

Water Sampling Report

Sauk River at St. Cloud, 2005-2006

INTRODUCTION

The Sauk River meanders 120 miles from the eastern portions of Douglas County within 3 miles of Alexandria into the Mississippi River near St. Cloud. The watershed, like the Sauk River, extends in a northwest to southeast direction. The overall watershed is about 75 miles in length with some areas being up to 20 to 30 miles in width.

According to data from the Minnesota Land Management Information Center (LMIC), the Sauk River watershed covers over 667,000 acres or approximately 1,007 square miles across portions of five counties. The portions of counties within the watershed include southeastern Douglas County, northeastern Pope County, southwestern Todd County, north central Meeker County, and the center third of Stearns County. (A very small portion of the watershed, 6 acres, overlaps into Morrison County). The table below provides the area distribution of the watershed by county.

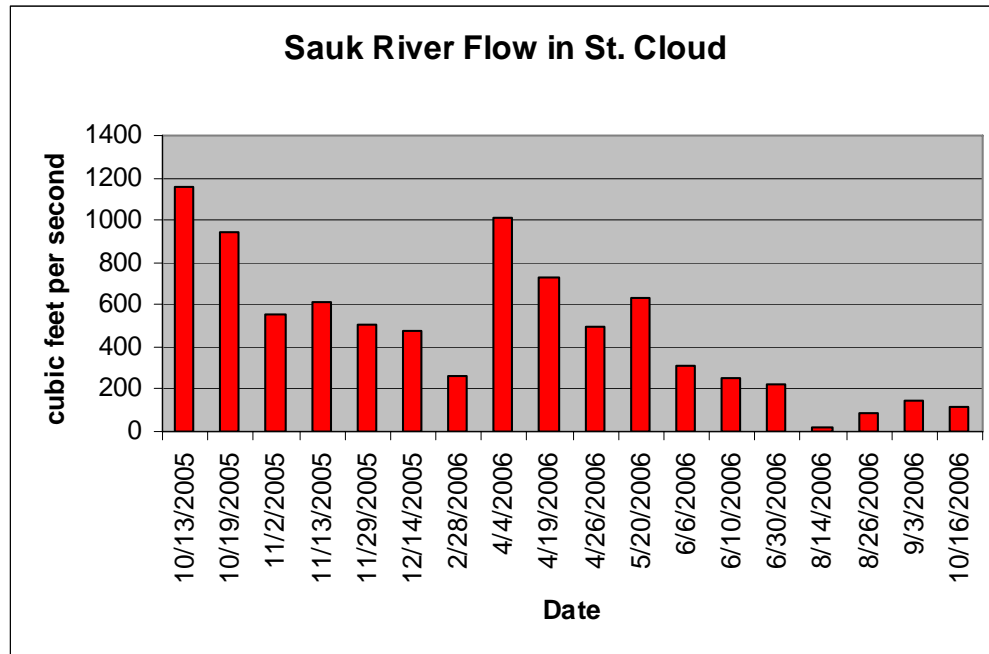
Distribution of Watershed Area by County

	Douglas	Pope	Meeker	Stearns	Todd	Total
Area (acres)	58,171	30,328	9,883	431,409	137,392	667,183
Area (sq. mi.)	90	47	15	674	215	1,041
Watershed (percent)	8.9	4.4	1.5	63.6	21.6	100.0

From October 13, 2005 to October 16, 2006, a study was conducted by volunteer researchers, Jake Galzki and Mitch Bender, from the Department of Environmental and Technological Studies at St. Cloud State University. The study examined coliform contamination, as well as nutrient loading of the Sauk River.

Biweekly grab samples were collected from a sampling location near the confluence of the Sauk and Mississippi Rivers in the St. Cloud metro area. Samples were also collected after rainfall events of 0.5 inches or greater. Samples were not collected when ice prohibited safe sample collection. Measurements of water quality included *E. coli*, total coliforms, phosphate-phosphorus, ammonia-nitrogen, nitrate-nitrogen, total solids, total suspended solids, conductivity, transparency, temperature and pH. Measurement of river flow was gathered from USGS data (gauge 05270500 near St. Cloud) and displayed in figure 1.

Figure 1: Sauk River flow data from USGS gauge 05270500 for each sampling date between October 13, 2005 and October 16, 2006.



MONITORING

The St. Cloud portion of the Sauk River has not frequently been monitored by the Sauk River Watershed District. However, monitoring is a critical part of successfully improving our rivers because it gives us a quantitative and qualitative outlook on the river system before, during, and after land use changes.

Water conditions were monitored on Sauk River by either Jake Galzki or Mitch Bender. The sample site was located at Heims Mill Canoe Access, where the Sauk River enters the Mississippi River near St. Cloud, MN (figure 2). Sampling was conducted biweekly, as well as after rainfall events of 0.5 inches or greater. Samples were not collected when ice prohibited safe sample collection. In total, there were 18 sampling dates between October 13, 2005 and October 16, 2006.

Transparency and temperature were measured on site using a transparency tube and a handheld thermometer. For all other analyses, three replicate grab samples were collected at the sampling site using a sampling bottle at the end of a telescoping pole (figure 2). This device gathered a composite sample of water from the center portion of the river. Analyses of *E. coli*, total coliforms, phosphate-phosphorus, ammonia-nitrogen, nitrate-nitrogen, total solids, total suspended solids, conductivity and pH were then conducted by Jake Galzki and Mitch Bender in the Environmental Instrumentation Laboratory in the Department of Environmental and Technological Studies at St. Cloud State University. Note: The analysis results for every water quality parameter displayed in this report are an average of the three replicate grab samples taken on each sampling date.

Figure 2: Heims Mill Canoe Access near the Sauk River's confluence with the Mississippi River (left). Jake Galzki collecting sample using a sampling bottle at the end of a telescoping pole (right).



SAMPLING RESULTS AND DATA INTERPRETATION

E. coli and Total Coliform

E. coli is a type of fecal coliform bacteria which can be harmful to humans. *E. coli* and other fecal coliform bacteria are found in the intestinal tracts of warm blooded creatures and are spread through feces. Although it is widely known that *E. coli* in food can cause illness, *E. coli* can also be potentially dangerous in our surface waters. *E. coli* and other fecal coliform bacteria can be flushed from animal feedlots, septic systems, and other sources during periods of rainfall and enter waterways via surface runoff. When humans ingest these bacteria, which can occur when lakes or rivers are used recreationally, they may become ill and suffer from symptoms ranging from abdominal cramping and diarrhea to kidney failure, paralysis, and, in very rare cases, death. However, most strains of *E. coli*, as well as most other fecal coliform strains, are harmless, but their presence should act as an indicator of potential health risks.

E. coli is currently recognized by the U.S. Environmental Protection Agency (EPA) and the Minnesota Pollution Control Agency (MPCA) as the standard coliform indicator for recreational waters. According to the Ambient Water Quality Criteria for Bacteria (1986), the EPA recommends an *E. coli* standard for recreational waters of 126 colony forming units (cfu) per 100 mL of water based on a 30 day geometric mean of samples collected during dry weather conditions or 235 cfu per 100 mL of water for any single sample. For this study, samples collected were compared to the 235 cfu per 100 mL of water for a single sample.

E. coli averaged 148 cfu per 100 mL of water during the 12 month study. The 235 cfu per 100 mL of water standard was exceeded during 3 of 18 sampling dates, and each of the 3 dates followed a rainfall event (11/13/05, 11/29/05 and 9/3/06) (figure 3). Since most surface waters are not recreationally used after October 1, only one sampling date (9/3/06) posed potential harm to recreational users. However, 8 other sampling dates exceeded 100 cfu per 100 mL of water. While 100 cfu per 100 mL of water does not exceed EPA or MPCA standards for recreational waters, this amount of contamination may be an indicator that this portion of the river should be monitored closely in the future.

There also appeared to be a correlation between higher levels of *E. coli* contamination in the river and rainfall events. Rainfall events preceded 7 of the 8 sampling dates that exceeded 100 cfu per 100 mL of water. Surface runoff may play a significant role in *E. coli* contamination of the Sauk River. Attempts should be made to determine sources of *E. coli* contamination and efforts should be made to prevent *E. coli* contaminated runoff from entering the river.

Measurement of total coliforms in water can be used to indicate the presence of fecal contamination, however, presence of coliforms is not a definitive way to measure public health risk. For this reason, the EPA and the MPCA have begun using *E. coli* as the standard coliform indicator for recreational waters. For this report, the measure of total coliforms as seen in figure 4 is used only to show a possible relationship between coliform contamination in the Sauk River and rainfall events. Of the 10 sampling dates with the highest measurements of total coliforms, 7 correlated with rainfall events (10/13/05, 11/13/05, 11/29/05, 6/6/06, 6/10/06, 9/3/06 and 10/16/06).

Figure 3: *E. coli* level for each sampling date. The EPA recreational standard of 235 colony forming units (cfu) per 100 mL of water for a single sample is represented by the red line.

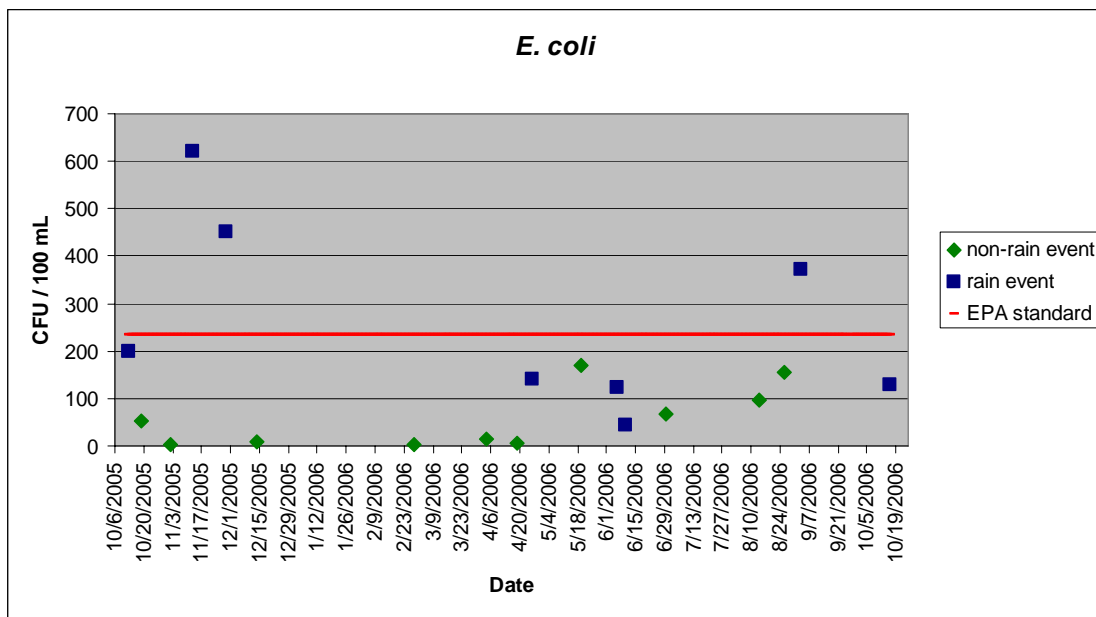
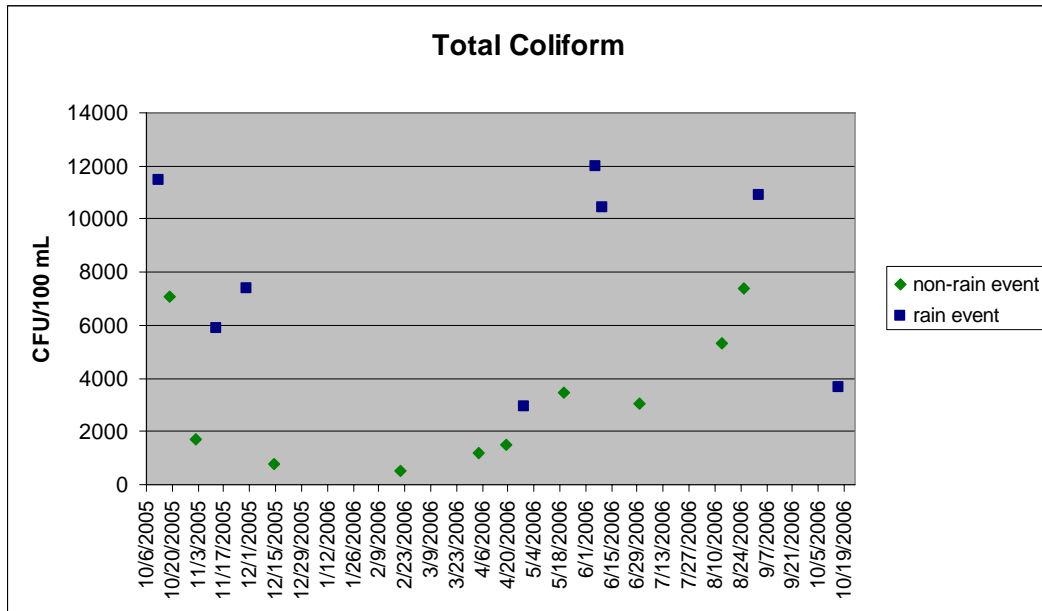


Figure 4: Total coliform level for each sampling date.



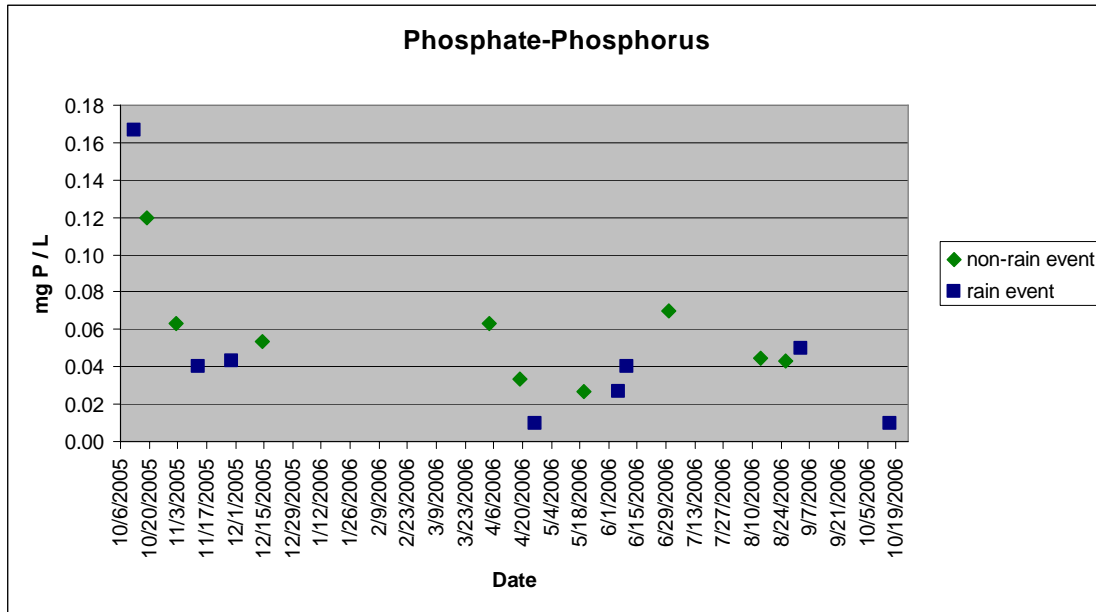
Phosphate-Phosphorus

Phosphorus is an important metabolic nutrient necessary for growth of plants and animals. Municipal and industrial wastewater, septic tanks, feedlot discharges and animal wastes (including birds and fish) are common sources of phosphorus in aquatic systems. Influxes of phosphorus into a body of water often correlate with runoff from rainfall events. Phosphorus in aquatic systems may be found in organic or inorganic forms. Organic phosphorus is composed of mostly living or dead suspended or dissolved organic matter. Inorganic phosphorus is most commonly found as phosphate (PO_4). The combination of all organic and inorganic forms of phosphorus is referred to as total phosphorus. Because both organic and inorganic phosphorus forms act as nutrients in aquatic systems, monitoring total phosphorus may be of interest, however it may be easier and more practical to monitor PO_4 instead.

Phosphorus, especially in dissolved form, can be easily utilized by aquatic plants, which may help provide food for fish. However, since it is a nutrient, increasing inputs of phosphorus in lakes, streams and rivers have been associated with water quality issues, such as eutrophication and hypoxia. Eutrophication and hypoxia can ultimately degrade water quality, cause loss of biodiversity, fish kills, and loss of recreational value. The eutrophication threshold for phosphorus limited waters is between 0.02 and 0.1 mg of total phosphorus per liter of water (mg P/L) and PO_4 concentrations as low as 0.005 mg P/L are enough to maintain eutrophic conditions in some water systems.

Phosphate-phosphorus concentrations for nearly all sampling dates exceeded the 0.02 mg P/L threshold and the average concentration during the 12 month study was 0.05 mg P/L (figure 5). Therefore, there is reason to continue monitoring phosphorus loading and to further investigate possible sources of phosphorus to the Sauk River. There did not appear to be a correlation between phosphate-phosphorus concentrations and rainfall events.

Figure 5: Phosphate-phosphorus concentration for each sampling date.



Ammonia-Nitrogen and Nitrate-Nitrogen

Nitrogen is found in many forms and concentrations in water. Municipal and industrial wastewater, septic tanks, feedlot discharges and animal wastes (including birds and fish) are common sources of nitrogen in aquatic systems. Nitrogen in aquatic systems may be found in organic or inorganic forms. Organic nitrogen is composed of mostly living or dead suspended or dissolved organic matter. Inorganic nitrogen is most commonly found as nitrite (NO_2^-), nitrate (NO_3^-) or ammonia (NH_3^+). The combination of all organic and inorganic forms of nitrogen is referred to as total nitrogen. Because both organic and inorganic nitrogen forms act as nutrients in aquatic systems, monitoring total nitrogen may be of interest, however it may be easier and more practical to monitor inorganic forms, such as NO_3^- , NH_3^+ .

Nitrogen may threaten an aquatic system in several ways. First, nitrogen in the form of NO_2^- and NH_3^+ can be toxic. Nitrite toxicity is relatively rare since in most cases, bacteria will rapidly convert NO_2^- to NO_3^- . With regards to NH_3^+ toxicity, plants are typically more tolerant than invertebrates and fish, and invertebrates are more tolerant than fish. Ammonia (NH_3^+) toxicity is highly dependent on pH and temperature. Lastly, since it is a nutrient, increasing inputs of nitrogen in lakes, streams and rivers have been associated with water quality issues, such as eutrophication and hypoxia. Eutrophication and hypoxia can ultimately degrade water quality, cause loss of biodiversity, fish kills, and loss of recreational value.

The eutrophication threshold for most water systems is between 0.5 and 1.0 mg of nitrogen per liter of water (mg N/L). The average concentration of ammonia-nitrogen and nitrate-nitrogen for the 12 month study was 0.1 and 1.4 mg N/L, respectively (figures 6 and 7). The eco-region average for ammonia-nitrogen is 0.2 mg N/L. The ammonia-nitrogen average concentration in this study was below both the eutrophication threshold and the eco-region average. However, nitrate-nitrogen concentrations for nearly all sampling dates exceeded the eutrophication threshold.

Since only two forms of nitrogen were analyzed in this study and the sum of these two forms exceeded the eutrophication threshold, there is reason to continue monitoring nitrogen loading and to further investigate possible sources of nitrogen to the Sauk River. There did not appear to be a correlation between ammonia-nitrogen or nitrate-nitrogen concentrations and rainfall events. The highest concentrations of nitrate-nitrogen were found just before ice-in and just after ice-out conditions.

Figure 6: Ammonia-nitrogen concentration for each sampling date.

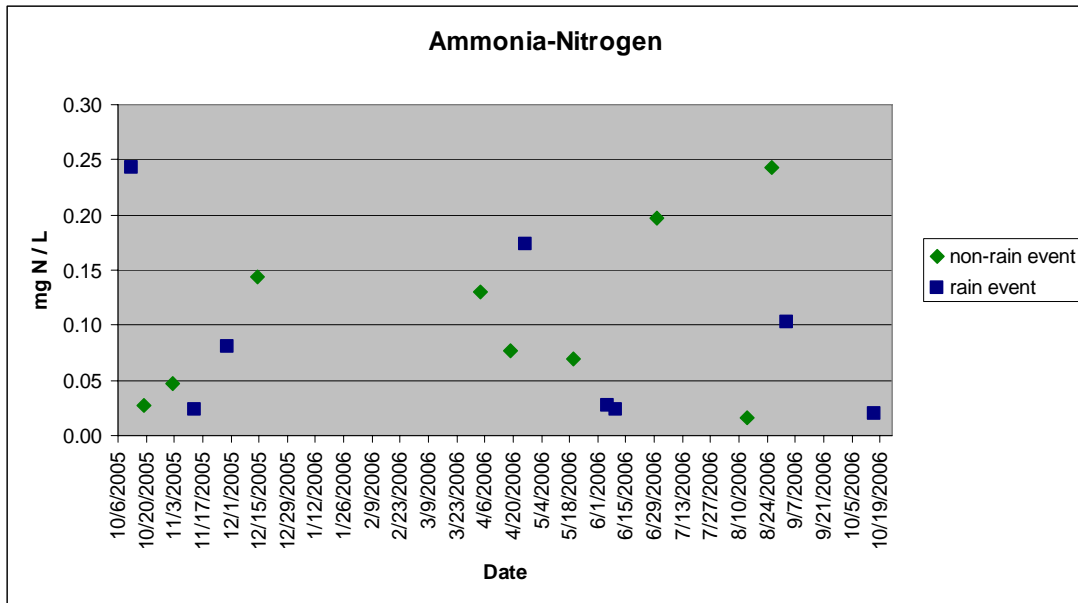
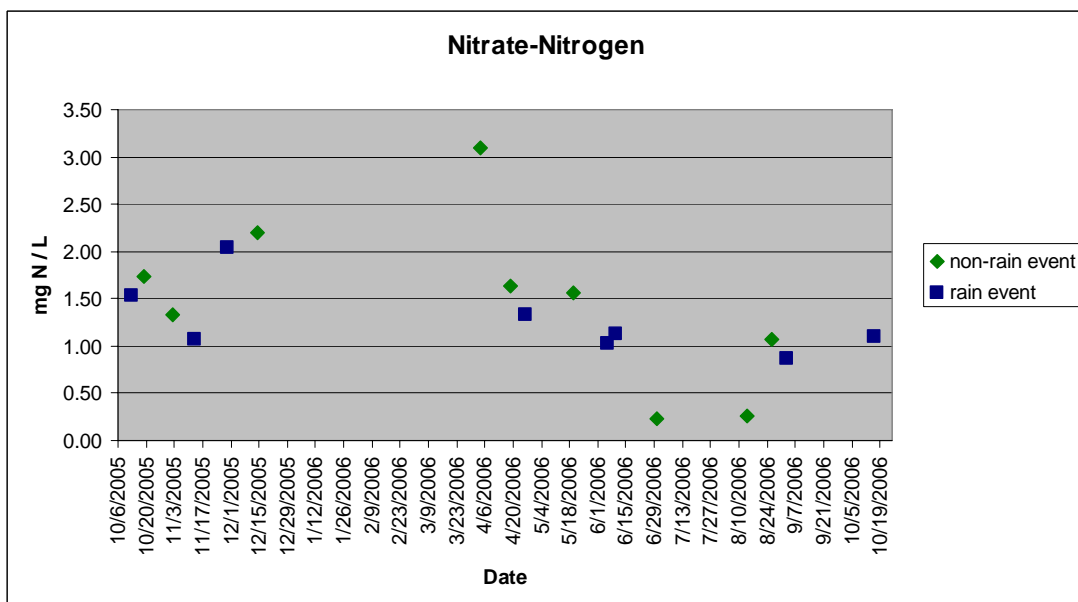


Figure 7: Nitrate-nitrogen concentration for each sampling date.



Total Solids, Total Suspended Solids and Dissolved Solids

Total solids (TS) refer to all materials dissolved and suspended in water. Total suspended solids (TSS) include suspended materials, such as plankton, small invertebrates, silt and clay. Dissolved solids include materials, such as minerals, road salt, nutrients and metals, in dissolved form.

High TSS readings in a body of water may indicate erosion and sedimentation problems, especially in areas of development and farming. Runoff from rainfall events can increase the amount of TSS, however, algal blooms caused by influxes of nutrients can also contribute to high TSS readings.

Suspended solids may threaten an aquatic system in several ways. First, suspended solids can affect water transparency and temperature. Elevated TSS can cause a body of water to appear cloudy or muddy, and the suspended particles can absorb energy from the sun thereby increasing the water temperature. Second, suspended solids can interfere with spawning and may clog gills, and breathing and feeding apparatus of fish and aquatic invertebrates. Furthermore, suspended solids can carry attached toxins and heavy metals.

The average TS for this study was 365 mg/L (figure 8). The average TSS for this study was 12.29 mg/L (figure 9), which is higher than the eco-region average of 2-6 mg/L. This may be due to current land development in the area. Monitoring should be continued and attempts should be made to investigate possible sources of suspended solids to the Sauk River. There did not appear to be a correlation between TS and TSS concentrations and rainfall events.

Suspended solids can be filtered out, while dissolved solids cannot. To gain an estimate of the amount of dissolved solids, total suspended solids may be subtracted from the total solids. In this study it can be concluded that most solids were in dissolved form. Another method of indirectly determining dissolved solids is measuring conductivity. Conductivity is discussed in the next section.

Figure 8: Total solid concentration for each sampling date.

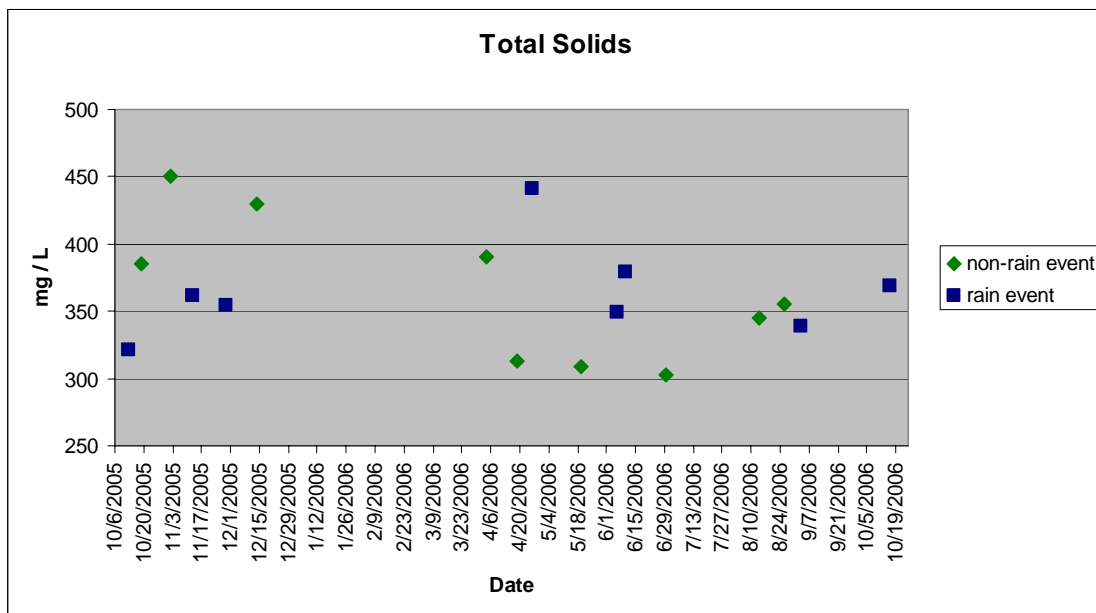
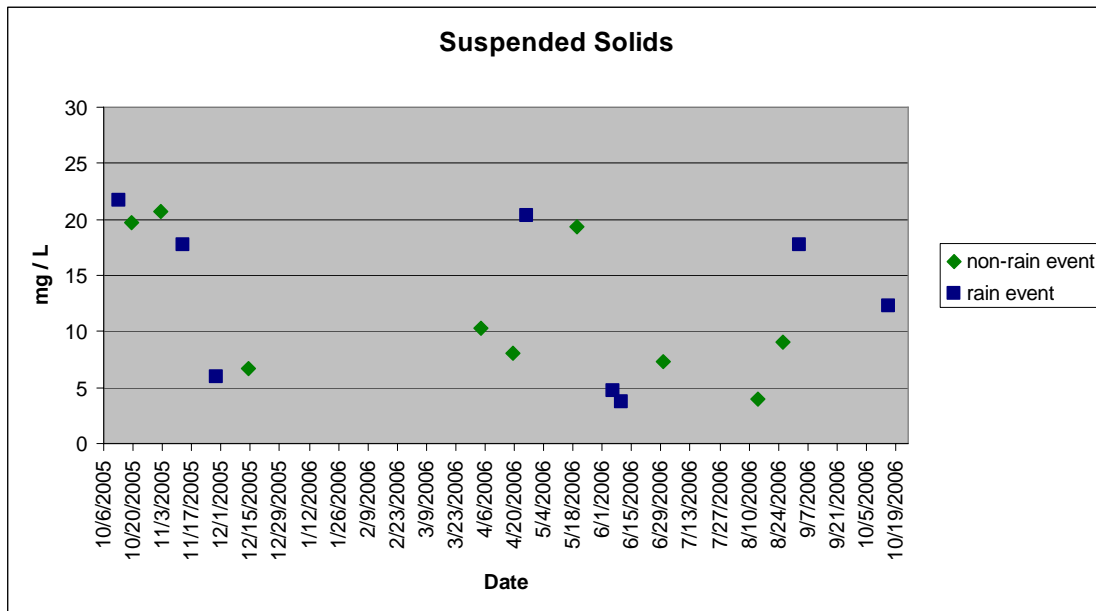


Figure 9: Total suspended solid concentration for each sampling date.



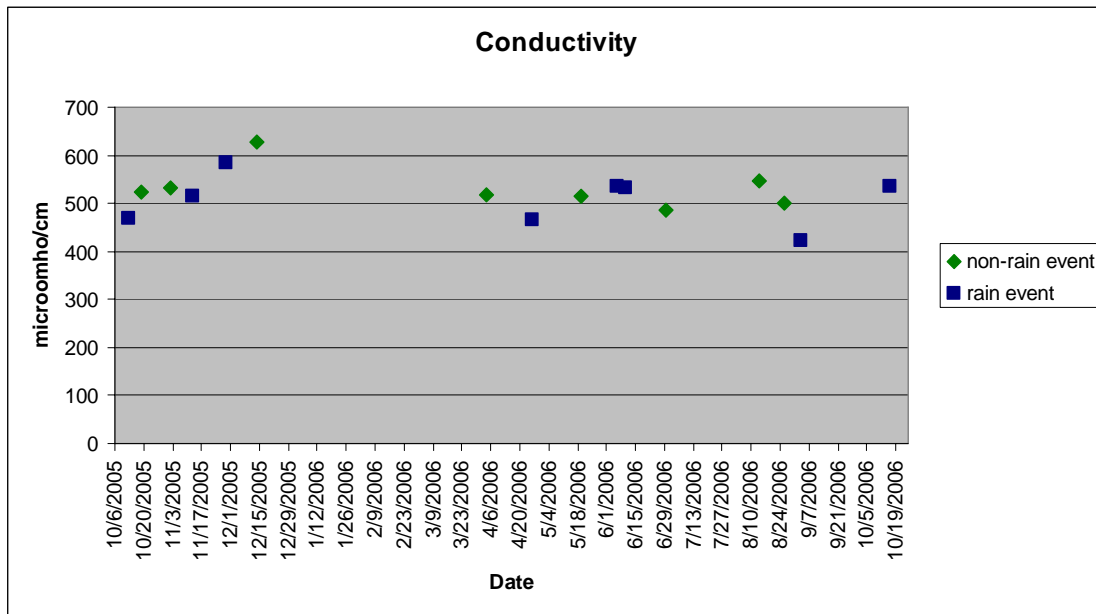
Conductivity

Conductivity is measured by passing an electrical current through water. This measurement may be used to estimate the amount of dissolve solids in the water, since inorganic dissolve solids, such as dissolved minerals, road salt, nutrients and metals increase the conductivity of water. Geology may also influence conductivity of water. For example, if a river runs though an area with granite bedrock, conductivity will be lower due to the inert materials found in granite.

According to the EPA, the conductivity of most rivers in the U.S. range from 50 to 1500 microomho/cm. A conductivity range of 150 to 500 microomho/cm is best for streams supporting good mixed fisheries.

During this study, conductivity values averaged 520 microomho/cm (figure 10), which compared to the range suggested by the EPA for good mixed fisheries, raises some concern for this section of the river. When comparing sampling dates, little difference was observed. Furthermore, there did not appear to be a correlation between conductivity and rainfall events.

Figure 10: Conductivity for each sampling date.



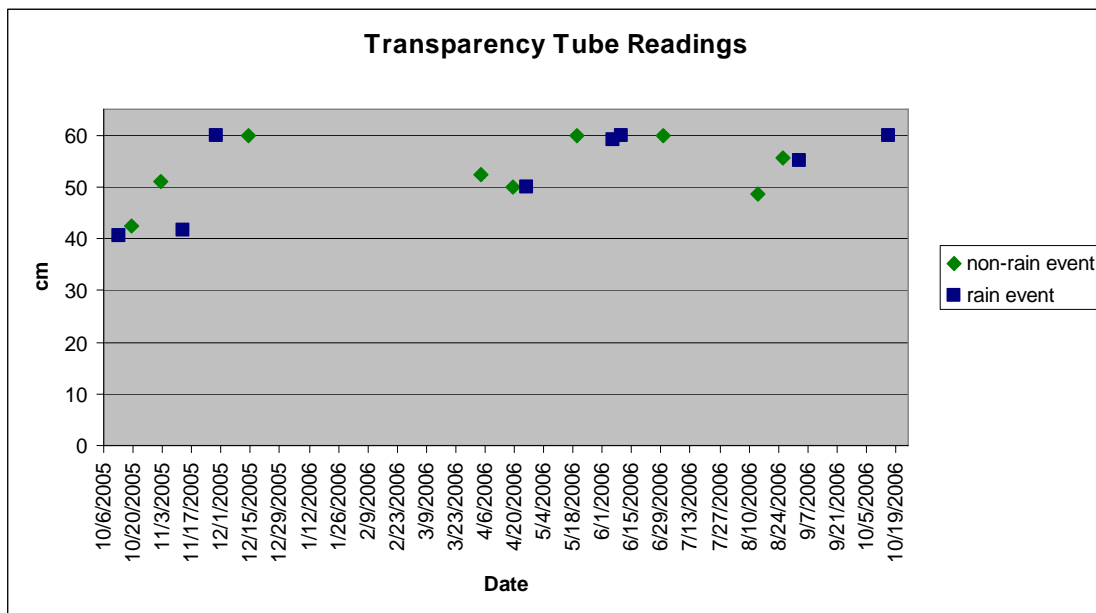
Transparency

Transparency is based on the amount of light that can be transmitted through water. Transparency is affected by the cloudiness of the water, also known as turbidity. Suspended materials, such as algae and sediment, increase turbidity and decrease transparency. In highly turbid waters, enough sunlight can be blocked to prevent the growth of aquatic vegetation. If sufficient aquatic vegetation does not grow, dissolved oxygen levels may decrease in the water. Furthermore, the sediment and particles in highly turbid waters will absorb sunlight, which can increase the temperature of the water. An increase in water temperature can decrease the dissolved oxygen levels of water since warm water holds less oxygen than cool water.

Measuring transparency is an indirect method for determining the turbidity. Measuring transparency can also be used to evaluate whether soil erosion and/or algal grow is a problem. Transparency can be measured using a Secchi disc in deeper waters, such as a lake, or a transparency tube in shallow waters, such as a creek or small river. For this study, a transparency tube was used.

The MPCA has set a turbidity standard of 25 nephelometric turbidity units (NTU) for Minnesota waters. A transparency tube reading of 20 cm is equivalent to 25 NTU. Any waters with a transparency tube reading of 20 cm or less is considered impaired for turbidity. In this study, transparency tube readings averaged 53 cm; well above the MPCA standard (figure 11). There did not appear to be a correlation between transparency tube readings and rainfall events.

Figure 11: Transparency tube reading for each sampling date.



Temperature

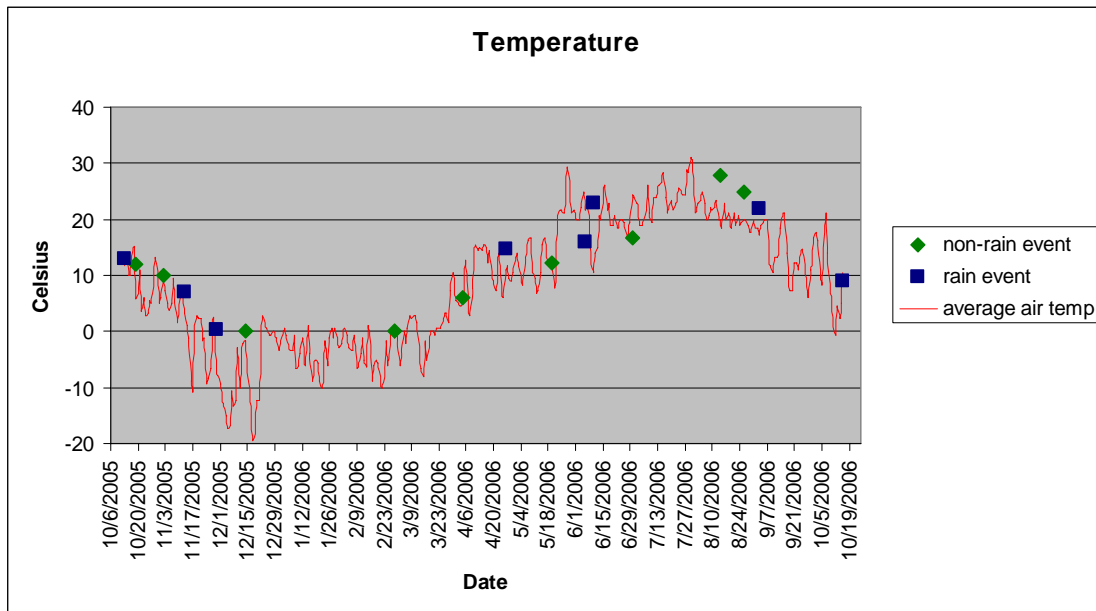
Temperature influences many processes in a river, such as dissolved oxygen content, nutrient release and algae growth. Fish migration and spawning behavior are also influenced by temperature. Water temperature changes beyond natural seasonal fluctuations can severely impact aquatic ecosystems.

If temperature in the river is changing beyond natural seasonal fluctuations it may be a result of:

- Thermal pollution entering the river. Warmer water from industrial discharges or stormwater runoff from urban surfaces, such as parking lots, are common sources of thermal pollution.
- Shade elimination due to changes in riparian cover. If vegetation along the banks of the river is removed, more sunlight may hit the water's surface, thereby warming the river.
- Increased sediment and other suspended solids. Particles in turbid waters absorb sunlight, which warms the river.

All temperature changes observed during this study appeared to be within natural seasonal fluctuations. Figure 12 shows water temperature measurements with average air temperature recorded for St. Cloud by the National Weather Service. There did not appear to be a correlation between water temperature and rainfall events.

Figure 12: Water temperature measurement and average air temperature for each sampling date.



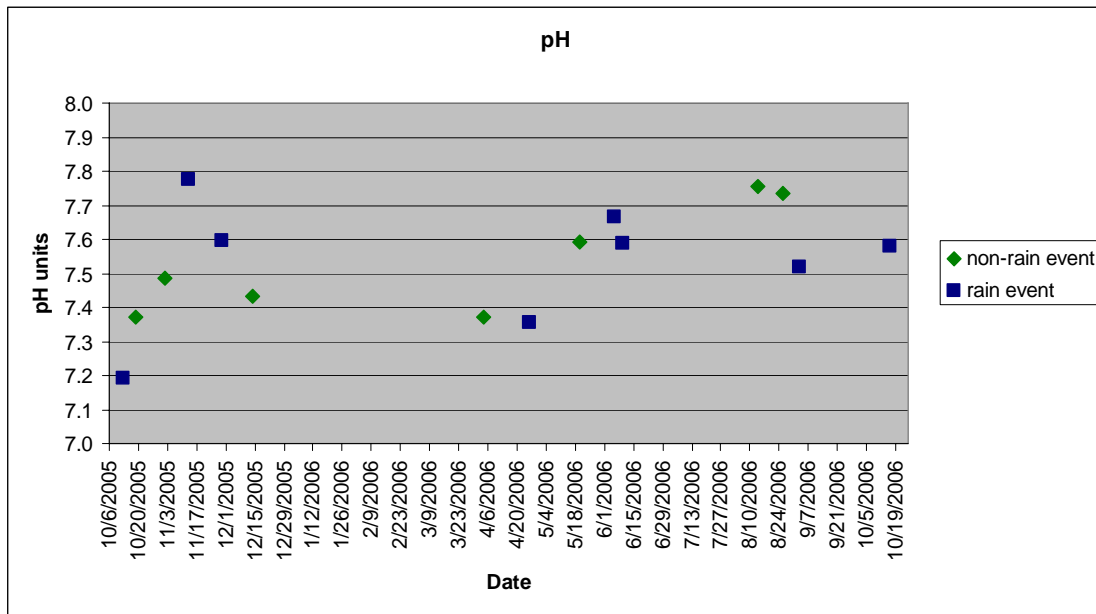
pH

pH is a measure of the degree of acidity (concentration of H^+ ions) in water. The pH scale ranges from 0 to 14, in which 7 is neutral, values less than 7 are acidic and values greater than 7 are alkaline. Every unit of change on the pH scale represents a tenfold change in H^+ ion concentration. For example pH3 equals 0.001 g H^+ /L, whereas pH 4 equals 0.0001 g H^+ /L.

The pH of an aquatic system is largely influenced by the geology of the area, however, land use and runoff can also affect pH. A pH range of 6.0 to 9.0 is suitable for most freshwater aquatic systems. The optimum range for most fish eggs is between 6.0 and 7.2, while the optimum range for algae growth is 7.5 to 8.4.

During this study, pH values averaged 7.6, which is considered near optimal (figure 13). There did not appear to be a correlation between pH and rainfall events.

Figure 13: pH for each sampling date.



Rainfall Events

With the exception of coliform contamination, rainfall events did not appear to have a strong influence on many water quality parameters. Since the Sauk River is nearly 120 miles in length, and the river drains approximately 1000 square miles of land, rainfall events in the St. Cloud area may have little influence on the river's overall water quality. However, the effects of rainfall and runoff on water quality should not be underestimated.

WATER QUALITY DATA SUMMARY

E. Coli Mean: 148 colony forming units per 100 mL of water (cfu/100 mL)
E. Coli # of Observations: 18
E. Coli Minimum: 3 cfu/100 mL and Maximum: 620 cfu/100 mL

Total Coliform Mean: 5369 cfu/100 mL
 Total Coliform # of Observations: 18
 Total Coliform Minimum: 506 cfu/100 mL and Maximum: 11963 cfu/100 mL

Phosphate-Phosphorus Mean: 0.05 mg P/L
 Phosphate-Phosphorus # of Observations: 17
 Phosphate-Phosphorus Minimum: 0.01 mg P/L and Maximum: 0.17 mg P/L

Ammonia-Nitrogen Mean: 0.10 mg N/L
 Ammonia-Nitrogen # of Observations: 17
 Ammonia-Nitrogen Minimum: 0.02 mg N/L and Maximum: 0.24 mg N/L
 Eco-region Average NCHF: 0.20 mg N/L

Nitrate-Nitrogen Mean: 1.37 mg N/L
Nitrate-Nitrogen # of Observations: 17
Nitrate-Nitrogen Minimum: 0.23 mg N/L and Maximum: 3.10 mg N/L

Total Solids Mean: 365 mg/L
Total Solids # of Observations: 17
Total Solids Minimum: 302 mg/L and Maximum: 451 mg/L

Total Suspended Solids Mean: 12.29 mg/L
Total Suspended Solids # of Observations: 17
Total Suspended Solids Minimum: 3.67 mg/L and Maximum: 21.67 mg/L
Eco-region Average NCHF: 2-6 mg/L

Conductivity Mean: 520 microomho/cm
Conductivity # of Observations: 17
Conductivity Minimum: 423 microomho/cm and Maximum: 628 microomho/cm

Transparency Mean: 53 cm
Transparency # of Observations: 17
Transparency Minimum: 41 cm and Maximum: 60 cm

Temperature Mean: 12.6 0°C
Temperature # of Observations: 18
Temperature Minimum: 0.0°C and Maximum: 27.9°C

pH Mean: 7.6
pH # of Observations: 17
pH Minimum: 7.2 and Maximum: 7.8

RECOMMENDATIONS AND SUGGESTED ACTIONS

The Sauk River Watershed District, partnering agencies and volunteers work towards maintaining and improving lakes and streams within the District. We have these partnerships with land owners, municipalities and volunteers to create successful projects and programs to reach this goal. The following recommendations are offered to support the current activities, identify opportunities, and provide ideas for future endeavors. It should be remembered that maintaining and/or improving water quality is a long-term commitment. There are no quick fixes that produce immediate and lasting improvements in water quality. Only individual behavior changes, accumulated across the watershed and continuing over time, can begin to have positive impacts upon water quality. The rewards for such actions at times can be difficult to identify and require a long time to become noticeable. Those involved in these efforts must keep in mind that their collective influence is eliciting positive change that will be realized at some future date.

- **Continue water quality analysis.** Documenting the values and changes of water quality on the Sauk River provides a valuable piece to the puzzle of understanding the dynamics of the watershed. If feasible, continue monitoring efforts from ice-out to ice-in on the river.

- **Develop contingency plans for the lower Sauk River.** Create detailed procedures for continued sampling or intensive sampling on the river if it exhibits conditions that are a cause for concern (e.g., elevated levels of *E. coli*). Define a set of threshold criteria that indicate when the river may exceed acceptable conditions and necessitate the implementation of the contingency plan.
- **Develop a long-term management plan for the lower Sauk River.** Complete a program, perhaps using the Initiative Foundation's 'Healthy Lakes and Rivers Program' to create a long-term plan for caring for the Sauk River. Completing a plan similar to this allows many citizens to get involved and partnerships with local and state agencies to flourish. It allows goals to be clearly identified and the action plan created.
- **Establish demonstrations highlighting best management practices on rivers.** A picture is worth a thousand words. Having a number of demonstrations highlighting river best management practices, such as stormwater education, shoreland landscaping, bank stabilization, and septic system maintenance, can get a lot of good discussion and momentum started around these topics within the river community.
- **Communicate water problems and solutions with area farmers and septic system owners.** *E. coli* contamination can seriously affect the recreational value of the Sauk River. Feedlots and un-maintained septic systems may be contributors of this contamination. Special educational outreaches should be focused on these two parties.
- **Do not hesitate to retell important messages.** Even the most basic messages may find a new and receptive audience. Provide area residents with resources that help them make good decisions and become responsible stewards by partnering with municipalities, the watershed district, and county soil and water conservation districts (e.g., stormwater publications which promote proactive practices).