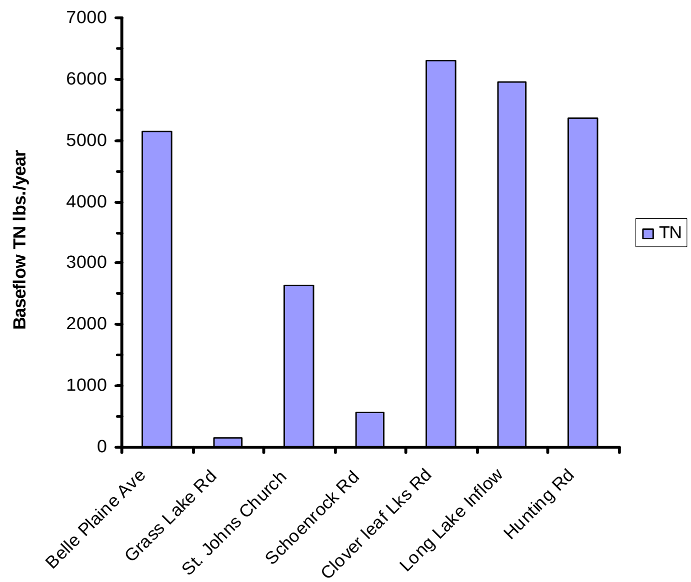


Figure 8. Baseflow yield estimates of total nitrogen for each sub-watershed.

the Schoenick Creek Watershed and its drainage basin is the largest, encompassing 2,885 acres (34.3% of the entire Schoenick Creek Watershed). There are nine different land types in this sub-watershed including woodlands (833 acres or 28.9%), non-irrigated cropland (1,443 acres or 50.1%), open land (397 acres or 13.8%), public utilites (78 acres or 2.7%), residential (53 acres or 1.8%) being most prevalent (Table 2 & 3). Two types of soil that are present in this basin include sand (96%) and loamy sand (4%).

During baseflow this site had the highest concentrations of both SRP and Total P, with 30% as SRP. A similar relationship exists with nitrogen, where most is organic nitrogen. These forms of nitrogen and phosphorus are a result of particles suspended (instead of dissolved) in the water. This is unusual for baseflow condition. Table 8 shows estimated yields of reactive and total phosphorus and total nitrogen. Phosphorus yields at this site were the greatest of all sub-watersheds (Figure 7). During many runoff events, dilution occurred and phosphorus concentrations were below those measured during baseflow. Overall, suspended solids were fairly low and little variation was measured in chloride, however, concentrations always remained elevated. This indicates a constant source of chlorides predominantly from groundwater.

Grass Lake Road

This site was sampled upstream from the road crossing where an active farming business exists just adjacent to the stream. Here the stream bottom consists of mostly sand, gravel, and some silt with detritus. The Grass Lake Rd sampling site is located on an unnamed tributary that flows into Schoenick Creek from the west; the sub-watershed that drains to this sample site is 748 acres (8.9% of the Schoenick Creek watershed). Currently, all ten land types occur in this sub-watershed. Woodlands and non-irrigated cropland are the two predominant land uses with 276 (36.9% of sub-watershed) and 408 acres (54.5% of sub-watershed) of each, respectively (Tables 2 & 3). Other agriculture, residential, open land, and public utilities are all almost equally present in significantly less acreage. There are two types of soil found in the Grass Lake Rd sub-watershed: sand (96%) and fine sand (4%).

All samples collected at the Grass Lake Rd site had elevated chloride concentrations, and during the September 2003 event the 59 mg/L chloride concentration was the maximum concentration of all samples collected during this study. The highest concentrations of nitrogen and phosphorus at this site occurred during October 2002 and September 2003. Total nitrogen was 27 and 30 mg/L, and total phosphorus 7,190 and 8,620 ug/L, respectively. This site also had the greatest suspended solid measurement of 2,120 mg/L in October 2002. Flow at this site was dominated by event runoff, and the portion of flow due to baseflow at the Grass Lake Rd site was the lowest for all sites. Baseflow water quality samples at this site indicated high concentrations of phosphorus and nitrogen; however, due to little flow during baseflow conditions at this site the baseflow yields were the second lowest of all sites. The baseflow yields here only comprise a small portion of the total yield; because the amount of nutrients in the stream flow increase when runoff increases during precipitation events, additional particles containing phosphorous and nitrogen are not present during baseflow. Upstream land use practices should be adjusted to provide better filtration of water, particularly in the fall, to reduce inputs.

St. John's Church Road

This sample site is located on Schoenick Creek just upstream of the road crossing, where the channel is defined and sinuous. The stream bottom type is composed of mostly sand, with some gravel and cobble. This site is the next downstream from Belle Plaine Ave. Its watershed comprises 1,617 acres (19.2% of the Schoenick Creek watershed). There are eight land uses present in this sub-watershed. The predominant land uses include woodlands (887 acres or 54.9%), non-irrigated cropland (581 acres or 35.9%) and vacant land (105 acres or 6.5%). The three types of soil that exist within the boundaries of the St.

John's Church Rd sub-watershed are silt loam (82%), sand (16%), and fine sandy loam (2%).

This site had the second highest concentrations of both phosphorus and nitrogen during baseflow. However, due to the low stream flow during baseflow, the baseflow yields for nitrogen and phosphorus were the lowest of all the main channel sample sites, but still greater than the baseflow yields for the tributaries. Baseflow nutrient yields only represent a small portion of the total yield occurring at this site because concentrations of the nutrients in the stream will increase during precipitation events when direct runoff contributes to stream flow. Nitrogen was mostly in the ammonium and organic forms, indicating low oxygen conditions. Chloride concentrations during runoff were both higher and lower than baseflow. The greatest chloride concentrations were measured in March and the greatest suspended solids concentrations in September.

Schoenrock Lake Road

The Schoenrock Lake Rd sample site is located just upstream from the road crossing on an unnamed tributary that flows into Schoenick Creek from the east. The stream bottom type of this tributary is comprised of sand and some gravel. The Schoenrock Lake Rd sub-watershed encompasses 702 acres (8.3% of the Schoenick Creek watershed). There are eight different land use types found in this sub-watershed with the predominant types including woodlands (154 acres or 21.9%), non-irrigated cropland (427 acres or 60.8%), and vacant land (61 acres or 8.7%) (Tables 2 & 3). The two soil types present in this sub-watershed are silt loam and fine sandy loam, with each comprising 62% and 38%, respectively.

The highest concentrations of nitrate and chloride occurred during baseflow at this site, indicating the inputs were the result of groundwater contributions. Although total phosphorus was elevated during baseflow, the greatest concentrations occurred in October 2002. The baseflow yields of total phosphorus were the lowest of all the sample sites and the baseflow yields of total nitrogen were the second lowest. The amount of water flowing past this site during baseflow is very low, and the concentrations of phosphorus and nitrogen flowing past the sample site during baseflow conditions only represent a minor portion of the total yield occurring at this site, because amounts of nutrients in the stream will increase during precipitation events when direct runoff contributes to stream flow. The highest concentrations of TSS occurred in June 2003.

Cloverleaf Lakes Road

Cloverleaf Lakes Road sample site was located in Schoenick Creek just upstream of the road crossing. At this location the river is branched by an island and the flow is directed through two large culverts, the stream bottom type at this location is almost completely sand with some silt. Although some water at this location includes other sub-watersheds of upstream sample sites; the Cloverleaf Lakes Rd. sub-watershed that excludes the upstream sites is the second smallest of the seven sub-watersheds and is comprised of 621 acres (7.4% of the Schoenick Creek watershed). There are eight land use types in the sub-watershed; the most dominant including woodlands (313 acres or 50.4%), non-irrigated cropland (99 acres or 15.9%), residential (73 acres or 11.8%), and open water

(89 acres 14.3%) (Tables 2 & 3). Silt loam, fine sand, and sand are the major soil types present in the sub-watershed, with 61% fine sand, 31% silt loam, and 8% sand.

During baseflow some of the lowest concentrations of nitrogen, phosphorus, and chloride were measured in samples collected at this site, although the phosphorus was still considered elevated. Baseflow yields of total phosphorus was third greatest for all sample sites and the baseflow yield for total nitrogen was the greatest of all sites. However, baseflow nutrient yields only represent a small portion of the total yield occurring at this site because the amount of the nutrients in the stream will increase during precipitation events when direct runoff contributes to stream flow. The highest concentrations of phosphorus and suspended solids occurred in the fall of both years indicating the need for additional vegetative buffers and/or reduced soil tilth, greater crop residual, and incorporation of land spread manure.

Long Lake Inflow

The Long Lake inflow sample site was located approximately 50 yards upstream of where Schoenick Creek enters into Long Lake. Here the stream bottom consists of mostly sand and some silt. The total watershed that drains to this site is an accumulation of the land comprising the Grass Lake Rd sub-watershed, Belle Plaine Ave sub-watershed, St. John's Church Rd sub-watershed in addition to its own land. The individual Long Lake inflow sub-watershed is the smallest of all seven sub-watersheds, and is 485 acres. Nine land uses exist with the predominant types consisting of woodlands (62 acres or 12.8%), non-irrigated cropland (314 acres or 64.7%), and vacant land (42 acres or 8.7%). Public utilities and commercial/industrial land types are present in similar quantities with 20 (4.1%) and 21 (4.3%) acres, respectively. Two types of soil present in this sub-watershed are silt loam and sand with 41% and 59%, respectively.

Samples at this site were collected during event conditions in October 2002, June and September 2003. During all events, chloride concentrations remained relatively low for this watershed. The greatest concentrations of all forms of nitrogen and phosphorus as well as suspended solids were measured in the fall samples. Baseflow samples were not collected at this site. To get an estimate for the baseflow yields of phosphorus and nitrogen we applied the flow measurement and water sample analysis from June 2003 to simulate baseflow sampling. Baseflow yields at this site for total phosphorus and nitrogen were the second greatest of all sites. It should be noted that baseflow nutrient yields only represent a small portion of the total yield occurring at this site because concentrations of the nutrients in the stream will increase during precipitation events when direct runoff contributes to stream flow.

Hunting Road

Hunting Road sample site is the last sample point in the Schoenick Creek Watershed. This is the southern most sub-watershed in the Shoenick Creek watershed; water that drains from all other sub-watersheds flow past this point. This site was located just upstream from the road crossing, and its sub-watershed comprises 1,351 acres (16.1% of the Schoenick Creek watershed). The stream bottom cover consists of mostly sand, gravel, and some silt. There are nine land types present in this sub-watershed with woodlands and non-irrigated cropland most prevalent at 908 acres (67.2%) and 276 acres (20.4%) of each, respectively. Open water (45 acres or 3.3%), vacant land (58 acres or 4.3%), and public utilities (33 acres or 2.4%) comprise a considerable portion of other land uses present in this sub-watershed. Three types of soil found in this sub-watershed include silt loam (29%), fine sand (50%), and fine sandy loam (21%).

During baseflow chloride was lower than concentrations measured at Cloverleaf Lakes Road and total nitrogen, total and reactive phosphorus were similar to those measured at Cloverleaf Lakes Road. The yield of total and reactive phosphorus estimated at this site is not representative of the total yield, because concentrations of the nutrients in the stream will increase during precipitation events when direct runoff contributes to stream flow. During runoff, the March samples had the highest concentrations of chloride, total phosphorus, and all forms of nitrogen measured at this site. This may be due to the runoff of unicorporated manure in the watershed.

COMPUTER MODELING (McGinley and Lambrecht)

Simulating Land Use Impacts on Phosphorus Inputs

To gain a better understanding of the Schoenick Creek watershed a computerized model of the watershed was developed using information collected during the study and assumptions based on other studies. The model allowed us to gain insight into how each sub-watershed may be affecting phosphorus and water flow within the stream. Computer models can be a useful tool in combination with site-specific data; however, it should be noted that these are only simulations and the variability between the model and events within the actual watershed rarely can be accounted for. Therefore, management strategies based on models should consider the limits of what the model will allow.

Version 3.0 of the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) was used. This model was developed to promote better assessment and integration of point and nonpoint sources in watershed and water quality management. BASINS® takes into account environmental background and monitoring, and point/nonpoint source loading. Environmental data for the geographic area of Schoenick Creek was imported from the Basins website. We delineated the watershed by importing a digital elevation model of Wisconsin into the BASINS program and selected an outlet point to identify the area of land that contributed to stream flow, in our case it was the Hunting Rd crossing. For delineating all sub-watersheds in the watershed each of sampling sites was selected as an outlet.

Processes in the watershed were simulated using a Soil Water and Assessment Tool (SWAT), which is a physically based, watershed scale model that was developed to predict the impacts of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land uses and management conditions over long periods of time. The model calculates an average response that is applied to similar areas ("hydrologic response units") in the watershed and combines them. Six categories of land use were used including alfalfa, corn (row crops), pasture, wetland, and open water. Five different classes of soils were implemented by the model. These varied the porosity, permeability, moisture content, and drainage capacities in different regions. To confirm that SWAT was simulating the Schoenick Creek watershed on an appropriate scale the model was loaded with 13 years of daily precipitation data collected from the closest and most practical NOAA recording station (SHAWANO 2 SSW). Predicted stream flow was compared to the flow recorded during this study for the same time frame at St. John's Church Rd and Cloverleaf Lakes Rd, using Solinst level logger pressure transducers (Figures 9 & 10).

Adjustments to the model were made to improve the fit of the model to collected data. The calibration process used adjustments in several model inputs to better match the measured data. First the hydrologic parameters were adjusted such as the runoff curve numbers for various land uses.

Nutrient and sediment calibration was based on estimating manure and fertilizer phosphorus additions, adjusting slope length and average slope for each hydrologic response unit. We approximated phosphorus additions through spring and fall application of phosphorus on those portions of the model assumed to contain corn. Fifty pounds of phosphorus (elemental P)/acre/year was divided between a spring and fall application. Crop rotation was simplified by dividing the watershed into corn and alfalfa. In this preliminary modeling we did not include crop rotation on individual fields, but assumed that the distribution within each sub-watershed would mimic crop rotation at the sub-watershed scale.

From the flow and concentration measurements a rough estimate of nutrient loading in the form of phosphorus within the watershed, and for each sub-watershed was calculated. The results are shown in Figures 7 and 8. A 30 year simulation of the computerized model of the Schoenick Creek watershed was run and compared with concentrations of phosphorus output for all seven sub-watersheds to phosphorus export coefficients provided by Panuska and Lillie (1995) for watersheds with similar land use classifications (Table 10).

The model predictions are shown in Figures 9 and 10, where measured flow in the stream reach of Schoenick Creek is compared to daily averages of flow predicted by SWAT. A 3-year daily simulation that ended with monitored period was run, and compared the actual and simulated flow from April to October for St. John's Church Rd, and from March to October for Cloverleaf Lakes Rd for the last year of the simulation. SWAT predicted there to be more baseflow in the model than we observed and was also far more sensitive to precipitation events than our pressure transducers recorded. Differences in flow peak magnitude could be related to the daily average estimated in the models and were not used to calibrate the model. In this preliminary model evaluation, we matched the general response of the watershed. The watershed response is obviously very sensitive to precipitation. Variations in intensity and quantity of precipitation throughout the watershed are expected to have a significant impact on the comparison between predicted and observed flow.

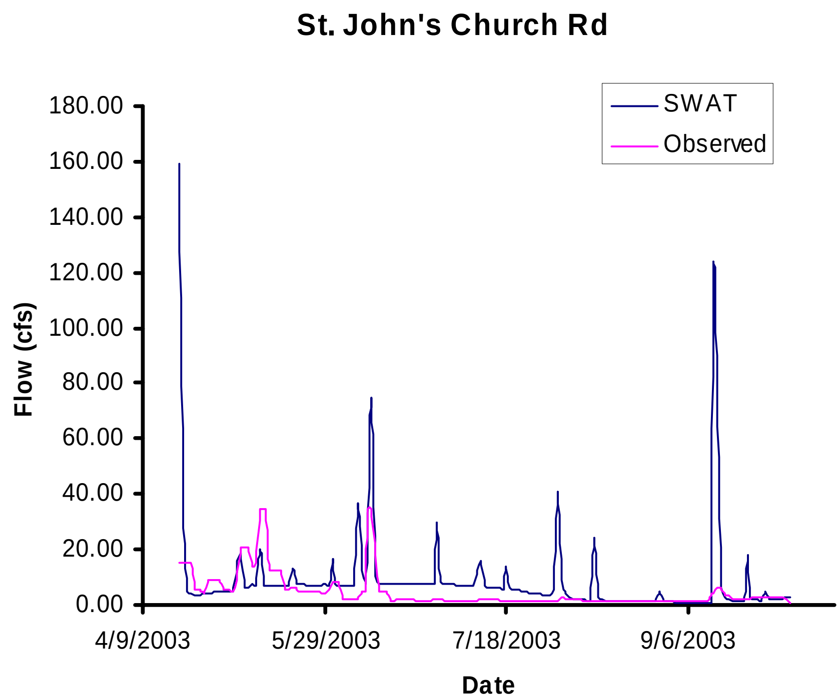


Figure 9. Stream flow predicted by SWAT and the flow that we actually measured for the period of 4/19/2004 through 10/4/2004.

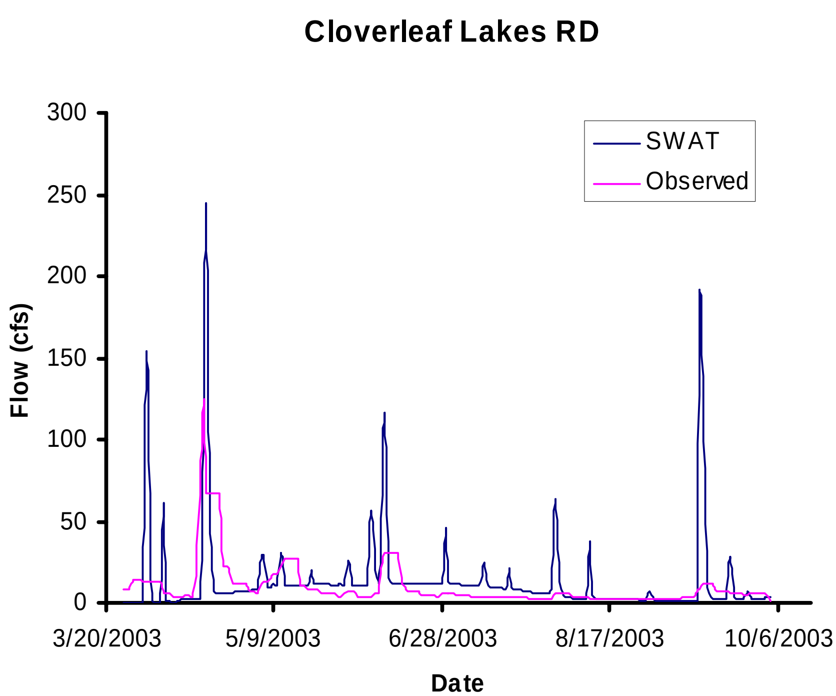


Figure 10. Stream flow predicted by SWAT and the flow that we actually measured for the period of 3/25/2004 through 10/4/2004.

Even after making some adjustments in the hydrologic parameters, the SWAT model over estimated the stream flow at some times and under estimated them at others. Overall, however, the model predicted more runoff than was actually observed. If the model is over predicting stream flow, it will also over predict phosphorus and sediment loading. Sources of uncertainty that may contribute to the over prediction include: (1) precipitation data entered into the model was from the closest NOAA precipitation recording station and not actually the precipitation occurring at these two locations and (2) the Solinst level loggers did not record at consistent percentages of increases and decreases in stream depth. Table 9 shows the differences in the amount of water observed to be flowing in Schoenick Creek at St. John's Church Rd and Cloverleaf Lakes Rd, and the amount predicted by SWAT during our respective dates of measuring in the 3 year simulation. In the model it is likely that the amount of water flowing in the stream was over estimated for all sub-watersheds during the 30 year simulation; thus, the estimated yearly average of flow at the sub-watershed outlets are potentially high.

Table 9. Values for discharges observed and those predicted by SWAT, with the percent error of over estimation of stream flow occurring within the SWAT model for both St. John's Church Rd and Cloverleaf Lakes Rd sites, with a duration of 169 days and 194 days, respectively.

Flow Monitoring Station and Sub-watershed	Total Volume 10^6 ft^3	SWAT 10^6 ft^3	% Error
St. John's Church Rd	59. 6	106.1	54.9
Cloverleaf Lakes Rd	129.2	233.3	73.3

Table 10 shows the average yearly predicted phosphorus inputs (lbs/acre) for each of the seven sub-watersheds. Based on percentage of agriculture and forest in each sub-watershed and the most likely phosphorus export coefficient (lbs/acre) from Panuska and Lillie, the most likely amount of phosphorus was also estimated to be leaving each sub-watershed. Table 10 shows that total phosphorus leaving the land in each sub-watershed is greater than the most likely values we estimated found from the study conducted by Panuska and Lillie. In four of the sub-watersheds in the Schoenick Creek watershed, total phosphorus is more than 3-5 times that of the export coefficients of watersheds with similar land uses. However, the large amount of water contributing to stream flow may also be carrying too much phosphorus, so proportionately these inputs of phosphorus may be representative of the actual inputs but may potentially be high. The calibrated model was used to simulate long-term phosphorus loading from all sub-watersheds.

Table 10. Yearly averages for predicted amounts of sub-watershed contributions of soluble phosphorus and total phosphorus with most likely values of phosphorus contributions from watersheds of similar land use, found in study conducted by Panuski and Lillie in 1995.

Sub-watershed	Soluble P (lbs/sub-watershed)	Total P (lbs/sub-watershed)	Most Likely Total P (lbs/sub-watershed)
Hunting Rd	531.4	1347.4	1054.0
Cloverleaf Lakes Rd	214.8	524.9	484.5
Schoenrock Rd	769.0	2375.9	417.8
Grasslake Rd	672.6	1617.1	336.9
St. John's Church Rd	888.3	3005.6	1261.5
Bell Plaine Ave	2652.2	6905.5	2250.8
Long Lake Inflow	606.6	1680.9	378.4

In Table 11 predictions of water flow in Schoenick Creek and two of its tributaries are shown. The average flow (ft^3/sec) is shown for each sub-watershed and gives an idea of how much water may be flowing in that section of the stream at a particular time. Discharge (ft^3/yr) is an estimation of how much water is flowing through the outlet of each sub-watershed in one year. Discharge (ft^3/yr) shows that some of the same water flowing through an upper location can make its way downstream and contribute to flow at a lower location. So an amount of stream flow, directly resulting from the contributions of a particular sub-watershed was calculated and shown in Table 11 as sub-watershed (ft^3/yr). For example, because the stream flow at one site influences the flow at a more downstream site; the flow at Cloverleaf Lakes Rd was a combination of its own sub-watershed contributions and the outflow of water at the Long Lake Inflow site and at Schoenrock Rd site. The discharge at the Long Lake Inflow site was influenced by stream flow at Grass Lake Rd and St. John's Church Rd sites. Because it is difficult to account for all sources of uncertainty in this modeling effort the model parameters were not further adjusted; however, the results must be interpreted with care. They probably allow a relative comparison of sub-watersheds to be made, but should be interpreted cautiously in terms of actual loads.

Table 11. Predictions of average flow (ft^3/sec), average discharge of water (ft^3/yr), and the contribution of average discharge for each sub-watershed over a period of, estimated form a 30 year simulation.

Sub-watershed	Flow (ft^3/s)	Flow (10^6 ft^3/year)	Sub-watershed (10^6 ft^3/year)
Hunting Rd	13.9	439.2	65.2
Cloverleaf Lakes Rd	11.9	373.9	25.8
Schoenrock Rd	1.2	37.0	37.0
Grass Lake Rd	1.3	40.7	40.7
St. John's Church Rd	7.7	242.6	74.9
Bell Plaine Ave	5.3	167.7	167.7
Long Lake Inflow	9.9	311.0	27.6
Total			**439.2**

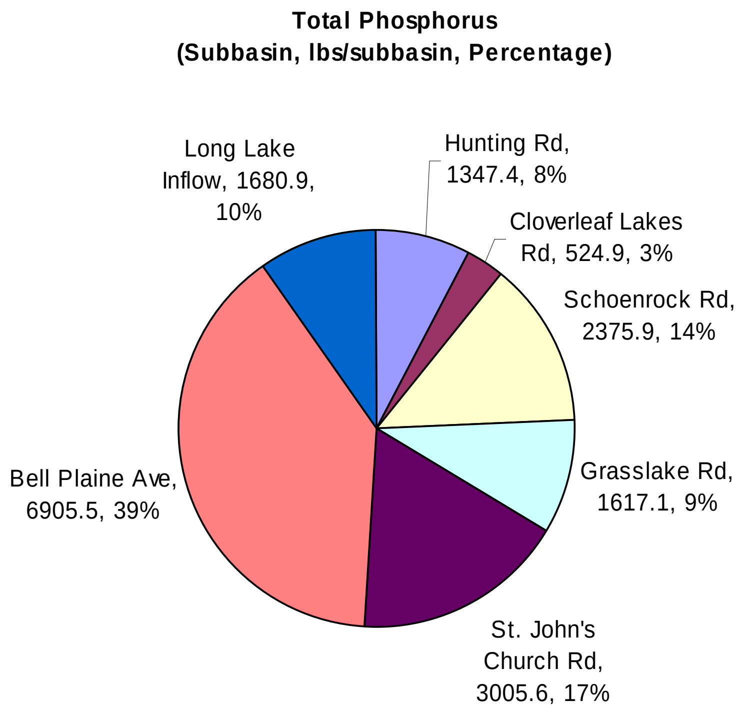


Figure 11. Average sub-watershed estimated inputs (lbs) of total phosphorus to Schoenick Creek for a 1-year period from a 30-year simulation in SWAT.

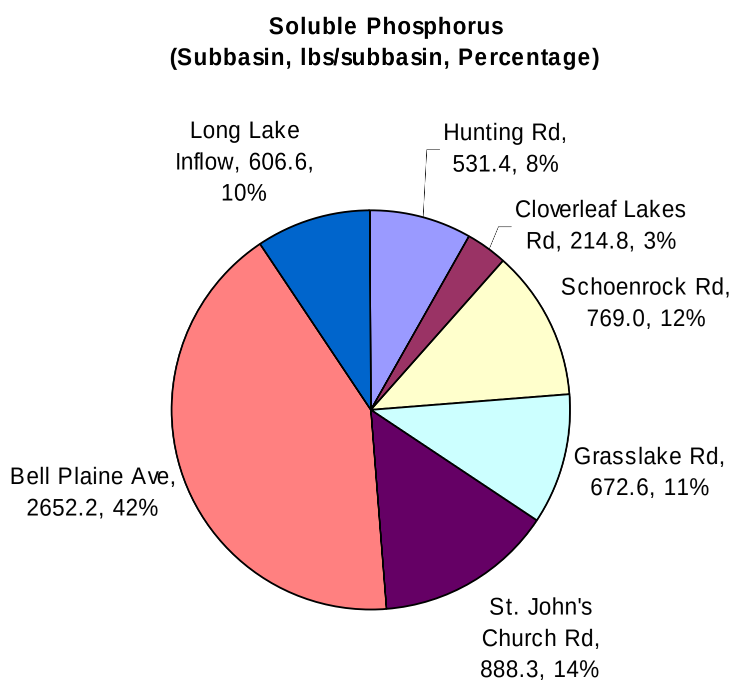


Figure 12. Estimated average sub-watershed inputs (lbs) of soluble reactive phosphorus to Schoenick Creek for a 1-year period from a 30-year simulation in SWAT.

LONG LAKE RESIDENTIAL SOIL SURVEY

During September 2002 a soil survey was conducted by Agsource Cooperative Services, and samples were collected from a number of Long Lake shoreland property owners. Twenty-four different lot samples were analyzed; 18 samples were taken from the north side of Long Lake and 6 samples were taken from the south side (Figure 13). Each soil sample was analyzed for pH, percent organic matter, phosphorus, and potassium. In the evaluation of the soil adjacent to Long Lake soil types was evaluated including some of the general characteristics using maps from the Shawano County soil survey.

There were six different types of soil that existed directly adjacent to the perimeter of Long Lake. These soils include Shawano loamy fine sand with 1 to 6 percent slopes (SfB), Shawano loamy fine sand with 6 to 12 percent slopes (SfC), Menahga loamy sand with 2 to 6 percent slopes (MnB), Cormant mucky loamy fine sand (Co), Marky and Cathro mucks (Mk), and Rousseau loamy fine sand with 2 to 6 percent slopes (RsB). The eastern part of the lake where Schoenick Creek enters and leaves consists of Marky and Cathro mucks, and a small section towards the west end of the lake along the southern shore the soil is where Cormant mucky loamy fine sand is located. These soils are poorly to very poorly drained, and exhibit moderate to rapid permeability. However, the majority of the soil around the lake is loamy sand and loamy fine sand. This soil is moderately to excessively drained, has a rapid permeability, low available water capacity, and usually have little organic matter. Because of characteristics in the soil such as rapid permeability and excessive drainage, soil around the lake readily accepts effluents from the surface, but they do a poor job of filtering it. This can ultimately lead to pollution of the groundwater and eventually the lake.

The average value of pH for the soils sampled was 6.5 with values ranging from 5.2 to 7.5. The samples indicated that the average pH of soils around Long Lake is slightly acidic. The average percent of organic matter for the sampled lots was 2.4 with values of percent organic matter ranging from 1.2% to 4.3%. The average soil concentration of phosphorus was 116.2 mg/kg with the twenty-four values ranging from 40.0 to 209.4 mg/kg. Potassium values for the sampled soils averaged 53.1 mg/kg with values ranging from 26.0 to 104.0 mg/kg. According to UW-Extension, turf does not require more than 20 mg/kg phosphorus.

Phosphorus is continually being transferred from land to water, the rates at which this occurs varies between ecosystems. When the rates at which phosphorus transferred from land to water become too high the biological productivity of the water can lead to the degradation in the water quality impacting the ecosystem and its lakes. At a soil concentration of 116 mg/kg, the top six inches of soil contain approximately 250 lbs of phosphorus per acre. In contrast annual losses of phosphorus in water greater than 0.1 pounds/acre/year may be excessive from a surface water quality perspective (McGinley, 2003). The concentration of phosphorus in the soil shows how the runoff that transports sediment and vegetation can transfer phosphorus from land to Long Lake.

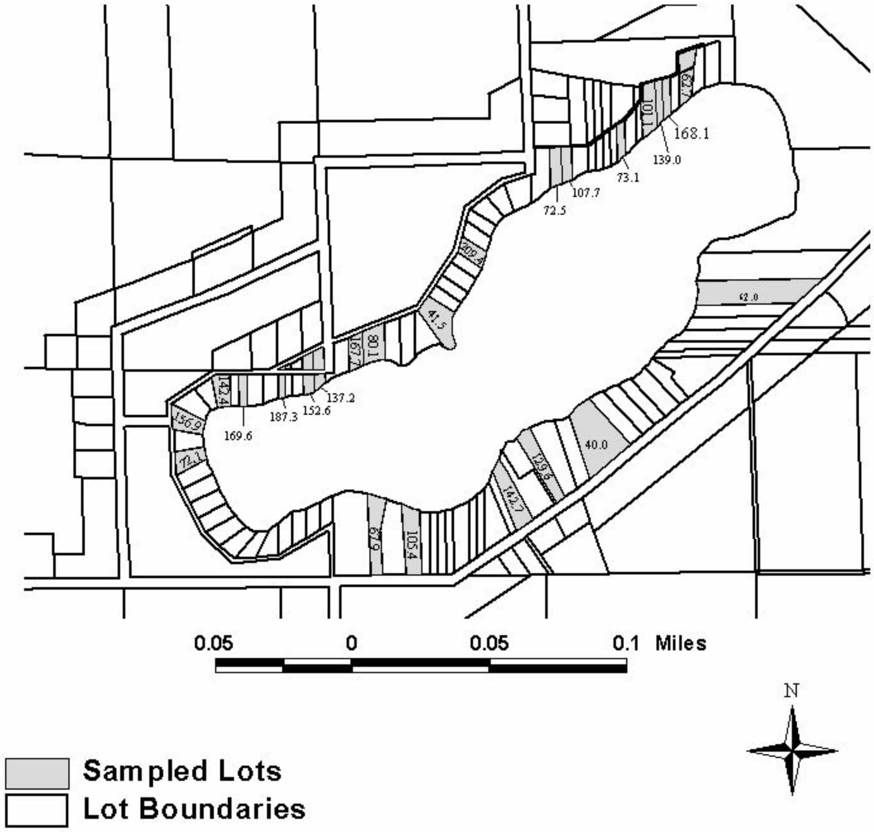


Figure 13. Location of soil sample sites and phosphorus results near Long Lake, Shawano Co. WI.

MID-LAKE WATER QUALITY

Mid-lake profiles of the deep holes in Long and Schoenick Lakes and water quality samples were collected on three separate occasions between April 2002 and October 2003. Water clarity (Secchi disc depth) was determined every sampling period. Dissolved oxygen and temperature were measured throughout the water column on all eight sampling periods, while conductivity and pH were measured on three sample dates. Water quality samples for alkalinity, total hardness, calcium hardness, reactive phosphorus, total phosphorus, ammonium, nitrate, total Kjeldhal nitrogen, chloride, sulfate, potassium, sodium, turbidity, and color analyses were collected in October 2003 and April 2003. Total phosphorus, chlorophyll *a*, and Secchi depth data from WDNR self-help data were combined with the UWSP data set for Long Lake. The following is a summary and discussion of the results and water quality characteristics of Long Lake based on these data. It is important to note that lake water quality can vary significantly with precipitation, temperature, date of ice off, and other climatic factors. Sampling should be accomplished routinely over a number of years to obtain the most accurate representation of a lake's water quality.

Dissolved Oxygen and Temperature

Dissolved oxygen is the key dissolved gas in a thriving aquatic ecosystem since many aquatic organisms are dependent on it for survival. It enters lakes by mixing with the air and photosynthetic activity from aquatic plants. Greater wind and wave interaction in combination with the fetch (length) of a lake causes a greater transfer of oxygen into the water.

Decaying plants and other biological organisms reduce lake oxygen as it is consumed during decomposition. An increase in nutrients to a lake from lawn and agricultural fertilizers, animal waste can increase aquatic plant and algae growth which then increases the amount of material being decomposed which in turn lowers oxygen concentrations.

Concentrations of dissolved oxygen in water are impacted by temperature of the water; as the temperature of water becomes colder more gases are capable of dissolving into solution (Table 12). Therefore as temperature increases, the maximum amount of dissolved oxygen that can be kept in solution decreases.

Table 12. The solubility of oxygen for various Temperatures.

Temperature		Oxygen Solubility (mg/L)
ºF	ºC	
0	32	15
5	41	13
10	50	11
15	59	10
20	68	9
25	77	8
*Taken from (Shaw et al. 6)		

The density of water also changes with temperature and is associated with lake mixing or *overturn*. In a typical year in Wisconsin, after lake ice melts in early spring, the temperature of lake water is similar from top to bottom (Figure 14). The presence of wind in combination with temperature changes will cause the lake to uniformly mix water from top to bottom and as a result, so will dissolved oxygen. As surface water warms in the spring, its density decreases, keeping the warmer water "floating" above the cooler, denser water (Figure 15). During the summer, this results in lake layering or *stratification*. The surface water remains in contact with atmospheric oxygen but prevents oxygen from being added to the lower layers by sealing them until mixing occurs again. When layering exists for extended periods of time dissolved oxygen begins to be depleted in the bottom layer, or *hypolimnion*, as organisms consume it. If the concentration of dissolved oxygen becomes too depleted (less than 2mg/l) most fish and aquatic insects are incapable of surviving such conditions.

During the fall, lake temperatures again become nearly uniform as the season cools the water. Dissolved oxygen becomes consistent and the lake experiences fall overturn when enough cold water near the surface falls to the bottom causing the warm water to rise to the top. This can replenish the water column with dissolved oxygen as it circulates back to the surface where oxygen can enter. This mixing can also introduce oxygen demanding material from the lake bottom throughout the lake and reduce oxygen concentrations.

In winter, layering is created by colder temperatures at the ice's surface than at the lake bottom. Without atmospheric contact, oxygen is not added to the system and can be depleted throughout the winter. In years of extended snow fall or cold weather additional periods of oxygen removal from the water body can cause winter kills of fish and other species.

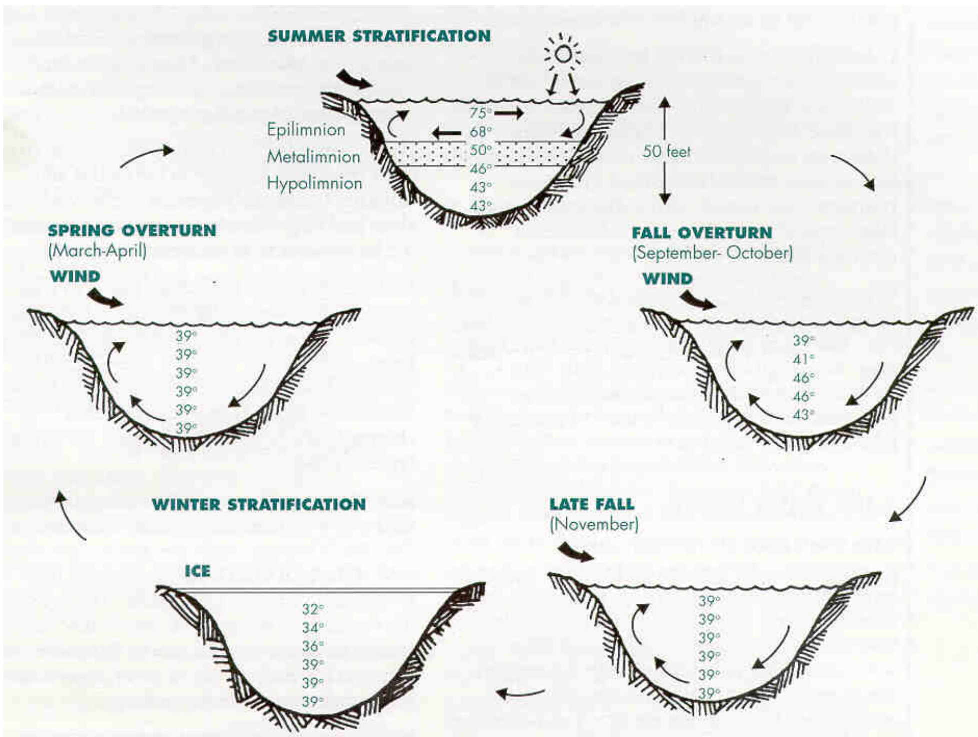
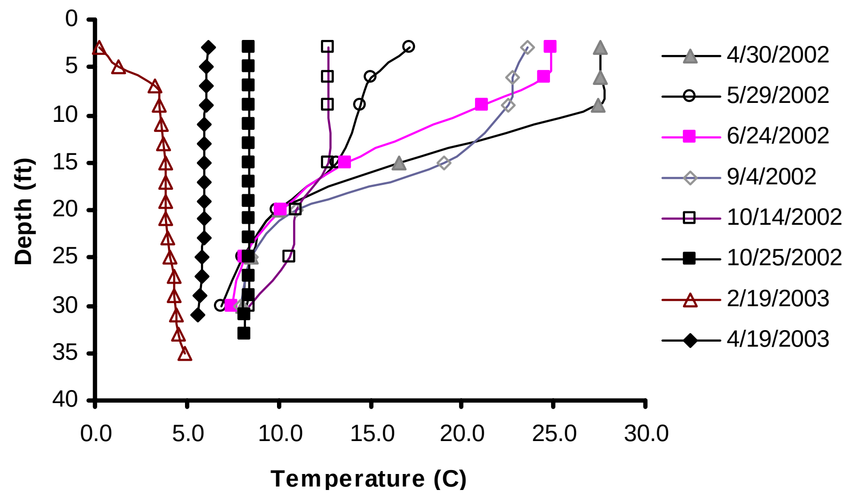


Figure 14. Diagram of seasonal temperature variation and mixing in a typical lake in Wisconsin. (From Shaw et al.)

Figure 15. Schematic showing layering of a lake during stratification.

Long Lake experiences complete seasonal mixing and stratification. The lake's shape and orientation to the major winds help this to occur. The temperature profile for Long and Schoenick Lakes are shown in Figure 16. Both lakes were completely mixed during October 2002 and April 2003. During other periods of the year Long Lake was stratified. When Long Lake was completely stratified the epilimnion occurs approximately from 0 – 12 feet, the metalimnion occurs from 12 – 21 feet, and the hypolimnion formed around 21 feet to the bottom of the lake. It is assumed that stratification also occurs in Schoenick Lake, however no self-help data were available to determine the extent of stratification.

Long Lake Temperature Profiles (2002-2003)



Schoenick Lake Temperature Profiles (2002-2003)

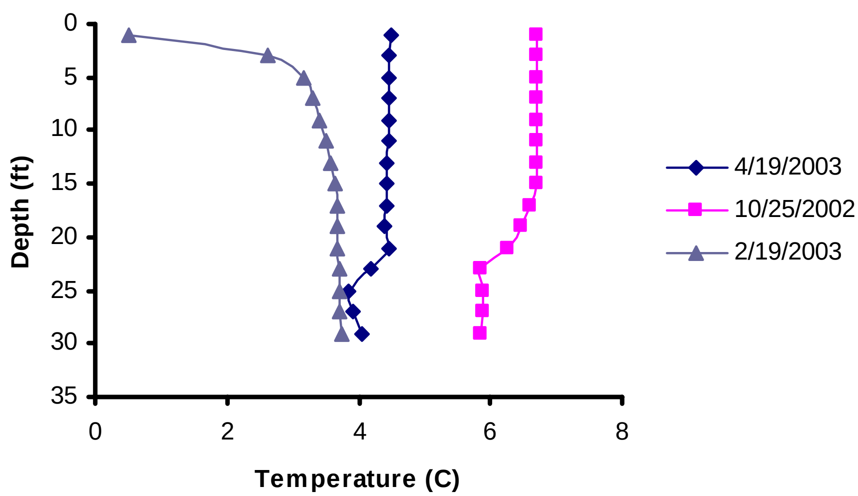
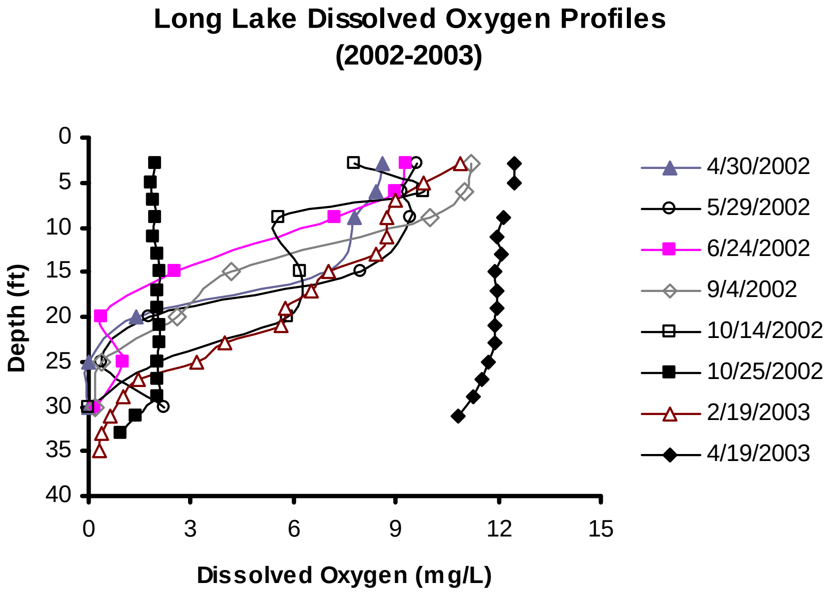


Figure 16. Temperature profiles in Long and Schoenick Lakes collected in 2002-03.

Dissolved oxygen concentrations varied throughout the sampling periods (Figure 17). During October 2002 and April 2003 dissolved oxygen was nearly completely mixed throughout the water column in Long Lake; however, during the fall overturn the dissolved oxygen concentrations ranged between 0.98 and 2.12 mg/L and during the spring overturn period ranged between 10.81 and 12.46 mg/L. This difference likely occurred because in the fall the sample was collected as overturn was occurring. The dissolved oxygen concentrations for the fall turnover sampling period are well below the minimum concentrations of 5.0 mg/L suggested by Shaw et al to maintain fish survivability and growth (Figure 17). In years when ice over occurs quickly after overturn, the system may be susceptible to winter fish kills. The majority of the mid lake sampling has shown that dissolved oxygen concentrations in the hypolimnetic zone (below 21 ft) were at or below the minimum of 5 mg/L required by fish making this layer of the lake unusable by fish. In Schoenick Lake the temperature profiles indicated that the lake was nearly mixed, but the dissolved oxygen was well below 5 mg/L in the lower 5 feet of water.



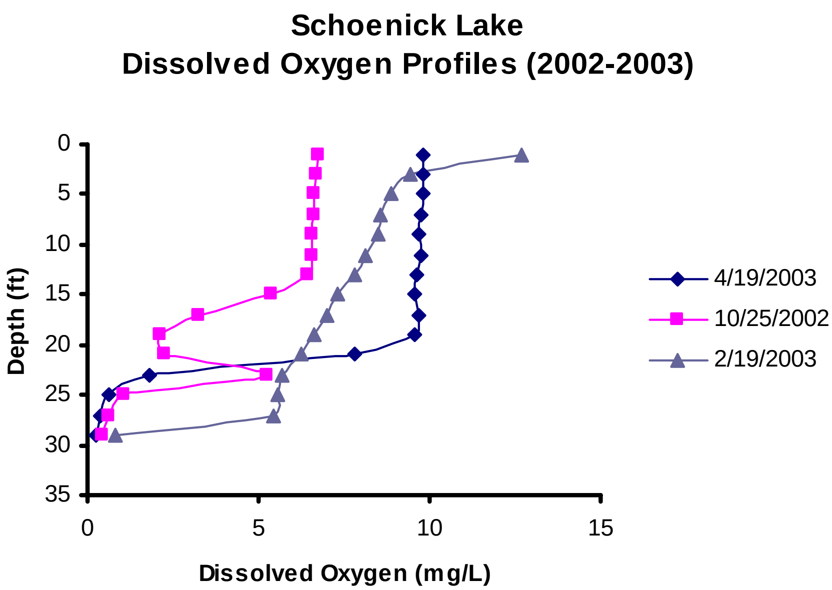


Figure 17. Profiles of dissolved oxygen in Long and Schoenick Lakes in 2002-03.

Water Clarity

Water clarity is a measure of light transparency measured by an instrument called a Secchi disc. The depth to which light can penetrate is important because plants need light for growth. Aquatic plants grow in the area where light penetrates to the lake bottom. The depth of water clarity is affected by algae, dissolved minerals, organic acids, and suspended solids, all of which are able to impact light penetration due to their light absorbing capacities. In this way, water clarity is an indication of the amount of materials suspended in the water and materials dissolved in the water (color).

The Long and Schoenick Lake measurements are shown in Table 13. Color is a measure of the staining of the water. In Long Lake color was considered low, and in Schoenick Lake color was low in October and medium in April. The increased color was likely due to wetland inputs. During these same sampling events, water clarity ranged between fair and poor.

Table 13. Measurements of turbidity, color, and the depth of water clarity during overturn events in Long and Schoenick Lakes, Shawano Co., WI.

Site	Date	Turbidity (NTU)	Color (CU)	Water Clarity (ft)
Long Lake	10/25/2002	1.5	20	8.5
Long Lake	4/19/2003	1.8	33	4
Schoenick Lake	10/25/2002	2.6	34	5.5
Schoenick Lake	4/19/2003	2.5	77	4

Table 14. Water Quality Rating for Secchi disc measurements.

Water Clarity	Secchi Depth (ft)
Very Poor	3
Poor	5
Fair	7
Good	10
Very Good	20
Excellent	32

Long Lake water clarity data was collected between May and October 1990 to 2003. Water clarity measurements shown in Figure 18 ranged from 2-13.5 feet and averaged 6.2 feet from 1990 to 2003. Variation in measurements can occur due to year-to-year climatic variations such as severity of winter, amount and timing of precipitation, and temperature. When the Long Lake data were analyzed for long term trends by month, May, July, and October measurements indicated some improvement over time, while June showed a slight reduction in clarity. Secchi depth was measured twice during this study in Schoenick Lake. The depths were 4 feet in April and 5.5 feet in October.

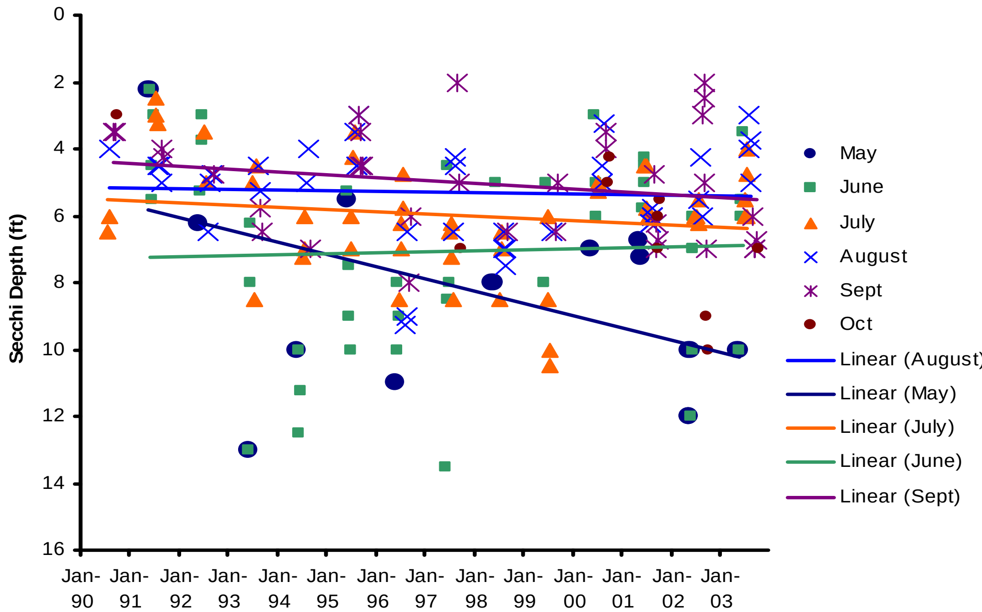


Figure 18. Long Lake water clarity with seasonal variations for data obtained from WDNR self-help data (1990-2003) and data from this study,.

A good indicator of the amount of algae affecting water clarity in the water column is chlorophyll *a*. Chlorophyll *a* concentrations are frequently inversely correlated with Secchi depth (the higher the chlorophyll *a* concentrations, the lower the Secchi depth). Algae and therefore chlorophyll *a* concentrations change throughout the growing season and from year to year depending on nutrient input and weather (Shaw et al., 2000). All of the chlorophyll *a* data available for Long Lake was obtained from the self-help database. Chorophyll *a* was paired with Secchi depth data for identical sampling dates (Figure 19). Water clarity was found to be the poorest when the concentration of chlorophyll *a* were the greatest indicating the algae growth is playing a large role in the water clarity found in Long Lake during the summer. No chlorophyll *a* data were located for Schoenick Lake.

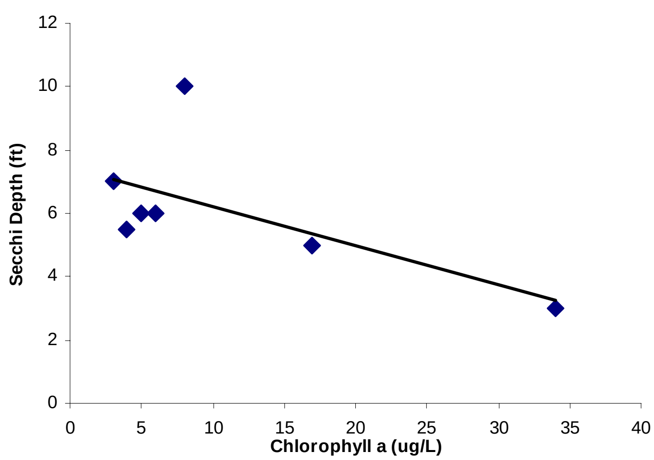


Figure 19. Chlorophyll *a* and Secchi depth measurements in Long Lake from June 2001 through October 2002.

Alkalinity and Hardness

Alkalinity and hardness can have tremendous impacts on the biological life within an aquatic system because of the ability of some organisms to consume calcium in the development of bones, shells, and exoskeletons. A lake's hardness and alkalinity are affected by the type of minerals in the soil and watershed bedrock, and by how much the lake water comes in contact with these minerals (Shaw et al., 2000). Lakes with geology in the surrounding watershed that contain limestone minerals such as calcite and dolomite have water with higher hardness and alkalinity (Shaw et al., 2000). The alkalinity provides acid buffering and the hardness provides calcium (Ca^{2+}) and magnesium (Mg^{2+}). Lakes with high concentrations of calcium and magnesium are called hard water lakes and those with low concentrations are called soft water lakes. Hard water lakes tend to be overall more productive and produce more fish and aquatic plants than soft water lakes (Shaw et al.,2000).

During October 2002 and April 2003 water samples for analysis of alkalinity and hardness were collected. These results are shown in Table 15. Long Lake's alkalinity was 144 and 146 mg/l for each date, respectively; and alkalinity in Schoenick Lake was 162 and 136 mg/l, respectively. Total hardness concentrations in Long Lake were 152 and 157 mg/l for October and April sampling, and in Schoenick Lake were 176 and 161 mg/l, respectively. Calcium made up about 53% of the hardness that was measured in both lakes. Based on total hardness measurements both Long and Schoenick Lakes can be classified as hard water lakes (Table 16). Both of these lakes are well buffered against acid rain.

Table 15. Average concentrations of alkalinity, and total and calcium hardness in Long and Schoenick Lakes collected on 10/25/2002 and 4/19/2003.

Site	Date	Alkalinity (mg/l)	Total Hardness (mg/l)	Calcium Hardness (mg/l)
Long Lake	10/25/2002	144	152	77
Long Lake	4/19/2003	146	157	84
Schoenick Lake	10/25/2002	162	176	95
Schoenick Lake	4/19/2003	136	161	87

Table 16. Categories of total hardness in Wisconsin lakes (from Shaw et al.).

Hardness Catagory	Total Hardness in mg/L as $CaCO_3$
Soft	0 – 60 mg/L
Mderately Hard	61 – 120 mg/L
Hard	121 – 180 mg/L
Very Hard	> 180 mg/L

Potential of Hydrogen (pH)

pH describes the lake water's acid concentrations by measuring hydrogen ions (H+) in solution. pH is measured on a scale ranging between 1 and 14 with lower values indicating acidic conditions and higher pH values indicating basic conditions. Lakes with low pH values often allow metals (aluminum, zinc, mercury) which can be located in the lake sediment, to become soluble. These metals can then make their way into the food chain and bioaccumulate in larger organisms (Shaw et al., 2000). Conversely, lakes with a high pH provide buffering against acidic conditions. Higher pH values are created when limestone or dolomite (carbonate minerals) are found in the watershed geology. Groundwater dissolves these rocks and once in the lake, neutralizes the acid from rainfall. The value of pH can change throughout the day, year, and depth because of chemical interaction with photosynthesizing biota, which effectively lower the pH by releasing carbon dioxide during respiration.

During the three sampling periods where the pH profiles of Long and Schoenick Lakes were evaluated, pH levels averaged to be slightly above neutral conditions, perfectly healthy for the residing aquatic ecosystems (Figure 20). It is normal to observe pH levels decreasing towards the lake bottom, which is the case for Long and Schoenick Lake. This is due to changes taking place from decomposition and the lack of oxygen at these depths.

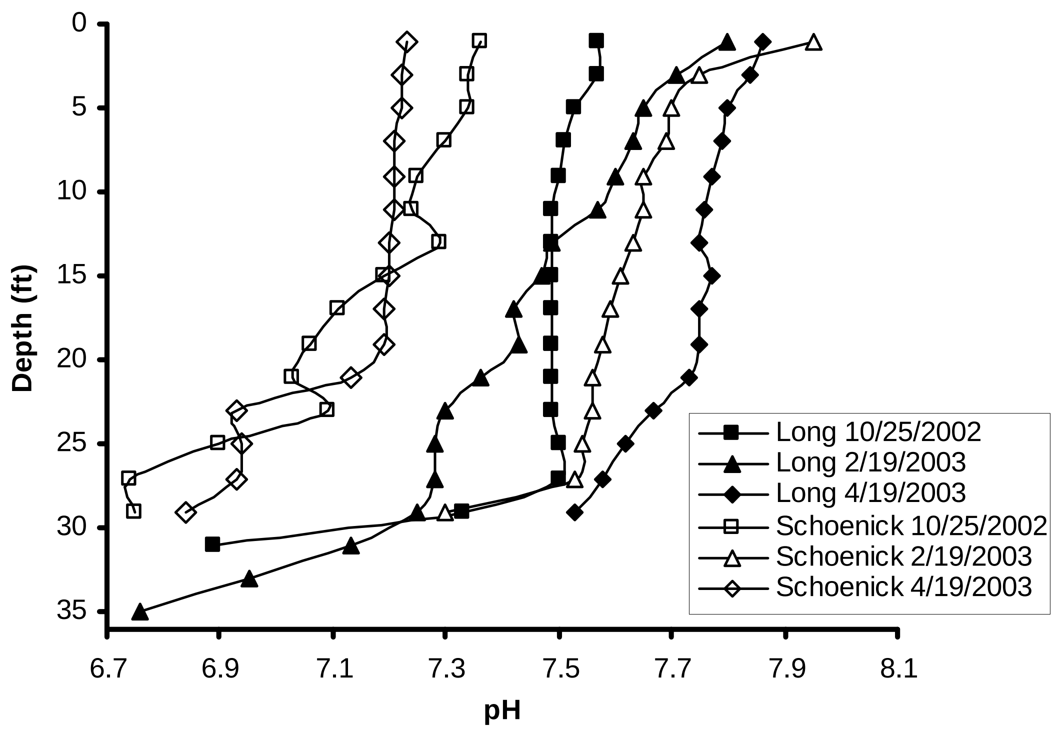


Figure 20. Profile of pH in Long and Schoenick Lakes, Shawano Co., WI .

Conductivity

Conductivity is a measure of water's ability to conduct an electric current which is a direct measure of dissolved minerals and salts in water. Many of these compounds can result naturally from dissolution of local minerals or unnaturally by wastewater from septic systems, agricultural/lawn/garden fertilizers, animal waste, and road salt runoff. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans (Shaw et al. 2000).

In both Long and Schoenick Lakes conductivity was measured throughout the water column for three sampling periods. In Long Lake conductivity ranged from 287 to 459 umhos and averaged 314 umhos/cm. In Schoenick Lake conductivity ranged from 307 to 448 umhos/cm and averaged 359 umhos (Figure 21). Conductivity for both lakes was about double the total hardness for both lakes. Conductivity was highest in both lakes in the winter reflecting less surface runoff and more groundwater input. Conducitvity was relatively uniform with depth and it increased near the bottom where dissolved solutes are normally higher.

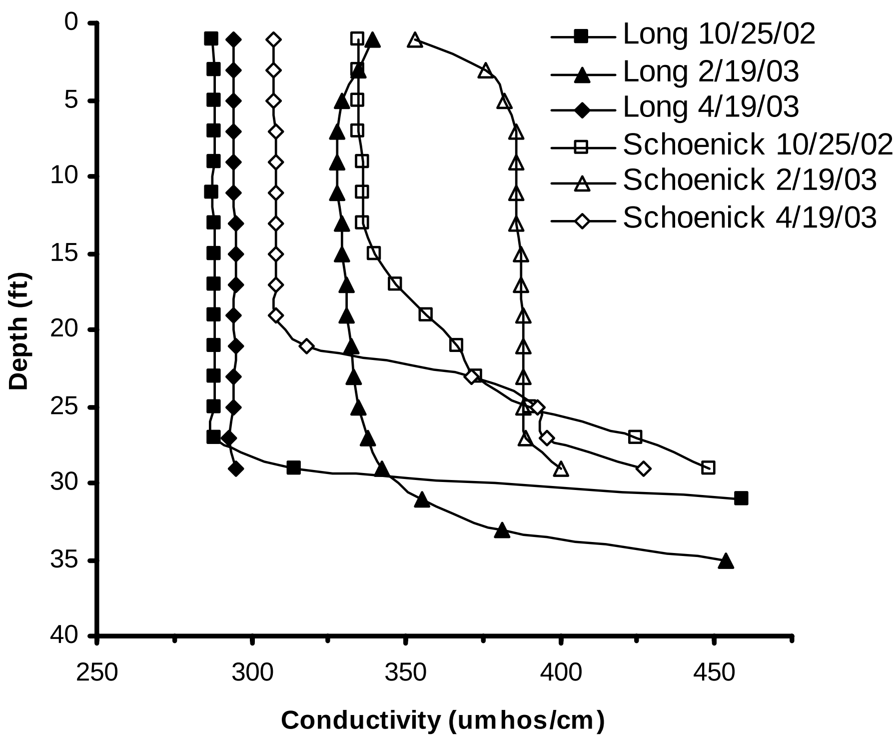


Figure 21. Profile of conductivity in Long and Schoenick Lakes during three sampling periods.

Chloride

Chloride is not commonly found in Wisconsin rocks and soil therefore when chloride occurs in elevated concentrations in water it is generally of human-related origin. Chloride is non-reactive in nature and is not degraded by microorganisms. As a result, it is readily leached through the soil and into the groundwater. Chloride is a common constituent in animal and human wastes, potash fertilizer, and road salting chemicals. In Wisconsin, chloride is not generally found in concentrations that are problematic to aquatic organisms, but is used as an indicator.

In the Schoenick Creek watershed, expected concentrations of chloride in surface waters are 3 to10 mg/L (Shaw et al., 2000). Chloride concentrations in Long Lake ranged from 6.5 to 7.0 mg/L. In Schoenick Lake, chloride concentrations ranged from 9.5 to 12.5 mg/L.

Potassium & Sodium

Concentrations of sodium and potassium are naturally very low in lake water as there are few natural sources in Wisconsin. Therefore, when found in lake water, sodium and potassium may be indicators of pollution. Sources of sodium include road salt, fertilizer, and human and animal wastes. Potassium is also found in animal waste with other sources including potash fertilizer (Shaw et al., 2000).

In Long Lake sodium averaged 6.4 mg/L and potassium averaged 3.3 mg/L. In Schoenick Lake sodium concentrations averaged 6.3 mg/L and potassium concentrations averaged 4.6 mg/L. These potassium concentrations are considered normal in Long Lake and slightly elevated in Schoenick Lake.

Sulfate

Sulfate enters naturally into lakes through solution from groundwater and unnaturally through acid rain deposition caused by the burning of sulfate containing products such as coal. In the low oxygen conditions found in the bottom layer of Long and Schoenick Lakes the sulfate is changed into sulfide, which readily binds to most metal elements such as iron and mercury, rendering them insoluble. In Long Lake sulfate concentrations averaged from 10.4 mg/L while sulfate concentrations in Schoenick Lake were 14.0 mg/L for all sampling periods. Theses concentrations are normal since sulfate concentrations in this region generally range between less than 10 to 20 mg/L (Shaw et. al., 2000).

Nitrogen

Nitrogen is an important biological element. It is second only to phosphorus as a key nutrient that influences aquatic plant and algal growth in lakes. In Wisconsin, minimal nitrogen occurs naturally in soil minerals, but it is a major component of all plant and animal tissue, and therefore, organic matter. In agricultural regions it is often found in rainfall with precipitation as the primary nitrogen source in some seepage and drainage lakes. It also travels in groundwater and surface runoff, therefore nitrogen enters the system both as soluble and particulate forms. Sources of nitrogen are often directly related to local land uses including septic systems, sewage treatment plants, lawn and garden fertilizers, and agricultural sources.

Nitrogen enters and exists in lakes in a variety of forms. The most common include ammonium (NH_4^+), nitrate (NO_3^-), nitrite NO_2^-, and organic nitrogen. These forms summed yield total nitrogen. Aquatic plants and algae can use all inorganic forms of nitrogen (NH_4^+, NO_2^-, and NO_3^-) and if these inorganic forms of nitrogen exceed 0.3 mg/L in spring, there is sufficient nitrogen to support summer algae blooms (Shaw et al., 2000). Ammonium is the most available form of nitrogen to aquatic plants.

Table 17 shows nitrogen concentrations in Long and Schoenick Lakes. During all sampling periods (including spring overturn), inorganic concentrations of nitrogen (NH_4^+ and NO_2+NO_3- N) exceeded the minimum concentration of 0.3 mg/l needed to support summer algae blooms at all layers in winter and fall and spring overturn in both lakes. The majority of the nitrogen in the lakes was in the organic (particulate form). During winter ammonium concentrations tended to increase from the upper layer down to the bottom layer. Ammonium builds up in winter because there are no plants for assimilation and some ammonium is being released into the water at the bottom of the lake from decomposition and lack of oxygen.

Table 17. Concentrations of nitrogen in Long and Schoenick Lakes, Shawano County during 2003.

	Long Lake - Nitrogen (mg/l)			
	NH_4^+	NO_2^-+NO_3^- (N)	Organic N	Total N
Winter-Top	0.42	0.28	0.81	1.51
Winter-Middle	0.78	0.20	0.85	1.83
Winter-Bottom	1.77	0.02	1.01	2.80
Fall Turnover	0.58	0.12	0.97	1.67
Spring Turnover	0.25	0.46	0.98	1.69
	Schoenick Lake - Nitrogen (mg/l)			
	NH_4^+	NO_2^-+NO_3^- (N)	Organic N	Total N
WinterTop	0.24	0.38	0.78	1.40
Winter-Middle	0.34	0.32	0.88	1.54
Winter-Bottom	0.35	0.32	0.9	1.57
Fall Turnover	0.31	0.10	1.07	1.48
Spring Turnover	0.10	0.48	1.13	1.71

Phosphorus

In Wisconsin, phosphorus is the most significant limiting nutrient for most lakes. Phosphorus is the primary element that leads to the development of nuisance algae (Wetzel, 2002 and Cogger, 1988). Phosphorus is present naturally on the lake shore and in the watershed, found in the soil and plants. It transfers to the lake from the erosion of soil, animal waste, septic systems, fertilizers, inland recycling, and atmospheric deposition. In a study on urban lakes by the United States Geological Survey's Waschbusch, Selbig, and Bannerman, it was determined that streets and lawns were contributing 80% of the dissolved phosphorus to the urban lakes, with lawns contributing more than streets.

High concentrations of phosphorus are primarily transported to lakes in surface runoff. Phosphorus is reactive and adheres to soil particles. If those particles are disturbed or if water containing phosphorus from decaying vegetation or animals and fertilizer is conveyed directly to the lake, phosphorus is transferred from land to water. Soil has a large capacity to hold phosphorus but where there are significant sources of phosphorus (i.e. barnyards, septic drainfields, over application of fertilizer) the soil holding capacity can be exceeded allowing excess phosphorus to leach to the groundwater. Once in a lake, a portion of the phosphorus becomes part of the aquatic system in the form of plant and animal tissue and sediments. The phosphorus continues to cycle within the system, and is very difficult to remove once it enters.

In this study, two forms of phosphorus were measured: soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is dissolved phosphorus in the water column that is readily available for plants and algae to utilize. It is usually present in low concentrations, and is quickly taken up by aquatic plants (Wetzel 2002). TP is a measure of the dissolved phosphorus plus organic and inorganic phosphorus suspended in the water. Examples of organic phosphorus would be decaying plant or animal matter or phosphorus that is bound to soil particles.

TP is used as a measure of overall lake phosphorus because its concentrations are more stable than SRP. Phosphorus availability can vary when the lake is stratified, oxygen concentrations and pH become reduced in the bottom layer (hypolimnion) of the lake. These conditions result in the release of phosphorus from sediment and decaying plant and animal material and phosphorus goes into solution in the water column. During spring and fall overturn, this phosphorus-laden water mixes with the rest of the lake water, making it available to algae and aquatic plants.

Mid lake samples were analyzed for soluble reactive phosphorus and total phosphorus during three different periods for Long and Schoenick Lake; two of these samples were from fall and spring overturn, the third sample was collected during February 2003. Data from these three dates were combined with total phosphorus data from the WDNR self-help data set for Long Lake and are shown in Figure 22.

Of the 13 samples for total phosphorus in the epilimnion of Long Lake only 5 were below the recommended 30 ug/L to prevent nuisance algal blooms and excessive plant growth. Total phosphorus in the top layer of Long Lake ranged from 18 - 99 ug/L and averaged 43 ug/L. Total phosphorus in Schoenick Lake was also very high. There were only three sampling periods, but at a depth of 6 feet the total phosphorus concentrations averaged 88 ug/L. Samples of reactive and total phosphorus were collected from the epilimnion of Schoenick Lake in October 2002 and from the hypolimnion of Long Lake in February 2003. Reactive and total phosphorus and in Schoenick Lake were 98 and 142 ug/L, respectively; and in Long Lake these values were 275 and 343 ug/L, respectively. These samples are not shown in Figure 22, however, all other reactive and total phosphorus samples from both lakes are.

Reactive phosphorus data was only collected during the non-growing season. During this period reactive phosphorus isn't being assimilated by plants so these concentrations are indicative of what type concentrations might be available to plants for growth when daylight hours and temperatures increase. Reactive phosphorus concentrations for the three sampling periods was lowest in both Long and Schoenick Lake in April of 2003 and were between 10 and 15 percent of the total phosphorus concentrations in both lakes.

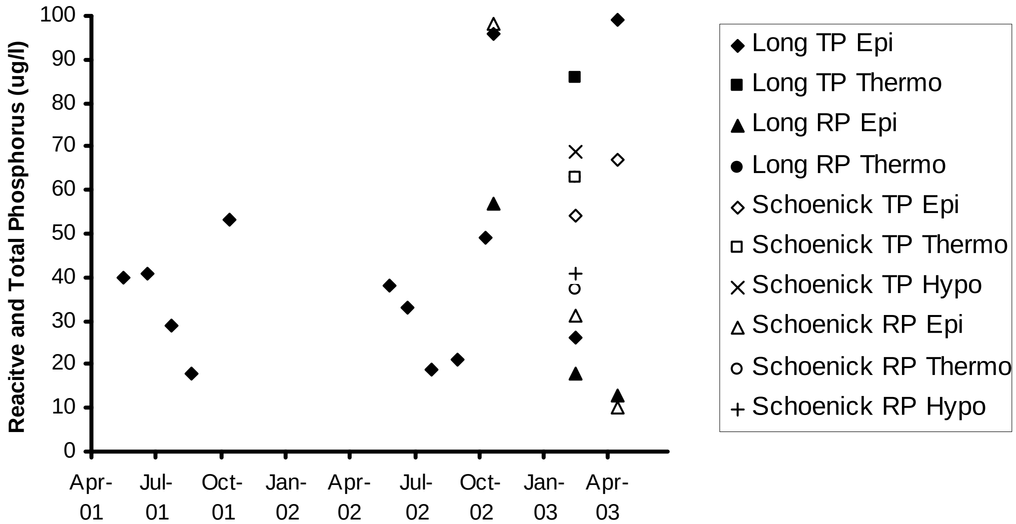


Figure 22. Reactive and total phosphorus concentrations for Long and Schoenick Lakes, from March 2001 through April 2003.

Table 18. Reactive and Total P (ug/l) from fall, spring, and winter sampling during this study for Long and Schoenick Lakes and WDNR self-help from 2001 to 2003 for Long Lake.

	Overturn Average		Growing Season Average			Winter Average	
	Total P (ug/L)	Reactive P (ug/L)	Total P (ug/L)			Total P (ug/L)	Reactive P (ug/L)
			Min	Mean	Max		
Long-mixed fall	96	57					
Long-mixed spring	99	13					
Long-top			18	34	53	26	18
Long-middle						86	63
Long-bottom						343	275
Schoenick-mixed spring	67	10					
Schoenick-mixed fall	142	98					
Schoenick-top						54	31
Schoenick-mid						63	37
Schoenick-bottom						69	41

Total Nitrogen to Total Phosphorus Ratio

In Wisconsin lakes, either nitrogen or phosphorus concentrations control the amount of algae and aquatic plant growth. In lakes that are limited by nitrogen the ratio of total nitrogen to total phosphorus is 10:1. Meaning that for every 10 nitrogen molecules there is 1 phosphorus molecule. If limitation varies from year to year there is a ratio between 10:1 and 15:1. When lakes are limited by phosphorus ratios are above 15:1 (Wetzel, 2002).

Total nitrogen to total phosphorus ratios for Long and Schoenick Lakes are shown in Table 19. In Long Lake phosphorus was the limiting nutrient indicated by ratios above

15:1. In Schoenick Lake phosphorus was the limiting nutrient in the fall and nitrogen was in the spring, indicating that management of both of these nutrients are important in this lake and the Schoenick Creek Watershed. Using the overturn data, Long Lake was phosphorus limited, while Schoenick Lake was nitrogen limited in the fall and phosphorus limited in the summer.

Table 19. Ratios of total nitrogen to total phosphorus for Long and Schoenick Lakes.

Long Lake - Total Nitrogen:Total Phosphorus			
	Total N	**Total P**	**TN:TP**
Fall Overturn	1.67	0.096	17:1
Spring Overturn	1.69	0.099	17:1
Schoenick Lake - Total Nitrogen:Total Phosphorus			
	Total N	**Total P**	**TN:TP**
Fall Overturn	1.48	0.142	10:1
Spring Overturn	1.71	0.067	26:1

GROUNDWATER SAMPLING

During late August of 2002 groundwater entering and leaving Long Lake was evaluated at 62 sites around the perimeter of the lake in water approximately 18 inches deep using small wells (mini peizometers) (Figure 23). Groundwater was found to be entering the lake at 70% of the sites and exiting the lake at 3%. Twenty-seven percent of the sites had little groundwater entering or leaving (Figure 24). At the sites where water was flowing into the lake, samples were taken for analysis of nitrate, ammonium, reactive phosphorus, chloride, temperature, and conductivity.

Background Groundwater Quality

Water quality at 20 mini piezometer sites show little or no influence from human activity. For all background groundwater quality sites, concentrations of nitrate, ammonium, reactive phosphorus, and chloride were found to be normal for this region (Kammerer Jr., 1995). These normal concentrations were measured at site numbers 1, 2, 4, 7, 12, 14, 17, 18, 27, 35-37, 39-41, 43-45, 48, and 50. Chloride concentrations ranged from less than 0.5 to 3.5 mg/L. Reactive phosphorus concentrations ranged from 8 to 23 ug/L. Concentrations of nitrates varied from 0.02 to 0.24 mg/L. The other mini piezometer sites had water quality that differed from these background concentrations. Those sites are discussed by combinations of different water quality chemistries.

Chloride

Chloride concentrations are increased in groundwater as a result of septic systems, animal waste, agriculture fertilizers, in addition to road-salting chemicals. Winter road salt application is a necessity to reduce hazardous road conditions, but this can move to groundwater when the salt dissolves and is carried by percolating water to the groundwater table. We identified road salt as a likely impact to groundwater at particular sites because other constituents such as reactive phosphorus, nitrate, and ammonium were present in relatively low concentrations. Increased chloride in groundwater also increases the conductivity of the groundwater.

The groundwater study identified seven sites (11.3 % of all sites), with elevated concentrations of chloride that appear impacted by the application of road salt. Site numbers 10, 15, 16, 29, 30, 33, and 46 were those sites with elevated concentrations of chloride ranging from 2.0 to 27.0 mg/L. All of the sites with high concentrations of chloride are located near roads where salt application is likely.

Nutrients and Chlorides
Several of the mini piezometer sites had elevated concentrations of nutrients such as nitrogen and phosphorus, in addition to chloride. It is more difficult to isolate specific causes of these conditions, but we divided those results on the basis of temperature and degree of upwelling into two groups: local impacts, and regional impacts.

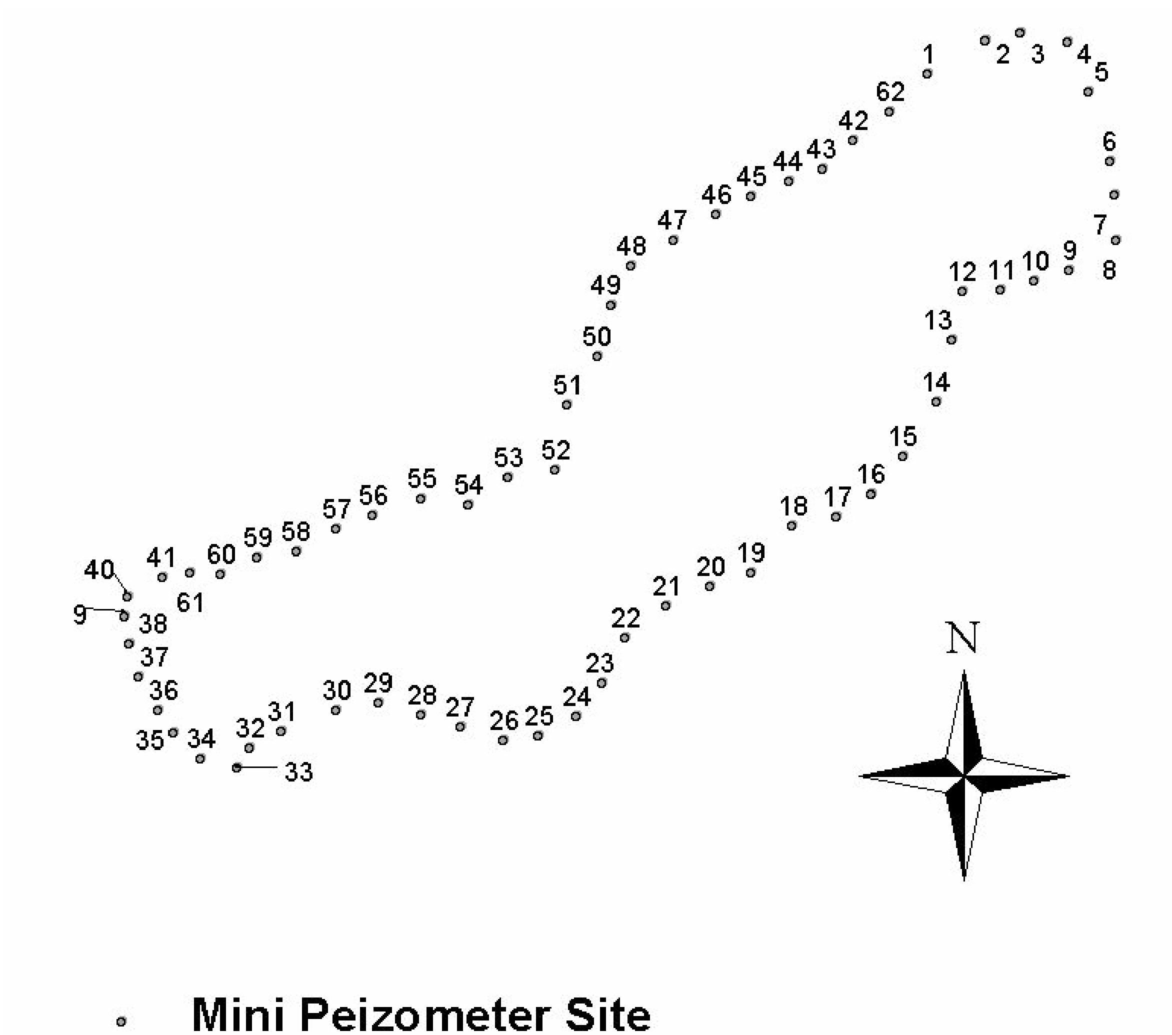


Figure 23. Location of groundwater sample sites around Schoenick Lake, Shawano County, WI.

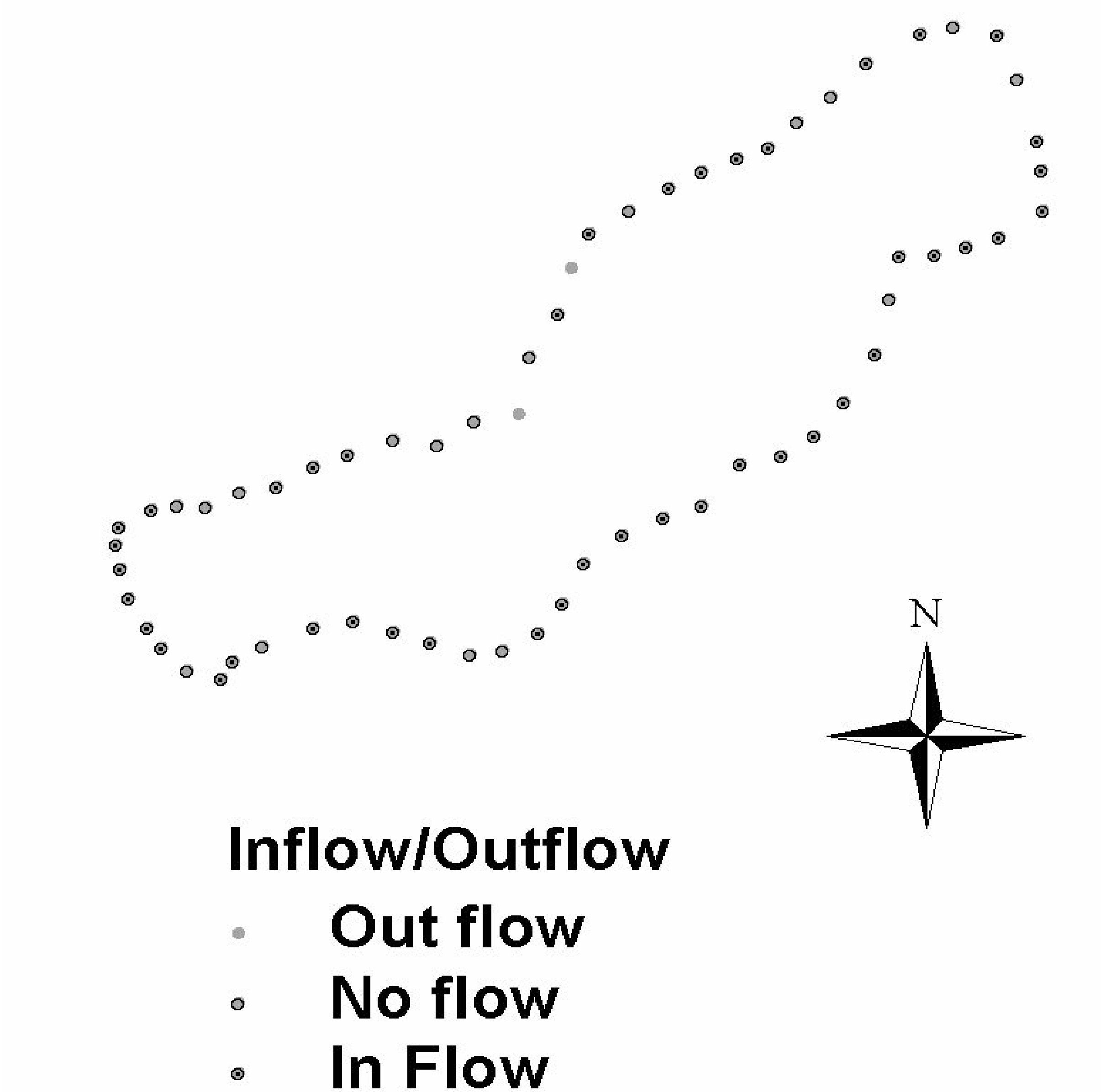


Figure 24. Location in Long Lake, Shawano Co. where groundwater is entering, leaving, or static.

Local Impacts

Local impacts on groundwater water quality are the result of contamination from septic systems, lawn fertilizers, road salt, and animal or livestock waste. Local impacts on groundwater quality are distinguished by having high concentrations of nitrate, ammonium, reactive phosphorus, in addition to chloride, all in the presence of warmer groundwater temperatures. Warmer groundwater temperatures are the result of having a flow path that is shorter and closer to the surface of the soil.

During the study groundwater was found to be locally impacted at nine separate sites (20% of the inflow sites). These sites included numbers 6, 9, 11, 28, 32, 38, 56, 57, and 58. Concentrations of nitrate at these locally impacted sites ranged from 1.48 – 10.5 mg/L with concentrations of chloride ranging from 7.5 – 184.0 mg/L. Values of reactive phosphorus ranged from less than 3 ug/L to1,060 ug/L. These values indicate contamination of groundwater from local impacts and contamination may be the result of septic systems, lawn fertilizers, animal waster and road salt. The temperature of groundwater at these sites ranged from 15.0ºC – 25.4ºC

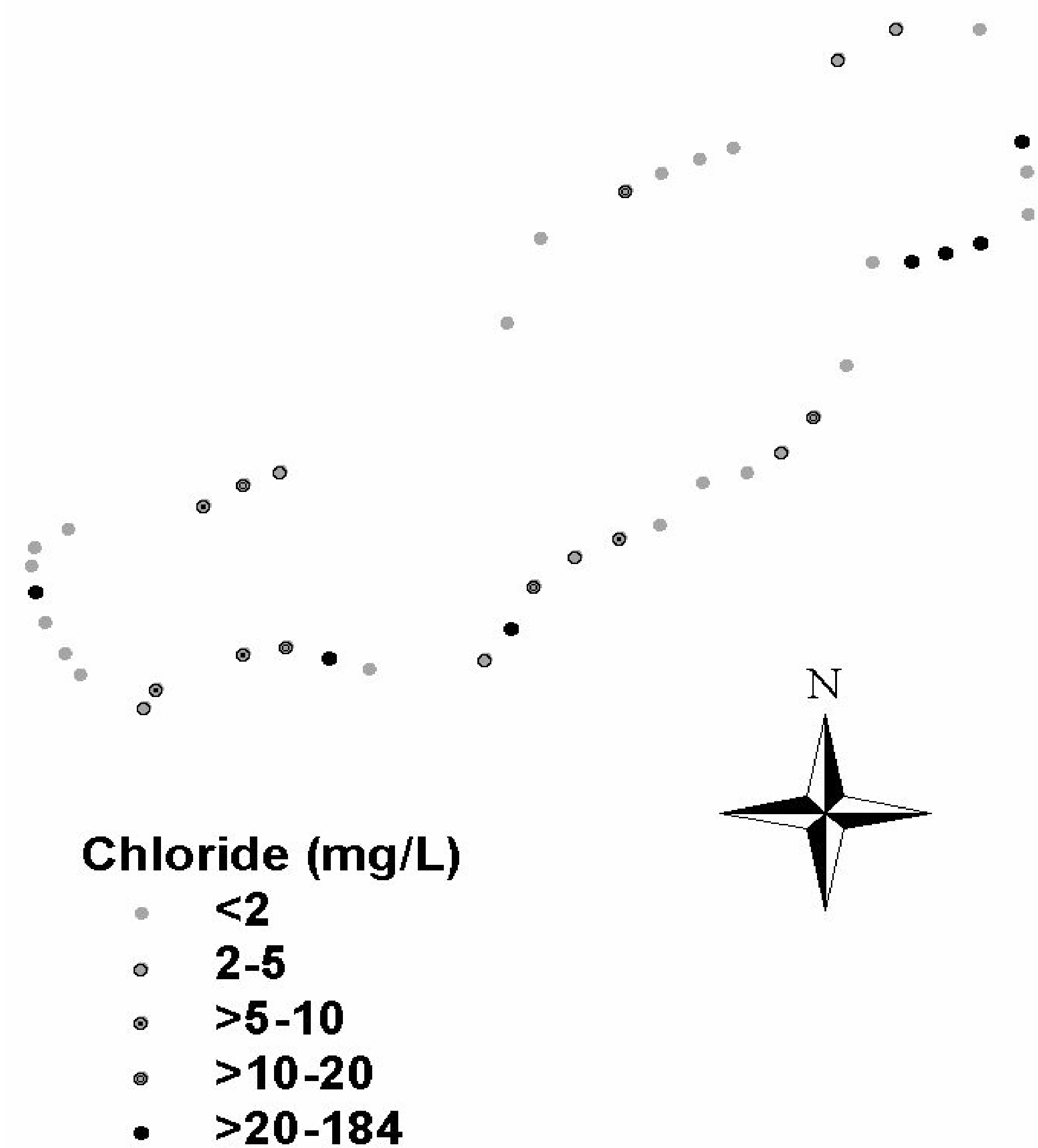


Figure 25. Chloride concentrations in groundwater samples around Long Lake, Shawano Co, WI.

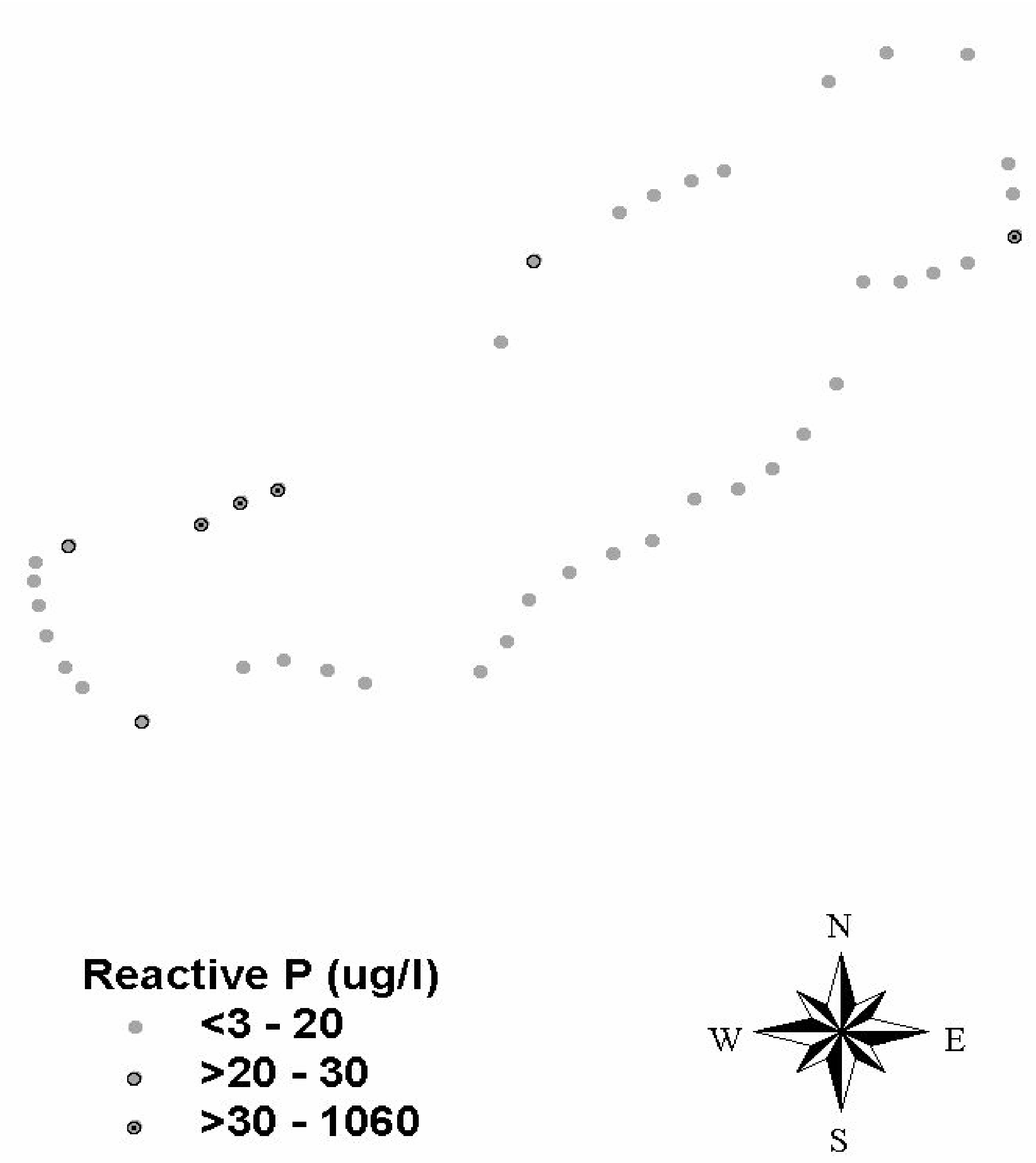


Figure 26. Soluble reactive phosphorus concentrations in groundwater samples around Long Lake, Shawano Co, WI.

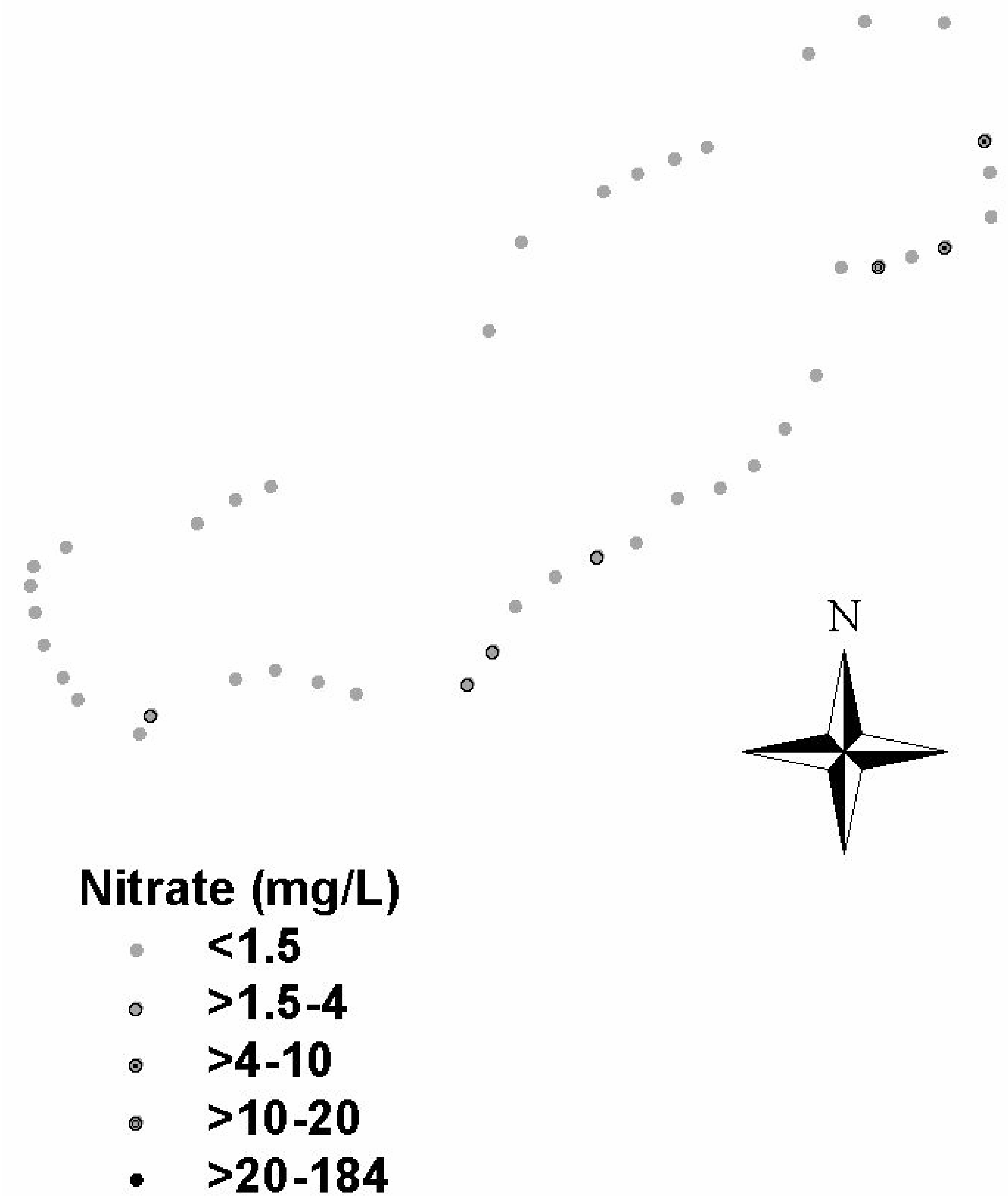


Figure 27. Nitrate concentrations in groundwater samples around Long Lake, Shawano Co, WI.

Regional Impacts

Regional impacts on groundwater water quality are the result of similar activities that influence local impacts. However in the Schoenick Creek Watershed, the dominant land use is agriculture, more specifically non-irrigated cropland and the majority of the soils within these agricultural areas are moderately to rapidly permeable and well drained. Thus, regional impacts on groundwater flowing into Long Lake are the result of agricultural fertilizer application, and can be identified by higher concentrations of chloride and nitrate or reactive phosphorus traveling in a deep groundwater flow path which is indicated by a colder groundwater temperature and a greater level of static head within the mini piezometer.

During the mini piezometer study groundwater was found to be regionally impacted at six separate sites; are all adjacent to one another along the perimeter of the lake. These sites include numbers 19-24, and all are located along the southern shoreline. The static head ranged from 21.7 inches up to 27.0 inches. The groundwater temperature of these sites ranged from 13.5ºC all the way up to 23.8ºC. Chloride concentrations were all above the detectable limit and ranged from 1.0 mg/L up to 21.0 mg/L. Reactive phosphorus concentrations ranged from 5 ug/L – 20 ug/L, and concentrations of nitrate varied from 0.04 mg/L – 2.1 mg/L.

Wetland Impacts

Groundwater impacted by wetlands can be identified by evaluating the concentrations of chemical constituents in the sample. In a natural wetland environment, anoxic or oxygen depleted conditions usually exist within the mucky to moist sediment residing there. Higher concentrations of reactive phosphorus and ammonium with very low concentrations of chloride are indicative of wetland impacted groundwater. During storm events streams and lakes may receive plumes of reactive phosphorus where wetland soils are fully saturated with reactive phosphorus. Reactive phosphorus will readily bind to cation exchange sites throughout all of the soil horizons down to the top of the groundwater table. When all of these exchange sites have become completely filled reactive phosphorus will readily enter the groundwater and leach to surface water areas.

During the mini piezometer study only site number 8 indicated groundwater quality was directly related to wetland impacts. Concentrations of reactive phosphorus and ammonium were 36 ug/L and 0.120 mg/L, respectively; the concentration of chloride at this site was less than 0.5 mg/L. These values are fairly low for groundwater entering lakes, but compared to mini piezometers located before and after Site 8 these values are elevated. The soil type adjacent to Site 8 is marky or cathro muck and considered a hydric soil typical of wetlands and capable of leaching elevated concentrations of reactive phosphorus and ammonium to the lake.

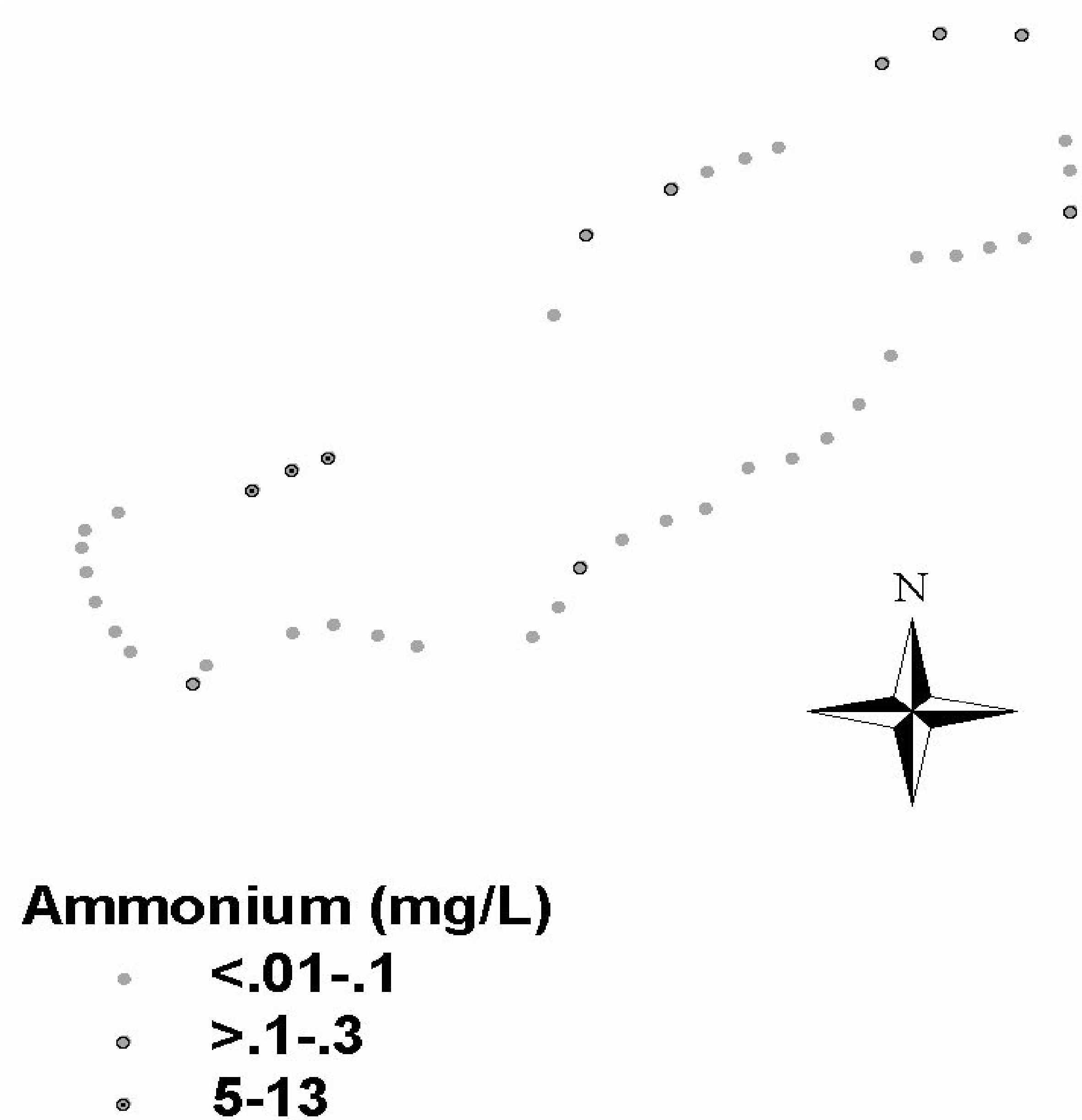


Figure 28. Ammonium concentrations in groundwater samples around Long Lake, Shawano Co, WI.

Schoenick Creek Watershed Improvement Project - Citizen Education

1. Landowners in the watershed were notified of the goals and objectives of the approved grant project, told of the project timeline and given the name of the County Conservationist would serve as the local contact person for the project.

2. Information about the progress of the project was included in three annual Long Lake Association letters and shared with landowners through contact with UW Extension and County Conservation agents. Members of the project task force provided additional project information during the collection of water samples and at other local meetings. Prior to the final public meeting, an article appeared in the local newspaper that described the project and presented some of the preliminary findings.

3. The Long Lake Association held three meetings during the project. The county Extension agent and others provided information at these meetings on lawn maintenance, using phosphorus free fertilizer and improved shoreline management as well as enlisted people to conduct soil tests on their property. Twenty four properties were tested.

4. Throughout the duration of the project, members of the task force contacted local landowners about the need to reduce phosphorus through better fertilizer applications, the importance of reducing erosion and the impact that animal feedlots have on water quality.

5. A meeting was held with area schoolteachers to explain the WAV water-testing program. Kris Stepanuck, state Water Action Volunteer monitoring coordinator gave a presentation and teachers were invited to attend a training program. Several teachers took the course.

6. The final citizen meeting for the project was held on May 25, 2004 at the Belle Plaine Town Hall. Forty-eight people attended the meeting. Nancy Turyk from the Center for Watershed Science and Education, UW Stevens Point presented the findings of the water quality study. Linda Stoll from the Fox-Wolf Watershed Alliance led the follow-up discussion. The attendees identified these items for further action:

   - Take one or two areas and target remediation efforts – Belle Plaine Ave and Grass Lake Rd
   - Reconstruct and enhance wetlands above the lakes
   - Investigate the phosphorus contribution from the nursing home lagoons
   - "Slow the Flow" – buffers, stream flow: meanders, riffles and pools
   - Phosphorous –free fertilizer for turf areas
   - Nutrient and manure management – crop and barnyard

- Continued river monitoring
- Better management of erosion from farms and construction sites

Seven people signed up to become part of the volunteer monitoring program.

7. A follow-up meeting was scheduled for June 15, 2004 at the Shawano Court House to develop a work plan. Eight members of the task force attended the meeting and created a work plan for continued improvement of the Schoenick Creek watershed.

Conclusions/Recommendations

- Phosphorus is at problematic concentrations throughout the watershed. Some phosphorus occurs naturally in wetland sediments, but much is the result of fertilizer application and animal waste. The percent of total phosphorus coming from each sub-watershed was estimated using the SWAT model. The resulting percentages were Belle Plaine Ave (39%), St. John's Rd (17%), Shoenrock Rd (14%), Long Lake Inflow (10%), Grass Lake Rd (9%), Hunting Rd (8%), Cloverleaf Lakes Rd (3%).
    - As phosphorus is abundant throughout the entire watershed, <u>all landowners</u> should be engaged in reducing inputs on their land. If necessary, UW-Extension and/or the DNR could be contacted to provide additional information about phosphorus reduction.
    - The Shawano County Land Conservation Department should consider prioritizing work in the sub-watersheds that are having the greatest inputs to Schoenick Creek.
- A large percent of the phosphorus measured in the water samples is in the particulate form.
    - Efforts should be made by all landowners to minimize the amount and time that soil is exposed during construction, agriculture, etc.
    - Appropriate silt fences should be installed during construction.
    - Multiple layer (trees, shrubs, tall forbs/grasses) vegetative buffers should remain intact or be remediated to allow for maximum filtration of water moving towards the creek, tributaries, lakes, and wetlands.
    - Agricultural best management practices can include the use of cover crops, reducing soil tilth, and managing solid manure.
- The stream water at the Schoenrock Rd site received most of its nitrogen inputs from groundwater.
    - Land use practices in the sub-watershed should be focused towards the reduction of contaminant infiltration to groundwater.
    - Private wells in this sub-watershed should be analyzed for nitrate.
- The tributary at Grass Lake Rd had extremely high concentrations of solids, nitrogen, and phosphorus.
    - Best management practices should be employed to reduce these inputs. These practices should include vegetative buffers, increasing field residual and/or decreasing soil tilth, incorporation of land spread manure, etc.
    - The Shawano County Land Conservation Department is available to assist with determining which practices are appropriate for a given parcel of land.
- Phosphorus concentrations in Long and Schoenick Lakes are significantly above concentrations that exacerbate the growth of algae and aquatic plants. External inputs have been identified in this study for both shoreland and watershed-wide land use practices.
    - Shoreland best management practices should include the restoration of buffers (35 feet from the lake), elimination of phosphorus used on lawns,

    - control of soil erosion during construction, and use of rain gardens to slow runoff of water from rooftops.
    - Internal loading is a portion of the observed phosphorus, but the amount is currently unknown.
- Groundwater was sampled at 62 sites around Long Lake. Seventy percent of the sampled sites showed groundwater flowing into the lake. Based on water quality at these sites; 14% indicated regional impacts, 20% exhibited local impacts, 20% were impacted by road salt and 46% indicated no influence.
    - Land use practices locally and regionally should be conducted in a way to minimize inputs to the groundwater.
- The phosphorus testing on shoreland properties demonstrated that the soil contains high phosphorus concentrations. Activities that increase runoff across these soils or convey soil to the water is likely to transfer excessive P.
    - Phosphorus fertilizer additions should be made carefully and then be based on soil test results.
    - Elimination of fertilizer or use of non-phosphorus fertilizer (as indicated by soil test results) is recommended to all homeowners living along lakes, creeks, and tributaries.
- During the times of year when Long Lake was stratified, only the upper 20 feet of the lake had high enough oxygen concentrations to support most aquatic biota. In addition, dissolved oxygen concentrations in Long Lake were extremely low during overturn. This can be problematic if conditions prevent replenishment of dissolved oxygen prior to ice-on in the fall.
    - Routine monitoring of temperature and dissolved oxygen should be measured every foot throughout the water column with a high quality probe to determine the dissolved oxygen availability over time and during different seasons.
    - Deteriorating conditions may require snow plowing the lake in the winter (to increase macrophyte growth and hence, production of oxygen), or aeration.
- Stream monitoring should continue at the same sampling sites.
    - At a minimum, samples should be collected once or twice/year and be lab analyzed for nitrogen, phosphorus, chloride, and suspended solids.
    - Water Action Volunteer sampling should be considered to supplement the lab data.
    - Staff gages should be installed at each sampling site if samples will be collected during events.
- Watershed residents should continue to learn about how they can minimize impacts and how land use practices can be employed to improve water quality in the Schoenick Creek Watershed.
    - This can be conducted through a watershed group, lake association, or as individuals.
    - Attend session hosted by the DNR and UW-Extension.
    - Request information about specific topics not covered by the above for presentations at community meetings/picnics.

Work Plan for Improving the Schoenick Creek Watershed

The action items that were identified by attendees of the May 25, 2004 final report to the citizens meeting that was held at the Belle Plaine Town Hall were discussed by the task force committee on June 15, 2004 at the Shawano Court House. Following is the resulting workplan.

1. Phosphorus is at problematic concentrations throughout the watershed. The task force identified two sub-watersheds on which to focus their efforts. The greatest percentage of phosphorus loading comes from the Belle Plaine Ave. subwatershed. The two most likely sources for phosphorus are from over-application on agricultural fields and the sewage lagoons of the county nursing home. Ron Ostrowski, county conservationist has agreed to contact farmers in this area about nutrient management plans for their fields. He will also contact the director of the nursing home and share the results of the study. Sewer service is now available for the nursing home. Connecting to the sewer service may be possible. The County will explore the feasibility if the present sewage treatment lagoons prove to be faulty.

   Grass Lake sub-watershed also has high concentrations of solids, nitrogen and phosphorus. Ron Ostrowski will work with NRCS to approach key landowners about manure management on their farms as well as the creation of nutrient management plans for their fields.

2. State and County regulations address the issues of erosion control and manure and nutrient management. It is unknown how many landowners in the watershed are in compliance with these regulations. The Ron Ostrowski has already been in contact with several landowners in regards to better management of their farms but others need to hear the results of the study. Working with NRCS, Extension and the Agricultural Services Department, he will schedule a meeting for farmers in the watershed to share the results of the study, explain existing regulations and the availability of cost share dollars for improvement. Nancy Turyk will prepare a summary handout of the report to be used at this meeting.

3. There is a potential for nitrate issues in the wells in the Schoenrock Rd sub-watershed. Jin Resick, county CNRD agent is already working on well education. He will acquire a list of landowners with wells in this area and send them a letter sharing the results of the study in regards to nitrates and suggest that they have their wells tested if have not already done so in the past year.

4. The majority of residential owners live around Long Lake. The next annual meeting of the landowners will take place the end of June. Information will be placed in the annual letter to landowners about the results of the study. Education on phosphorus-free fertilizer will be presented at the meeting and landowners will

be encouraged to test their soil if they have not already done so. Additional information will also be presented on shoreline management. The Lake Association board will be responsible for these presentations.

5. Long Lake has problems with low dissolved oxygen, especially during lake turnover. The Lake Association will encourage landowners to remove snow from the ice along the shoreline wherever possible to allow sunlight to reach plants in the littoral zone. This low-cost solution has been successful in other lakes in the area.

6. Continued volunteer monitoring was identified as extremely important to water quality improvement. Seven people signed up at the public meeting to help with this. One of who was the director of a church camp. The local middle and senior high schools also expressed interest in monitoring. The Lake Association will continue with its Adopt-a-Lake program. Jim Resick will schedule a meeting of those interested in monitoring to identify training needs and discuss further coordination. Fox-Wolf Watershed Alliance will have an LTE for one year that will work with local groups to develop a basin-wide volunteer monitoring network. This person will contact Resick as soon as they are hired to move this program forward.

7. Linda Stoll, Fox-Wolf Watershed Alliance will contact UW Sea Grant for available programs that fund wetland restoration and enhancement and share this information with Ron Ostrowski.

8. The Long Lake Association has contacted UW Stevens Point about the possibility of doing an algae assessment for Long Lake. The Association will pursue this study.

9. Continued citizen education was identified as an on-going need. The Long Lake Association website will be updated with airphotos taken of the watershed, the results of the study and the handout that is being prepared for farmers. Additional information will be added as it is identified by the task force.

The Schoenick Creek Task Force has agreed to meet in one month to report on progress and take further steps to improve the watershed.

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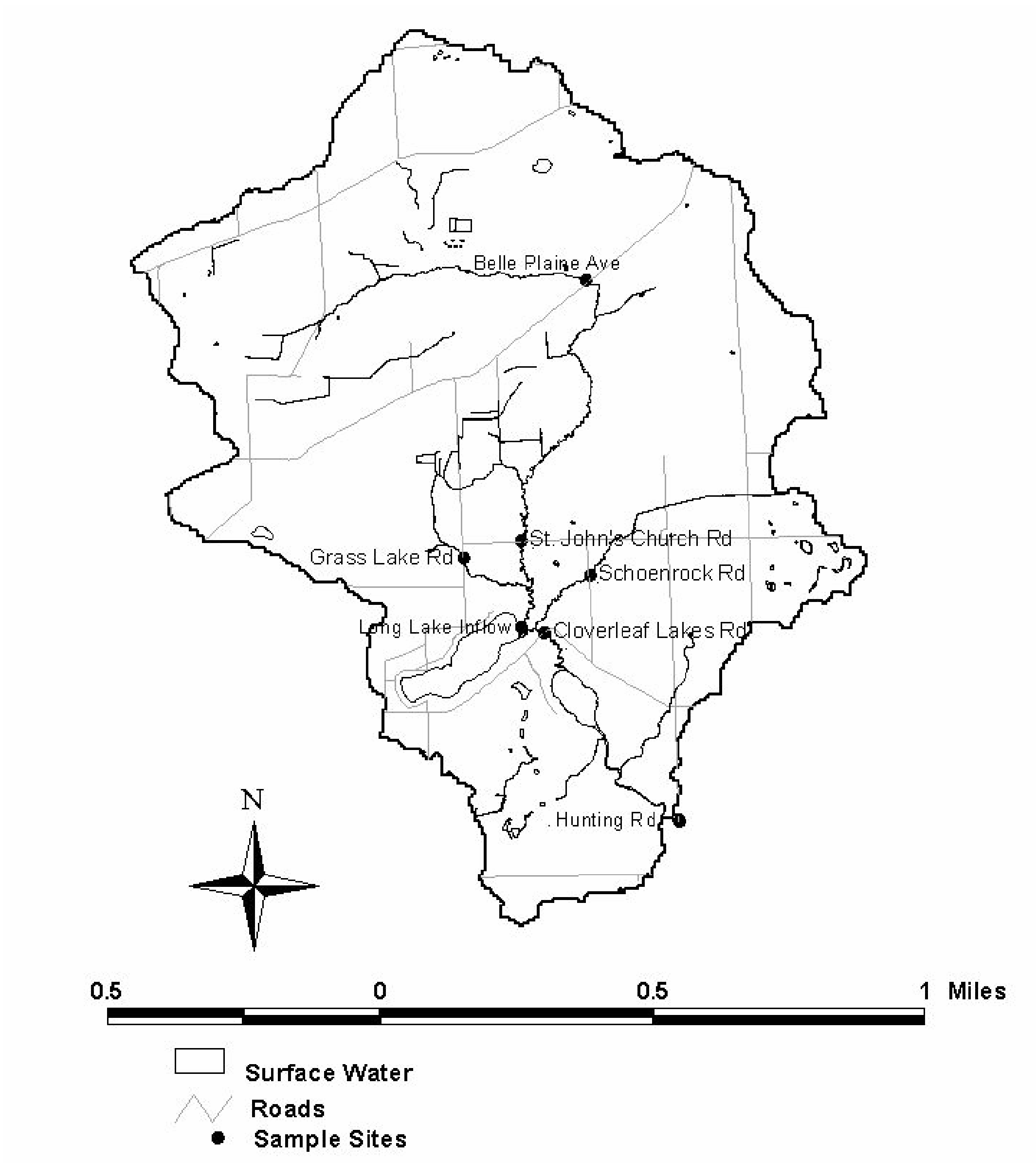
Belle Plaine Ave
St. John's Church Rd
Grass Lake Rd
Schoenrock Rd
Long Lake Inflow
Cloverleaf Lakes Rd
Hunting Rd
N
0.5
0
0.5
1 Miles
Surface Water
Roads
Sample Sites