Chapter 7

Conclusions & Goals

Seven Mile Creek Diagnostic Study

The primary scope of the Seven Mile Creek Water Resource Investigation was to measure the movement of sediments and associated pollutants within the watershed and factors affecting their transport to the creek and Minnesota River. Examination of the relationship between land use and water quality was the primary method for documenting such factors. The second main goal of the diagnostic study was to determine realistic goals for both the watershed and Minnesota River and ultimately how and where to implement cost effective practices which would help reach those goals.

Water quality and quantity monitoring over a variety of flows and seasons provided information about both spatial and temporal variability in water quality during the two-year study. Like many other watersheds in the southern portion of the Minnesota River Basin, water quality in Seven Mile is impaired by non-point source pollutants. Because there are no communities or permitted discharges, there are no point sources of pollution located within the watershed. Pollution from the drainage ditch tributaries supplying Seven Mile Creek and the creek itself consists primarily of sediment, phosphorus, nitrogen and bacteria. All of these pollutants increase substantially during and after rain events within the entire watershed. The most significant levels occur during the early growing season, typically April through July. During this period, levels increase far above recommended levels.

Sediment

Pollution from the drainage ditch tributaries supplying Seven Mile Creek and the creek itself consists primarily of sediment, phosphorus, nitrogen, and bacteria. Seven Mile Creek delivers about 6,712 tons of sediment each year to the Minnesota River during the growing season (April through September) or about 570 pounds per acre or 52 pounds/acre/inch of runoff. The primary source of sediment in the watershed is bank erosion. Bank erosion sources are mainly found within the lower reaches of watershed 2 and 3. Other major pathways for sediment include upland erosion from cultivated cropland, riparian corridor and open tile intakes. It is estimated that approximately 40% of the sediment is due to bank erosion sources, about 40% from upland sources, and the remaining 20% is split between that area closest to the drainage ditches and around open tile intakes. More frequent, and higher intensity flows from CD 46a and in particular CD13 is the main reason for the accelerated bank erosion processes. Natural stream channels within the system are adjusting to dissipate the increases in stream flow energy. Stream bank slumping and incising through much of the non-ditched riparian corridors of the lower portion of watershed 2 and watershed 3 are evidence to the effects of the land use and hydrology changes. Other reasons for accelerated sediment losses are due to the steep land gradient drop in watershed 3 and the dynamics of climate.

Phosphorus

Seven Mile Creek also generates about 10.7-tons/growing season of total phosphorus. This translates to 0.9 lbs./acre or 0.156 lbs./acre/inch of runoff. Average concentration is 0.340 mg/l for total phosphorus and 0.239 mg/l for dissolved reactive phosphorus. Approximately 60% of the phosphorus was measured in the more soluble orthophosphorus form. This high percentage indicates a very potent and detrimental form of phosphorus to the environment. Over 70% of the phosphorus is delivered in the months of April, May and June. Spring runoff from cultivated fields is presumed to be the main reason for this substantial loading period. Although not substantial in terms of yield, phosphorus concentrations increase substantially in the upper watersheds during low flow periods. This can be attributed to septic influences and pH/dissolved oxygen chemical reactions. Modeling conducted by the BNC Board and MPCA staff has estimated that over half of the measured phosphorus load arises from upland sources, around 15% from bank erosion, and the remaining divided among non-complying septics (12%), riparian corridor (11%) and open tile intakes (11%).

Nitrates

Nitrate loads generated from Seven Mile Creek were the most alarming. For its size, Seven Mile Creek has the highest loads overall when compared to nine other watersheds within the Minnesota River Basin for year 2000. The two-year average nitrate load measured from the watershed amounts to 320 tons or about 27 pound/acre or about 3.2 pounds/acre/inch of runoff. Flow weighted average concentrations were about 14 mg/l during 2000 and 2001 growing seasons.

Table 34. Nitrate losses from 1987-1994 averaged across a corn-soybean rotation at the Waseca Southern Research and Outreach Center research fields found the following nitrate –N losses from tile drainage water.

Treatment	Nitrate-N loss (Pounds/acre/inch of runoff)
Fall Applied Anhydrous Ammonia w/o N-serve	3.8
Fall Applied Anhydrous Ammonia with N-serve	3.1
Spring Applied Anhydrous Ammonia before planting w/o N-serve	3.1
Spring Applied Anhydrous Ammonia before planting (40%) and side-dressed when corn was 12” tall (60%)	3.3

The results of the Waseca Research Station indicated that Seven Mile Creek nitrate values are similar to that of nitrogen coming straight from a field. This demonstrates that in Seven Mile the primary source of nitrate is tile drainage losses from cultivated row cropped land receiving excessive amounts of fertilizer and manure. The 1996 St. Peter Wellhead Protection Survey FANMAP survey also coincides with this reasoning. In the survey, which interviewed many of the same farmers within the watershed, it was found that producers were applying about 30-50 pounds over the University of MN extension corn fertilizer recommendations. The report concluded that producers and fertilizer dealers were simply not crediting for manure and legume nitrogen contributions. Based on a basic Nitrogen mass balance conducted on the watershed scale, it was found that mineralization (46%), fertilizers (28%), soybean fixation (15%), precipitation (7%), manure (4%), and ammonia redeposition (1%) make up the nitrogen sources. When subtracting the sources from the losses such as crop removal, it is estimated that there is a 60 lb/acre long term potentially leachable nitrogen source within the watershed. The extensive network of public and private surface and subsurface tile drainage may also be accelerating nitrate losses within the watershed. There are about 50 miles of public drainage systems with many more miles of private drainage tile. This drainage network provides a direct pathway for nitrate to travel from the soil profile, to the sub-surface drainage tile, to the ditches and eventually Seven Mile Creek. Unlike larger watersheds, which typically have more floodplains, mud flats, meanders, and other natural areas (where anaerobic bacteria can thrive and consume oxygen molecules from the No_3 thereby reducing nitrogen to a gaseous form = denitrification), the current physiography of Seven Mile is not conducive to such natural processes. The 30-50 pounds of surplus N/acre which are being supplied on average above UM recommendations through commercial fertilizer sources and the inputs derived from natural processes such as mineralization, land use changes, and the extensive network of tile drainage all help explain the high nitrate concentrations found in Seven Mile Creek.

Conclusions:

The two-year study has provided some very important results that could be utilized for the enhancement of watershed based projects throughout the Middle Minnesota Major Watershed and state. The Seven Mile Project provides some interesting results that suggest small watersheds (<20,000 acres in size) can produce very large pollutant loads. The information derived in this report could be extrapolated to other similar watersheds, especially in the eastern half of the Middle Minnesota Major River Basin.

Hydrology

- Changes in watershed hydrology and land use- (ditching, extensive network of tile subsurface tile drainage tile, draining of wetlands) are considered the largest factors affecting water quality in Seven Mile Creek Watershed. <u>Sediment, Phosphorus and Nitrogen losses are directly correlated with increases in drainage.</u>

- Water Storage is considered the most important best management practice. Wetland restoration, retention basins and/or culvert downsizing may be an important BMP for controlling peak water flows downstream.

- The extensive network of drainage systems within the watershed that have been installed over the past half-century are severely increasing the rate of stream bank instability, and stream bank erosion processes. Watershed 3 is considered the biggest contributor to this problem.

- Surface water at times is contributing to groundwater in watershed 3. This has important water quality implications, since surface water is also adding high levels of nitrates. It is not known how much of an effect this could be having on the groundwater aquifers in the area.

Sediment

- Most of the sediment load, 50%, is derived from bank erosion sources.

- RUSLE values are well below tolerable soil loss limits (5 tons acre/year) for this watershed in most upland areas.

- Conservation tillage on soils indicated by RUSLE as > 5 tons/acre/year may be the most efficient way of decreasing upland sediment loads.

- Sediment from upland sources are highest during the months of May and June.

Phosphorus

- Phosphorus concentrations and loads are being added to the Minnesota River.

- Most of the phosphorus within the watershed (52%) is coming from upland sources (cultivated soil).

- Sediments and phosphorus are directly correlated. The majority of the total phosphorus and soluble phosphorus is derived during storm events and spring snowmelt conditions. Over 70% of the phosphorus loading is occurring during spring runoff conditions.

- 60% of the total phosphorus in the watershed is in the more detrimental dissolved form.

Nitrates

- When compared to nine other watersheds in the MN River Basin, Seven Mile is the heaviest loader for its size.

- Nitrates are elevated in much of the watershed up until the end of July. After July leaching is minimized due to crop uptake and little or no leaching because of high evapo-transpiration rates during this part of the season. Highest loads and concentrations occur at the mouth of watershed 1.

- Based on samples taken from storm events, much of the nitrate is reaching the river through a shallow subsurface pathway. This pathway is mainly through underground public and private tile systems.

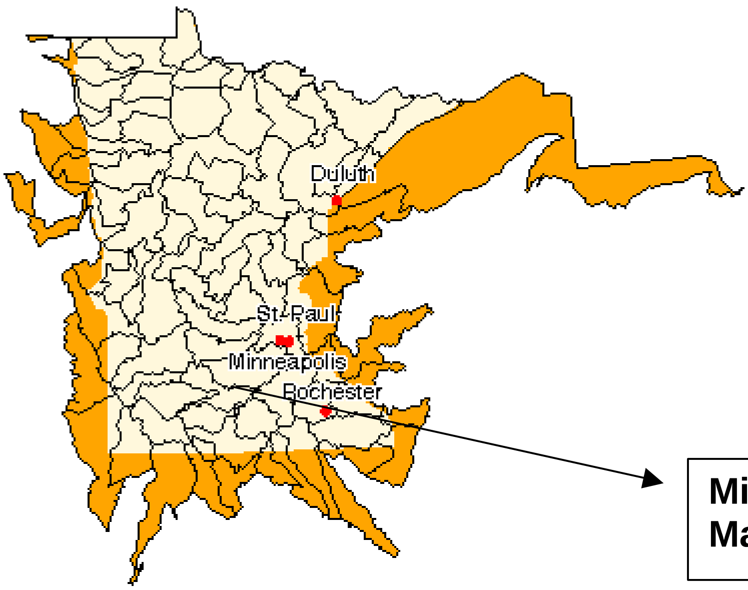
- It appears over fertilization and mineralization are the main causes for elevated No_3 levels in Seven Mile.

Pathogens

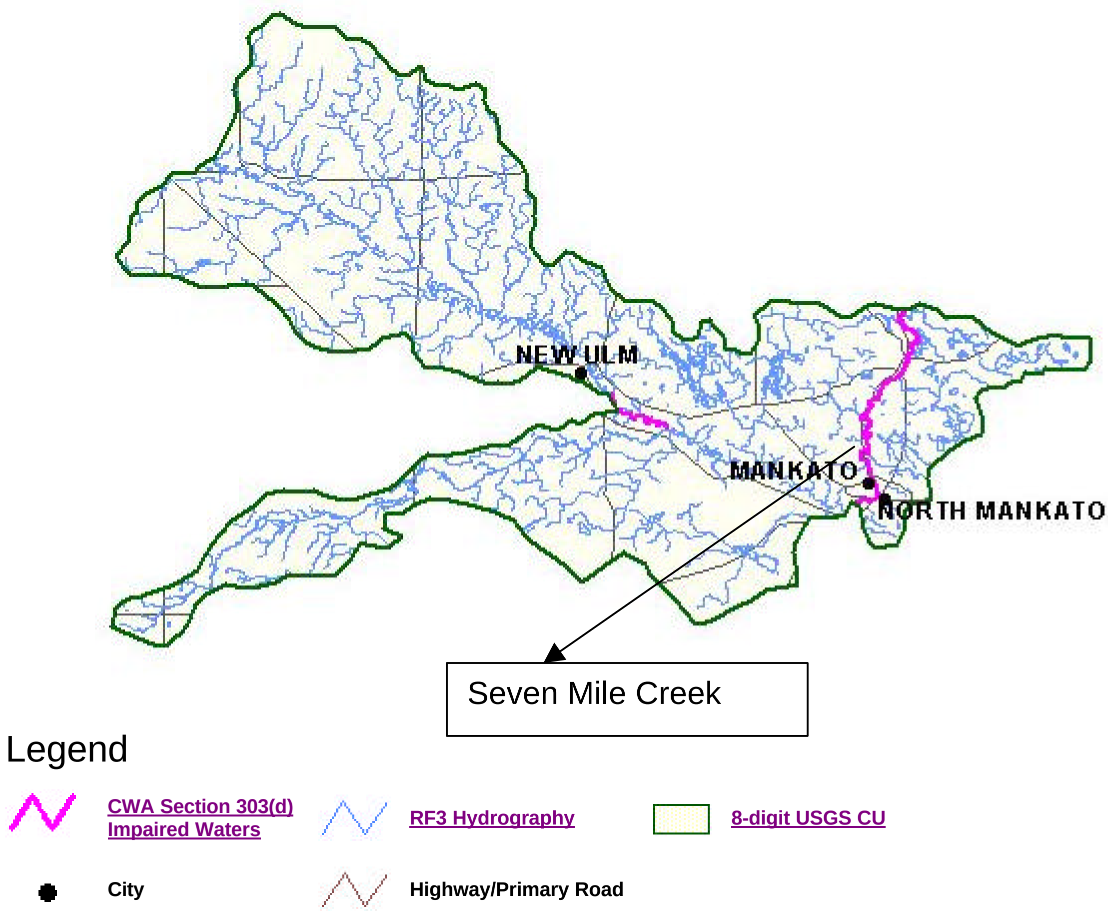
- High levels of fecal bacteria typically occur in July and August within the park. This should be of particular concern to the park users and county park managers.

- Most of the elevated fecal coliform bacteria counts occur during runoff events, suggesting sources of bacteria from feedlots and spreading acres. High counts during low flow conditions did occur as well during the study suggesting point sources. Failing septic systems are considered a large contributor to high bacteria concentrations during low flow events.

Map 33



Middle MN River Major Watershed.



Map 34. The Minnesota River from Mankato to Shakopee is considered a TMDL stretch of river. Eventually the state of MN and EPA must submit guidelines that limit the amount of pollutants within this reach of the river. Seven Mile Creek watershed contributes considerable pollutant loads for its size to this section.

TMDL Definition – What is a total maximum daily load (TMDL)?

A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Water quality standards are set by states, territories, and tribes. They identify the uses for each water body, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use.

A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. The calculation must include a margin of safety to ensure that the water body can be used for the purposes the state has designated. The calculation must also account for seasonal variation in water quality.

The Clean Water Act of 1972, section 303, establishes the water quality standards and TMDL programs.

The New TMDL Rule

These recommendations were used to guide the development of proposed changes to the TMDL regulations, which EPA issued in draft in August, 1999. After a long comment period, hundreds of meetings and conference calls, much debate, and the Agency's review and serious consideration of over 34,000 comments, the final rule was published on July 13, 2000. However, Congress added a "rider" to one of their appropriations bills that prohibits EPA from spending FY2000 and FY2001 money to implement this new rule.

Current TMDL Program

The current rule remains in effect until 30 days after Congress permits EPA to implement the new rule. TMDLs continue to be developed and completed under the current rule, as required by the 1972 law and many court orders. The regulations that currently apply are those that were issued in 1985 and amended in 1992 (40 CFR Part 130, section 130.7). These regulations mandate that states, territories, and authorized tribes list impaired and threatened waters and develop TMDLs.

TMDLs and Seven Mile Creek

The state of Minnesota will eventually need to develop and submit TMDLs for designated areas of impaired water bodies within the state. Seven Mile is located adjacent to a impaired area (map 34). This report maybe used by policy makers to help them develop realistic and attainable TMDLs for this stretch of river.

Watershed Water Quality Goals

Factors used to derive attainable water quality goals for Seven Mile Creek:

- Minnesota River and TMDL goals
- Develop a list of action priorities which provide the most effective enhancement for water quality with the smallest economic impact on stakeholders.
- Revised Universal Soil Loss Equation model
- FLUX loading model
- Sediment and nutrient delivery pathway modeling
- Red Top Farms Nitrogen Management Demonstration Site
- Current EPA water quality standards for surface and groundwater

For the purpose of setting water quality goals for this watershed, concentration and loads were considered to be a 1:1 correlation. This is based on a concentration vs. yield regression analysis.

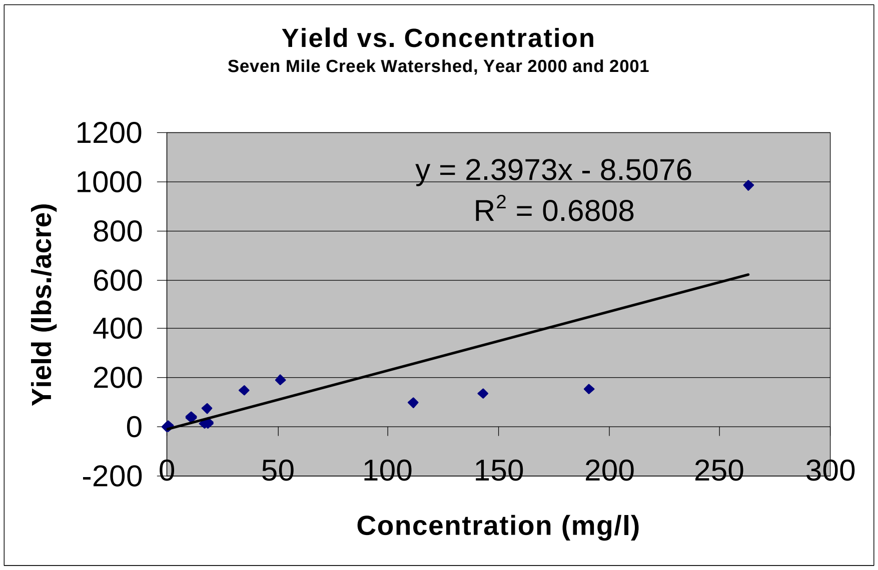


Figure 38. Yield vs. concentration for Seven Mile Creek.

Goals

- Secure buffers on half the eligible acres within the watershed (300 acres).
- Stabilize large stream bank erosion site (which yields an estimated 50 tons per year).
- Replace 50 open tile intakes with gravel inlets.
- Alter rate, timing, and method of phosphorus and nitrogen applications. Apply 0 pounds per acre of broadcast P for soils that test high/very high in P, apply in the spring, and band/incorporate fertilizer. For nitrogen, apply at UM recs (120 lbs/acre); apply urea or anhydrous ammonia in the spring.
- No net increase of public drainage within the watershed.
- Upgrade most to all non-complying septics in the watershed (70-100 homes).
- Encourage conservation tillage on highly erodible areas, particularly soybean ground.
- Get producers and fertilizer dealers to apply nitrogen at UM Recommendations on a majority of the corn acres (10,000 acres) in the watershed.
- Encourage and facilitate record keeping and nutrient management plans for crop, livestock, and dairy producers.
- Manage stream for brown trout fishery.

Sediments

The 2000-2001 flow-weighted mean total suspended solids (TSS) concentration at the mouth of Seven Mile Creek Watershed was 277 mg/l and the average yield was found to be 570 lbs./acre. Based on eco-region reference values, as well as the turbidity standard for the watershed (which can be roughly equated to TSS), a flow-weighted mean concentration in the 50-100 mg/l range would be desirable. This may not be a feasible goal, however, in a three-year project due to excessive bank erosion within lower reaches of the watershed. The soil erosion potential model (RUSLE), summarized in tables 7 and 8 of chapter 2 and the sediment erosion model discussed in chapter 6 provide some sense for what might be feasible. Chapter 6 contains major pathways of soil erosion within the watershed. If soil erosion best management practices were targeted toward half the manageable sediment sources such as open tile intakes, riparian corridors, and upland sources, and assuming on average BMPs such as gravel inlets, and waterways, prevent 50% of the soil from entering Seven Mile, the sediment load would get reduced by 25% or an average of 1,678 tons of soil per year. **Based on these figures, a load reduction goal of about 25% is aggressive, yet reasonable. This translates to a flow-weighted mean concentration goal of about 200 mg/l or 430 lbs/acre.**[1]

Assume 50% reduction of pollutant delivery to surface water due to best management practices and water quality outcomes in 5-10 years.

Phosphorus

Based on eco-region reference values, as well as comparisons with other watersheds and the Minnesota River, total phosphorus concentrations and yield in SMC Watershed is high, particularly for dissolved reactive phosphorus. Eco-region reference values, as well as phosphorus levels recommended for the MN River Basin, a flow-weighted mean concentration of less than 0.150 mg/l of total phosphorus would be desirable. There are many sources of P, but in this watershed sources are mainly derived from: human and animal waste, soil attached, and commercially applied fertilizer. Figure 34 in chapter 6 helps to set some realistic water quality outcomes after a period of accelerated BMP implementation. It was assumed that BMPs would prevent 50% the phosphorus from reaching the Creek. Assuming most failing septic systems in the watershed were fixed (12% reduction), 50 open intakes replaced (2% reduction), and half of upland areas were secured in conservation tillage (25% reduction), then when all these reductions are added up it equates to a 40% reduction. However, this may not be realistic considering the complexities of adoption rates and soil/phosphorus interactions within the watershed. In addition, Pete Cooper's work of the NRCS provides some indication of what may be more realistic. Average soil phosphorus tests in the watershed interpret as high and very high for the Olsen and Bray methods (Blue Earth Agronimics). Normal application rates of phosphorus in the watershed ranges from 45-75 lbs/acre. This is an over application of about 35-65 lbs/ acre above UM recs considering the soil test interpretations. If most of the producers switched from fall broadcast to spring banding of fertilizer, Cooper's research on farms in the eastern potion of the Minnesota River Basin suggest phosphorus losses could be reduced by 20%. **A combination of soil saving measures along with the alterations of rate, timing, and method of application of phosphorus within the upland zone could result in a more attainable goal of a 25% reduction in the**

[1] Assume percent reductions apply equally to flow weighted mean concentrations and yields. For the goal setting process it was assumed flow weighted mean concentrations and yields were equal. In most years during the study the two categories--- FWMC(mg/l) and yields (lbs./acre) were similar enough to assume correlation.

average phosphorus loads/concentrations. This translates into a goal of 0.255g/ml FWMC or 0.684 lbs./acre total phosphorus yield at the mouth of the watershed in a ten to fifteen year time frame.

Nitrate Nitrogen

Based on eco-region reference values, as well as the nitrate standard being recommended for the MN River Basin, a flow-weighted mean concentration less than 10 mg/l would be desirable. The flow-weighted mean concentration for nitrate nitrogen for SMC is 14 mg/l. An average load of 27 pounds per acre of Nitrate-N leaves the watershed system on average during the growing season. In the lower reaches of the watershed, where an interconnectedness of surface water and groundwater has been observed, maintaining a nitrate concentration below 10mg/l is important. To further refine nitrate reduction goals in the watershed recent research from Red Top Farms was used. Research conducted by Minnesota Department of Agriculture special projects unit staff at the Red Top Farm in Nicollet County, within the watershed, have documented reductions in tile drainage nitrate of up to 60% (from average of 23 mg/l to 11.5 mg/l) when nitrogen rates are reduced to UM Recommendations.

Water quality results from the first four years of the Red Top Farms study[2] indicate that producers can have a profound impact on the amount of nitrate leaching from their fields. Nitrate (No_3-N) concentrations in 1995-96 drainage waters (subsurface drainage tile) at the start of the demonstration were typically 20-25 mg/l. These numbers appeared to be typical ranges found under tile-drainage fields in southern Minnesota. By simply changing several basic nitrogen management strategies during the 1997 corn season, significant water quality improvements were observed. The farmer at Red Top switched to a spring-applied nitrogen program and lowered his fertilizer inputs to take the full 40 lb./acre legume credit from the previous year soybeans. Implementation of existing Nitrogen BMPs and University of MN Fertilizer Recommendations for southern MN resulted in a 40-60% reduction in the nitrate concentrations and no yield loss. Additionally, the results have been extremely positive for the majority of pesticide products that have been studied at the site since 1996. Figure 39 shows the decrease in nitrate within the tile water of the demonstration field at Red Top after key nitrogen management changes occurred.

[2] Minnesota Department of Agriculture, Red Top Farm Demonstration Site, Montgomery & Wotzka, 2000.

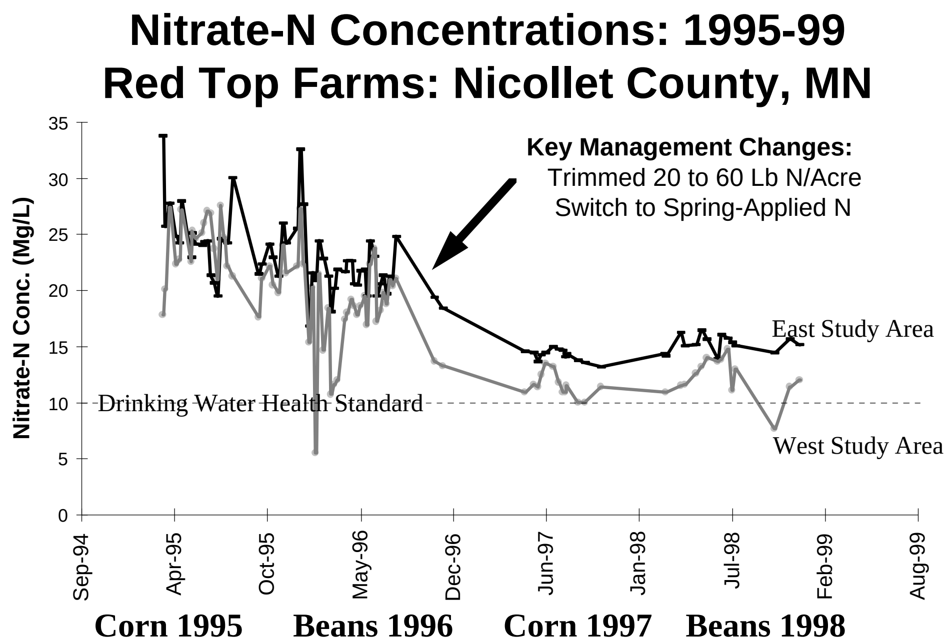


Figure 39. Nitrate reductions at Red Top Farms Study (1995-1999). Sub-surface tile drainage from two 30-acre fields is monitored for nitrate-nitrogen at the Nicollet County farm. The graphic above shows the response after improvements in nitrogen management were implemented. By simply changing several basic nitrogen management strategies, reductions of 40-60% were documented.

With intensive nutrient management activities in the watershed, similar reductions are feasible. In SMC, a combination of key education based nitrogen management changes on corn acres and utilization of floodplains and wetlands, **a 40% reduction in nitrate concentrations and yields would be aggressive yet attainable in ten years. This translates to a long-term flow-weighted mean concentration goal of about 8.5 mg/l or 16.0 lb./acre yield at the mouth of the watershed.**

Pathogens

Concentrations above 200 col./100ml were observed during both high flows and low flows indicating feedlot/manure spreading acres and septics. Overall, fecal coliform bacteria levels in Seven Mile Creek are of concern due to the high recreational use of the waters by park visitors. Upgrading all the failing septics and proper manure management will have a very large impact on reducing bacteria levels. This should be of concern for park visitors and managers. **As such, the goal of this project is to consistently meet state water quality standards for fecal coliform bacteria.** (below 200 col./100ml)

Biological-Fishery

Management plans have been documented for the creek regarding the biological structure, and informal fisheries goals by the DNR have been set as a result of fish surveys. Game fish such as walleye, northern pike, and small mouth bass have been present in the lower creek area during spawning periods and their presence should be of special concern to the area along with the stocked trout populations. The following are general informal guidelines presented by the DNR.

- **No net increase in public drainage for the watershed.**
- **Increase of water storage within the watershed through the use of wetlands.**
- **Maintain adequate DO, pH and temperature levels suitable for trout production.**
- **Maintain temperature levels below 70 ^{o}F.**
- **Maintain DO levels above 6 mg/l.**

Realistic Water Quality Goals for the Watershed within a 5-10 year time period:

- **25% reduction in TSS**
- **25% reduction in Phosphorus**
- **40% reduction in Nitrates**
- **Fecal Bacteria below 200col./100 ml at all times**

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With all these goals in mind an estimated total of:

- **1678 tons of soil/ year**
- **2.7 tons of phosphorus/year**
- **125 tons of nitrate/year**

could be reduced from entering the impaired TMDL designated reach of the Minnesota River from Seven Mile Creek every year.