REPORT TO THE ENVIRONMENTAL QUALITY COMMISSION

AND THE CITY COUNCIL, NORTHFIELD, MINNESOTA

Water Quality of the Cannon River, 1978

Submitted by Jerry R. Mohrig, Ph.D.
March 1980

In the autumn of 1977 the Environmental Quality Commission (EQC) requested a water quality study of the Cannon River at Northfield. The City Council provided $1,000 for the study, which was carried out by members of the EQC, with samples analyzed by Serco Laboratories in Roseville, Minnesota.

Northfield has two major water resources, the Cannon River and the Sibley Marsh. Rather than attempting to save every small wetland within the city limits, the commission thought it best to place a sustained effort into conserving these two major water resources, so that our citizens could enjoy them now and their children could do the same in the future. The purpose of this study was to discover the health of the river both above and below Northfield, to provide a balance sheet of our town's effect on the Cannon.

Before the study, we simply did not know much about the quality of the river water that came to us. Of course, the staff of the Northfield Waste Water Treatment Plant (WWTP) took samples on a regular basis, but only near the plant itself. The last systematic data on the river above Northfield had been done over a two-day period in February 1972.[1]

Mr. Larry Turner of Northfield's Water Department, Prof. Ed Buchwald from Carleton's Geology Department, and I planned the study late in 1977. Our strategy was to plan a simple, straightforward analysis of water quality. The samples were collected by Prof. Buchwald, Carleton student Mark Hollingsworth, EQC member Terry Sullivan, and me. In order that the data be as reliable as possible, a commercial water testing laboratory, used also by the City Water Department, was chosen to do the analyses.

METHODS

The study was conducted from December 1977 through December 1978.[2] Nine sets of samples were taken during this time, refrigerated and then sent by bus directly to Serco Labs. In order to reach the laboratory by early afternoon, all river samples were taken from 7:00 - 9:00 A.M. and sent to Roseville on the 9:50 A.M. bus. Serco labs provided the necessary sterile and non-sterile sampling bottles.

Three sampling sites near Northfield were chosen. The first was at the Highway 3 bridge south of Fifth Street, the second just south of the WWTP and the third north of the WWTP. These three sites had a number of advantages. They allowed us to assess the water quality flowing into and out of the city and to isolate the effect of the Waste Water Treatment Plant on water quality. In addition, they were accessible spots that had good water flow patterns. A more detailed description of the sampling sites is given in Appendix I.

The measurement of dissolved oxygen is crucial in understanding water quality, but must also be done immediately upon sampling. The amount of dissolved oxygen generally has been considered as significant in the protection of aesthetic qualities of water as well as for the maintenance of fish and other aquatic life. When the dissolved oxygen level is low, the water has an unpleasant odor and the fish die.

We chose to use the dissolved oxygen meter graciously provided by the Carleton Biology Department; results were cross checked using the dissolved oxygen meter at the WWTP and by calibrating our results by the standard azide modification of the Winkler chemical titration.[3] The work on this latter method was done as a research project by Mark Hollingsworth, working with me at the Carleton Chemistry Department.

A second standard measure of water quality is the five-day Biochemical

Oxygen Demand (BOD_5). When large amounts of organic wastes are present in water, the demand for oxygen to oxidize them is great. This in turn can lower the dissolved oxygen level.

Clear water is always more appealing than muddy water. The standard test for water clarity is measurement of total suspended solids. This was the third test that was routinely carried out in our water testing program.

Even before people knew that microscopic organisms could cause disease, impure water was recognized as a medium for the transfer of disease. In order to quantify pollution levels, the use of biological indicator organisms has been essential. Bacteria of the coliform group, which live in the intestines of warm-blooded animals, are considered the primary indicators of fecal contamination and are one of the most frequently applied indicators of water quality. The number of fecal coliforms present is indicative of the degree of health risk associated with using the water for drinking or swimming. High fecal coliform counts may indicate the presence of pathogenic organisms that cause skin irritations and intestinal diseases. Fecal coliforms usually enter rivers through effluent from polluted runoff (manure) and deficient sewage and septic treatment systems.

The last regular measure of water quality that we used was pH, the measure of acidity or alkalinity of the river.

Along with these standard tests of water quality, we took note of the weather conditions at the time of the testing and the precipitation during the previous weeks. The flow rate of the river was also measured using the Carleton river monitoring station.

RESULTS

The Minnesota Pollution Control agency has classified the Cannon as a 2B river. The 2B classification is defined in the following way:

"The quality of this class of the intrastate waters of the state shall be such as to permit the propagation and maintenance of cool- or warm-water sport or commercial fishing and be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable."

This classification is a goal and is not meant to reflect the present water quality. Few of us would swim in the Cannon River, although this was a regular and normal thing to do in the early part of our century.

Before I list the data which we obtained, it will be useful to give the standards of water quality that the river should meet. The dissolved oxygen level should be not less than six milligrams per liter from April 1 through May 31 (spawning season) and not less than five milligrams per liter at other times. These levels can insure healthy fish populations. For bathing waters, the fecal coliform bacterial level should not exceed a mean value of 200 per 100 mL, based on a minimum of five samples taken over a 30-day period. No more than ten percent of the total samples taken during any 30-day period should exceed 400 coliform per 100 mL.

Table I presents in tabular data our main results for the year. Listed in separate columns are values for the five-day Biochemical Oxygen Demand, Dissolved Oxygen, Suspended Solids, pH, Fecal Coliform Bacteria and the River Flow. This data will be discussed in the next section. Before that, however, I should mention that during the course of the study we monitored other parameters from time to time. Past studies[1] mentioned excessive cyanide levels in the wastes discharged by the WWTP and 3M Dynacolor plant. We checked the cyanide level in May and found them to be insignificant ($<$ 0.01 mg/liter) both above and below the Waste Water Treatment Plant. The concentration of copper was also very low (3.5 μg/liter). Total solids,

Table I

Cannon River Study - 1978

EQC	BOD_5 (mg/L)	Dissolved O_2 (ppm)	Suspended Solids (mg/L)	pH	Fecal Coliform Bacteria (no./100 mL)	Flow Rate (cu. ft./sec.) (see Appendix IV)
Dec. 22, 1977						
Hwy 3 Bridge	< 3	10.6	7	7.6	100	
Above WWTP	< 3	11.6	7	7.2	180	140
Below WWTP	< 3	10.8	7	7.5	80	
Feb. 2, 1978						
Hwy 3 Bridge	8	8.1	9	6.9	< 10	
Above WWTP	< 3	9.2	5	7.5	40	140
Below WWTP	4	9.8	5	7.6	< 10	
March 15, 1978						
Hwy 3 Bridge	< 3	9.6	7	7.8	< 20	
Above WWTP	< 3	10.6	10	7.6	20	140
Below WWTP	< 3	10.3	10	7.8	1260	
Thaw						
May 11, 1978						
Hwy 3 Bridge	4	8.7	18	8.3	20	
Above WWTP	4	9.1	17	8.2	260	498
Below WWTP	5	9.4	20	7.8	470	
June 30, 1978						
Hwy 3 Bridge	4	5.7	110	7.8	150	
Above WWTP	5	6.6	106 (25 NTU)	7.8	< 10, < 10	85
Below WWTP	5	6.55	118 (27 NTU)	7.6	930, < 10	
July 28, 1978						
Hwy 3 Bridge	4	-	80 (26 NTU)	8.0	60, 410	
Above WWTP	5	7.9	- (32 NTU)	8.0	220	129
Below WWTP	3	7.8	90 (31 NTU)	8.0	60, 780	
Sept. 1, 1978						
Hwy 3 Bridge	2	6.5	6	8.4	180, 280	
Above WWTP	3	7.7	19	8.4	700	53
Below WWTP	4	7.6	5	8.3	430, 300	
Sept. 28, 1978						
Hwy 3 Bridge	< 3	7.7	22	8.2	140	
Above WWTP	3	8.6	30	8.2	310 ± 27	76
Below WWTP	4	8.3	24	8.2	230 ± 10	
Waterford Bridge	4		29	8.2	200	
Nov. 30, 1978						
Hwy 3 Bridge	< 3	10.5	6	8.3	30	
Above WWTP	< 3	10.5	12	8.2	70 ± 20	60
Below WWTP	3	10.8	12	8.1	3295 ± 355	

total volatile solids and suspended volatile solids were measured from December through May to provide a baseline for Carleton's river monitoring station. The values were:

	Suspended Volatile Solids (mg/L)	Total Solids (mg/L)	Total Volatile Solids (mg/L)
Dec. 22, 1977			
Hwy 3 Bridge	2	-	-
Above WWTP	2	-	-
Below WWTP	1	-	-
Feb. 2, 1978			
Above WWTP	2	528	121
March 15, 1978			
Hwy 3 Bridge	4	474	156
Above WWTP	4	483	142
Below WWTP	4	479	155
May 11, 1978			
Above WWTP	-	418	-

Since the fecal coliform bacterial counts were very high at times, we took some care to assess the validity of these data. In particular, we were intrigued by the fact that fecal coliform counts were sometimes highest above the Waste Water Treatment Plant. The scattered coliform values were also of concern. From September through November, we sought to probe this phenomenon. Fecal coliform tests were done in different ways as follows:

	Fecal Coliform by Multiple Tube Fermentation Technique (no./100 mL)	Fecal Coliform as Assayed by WWTP Personnel (no./100 mL)
Sept. 1, 1978		
Hwy 3 Bridge	93	-
Above WWTP	460	170
Below WWTP	240	684

	Fecal Streptococcus (no./100 mL)
Sept. 28, 1978	
Above WWTP	526 ± 51
Nov. 30, 1978	
Hwy 3 Bridge	30
Above WWTP	30
Below WWTP	5380 ± 140

DISCUSSION

This year-long study of Cannon River water quality shows some conclusive facts for 1978. First of all, the river water coming to us from the south was of higher quality than the water leaving the city. We cannot claim that water quality problems in the river are not of our own making.

Secondly, the prime indicator of water quality for a healthy fish population, that is the dissolved oxygen level, was consistently high. It was always above the state standard for the river. On this basis, there is reason to expect the Cannon to support a healthy fish population.

In the third place, the fecal coliform levels on at least two occasions were extremely high (March 15 and November 30). These results surely suggest poor sewage treatment by the WWTP. As the treatment plant has received more and more volume of waste water, its efficiency has suffered. In 1979, the WWTP processed on the average 100,000 gallons per day more than the quantity it was designed to purify (see Appendix II). Efficiency must suffer under these conditions. Our data were for a year when on the average the plant processed an amount just under its designed capacity. Even then, the fecal coliform counts were substantially higher than desired.

Surprised that fecal coliform values were sometimes higher above the Waste Water Treatment Plant than below it, we suspected some other source of fecal matter within the city limits. One possibility was the large duck population that has been living on or near the river for some years. Serco Laboratories suggested that we test not only for fecal coliform (FC) but also for fecal streptococcus (FS) bacteria. Numerous studies have shown that animals harbor in their GI tract a higher number of fecal streptococcus than fecal coliform. The reverse is true for human beings. When the ratio FC/FS is greater than or equal to four, the pollution is probably derived from human wastes. A ratio of FC/FS less than or equal to 0.7 indicates pollution from livestock or poultry. In September 1978 the FC/FS ratio was 0.6. With such limited data it is impossible to be conclusive, but the data suggest that the ducks may play a role in the higher than expected fecal levels in the river above the Waste Water Treatment Plant. In order to confirm or deny this relationship, more tests would have to be run.

The dissolved oxygen values obtained by Mark Hollingsworth (see Appendix III) were consistently higher than those measured at the Waste Water Treatment Plant. He was extremely careful in his methodology and his analyses. There is some question as to whether or not the dissolved oxygen meter at the WWTP is being calibrated correctly. Probably this has not caused much of a problem in the past, as the WWTP values are low; this would always err on the side of safety. In the future, however, it would be better for the WWTP to purchase one of the modern dissolved oxygen meters now available commercially or at the least, examine the calibration of the present dissolved oxygen meter.

References

1. "Minnesota Pollution Control Agency Memorandum on Investigation of the Cannon River and Sources of Wastes In and Near Northfield," March 1972, by Dennis Anderson and Mike R. Carroll; Attachment A, "Comprehensive Survey of the Cannon River" by Joel G. Schilling.

2. "Cannon River Water Quality Study, 1978," Laboratory Notebook kept by Jerry R. Mohrig.

3. "The Use of a Galvanic Cell Oxygen Analyzer in a Study of the Cannon River at Northfield, Minnesota" by Mark Hollingsworth, September 1979.

Appendix I

SAMPLING SITES

Highway 3 Bridge (between Fifth and Woodley Streets)

Samples were taken in the middle of the river (about 75 cm deep) to the west of the bridge, even with the foot bridge on the south shore. In the winter we bored through the ice; in the summer we used wading boots.

Above Waste Water Treatment Plant

Samples were taken about 0.3 meters from the west shore of the river on a line from the railroad tracks-road intersection to the Carleton water tower. The water depth was about 80 cm at the point of sampling and the water current was strong there.

Below Waste Water Treatment Plant

Samples were taken about 1.5 meters from shore, about 120 meters downstream from the first tree after the open stream bank below the Treatment Plant. The water depth was about 40 cm at the sampling point and the water current was strong there. We waded into the river in order to obtain the samples.

Appendix II

Northfield's N.P.D.E.S. National Pollutants Discharge Elimination System discharge B.O.D. and S.S. interim standards are:

Biochemical Oxygen Demand	65 mg/liter
Total Suspended Solids	60 mg/liter
W.W.T. Plant Design Flow	1.65 million gallons/day

The design criteria for the new WWTP, as set by the MPCA, are:

Biochemical Oxygen Demand	25 mg/liter
Suspended Solids	30 mg/liter

1978 Average Monthly Discharge Results:

Month	Average Flow	Average B.O.D.	Average S.S.
January	1.4	64	63
February	1.5	57	60
March	1.5	62	69
April	1.8	71	62
May	1.7	67	58
June	1.6	31	46
July	1.6	26	43
August	1.4	15	42
September	1.6	35	56
October	1.7	36	48
November	1.6	39	45
December	1.5	50	48

1979 Average Monthly Discharge Results:

January	1.7	82	53
February	1.8	89	60
March	2.0	50	48
April	2.3	52	48
May	1.9	40	48
June	1.6	29	37
July	1.5	31	37
August	1.9	30	43
September	2.1	30	39
October	1.8	43	39
November	1.7	38	38
December	1.6	44	48
1979 Yearly Averages	1.8	47	45

Appendix III

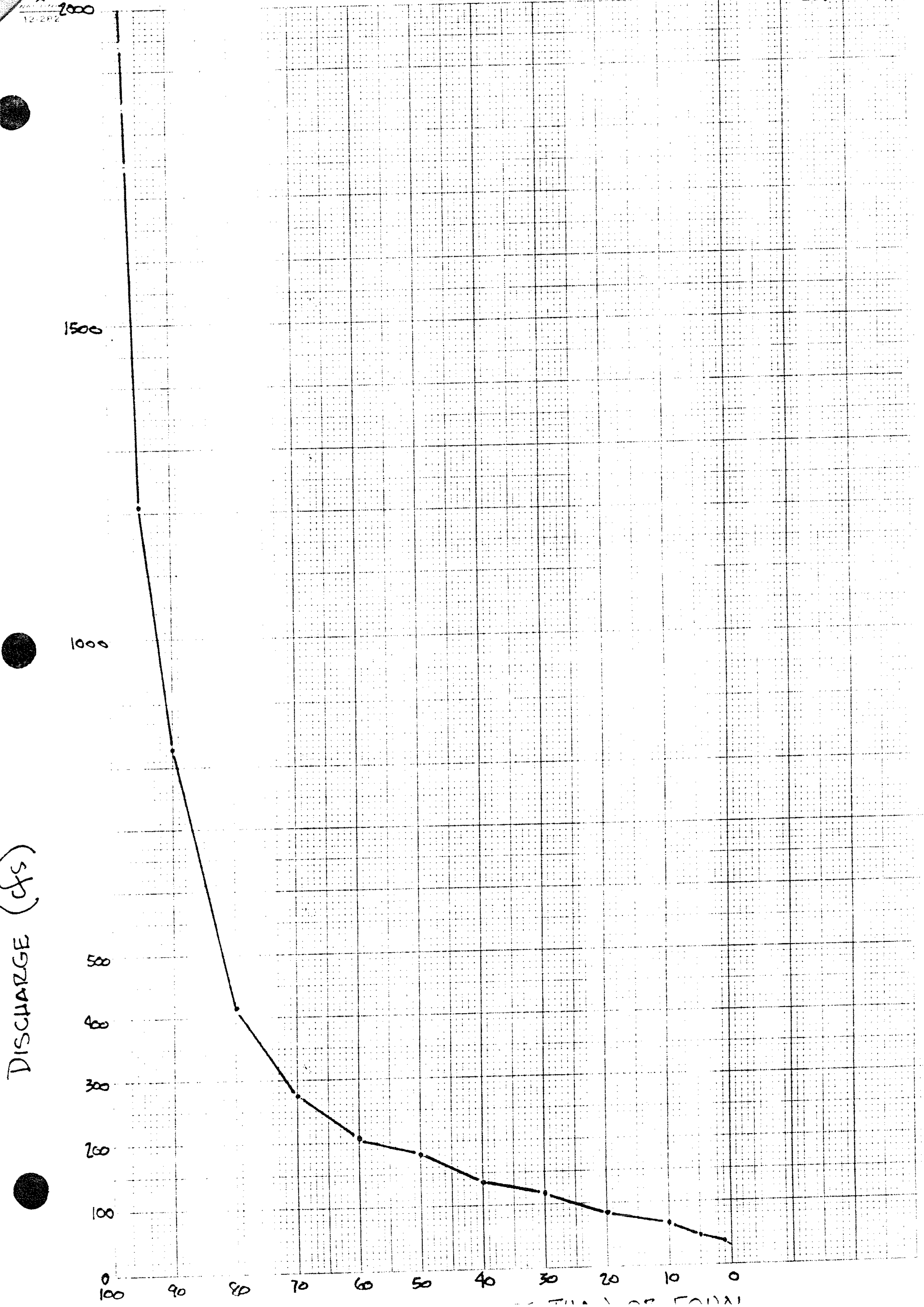
RIVER STUDY'S VALUES COMPARED WITH THOSE OBTAINED AT THE NORTHFIELD WWTP

DISSOLVED OXYGEN VALUES

		Above City			Above WWTP			Below WWTP		
Date	Method	T (°C)	D.O. (mg/L)	Cond. (μmhos)	T (°C)	D.O. (mg/L)	Cond. (μmhos)	T (°C)	D.O. (mg/L)	Cond. (μmhos)
2-2-78	WWTP	NA	8.1	NA	NA	9.2	NA	NA	9.8	NA
	RS	0.0	NA	110	0.0	NA	33	0.0	NA	51
3-15-78	WWTP	0.2	9.6	NA	0.3	10.6	NA	1.0	10.3	NA
	RS	0.0	11.2	NA	0.3	13.2	NA	0.9	13.4	NA
5-11-78	WWTP	NA	8.7	NA	15.4	9.1	NA	NA	9.4	NA
	RS	14.1	10.75	NA	14.0	10.1, 10.4	NA	14.0	10.1, 10.2	NA
6-30-78	WWTP	24.5	5.7	NA	24.2	6.6	NA	24.0	6.55	NA
	RS	24.2	7.4 ± .05	600	24.0	7.57 ± .05	650 ± 25	24.1	7.52 ± .05	650
7-28-78	WWTP	NA	NA	NA	NA	7.9	NA	21.2, 21.1	7.8, 7.85-7.9	NA
	RS	20.75	8.26	700	20.8	8.00	680 ± 20	20.8	7.7	700
11-30-78	WWTP	1.00 → 2.5	10.5	NA	0.2	10.5 ± 0.2	480*	1.1	10.8	525**
	RS	-0.1	10.3	30	-0.2	10.0 ± .15	60	0.0	10.3 ± .2	45?

* at 3.0 °C　　　** at 2.8 °C

Values taken from May through July when water temperature was above 5 °C are the most reliable.


2000
1500
1000
500
400
300
200
100
0
DISCHARGE (cfs)
100
90
80
70
60
50
40
30
20
10
0