WATER QUALITY ASSESSMENT OF THE PLOVER RIVER WATERSHED

LANGLADE, MARATHON AND PORTAGE COUNTIES, WISCONSIN

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Report to the Wisconsin Department of Natural Resources

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Acknowledgements

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- Plover River Alliance
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- Marathon and Portage County Land Conservation Departments
- Stevens Point Water and Sewer
- Bill Cook Chapter Izaak Walton League
- Portage County Wildlife Club
- University of Wisconsin Environmental Task Force Program

Executive Summary

This project was initiated by members of the community and agency personnel to assess current water quality conditions in the Plover River. Areas that impact the river were determined by sub-watershed to better focus agency resources to the areas that can most likely improve river water quality though improved land use practices. Results of this project will also be used by landowners within the watershed to develop protection strategies and understand how they can adjust their land use management practices to ensure the protection of the river for future generations.

The Plover River travels southwesterly for 42 miles through Langlade, Marathon, and Portage Counties. Many rural and urban residents enjoy the Plover River and its watershed though activities that include swimming, fishing, canoeing, cross country skiing, hiking, and relaxation through its aesthetic beauty. In addition, the Stevens Point municipal well field, which provides drinking water for the entire Stevens Point area, is located in the lower end of the watershed. According to the Plover River Plan, 64% of the water that comes from the wells originates directly from the Plover River itself; therefore, it is essential that Portage County work to protect the Plover River. (PCPZD, 2000).

The assessment of the Plover River was accomplished by completing a longitudinal study of water quality on the Plover River between June 2000 and July 2001. Although some sporadic water quality data has been collected, comprehensive sampling from headwaters to mouth has never been conducted. Water quality data is essential for a beneficial management plan to be implemented thus protecting the river and its watershed for multiple uses.

Portage and Marathon County Land Conservation Department staff collected water quality samples from 18 locations along the Plover River. Samples from the 18 sites were collected for summer and winter baseflow (low flow, mostly groundwater fed) and runoff events (storm events and/or snow melt). Siphon samplers were used to collect the storm flow events. These samplers collect the water sample once the river reaches a certain height during a given runoff event.

Following the collection of water samples, the UWSP Environmental Task Force laboratory (ETF) analyzed the samples for a variety of constituents. All samples were analyzed for nitrate plus nitrite nitrogen, ammonium nitrogen, total Kjeldahl nitrogen, total phosphorus, reactive phosphorus, and chloride. In addition, the event flow samples were analyzed for total suspended solids (TSS) and volatile suspended solids (VSS) and fecal coliform were analyzed during four events. Sites with elevated nitrogen were also analyzed once for Triazine and seven of the sites with the highest Triazine concentrations were tested for additional pesticides. The data from these constituents were used in concert with land use information to determine areas of groundwater and runoff related non-point pollution; this information can than be used to identify the best management strategies for these areas.

Overall, the Plover River has good water quality when compared with other rivers located in Central Wisconsin. This is likely due to the fact that the river is well buffered though most of the system, most natural wetlands still exist, and development is not very intense (except for the lower end). Wetlands act as nutrient sinks and reduce the impacts of heavy rain events. The river system had four distinct segments based on discharge, water quality, and associated land use. The headwaters are predominantly wooded, with minimal development impacts, the next segment downstream has lower impact agriculture (i.e. hay, grazing), the third segment has increasing row crops, and the fourth segment is predominantly urban. Re-release of nutrients appears to occur in the upper portion of the watershed during events. Fecal coliform counts were in excess of the swimming beach standards in many of the samples taken during rain events. Nitrate concentrations gradually increase from headwaters downstream, and inputs are predominantly from groundwater discharging to the river. Several of the tributaries in the third segment have elevated nitrate as high as 20 mg/L during baseflow conditions. Triazine was detected in eight of the nine samples tested and pesticides were detected in all seven samples that were tested.

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Background Information

Water quality in the Plover River has never been studied for its entire length. Water quality data is essential for a beneficial management plan to be implemented; determinations can be made such as which stretches need remediation and which should be focused on protection and ultimately, how best to protect the watershed for its multiple uses. This data can be used in the future to re-assess management and determine whether the water quality is changing over time.

Uses of the Plover River and its immediate corridor include aesthetics, cross-country skiing, hiking, birding, swimming, fishing, and canoeing. In addition, wells for the Stevens Point municipality, which provide drinking water for the entire Stevens Point area, are located at the lower end of the watershed, near site 18 (Figure 3). According to the Golden Sands Phase II proposal, 64% of the water going to the wells comes from the Plover River. (PCPZD 2000)

The Plover River was studied on a watershed scale from June 2000 to August 2001. According to the BASINS website, a watershed can be defined as an area of land in which all rain and snow runoff, as well as tributaries, drain into a common body of water such as a river or lake (Murphy 2000). A watershed's boundaries are delineated by topography; the highest points on the landscape separate one watershed from another. Many rivers in Wisconsin also have groundwater sheds that are defined by boundaries found below ground and relating to the slope of the water table. Sometimes the topographic and groundwater sheds are approximately the same land areas, on other occasions they are very different.

In this study, 18 sites were selected for sample analysis: 13 sites on the main stream, 2 tributaries, and 3 ditches (Figure 3). During the study, two types of samples were taken, runoff events and baseflow samples. Stream flow was measured during the collection of baseflow samples.

Baseflow sampling was conducted when runoff was nonexistent, therefore acting as an indicator of average groundwater quality, since groundwater is the only source of recharge during baseflow time periods. Typically this condition is present in parts of the summer, late fall, and winter. During the fall season biological processes are slower, giving a clearer picture of baseflow water quality due to minimal nutrient uptake by aquatic plants.

Runoff event sampling was instituted during runoff events via siphon sampler or grab samples. Event flow allows one to evaluate the constituents that enter the river via surface runoff (nutrients, sediment, pesticides, and bacteria). Many of these constituents are related to the land use practices within the watershed.

Study Area and Land Uses

The Plover River, which has a 147 square mile watershed within the Wisconsin River Basin, travels southwesterly for 42 miles from Langlade through Marathon, and Portage Counties (Figures 1 and 2). The watershed is not terribly complex; it has a very long and narrow shape, and some small tributaries that feed the Plover, including several agricultural ditches. Big Bass and Pike Lakes are located within the watershed and there are three impoundments found along the length of the river: Bentley Pond, Jordan Pond, and McDill Pond. The average elevation drop along the river is approximately five feet per mile (Lyden 2001). The Plover River's headwaters are located west of the village of Aniwa.

The Plover River watershed can be characterized as being dominated by forests and wetlands in the northern reaches; however, wetlands are located throughout the watershed. Agriculture also is prevalent within this watershed, more so in the southern portion of the watershed. (Figure 4) With the exception of the rural housing and the small urban areas of the village of Hatley and the unincorporated village of Bevent, the only major urban area in the watershed is the city of Stevens Point, which is located in the southern most part of the watershed (Figures 2 and 3). For most of its length, the river has a buffered riparian zone, a vegetated area adjacent to a river.

A major use of the Plover River watershed is recreation. Fishing is dominant north of the unincorporated village of Bevent, where the Plover is a cold water trout stream. The majority of the river can be canoed and kayaked. Portage County has a system of jogging and cross-country ski trails through the watershed. The large forested areas also allow for hunting along the Plover's corridor. During the summer months, both Iverson and Jordan parks serve as public swimming areas on the Plover River. Some of the Stevens Point municipal wells are located at the lower end of the watershed near site 18 (Figure 3).

Groundwater Flow

The groundwater in the Plover River Watershed flows from the outer most boundaries of the watershed towards the river. Basically the groundwater flow mimics the surface topography. The eastern border of the watershed is hydrogeologically separated from surrounding watersheds by a groundwater divide. The groundwater east of the groundwater divide boundary flows towards the Fox-Wolf Basin and west of the boundary the groundwater flows towards the Plover River and eventually the Wisconsin River Basin (Lippelt 1981). Due to the limits of the study, the specific segments of the Plover River that are receiving groundwater through recharge, or losing through down welling are not known.

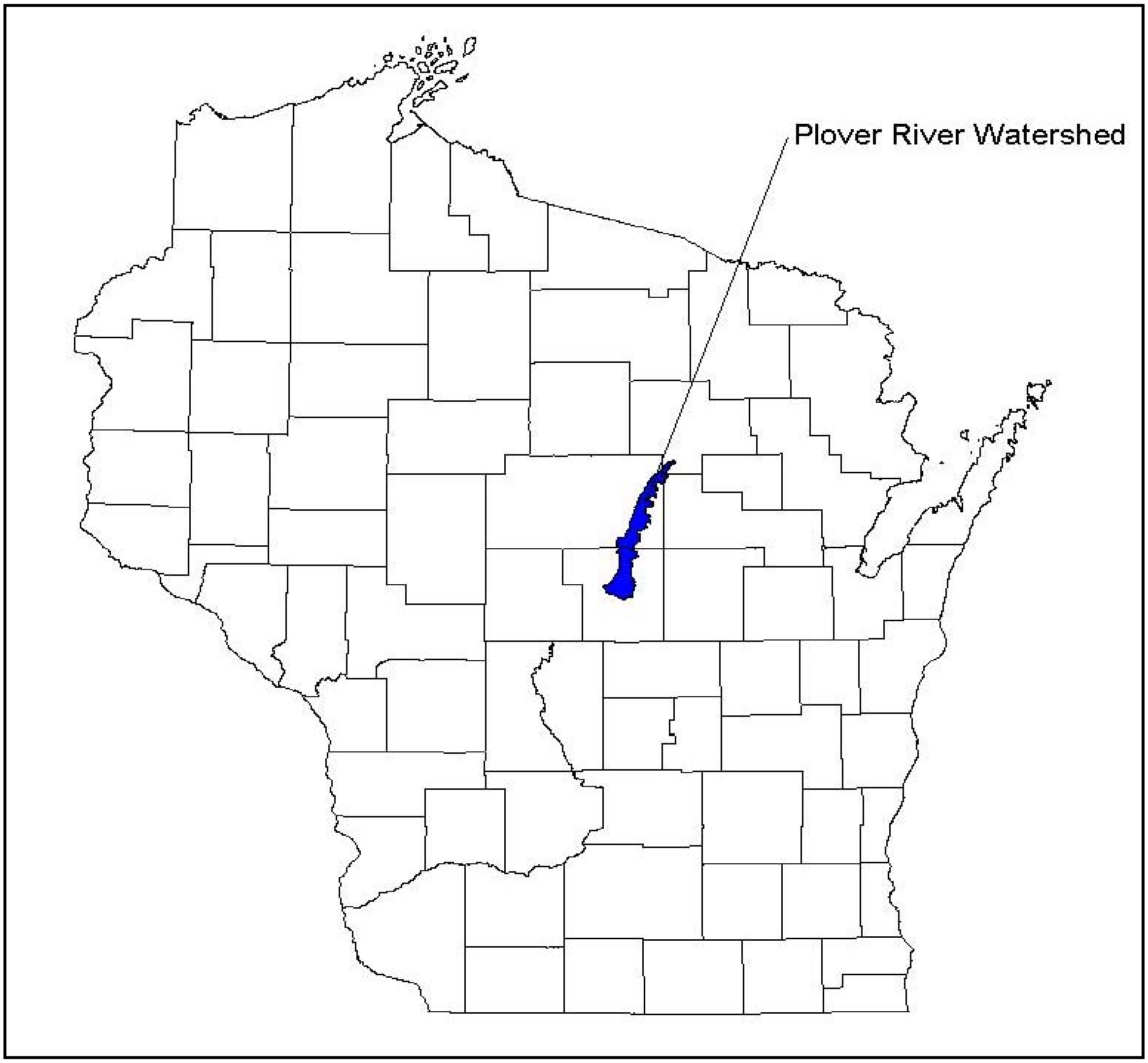

Figure 1: Location of the Plover River Watershed within Wisconsin.

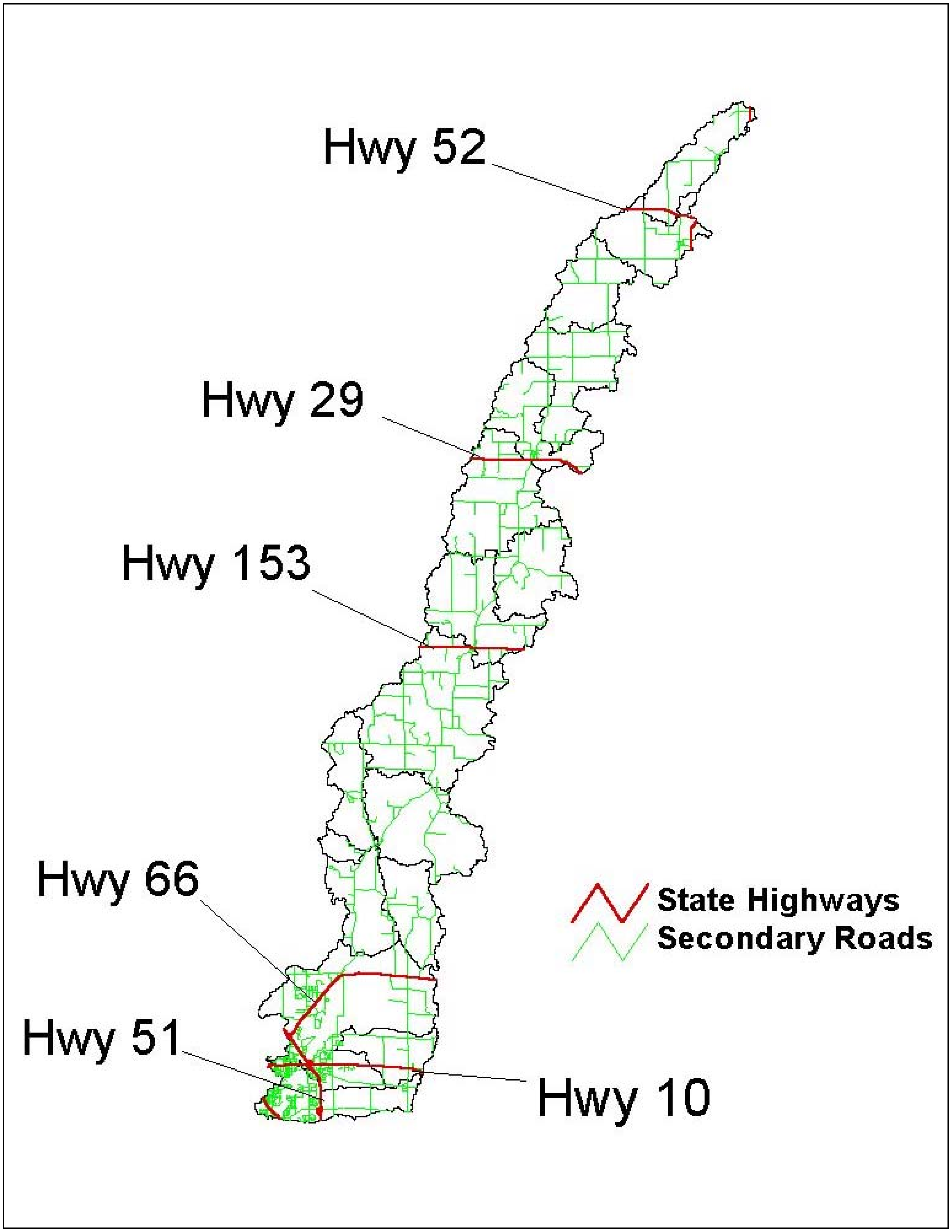

Figure 2: Roadways within the Plover River Watershed. Sample site sub-watershed boundaries are indicated.

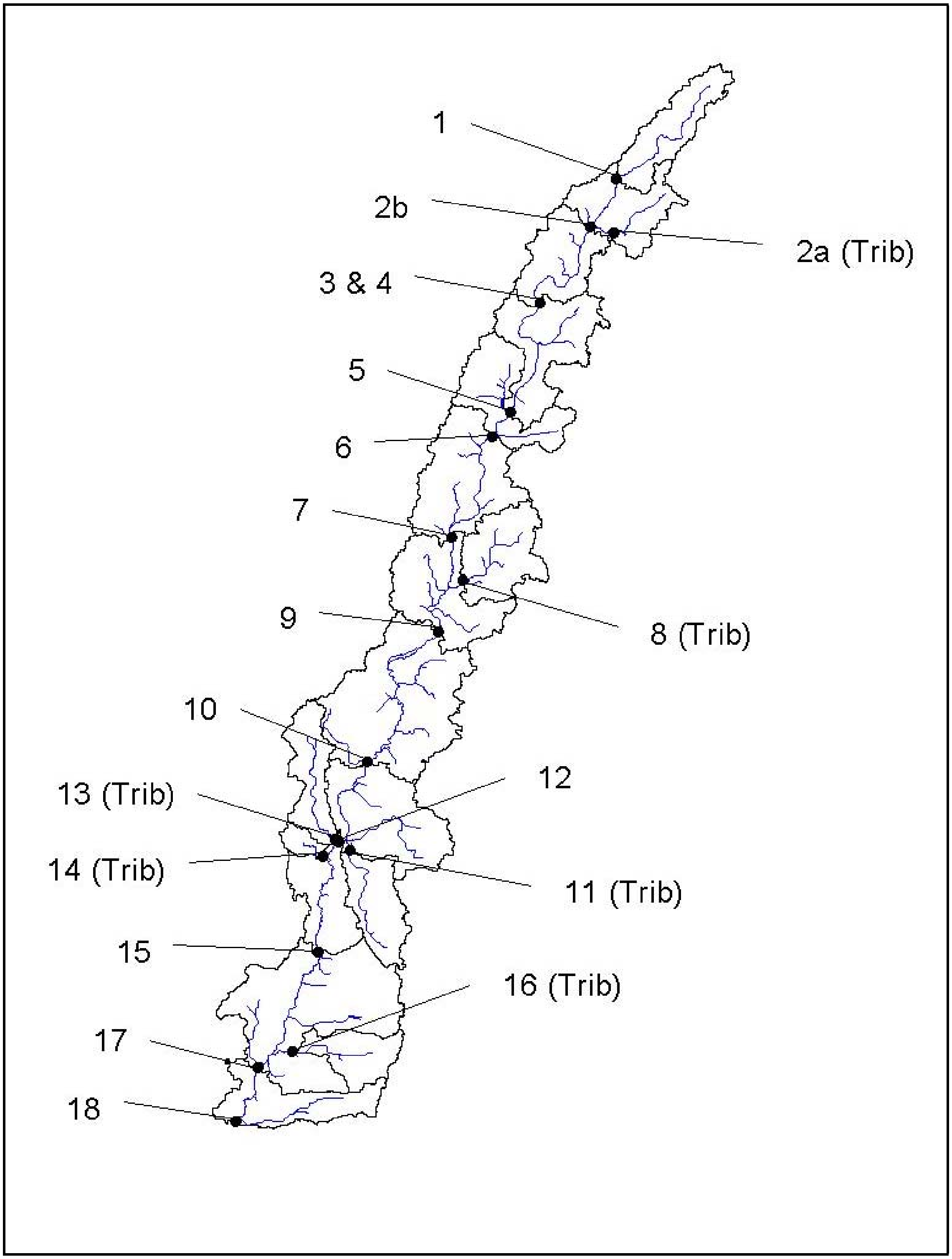

Figure 3: Sample site locations and associated site sub-watersheds within Plover River Watershed.

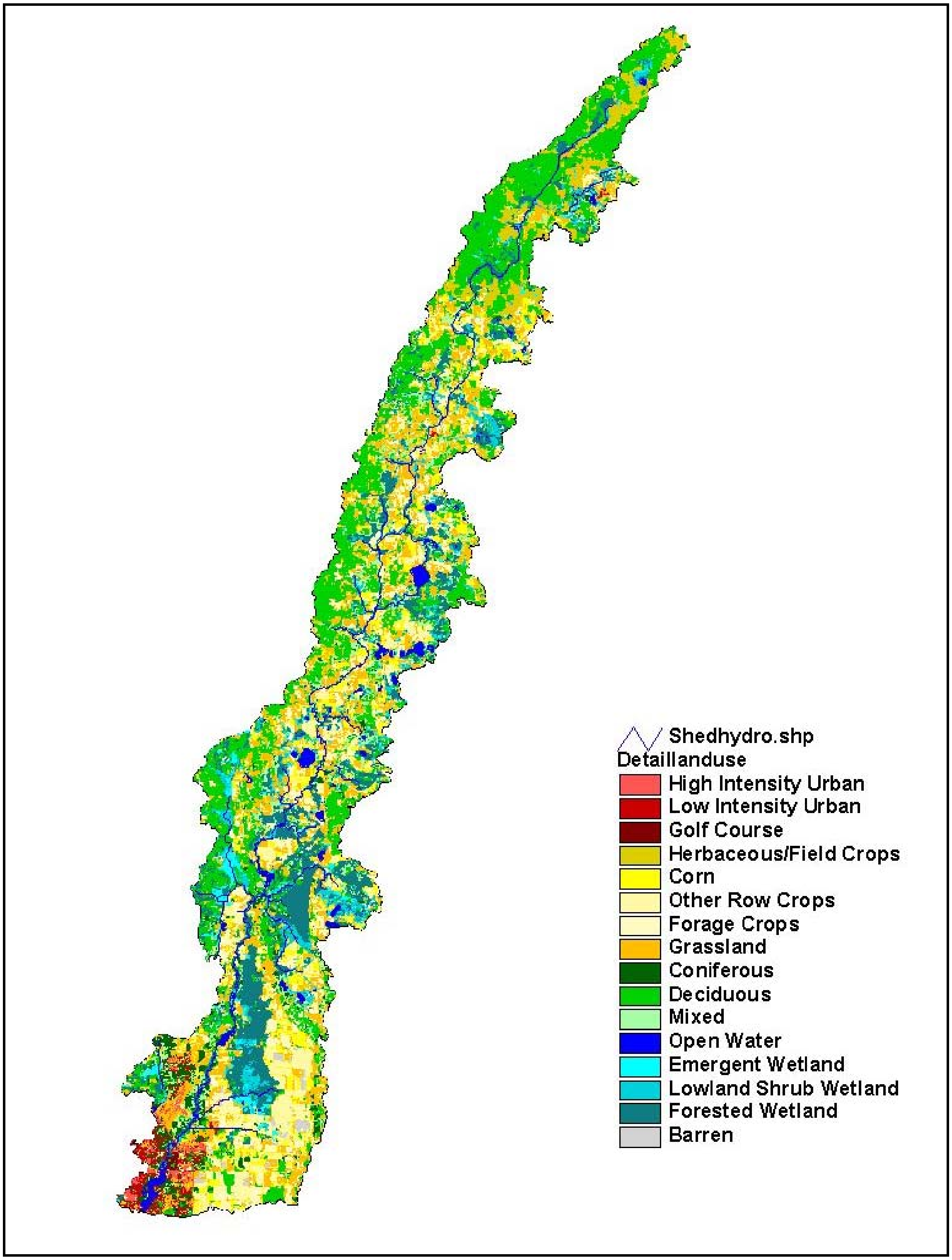

Figure 4: Land uses of Plover River Watershed (From WISCLAND Land Cover Data collected between 1991 and 1993.)

Geology

The Pleistocene geology is fairly similar through much of the watershed. Throughout the entire river basin lies non-glacial stream sediment (silt, sand, and gravelly sand) deposited on the floodplains from the modern river. The non-glacial sediment is found immediately next to the Plover River. Outside of the non-glacial stream sediment is melt water stream sediment of the Horicon Formation. This sediment was deposited on solid ground by streams created from the Green Bay Lobe. The sediment consists of dolomitic sand, gravelly sand, and sandy gravel (Clayton 1986 & Attig 1989).

The bedrock geology of the watershed differs in the Northern portion compared to the Southern portion. Wolf River granite dominates much of the Marathon County portion of the watershed, which consists of coarse grained, porphyritic hornblende (LaBerge 1983). The southern tip of Marathon County and all of Portage County contains of Red River Adamellite that is comprised of medium to coarse-grained porphyritic Adamellite (Greenberg 1986).

Morphology

The soils of the northern portion of the watershed are predominantly dominated by soils underlain by loamy glacial till. Kennan – Hatley soil association is the major soil type from this classification in the watershed. It is identified as being a deep, cobbly, bouldery, silty, and loamy soil on moraines and drumlins. The soils of the northern portion of the watershed are predominantly sandy and well drained. One soil association, although less prevailing is the Kennan – Hatley soil association, which is underlain by siltly, loamy, or sandy alluvial, lacustrine, or outwash deposits. The other soil association in the watershed is the Chetek-Rosholt-Oesterle association, which is classified as being deep, nearly level to steep, well drained with silt and loamy soils on outwash plains and stream terraces (Fiala 1989).

The soils of the southern portion of the watershed are predominately dominated through the formation of outwash sand and gravel. An example of one type of these soils is the Plainfield-Friendship association that is excessively to moderately drained, with nearly level to sloping soils that form in sandy deposits. Also within the watershed exist soils that are formed through the deposition of alluvium or organic deposits. The Markey-Seelyville-Cathro association is major type of organic deposit in the watershed. It is classified as very poorly drained with nearly level soils forming in organic deposits over sandy and loamy deposits. (Otter 1978)

Objectives

- Collect water quality data and identify areas within the watershed that may contribute to reduced water quality.
- Establish a foundation of water quality data that is representative of current conditions.
- Summarize data in a format that will assist citizens and local agencies in understanding the functions within the Plover River Watershed and help lead to river protection strategies.

Methods

Eighteen sample sights were selected throughout the watershed; most were located next to roads or bridges. Sampling was conducted during baseflow and runoff events, and for fecal coliform and pesticides.

When a baseflow sample was taken three bottles were filled with sample from each site using a 60 mL plastic syringe. One 60 mL polyethylene bottle, which was preserved with 1 molar H_2SO_4, was filled with filtered sample. Samples were filtered using an in-line plastic filter cassette screwed onto the plastic syringe. A .45 µm filter paper was used as the fine filter paper and a 934 / AH glass filter is used for the coarse filter paper. Both filters are 47 mm in diameter and were layered with the sample moving through the 934 / AH first. The filter papers (coarse and fine) were placed with the grid pattern sides facing one another. The second bottle was a 60 mL polyethylene bottle, which was preserved with 1 molar H_2SO_4, and filled with unfiltered sample. The third bottle was a 500 mL polyethylene bottle that was left unpreserved and unfiltered.

River discharge was measured at each site during the time baseflow samples were collected 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. The number of velocity measurements per stream transect varied with stream width. For example, a 12-foot section of the river had velocity measurements taken every foot, and a 63-foot section of the river had measurements taken every 7 feet.

In most cases, event flow was sampled through the use of a siphon sampler. Figure 5 shows the siphon samplers 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 are bent into the given configuration. The clear PVC sampling tubing is then inserted into a neoprene stopper and the stopper is inserted into the 500 mL polyethylene-sampling bottle. The clear PVC sampling tubing is supported by a flat piece of gray PVC. (Figure 5), and the 500 mL sampling bottle apparatus is held in place with a schedule 40 white PVC bottle bracket.

The bottle bracket slides onto a fence post that was pounded approximately 18 inches into the streambed. The siphon sampler was positioned to sample an anticipated rise in the stream from a storm event. At eighteen of the sites, two siphon samplers were located near each other, but were positioned at different heights to enable sample collection at two points in an event. The siphon samplers were located in areas of the Plover River that avoided most canoeists.

Siphon samplers were set to trigger when the river level reaches a specific height during a storm event. See Appendix G for monthly precipitation data. This height varied from site to site depending upon the morphology of the stream (size, shape, and location within watershed). Once the water crests the top of the lower tube, the river water enters the tubing and fills the 500 mL Polypropylene sample bottle. The sample is then transferred into three separate bottles (See Baseflow Sampling for description of sample bottles) to properly preserve samples for the various analyses.

Both baseflow and event samples that were collected are stored on ice and sent 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),

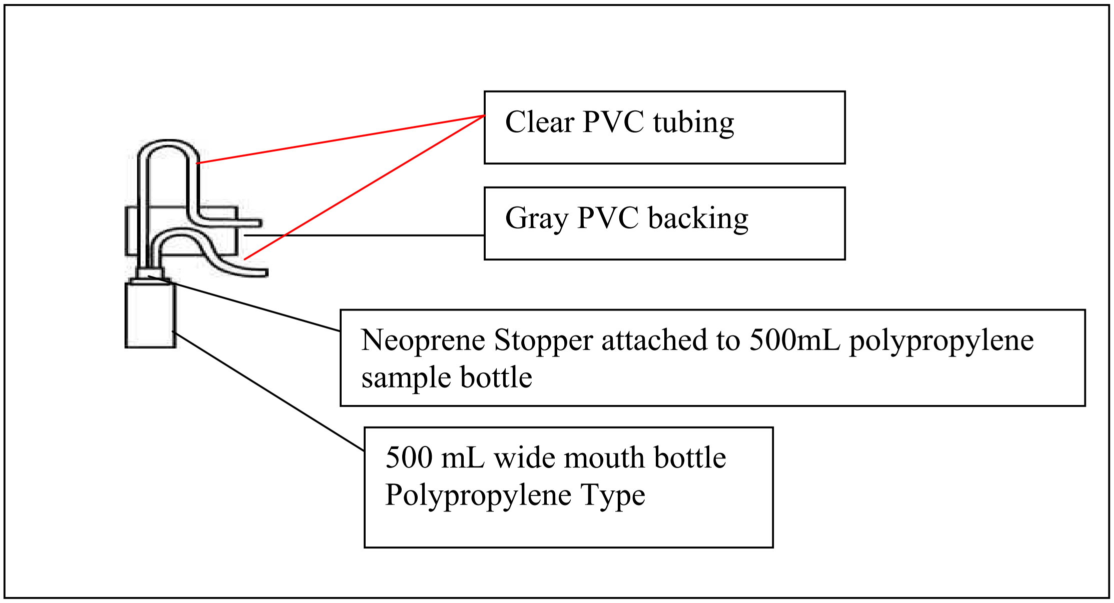

Figure 5: Diagram showing the runoff event siphon sampler assembly.

ammonium– N (NH_4, N_2), total and reactive P, and chloride. Event samples were analyzed for total suspended solids, volatile suspended solids, nitrate + nitrite–N, NH4–N, total Kjeldahl nitrogen (TKN), total and reactive P, and chloride. The analyses run in the Environmental Task Force Lab followed the methodology contained in Table 1. Nitrate + nitrite–N, ammonium– N (NH_4, N_2), total and reactive P, TKN, and chloride were all analyzed using the latchet method. Fecal coliform, total suspended solids, and volatile suspended solids, and pesticides were all analyzed using standard methods. (Franson 1995) Load and yield were calculated for nitrate, reactive P, and total P. The load and yield calculations help to interpret the sub-watershed and land area nutrient inputs to the river at a given point. Both were calculated using baseflow discharges and nutrient concentrations for the samples collected on the respective dates. 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. 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. All load and yield values are located in Appendix F.

Fecal coliform was also tested during many of the summer runoff events on all the sample sites on the watershed. The fecal coliform samples were collected by grab method using a 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 take the sample, the mouth of the bottle was placed at a perpendicular angle 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 upstream, 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.

Funding permitted the analysis of Triazine from nine sample sites within the watershed. The sites were selected from sample sites that had elevated nitrate and chloride concentrations, this includes sites nine through eighteen. Each sample was taken in a 50 mL polypropylene bottle.

Nitrogen / Phosphorus (N/P) pesticides were sampled at seven sites within the watershed as permitted by grant funds. Elevated concentrations of triazine were used in sample site selection for N/P pesticides analysis. A 500 mL brown glass bottle was used to take a grab sample from the river. Samples were collected at the same time as the triazine samples, June 13th, 2001.

Table 1: Analytical Methods and Corresponding Detection Limits for water quality analyses run in the UWSP Environmental Task Force Lab.

Analyses	Method	Method Detection Limit
Chloride	Automated Ferricyanide 4500 C1 E	0.2 mg/L
Fecal Coliform	Membrane Filter 922 D	Not applicable
Nitrogen, Ammonia	Automated Salicylate 4500-NH_3 G	0.01 mg/L
Nitrogen, Nitrate + Nitrite	Automated Cadmium Reduction 4500-NO_3 F	0.021 mg/L
Nitrogen, Total Kjeldahl	Block Digester; Auto Salicylate 4500-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
Total Suspended Solids	Gravimetric 2540 D	2.0 mg/L
Volatile Suspended Solids	Gravimetric 2540 E	2.0 mg/L
Triazine	Enzyme Linked Immunosorbant assay	0.05 mg/L
N/P Pesticides	EPA Method 8270	Varies

Water Quality Interpretation

Nutrients

A primary main nutrient within the Plover River watershed is nitrogen. In an aquatic ecosystem, it is imperative to have nitrogen in its various forms for plant and animal growth and survival. However, having an excess of nitrogen can have devastating effects on the ecosystem, affecting the plant life, invertebrates, fish and humans. As on land, nitrogen can influence plant growth as elevated concentrations can lead to abundant plant growth. This can affect the types of plants and ecological communities that are present as available oxygen is decreased during the decomposition of plant material.

Excess nutrients can be transported to rivers via groundwater, overland flow, and sedimentation.

Nitrogen can be found in several forms: $NO_2 + NO_3$, NH_4, N_2 and TKN. The different forms of nitrogen are formed both through biological and physical mechanisms. The nitrogen cycle illustrates how the different forms of nitrogen are derived and transformed (Figure 6). The forms of nitrogen analyzed in this study included nitrate + nitrite ($NO_2 + NO_3$), ammonia (NH_4), and total Kjeldahl nitrogen (TKN).

Nitrate is a highly soluble form of nitrogen that is formed through nitrogen fixation and deposition. Deposition of nitrate in surface water is derived from sources such as livestock excrement, nitrogenous fertilizers, irrigation return flows, lawn fertilizers, septic systems, and wildlife. These multiple sources are transported across the land and into the river via overland flow, unsaturated flow, and via groundwater transport. (NCSWQG 2002)

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 6). 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 lake or river. (NCSWQG 2002)

Ammonium 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 NH4 include sources such as livestock waste, fertilizers, and spillage during transportation of the NH4 fertilizer. Septic systems and improper disposal of household cleaning products containing ammonia are also sources of ammonia in the rivers. A natural source of NH4 release in the environment is wetlands. Wetlands initially act as sink for nutrients like nitrogen; however, given the right conditions ammonia can be released. Ammonia is transported into rivers via overland flow after a precipitation event. It is also transported to surface water through groundwater recharge. (NCSWQG 2002)

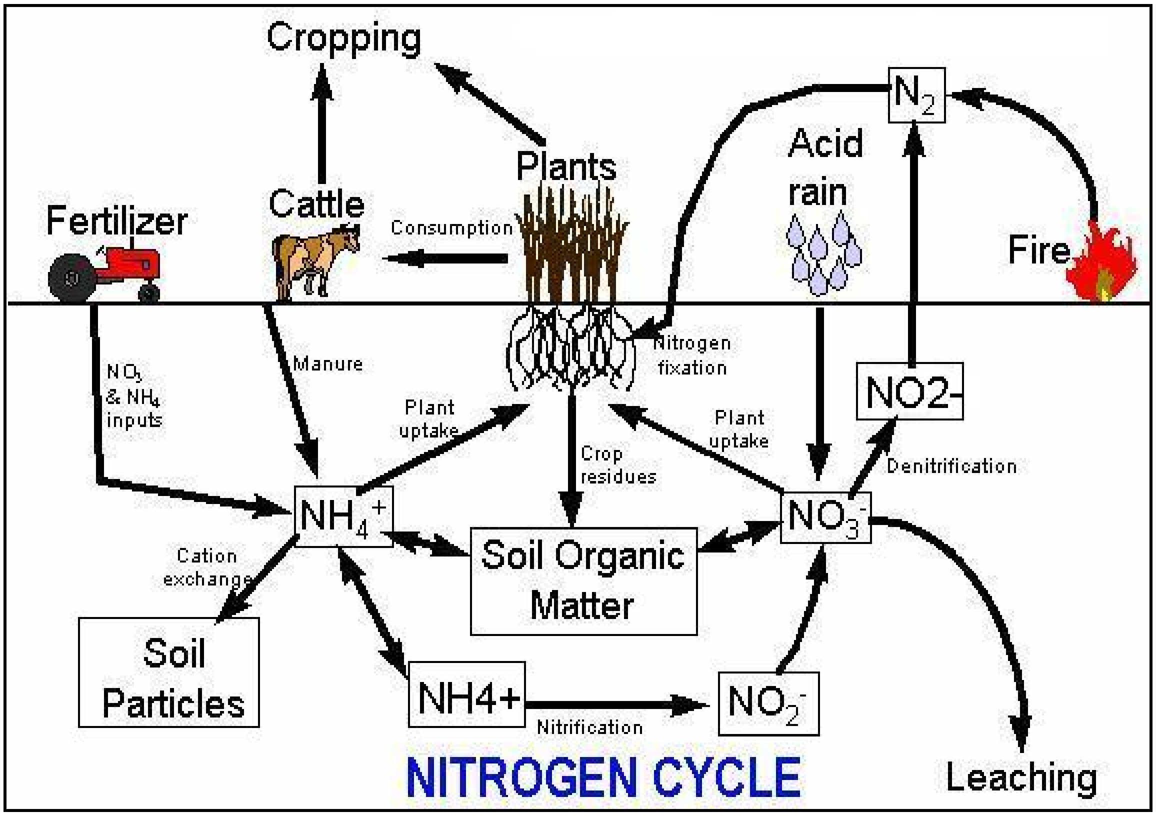

Figure 6: Diagram of the transformation of various forms of nitrogen within the environment. (University of Minnesota 2000)

Total Kjeldahl nitrogen is the last constituent in nitrogen series that was tested in this water quality study. Total Kjeldahl nitrogen represents the fraction of total nitrogen that is unavailable for growth or contained in organic nitrogen and NH4. Total Kjeldahl nitrogen holds the potential for later release in pools, from wetlands or with changing conditions downstream.

Phosphorus is the other important nutrient in the watershed. In most Wisconsin river ecosystems, phosphorus is a limiting nutrient, meaning that when all the phosphorus has been consumed, plant growth will cease. An increase in the level of phosphorus will lead to more nitrogen being used and combined with this process will lead to increased plant growth. (NCSWQG 2002)

Within the Plover River watershed, phosphorus is associated with several sources. Phosphorus can come from animal waste through barnyard runoff, manure applied field runoff, and direct access of livestock into the surface water itself. It is also found in agricultural and lawn/garden fertilizers and over time, phosphorus associated with septic systems can move from the drainfield to groundwater. Phosphorus frequently adsorbs to soil particles that are later eroded away, but once the adsorption sites on soil are exhausted, phosphorus can leach into the groundwater, later discharging to a surface water body. Like nitrogen, phosphorus can also be re-released from wetland sediments. Dying vegetation releases phosphorus from its tissue, therefore, in the fall trees along a river can contribute some phosphorus through leaf drop. Phosphorus is necessary for a healthy aquatic ecosystem, yet in excess can lead to multiple surface water related problems such as: increase aquatic plant growth, cause taste and odor problems in waters used for human consumption, and oxygen consumption from excessive plant decomposition can lead to fish kills. (Shaw 1995)

Fecal Coliform

Fecal coliform bacteria are an important constituent studied in the determination of water quality. Fecal coliform are bacteria derived from the intestinal tract of warm-blooded animals. Sources of the bacteria are wildlife, feedlots, manure applications to fields, wastewater treatment plant discharges, 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). 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.

Chloride

Chloride is a common ion used as an indicator of other contaminants within a watershed and can be used as a tracer. Chloride can originate from numerous sources such as animal and human waste, potassium chloride fertilizers used in agriculture and lawns. Chloride can also be derived from the dissolution of halite (road salt) that is applied to roads in the winter months (Boutt 1999). As microorganisms do not degrade chloride, it's more long-lived then nitrate. Numerous studies show that chloride concentrations tend to be higher during baseflow, when groundwater is the dominant contributor to a river and the opposite holds true when runoff is high and solute concentrations are diluted (Barker 1986).

Atrazine

Atrazine belongs to the chemical class Triazine. Atrazine, a triazine herbicide, is one of the most frequently used selective pesticides in the United States. Its primary function is to control broadleaf and annual grasses (NCSWQG 2002). Atrazine is taken up through plant roots and foliage. Although this process takes the atrazine out of the shallow subsurface, it inhibits the growth of the plants by limiting photosynthesis (Oregon State University 1996). Atrazine was most widely used between 1987 and 1989 throughout the Midwest, including Wisconsin, however it is still quite widely used today (EPA Consumer Fact Sheet – Atrazine 2001). If atrazine is used, following current best management practices can reduce its effects 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 subsurface conditions of the Plover Watershed, atrazine is very mobile through the soil horizons, therefore threatening groundwater. Wisconsin has a 3 ug/L drinking water standard for atrazine, but no standards for surface water exist.

Total Suspended Solids

TSS (total suspended solids) is the sediment particles that are floating in a water column. TSS can be an indicator of runoff from sources such as agricultural fields, construction sites, and forested areas. High concentrations of TSS can transport other constituents, such as pesticides, nutrients, and bacteria that adhere to soil colloids and travel into the river through overland flow during a storm event. (EPA – Turbidity and Solids 2000). Excess TSS can also turn waters murky; therefore, limiting the amount of sunlight able to reach the rivers. The decrease in sunlight inhibits plant growth in the rivers. Another problem associated with high TSS is an increase in water temperature. When the river is dark, murky color it will absorb light, therefore increasing the water temperature and inhibiting invertebrate and fish habitat by lower oxygen concentrations (Murphy 2000).

Volatile Suspended Solids

VSS (volatile suspended solids) is the portion of the TSS that is due to organic particles. Sources of this suspended organic matter are frequently from wetlands that are disturbed. Like TSS, the organic colloids can have nutrients and pesticides associated with them. They are classified as volatile suspended solids because they are "volatilized" into the air when a TSS sample is heated to 550 degrees Fahrenheit.

Results

Land use / Sub-basins Description

There are 17 sub-watersheds within the Plover River Watershed that are related to the sampling sites used during this study (Figure 7). A sub-watershed is the land area that contributes hydrologically to a given area. Sub-watersheds are delineated the same way the entire watershed is, with the use of topography (surface elevation). With the exception of sites 3 and 4, which have the same sub-watershed, each of the sample sites has its own sub-watershed. Deriving the sub-watersheds allows for a better understanding of the landscape that is contributing to water quality for each individual sampling site and will assist the Land Conservation Departments in determining areas that may need implementation of best management practices to improve water quality within a given stretch of the river.

The sub-watersheds in this study were delineated using electronic digital elevation models (DEMs), and Arc View's spatial analyst along with their CRWR preprocessor. Overlying the land use maps helped to relate water quality with associated land uses in each sub-watershed. WISCLAND was the land cover used, which contains land use imagery collected between August 1991 and May 1993. (Figure 4) WISCLAND characterizes the landscape by classifying each 30-meter by 30-meter area within the watershed, assuming one dominant land use for each area. Appendix A contains a summary of the land uses within each sub-watershed.

The Plover River watershed can be characterized as being dominated by forests and wetlands in the northern reaches. Agriculture exists throughout the watershed, but different practices exist. The northern half is predominantly grazing and non-row crops and row-crops become more dominant in the southern portion of the watershed. Wetlands are located throughout the entire watershed helping to reduce major fluctuations in water levels and flooding. With the exception of the small urban areas of Hatley and Bevent, the only major urban area in the watershed is the Town of Hull and City of Stevens Point, which is located in the southern most part of the watershed.

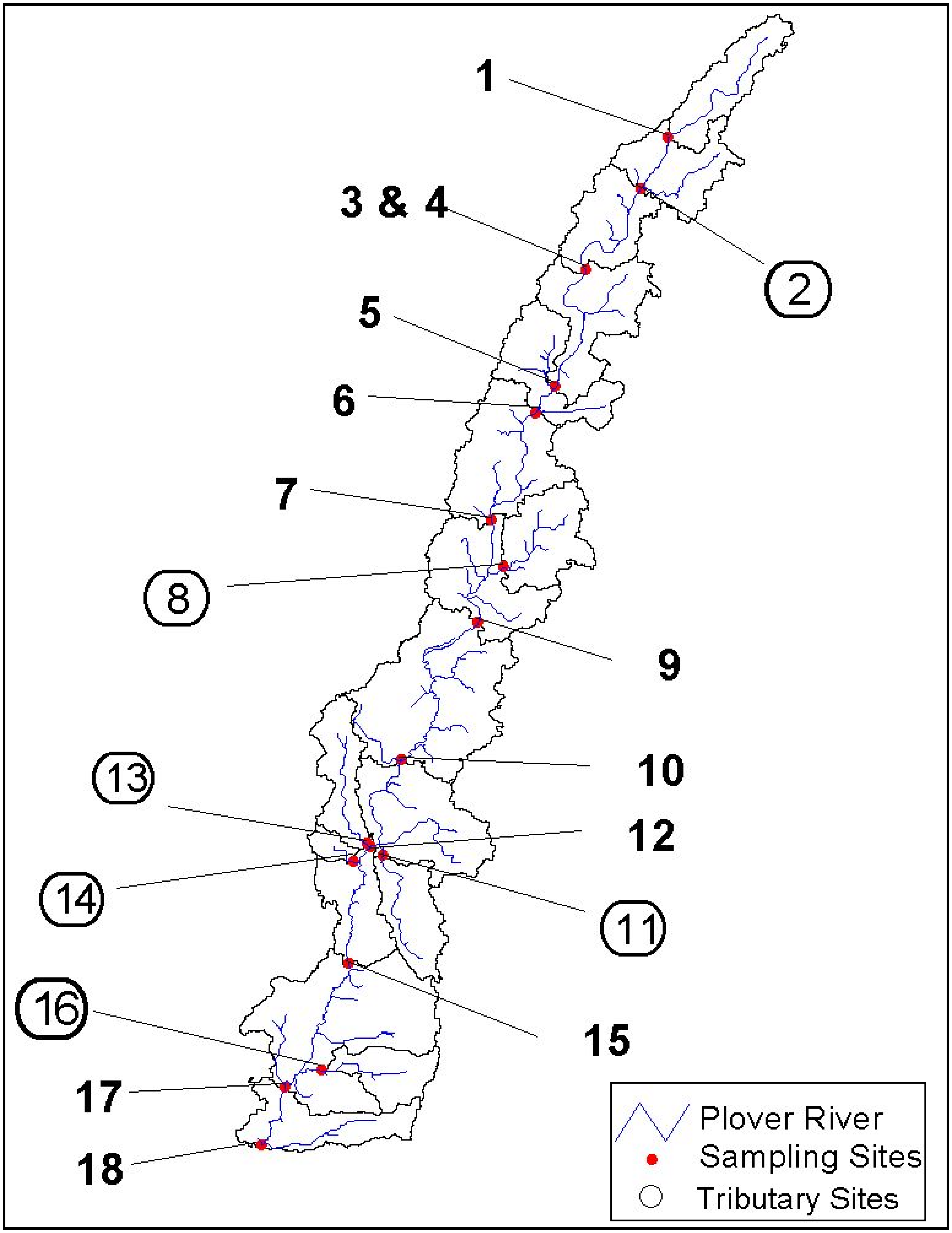

Figure 7: Map of Plover River watershed sample site locations and related sub-watersheds

In relation to land use, soil type was characterized for each sub-watershed with the use of the Marathon and Portage County Soil Survey books. Soil type was used to help predict the level of precipitation infiltration occurring within each sub-watershed.

Based on discharge, common land uses, and water quality results, the watershed had four fairly distinct segments. (Figure 8) The following land use descriptions for each site and the water quality discussion are broken into these four segments. Table 2 shows the land use composition for each sample site sub-watershed. The sub-watershed size and land use refers to the area between two sites that drains to the downstream site. Table 3 shows the cumulative land use affecting each sample site. The cumulative land use is the total area of the watershed draining to a given sample site. It is important to analyze overall land use contributing to a site as well as the land uses contributing below the previous site to assess the water quality data as accurately as possible. A more detailed analysis of land uses for each sub-watershed is presented in Appendix A.

Segment A

Site 1 (Highway 52) is located in the headwaters of the watershed. This site is part of the main channel of the Plover River. The stream's substrate is made up of a fine to medium size gravel and the banks are comprised of thick vegetation. The dominant soil association of this sub-watershed is the Chetek-Rosholt-Oesterle association. Five thousand two hundred and thirty acres of land contribute to the sites water quality. The land use in this sub-watershed is dominated by forests, which make up 57% of the sub-watershed.

Site 2 (Sportsman Road) is located in a forest-dominated section of the watershed. This portion of the stream's substrate is made up of gravel with small rocks and the stream banks are well vegetated. The dominant soil association of the sub-watershed is the Kennan – Hatley association. The sub-watershed for this sample site is 5,687 acres and has a total contributing area of 10,917 acres of land. The land use of the sub-watershed and overall contributing land is dominated by forests, which make up

Table 2: Land uses for each sample site sub-watershed. Sites on the Plover River are bold.

Site Number		Urban	Agriculture	Grassland	Forested	Open Water	Wetland	Barren	Total
1	Acres	0	1,057	470	3,007	20	676	0	5,230
	%	0.0	20.0	8.9	57.0	0.4	12.8	0	
2	Acres	40	682	822	3,097	37	1,009	0	5,687
	%	0.7	11.9	14.4	54.1	0.6	17.6	0	
3 and 4	Acres	0	895	313	3,598	3	662	0	5,471
	%	0.0	16.2	5.7	65.1	0.1	12.0	0	
5	Acres	0	2,784	2,049	2,026	58	877	0	7,794
	%	0.0	35.7	26.3	26.0	0.7	11.2	0	
6	Acres	20	848	1,217	2,850	25	1,223	0	6,183
	%	0.3	13.7	19.7	46.1	0.4	19.8	0	
7	Acres	0	2,054	2,548	3,336	108	1,377	0	9,423
	%	0.0	22.0	27.0	36.0	1.0	16.0	0	
8	Acres	0	1256	1140	1937	252	1510	0	6095
	%	0.0	20.6	18.7	31.8	4.1	24.8	0	
9	Acres	0	1,774	1,395	3,549	258	914	0	7,890
	%	0.0	22.5	17.7	45.0	3.3	11.6	0	
10	Acres	0	3,775	4,095	4,988	432	2,494	0	15,784
	%	0.0	23.9	25.9	31.6	2.7	15.8	0	
11	Acres	0	1,080	904	1,443	63	1,332	0	4,822
	%	0.0	22.3	18.7	29.8	1.3	27.5	0	
12	Acres	0	1,723	1,331	1,948	232	4,149	20	9,403
	%	0.0	18.3	14.1	20.7	2.5	44.1	0.2	
13	Acres	0	516	338	2,280	3	1,394	7	4,538
	%	0.0	11.4	7.4	50.1	0.1	30.7	0.2	
14	Acres	0	146	45	353	3	398	0	945
	%	0.0	15.4	4.8	37.1	0.4	41.8	0.0	
15	Acres	0	1,152	898	1,141	28	1,869	41	5,129
	%	0.0	22.3	17.4	22.1	0.5	36.2	0.8	
16	Acres	20	2,109	625	512	10	491	239	4,006
	%	0.5	55.9	16.6	13.6	0.3	6.7	6.3	
17	Acres	974	4,436	3,021	4,031	117	3,830	297	16,706
	%	5.9	26.9	18.3	24.4	0.7	21.4	1.8	
18	Acres	1,522	1,733	821	1,309	238	82	111	5,816
	%	26.1	29.7	14.1	22.5	4.1	1.4	1.9	

Table 3: Cumulative land uses contributing to each sample site. Sites located in the Plover River are bold.

Site Number		Urban	Agriculture	Grassland	Forested	Open Water	Wetland	Barren	Total
1	**Acre**	0	1,057	470	3,007	20	676	0	5,230
	%	0.0	20.0	8.9	57.0	0.4	12.8	0	
2	**Acre**	40	1,739	1,292	6,104	57	1,685	0	10,917
	%	0.4	15.9	11.8	55.9	0.5	15.4	0	
3 and 4	**Acre**	40	2,634	1,605	9,702	60	2,347	0	16,388
	%	0.2	16.1	9.8	59.2	0.4	14.3	0	
5	**Acre**	40	5,418	3,654	11,728	118	3,224	0	24,182
	%	0.2	22.4	15.1	48.5	0.5	13.3	0	
6	**Acre**	60	6,266	4,871	14,578	143	4,447	0	30,365
	%	0.2	20.6	16.0	48.0	0.5	14.6	0	
7	**Acre**	60	8,320	7,419	17,914	251	5,824	0	39,788
	%	0.2	20.9	18.6	45.0	0.6	14.6	0	
8	**Acre**	0	1256	1140	1937	252	1510	0	6,095
	%	0.0	20.6	18.7	31.8	4.1	24.8	0	
9	**Acre**	60	11,350	9,954	23,400	761	8,248	0	53,773
	%	0.1	21.1	18.5	43.5	1.4	15.3	0	
10	**Acre**	60	15,125	14,049	28,388	1,193	10,742	0	69,557
	%	0.1	21.7	20.2	40.8	1.7	15.4	0	
11	**Acre**	0	1,080	904	1,443	63	1,332	0	4,822
	%	0	22.3	18.7	29.8	1.3	27.5	0	
12	**Acre**	60	17,928	16,284	31,779	1,488	16,223	20	83,782
	%	0.1	21.4	19.4	37.9	1.8	19.4	0	
13	**Acre**	0	516	338	2,280	3	1,394	7	4,538
	%	0	11.4	7.4	50.1	0.1	30.7	0.2	
14	**Acre**	0	146	45	353	3	398	0	945
	%	0	15.4	4.8	37.1	0.4	41.8	0	
15	**Acre**	60	19,742	17,565	35,553	1,522	19,884	68	94,394
	%	0.1	20.9	18.6	37.7	1.6	21.1	0.1	
16	**Acre**	20	2,109	625	512	10	491	239	4,006
	%	0.5	55.9	16.6	13.6	0.3	6.7	6.3	
17	**Acre**	1,054	26,287	21,211	40,096	1,649	24,205	604	115,106
	%	0.9	22.8	18.4	34.8	1.4	21.0	0.5	
18	**Acre**	2,576	28,020	22,032	41,405	1,887	24,287	715	120,922
	%	2.1	23.2	18.2	34.2	1.6	20.1	0.6	

approximately 54%. As several crews were involved with sample collection throughout the study, inadvertently there were two different sample locations being sampled at this point in the watershed. One location was on the Plover River itself (denoted as 2b in Appendix A) and the other location was Aniwa Creek (denoted as 2a in Appendix A). All of the siphon samples and most baseflow samples were taken from Aniwa Creek, a tributary of the Plover River.

Site 3 (Pine View Road – above) is located in a predominantly forested section of the watershed. This site is located in the main channel of the Plover River. Sand and gravel are the primary substrate in this section of stream, with portions of the banks comprised of vegetation and an area of cattle grazing adjacent and into the river. The dominant soil association of the sub-watershed is the Kennan - Hatley association. The sampling site is located to the north of the Pine View Road bridge and is stationed upstream of a watering ramp for cattle, which penetrates the river. This site has 16,524 acres of land contributing to the water quality sampled at this site. The land use is dominated by forests, which make up 65% of the contributing land.

Site 4 (Pine View Road – below) is located in a predominantly forested section of the watershed with an agriculture influence. This site is part of the main channel of the Plover River and is located 100 meter south of the Pine View Road Bridge, and approximately 200 meters downstream from site 3. This site involves the same sub-watershed as described above for sample site 3, however it includes the cattle access area just down stream of site 3.

Segment B

Site 5 (Highway Y Bridge) is located in a predominantly forested section of the watershed. Site 5 is just upstream from the village of Hatley located on the main channel of the Plover River. This portion of the stream's substrate is made up of sand with large rocks and scattered boulders. The stream banks near the site include a narrow vegetative buffer with agricultural fields beyond the buffer. The dominant soil association in the sub-watershed is the Kennan – Hatley and Chetek-Rosholt-Oesterle associations. The land use in this sites' 7,794-acre sub-watershed is 36% agriculture, 26% grassland, and 26% forested. Overall, there are a total of 24,182 acres of land contributing to this sites' water quality and the dominant land use in this area is 48% forested.

Site 6 (Highway 29) is located in a predominantly forested portion of the watershed. Site 6 is just below the village of Hatley. This site is part of the main channel of the Plover River. This portion of the stream substrate is made up of sand with large rocks. The banks upstream and downstream of the Highway 29 bridge are comprised of deciduous trees. The dominant soil association of the sub-watershed is the Chetek-Rosholt-Oesterle association. The primary land uses in the cumulative watershed are forests (46%) and agriculture (21%). The sites sub-watershed is comprised of 46% forest, 20% wetland, and 20% grassland.

Site 7 (Plover River Road) is located in a predominantly forested section of the watershed. This site is part of the main channel of the Plover River. This portion of the stream's substrate is made up of sand and small rocks and sporadic large boulders. The banks are comprised of thick vegetation. The dominant soil association of the sub-watershed is the Chetek-Rosholt-Oesterle association. The sites' 9,423-acre sub-watershed is comprised mostly of forest (36%), grassland (27%), and agriculture (22%). The overall contributing land use is dominated by forests (46%) and agriculture (21%) and the contributing area is 39,788 acres.

Site 8 (Highway Y – Pike Lake Area) is a tributary to the Plover River, as it flows from Pike Lake into the Plover River. This portion of the stream's substrate is made up of sand with medium size rocks. The banks are comprised of dense wetland vegetation. The dominant soil association of the sub-watershed is the Kennan – Hatley association. 6,095 acres of land contribute to the sites water quality. The land use is comprised of forests (32%), wetlands (25%), agriculture (21%), and grassland (19%).

Site 9 (Highway 153) is located in a predominantly forested dominated section of the watershed with agricultural cropped or grazed fields adjacent to the sampling site. This site is part of the main channel of the Plover River. This portion of the stream's substrate is gravelly with large rocks. The banks are comprised of native vegetation. The dominant soil association of the sub-watershed is the Chetek-Rosholt-Oesterle association. Land use composition of both the sample site sub-watershed and contributing area are very similar: approximately 45% forest, 22% agriculture, and 28% grassland.

Segment C

Site 10 (Shantytown Rd) is located in a predominantly forest dominated section of the watershed. This site is located in the main channel of the Plover River where the stream's substrate is made up of a sand base with large rock. The banks are comprised of thick vegetation. The dominant soil association of the sub-watershed is the Mahtomedi – Graycalm - Meehan association. This sites immediate sub-watershed is 15,784 acres and is comprised of forest (32%), grassland (26%), agriculture (24%), and wetlands (16%). The total area of land contributing to this site is 69,557 acres with relatively similar land use composition as the sub-watershed.

Site 11 (North Star Road Tributary) is a tributary of the Plover River. This portion of the stream's substrate is made up of sand with small rocks with the banks comprised of dense vegetation. The dominant soil association of the sub-watershed is the Markey – Seelyeville – Cathro association. The sub-watershed is 4,845 acres with land uses in the sub-watershed comprised of forests (30%), wetlands (28%), agriculture (22%), and grasslands (19%).

Site 12 (Bentley Bridge) is located in the main channel of the Plover River downstream from the Bentley Pond impoundment. This portion of stream's substrate is made up of sand with pebbles and small rocks. The banks are comprised of thick vegetation. The dominant soil association of the sub-watershed is the Roscommon – Meehan – Markey association. The sites' sub-watershed is 9,403 acres and is comprised of wetlands (44%), forest (21%), agriculture (18%), and grassland (14%). The cumulative watershed is 83,782 acres.

Site 13 is a tributary to the Plover River. This portion of stream is made up of a sandy substrate with banks comprised of dense vegetation. The dominant soil association of the sub-watershed is the Roscommon – Meehan – Markey association. 4,549 acres of land contribute to the site's water quality. Predominant land use in this sub-watershed is forest (50%), wetland (31%).

Site 14 is located in a predominantly agriculturally dominated section of the watershed. This site is a tributary of the Plover River. This portion of stream's substrate is made up of vegetation. The banks are comprised of grasses with agricultural fields along both sides of the ditch. The dominant soil association of the sub-watershed is the Plainfield – Friendship association. 952 acres of land contribute to the sites' water quality. The dominant land use in the sub-watershed is wetlands, making up 42% of the sub-watershed.

Site 15 (Jordan North) is located on the main channel of the Plover River. This portion of the stream is made up of a sandy substrate with banks comprised of vegetation. The dominant soil association of the sub-watershed is the Plainfield – Friendship association. This sites' sub-watershed is 5,129 acres and has a mix of land uses including wetland (36%), forest (22%), agriculture (22%), and grassland (17%). Overall, 94,394 acres of land contribute to the sites water quality.

Segment D

Site 16 is a tributary of the Plover River. Land use in this sites' sub-watershed has the greatest percentage of agriculture in the watershed (56%). Other land uses in this 4,006-acre sub-watershed include grassland (17%), forest (14%), wetland (7%), barren (6%), and the beginning of the urban activities (0.5%). This portion of the stream's substrate is made up of sand and gravel. The banks are wooded downstream and lawns comprise the upstream portion of the sampling site. The dominant soil association of the sub-watershed is the Roscommon – Meehan – Markey association as well as wet, loamy, mostly muck soils.

Site 17 (Hwy 10 – Iverson) is located in the main channel of the Plover River, downstream from the Jordan Pond impoundment. This portion of the stream's substrate is made up of sand. The banks are comprised of vegetation and man-made rock rip-rap. The dominant soil association of the sub-watershed is the Plainfield – Friendship association. This sites' sub-watershed is 16,706 acres with land use comprised of agriculture (27%), forest (24%), wetland (21%), grassland (18%), and urban (6%). The cumulative watershed is 115,106 acres.

Site 18 (McDill) is located near the watershed's discharge point, the Wisconsin River. This site is located in the main channel of the Plover River just downstream of the McDill Pond. This portion of stream is made up of a sand substrate with banks comprised of thin vegetation, as is common in this urbanized area. The dominant soil association of the sub-watershed is the Plainfield – Friendship association. This sites' sub-watershed is 5,816 acres and has the largest urban component (26%). Other land uses are agriculture (30%), forest (23%), and grassland (14%). Wetlands (1.4%) make up the smallest percent of all sub-watersheds in the system. The cumulative watershed effecting this site is 120,922 acres and is comprised of forest (34%), agriculture (23%), wetland (20%), grassland (18%), urban (2%) and barren (0.6%).

Longitudinal Water Quality Analysis

Overall, the Plover River has pretty good water quality. There are clearly some segments of the river and its tributaries that contribute more contaminants than others, and land use practices in these areas should be addressed. It is evident that many of the constituents found in the river/tributary water are entering the river via groundwater discharge, and therefore may be originating from out in the watershed and not just from land use practices adjacent to the river. Bearing in mind that it is generally less expensive for citizens to protect this current status than it would be to "repair" the water quality should it be allowed to degrade, it is important for landowners in the watershed to be educated as to the effects their land use practices could have on water quality as well as which practices may minimize impacts to the water quality.

The following is a discussion on the results obtained from this study. To ease understanding, based on discharge volume and observed water quality, the river was broken into four segments. (Figure 8) Discussion also follows on the fecal coliform and pesticide sub-studies that were conducted in year two of this study. Figures referenced in the following section can be found at the end of the chapter.

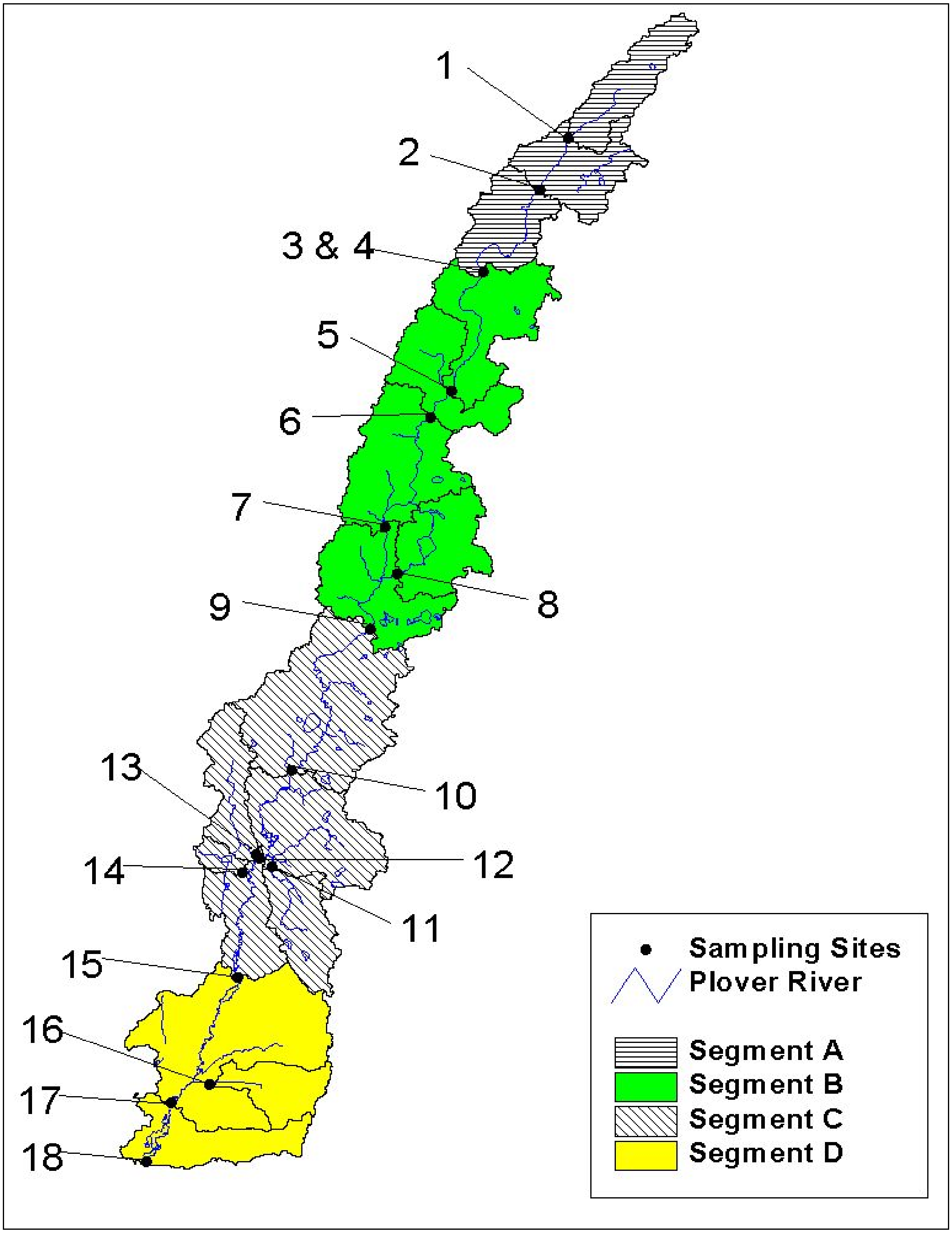

Figure 8: Watershed segments based on discharge, water quality, and landuse

Segment A

Segment A includes sites one through four. It is identified as the headwaters of the Plover River study area. Forests dominate the land in this segment, making up over 50% of each sub-watershed land use (Figure 10). Discharge increases from 1 cfs (cubic feet per second) at site one to 20 cfs by site 4 (Figure 25). These headwaters are predominantly groundwater fed.

Site two differs from the general trend of the other sites in the segment during several events. This is due to the fact that site two was inadvertently sampled at two different locations. One location was on the Plover River itself (denoted as 2b in Appendix A) and the other location was Aniwa Creek (denoted as 2a in Appendix A). The siphon samples and several baseflow samples were taken from Aniwa Creek, a tributary of the Plover River, instead of the Plover River itself so the water quality differs from the main channels chemistry. Concentrations on all of the water chemistry graphs are samples taken from Site 2b, in the Plover River. Site three and four are located in close proximity to one another. Site three is just above a cattle-watering area (which is being addressed by the landowner and the Marathon County Land Conservation Department). Site four is located just downstream of the animal impacted area.

The nitrate constituent is relatively low in value during both event flow and baseflow conditions. Mean nitrate concentration is around 0.65 mg/L during baseflow and 0.42 mg/L during events (Figures 11 and 12). The Aniwa Creek tributary contributes an average nitrate concentration of 0.70 mg/L during baseflow and 0.10 mg/L during eventflow. The low values in nitrate through segment A may be due to the forest-dominated landscape, which allows for the uptake of nitrate by plants and agricultural practices that tend to have lower impacts to water quality. Average nitrate load and yield for sites one, two, three, and four are reported in Table 4, Figure 27, Figure 30 and Appendix F.

Table 4: Average nitrate load and yield for sites 1,2, 3, and 4 during baseflow conditions.

Site	Average NO_3 Load (lbs/day)	Average NO_3 Yield (lbs/year/acre)
1	4.48	0.31
2	23.22	1.48
3	6.88	0.45
4	41.79	2.76

The trend in TKN concentrations is similar during base and event conditions; however, TKN concentrations are elevated during events (Figure 14). This elevation is due to an increase in organic particles entering the water during runoff events, which may relate to material released from the river, wetlands, or soil erosion from uplands. TKN values increase slightly from site three to four during baseflow, while NH_4 remains fairly constant. The difference in TKN and NH_4 in this area is a result of organic bound nitrogen, which is from the cattle in the stream between sites three and four. During events, NH_4 concentrations are very sporadic from site one to site four (range is 0.01 to 0.20 mg/L). The concentration of NH_4 decreases considerably from site one to site two, on average from 0.20 to <0.01 mg/L (Figure 16). A possible reason for a high level of NH_4 at site one during an event may be the release of NH_4 from wetlands, which can store NH_4 (Figure 4). These are some of the higher values found in the watershed and indicate the level to which wetlands can contribute significant organic and reduced forms of nitrogen to the river given the right set of circumstances.

Chloride decreases slightly in concentration during event flow compared to the baseflow; giving indication that runoff acts as a dilutor of solutes originating from groundwater inputs (Figures 21 and 22). Chloride concentrations are low at site 1 and increase at sites three and four from inputs of higher concentrations from Aniwa Creek. Chloride concentrations begin to rise as you move down stream and as agriculture has a greater impact.

Reactive phosphorus and total phosphorus both share similar trends during event flow. Both constituents decrease in mean concentration from sites one to two and below site three, they both increase in average concentration. From site three to four, event flow reactive P average concentrations increased from 0.02 to 0.08 mg/L and event flow TP average concentrations increased from 0.04 to 0.17 mg/L (Figures 18 and 20). The August 14th, 2000 event of 0.20 mg/L TP is strongly affecting the average concentrations at site 4 (Figure 26). The storm event flushed material from the cattle-watering ramp between sites 3 and 4. The baseflow concentrations of reactive and TP exhibited little variation and averaged around 0.03 mg/L and 0.05 mg/L, respectively. Average reactive phosphorus load and yield for sites one through four is reported in Table 5, Figure 29, Figure 32, and Appendix F. Average total phosphorus load and yield for sites one through four was reported in Table 5, Figure 28, Figure 31, and Appendix F. Nutrients yields resulted in negative values, however, this is not directly related to the land within the watershed, but is likely due to in-stream losses or dilution from groundwater inflow. The negative values are reported as N/A in the tables.

Table 5: Average reactive and total P load and yield for sites 1, 2, 3, and 4 during baseflow conditions.

Site	Average Total P Load (lbs/day)	Average Total P Yield (lbs/year/acre)	Average Reactive P Load (lbs/day)	Average Reactive P Yield (lbs/year/acre)
1	0.38	0.03	0.30	0.02
2	1.48	0.10	1.03	0.07
3	3.41	0.24	2.13	0.15
4	-0.24	N/A*	0.07	0.01

*Nutrients yields resulted in negative values, however, this is not directly related to the land within the watershed, but is likely due to in-stream losses or dilution from groundwater inflow.

The overall trend for TSS concentrations in Segment A is a decreasing trend as shown in Figures 22 and 23. TSS concentrations are high at site one, with an average value of 71 mg/L. Part of that may be due to sediments being washed out of the wetland area upstream from site one. Aniwa Creek contributed an average of 30.67 mg/L of TSS to the river. The concentration of TSS diminishes to an average concentration of 26 mg/L at site four. When comparing precipitation to TSS concentrations it is apparent that during larger storm events the TSS concentrations are much higher than other events sampled from the same site. The highest suspended solid concentrations for Segment A all come from the August 14th, 2000 event. Other factors that also contribute to the concentration of TSS entering the river include the amount of exposed soil, amount and type of vegetative cover, and topography.

VSS concentrations are at least half the concentration of TSS values between sites one and four. (Appendix A) Segment A possess a positive correlation between TSS and VSS. (Figure 24) The constant ratio between TSS and VSS means that organic sources are impacting the watershed.

Segment B

Segment B consists of sites five through nine. The dominant land uses in this segment are forests (37%), and agriculture (23%), and grasslands (22%). All three land uses make up a considerable percentage (82%) of the combined sub-watersheds in this segment.

During baseflow measurements, it was observed that discharge increases considerably from site five to site nine. Discharge increases from an average of 35 cfs at site five to near 60 cfs at site nine. (Figure 25)

Nitrate levels in both baseflow and event flow conditions remain at a constant level between sites four and nine. Nitrate concentrations during baseflow averaged one mg/L. Site eight, a tributary to the Plover, had an average baseflow nitrate concentration of 0.22 mg/L and an average discharge of 1.26 cfs. The mean concentration and average discharge resulted in nitrate loading of about 1.8 lbs/day and flux approximately 0.1 lbs/ac/yr at site eight. This site had an average event flow nitrate concentration of 0.45 mg/L. Nitrate concentrations on the main river during event flow averaged 0.70 mg/L. Nitrate concentrations during baseflow remain higher than event concentrations; therefore the main source of nitrate is through groundwater recharge into the river and storm events are diluting the concentration of nitrate (Figures 11 and 12). Average nitrate load and yield concentrations for sites five through nine are reported in Table 6, Figure 27, Figure 30, and Appendix F.

Table 6: Average nitrate load and yield for sites 4, 5, 6, 7, 8, and 9 during baseflow conditions.

Site	Average NO_3 Load (lbs/day)	Average NO_3 Yield (lbs/year/acre)
5	94.12	4.40
6	4.55	0.27
7	52.40	2.03
8	1.77	0.11
9	98.14	4.54

TKN concentrations increase from site five to six during storm events and baseflow (Figure 14). One possible source for this may be a wetland-dominated tributary that flows into the Plover River above site six. Event TKN concentrations continue to increase to site seven; however, NH_4 decreases in concentration over that same stream length (Figures 14 and 16). This may be due to NH_4 uptake by plants. Baseflow NH_4 concentrations follow a decreasing trend from site five to nine, whereas event flow NH_4 concentrations possess an overall increasing trend. This contrasting trend indicates the NH_4 is originating from overland flow through wetlands during storm events.

Baseflow TP concentrations remain nearly level averaging 0.04 mg/L. The event flow TP increases from site five to six and then levels off (Figure 18). The increase in TP, as well as an increase in TKN and TSS, suggests that organic matter is causing a slight increase in the concentrations. This organic matter could be originating from farmland runoff or wetlands; both types of land uses are prevalent between sites five and six (Figure 4). Average reactive phosphorus load and yield is reported in Table 7, Figure 29, Figure 32, and Appendix F. Average total phosphorus load and yield is reported in Table 7, Figure 28, Figure 31, and Appendix F.

During both baseflow and event flow, chloride values seem to increase slightly throughout segment B, with the exception of site five. Runoff during the August 8th, 2000 storm event had high chloride concentrations in the sample collected from this site. The rest of the sites within the segment have a little variation between the maximum and

Table 7: Average reactive and total P load and yield for sites 5, 6, 7, 8, and 9 during baseflow conditions.

Site	**Average Total P Load (lbs/day)**	**Average Total P Yield (lbs/year/acre)**	**Average Reactive P Load (lbs/day)**	**Average Reactive P Yield (lbs/year/acre)**
5	1.85	0.13	0.36	0.02
6	1.13	0.08	-0.43	N/A*
7	0.64	0.04	0.83	0.06
8	0.37	0.03	0.05	0.00
9	6.34	0.44	0.37	0.03

*Nutrients were lower than upstream sites, however, this is not directly related to the land within the watershed, but is likely due to in-stream losses or dilution from groundwater inflow.

minimum. The event flow chloride concentrations show a gradual increase from sites five through nine. The baseflow concentrations show a similar pattern, but are higher than the event flow chloride concentrations, again indicating that much of the chloride is entering the river from groundwater discharge.

TSS concentrations between sites five through nine follow a decreasing trend. There are two noticeable spikes in TSS concentration that tend to pull the trend line upward (Figure 23). Site six had a concentration of 71 mg/L from the August 14th storm event. This increased concentration is consistent with the increase in TP and TKN, all which are related to organic solids that moved to the system via surface runoff. The August 14th, 2000 event resulted in concentrations as high as 165 mg/L TSS at site nine. The high concentrations of TSS provided by the August 14th, 2000 event also contributed maximum values of TP and TKN at site nine. TP and TKN are positively correlated with organic solids. The high values of TKN and TP can be directly linked with the high TSS value. Prior to the August 8th and 14th rain events, there had been very little rainfall through the month of July and the beginning of August (Figure 26). The sudden heavy rainfall may have acted as a catalyst, washing sediments from fields.

Volatile suspended solids averaged 50% of the TSS concentration. This indicates that half of the sediment moving through this segment has an organic component, such as animal waste and/or wetlands as opposed to bank erosion, which is dominated by sand (non-organic material) in this river system.

Segment C

Segment C is comprised of sites ten through fifteen. The land uses within this segment are a mixture of forest, wetland, grassland, and agriculture. Sites ten, twelve and fifteen are located in the Plover River and sites eleven, thirteen, and fourteen are all tributaries within the segment. Discharge increases significantly in this segment, suggesting an increase in groundwater contributions (Figure 25).

Nitrate concentrations are elevated compared to segments A and B (Figure 11 & 12). The baseflow nitrate concentrations are consistent at a value of 1.60 mg/L. Within the tributaries, site eleven contributes an average concentration of 2.2 mg/L, site thirteen contributes an average concentration of 0.3 mg/L, and site fourteen contributes an average concentration of 2.3 mg/L during baseflow conditions (Appendix B). Although these concentrations are slightly elevated compared to upstream, these levels are still relatively low for the area. Average nitrate load and yield concentrations for sites ten through fifteen are reported in Table 8, Figure 27, Figure 30, and Appendix F.

Table 8: Nitrate load and yield for sites 10, 11, 12, 13, 14, and 15 during baseflow conditions.

Site	**Average NO_3 Load (lbs/day)**	**Average NO_3 Yield (lbs/year/acre)**
10	427.28	9.88
11	19.61	1.48
12	76.79	2.98
13	0.34	0.03
14	5.02	1.92
15	-7.61	N/A*

The event flow nitrate concentrations averages are 1.3 mg/L. The event of April 13th, 2001 produced a maximum concentration of 4.4 mg/L at site twelve (Figure 12). This increased concentration may have been due to runoff from farm fields upstream of the site. Site eleven contributes an average concentration of 0.8 mg/L, site thirteen contributes an average concentration of 0.1 mg/L, and site fourteen contributes an average concentration of 0.6 mg/L during event flow conditions (Appendix B). In general there are lower concentrations during baseflow.

Concentrations of NH_4 in this segment remained fairly low during all sample periods. Baseflow NH_4 concentrations steadily increase from 0.01 mg/L at site 10 to 0.06 mg/L at site 15 (Figure 15). Segment C has an average baseflow NH_4 concentration of 0.04 mg/L. Average tributary inputs during baseflow are: 0.10 mg/L at site eleven, 0.18 mg/L at site thirteen, and 0.19 mg/L at site fourteen. The NH_4 is not usually transported through groundwater, but is generally found in reducing conditions like wetlands. Based on the close proximity of agricultural land in relation to the sites, agricultural inputs may also be contributing (Figure 4).

The event flow NH_4 average concentration in the river was 0.04 mg/L (Figure 16). Event flow average tributary values were: 0.03 mg/L at site eleven, 0.12 mg/L at site thirteen, and 0.11 mg/L at site fourteen. The release of NH_4 from wetlands, barnyards, and fields during a storm event may be the cause for the slightly increased tributary concentrations.

Baseflow concentrations of TP remain constant in the main river at a concentration of 0.03 mg/L (Figure 17). Tributaries were found to have 0.03 mg/L at site eleven, 0.05 mg/L at site thirteen, and 0.14 mg/L at site fourteen. Event flow concentrations of TP increase in the river from 0.05 mg/L at site twelve to 0.08 mg/L at site fifteen (Figure 18). During event flow conditions site eleven contributes an average concentration of 0.06 mg/L, site thirteen contributes an average of 0.07 mg/L, and site fourteen contributes an average of 0.17 mg/L. The elevated concentrations from the tributaries may account for the increased concentrations from site twelve to site fifteen. Both baseflow and event flow concentrations of reactive P is minimal. The baseflow reactive P average concentration is 0.01mg/L and the event flow reactive P average concentration is 0.02 mg/L (Figures 19 and 20). Average reactive phosphorus load and yield for sites ten through fifteen is reported in Table 9, Figure 29, Figure 32, and Appendix F. Average total phosphorus load and yield for sites ten through fifteen are reported in Table 9, Figure 28, Figure 31, and Appendix F.

Table 9: Average reactive and total P load and yield for sites 10, 11, 12, 13, 14, and 15 during baseflow conditions.

Site	Average Total P Load (lbs/day)	Average Total P Yield (lbs/year/acre)	Average Reactive P Load (lbs/day)	Average Reactive P Yield (lbs/year/acre)
10	-0.08	N/A*	1.16	0.08
11	0.20	0.01	0.08	0.01
12	-0.83	N/A*	0.10	0.01
13	0.10	0.01	0.05	0.00
14	0.30	0.02	0.02	0.00
15	2.50	0.17	-1.57	N/A*

*Nutrients yields resulted in negative values, however, this is not directly related to the land within the watershed, but is likely due to in-stream losses or dilution from groundwater inflow.

Chloride values show an increasing trend during baseflow and a decreasing trend during event flow (Figures 21 and 22). Baseflow concentrations average 8.5 mg/L. During baseflow conditions, tributary site eleven contributes an average concentration of 10.9 mg/L, site thirteen contributes an average of 1.9 mg/L, and site fourteen contributes an average of 17.7 mg/l. The increase in chloride in the segment, with high inputs from tributary sites eleven and fourteen, would suggest high levels of chloride entering the system through groundwater recharge, most likely from agricultural activity.

Average event flow concentrations of chloride are 7.2 mg/L for sites located directly on the river and the maximum concentration of 16.4 mg/L was collected at site ten on June 2nd, 2000 (Figures 22 and 26). As noted upstream, storm events dilute the baseflow concentrations of chloride. During event flow conditions, tributary site eleven contributes an average concentration of 6.7 mg/L, site thirteen an average of 0.6 mg/L, and site fourteen had an average of 5.9 mg/L.

TSS follows a decreasing trend from site ten to site fifteen (Figure 23). The average TSS concentration within segment C is 18 mg/L. The highest concentrations in this segment were measured during two August, 2000 storm events, 71mg/L from site thirteen during the August 14th, 2000 storm event and 77 mg/L from site fifteen during the August 9th, 2000 storm event (Figure 23). The average TSS concentrations from tributary sites eleven, thirteen, and fourteen were 9.5, 27, and 7 mg/L, respectively.

The VSS from the tributaries have a higher ratio of VSS to TSS, suggesting that the solids that originate from the tributaries come from a more organic source such as animal waste or wetlands, both are plausible sources in all three tributaries in segment C.

Segment D

Segment D is comprised of sites sixteen through site eighteen. Site sixteen is a tributary, and sites seventeen and eighteen are located in the Plover River. This segment begins downstream of Jordan pond and the final sample site is just downstream of McDill Pond. The mixed land uses within this segment include agriculture, urban grassland and some forest. The city of Stevens Point is located within this segment, creating a large urban influence (Figure 4). Despite the fact that some groundwater is drawn away from the river in this segment to supply municipal water to Stevens Point, there is a 30 % increase in discharge in this segment and a 28% increase in drainage area.

Average nitrate concentrations increase through segment D during baseflow conditions (Figure 11). Site sixteen, a tributary, contributes an average concentration of 19.3 mg/L. The high levels of nitrate contaminated groundwater discharging to site sixteen is likely due to the agricultural dominated sub-watershed, with predominantly sand substrate that allows nitrates from fertilizer to readily leach into the groundwater (Figure 4). Average nitrate concentrations at sites seventeen and eighteen are approximately 2.1 mg/L. The average concentration from sites seventeen and eighteen increased from segment C's average baseflow nitrate concentration of 1.6 mg/L. This increase is likely due to tributary site sixteen contributing high concentrations, yet in relatively small volumes. The average event flow nitrate concentrations are less than that of baseflow. This indicates that groundwater influences nitrate concentrations more so than runoff in the region. Average nitrate load and yield concentrations for sites sixteen through eighteen are reported in Table 10, Figure 27, Figure 30, and Appendix F.

NH_4 concentrations decrease slightly during baseflow conditions. During event flow conditions, NH_4 peaks in concentration at site seventeen (Figure 16). The increase in NH_4 levels at site seventeen may be due to the effects of agricultural runoff or the flushing of the wetlands during storm events.

Table 10: Nitrate load and yield for sites 16, 17, and 18 during baseflow conditions.

Site	**Average NO_3 Load (lbs/day)**	**Average NO_3 Yield (lbs/year/acre)**
16	119.05	11.52
17	347.30	7.67
18	83.35	5.22

*Nutrients yields resulted in negative values, however, this is not directly related to the land within the watershed, but is likely due to in-stream losses or dilution from groundwater inflow.

Average TKN baseflow concentrations increase from 0.27 mg/L at site seventeen to 0.71mg/L at site eighteen (Figure 13). Site sixteen contributes an average TKN concentration of 0.72 mg/L. The increase in TKN concentrations from site sixteen to eighteen and the decrease of NH_4 concentrations from the same segment would indicate the presence of organic materials above site eighteen. Event flow concentrations of TKN, averaging 0.61 mg/L, are minimal in comparison to site sixteen. This site contributes the highest value of TKN of all sites sampled, with an event flow average concentration of 1.5 mg/L (Figure 14). The NH_4 concentration at site sixteen is minimal, so an increasing TKN value would indicate nutrients associated with organic inputs into the tributary. This same organic relationship is evidenced by the increase in TP. Site sixteen has an average event flow TP concentration of 0.74 mg/L. With the exception of TP event flow concentrations at site sixteen, the average baseflow and event flow TP concentrations are minimal (Figures 17 and 18). Both event flow and baseflow reactive P concentrations are minimal. Segment D's reactive P concentrations from both event flow and baseflow are the lowest concentrations in the watershed (Figures 19 and 20). Average reactive phosphorus load and yield for sites sixteen through eighteen is reported in Table 11, Figure 29, Figure 32, and Appendix F. Average total phosphorus yield for sites sixteen through eighteen are reported Table 11, Figure 28, Figure 31, and Appendix F.

Both the event flow and baseflow average chloride concentrations increase in segment four (Figures 21 and 22). The mean concentration reaches 13 mg/L at site eighteen during events, and 14 mg/L during baseflow conditions. A contributing factor

Table 11: Reactive and total P load and yield for sites 16, 17, and 18 during baseflow conditions.

Site	Average Total P Load (lbs/day)	Average Total P Yield (lbs/year/acre)	Average Reactive P Load (lbs/day)	Average Reactive P Yield (lbs/year/acre)
16	0.36	0.02	0.24	0.02
17	-2.84	N/A*	0.12	0.01
18	1.17	0.08	0.28	0.02

*Nutrients yields resulted in negative values, however, this is not directly related to the land within the watershed, but is likely due to in-stream losses or dilution from groundwater inflow.

to site eighteen average concentrations may be the input from site sixteen, which contributes an average chloride concentration of 30 mg/L during baseflow and 22.53 mg/L during event flow. These high concentrations from site sixteen are likely linked to agriculture. In addition, there are many chloride sources from urban land use practices. The overall high concentration of chloride within segment D is likely due to a combination of row-crop agriculture, the increased application of road salt, and septic system influence.

Examining land use allows for possible sources of degradation to segment D. Besides road salt and dense agriculture along the east of the segment, there is golf coarse, and other urban land use practices such as lawn fertilizing and septic systems between sites seventeen and eighteen. (Figure 3 & 4)

The TSS concentrations within segment D are the lowest of the watershed (Figure 23). Impoundments (such as Jordan and McDill Ponds) slow the velocity of water which allows particles to fall out of the water column and become part of the sediment. In addition, the well-vegetated stream banks and rip-rap in Iverson Park reduce stream bank erosion. The average TSS concentration is 9.2 mg/L for sites sixteen to eighteen. Volatile suspended solids make up an average of 59 % of the TSS.

Fecal Coliform

Fecal coliform bacteria is derived from the intestinal track of warm-blooded animals; however, distinguishing what type of animal, domestic or wild, is contributing to the high levels of fecal coliform bacteria is difficult. Wildlife waste can be washed out of wetlands during a storm event or animal waste can be washed from fields, both contributing to the fecal coliform concentrations. Although human waste is another source, sources of un-treated human waste are not known to be present in the Plover River watershed. Currently, the only option for distinguishing the type of animal that has produced the fecal coliform is by use of DNA (Farag 135). The DNA method was too costly of a process to be used in this study.

Fecal coliform bacteria samples were taken during four separate storm events between 2000 and 2001. The concentrations presented in Figure 9 indicate the majority of the samples taken were above the swimming beach health standard of 200 MFFCC. Samples from the northern portion of the watershed, (sites one through seven) contained the largest quantities of fecal coliform Other high values from the northern reaches of the watershed may have originated from cattle, wildlife, or both.

The fecal coliform concentrations can be correlated with the concentration of TSS because the bacteria can attach to the sediment particles (Murphy 2000). During the times of high fecal counts the TSS values associated with the same storm events are also very high. For example, site four had a fecal coliform count of 5,200 MFFCC/100mL and a TSS value of 66.0 mg/L during the August 14th, 2000 storm event. Such high fecal coliform counts can be considered unnatural and linked to the presence of cattle in the region directly above site four.

A fecal coliform concentration of 156,000 was detected at site fourteen on August 15th, 2000. (Figure 9) The land use adjacent to site fourteen is predominately agricultural and the high concentration could be linked to the spreading of animal waste to the surrounding fields (Figure 4).

Although the overall trend in fecal coliform bacteria is decreasing, the concentration from site one to eighteen is well above the health standard of 200 MFFCC/100 mL. Although the direct sources of the fecal concentrations are not clear, it is important to address fecal coliform bacteria as a threat to water quality the Plover River watershed.

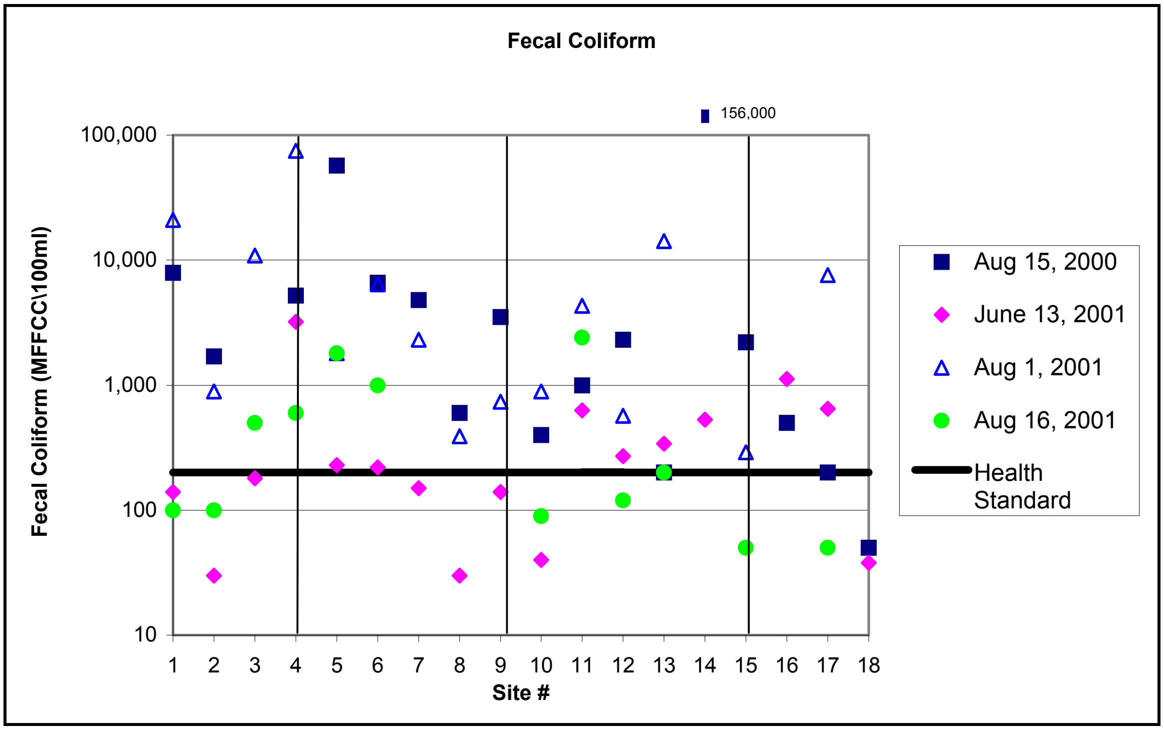

Figure 9: Fecal Coliform Bacteria Concentrations for four sampling dates.

Pesticides

Pesticides do not occur naturally in the environment. Those pesticides that are leached into the subsurface penetrate the water table and once in the groundwater the breakdown of the pesticides is minimal. The pesticides then enter the river ecosystem through groundwater discharge. Nine sample sites were selected for triazine screens in June 2001. (Table 12) As pesticides frequently move through the environment with fertilizers, elevated nitrate and/or chloride concentrations were used in the site selection process. Triazine was detected at all but one of these sites; however, they were all below the level of quantification. This means that presence/absence of triazine can be determined, but specific quantities cannot. Following the triazine screen, seven sites along the Plover River were selected for more comprehensive pesticide analysis.

A variety of pesticides were present in the seven samples, but most were below the level of quantification. The pesticides that were detected are all variations of corn herbicides (Poplyk 1989). A major pesticide within the triazine chemical class is atrazine, which was a common herbicide found in the samples. The pesticides that were detected from the seven sites selected from the Plover River and its tributaries are listed in Table 13. Site thirteen has a larger quantity of agriculture - related pesticides than the other sites listed. (Table 13) Site thirteen's subwatershed also has a smaller percentage of agriculture. (Figure 10) This inverse relationship illustrates that the amount of land in the subwatershed does not always impact water quality. Another factor that may have led to a higher concentration of pesticides at site thirteen is the proximity of the agriculture land to the river or tributary.

Atrazine will usually enter the river ecosystem through groundwater recharge. According to draft water quality USEPA guidelines (2001), concentrations of atrazine below 10 ppb can cause serious problems to the plant and animal communities of aquatic ecosystems. In addition, once atrazine enters into aquatic species, it has the tendency to accumulate in the tissues of the species. Atrazine has been determined to be chronic to brown trout, a species of fish in the Plover River, at a level of 88 ppb. Atrazine is considered toxic to aquatic plants, both algae and microphytes, at a concentration of 10 ppb and above, although several species of freshwater plants do react unfavorably to atrazine at concentrations lower than 10 ppb. Although the effect of atrazine alone on aquatic systems has been studied, the effect of atrazine when combined with constituents such as nitrate is still unknown.

Table 12: Triazine Data for 9 samples sites in Plover River Watershed

Site Number	Triazine Concentration (ppb)
9	0.08
10	<0.05
11	0.09
12	0.18
13	0.25
14	0.25
15	0.32
16	0.13
17	0.21
Detection Limit is 0.05 ppb Values between 0.01 and 0.05 ppb are not quantitative	

Table 13: Pesticides in the Plover River and tributaries sampled June 2001. Concentrations are reported in parts per billion (ug/l)

	Site 9	Site 11	Site 13	Site 14	Site 16	Site 17	Site 18
Molinate			0.122 *				
Triflurian						0.321	
Diaminoatrazine			0.204 *				
De-Isoproply Atrazine		0.324 *	0.692 *	0.882		0.675 *	0.547 *
De-Ethyl Atrazine			0.143 *	0.469 *	0.78	0.681 *	0.472 *
Prometon			0.499 *	0.513			
Terbufos			0.146 *				
Atrazine		0.211 *	0.320 *	0.255 *	0.311 *	0.193 *	0.184 *
Carbofuran			0.161 *				
Acetochlor			0.140 *				
Alachor			0.428 *	0.255 *	0.311 *		
Metribuzin			0.277 *				
Metolachlor			0.136 *	0.108 *			
Isopropalin			0.110 *				
Pendimethalin	0.116 *	0.122 *	0.171 *	0.135 *	0.104 *	0.109 *	
Oxidiazon			0.110 *				

* = Analyte detected at a concentration above the limit of detection limit, but below the limit of quantification

Temperature Monitoring Data

Contributed by the Department of Natural Resources (M. Hazuga and A. Hauber)

The Department of Natural Resources (DNR) completed baseline-monitoring surveys in the summer of 2000 in the Plover River Watershed. Components of the baseline monitoring included fishery surveys, habitat evaluations, macroinvertebrate sampling and continuous temperature monitoring. The Plover River Group purchased HOBO continuous temperature recorders, through a Rivers Protection Grant, to assist the department with collecting temperature data. Continuous temperature monitoring was completed at 15 sites in the watersheds on the Plover River, Little Plover River, Pike Creek, North Creek and Aniwa Creek. A summary of temperature data for each site can be found in Table 14.

Water temperature is an important limiting factor to trout populations. Suitable water temperatures are required during spawning, egg and fry development and for carry-over of adult fish. Studies have been completed to determine the optimal temperature range for trout, however these optimal ranges vary between studies. The US Fish and Wildlife Service developed Habitat Suitability Index models for trout and based on reviews of these studies suggest the optimal temperature range for brook trout is 52-61 degrees Fahrenheit (11-16 C) and the maximum limiting temperature is 75 degrees Fahrenheit (24 C). The optimal temperature range for brown trout is 54-66 degrees Fahrenheit (12-19 C) and the maximum limiting temperature is 81 degrees Fahrenheit (27.2 C).

Survey results indicate higher densities of brook and brown trout are found in the upstream reaches of the Plover River (upstream of Hatley) where water temperatures tended to be colder and spent the majority of the time within the optimal range for trout. Water temperatures downstream of Hatley increased rapidly and spent much less time in the optimal range for trout. Brook and brown trout numbers also declined in this reach. Surveys completed at Pinery Road (downstream of Hatley) found an increase in trout numbers and a decrease in water temperature. The improvement at this site is likely a result of a cold water spring inputs approximately ¼ mile upstream of the road.

Temperature monitoring results indicate elevated water temperatures, downstream of Hatley, are a limiting factor to the coldwater fishery in the Plover River. Warmer water temperatures are likely a result of reduced groundwater input and poor habitat conditions. Segments of the river below Hatley are very wide and shallow with slow velocities resulting in increased water temperatures through solar radiation.

Cold-water temperatures in the upper Plover River are likely a result of significant ground water inputs and improved habitat conditions. Prior to habitat improvement, the upper Plover River was wide and shallow and lacked suitable cover for adult fish. Through efforts of Trout Unlimited and the Department, habitat has been greatly improved in this reach. Improvements in habitat have resulted in a narrower and deeper stream channel that provides cover for fish and has likely had a positive effect on stream temperatures. As a result, fish densities have increased and size structure has improved. Habitat improvement projects continue on the river downstream of Hatley and should have a positive effect on trout populations and water temperature.

Pike Lake Creek is a small stream that flows out of Pike Lake to the Plover River. Temperature monitoring results indicate the stream is likely a warm water stream and does not have adequate temperatures to support a cold-water fishery.

Table 14: Plover River Temperature Monitoring from June 26 – August 31, 2000

Location	Temperature (F) Max.	Min.	Ave.	% Optimal Brook	% Optimal Brown	CPUE/mi Brook	CPUE/mi Brown	Station Distance (F)	Number Brook	Number Brown
Site 8	82.2	60.8	70.4	0	12					
Site 2a	78.0	56.7	67.4	5	51					
Highland	62.9	44.7	52.4	98	100	1466	357	1300	361	88
CTH Z	68.3	49.7	58.3	78	98	272	686	2255	116	293
Birnamwood Road						228	904	2640	114	452
Site 5	77.3	56.0	65.5	14	57	89	290	656	11	36
Site 6	77.3	56.0	66.1	12	51					
Site 7	77.3	57.4	66.5	10	48	26	0	2200	11	
Site 9	78.7	57.4	67.5	6	40	0	4	1310		1
Pinery Road	75.2	56.0	65.9	9.5	49.5		2.718847	1942	25	1
Site 10	76.6	57.4	67.0	5.2	38.2					
Site12	76.6	60.1	69.7	0.7	14					
Sharron Town Road	80.1	60.1	69.4	1	18					
Jordan (Below)	79.4	64.2	72.0	0	3					

* Optimal Temperature for Brook Trout 52 to 61 degrees Fahrenheit
* Optimal Temperature for Brown Trout 54 to 66 degrees Fahrenheit

Aniwa Creek is a five-mile Class II trout stream that originates in Shawano County from a small pond in Aniwa and flows to the upper Plover River in Marathon County. Temperature monitoring results indicate water temperatures are not optimal for brook trout but may be adequate from brown trout. A fishery survey near the mouth found one brown trout.

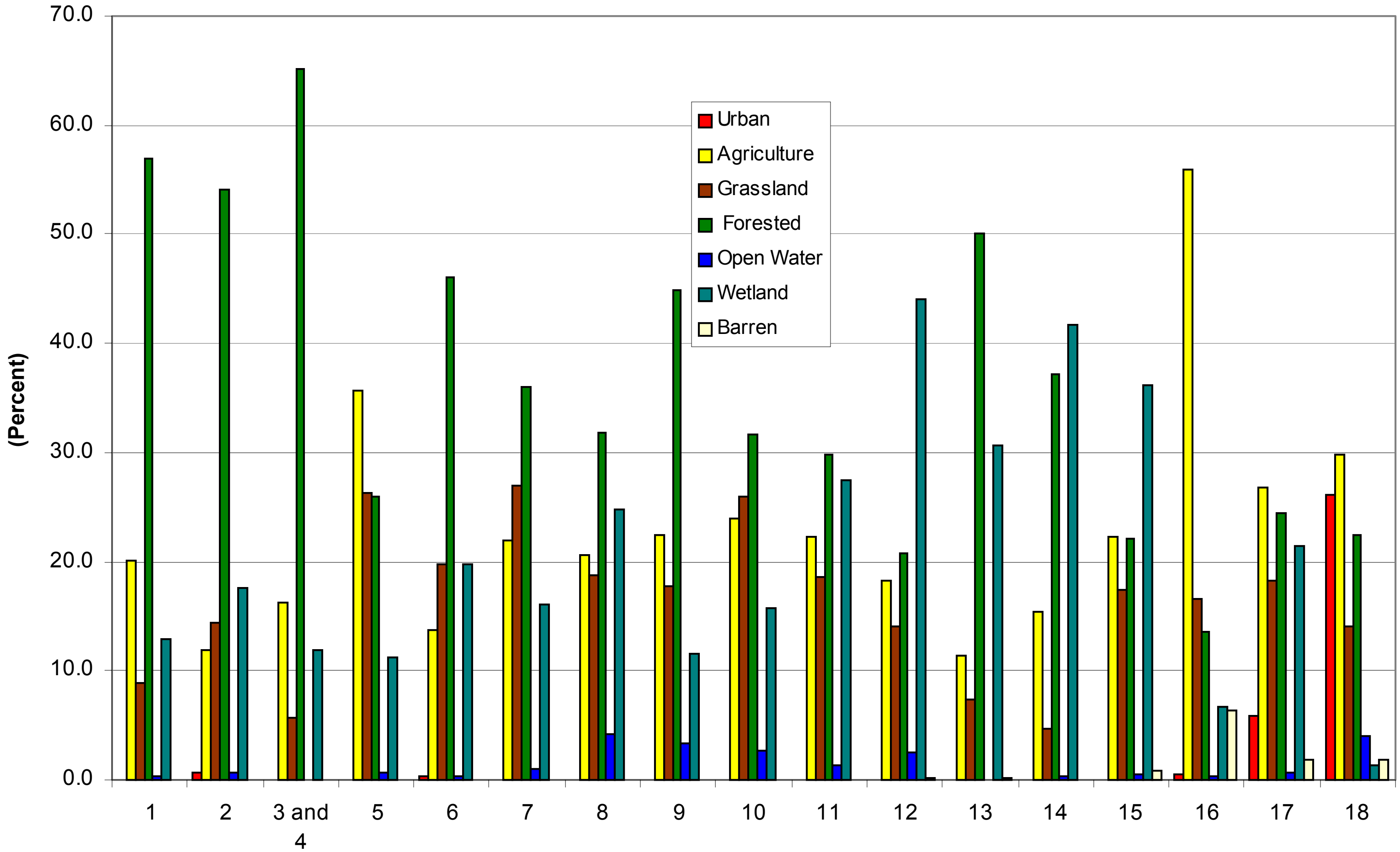

Figure 10: Graph of general land uses in each sample site sub-watershed.

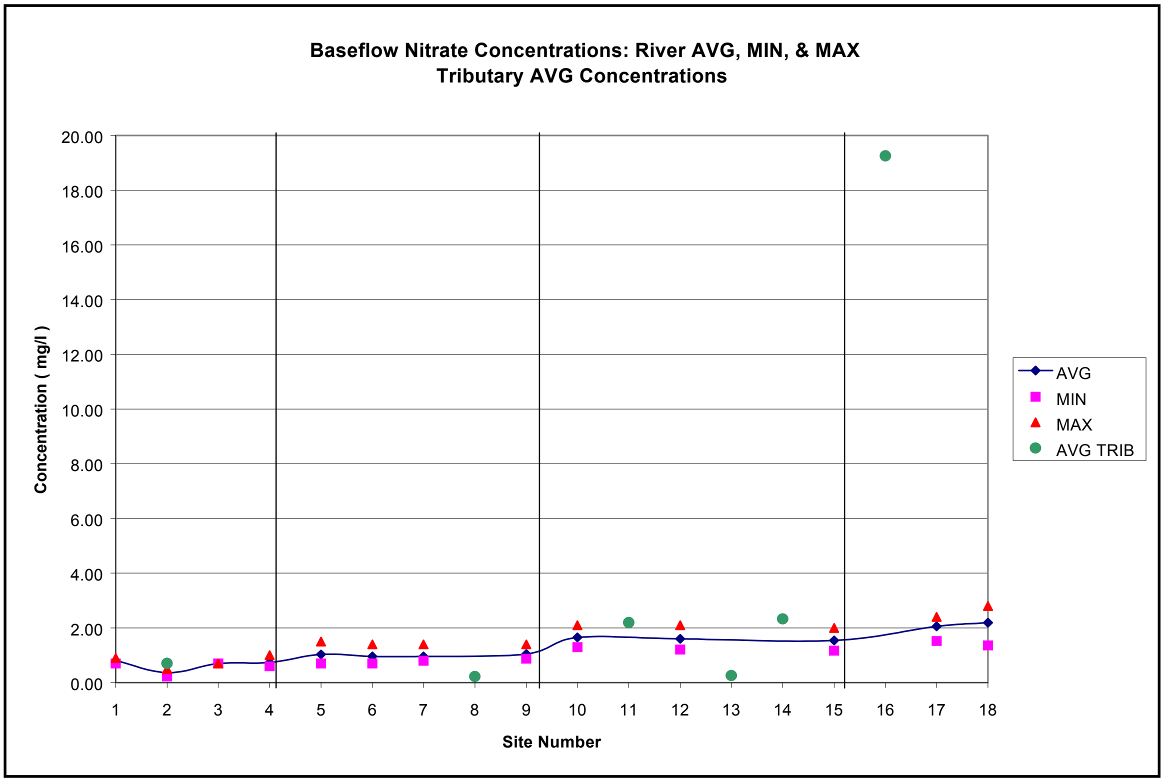

Figure 11: Average Baseflow Nitrate Concentrations for Sampling Sites

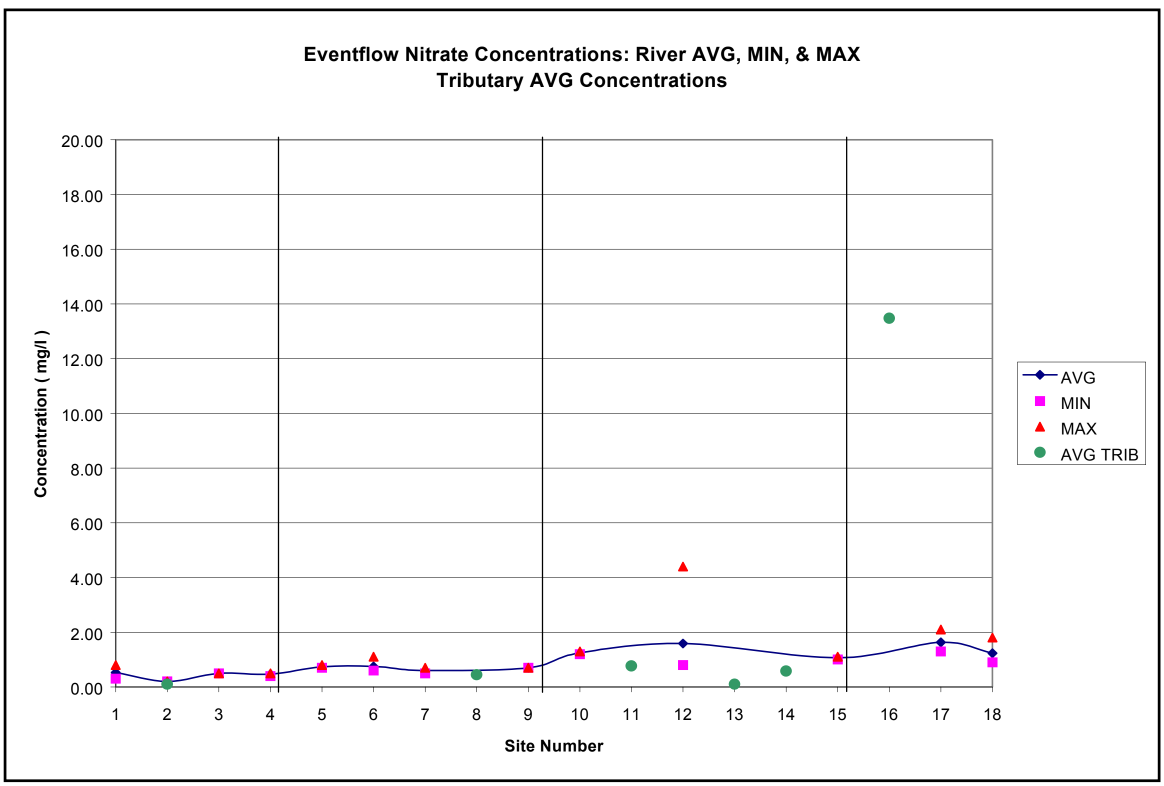

Figure 12: Average Event flow Nitrate Concentrations for Sampling Sites

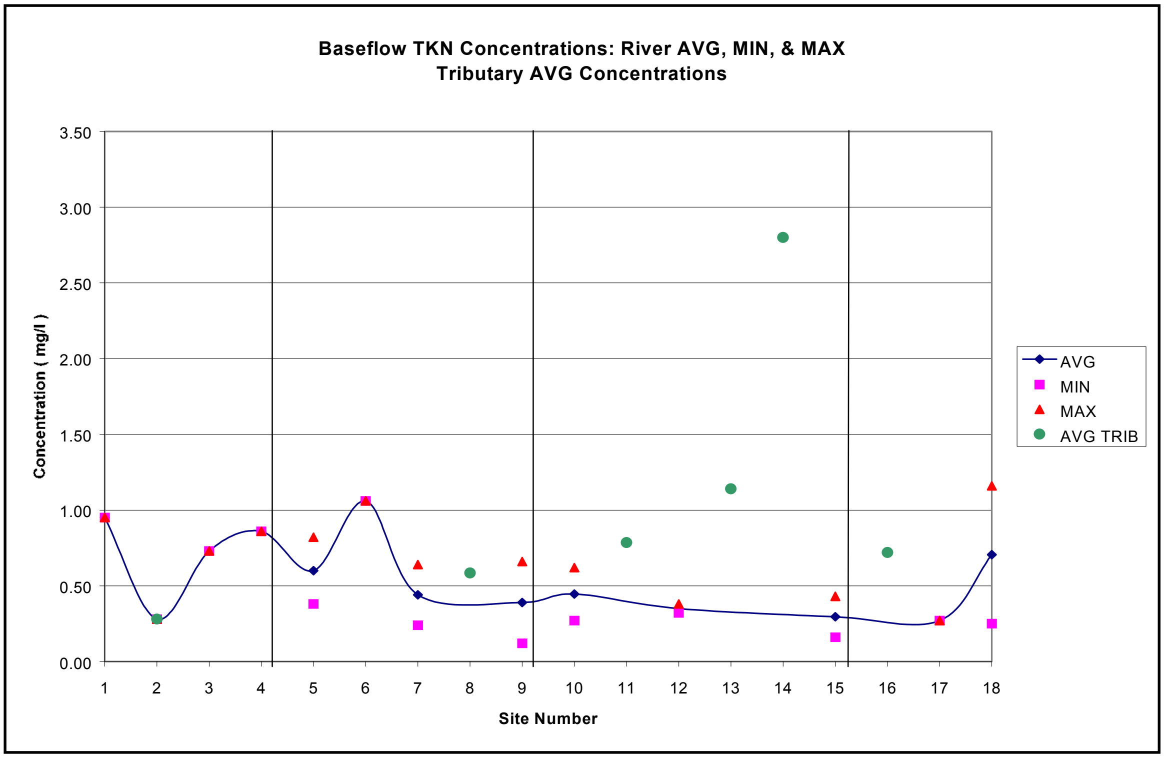

Figure 13: Average Baseflow TKN Concentrations for Sampling Sites

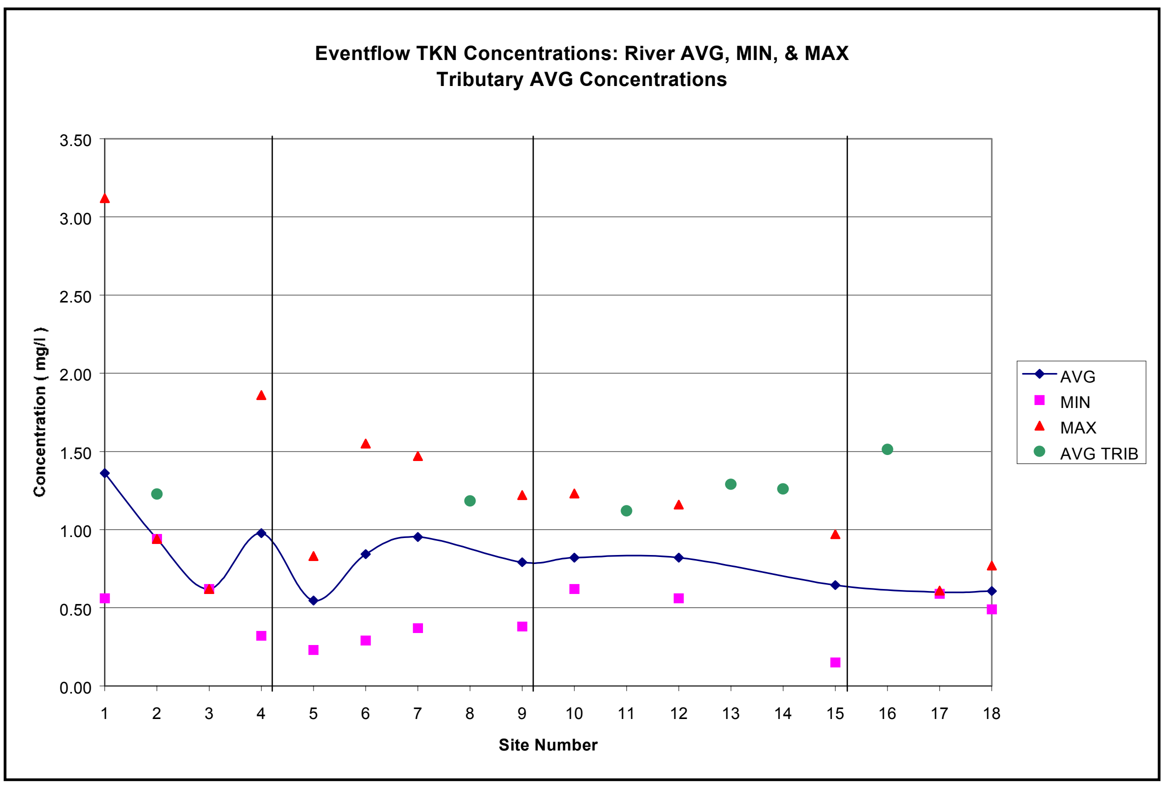

Figure 14: Average Event flow TKN Concentrations for Sampling Sites

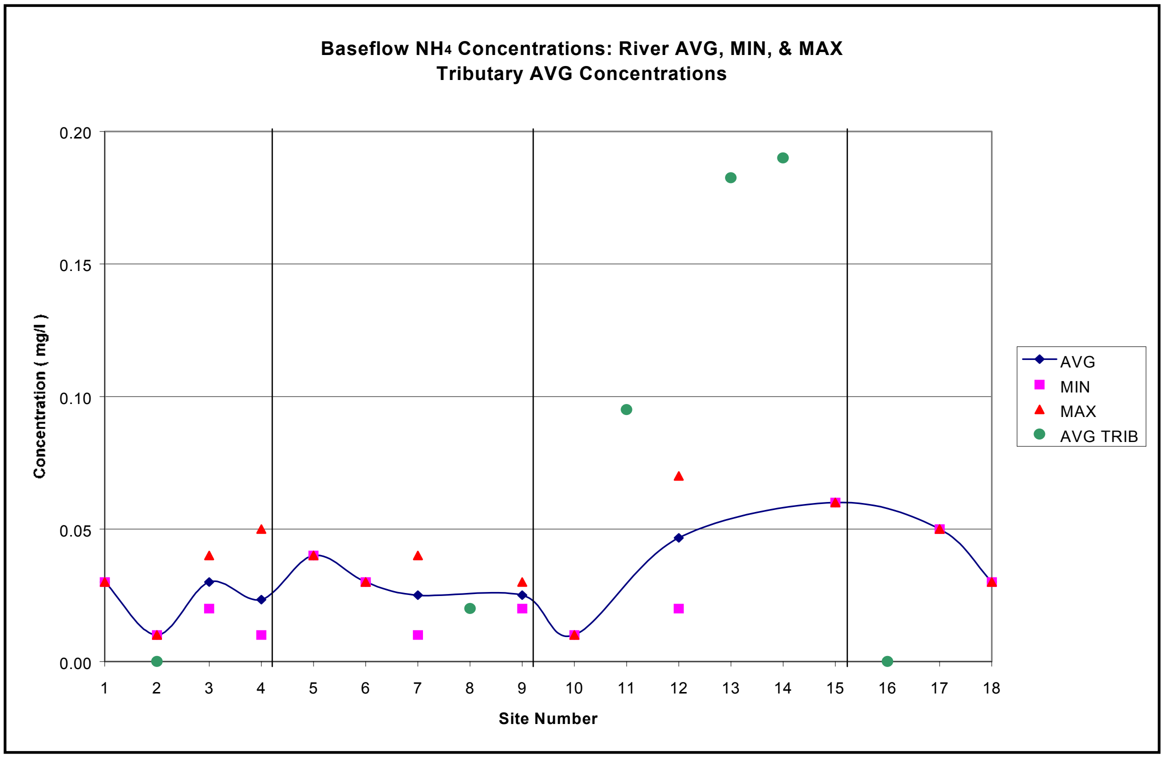

Figure 15: Average Baseflow Ammonia Concentrations for Sampling Sites

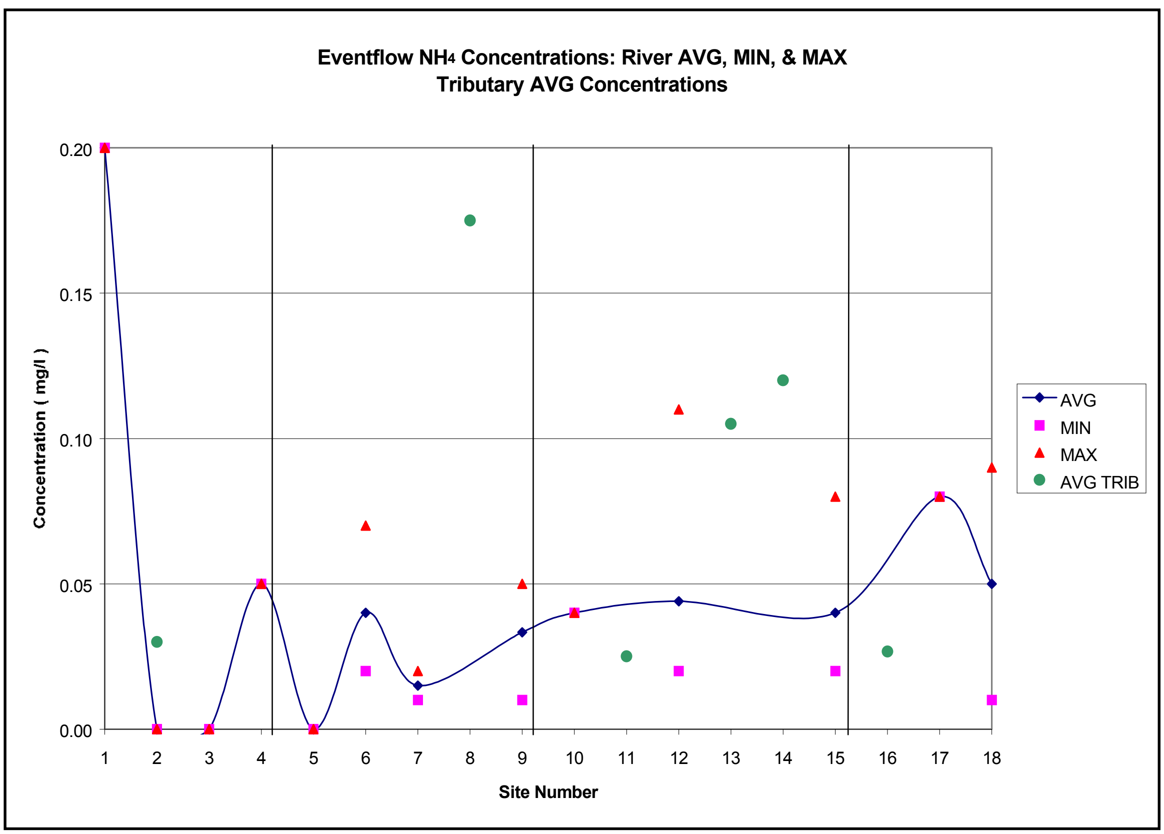

Figure 16: Average Event flow Ammonia Concentrations for Sampling Sites

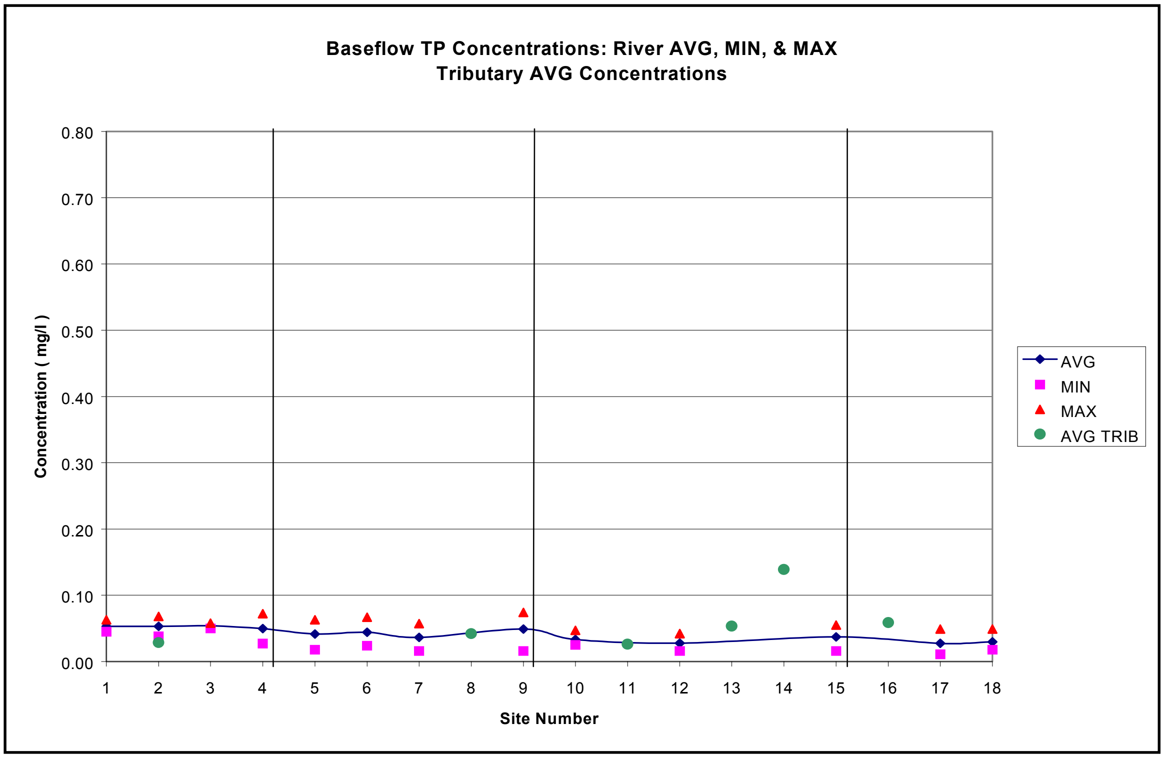

Figure 17: Average Baseflow TP Concentrations for Sampling Sites

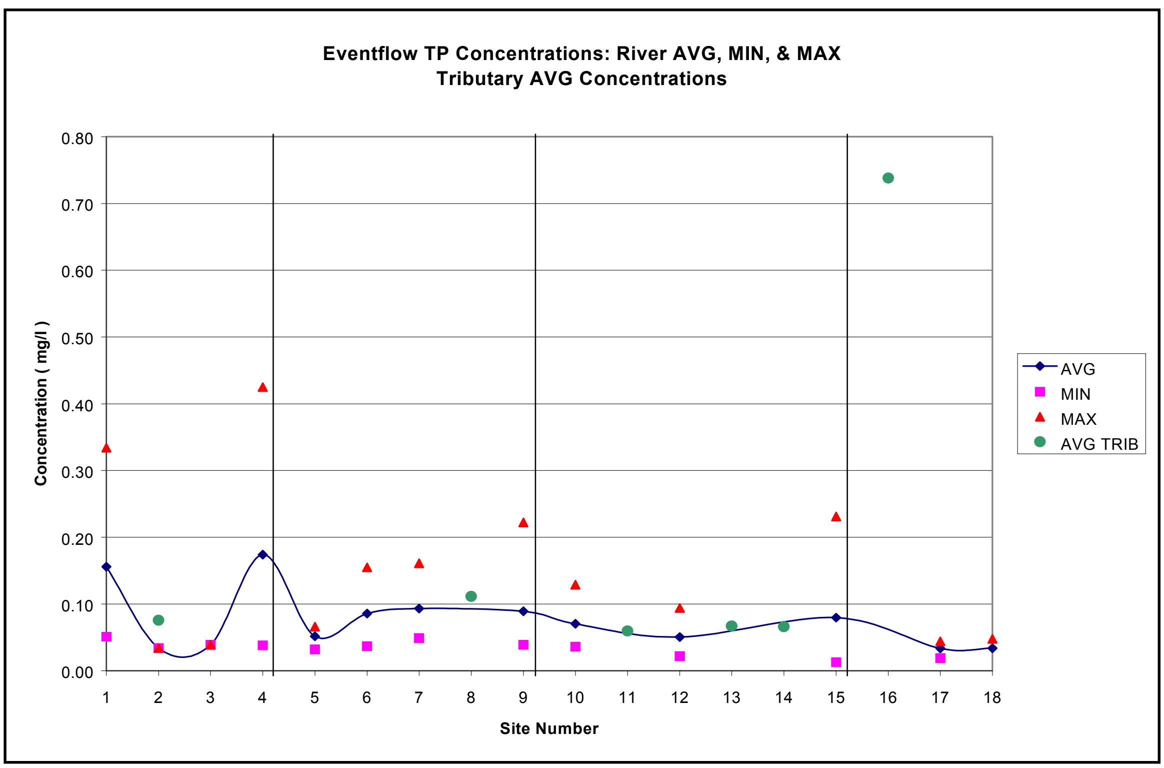

Figure 18: Average Event flow TP Concentrations for Sampling Sites

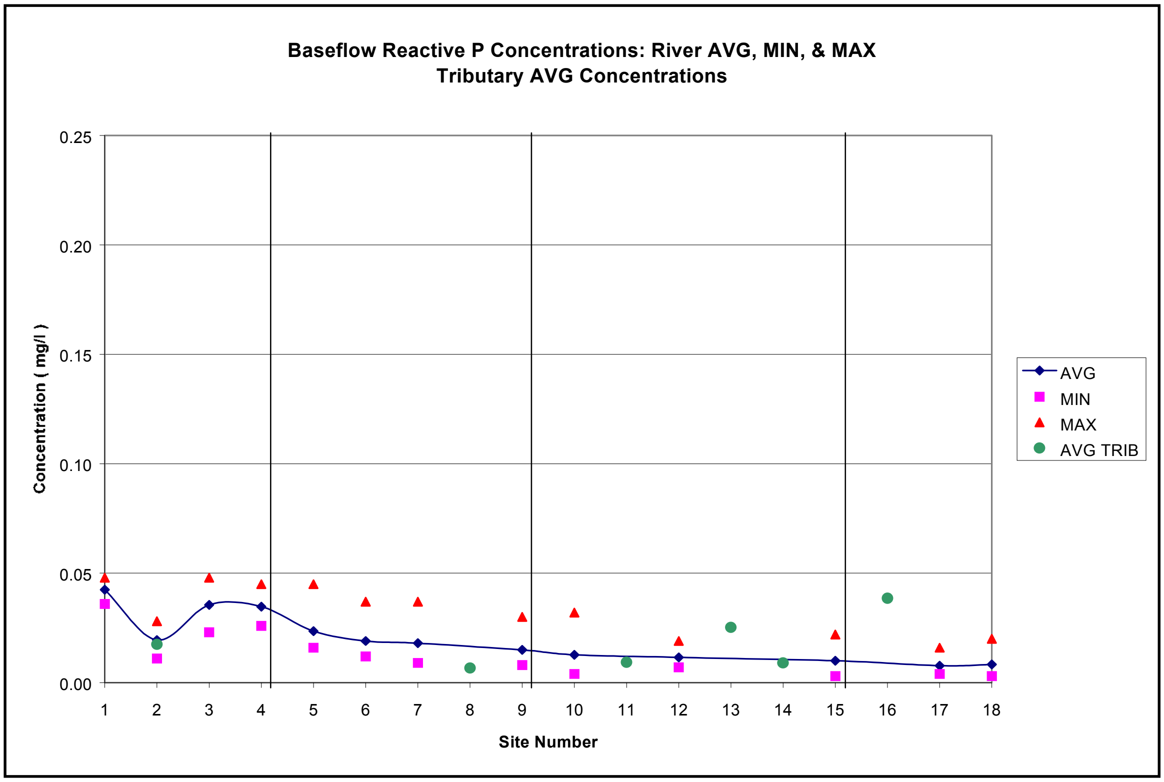

Figure 19: Average Baseflow Reactive P Concentrations for Sampling Sites

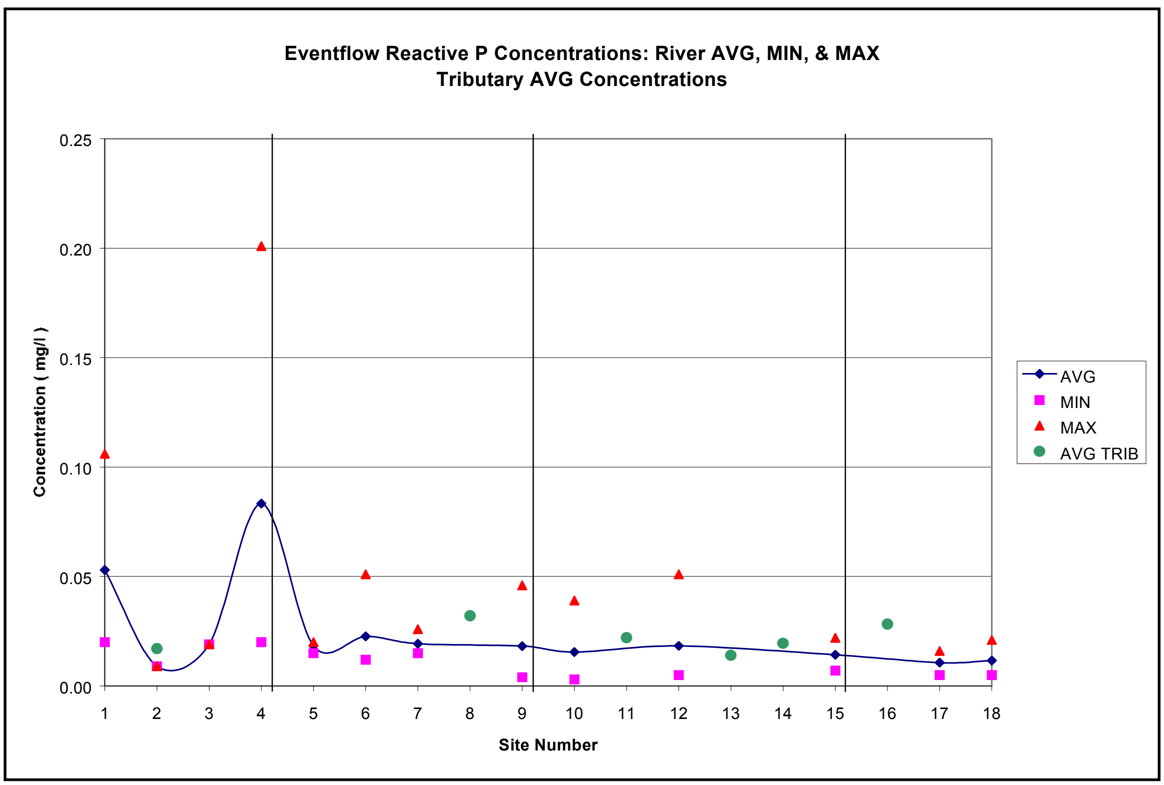

Figure 20: Average Event flow Reactive P Concentrations for Sampling Sites

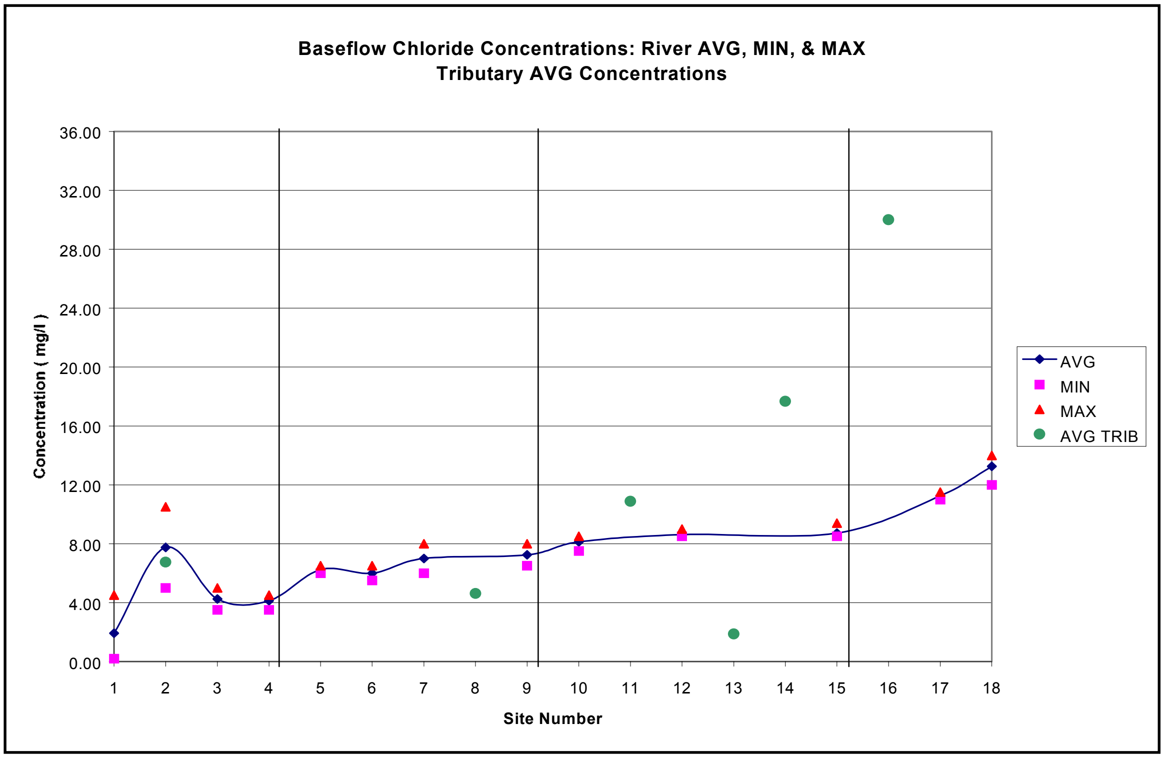

Figure 21: Average Baseflow Chloride Concentrations for Sampling Sites

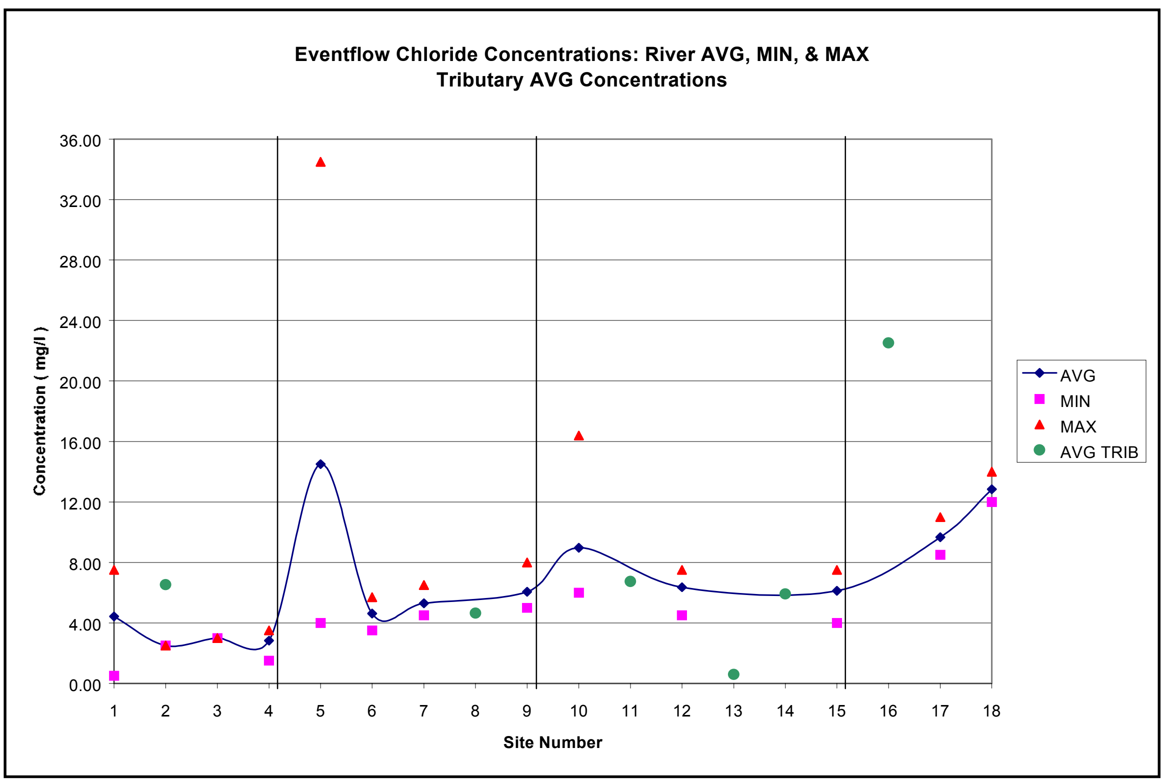

Figure 22: Average Event flow Chloride Concentrations for Sampling Sites

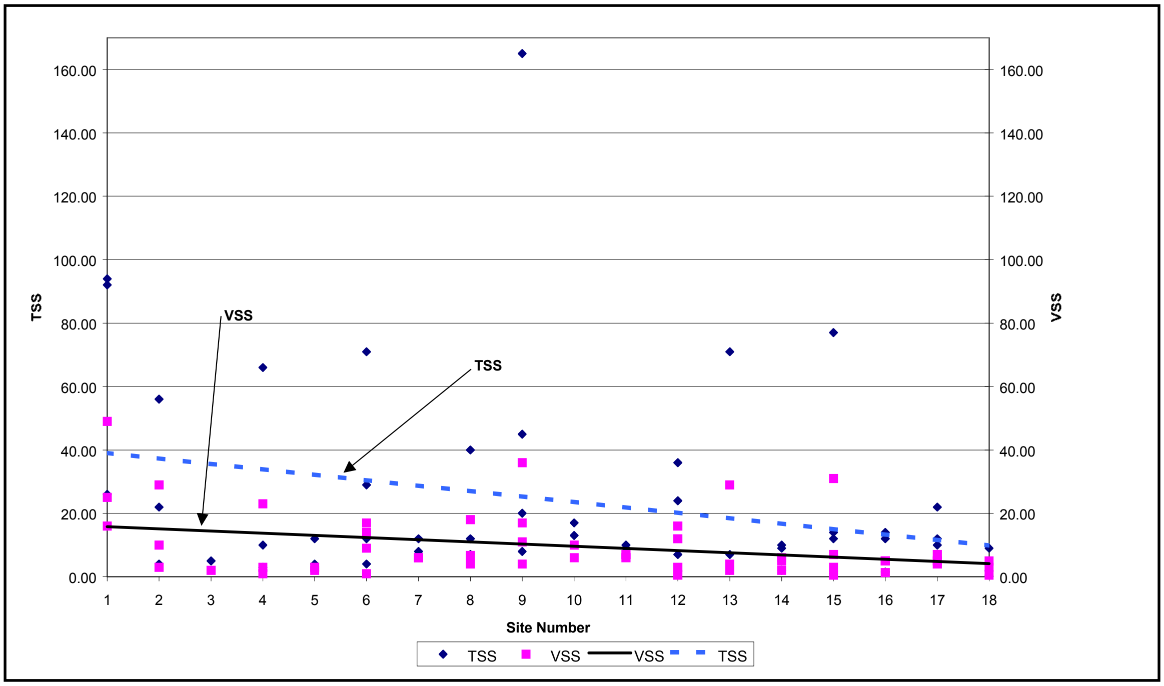

Figure 23: Total and volatile suspended solid sample concentrations and associated trend lines. Samples were collected during events from each study site.

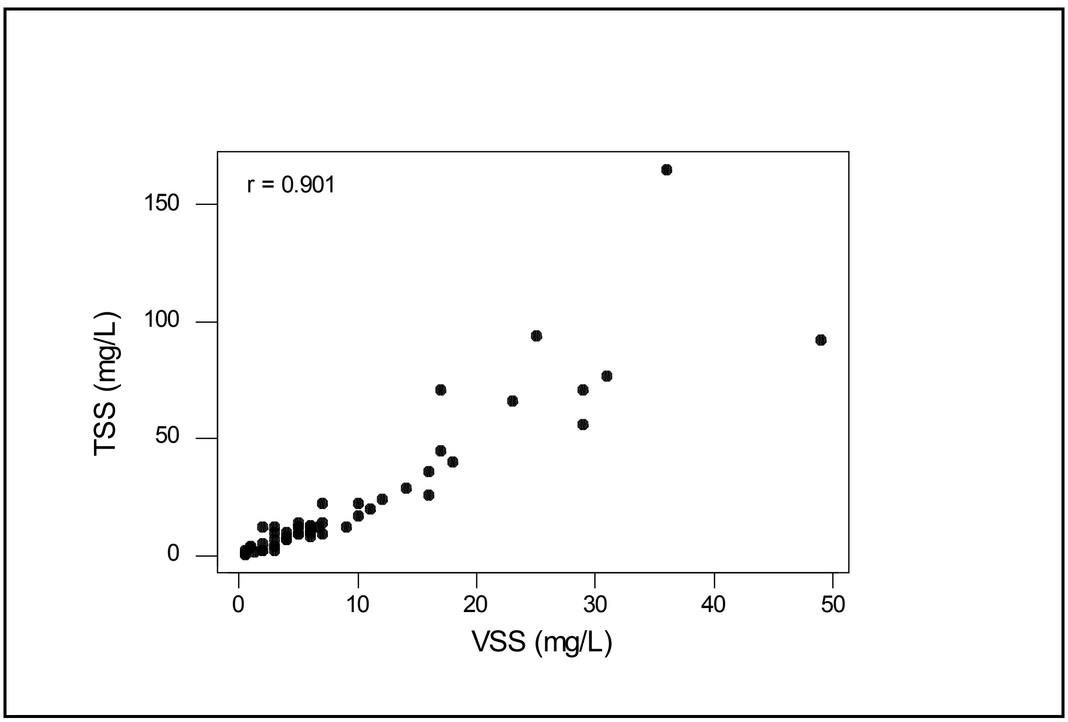

Figure 24: Total and volatile suspended solid concentrations (mg/L) and resulting Pearson correlation coefficient.

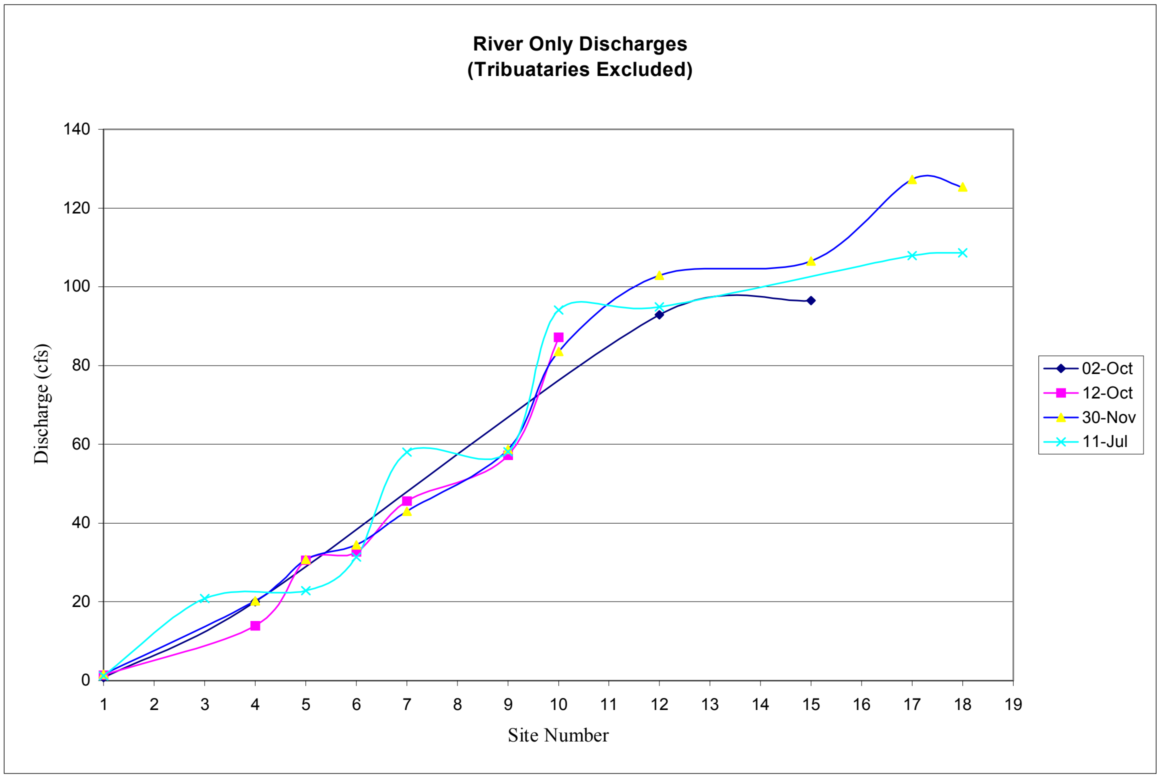

Figure 25: River Discharges for Baseflow Sampling Dates

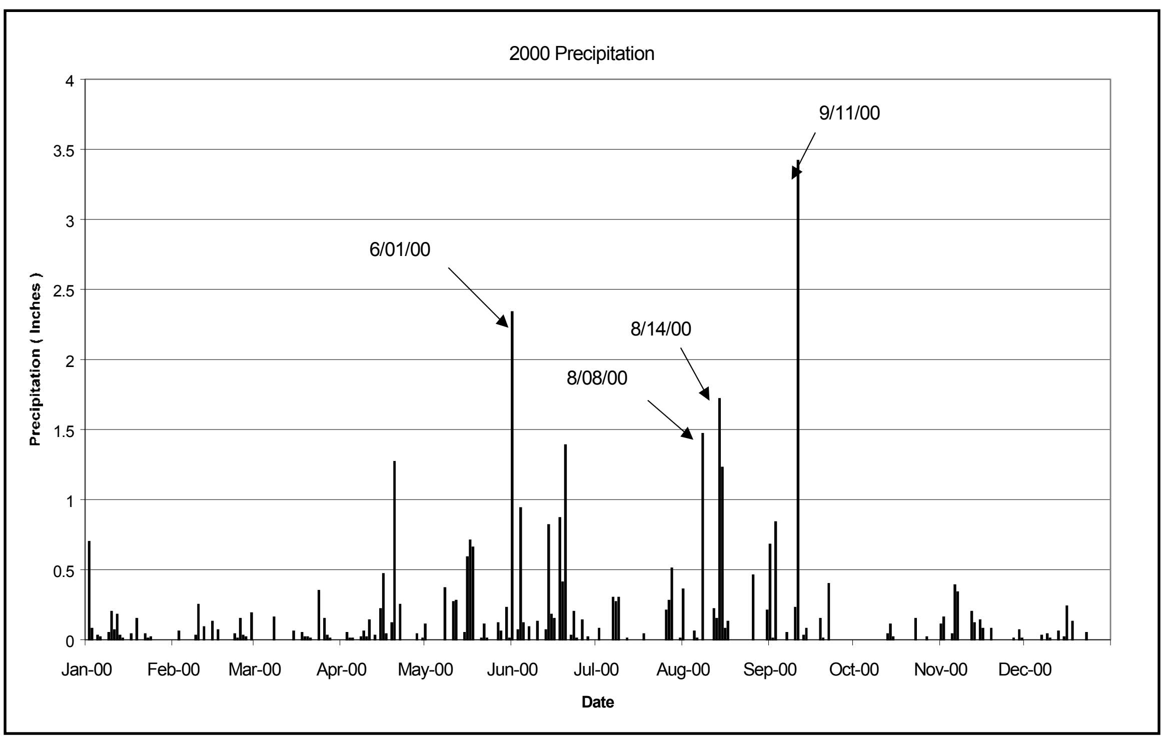

Figure 26: Precipitation Data for 2000

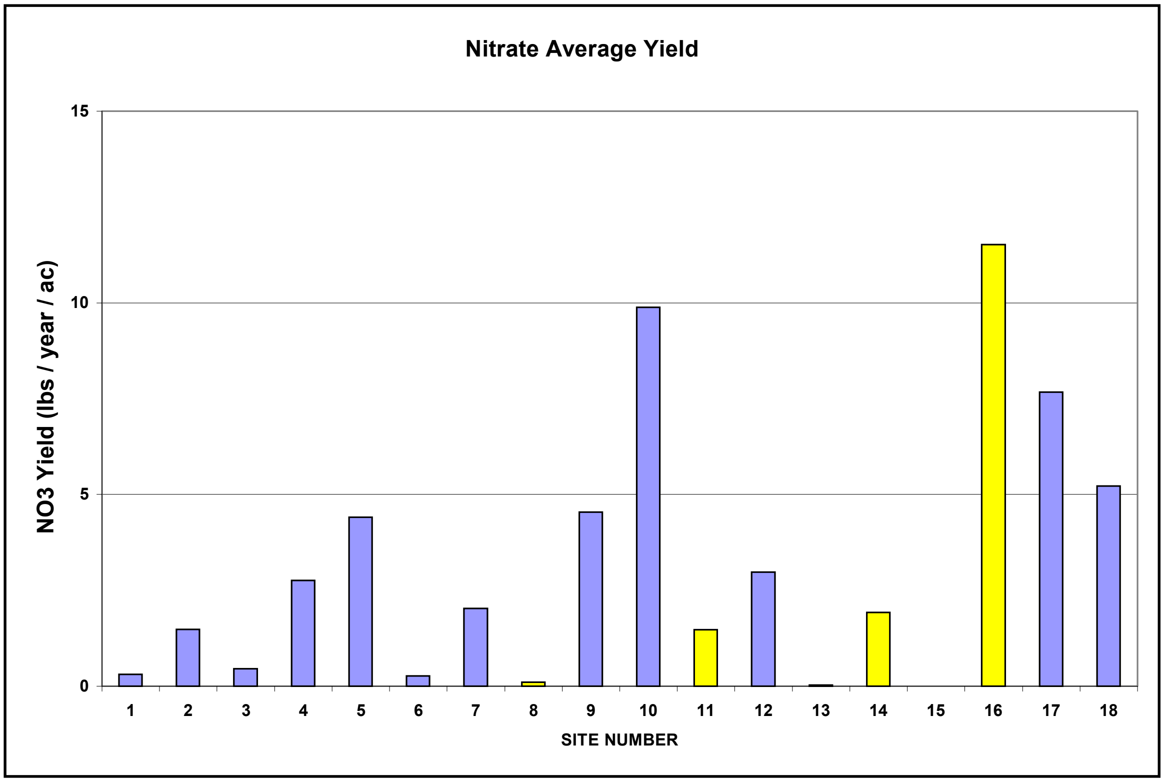

Figure 27: Average Nitrate Yield (lbs/year/acre) during Baseflow for each Sampling Site

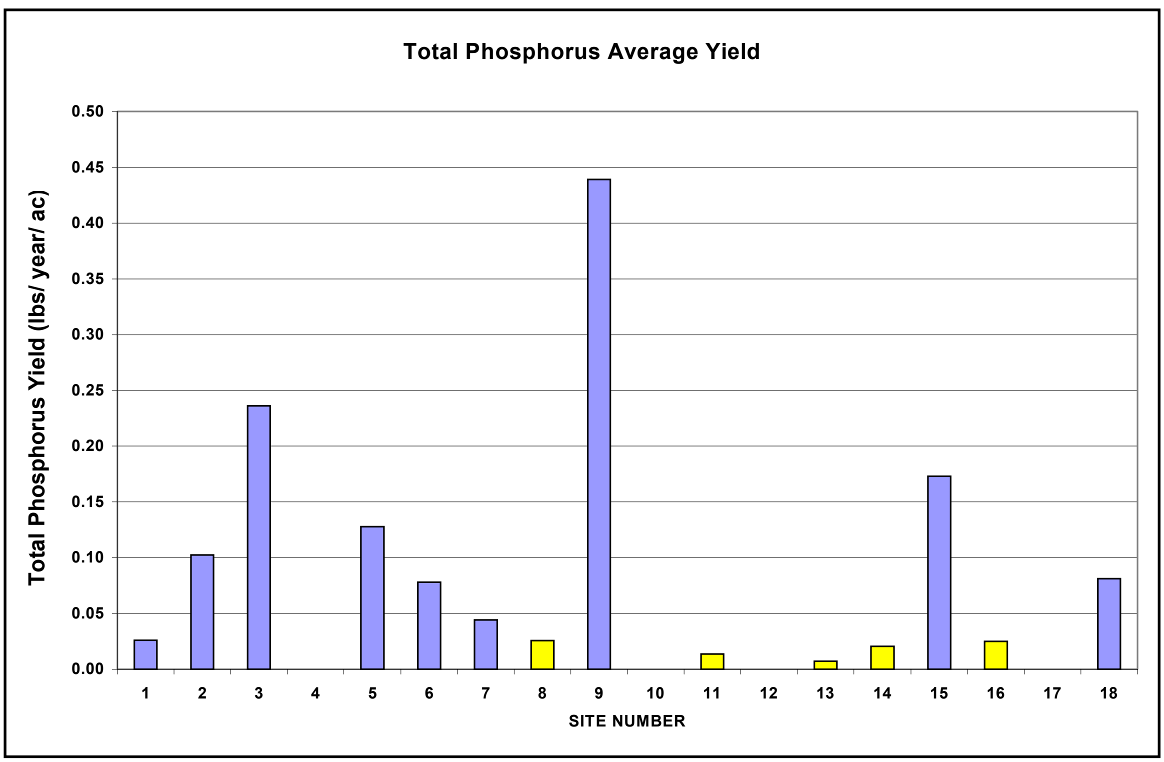

Figure 28: Average Total Phosphorus Yield (lbs/year/acre) during Baseflow for each Sampling Site

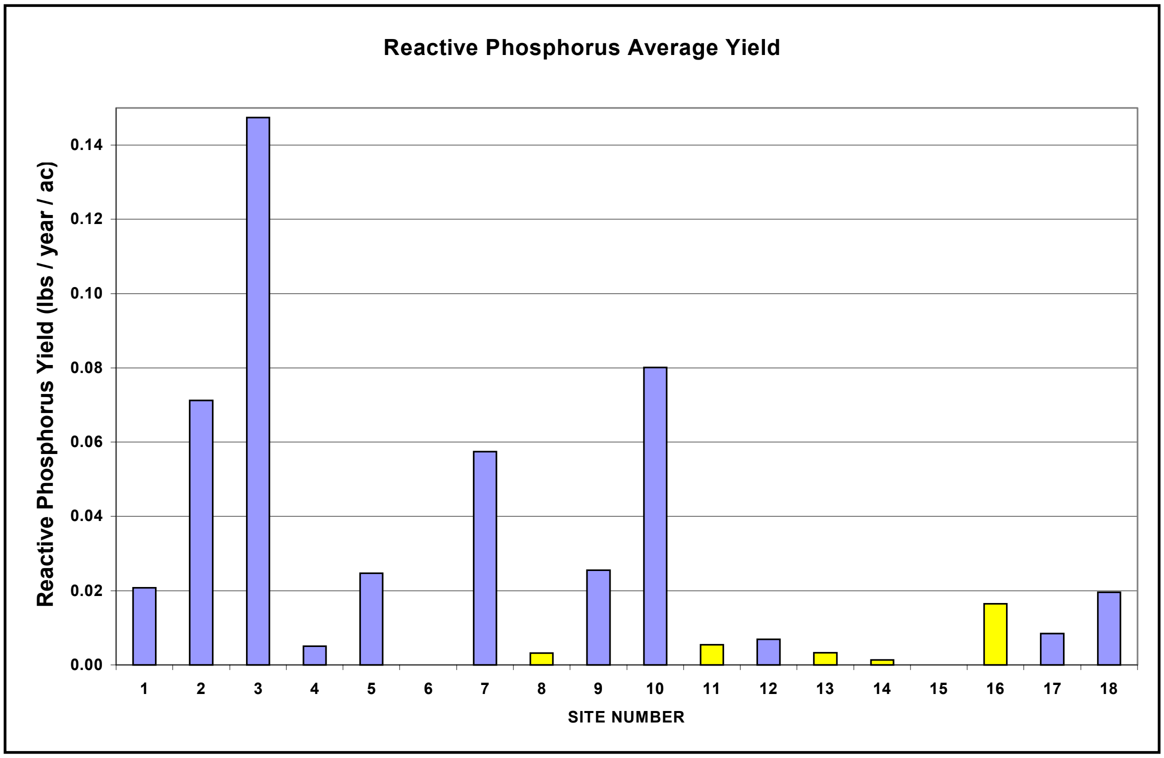

Figure 29: Average Reactive Phosphorus Yield (lbs/year/acre) during Baseflow for each Sampling Site

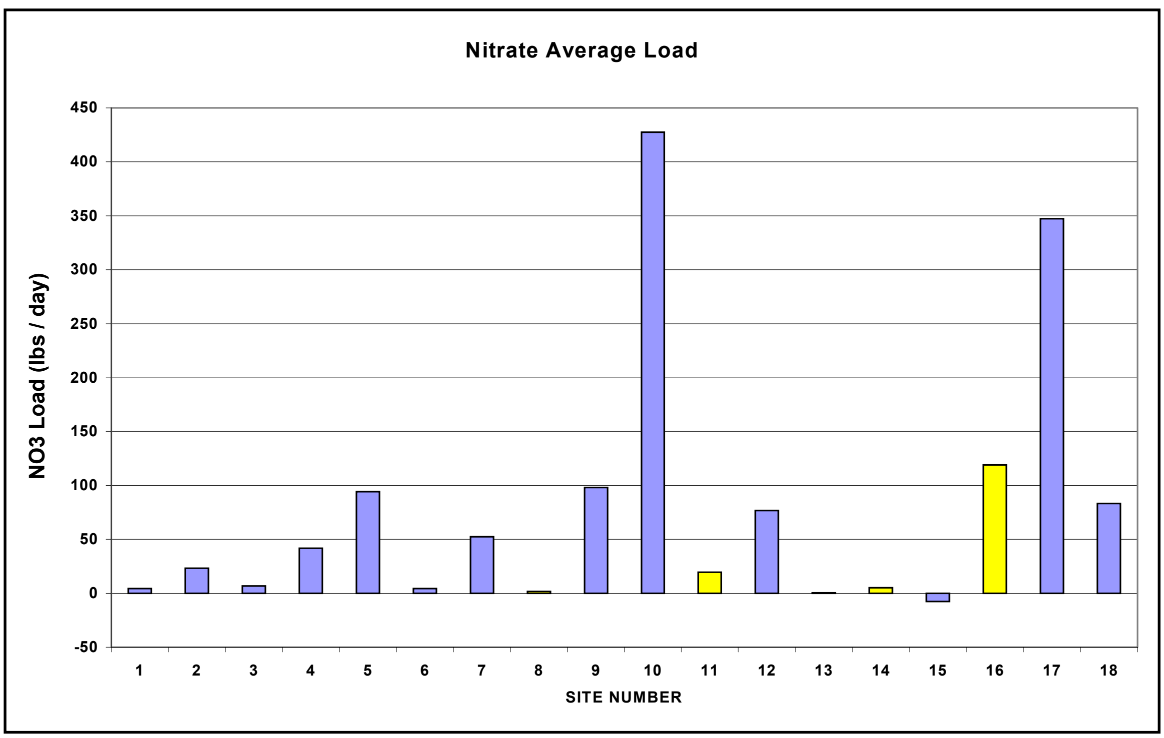

Figure 30: Average Nitrate Load (lbs/day) during Baseflow for each Sampling Site

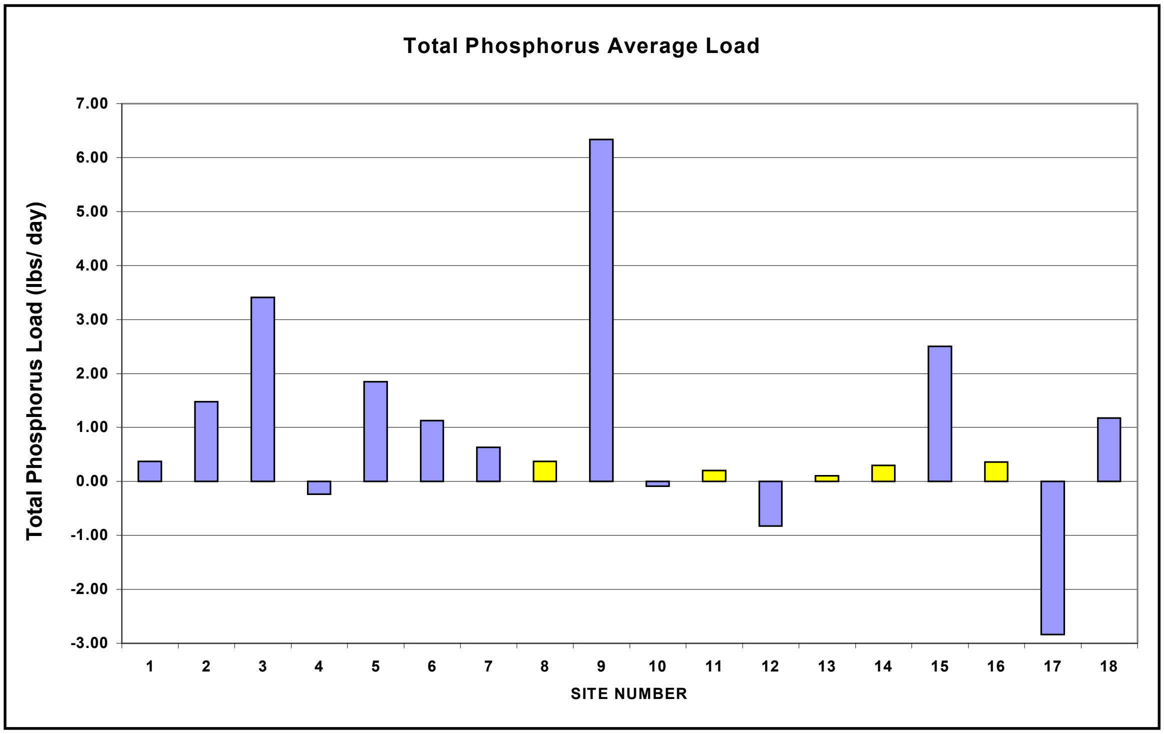

Figure 31: Average Total Phosphorus Load (lbs/day) during Baseflow for each Sampling Site

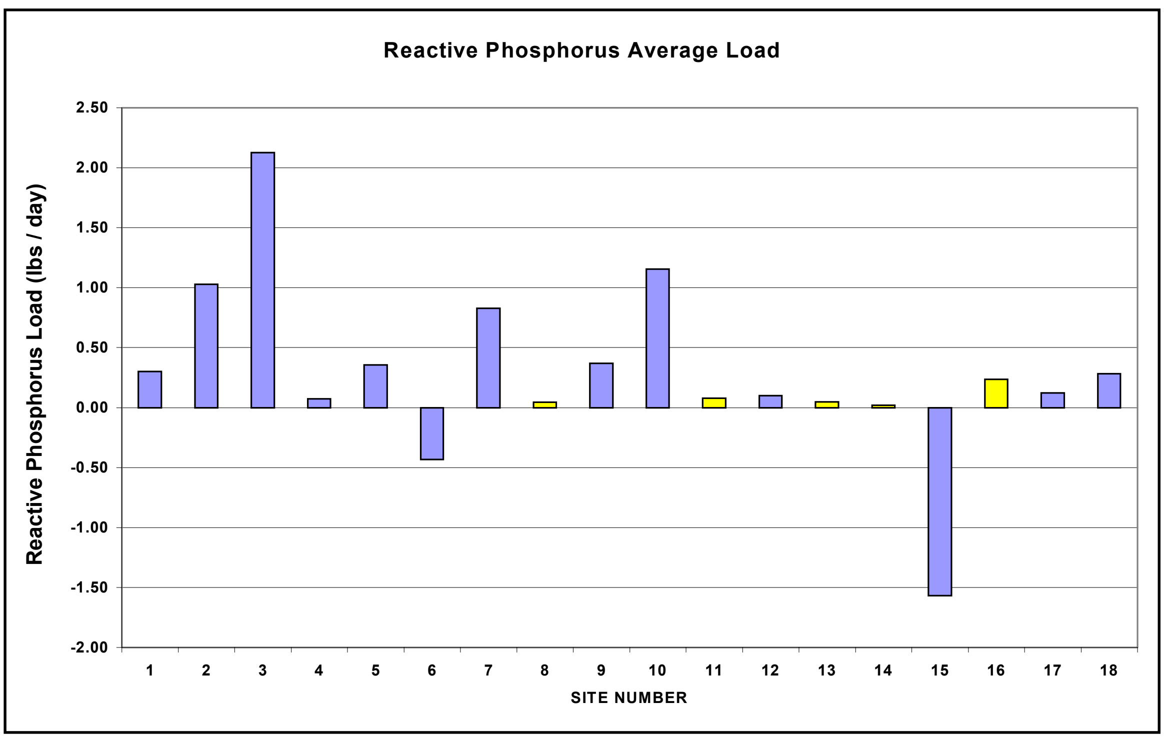

Figure 32: Average Reactive Phosphorus Load (lbs/day) during Baseflow for each Sampling Site

Conclusions

- Inputs to the Plover River are found in three zones. The upper end receives the greatest amount of fecal coliform bacteria. The mid section receives some pesticides and nutrients, and the water quality in the lower end exhibits urban impacts.

- Water quality in the Plover River is in generally good condition. To maintain current water quality status, efforts should be made to protect the watershed and river corridor.

- Areas resulting in higher concentrations of contaminants should be further evaluated and practices should be implemented to reduce inputs whenever possible. This includes addressing high concentrations of nitrate in sub-watershed 17 and pesticides in sub-watershed 12.

- Inputs to the Plover River are entering the system during both runoff events and through groundwater discharge.

- Nitrate and chloride concentrations in tributaries are similar for baseflow and runoff events. Concentrations are slightly lower during runoff indicating that groundwater is a major contributor of nitrate and chloride from fertilizer leaching.

- Moving from headwaters downstream, chloride concentrations show an increasing trend. This is due to greater influence of agriculture and development in the watershed. The same is true for TKN and Total P in tributaries.

- Runoff samples from tributaries and the Plover River show fairly low concentrations of measured chemistries compared to most watersheds in the Central Sands. Short flow paths, well-buffered streams; along with minimal surface runoff help keep the values low.

- Some concentrations in the lower part of the watershed are high enough to support excessive growth of algae and aquatic plants.

- Water quality should be monitored routinely to determine if changes are occurring.

- Discharge should be measured above and below the Stevens Point municipal well field to determine how pumping is effecting the river flow.

- Total P and TKN values decrease moving down river in spite of nutrient impacts from tributaries. The presence of impoundments that act as nutrient traps plus increasing aquatic plant growth in the slower moving river segments allow for nutrient removal from the system. It is possible that significant amounts of these nutrients are building up in impoundment sediments that could be released in late fall or winter as plants die and decay.

- Temperature monitoring results indicate water temperatures on the Plover River upstream of Hatley were adequate for trout survival and reproduction. Water temperatures downstream of Hatley increased and spent much less time in the optimal range for trout. Fishery surveys found the highest densities of trout upstream of Hatley where cold water temperatures and improved habitat conditions exist.

- Trout densities declined at stations downstream of Hatley and their occurrence was more inconsistent. Trout were generally found in areas of localized cold water inputs, which resulted in lower water temperatures. One such site was at Pinery Road where a spring pond approximately ¼ mile upstream apparently lowered water temperatures resulting in slightly higher densities of trout at the site.

- Habitat improvements on the Plover River upstream from Hatley likely had a positive influence on stream temperatures. The river downstream of Hatley is relatively wide and shallow which promotes warmer water temperatures through solar radiation. Habitat improvement projects planned for this section of the river will create a narrower and deeper stream channel that will provide more cover and should reduce the effects of solar radiation.

- Temperature monitoring should be completed annually at selected sites to evaluate the effects of habitat improvement on water temperature and to access natural variability.

Literature Cited

Aichele, S. (USGS), R. Hill-Rowley (CAER), and M. Malone (CAER). Arsenic, Nitrate, and Chloride in Groundwater, Oakland County, Michigan. 23 September 2000. http://mi.water.usgs.gov/reports/Aichele1.html.

Attig, John W., Maureen A. Muldoon. "Pleistocene Geology of Marathon County, Wisconsin." 1989.

Barker, James L. "Temporal Changes in Sulfate, Chloride, and Sodium Concentrations in Four Eastern Pennsylvania Streams." USGS Water Resources Investigation Report 85-4074. 1986.

Boutt, David F. INTERPRETING THE IMPACTS OF LAND USE ON WATER QUALITY USING GROUNDWATER FLOW AND TRANSPORT SIMULATIONS IN THE GRAND TRAVERSE BAY WATERSHED . 1999. http://www.nmt.edu/~dboutt/thesis_text.pdf.

Christensen, Vicotria G., Larry M. Pope. "Occurrence of Dissolved Soilds, Nutrients, Atrazine, and Fecal Coliform Bacteria During Low Flow in the Cheney Reservior Watershed, South-Central Kansas, 1996." USGS Water - Resources Investigations Report 97-4153. 07 September 2000. http://ks.water.usgs.gov/Kansas/pubs/reports/wrir.97-4153.html.

Clayton, Lee. "Pleistocene Geology of Portage County, Wisconsin." . 1986.

Conservation Technology Information Center. "Water Quality." Know Your Watershed. 26 November 2001. http://www.ctic.purdue.edu/KYW/TipsAndHints/Page16.html.

EPA. "Consumer Fact Sheet on Atrazine." EPA - Groundwater and Drinking water. 12 March 2001. http://www.epa.gov/safewater/dwh/c-soc/atrazine.html.

EPA. "Turbidity and Total Solids." Volunteer Estuary Monitoring : A Methods Manual . 4 August 2000. http://www.epa.gov/owow/estuaries/monitor/chptr15.html.

Farag, Aida M, et al. "Water Quality in Three Creeks in the Backcountry of Grand Teton National Park, USA." Journal of Freshwater Ecology. 16 vols. March 2001.

Fiala, William; David Buss, Sam Hagedorn, Kim Kidney, and John Werlein. "Soil Survey of Marathon County, Wisconsin." Sept. 1989.

Franson, Mary Ann (Editor). Standard Methods for the Examination of Water and Wastewater. 19 ed. 1995.

Greenberg, J.K., B.A. Brown. "Bedrock Geology of Portage County, Wisconsin." . 1986.

Hamel, Kathy. "A Citizen's Guide to Understanding and Monitoring Lakes and Streams." Washington State Department of Ecology: Water Quality Program. 30 October 2001. http://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/fecalcoliform.html.

LaBerge, Gene, P.E. Meyers. "Bedrock Geology of Marathon County, Wisconsin." . 1983.

Lauhn-Jensen, Kristin. "Swim At Your Own Risk." Conscious Choices: The Journal of Ecology & Natural Living July 1995.

Lippelt, I.D. "Water Table Elevation Map of Marathon County." . 1981.

Lippelt, I.D. "Water Table Elevation Map of Portage County." . 1981

Lyden, Tiffany. "McDill Pond Lake Management Plan." . Feb. 2001. Environmental Task Force Program, Univ. Wisconsin-Stevens Point.

Murphy, Sheila . "BASINS: Information on Water Quality Parameters." Boulder Creek Watershed COB Water QualityMonitoring Sites. 13 September 2000. http://bcn.boulder.co.us/basin/data/NUTRIENTS/info/.

North Carolina State Water Quality Group (**NCSWQG**). "Water Quality and Land Treatment Education Component." Watershedss: A Decision Support System for Non-Point Source Pollution. 21 January 2002. http://h2osparc.wq.ncsu.edu/info/index.html.

Otter, Augustine; William Fiala. "." Soil Survey of Portage County, Wisconsin. Dec. 1978.

Oregon State University. "Pestcide Information Profiles - Atrazine." Extoxnet. June 1996. http://ace.orst.edu/cgi-bin/mfs/01/pips/atrazine.htm.

Poplyk, Jean (Ed). Farm Chemical Handbook '89. Meister Publishing, 1989.

Portage County Planning and Zoning Department (**PCPZD**). "The Plover River Plan." . 2000.

Shaw, Byron. "Outline of Phosphorus Impact on the Environment." . October 1995.

University of Minnesota. Nitrogen Cycle Diagram. Janraury 2002. http://www.soils.umn.edu/academics/classes/soil2125/doc/s9chap2.htm.

USGS. "Measurement and Anaylsis of Sediment Loads in Streams." Report No. 13. 1961.

USGS. Terraserver.com: A look from above. 8 November 2001. http://www.terraserver.com/.

UW-Stevens Point Environmental Task Force. "Interpreting Your Triazine Screen Result." . November 2000.

APPENDICES