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Acknowledgements

The project partner organizations involved in implementation of this project have been the Red Lake Watershed District, Marshall-Beltrami SWCD, HDR Engineering, and the Red Lake DNR. The Marshall-Beltrami SWCD can conduct monitoring within Beltrami County and Marshall County. The assistance with sampling was especially valuable when tile was flowing, but RLWD staff were busy collecting samples elsewhere. The Marshall-Beltrami SWCD will likely collect the majority of the samples collected at the Marshall and Beltrami County sites because they are willing to do so and also because these sites are "out of the way" for RLWD staff and are not located near any other RLWD monitoring projects. HDR Engineering will assist the RLWD in designing an accurate flow monitoring system for making comparisons between tile drainage and surface drainage.

Project Participants and Advisors:

- Corey Hanson, Red Lake Watershed District Water Quality Coordinator
- Nate Dalager and Keith Winter of HDR Engineering
- Lisa Newton, District Technician, Marshall-Beltrami Soil and Water Conservation District
- Molly MacGregor, MPCA Red River Basin Coordinator, was instrumental in the grant application process.
- Red Lake Band of Chippewa
    - Darrell Schindler, Aquatic Biologist, Red Lake Department of Natural Resources
    - Joel Rhode, Red Lake Department of Natural Resources
- Dave Bachand, Landowner and Farmer, Red Lake County
- Kevin Yaggie, Landowner and Farmer, Red Lake County
- Red Lake Band of Chippewa, Wild Rice Producer, Clearwater County
- Clearwater Rice, Wild Rice Producer, Clearwater County
    - Rod Skoe, Owner
    - Don Barron
- Stanley Farms, Inc., Landowner and Farmer, Marshall and Beltrami Counties
    - Todd Stanley
    - Arnold Stanley
- James and Steven Sparby, Landowners and Farmers, Marshall County
- Hans Kandel, Extension Educator/Professor, University of Minnesota Crookston

- Red River Watershed Management Board Technical Advisory Committee
    - Charlie Anderson
    - Dan Thul
    - Ron Adrian
    - Jerry Bents
    - Nate Dalager
- Gary Sands, Associate Professor and Extension Engineer, University of Minnesota
- Field Drainage, Inc.
- James Blix, Water Quality/Natural Resources Technician, Red Lake Watershed District
- Jim Steenerson – Northwest Minnesota Foundation Grants Specialist
- Peggy Crandall – Northwest Minnesota Foundation Grants Services Associate
- Greg Hilgeman – Landowner
- Paul Imle – Landowner
- John Gunvalson – Landowner

Abstract

The Red Lake Watershed District and its project partners have been studying the water quality characteristics of tile drainage within the Red River Basin. The theories about tile drainage being tested are that it should have:

1. Lower total phosphorus concentrations
2. Lower total suspended solids concentrations
3. Higher nitrate concentrations
4. Lower peak flows from a field
5. Greater total volume of drainage from a field over time.

The data collected seem to support these theories, with the exception of wild rice drainage. When main line tile drainage is used in wild rice paddies without internal surface drainage, it has all the same benefits as conventional tile drainage (low phosphorus and sediment) and has low nitrate levels instead the high levels that were found in conventional agriculture tile drainage. It also has many benefits to the wild rice farmer. Because of the impact drawdown of surface drained paddies has upon water quality in the Clearwater River, complete conversion of wild rice paddies to main line tile drainage is imperative.

Executive Summary

The amount of tile drainage in northwestern Minnesota has been increasing. There has been interest among natural resource and water management professionals about the effect this trend will have upon water quality within the Red River Basin. The tiling methods would be different from southern Minnesota – flatter terrain needs no surface inlets. Prior to this study, there were differing opinions about what water quality from tile drainage would be like, even though little data had been collected. The theories being tested with this study are:

- Tile drainage should have lower suspended solids concentrations than surface drainage.
- Tile drainage should have lower total phosphorus concentrations than surface drainage
- Tile drainage will likely have higher nitrate concentrations than surface drainage
- Storm runoff from a tile drained field should have lower peak flows than a surface drained field*
- Storm runoff from a tile drained field will likely have a greater total volume of runoff over time than a surface drained field.*

*An add-on component of the project. Work is being completed by HDR Engineering.

Data collected for this study up to this point support these theories. There have been some exceptions and other questions that have been answered through this monitoring. With conventional agriculture, there seems to be a water quality trade-off. We get lowered sediment and phosphorus concentrations, but nitrate concentrations are increased. Monitoring of wild rice paddies during drawdown in late summer has shown that without main line tile and elimination of internal ditching, wild rice paddy drainage has a very detrimental effect upon water quality in the Clearwater River. The benefits of main line tile drainage in wild rice paddies were that drainage water was clean, clear, and had low nitrate levels. Plus, it had low nitrate levels.

A major recommendation of this study would be the complete conversion of wild rice paddies to main line tile drainage. There should also be further research into the effect that higher levels of nitrates and specific conductivity in tile discharge may have upon our rivers. The net result of conversion to tile drainage from surface drainage appears to be less sediment and phosphorus loss due to water erosion, but increased total nitrogen loss due to excessive leaching of nitrates (even though surface drainage has higher concentrations of total Kjeldahl nitrogen - ammonia plus organic nitrogen).

Problem Identification/Background

Introduction

This study was designed to gather real-world data to better understand the potential impact that increased tile drainage may have within the Red River Basin. Prior to this project, there were a lot of differing opinions about how the increasing amount of tile drainage in the Red River Basin would affect water quality. However, there was a lack of actual water quality data from tile drainage within the basin. This study was designed to provide actual data from tile drainage in several different areas throughout the Red Lake Watershed District. In this study, tile drainage water quality has been compared with surface drainage water quality. The study also compares flow (surface. vs. tile) and different methods of tile drainage. The study includes both conventional agriculture and wild rice paddy drainage.

The Red Lake Watershed District had the opportunity to conduct this study for several reasons. First of all, the watershed district has the ability to conduct the project. The RLWD has been conducting regular water quality monitoring and sampling at over 30 sites for more than 20 years on rivers and streams throughout the district and also conducts lake monitoring. The RLWD has the necessary technical resources in full-time water quality staff, up-to-date equipment, plus the financial ability to initiate intensive studies. These additional studies are usually, but not always, grant funded. The RLWD uses the services of RMB Environmental Laboratories, a Minnesota Department of Health certified laboratory, for sample analysis. The RLWD has also recently completed the Minnesota Board of Water and Soil Resources funded Red River Watershed Assessment Protocol Project under which the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* and the *Red River Watershed Water Quality Reporting Handbook* were created. The Protocol project gave the RLWD the opportunity to produce examples of what can be done with a water quality monitoring program (website, online water quality database, FLUX modeling, and comprehensive water quality report). The RLWD water quality program has developed a working relationship with the MPCA and has involved landowners in its planning process. In fact, one of the important factors in the development of this project was the desire of local farmers to learn more about the water quality of what is flowing from their tile.

There actually were so many landowners interested in the study that, although they were included in the search for suitable monitoring sites, it was not possible to include all of their farms in the study. In addition to landowner interest, there also was interest

in the study from the Red River Basin Water Quality Team, local scientists, Minnesota Pollution Control Agency, University of Minnesota Extension Service, and the Red Lake Nation Department of Natural Resources. The original focus of the project was tile drainage installed in wild rice paddies, but it was expanded to include conventional agriculture (grains/row crops). The Red Lake Watershed District has received a $17,500 grant from the Northwest Minnesota Foundation to study the effects of tile drainage on water quality. The Red Lake Watershed Farm to Stream Project will compare different tiling techniques, tile drainage with surface drainage, and agricultural drainage with natural drainage. The original total predicted cost of the project was $35,000. Due to increasing interest in the project, additional funding for accurate flow monitoring was provided by the Red River Watershed Management Board. The Marshall-Beltrami SWCD also received a grant for collecting tile drainage water quality samples in Beltrami County. The study was conducted in 2005 and 2006 with the possibility that flow monitoring may continue into the future. With an extension of the grant from the Northwest Minnesota Foundation, the study was continued through 2007. It would be beneficial to continue the flow monitoring portion (and perhaps storm runoff water quality sampling) into 2008 and maybe longer. Results are presented here in the form of a scientific report and are summarized in the form of informational pamphlets as well. Study results will also be available on the RLWD website (http://www.redlakewatershed.org).

The amount of tile drainage within the Red River Valley has been increasing, as has interest in its effects upon water quality and flow volume. It was anticipated that the water quality characteristics of tile drainage within the Red River Basin will differ from southern Minnesota. One of the main reasons for this is a lack of surface inlets in tile systems within the Red River Basin. According to *Agricultural Drainage Issues and Answers*, "surface inlets provide a fairly pathway for sediment and other contaminants in surface runoff to reach nearby surface waters." The theories being tested with this study are based upon some sampling conducted by the Marshall-Beltrami Soil and Water Conservation District, studies from other regions, and predictions of scientists. These theories include, but are not limited to:

- Tile drainage should have lower suspended solids concentrations than surface drainage.
- Tile drainage should have lower total phosphorus concentrations than surface drainage
- Tile drainage will likely have higher nitrate concentrations than surface drainage

- Storm runoff from a tile drained field should generate lower peak flows than a surface drained field
- Storm runoff from a tile drained field will likely generate a greater total volume of runoff over time than a surface drained field.

Even though tile drainage may reduce the amount of soil erosion, total suspended solids loadings, and total phosphorus concentrations, there is still concern that it may increase concentrations of nitrates in streams and rivers. Some drainage management practices may be able to reduce nitrogen losses through increased denitrification and reduced leaching. These methods include proper nutrient management, shallow tile drainage, and controlled tile drainage.

Water quality samples were be collected and analyzed for total suspended solids, total phosphorus, orthophosphorus, total nitrogen (total Kjeldahl nitrogen + nitrate + nitrites), and nitrates. Field measurements were collected for dissolved oxygen, temperature, conductivity, pH, turbidity, and transparency where possible. Turbidity analysis was conducted at all sampling sites. Although it was not feasible to get accurate flow measurements from every monitoring site for this study, supplemental funding was received from the Red River Watershed Management Board to make an accurate comparison between tile and surface drainage flows. Monitoring sites were chosen for each comparison (water quality and/or quantity) so that the characteristics of the watershed would be comparable. The different types of tile drainage outlets that will be compared for the water quality study include gravity outlets, pumping stations, and water control structures. The primary goal of this study is to successfully collect water quality and flow data from gravity tile drainage outlets, pumped tile drainage outlets, controlled tile drainage outlets, surface drainage, and reference sites. Study areas are located in the Clearwater River watershed in Red Lake and Clearwater Counties, and also in the Thief River watershed near Grygla.

Project Goals

- Characterize sediment and nutrient concentrations from tile drainage in the Red River Basin.
- Document sediment and nutrient concentrations from different types of tile outlets.
- Compare sediment and nutrient concentrations from tile drainage with concentrations from surface drainage and natural background levels.

- Accurately study the effect that tile drainage has upon flow.
    - Peak flow volumes versus surface drainage
    - Total flow volume versus surface drainage
- Collect an amount of data that is sufficient for drawing conclusions.
- Provide information that can be used for decision making within the Red River Basin.

Benefits of Tile Drainage to the Farmers

It is well documented that tile drainage has many benefits to the farmers that install it. According to University of Minnesota Associate Professor and Extension Engineer Dr. Gary Sands, some of these benefits come from an increase in crop yields and improved field conditions and include:

1. Increased Profits
2. Extended growing season
3. Decreased plant stress
4. Reduced wetness-related diseases
5. Decreased soil compaction
6. Decreased salts on the farmers' land
7. Increased infiltration
8. Less ditches needed within the field = more area to grow crops
9. Reduced soil erosion from runoff
10. Timely tillage, planting, and harvesting

I have learned from wild rice farmers and Red Lake Nation Department of Natural Resources staff that main line tile drainage also has benefits for wild rice farming. These benefits include but are not limited to:

1. More evenness of rice quality and maturity
2. Less ditch maintenance
    a. No internal ditches
    b. Less sediment loading
3. Fewer ruts during harvest
4. More control over drainage
5. No top soil loss
6. Ends of tile outlets don't get plugged if main line tile is used instead of internal perimeter ditches

Figure 1. Recently harvested main-line tile drained wild rice paddy

Figure 2. Installation of wild rice paddy tile drainage

Red River Basin Water Quality Issues

Many streams and rivers within the Red River Basin, especially within the Red River Valley ecoregion, elevated concentrations of sediment. Many of these streams are listed on the MPCA's 303(d) List of Impaired Waters as being impaired by turbidity. Eutrophication within Lake Winnipeg due to excess phosphorus loading is another major problem within the Red River Watershed.

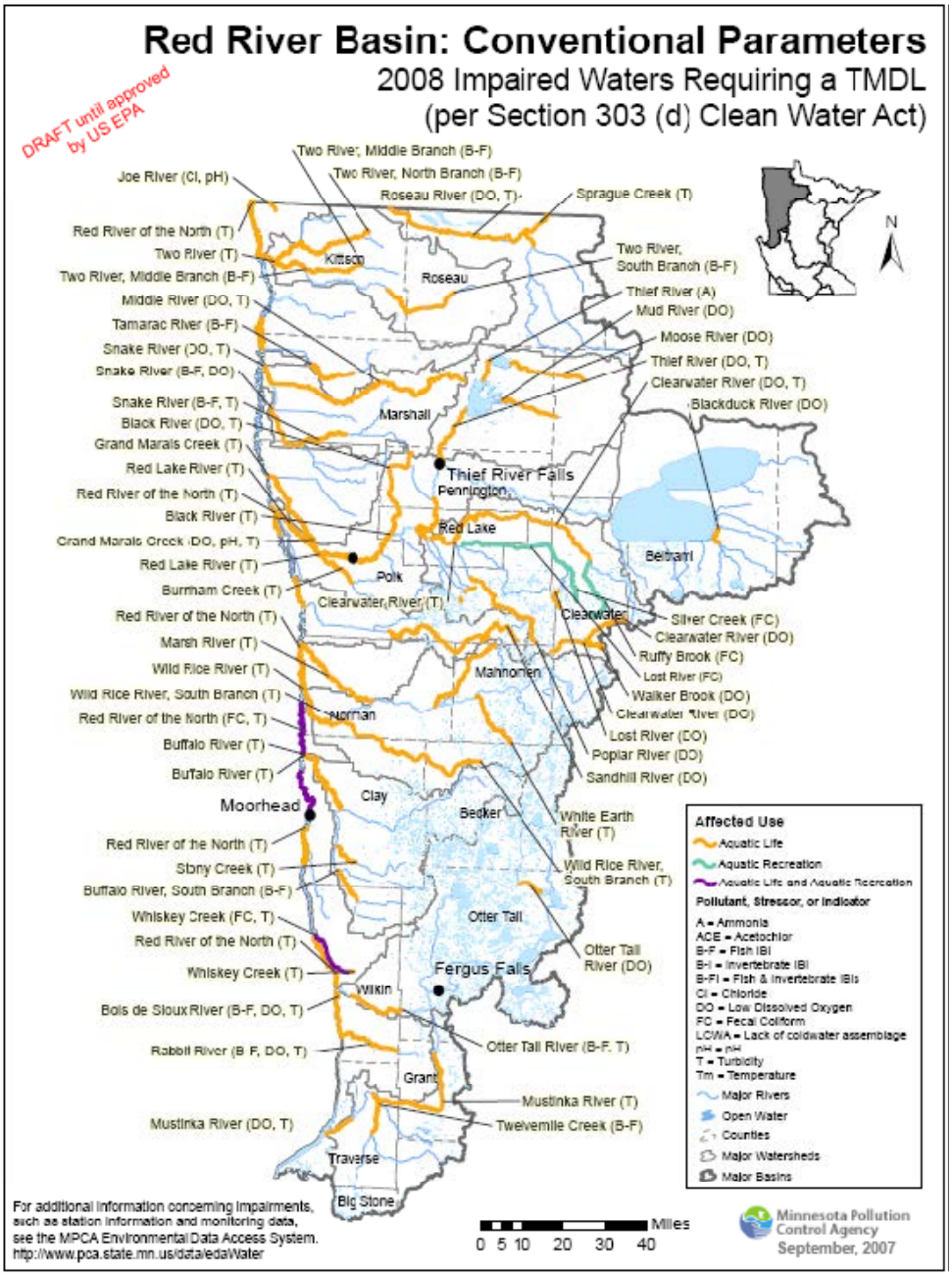


Figure 3. Red River Basin Water Quality Impairments

Project/Task Description

Project Budget

Table 1. Tile Drainage Study Project Budget

Expenditures	NWF	Other Sources Cash	Other Sources In-Kind	TOTAL
I. PERSONNEL				
A. Salaries and Wages	$13,500		$7,250	$20,750
B. Fringe Benefits	$0		$0	$0
II. CONSULTANTS & CONTRACT SERVICES				
III. NON-PERSONNEL				
A. Space Costs				$0
B. Rental, Lease, or Equip. Purchase		$3,250		$3,250
C. Technology Related Expenses				$0
D. Consumable Expenses				$0
E. Travel				$0
F. Telephone				$0
G. Evaluation (not to exceed 5% of total project cost)			$1,500	$1,500
H. Laboratory Analysis	$4,000	$5,000	$0	$9,000
I. Printing Costs		$200		$200
J. Construction Materials (monitoring station setup)		$300		$300
TOTAL COSTS	$17,500	$8,750	$8,750	**$35,000**

Project Area

This project is intended to collect tile drainage data from within the Red River Basin. Most of the data that was available prior to this study was from outside of the basin. This study took place, more specifically, within the Red Lake Watershed District and within the Thief River and Clearwater River major subwatersheds.

The monitoring sites in Red Lake County lie within the Red River Valley Ecoregion. The tile monitoring sites near Grygla, within the Thief River watershed, are in the Northern Minnesota Wetlands Ecoregion. The Red Lake Nation wild rice paddy monitoring sites are located near the eastern boundary of the Red River Valley Ecoregion.

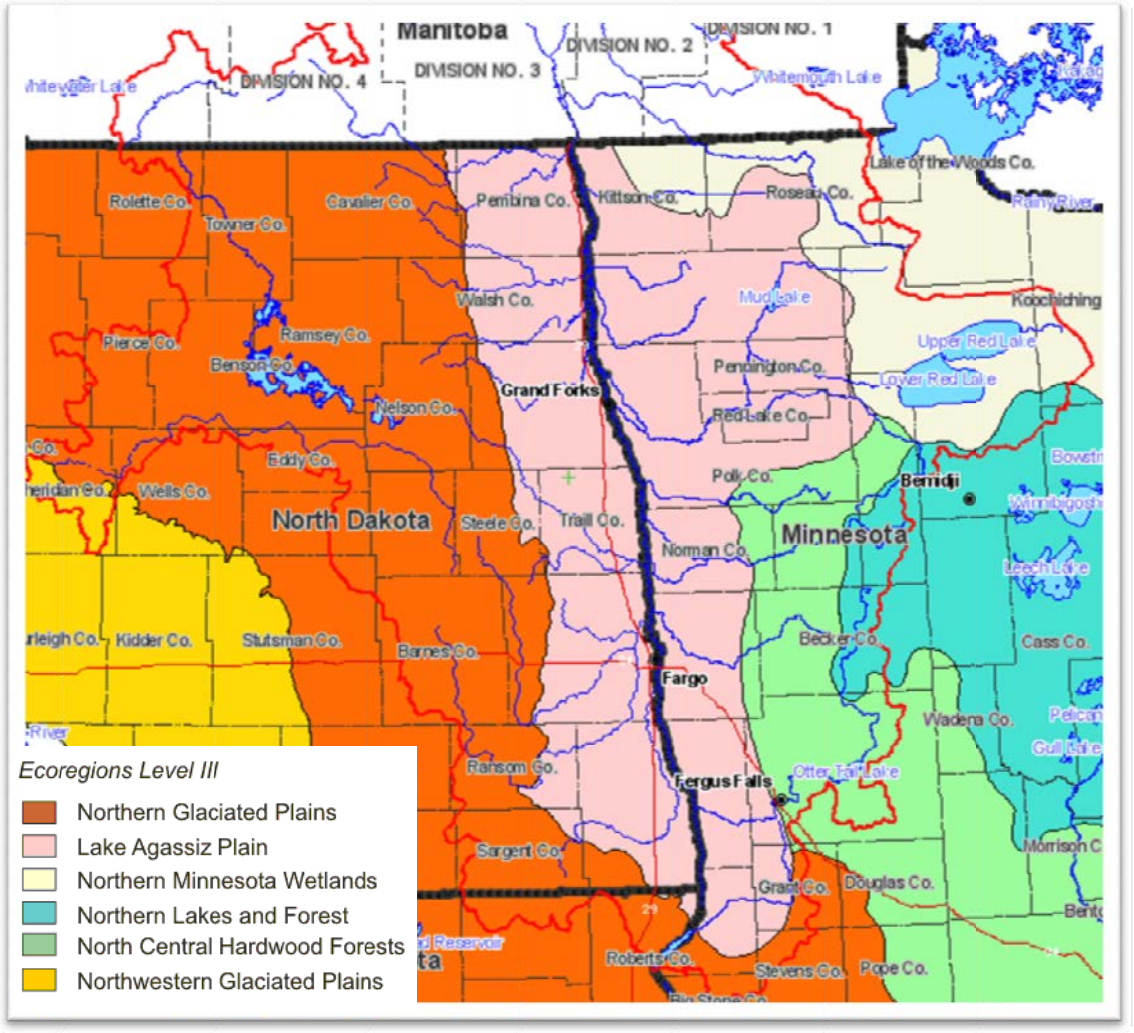


Figure 4. Red River Basin Ecoregions in Minnesota and North Dakota

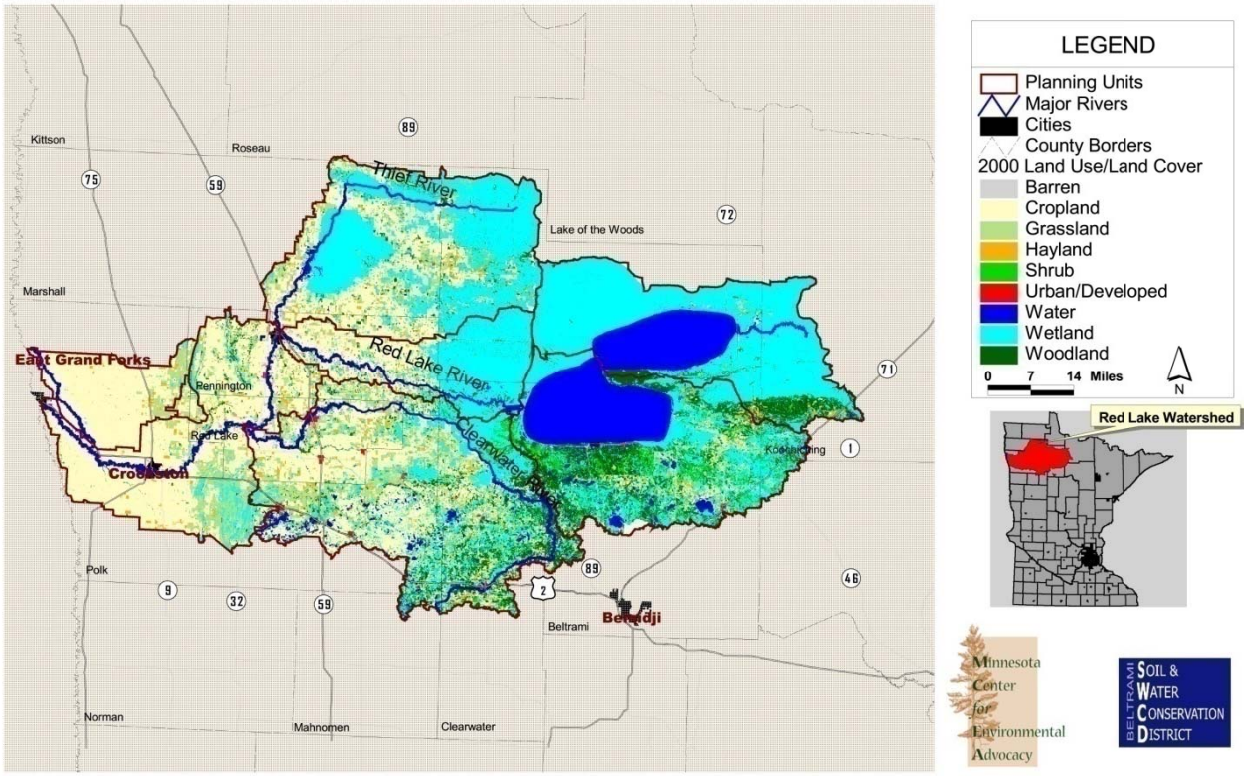


Figure 5. Red Lake Watershed District Map

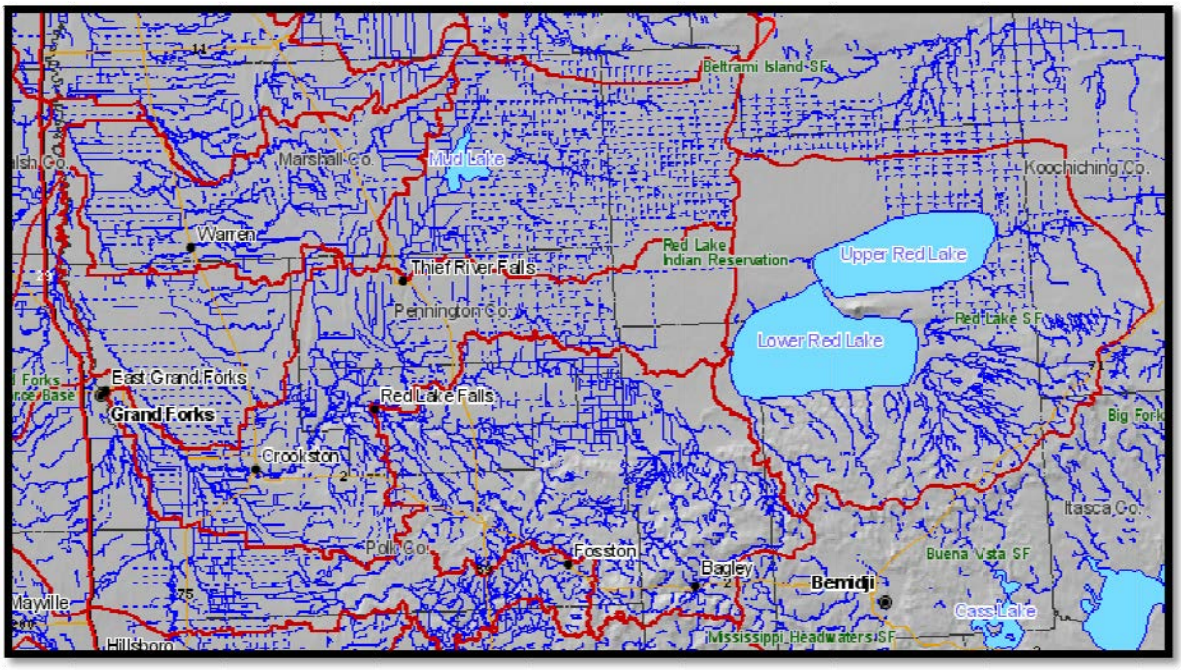


Figure 6. RLWD Shaded Relief and Streams

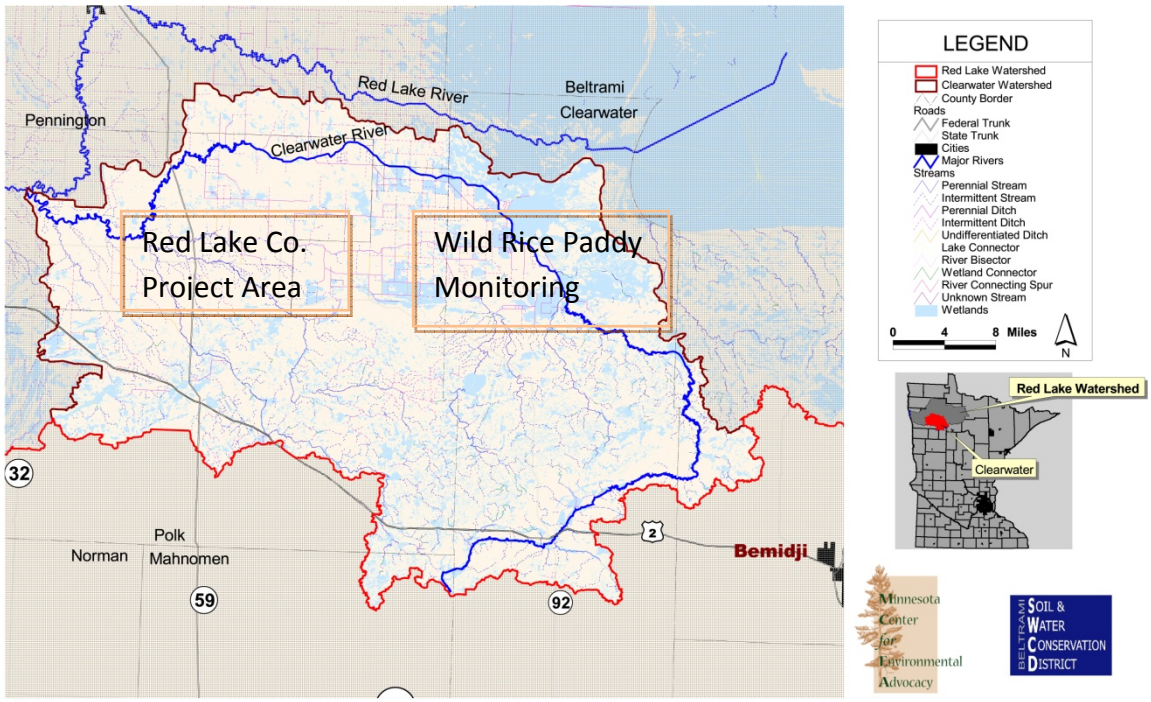


Figure 7. Clearwater River Watershed Map

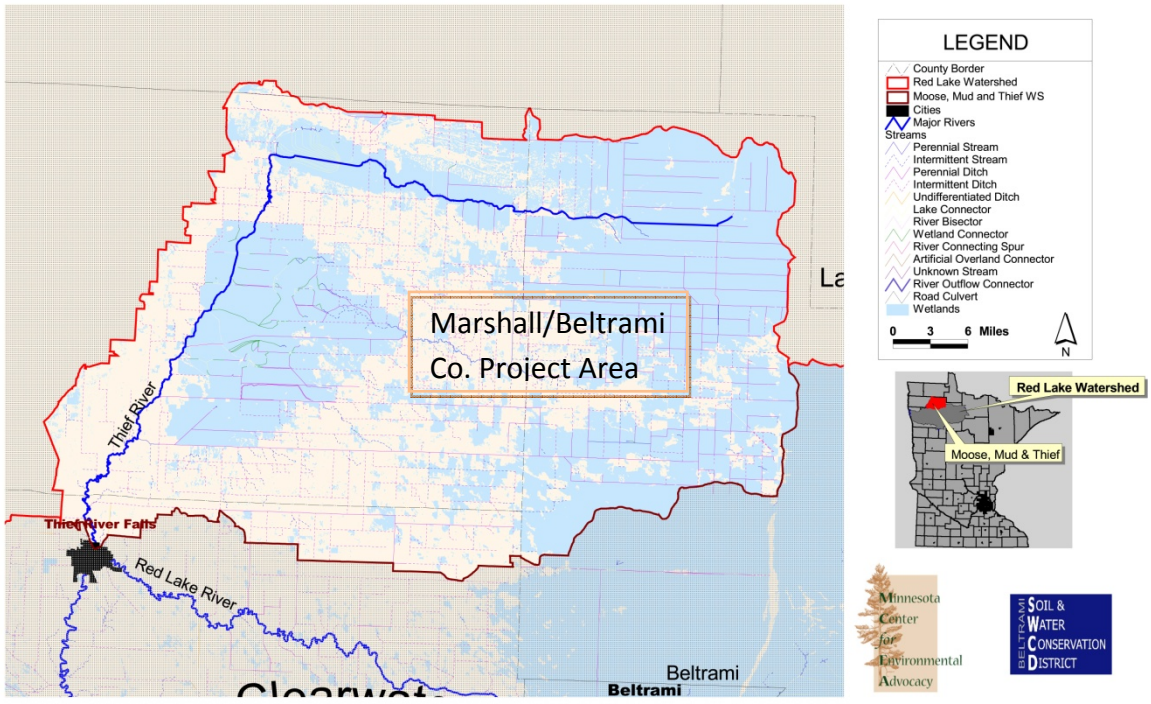


Figure 8. Thief River Watershed Map

Much of the Red River Basin has a flat topography and was once the lake bed of glacial Lake Agassiz. In southern Minnesota, surface inlets are used to drain ponded areas in more uneven topography. Because of the flat topography in the Red River Basin, pattern tiling can provide even drainage throughout the field without the use of surface inlets. This study focuses on tile installations **without** surface inlets.

Sampling Sites

Monitoring for this project is essentially taking place in three areas. These areas include Red Lake County – near the town of Brooks, Clearwater County wild rice paddies along the Clearwater River north of Gonvick, and Marshall County – near the town of Grygla.

The Red Lake County sites on Bachand and Yaggie land will be used to monitor water quality and quantity. The sites are located east of Brooks, MN in Red Lake County. The flow monitoring at the Red Lake County sites is sponsored by the Red River Watershed Management Board and involves installation of specialized flow measurement structures. The flow monitoring is directed by Nate Dalager from HDR Engineering for the Red River Watershed Management Board. The RLWD conducts regular water quality monitoring at these sites and provides assistance to the water quantity monitoring part of the project. These sites will monitor the following types of drainage:

- Surface drainage from a surface drained field
- Tile drainage
- Surface drainage from a tiled field

The Clearwater County monitoring sites compared water quality among different types of drainage and outlet types in wild rice paddies. Red Lake Nation rice paddies were monitored in 2005 and 2006. The types of drainage compared include:

- Surface drainage via internal ditches
- Pattern tile drainage with regularly spaced outlets that discharge into internal perimeter drainage ditches
- Main line tile drainage **without** internal surface drainage. The main line tile brings water through the paddy's dike and into a ditch (which ideally would be well maintained and stable).

The sites in Marshall and Beltrami County are located within 7.7 miles of each other and compare water quality among:

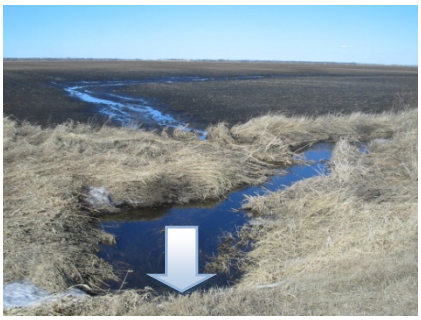
- Gravity tile
- Pumped tile
- Surface drainage
- Natural background (non-impacted)

These sites are primarily monitored by Lisa Newton of the Marshall-Beltrami County Soil and Water Conservation District.

Site Descriptions

Red Lake County Sites:

Bachand Tile + Surface.



This site was monitored and sampled at the beginning of the project before it was possible to sample surface and tile drainage separately from this field. Samples and field measurements were taken from the upstream end of the culvert. The water at this site originated from both surface and tile drainage. Samples are no longer collected here, but instead are collected separately at the Bachand Surface and Bachand Tile monitoring sites. This site and the Bachand Tile and Bachand Surface sites are located along Hwy 92, east of Brooks, Minnesota. This field is located in Section 8 of Lambert Township in Red Lake County. Water quality samples were collected where flow from the Bachand field crosses Highway 92 on the south side of Section 8.

Fertilizer application on the Bachand field during the study has been:

- 2005: 15N – 30P – 60K dry applied with seed plus 100 units of anhydrous ammonia.
- 2006: No fertilizer

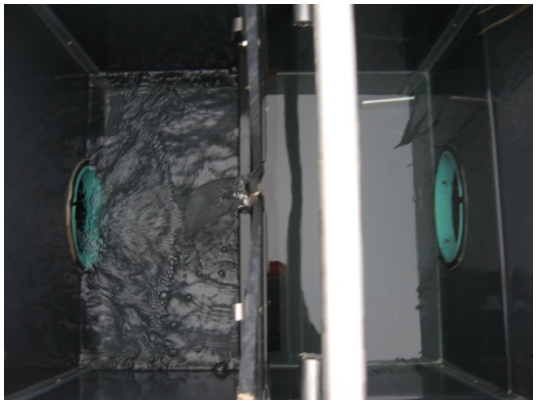
The crops grown on this field during the study have been:

- 2005 – Spring Wheat
  - Planted on April 14th
  - Harvested on August 25th
- 2006 – Soybeans
  - Planted on May 15th
  - Harvested on September 20th

Bachand Tile

This is the water control structure that was installed on the end of a main line tile line. Field Drainage, Inc. of Brooks, Minnesota installed the structure. Water comes into the structure through the tile line, flows over a v-notch weir, and then exits the structure through a short length of pipe. A HOBO Water Level Data Logger is placed on the bottom of the field (upstream) side of the water control structure to collect a continuous record (1 measurement every 15 minutes) of water levels within the water control structure. This water level data can be translated into flow using a table and/or equation for calculating flow over v-notch weirs. A rating curve has been developed for the weir within this structure.

The tile drainage at this site was installed in 1995. The tiles were placed at about 40 inches deep with 120 foot spacing. The longest run of tile line in the field is ¾ mile. The diameter of the outlet pipe is 8 inches.



Field measurements for dissolved oxygen, conductivity, temperature, and pH can be taken at this site, with some caution. The probe was rinsed with water flowing over the weir before it was placed into the water pooled on the upstream side of the weir.

Bachand Surface

This monitoring site is used to monitor the surface drainage from the Bachand field. An h-flume installed to catch and measure any surface runoff that comes from the Bachand field. Dip samples can be taken from the end of the structure. There is a HOBO Water Level Data Logger installed within the stilling well on the side of the structure to collect a continuous record (1 measurement every 15 minutes) of water levels within the flume. Level logger readings are correlated with manual measurements of water depth at the end of the flume. The water level data can be translated into flow using a table and/or equation for calculating flow through an h-flume.

The stilling well has a locking cap that is secured with a RLWD padlock. Some landscaping has been done to ensure that water coming from the field funnels through the structure. Erosion control fiber blanket was installed around the structure to minimize erosion from ground disturbed during installation.

The site is affected by backwater from the Hill River. The structure will need to be raised if monitoring is continued beyond 2007. This will help maintain head over the tail-water and reduce erosion. Modification of the structure may be necessary to “funnel” flow through the flume during high flows.

Figure 9. Stilling Well and Gauge on Bachand Surface H-Flume

Yaggie 1

We needed to find a surface drained field nearby the Bachand field in order to make valid water quality and flow comparisons. This was actually the second site that was seriously considered as a surface drained site, but the first surface drained site in Red Lake County where samples were collected. The first site considered was south of Hwy 92 on a field owned by Keith Swenson - near a University of Minnesota tile drainage research plot. When it was determined that the Swenson site would not work for accurate flow measurement without adverse affects to the farmer's crop, new sites were scouted for the project. The first choice was the Yaggie 1 site. The site is located on the north side of Section 1 of Poplar Township in Red Lake County, just east of the middle of the north end of the section. This monitoring site receives water from surface drainage on Kevin Yaggie and LeRoy Robert Carriere land. Initially, the outfall end of the culvert looked like a good place for a flume. Unfortunately, when water levels in the Lost River rose shortly after we started monitoring, we learned that the river water rises to the level of the culvert. This would make unobstructed flow measurement impossible during periods of high flow. The downstream end of the culvert is lower because of the drop structure on the upstream end. This site was abandoned in favor of Yaggie 2.

Yaggie 2

This site is located west of Yaggie 1 along a township road in Poplar River Township. There is more of a fall between the downstream end of this culvert and the Lost River than there is at the Yaggie 1 site. It would allow for unobstructed flow through the h-flume. Therefore this site became the official site for measuring flow from a surface-drained field. The h-flume used for flow measurement and this site is identical to the one at the Bachand Surface site. This site is located along north side of Section 1 of Poplar Township in Red Lake County, near the northwest corner of the section. The rear of the flume was sealed with Quikrete to make sure the water would flow out of the correct end of the flume.

Clearwater County Wild Rice Paddy Sites:

RLN Surface

This site is the outlet of a Red Lake Band of Chippewa wild rice paddy drained only by internal surface ditches. Samples were collected at the water control structure where water was discharged from the paddy. This is a good site for flow measurement because the water control structure exhibits weir flow. Flow was measured using a HOBO Water Level Data Logger housed within a stilling well that was attached to the side of the water control structure. An additional HOBO Water Level Data Logger was suspended within the stilling well for the collection of data for barometric compensation for the area. This wild rice paddy discharges directly into the Clearwater River. This outlet is located near the northeast corner of Section 22 of Hangaard Township in Clearwater County.

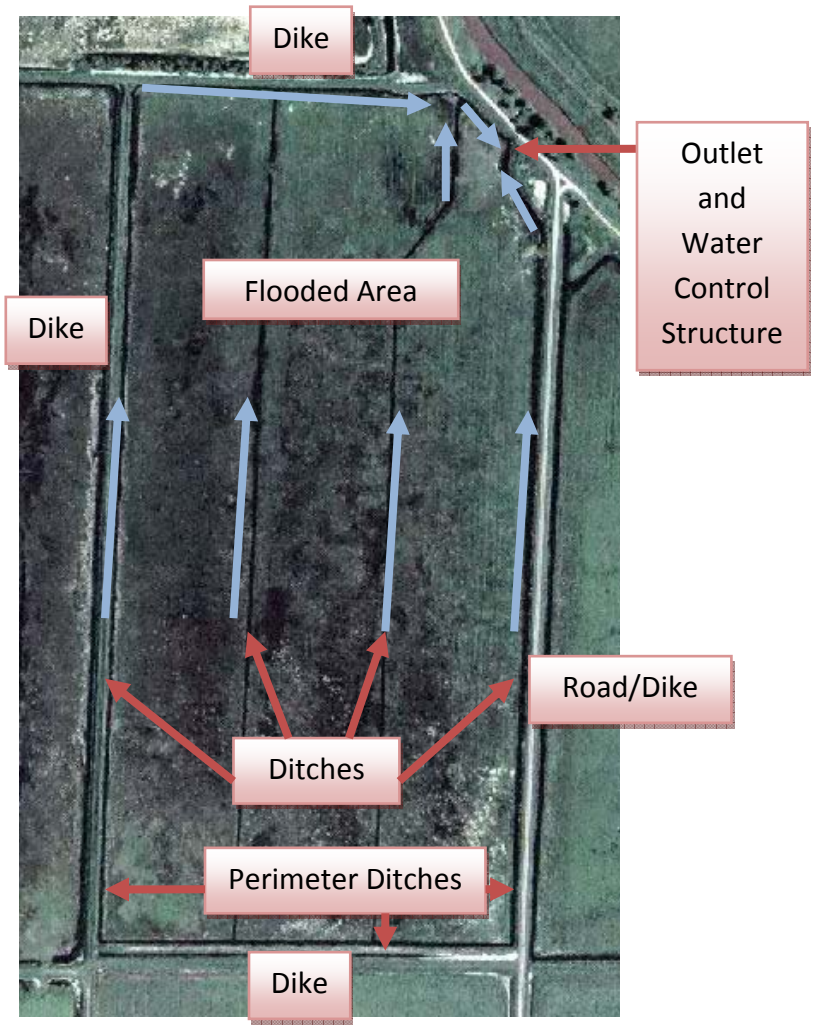


Figure 10. Surface drained paddy aerial photo and diagram.

RLN Tiled

This site is located at the outlet of a Red Lake Band of Chippewa wild rice paddy that has tile drains within the paddy that drain into internal perimeter surface ditches. These ditches carry water along the inside of the dike surrounding the paddy toward an outlet on the NE corner of the paddy. Due to backwater from the next paddy, this site didn't consistently exhibit weir flow, so flow wasn't reliably quantifiable at this site. The outlet structure of this paddy is located on a dike that runs east-to-west just off of the west side of a minimum maintenance access road that runs north-to-south along the border of Sections 34 and 35 of Hangaard Township in Clearwater County. The outlet structure and dike are located just north of the midway point of Section 34 of Hangaard Township.

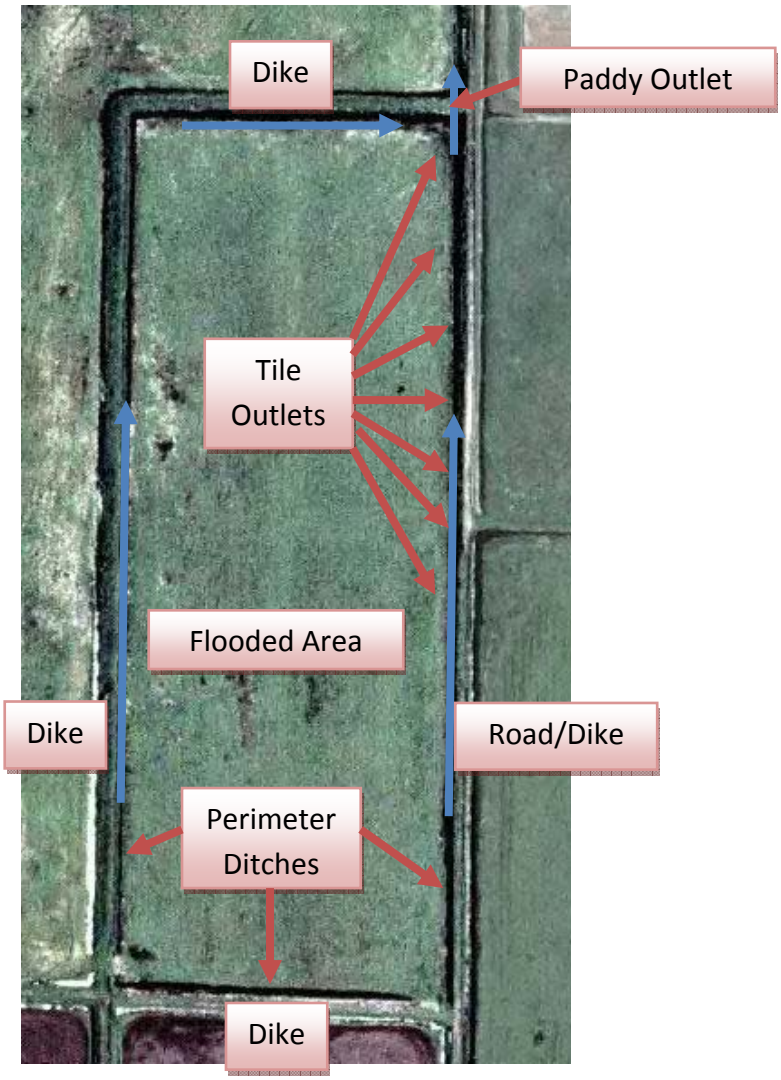


Figure 11. Diagram of a tile drained field with internal perimeter ditches.

RLN Main Line Tile

This water control structure drains water from a paddy in which tile lines drain into a main line tile. The main line tile then crosses the dike (which is a road) and flows through a water control structure to a grassed waterway. The structure is located on the north side of the northwest corner of the northeast corner of Section 3 of Winsor Township in Clearwater County, along the south side of the road that runs along the border of Winsor and Hangaard Township. The system does not need interior surface ditching. So it does not have the erosion problems exhibited by the other paddy drainage systems.

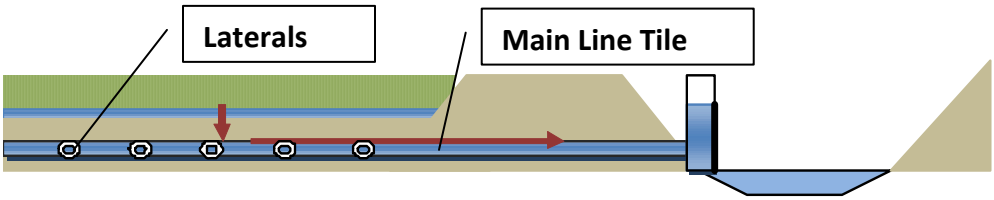


Figure 12. Diagram of a Red Lake Nation Main Line Tile System and Outlet.

Clearwater Rice

This wild rice operation is owned by (State Senator) Rod Skoe. Don Barron, a retired soil scientist and advocate of this project, is also involved with this wild rice operation. Tile drainage was installed on this farm as part of the Implementation Phase of the Clearwater Nonpoint Study Clean Water Partnership project. Several candidate sites were examined at this farm for use in this study. The small size of the structures, unfortunately, was not conducive to flow monitoring or water sampling. Stilling wells would need to be place inside the structures instead of beside the structures, which may have interfered with operation of the structures. The structures are also narrower and placed within the dike so it was difficult to collect a sample (even with a vertical Kemmerer sampling device) without disturbing the rust that lines the inner walls of the structure. Only one sample was collected in 2005 from a main-line tile outlet.

Figure 13. View down a Clearwater Rice Main Line Tile Water Control Structure

Marshall County Sites:

Stanley GT1 and Stanley GT2

These sites monitor water quality concentrations from tile outlets on a Stanley Farms field. This field is drained by regularly spaced drain tiles that outlet into a township ditch along County Hwy 54. GT1 was initially the most visible and easily sampled of the tile outlets. It can be accessed by driving on a trail along the edge of the field that begins in Arnold Stanley's yard. It is approximately 890 feet north of the farmstead and south of the third power line pole north of the farmstead.

GT2 is located near County Road 55 on the north side of the field. It is northernmost tile outlet on this field. GT2 is not as easy to access as GT1 during wet periods. During wet periods, it is necessary to walk across a wet township road ditch and the water level in the receiving ditch may be high enough to cover the tile outlet. It was sampled more frequently because it runs longer into dry periods than GT1. So, GT1 will be sampled during wet periods (or whenever it is flowing) and GT2 will be sampled during dry periods (or whenever GT1 isn't flowing). These sites are located on the west side of Section 13 of Valley Township in Marshall County. They are on the east side of County Highway 54 and are along the field north of Arnold Stanley's home.

The tiling system on this field was installed in the year 2000. The depths range from 3.5 to 6 feet. The spacing is approximately 100 feet. Each of the 50 tile lines installed in the field is 2,500 feet long.

Crops grown on this field during the study were:

- 2005 – Canola, planted on April 20th
- 2006 – Soybeans, planted on May 16th

Fertilizer application on this field during the study has involved:

- 125N – 30P – 60K applied at seeding in 2005
- 30P – 60K applied at seeding in 2006

Sparby – Surface Drained Field

This field is surface drained and a portion of the field flows to a single point, through a culvert, and into a township ditch. Samples are collected at the outfall of the downstream end of the culvert. This site is located on the west side of Section 7 of Valley Township in Marshall County. The Sparby monitoring site does have a small drainage area. Surface runoff events and sampling opportunities have been infrequent at the site.

Beltrami County Sites:

Stanley PT

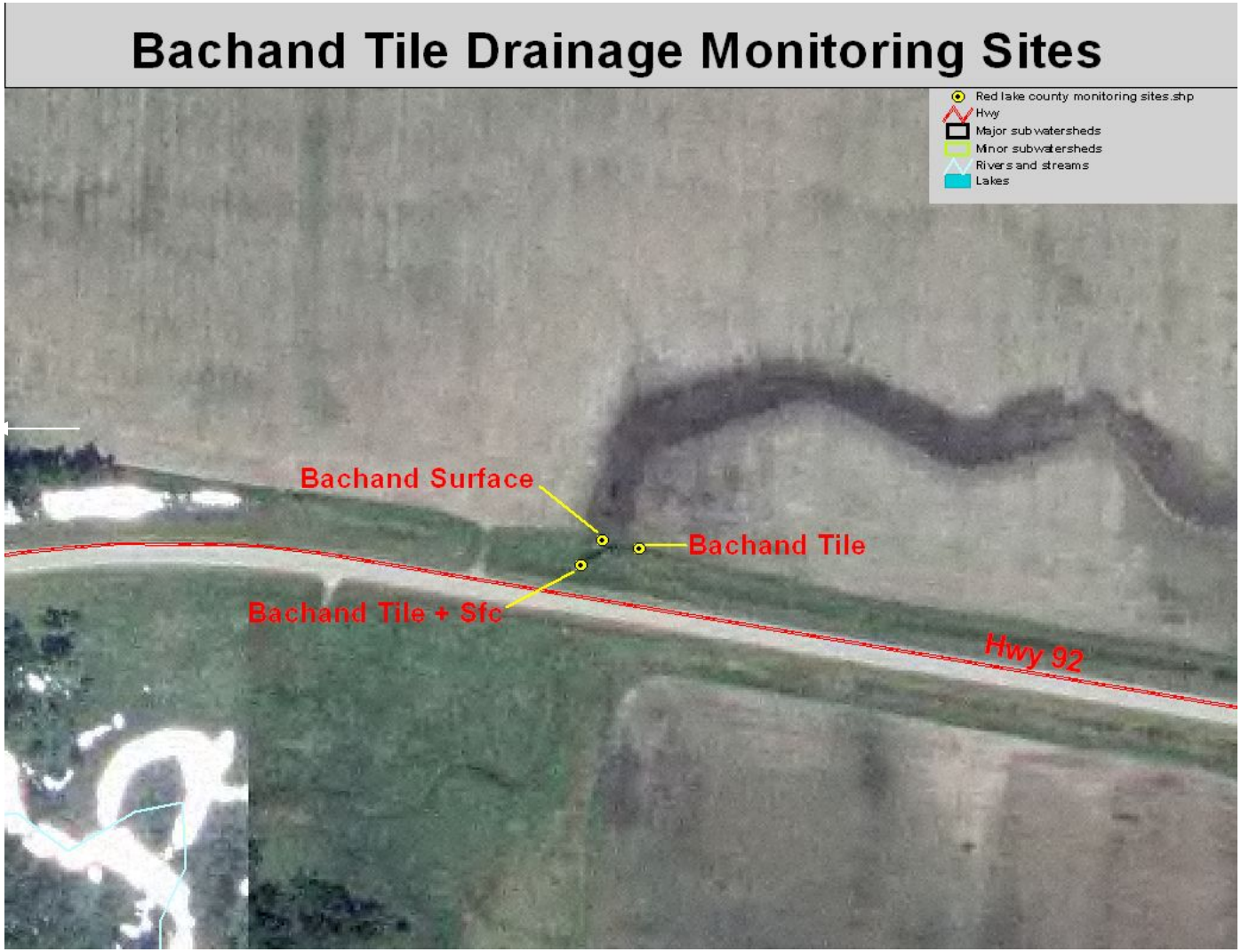
This is a Stanley Farms' pumped tile outlet. Samples are collected at the end of the black corrugated outlet pipe while the pump is running. The pump can be triggered to run by opening the cover to the reservoir and raising the float. A new pump was installed in the fall of 2005. Samples are collected from the pump that is closest to the road (first pump installed). This site is located where Sections 12 and 13 of Marshall County and Sections 7 and 18 of Beltrami County meet. The pumps are along the north side of Marshall County Highway 55/Beltrami County Highway 44 (gravel road) at the section line.

Wheat was grown at this site in 2006 and was harvested by early August.

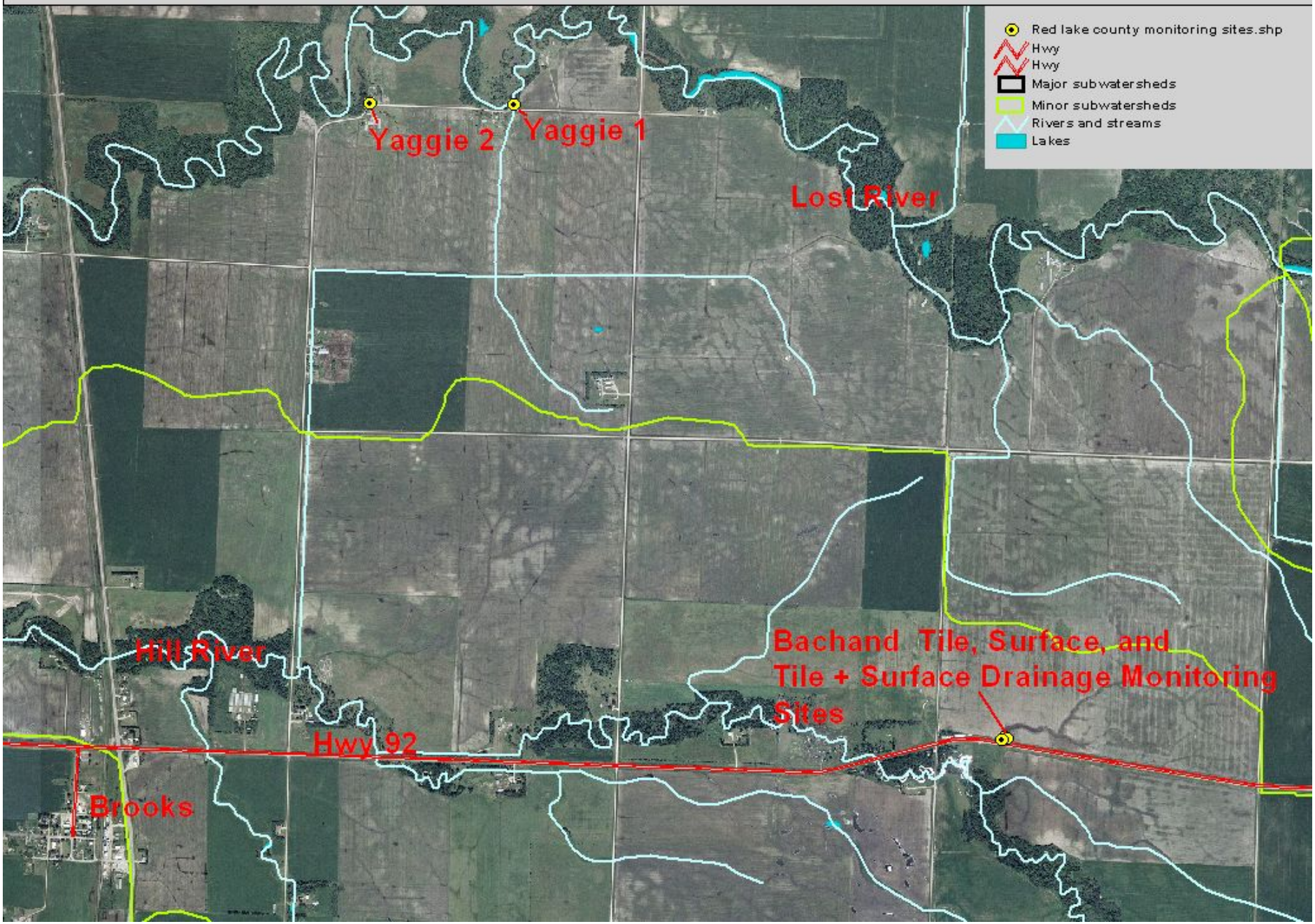
Beltrami Natural

This site is used to collect data on natural background water quality concentrations in the Marshall-Beltrami County area. The water that flows through this site comes from forested public land on the east side of the project area. The monitoring site is located where Benwood Road NW turns north along the north side of Section 3 of Benville Township.

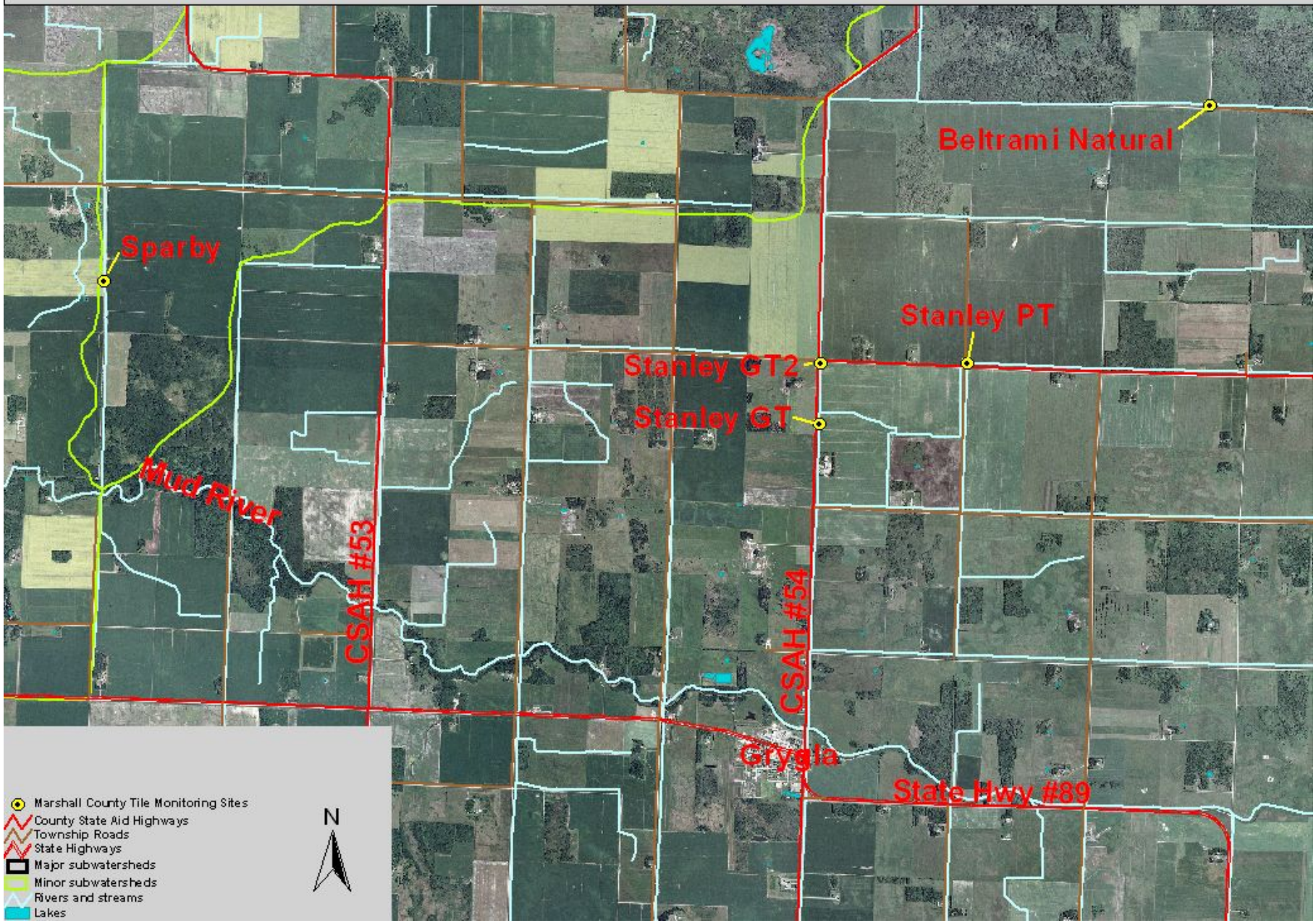
Maps


Bachand Tile Drainage Monitoring Sites
Red lake county monitoring sites.shp
Hwy
Major subwatersheds
Minor subwatersheds
Rivers and streams
Lakes
Bachand Surface
Bachand Tile
Bachand Tile + Sfc
Hwy 92

Red Lake County Tile Drainage Monitoring Sites

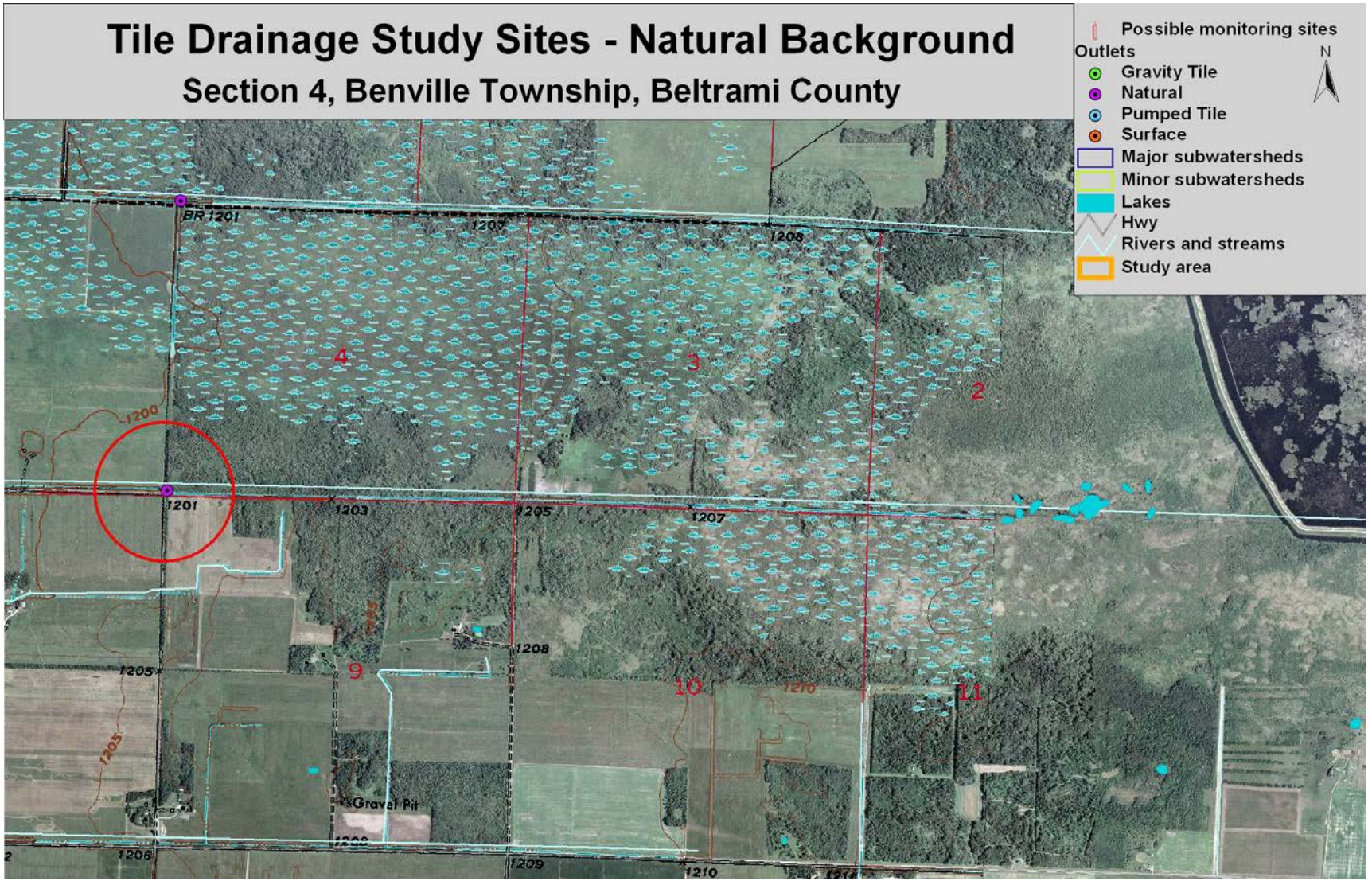


Marshall/Beltrami County Tile Drainage Monitoring Sites

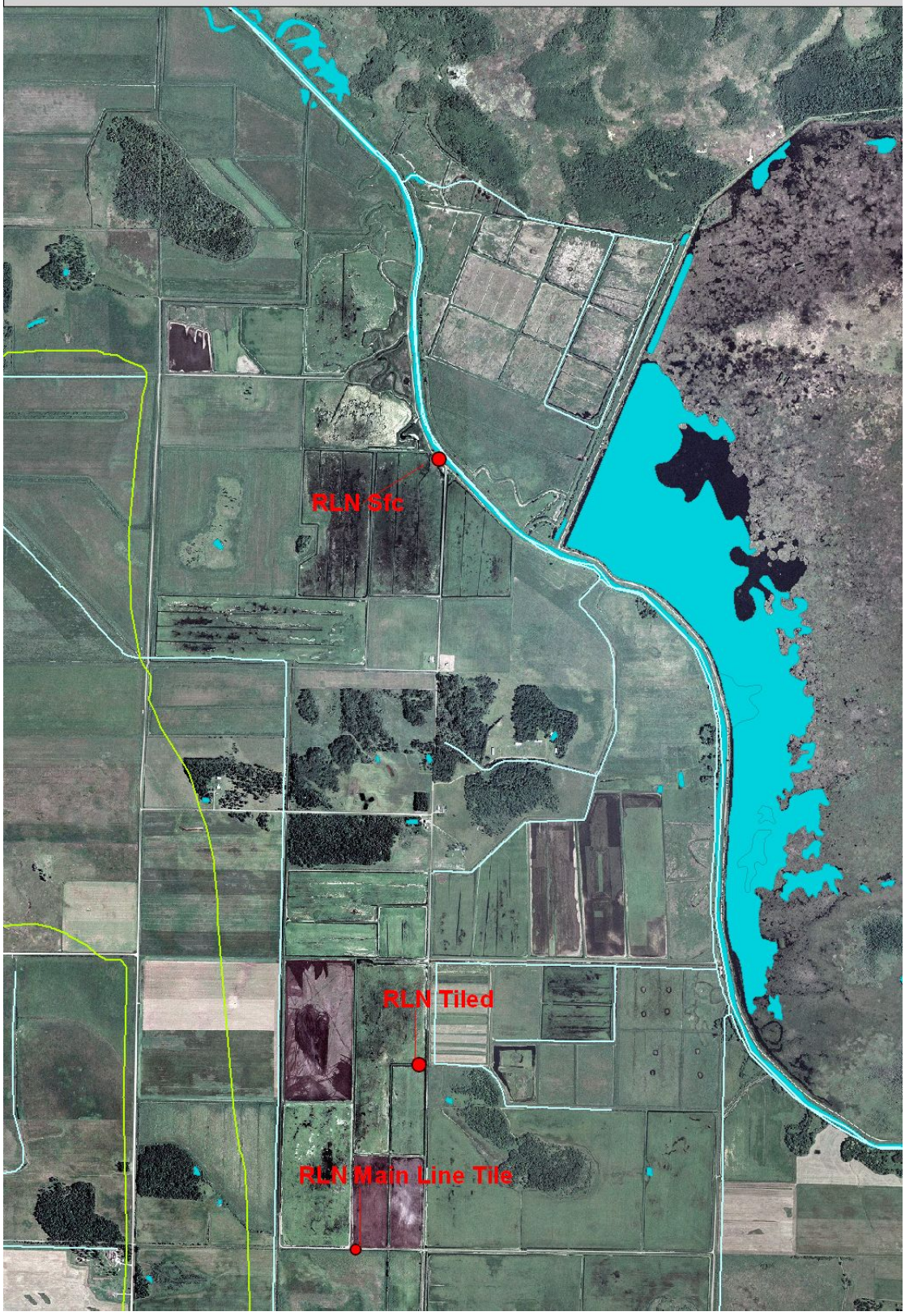


Tile Drainage Study Sites - Natural Background

Section 4, Benville Township, Beltrami County



Red Lake Nation Wild Rice Paddies



Site Photos

Bachand Site – Tile and Surface Drained Field Monitored for Flow and Water Quality

Figure 14. Bachand Tile Drainage Water Control Structure

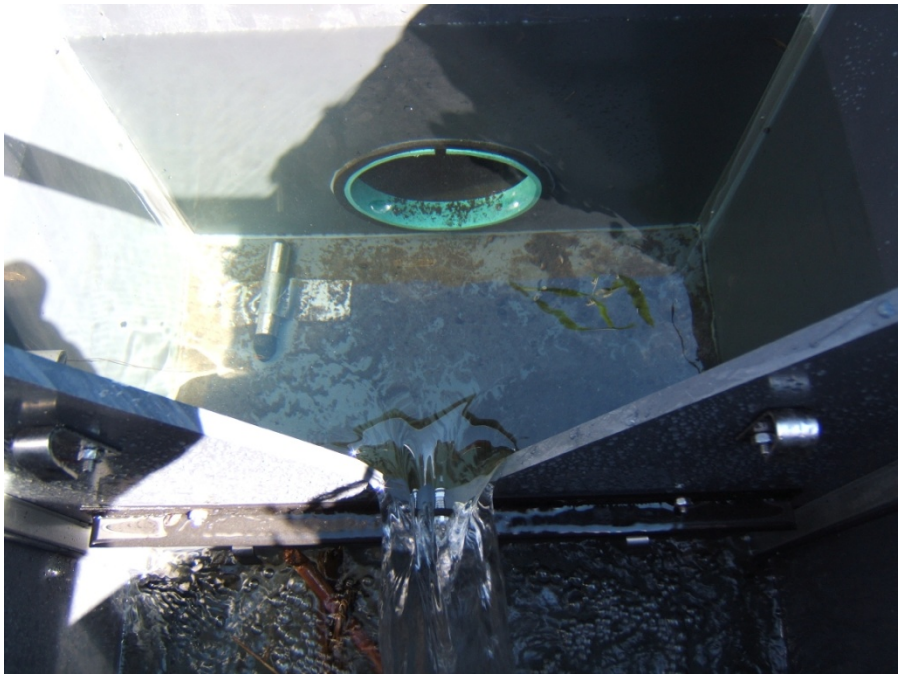


Figure 15. V-Notch Weir and HOBO Water Level Data Logger in the Bachand Water Control Structure

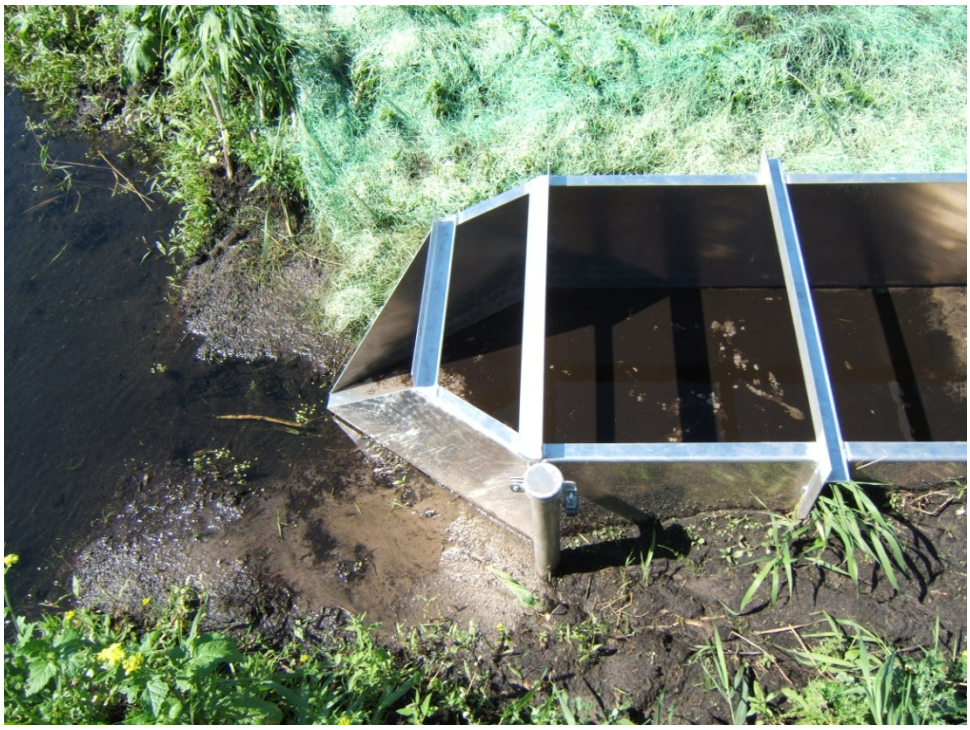


Figure 16. H-Flume for Surface Flow Measurement at the Bachand Site

Figure 17. Rainfall and Barometric Pressure Monitoring Equipment at the Bachand Site

Figure 18. Bachand Field, Post-Harvest 2005

Yaggie 2 Site – Surface Drained Field Monitored for Flow and Water Quality

Figure 19. H-Flume on Downstream End of Yaggie 2 Culvert