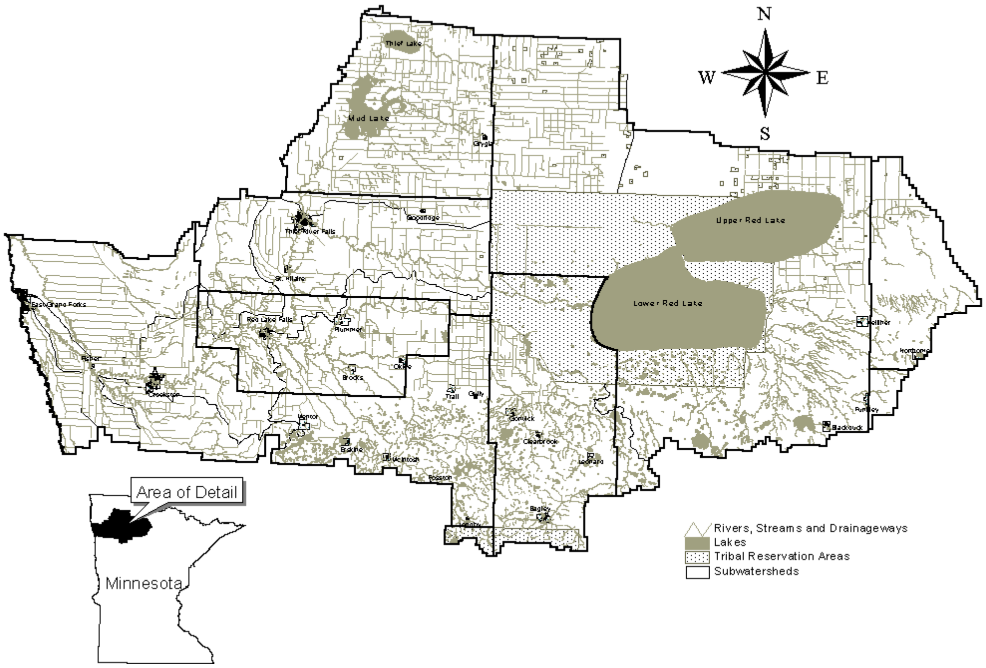
RLWD Water Quality Report
July 2004



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1.0 EXECUTIVE SUMMARY

The Red Lake Watershed District's Water Quality Project has been ongoing since 1984. The district's commitment to this project reflects the recently heightened awareness and increased concern for water quality from the public and agencies alike. Fifty-five sites located throughout the district were samples seasonally beginning in 1984. Sampling was reduced to 30 sites in 1990. The Red Lake Watershed District (RLWD) currently monitors over 30 sites four times per year. Sampling sites are located in all major subwatersheds within the RLWD. The RLWD long-term monitoring program collects data for dissolved oxygen, water temperature, conductivity, pH, total phosphorus, orthophosphorus, total suspended solids, total dissolved solids, total Kjeldahl nitrogen, ammonia nitrogen, nitrates and nitrites, fecal coliform, and chemical oxygen demand.

The goals of the RLWD water quality program include the evaluation of water quality, identification of pollution sources, water quality improvement, and public education. The means of achieving these goals may vary depending upon the purpose of the monitoring being conducted. The RLWD monitoring program consists of a long-term monitoring program, special studies, and investigative monitoring. Other organizations within the RLWD are also collecting water quality data. These include high schools involved in the River Watch program, the Red Lake Department of Natural Resources, the Minnesota Pollution Control Agency, and Soil and Water Conservation Districts. The RLWD Water Quality Coordinator is responsible for directing the RLWD monitoring program and working with other natural resource professionals in order to coordinate monitoring efforts and share information. The Red River Basin Monitoring Advisory Committee and the Red River Basin Water Quality Team are two groups that facilitate this cooperation among agencies.

Some of the data analysis conducted for this report includes the creation of histograms and time series plots using Microsoft Excel, data censoring by simple substitution, and the calculation of annual loads by the FLUX modeling program. Comparisons were made among sites based on mean concentrations, EPA standards, and minimally impacted values. Water quality data is interpreted for the identification of problems, impacts, trends, and patterns.

The RLWD long-term monitoring program is undergoing changes that will increase its efficiency and the usability of the data collected, without greatly increasing costs. Data will be collected on a schedule that is more suitable for assessments. Data will be entered into the EPA's national water quality database STORET regularly. Analysis for two parameters for which data is not used may be discontinued. Site location will continue to be based on the locations of USGS gauges, position within a watershed, project locations, locations of other agencies' monitoring sites, and the locations of impaired reaches. Flow measurements will be collected at sites that lack rating curves. The RLWD has spent an average of $41,000 per year on its water quality program since it began. The amount spent varies each year however, based upon the amount of time spent on other water quality projects.

Water quality varies throughout the Red Lake Watershed District. The Red Lakes subwatershed, upper Red Lake River subwatershed, and the upper Clearwater River subwatershed in the eastern part of the RLWD are characterized by good water quality. Some streams within these areas have even seen improvement in recent years. As the rivers travel further west into the Red River

Valley, however, they encounter lower gradients, increased drainage, and channelization. These factors and others negatively affect water quality and biotic integrity. The Thief River, which joins the Red Lake River from the North, has relatively good water quality during normal flow conditions, particularly during summer months. However, during bank-full flows as well as low-flow situations, water quality can become impaired. Dissolved oxygen levels plummet while total dissolved solids and conductivity levels increase during winter occurrences of low-flow. Total suspended solids and phosphorus levels greatly increase during occurrences of high flow, whether this high flow is from runoff, the release of water from Agassiz National Wildlife Refuge, or both. On the lower Red Lake River and on Grand Marais Creek, high turbidity and total suspended solids levels are a regular occurrence.

2.0 PROGRAM DESCRIPTION

2.1 Origins and Development of the RLWD Water Quality Program

Before the onset of the RLWD water quality project, water quality throughout the district had been overlooked as a problem for a long time. Beginning in the 1980's, the quality of water within the district has become a more important issue. Prompted by an increased local concern with water quality and the proposal to build the Maple Lake Project in the late 1970's, the Red Lake Watershed District initiated a water quality project. Although the water quality project didn't officially start until 1985, monitoring began in 1984.

In 1984, the RLWD selected fifty-five sites to be monitored, and sampling began in April of that year. The collection of samples took place five times during the first year and four times after that (see Table 1). Beginning in 1984, water was tested for pH, conductivity (specific conductance), turbidity, stage, flow, temperature, total phosphorus, orthophosphorus, nitrates, dissolved oxygen, and alkalinity. Fecal coliform analysis began in 1989. Site selection was based on proximity to waste water discharge sites, areas of agricultural impact, wildlife impoundments, and sites that represent the overall characteristics of the district.

In the summer of 1990, the number of monitoring sites was reduced to thirty (see Figure 2). The amount of time to collect samples, economical feasibility, and proximity to major project activity were the major reasons for the reduction of sites. Chemical oxygen demand, total Kjeldahl nitrogen, total suspended solids, and ammonia nitrogen analysis began in 1992. Analysis for nitrates and nitrites began in 1998 and total dissolved solids analysis was added in 1999. Chloride analysis occurred only during the 1998 sampling season. The sampling plan has the flexibility of sampling at different locations and different intervals or at less frequent intervals that are based on seasonal flow, low flow, accidental spills, rainfall events, or at the request of concerned parties.

When the project began, the major objective was to establish baseline data that could be compared to data collected in the future. The objectives have changed somewhat since the onset of the project. The data continues to be complied for baseline information, but stored data can now be used for comparative analysis in identifying "problem" areas within the watershed. The data can also be used as an educational tool to inform citizens of past and current trends in water quality.

Samples are collected and analyzed according to the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed*. Samples are collected from streams either directly with the sample bottles or by using a Kemmerer sampler, depending on stream depth. A Sonde/Hydrolab is used for field measurements of water temperature, dissolved oxygen, pH, and conductivity. The samples are placed in sterile bottles and kept on ice for transport to the laboratory.

The following list is the laboratory tests originally performed on the samples:

Water Temperature	Alkalinity
Nitrate-Nitrogen	Fecal Coliform*
pH (field)	Dissolved Oxygen*
Total Phosphorus	Turbidity
Conductivity (field)	

*Selectively tested

The parameter list has been upgraded since 1993 to include the following:

Water Temperature	Dissolved Oxygen (field)
Total Kjeldahl Nitrogen	Turbidity (field)
pH (field)	Nitrates and Nitrites
Total Phosphorus	Chemical Oxygen Demand
Conductivity (field)	Ammonia Nitrogen
Ortho Phosphorus	Chloride *
Fecal Coliform	Total Organic Carbon
Alkalinity	

*Selectively tested

Upgraded methods and improved instrumentation allow for a greater number of parameters. Throughout the history of the monitoring program, quality assurance and quality control (QA/QC) has grown in importance. Blanks and duplicate samples began to be analyzed in the third year of the project as a QA/QC measure. The QA/QC guidelines followed through 2002 were a result of the district's involvement in the Clearwater River Non-point Study. The procedures that are now used are described in the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed*. They are similar to the previous methods but are improved in order to increase the accuracy and reliability of monitoring data. In April of 1992, the laboratory at the University of Minnesota, Crookston became certified by the Minnesota Department of Health as a water quality laboratory. Samples were analyzed at the laboratory until 1998. Since then, samples have been shipped to the RMB Environmental Laboratories in Detroit Lakes for analysis.

The Red Lake Watershed District can be broken down into five major subwatersheds: Upper and Lower Red Lakes, Red Lake River, Clearwater River, Thief River, and Grand Marais River (see Figure 1). The Red Lakes, Red Lake River, Clearwater River, and Thief River subwatersheds together form the entire watershed of the Red Lake River. The Grand Marais Creek subwatershed flows directly into the Red River of the North. The RLWD boundary also falls within four of the seven ecoregions in Minnesota (see Figure 2). The district maintains water quality sites within all four ecoregions.

Water carries dissolved and suspended materials from watersheds, stream channels, lake bottoms, and the atmosphere. Water bodies are constantly receiving these materials. Water quality reflects the history of the water body as well as the condition of the new incoming water. The quality of past and present land use practices has a great influence on water quality. Water quality can reflect impacts from such things as channel alteration, urban runoff, and agricultural runoff. It can also show results of water quality improvement projects such as wastewater treatment plant improvements, erosion control and stream bank restoration projects, buffer strip implementation, storm water retention, and best management practice implementation.

Wide ranges of water quality conditions exist throughout the RLWD. These reflect the variance of land use practices and geologic features across the district. They range from the nutrient rich, oxygen poor, highly turbid channels of the Grand Marais River to the clear and clean water of the Clearwater River. When a wide range of water quality conditions exist, naturally a variety of uses will also exist. These range from an outlet for wastewater discharge to managing a stream to support a fishery.

The analytical tests conducted on water samples aid in the understanding of how "polluted" a water body is. The level of pollution can determine the acceptable uses for this water. For example, none of the surface water in the district is suitable for human consumption without purification, but the water is good for livestock watering or a fishery. Results could be broken down further for recommendations of what type of recreational activities are acceptable for the body of water in question. Water quality testing is also essential for identifying areas where the beneficial uses of a waterbody may be threatened.

It is not the watershed district's intent to duplicate other testing programs within the district but to compliment them. The RLWD currently coordinates sampling efforts with the MPCA, SWCDs, Red Lake DNR, Red River Watershed Management Board, Red River Basin Institute and local schools involved in the River Watch Program. The agencies and volunteer groups listed above have collected long-term and short-term data in different areas of the district.
(See Figures 5, 6, 7 and tables 2 and 3).

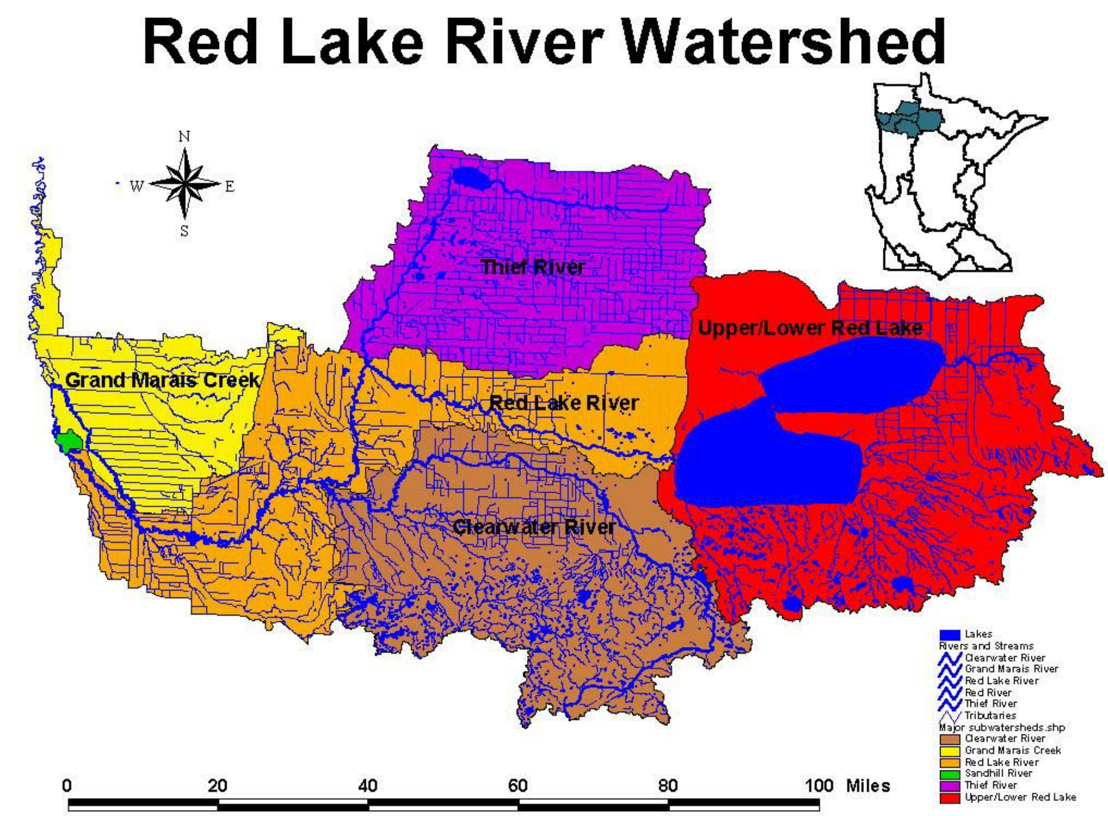

Figure 1. Red Lake Watershed District Subwatersheds

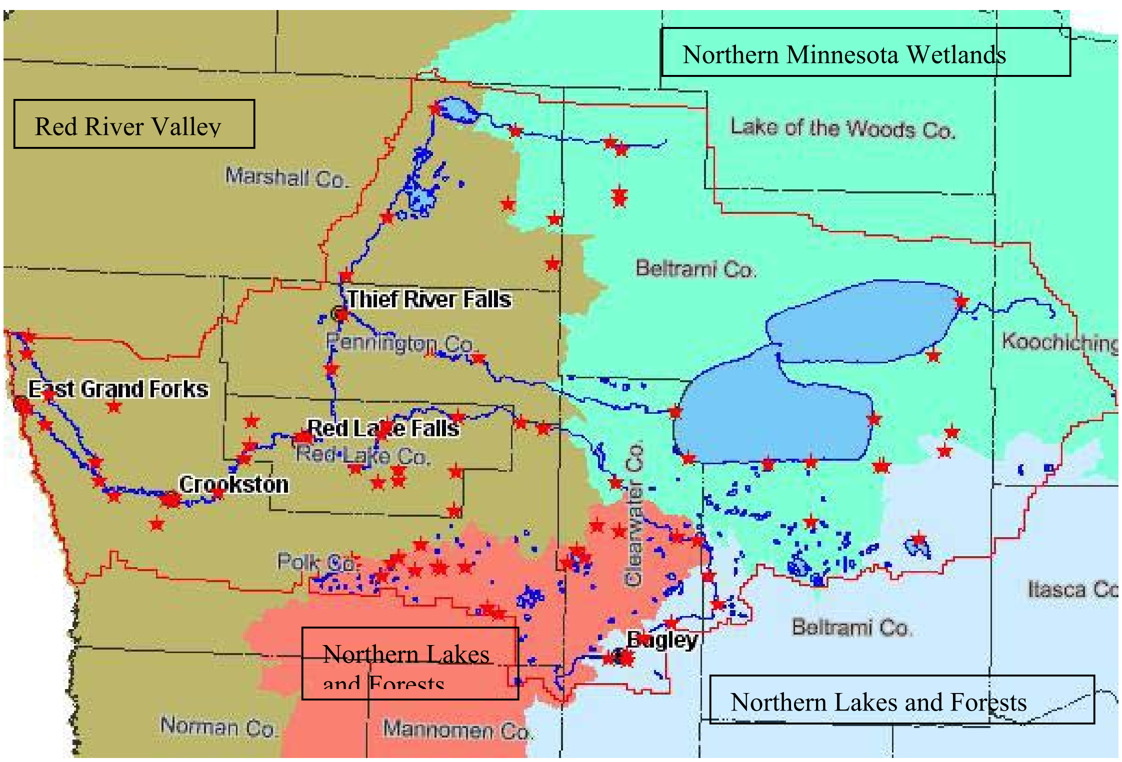

Figure 2. Red Lake Watershed District Ecoregions

2.2 Overview of RLWD Monitoring Locations

This section will describe the locations of most of the water quality monitoring sites within the Red Lake River watershed. The historical sites are sites that were monitored at the beginning of the water quality program but then discontinued when the number of sampling sites was reduced in 1992. Descriptions of the RLWD's current sites and some recently discontinued sites are organized by subwatershed. Since there are other groups and agencies conducting monitoring programs within the RLWD, the locations of their monitoring sites are included in this section of the report as well.

Many of the RLWD monitoring sites were chosen because the sites were also USGS flow monitoring stations. This flow data is used for the quantification of nutrient and sediment loads. The RLWD currently monitors USGS gauge locations at sites 790, 780, 782, 757, 797, and 750. Each monitoring site has been chosen based on its strategic position within a stream or river's watershed, proximity to a RLWD project, impaired reaches, and/or proximity to a potential source of pollution. The inlets and outlets of several lakes are also monitored in order to evaluate the amount of nutrients that are being delivered to and retained by the lakes. These sites include 53-I and 53-O for Maple Lake, 50-I and 50-O for Pine Lake, 59 and 63 for Badger and Mitchell Lakes, and also sites 131 and 52 for Clearwater Lake. Site selection can also be based upon a particular project, such as the Poplar River Diversion Project, to which sites 109, 59, 63, 53-I, and 53-O are associated. See section 6.2 for more information on the diversion project.

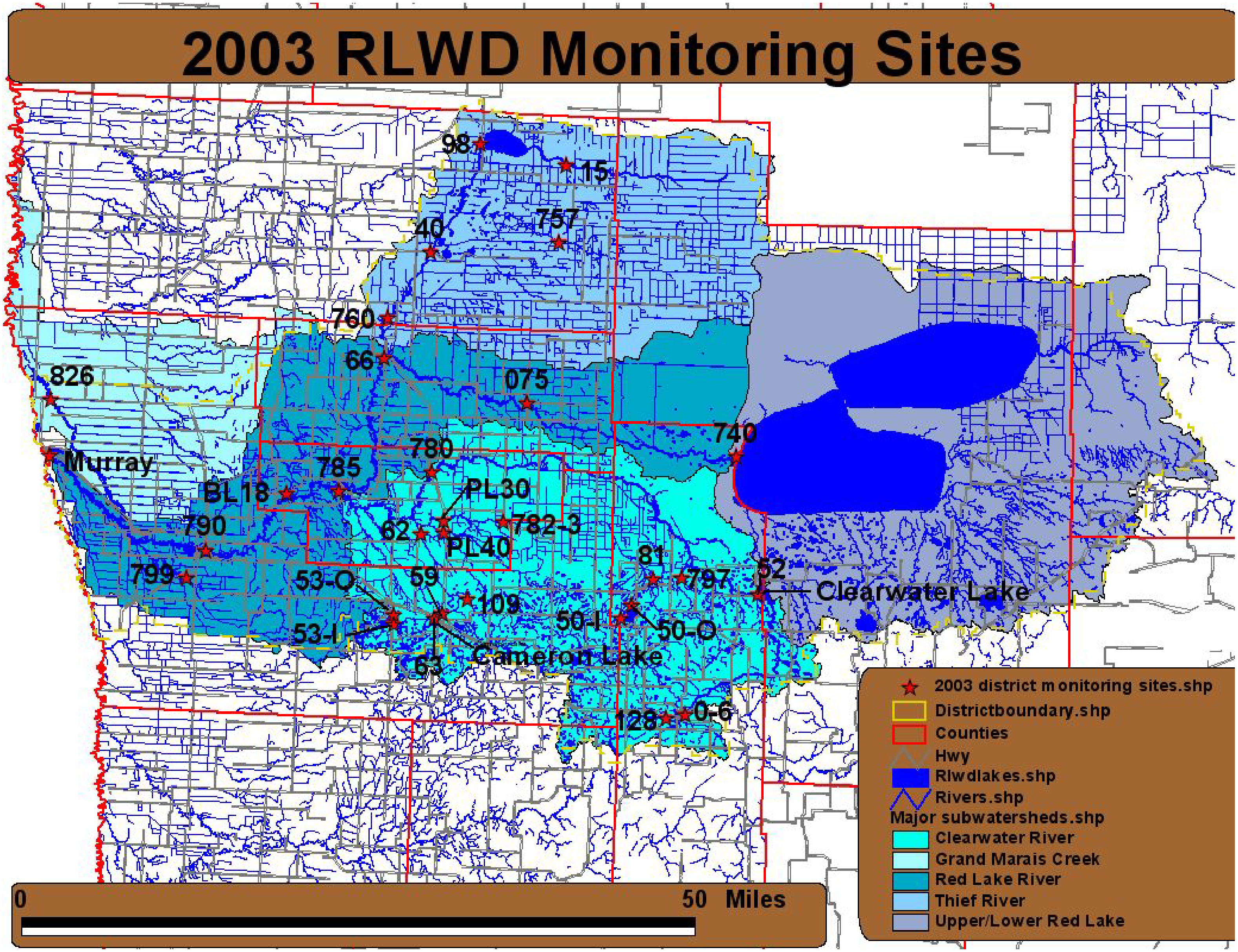

Figure 3. 2003 Monitoring Sites

2.2.1 Historical Monitoring Sites

The list of RLWD historical monitoring sites below includes sites that were included in the original monitoring network of fifty sites, but were dropped when the network was reduced to 30 sites. It also includes sites that were only monitored during the Clearwater River Nonpoint Study.

Table 1. Historical Monitoring Sites

Site	Water Body	County	Location
0-1	Clearwater River	Clearwater	CSAH 5 crossing
0-2	Poplar River	Polk	County Road 8
0-4	Poplar River	Polk	County Road 30
0-5	Poplar River	Polk	County Road 6
2	Clearwater River	Polk	County Road 2
10	Clearwater River	Red Lake	RR trestle in Red Lake Falls
13	Clearwater River	Red Lake	County Road 5
19	Walker Brook	Clearwater	CR #19, Stream Gauge 133, monitoring resumed in 2002
24	Clearwater River	Beltrami	CR #24, S.G. #131, monitoring resumed in '02
37	Clearwater River	Pennington	County Road 96
50	Pine Lake	Clearwater	2.5 mi. S of Gonvick
54	Hill River	Polk	Twp Rd. 4 mi NE of McIntosh
60	Clearwater River	Clearwater	Twp Rd. near Bagley WWTP
82	Clearwater River	Red Lake	County Road 12 bridge
0-0	Blackduck River	Beltrami	County Road 30 bridge
735-3	Tamarac River	Beltrami	Hwy 72 bridge
735-6	Shotley Brook	Beltrami	County Road 23
736-3	Battle River	Beltrami	County Road 36
737-7	Blackduck River	Beltrami	Hwy 1 bridge
737-9	Cormorant River	Beltrami	County Road 36
739-8	Sand River	Red Lake Reservation	Hwy # 1 bridge
NEB1	Mud River	Beltrami	County Road 32 bridge
39	Red Lake River	Pennington	CR 22 - Kratka Bridge
70	County Ditch #2	Polk	Hwy 220 bridge
77C/P	Little Black River	Red Lake	NW of RLF, Little Black River Dam outlet
83	Red Lake River	Polk	CR #11 Gentilly Bridge
89	Burnham Creek	Polk	County Road 216
96	Red Lake River	Polk	County Road 15
100	Red Lake River	Pennington	County Road 3
108	Red Lake River	Red Lake	1 mi. N of Red Lake Falls, CR #13
220	Red Lake River	Polk	Mallory bridge, Hwy 220
Bypass	Red Lake River	Polk	Hwy 75 bridge
114	Mud River	Beltrami	County Road 44
119	Moose River	Beltrami	Moose R. Impoundment outlet

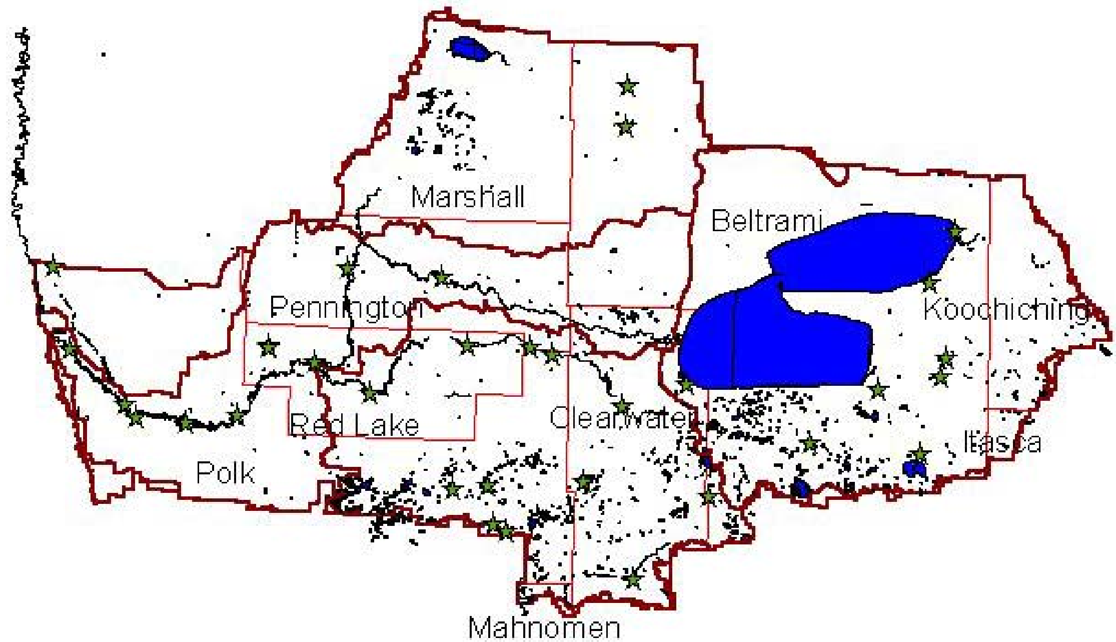

Figure 4. Red Lake Watershed District Historical Sites

2.2.2 Clearwater River Monitoring Sites

<u>128</u>
This site is located on County Road #25, southwest of Bagley, at the beginning of the Clearwater River. This site monitors the water quality of the headwaters of the Clearwater River and is located upstream of the City of Bagley. This site frequently experiences low dissolved oxygen levels. This is a current long-term monitoring site and has also been included in the Clearwater Nonpoint Study, Clearwater Lake Water Quality Model Study, and is a site for the Clearbrook-Gonvick High School River Watch program.

<u>O-6</u>
This Clearwater River monitoring site is located east of Bagley at the US Highway #2 Bridge. This is the first site downstream from Bagley so data from this site can be compared to data from site #128 to show any impact from the city on the river. The water at this site is clean and clear, without much stream bank erosion. This site is impaired for aquatic life by periodic low dissolved oxygen levels. This current long-term monitoring site was also part of the Clearwater Nonpoint Study.

<u>52</u>
At this site, samples are taken from the upstream side of the Clearwater Dam along Clearwater County Road 4 where the Clearwater River flows out of Clearwater Lake. The projects that have involved this site are the long-term district monitoring program (current site), Clearwater Nonpoint Study, Clearwater Water Quality Model, Clearwater River Habitat and Bioassessment Study, and Clearbrook-Gonvick River Watch. Major concerns of lake residents include increases of nutrients, weed growth, and algae blooms. Since much of the sediment and nutrients

entering the lake are deposited before it reaches this site and low dissolved oxygen is not a significant problem in Clearwater Lake, the water quality at this site is normally very good.

50-I

This current long-term monitoring site monitors water flowing into Pine Lake. It is located on the Lost River south of Gonvick on a township gravel road immediately upstream of where the river enters the lake. This site is very sparsely settled, with an abundance of wildlife activity in and around the waters edge. This site has had high fecal coliform levels and low dissolved oxygen levels. Flow and water quality may be affected by beaver dams which are commonly located downstream of this site.

50-O

This is the Pine Lake outlet water quality monitoring site. It is located on the Lost River at a township gravel road that is the first crossing downstream of Pine Lake. This site is located approximately two miles south of Gonvick and then west on the township road just north of the lake. Beaver dams are commonly located upstream of this site. An observed water quality problem at this site has been high fecal coliform levels.

81

Silver Creek is a tributary of the Lost River. This long-term monitoring site is located on the lower end of the Silver Creek watershed on Clearwater County Road #111, north of Gonvick. The Silver Creek watershed is part of a buffer strip initiative program being implemented by the Clearwater County SWCD in cooperation with the RLWD and the Red River Basin Commission. This project involves concentrated implementation of riparian buffer strips within the Silver Creek watershed. Both agricultural runoff and storm water runoff are possible causes of water quality problems for Silver Creek. The main water quality problem observed at this site is the frequency of high fecal coliform concentrations. This site is monitored monthly in order to evaluate the success of the buffer initiative.

797

This is the current long-term monitoring site that monitors the quality of water coming from the Ruffy Brook watershed, a tributary of the Clearwater River. This site is located north of Clearbrook on Clearwater County Road #67. The main concerns for Ruffy Brook are high fecal coliform levels, and total dissolved solids (TDS). This site may be impacted by large expanses of agricultural activities with a lack of buffers within its watershed and along the stream channel. Ruffy Brook may also be contributing to a fecal coliform impairment on the Clearwater River.

782

This long-term monitoring site is used to monitor water quality on the Lost River. It is located on Red Lake County Hwy #5 just outside the city of Oklee. Fecal coliform levels are the major concern for this site. Stormwater from the city of Oklee enters the river upstream of this site. This site is a USGS gauging station and a Red Lake County Central High School River Watch site and also a Clearwater River Nonpoint Study site.

PL30

This recent addition to the RLWD district monitoring program is located on the Lost River, near its confluence with the Clearwater River and upstream of where it is joined by the Hill River. This site is approximately 1 mile north of Brooks. This site has been a River Watch site for Red Lake County Central High School. Sampling results show a problem of excess nitrates and nitrites. This is also a secondary site for the Red River Basin Monitoring Network, and a site in the Clearwater River Nonpoint Study.

PL40

This recent addition to the RLWD district monitoring program is located on Hill River just north of Brooks and upstream of the river's confluence with the Lost River. There is some urban development and large expanses agricultural activity within the watershed. This river has high amounts of nitrates and nitrites in the water and a total suspended solids problem. This was a new site in 2003 and is a River Watch site for Red Lake County Central High School. This is also a secondary site for the Red River Basin Monitoring Network and part of the Clearwater River Nonpoint Study.

780

This site is on the Clearwater River, located on township gravel road upstream of Plummer. This is a site that has been important to the Red Lake Watershed for many reasons; it has been part of the Clearwater Nonpoint Study, a River Watch site for Red Lake County Central High School, a site for the Clearwater River Habitat and Bioassessment Study, and a USGS gauging station location. The main concern here is the amount of total suspended solids. Stream bank erosion, agricultural areas, or development along the river could be potential sources of this sediment. The amount of flow at this site is monitored by RLWD engineering staff for the purpose of regulating the amount of water used from the river for wild rice production

109

This Poplar River monitoring site is located on the Poplar River near the water control structure for the Poplar River Diversion Project. The Poplar River Diversion Project is designed to divert water from the Poplar River through a ditch into Badger Lake, through Badger Lake into Mitchell Lake, then through J.D. 73 into Maple Lake to maintain lake levels during drought periods. The project has never been used for this purpose since its construction in 1937. This site is located on a township road upstream of the Highway 59 crossing of the Poplar River. The Poplar River eventually flows into the Clearwater River. This river has experienced minimal channel alteration, but is periodically impacted by wastewater from the City of Fosston, agricultural runoff, and low flow. Results at this site have shown high total dissolved solids levels and low dissolved oxygen levels.

62

This site is where CSAH 92 crosses the Poplar River near its confluence with the Clearwater River. The site is west of Brooks. This river is a tributary of the Clearwater River. This river looks relatively pristine and native, but the frequency of high fecal coliform levels raises concern. Agriculture is prevalent in the watershed. This is a secondary site for the Red River Basin Monitoring Network and was a site for the Clearwater River Nonpoint Study.

59

This current long-term monitoring site is the main inlet of Badger Lake. It is located on Polk County Road #208 north of Erskine and just downstream of where the stream crosses Highway 59 and passes under railroad tracks. This site is located on the path of the Poplar River Diversion Project. If the Poplar River Diversion were ever used, this site would monitor water diverted from the Poplar River. This water would then pass into Badger Lake, through the channel monitored by Site #63, into Mitchell Lake, through JD #73, and then into Maple Lake. Wetlands upstream of this site were ditched as part of the diversion project. Major concerns at this site include low dissolved oxygen levels that, in the winter, pose a problem for the fish in the lake (winter aeration is often necessary). This site is also part of the Win-E-Mac High School River Watch program.

63

This site is on the Mitchell/Badger channel that crosses US Highway #2 between Mentor and Erskine. This channel links the two lakes so that water can flow from Badger Lake to Mitchell Lake and eventually into Maple Lake as part of the Poplar River Diversion Project. Low dissolved oxygen levels are a problem at this site.

53-I

This long-term monitoring site is located at the main inlet of Maple Lake. Samples are collected just downstream of where Polk County Highway #10 crosses Judicial Ditch #73 just before the ditch enters the lake. JD #73 enters Maple Lake from the East after flowing through Rydell NWR. This ditch cuts through the wetland areas upstream of Maple Lake, so rainfall events flush large amounts of total phosphorus and sediment into the lake. A large percentage of the nutrient loading to Maple Lake occurs through this site. Normally, wetlands are effective for filtering sediment, but the high flows associated with the ditches traveling through these wetlands often suspend and carry the accumulated sediment and nutrients downstream into the lake.

53-O

This is the Maple Lake Outlet monitoring site, located at the Polk County Highway #10 crossing. There is normally a significant amount of flow going through this site. This site was part of the Maple Lake Study and is a current long-term district monitoring site. There have not been many major water quality problems observed at this site. The lake apparently retains a large amount of the sediment and nutrients that it receives from its inlets and immediate watershed. However, after heavy rains, local residents have observed a plume of sediment entering the lake at 53-I, looping through the northeast bay of the lake, and exiting at the outlet

85

This is the Bee Lake Inlet monitoring site, located on Polk County Road #37. Concerns here are the low dissolved oxygen levels from the low flows out of the lakes. This site was sampled through 2002. The Win-E-Mac River Watch program can effectively monitor the dissolved oxygen levels at this site.

785
This site is co-located with the USGS gauge on the Clearwater River in Red Lake Falls. There are some occurrences of bank slumping and steep cliffs at this site. Relatively high levels of total suspended solids have been observed at this site. This site is currently a long-term monitoring site, Red Lake Falls High School River Watch site, and a primary site for the Red River Basin Monitoring Network. It was also a site for the Clearwater River Habitat and Bioassessment Study and the Clearwater River Nonpoint Study.

2.2.3 Red Lake River Monitoring Sites

740
The beginning of the Red Lake River at the Red Lake Dam is monitored at this site. The dam from which samples are taken is just upstream of where State Highway 89/1 crosses the Red Lake River. There is a USGS gauging station at this site. This site was co-monitored by the RLWD and the Red Lake DNR through 2003 and is now monitored only by the RLDNR.

750
Site #750 is a current long-term monitoring site and USGS gauging location on the Red Lake River at the Highlanding Bridge, which is located on Pennington County Road #24. The river flows west-northwest from this site to the city of Thief River Falls. The location of this site is strategic in monitoring the quality of water upstream of the city. There are other crossings upstream of Thief River Falls that are closer to the city than Highlanding, but the USGS flow data at Highlanding is very valuable and increases the usefulness of the water quality data collected there. The water quality at this site is relatively good.

66
This site monitors the Red Lake River in Thief River Falls at the 1st Street Bridge. This site's location is important for monitoring water quality upstream of the city's water source and downstream of the confluence of the Thief River with the Red Lake River. Fecal coliform levels sometimes do not meet standards, but not frequently enough to qualify the river as impaired. Dissolved oxygen levels have only been below the standard of 5 mg/L once, during conditions of very low flow in August of 2003. Otherwise, water quality at this site is quite good. This is a current district monitoring site and also a secondary site for the Red River Basin Monitoring Network. The RLWD will continue monitoring this site during the winter (for a total of 5 samples each year) to test water quality under the ice because of the sites importance to the water supply of Thief River Falls.

BL18
In 2003, the RLWD began monitoring the Black River, a tributary of the Red Lake River, as a part of the long-term monitoring program in an effort to monitor as many secondary Red River Basin Monitoring Network sites as possible. The monitoring site is at Red Lake County Road #18 near Huot, which is the last crossing of the river before it enters the Red Lake River. This site is also a Red Lake Falls High School River Watch site.

790
Site #790 is a current long-term monitoring site and USGS gauging location on the Red Lake River at the Sampson Bridge on Roberts Street in Crookston. By the time the Red Lake River reaches this site, it has taken on a brown color due to changes in soils and land use as it flows through the Red River Valley ecoregion. The water quality problems here are the high levels of total suspended solids (TSS) and fecal coliform levels. This is also a Crookston High School River Watch site.

799
This is the RWLD long-term monitoring site on Burnham Creek, a tributary of the Red Lake River. The sparsely populated area has a high percentage of agricultural lands surrounding the river, with minimal windbreaks in some areas of the watershed. High levels of total suspended solids (TSS), low dissolved oxygen levels, and high conductivity readings make this site one of the most polluted in the district. Soils and land use are likely the main contributing factors to the Burnham Creek problems. This is also a Crookston High School River Watch site.

Murray Bridge
The RLWD uses this site to monitor water quality in the Red Lake River in East Grand Forks prior to its confluence with the Red River of the North. This is also a River Watch site for Sacred Heart High School and East Grand Forks Public High School. High total suspended solids levels occur frequently between this site and Crookston on the Red Lake River. A large portion of the anthropogenic contributions to the sediment levels in the river can be attributed to agricultural runoff, altered hydrology, and storm water runoff from Thief River Falls, Red Lake Falls, Crookston, and East Grand Forks. Protecting water quality at this site is important for protecting the public water supplies of Grand Forks and East Grand Forks, the source of which is the Red Lake River.

86
The RLWD began sampling this site as part of its district monitoring program in 2004. It is located at the CR 11 crossing of Gentilly Creek, in the town of Gentilly. Initial sampling results show a relatively high, but not excessive, level of nitrogen in the water.

2.2.4 Thief River Monitoring Sites

15
This current long-term monitoring site is located on the Moose River at the State Highway 89 crossing. The water is stained a tea-color as it flows out of the lowland swamps of the Beltrami Island State Forest and the Moose River impoundment. This site is located upstream of Thief Lake. Low dissolved oxygen levels are a frequent occurrence at this sight. Also, orthophosphorus levels reach high levels each winter. The Marshall County SWCD and the Grygla River Watch program also monitor water quality at this site. It was also part of the Total Suspended Sediment Loadings Study completed in June 2003 by Houston Engineering for the Pennington County SWCD.

757

This site is located where State Highway 89 crosses the Mud River directly south of site 15, northwest of Grygla. The frequency of high levels of total suspended solids and total dissolved solids, as of 2004, is high enough to impair the ability of this reach of the river to support aquatic life. The river occasionally experiences high conductivity and low dissolved oxygen levels during the winter. This river also comes out of the Beltrami Island State Forest and also has agricultural lands surrounding it. The Marshall County SWCD and the Grygla River Watch program also monitor this current RLWD long-term monitoring site.

98

This site monitors the Thief River as it leaves the Thief Lake Wildlife Refuge, just downstream of the Thief Lake Dam on Marshall County Road 49. This river is home to many different species of wildlife. The frequency of high fecal coliform levels is a problem that has been observed at this site. This is a current RLWD long-term monitoring site and is also monitored by the Marshall County SWCD.

40

This site on the Thief River is located downstream of the outlet of Agassiz National Wildlife Refuge on Marshall County Road #7. It is a current long-term monitoring site for the RLWD and is also monitored by the Marshall County SWCD. High levels of total suspended solids, high total dissolved solids, high winter orthophosphorus levels, and low dissolved oxygen levels are major concerns at this site. Because both the Thief River and the Mud River flow through Agassiz NWR, much of the sediment, nutrient rich detritus, and even large clumps of cattails within this large wetland are swept downstream during high flow events and when the refuge is releasing water. Moderating the flow from the refuge or allowing some water to bypass the refuge in the natural channel of the Thief River may help alleviate some of the water quality problems. In most winters, little water is released from either Thief Lake or Agassiz NWR so there is very little flow and very little oxygen left in the water. The anaerobic conditions in the pools and the river make them uninhabitable or fish in the winter and also facilitate the production of hydrogen sulfide, which causes odor problems at the Thief River Falls dam. The high TDS levels that occur during the winter and early spring also affect the odor and quality of the public water supply in Thief River Falls. High total suspended solids and total phosphorus levels are associated with the annual release of water from Agassiz NWR in the spring and in late fall. Installation of cross-vane weirs could help stabilize the channel in the Thief River, aerate water, and volatilize hydrogen sulfide, as long as flow is sufficient.

760

This current RLWD long-term monitoring site is located on the Thief River at Hillyer Bridge, which is approximately three miles north of Thief River Falls on County Road 77 in Marshall County. The Thief River contributes to the public water supply of Thief River Falls and generally has poorer water quality than the Red Lake River where the two rivers meet. According to RLWD data through 2003, the river is impaired at this site for dissolved oxygen, total suspended solids, and total dissolved solids. Very high TDS and low DO levels have occurred nearly every winter this site has been sampled. High fecal coliform levels have been recorded at this site, but not to a high enough extent to cause the river to be impaired for this parameter. High total suspended solids and total phosphorus levels are associated with the annual release of water from Agassiz NWR in the spring and in late fall. The City of Thief River Falls water treatment plant needs to treat water more heavily in the spring as well. Since the water quality on the Red Lake River is relatively good, the water quality problems that necessitate the extra treatment are most likely coming from the Thief River. This is a USGS gauging station and is also a primary site for the Red River Basin Monitoring Network that is monitored by the MPCA.

2.2.5 Grand Marais Creek Monitoring Sites

826

This is the current RLWD long-term monitoring site on Grand Marais Creek, a tributary of the Red River of the North. The site is located at the State Highway 220 crossing. There is a primary monitoring site for the Red River Basin Monitoring Network (RRBMN) located downstream of site #826 that is monitored by the MPCA. Water quality is very poor in Grand Marais Creek. In fact, it is normally one of the worst sites for water quality within the RLWD. This muddy looking river frequently has high conductivity, high total dissolved solids, high total suspended solids, and low dissolved oxygen readings. A predominately agricultural watershed and highly modified hydrology have an impact on water quality in the river. The altered hydrology consists of a high concentration of drainage ditches entering the river from the east and an actively eroding ditch downstream of our #826 that diverts water from Grand Marais Creek's natural channel straight west into the Red River. The RRBMN monitors water quality at on this ditch. Although there are farming operations within the watershed that maintain windbreaks, buffers, and other best management practices to minimize erosion, there are many that do not. This is highly evident in the winter when fields are barren and the ditches next to fields without windbreaks are filled with soil from wind erosion while fields with windbreaks, cover crops, or crop residue have little erosion. The high turbidity and low transparency of the water prevents the passage of light so that vegetation next to the river is killed whenever the river rises over its banks.

2.2.6 Red Lakes Monitoring Sites

Cooperation and communication among agencies through groups such as the Red River Basin Monitoring Advisory Committee has allowed for better coordination of monitoring efforts. This coordination facilitates the monitoring of a greater number of sites via the reduction of duplication. Standard methods have been created and are used from monitoring program to monitoring program to ensure that data is comparable. In 2002, the RLWD and RLDNR learned that both organizations had been monitoring the same sites for over 10 years. These sites were NEB-2 and the Lower Red Lake Dam (#740 on the Red Lake River) monitoring site.

NEB2

This site is in the city of Redby at the crossing of State Highway 89/1 and Mud Creek. This site was monitored through 2002. It was dropped for the 2003 sampling year because of duplication of sampling efforts between the RLWD and the RLDNR, a hazardous site location (narrow bridge), and a lack of water quality programs in the area. There is a fish hatchery downstream and it has good dissolved oxygen levels.

2.3 Overview of River Watch Monitoring Locations

The RLWD sponsors River Watch programs for nine schools. The goals of the program are to develop baseline water quality data, provide hands-on "real world" science opportunities for students, and promote greater citizen awareness and understanding of watersheds and the role of watershed districts. Senior high students from participating schools perform the monitoring including field collection and lab analysis. Field measurements of dissolved oxygen, water temperature, pH, conductivity, transparency, turbidity, stage, water depth, and stream width are collected at each site along with appearance and recreational suitability observations. Each school collects data at least once per month. River Watch groups prepare reports based upon monitoring results. These reports are then presented at area River Watch forums. In addition to the schools listed below, Bagley will be starting a River Watch program in 2004. Some schools plan on adding or changing monitoring sites as well.

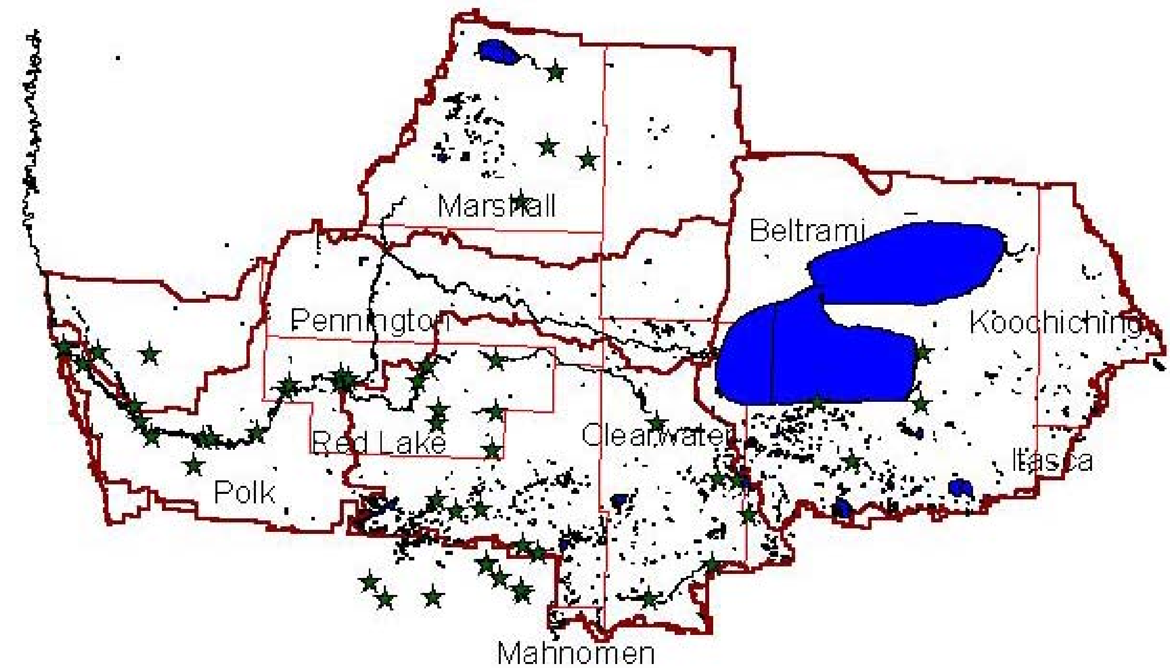

Figure 5. River Watch Sites Within the Red Lake Watershed District

Table 2. River Watch Monitoring Sites

School	Site Name	River
Clearbrook/Gonvick	CG 40	Clearwater River
Clearbrook/Gonvick	CG 20	Clearwater River
Clearbrook/Gonvick	CG 50	Clearwater River
Clearbrook/Gonvick	CG 30	Clearwater River
Clearbrook/Gonvick	CG 35	Clearwater Lake outlet
Clearbrook/Gonvick	CG 10	Clearwater River
Crookston	Gentilly Bridge	Red Lake River
Crookston	Sampson Bridge	Red Lake River
Crookston	Broadway Bridge	Red Lake River
Crookston	Burnham Creek	Burnham Creek
Crookston	#75 Bypass Bridge	Red Lake River
East Grand Forks Public	CR #19 Bridge	Grand Marais River
East Grand Forks Public, East Grand Forks Sacred Heart	Sorlie Bridge	Red River of the North
East Grand Forks Public, East Grand Forks Sacred Heart	Point Bridge	Red River of the North
East Grand Forks Public, East Grand Forks Sacred Heart	Murray Bridge	Red River of the North
East Grand Forks Public, East Grand Forks Sacred Heart	Mallory Bridge	Red Lake River
Fisher	BC1	Burnham Creek
Fisher	F1	Red Lake River
Fisher	FGM1	Grand Marais Creek
Fisher	Keywest	CD 126
Fosston	POP 10	Poplar River
Fosston	POP 20	Poplar River
Grygla	Moose	Moose R. Impoundment outlet
Grygla	D11	Ditch 11 - Mud River
Grygla	D20	Ditch 20
Grygla	Dike	Mud River
Red Lake	Battle	Battle Creek
Red Lake	Black	Blackduck River
Red Lake	Mud	Mud Creek
Red Lake	Pike	Pike Creek
Red Lake County Central	OK 10	Clearwater River
Red Lake County Central	OK 30	Hill River
Red Lake County Central	PL 10	Clearwater River
Red Lake County Central	PL 20	Clearwater River
Red Lake County Central	PL 30	Lost River
Red Lake County Central	PL 40	Hill River
Red Lake County Central	OK 20	Lost River
Red Lake Falls	BL10	Black River
Red Lake Falls	RL20	Red Lake River
Red Lake Falls	RL 10	Red Lake River
Red Lake Falls	CL 10	Clearwater River
WinEMac	WinPop	Poplar River
WinEMac	Bad8	Badger Lake Inlet
WinEMac	Oak 15	Oak Lake Outlet

2.4 Overview of Red Lake DNR Monitoring Locations

The Red Lake Department of Natural Resources monitors water quality at all the inlets to the Upper and Lower Red Lakes, as well as the Red Lake Dam. Below is a chart listing the portion of the RLDNR sites that are part of the EPA STORET database.

Table 3. RLDNR Monitoring Sites from STORET

Station ID	Description
RLI001	BATTLE R AT PONEMAH RD 0.2 MI UPST OF THE MOUTH
RLI002	BIG STONE LK AT SH-1, 300' UPST LOWER RED LAKE
RLI003	BLACKDUCK R AT PONEMAH RD 7 MILES E REDBY
RLI004	RED LAKE R AT LOWER RED LAKE OUTLET DAM
RLI005	SANDY R AT SH-1 10 MILES W OF RED LAKE
RLI006	SANDY R AT I.S.#6, 3/4 MI UPST FROM SH-1
RLI007	SHOTLEY BK 100 FEET UPST MOUTH AT UPPER RED LK
RLI008	TAMARAC R UPST OF SH-72 AT WASHKISH
RLI009	MAHNOMIN (sic) R 1/4 MI UPST MOUTH AT UPPER RED LAKE
RLI010	PIKE CK AT I.S.#12 2 MI SE OF RED LAKE
RLI011	PIKE CK 100' UPST MOUTH IN RED LAKE
RLI012	PIKE CK S OF BIA MAINT. BLDG IN RED LAKE
RLI013	MUD R 100 FT UPST LOWER RED LAKE AT REDBY
RLI014	L ROCK CK 100 FT UPST LOWER RED LAKE 4 MI W RED
RLI015	CLEARWATER R AT KIWOSAY INLLET DITCH ROAD
RLI016	CLEARWATER R AT KIWOSAY WILD. AREA ACCESS RD.
RLI017	NO CORMORANT R AT CSAH-23 3 MI S OF SAUM
RLI018	N BR BATTLE R AT CR-106 1.75 MI N OF SAUM

2.5 Overview of MPCA Monitoring Locations

The MPCA, with guidance from local agencies and the Red River Basin Monitoring Advisory Committee, have developed a monitoring plan called the Red River Basin Monitoring Network. For this plan, main stem, primary, and secondary monitoring sites were identified. Main stem sites are located along the main stem of the Red River of the North. Primary sites are located near the mouths of the major tributaries of the Red River and secondary sites are located on major tributaries of these. The RLWD monitors most of the primary and secondary sites within the district boundary. The RLWD monitoring sites that function as primary sites are sites 826, 740, 760, 785, and the Murray Bridge. RLWD monitoring sites that function as secondary sites include PL30, PL40, BL18, 66, 62, and 799.

Red River Basin MN Condition Monitoring Sites

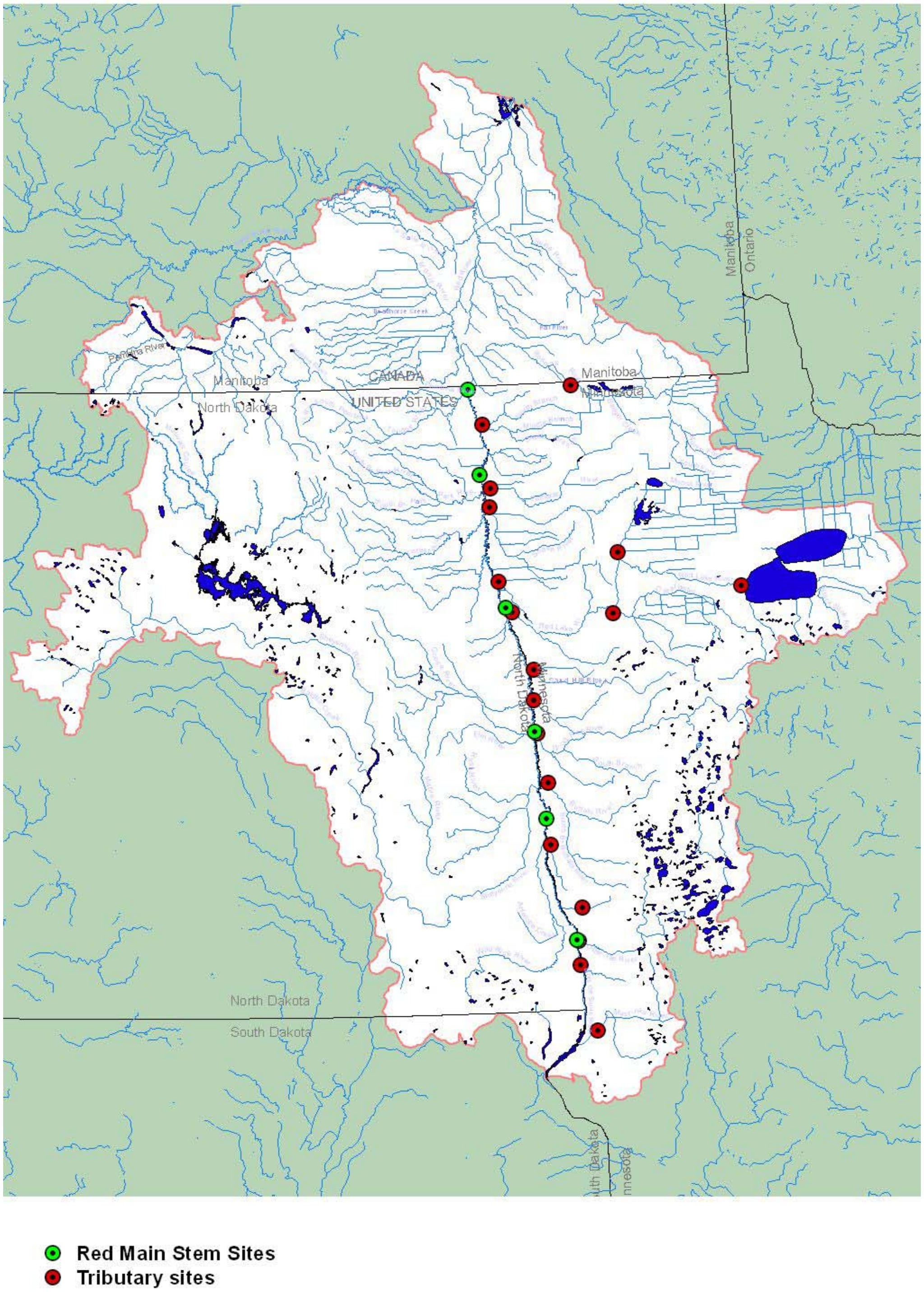

Figure 6. Primary and Main-Stem Red River Basin Monitoring Network Condition-Monitoring Program Sites.

2.6 Overview of SWCD Monitoring Locations

Several Soil and Water Conservation Districts within the RLWD conduct monitoring programs of their own. The Marshall-Beltrami, Pennington, and Red Lake SWCDs all conduct stream monitoring. The Clearwater and Beltrami SWCDs conduct their own lake monitoring programs and have assisted the RLWD with stream monitoring for special studies.

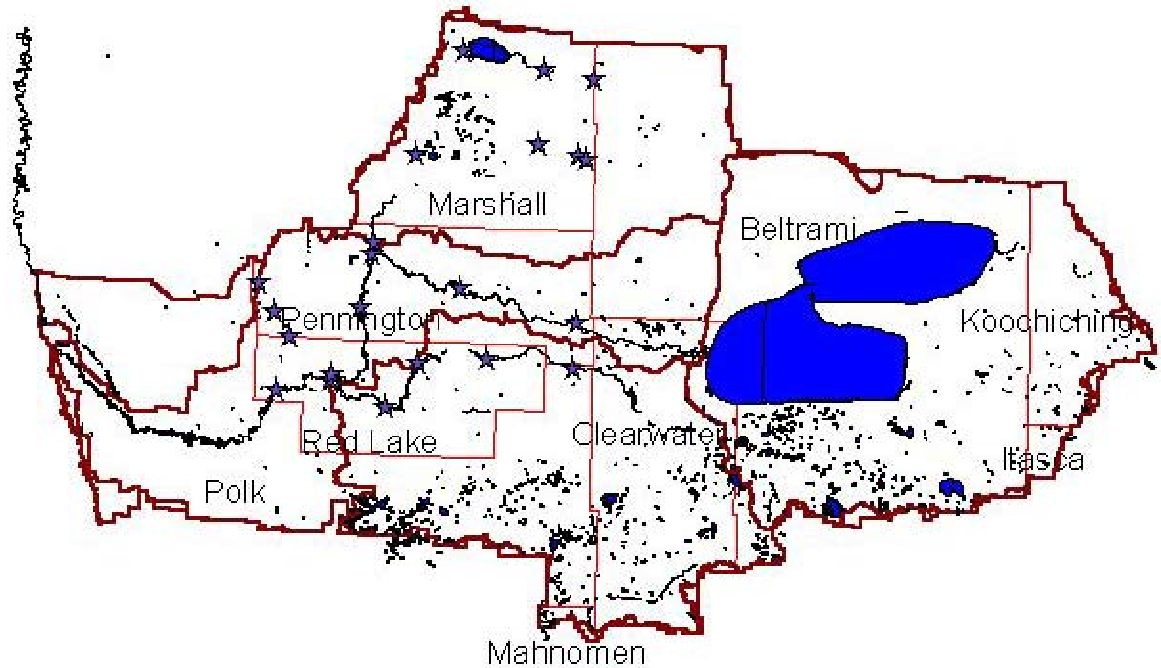

Figure 7. Soil and Water Conservation District Monitoring Sites Within the RLWD

2.7 Overview of FDR Monitoring Locations

Water quality monitoring has been a part of Flood Damage Reduction projects in the Red River Basin. This is often done to assess the benefit of natural resource enhancement features of the projects or to make sure that the project does not have any negative impacts. The FDR sites featured in the RLWD are associated with Project 60, the Grand Marais Creek Subwatershed Project.

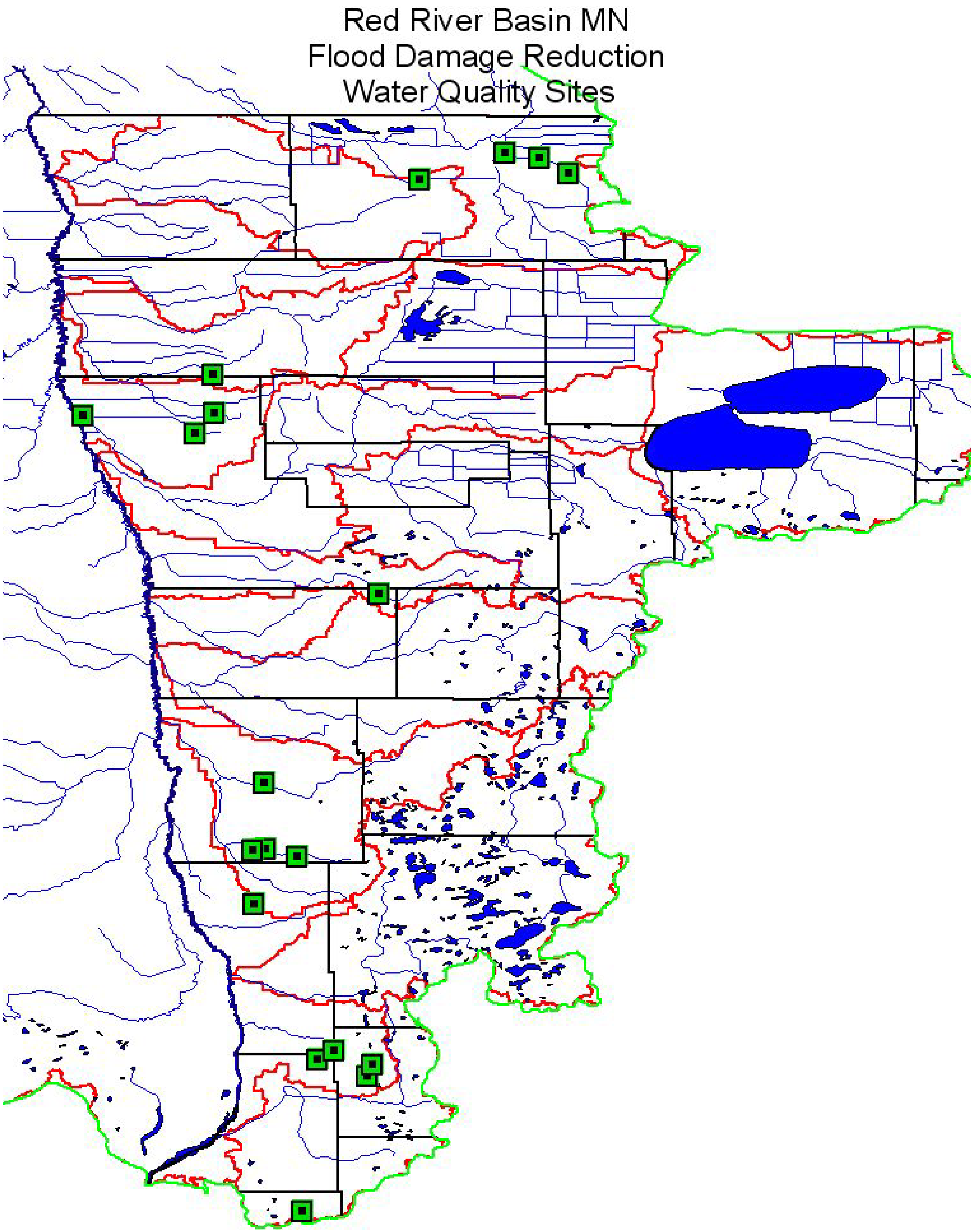

Figure 8. FDR Monitoring Sites In the Red River Basin.

2.3 Purpose of the Report

The main goal of this report is to evaluate the present water quality project and provide direction for future district monitoring activities. This report will include statistical analysis of data showing water quality trends and comparison of water quality data to what should be reasonably expected. The report will also provide recommendation for future monitoring activities and for enhancing communication with other state and federal agencies. Summarized reports of water quality related activities will continue to be published in RLWD annual reports.

The purpose for this water quality report is to provide information to the public, agencies, and other organizations, so as to make others aware of any water quality problems and concerns, and to give them an example of the types of data and sampling techniques used.

3.0 MONITORING GOALS AND OBJECTIVES

3.1 Organization of the Program

The RLWD water quality monitoring program is directed by the RLWD Water Quality Coordinator within the budget guidelines set by the RLWD Administrator and the RLWD Board of Managers. The Administrator and/or the Board of Managers shall approve changes to the monitoring plan and the initiation of new monitoring projects that are suggested by the Water Quality Coordinator. The Water Quality Technician assists the Water Quality Coordinator with fieldwork, data entry, data analysis, GIS, and public education. In order to coordinate monitoring efforts with other agencies, keep up-to-date with current monitoring methods, report on RLWD monitoring activities, and provide expertise and assistance to other agencies, the Water Quality Coordinator will attend Red River Basin Monitoring Advisory Committee meetings, county water plan meetings, and Red River Basin Water Quality Team meetings. RLWD board manager and public input will also be considered when choosing monitoring sites.

3.2 Goals by Program Aspect

The first set of goals for the RLWD water quality project were outlined in the 1985 RLWD Annual Report.

> "The goals of the plan are to determine the quality of the waters of the district and establish methods of maintaining and improving its quality. The means of achieving these goals are: determining the present water quality; developing a policy regarding emergency procedures following accidental discharge; locating sources of water pollution; determining the cause and evaluating the severity of each problem; working with other agencies in planning solutions to each problem; and educating the citizens of the district in how they can reduce pollution."

These basic goals still form the foundation of the RLWD water quality project. The long-term monitoring project is still in place to determine present water quality. In addition to regular monitoring, a significant aspect of the RLWD water quality program involves the initiation of new projects aimed at improving water quality, such as erosion control and stream bank restoration projects. Source water assessments have been created to provide a framework for the development and implementation of a source water protection plan. Data analysis, strategic location of monitoring sites, and intensive monitoring projects have been used to locate sources of water quality problems. The RLWD continues to work with other agencies to coordinate monitoring efforts. Also, the RLWD is involved with programs such as River Watch, Make-A-Splash, and Envirothon to provide opportunities for public education.

3.2.1 Long Term

Long-term monitoring is useful for identifying trends. The RLWD long-term monitoring program has been in place since 1984. There are about 30 core sites that have been monitored since this time and should continue to be monitored at least four times per year. Through 2003, these sites were monitored on a quarterly basis. Sites were sampled at approximately the same time each year: February, May, August, and October. Field measurements of dissolved oxygen, water temperature, pH, and conductivity are collected at each site. Samples have been analyzed for total phosphorus, orthophosphorus, total suspended solids, total dissolved solids, fecal coliform, total Kjeldahl nitrogen, ammonia nitrogen, nitrates and nitrites, alkalinity, and chemical oxygen demand. Most of the data used for the statistical analysis in this report is from the RLWD long-term monitoring program.

3.2.2 Special Studies

Part of the RLWD water quality program involves special studies that are often funded by a cost-share agreement between the RLWD and another state agency, federal agency, city, or citizen organization. EPA 319 Grants and Loans, Minnesota Board of Water and Soil Resources Challenge Grants, Red River Watershed Management Board, MPCA TMDL funding, Clearwater Lake Area Association, Maple Lake Improvement District, and the University of Minnesota Crookston, are examples of groups that have helped fund past and present water quality projects. Broader studies such as the RLWD long-term district monitoring program and the Clearwater River Nonpoint Study have identified problem areas within the watershed district. Special studies can be conducted to pinpoint the source of these problems and/or intensively monitor the results of projects aimed at water quality improvement. These special projects often differ from the district monitoring program by involving more frequent sampling, shorter project time spans, fewer parameters, and a more intensive distribution of sites. The list of past and present RLWD special projects includes the Clearwater River Intensive Low Flow Monitoring, Good Lake Impoundment Water Quality Study, Total Suspended Sediment Loadings on the Red Lake, Thief, Mud, and Moose Rivers Study, Cross Lake and Turtle Lake Water Quality Study, Beaver Pond Water Quality Study, TMDLs on the Clearwater River, Clearwater Lake monitoring, Maple Lake monitoring, and Clearwater Lake Water Quality Model projects.

Current special studies include the Red River Basin Buffer Initiative, Maple Lake Monitoring, and the Clearwater River Small Cities Stormwater Project. The Red River Basin Buffer Strip Initiative project involves monthly monitoring at the Silver Creek long-term monitoring site (#81). The extra monitoring at this site is conducted as part of a cost share agreement between the RLWD and the Red River Basin Commission.

The Maple Lake monitoring is being conducted as part of a cost share agreement between the RLWD and the Maple Lake District. The quality of water in Maple Lake is another topic that has drawn local interest. This is one of the few recreational lakes located within the RLWD. Water quality on the lake has been undesirable and high levels of nutrients have been entering the lake. A large amount of the phosphorus and sediment entering the lake comes from the main inlet of the lake, Judicial Ditch #73. Before entering the lake, the ditch flows through wetlands, from which a large amount of decaying plant material is flushed during runoff events. More intensive monitoring will be conducted in 2004 on all the inlets and outlets of the lake, as well as at three sites within the lake itself.

The Clearwater River Small Cities Stormwater Project is being conducted in order to determine the need for storm water retention in the cities of Clearbrook and Gonvick. Storm water modeling will be conducted to determine the ideal size and location of storm water retention ponds in the cities. The sediment and nutrient reduction estimates will be compared to monitoring results.

The RLWD will at times conduct special studies without any help from outside organizations. Sometimes, this is in the form of investigative sampling.

3.2.3 Investigative

The water quality budget of the RLWD is flexible enough to allow for additional, short term monitoring at sites identified by concerned citizens, RLWD staff, or RLWD board managers. This sampling is sometimes used to answer a specific question about a particular water body such as: where does the hydrogen sulfide on the Red Lake River in Thief River Falls come from and what can be done about it? Examples of investigative sampling/studies include the Hydrogen Sulfide Problems in Thief River Falls Study, the Cameron Lake Investigative Study, and 2004 monitoring of the Poplar River upstream and downstream of the Fosston wastewater treatment lagoons.

4.0 STATISTICAL ANALYSIS METHODS

4.1 Histograms

A histogram is a graphical presentation of the frequency distribution of a data set. Histograms can be applied to water quality results to aid in determining the "normal" range of results. If the observations are normally distributed the heights of the columns should be roughly shaped like the Normal distribution curve (the superimposed blue line). See the example below.

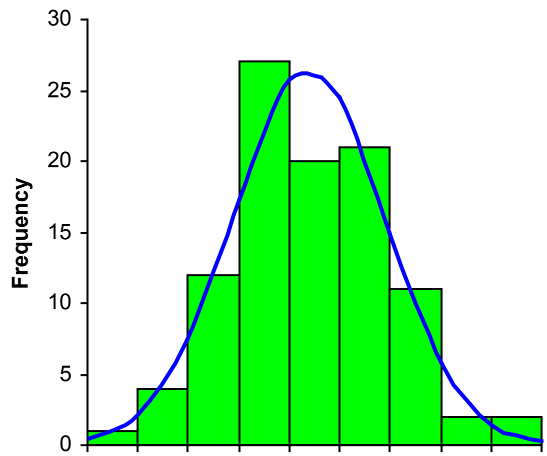

Figure 9. Example Histogram

For each monitoring site, a set of histograms has been created showing the distribution of results for each parameter. Observations from these are used throughout this report. Frequently high or frequently low levels of a particular parameter are made visually evident by these histograms. For example, conductivity is frequently high at sites 799 and 826 on Burnham Creek and Grand Marais Creek, respectively. On the other hand, conductivity levels are frequently lower at sites 53-O, 53-I, and 50-O. Sample results for most sites seemed to lie within the range of 400 to 600 µS/cm.

Most ammonia nitrogen results within the RLWD were very low, around zero. Chemical oxygen demand was higher in the lower Red Lake River Watershed at the Murray Bridge and Grand Marais Creek sites as well as the Pine Lake and Maple Lake Outlets in the Clearwater River subwatershed. For dissolved oxygen, the only site with all values greater than 7 mg/L was site 740 at the Lower Red Lake Outlet. There were several sites that were frequently below the standard level of 5 mg/L of dissolved oxygen required for aquatic life including 53-O, 53-I, and 50-O. The abnormality of spikes in fecal coliform levels is made visually evident by histograms. Sites with such spikes include sites 128, 50-I, 81, 782, 797, 59, 63, 109, and 785. At the Clearwater Lake outlet (site 52), fecal coliform levels are normally very low, near the minimum detection limit, so that even a result of 17.5 col/100ml is an abnormally high result. Most fecal coliform sample results at RLWD monitoring sites lie between 0 col/100ml and 100 col/100ml. Few problems are found with pH levels. The lower Red Lake River has significantly higher levels of total dissolved solids than the upper Red Lake River. The Grand Marais Creek long-term monitoring site frequently has TDS levels greater than 500 mg/L and as high as high as 1000 mg/L. Total suspended solids levels are generally low in the Clearwater River watershed, although spikes have been recorded at 53-I, 53-O, and 785. Upper Red Lake River TSS levels are relatively evenly distributed between 0 mg/L and 25 mg/L. On the lower Red Lake River, levels are most frequently around 25 mg/L and several results have been much higher. Water temperature at RLWD long-term monitoring sites is frequently between 10 and 15 degrees Celsius.

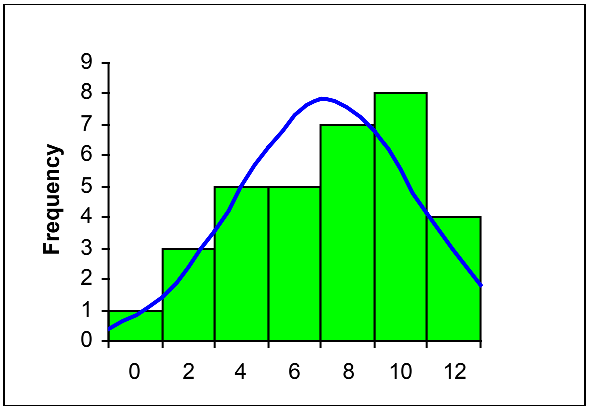

Figure 10. Histogram of Dissolved Oxygen at Site 40 on the Thief River.

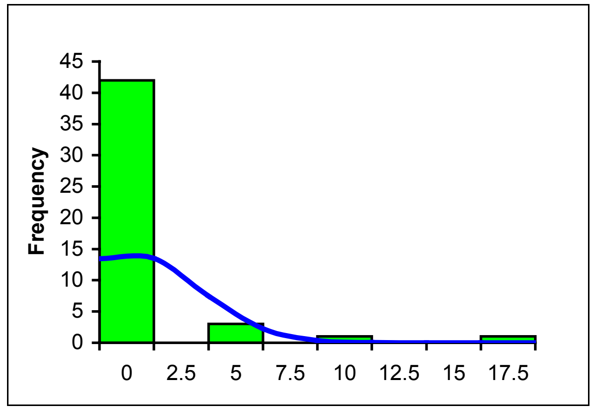

Figure 13. Fecal Coliform Histogram for Site 52 on the Clearwater River.

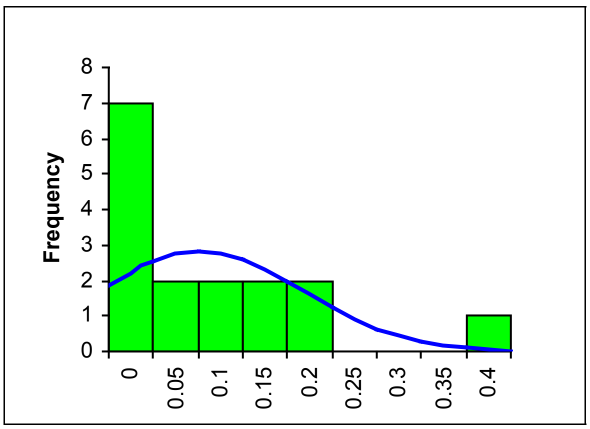

Figure 11. Ammonia Histogram for Site 785 on the Clearwater River.

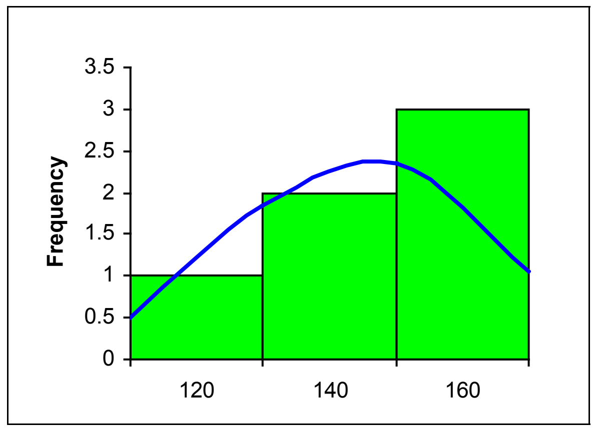

Figure 14. Total Dissolved Solids Histogram for Site 750 on the Upper Red Lake River.

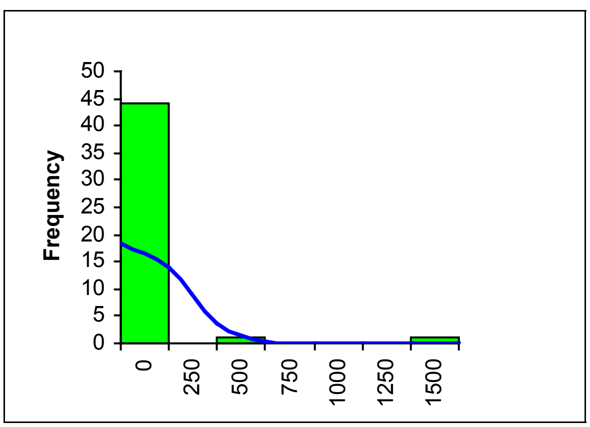

Figure 12. Fecal Coliform Histogram for Site 128 on the Clearwater River.

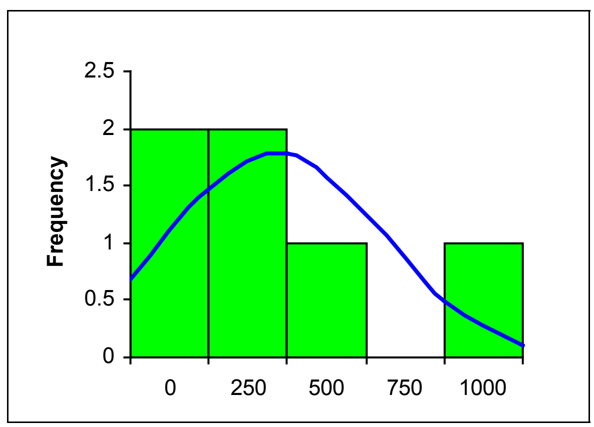

Figure 15. Total Dissolved Solids Histogram for Site 826.

4.2 Data Censoring Methods

Censored data is defined as a data set in which the only values reported are those that are above a predetermined level. The accuracy limits of laboratory equipment are expressed by minimum detection limits (MDLs), or the smallest concentration that can be accurately measured. When results that are below the detection limit (BDL) are received from the laboratory, they are expressed as less than a particular value (i.e. <1 mg/L for suspended solids). A precise value cannot be assigned to results below the MDL by the laboratory, so questions arise during statistical analysis about what to do with this data. Leaving out these results would create a biased data set, so a method is needed for "uncensoring" this data.

There are several options for analyzing this censored data. These are simple substitution; distributional methods such as the probability plot, maximum-likelihood estimation (MLE), and fill-in with expected values MLE techniques; and the Helsel's Robust Method. In November of 2002, Houston Engineering, Inc. completed a study entitled *Statistical Methods for Analyzing Censored Water Quality Data Sets*. In this study, the options of simple substitution, Helsel's Robust Method, and discarding all BDL data were compared in order to determine which censoring method works best.

The simple substitution method substitutes a numerical value for each BDL reading. This value can be zero, the MDL itself, or a value that is one-half the MDL. The simple substitution method can be used with multiple reporting limits without losing information. A weakness of the simple substitution method is a potential bias within the range of values between zero and the MDL toward whichever value is chosen.

The probability plot method is a distributional method that is based upon the assumption that data above and below the MDL follow a statistical distribution. This method can be useful for the calculation of percentiles statistics. If the data doesn't follow a normal or lognormal distribution, however, the probability plot method may perform poorly for the computation of moment statistics such as the mean and standard deviation of the data set.

The Helsel's Robust Method combines data above the MDL with values assigned to the BDL readings by assuming a distributional shape (log-normal), to estimate summary statistics. The calculated values of the BDL readings are not estimates of specific samples, but are used collectively for estimating summary statistics. They are not useful for trend analysis. The Helsel's Robust Method has an advantage over the probability plot, MLE, and fill-in with expected MLE methods. It is not as sensitive to the fit of a distribution because actual values are used and the estimated summary statistics are computed in original units, avoiding transformational bias.

The results of Houston Engineering's study show that the simple substitution method gave the most consistent and credible results. The report recommended that, in order to acquire results for a best and worst case scenario, data should be calculated with the BDL values set at zero and again with the BDL values set at the MDL. For simple calculations of summary statistics, the RLWD will replace the BDL values with ½ the MDL. This method is also used by other agencies conducting monitoring within the RLWD. Censoring data with the same method will make data analysis results comparable among agencies.

4.3 Trend Detection Methods

The simplest form of trend detection used is to simply plot the data with time on the x-axis and concentration/load on the y-axis. These plots can be created easily using Microsoft Excel. If a trend is indefinite using this method, there are other techniques that can be applied. Regression analysis (or a trend line in Microsoft Excel) can be used to show a trend in data that is highly variable (i.e. annual fluctuations).

5.0 STATUS OF WATER QUALITY WITHIN THE DISTRICT

5.1 General Comparison

5.1.1 Comparison of Mean Concentrations Between Sites and by Region

The following graphs and maps show mean concentrations for each parameter at each site through 2002. These maps can be used to compare sites spatially. There are many observations that can be taken from each map. Alkalinity throughout the RLWD is at a level that provides an adequate buffer against abrupt changes in pH. 100-200 mg/L or greater is a desirable range for alkalinity. Mean ammonia nitrogen levels increase downstream on the Thief River. Ammonia levels also show a general increase from upstream to downstream on the Red Lake River, with the exception of a drop in concentration within the Thief River Falls reservoir. Only a few chloride samples have been collected at selected sites within the RLWD. Most of the observed levels pose no threat to aquatic life with the exception of site #826 on Grand Marais Creek at which a level of chlorides was recorded in May 1998 that was high enough to indicate pollution. This level was fortunately not high enough to be harmful to aquatic life, however. Chemical oxygen demand was highest in the Thief River watershed and Grand Marais Creek. The relatively high COD levels at site 63 are particularly undesirable because the channel connects a chain of lakes, some of which need aeration in the winter due to low dissolved oxygen levels. Conductivity is high at many sites located on the lower ends of their respective watersheds. Erosion and fertilizer runoff are just a couple of the factors that may contributing to these high levels.

Certain areas are more susceptible to low dissolved oxygen levels than others, particularly headwaters reaches (0-6, 15, 50-I) and those receiving water that flows through wetlands and organic soils (59, 0-6, 50-I). Some sites exhibit frequently high levels of fecal coliform bacteria. One of these sites is 782 on the Lost River. The average concentration is high due to a high spike recorded in February 1992 of 30,000 col/100ml. Nitrate levels on the Clearwater, Lost, hill, and Poplar Rivers increase as these rivers enter the Red River Valley ecoregion. Thief Lake and Agassiz NWR seem to be helping to decrease nitrate levels. Pine Lake, Badger Lake, and Maple Lake show an increase in nitrates, but show a decrease in nitrates and nitrites from inlet to outlet. The levels of pH in the RLWD lie within the desirable range. Most lakes and reservoirs within the RLWD retain total phosphorus, except for some sites such as Agassiz NWR that become sources of total phosphorus during high flow periods. Grand Marais Creek had the highest average total phosphorus concentration. It also had the highest level of total dissolved solids, possible due to erosion and fertilizer runoff.

Total suspended solids and turbidity on the Red Lake River increase as it travels from its source to its confluence with the Red River of the North. TSS and turbidity levels in the Clearwater River watershed are low, with the exception of site 785, which is located in the Red River Valley ecoregion. Turbidity levels on the Thief River are highly variable, with high levels in the spring and late fall that coincide with discharge from Agassiz NWR and low levels of turbidity and TSS during normal flows in the summer. Water temperature can limit cold-water fisheries if it is too high. This is the case on some tributaries of the Clearwater River that have high enough dissolved oxygen levels and, according to local history, used to support trout fisheries. Increases in turbidity can raise temperatures.

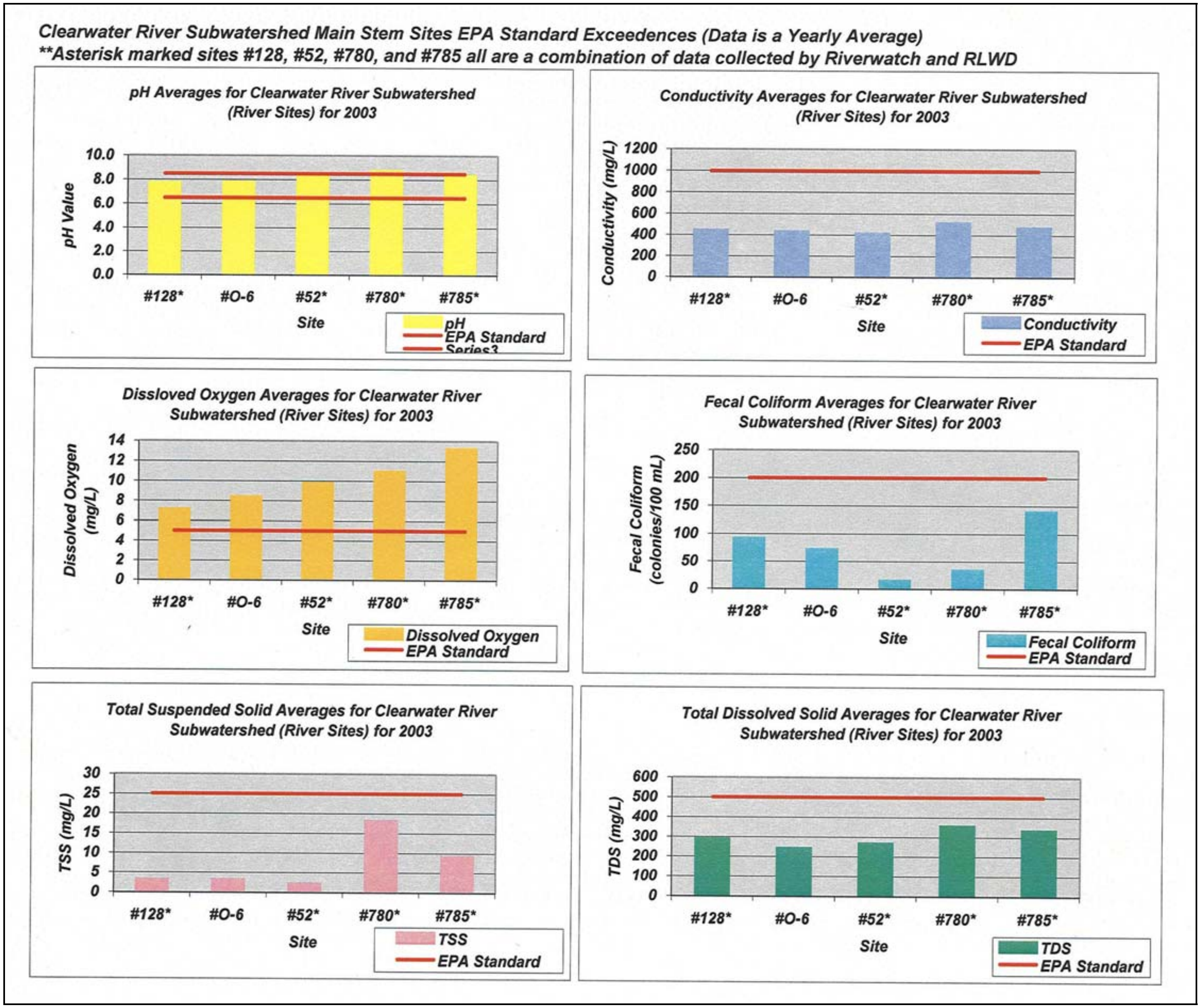

Figure 16. Bar Charts of Average Concentrations (1 of 5)

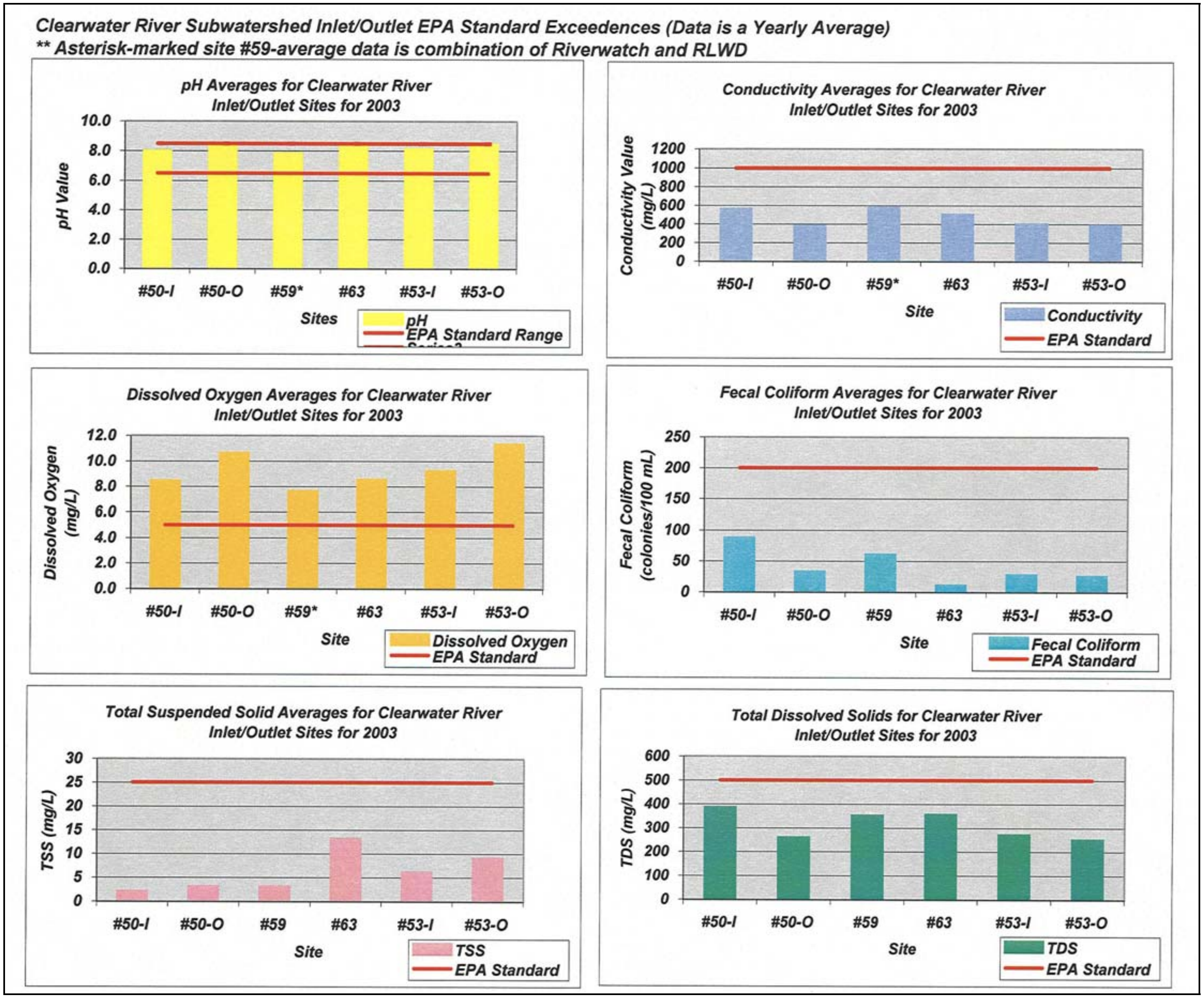

Figure 17. Bar Charts of Average Concentrations (2 of 5)

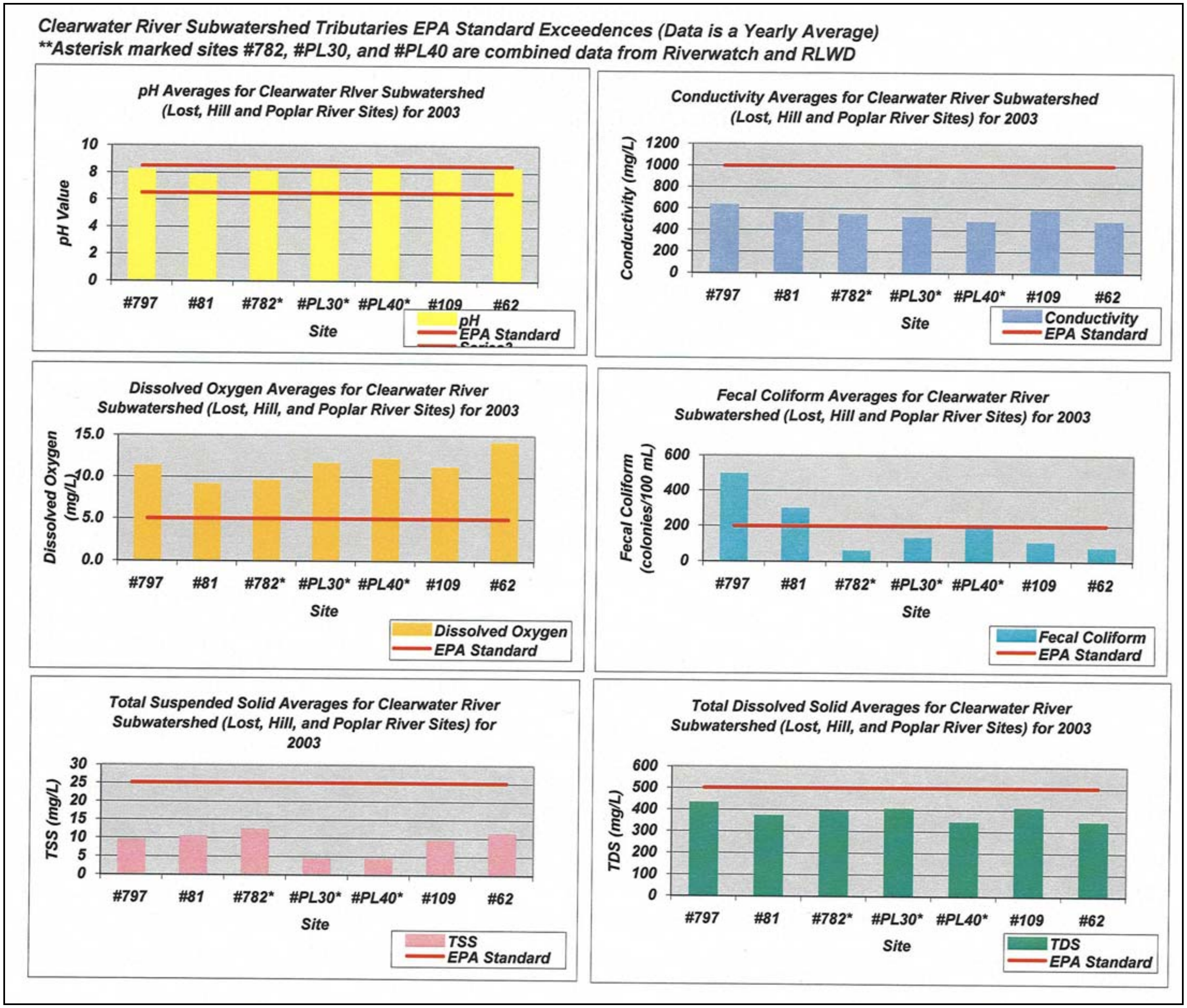

Figure 18. Bar Charts of Average Concentrations (3 of 5)

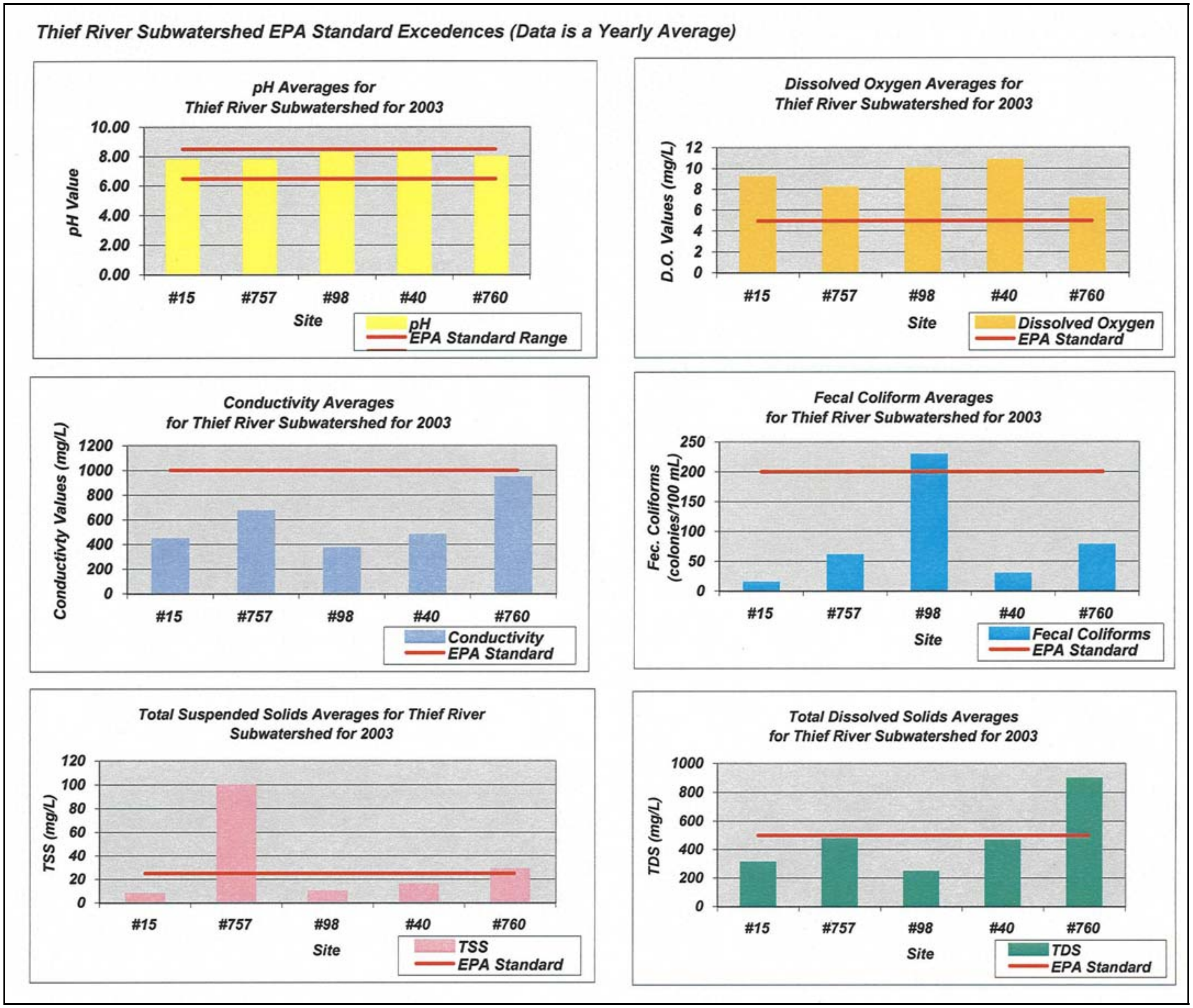

Figure 19. Bar Charts of Average Concentrations (4 of 5)

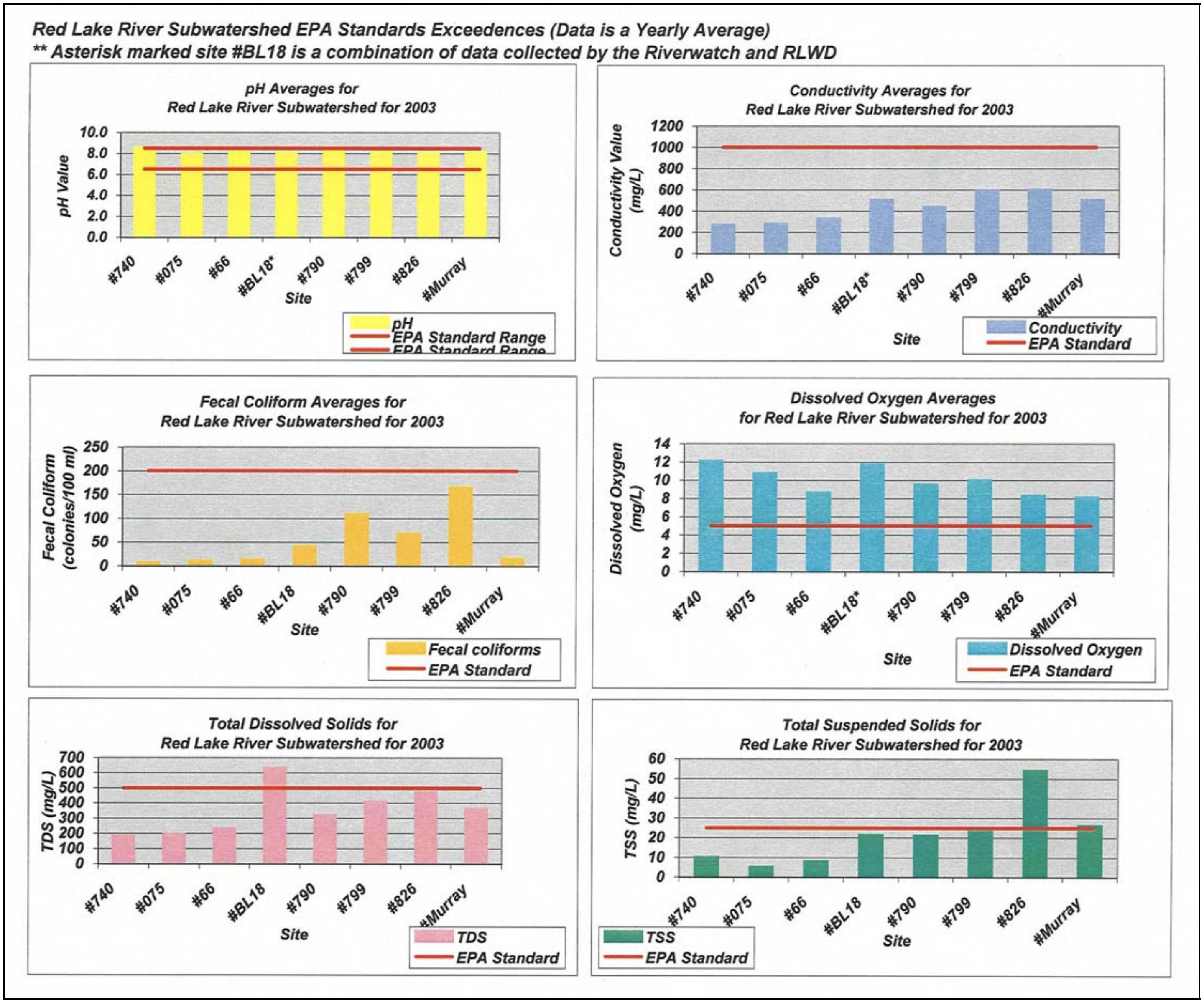

Figure 20. Bar Charts of Average Concentrations (5 of 5).

Alkalinity Means for District Monitoring Sites

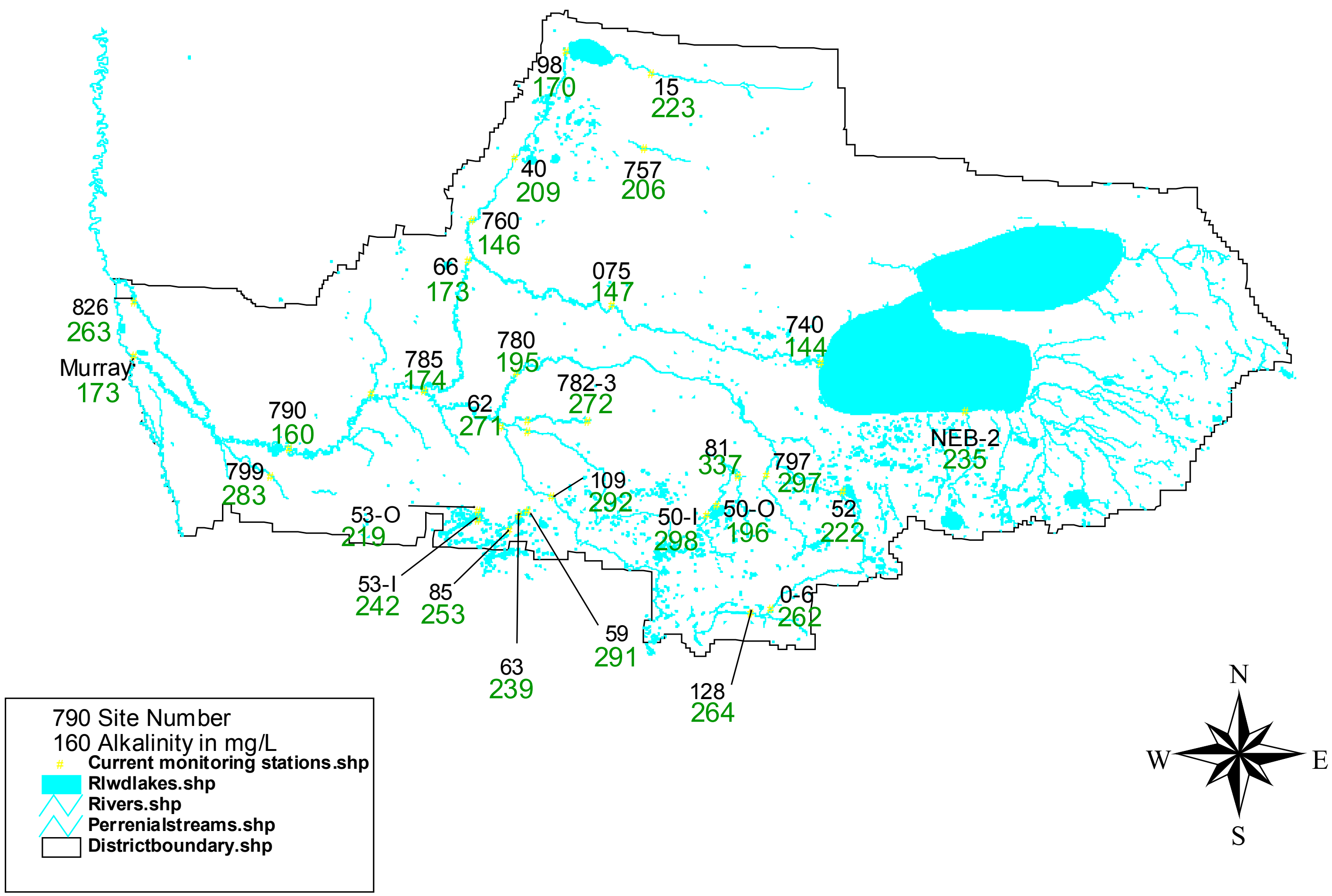

Figure 21. Mean Alkalinity Values Map.

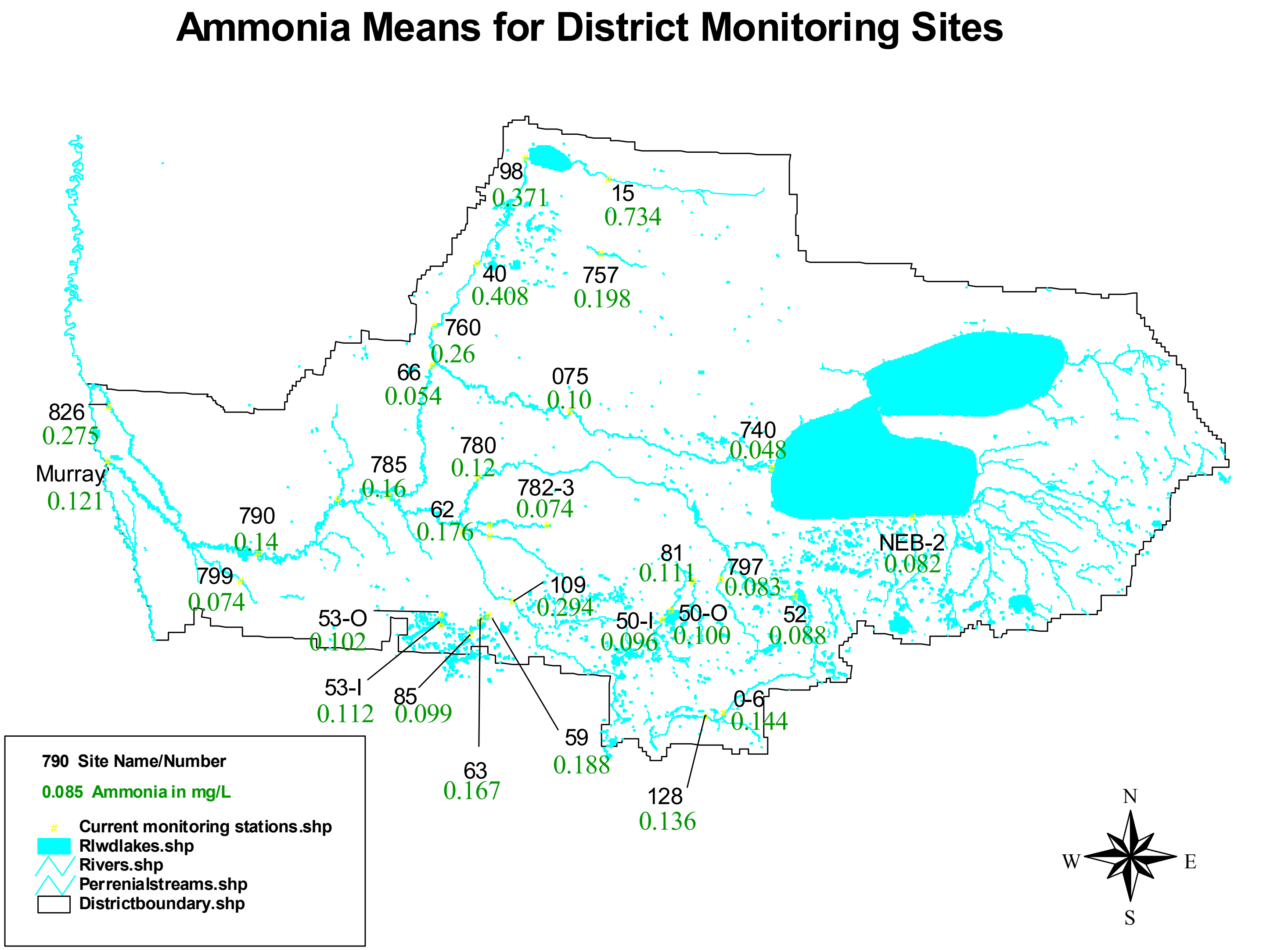

Figure 22. Mean Ammonia Values Map.

Chloride Means for District Monitoring Sites

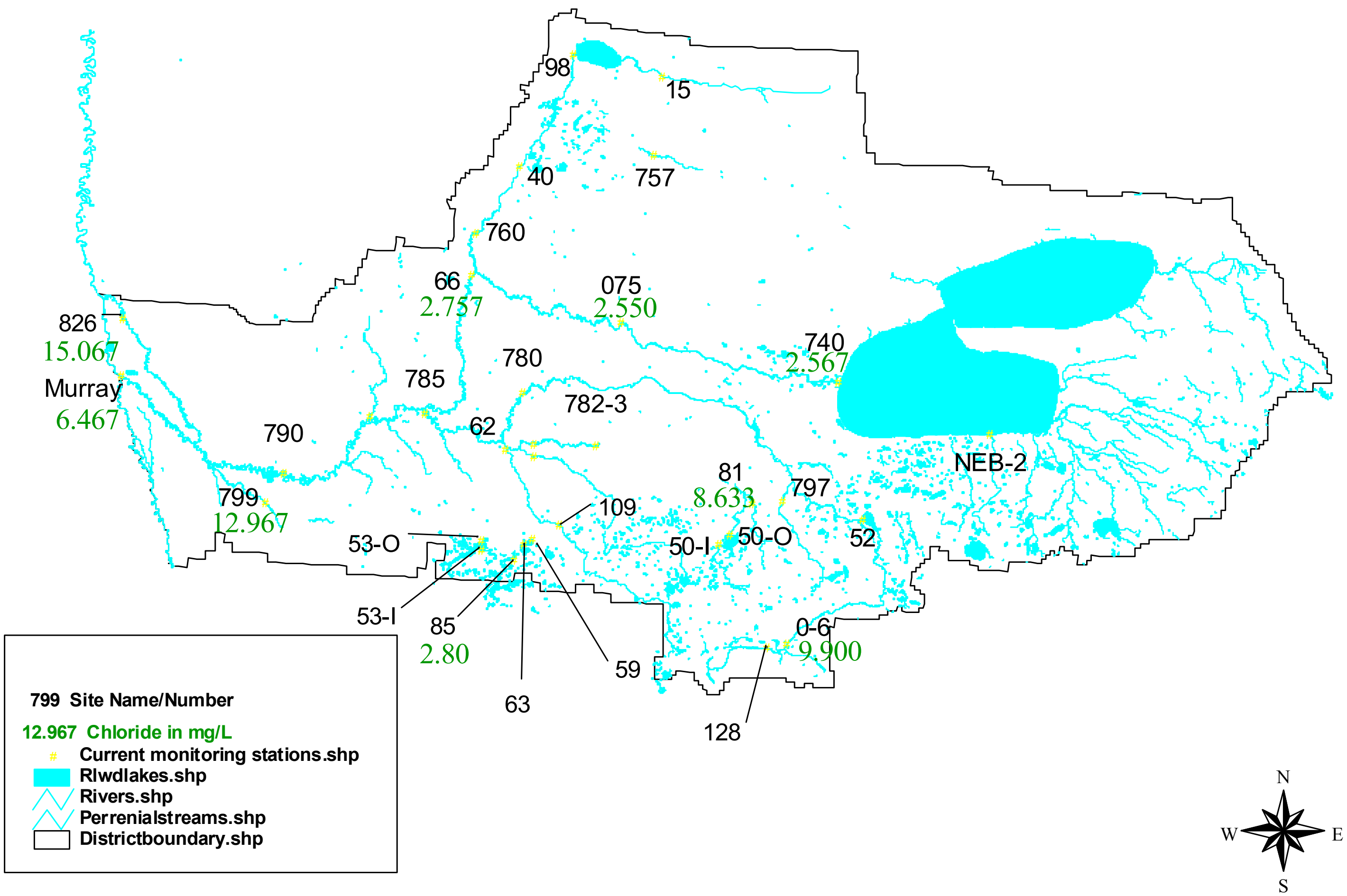

Figure 23. Mean Chloride Values Map.

COD Means for District Monitoring Sites

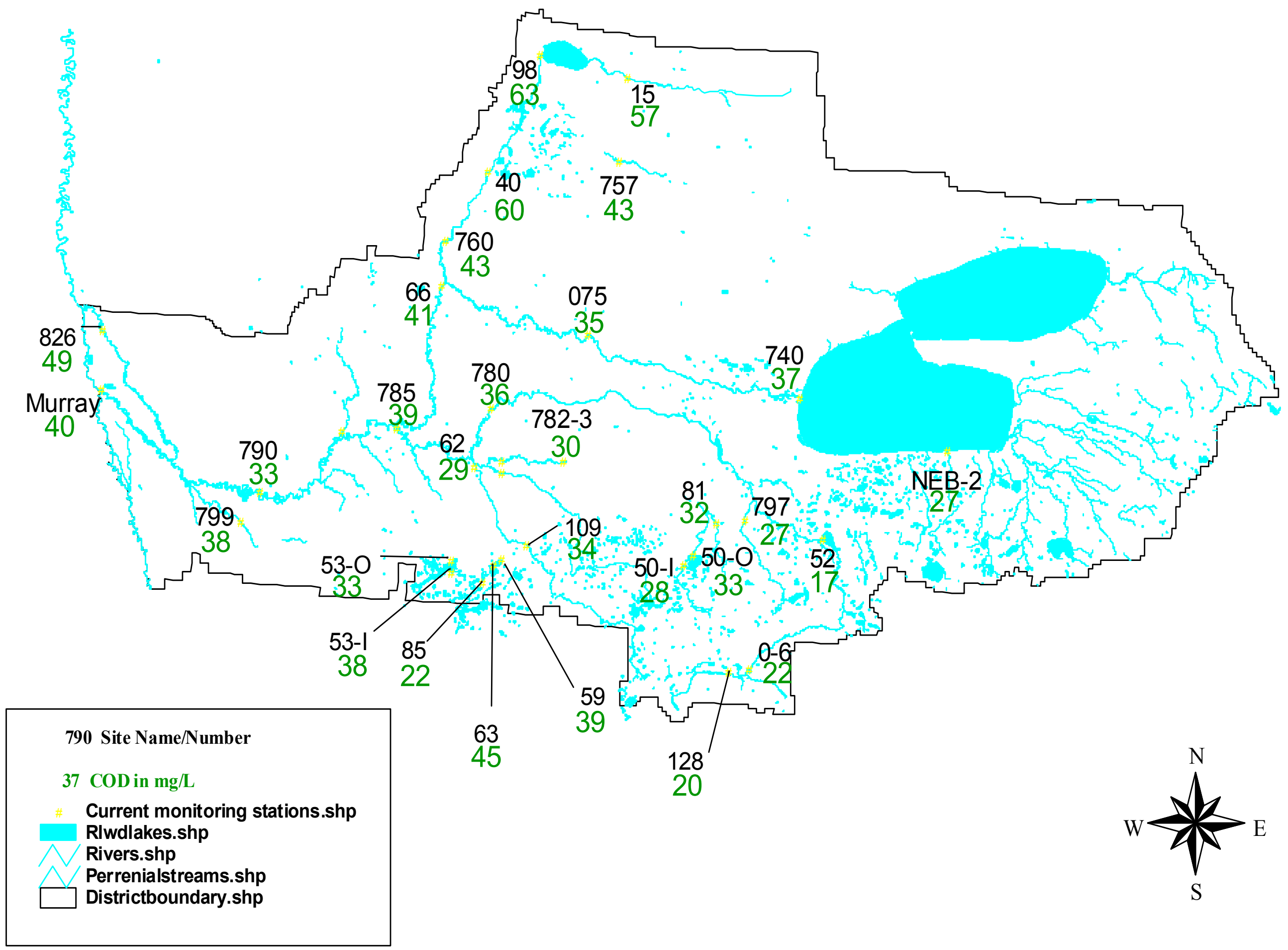

Figure 24. Mean COD Values Map.

Conductivity Means for District Monitoring Sites

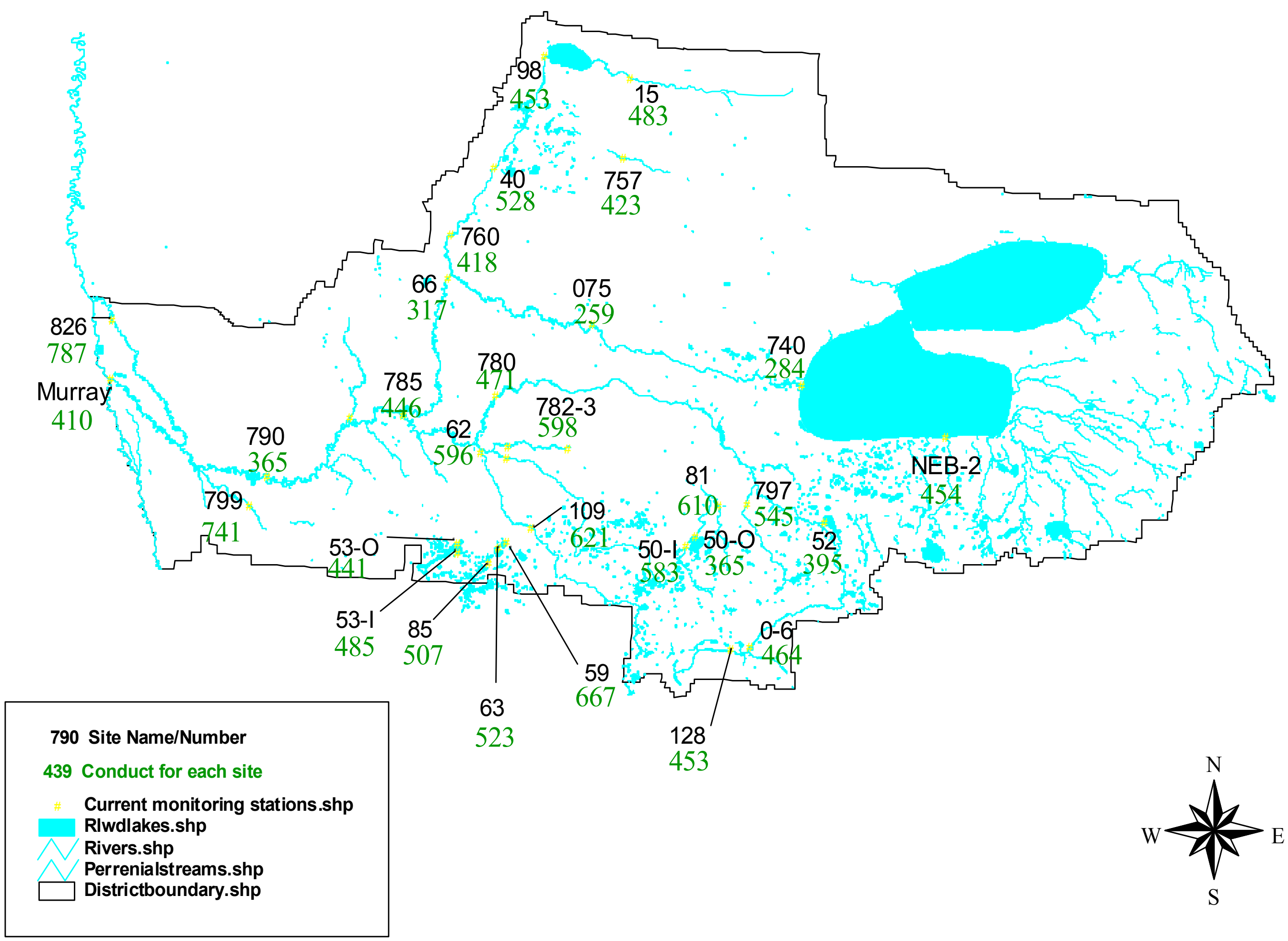

Figure 25. Mean Conductivity Values Map.

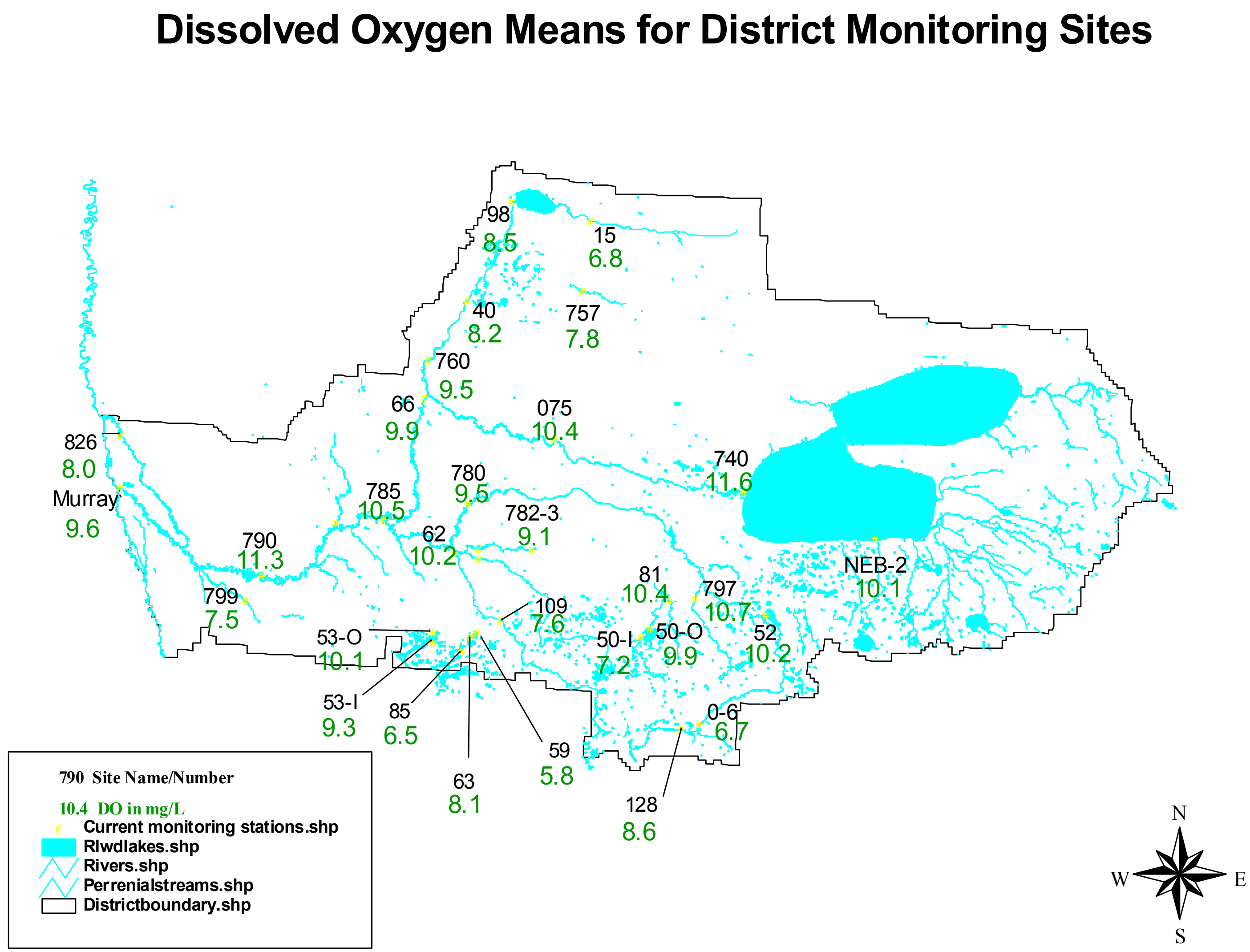

Figure 26. Mean Dissolved Oxygen Levels Map.

Fecal Coliform Means for District Monitoring Sites

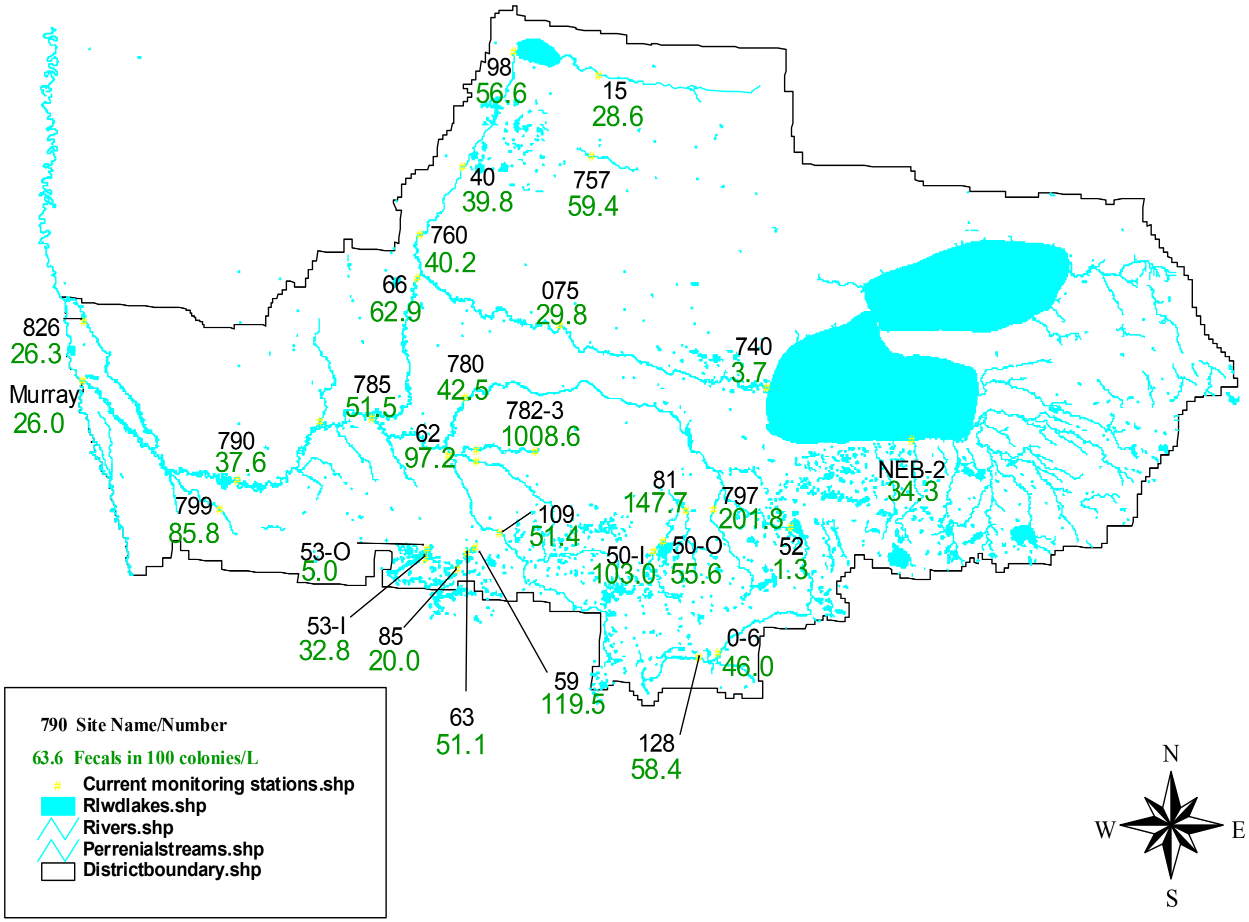

Figure 27. Mean Fecal Coliform Values Map

Nitrate Means for District Monitoring Sites

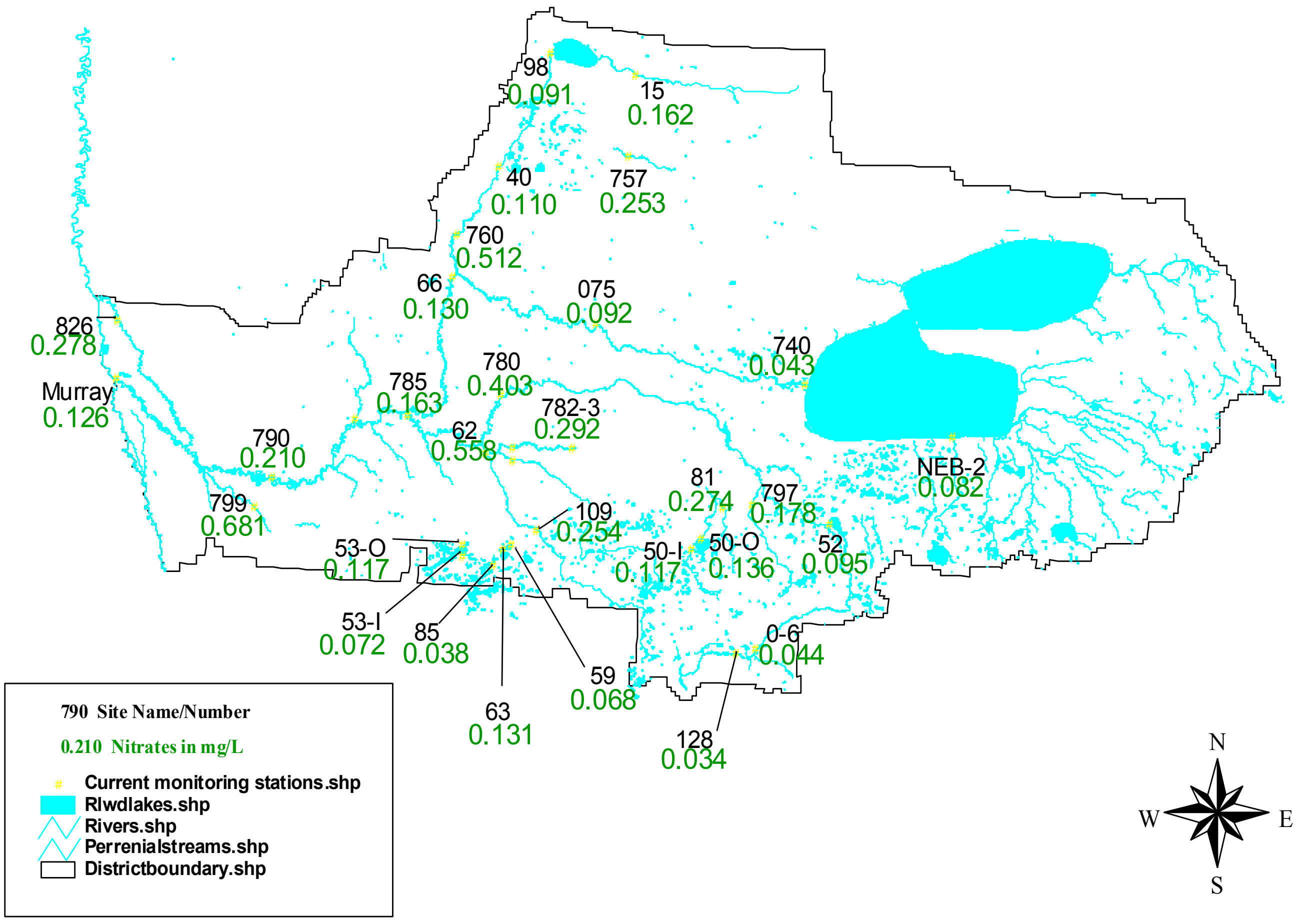

Figure 28. Mean Nitrate Values Map.

Nitrate/Nitrite Means for District Monitoring Sites

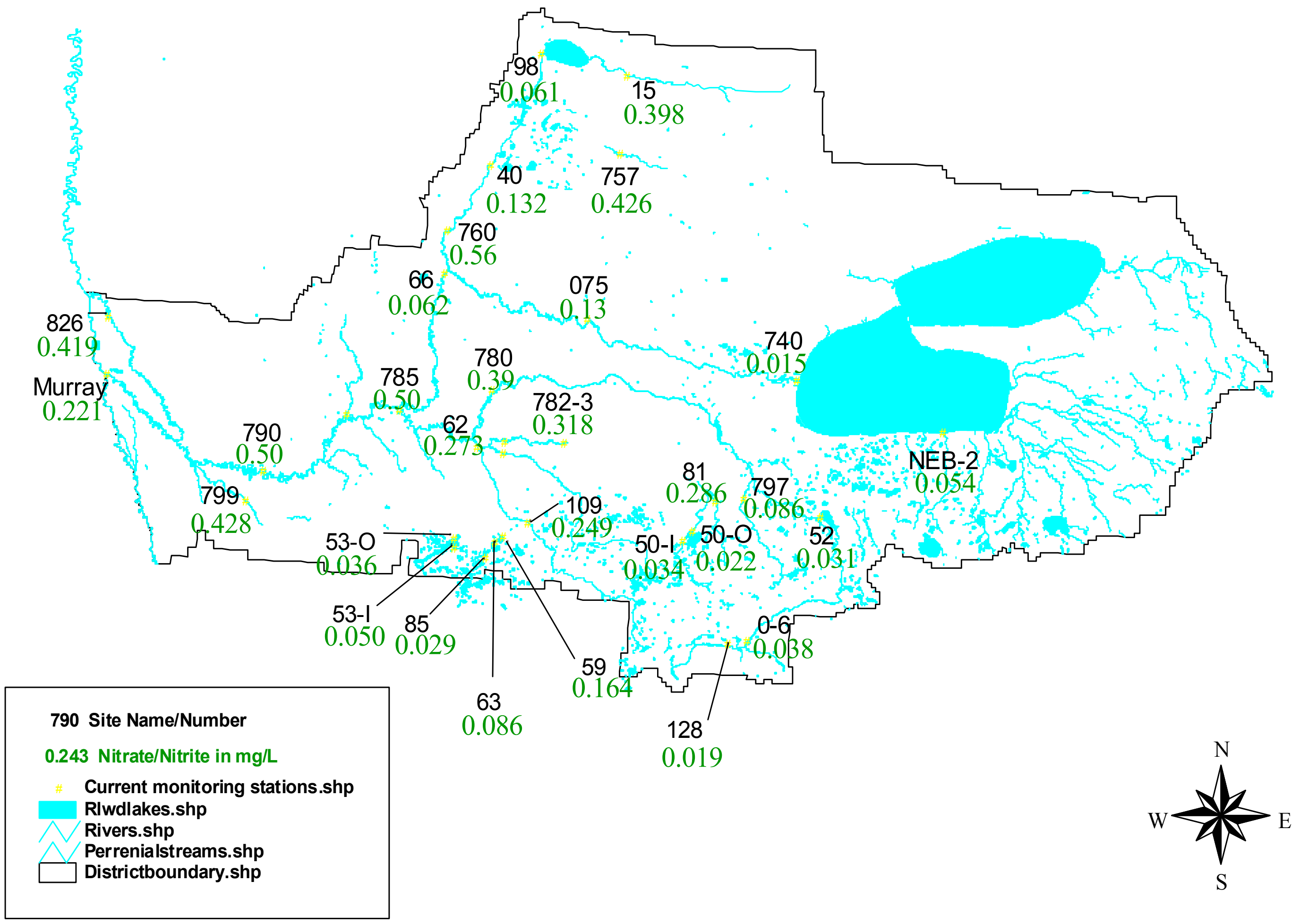

Figure 29. Mean Nitrate and Nitrites Values Map.

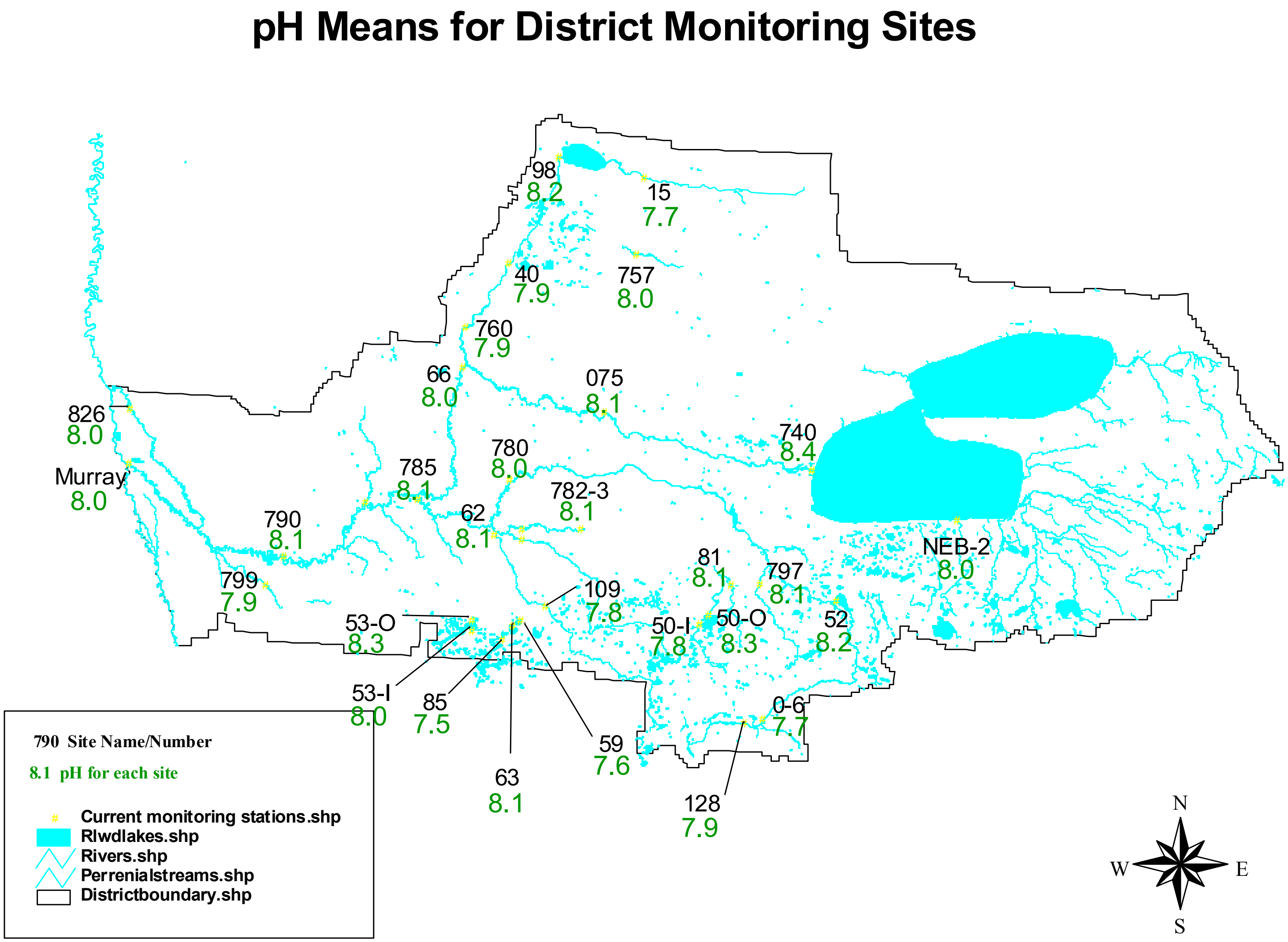

Figure 30. Mean pH Values Map

TKN Means for District Monitoring Sites

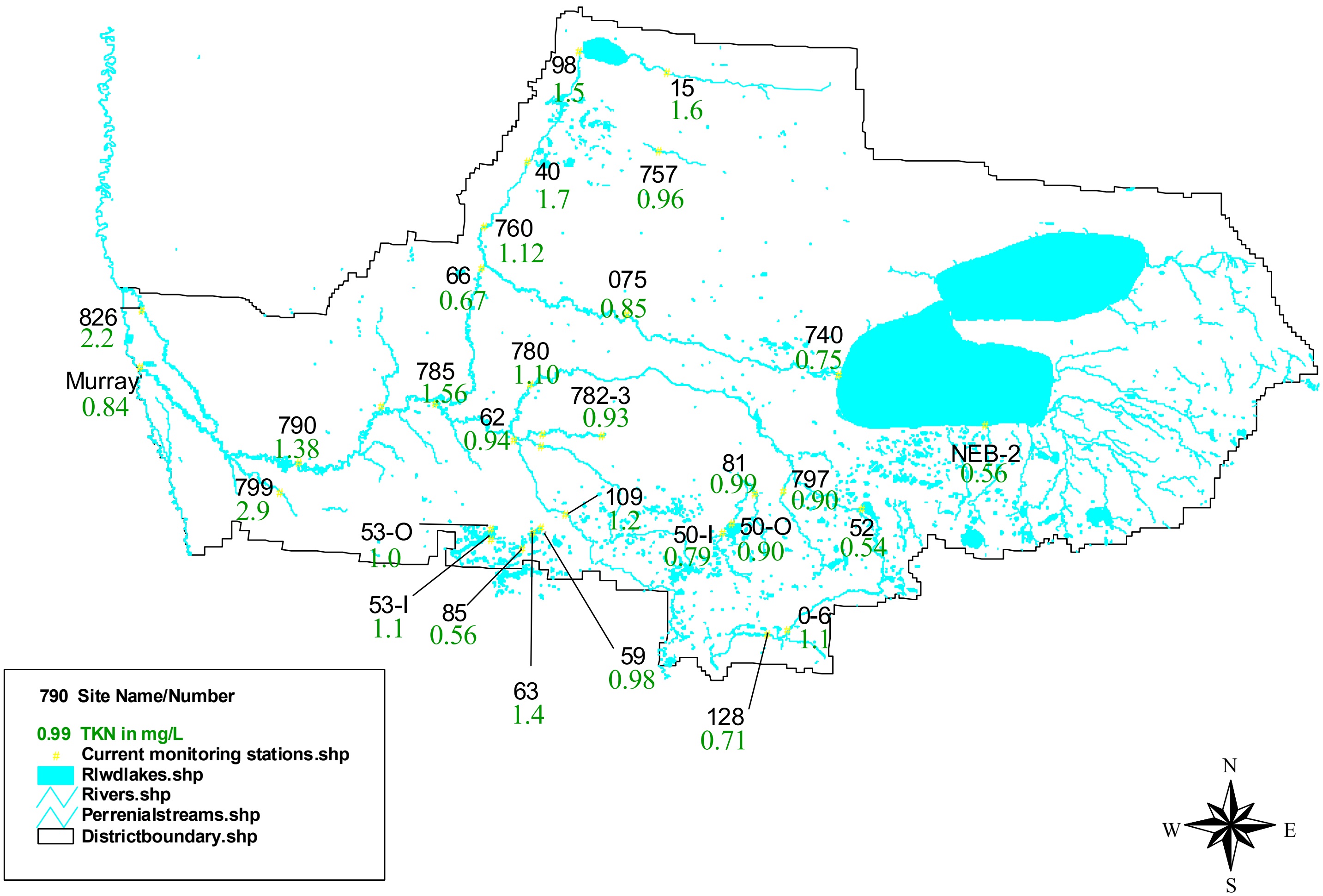

Figure 31. Mean Total Kjeldahl Nitrogen Values Map.

Total Phosphorus Means for District Monitoring Sites

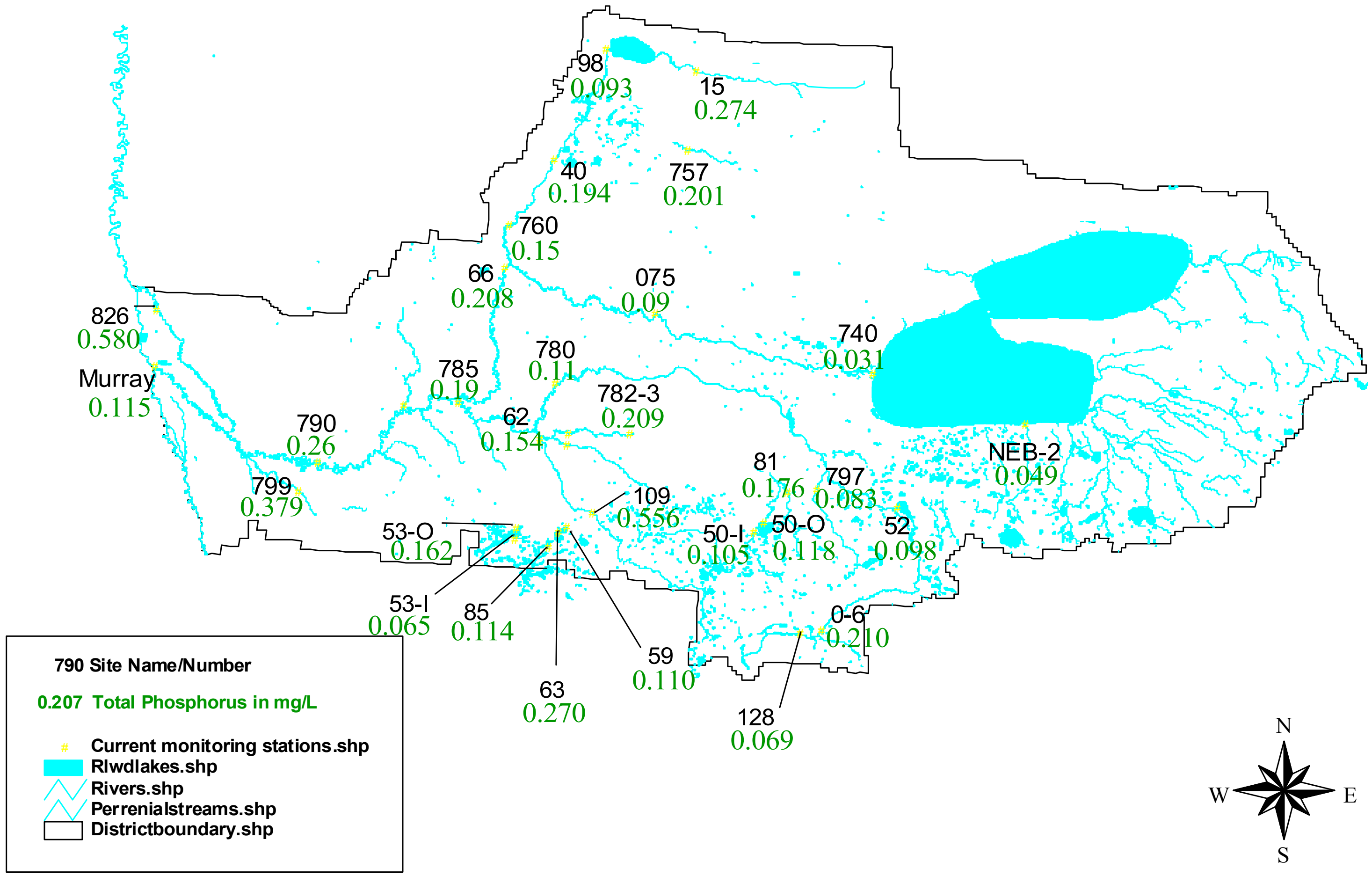

Figure 32. Mean Total Phosphorus Values Map.

TDS Means for District Monitoring Sites

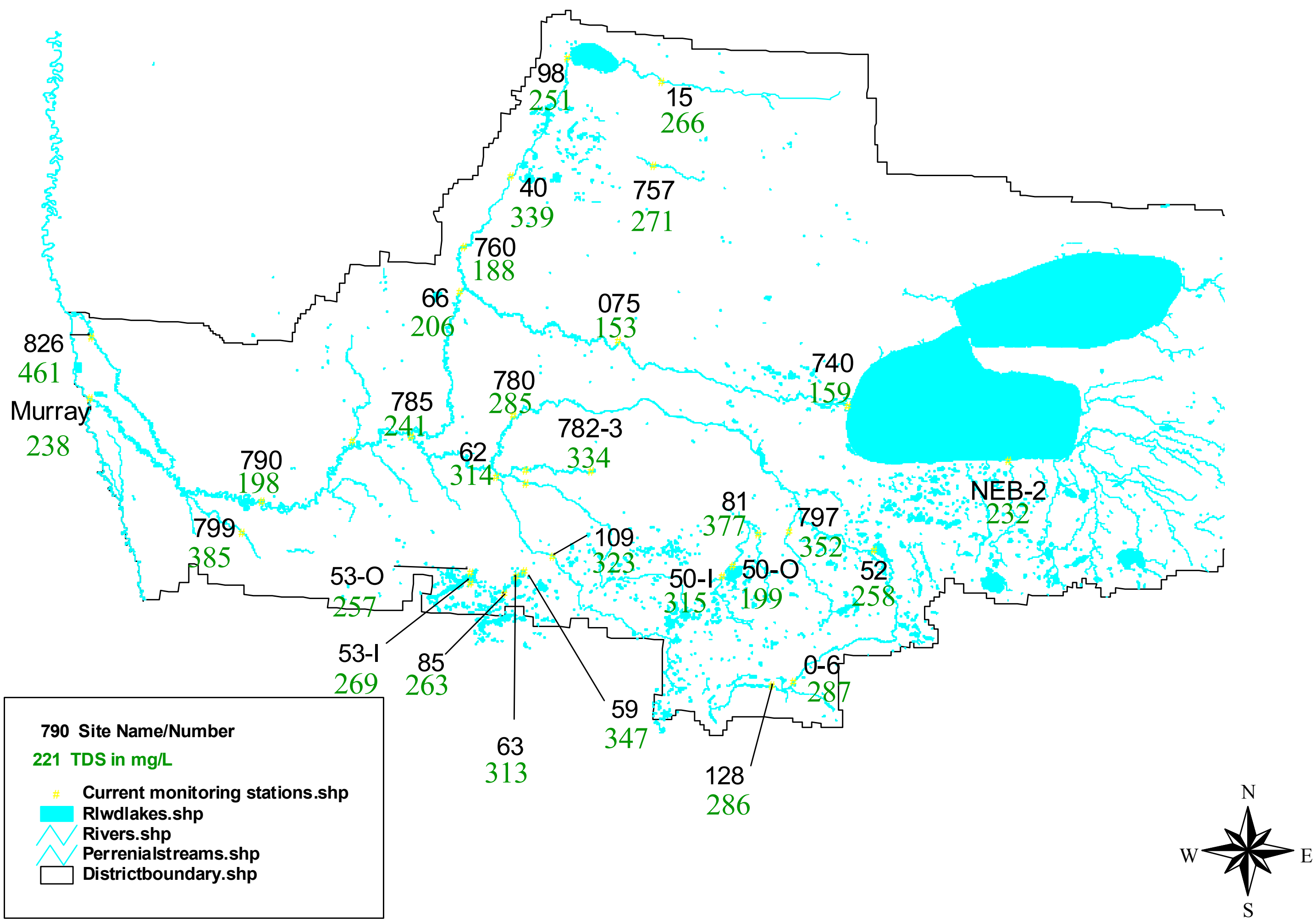

Figure 33. Mean Total Dissolved Solids Values Map.

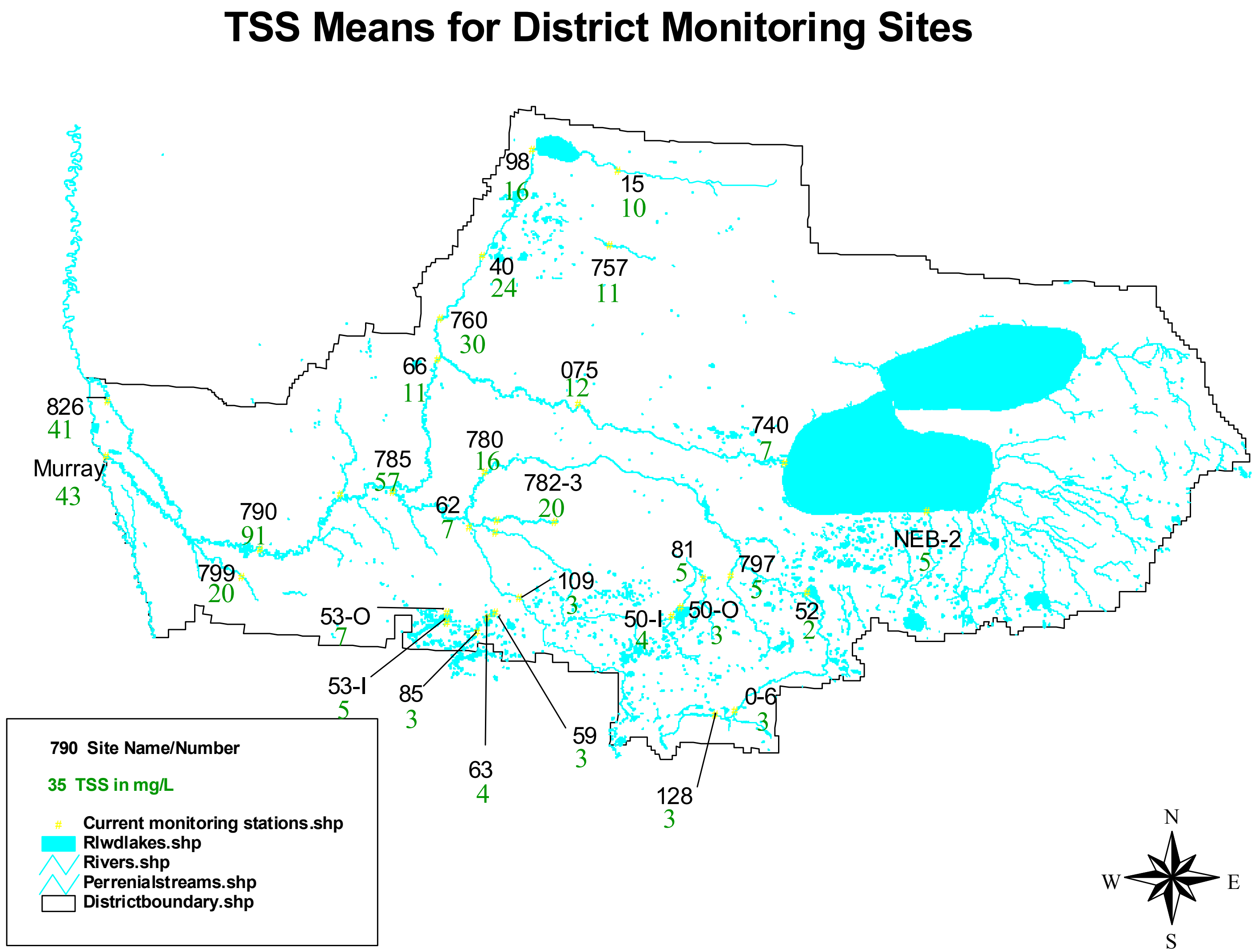

Figure 34. Mean Total Suspended Solids Values Map.

Turbidity Means for District Monitoring Sites

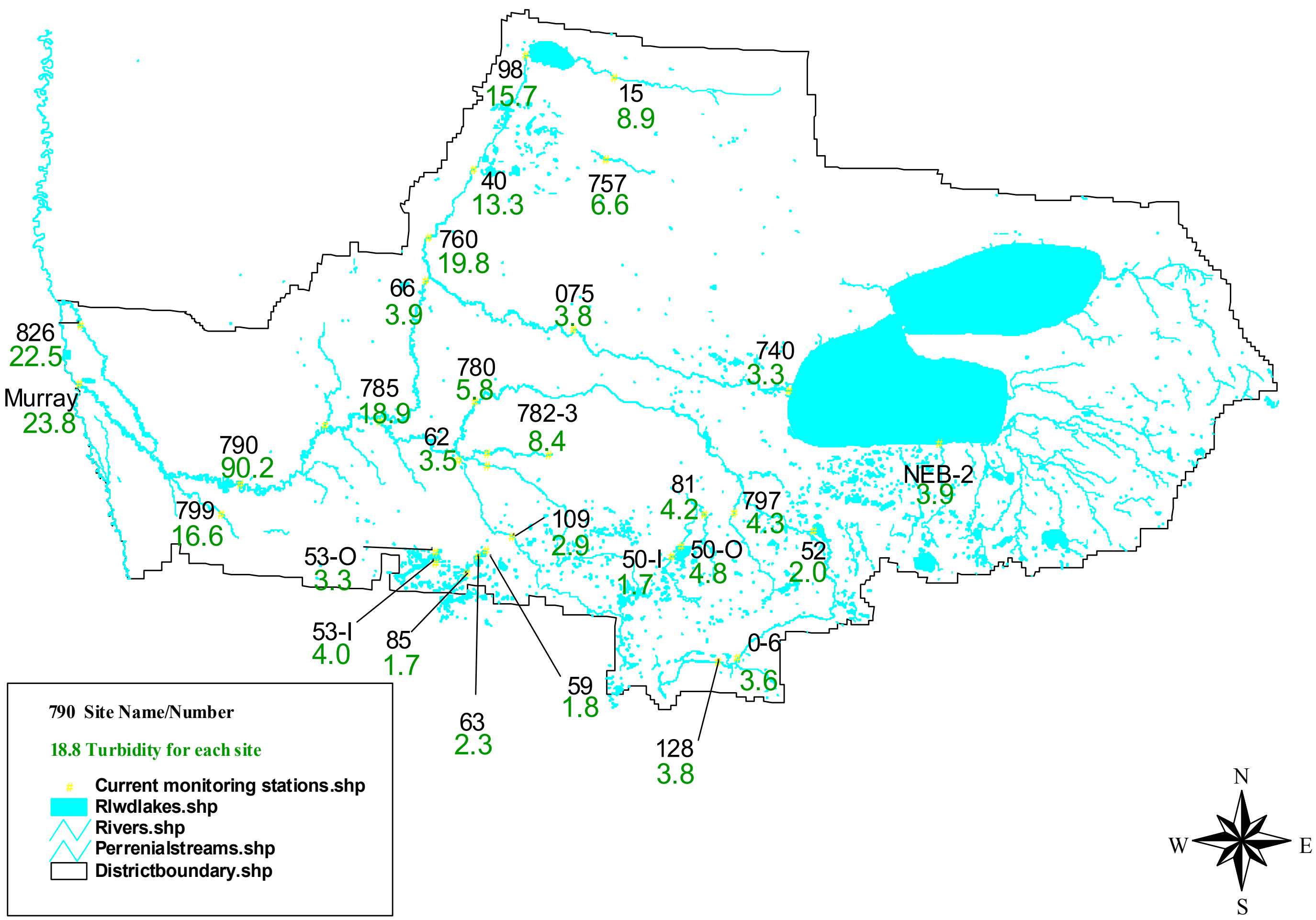

Figure 35. Mean Turbidity Values Map.

Water Temperature in Celsius for District Monitoring Sites

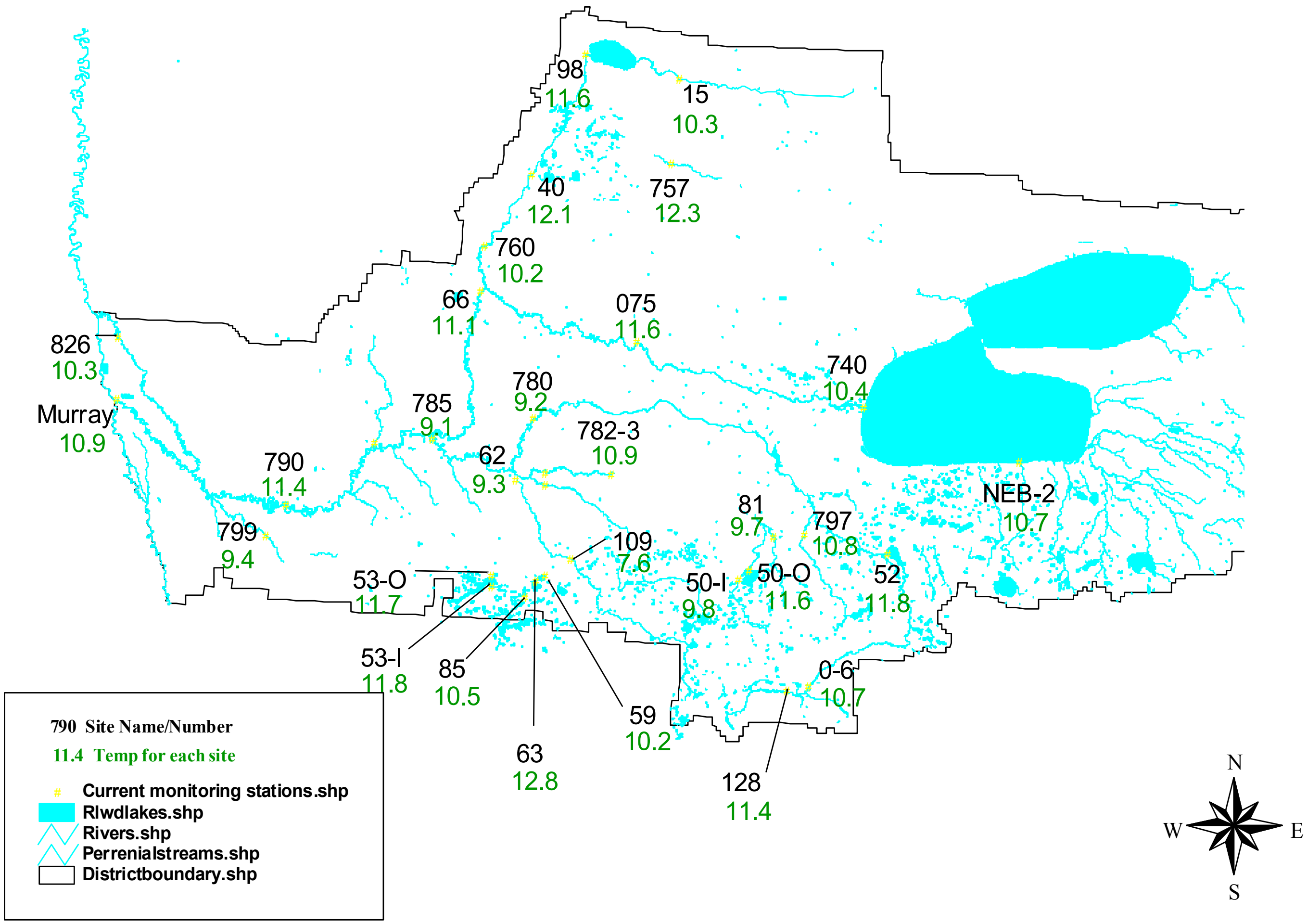

Figure 36. Mean Water Temperature Values Map.

5.1.2 Comparison to EPA standards for Minnesota

The EPA water quality standards for Minnesota are the standards that the MPCA currently uses to assess waters throughout the state for the TMDL program. These standards represent levels at which streams become impaired for a specified use. For example, a fecal coliform level of 200 mg/L makes a stream unsafe for recreation because accidental ingestion may cause illness. Likewise, high frequencies of dissolved oxygen levels that fall below the standard of 5 mg/L impair the ability of aquatic life to survive in a stream. When a stream reach is determined to be impaired, it is put on the MPCA list of impaired waters. Then it is put on a schedule of streams that will be the subjects of TMDL studies. The goal of these studies is to quantify the impact of each source of the pollutant of concern and make recommendations for load reductions from each source. Sometimes these studies show that the impairments are naturally occurring, especially in headwaters regions that are minimally impacted by human activity.

These standards sometimes draw criticism because the MPCA assessments end up being based upon standards that are single values applied to the whole state and do not vary by watershed or ecoregion. For example, the standard for total suspended solids is 25 mg/L. According to the MPCA methods for determination of impairment, the lower reaches of the Red Lake River will have a hard time meeting the standard due to relatively high background levels. On the other hand, if the upper reaches of the Clearwater River watershed were even beginning to approach this standard, this would mean that something has happened in the watershed to significantly impact water quality in the river. Some standards can vary by use classification, however. Since a ditch, for example, cannot be expected to meet the same water quality standards as a trout stream, it is put into a different beneficial use class. The re-classification of a stream is one option that may be addressed during a TMDL study.

RLWD monitoring data from through 2002 was recently added to the STORET database (well over ten years of data). It was submitted to STORET in early 2003, but was not entered into the database in time to be included in the assessment process for the 2004 MPCA 303d List of Impaired Waters. Until recently, the only data from the RLWD in STORET was data collected in 1992-1993 for the Clearwater River Nonpoint Study. The MPCA only uses water quality data from this database when assessing state waters. Data entered into STORET must meet several quality assurance requirements. Standard operating procedures, laboratory analysis methods, and proof of laboratory certification must be submitted along with site information in order to establish monitoring sites and get data entered into STORET.

For all RLWD data collected through 2003, the RLWD conducted an assessment of its long-term monitoring sites using RLWD data and the MPCA Methods for Assessing Surface Waters. This assessment provides a preview of future MPCA lists of impaired waters. The next list will be released in 2006 and is expected to feature a greater number of impaired reaches within the RLWD because of the recently submitted data.

The tables on the following pages list the results of this assessment. In order to be listed for conventional parameters such as dissolved oxygen and turbidity, a site must fail to meet the standards for greater than 10% of the samples from the most recent ten years of data. A level of 10% indicates partial use support and if the rate is 25% or higher, the stream is considered to be non-supporting for its designated use. Fecal coliform assessment is a little different because it involves two steps. The first step is to determine the percentage of samples from the most recent ten years of data that exceed the standard of 200 col/100 ml. If this is greater than 10%, the assessment continues to the second step. The aggregate geometric mean concentration for each calendar month is then found and if one or months have a mean greater than the standard, the site and its respective reach are deemed to be impaired and are included on the 303d list of impaired waters. The tables below show the results of this assessment.

Table 4. Assessment Results for the Red Lake River Watershed.

Mud River #NEB-2, in City of Redby					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	19	0	0.00%	No	Full
pH	19	0	0.00%	No	Full
Conductivity	21	0	0.00%	No	Full
Total Suspended Solids	19	0	0.00%	No	Full
Total Dissolved Solids	6	0	0.00%	No	Insufficient Data
Fecal Coliform	17	0	0.00%	No	Full

Red Lake River #740, Red Lakes Outlet					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	31	1	3.23%	No	Full
pH	28	11	39.29%	Yes	Non
Conductivity	32	0	0.00%	No	Full
Total Suspended Solids	36	1	2.78%	No	Full
Total Dissolved Solids	8	0	0.00%	No	Insufficient Data
Fecal Coliform	28	0	0.00%	No	Full

Red Lake River #075 Highlanding Bridge					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	1	2.94%	No	Full
pH	33	1	3.03%	No	Full
Conductivity	34	0	0.00%	No	Full
Total Suspended Solids	31	1	3.23%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	31	1	3.23%	No	Full

Red Lake River #66, 1st St. Bridge in Thief River Falls					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	1	2.94%	No	Full
pH	33	1	3.03%	No	Full
Conductivity	34	0	0.00%	No	Full
Total Suspended Solids	30	1	3.33%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	29	2	6.90%	No	Full

Black River #BL18, near Old Treaty Crossing State Park					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	22	0	0.00%	No	Full
pH	17	0	0.00%	No	Full
Conductivity	22	0	0.00%	No	Full
Total Suspended Solids	9	2	22.22%	No	Insufficient Data
Total Dissolved Solids	4	1	25.00%	No	Insufficient Data
Fecal Coliform	4	0	0.00%	No	Insufficient Data

Red Lake River #790 Sampson Bridge, in City of Crookston					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	33	0	0.00%	No	Full
pH	35	4	11.43%	Yes	Partial
Conductivity	36	0	0.00%	No	Full
Total Suspended Solids	33	15	45.45%	Yes	Non
Total Dissolved Solids	9	0	0.00%	No	Insufficient Data
Fecal Coliform	33	2	6.06%	No	Full

Burnham Creek #799, near City of Crookston					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	23	1	4.35%	No	Full
pH	27	3	11.11%	Yes	Partial
Conductivity	28	4	14.29%	Yes	Partial
Total Suspended Solids	24	4	16.67%	Yes	Partial
Total Dissolved Solids	9	2	22.22%	No	Insufficient Data
Fecal Coliform	26	1	3.85%	No	Full

Grand Marais Creek #826, on US Hwy #220, near City of East Grand Forks					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	27	6	22.22%	Yes	Partial
pH	30	4	13.33%	Yes	Partial
Conductivity	30	4	13.33%	Yes	Partial
Total Suspended Solids	28	18	64.29%	Yes	Non
Total Dissolved Solids	10	5	50.00%	Yes	Non
Fecal Coliform	26	2	7.69%	No	Full

Red Lake River Murray Bridge in City of East Grand Forks					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	0	0.00%	No	Full
pH	35	3	8.57%	No	Full
Conductivity	32	0	0.00%	No	Full
Total Suspended Solids	33	16	48.48%	Yes	Non
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	34	1	2.94%	No	Full

Table 5. Assessment Results for Thief River Watershed Sites.

Site #15, Moose River at Hwy 89					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	8	23.53%	Yes	Partial
pH	36	4	11.11%	Yes	Partial
Conductivity	36	0	0.00%	No	Full
Total Suspended Solids	32	1	3.13%	No	Full
Total Dissolved Solids	9	0	0.00%	No	Insufficient Data
Fecal Coliform	31	0	0.00%	No	Full
Site # 757-0, Mud River at Hwy 89					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	1	2.94%	No	Full
pH	33	4	12.12%	Yes	Partial
Conductivity	34	2	5.88%	No	Full
Total Suspended Solids	30	3	10.00%	Yes	Partial
Total Dissolved Solids	10	2	20.00%	Yes	Partial
Fecal Coliform	28	1	3.57%	No	Full

Site # 98, Thief River at the Thief Lake Outlet					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	33	3	9.09%	No	Full
pH	34	4	11.76%	Yes	Partial
Conductivity	35	1	2.86%	No	Full
Total Suspended Solids	32	2	6.25%	No	Insufficient Data
Total Dissolved Solids	7	0	0.00%	No	Insufficient Data
Fecal Coliform	27	3	11.11%	No	Full

Site # 40, Thief River at Agassiz MWR Outlet					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	32	6	18.75%	Yes	Partial
pH	33	4	12.12%	Yes	Partial
Conductivity	34	3	8.82%	No	Full
Total Suspended Solids	31	7	22.58%	Yes	Partial
Total Dissolved Solids	9	3	33.33%	No	Insufficient Data
Fecal Coliform	28	1	3.57%	No	Full

Site # 760 Thief River at the Hillyer Bridge					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would It Be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	7	20.59%	Yes	Partial
pH	35	1	2.86%	No	Full
Conductivity	36	5	13.89%	Yes	Partial
Total Suspended Solids	32	8	25.00%	Yes	Non
Total Dissolved Solids	9	2	22.22%	No	Insufficient Data
Fecal Coliform	32	3	9.38%	No	Full

Table 6. Assessment Results for Clearwater River Sites

Clearwater River #128 near City of Bagley					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	63	10	15.87%	Yes	Partial
pH	91	2	2.20%	No	Full
Conductivity	95	0	0.00%	No	Full
Total Suspended Solids	83	0	0.00%	No	Full
Total Dissolved Solids	29	0	0.00%	No	Full
Fecal Coliform	51	3	5.88%	No	Full

Clearwater River #O-6 on US Hwy #2 Bridge outside of Bagley					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	35	9	25.71%	Yes	Non
pH	33	1	3.03%	No	Full
Conductivity	36	0	0.00%	No	Full
Total Suspended Solids	36	0	0.00%	No	Full
Total Dissolved Solids	8	0	0.00%	No	Insufficient Data
Fecal Coliform	33	2	6.06%	No	Full

Clearwater River #52 Clearwater Lake Outlet					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	73	0	0.00%	No	Full
pH	70	11	15.71%	Yes	Partial
Conductivity	75	0	0.00%	No	Full
Total Suspended Solids	56	0	0.00%	No	Full
Total Dissolved Solids	33	0	0.00%	No	Full
Fecal Coliform	48	0	0.00%	No	Full

Clearwater River #780 on US Hwy #59 Bridge near Plummer					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	61	1	1.64%	No	Full
pH	60	3	5.00%	No	Full
Conductivity	60	0	0.00%	No	Full
Total Suspended Solids	37	7	18.92%	Yes	Partial
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	29	2	6.90%	No	Full

Clearwater River #785 Klondike Bridge in Red Lake Falls					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	54	0	0.00%	No	Full
pH	44	8	18.18%	Yes	Partial
Conductivity	53	0	0.00%	No	Full
Total Suspended Solids	32	9	28.13%	Yes	Non
Total Dissolved Solids	11	0	0.00%	No	Full
Fecal Coliform	31	2	6.45%	No	Full

Table 7. Assessment Results for Clearwater River Tributaries

Ruffy Brook #797 near City of Gonvick					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	12	0	0.00%	No	Full
pH	30	0	0.00%	No	Full
Conductivity	34	0	0.00%	No	Full
Total Suspended Solids	24	0	0.00%	No	Full
Total Dissolved Solids	10	2	20.00%	Yes	Partial
Fecal Coliform	29	8	27.59%	Yes	Non

Silver Creek #81 near City of Gonvick					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	43	0	0.00%	No	Full
pH	40	4	10.00%	Yes	Partial
Conductivity	44	0	0.00%	No	Full
Total Suspended Solids	42	1	2.38%	No	Full
Total Dissolved Solids	20	0	0.00%	No	Full
Fecal Coliform	40	8	20.00%	Yes	Non

Lost River #782, in City of Oklee					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	0	0.00%	No	Full
pH	36	1	2.78%	No	Full
Conductivity	37	0	0.00%	No	Full
Total Suspended Solids	32	1	3.13%	No	Full
Total Dissolved Solids	10	1	10.00%	Yes	Partial
Fecal Coliform	31	0	0.00%	Yes	Partial

Lost River #PL30, near City of Brooks					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	18	0	0.00%	No	Full
pH	18	1	5.56%	No	Full
Conductivity	18	0	0.00%	No	Full
Total Suspended Solids	4	0	0.00%	No	Insufficient Data
Total Dissolved Solids	4	1	25.00%	No	Insufficient Data
Fecal Coliform	4	1	25.00%	No	Insufficient Data

Hill River #PL40, in City of Brooks					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	23	0	0.00%	No	Full
pH	23	5	21.74%	Yes	Partial
Conductivity	23	0	0.00%	No	Full
Total Suspended Solids	13	3	23.08%	Yes	Partial
Total Dissolved Solids	4	0	0.00%	No	Insufficient Data
Fecal Coliform	9	2	22.22%	No	Insufficient Data

Poplar River #109, near City of Brooks					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	35	4	11.43%	Yes	Partial
pH	33	0	0.00%	No	Full
Conductivity	36	0	0.00%	No	Full
Total Suspended Solids	33	0	0.00%	No	Full
Total Dissolved Solids	10	1	10.00%	Yes	Partial
Fecal Coliform	32	3	9.38%	No	Full

Poplar River #62, on US Hwy #92, near City of Brooks					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	34	0	0.00%	No	Full
pH	34	3	8.82%	No	Full
Conductivity	35	0	0.00%	No	Full
Total Suspended Solids	32	0	0.00%	No	Full
Total Dissolved Solids	9	0	0.00%	No	Insufficient Data
Fecal Coliform	32	4	12.50%	Yes	Non

Table 8. Assessment Results for Inlets and Outlets of Lakes in the RLWD

Lost River #50-I Inlet to Pine Lake					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	35	5	14.29%	Yes	Partial
pH	32	1	3.13%	No	Full
Conductivity	35	0	0.00%	No	Full
Total Suspended Solids	31	1	3.23%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	31	4	12.90%	Yes	Partial

Lost River #50-O Outlet to Pine Lake					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	32	0	0.00%	No	Full
pH	29	10	34.48%	Yes	Non
Conductivity	33	0	0.00%	No	Full
Total Suspended Solids	33	0	0.00%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	29	3	10.34%	Yes	Partial

Badger Creek #59 on US Hwy #59 near Erskine					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	50	19	38.00%	Yes	Non
pH	48	0	0.00%	No	Full
Conductivity	51	0	0.00%	No	Full
Total Suspended Solids	33	0	0.00%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	32	2	6.25%	No	Full

Poplar River #63 on US Hwy #2 link between Badger and Mitchell Lakes near Erskine					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	33	4	12.12%	Yes	Partial
pH	32	7	21.88%	Yes	Partial
Conductivity	34	0	0.00%	No	Full
Total Suspended Solids	30	0	0.00%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	28	2	7.14%	No	Full

Badger Creek #53-I Maple Lake Inlet					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	35	3	8.57%	No	Full
pH	33	3	9.09%	No	Full
Conductivity	36	0	0.00%	No	Full
Total Suspended Solids	33	1	3.03%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	31	2	6.45%	No	Full

Badger Creek #53-O Maple Lake Outlet					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	35	0	0.00%	No	Full
pH	33	10	30.30%	Yes	Non
Conductivity	36	0	0.00%	No	Full
Total Suspended Solids	31	1	3.23%	No	Full
Total Dissolved Solids	10	0	0.00%	No	Full
Fecal Coliform	31	0	0.00%	No	Full

Bee Lake #85					
Parameter	**# Samples**	**Exceedances**	**% Exceedances**	**Would it be Listed?**	**Designated Use Support**
Dissolved Oxygen	28	11	39.29%	Yes	Non
pH	26	0	0.00%	No	Full
Conductivity	28	0	0.00%	No	Full
Total Suspended Solids	24	0	0.00%	No	Full
Total Dissolved Solids	5	0	0.00%	No	Insufficient Data
Fecal Coliform	23	0	0.00%	No	Full

5.1.3 Comparison to MPCA "Minimally Impacted Streams"

The MPCA has created a set of minimally impacted stream values based upon water quality results at the 75th percentile of each parameter for a set of data collected from least impacted streams. There is a set of values for each ecoregion. Comparing water quality data to these values can be useful because there are similar topography, soils, vegetation, hydrology, climate, and land use characteristics affecting water quality throughout each ecoregion. Below is a table showing the values. The ecoregions within the RLWD include the North Central Hardwood, Northern Lakes and Forest, and Northern Minnesota Wetlands to the East and the Red River Valley in the western part of the watershed district.

Table 9. Values for Minimally Impacted Streams, by Ecoregion.

	NLF	NCH	RRV	NMW	NGP	WCB
Cond.	270	340	658	250	1100	790
pH	7.9	8.1	8.3	7.9	8.2	8.2
TSS	6.4	16.1	56.5	17.2	65.5	57.5
T.Ammon.	0.2	0.22	0.29	0.2	0.31	0.39
NO2NO3	0.09	0.29	0.2	0.08	0.52	5.62
T.Phosph.	0.052	0.17	0.322	0.092	0.271	0.34
Fec.Col.	20	330	230	50	700	790
TempC	17.6	20	19.9	17.2	20.5	19.2
Turbid.	4.3	8.5	23	10	23.7	22
BOD5	1.7	3.4	4.2	2.2	4.5	5.6

Histograms created for RLWD monitoring sites show that levels of nitrates and nitrites for sites 782, 780, 62, 785, and 757 are frequently high when compared to ecoregion values. Total phosphorus levels are relatively high at sites 790 and 15. Box plot analysis results are summarized in the following table. This type of analysis produces quartile values. Since the MPCA minimally impacted stream values listed in Table 9 represent the 75th quartiles of their respective data sets, the 75th quartiles from the box plot analysis of water quality monitoring sites are compared with these values.

Table 10. Comparison of 75th Quartile Values for RLWD Stream Monitoring Sites with 75th Quartile Values for MPCA Minimally Impacted Streams.

Site	Temp	pH	Cond	Nitrates and Nitrites	TP	Amm. N	TSS	Turbidity	Fecal Coliform
Red River Valley Ecoregion									
Standards:	19.9	8.3	658	0.2	0.322	0.29	56.5	23	230
2*	23.00	8.55	500.00		0.32			11.55	
13*	22.00	8.43	510.00		0.35			5.35	0.00
750	19.75	8.27	315.50	0.03	0.07	0.14	19.50	4.65	24.75
37*	17.88	7.95	623.75		0.17			6.45	94.00
Murray Bridge	20.86	8.20	458.25	0.23	0.15	0.11	69.00	203.00	29.50
108*	19.00	8.28	406.50		0.20			5.00	
780	17.20	8.16	587.50	0.53	0.13	0.14	18.40	8.16	60.00
70*	12.15		541.50		0.33			55.50	
40	20.00	8.18	561.00	0.06	0.18	0.55	21.00	9.98	38.00
98	19.35	8.46	473.25	0.03	0.09	0.22	12.25	10.28	32.00
757	20.40	8.26	483.00	0.48	0.11	0.20	18.00	8.32	94.00
760	19.27	8.14	683.75	0.18	0.16	0.33	26.00	23.00	82.00
66	20.58	8.25	348.00	0.04	0.13	0.10	14.25	4.66	24.50
77c*	16.50				3.00			6.75	
77p*	18.75	9.03	411.00		0.27			6.50	
83*	21.98	8.32	503.25		0.37			10.00	
89*	12.73	8.00	613.00		0.23			10.00	
96*	22.18	8.32	550.00		0.07			12.00	2.50
100*	20.55	8.32	416.50		0.16			5.00	
220*	20.00	8.29	482.00		0.13			11.25	5.00
790	20.00	8.38	431.50	0.18	0.28	0.17	38.00	13.23	52.00
799	16.83	8.17	843.25	0.41	0.41	0.10	18.75	13.73	109.50
826	19.07	8.15	806.88	0.18	0.75	0.18	51.75	29.58	38.00
Bypass*	12.83	8.22	457.00		0.26			8.00	41.25
10*	14.33	8.41	567.25		0.12			7.80	
82*	24.00	8.28	525.00		0.28			6.00	
62	17.10	8.31	696.50	0.45	0.16	0.14	10.75	3.50	88.25
782-3	17.47	8.28	646.50	0.46	0.19	0.08	14.25	11.75	54.00
785	15.80	8.35	594.00	0.50	0.17	0.18	42.50	9.00	46.00

Site	Temp	pH	Cond	Nitrates and Nitrites	TP	Amm. N	TSS	Turbidity	Fecal Coliform
Northern Minnesota Wetlands Ecoregion									
Standards:	**17.2**	**7.9**	**250**	**0.08**	**0.092**	**0.2**	**17.2**	**10**	**50**
15	18.60	7.99	618.00	0.18	0.20	0.28	15.00	11.58	34.00
114*	20.75	8.16	506.50		0.15			11.75	0.50
119*	22.08	8.07	488.50		0.13			11.50	
0-1*	19.45	8.50	464.00		0.14			6.18	
Neb-1*	16.85	7.86	608.00		0.22			9.25	7.75
735-5*	20.00	8.25	206.75		0.21			11.75	46.25
735-6*	19.95	8.91	297.25		0.34			7.00	50.50
736.3*	19.28	8.34	508.25		0.26			5.80	95.50
737-7*	17.90	8.42	410.00		0.20			5.40	22.00
Neb-2	18.36	8.14	534.50	0.10	0.06	0.13	6.00	4.70	40.00
740	19.90	8.53	308.00	0.01	0.04	0.03	10.00	4.25	0.00
739-8*	18.75	8.61	474.25		0.70			5.00	57.00
North Central Hardwood Forests Ecoregion									
Standards:	**20**	**8.1**	**340**	**0.29**	**0.17**	**0.22**	**16.1**	**8.5**	**330**
53-I	20.90	8.30	529.75	0.01	0.05	0.14	5.00	4.06	42.25
53-O	21.95	8.50	486.00	0.05	0.07	0.13	9.00	4.00	6.00
59	19.35	7.80	737.00	0.20	0.10	0.18	3.00	1.98	58.50
63	22.06	8.40	585.00	0.03	0.15	0.11	4.25	2.17	24.00
109	18.85	8.07	685.75	0.37	0.25	0.31	3.00	4.00	55.75
54*	14.00	8.50	427.50		0.97			2.65	
0-2*	22.00	8.05	607.00		0.40			4.88	20.00
50*	14.78	8.84	430.25		0.25			6.50	
50-I	18.25	7.95	649.60	0.01	0.11	0.13	3.50	3.95	96.50
50-O	19.38	8.54	394.00	0.02	0.05	0.16	4.00	4.43	67.00
0-4*	18.30	8.09	552.75		0.48			5.60	12.50
0-5*	15.63	8.00	477.00		1.02			4.50	
797	18.15	8.27	641.00	0.13	0.09	0.12	7.75	5.48	214.00
81	18.20	8.34	700.50	0.50	0.11	0.14	6.23	5.12	147.50
85	19.55	7.83	558.25	0.04	0.06	0.16	3.50	2.48	26.00
Northern Lakes and Forest Ecoregion									
Standards:	**17.6**	**7.9**	**270**	**0.09**	**0.052**	**0.2**	**6.4**	**4.3**	**20**
737-9*	18.35	8.20	310.00		0.45			6.05	107.75
52	20.00	8.43	444.50	0.05	0.04	0.13	3.00	2.92	1.00
19* (133)	21.85	7.96	520.00		0.47			12.00	0.50
24* (131)	21.00	7.98	520.00		0.10			9.50	
0-0*	25.00	8.77	255.75		0.82			5.55	
128	19.39	8.05	498.00	0.02	0.05	0.21	4.10	2.86	16.00
0-6	18.40	7.95	538.00	0.06	0.16	0.22	5.00	4.40	24.00
60	21.75	7.82	520.25		0.06			4.90	
*	**= Historical Monitoring Site**								
(green shading)	= Water quality is worse than minimally impacted sites.								

When compared to corresponding values for minimally impacted streams within each ecoregion, sites within the Red River Valley do not look any more impacted than sites in other ecoregions. Most minimally impacted values for the ecoregions in the upper part of the watershed are tougher standards to meet than the values for the Red River Valley. Few sites within the Red River Valley are above the minimally impacted value for turbidity while the majority of sites within the Northern Lakes and Forests ecoregion are greater than the minimally impacted value. Most sites in the RLWD have relatively high results for water temperature. Most sites in ecoregions other than the Red River Valley have relatively high conductivity and total phosphorus levels.

5.2 Trend Analysis

In order to identify trends in concentration data, the RLWD used time series plots and linear regression (trend lines) to determine whether a particular parameter has been increasing or decreasing over time. Times series graphs such as the two examples below were created for all monitoring sites and parameters. They were then examined to identify whether or not each graph showed a definite trend. Linear regression was used for most of the analysis, but moving average analysis was effective on others for discerning recent trends. The results of this analysis were summarized in a table that shows whether there is an upward trend (U), downward trend (D), or no identifiable trend (X) for each parameter at each site.

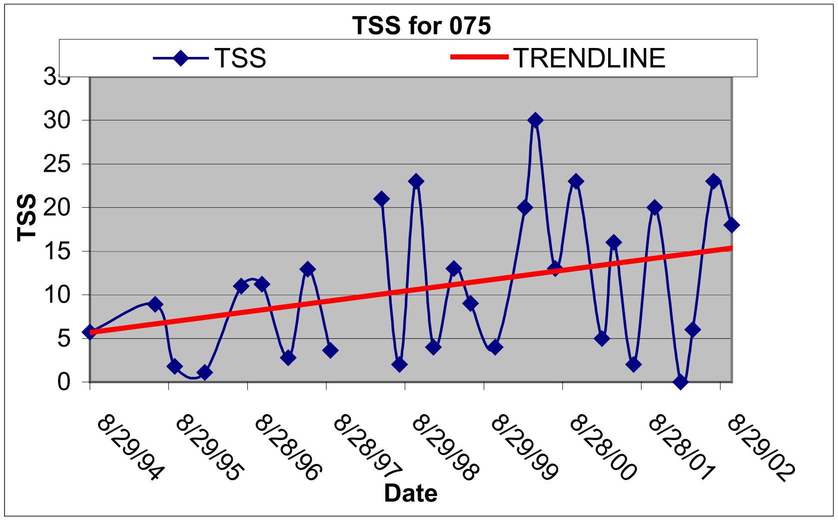

Figure 37. Example of Upward Trend.

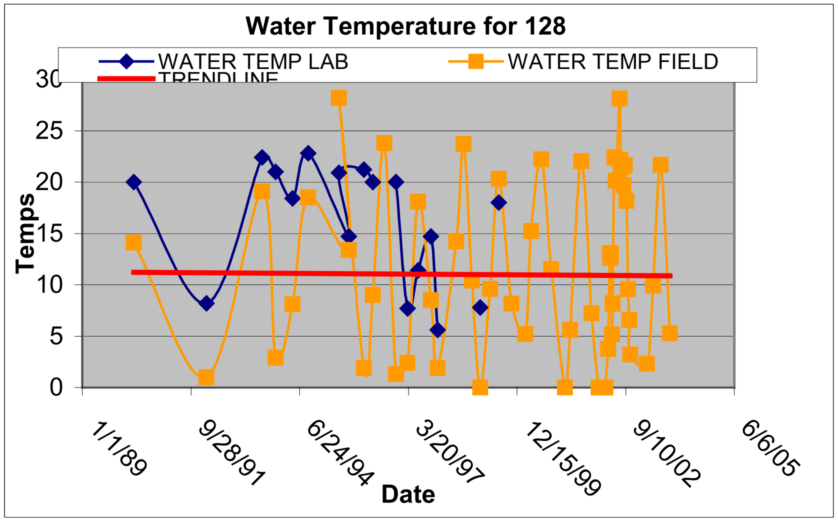

Figure 38. Example of Steady/No trend.

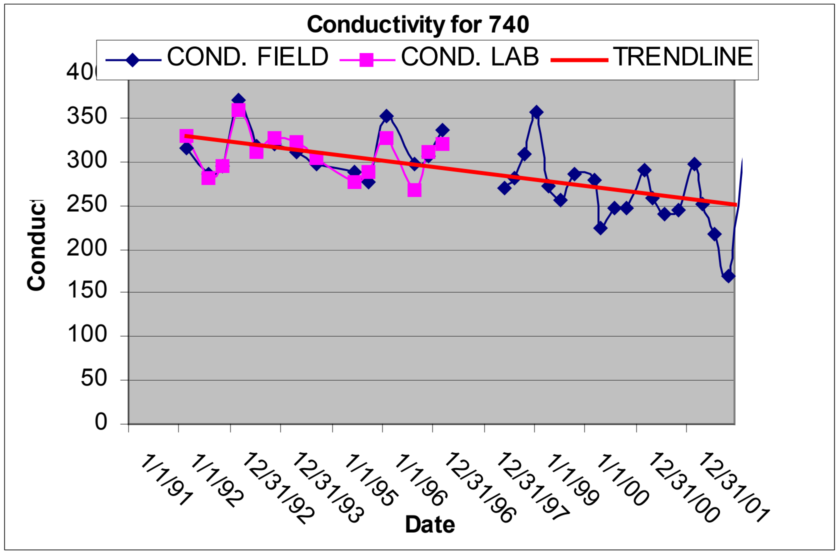

Figure 39. Example of Downward Trend.

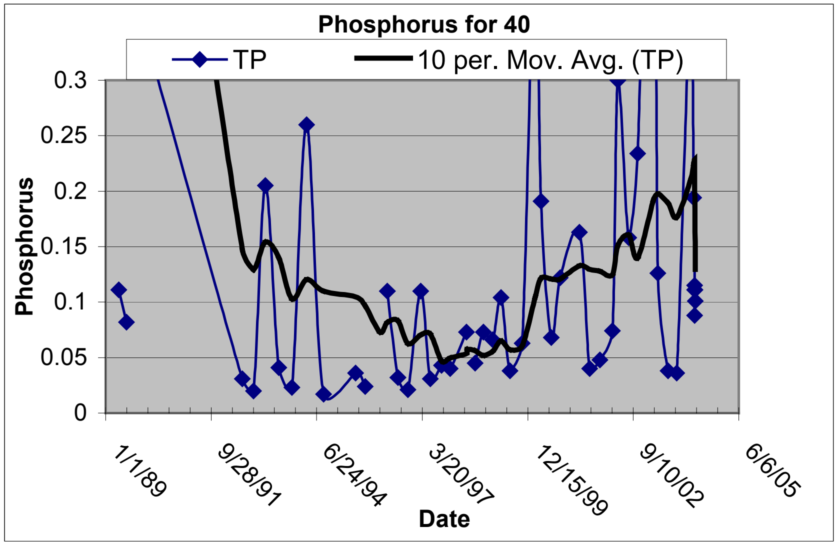

Figure 40 Example of Moving Average.

Table 11. Trend Analysis Results

1984 - 2003 Trend Analysis Results for District Monitoring Sites																
U=Upward Trend D=Downward Trend X=No Significant Trend Letters in **Bold** indicate trends that are particularly evident																
Site	**Temp**	**pH**	**Sp. Cond**	**DO**	**Nitrates and Nitrites**	**Nitrates**	**TP**	**OP**	**Amm. N**	**Fecal Coliform**	**TSS**	**TDS**	**COD**	**TKN**	**Alkalinity**	**Turbidity**
Clearwater River Subwatershed																
0-6	D	D	D	U	D	U	X	D	X	D	D	D	X	X	D	U
50-I	D	U	D	**U**	U	U	D	D	D	D	X	U	D	**D**	D	X
50-O	D	X	D	U	D	U	D	D	U	D	D	U	U	X	X	D
52	U	X	D	X	D	U	D	D	U	U	D	U	U	D	U	U
53-I	D	X	D	U	U	U	D	X	U	D	D	D	D	D	D	X
53-O	X	X	**D**	U	U	D	U	U	U	U	D	X	D	U	D	U
59	D	X	D	U	U	X	D	X	U	U	U	U	D	U	D	U
62	U	U	X	U	U	X	U	U	D	D	U	U	U	D	D	U
63	D	D	D	U	D	U	D	X	U	D	U	U	D	U	U	U
81	X	X	**D**	X	D	U	X	D	U	U	U	U	D	D	D	U
85	D	U	D	U	X	U	D	D	X	X	D	**D**	D	D	D	D
109	D	X	D	X	U	D	D	U	D	D	U	U	D	U	X	X
128	X	X	D	U	X	D	D	U	X	U	D	**U**	U	D	D	D
780	U	U	D	U	U	U	U	U	X	D	U	U	U	D	D	U
782	U	X	D	U	D	U	D	D	U	X	D	U	U	D	X	U
785	D	X	**D**	U	D	X	X	X	U	X	X	**U**	D	X	D	U
797	X	U	D	U	X	U	U	D	U	U	X	**U**	D	D	U	U
Upper and Lower Red Lakes Subwatershed																
NEB-2	U	U	D	D	U	U	X	U	U	D	U	**U**	U	**U**	D	**U**
Thief River Subwatershed																
15	D	U	U	U	X	X	D	X	U	D	**U**	U	D	U	D	D
40	D	U	U	U	D	X	U	U	X	D	U	U	U	U	D	U
98	D	U	U	U	D	D	U	U	U	D	X	U	D	D	U	U
757	D	U	U	U	X	X	X	D	U	D	U	D	U	U	X	U
760	D	U	D	U	D	X	X	U	U	D	**U**	X	X	U	U	**U**
Red Lake River Subwatershed																
66	D	X	U	D	D	X	D	D	U	X	**U**	**U**	X	X	X	**U**
740	X	U	**D**	U	X	X	U	U	U	D	U	U	D	U	D	U
750	D	D	D	D	D	X	D	U	U	D	U	X	D	D	D	U
790	D	U	X	U	D	D	D	D	D	D	U	U	U	X	D	U
799	U	D	U	**U**	X	X	D	D	U	D	X	**U**	D	D	U	U
Murray Bridge	D	U	**D**	U	D	U	U	U	U	X	U	**U**	X	U	D	U
Grand Marais Creek																
826	X	U	U	U	D	U	D	U	D	X	**U**	D	D	D	X	U

5.3 Annual Loads

Annual loads are a measure of the total mass of a pollutant carried by a river or stream past a particular point during a year. Since daily water quality monitoring of a site is normally not feasible, water quality modeling software is used to estimate annual loads based upon available water quality and daily average flow data. Continuous flow measurement data is most desirable and is collected by the USGS at certain sites within the RLWD. Water quality data from long-term water quality monitoring sites co-located with USGS stations, along with flow data from these stations was imported into the FLUX modeling program. These sites were 760 on the Thief River, 785 on the Clearwater River, 790 on the Red Lake River, 750 on the Red Lake River, and 780 on the Clearwater River. This software uses six different methods of statistical analysis to determine the annual loads using flow and concentration data. Flow-weighted-mean concentrations were calculated using total flow volumes and annual FLUX rates. A coefficient of variance (amount of inaccuracy) is calculated along with the results from each method. A lower coefficient of variance means that the results have a higher level of accuracy. Flow data can also be stratified, separating high flows from low flows and sometimes lowering the overall coefficient of variance. Results were obtained for both flow and seasonal stratification.

Based upon optimal stratification results, site 750 on the Red Lake River near Highlanding had the highest average alkalinity, chemical oxygen demand (COD), and total suspended solids (TSS) annual loads. Site 760 on the Thief River had the highest annual load for ammonia nitrogen and the highest flow-weighted-mean concentrations of ammonia nitrogen, COD, and nitrates and nitrites. Site 780 on the Clearwater River near Plummer had the highest flow-weighted-mean concentrations of conductivity and total dissolved solids. This makes sense since these two parameters are positively related. Site 785 on the Clearwater River in Red Lake Falls has the highest average annual loads of total Kjeldahl nitrogen (TKN), nitrates and nitrites, fecal coliform, and orthophosphorus as well as the highest flow-weighted-mean concentrations of fecal coliform, orthophosphorus, and TKN. Levels of nitrates and nitrites are generally high throughout the lower Clearwater River watershed relative to the rest of the RLWD, even on tributaries such as the Hill River. This may be a result of agricultural runoff. The high fecal coliform levels come as no surprise because some river reaches within the Clearwater River watershed are listed as impaired for fecal coliform. Site number 790 on the Red Lake River in Crookston has the highest annual loads for total phosphorus (TP) and TSS. This site also has the highest flow-weighted-mean concentrations of dissolved oxygen (DO), TP, TSS, and turbidity. The high phosphorus turbidity levels are associated with the high TSS levels. The relatively high DO levels at 790 can be attributed to the dam and rapids located upstream of the sampling site that keep water open and aerated during the winter. If a site has lower flow than another, it can have higher concentrations of pollutants, but still have lower loads.

Flow stratification shows that loading is greatest at higher flows. A comparison of actual to optimal sample collection percentages shows that more samples need to be collected during high flows and less need to be collected during low flows. Seasonal stratification shows that fecal coliform loading is highest during the summer. Nitrate and nitrite loading is highest in the spring. Orthophosphorus loads are highest in the spring at most sites. TKN loads and concentrations are significantly higher in the spring at sites 785 and 790. The timing of high total phosphorus loads varies by site. TSS loads and concentrations are highest during spring runoff at most sites.

Table 12. Average Annual Loads Using Optimal Stratification

Average Annual Loads Computed Using Optimal Stratification with Lowest COV													
	Alkal-inity	Amm. N	COD	Cond.	DO	Fecal Coliform	Nitrates and Nitrites	OP	TDS	TKN	TP	TSS	Turb-idity
Minimally Impacted		0.20				20.00	0.09				0.05	6.40	
EPA Standards				1,000	5.00	200.00			500.00			25.00	
GS 05-0760 Thief River North of Thief River Falls													
# Of Samples	26	17	36	22	33	30	24	32	6	31	36	28	22
Flow Vol. (millions of m^3/yr)	245.57	245.57	245.57	246	245.57	245.57	245.57	245.57	245.57	245.57	245.57	245.57	245.57
FLUX Rate (Tons/Yr.)	39,576.57	71.07	11,672.64		2,572.99	10,872.49	151.89	17.28	50,977.4	301.91	40.48	8,055.25	
Tons/sq. mile	40.18	0.07	11.85		2.61	11.04	0.15	0.02	51.75	0.31	0.04	8.18	
Flow Weighted Mean Conc.	146.20	0.26	43.12	418	9.51	40.16	0.56	0.06	188.32	1.12	0.15	29.76	19.78
GS 05-0785 Clearwater River at Red Lake Falls													
# Of Samples	35	11	36	35	35	25	38	38	5	25	42	27	28
Flow Vol. (millions of m^3/yr)	352.27	352.28	352.27	352	352.27	352.27	352.27	352.27	352.23	352.27	352.27	352.27	352.27
FLUX Rate (Tons/Yr.)	67,561.39	60.44	15,145.92		4,074.65	19,995.05	195.94	38.04	93,677	607.20	73.70	22,247.83	
Tons/sq. mile	48.96	0.04	10.98		2.95	14.49	0.14	0.03	67.88	0.44	0.05	16.12	
Flow Weighted Mean Conc.	173.99	0.16	39.00	446	10.49	51.49	0.50	0.10	241.27	1.56	0.19	57.29	18.95
GS 05-0790 Red Lake River in Crookston													
# Of Samples	42	12	38	43	36	26	47	40	5	24	51	28	15
Flow Vol. (millions of m^3/yr)	262.73	262.73	262.73	263	262.73	262.73	262.73	262.73	262.73	262.73	262.73	262.73	262.73
FLUX Rate (Tons/Yr.)	46,209.82	40.92	9,494.71		3,263.88	10,885.78	144.37	20.24	57,474.93	400.67	76.36	26,240.19	
Tons/sq. mile	8.77	0.01	1.80		0.62	2.07	0.03	0.00	10.91	0.08	0.01	4.98	
Flow Weighted Mean Conc.	159.56	0.14	32.78	365	11.27	37.59	0.50	0.07	198.46	1.38	0.26	90.61	90.16

	Alkal-inity	Amm. N	COD	Sp. Cond.	DO	Fecal Coliform	Nitrates and Nitrites	OP	TDS	TKN	TP	TSS	Turb-idity
Minimally Impacted		0.20				20.00	0.09				0.05	6.40	
EPA Standards				1,000	5.00	200.00			500.00			25.00	
GS 05-0750 Red Lake River at Highlanding													
# Of Samples	**44**	**12**	**34**	**43**	**35**	**24**	**39**	**35**	**6**	**22**	**50**	**26**	**40**
Flow Vol. (millions of m^3/yr)	574.01	574.01	574.01	574	574.00	574.00	574.01	574.01	165.30	574.00	574.01	574.01	574.01
FLUX Rate (Tons/Yr.)	93,215.44	65.90	22,413.07		6,553.88	18,861.94	80.07	6.59	96,353.07	537.40	55.28	7,421.28	
Tons/sq. mile	40.53	0.03	9.74		2.85	8.20	0.03	0.00	41.89	0.23	0.02	3.23	
Flow Weighted Mean Conc.	147.32	0.10	35.42	259	10.36	29.81	0.13	0.01	152.81	0.85	0.09	11.73	3.81
GS 05-0780 Clearwater River at Plummer													
# Of Samples	**27**	**12**	**35**	**27**	**35**	**26**	**31**	**34**	**6**	**26**	**33**	**28**	**20**
Flow Vol. (millions of m^3/yr)	165.30	165.31	165.30	165	165.30	165.30	165.30	165.30	165.31	165.31	165.30	165.31	165.30
FLUX Rate (Tons/Yr.)	35,451.82	22.22	6,635.32		1,725.06	7,744.25	71.78	10.51	51,949.72	301.32	19.93	2,977.51	
Tons/sq. mile	63.88	0.04	11.96		3.11	13.95	0.13	0.02	93.60	0.54	0.04	5.36	
Flow Weighted Mean Conc.	194.56	0.12	36.41	471	9.47	42.50	0.39	0.06	285.10	1.10	0.11	16.34	5.81

Table 13. FLUX Modeling Results Using Flow Stratification – Percentages for Alkalinity and COD.

	Alkalinity					COD				
	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance
	GS 05-760-0 Flow Stratification									
Low	42.3%	43.9%	6.4%	16.3%	0.593	47.2%	45.4%	6.4%	13.3%	0.409
Med	30.8%	5.6%	17.9%	23.1%	0.063	27.8%	12.0%	17.9%	23.6%	80.000
High	26.9%	50.5%	75.7%	60.6%	0.230	25.0%	42.6%	75.7%	63.1%	0.112
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.170**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.091**
	GS 05-785-0 Flow Stratification									
Low	54.3%	27.3%	15.1%	23.3%	0.064	44.4%	8.4%	15.1%	9.6%	0.081
Med	37.1%	21.2%	31.2%	40.5%	0.034	44.4%	25.4%	31.2%	30.5%	0.078
High	8.6%	51.5%	53.8%	36.2%	0.195	11.1%	66.2%	53.8%	59.9%	0.207
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.073**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.126**
	GS 05-790-0 Flow Stratification									
Low	69.0%	25.2%	6.7%	8.8%	0.085	57.9%	8.1%	6.7%	7.2%	0.135
Med	16.7%	25.7%	19.4%	18.8%	0.083	21.1%	13.7%	19.4%	27.0%	0.101
High	14.3%	49.1%	73.9%	72.3%	0.045	21.1%	78.3%	73.9%	65.8%	0.237
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.037**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.159**
	GS 05-750-0 Flow Stratification									
Low	29.5%	8.5%	5.1%	5.7%	0.098	14.7%	8.6%	5.1%	6.0%	0.165
Med	56.8%	71.4%	78.3%	81.4%	0.041	61.8%	70.9%	78.3%	74.5%	0.053
High	13.6%	20.1%	16.6%	13.0%	0.149	23.5%	20.5%	16.6%	19.5%	0.095
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.039**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.045**
	GS 05-780-0 Flow Stratification									
Low	74.1%	9.7%	31.4%	43.4%	0.045	42.9%	9.1%	16.0%	13.3%	0.080
Med	25.9%	90.3%	68.6%	56.6%	0.542	48.6%	49.1%	35.0%	44.0%	0.123
High						8.6%	41.9%	49.1%	42.7%	0.258
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.307**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.123**

Table 14. FLUX Modeling Results Using Flow Stratification – Percentages for Dissolved Oxygen and Fecal Coliform.

	DO					Fecal Coliform				
	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance
	GS 05-760-0 Flow Stratification									
Low	45.5%	6.3%	6.4%	5.7%	0.086	53.3%	22.8%	6.4%	18.0%	0.386
Med	27.3%	12.8%	17.9%	20.3%	0.063	23.3%	7.4%	17.9%	13.5%	0.252
High	27.3%	80.9%	75.7%	74.0%	0.109	23.3%	69.9%	75.7%	68.4%	0.472
Total/ Average	**100.1%**	**100.0%**	**100.0%**	**100.0%**	**0.082**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.332**
	GS 05-785-0 Flow Stratification									
Low	42.9%	17.7%	15.1%	12.5%	0.062	40.0%	6.9%	15.1%	8.3%	0.239
Med	45.7%	38.4%	31.2%	28.5%	0.057	48.0%	67.8%	31.2%	56.1%	0.317
High	11.4%	43.8%	53.8%	58.9%	0.063	12.0%	25.3%	53.8%	35.6%	0.374
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.041**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.223**
	GS 05-790-0 Flow Stratification									
Low	61.1%	6.2%	6.7%	5.6%	0.075	50.0%	38.9%	6.7%	25.8%	0.405
Med	16.7%	15.1%	19.4%	17.2%	0.112	23.1%	7.9%	19.4%	11.3%	0.275
High	22.2%	78.7%	73.9%	77.2%	0.113	26.9%	53.2%	73.9%	62.9%	0.309
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.090**	**100.0%**	**100.0%**	**100.0%**		**0.223**
	GS 05-750-0 Flow Stratification									
Low	22.9%	21.6%	16.4%	17.6%	0.110	20.8%	7.2%	16.4%	8.2%	0.515
Med	77.1%	78.4%	83.6%	82.4%	0.047	79.2%	92.8%	83.6%	91.8%	0.305
High										
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.043**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.283**
	GS 05-780-0 Flow Stratification									
Low	42.9%	23.0%	16.0%	16.2%	0.051	73.1%	44.8%	31.4%	57.0%	0.318
Med	48.6%	62.1%	35.0%	30.9%	0.067	26.9%	55.2%	68.6%	43.0%	0.856
High	8.6%	14.9%	49.1%	52.9%	0.022					
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.025**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.410**

Table 15. FLUX Modeling Results Using Flow Stratification – Percentages for Nitrates + Nitrates and Orthophosphorus.

	Nitrates and Nitrites					OP				
	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance
	GS 05-760-0 Flow Stratification									
Low	45.8%	29.3%	6.4%	12.1%	1.027	53.1%	10.7%	6.4%	4.2%	0.586
Med	29.2%	4.4%	17.9%	4.8%	0.482	21.9%	28.3%	17.9%	12.7%	0.797
High	25.0%	66.4%	75.7%	83.1%	0.460	25.0%	61.0%	75.7%	83.1%	0.246
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.402**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.229**
	GS 05-785-0 Flow Stratification									
Low	50.0%	4.8%	15.1%	4.9%	0.251	68.4%	8.3%	29.5%	10.5%	0.245
Med	39.5%	35.3%	31.2%	31.9%	0.316	31.6%	91.7%	70.5%	89.5%	0.467
High	10.5%	59.9%	53.8%	63.2%	0.525					
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.347**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.419**
	GS 05-790-0 Flow Stratification									
Low	70.2%	4.0%	6.7%	2.6%	0.356	57.5%	2.7%	6.7%	2.9%	0.179
Med	14.9%	8.0%	19.4%	8.2%	0.491	22.5%	15.9%	19.4%	11.9%	0.410
High	14.9%	88.0%	73.9%	89.2%	0.496	20.0%	81.4%	73.9%	85.1%	0.313
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.445**	**100.0%**	**100.0%**	**100.0%**	**99.9%**	**0.271**
	GS 05-750-0 Flow Stratification									
Low	33.3%	13.0%	16.4%	14.6%	0.473	100.0%	100.0%	100.0%	100.0%	0.148
Med	66.7%	87.0%	83.6%	85.4%	0.383					
High										
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.334**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.148**
	GS 05-780-0 Flow Stratification									
Low	35.5%	7.0%	16.0%	12.7%	0.180	41.2%	17.0%	16.0%	11.7%	0.264
Med	54.8%	49.1%	35.0%	50.1%	0.258	50.0%	65.3%	35.0%	52.6%	0.205
High	9.7%	43.9%	49.1%	37.2%	0.738	8.8%	17.7%	49.1%	35.7%	0.195
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.305**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.132**

Table 16. FLUX Modeling Results Using Flow Stratification – Percentages for Total Dissolved Solids and Total Kjeldahl Nitrogen.

	TDS					TKN				
	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance
	GS 05-760-0 Flow Stratification									
Low	100.0%	100.0%	100.0%	100.0%	0.327	45.2%	9.0%	6.4%	6.3%	0.206
Med						32.3%	16.3%	17.9%	20.9%	0.134
High						22.6%	74.7%	75.7%	72.8%	0.210
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.327**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.156**
	GS 05-785-0 Flow Stratification									
Low	100.0%	100.0%	100.0%	100.0%	0.208	100.0%	100.0%	100.0%	100.0%	0.377
Med										
High										
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.208**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.38**
	GS 05-790-0 Flow Stratification									
Low	100.0%	100.0%	100.0%	100.0%	0.135	41.7%	1.1%	6.7%	4.8%	0.084
Med						29.2%	8.2%	19.4%	19.5%	0.185
High						29.2%	90.7%	73.9%	75.7%	0.527
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.135**	**100.0%**	**100.0%**		**100.0%**	**0.401**
	GS 05-750-0 Flow Stratification									
Low	100.0%	100.0%	100.0%	100.0%	0.052	100.0%	100.0%	100.0%	100.0%	0.090
Med										
High										
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.052**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.090**
	GS 05-780-0 Flow Stratification									
Low	100.0%	100.0%	100.0%	100.0%	0.029	100.0%	100.0%	100.0%	100.0%	0.180
Med										
High										
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.029**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.180**

Table 17. FLUX Modeling Results Using Flow Stratification – Percentages for Total Phosphorus and Total Suspended Solids

	TP					TSS				
	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance	Actual % of Samples Collected	Optimal % of Samples	Percent of Volume	Percent of Mass	Co-efficient of Variance
	GS 05-760-0 Flow Stratification									
Low	47.2%	38.7%	6.4%	11.7%	0.740	42.9%	5.2%	6.4%	2.1%	0.347
Med	27.8%	9.0%	17.9%	9.6%	0.271	28.6%	20.2%	17.9%	12.5%	0.282
High	25.0%	52.3%	75.7%	78.8%	0.203	28.6%	74.6%	75.7%	85.4%	0.152
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.184**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.135**
	GS 05-785-0 Flow Stratification									
Low	52.4%	9.7%	15.1%	7.6%	0.261	100.0%	100.0%	100.0%	100.0%	0.461
Med	38.1%	40.6%	31.2%	32.1%	0.301					
High	9.5%	49.7%	53.8%	60.4%	0.392					
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.256**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.461**
	GS 05-790-0 Flow Stratification									
Low	68.6%	10.6%	6.7%	4.0%	0.362	53.6%	1.1%	6.7%		0.199
Med	15.7%	7.3%	19.4%	7.8%	0.271	21.4%	5.1%	19.4%	6.0%	0.281
High	15.7%	82.0%	73.9%	88.2%	0.267	25.0%	93.8%	73.9%	92.8%	0.313
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.237**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.291**
	GS 05-750-0 Flow Stratification									
Low	32.0%	10.3%	16.4%	11.7%	0.328	100.0%	100.0%	100.0%	100.0%	0.143
Med	68.0%	89.7%	83.6%	88.3%	0.257					
High										
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.231**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.143**
	GS 05-780-0 Flow Stratification									
Low	42.4%	18.4%	10.6%	6.1%	0.202	100.0%	100.0%	100.0%	100.0%	0.174
Med	48.5%	75.3%	46.8%	90.4%	0.176					
High	9.1%	6.4%	42.6%	3.5%	0.038					
Total/ Average	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.087**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.174**

Table 18. FLUX Modeling Results Using Seasonal (Quarterly) Stratification for Alkalinity and Ammonia.

	Alkalinity				Ammonia			
Dates	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance
GS 05-760-0 Seasonal Stratification								
12/01 - 03/15	23,691.37	1,122.93	19.14	0.528	90.78	4.30	19.14	0.554
03/15 - 0615	53,861.88	100.52	486.12	0.354	145.82	0.27	486.12	0.512
06/15 - 09/01	56,331.66	150.50	339.57	0.049	46.64	0.12	339.57	0.576
09/01 - 12/01	27,640.45	148.62	168.72	0.259	32.99	0.18	168.72	0.305
Total/ Average	**39,576.57**	**146.20**	**245.57**	**0.159**	**81.01**	**0.30**	**245.57**	**0.303**
GS 05-785-0 Seasonal Stratification								
12/01 - 03/15	34,782.09	256.72	122.91	0.136				
03/15 - 0615	91,989.05	130.97	637.18	0.216				
06/15 - 09/01	123,126.75	243.57	458.60	0.020				
09/01 - 12/01	56,699.55	236.71	217.30	0.078				
Total/ Average	**73,989.14**	**190.54**	**352.27**	**0.074**	**X**	**X**	**X**	**X**
GS 05-790-0 Seasonal Stratification								
12/01 - 03/15	4,329.74	186.93	21.01	0.090				
03/15 - 0615	84,199.46	160.27	476.59	0.071				
06/15 - 09/01	79,378.96	173.43	415.21					
09/01 - 12/01	24,845.82	129.24	174.41	0.275				
Total/ Average	**46,410.28**	**160.25**	**262.73**	**0.053**	**X**	**X**	**X**	**X**
GS 05-750-0 Seasonal Stratification								
12/01 - 03/15	90,400.14	153.14	535.51	0.141				
03/15 - 0615	776,066.11	115.94	607.22	0.156				
06/15 - 09/01	102,842.23	154.35	604.45	0.048				
09/01 - 12/01	90,029.73	146.16	558.78	0.031				
Total/ Average	**89,743.65**	**141.84**	**574.00**	**0.055**	**X**	**X**	**X**	**X**
GS 05-780-0 Seasonal Stratification								
12/01 - 03/15	14,721.85	206.25	64.75	0.203				
03/15 - 0615	43,786.08	139.47	284.82	0.694				
06/15 - 09/01	60,757.12	244.93	225.04	0.076				
09/01 - 12/01	27,965.98	248.71	102.01	0.035				
Total/ Average	**35,451.82**	**194.56**	**165.30**	**0.224**	**X**	**X**	**X**	**X**

Table 19. FLUX Modeling Results Using Seasonal (Quarterly) Stratification for Chemical Oxygen Demand and Dissolved Oxygen.

	COD				DO			
Dates	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance
GS 05-760-0 Seasonal Stratification								
12/01 - 03/15	4,080.78	193.42	19.14	0.732	157.90	7.48	19.14	0.612
03/15 - 0615	17,357.14	32.39	486.12	0.091	5,513.67	10.29	486.12	0.106
06/15 - 09/01	18,733.67	50.05		0.120	2,532.88	6.77	339.57	0.128
09/01 - 12/01	8,814.08	47.39	168.72	0.188	2,310.06	12.42	168.72	0.019
Total/ Average	**11,862.77**	**43.82**	**245.57**	**0.095**	**2,572.99**	**9.51**	**245.57**	**0.065**
GS 05-785-0 Seasonal Stratification								
12/01 - 03/15	3,995.43	29.49	122.91	0.235	1,136.67	8.39	122.91	0.056
03/15 - 0615	29,422.32	41.89	637.18	0.190	8,246.76	12.00	637.18	0.063
06/15 - 09/01	19,617.68	38.81	458.60	0.119	4,009.95	7.93	458.60	0.038
09/01 - 12/01	8,737.52	36.48	217.30	0.164	2,839.91	11.86	217.30	0.075
Total/ Average	**15,145.92**	**39.00**	**352.27**	**0.106**	**4,074.65**	**10.49**	**352.27**	**0.037**
GS 05-790-0 Seasonal Stratification								
12/01 - 03/15	74.20	32.03	21.01	0.277	309.13	13.35	21.01	0.092
03/15 - 0615	15,718.86	29.92	476.59	0.313	6,604.21	12.57	476.59	0.118
06/15 - 09/01	17,041.60	37.23	415.21	0.221	3,943.11	8.62	415.21	0.222
09/01 - 12/01	5,277.75	27.45	174.41	0.641	2,450.68	12.75	174.41	0.047
Total/ Average	**9,282.73**	**32.05**	**262.73**	**0.187**	**3,263.88**	**11.27**	**262.73**	**0.085**
GS 05-750-0 Seasonal Stratification								
12/01 - 03/15	19,081.97	32.33	535.51	0.087	7,561.48	12.81	535.51	0.037
03/15 - 0615	25,982.78	38.82	607.22		6,643.77	9.93	607.22	0.047
06/15 - 09/01	22,317.48	33.50	604.45	0.097	4,635.94	6.96	604.45	0.049
09/01 - 12/01	25,359.32	41.17	558.78	0.151	6,943.07	11.27	558.78	0.059
Total/ Average	**23,060.19**	**36.45**	**574.00**	**0.051**	**6,553.88**	**10.36**	**574.00**	**0.024**
GS 05-780-0 Seasonal Stratification								
12/01 - 03/15	1,993.20	27.92	64.75	0.093	717.75	10.06	64.75	0.077
03/15 - 0615	9,004.53	28.68	284.82	0.225	3,308.88	10.54	284.82	0.024
06/15 - 09/01	13,763.76	55.49	225.04	0.127	1,737.33	7.00	225.04	0.064
09/01 - 12/01	3,169.28	28.19	102.01	0.079	1,200.09	10.67	102.01	0.058
Total/ Average	**6,634.32**	**36.41**	**165.30**	**0.098**	**1,725.06**	**9.47**	**165.30**	**0.023**

Table 20. FLUX Modeling Results Using Seasonal (Quarterly) Stratification for Chemical Oxygen Demand and Dissolved Oxygen.

Dates	Fecal Coliform				Nitrates and Nitrites			
	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance
GS 05-760-0 Seasonal Stratification								
12/01 - 03/15	358.49	16.99	19.14	0.284	1.12	0.05	19.14	0.218
03/15 - 0615	2,509.53	4.68	486.12		217.55	0.41	486.12	0.423
06/15 - 09/01		90.52	339.57	0.211	131.20	0.35	339.57	2.505
09/01 - 12/01	10,818.16	58.17	168.72	0.416	316.77	1.70	168.72	0.937
Total/ Average	**10,872.49**	**40.16**	**245.57**	**0.178**	**161.82**	**0.60**	**245.57**	**0.650**
GS 05-785-0 Seasonal Stratification								
12/01 - 03/15	2,626.23	19.38	122.91	0.328	48.60	0.36	122.91	0.301
03/15 - 0615	22,759.76	32.40	637.18	0.348	408.03	0.58	637.18	0.490
06/15 - 09/01	30,280.17	59.90	458.60	0.399	145.91	0.29	458.60	0.218
09/01 - 12/01	27,923.51	116.57	217.30	0.421	181.44	0.76	217.30	0.648
Total/ Average	**19,995.05**	**51.49**	**352.27**	**0.220**	**195.94**	**0.50**	**352.27**	**0.308**
GS 05-790-0 Seasonal Stratification								
12/01 - 03/15	943.03	40.71		0.229	5.72	0.25	21.01	0.34
03/15 - 0615	13,196.66	25.12	476.59	0.428	317.34	0.60	476.59	0.65
06/15 - 09/01	28,512.52	62.30	415.21	0.500	49.69	0.11	415.21	0.33
09/01 - 12/01	4,732.77	24.62	174.41	0.279	187.01	0.97	174.41	0.91
Total/ Average	**11,017.18**	**38.04**	**262.73**	**0.315**	**141.30**	**0.49**	**262.73**	**0.48**
GS 05-750-0 Seasonal Stratification								
12/01 - 03/15	2,227.66	3.77	535.51	0.466	135.28	0.23	535.51	0.671
03/15 - 0615	7,881.23	11.77	607.22	0.403	97.66	0.15	607.22	0.538
06/15 - 09/01	56,802.49	85.25	604.45	0.295	34.85	0.05	604.45	0.418
09/01 - 12/01	16,682.88	27.08	558.78	0.472	52.18	0.08	558.78	0.630
Total/ Average	**18,861.94**	**29.81**	**574.00**	**0.221**	**83.85**	**0.13**	**574.00**	**0.364**
GS 05-780-0 Seasonal Stratification								
12/01 - 03/15	955.91	13.39	64.75	0.622	46.34	0.65	64.75	0.370
03/15 - 0615	3,731.16	11.88	284.82	1.033	73.47	0.23	284.82	0.666
06/15 - 09/01	21,639.68	87.23	225.04	0.226	134.82	0.54	225.04	0.313
09/01 - 12/01	7,388.22	65.71	102.01	0.879	43.69	0.39	102.01	0.625
Total/ Average	**7,744.25**	**42.50**	**165.30**	**0.281**	**71.78**	**0.39**	**165.30**	**0.246**

Table 21. FLUX Modeling Results Using Seasonal (Quarterly) Stratification for Orthophosphorus and Total Kjeldahl Nitrogen.

	OP				TKN			
Dates	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance
GS 05-760-0 Seasonal Stratification								
12/01 - 03/15	2.57		19.14	0.934	26.30	1.25	19.14	0.222
03/15 - 0615	41.38	0.08	486.12	0.286	484.56	0.90	486.12	0.273
06/15 - 09/01	12.80	0.03	339.57	0.457	507.07	1.35	339.57	0.106
09/01 - 12/01	12.02	0.06	168.72	0.889	241.27	1.30	168.72	0.267
Total/ Average	**17.03**	**0.06**	**245.57**	**0.249**	**301.91**	**1.12**	**245.57**	**0.130**
GS 05-785-0 Seasonal Stratification								
12/01 - 03/15	6.31	0.05	122.91	0.362	175.27	1.29	122.91	0.256
03/15 - 0615	97.70	0.14	637.18	0.517	1,403.15	2.00	637.18	0.782
06/15 - 09/01	32.98	0.07	458.60	0.173	477.79	0.95	458.60	0.285
09/01 - 12/01	14.99	0.06	217.30	0.288	183.23	0.76	217.30	0.319
Total/ Average	**38.04**	**0.10**	**352.27**	**0.350**	**563.07**	**1.45**	**352.27**	**0.513**
GS 05-790-0 Seasonal Stratification								
12/01 - 03/15	0.48	0.02	21.01	1.663	21.40	0.92	21.01	0.182
03/15 - 0615	49.25	0.09	476.59	0.383	725.54	1.38	476.59	0.700
06/15 - 09/01	21.20	0.05	415.21	0.173	517.78	1.13	415.21	0.163
09/01 - 12/01	10.88	0.06	174.41	0.779	379.90	1.98	174.41	0.233
Total/ Average	**20.24**	**0.07**	**262.73**	**0.268**	**400.67**	**1.38**	**262.73**	**0.338**
GS 05-750-0 Seasonal Stratification								
12/01 - 03/15	5.18	0.01	535.51	0.299	345.05	0.58	535.51	0.360
03/15 - 0615	9.89	0.01	607.22	0.309	655.20	0.99	607.22	0.039
06/15 - 09/01	6.24	0.01	604.45	0.195	668.68	1.00	604.45	0.205
09/01 - 12/01	4.19	0.01	558.78	0.213	528.34	0.86	558.78	0.100
Total/ Average	**6.34**	**0.01**	**574.00**	**0.150**	**537.40**	**0.85**	**574.00**	**0.090**
GS 05-780-0 Seasonal Stratification								
12/01 - 03/15	2.50	0.04	64.75	0.281	49.71	0.70	64.75	0.048
03/15 - 0615	10.79	0.03	284.82	0.181	339.59	1.08	284.82	0.393
06/15 - 09/01	28.52	0.12	225.04	0.183	356.97	1.44	225.04	0.231
09/01 - 12/01	3.54	0.03	102.01	0.275	97.05	0.86	102.01	0.154
Total/ Average	**10.51**	**0.06**	**165.30**	**0.121**	**202.50**	**1.11**	**165.30**	**0.192**

Table 22. FLUX Modeling Results Using Seasonal (Quarterly) Stratification for Total Phosphorus and Total Suspended Solids.

	TP				TSS			
Dates	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance	FLUX Rate (Tons/Yr.)	Flow Weighted Mean Conc.	Flow Vol. (millions of m^3/yr)	Co-efficient of Variance
GS 05-760-0 Seasonal Stratification								
12/01 - 03/15	18.06	0.86	19.14	0.896	232.67	11.03	19.14	0.942
03/15 - 0615	89.42	0.17	486.12	0.261	17,484.31	32.63	486.12	0.291
06/15 - 09/01	40.74	0.11	339.57	0.351	12,530.47	33.48	339.57	0.260
09/01 - 12/01	19.53	0.11	168.72	0.586	4,343.69	23.36	168.72	0.440
Total/ Average	**41.64**	**0.15**	**245.57**	**0.206**	**8,356.02**	**30.87**	**245.57**	**0.187**
GS 05-785-0 Seasonal Stratification								
12/01 - 03/15	11.52	0.09	122.91	0.257	1,417.48	10.46	122.91	0.577
03/15 - 0615	139.48	0.20	637.18	0.362	66,620.77	94.85	637.18	0.564
06/15 - 09/01	153.88	0.30	458.60	0.477	11,498.90	22.75	458.60	0.179
09/01 - 12/01	29.40	0.12	217.30	0.343	8,031.34	33.53	217.30	0.448
Total/ Average	**79.79**	**0.21**	**352.27**	**0.259**	**22,247.83**	**57.29**	**352.27**	**0.444**
GS 05-790-0 Seasonal Stratification								
12/01 - 03/15	3.15	0.14	21.01	1.156	215.27	9.29	21.01	1.082
03/15 - 0615	188.95	0.36	476.59	0.318	69,114.13	131.56	476.59	0.373
06/15 - 09/01	75.81	0.17	415.21	0.248	26,819.04	58.60	415.21	0.294
09/01 - 12/01	39.89	0.21	174.41	0.764	9,584.46	49.85	174.41	0.706
Total/ Average	**76.36**	**0.26**	**262.73**	**0.234**	**26,240.19**	**90.61**	**262.73**	**0.272**
GS 05-750-0 Seasonal Stratification								
12/01 - 03/15	106.67	0.18	535.51	0.501	3,893.54	6.60	535.51	0.493
03/15 - 0615	42.31	0.06	607.22	0.122	10,957.88	16.37	607.22	0.215
06/15 - 09/01	52.70	0.08	604.45	0.282	6,553.26	9.84	604.45	0.284
09/01 - 12/01	25.63	0.04	558.78		7,283.38	11.82	558.78	0.259
Total/ Average	**58.93**	**0.09**	**574.00**	**0.268**	**7,075.95**	**11.18**	**574.00**	**0.144**
GS 05-780-0 Seasonal Stratification								
12/01 - 03/15	4.43	0.06	64.75	0.189	403.52	5.65	64.75	0.360
03/15 - 0615	30.14	0.10	284.82	0.039	4,622.91	14.72	284.82	0.171
06/15 - 09/01	53.36	0.22	225.04	0.205	8,641.20	34.83	225.04	0.316
09/01 - 12/01	8.97	0.08	102.01	0.226	925.27	8.23	102.01	0.410
Total/ Average	**22.75**	**0.12**	**165.30**	**0.107**	**3,399.59**	**18.66**	**165.30**	**0.186**

5.4 Stream Monitoring Data Interpretation

The purpose of this section is to document any conclusions, question, or observations that may be derived from the stream data collected by the RLWD. Some observations and conclusions are made after data is reviewed in order to answer a specific question placed during a water-planning meeting. Others may come about from an attempt to explain a water quality problem that is obvious to everyone. Hidden inside the RLWD monitoring data are the answers to many questions.

In the late winter of early every year, the Thief River, which contributes to the public water supply of Thief River Falls, becomes anoxic and exhibits high levels of orthophosphorus and conductivity. This condition allows for the release of hydrogen sulfide by anaerobic decomposition. In the spring of 2003 this became particularly evident. Conductivity and total dissolved solids were extremely high in the early spring, 2535 and 1930 mg/L respectively. High conductivity/TDS levels normally indicate erosion. In this case, they may have been caused in part by concentrated runoff from sediment deposited in ditches during the winter. There was a high amount of wind erosion during the winter of 2002-2003, but not much snow (to dilute runoff). Ditches generally do not carry much sediment (TSS levels were okay) but the minerals dissolved from the newly deposited sediment into runoff from melting snow would have contributed to the high concentration of TDS and the resulting high conductivity levels. The amount of water existing as ice on the river (>3' thick) may have further minimized any chance of dilution, therefore exacerbating the problem and preventing the aeration of the water as well (low dissolved oxygen levels are common during the winter on the Thief River). When Agassiz NWR started releasing water later in the spring (late April – early May), it caused a different water quality problem on the river. High amounts of organic matter were flushed downstream. This contributed to a spike in total phosphorous (208 ppb) and TSS (76 mg/L) levels. Phosphorous is contained in sediment and organic matter. Organic matter doesn't dissolve in water (TDS levels were back to normal by this time), so it is would be a constituent of the suspended solids and nutrients in the water. Studies have also shown that much of the sediment loads in the Thief River come from channel erosion. More erosion occurs during high flows (such as when large amounts of water are released into the river) than at low or average flows, so the sudden influx of large amounts of water may have increased the amount of sediment from channel and stream bank erosion as well.

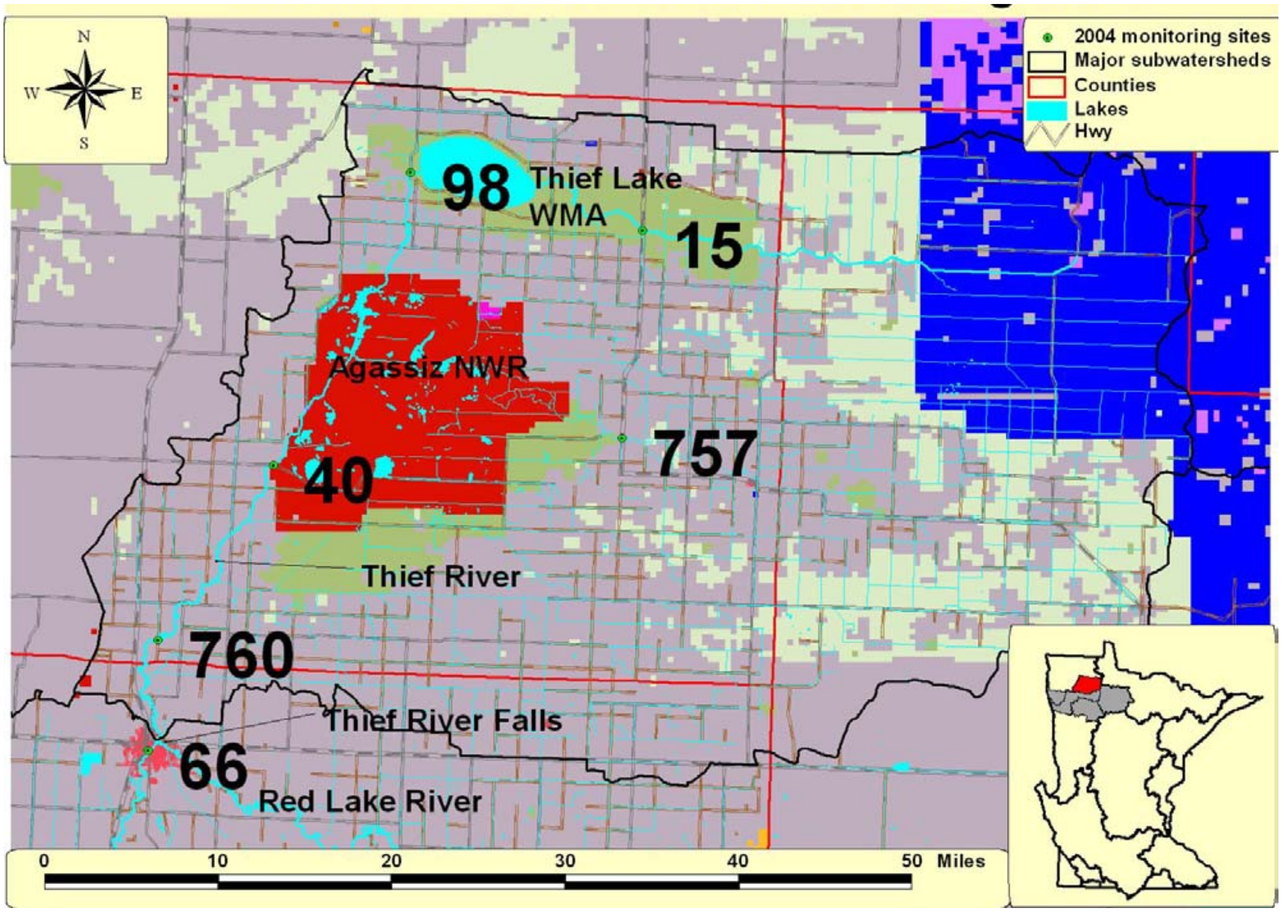

Figure 37. Thief River Watershed.

The high concentrations of pollutants entering the Thief River Falls Reservoir from the Thief River in the spring degrades the quality of water entering the city's water treatment plant surface water intakes. This water requires extra treatment, which involves treatment for taste and odor as well as chlorination. The increase in chlorination is evident in the city's public water supply during this time period. The water has a strong chlorine smell and the taste prompts many residents to buy bottled water for drinking. Improving water quality on the Thief River should be a priority of the RLWD, the City of Thief River Falls, other local agencies, and local landowners. Chlorination of water is necessary for the prevention of disease, but chlorination byproducts such as trihalomethanes (THMs) have been linked to cancer as well as elevated risks of birth defects and miscarriages. Chlorination byproducts are created when chlorine is combined with organic materials. Therefore, increases in sediment and nutrients cause an increase in potentially harmful chlorination byproducts. A report by the Environmental Working Group listed East Grand Forks and Thief River Falls as having elevated levels of chlorination byproducts. These cities ranked third and fourth in the state, respectively, for elevated risk of birth defects and miscarriages from high levels of chlorination byproducts in tap water. This report states that there is a 53% chance in Thief River Falls and a 55% chance in East Grand Forks that a pregnancy may be served water with high THMs (above 80 ppb) for an entire trimester. The cancer risk from THMs in East Grand Forks is the highest in the state. Thief River Falls has the third highest cancer risk from THMs. These cities also have the second (EGF) and third (TRF) highest recorded single THM measurements in the state.

We can reduce our exposure to chlorination byproducts by improving the quality of water within our rivers. The Red Lake River has relatively high background levels of sediment, but this does not mean improving the water quality in this river is impossible. Sediment loading from runoff increases the concentrations of suspended solids above natural levels. Additional erosion control measures and best management practices (which are lacking in many areas across this watershed) will be needed to reduce levels of sediment and nutrients entering the river. The Thief River exhibits water quality that meets standards during normal flows. However, during high flow periods and extremely low flow periods, water quality is significantly impacted. The hydrology within this watershed has been highly altered by drainage and impoundments that may be the primary factors behind the water quality problems in the Thief River.

Figure 38. Aerial Photo of Thief River/Red Lake River Confluence.

The RLWD is currently participating in a TMDL study on two impaired reaches within the Clearwater River watershed. The trout stream portion of the Clearwater River is listed as impaired for fecal coliform. Walker Brook, a tributary that enters the Clearwater River near Bagley, is impaired for dissolved oxygen. Both listings were based upon data collected for the Clearwater Nonpoint Study in 1992 and 1993. The Clearwater River was monitored intensively once again in 2002 for the Clearwater Lake Water Quality Model Project. The Clearwater SWCD also collected fecal coliform samples in late summer and fall of 2002. The new data shows that the reach is no longer impaired for fecal coliform. Only one set of samples exceeded the standard of 200 coliforms/100ml. These samples were collected during a large rainfall and runoff event. The results of the study will recommend that the trout stream reach of the Clearwater River be de-listed. The Walker Brook impairment, on the other hand, is still impaired by low dissolved oxygen levels. Ancient, oxygen depleted ground water is a major source of water for this stream. The stream also flows through organic soils and fens. The decomposition occurring in these depletes oxygen further.

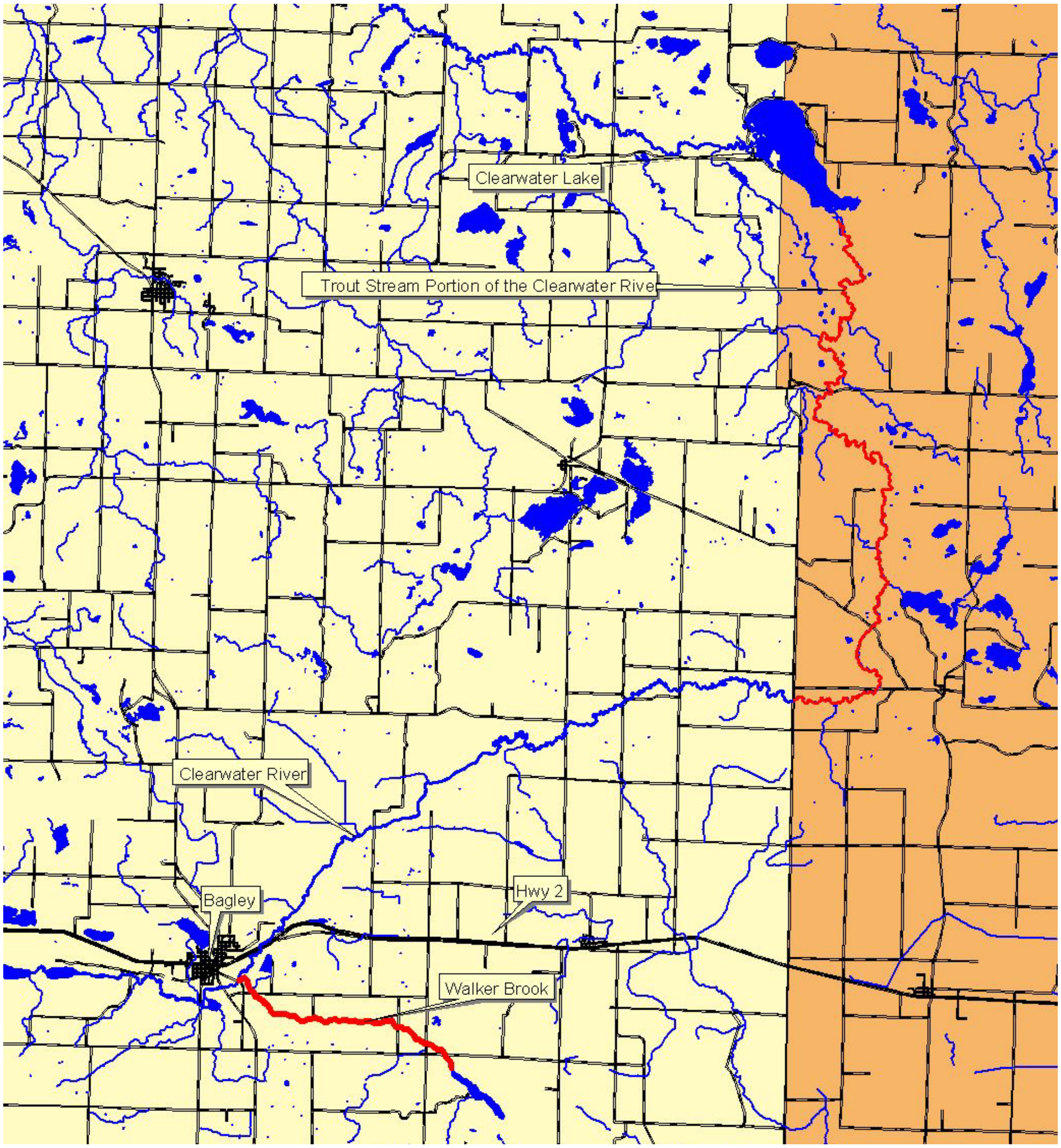

Figure 39. Area of Concern for the TMDLs on the Clearwater River Study.

5.5 Lake Monitoring Results

The RLWD has periodically monitored lakes in the past for special studies and now conducts yearly monitoring on several lakes within the district. The lakes that are currently monitored include Clearwater Lake, Cameron Lake, and Maple Lake. Pine, Cross, and Turtle Lakes have also been monitored in the past. Secchi depth readings, phosphorus samples, chlorophyll-a samples, dissolved oxygen profiles, temperatures profiles, and recreational suitability data are collected at each lake-monitoring site. Lakes are normally sampled monthly during the summer months. The Clearwater Lake Area Association (CLAA) and the Maple Lake Improvement District each aid the monitoring efforts on their respective lakes by paying for sample analysis and by providing the use of a boat and a volunteer to help with sampling. The monitoring conducted at each site is used to calculate the trophic state of the lake. The trophic state index (TSI) is a score based upon total phosphorus, Secchi disk, and chlorophyll-a readings. It is used to classify the growth and productivity of a lake. Lakes may be oligotrophic (<30), mesotrophic (40-50), eutrophic (50-60), or hypereutrophic (>70). Lakes with higher TSI scores have less transparent water, higher levels of nutrients, and higher amounts of algae in the water. Temperature and dissolved oxygen profiles show whether a lake is stratified or mixed at the time of sampling.

Clearwater Lake straddles the Clearwater County and Beltrami County border along the path of the Clearwater River. The water quality within this lake is normally quite good. High algae blooms and a sharp increase in the trophic state of the lake in 1997 increased local concern over the water quality of the lake. These water quality problems were most likely caused by high flows in the watershed and untreated wastewater bypassed by the overloaded Bagley wastewater treatment facility. In 2003, the Clearwater Lake Water Quality Model Study and the Clearwater Lake Management Plan were completed. The study found that the water quality within the lake has recovered since 1997 and the average trophic state levels are at a desirable level within the mesotrophic range. After 1997, there was a weed problem on the lake. The amount of floating vegetation has decreased since then, but the amount of rooted vegetation has increased in recent years, making access to the lake difficult from some docks and nearly blocking entrance to the southeast bay of the lake. This increased growth in vegetation may be due to phosphorus that has settled to the bottom of the lake. Clearwater Lake is monitored by the RLWD in cooperation with the CLAA and is also monitored once every three years by the Clearwater SWCD. The Clearwater Lake Management Plan sets goals for protecting and improving the water quality within the lake.

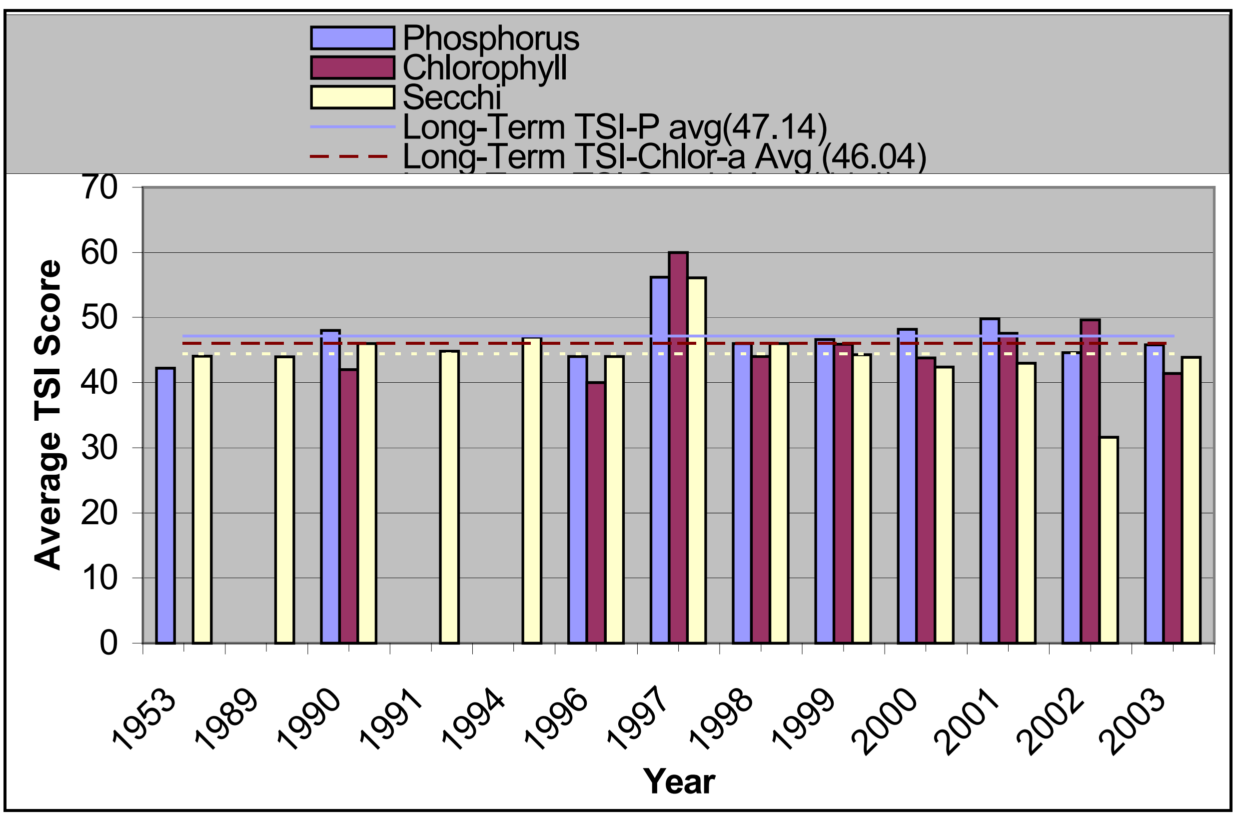

Figure 40. Clearwater Lake TSI Scores.

RLWD monitoring of Maple Lake began in 2004 at three sites within the lake. The inlets and outlets of the lake are being monitored too. See Section 3.2.2 and Section 6.2 for more information.

The Cameron Lake Investigative Study of 1997 reports that Cameron Lake has and continues to be impacted by a large amounts of nutrients entering the lake. Historically, sewage from the town of Erskine was dumped into the lake along with wastewater from a creamery. Today, high phosphorus levels are found in some of the inlets to the lake. Current sources of this phosphorus may be internal loading from the nutrient rich sediment of the lake, agriculture, and storm water from the city. Cameron Lake is a shallow hyper-eutrophic lake. Nutrients in the sediment are frequently mixed into the water column, resulting in an abundance of algae. There is local interest in doing something to restore the lake. Solutions are expensive, however, and may require grant money. The monitoring conducted by the RLWD will provide background data that will be used to justify a future restoration project and measure the success of the project.

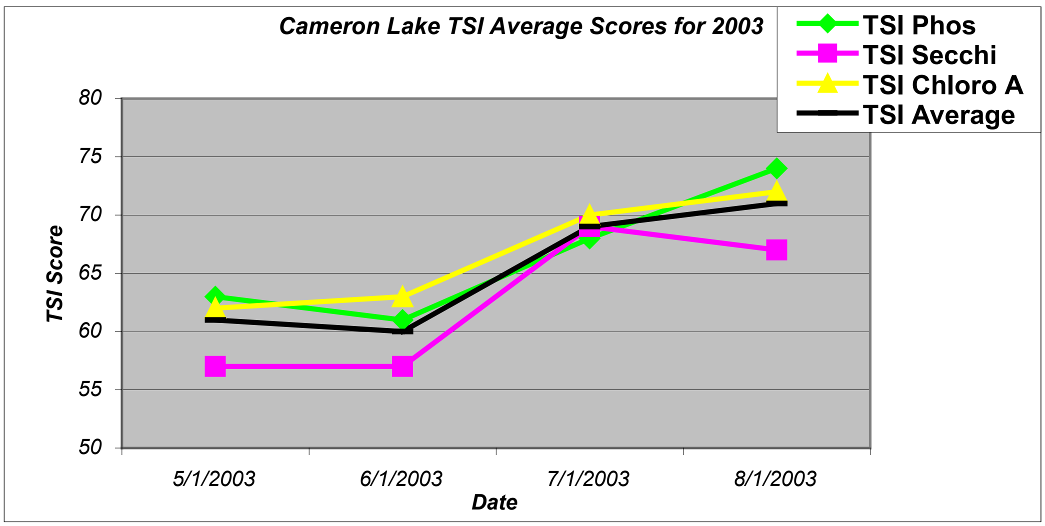

Figure 41. Cameron Lake TSI Values.

6.0 RECOMMENDATIONS FOR FUTURE MONITORING ACTIVITIES

6.1 Modifications to Goals and Objectives

The goal of the RLWD long-term monitoring program should be the collection of the highest quality and most useful data as possible within the RLWD. This data should be collected in such a manner as to allow for long-term trend determination, assessment based on MPCA protocols, load estimation, identification of pollution sources, and various other types of data analysis. The monitoring, unless otherwise authorized by the RLWD Board of Managers, should be conducted within the current number of samples and number of sites. The basic long-term monitoring plan is to sample approximately 30 sites 4 times per year, with allowance for investigative sampling and selective winter sampling.

Another way the RLWD long-term monitoring program data can be used for fair, representative assessments of water bodies within the RLWD is by collecting samples in such a way that the minimum requirements of MPCA 305b assessment protocols are met. The first requirement of these assessments is a minimum number of samples. This requirement is usually ten samples within the most recent ten years of data, so the RLWD collects more than enough samples at each site to meet this requirement. Fecal coliform assessments, however, have two steps. The first step involves determining whether sample results from the most recent ten years have exceeded the standard more than ten percent of the time. The second step looks for an aggregate average for any calendar month that is greater than the standard of 200 col/100 ml. The EPA makes a higher recommendation that five or more samples be collected in one individual month and then averaged. Since very few monitoring programs within the State of Minnesota that sample fecal coliform at this rate, the MPCA devised a method in which an aggregate average fecal coliform value for each calendar month is calculated from the most recent ten years of data (all June samples from 1994 through 2004). Fecal coliform values can vary throughout the year, but the past monitoring schedule was sampling the same times of the year every year. The new monitoring schedule with alternating months (see Section 3.2.1) will collect at least five samples per ten years of data for most of the open water months. This will ensure that any future assessments will be representative. To make sure that RLWD data is used for MPCA assessments, monitoring data should be submitted to the EPA STORET database regularly. The MPCA conducts biennial assessments (2001, 2003, 2005) and creates biennial lists based upon these assessments (2002, 2004, 2006). Data should be submitted in a timely fashion so that an updated data set is available for each assessment.

Data should be collected where annual load estimation is beneficial. Due to their importance for load calculation, the RLWD will continue to monitor sites co-located with USGS gauges. At other monitoring sites that are not located at USGS gauges stations and do not have rating curves, flow measurements should be taken at a range of flow levels so that complete rating curves can be created for all monitoring sites. These rating curves can be used to estimated flow using stage data collected over the years. RLWD continuous stage recording equipment should be utilized to its full potential at these monitoring sites.

For 2004-05, the RLWD will continue to collect field measurements for turbidity, transparency, pH, DO, and conductivity at district monitoring sites. RMB Environmental Laboratories will continue to analyze samples for TSS, TDS, TP, OP, fecal coliform, TKN, Ammonia N, Nitrates and Nitrites, and COD.

In order to achieve sooner and more accurate assessments of fecal coliform data (and to minimize the extent of bias created by one high sample result), fecal coliform monitoring results from the RLWD long-term monitoring program should be checked for levels exceeding the standard of 200 col/100ml when they are received. If sampling results for a site exceed fecal coliform standards, additional samples should be collected during the same month, if possible. Of course, the ability to do this depends on how quickly results are returned and the time of month at which samples are collected. If samples are collected in the beginning of each month, there may be enough time after results are received to collect additional (preferably 5) samples in that month.

Beginning in 2004, a new sampling schedule will be followed for the long-term monitoring program that will ensure that data will more completely assess streams and rivers in the RLWD while staying within the current budget and not monitoring any fewer sites. This new monitoring program is intended to be the most efficient and strategic sampling program possible using the current available budget. At least five samples per aggregate calendar month for the most recent 10 years of data are needed to assess a stream for fecal coliform. This new monitoring plan will allow for the assessment of all open water months (April – October). Sampling for each year will begin at ice-out. This normally occurs in either March or April. The other three months sampled will alternate each year. On the table below, note that the month in which sampling may resume is sometimes the same for two years in a row. For years in which ice-out occurs during the same month in consecutive years, the starting month will be the same, but the rest of the months will be sampled following the alternating schedule. There may be some years where April and May are sampled or that March and June are sampled, dependent upon when ice comes off the rivers. Odd year sampling rounds will be scheduled in March, May, July, and September. Even year sets of samples will be scheduled in April, June, August, and October. The table below shows an example of this schedule. Note that the alternation of the highlighted months does not vary. It is only the starting month that will vary because of weather conditions. Sometimes, April will be sampled several years in a row, and the same thing may happen for March if there is an early thaw in consecutive years. Also note that March should have been sampled in 2004 but ice was not off the rivers until April.

Table 23. Yearly Sampling Schedule.

Year	Month #1	Month #2	Month #3	Month #4	Schedule
2004	April	June	August	October	Even Year
2005	April	May	July	September	Odd Year
2006	March	June	August	October	Even Year
2007	April	May	July	September	Odd Year
2008	March	June	August	October	Even Year
2009	April	May	July	September	Odd Year
2010	March	June	August	October	Even Year
2011	April	May	July	September	Odd Year
2012	March	June	August	October	Even Year
2013	April	May	July	September	Odd Year
2014	March	June	August	October	Even Year

The RLWD long-term monitoring program collects data from a relatively long list of parameters. The number of stream water quality parameters monitored by the RLWD program is higher than the number monitored by any other agency's long-term monitoring program within the Red Lake River watershed and possibly within the entire Red River Basin. Alkalinity will be dropped from the list of parameters beginning in 2004. Alkalinity analysis will be suspended because results have remained relatively consistent and are rarely used in analysis. COD can be useful in explaining low dissolved oxygen levels, but the analysis costs twice as much as other types of and the results are rarely used. A more efficient use of RLWD funds would be to drop these two parameters in favor of monitoring a higher number of sites for the parameters that are used to assess a water body. Alkalinity and COD measurements can be reserved for special studies or only collected for certain sites where such information may be useful for explaining a water quality problem.

6.2 Modifications to the Monitoring Network

There are several ways to get the maximum benefit from RLWD quarterly sampling data for the purpose of assessing RLWD waters. One of these is proper site selection. In order to achieve the most strategic site selection, the RLWD will work with the Red River Basin Monitoring Network to ensure that primary and secondary monitoring sites are sufficiently monitored. Primary sites within the RRBMN measure water quality near the bottom of each major subwatershed of the Red River of the North. The Red Lake River, Clearwater River, and the Thief River are each monitored at primary sites. Secondary sites are the tributaries of these major rivers, such as the Lost River, Hill River, Poplar River, Burnham Creek, and the Black River.

For 2004, SG #131, the Clearwater Lake Inlet, will be monitored because it lies on the trout stream portion of the Clearwater River, which was listed as impaired for fecal coliform. The Red Lake Dam monitoring site will be dropped in 2004 in order to avoid duplication of sampling efforts among agencies. The Red Lake DNR monitoring program will effectively monitor this site. Supplemental through-ice samples will be collected at selected sites on the Thief and Red Lake Rivers at the Thief Lake outlet (98), downstream of Agassiz NWR (40), Hillyer Bridge (760), First Street Bridge in Thief River Falls (66), and Murray Bridge in East Grand Forks. Investigative samples will be collected upstream (POP10) and downstream (POP20) of the Fosston lagoons when they are discharging. Water quality has been severely degraded downstream of the lagoons in the past during the discharge period. Site number 86 in Gentilly will be sampled during district monitoring sampling runs.

There are some changes to the monitoring program that have not been made for the 2004 monitoring season, but may be considered in the future. One of these involves considering that the Poplar River Diversion has never been used. There are three current monitoring sites that are primarily associated with this project (109, 59, and 63). The Maple lake monitoring sites (53-I and 53-O) also relate to this project, but the water quality within Maple Lake is of such concern that these sites should be a permanent part of the monitoring program. Sites 59 and 63 may have some importance pertaining to water quality in Badger Lake. Site 109 is positioned to monitor the quality of water that would go into the Poplar River diversion channel from the Poplar River if the water control structure were ever opened. These three sites may have the least strategic significance of the RLWD long-term monitoring sites, simply because the diversion project is not used. If the project were to be actively used, they would have special importance as monitoring sites. These sites could be dropped in the future to compensate for any future additions of strategically important monitoring sites.

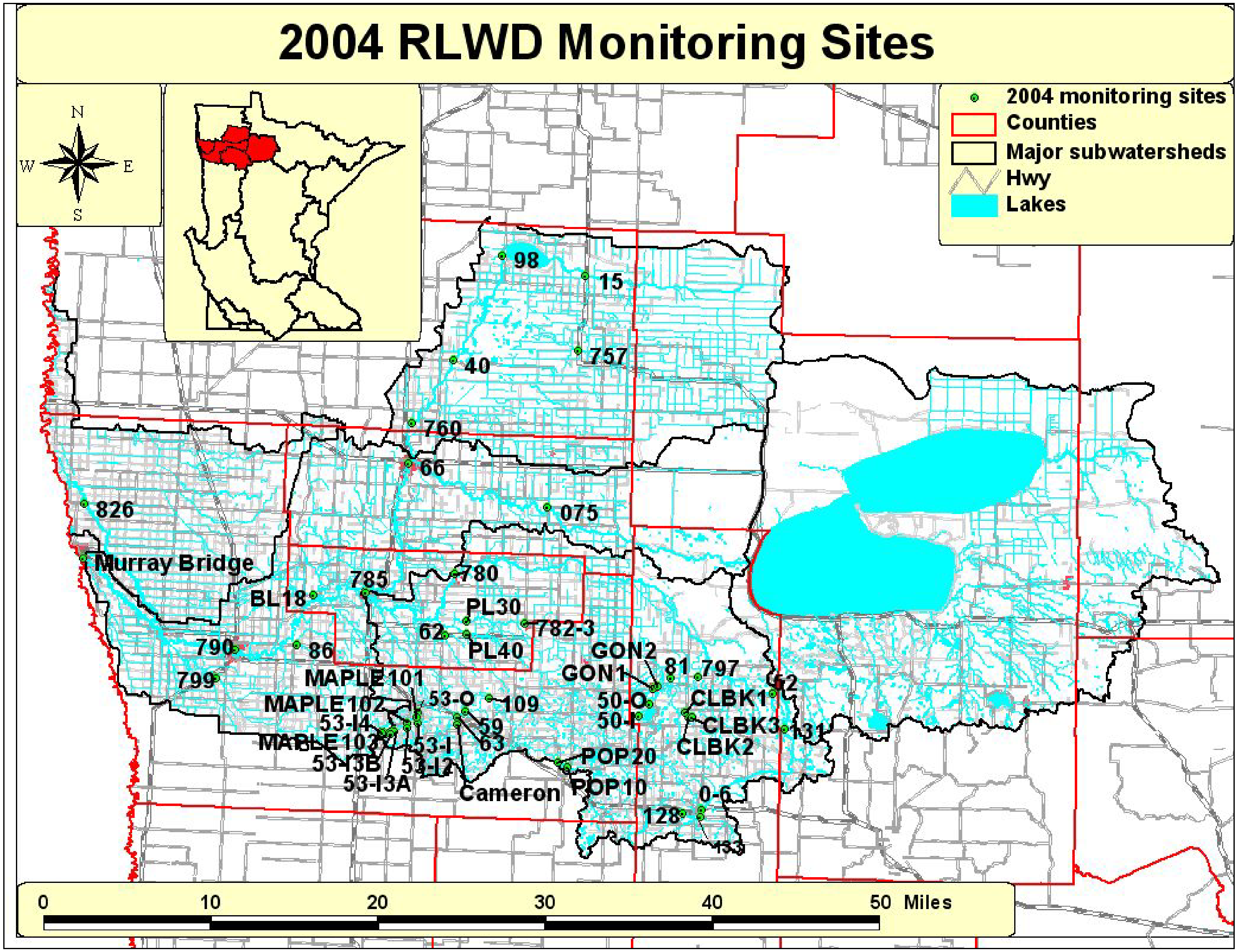

Figure 42. 2004 Monitoring Sites.

6.3 Future Monitoring Costs

The Red Lake Watershed District has spent an average of $41,000 per year on its water quality program. The following table is a breakdown of annual expenditures for the project since its initial implementation starting in 1984 with some years missing.

Table 24. Water Quality Program Expenditures.

Year	Water Quality Program Expenditures
1984	$6,786.28
1985	$10,305.08
1986	$9,034.11
1987	$9,924.41
1988	$24,057.91
1989	$23,384.52
1990	$10,956.03
1991	$52,873.32
1992	$16,016.51
1993	$25,270.00
1994	$33,114.00
1995	$100,443.00
1996	$33,114.00
1997	$86,666.00
1998	$107,983.00
1999	$94,849.00
2000	$64,735.00
2001	$92,299.00
2002	$57,255.00
2003	$59,502.00

The increased annual expenditures in 1991 was a result of contracting of a private lab to do some sample analysis and the hiring of a full time person exclusively for the water quality project. The obvious decrease from 1991 to 1992 is a result of the time charged to the Clearwater Non-point Study. In 2002, the RLWD hired a water quality technician to assist the water quality coordinator. The projected increase in overall expenditures and costs per sample will be approximately three to four percent a year.

In the future, the number of monitoring sites and sampling frequency for the RLWD long-term monitoring program will be kept at approximately the same level. This is done so that the amount spent on the RLWD water quality program remains at a level that is acceptable to the RLWD Board of Managers. Costs should be expected to rise a little each year due to increases in wages and any future increases in the cost of analysis. In the RLWD budget, monitoring and office work fall under the same project code but are differentiated by work type (19 for water quality field work and 7 for engineering office work). However, for budget and salary purposes, they are combined. Therefore, the amount of time spent in the office on data entry, data analysis, correspondence, and meetings has nearly as much impact on the level of water quality program expenditures for each year as field work and sample analysis. For 2004, additional sites were added to the program (others were dropped, but the number did increase from 31 to 33). Alkalinity analysis was dropped from the program for this year because of the money savings and because the data is not used for assessments or data interpretation. Sampling results for alkalinity from within the RLWD have consistently been at desirable levels. Dropping alkalinity will save the program at least $1200 per year. COD is another parameter that could possibly be dropped from the program in order to save money. It is still part of the monitoring program in 2004, but if reducing the budget becomes a necessity in order accommodate additional sites or rises in the cost of analysis, dropping COD would save $18.50 per sample (it is the most expensive), or nearly $2500 per year.

6.4 Potential Funding Sources

Funding for special water quality monitoring and implementation projects should be sought whenever possible. Examples of such projects include studies that require more intensive monitoring than is allowed under the budget constraints of the RLWD long-term monitoring program. Funding sources that the RLWD has utilized in the past include EPA 319 Grants and loans, BWSR Challenge Grants, a TMDL Study, and the Red River Watershed Management Board. Examples of 319 Grant projects include the Clearwater River Bank Stabilization/Revitalization Project and the Glacial Ridge Project. The RLWD has received BWSR Challenge Grant money for the Clearwater Lake Water Quality Model Project, and the Red River Watershed Assessment Protocol Project (which funded the development of this report). Both 319 grants and BWSR Challenge grants are awarded over a period of two years. The RLWD Water Quality Coordinator works closely with the MPCA Red River Basin Coordinator in order to identify potential funding sources and put together applications. Additional funding sources include Northwest Minnesota Foundation grants and EPA Watershed Initiative grants.

Every year, the MPCA administers funding for EPA Clean Water Partnership and Section 319 projects. These grants are aimed at addressing nonpoint-source water pollution by supporting projects initiated by local units of government and citizens. These grants require a one-to-one match from the local participants. A local unit of government must sponsor a CWP project, but Section 319 grants are open to all entities except federal agencies. Other differences between the two grants are that the CWP grants are funded with state money and 319 grants are funded with federal money. The CWP funds cannot be used for in-lake treatment and the 319 funds cannot be spent on diagnostic work. The application period is opened in late summer and remains open for 60 days. The 2004 application deadline is Monday, October 18.

Minnesota Board of Water and Soil Resources Local Water Management Challenge Grants help local governments manage surface water, groundwater, and related resources. These grants put emphasis on lake management planning and priorities identified under local water plans. There are four categories under which to apply: land and water conservation practices, monitoring, inventory, and education/information. Preference has been given to lake management plan projects. The 2003 application period was from June 10th through July 1st.

There are many river reaches within the RLWD that are listed as impaired on the MPCA 303d List of Impaired Waters (the TMDL list). The cause of the impairment and recommendations for rectifying the impairment are examined by a TMDL (Total Maximum Daily Loads) study. These studies are funded by the MPCA and involve local agencies and experts. The current study is focusing on a fecal coliform impairment on the trout stream portion of the Clearwater River and dissolved oxygen impairment on Walker Brook. The RLWD acts as a fiscal agent for the project by receiving money from the MPCA and distributing it to the project partners. The RLWD's responsibilities in this project include monitoring, data analysis, water quality modeling, assisting with load allocations, contributing to the final report, and project administration.

Below is a table showing the total amount of money the RLWD has recently received form each source.

Table 25. Outside Funding Received by the RLWD for Water Quality Projects.

Outside Funding Received by the RLWD for Water Quality Projects since 2001				
Source	319 Grants	BWSR	RRWMB	TMDLs
Amount Received	$684,500.00	$80,750.00	$25,000.00	$32,450.00

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