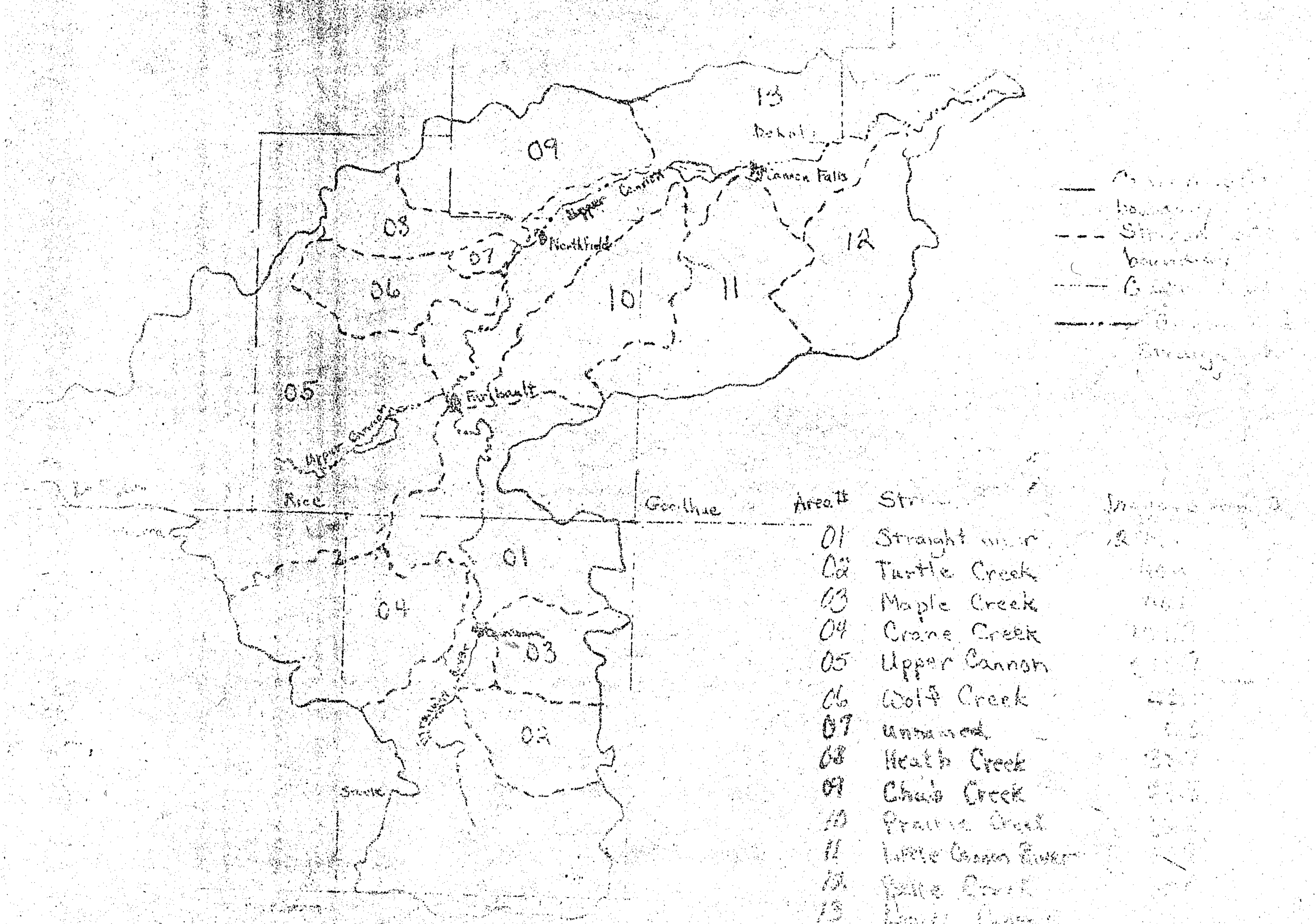
1969 Study of Cannon River Quality



Area #	Stream	[illegible]
01	Straight River	[illegible]
02	Turtle Creek	[illegible]
03	Maple Creek	[illegible]
04	Crane Creek	[illegible]
05	Upper Cannon	[illegible]
06	Wolf Creek	[illegible]
07	unnamed	[illegible]
08	Heath Creek	[illegible]
09	Chub Creek	[illegible]
10	Prairie Creek	[illegible]
11	Little Cannon River	[illegible]
12	Belle Creek	[illegible]
13	Lower Cannon	[illegible]

Nitrate Tests on the Cannon River, Summer 1969

In testing water samples from the Cannon River between Faribault, Minnesota, and Cannon Falls during a six-week period, concentrations of nitrates far exceeded any previously recorded by the U.S. Geological Survey between 1961 and 1967. The highest concentration in the USGS water quality reports was that of April 1st, 1962 -- 17 parts per million. The highest value found in the summer of 1969 was 30.0 ppm, and the mean for all samples taken from the Cannon in July was 16.4 ppm.

Ideally, a study of the change in the concentration of nitrate would be based on evidence from records giving both the mean nitrate concentration and the total discharge for each month fur a period of years. The nitrate testing done by the USGS was monthly for the three water years 1964, 1965, and 1966. There are records for one day in each of the water years 1961, 1962, 1963, and 1967. Figure 1 gives the complete chemical analyses of the Cannon during the seven-year period. Figure 2 shows their nitrate data correlated with the mean discharge for each month during the three years. All tests were done at Welch, Minnesota.

It will be seen in figure 3 that the water year 1964 was extraordinarily dry; the water years 1966 and 1967 were somewhat wetter than the average, computed from nearly forty years of records; and the water year 1965, as well as 1969, was extremely wet. The maximum nitrate concentration in 1964 was 10 ppm, as opposed to 13 ppm in 1965, 1966, and 1967. All six of the concentrations of nitrate above 10 ppm during the years 1961-1967 were recorded in the months February-April, the months of the spring melt. This strongly suggests that soil fertilizer carried into the Cannon in the runoff is largely responsible for the excess nitrate.

Natural waters contain little free nitrate. It is usually estimated that over .3 parts per million nitrate will lead to heavy algal growth in streams.[1] The quantity of nitrogen available has definitely been shown to limit algal populations. An algal bloom occurs when surface waters contain excess nutrients. The death of the algae, especially mass deaths as occur in cool weather or during a period of cloudy weather, "owerburdens the water with organic matter, which on being oxidized by microorganisms depletes the oxygen content of the water, causing the natural cycles of self-purification to collapse."[2] The build-up of toxins then can completely inhibit bacterial action.[3]

Nitrates can also be toxic to animal life. Water with nitrate concentrations over 10 ppm is unsafe for human consumption. Bacteria in an infant's intestine convert nitrates to nitrites, which combine with hemoglobin to cause an asphyxiating disease, methemglobinemia. Concentrations over 5 ppm are considered excessive in the drinking water of domestic animals. Cows, for instance, which drink high-nitrate water can produce milk harmful to babies.

The nitrate of surface waters has several sources. Which source or sources are leading to nitrate pollution must be determined. Fertilizers, animal wastes from feedlots, urban sewage, and nitrogen compounds present in precipitation contribute to nitrate in waters. The nitrogen in rain and snow comes from the atmosphere. I would be interested in analyzing rainwater in the Cannon Valley but would not expect the nitrogen content to be as high as that falling in an urban area where industrial smokes constantly pour impurities into the atmosphere. The other sources of atmospheric nitrogen are electrical discharges, terrestrial decomposition, and volcanic eruptions.[4] Sewage treatment plants along the Cannon and Straight Rivers serve over 45,000 people. Cattle, pigs, sheep, chickens, and turkeys are raised in parts of the Cannon valley. "The relative importance of the contribution of nitrogen from sewage and manure to the river can be evaluated by examining the ammonia content of the river, for it is well-known that this substance reflects the input of organic wates."[5] The euthrophic condition of the lakes in the Upper Cannon drainage area may be attributable to seepage from the sewage disposal system of individual dwellings. Fertilizers are the source most suspect in the case of the Cannon as a whole. The positive correlation between times of high discharge, directly related to the amount of rainfall and runoff, and times of high nitrate content point to the conclusion that this is the main source of the pollution.

My nitrate data[6] for the Cannon River between Faribault and Cannon Falls and for the Straight River as it enters Faribault before it empties into the Cannon is presented in figure 4. The numbered sample points are shown in figure 5. I chose to sample the Straight because it contributes nearly one-fifth of the Cannon's total discharge. Figure 4 shows that for all sample points there was more than a 50% decrease in nitrates between July 2 and August 7. This drop can be correlated with the decreasing discharge of the River (see figure 6). We might expect a peak in nitrate concentration in July because of heavy rains at the end of June. Such high concentrations are unprecedented on the Cannon during the summer; however, it is possible that a peak level could be missed by the monthly sampling of the Geological Survey.

A study done by the Illinois State Water Survey in November, 1968, showed a "two-month delay between the period of peak water discharge and peak nitrate concentration [here the highest monthly mean of the year]. This suggests that the nitrate reaches the river by way of percolation into the soil and groundwater movement rather than in the immediate runoff from precipitation."[7] Such a relationship between peak discharge and peak nitrate level is not apparent in the data available on the Cannon and probably could not be substantiated by the limited testing done.

The levels of nitrate determined for samples along the Cannon can be compared with the USGS data from Welch. A test on a sampler from Welch on July 24 was in line with the results of samples from other points on the same day.

With the exception of the Cannon Falls sample on July 2 and the Highway 218 point between Faribault and Dundas on July 30, the nitrate levels for all samples indicate a consistently high but decreasing nitrate level along the chosen stretch of the River.

Results of nitrate tests on the Upper Cannon and on tributaries of the River are listed in figure 7. With this supplement to the more intensive sampling, a number of trends become noteworthy.

1) Nitrate levels on the Straight River were higher than those found at any point on the Cannon in the same two-day period of testing, except for the samples of July 2.

2) No other tributary tested had levels of nitrate comparable to those of the Straight. All but Heath Creek, tested on July 14, had levels substantially lower than those of the Cannon itself.

3) The Upper Cannon, below Waterville and in Cannon and Wells Lakes had strikingly low levels of nitrates in comparison to those of the Lower Cannon for the same date. Here there was algal growth much thicker than at any other sample point besides Union Lake, where a low nitrate level was found early in July. Unlike the Straight River during the summer which had a high free nitrate content and relatively little algae, the Upper Cannon must contribute to the nitrate of the Lower Cannon indirectly, by the death and decomposition of the billions of algae.

Assuming inorganic fertilizers are the main source of nitrate in the Cannon, what explanation is there for the high concentrations found in summer, 1969? It could be that the amount of fertilizer used has simply increased in the past five years to account for this. It could also be that the character of the water year was such that more fertilizer than in previous years was washed into the river during the first half of the summer.

Warren Liebenstein, Rice Country's agricultural agent, described a typical year's fertilizing schedule.[8] In the past, most fertilizer was applied in the spring. Recently, however, it has become customary to apply a considerable amount in the fall. In the spring a starter fertilizer is applied at planting time. Now the fall of 1968, with an unseasonable amount of rain, was unsuitable for the application of fertilizer. The bulk of fall fertilizing is done in October. This past fall little was applied at this time. The farmers of the Cannon valley must have compensated by applying a greater amount of fertilizer in the spring. This anomaly in the fertilizing schedule of the 1969 water year could be responsible for the high nitrate level found in the summer. If this hypothesis holds, nitrate levels will not reach the heights found in summer 1969 when fertilizers are applied normally.

Nitrate tests should be done throughout the year if more definite statements are to be made. Results of testing next July could be profitably compared with the results of the 1969 summer.

Dissolved Oxygen

Dissolved oxygen levels recorded at the Northfield and Faribault sewage plants and in my own testing indicate that the Cannon's DO content is above the minimum set by the Minnesota Pollution Control Agency. The state's standards for quality and purity of intrastate waters are given in WPC 14. For waters to permit the propagation and maintenance of sport and commercial fishes dissolved oxygen levels should be as follows:

Not less than 7 milligrams per liter (ppm) from October 1st and continuing through May 31st
and
Not less than 5 mg/liter at other times

or the less strict standards:
Not less than 6 mg/liter from April 1st through May 31st
and
Not less than 5 mg/liter at other times.[9]

Determination of dissolved oxygen is not included in the chemical analysis of surface waters carried out by the Geological Survey. The earliest DO tests found are from December, 1965. Employees of the Northfield sewage treatment plant found a high level of oxygen, which was not lowered by the output of the plant (see figure 8). Bacterial action on wastes, i.e. excessive organic matter, can deplete the water's free dissolved oxygen. In extreme cases of pollution, a septic zone results some distance below the source of pollution; only organisms that can live in anaerobic conditions survive.[10]

The Faribault sewage treatment plant began DO tests on river water this May and plans to continue to do these each month. Their data for May-August 1969 is given in figure 9. The effluent of the plant has not brought the oxygen level dangerously low. It is to be expected that the DO level decreases during the summer, as seen in this figure. The saturation level of dissolved gases is lower for warmer water than for cold, and it has been shown that the lowest concentrations of DO in bodies of clean freshwater are found in the summer. Furthermore, "summer is usually the critical period for organic pollution." With higher temperatures, bacterial action is accelerated, wastes are degraded more rapidly, and dissolved oxygen is drawn upon more heavily.[11]

My own data on the dissolved oxygen of the river shows levels between 9.48 milligrams per liter (or parts per million) and 5.82 mg/liter. (See figure 10). Using the Winkler method I carried out each test in the field except for the final titration with sodium thiosulfate, which was done within one hour of the collection of the samples. The samples were from the Cannon between Faribault and Byllesby Reservoir. The result of the one DO test done on water from the Straight River at Tonka Park in Faribault was comparable to those ofother samples from the Cannon on the same day.

If low levels of dissolved oxygen, below 5 mg/liter, were to persist in the River, the environment would be deadly to river biota. "Minimum amounts rather than averages are most critical. Any species can survive something less than the optimum concentration of DO for a limited period of time. There is, however, some concentration for any given temperature, which will eventually result in the death of that species.? Low levels of free dissolved oxygen may also increase the toxicity of certain chemicals.[12] A fish "kill" may occur: fish of one species or of a number of species die en masse.

Footnotes

[1] Barry Commoner, Threats to the Integrity of the Nitrogen Cycle, December, 1968, p. 13.

[2] Commoner, pp. 3-4.

[3] Allen V. Kneese, "Types of Pollutants", in The Water Crisis, ed. George A. Nikolaieff (H.W. Wilson: New York, 1967), p. 67.

[4] Franz Ruttner, Fundamentals of Limnology, trans. D. G. Frey and E. J. Fry (University of Toronto Press, 1953), p. 79.

[5] Commoner, p. 17.

[6] The nitrate test used was an American Society for Testing and Material standard test for nitrate ion in industrial water.

[7] Commoner, p. 11.

[8] Interview with Mr. Warren Liebenstein, August 6, 1969.

[9] Minnesota Administrative Rules and Regulations: Rules, Regulations, Classifications and Water Standards, Minnesota PCA, 1968, pp. 66-67.

[10] Applied Biology Seminar of the Federal Water Pollution Control Administration, U.S. Department of the Interior, January, 1969.

[11] Kneese, pp. 67-68.

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Figure 1 (9)

Summary of USGS quality data on the Cannon River at Welch, Minnesota
chemical analyses in parts per million

Date	Inst. Discharge	Silica	Al	Fe	Mn	Ca	Mg	Na	K	HCO_3
8-16-63	151 cfs	11		.04	.00	54	22	9.8	3.8	226
4-1-62	4190	7.0		.10	.05	31	9.1	3.0	4.8	105
3-21-63	840	14		.14	.14	64	19	10	8.0	235
10-22-63	308	6.5	.0	.02	.04	59	25	12	3.3	256
11-19-63	70.7	5.5	.3	.09	.04	62	26	15	3.7	277
12-6-63	95.0	3.5	.1	.01	.00	65	27	17	3.9	283
1-9-64	74.3	11	.2	.03	.04	74	28	15	3.5	315
2-17-64	60.2	11	.2	.05	.10	67	28	9.5	2.8	304
3-20-64	84.8	12	.3	.05	.08	65	24	12	3.8	276
4-17-64	100	11	.2	.03	.05	60	21	10	3.8	294
5-14-64	155	4.9	.0	.02	.05	57	23	10	3.9	232
5-15-64	145					60	22			236
6-13-64	91.3	4.4	.1	.10	.19	58	24	9.5	3.7	249
7-25-64	76.8	10	.1	.04	.13	56	26	12	3.5	255
8-28-64	84.0	7.9	.3	.05	.00	51	25	12	3.5	238
9-21-64	115	13	.3	.04	.05	58	25	9.2	3.7	247
9-24-64	148	13	.2	.03	.02	59	22	11	4.5	225
10-16-64	111	10	.2	.03	.04	66	24	11	4.3	258
11-13-64	91.2	4.3	.2	.03	.03	57	26	11	3.7	247
12-11-64	131	6.6	.6	.05	.03	65	26	13	4.9	267
1-15-65	106	11	.5	.05	.11	89	26	17	4.3	329
2-19-65	101	13	.7	.07	.19	65	27	16	4.7	276
3-26-65	146	11	.0	.06	.19	59	20	8.1	4.5	224
4-26-65	2870	9.9	.1	.10	.12	42	13	3.7	4.5	150
5-15-65	771	4.8	.1	.05	.03	56	19	5.2	4.3	215
7-30-65	133	16	.4	.04	.06	66	22	6.5	3.7	255
8-27-65	120	15	.2	.05	.13	70	23	9.1	3.7	277
9-27-65	746	17	.3	.03	.09	74	22	8.6	4.4	278
10-29-65	171	17	.4	.02	.01	80	25	6.9	3.7	304
11-29-65	177	13	.9	.02	.01	84	28	9.5	3.5	325
12-20-65	164	12	.3	.01	.08	80	28	8.6	3.3	318
1-24-66	82	14	.2	.02	.18	48	30	8.2	3.0	229
3-4-66	8470	10	.7	.14	.09	51	14	6.0	6.4	186
5-5-66	746	3.7	.6	.06	.07	56	24	6.6	3.5	228
6-7-66	324	3.4	.6	.02	.06	61	26	7.7	3.7	253
8-1-66	81	11	.1	.01	.14	53	28	5.7	2.6	254
3-25-67	6890	7.1				35	9.4	3.6	6.1	122

Fig 1(b)

CO_3	SO_4	Cl	F	NO_3	PO_4	B	Dissolved Solids*	Hardness (Total)**	Specific Conductance***	pH	Color
0	41	13	.2	5.7		.04	272	226	471	7.2	8
0	18	5.1	.2	17		.01	147	115	251	6.7	30
0	38	15	.2	14		.06	314	238	507	7.0	45
0	35	15	.2	3.7	.43	.04	299	248	501	7.7	4
0	38	19	.3	4.7	.30	.05	325	262	550	7.4	5
0	39	22	.3	4.3	.22	.06	336	272	570	7.6	5
0	38	19	.2	8.6	.65	.05	359	301	609	7.5	5
0	30	21	.2	5.8	.14	.03	350	281	543	8.2	2
0	31	14	.2	8.3	.73	.04	307	259	534	7.6	5
0	36	13	.2	7.6	.59	.04	287	237	495	7.5	7
0	48	13	.2	3.4	.22	.04	299	236	490	7.2	15
0							304	241	493	7.8	
0	44	11	.3	4.9	.25	.02	305	245	446	7.8	9
0	41	17	.3	4.5	.41	.02	302	248	518	7.4	6
0	36	15	.3	4.0	.24	.03	283	231	493	7.4	6
0	39	12	.3	7.7	.08	.06	304	246	493	7.6	15
0	45	14	.3	10	.39	.04	293	236	486	7.3	6
0	49	14	.3	6.2		.09	332	316	535	7.4	12
0	45	14	.2	4.4		.04	308	293	509	7.4	5
0	43	18	.3	7.6		.03	330	317	563	7.5	5
0	51	20	.3	8.0		.06	394	384	658	7.8	5
0	41	20	.3	12		.04	342	322	573	7.1	5
0	34	10	.2	13		.05	302	274	482	7.4	12
0	28	6.4	.2	9.9		.04	216	193	327	7.9	28
0	37	7.4	.2	4.4		.04	278	256	429	7.6	22
0	38	10	.2	7.9		.03	308	298	496	7.6	21
0	40	13	.2	4.9		.05	327	311	532	7.4	15
0	46	13	.2	2.8		.06	352	324	548	7.2	30
0	44	11	.3	9.0		.03	366	353	569	7.4	10
0	51	14	.2	7.2		.03	389	379	623	7.4	5
0	46	12	.3	8.7		.03	364	367	599	8.1	18
0	44	10	.2	8.0		.01	286	293	480	8.3	8
0	27	9.8	.2	13		.03	253	219	397	7.6	33
0	46	11	.2	5.2		.05	292	287	465	7.6	15
0	46	11	.2	3.7		.03	302	308	504	8.1	10
0	34	8.2	.2	.6		.05	275	284	477	8.1	3
0	20	7.2	.1	13		.23	188	152	285	7.9	28

notes: *residue at 180°C; **as $CaCO_3$; ***micromhos at 25°C.

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Time vs. mean monthly discharge, Cannon at Welch;
time vs. nitrate concentration, by sample during month at Welch   USGS records

	1964 water year			1965 water year			1966 water year			1969 water year
Month	Mean discharge	NO_3 (ppm)	Date of NO_3 sampling	Mean discharge	NO_3 (ppm)	Date, sample	Mean discharge	NO_3 (ppm)	Date, sample	Mean discharge
Oct	119 cfs	3.7	10-22-63	213 cfs	6.2	10-26-64	826 cfs	9.0	10-27-65	1790 cfs
Nov	125	4.7	11-19-63	148	4.4	11-19	357	7.2	11-27	943
Dec	188	4.3	12-6-63	177	7.6	12-11	508	8.7	12-20	438
Jan	133	8.6	1-9-64	163	8.0	1-15-65	391	8.0	1-24-66	352
Feb	133	5.8	2-17-64	270	12.	2-19	1741			338
Mar	190	8.3	3-20	975	13	3-26	1561	13	3-4	1930
Apr	157	7.6	4-17	8240	9.9	4-26	1281			2690
May	315	3.4	5-14	1543	4.4	5-15	512	5.2	5-5	1110
June	160	4.9	6-13	670			367	3.7	6-7	480
July	141	4.5	7-25	842	7.9	7-30	187			
Aug	109	4.0	8-28	272	4.9	8-27	163	.6	8-1	
Sept	446	8.8	9-21	547	2.8	9-27	155			

7.7 ppm; 9-24,
10. ppm

mean NO_3 for '64
= 5.7 ppm

mean NO_3 for
'65 = 7.4 ppm

mean NO_3 for
'66 = 6.9 ppm

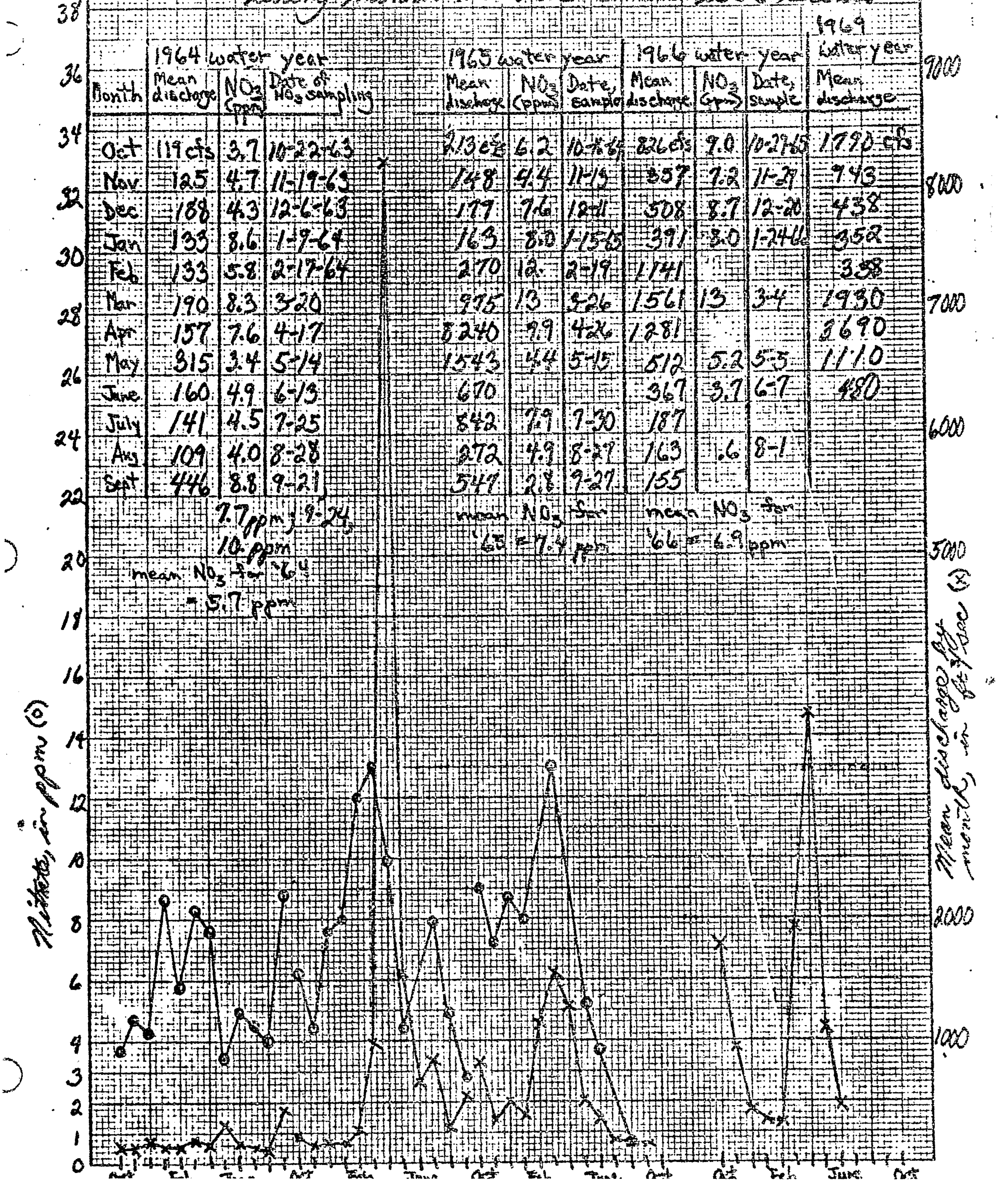
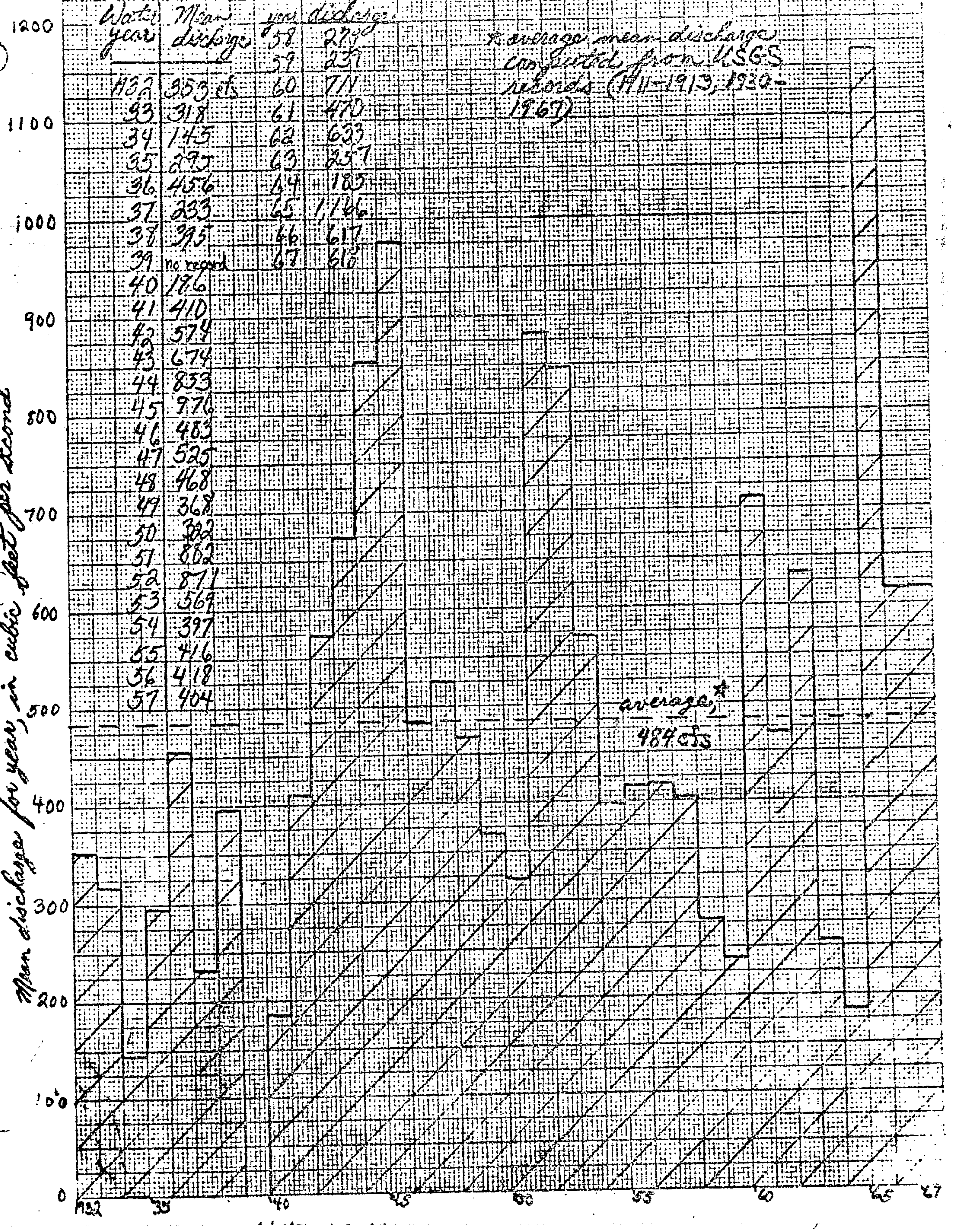


Figure 3

Time vs. Mean discharge of year   Cannon River at Welch, Minn.



Water year	Mean discharge	year	discharge
		58	278
		59	237
1932	353 cfs	60	711
33	318	61	470
34	145	62	633
35	295	63	237
36	456	64	185
37	233	65	1,166
38	395	66	617
39	no record	67	616
40	186		
41	410		
42	574		
43	674		
44	833		
45	976		
46	483		
47	525		
48	468		
49	368		
50	382		
51	862		
52	871		
53	569		
54	397		
55	416		
56	418		
57	404		

* average mean discharge computed from USGS records (1911-1913, 1930-1967)

Time vs. Nitrate in ppm

Summer 1969

Sample point	① Tate Park	② 218, F-D	③ Dundas	④ 218, North	⑤ Water-ford	⑥ Byllesby	⑦ Cannon Falls
July 2-3	26.5	29.0	25.0	27.0		30.0	11.0
July 8-9	20.5	20.0	20.0	17.0	19.0	20.0	15.5
July 14-15	24.0	18.0	14.5	14.0	21.0	18.0	16.0
July 23-24	18.0			12.0	15.0	13.0	
July 30-31	15.0	3.0			9.5	7.5	
August 7	9.0	6.5		6.0	8.0	7.5	
mean for July	20.8	17.5	19.8	17.8	12.9	17.7	14.2

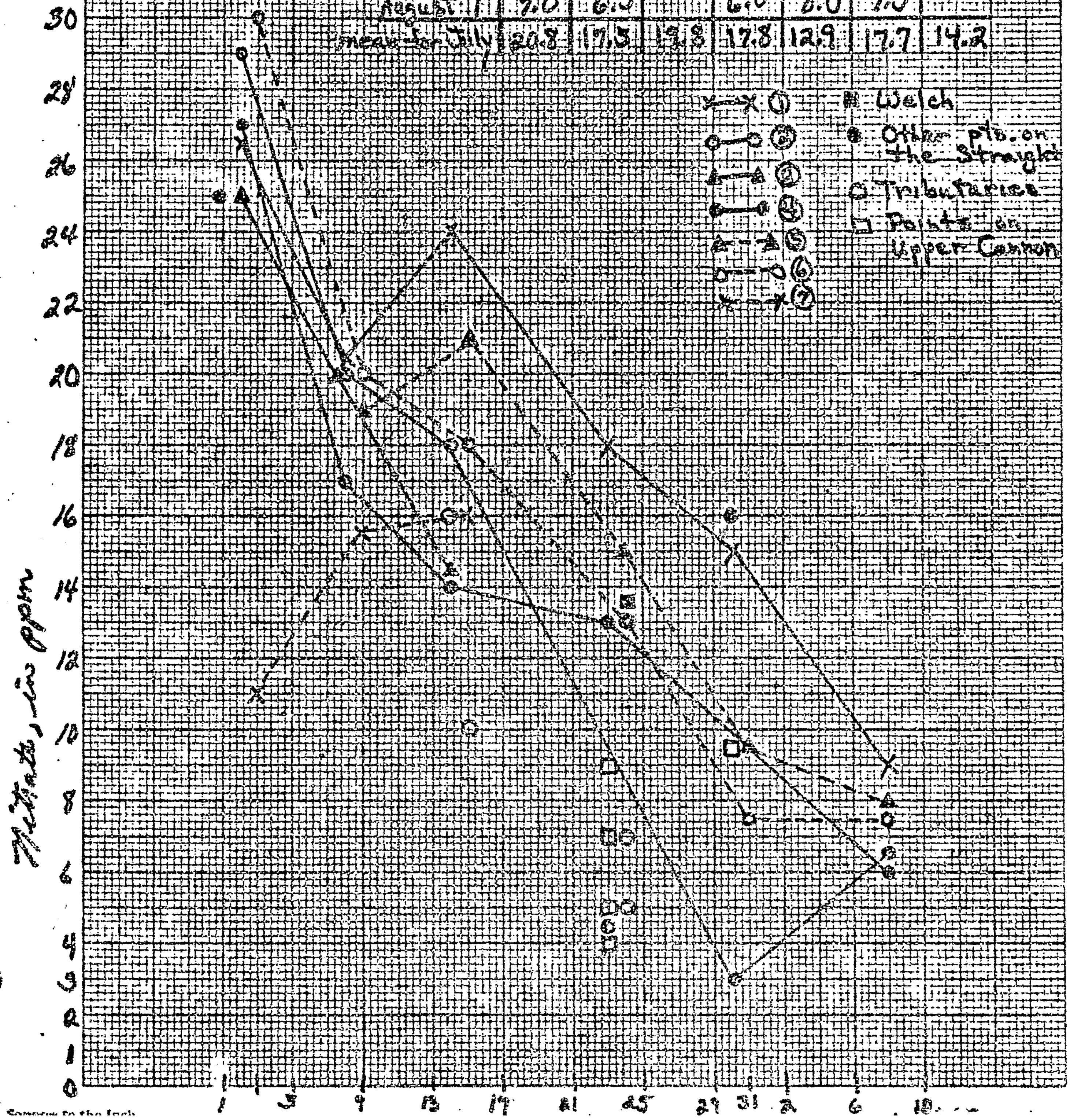
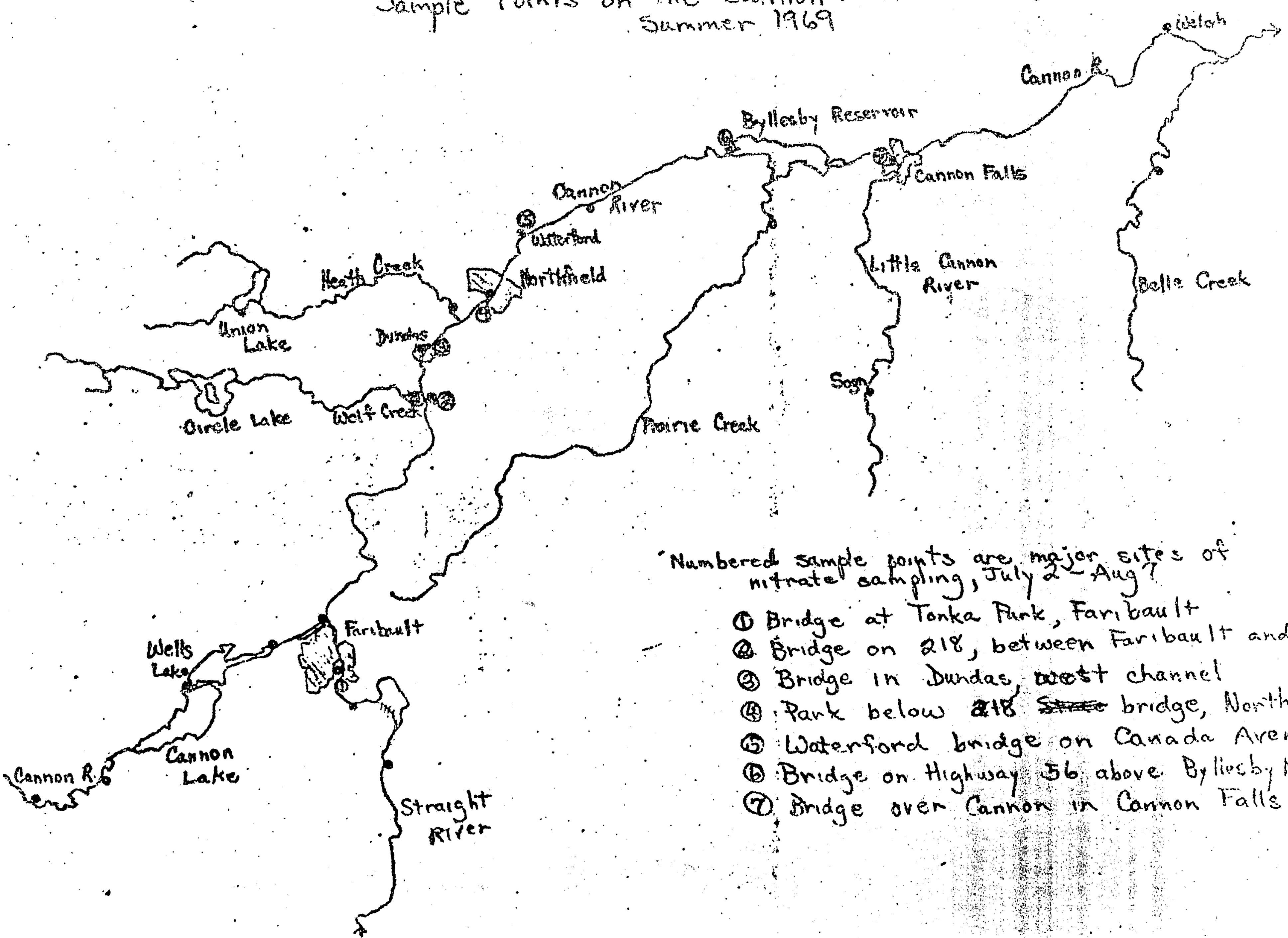


Figure 5

Sample Points on the Cannon + Tributaries
Summer 1969



"Numbered sample points are major sites of nitrate sampling, July 2 - Aug 7

① Bridge at Tonka Park, Faribault
② Bridge on 218, between Faribault and Dunda
③ Bridge in Dundas, west channel
④ Park below 218 ~~Street~~ bridge, Northfield
⑤ Waterford bridge on Canada Avenue.
⑥ Bridge on Highway 56 above Byllesby Res
⑦ Bridge over Cannon in Cannon Falls

Time vs. Discharge at Welch, Minnesota   Summer 1969

USGS Data

Date	Discharge	Date	Discharge
7-01	894	7-21	811
7-02	906	7-22	674
7-03	829	7-23	641
7-04	760	7-24	571
7-05	695	7-25	544
7-06	569	7-26	511
7-07	491	7-27	511
7-08	600	7-28	482
7-09	625	7-29	468
7-10	567	7-30	448
7-11	545	7-31	510
7-12	490	8-01	446
7-13	539	8-02	399
7-14	1140	8-03	371
7-15	1140	8-04	347
7-16	992	8-05	326
7-17	872	8-06	314
7-18	910	8-07	323
7-19	1000	8-08	291
7-20	982		

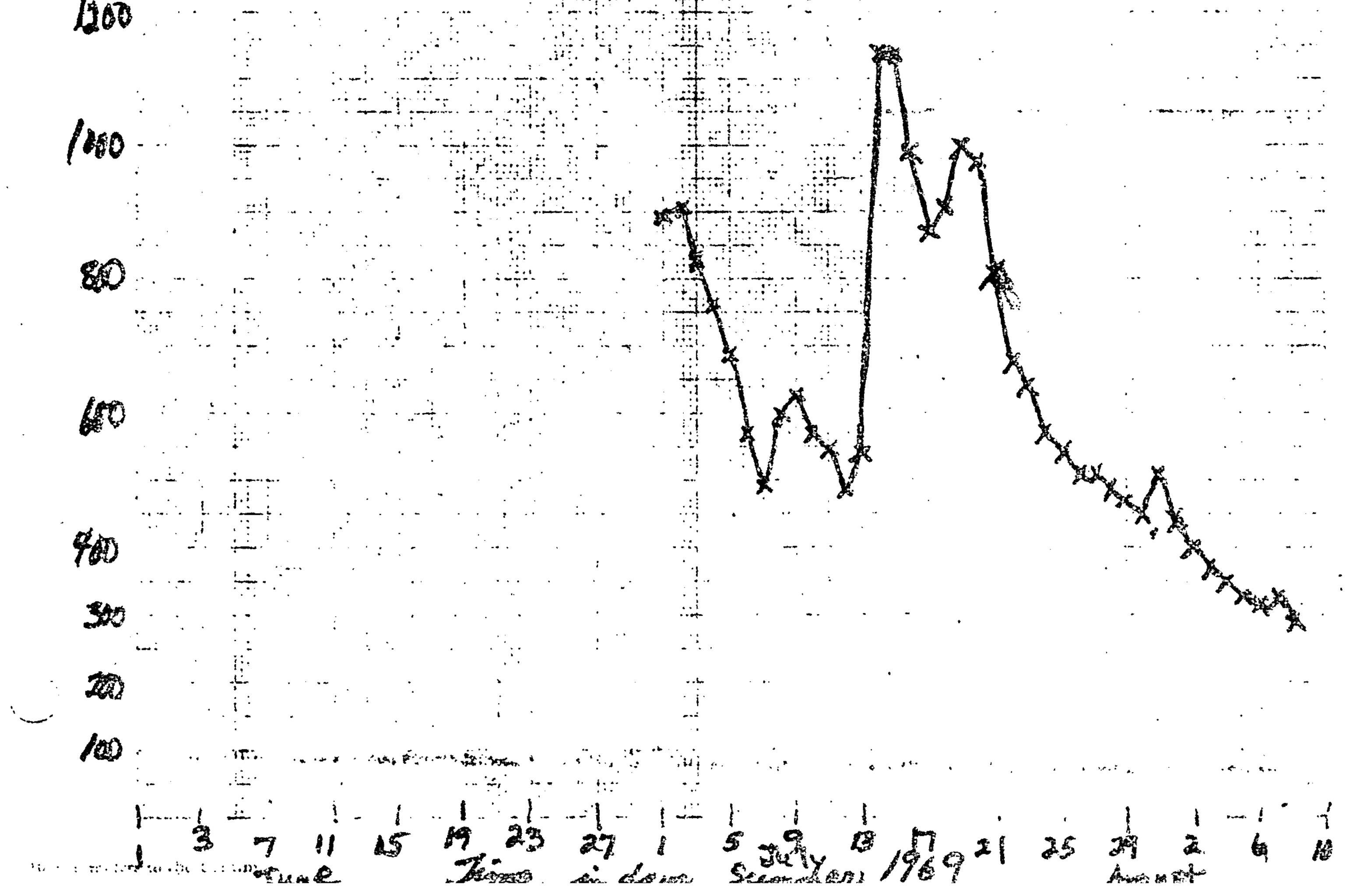


Figure 7

Nitrate Tests, Summer 1969

Samples are from points on the Cannon River not included in the preceding figure, from tributaries, and from lakes in the Cannon Valley.

Date	Sample point	NO_3 in ppm
7/2	Straight River 1½ miles above Faribault	25.0
7/7	Union Lake	2.0
7/9	Cannon between Waterford and Byllesby	15.0
7/14	Heath Creek	16.0
7/15	Prairie Creek	10.0
7/23	Cannon at Hwy. 60, west bridge to Waterville	4.0
7/23	Cannon at Hwy. 60, east bridge to Waterville	5.0
7/23	Channel between Cannon and Wells Lakes	9.0
7/23	Spillway 978, Wells Lake	7.0
7/23	Wolf Creek	4.5
7/24	Little Cannon at Sogn	5.0
7/24	Belle Creek	7.0
7/24	Cannon at Welch	13.5
7/30	Straight River 5 miles above Faribault	16.0
7/30	Cannon at Faribo Mills, bridge below spillway 964	9.5

Northfield Sewage Treatment Plant: tests on Cannon River water,
J. Turner, J. Hall, R. Ebersole, December 28, 1965

Ebersole

	Dilution	D.O.	Temp.	pH	BOD	bacteria count	size of colonies
Above Dundas	100%	13.3	1°C	8.5	4.1	10,000 MPN/100ml	90% small 10% large
5th St. Bridge in Northfield	100%	13.0	0°	8.3	3.8	15,000 MPN/100 ml	90% small 10% large
Above Plant	100%	13.0	0°	8.5	2.7	10,000 MPN/100 ml	80% small 20% large
Below Plant	100%	13.7	0°	8.3	4.5	21,000 MPN/100 ml	100% small
Above Byllesby Reservoir at Hway. 56 bridge	100%	12.9	0°	8.5	1.5	6,000 MPN/100 ml	70% small 30% large

Notes: no sign or evidence of coliform organisms in millipore samples
turbidity, color and odor was clear to the naked eye and nose

Time vs. Concentration of dissolved oxygen, data of Faribault sewage treatment plant

date location of sample	May 20		June 20		July 9		July 30	
	DO, ppm	Temp	DO	Temp	DO	Temp	DO	Temp
1500 ft. above the outfall (Straight River)	12.0	15°C	10.8	17°	8.5	26°	7.6	23°
effluent of plant (outfall)	4.0	15°	11.0	17°	7.9	25°	7.4	21°
1500 ft below outfall (Straight)	11.2	15°	10.9	17°	8.1	25°	7.2	24°
1½ miles below plant (Cannon River)	10.1	16°	10.0	17°	8.5	26°	7.4	24°
5 miles below plant (Cannon)	10.4	15°	9.0	17°	8.0	25°	6.1	24°