The effects of water quality and quantity on the fauna of a non-glacial Alaskan river
James E. Morrow

THE EFFECTS OF WATER QUALITY AND QUANTITY ON THE FAUNA OF A NON-GLACIAL ALASKAN RIVER

by

James E. Morrow

Report IWR-15

THE EFFECTS OF WATER QUALITY AND QUANTITY OF THE FAUNA OF A NON-GLACIAL ALASKAN RIVER

A Completion Report

by

James E. Morrow [1]

Project Number: A-010-ALAS

Agreement Number: 14-01-0001-1621

The work upon which this report is based was partially supported by funds provided by the U. S. Department of the Interior, Office of Water Resources Research, as authorized under the Water Resources Research Act of 1964.

UNIVERSITY OF ALASKA
Institute of Water Resources
Report No. IWR-15
College, Alaska

1971

(1) Professor of Zoology, University of Alaska

INTRODUCTION

Original notice that the project had been approved and funded was received by letter from Dr. Charles E. Behlke, then Director of the University of Alaska Institute of Water Resources Research, dated 24 November 1965.

More than 100 notices of the availability of graduate research assistantships under this project were sent out in December 1965. About 50 responses were received, seven resulting in applications. Two, Mr. Marshall Danby and Mr. Lynn Boddie, were accepted. Due to late graduations of their respective universities, neither was available for field work until late June. Mr. Danby resigned from the university at the end of the fall semester of 1966. Mr. David Nelson, a post-graduate student in fisheries biology at the University of Alaska, was employed on an hourly basis, beginning mid-September 1966. For the 1967 summer field season, he was placed on salary. Mr. Gian Vascotto was admitted to graduate study and joined the project for the 1967 field season.

Mr. Joseph Nava, then an undergraduate student in Wildlife Management at the University of Alaska, was hired on 10 March 1966, to aid in sorting, cleaning and preparing new equipment, as well as checking and repairing old equipment borrowed from the Department of Wildlife Management.

Field work was begun in late June, 1966. A camp, housed in two large tents, and including cots, camp chairs, cooking and eating tables, lab table, etc., was set up on the left bank of the Chatanika River about 100 meters below the confluence of Faith and McManus Creeks. (See Fig. 1) Transportation was provided by a 1/2 ton 4 wheel drive GMC pickup truck belonging to the Department of Wildlife Management. In mid-July, the camp was almost totally destroyed by a bear. Tents, cots, camp chairs, indeed everything made of canvas, was torn up. Contents of the camp were scattered over a wide area, and most of the records of the first two weeks were lost. Tents and cots were replaced, but a few days later the camp was again destroyed, presumably by the same bear. We then expended about $200.00 for building materials and built a small cabin. One night a few weeks later, a bear tried to enter the cabin but was frightened off by a shot through the door from a .41 magnum revolver. No further trouble was experienced with bears.

Stream depth gauges, each consisting of a stake marked in 0.1 foot intervals driven into the stream bottom were set up on the Chatanika River at station 2; on McManus Creek, left bank, about 300 meters upstream from the confluence with Faith Creek; and on Faith Creek, right side, just below the Steese Highway bridge. Zero water levels for each gauge were arbitrarily set, and depths were read at least once a day.

Sampling stations were established at six points, as follows (also, see map, Fig. 1.):

Station 1 - On the right bank of the Chatanika River, about 1.5 km below the confluence of Faith and McManus Creeks.

Station 2 - On the left bank of the Chatanika River, at the base camp.

Station 3 - On the right bank of McManus Creek, near the end of the Faith Creek trail.

Station 4 - On the left bank of McManus Creek, opposite the mouth of Montana Creek.

Station 5 - On a small island in Faith Creek, about 300 meters below the trail crossing.

Station 6 - On a small hillock about 3 meters high at the junction of Hope and Charity Creeks, upper end of Faith Creek.

Each station consisted of a rain gauge and a 7-day recording thermometer. Locations were chosen to provide unobstructed fall to the rain gauge and also shade and ventilation for the thermometers. The latter were placed in 3 lb. coffee cans nailed to trees, thus providing shelter and ventilation.

Weekly observations at each station included the following:

Water temperature in ^{o}C; rainfall; Fe++ and total Fe; ammonia nitrogen; nitrite nitrogen; nitrate nitrogen; DO; pH; poly- and ortho-phosphate; turbidity; CO_2; phenolphthalein alkalinity; and methyl/orange alkalinity. In addition, bottom fauna of the stream was sampled at each station by means of a Surber sampler. Three such samples were taken at each station each week.

To study the fish fauna, 24 seining stations were established on the Chatanika River and McManus Creek. Station S-1 was just above the dam at Mile 69 Steese Highway, Station S-24 at the Montana Creek road maintenance camp about 2 km upstream from the mouth of Montana Creek. Twelve such stations were set up on Faith Creek, Station S-25 just above the Steese Highway bridge, Station S-36 at the junction of Deep Creek and Faith Creek. Grayling (*Thymallus arcticus*) collected at these stations were marked with monel peduncle tags (fish over 15 cm. long, 1966), spaghetti tags (fish over 15 cm. long, 1967), or fin-clipped (fish less than 15 cm. long, both years), and released for studies of movement and population estimates.

Fyke nets of 1/8" mesh were fished in the Davidson Ditch, just below the diversion dam, to determine whether significant numbers of grayling were lost to the ditch. This ditch, it may be mentioned, was dug in the 1920's to carry water nearly 65 km. from the upper Chatanika River to the placer gold mines near the town of Chatanika. Subsequently, the ditch and flumes were acquired by the Chatanika Power Company. The power plant at Mile 32 Steese Highway was destroyed by the flood of August 10-13, 1967, and the ditch blocked off, so the information we collected on this point is now of academic interest only.

RESULTS

FISH FAUNA

Although the lower reaches of the Chatanika River hold quite a few fish species, including pike (Esox lucius), sucker (Catostomus catostomus), chub (Hybopsis plumbea), grayling (Thymallus arcticus), slimy sculpin (Cottus cognatus), at least two species of whitefish (Coregonus sp.), and seasonally, king and chum salmon (Oncorhynchus tshawytscha and O. keta), and sheefish (Stenodus leucichthys), the fauna of the study area is depauperate, consisting only of grayling and slimy sculpin. Although the latter is of very limited use, being a forage species for carnivores, the former is highly regarded by anglers and is the object of a rather intensive sport fishery in this area.

Schallock (1965), Wojcik (1955) and, to a lesser extend, Reed (1964) had studied the grayling populations of the Chatanika River below the dam at Mile 69.2, but it was still unknown what relations existed between the above-dam and below-dam populations. We therefore planned work that would, we hoped, answer three questions:

1. Do grayling pass the dam, either directly or via the Davidson Ditch, in either direction in significant numbers?

2. Do the age structure and growth rates of the above-dam group differ from those of the below-dam population?

3. How large is the above-dam population?

Schallock (1965), working primarily on the basis of fish tagged well downstream from the dam, concluded that there was virtually no exchange of individuals across this barrier. To test the validity of his conclusions, we tagged fish larger than 150 mm FL and fin-clipped smaller ones as follows:

1966 - 395 tagged, 199 fin-clipped.

1967 - 94 tagged, 289 fin-clipped.

Recoveries were:

1966 - 33 tagged, 0 fin-clipped.

1967 - 17 tagged in 1966, 38 tagged in 1967, 7 fin-clipped 1967.

1968 - 1 tagged in 1966, 4 tagged in 1967, 0 fin-clipped.

In general, tag recoveries indicate only a more-or-less random movement up and downstream. Except in the region below the confluence of McManus and Faith Creeks, fish tagged in a creek were recovered in the same creek. Two fish tagged in Faith Creek in 1966 were recovered 10 months later below the dam. Two fish tagged in McManus Creek in 1967 were recovered below the dam in 1968.

It is obvious, then, that some fish do pass over the dam in a downstream direction, but the returns are too few to allow a reasonable estimate of the number.

As far as upstream movement over the dam is concerned, Schallock (1965) reported that, although he had seen many fish leaping in apparent attempts to surmount the dam, none were observed to succeed. However, his observations were made during the day in mid- to late summer, when the water was low. By contrast, on June 13, 1967, between 2145 and 2300 hours, Mr. Vascotto observed ten attempts by fish to go upstream over the dam, of which two were successful. The water at this time was still fairly high, with a drop of less than 5 feet from the top of the dam to the stream below. If Mr. Vascotto's observations are representative, there would seem to be no reason why a fairly large number of grayling could not pass over the dam during periods of moderately high water.

To determine whether fish were passing to or from the study area via the Davidson Ditch, fyke nets of 1/8" mesh were fished in the ditch for totals of 168 hours in 1966 and 47 hours in 1967. The nets, fished for periods of 2.5 to 24.5 hours in both daylight and darkness, were so arranged as to block the ditch completely and to catch both upstream and downstream migrants. The nets were placed approximately 300 meters downstream from the sluice gate at the diversion dam. Twelve grayling and twenty-two sculpins were taken in 1966, all during the night. No fish were caught in 1967. We conclude that there were no significant losses of grayling into the ditch at this point.

In the tagging operations, each fish was anesthetized with tricaine methane sulfonate, fork length measured to the nearest millimeter, wet weight to the nearest gram, and a scale sample taken for later study. Analyses of these data yielded results that are similar to those of Schallock (1965, Table 8, p. 27), and Wojcik (1955, Table 5, p. 36 a) when Wojcik's results are corrected for the loss of the first annulus (See Schallock, 1965, pp. 21-25; Kruse, 1959). We conclude that growth rates and age structure of the upstream population do not differ significantly from those of the grayling in other parts of the river.

Population estimates of the number of tagable size grayling (i.e., fish larger than about 150 mm FL), occupying the stream above the dam are based on the marking experiments conducted in 1966 and 1967 and on extrapolation of Mr. Vascotto's counts of fish in pools (Vascotto, 1970). The tags used in 1966 were monel peduncle tags. These were not satisfactory in that an undetermined number of tags fell out, leaving ulcerous-looking sores and scars, and both the tags and scars appeared to reduce survival ability (see, for example, Vascotto, 1970). Hence, spaghetti tags, inserted below the dorsal fin, were used in 1967. These appeared to have no adverse effects.

Fin-clipping, coded according to locality and year, was employed on smaller fishes.

Due primarily to the paucity of returns, the irregularity of the recoveries, and the loss of an unknown number of tags, the use of the more sophisticated formulae for estimating population size is not warranted (Lagler, 1956, Chap. 12). Probably the most satisfactory treatment that can be utilized is the Lincoln index, or one of the similar proportions. By this means, estimates of the population of Faith and McManus Creeks have been obtained, that range from a low value of 1,100 to a high value of just under 10,700 grayling larger than 15 cm. Fl. The average for 8 different treatments is approximately 5,600 fish in the 60 odd miles of stream. This value is closely approached by two of the individual treatments. Vascotto (1970) gives data that show an average population of 9.7 fish per pool in the six pools of McManus Creek that he studied intensively. If this average can legitimately be extropolated to the 43 major pools on McManus Creek and the 33 major pools on Faith Creek, we have an estimated population of 739 grayling. Allowing for additional fish in small pools and other area, perhaps 1,000 fish is a reasonable estimate by this method. In view of these data, and observed angling success in this area, we believe that the lower estimate is more realistic and that the population of tagable sized grayling in these two streams probably numbers somewhere between 1,000 and 2,000 individuals. It seems highly unlikely that the grayling of Faith and McManus Creeks make a significant contribution to the populations of the downstream areas.

BOTTOM FAUNA

As noted earlier, some of the data and material for late June and early July 1966 were destroyed when the base camp was wrecked by a bear. Worse still, the great flood of August 1967 completely inundated the cabin, carrying away all the specimens stored in boxes beneath the cabin and reducing most of the records to a pulpy mess. Some data had, fortunately, been brought to the laboratory in Fairbanks the day before, to be copied into the permanent records. We cannot, then, give accurate, quantitative information on bottom fauna before the flood, but must summarize on the basis of the fragmentary records remaining and on the basis of statements contained in progress reports.

At each station, three Surber samples were taken on the next major riffle upstream from the station, at about the middle of the length of the riffle. One sample was taken near the center of the stream, with an additional one about halfway to the bank on each side.

There was considerable variation in the bottom fauna from sample to sample, even on the same riffle, so much so that statistical treatment of data is not warranted. However, certain trends are present and are probably meaningful.

In the lower portions of the stream, especially at Stations 1 and 2, Ephemeroptera were the dominant organisms in the early part of the summer.

By August there was a decrease in members of this group and an increase in Tendepedidae (Diptera), so that the latter were numerically dominant. Ephemeroptera continued to decrease through August and September. The tendepedids, on the other hand, reached greatest abundance in the latter part of August, then declined in numbers. Plecoptera, never abundant in this part of the stream, also reached their peak in mid-August, while Trichoptera, likewise rather scarce, appeared to be more numerous in September and early October. Simuliidae and Tipulidae were rare here.

In the upper reaches of the streams, Ephemeroptera were scarce and Plecoptera were the dominant organisms in the first part of the summer. Tendipedids were relatively scarce here, their place being taken by the Simuliidae. This group reached greatest abundance in mid-July, when they sometimes appeared as patches of black carpet on the stream bed.

These distributions, both physical and temporal, are just about what would be expected in the light of our knowledge of these insects in other areas.

In the summer of 1967, minor floods were recorded on Faith and McManus Creeks on July 7 to 10 and July 20 to 29. The former and lesser of the two was not reflected on the Chatanika River (Station 2) depth gauge, but the latter removed that stake. (See Table 7). Immediately after each of these high water periods, the bottom fauna was severely reduced. Surber samples often yielded no organisms at all. However, within a week or so nearly all groups of organisms were again present in the sample areas. Due to the general decline in numbers that seems to occur concurrent with the season, and the close temporal spacing of these floods, it is not possible to state whether or not the observed numbers represented normal population levels. After the great August flood, one additional collecting trip was made, on September 5, 1967, to Stations 2, 3 and 5. We found no bottom organisms at all at any of these stations.

WATER CHARACTERISTICS

Except for the information from the first part of 1966, which was lost when the bear destroyed the base camp, complete data are available on this subject and are shown in Tables 1 through 7. Alkalinity and CO_2 were determined by standard titration methods (Lagler, 1956). All other chemical parameters were determined by use of a Hach battery operated portable colorimeter.

As can be seen from these tables, the water in these creeks is remarkably pure, and except for the high nitrate nitrogen values in July of 1966, there is relatively insignificant variation in any of the parameters shown in Tables 1 through 6. Nitrate nitrogen determinations in 1967 were not satisfactory. Apparently the chemicals for this test were over-age. CO_2 determinations in 1967 were all recorded as zero in the field book. However, in view of the pH and MO values, this is impossible and was probably due to operator error. Phenolphthalein alkalinity was always zero.

Water levels in 1966 were remarkably uniform. In 1967, on the other hand, there was considerable fluctuation. Spring high water lasted well into June. In early July, moderate rains produced a slight but definite rise in both Faith and McManus Creeks. In McManus Creek, where the rise was greatest, it resulted in scouring and grinding of the bottoms to the extent that the bottom fauna on the riffles was noticeably reduced in quantity. Rather severe rains in the week ending 24 July produced a rise of 1.5 feet in McManus Creek and washed out the gauging stake at Station 2. This minor flood likewise drastically reduced the bottom organisms. Finally, in the second week of August, with the ground already saturated and unable to hold any more water, several inches of rain fell (See Table 2) and produced the great flood of 1967. Two of our students, Messrs. Boddie and Vascotto, were trapped on the left bank of the river and were rescued by helicopter from the high ground whither they had retreated. As already observed, the base camp cabin was completely inundated, most of the data and specimens were destroyed, and three of the six sampling stations simply disappeared. When we returned to the area on 23 August, the gauges at the three stations remaining all registered more than 10" of rain (Tables 4, 5, 6). When one considers that the average annual rainfall for this area is less than 12", the cause of the flood is quickly obvious!

LITERATURE CITED

Kruse, T. E. 1959. Grayling of Grebe Lake, Yellowstone National Park, Wyoming. Fish. Bull. 149, U.S. Fish. Wildl. Serv., 59: 307-351.

Lagler, K. F. 1956. Fresh water fishery biology. W. C. Brown Co., 421 pp.

Reed, R. J. 1964. Life history and migration patterns of arctic grayling, Thymallus arcticus, (Pallas), in the Tanana River drainage of Alaska. Alaska Dept. Fish, Game, Res. Rept. No. 2: 30 pp.

Schallock, E. W. 1965. Investigations dealing with probable grayling movement in relationship to water development projects. U.S. Fish. Wildl. Serv., Branch Riv. Bas. Studs., Res. Rept. Contract #14-17-005-36. Mimeo, 80 pp.

Vascotto, G. L. 1970. Summer ecology and behavior of the grayling of McManus Creek, Alaska. Unpubl: MS thesis, Univ. Alaska. 132 pp.

Wojcik, F. J. 1955. Life history and management of the grayling in Interior Alaska. Unpubl: MS thesis, Univ. Alaska. 54 pp.

TABLE 1. RAINFALL AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATER AT STATION 1.

DATE:	Water Temp. (° C)	Rain Gauge (inches)	Iron (Fe++)	Iron (Total)	N (NH_3)	N (NO_3)	N (NO_2)	DO	pH	PO_4 (Poly)	PO_4 (Ortho)	Turbidity	CO_2	MO Alk.	O_2 Sat., %
1966															
7/12	12.5	.0	-	.05	.07	2.7	0	6.0	7.05	-	-	8	2.3	-	55
7/19	12.5	*	-	.1	.01	1.1	0	6.5	7.10	-	-	0	2.3	32.5	61
7/26	12.0	.2	-	.12	0	1.8	.01	6.25	6.65	-	-	-	2.3	32.0	57
8/2	12.5	.3	.05	.08	0	.1	0	6.5	7.18	.30	.04	0	9.0	28.0	61
8/9	13.0	.19	0	.1	.09	.2	.002	6.25	6.78	.21	.03	0	1.9	24.9	60
8/17	10.0	.24	0	.1	.02	.1	0	6.1	6.70	.21	-	0	5.0	25.5	54
8/23	11.0	.07	0	.09	0	.05	.008	6.2	6.68	.25	.6	0	8.9	26.4	56
8/29	-	.43	.02	.11	0	0	.002	6.7	6.99	.14	.18	0	3.6	25.6	-
9/6	9.0	.13	.01	.10	0	0	.004	7.2	6.92	.18	.05	0	6.7	26.9	62
9/18						No Sample Taken									
9/25						No Sample Taken									
10/2	5.5	.56	.02	.03	0	.6	0	-	7.02	.19	.04	0	2.6	25.0	-
1967															
6/1						No Sample Taken									
6/10	3.5	.03	.04	.15	.28	-	0	10.0	7.5	-	.1	15	-	20.2	75
6/17						No Sample Taken									
6/24	13.5	.14	.04	.08	.1	-	0	8.5	7.28	.22	0	0	-	30.5	81
7/1	10.0	.32	.05	.06	.47	-	0	9.0	7.19	.2	.1	5	-	37.4	79
7/9	11.0	.64	.04	.13	.82	-	.001	8.8	7.31	.35	.05	0	-	34.5	78
7/15	11.0	.03	.04	.10	.45	-	.002	7.6	6.99	.45	.05	1	-	41.8	68
7/24	5.0	1.7	.03	.17	.29	-	0	9.8	7.15	.20	.1	3	-	29.5	76
7/30	7.5	.38	.05	.12	.45	-	.001	9.5	7.63	.07	.02	8	-	31.4	78
8/5	11.0	.10	.05	.08	3.0	-	0	-	-	.27	.05	-	-	-	-

*Turned over

TABLE 2. RAINFALL AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATER AT STATION 2.

DATE:	Water Temp. (° C)	Rain Gauge (inches)	Iron (Fe++)	Iron (Total)	N (NH_3)	N (NO_3)	N (NO_2)	DO	pH	PO_4 (Poly)	PO_4 (Ortho)	Turbidity	CO_2	MO Alk.	O_2 Sat., %
1966															
7/12	12.0	0	-	.05	.05	3.0	0	8.1	7.28	-	-	9	1.5	-	75
7/19	13.5	.74	-	.05	0	4.6	0	7.2	7.21	-	-	0	2.2	20.0	68
7/26	15.0	.14	-	.05	0	4.2	.01	7.1	6.48	-	-	0	2.5	22.5	70
8/2	13.0	.21	0	.05	.02	-	.05	7.75	7.6	.31	.1	0	4.0	21.5	73
8/9	14.0	.10	.01	.05	.11	0	.003	7.4	6.84	.32	.1	0	2.0	24.5	70
8/17	9.0	.08	.08	.05	.02	.1	0	7.9	6.28	.25	.1	0	1.2	22.8	68
8/23	10.0	.15	0	.02	0	0	.007	7.7	6.82	.21	.48	0	1.7	25.0	68
8/29	10.0	.13	.04	.06	0	.02	.004	8.0	6.98	.18	.08	0	1.4	25.0	70
9/6	7.0	.21	.02	.06	0	.2	.008	8.8	7.19	2.2	.1	0	1.6	24.6	72
9/18	6.0	.19	0	.02	0	.15	.005	8.2	7.35	.15	.09	0	.9	25.0	65
9/25	5.5	.13	.12	.12	.08	.18	.006	11.1	7.15	.25	.18	12	1.0	25.4	87
10/2	4.5	.01	.01	.04	0	.37	0	9.7	7.24	.17	.07	0	.7	23.9	73
10/9	.5	0	.05	.1	.01	.2	.005	9.2	7.42	.19	.09	50	1.1	25.3	63
1967															
6/1	2.0	-	.05	.35	.4	.21	0					28			
6/10	7.5	.04	.03	.15	.17	-	0	8.9	6.95		.15	12	-	20.4	73
6/17	-	.21	.03	.1	.14	-	0	8.4	7.03	.18	.08	2	-	24.5	-
6/24	12.0	.91	.03	.08	.07	-	0	9.3	7.25	.25	.05	0	-	33.5	85
7/1	10.1	.56	.02	.05	.21	-	0	8.5	7.02	.15	.05	2	-	38.4	76
7/9	9.5	1.15	.04	.13	.43	-	0	8.9	7.2	.30	.05	5	-	34.2	77
7/16	14.0	.01	.02	.03	.44	-	.005	8.1	7.25	.37	.02	0	-	39.6	78
7/26	5.0	-	.03	.18	.35	-	0	9.5	7.3	.28	.05	8	-	24.5	74
7/30	6.0	1.37	.03	.13	.58	-	0	9.3	7.6	.04	.04	0	-	31.5	74
8/5	12.0	.13	.01	.08	.44	-	0	-	-	.25	.05	-	-	-	-
8/12	-	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 3. RAINFALL AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATER AT STATION 3.

DATE:	Water Temp. (° C)	Rain Gauge (inches)	Iron (Fe++)	Iron (Total)	N (NH_3)	N (NO_3)	N (NO_2)	DO	pH	PO_4 (Poly)	PO_4 (Ortho)	Turbidity	CO_2	MO Alk.	O_2 Sat., %
1966															
7/12	12.0	0	-	.1	0	.61	0	7.3	7.13	-	-	9	2.0	-	67
7/19	12.5	.55	-	.09	0	4.75	0	7.6	7.20	-	-	5	1.0	15.2	71
7/26	13.5	.03	-	.05	0	4.0	.005	7.9	6.65	-	-	4	2.0	17.5	75
8/2	13.0	.11	0	.07	.01	0	.003	7.5	7.35	.32	.08	6	1.5	18.0	70
8/9	13.0	.14	.02	.05	.03	.1	.005	8.1	6.82	.29	.10	5	.9	27.3	76
8/17	14.0	.15	.03	.08	.03	.1	.005	8.2	6.08	.30	.09	0	2.0	17.2	79
8/23	10.0	.09	0	.07	0	0	.008	8.2	6.84	.2	.44	0	1.5	18.5	72
8/29	9.5	.69	.02	.06	0	0	.004	8.4	6.82	.3	.12	0	1.0	17.5	73
9/6	7.0	*	.02	.05	0	0	.009	9.1	7.1	.25	.13	0	2.0	17.8	74
9/18	6.0	.27	0	.01	0	.1	.008	8.6	7.28	.27	.09	0	.9	17.6	68
9/25	4.5	.25	.05	.06	.03	.35	.005	11.9	7.10	.27	.12	2	.9	17.2	91
10/2	4.0	.01	.01	.06	0	.07	.001	11.0	7.2	.21	.08	0	.9	16.5	83
1967															
6/10	5.0	.06	.02	.15	.16	-	0	9.2	6.82		.1	22		12.7	71
6/17	8.5	.56	.01	.1	.12	-	0	8.9	6.75	.13	.1	5		11.0	75
6/24	10.0	.63	.03	.07	.06	-	0	9.3	7.12	.19	.1	0		15.0	81
7/1	8.0	.70	.06	.12	.31	-	0	9.1	7.02	.16	.1	3		19.2	76
7/9	11.0	.52	.02	.12	.20			8.7	7.09	.28	.13	0		17.6	78
7/16	12.0	.13	.04	.06	.85		.003	8.5	7.12	.8	.05	0		21.7	78
7/24	5.0	3.4	.06	.09	.20		.003	9.6	7.01	.16	.12	5		15.9	75
7/30	8.0	1.10	.03	.09	.28		0	9.4	7.51	.03	.02	0		17.4	78
8/5	11.5	.27	0	.06	1.30		0			.05	0				

TABLE 4. RAINFALL AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATER AT STATION 4.

DATE:	Water Temp. (° C)	Rain Gauge (inches)	Iron (Fe++)	Iron (Total)	N (NH_3)	N (NO_3)	N (NO_2)	DO	pH	PO_4 (Poly)	PO_4 (Ortho)	Turbidity	CO_2	MO Alk.	O_2 Sat., %
1966															
7/12	11.0	0	-	.02	.05	.85	0	8.5	7.15	-	-	8	1.0	-	77
7/19	10.0	.23	-	1.7	.05	3.9	0	7.5	7.23	-	-	93	2.0	15.0	67
7/26	12.0	.04	-	.25	0	3.92	.008	8.3	6.58	-	-	0	2.5	16.5	77
8/2	11.0	.04	0	.13	0	.15	.005	8.4	7.32	.30	.09	21	2.5	15.5	76
8/9	12.0	.13	.01	1.35	.22	.09	.005	7.4	6.9	.24	.1	115	0.8	19.3	68
8/17	13.0	.22	0	.06	.12	.15	.002	7.6	7.07	.15	.1	52	1.4	16.6	72
8/23	8.5	.08	.04	.1	0	.03	.008	8.2	6.9	.10	.52	0	1.0	16.1	70
8/29	9.0	.36	.05	.08	0	0	.007	8.5	6.75	.28	.13	0	.9	15.2	73
9/6	5.0	.12	.08	.07	0	.08	.01	9.6	6.96	.30	.18	0	2.5	15.5	75
9/18						No Sample Taken									
9/25	4.0	.37	.06	.10	0	.28	0	9.9	7.13	.22	.15	0	0.7	1.58	75
10/2	3.5	.01	0	.03	.05	.3	0	10.4	7.15	.20	.09	0	1.4	14.1	78
1967															
6/17	7.0		.01	.1	.13	-		9.4	6.68	.11	.03	19		8.9	77
6/24	8.5	.47	.05	.1	.04	-	0	9.3	7.1	.15	.15	5		11.3	79
7/1	8.0	.84	.05	.05	.25	-	0	9.4	7.0	.16	.1	2		15.6	79
7/9	8.0	.89	.04	.05	.05		0	9.0	7.05	.31	.15	0		10.9	76
7/16	12.0	.29	.03	.07	.35		.001	8.4	7.11	.27	.07	0		20.4	77
7/24	5.0	3.0	.02	.10	.13		.003	9.5	7.0	.28	.13	0		12.1	73
7/30	7.5	.90	.02	.05	.17		.002	9.4	7.49	.02	.02	0		14.5	78
8/5	11.0	.37	.02	.04	.50		0			.19	.17				
8/23		10.5													

TABLE 5. RAINFALL AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATER AT STATION 5.

DATE:	Water Temp. (° C)	Rain Gauge (inches)	Iron (Fe++)	Iron (Total)	N (NH_3)	N (NO_3)	N (NO_2)	DO	pH	PO_4 (Poly)	PO_4 (Ortho)	Turbidity	CO_2	MO Alk.	O_2 Sat., %
1966															
7/12	13.0	0	-	0	.04	.87	0	8.0	7.35	-	-	9	2.5	-	76
7/19	11.0	.43	-	.02	0	4.6	0	8.1	7.40	-	-	1	2.0	36.0	73
7/26	12.0	.02	-	0	0	4.2	.05	8.1	6.45	-	-	0	3.0	34.5	74
8/2	11.0	.19	.05	0	.02	0	.007	7.1	7.63	.23	.02	0	3.5	29.5	74
8/9	12.0	.16	0	.03	.01	0	.002	7.8	6.78	.19	.01	0	1.0	31.6	72
8/17	8.5	.17	0	0	0	.02	0	8.4	7.32	.11	.01	0	1.3	31.9	72
8/23	9.0	.06	0	.02	0	0	.011	8.0	7.19	.18	.11	0	1.0	33.0	69
8/29	10.0	.63	0	.02	0	0	.003	8.5	7.10	.17	.09	0	1.4	34.3	75
9/6	5.0	.09	0	.02	0	.04	.08	9.5	7.28	.18	.05	0	1.7	34.0	73
9/18	6.0	.18	.02	.05	.01	.11	.008	7.2		.25	.11	5	.8	33.5	58
9/25	5.0	.33	.02	.06	.04	.35	.003	10.1	7.32	.17	.08	0	1.3	34.5	78
10/2	2.5	.01	0	0	0	.32	0	10.5	7.33	.08	.02	0	.9	33.3	77
10/9	0	.60	0	0	0	.3	0	6.5	7.45	.17	.09	0	.7	33.6	45
1967															
6/10	6.0	.5	.01	.15	3.0	-	0	9.0	7.09		.15	20		12.5	72
6/24	-	1.33	.02	.13	.09	-	0	8.5	7.28	.12	.12	22		20.5	-
7/1	9.0	.95	.05	.07	.23	-	0	9.2	7.1	.21	.03	5		40.2	79
7/9	9.0	.59	.04	.05	.13		0	8.7	7.31	.31	.10	0		34.4	75
7/16	14.0	.33	.02	.11	.27		.004	8.2	7.31	.34	.05	0		51.6	79
7/26	5.0	4.5	.03	.18	.52		.003	9.5	7.3	.32	.11	8		32.0	73
7/30	8.5	.40	.02	.10	.28		0	8.5	7.79	.32	.05	0		37.4	72
8/5	11.0	.43	.05	.06	.32		0			.45	.03				-
8/23		10.6													

TABLE 6. RAINFALL AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE WATER AT STATION 6.

DATE:	Water Temp. (° C)	Rain Gauge (inches)	Iron (Fe++)	Iron (Total)	N (NH_3)	N (NO_3)	N (NO_2)	DO	pH	PO_4 (Poly)	PO_4 (Ortho)	Turbidity	CO_2	MO Alk.	O_2 Sat., %
1966															
7/12	10.5	0	-	.1	.02	.88	0	7.0	7.22	-	-	7	2.0	-	63
7/19	8.5	4.0	-	0	.01	3.3	0	8.6	7.6	-	-	0	2.6	43.0	73
7/26	9.0	.3	-	.03	0	3.8	.012	8.4	6.47	-	-	0	2.0	44.5	72
8/2	8.5	.9	0	.04	.03	.04	.008	8.6	-	.29	.08	0	3.0	37.5	73
8/9	9.0	2.0	0	.05	.02	.03	.006	8.3	6.87	.25	.11	0	1.1	40.4	72
8/17	7.0	1.0	0	.02	0	.02	0	8.3	7.39	.19	.09	0	1.3	40.2	68
8/23	7.0	2.5	0	.02	0	.05	.007	8.4	7.28	.11	.16	0	1.0	45.1	68
8/29	8.0	5.4	0	.05	0	.05	.005	8.7	7.19	.15	.08	0	1.5	42.4	73
9/6	3.5	.5	.03	.05	0	.19	.07	10.0	7.38	.19	.9	0	1.5	42.7	75
9/18	4.5	3.1	.02	.05	.01	.16	.007	9.0	7.50	.28	.13	0	1.4	42.5	68
9/25	4.0	2.8	.01	.02	.01	.39	.003	10.2	7.40	.38	.06	0	1.0	42.9	77
10/2	2.0	.1	0	.04	0	.35	0	12.5	7.49	.21	.09	0	.8	42.9	90
10/9	0	2.0	0	.05	0	.34	.001	9.6	7.6	.20	.08	0	.7	42.8	66
1967															
6/10	5.5	.5	.04	.14	*	-	0	9.2	7.8	.25	.16	22		26.6	72
6/17	8.0	.65	.01	.1	2.1	-	0	8.5	7.1	.14	.12	21		29.4	71
6/24	-	.63	.03	.08	.06	-	0	9.25	6.65	.18	.10	4		35.2	-
7/1	8.0	1.15	.03	.05	.23	-	0	9.2	7.0	.25	.05	0		47.5	77
7/9	9.0	.51	.11	.17	2.25	-	0	8.6	7.38	.25	.01	0		41.5	74
7/16	13.0	.02	.04	.12	.25		.003	9.1	7.35	.27	.04	2		50.8	85
7/26	4.0	3.6	.01	.10	.33		.003	9.6	7.31	.26	.10	4		36.5	72
7/30	8.5	.67	.01	.06	.24		0	9.6	7.82	.43	.06	1		45.5	81
8/5	12.0	.24	.02	.03	.2		0			.66	.24				
8/23		10.25													

*Off Scale

TABLE 7. WATER LEVELS IN LOWER FAITH AND MC MANUS CREEKS AND THE UPPER CHATANIKA RIVER. ZERO LEVELS ARE ARBITRARY AND DO NOT CORRESPOND FROM STATION TO STATION OR FROM YEAR TO YEAR. WATER LEVELS IN FEET.

DATE	STATION		
	CHATANIKA RIVER	FAITH CREEK	MC MANUS CREEK
1966			
20 Jul	1.0	1.3	1.0
2 Aug	.8	1.2	.9
3	.8	1.1	.9
4	.8	1.2	.9
5	.8	1.2	.9
6	-	-	-
7	.8	1.1	.8
8	.7	1.1	.8
9	-	-	-
10	-	-	-
11	.7	1.1	.8
12	.7	1.1	.8
13	.7	1.1	.8
14	-	-	-
15	-	-	-
16	.7	1.1	.8
17	.7	1.1	.8
18	.7	1.1	.8
19	.7	1.1	.8
20	.7	1.1	.8
21	.7	1.1	.8

TABLE 7. Cont'd.

DATE	STATION		
	CHATANIKA RIVER	FAITH CREEK	MC MANUS CREEK
1966			
22 Aug	.7	1.1	.8
23	.7	1.1	.8
24	.8	1.1	.8
25	.8	1.2	.9
26	.8	1.2	.9
27	.8	1.1	.8
28	.8	1.1	.8
29	.8	1.1	.9
30	.8	1.1	.8
31	-	-	-
1 Sep	-	-	-
2	.7	1.1	.8
3	.7	1.1	.8
4	.7	1.1	.8
5	.7	1.1	.8
1967			
28 May	2.0	-	-
29	-	-	-
30	-	-	-
1 June	1.7	-	-
2	1.3	-	-
3	1.2	-	2.2
4	.8	2.0	1.9

TABLE 7. Cont'd.

DATE	STATION CHATANIKA RIVER	FAITH CREEK	MC MANUS CREEK
1967			
5 June	-	-	-
6	-	-	-
7	1.5	-	2.2
8	1.1	2.0	1.9
9	1.2	2.4	2.1
10	.7*	2.1	1.8
11	.3	1.9	1.6
12	.4	2.0	1.5
13	.6	2.1	1.5
14	.4	1.9	1.5
15	.4	1.9	1.6
16	.3	1.7	1.5
17	.2	1.8	1.3
18	0	1.6	1.3
19	- .2	1.4	1.2
20	- .1	1.5	1.1
21	- .2	1.4	1.2
22	.1	1.7	1.4
23	0	1.5	1.4
24	- .4	1.3	1.1
25	- .5	1.1	1.0
26	- .5	1.0	1.0

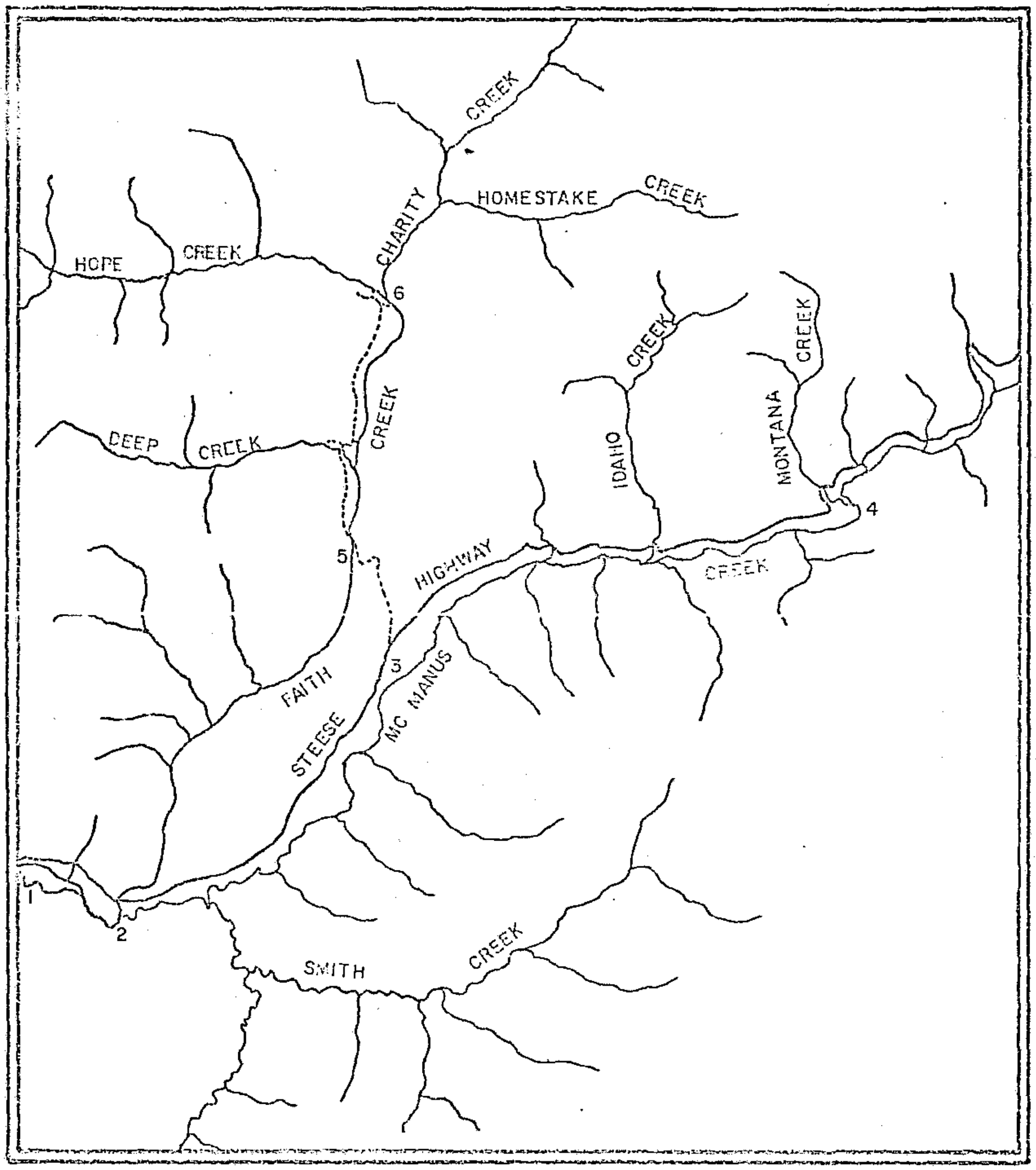
*Stake accidentally knocked out. Reset.

TABLE 7. Cont'd.

DATE	STATION CHATANIKA RIVER	FAITH CREEK	MC MANUS CREEK
1967 27 June	- .6	1.0	.9
28	- .6	1.0	.9
29	- .6	1.0	.9
30	- .5	1.2	1.1
1 Jul	- .4	1.2	1.1
2	- .4	1.1	1.2
3	- .5	1.2	1.1
4	- .6	1.0	1.0
5	- .5	1.1	1.0
6	- .5	1.0	.9
7	- .3	1.1	1.4
8	- .2	1.1	1.5
9	- .3	1.2	1.3
10	- .4	1.2	1.1
11	- .6	1.0	1.0
12	- .6	.9	.9
13	- .6	.9	.9
14	- .7	.9	.9
15	- .7	.9	.9
16	- .8	.8	.8
17	- .7	.8	.8
18	- .8	.9	.8
19	- .7	.9	.9

TABLE 7. Cont'd.

DATE	STATION		
	CHATANIKA RIVER	FAITH CREEK	MC MANUS CREEK
1967			
20 July	+ .1	1.7	1.4
21	0	1.6	1.4
22	-	-	-
23	Stake washed out 22 July	1.6	1.6
24		1.5	1.6
25		1.5	2.0
26		-	-
27		-	-
28		-	-
29		1.4	2.4
30		-	-
31		1.3	1.3
1 Aug		1.4	1.3
2		-	-
3		1.1	1.1
4		1.1	1.1
5		1.0	1.1
6		1.1	1.1
7		.9	1.0
8		1.0	1.0
9		1.7	1.5
10		1.9	1.6


CREEK
HOMESTAKE
CREEK
CHARITY
HOPE
CREEK
6
CREEK
DEEP
CREEK
IDAHO
CREEK
MONTANA
CREEK
4
5
HIGHWAY
CREEK
3
FAITH
MC MANUS
STEESE
1
2
SMITH
CREEK