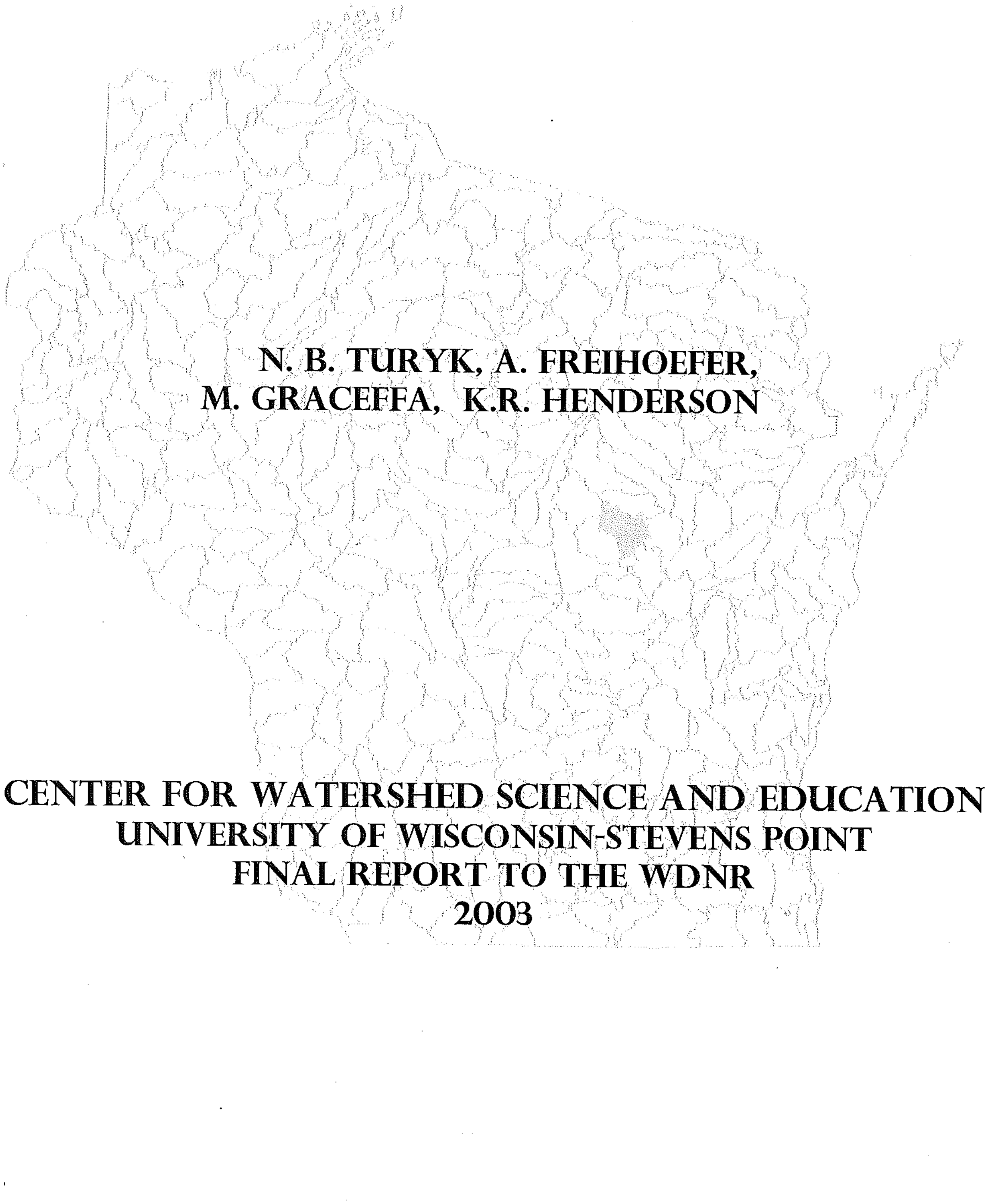
WATER QUALITY ASSESSMENT OF THE LOWER LITTLE WOLF WATERSHED



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FINAL REPORT TO THE WDNR
2003

College of Natural Resources

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EXECUTIVE SUMMARY

The 152 square-mile Lower Little Wolf Watershed is a USDA-EQIP priority area in Central Wisconsin. Predominant land uses that may affect water quality within the watershed include rural residential developments, row-crop and animal agriculture. The UWSP Center for Watershed Science and Education (formerly Environmental Task Force Program), working jointly with the Waupaca County Land and Water Conservation Department and Fox-Wolf 2000, designed a study to assess water quality within the watershed and deliver the results to the public.

Thirteen sites were monitored through collection of event and baseflow samples, discharge measurements, and physical descriptions of each site. Siphon sampling devices to collect event samples were used in combination with baseflow grab samples collected from spring through fall of 2001 to determine: 1) the importance of groundwater and runoff processes to stream water quality, 2) if there were specific times of the year that land use practices most effect water quality and 3) which sub-watersheds have the greatest need for remediation. Nutrients, chloride, total suspended solids, fecal coliform, and triazine were tested at all sample sites. Sub-watersheds were delineated to identify land areas associated with each site.

The results of the monitoring and subsequent evaluation showed that water quality in the sub-watersheds varied due to differences in soil type, topography, amount of groundwater input, land uses, and seasonality. Soil type plays a role in the amount of runoff and therefore, the amount of contaminants transported to the streams during runoff events. The western side of the watershed has predominantly well drained soils. Many of the inputs to these steams are related to groundwater inputs and are less related to runoff events. The southern and eastern portions of the watershed have heavier soil therefore, runoff plays a stronger roll in delivering contaminants to the streams. Water quality in the Lower Little Wolf River Watershed ranges from very good in some streams to very poor in others. Streams that have overall good water quality are Spaulding Creek and Upper Whitcomb Creek. These streams represent the water quality background levels in well–drained soils of the watershed.

Triazine (an herbicide) was detected in samples at all 13 sites. Beaver Creek and Little Creek are the sub-watersheds of greatest concern. Triazine concentrations ranged from the detection limit to as high as 12 µg/L. The later concentration is excessively high for this region of the United States. ~~Total phosphorus and total suspended solids concentrations during event flows were in concentrations ranging from 0.025 to 1.7 mg/L and 1 to 892 mg/L, respectively. The early spring runoff events resulted in high inputs of phosphorus to all of the streams. Maximum concentrations of total suspended solids during runoff events are about half of what was measured in 1995/1996 in Blake Creek and the lower end of the Lower Little Wolf River likely because of best management practices that have been implemented in the area.~~

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The Lower Little Wolf Priority Watershed Project has been in the implementation phase since 1997. To date, 238 contracts have been signed with landowners in the watershed. The watershed inventory showed a delivery of 5,200 lbs. of phosphorus from barnyard runoff, 25,715 lbs. of phosphorus from upland erosion, 17,143 tons of sediment from uplands, 2,000 tons of sediment from shoreline erosion and 10,000 tons of sediment from gully erosion. Barnyard runoff control projects installed has resulted in a 2,068 lb. reduction of phosphorus to the stream. Phosphorus attached to particulate matter (soil or sedimentation) has been reduced by 30,400 lbs. per year. Nutrient management plans account for an additional 5,303 lbs of phosphorus per year. According to the BARNY model sedimentation from all sources has been reduced by 22,982 tons per year. The Lower Little Wolf Priority Watershed goals have been for the most part achieved. Total phosphorus and total suspended solids concentrations during event flows were in concentrations ranging from 0.025 to 1.7 mg/L and 1 to 892 mg/L, respectively. The early spring runoff events resulted in high inputs of phosphorus to all of the streams. The project will continue through 2008 with two technicians assigned to the watershed. To date much of the work has been conducted in the Blake Creek and primary Lower Little Wolf River sub-watersheds.

Monitoring of the streams should continue to provide a long-term record for the watershed. This will help to determine if changes in the watershed are having positive or negative impacts to water quality. Citizens and agency personnel should work together to determine goals for the sub-watershed. Efforts should be made to achieve these goals through education and planning. If continued, this partnership can benefit the long-term management of the Lower Little Wolf River.

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INTRODUCTION

Background Information

The Lower Little Wolf watershed is home to both residential and farming communities, and a source of recreation for many outdoor enthusiasts including camping, fishing, canoeing/boating, hiking, hunting, and trapping. Despite the human activity throughout the years, little is known about the past and current water quality of the rivers and tributaries of this watershed. The purpose of this study was to assess the current water quality of the Lower Little Wolf River and its tributaries, identify areas within the watershed that are most affecting the water quality, and enable Waupaca County personnel to prioritize their efforts in the areas most needing attention, ultimately resulting in the overall improvement of the river system. With this information, residents of the watershed can gain insight on the water quality and what role they can play in improving it.

The Lower Little Wolf Watershed was designated as a DNR Priority Watershed in 1996. In 1998 it was selected as a USDA-Environmental Quality Incentive Program priority area. In 1997-98 DNR biologists conducted preliminary water quality, habitat and biotic index surveys. Waupaca County Land and Water Conservation Department personnel completed an inventory of non-point pollution sources including barnyard runoff, manure spreading, sediment delivery from cornfields, and streambank erosion. Some of the problems that were visually identified included sedimentation, lack of or degraded fish habitat, and degradation from agriculture including 1,570 feet of banks trampled by livestock. Since the inventory was completed, technicians have installed a number of non-point pollution control projects along with establishing more than 14,000 acres of conservation tillage. Nutrient management is a priority practice in the watershed project.

Past and current problems within watershed and sub-watersheds include:

- Excessive sedimentation
- Lack of fish habitat and fish habitat degradation
- Excessive nutrient loading of surface and groundwater
- High levels of suspended solids, total phosphorus, ortho phosphorus, bacteria, nitrate and pesticides in the river/tributaries The Lower Little Wolf watershed is home to both residential and farming communities, and a source of recreation for many outdoor enthusiasts including camping, fishing, canoeing/boating, hiking, hunting, and trapping. Despite the human activity throughout the years, little is known about the past and current water quality of the rivers and tributaries of this watershed. The purpose of this study was to assess the current water quality of the Lower Little Wolf River and its

tributaries, identify areas within the watershed that are most affecting the water quality, and enable county personnel to prioritize their efforts in the areas most needing attention, ultimately resulting in the overall improvement of the river system. With this information, residents of the watershed can gain insight on the water quality and what role they can play in improving it.

- Non-point pollution
- Degradation from agriculture including 1,570 ft. of banks trampled by livestock. 3 lakes considered severely degraded.

Study Design and Objectives

This study was designed to assess the current water quality conditions in the Lower Little Wolf River and its tributaries, identify areas within the watershed that are most significantly affecting the water quality, and enable prioritization of their in the areas most needing attention ultimately resulting in the overall improvement of the water quality. Objectives included:

- Collect current water quality data from primary tributaries and the main stem of the Lower Little Wolf River.
- Identify priority areas within the watershed likely contributing the most to water quality so that efforts can be concentrated in the areas that need the most attention.
- Summarize data in a format that will assist citizens and local agencies in understanding the functions within the Lower Little Wolf River watershed and help lead to effective river protection strategies.

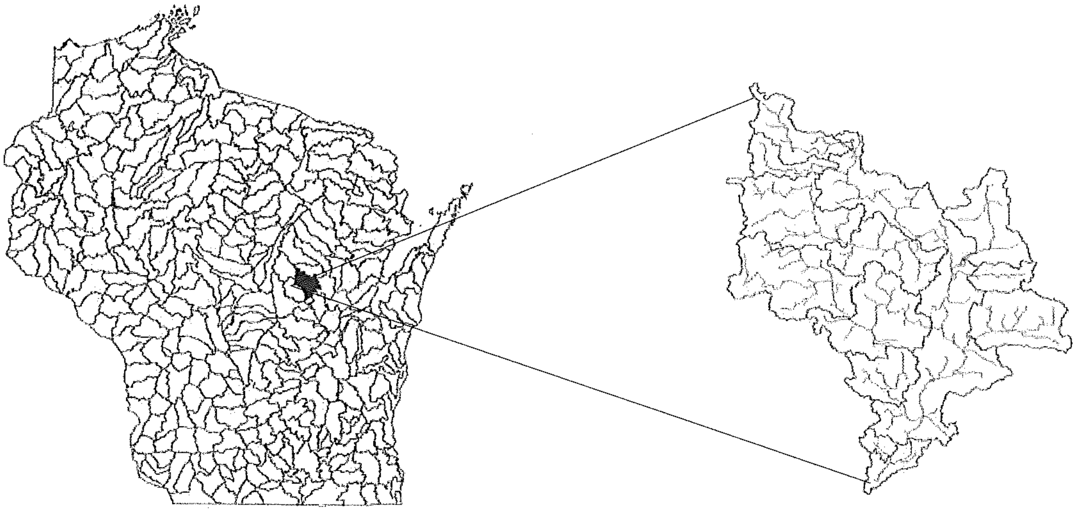
The study was conducted between March 2001 and April 2002. It included sampling water at 13 sites 7 times over the year. Conditions within the watershed ranged from 3 lakes and a few tributaries that were very degraded, to some tributaries that were Class I trout fisheries. The following report details the findings of this study and recommendations. These data can be utilized in the future to compare trends within the watershed.

Study Area Description

The Lower Little Wolf River Watershed is a 152-square mile drainage basin located approximately 15 miles north of Waupaca in Central Wisconsin. Figure 1 shows the location of the Lower Little Wolf surface watershed. The lower portion of the river begins at the hydroelectric dam in the Village of Big Falls and continues for approximately 27 miles to the confluence of the South Branch of the Little Wolf River. The Lower Little Wolf River Watershed has two cities within it including the Village of Big Falls, located on the northwest corner of the watershed, and the City of Manawa, located in the south central region of the watershed. Total population of the watershed is estimated at 5,049 people. There are a total of 150 miles of named and unnamed streams, along with 21 lakes in the watershed. (DNR, 1997)

Land use in just over half (52%) of the watershed is dominated by agriculture, primarily dairy farming. Land use in the rest of the watershed includes woodlands (22%), wetland (15%), grassland (6%), and less than 5% is considered developed. Figure 2 displays the distribution of general land uses within the watershed. Manufacturing is major economic activity in entire Waupaca County (USDA, 1981). Tourist and recreation in this watershed is minimal, but is focused around the water bodies in the watershed. Activities include camping, fishing, canoeing, hunting, and hiking in places such as the Little Wolf River and the Big Falls Pond County Parks, and Bear Lake Campground.

Figure 1. Location of the Lower Little Wolf River Watershed in Waupaca County, Wisconsin.

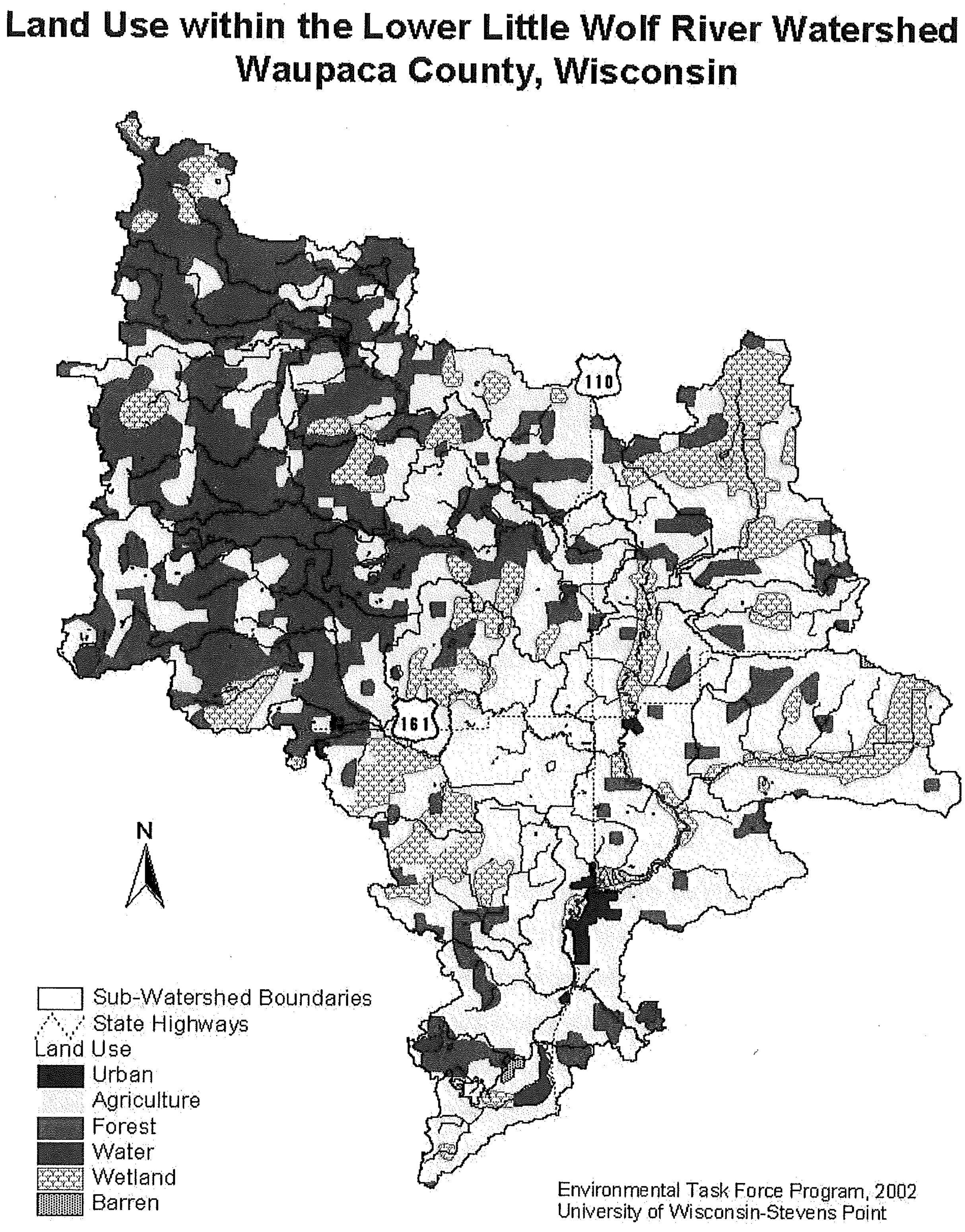


Water Quality Study

All of the tributaries and rivers in the Lower Little Wolf River watershed are fed by overland runoff (event flow) and most also by groundwater discharge to the river (baseflow). During the study, two types of samples were taken, storm/snow melt events and baseflow samples. Baseflow sampling was conducted when runoff was nonexistent This provides an indication of average groundwater quality, since groundwater is the only source of stream flow during these times. Typically this occurs during parts of the summer, late fall, and winter. Storm/snow melt event samples were collected using siphon samplers or grab samples. These samples show the constituents that enter the river via surface runoff (nutrients, sediment, pesticides, and bacteria). Many of the constituents found in both baseflow and event samples relate to the land use practices within the watershed.

Thirteen sample sites were selected in the Lower Little Wolf River Watershed. Figure 3 shows the location of these sample sites. Water samples were analyzed for nitrate+nitrite-N, ammonium-N, total Kjeldahl-N, total and reactive phosphorus, chloride, total suspended solids, fecal coliform, and triazine at the state-certified Environmental Task Force Lab. Streamflow was measured during the collection of baseflow samples.

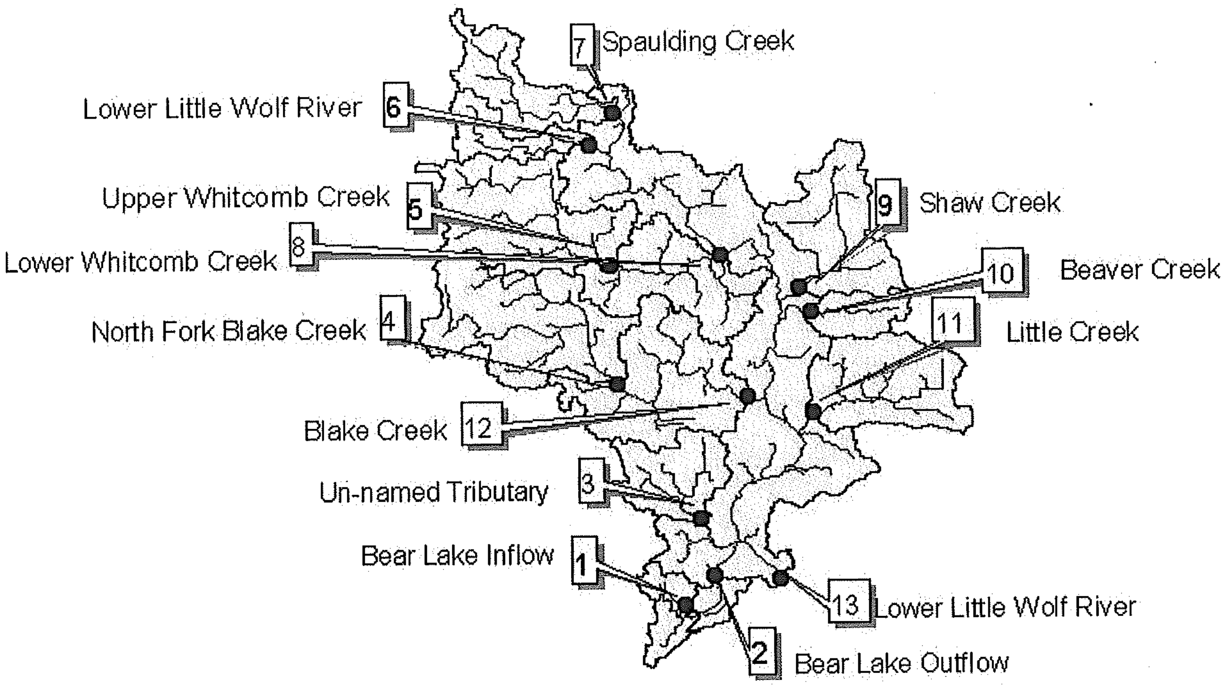
Figure 2. General land uses within the Lower Little Wolf River Watershed.



Land Use within the Lower Little Wolf River Watershed
Waupaca County, Wisconsin

Environmental Task Force Program, 2002
University of Wisconsin-Stevens Point

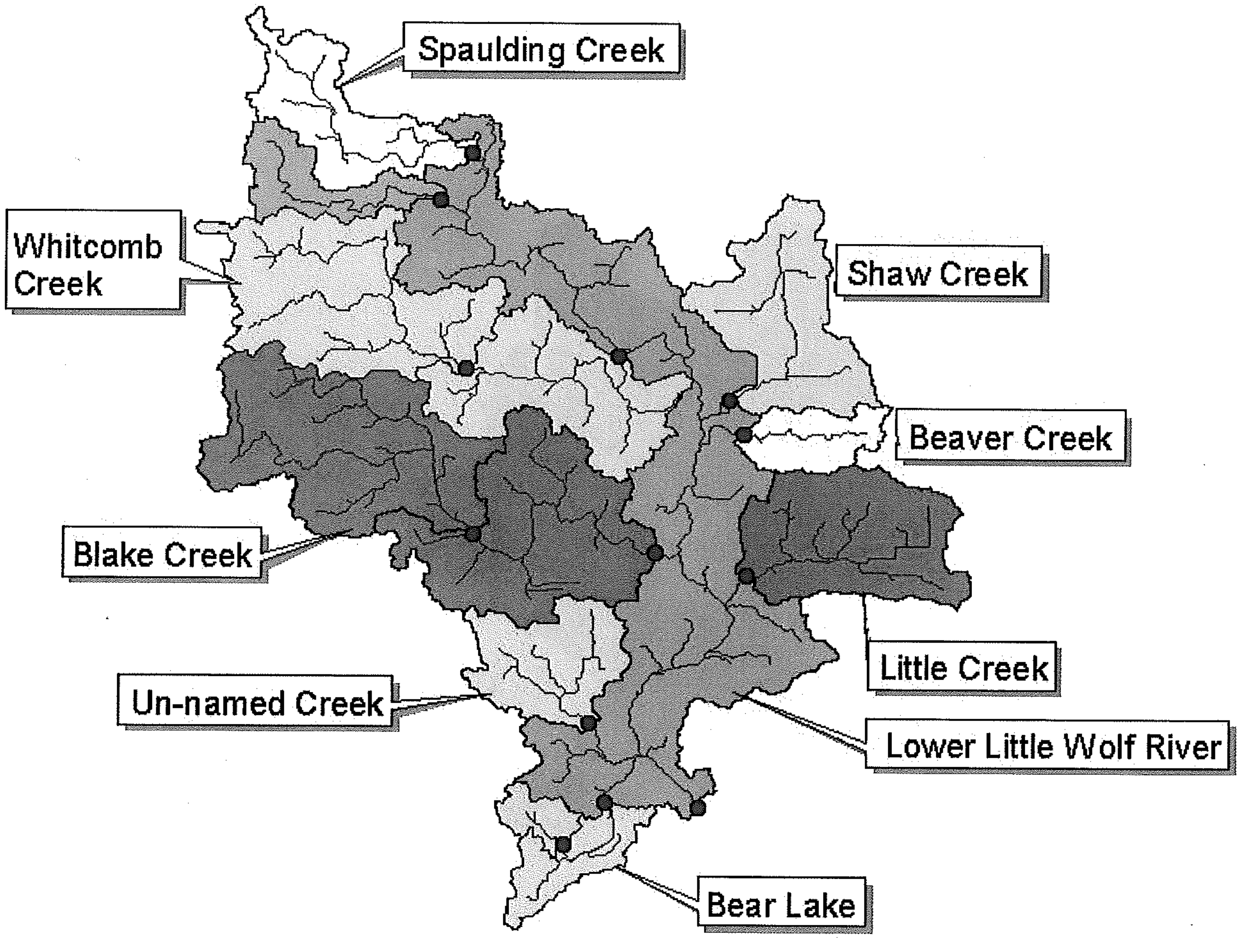
Figure 3. Location of water quality sampling sites in the Lower Little Wolf River Watershed, Waupaca County, Wisconsin.



Sub-watersheds

The Lower Little Wolf watershed was divided into nine primary sub-watersheds including: Spaulding Creek, Whitcomb Creek, Blake Creek, Bear Lake, Shaw Creek, Beaver Creek, Little Creek, an unnamed tributary to the river and the Lower Little Wolf. Figure 4 displays these sub-watersheds. The sub-watersheds are distinctly different; three have relatively good water quality with predominantly cold water Class I trout fisheries, (Spaulding, Whitcomb and Blake Creeks), whereas, Lower Little Wolf, Bear Lake, Beaver Creek, and Little Creek have comparatively degraded water quality and support either warm water sport fish or a forage fish base. Detailed analysis of the sub-watersheds is discussed in the results section.

Figure 4. Nine primary sub-watersheds in the Lower Little Wolf River Watershed.

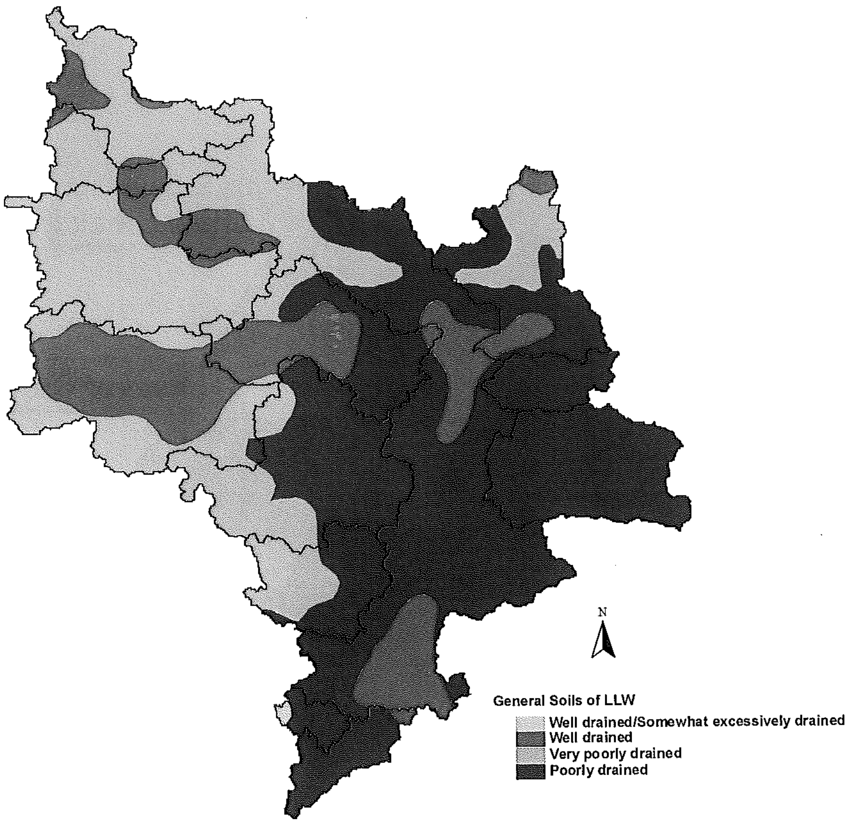


University of Wisconsin-Stevens Point
Environmental Task Force Program - 2002
Cartographer: Kelly R. Henderson

Soil

Glacial activity influenced the formation of the major Hortonville-Symco soils of the Lower Little Wolf region. Hortonville soils are moderately permeable, well-drained soils that are moderately suitable for houses and septic systems. Symco soils have moderate to slow permeability and are poorly drained, making them poorly suited for residence or septic systems (Soil Survey, 1981). In addition to the soil type, land use in parts of the watershed are also restricted by the slope. Figure 5 shows the distribution of soils throughout the Lower Little Wolf watershed.

Figure 5. Distribution of soils throughout the Lower Little Wolf River Watershed.



METHODS

Water Quality Sampling

Thirteen sample sites in the Lower Little Wolf Watershed were used in this study. Samples were collected during baseflow and event flow conditions over a one year period. Baseflow sampling was conducted when runoff was absent, therefore acting as an indicator of average groundwater quality, since groundwater is the only source of stream flow during baseflow periods.

Baseflow samples were collected on two different occasions: one in March and another in July. A 500 mL polyethylene bottle was used to collect the water sample from each site using the standard grab method. 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, was 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. Both filters were 47 mm in diameter and were layered with the pre-filter first. The third bottle was a 500 mL polyethylene bottle that was left unpreserved and unfiltered. After collection, the bottles were immediately placed in a cooler on ice.

Table 1. Sampling dates and corresponding flow regime.

	March		April	June		July	August
	Base	Event	Event	Event		Base	Event
	3/2/01	3/23/01	04/06/2001	6/6/01	6/12/01	07/12/2001	08/16/2001
1	*	*	*	*	*		
2	*	*	*	*	*	*	
3	*	*	*	*	*	*	
4	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*
9	*	*	*	*	*	*	*
7	*	*	*	*	*	*	*
8	*	*	*	*	*	*	
9	*	*	*	*	*	*	
10	*	*	*	*	*	*	
11	*	*	*	*	*	*	
12	*	*	*	*	*	*	
13	*	*	*	*	*	*	*

River discharge was measured at each site during baseflow sample collection using a Marsh McBirney Model 2000 portable current meter along with a 100-foot tape and two chaining pins. Measurements were taken at a constant interval along the rivers width as to collect 10-20 velocity readings for every site transect.

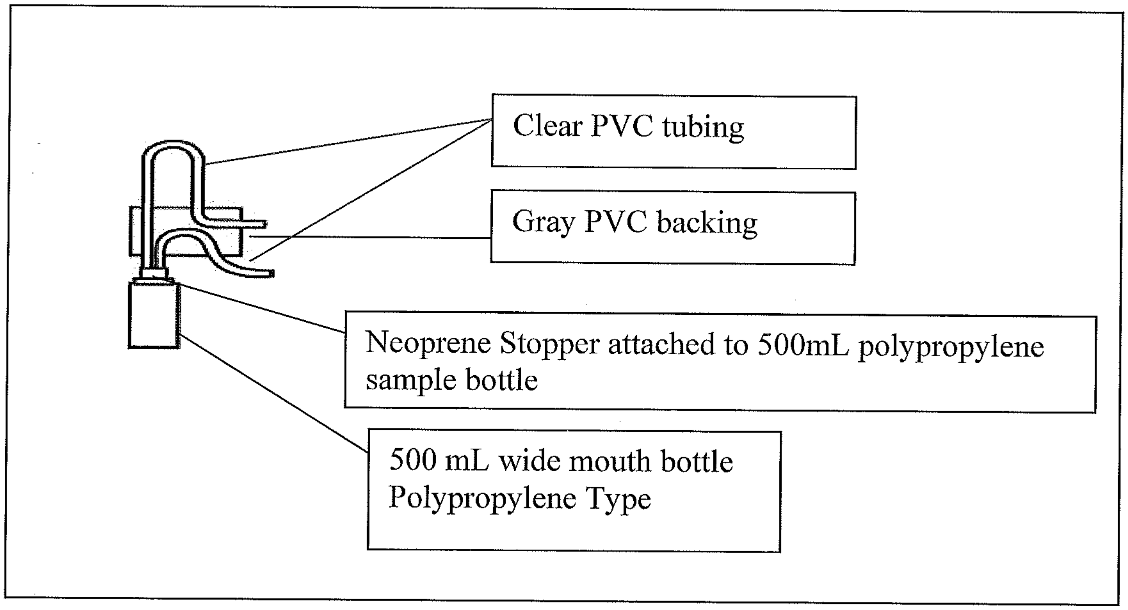
Runoff event samples were collected from all 13 sites in March, April, and twice in June. Runoff event sampling was instituted by use of siphon samplers or grab samples. Figure 6 illustrates the siphon sampler and its components. The siphon sampler used for this study was modified from devices designed by the USGS (USGS Report 13). The siphon sampler consists of two pieces of clear PVC sampling tubing, with an inside tube diameter of 0.28", which were bent into the shown configuration. The clear PVC tubing was inserted into a neoprene stopper and the stopper inserted into the 500 mL polyethylene-sampling bottle. The clear PVC sampling tubing was supported by a flat piece of gray PVC and the 500 mL sampling bottle apparatus was held in place with a Schedule 40 white PVC bottle.

The bottle bracket slid onto a "T" fence post that was inserted approximately 18 inches into the streambed. Two siphon samplers were set up at different heights at each site to capture two samples for each runoff event. 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 received by the state certified Environmental Task Force Lab (ETF) at the University of Wisconsin-Stevens Point in the 500 mL bottle where filtering and sample preservation was completed within 24 hours. The sample was then transferred into three separate bottles (See previous page on *Baseflow Sampling* for description of sample bottles) to properly preserve samples for the various analyses.

After collection, both baseflow and event samples were stored and transported on ice to the state-certified Environmental Task Force Lab (ETF) at the University of Wisconsin-Stevens Point. 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.

Event samples were analyzed for nitrate + nitrite-N, ammonium– N, total Kjedahl nitrogen, total P, reactive P, chloride, and TSS. Triazine was analyzed during one of the event sampling dates in conjunction with all normal tests. Each sample was collected using the grab method in a 50 mL polypropylene bottle.

Figure 6. Diagram showing the event flow siphon sampler components.



Fecal coliform was also tested during one of the summer events (June) on all the sample sites in the watershed. The fecal coliform samples were collected by grab method using a sterilized 250 mL high-density polyethylene bottle. The samples were taken at least one-foot below the water's surface to ensure that the sun's ultraviolet rays had not altered the number of viable bacteria. To collect the sample, the mouth of the bottle was placed perpendicular to the surface of the water. Once the bottle was submerged at a depth of at least one foot, the bottle was rotated so the mouth was facing downstream, parallel to the current of the river and the sample was collected. The sample bottle was then capped, stored on ice, and returned to the lab for analysis. In the lab three dilutions were made for each sample to insure accurate results.

The analyses run in the Environmental Task Force Lab followed the methodology in Table 2. Nitrate + nitrite–N, ammonium– N, total P, reactive P, TKN, and chloride were all analyzed using Latchet methods. Fecal coliform, total suspended solids, and triazine were all analyzed using standard methods. (Franson, 1995)

Load and yield calculations were used to quanitfy the sub-watershed and land area nutrient inputs at each sample point during baseflow. Load was calculated as the pounds of nutrient passing through a given point of stream per day. Yield was calculated as pounds of nutrient from a given sub-watershed per acre annually. Load and yield was calculated for nitrate, ammonium, TKN, organic-N, total N, reactive P, total P, and chloride. Inorganic N yield was also determined. Both were calculated using baseflow discharges and nutrient concentrations for samples collected on their respective dates.

Table 2. Analytical methods and corresponding detection limits for water quality analyses run in the UWSP Environmental Task Force Lab.

Analyses	**Method**	**Method Detection Limit**
Nitrogen, Nitrate+Nitrite	Automated Cadmium Reduction 4500-NO_3 F	0.021 mg/L
Nitrogen, Ammonia	Automated Salicylate 4500-NH_3 G	0.01 mg/L
Nitrogen, Total Kjeldahl	Block Digester; Auto Salicylate 4500-NH_3 G	0.08 mg/L
Phosphorus, Reactive	Automated Colorimetric 4500 P F	0.003 mg/L
Phosphorus, Total	Block Digestor, Automated 4500 P F	0.012 mg/L
Chloride	Automated Ferricyanide 4500 C1 E	0.2 mg/L
Total Suspended Solids	Gravimetric 2540 D	2.0 mg/L
Triazine	Enzyme Linked Immunosorbant assay	0.05 mg/L
Fecal Coliform	Membrane Filter 922 D	Not applicable

The watershed was delineated using the ESRI CRWR-Preprocessor. A 30 by 30 meter resolution DEM was used with the hydrology coverage. Sample sites were located with a GPS unit, which was then used to create a GIS coverage of the sample points. The sample sites were added as outlets for the final delineation of the Lower Little Wolf Watershed and associated sub-watersheds. The digitized watershed map was then compared to the DNR watershed boundary to check for reliability of the computer-generated watershed. The two delineations were very similar with the only difference being the Southwest portion of the watershed near Vesey Lake. The DNR delineation did not include this area; however, the computer-generated delineation did include this area in the Lower Little Wolf Watershed. Therefore, this area was included in all analyses in this report.

ArcView GIS land coverage's of Wisconsin were obtained from the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND). Land cover data was derived from Landsat Thematic Mapper (TM) satellite imagery acquired from fly-overs from 1991-1993. On the map, each pixel represents a 30 by 30 meter square resolution on the ground.

ArcView GIS 3.2a software was used with land use, soil, hydrology, road and topography coverages for data interpretation. Water quality data was also input into ArcView from database files to compare sub-watersheds within the basin.

WATER QUALITY INTERPRETATION

Nutrients

The presence of human activity in a watershed can affect the storage and movement of nutrients, resulting in an over abundance or lack of nutrients in a system. Excess nutrients can be transported to rivers via groundwater, overland flow, and sedimentation. In stream ecosystems, the effects of nutrient overloading can be difficult to see at a given site, as the water movement reduces the amount of time nutrients are available (residence time) and tree canopy can restrict light, making it difficult for algae to utilize nutrients at a given point. Slower moving streams or more complex stream systems (i.e. drainage type, channel structure) have a longer residence time (Newton, 1999). If the residence time is too short, unattached algae are swept downstream, giving them little chance to increase in population at that location, however, algae can accumulate in areas of slower moving water, such as pools or impoundments, possibly causing a population increase in that area. In addition, as the velocity of the river slows down, the nutrients that are carried by sediments in suspension in the water column also settle out. This settling is typical of impoundments where the residence time is longer due to the slowing of the water at that area. When the algae die, they are decomposed by bacteria. These bacteria consume available oxygen through respiration, reducing oxygen levels in the water.

Nitrogen (N)

Nitrogen is a major nutrient found within the Lower Little Wolf River and its tributaries. In an aquatic ecosystem, nitrogen in its various forms is critical for plant and animal growth and survival. However, an excess of nitrogen can negatively impact the ecosystem, affecting the plant life, invertebrates, fish and humans. For example, as on land, nitrogen can increase plant growth and elevated concentrations can lead to abundant plant growth. This can alter the types of plants and ecological communities that are present.

Nitrogen concentrations can be elevated by human activity such as lawn and agricultural fertilization, and animal and human waste. Nitrogen is transported to surface water bodies through groundwater, surface runoff, sedimentation, and in small quantities, by dry deposition and rain.

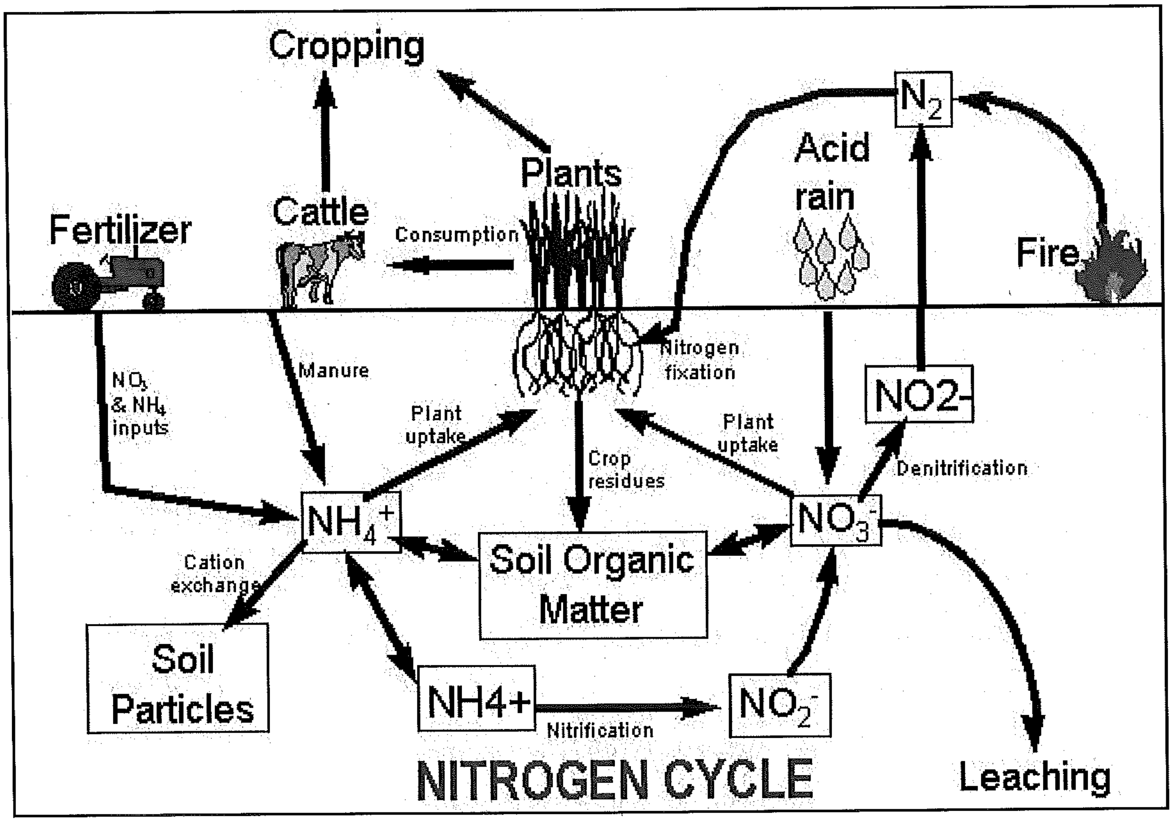
Nitrogen can be found in different forms. The different forms of nitrogen are converted both through biological and physical mechanisms. The nitrogen cycle illustrates how the different forms of nitrogen are derived and transformed (Figure 7). All sources of nitrogen are constantly under the influence of certain natural chemical changes producing the different forms of nitrogen. The most common input of nitrogen in many systems is through groundwater; however, nitrogen can be added at any point throughout the following scenario.

As rainwater falls to the ground, it percolates through soil and picks up nitrates, ammonium, and organic nitrogen. Organic nitrogen is then decomposed through microbiological activity in the soil and transformed to ammonium through the process of denitrification. This ammonium compound is oxidized by two groups of bacteria to form nitrate and an unstable intermediate nitrite product (which we are combining in the label of "nitrates") in a process called nitrification. Ammonium can be adsorbed to clay particles and moved with soil during sedimentation processes. Nitrates are large contributors of nutrient pollution since they are water-soluble and may move through the soil profile to groundwater by the process of leaching. The nitrates can then enter surface water bodies as groundwater recharge causing a constant inflow if nitrogen to the surface water bodies along their entire length.

The forms of nitrogen analyzed in this study included nitrate + nitrite ($NO_2 + NO_3$), ammonia (NH_4), total Kjeldahl nitrogen (TKN) and Total N. NO_3+NO_2-N, or nitrates as they will be referred to as in further discussion are a highly soluble form of nitrogen that is readily available for use by plants. Nitrate that is not utilized by plants can leach out of the soil profile and into groundwater. Nitrate can be input to streams through groundwater if the stream receives groundwater discharge. Most of the streams in the Lower Little Wolf Watershed are baseflow-dominated or have groundwater influences. Natural occurring concentrations of nitrate is typically less than 0.2 mg/L. Federal Drinking Water standards are 10 mg/L. It is unclear how nitrate effects aquatic ecosystems and fish morbidity and mortality. The nitrate in surface and groundwater is derived from sources such as livestock excrement, nitrogenous fertilizers, irrigation return flows, lawn fertilizers, septic systems, and wildlife. The nitrate that is applied to the land through fertilizers and manure spreading can follow several paths. It can either be taken up by plants, degraded by microorganisms in the substrate, removed by leaching of infiltrating water and thus transported into the groundwater, or the nitrate goes through denitrification, a process by which the nitrate is reduced to the gaseous form of nitrogen (Figure 7). Nitrate is extremely soluble, so if allowed to infiltrate the groundwater it will persist unless it is reduced to another form of nitrogen or moves to a discharge region such as a river, lake or wetland. Nitrate can be transported from land to water via overland flow, unsaturated flow, and via groundwater transport. (NCSWQG 2002)

Ammonium (NH_4) is another form of nitrogen pertinent to water quality. Ammonium serves as a secondary source of nitrogen to plant life (NCSWQG 2002). The major sources of NH_4 include livestock waste, fertilizers, and spillage during transport/application of NH_4 fertilizer. Septic systems and improper disposal of household cleaning products containing ammonia are other sources. A natural source of NH_4 release in the environment is wetlands. Wetlands can act as a sink for nutrients like nitrogen with some loss of nitrogen as nitrogen gas, however, given the right conditions ammonium can also be released. Ammonium is transported into rivers via overland flow after a precipitation event. It is also transported to surface water through groundwater discharge. (NCSWQG 2002). In certain conditions ammonia can be toxic to aquatic organisms.

Figure 7. Diagram of the transformation of various forms of nitrogen within the environment in an agricultural area. (University of Minnesota 2000)



Total Kjeldahl nitrogen (TKN) is the last constituent in nitrogen series that was analyzed in this water quality study. TKN is the total concentration of both organic nitrogen and ammonium. It represents the fraction of total nitrogen that is unavailable for plant growth and is bound to organic particles. Both ammonium and organic nitrogen are typically found in surface runoff because of their low solubility in water and bonds with organic particles in the soil. To move these forms of nitrogen, usually the bonded materials must be moved with them to affect water quality. TKN holds the potential for later release of nitrogen in pools, from wetlands or with changing conditions downstream.

Organic nitrogen was also interpreted from the gathered nitrogen data by subtracting the measured ammonium concentration from the TKN. Total nitrogen (total N) includes ammonium, nitrate, and organic N. This concentration was calculated by adding TKN and nitrate. USEPA recommendation levels for total N in streams in this region is less than 0.54 mg/L (USEPA, 2002).

Phosphorus (P)

Phosphorus is another major nutrient that is important to water quality in the Lower Little Wolf River Watershed. In most of Wisconsin's surface water, phosphorus is a limiting nutrient, meaning that plant growth is controlled by the amount of available phosphorus. In these systems, an increase in the level of phosphorus will lead to increased aquatic plant growth. (NCSWQG, 2002)

In the Lower Little Wolf River Watershed, there are numerous sources of phosphorus. Phosphorus can come from animal waste through barnyard runoff, manure applied field runoff, and direct access of livestock into the surface water itself. Dieing vegetation releases phosphorus. Therefore, even trees along a river contribute some phosphorus through leaf drop. Phosphorus is also found in agricultural and lawn/garden fertilizers and over time, phosphorus associated with septic systems can move from the drainfield to groundwater. While infiltrating, phosphorus adsorbs to soil particles, but once the adsorption sites on soil are exhausted, phosphorus can leach into the groundwater and eventually discharge to surface water. Like nitrogen, phosphorus can also be re-released from wetland sediments. Phosphorus is necessary for a healthy aquatic ecosystem, yet in excess it can lead to multiple water problems including: increased aquatic plant growth, taste and odor problems in waters used for human consumption, and oxygen consumption from excessive plant decomposition leading to fish kills. (Shaw 1995)

For this region of the country, acceptable levels of total phosphorus in a freshwater river are considered to be below 0.33 mg/l (USEPA, 2002). Levels typically increase as a result of human activity as excess phosphorus levels enter the environment via human and animal wastes, soil erosion, detergents, septic systems, and runoff from farmlands or lawns (Shaw, 1996).

Most often, phosphorus is measured as soluble reactive phosphorus, known as reactive P, and total phosphorus (total P) (Shaw, 1996). Reactive P is principally the inorganic dissolved form orthophosphate, which is a form that is readily available for plants and animals to use. Total p includes both organic P and reactive P. Total P includes less soluble forms of phosphorus, some of which may be less bio-available in the short term than other constituents in water. It is usually adsorbed to soil or organic matter and most often enters a river system via overland flow during runoff events. Particles will settle out in areas of lower velocity and as temperature, pH, and oxygen conditions change, the phosphorus can be released from the particle, changing to more soluble forms of phosphorus that can readily be taken up by plants.

Chloride

Chloride is not a nutrient nor toxin on its own, but it is an indicator of pollutants within the river system because elevated chloride usually signals the evidence of human activity. Where there is chloride there may be nitrates and other nutrients, which are coming into the river system. Sources of chloride include septic systems, animal waste, potassium chloride fertilizer, pesticides, and drainage from road-salting chemicals (Shaw, 1996). As microorganisms do not degrade chloride and it does not react with soil, it readily moves to the river. Numerous studies show that when chloride is moving to the river primarily via groundwater the concentrations tend to be higher during baseflow conditions (Barker, 1986). If chloride is moving to the system via runoff, concentrations will be elevated during runoff events and lower during baseflow.

Total Suspended Solids (TSS)

Total suspended solids (TSS) are the amount of solids, both organic or mineral, that remain ‘suspended’ within the water column (Hamel, 2002). Although suspended solids occur naturally through storm events and fish activity, they are also influenced by runoff from commercial, agricultural, and residential land uses within a watershed where soils are exposed or cultivated. During rainfall, snow melt, or wind storms, soil can be carried by either water or wind and deposited in low areas such as rivers. TSS can also move to a river through conduit discharges such as storm sewers and municipal or industrial effluent pipes or over impervious surfaces such as roads and driveways. Once in the system, bottom feeding fish like carp re-suspend sediment that has settled to the bottom of a river.

High concentrations of TSS can transport other constituents, such as pesticides, phosphorus, nitrogen, and bacteria that adhere to soil colloids and travel into the river through overland flow during a storm event. (USEPA, 2000 and Hamel, 2002). Excess TSS can also turn water murky; therefore, limiting the amount of sunlight able to reach the rivers. The decrease in sunlight inhibits plant growth in rivers. This loss of aquatic vegetation can increase the level of TSS by causing the riverbed to become unstable and increasing susceptibility to bank erosion. Another problem associated with high TSS is an increase in water temperature. When the river is a dark, murky color it will absorb light, therefore increasing the water temperature and inhibiting invertebrate and fish habitat by lower oxygen concentrations (Murphy, 2000).

The suspended particles, tinier than a grain of sand, may eventually settle to the river bottom where the velocity slows. This can blanket fish breeding or macroinvertebrate habitat, making those areas less desirable for use by some species. TSS can also affect various fish and aquatic species by creating a more turbid environment, making it harder to see.

Fecal Coliform

Fecal coliform are bacteria derived from the intestinal tract of warm-blooded animals. This bacteria is found naturally in surface water due to excretions from wildlife such as muskrat and white-tailed deer, waterfowl. Other sources of the bacteria include feedlots, landspreading of manure, and failing septic systems (Christensen, 1996). Fecal coliform multiply in warm and moist conditions, and in a river with varying temperatures, the number of fecal coliform in the river is not easily measured. Fecal Coliform can multiply more quickly in warm water with little sunlight, as ultraviolet rays can kill fecal coliform (Hamel, 2001).

Fecal coliform is responsible for the closure of many swimming beaches within Wisconsin (Lauhn-Jensen, 1995 and Hamel, 2002). Swimming in water with high levels of fecal coliform can lead to an increased chance for illness because pathogens may enter the mouth, ears, and cuts in the skin (Murphy, 2000). Therefore, keeping the levels of fecal coliform below the 200 MFFCC (membrane filter fecal coliform colonies/ 100 mL of water sample) health standard for beaches is a desirable goal. UV radiation and temperature outside the preferred range can quickly lead to the mortality of fecal coliform.

Atrazine

Atrazine, an herbicide, is one of the most frequently used selective pesticides in the United States. Atrazine was most widely used between 1987 and 1989 throughout the Midwest, including Wisconsin, however it is still quite widely used today (USEPA, 2001). Atrazine is taken up through plant roots and foliage and inhibits the growth of the plants by limiting photosynthesis (Oregon State University, 1996). Its primary function is to control broadleaf and annual grasses (NCSWQG, 2002). It is a potential health hazard to humans and animals with a federal drinking water standard of 3 ug/L. It belongs to the chemical group of Triazine which also includes other herbicides such as simazine, cyanazine, and propazine.

If atrazine is used, following current application rates and procedures can reduce its effect on the aquatic environment. Atrazine is classified as being very persistent in the soil substrate, although soil microorganisms can degrade atrazine at shallow depths (Oregon State University, 1996). In areas of low to medium clay content, similar to the some of the subsurface conditions in the Lower Little Wolf River Watershed, atrazine is very mobile through the soil horizons, therefore readily moving to groundwater.

Atrazine can move to water bodies via overland flow during rainstorms or via groundwater flow discharging to the water bodies. In river systems, the main concern with this chemical is the detrimental effects to aquatic biota. Toxicity to some aquatic plants occurs above 10 ug/L, however, more sensitive species can be affected by lower concentrations. Aquatic plant and animal community structure can be altered at concentrations above 10 ug/L (USEPA, 2001).

RESULTS AND DISCUSSION

Water samples were collected during both base flow and storm/snow melt events throughout the year from the Lower Little Wolf Rivers 13 sampling sites (Figure 8). All samples were collected and tested using standard methods as defined in the 16th Edition of "Standard Methods for the Examination of Water and Wastewater".

All standard units of measurements were used throughout this study:

- Nitrate and Nitrite, Ammonium-Nitrogen, Total Kjeldahl Nitrogen, Total Phosphorus, Reactive Phosphorus, Total Suspended Solids, and Chloride concentrations were measured as milligrams per liter (mg/L) which for the concentrations measured in this study, is approximately equivalent to parts per million (ppm) in water.
- Triazine measured in micrograms per liter (ug/L), or parts parts per billion (ppb). In this study, triazine samples were collected once during a spring runoff event in early June 2001.
- Fecal coliform is measured in membrane filter fecal coliform colonies per 100 mL of sample (MFFCC/100 mL). All fecal coliform measurements were taken during runoff events. Following each event, these fecal coliform numbers should return to a much lower count. This period between events is when most swimming recreation is taking place and therefore, it may be difficult to generalize the results of this study for contact recreation and additional baseflow testing would be recommended.

The Lower Little Wolf Watershed is a complex system with variations in topography, soil, hydrologic and land use. These variations affect the water quality in the tributaries and river as control the relationship between surface and groundwater, the amount of runoff from a given storm, and the movement of soil particles. Land use practices can significantly effect the impacts of a given land use. For example, best management practices can be employed to reduce soil movement by covering the land with vegetation or diverting water through vegetated or flat areas to slow water and/or filter particles. Agricultural best management practices such as management intensive grazing and nutrient management can reduce inputs to groundwater. In a residential setting impacts to surface water quality can be reduced by minimizing mowed areas, eliminating or reducing lawn and garden fertilizers and pesticides, minimizing impervious surfaces, setting back septic systems, and pre-treating stormwater effluent. Leaving or replacing vegetative buffers along streams can help to slow water movement to a stream, which can allow vegetation to filter particulates and utilize some of the nutrients being carried with surface runoff. Due to the variation in soil, topography, hydrology, and distance from a stream, the effectiveness of a specific land use practice will vary throughout the watershed.

Figure 8 shows the sub-watersheds based on the sample sites. Table 3 shows the percent land use for each of the sub-watersheds. The following describes each sub-watershed including current landuses, basic hydrology and soils, and water quality conditions. This discussion will be followed by baseflow load and yield estimates for each sub-watershed. Summary of the public meeting conclude the results and discussion section of the report. Digital photographs were taken at each sample site to visually document current conditions and can be found in the Appendices of electronic versions of this report.

Figure 8. Map of Lower Little Wolf River Watershed showing sub-watershed boundaries and respective sample site numbers.

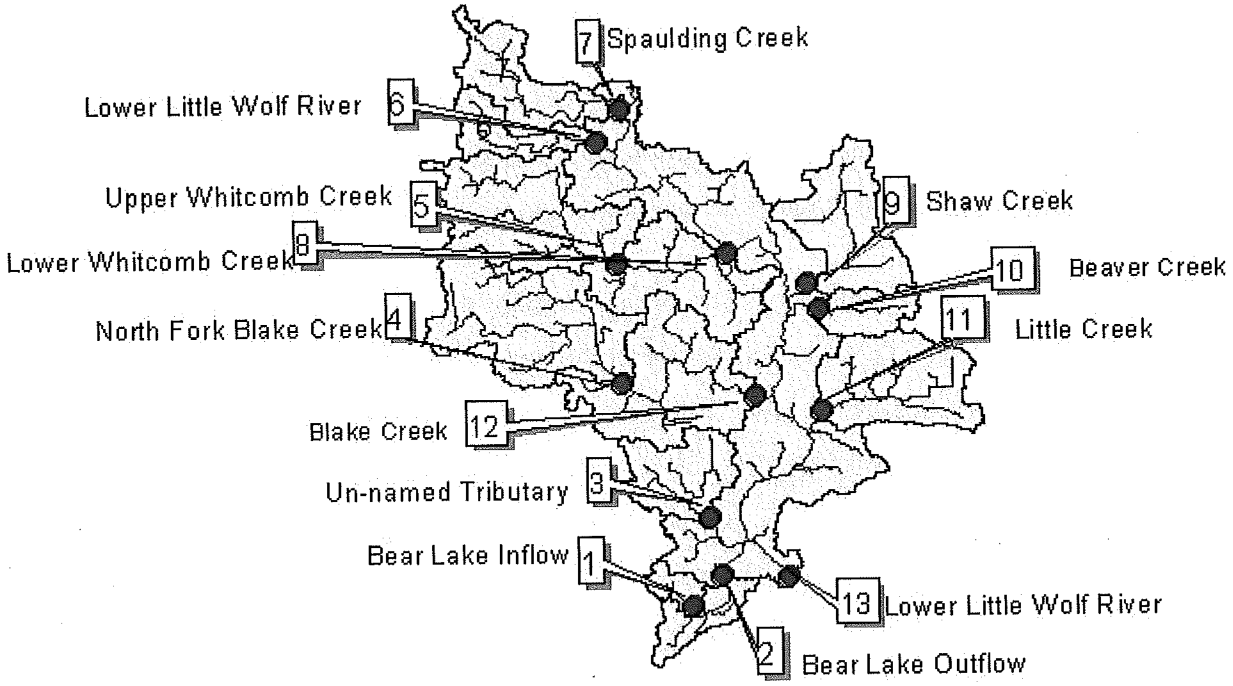


Table 3. Land uses in the sample site sub-watersheds of Lower Little Wolf River Watershed. The upper table shows percent land use, and the lower table shows acres of land use.

	Percent Land Use								
Sub-watershed	Sample Site	Urban-Low Intensity	Urban-High Intensity	Agriculture	Grassland	Forest	Open Water	Wetland	Barren
Bear L. Inflow	1			36	8	38	6	12	0.4
U& L Bear Lake	2			55	5	13	8	16	3
Thiel) — Unnamed Trib.	3			59	3	6		30	2
N. Fork Blake Cr.	4			15	18	43	2	22	0.1
U. Whitcomb Cr.	5			10	16	48	0.2	26	0.2
L. Little Wolf River	6			10	19	45	2	24	0.0
Spaulding Cr.	7			6	9	54	0.2	30	0.0
L. Whitcomb Cr.	8			48	5	21	2	22	0.9
Shaw Cr.	9			42	0.5	15	0.1	42	0.7
Beaver Cr.	10			70	3	5	0.0	20	2
Little Cr.	11			65	0.6	6	0.1	28	1
U & L Blake Cr.	12			54	7	11	0.3	27	2
All site LLW	13	0.8	1.0	58	6	15	0.9	14	2

	Acres of Land Use									
Sub-watershed	Sample Site	Urban-Low Intensity	Urban-High Intensity	Agriculture	Grassland	Forest	Open Water	Wetland	Barren	Total
Bear L. Inflow	1			369	79	383	64	122	4	1021
U& L Bear Lake	2			1281	119	301	196	369	73	2339
Unnamed Trib.	3			2711	150	293	1	1375	94	4624
N. Fork Blake Cr.	4			1691	2058	4862	256	2470	11	11348
U. Whitcomb Cr.	5			1050	1644	4946	21	2657	21	10339
L. Little Wolf River	6			284	556	1320	68	689		2917
Spaulding Cr.	7			338	470	2846	9	1591		5252
L. Whitcomb Cr.	8			3620	407	1550	182	1645	70	7475
Shaw Cr.	9			2922	38	1011	10	2964	51	6996
Beaver Cr.	10			1666	75	123		468	38	2371
Little Cr.	11			5013	44	438	9	2154	80	7737
U & L Blake Cr.	12			5473	683	1095	33	2697	156	10136
All site LLW	13	244	282	16720	1849	4317	268	4191	511	28381

Spaulding Creek

This is the northern-most sampled site in the watershed. Sample site 7 is located beneath a bridge on Spaulding Road off of Highway G. Here, a vegetative-buffered lowland area protects Spaulding Creek. Vegetation such as tag alder and reed canary grass line the creek banks. Clear brown water runs over the sandy streambed, which contains a high content of leaf litter. The nine square-miles of Site 7's sub-watershed drains towards Spaulding Creek. Primary landuses in this sub-watershed include forest (54%) and wetland (30%) shown in Table 3. Soils are well-drained loam. This is a perennial stream and receives much of its water from groundwater. Portions of its 10-mile stretch are designated by the Wisconsin DNR as Class I trout fisheries (WDNR, 1999).

Overall, the water quality of Spaulding Creek was quite good as there were low concentrations of nutrients and chloride. This river could serve as a good background/target level for the other sub-watersheds in the Lower Little Wolf Watershed that are located to the west of the Lower Little Wolf River, as they are of similar soil type. Few negative water quality impacts to the Lower Little Wolf River were coming from this sub-watershed.

Minimum, mean, and maximum concentrations and number of baseflow samples are displayed in Table 4. Concentrations of nitrate, chloride, reactive P and ammonium were all low during baseflow conditions, indicative of the groundwater that is feeding Spaulding Creek. Concentrations of these constituents were also low during event conditions however, total P was slightly elevated and TSS increased during some of the events (Table 5). This suggests that runoff is bringing some sediment and total P into the stream. Sources of total P and TSS could include near-stream direct runoff and/or bank erosion. Some re-release of nutrients such as ammonium and reactive P from wetland systems during storm events is a natural process. Ammonium, phosphorus , and low chloride concentrations in the event samples suggest minor wetland influences in this sub-watershed. This is not surprising as wetlands comprise approximately 30% of the landuse. Chloride concentrations were among the natural levels typically found in this region of the state.

Fecal coliform counts at Site 7 during the June storm event were 3,110 MFFCC/100mL. These counts were well above the safe level for swimming recreation of 200 MFFCC/100mL; however they were average compared with the rest of the sub-watersheds. Triazine was detected in the water, indicating some agricultural impacts to Spaulding Creek.

Table 4. Site 7 baseflow water chemistry data. Results are shown in mg/L.

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.50	2.5	0.017	*	0.002	0.01
Mean	0.61	2.5	0.019	*	0.003	0.01
Max	0.71	2.5	0.021	*	0.004	0.01
n	2	2	2		2	2

Table 5. Site 7 eventflow water chemistry data. Results are shown in mg/L except fecal coliform (MFFCC/100 mL) and Triazine (ug/L).

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal Coliform	Triazine
Min	0.05	0.5	0.042	0.76	0.002	0.005	6.0	3100	0.025
Mean	0.47	1.6	0.097	1.07	0.014	0.028	15.7	3100	0.043
Max	1.29	2.5	0.219	1.72	0.035	0.060	26.0	3100	0.060
n	7	7	7	6	7	7	7	1	2

Whitcomb Creek

Two sites were sampled in Whitcomb Creek; Site 5 represents water from the upper portion of the watershed and Site 8 receives water from the entire watershed. Site 5 was located on County Highway E, where Whitcomb Creek runs through two culverts below the road. The stream bottom at this site consists of sandy substrate along with a small amount of rubble. The creek is well buffered with abundant dogwood and willow shrubs. Water was clear brown, indicating organic acids derived from flow through upstream wetlands. Site 5's sub-watershed is 17 square-miles and includes Whitcomb Creek and the South Fork of Whitcomb Creek. Moen Lake is the only lake found within this sub-watershed. Primary landuses are forest (48%), wetland (26%), and grassland (16%) (Table 3).

Overall, Upper Whitcomb Creek had good water quality (Tables 6 and 7). Nitrate and chloride concentrations were relatively low. However, during most storm events, total P exceeded 0.033 mg/L, and total nitrogen exceeded 0.54 mg/L, concentrations that are great enough to enhance aquatic plant growth. These inputs may be related to release from wetlands, however, during the November event, the total suspended solid concentrations also rose. It is likely that these inputs were a result of fields with exposed soil. When compared with historic data, Upper Whitcomb Creek had similar water chemistry and had shown little change since

1996 (WDNR, 1997). Fecal coliform was 2,300 MFFCC/100mL during the June runoff event. The most likely sources of fecal coliform would be wild and/or domestic animals. Triazine concentrations were 0.025 ug/L. These concentrations indicate the presence of atrazine or degradation by products, but not at concentrations great enough to impact most aquatic biota.

Table 6. Minimum, mean, and maximum water chemistry concentrations for Site 5 during baseflow. (Units are mg/L.)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.80	3.0	0.010	*	0.002	0.01
Mean	0.83	3.3	0.019	*	0.003	0.01
Max	0.86	3.5	0.028	*	0.004	0.01
n	2	2	2		2	2

Table 7. Minimum, mean, and maximum water chemistry concentrations for Site 5 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	0.5	0.035	0.45	0.002	0.005	12.0	2300	0.025
Mean	0.54	2.2	0.066	1.13	0.009	0.020	28.2	2300	0.025
Max	0.93	3.0	0.129	2.01	0.025	0.080	53.0	2300	0.025
n	7	7	7	6	7	7	7	1	1

The downstream sample site in the Whitcomb Creek sub-watershed was Site 8. The samples were collected near a moderately buffered stretch of Whitcomb Creek on County Highway OO, with row crops and residential areas surrounding it. The riparian area consisted mainly of deciduous trees that grow along the moderately covered banks, along with other shrub species such as tag alder. The water was clear brown and the streambed was sand, rubble, and fine-sediment-covered bottom. From Site 5 to Site 8, 12 square-miles of additional land drains to the stream at Site 8, with agriculture making up the bulk of this additional land use (48%), followed by wetlands (22%), and forests (21%). As the river flows east through Site 5 on to Site 8, there is a significant change in land use from predominantly forests to predominantly agriculture, resulting in changes in the water chemistry (Tables 8 and 9). The combined Whitcomb Creek sub-watershed that drains to Site 8 (sub-watershed 5 plus sub-watershed 8) is approximately 28 square-miles. The primary land uses in the entire Whitcomb Creek sub-watershed were forests (37%), agriculture (26%), and wetlands (24%). Water collected at Site 8 represents what is leaving this tributary and contributing to the Lower Little Wolf River.

The concentrations of all constituents tested increased from Site 5 to Site 8. Average nitrate and chloride concentrations were slightly higher at Site 8 than Site 5. These concentrations were generally greater during baseflow conditions than runoff events, indicating that groundwater is the primary source. However, the greatest chloride concentration (6mg/L) was measured during the November storm; this event also had the greatest concentrations of total P (0.111 mg/L), and reactive P (0.044 mg/L).

The fecal coliform counts at Site 8 during the June event were well above the safe level for swimming recreation of 200 MFFCC/100mL with a count of 10,500 MFFCC/100 mL. This was the highest count of fecal coliform within the Lower Little Wolf River watershed for that date. The land uses in this sub-watershed suggest the input derived from domestic animals in the sub-watershed; however, the only way to definitively differentiate between domestic and wild animals as a source of fecal is through DNA analysis. Triazine was analyzed twice during a June event (at different points in the hydrograph). Concentrations in these samples were 0.025 and 0.070 ug/L.

Table 8. Minimum, mean, and maximum water chemistry concentrations for Site 8 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.98	4.5	0.029	*	0.008	0.01
Mean	1.04	4.8	0.030	*	0.010	0.02
Max	1.10	5.0	0.030	*	0.011	0.04
n	2	2	2		2	2

Table 9. Minimum, mean, and maximum water chemistry concentrations for Site 8 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	1.0	0.048	0.92	0.014	0.030	1.0	10500	0.025
Mean	0.49	3.4	0.074	1.09	0.030	0.068	11.4	10500	0.048
Max	0.80	6.0	0.111	1.34	0.054	0.180	27.0	10500	0.070
n	7	7	7	6	7	7	7	1	2

Shaw Creek

Shaw Creek was sampled in one location at Site 9. This site was located on Cleveland Rd. off of County Highway OO. There was very little vegetative buffer between the stream and the surrounding agricultural fields. Bank cover was minimal, consisting of only a few trees. The water was clear brown with some suspended sediment and flowed over a sandy bottom at Site 9. Eleven square-miles of land drains to Shaw Creek. Primary land use within this sub-watershed consisted of wetlands (42%) and agriculture (42%) (Table 3). The upper 2/3 of the floodplain and streambed soils are very poorly drained Cathro-Markey mucks and therefore, the stream flow is extremely flashy. The lower portion of the floodplain is predominantly well-drained Kennan-Rosholt loamy soils. Most of the groundwater inflow to the creek is likely discharging to the creek in the lower 1/3 of its length, where the well-drained soils are located.

Nitrate and chloride concentrations were elevated during both baseflow and runoff events. Average nitrate concentrations at Site 9 were relatively high in comparison to the rest of the watershed (Tables 10 and 11). These elevated concentrations are primarily due to agriculture. Triazine was detected during the June runoff event. Phosphorus (total and reactive) and ammonium concentrations were elevated during runoff events in comparison to baseflow. Sources of these nutrients are a combination of natural wetlands and agricultural runoff. The runoff event sampled in March 2001 had the highest concentrations of chloride, total and reactive P, nitrate, total Kjedahl nitrogen, and ammonium. These inputs were likely from winter land-spread manure.

Average total suspended solid concentrations were quite variable, with the highest concentrations measured in June. These solids moved to the river following spring planting while field soil was relatively bare. Fecal coliform counts at Site 9 during the June event were 5,000 MFFCC/100mL, well above the safe level for swimming recreation of 200 MFFCC/100mL. The land uses in this sub-watershed suggest the coliform originated from wild and/or domestic animals as it is comprised of mainly wetland and agricultural areas. Only one sample was collected from Shaw Creek in 1995. Current nitrate concentrations are greater than what was measured in that sample and total and reactive P concentrations are about the same.

Table 10. Minimum, mean, and maximum water chemistry concentrations for Site 9 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	2.00	9.0	0.048	*	0.027	0.01
Mean	3.01	10.3	0.049	*	0.028	0.08
Max	4.01	11.5	0.050	*	0.028	0.15
n	2	2	2		2	2

Table 11. Minimum, mean, and maximum water chemistry concentrations for Site 9 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal Coliform	Triazine
Min	0.60	4.5	0.045	0.97	0.017	0.010	3.0	5000	0.170
Mean	1.20	7.9	0.163	1.99	0.069	0.220	37.2	5000	0.250
Max	2.50	14.5	0.287	3.12	0.190	0.820	81.0	5000	0.330
n	6	6	6	5	6	6	6	1	2

Beaver Creek

Beaver Creek was sampled at Site 10, which was located off of County Highway O. The site was located in a grass waterway, intentionally planted with cattails and reed grass to reduce the runoff to the creek. Floodplain soils are predominantly poorly-drained Angelica silt loam and Hortonville-Symco soil in much of the sub-watershed. Approximately four square-miles of land drains to Site 10. The primary land uses within this sub-watershed included agriculture (70%) followed by wetlands (20%).

Most of the flow in Beaver Creek occurs during storms or thaw events, which is anticipated for these poorly-drained soils. Chemical inputs to the creek are primarily from runoff rather than groundwater discharge. Agricultural impacts were evident in all chemistries (Tables 12 and 13). Chloride and ammonium concentrations were always elevated, with chloride exceptionally high during baseflow and the July event (26.5 – 39.5 mg/L, respectivly). The source of increased chloride and ammonium during baseflow may have been animal waste applied to the fields that lie adjacent to Beaver Creek or fertilizers applied to cropland within the sub-watershed. Average triazine concentrations were 3.72 in the Beaver Creek sub-watershed. This is high for surface water and in comparison to the rest of the Lower Little Wolf watershed. The high concentrations reflect the high percentage of cropped agriculture within the sub-watershed as well as the clay soils. Application amount and timing should be reviewed for this and other pesticides and should be adjusted to reduce/prevent loss to Beaver Creek. Phosphorus (total and reactive) and total nitrogen were very high compared with most other sub-watersheds. TSS was low on average, indicating that the presence of grasses long the stream bank is successful in reducing sediment inputs to Beaver Creek. The exception was during the June storm where TSS was 31 mg/L. This occurred when fields were recently planted and devoid of protective vegetation. Due to the lack of flow in Beaver Creek during baseflow conditions, loads and yields could not be estimated. Fecal coliform was relatively low in comparison to the rest of the watershed at 800 MMFFC/100mL, however, still above the swimming health standard of 200 MFFCC/100mL.

Table 12. Minimum, mean, and maximum water chemistry concentrations for Site 10 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.10	26.5	0.107	*	0.040	0.12
Mean	0.15	33.0	0.279	*	0.056	0.43
Max	0.20	39.5	0.450	*	0.072	0.74
n	2	2	2		2	2

Table 13. Minimum, mean, and maximum water chemistry concentrations for Site 10 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	10.5	0.084	1.11	0.041	0.020	1.0	800	2.870
Mean	0.76	15.0	0.189	1.59	0.125	0.060	9.0	800	3.715
Max	2.50	31.5	0.278	2.00	0.226	0.140	31.0	800	4.560
n	6	6	6	6	6	6	6	1	2

Blake Creek

Blake Creek was sampled at two sites, Site 4 represents water quality in the North Fork of Blake Creek and the more downstream Site 12 represents Blake Creek. At Site 4, the North Fork of Blake Creek runs 20-30 feet wide underneath the well-traveled State Highway 161 bridge. Sand, boulders, and patches of rooted aquatic vegetation made up the stream bottom near the sampling site. The creek flowed through a wetland area south of the bridge. Water was clear brown, indicating a high level of natural organic acids from upstream wetlands. The banks were well buffered with grasses such as reed canary, shrubs such as willow and tag alder, and deciduous trees.

There are 18 square-miles of land that drain to Site 4. This sub-watershed consisted of mixed land uses including forests (43%), wetlands (22%), grassland (18%), and agriculture (15%) (Table 3). The North and South Fork of Blake Creek flow through this sub-watershed, and it contains four named lakes: Goodhal, Gregerson, Lutz, and Hatch. Predominant soils in the sub-watershed are well-drained loamy Kennan-Rosholt. North Fork of Blake Creek, is a 14-mile tributary of the North Branch of the Little Wolf River and is classified by the Wisconsin Department of Natural Resources as Class II trout waters above Highway 161 and a warm water sport fishery below Highway 161(WDNR, 1999).

Chloride concentrations were similar for both baseflow and runoff events (Tables 14 and 15). Chloride ranged from 3 to 5.5 mg/L. Nitrate was slightly elevated during baseflow, indicating inputs from groundwater discharge. Triazine concentrations were 0.025. During events, total P concentrations were frequently elevated along with reactive P and ammonium. These inputs were due to movement of particles with surface runoff and wetland influences. The March runoff event contained the highest concentrations of these chemistries, likely associated with winter land-spread manure. For most of the events, TSS concentrations were low in relation to the rest of the watershed. This is most likely due to the highly buffered riparian areas of the North Fork of Blake Creek. The higher concentrations of TSS occurred during the June and August events. Fecal coliform in June was 5,000 MFFCC/100mL. Compared to historic water quality, concentrations of total P and nitrates were similar, however, TSS are about half of what was previously measured. This may be due to the best management practices that have been implemented in this sub-watershed with the assistance of the Priority Watershed Project.

Blake Creek was sampled at Site 12, located on State Highway 110 where the creek flows under the bridge. Near the sample site there was a moderate buffer consisting of reed grass, willow, and planted spruce. Agricultural fields were located adjacent to this buffer. The water clarity/color was milky brown. Sixteen square-miles of land comprise the sub-watershed between Sites 4 and 12. Primary land uses within this sub-watershed included agriculture (54%) followed by wetlands (27%). Surface water features include Storm Lake located just southwest of the sampling site. The total sub-watershed draining to Site 12 includes the Site 4 sub-watershed plus the Site 12 sub-watershed. A change in land use can be seen as the river flows downstream, from predominantly forested to predominantly agricultural land use. Land use in this combined 34 square-mile sub-watershed was as follows: agriculture (33%), forests (28%), wetlands (24%), and grassland (13%).

Tables 16 and 17 show the water quality and number of samples collected at Site 12. Nitrate concentrations were slightly greater during baseflow conditions than during the events. Chloride concentrations were elevated (7 to 9.5 mg/L) during both flow regimes. During events, total P (average 0.084 mg/L), reactive P (average 0.044 mg/L), and ammonium (average 0.122 mg/L) were elevated. This can be due to agricultural inputs, but also linked to the presence of wetlands. The greatest concentrations of phosphorus, nitrogen, TSS, and chloride were during the March runoff event. This combination of inputs is indicative of animal waste entering the river, likely from winter land- spread manure. TSS ranged from 2 – 20 mg/L during the events. The highest concentrations occurred in the March and June events, carrying nutrients with the particulates during these events. Fecal coliform counts were 4,400 MFFCC/100 mL, again above the 200 MFFCC/100 mL swimming standard. Triazine was detected in the June sample, but at fairly low concentrations. During baseflow conditions higher concentrations of dissolved nutrients and chloride were measured at Site 12 as compared to Site 4. Concentrations during events at Site 12 were consistently greater for total and dissolved nutrients, chloride, fecal coliform, suspended solids, and triazine.

Table 14. Minimum, mean, and maximum water chemistry concentrations for Site 4 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	1.36	4.5	0.015	*	0.003	0.01
Mean	1.53	5.0	0.021	*	0.004	0.02
Max	1.70	5.5	0.026	*	0.004	0.03
n	2	2	2		2	2

Table 15. Minimum, mean, and maximum water chemistry concentrations for Site 4 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	3.0	0.036	0.78	0.002	0.005	3.0	5000	0.025
Mean	0.85	4.3	0.051	0.96	0.011	0.027	14.5	5000	0.025
Max	1.32	5.0	0.075	1.19	0.033	0.060	26.0	5000	0.025
n	8	8	8	7	8	8	8	1	1

Table 16. Minimum, mean, and maximum water chemistry concentrations for Site 12 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	1.18	7.5	0.023	*	0.008	0.01
Mean	1.34	7.8	0.039	*	0.009	0.02
Max	1.50	8.0	0.055	*	0.010	0.04
n	2	2	2		2	2

Table 17. Minimum, mean, and maximum water chemistry concentrations for Site 12 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	7.0	0.021	0.73	0.002	0.020	2.0	4400	0.150
Mean	0.71	8.1	0.098	1.11	0.051	0.145	11.5	4400	0.150
Max	1.00	9.5	0.230	1.89	0.145	0.470	21.0	4400	0.150
n	6	6	6	5	6	6	6	1	1

Little Creek

Little Creek was sampled at one downstream site. Site 11 was located off County Highway O at the intersection with Little Creek Road. The creekbed showed high sedimentation on the downstream side of the bridge, where the river widens. Surface vegetation such as duckweed was observed in small pockets. The water color was brown. The stretch of the river on the west side of the bridge was narrower than the east side, with clear water running over a sandy bottom. Site 11 has 13 square-miles of land that drains to it. Primary land use in this sub-watershed consisted of 65% agriculture followed by 27% wetlands (Table 3). Floodplain soils have pockets of very poorly-drained Seelyeville muck; the watershed soils are predominantly well-drained Hortonville fine sandy loam.

Little variability of chloride and nitrate concentrations occurred between baseflow and runoff events, indicating minimal groundwater discharge to the river (Tables 18 and 19). This relationship is supported by low discharge measured during baseflow (1.06 cubic foot per second). Significant concentrations of total P and nitrogen were entering the river via runoff during events throughout the year. Total suspended solid concentrations were quite variable (ranging from 2 to 63 mg/L); the greatest concentrations of TSS occurred during the June event, when fields had minimal vegetative growth. Fecal coliform was above the swimming standard, with an average concentration of 620 MFFCC/100mL.

The average concentration of triazine (17.75 ug/L) in Little Creek was significantly greater than the any of the other samples acquired in the Lower Little Wolf watershed. The use of atrazine with muck soils in the sub-watershed allowed for a tremendous amount of atrazine to reach the river. These concentrations were well above drinking water standards of 3 ug/L and above the 10 ug/L indicated to effect plant and animal communities. Use of pesticides in agricultural practices in this watershed should be addressed. Timing and application should be refined and agricultural practices using little or no pesticides should be considered. Private wells located in this watershed should be tested for atrazine contamination.

Table 18. Minimum, mean, and maximum water chemistry concentrations for Site 11 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.70	9.0	0.059	*	0.041	0.01
Mean	1.10	13.0	0.219	*	0.123	0.14
Max	1.50	17.0	0.379	*	0.205	0.26
n	2	2	2		2	2

Table 19. Minimum, mean, and maximum water chemistry concentrations for Site 11 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal Coliform	Triazine
Min	0.05	10.0	0.099	1.42	0.053	0.040	3.0	620	12.800
Mean	1.18	13.1	0.258	2.15	0.126	0.266	29.6	620	17.750
Max	2.82	17.0	0.392	2.82	0.197	1.010	63.0	620	22.700
n	7	7	7	6	7	7	7	1	2

Thiel Creek

Un-Named Tributary of Lower Little Wolf River

Site 3 was located off of County Highway B on Spring Creek Road where the creek flows through wooded pasture. This creek had little flow except during events. The stream bottom consisted of leafy debris and vegetated bank cover was minimal. The water was observed to have high turbidity and suspended solids. The upper portion of this sub-watershed is comprised of poorly drained mucky soils and the lower end has Hortonville and Plainfield loamy sands.

This results in low to no flow during baseflow conditions (little groundwater discharge to the stream) and much higher flow during events. The 8 square-miles of land that drains to Site 3 consisted of agriculture (59%) and wetlands (30%) (Table 3). There are no named open bodies of water within this sub-watershed.

Nitrate concentrations were relatively low during both baseflow and events (Tables 20 and 21). The March runoff event produced elevated concentrations of chloride, phosphorus, nitrogen, and suspended solids. Phosphorus always exceeded the concentrations necessary to enhance algae and aquatic plant growth. Some of this may be contributed by the mucky substance with high organic matter. Nitrogen was greatest in the form of organic nitrogen. Triazine levels averaged at 0.105 ug/L and the fecal coliform count during the June event was 7,000 MFFCC/100mL.

Table 20. Minimum, mean, and maximum water chemistry concentrations for Site 3 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.03	7.0	0.306	*	0.219	0.18
Mean	0.04	13.3	0.743	*	0.725	0.69
Max	0.05	19.5	1.180	*	1.230	1.20
n	2	2	2		2	2

Table 21. Minimum, mean, and maximum water chemistry concentrations for Site 3 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.04	7.0	0.144	1.21	0.077	0.020	1.0	7000	0.090
Mean	0.50	10.4	0.249	2.06	0.146	0.378	6.2	7000	0.105
Max	1.10	16.0	0.344	4.37	0.191	1.680	13.0	7000	0.120
	6	6	6	5	6	6	6	1	2

Bear Lake Sub-Watershed

The Bear Lake Watershed was sampled at two sites. Site 1 was located on the southern tip of the watershed and upstream from Bear Lake on a tributary of the Little Wolf River. Site 2 was located in the outflow of Bear Lake. Site 1 is flashy, with most of its flow during runoff and storm events. The stream bottom at Site 1 was covered with leafy debris. Vegetative cover on the stream banks was minimal, with trees as the primary riparian cover. Soil type in the floodplain is Seeleyville muck, however much of the upland soils are well-drained Hortonville loams. Site 1 has 1.7 square miles of land contributing to it, with mixed land use consisting of forests (38%), followed by agriculture (36%), and wetlands (12%) (Table 3). Bodies of water found within this sub-watershed are Vesey, Fox and Woodworth lakes as well as unnamed stretches of river, together comprising 6% of the sub-watershed.

Water quality within the stream is predominantly affected by events and only minimally by groundwater discharge consistent with the flashiness of the stream during runoff events and the minimal stream bank buffer. Nitrate concentrations were low during both baseflow and events (Tables 22 and 23). Chloride was elevated during baseflow, and events indicating human-related inputs to the system. Ammonium, total P, and reactive P were elevated during events along with TSS. During events TKN concentrations were higher than ammonium concentrations indicating nitrogen that is moving to the system is doing so via particulates. Movement of TSS along with total P was most significant during the June runoff event, with concentrations as great as 892 mg/L and 1.7 mg/L, respectively. These inputs were likely a result of the exposed muck soils following planting. Concentrations may be reduced during these large events by improving the vegetative buffers along the stream bank. The fecal coliform within the upper Bear Lake sub-watershed was the lowest of the samples collected in the Lower Little Wolf River Watershed, with an average concentration of 260 MFFCC/100mL. The triazine concentrations in the June sample were as high as 0.2 ug/L.

Site 2 was located in Spielberg Creek, at the outflow of Bear Lake. The 190-acre lake is located between Site 1 and Site 2. This natural drainage lake has a maximum depth of 62 feet.

Residence time (the amount of time water spends in the lake) is approximately 4 years. A study of the lake water quality and plant survey was conducted at the University of Wisconsin-Stevens Point between 2000/01. More detailed information about the lake and it nutrient balances can be found in "An Evaluation of Past and Present Water Quality Conditions in Bear Lake, Waupaca County, Wisconsin" (Cramlet and Turyk, 2002).

The stream bottom at Site 2 was comprised of sand and sediment with a large population of emergent and/or submergent vegetation. The west bank had mowed lawn to its edge, while grasses and some shrubs buffered the east bank. The sub-watershed draining to Site 2 is comprised of 5.2 square miles of land. Bear Lake is the primary feature in this sub-watershed, as well as unnamed stretches of river, which flow in and out of Bear Lake. Primary land uses between Sites 1 and 2 consisted of agriculture (49%), followed by forests (20%), and wetlands (15%). The water quality at this site reflected the influence of Bear Lake. The lake acts as a settling basin, removing much of the sediment and associated nutrients entering the system. It also reduces the extremes in flow that were identified at the upstream Site 1.

Table 22. Minimum, mean, and maximum water chemistry concentrations for Site 1 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.30	15.5	0.067	*	0.036	0.07
Mean	0.30	15.5	0.067	*	0.036	0.07
Max	0.30	15.5	0.067	*	0.036	0.07
N	1	1	1		1	1

Table 23. Minimum, mean, and maximum water chemistry concentrations for Site 1 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	6.5	0.038	0.90	0.025	0.005	4.0	260	0.110
Mean	0.55	11.8	0.699	2.65	0.069	0.055	346.0	260	0.155
Max	1.10	18.0	1.700	5.26	0.137	0.080	892.0	260	0.200
n	6	6	6	5	6	6	6	1	2

Nitrate and ammonium concentrations were minimal and similar for baseflow and runoff events (Tables 24 and 25). Chloride concentrations were elevated at both sites and during all flow conditions. If the inflow (Site 1) were the only source of chloride, these concentrations would be diluted from other low chloride inputs. Because these concentrations are similar to the inflow suggests that chloride is also entering the lake via groundwater and runoff to the lake. Triazine concentrations at this site were 0.25 ug/L.

Total and reactive P concentrations were lower during eventflow at the outflow Bear Lake site as compared to upstream from Bear Lake, indicating that Bear Lake acts as a sink for some of the constituents that flow into the lake during an event. Ammonium, reactive P, and total P all had higher concentrations during events than baseflow at Site 2. Overall, reactive and total P concentrations were less at Site 2 than Site 1, with percent differences in concentrations between Site 1 and Site 2 of 25% and 41%, respectively. TSS were always lower at Site 2 and were generally about 30% less than concentrations measured at Site 1. Fecal coliform at Site 2 was 300 MFFCC/100mL in the sample collected during the June 12 event.

Table 24. Minimum, mean, and maximum water chemistry concentrations for Site 2 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	0.02	9.5	0.028	*	0.002	0.01
Mean	0.21	10.5	0.034	*	0.002	0.01
Max	0.40	11.5	0.040	*	0.002	0.01
n	2	2	2		2	2

Table 25. Minimum, mean, and maximum water chemistry concentrations for Site 2 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal Coliform	Triazine
Min	0.05	9.0	0.040	0.95	0.009	0.020	1.0	300	0.250
Mean	0.13	9.8	0.188	1.32	0.016	0.133	3.9	300	0.250
Max	0.30	10.5	0.570	1.95	0.024	0.260	7.0	300	0.250
n	5	5	5	4	5	5	5	1	1

Lower Little Wolf Sub-watershed

The Lower Little Wolf River was sampled at two sites; Site 6 was located on the Little Wolf River just downstream of the dam in Big Falls and Site 13 was located off Highway 161 in the town of Big Falls. The impoundment above the dam near Site 6 contained abundant aquatic vegetation including lily pads and duckweed. Recreational opportunities at this site include fishing, picnicking, and boating. Below the dam, the riverbanks were lined with large boulders and rip-rap. Clear brown water runs through the dam and also through a large pipe, which was pumped into a building for hydropower production. Site 6's sub-watershed includes the 171 square-mile Upper Little Wolf River Watershed. The Upper Little Wolf River Watershed was listed as a medium priority for watershed selection due to "local significant animal waste problems and a soil erosion rate of 2.2 tons per acre per year". It was also considered highly susceptible to groundwater contamination from poor land management practices (WDNR, 2001).

The water chemistry measured at Site 6 was directly influenced by the upstream impoundment and the hypolimnetic dam. A *hypolimnetice dam* releases water from the impoundment from the bottom of the dam; this allows the temperature of the water that is leaving the impoundment to remain cooler since lake temperatures are colder nearest the bottom during the warmer summer months. Another characteristic of a dammed river is that as the velocity of the water slows when it flows into the impoundment, as this occurs the suspended particles and nutrients that entered the river upstream settle out. These particles accumulate on the lake bottom and over many years this accumulation has a significant effect on the water quality of the lake. The discharge of water from the hypolimnetic dam allows this sediment and nutrient rich water found at the bottom of the impoundment to flow into the downstream river at a steady, constant rate. These high concentrations of nutrients are measured at both baseflow and event flow periods. During the April 2002 event, a sample was taken from upstream of the impoundment as well as at Site 6, downstream from the dam in Big Falls. Concentrations of total and reactive P were actually greater downstream from the dam, demonstrating the effects of the hypolimentic dam and the impoundment of the river.

Nitrate concentrations were elevated, with averages of 2.6 mg/L during baseflow and 1.7 mg/L during runoff events (Tables 26 and 27). Chloride concentrations were also elevated and ranged between 5 and 9.5 mg/L. The impoundment minimizes the fluctuations of water level that is typical of events. Overall ammonium levels were minimal, but increased slightly during some events. Total and reactive P were generally lower during baseflow conditions, but concentrations were great enough to enhance plant growth during many of the events. The increase concentrations measured during events is likely due to flushing of nutrients that have settled to the bottom of the impoundment. Total suspended solid concentrations averaged 9.2 mg/L. The present maximum of TSS is half of the maximum measured during samples collected in 1995/6.

Fecal coliform counts were 3,900 MFFCC/100mL. The fecal coliform for this site was near the average for sites within the Lower Little Wolf watershed. Triazine concentrations averaged at 0.043 ug/L. Site 13 is located at the lower end of the Lower Little Wolf River off County Highway BB. The river widened on the east (downstream) side of the bridge where clear water flowed and occasionally creates riffles over a boulder bottom with leafy debris. Deciduous trees covered the steep, minimally vegetated bank. The land draining to Site 13 is approximately 159 square-miles. Water quality measured at Site 13 is affected by landuses in the entire watershed; which include agriculture (58%), forests (15%), and wetlands (14%). All tributaries flow into the main channel of the Lower Little Wolf River upstream from Site 13. The two impoundments, one in Big Falls and the other in Manawa, act as sediment and nutrient settling basins and influence the water quality measured at this site.

Table 26. Minimum, mean, and maximum water chemistry concentrations for Site 6 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	2.21	8.5	0.017	*	0.004	0.01
Mean	2.66	9.0	0.028	*	0.006	0.01
Max	3.10	9.5	0.039	*	0.007	0.01
n	2	2	2		2	2

Table 27. Minimum, mean, and maximum water chemistry concentrations for Site 6 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	5.0	0.025	0.35	0.002	0.005	0.5	3900	0.025
Mean	1.67	6.9	0.042	0.63	0.008	0.026	9.9	3900	0.043
Max	2.53	9.0	0.064	1.01	0.015	0.060	19.0	3900	0.060
n	8	8	8	7	8	8	8	1	2

This site had nitrate concentrations that ranged between 0.05 and 2.5 mg/L (Tables 28 and 29). The greatest concentration was measured during spring baseflow. Chloride concentrations were also elevated with a range between 5.5 and 12 mg/L. These concentrations were also higher during baseflow, indicating that groundwater was supplying much of the nitrate and chloride to the system. Ammonium concentrations were generally low, but varied with increased concentrations during the early spring events. The March 23rd 2001 event had the greatest concentrations of ammonium, total and reactive P, and chloride at 0.560, 0.225, 0.144, and 12 mg/L, respectively. This occurred at many of the sites throughout the watershed and was likely related to winter land-spread manure runoff during this early spring event; concentrations of nutrients in the stream were elevated because the ground was frozen when the storm occurred and there was no vegetation to stop the nutrients from entering the tributaries and the Lower Little Wolf River.

The fecal coliform count in the sample collected on June 12th, 2001at Site 13 was 7,000 MFFCC/100mL. The greatest triazine concentration measured at this site during the June 6th event was 0.720 ug/L. Triazine entered the Lower Little Wolf River from many of its tributaries, however, the greatest concentrations were measured in this study in Beaver and Little Creeks. Total suspended solid concentrations ranged between 1 and 19 mg/L, with an average of 10.3 mg/L.

Table 28. Minimum, mean, and maximum water chemistry concentrations for Site 13 during baseflow. (Units are mg/L)

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)
Min	1.00	10.0	0.026	*	0.009	0.01
Mean	1.75	10.5	0.027	*	0.011	0.02
Max	2.50	11.0	0.028	*	0.012	0.03
n	2	2	2		2	2

Table 29. Minimum, mean, and maximum water chemistry concentrations for Site 13 during events. (Units are mg/L except coliform (MFFCC/100mL) and triazine (ug/L))

	NO2 + NO3 (N)	Chloride	Total P	TKN	Reactive P	Ammonium (N)	Total Suspended Solids	Fecal coliform	Triazine
Min	0.05	5.5	0.006	0.37	0.002	0.005	1.0	7000	0.025
Mean	1.01	8.0	0.080	0.93	0.042	0.125	11.0	7000	0.373
Max	1.60	12.0	0.225	1.91	0.144	0.560	19.0	7000	0.720
n	7	7	7	6	7	7	7	1	2

Baseflow Load and Yield Estimates

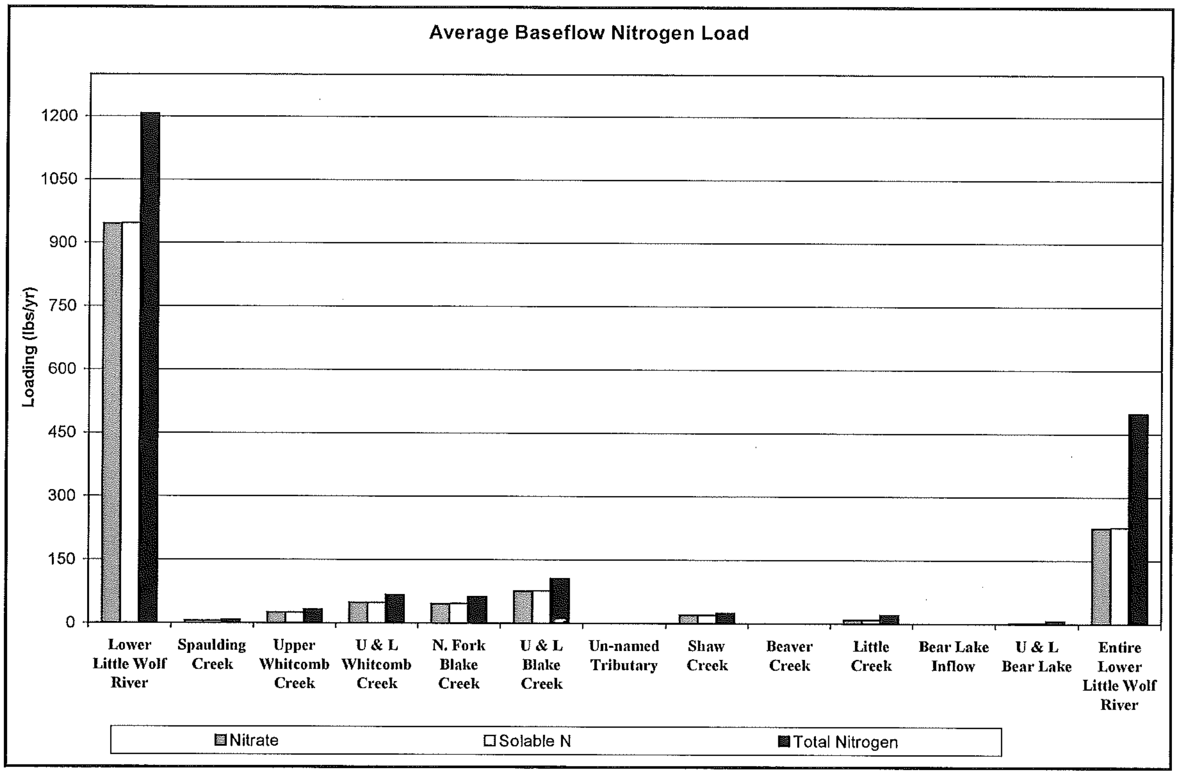
Load and yield were calculated for nitrate, ammonium, TKN, reactive P, total P, and chloride. The load and yield calculations help to interpret the sub-watershed and land area inputs to the river at a given point. However, as discharge (flow) was only measured during baseflow conditions; these quantities omit inputs or dilution to the river from runoff events. Load was calculated as the pounds of nutrient passing through a given point of stream per day using baseflow discharges and concentrations in the samples collected on the respective dates. Yield was the estimated pounds of nutrient per acre from a given sub-watershed annually and was calculated by multiplying the average concentration and the average baseflow dischage and dividing by the sub-watershed acreage. As yield produces an average amount per acre, it should be noted that inputs are not coming off the land equally from all land uses but it reflects an area-weighted average. Load and yield were not calculated for three of the sub-watersheds because the flow during baseflow conditions was too low to accurately quantify. These sub-watersheds include Un-named Tributary (Site 3), Beaver Creek (Site 10), and Bear Lake Inflow (Site 1).

Figure 9 shows nitrogen loading within the watershed. Nitrate, inorganic nitrogen and total nitrogen loads were estimated. Inorganic nitrogen made up the bulk of the nitrogen in all sub-watersheds except Site 13. The 171 square-mile Site 6 sub-watershed resulted in the greatest nitrogen loading, which averaged 1,200 lbs per year. Total nitrogen loading during baseflow to Site 13 was approximately 500 lbs per year. Many of the tributaries between Site 6 and 13 contribute nitrogen, yet concentrations down-river at Site 13 are reduced. This is likely due to settling of these nutrients in the Manawa Mill Pond. Figure 12 shows the amount of nitrogen per acre of land in a given sub-watershed. Although the Site 6 sub-watershed still contributes the greatest quantity of nitrogen per acre, Blake Creek sub-watersheds are contributing almost 2 lbs per acre per year of nitrogen to the system. Nitrate yield in North Fork of Blake Creek was slightly greater than the downstream Blake Creek sub-watershed.

Phosphorus loading and yield are displayed in Figure 10. There is quite a bit of variability in load from stream to stream. As would be expected, the highest loads are found in the main river. Site 6 on the Upper Little Wolf River transports just under 17 pound per year of total P during low flow. This quantity is likely due to the dam, which releases nutrient rich hypolimnetic water. Total phosphorus loading at Site 13 is approximately nine pounds per year. Phosphorus yields indicate that the greatest amount of phosphorus per acre is coming from Little Creek followed by Blake Creek. Total phosphorus yield in lower Whitcomb Creek is about three times that in upper Whitcomb Creek.

Chloride loading and yield reflect the trends of nitrogen and a strong correlation exists between the two. The main river had the highest loading concentrations with 4,060 lbs per year in the upper section and 3,190 lbs per year at the lower end of the watershed. The remainder of the sites were below 250 lbs per year with the exception of the Upper and Lower Blake Creek sub-watershed (Figure 11). Yields ranged between 1.7 and 8 lbs per acre per year for the tributaries. The main branch of the Little Wolf ranged from 8.2 to 13.8 lbs per acre per year with the greater yield coming from the Upper Little Wolf River Watershed.

Figure 9. Estimated average nitrogen load and yield during baseflow in the Lower Little Wolf River Watershed. Un-named tributary, Beaver Creek, and Bear Lake Inflow were omitted from these calculations due to lack of flow data.



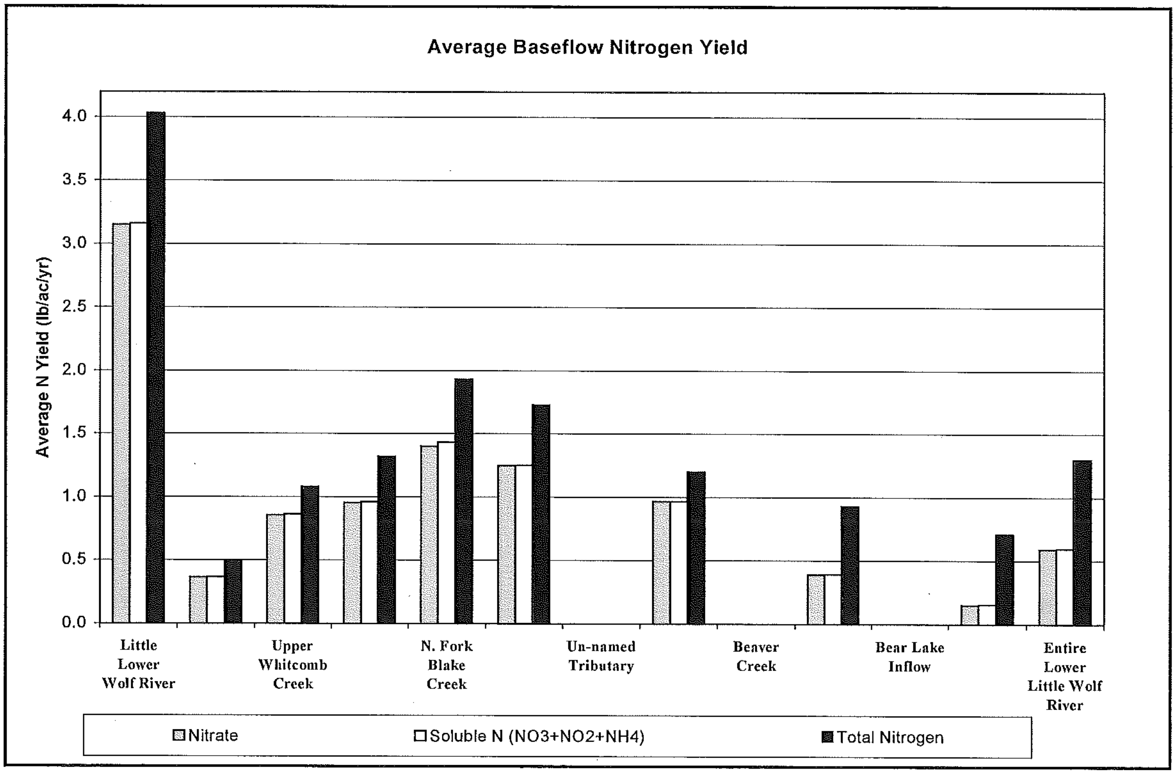
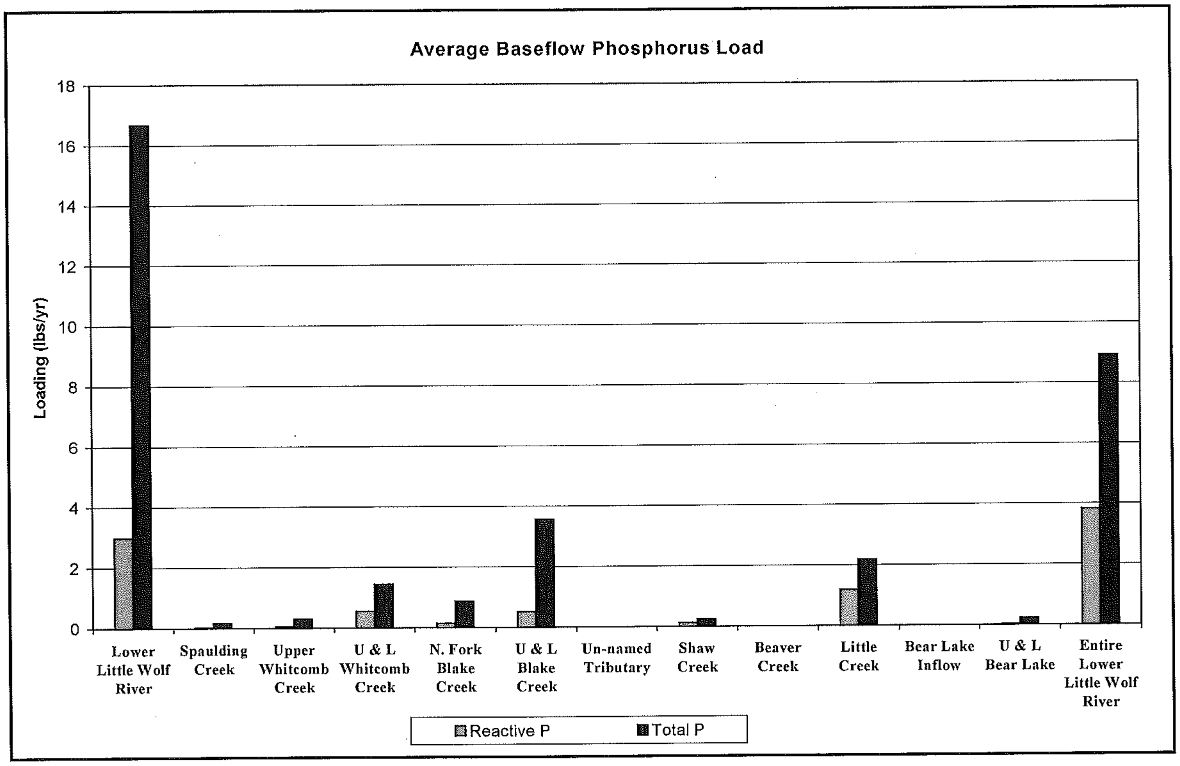


Figure 10. Estimated average phosphorus load and yield during baseflow in the Lower Little Wolf River Watershed. Un-named tributary, Beaver Creek, and Bear Lake Inflow were omitted from these calculations due to lack of flow data.



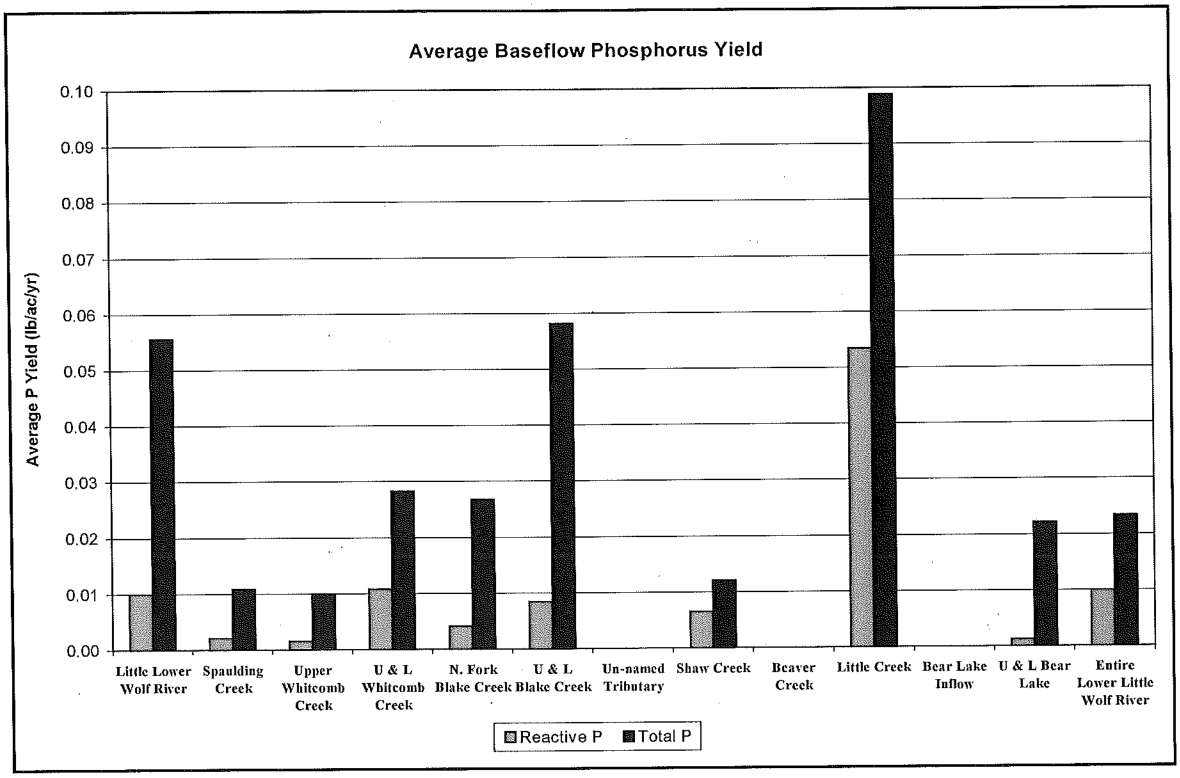
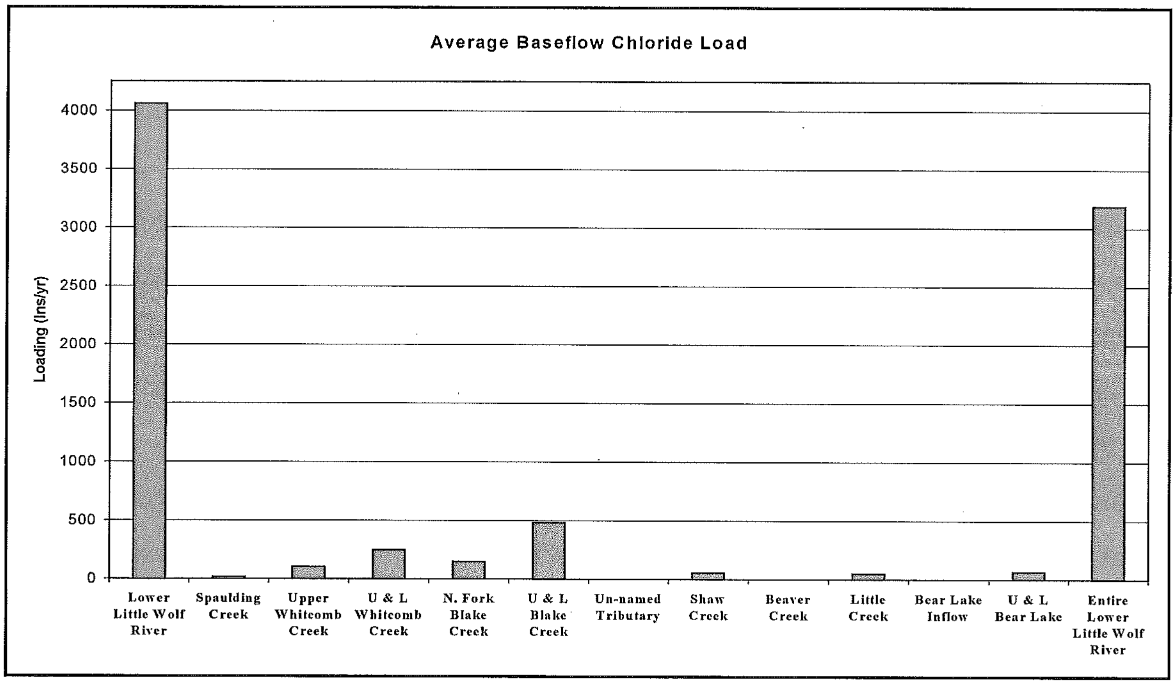
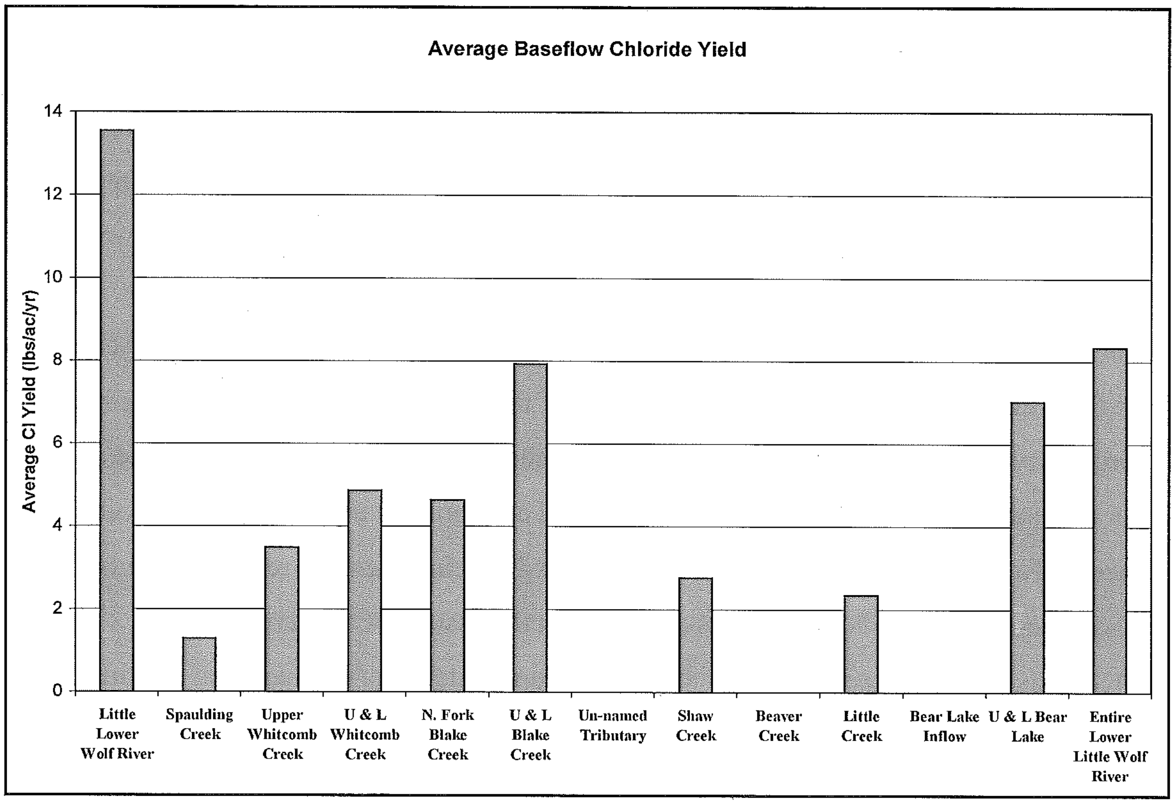


Figure 11. Estimated average chloride load and yield during baseflow in the Lower Little Wolf River Watershed. Un-named tributary, Beaver Creek, and Bear Lake Inflow were omitted from these calculations due to lack of flow data.





Public Meeting
Written by Linda Stoll, Fox-Wolf 2000

Fox-Wolf Basin 2000, a grant partner, was asked to provide public information on the project and to facilitate a meeting at the conclusion of the project to share the results with landowners and address issues and concerns within the watershed. Information was placed in the local newspapers in the fall of 2001 to inform the public of the assessment and to announce the public meeting in the spring.

A database of riparian landowners owning more than 20 acres in the watershed was obtained from the Waupaca Co. LCD and notices were sent to everyone in the database inviting them to attend a public meeting to hear the results of the water quality assessment. Meetings were held on April 10, 2002 at 1:00pm and at 6:30 pm. Linda Stoll of Fox-Wolf basin 2000 facilitated the meetings.

Nancy Turyk (Water Quality Specialist) and Kelly Henderson and Miranda Graceffa (students of the Environmental Task Force Program at UW Stevens Point) gave a presentation on the results of the water quality assessment they conducted. Dan Helf from WDNR discussed work his department was doing in the watershed and programs available to landowners. Corey Schuelke and Bruce Bushweiler of the Waupaca County Land and Water Conservation Department gave a presentation on work that had been done in the watershed and current programs available through his department to assist farmers in installing buffers, creating nutrient management plans and changing tilling practices. Tom Wilson, Waupaca County CRD agent, gave a presentation on county Smart Growth planning efforts that could impact water quality.

Thirty-five people from throughout the watershed attended the two meetings. Actual comments from the meetings are included at the end of this report. While citizens were happy with the progress that had been made, they acknowledged that there was still work to be done to enable this watershed to meet its water quality goals. The report by the UW Stevens Point Environmental Task Force identified areas that still need special attention relating to nutrient, pesiticide, and sediment inputs. Attendees agreed with the results of the report.

There was much concern with the cost of environmental improvements on a farm and the current state of agriculture (economics). Attendees found the cost-share programs to be important tools in making these changes. The Smart Growth Planning initiative was a topic for concern at both meetings. Citizens were uncertain how this would impact them and the county in general. This project was in its early stages and perhaps some of this confusion will be alleviated as the project progresses.

A few farmers have made the total transition to better environmental farming practices and have a wealth of knowledge about how to make this transition. Some of this was shared at these meetings. This is a resource that should be tapped.

Citizen Recommendations

The following recommendations were developed from the citizens' comments and the reports given by the Environmental Task Force, the DNR, the Land and Water Conservation Department and the County Extension Service. A specific list of comments from the meeting can be found in the Appendix.

- There is a continued need for monitoring information to track the results of changes in the watershed. Volunteer monitoring by riparian landowners and interested citizens offers the best chance of getting continuous information. The DNR "Water Action Volunteers" program and the River Monitoring Program could be used to establish watershed monitoring.
- The Land and Water Conservation Department and others should continue their efforts to educate farmers about the benefits of riparian buffers, better tillage practices and nutrient management plans. They should also help landowners identify and apply for cost-share opportunities to aid in making these changes. The results of the assessment by the Environmental Task Force Program at UW Stevens Point should be used to target these efforts.
- A detailed assessment of Beaver Creek and Little Creek subwatersheds should be made to determine site loadings, reduce pesticide inputs, and to develop a plan to improve these creeks to the point where they will support fish.
- Funding should be found to employ or help subsidize the costs for a crop scout to assist farmers in shifting to "no-till" and to develop nutrient management plans.
- The Priority Watershed Advisory committee should be reconvened with membership adjusted to be representational of all stakeholders, to assist with further actions in the watershed such as:
    - Smart Growth planning

  - Stormwater management
  - Citizen education
  - Assistance with farm programs
  - Triazine contamination

- A meeting should be held with interested citizens to explore the creation of a lake association for Manawa Millpond. This group would be able to address issues of concern such as:
  - Shoreline management
  - Restoration of the old landfill site
  - Riparian and upstream nutrient and sediment loading

CONCLUSIONS/RECOMMENDATIONS

- Water quality in the Lower Little Wolf River Watershed ranges from very good in some streams to very poor in others. Steams that have overall good water quality are Spaulding Creek and Upper Whitcomb Creek. These streams represent the water quality background levels in well–drained soils of the watershed.

- Soil types play a role in the amount of runoff and therefore, the amount of contaminants transported to the streams during runoff events. The western side of the watershed has predominantly well drained soils. Many of the inputs to these steams are related to groundwater inputs and are less related to runoff events. The southern and eastern portions of the watershed have heavier soil, therefore, runoff plays a stronger roll in delivering contaminants to the streams.

- Early spring runoff events result in high inputs of phosphorus to all of the streams. In most cases the source of these inputs is winter land spread manure. Land-spreading of animal waste is a likely source when the combination of elevated reactive phosphorous, chloride, and total suspended solid are present.

- Chloride makes a good indicator of impacted river water quality in this watershed as natural geologic sources of chloride are found in low concentrations. Sources of chloride can include animal and human waste, agricultural/lawn/garden fertilizers, road salt.

- Triazine was detected in samples at all 13 sites with Beaver Creek and Little Creek as areas of the greatest concern. As atrazine can readily move to groundwater, drinking water wells in the watershed should be tested.

- The sampled runoff event in June resulted in fecal coliform counts in exceedence of swimming beach standards of 200 MFFCC/100mL at all sites.

- The Bear Lake Infow, Un-named Tributary,and Beaver Creek sub-watersheds dominated mainly by runoff events with very minimal groundwater flow. Therefore, reducing inputs to these creeks would best be done by use of management practices that reduce soil erosion.and overland flow of contaminants.

- Spaulding, Whitcomb and Blake Creeks are all fed by groundwater. Nitrate and chloride inputs are greatest during low flow periods in these baseflow-dominated sub-watersheds.

- Maximum concentrations of total suspended solids during runoff events are about half of what was measured in 1995/1996 in Blake Creek and the lower end of the Lower Little Wolf River because of best management practices that have been implemented in the area.

- Recommended management practices will vary slightly depending upon the soil type, topography, and land uses within the watershed. Water quality in all creeks will benefit with the use of vegetated riparian protection such as buffer strips. In addition, water quality conditions in the creeks on heavier soils (south and east part of the watershed) can be maintained/improved by limiting soil erosion, minimizing winter land spreading of manure, limiting phosphorus applied to these soils, designing storm sewer discharge minimize sediment delivery, minimizing impervious surfaces/enhancing infiltration throughout the contributing sub-watersheds. These practices should be used to protect the streams with well-drained soils as well as controlling dissolved chemicals (i.e. nutrients and pesticides) by using best management practices throughout the sub-watersheds. Groundwater quality can be improved by using nutrient management practices when applying fertilizers to agricultural lands, lawns, and gardens. Other agricultural best management practices that reduce nutrients and pesticide inputs should be considered (for example management intensive grazing). Septic system density should be minimized and setback distances from streams should be increased.

- Routine monitoring should occur at all 13 sites to track changes in water quality and determine long term trends. It would be beneficial to add an additional site above the impoundment at Big Falls and an additional site on the Lower Little Wolf River between Site 6 and Site 13.

- Local government and citizens should work together to set goals for the water quality of the streams in the Lower Little Wolf watershed and design strategies to achieve these goals. These goals should be reflected in the local Town and County Plans and educational material should be developed and delivered to watershed residents.

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APPENDICES

Comments from the Facilitated Meetings

- It is significant that changing from mold-board plowing to no-till can reduce total suspended solids running into a stream by 50%
- We need more information – especially temperature and clarity (turbidity)
- There was an advisory committee set up for the priority watershed, what happened to it?
- It's upsetting that Beaver and Little Creek will not support fish
- When we talk about economic development and the economics of farming, we need to talk about the water needs of farmers as well
- Manawa Millpond has some serious plant issues. There are concerned citizens. What can they do?
- Will there be any "stick" to make the communities in this watershed handle stormwater better?
- If we don't join the county effort for Smart Growth, what will that mean?
- Will there be money available for Smart Growth planning?
- Development can have an adverse impact. We need proper tools to manage it.
- We have no construction site erosion control of post construction stormwater management. As development comes, our streams are going to get worse.
- This area is not regulated by the EPA Phase 2 program. Smart Growth does not take effect until 2010. Do we have to wait?
- We have concern that for some of the monitoring, only one set of samples was taken. ?? There were 7 sets of samples collected. How will land use change affect monitoring numbers if it takes 1-20 years to see the results of the change?
- It will be the better farm managers that survive. They will do a better job with runoff and water quality will increase.
- We need information on how to bundle programs to get the most money.
- We need information on other people's planning efforts. Are there websites we can use?
- Volunteer monitoring may help track changes.
- We should shift some of the nutrient management dollars to fund a good crop scout that could help farmers shift to "no-till", nutrient plans.
- We feel that we are doing a good job with cleaning up the waters. I wish we could do more for the millpond.
- What are the problems, the sites that we are not addressing? The LCD needs help in locating these.
- Who determines what are the floodplains? Can we dispute FEMA designations?

There is an old landfill near County Highway N. How can we clean this up? It's part of the millpond.

Water Chemistry

Land Uses by Sub-watershed