Chapter 3 Approach and Methods

Water Quality Monitoring

As part of the Phase I CWP Diagnostic study for the Little Cottonwood River Watershed sediment and nutrient loadings were calculated for the river along various locations. In addition, bacteria, dissolved oxygen, transparency, pH, and temperature levels were studied. The information derived from water quality monitoring will:

- Help identify areas within the watershed that are contributing more or less of a particular pollutant of concern and therefore increase the efficiency of implementing sparse cost share dollars.

- Allow water resource managers to rank the LCR with other similar watersheds with the MN River basin in an effort to prioritize funding and clean up efforts.

- Help determine realistic goals, and reductions needed to meet both state and local goals.

Four main-stem water quality-monitoring sites were established on the Little Cottonwood River at intervals ranging from 10 to 40 river miles. See map 13. Table 17 lists the exact distances between monitoring sites. The four sites were selected based on spatial proximity to areas of environmental concern, feasibility of determining stream discharge relationships, and previous monitoring history. The four sites are characterized as the Headwaters, Upper Site, Middle Site, and Mouth Site and are labeled as sites 1, 2, 3, 4 respectively. All four sites are located on the main channel of the LCR. The locations of all water quality-sampling sites are shown graphically on map 14 with respected subsheds, and detailed site descriptions can be found in section F of the Appendix. Photos 1-4 at the end of this chapter are also included to portray the overall setting of monitoring sites as well as some of the equipment used for the study.

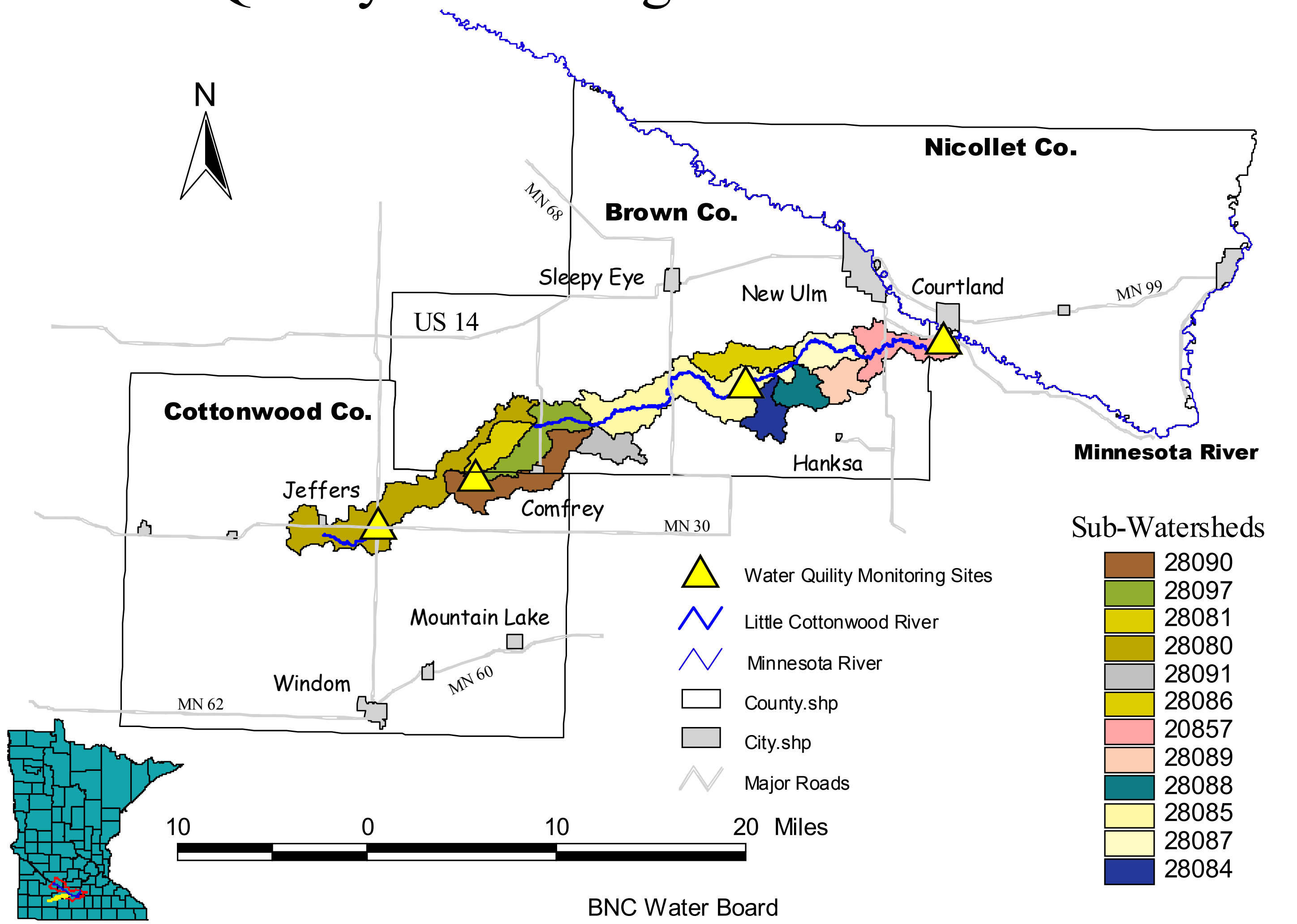
Table 17

Distances between monitoring sites

Water Quality Monitoring Intervals	River Mile Distance
Site 1 to Site 2	9.8
Site 2 to Site 3	38.5
Site 3 to Site 4	26

Little Cottonwood Watershed

Water Quality Monitoring Sites and Sub-Watersheds



Basis for Site Selection. The watershed is characterized as very long and narrow with many first order tributaries. Tributaries and therefore minor-sheds of the Little Cottonwood River were not directly monitored. Instead, flow weighted mean concentrations and loading rates were calculated for particular segments of the river rather than for each or some of the 12 sub-sheds supplying the Little Cottonwood. Since many of the streams supplying the LCR are first order in nature, it is assumed large differences in water quality are negligible and therefore did not merit loading estimates.

Specifics for each site

Site 1 is located East of Jeffers on US highway 71. This site is not equipped with stage monitoring equipment.

Site 2 is located 8 miles west of Comfrey on County Road 10. In 1998 USGS was contracted to develop a stage discharge relationship and equip the site with stage sensing equipment. A N-gas bubbler system was installed with a Sutron pressure transducer and Cambell Scientfic CR10 datalogger. Due to the flashy nature of the water flows in this part of the watershed a Sigma auto sampler was installed to help characterize storm water runoff in 1999. A USGS Cambell program was used for 1998 and part of 1999. Once the stage actuated sampler was put on line a MPCA program was substituted. This site was maintained by BNC staff from 1998-2000. A Texas Instruments tipping bucket rain gauge was in operation at this site from June 1999-October 2000.

Site 3 is located on CR 22, 8 miles West of State Highway 13. This site was established and maintained by MPCA Mankato field office staff in 1998. A staff gauge, DRUCK pressure transducer, and CR10 datalogger were installed to determine stage. MPCA hydrologists developed the rating curve for this site in 1998 and 1999. Flows were not determined in 2000 due to budget constraints. A Texas Instruments tipping bucket rain gage was in operation at this site from 1998-1999.

Site 4 is near the mouth of the LCR. A Class A permanent USGS gaging station with a gas bubbler system determines stage and flow.

Sampling Protocol

Samples were collected at all four sites during monthly scheduled times from March through October in 1998, 1999, and April through August in 2000. In addition, water samples were collected over a range of river discharge conditions to characterize the change in water quality as the river responded to both dry and wet conditions. Additional samples were taken at all four sites during low flow (baseflow conditions) to assess the influence of point sources of pollution such as septics. Conversely samples were also taken during high flow to document the effects of non-point source pollution from storm water runoff. Strict attention was made during the monitoring season to gather a wide spectrum of climatic/flow conditions to insure the best possible representation of the water quality in the watershed at the time of the study.

Sampling for water quality parameters and flows under climatic conditions included:

- ❖ Early Spring (first storm after snow melt)
- ❖ Emergent Crop Period Storm
- ❖ High Evapo-transpiration (ET) - Low Flow (late July or early August)
- ❖ Post ET (fall) Low Flow (late fall)

In general, all four sites were sampled from early April through October. Year 2000 monitoring was cut short to allow time for assimilation of data into this report, and ended in August. In 1998, 8 samples were captured. In 1999 a very intensive monitoring campaign yielded 16 samples and in monitoring season 2000, 8 samples were taken. During the course of the study (March 1998- August 2000), a total of 32 water samples were taken from all four sites.

Monitoring Season Description

1998

Intensive monitoring for the LCR CWP started in March of 1998. However, due to extraordinary circumstances, monitoring ceased for most of the early spring and part of the summer season. On March 29, a substantial portion of the Little Cottonwood River watershed was damaged by a powerful tornado. The path of the tornado entered the watershed near its headwaters south of Jeffers, paralleled the river to the town of Comfrey where 75% of the buildings were destroyed, continued east-northeast to rejoin the watershed near its mouth. The same storm spawned another tornado, which devastated east Nicollet County, including the office and lab of the BNC Water Quality staff. Because so much of the community of watershed residents are involved in clean-up and recovery, and because so much of the staff of the BNC Water Quality Board, as well as the county staff of the three counties were also involved in recovery, this project was "put on hold" for one year. Monitoring continued through the dedication of MPCA staff, and some education and outreach activities also continued, but the timeline of the original project was extended for 12 months. Despite the circumstances a total of 8 samples were taken and loading rates were calculated at sites 2, 3, and 4. Site 1 does not have stage recording devices.

It is felt that loading rates for 1998 are underestimated due to the climatic conditions of that year. A combination of lower flows during much of the monitoring season, and low number of samples taken during high spring time flow conditions contributes to the underestimation of loads and concentrations.

1999

In 1999 monitoring continued. Beginning in early April, a total of 16 samples were taken at all four sites. Loading rates were calculated for sites 2, 3,and 4. Due to the large number of samples and collection times the loading rates are well representative of that season. Collection of samples during high and low flow regimes were well documented throughout the monitoring season.

2000

Although the diagnostic study should have ended in 1999, additional grant money was secured to help fund continued monitoring of the LCR in 2000. A total of eight samples were taken under very low flow and very high flow conditions. To allow enough time for reporting the last grab samples were taken in late August. Normally samples would be taken in through post evapotranspiration (late fall).

Water samples were sampled and analyzed according to methods adopted by the USGS MPCA, and US Environmental Protection Agency protocol. Collection of all grab samples followed protocols established by the Environmental Protection Agency[1].

Samples were field-tested using portable meters for pH, temperature, specific conductance, dissolved oxygen and transparency. Field meters were calibrated before each day of use. Samples were analyzed by the Brown Nicollet Environmental Health state certified lab in St. Peter, MN for the following parameters: total suspended solids, total phosphorus, ortho-phosphorus, nitrate-nitrogen, fecal coliform bacteria, total coliform bacteria, and fecal streptococcus bacteria. Reporting units and methods are shown in table 18.

[1] U.S., Environmental Protection Agency, Handbook for Sample Preservation of water and Wastewater. 1982.

Table18

Reporting Units and Method

Constituent or physical Property	Reporting Unit	Laboratory Method
Bacteria, fecal coliform, membrane filter	Col/100ml	Membrane filter
Bacteria, fecal streptococci, membrane filter	Col/100ml	Membrane filter
Bacteria, total coliform, membrane filter	Col/100ml	Membrane filter
Discharge	ft^3/sec	Velocity meter
Dissolved oxygen (DO)	mg/L	Membrane electrode
Nitrogen, as No3-N	mg/l	Electrode or Hach Spectrophoto meter
PH	Units	Electrometric
Phosphorus, dissolved ortho as P	mg/L	Hach manual digestion with automated color development
Phosphorus, total as P	mg/L	Hach manual digestion with automated color development
Sediment, suspended, concentration (TSS)	mg/L	Filtration and membrane
Specific Conductance	micromhos/cm	Wheatstone-Bridge meter
Transparency (tube)	cm	
Water Temperature	℃	

Water Quality Monitoring Equipment

The instruments at sites 2, 3 and 4 provided a detailed account of the conditions in the river 24 hours a day. The instruments continually monitored stage (water elevation) every 60 seconds. At site 2, an automatic sampler was installed. An automatic sampler collects 24 water samples every 2 hours from the river when pre-determined stage conditions are met. At sites 2 and 3 a rain gage was also installed to measure cumulative rainfall amounts and rainfall intensities. During a rain event, the rain gage records every .01-inch of precipitation. The operation of all these instruments is coordinated by a CR 10 data logger, which also stores and outputs the data. The datalogger program outputs a line of information every 15 minutes, including Julian date, time, automatic sampling data, and precipitation amounts. It also triggers the automatic sampler to start and stop sampling according to preset stage conditions. All of the data from the CR10 was downloaded as a comma delimited ASCII file. PC208, a Cambell Scientific program, was used to manage and calculate the large data files.

Discharge Ratings

Stream flow at sites 2, 3, and 4 were determined by developing a stream discharge relationship. USGS hydrologists and BNC staff determined established rating curves for sites 2 and 4. Site 2 rating curve was last updated in 1999. Site 4 rating curve is updated annually by USGS personnel. Rating curves for site 3 was developed in 1998 and 1999 by MPCA hydrologists.

Development and use of stage-discharge relationships required measurement of stage, datum, channel dimensions, water velocity and discharge as specified in the MPCA quality control manual and USGS protocol. Periodic readings were taken at each site with a reading near zero flow up to moderate and high flow conditions with wading rod and Price or Pygmy current meters.

Total discharge and instantaneous stage were plotted using Microsoft Excel and 2nd order polynomial equations and associated R^2 values were calculated to describe the stage-discharge relationship.

Flow Conversion and Data Management

Average 15-minute stage readings were converted to flow through Cambell Scientific PC 208 software. The average 15-minute flow values were simultaneously converted to average daily flows by substitution into to the derived rating equation. Precipitation data was also converted to total daily precipitation amounts. The data was then exported to Excel as an ASCII file and graphed/managed as an Excel workbook.

Field Equipment

Instruments used to determine field parameters includes an Orion 835a D.O./Temp probe, Hach conductivity meter, MPCA transparency tube, and ISFET model IQ125 pH meter. Both the dissolved oxygen and pH meter were calibrated before each use. Current readings were taken using AA Price (>1.5') or Pygmy (<1.5') meter with a 6' wading rod. During high flows, velocities were measured using a bridge board apparatus.

Water Sample Analysis

All parameters except Fecal Sreptoocci were tested by the Brown Nicollet Environmental Health (BNEH) laboratory in St. Peter MN. Fecal Strep was analyzed by MVTL laboratories of New Ulm, MN. Transportation of samples from field to lab was done by project staff. Samples were transported in ice filled coolers, and analyzed within 48 hours of sample collection.

The BNEH lab is a certified state lab. Therefore the lab is open to audit by the MPCA, MDH. Minnesota State lab number is 027-103-259 and EPA lab code is MN00090.

Quality Assurance

Only approved laboratory and field methodology was used in the capture of water quality data. Clear and accurate data was the continuous objective. In the event that errors did occur, they were identified and corrected. Both field and laboratory staff were readily able to identify outliers. When these emerged, re-sampling was performed as soon as possible, instruments were checked, and/or unusual circumstances (such as rainfall dilution or contamination by a point source) were identified and annotated.

Flow Weighted Mean Concentrations and Loading Rates

FLUX Calculations

Individual water samples, particularly those with no associated flows, gives only a snap shot in time of water quality conditions. Large variations in climatic conditions, and therefore flows can influence the chemical and physical make up of riverine systems on a daily or even hourly basis. To obtain a better representation of water quality during a particular season, flow weighted mean concentrations (FWMC), mass and loading rates (e.g. tons of sediment per day) are often used to help accurately portray water quality. A statistical computer model, FLUX Version 4.5, was used to determine FWMC's and loading rates for the LCR.

FLUX is an interactive program developed by the U.S. Army Corp of Engineers that allows the user to estimate loadings from grab sample concentration data and continuous flow records.[2] It is designed for use in estimating loadings of nutrients or other water quality components passing a tributary sampling station over a given period of time. The estimates are based on flow-weighted average concentrations multiplied by the mean flow over the monitoring period. Data requirements include:

1) grab-sample water chemistry results, typically measured at a weekly to monthly frequency for the growing season.

2) Water sample results from several storm events.

3) Corresponding flow measurements (instantaneous or daily-mean values)

4) Complete flow record for the period of interest

Using six calculation techniques, FLUX maps the flow/concentration relationship developed from the sample record onto the entire flow record to calculate total mass discharge and associated error statistics. An option to stratify the statistics into groups based upon flow, date, and or season is also possible. In many cases stratification allows one to decrease the coefficient of variance and thereby increases the accuracy and precision of FWMC and loading rates. Flux also provides information, which can be used to improve the efficiencies of future monitoring programs.[3]

FWMC and yield categories

To enhance the ability of the public and resource managers to understand, evaluate, and communicate what is acceptable and not acceptable in terms of water quality, categories for FWMC's and yields were selected. Three levels of water quality impairment were chosen. Values were separated into low, moderate, and high. The three categories were selected based on two approaches. The first approach compared LCR values with values

[2] Department of the Army, U.S. Army Corp of Engineers, Empirical Methods for predicting Eutrophication in Impoundments, Report 4, Phase3, Application Manual,1987..

[3] FLUX Stream Loaf Computations Version 4.5 Environmental Laboratory USAE Waterways Experiment Station Vicksburg MS, 1995.

from similar watersheds in the MN River basin currently in diagnostic studies. The Chippewa, Blue Earth, Redwood, Cottonwood, Hawk Creek, and Yellow Medicine values at the mouth were used in comparison with the LCR. These watersheds are similar to the LCR in monitoring techniques, loading estimate methods, and land use/land cover.

In addition, MPCA Ecoregion values from minimally impacted streams were used to further refine the categories.[4] See Appendix section K for further detail. In Minnesota there are 7 defined ecoregions. The LCR is part of the Western Corn Belt Plains ecoregion. Summer mean values from 1970-1992 were used to help determine the categories. Impairment categories and associated range of values are shown below in table—The colors indicated are used on a number of maps in chapter 5.

Table 19

FWMC Impairment Categories

Parameter	Low (Green)	Moderate (Yellow)	High (Red)
TSS	0-100	100-175	>175
TP	0-.21	.220-.340	>.340
No3-N	0-5	5.1-9.9	>10

All values expressed in mg/L

Table 20

Yield Impairment Categories

Parameter	Low (Green)	Moderate (Yellow)	High (Red)
TSS	0-100	100-250	>250
TP	0-.200	.210-.500	>.510
No3-N*	NA	NA	NA

All values expressed as lbs./Acre

*At this time yield categories have not been determined for No3-N

[4] Water Quality Division, Selected Water Qualtity Characteristics of Minimally Impacted Streams from Minnesota's Seven Ecoreresions. February 1993.

Ecoregions and Stream Water Quality

The U.S. Environmental Protection Agency has divided the continental United States into ecoregions based on soils, geomorphology, land use, and potential natural vegetation. For Minnesota, this results in seven fairly distinct ecoregions (map 14a). For example, the Northern Lakes and Forests ecoregion (NLF) is predominantly forested with numerous lakes and covers the northeastern part of MN. The Western Corn Belt Plaines ecorregion, located in the southern third of MN, has rolling terrain and is extensively cultivated with row crops. Land use, topography, and water quality characteristics of the ecoeregions were reviewed to assess the non-point source pollution problems across the state. This review can be found in a 1993 MPCA report by McCollor and Heiskary. The ecoregion framework provides a good basis for evaluating differences and similarities in Minnesota's streams. Reference streams, which are felt to be representative and reflect expected water quality for a region, were sampled by the MPCA to characterize stream conditions for each ecoregion. This provides a baseline with which to compare other streams. In other words, the reference streams are one yardstick by which to measure other streams. Table 21 lists the typical total phosphorus, total suspended solids, and turbidity for reference streams in six ecoregions[5]. Appendix K is a photocopy of the ecoregion values for the Western Corn Belt Plaines taken from the 1993 McCollor and Heiskary report. This study uses the ecoregion values as a reference when assessing the degree of water quality impairment within the Little Cottonwood River.

> **Ecoregions** are based on similarities of land use, soils, land surface form, and potential natural vegetation. Water Quality information from minimally impacted streams by the MPCA within these regions is used to assess the degree of impairment on a water resource.

[5] MPCA, 1998 Report on the Water Quality of MN Streams, Environmental Outcomes Division, 1998.

Map 14a[5]

Minnesota's Seven Ecoregions. Mapped by USEPA.

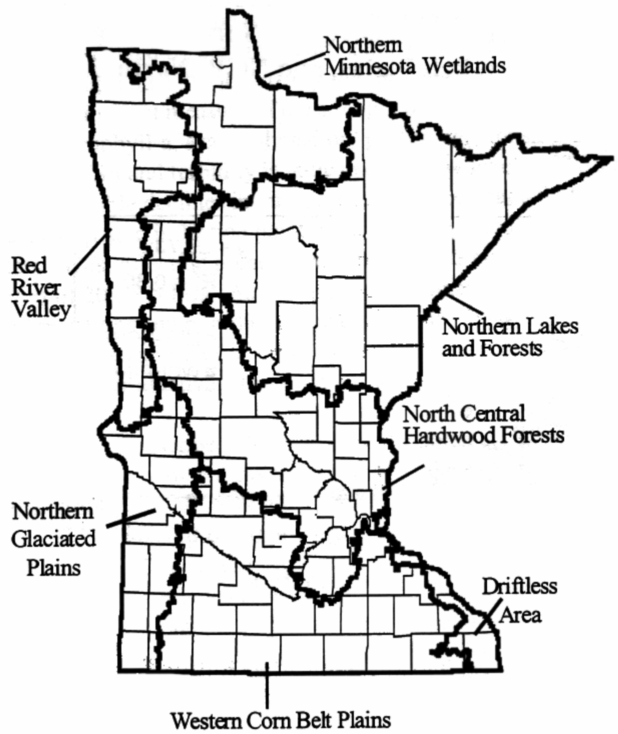


Table 21 Interquartile Range of Concentrations for Reference Streams in Minnesota by Ecoregion.[1] Distributions of annual data from 1970-1992 (McCollor and Heiskary, 1993; note 1 mg/L = 1 ppm = 1,000 ppb)

	Total Phosphorus (mg/L)			Total Suspended Solids (mg/L)			Turbidity (NTU)		
Region/ Percentile	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**
NLF	0.02	0.04	0.05	1.8	3.3	6.0	1.7	2.5	4.3
NMW	0.04	0.06	0.09	4.8	8.6	16.0	4.1	6.0	10.0
NCHF	0.06	0.09	0.15	4.8	8.8	16.0	3.0	5.1	8.5
NGP	0.09	0.16	0.25	11.0	34.0	63.0	5.6	15.0	23.5
RRV	0.11	0.19	0.30	11.0	28.0	59.0	6.0	12.0	23.0
WCBP	0.16	0.24	0.33	10.0	27.0	61.0	5.2	12.0	22.0

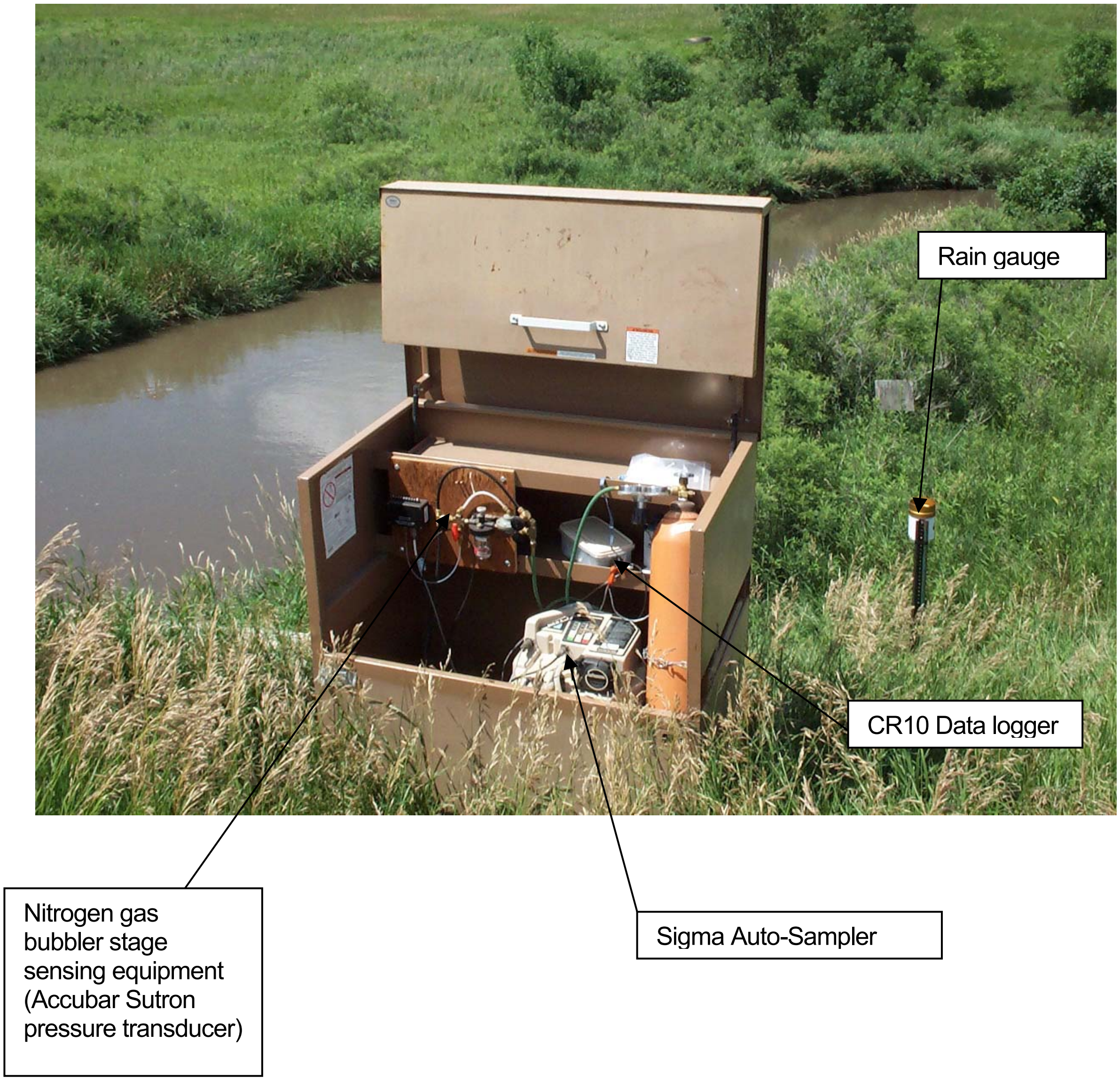
[1]Interquartile range is determined by sorting measures from lowest to highest and represents those measures between the 25th and 75th percentile.

Site 1

Monitoring site 1 near Highway 71. View looking West upstream. Also location for stream incising study by MPCA

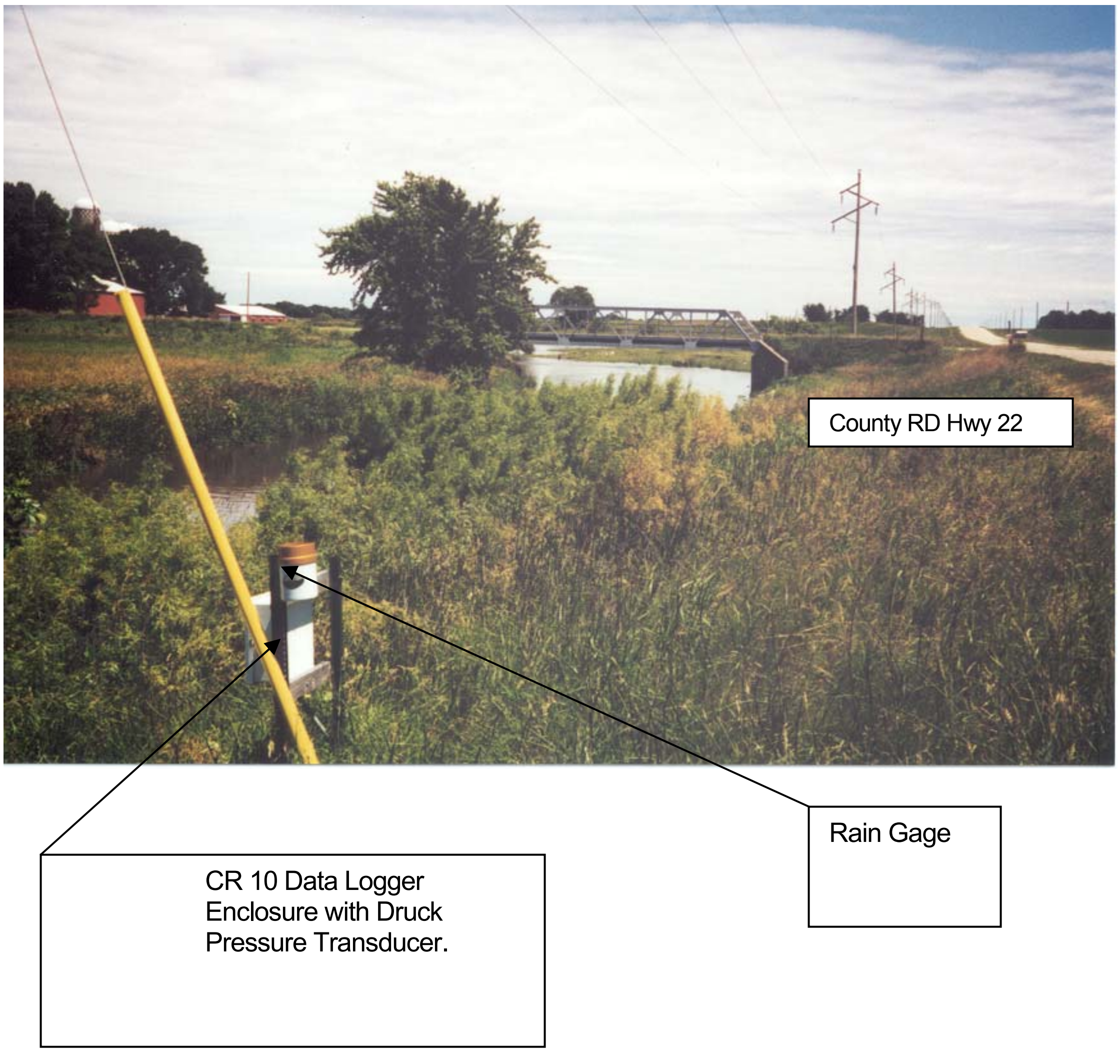
Site 2

Located 8 miles west of Comfrey on Country Road 10 bridge.



Site 3

View looking NE downstream. Site located on highway 22 between highway 13 and 4.



Site 4

Sample location at mouth near Hwy 68. Class A gaging stream downstream 500 yards. Picture taken high flow. April 9, 1999 Spring rainfall and runoff.