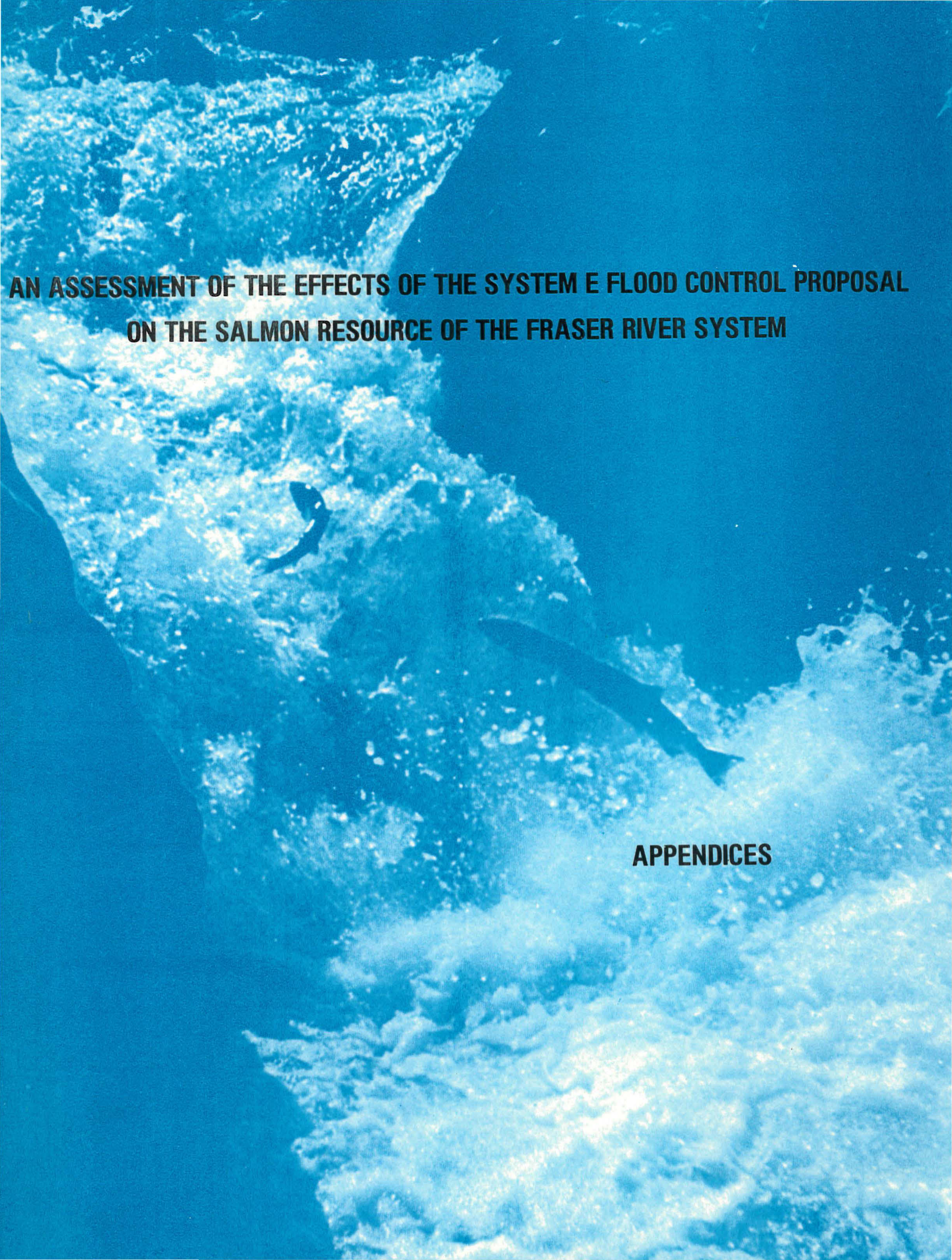
AN ASSESSMENT OF THE EFFECTS OF THE SYSTEM E FLOOD CONTROL PROPOSAL ON THE SALMON RESOURCE OF THE FRASER RIVER SYSTEM



APPENDICES

PHOTOGRAPH: Karl Kupka

132609

APPENDICES

Appendix A

Field Survey Data

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APPENDIX B

EVALUATION OF THE FRASER RIVER SALMON RESOURCE
AFFECTED BY SYSTEM E DEVELOPMENTS

Appendix A
System E Field Survey Data

INTRODUCTION

System E is a proposed group of hydro-electric power and storage projects designed to provide flood control on the Fraser River by regulation of runoff in its headwaters. The basins affected by this proposed development were surveyed in 1971 and 1972 to determine their potential capacity for anadromous stocks, to substantiate the present escapement records, and to establish the present water quality and water temperatures of the upstream and downstream areas.

The eight dam sites are shown in Figure 1-1, and descriptions of each proposed development are contained in Chapter I. Interpretation of the survey data is contained in the appropriate chapters of this Report. The data from the field survey was sufficient to ensure a reasonably accurate estimate of the potential of the affected areas, and to forecast the effects of water quality, temperature, and hydrological changes on the anadromous stocks. Intensive examination of some areas, however, was not possible.

The field survey was conducted by land vehicle, boat and helicopter. Present escapement figures were compiled from fishery records, substantiated by field observations. Juvenile sampling was by pole net, seal-bomb, beach seine and electro-fishing techniques. The potential capacity of all streams in the affected basins was estimated on the basis of chinook spawning requirements. The amount of potential spawning area in square yards was divided by 12 to obtain the number of spawners each stream was theoretically capable of supporting (after Burner, 1951). Stream suitability was determined from physical and chemical parameters, including streambed composition, and accessibility of suitable spawning areas.

Comments on turbidity, forest cover, type and extent of streamside cover and stream bank composition were also recorded. Stream lengths and lake areas were calculated from detailed topographic maps.

Water quality and temperature regimes of upstream and downstream areas were obtained on-site employing a HACH DR-EL "Direct Reading" portable field kit. A detailed description of the analytic techniques utilized is contained in Chapter V. The extent of water sampling was limited. Most samples were instantaneous and although they do not provide conclusive evidence with regard to the suitability of the streams, the results were used as a factor in assessing stream potential for salmonid production.

Appendix A contains the results of the field surveys and is divided into five sections: Grand Canyon Basin (A1), McGregor River Basin (A2), Cariboo River Basin (A3), Clearwater River Basin (A4), each of which provides a description of the affected basin and the major river and tributary streams. Section A5 contains the results of the Water Quality Survey.

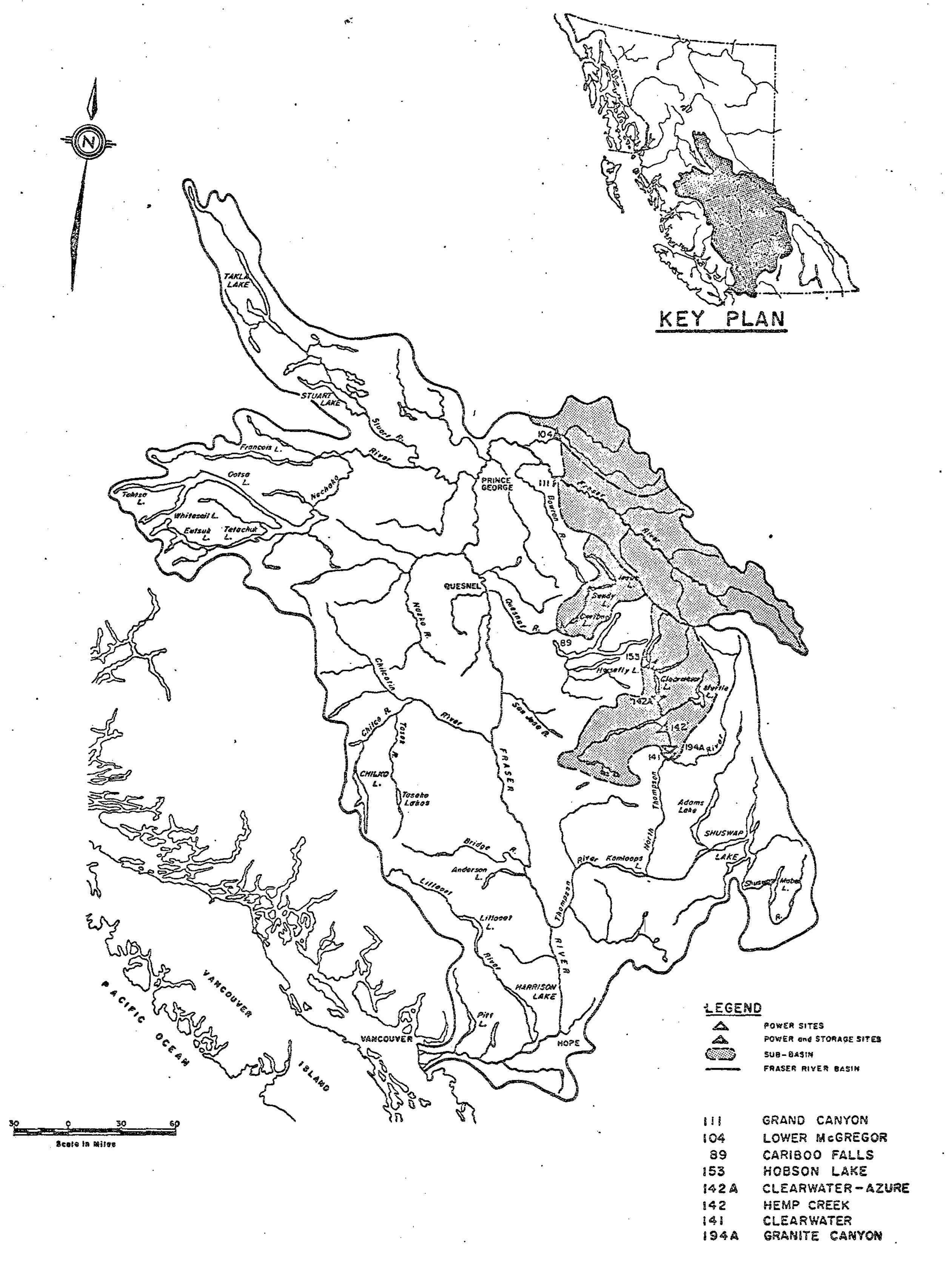


FIG. 1-1 LOCATION OF SYSTEM E PROJECTS WITHIN THE FRASER RIVER BASIN

Appendix A1

GRAND CANYON BASIN

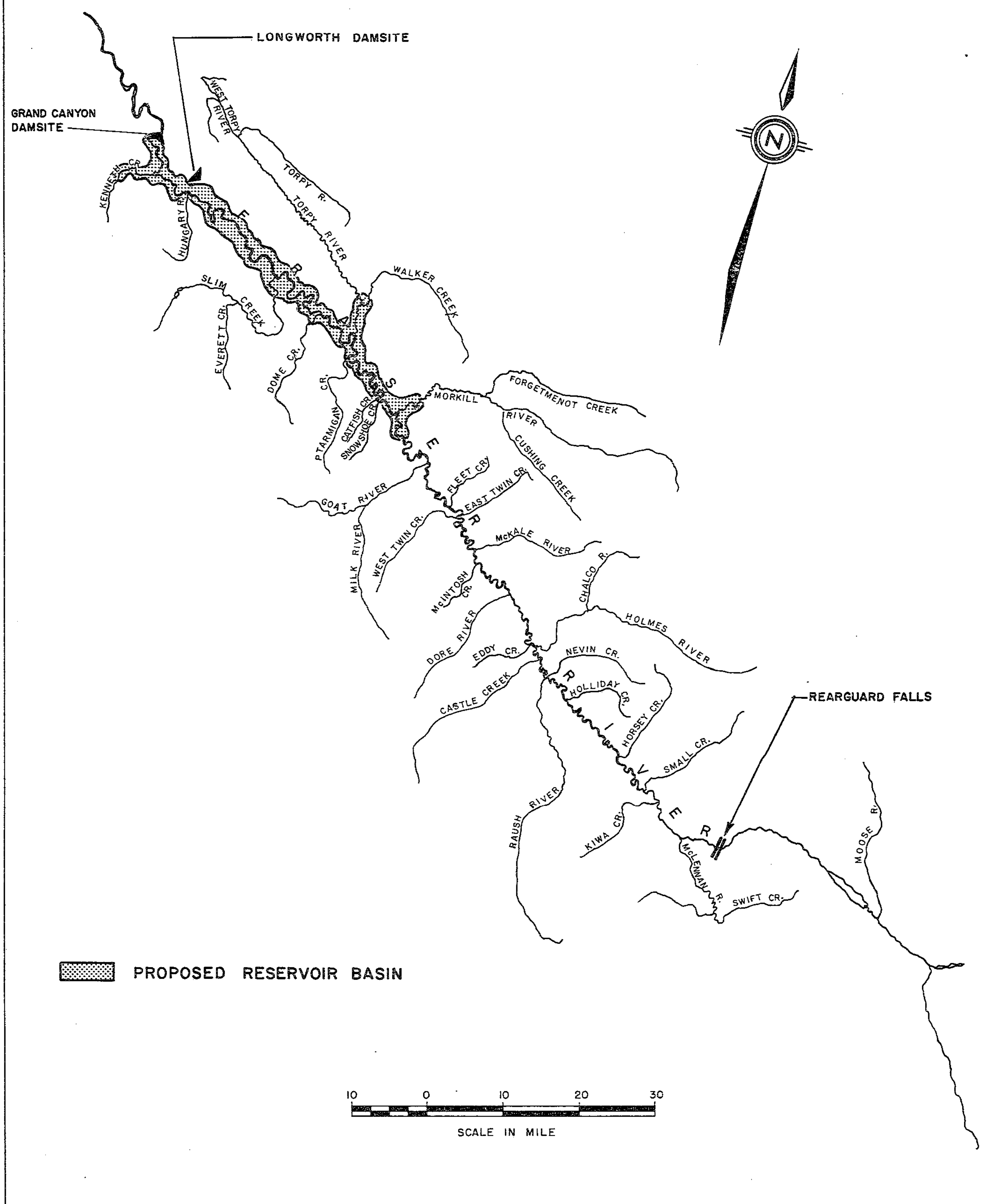


FIG. A1-1 GRAND CANYON BASIN

A1 GRAND CANYON BASIN (FIG. A1-1)

This section of Appendix A contains descriptions of the upper Fraser River drainage basin, from the proposed Grand Canyon dam site to the river source, and of the tributary streams surveyed in 1971; a summary of length-weight relationships of the juvenile chinook collected and a summary of the physio-chemical measurements of the streams sampled are presented.

A1.1 DESCRIPTION OF DRAINAGE BASIN

A1.1.1 GENERAL

The Fraser River begins at Moose Lake, 310 air miles northeast of Vancouver and 170 air miles southeast of Prince George. It flows westerly for 20 miles to the Rocky Mountain Trench, which it follows northwesterly for 120 miles to Sinclair Mills. Here it changes course, angling westward around the top of the Cariboo Mountains in the Fraser Plateau and finally flowing southwest to Prince George. That portion of the Fraser River drainage upstream from the proposed Grand Canyon dam site includes approximately 5,500 square miles of sub-alpine forest, and is some 200 miles long, approximately 25% of the river's total length.

The Fraser River in this area is large and turbid, meandering northwesterly through a wide valley flanked by the Rocky Mountains to the east and the Cariboo Mountains to the west.

A heavy annual precipitation results in a vegetation cover more dense than that indicated by the elevation (over 2,000 ft.). Forest cover on the valley slopes is predominantly climax hemlock, cedar and spruce, with few forest openings. The valley bottom has a more varied composition consisting of spruce with stands of cottonwood, birch, aspen, willow and alder along the river or on burned and logged areas, large sphagnum bogs, and agricultural land.

A1.1.2 RESERVOIR BASIN

The proposed Grand Canyon reservoir basin commences at Grand Canyon and extends southeastward up the Rocky Mountain Trench for 50 miles. It has a maximum reservoir elevation of 2,135 feet, a minimum of 2,080 feet, and an area of 49,700 acres. Arms extend four miles up Kenneth Creek, six miles along the Torpy River, three miles up the Morkill River and one and a half miles up Walker Creek.

A1.1.3 SOILS

The basin is almost totally composed of post-glacial till and gravel outwash fans. Some of this material is very deep in the flat bottom land. Post-glacial lake deposit material is common, and is especially apparent in the Dome and Ptarmigan creek areas where unstable clay and soap cliffs arise approximately 300 feet above the river. Some of the soils support marginal agriculture but are generally too acidic and poorly drained to support good crops. However, where lower rainfall is experienced soils are more productive.

The soils in the steep mountain slopes, outside the basin, are thin and acidic, and are best suited for timber production. They do, however, contain considerable fines, and have a tendency to erode quickly once forest cover is removed. Large rock outcroppings are rarely encountered except at the three and one-half mile long Grand Canyon, which is flanked by limestone formations. Some folded sedimentary rocks at Ptarmigan Creek and in the main stem Fraser at Crescent Spur also exist.

A1.1.4 TOPOGRAPHY

This sub-basin lies totally within a relatively flat (0 to 30%) one to three mile wide Rocky Mountain trench (2,000 to 2,100 ft. elevation). Local relief undulations of 100 ft. occur in the bottom land, with a number of small hills evident at Slim, Dome and Ptarmigan creeks. These areas arise just sufficiently to escape the basin and would form islands in the reservoir. Many acres of boggy land also occur in the bottom land.

Above the basin (2,135 ft. elevation), many 200 to 400 ft. high hills and river-formed cliffs exist. These level off to form rolling trenches which extend away from the river for one-half to one mile before intersecting the mountain slopes. The flanking mountains and high plateaus intersect the flat bottom land area very abruptly; slopes of 50% plus are common.

A1.1.5 CLIMATE

The basin itself experiences variable precipitation: the area between Grand Canyon and Penny receives 20 to 40 inches per year; areas further up the valley have approximately 15 to 20 inches per year. Immediately adjacent to the basin precipitation rises sharply to 30 to 50 inches per year along the mountain sides. Approximately one-third of the annual precipitation is snow, some 8 to 9 feet per winter. The basin receives the bulk of its moisture during the summer, fall, and winter; spring is normally dry.

The temperature regime of the upper Grand Canyon sub-basin is similar to that of the McGregor and Cariboo basins with short warm summers and long cold winters. However, this basin's climate is not quite as harsh; there are more frost-free days (50 to 100 days) and slightly higher summer and winter temperatures. On adjacent mountain sides, the temperature regime is more severe.

A1.1.6 ACCESS

The Fraser River is navigable from Prince George to Tête Jaune Cache. However, in the fall, during low water, the Grand Canyon area can be very treacherous. The lower few miles of the Torpy and Morkill rivers are navigable to experienced boaters during high water only.

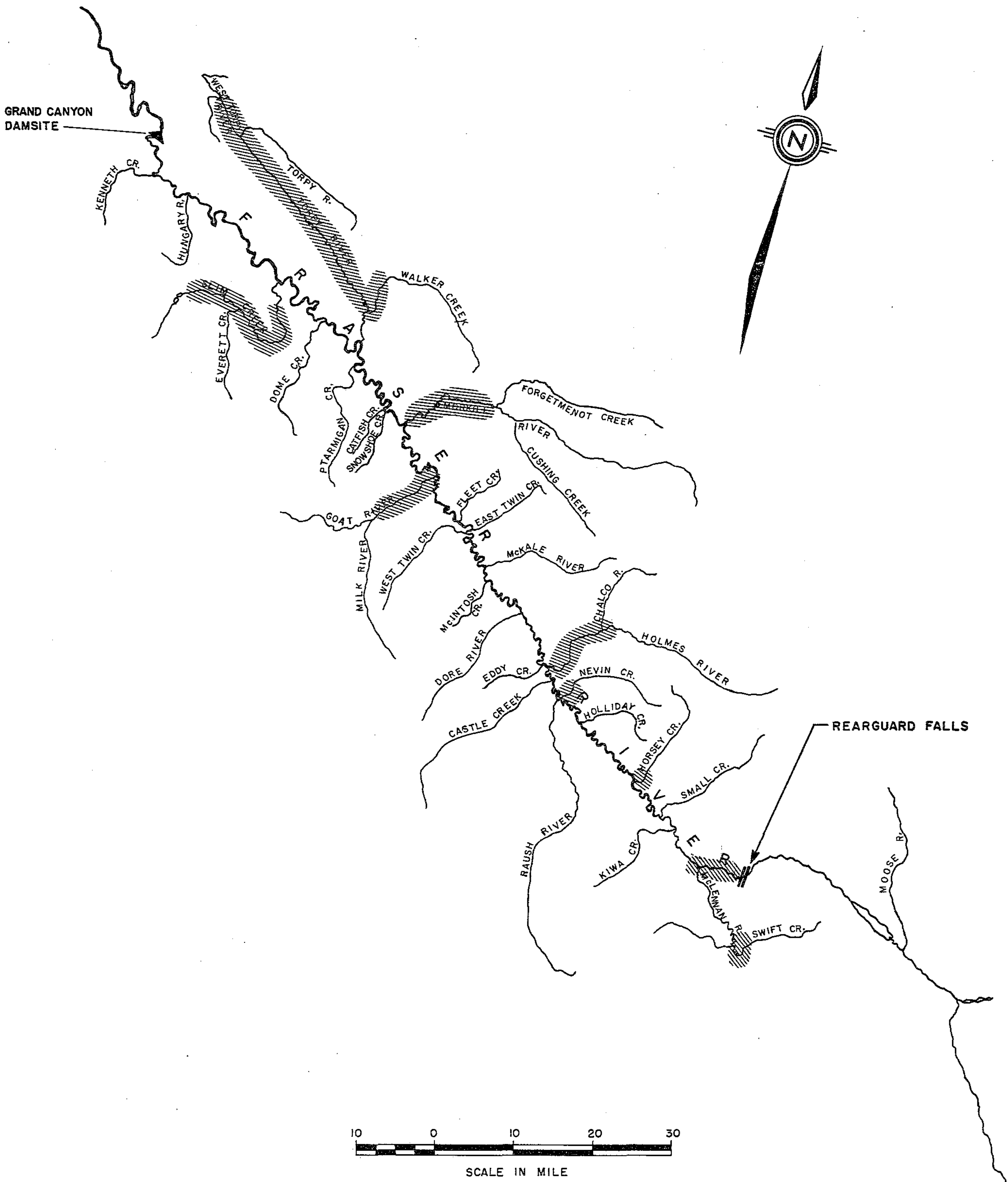


FIG. A1-2 PRESENTLY UTILIZED SPAWNING AREAS

A1.2 ANADROMOUS STOCKS

Many streams in the areas upstream from the proposed Grand Canyon dam site presently support substantial runs of chinook salmon. Average escapement to this basin is approximately 5,800 chinook per year. Migrational runs to this area generally occur from the beginning of July to the end of September. Downstream juvenile migration occurs from mid-April to late July. However, an unknown proportion of the juvenile chinook rear in the streams for periods up to one year before migrating seaward.

This Section of Appendix A1 contains descriptions of all streams surveyed in the basin and is divided into streams presently supporting anadromous fish, streams presently not utilized but which contain potential spawning areas, and streams regarded as having no potential for salmon propagation.

A1.2.1 STREAMS PRESENTLY UTILIZED

Eighteen streams presently support runs of chinook salmon. The major spawning areas (Fig. A1-2) are in the main stem Fraser near Tête Jaune Cache, Slim Creek, Morkill River, Torpy River and its tributaries, Walker and Keg creeks. Each productive stream is described in upstream order from the site of the proposed Grand Canyon project.

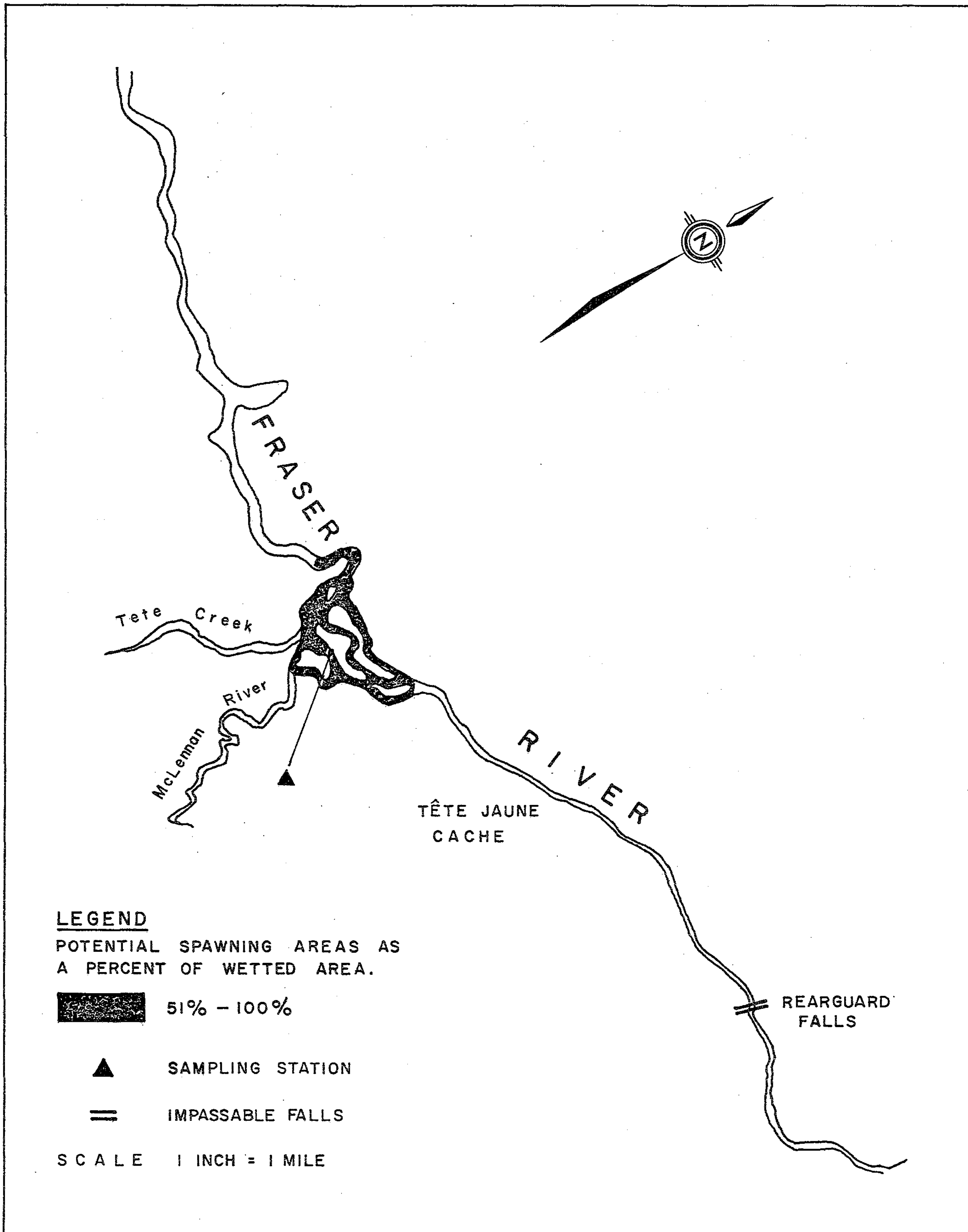


FIG. A1-3 TOTAL POTENTIAL SPAWNING AREA: UPPER FRASER RIVER

FRASER RIVER (FIG. A1-3)

During the aerial survey on August 27, 1972, the water was turbid, but as the river devides into three channels at Tête Jaune and is fairly shallow, the streambed was visible. Approximately 1,500 chinook salmon were spawning in this area at that time.

Reports for the period 1951 to 1970 indicate an average escapement to the Tête Jaune spawning grounds of 3,082 chinook salmon with peaks of 7,500 in several years. Spawning usually commences in early August, peaks in late August, and is complete by mid-September.

The Fraser River is passable to salmon migration to Rearguard Falls, 3 miles upstream from Tête Jaune Cache. Some reports indicate that in low water years Rearguard Falls is passable and chinook have ascended to the outlet of Moose Lake (see Plates A1-1, -2). However, Tête Jaune is the only area in the upper Fraser main stem where chinook salmon spawning has been consistently documented.

There is an estimated 221,760 square yards of suitable spawning gravel in the Tête Jaune area, capableof supporting a theoretical population of 18,480 chinook (Table A1.1). However, it should be noted that this spawning ground may not be the only area of the upper Fraser River utilized by chinook salmon. On the basis of exposed gravel bars visible during the aerial survey other suitable spawning areas may exist. There is also the possibility that chinook salmon may spawn in the deeper areas of the Fraser as was recently documented in the Columbia River where spawning was observed at water depths of 25 feet and deeper.

TABLE A1.1 Potential Spawning Areas: Fraser River at Tête Jaune Cache

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
Left Channel	1,760	60	105,600	79,200	75	6,600
Centre Channel	1,936	60	116,160	87,110	75	7,260
Right Channel	1,232	60	73,920	55,440	75	4,620
TOTAL	4,928	-	295,680	221,760	-	18,480

TABLE A1.2 Chinook Salmon Escapements to Tête Jaune Cache Area 1951 - 1971

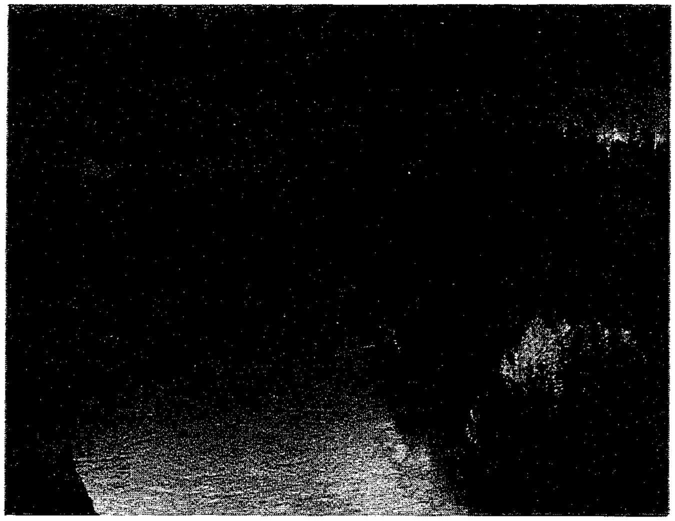
Year	No. of Fish	Year	No. of Fish
1951	7,500	1962	750*
1952	7,000	1963	1,500*
1953	9,000	1964	1,500
1954	7,500	1965	400
1955	4,500	1966	1,000**
1956	4,500	1967	750⌿
1957	5,500	1968	1,350⌿
1958	5,500	1969	1,300⌿
1959	1,500	1970	1,800
1960	475	1971	1,200
1961	200*	Average:	3,082

** Estimate includes escapement to Goat and Holmes Rivers and Nevin and Horsey Creeks*

*** Estimate includes escapement to Holmes River*

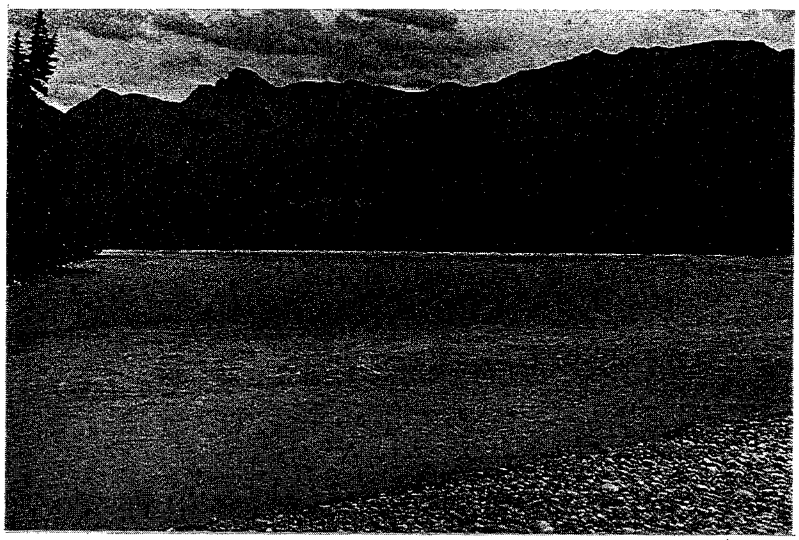
⌿ Estimate includes escapement to Swift Creek

FRASER RIVER

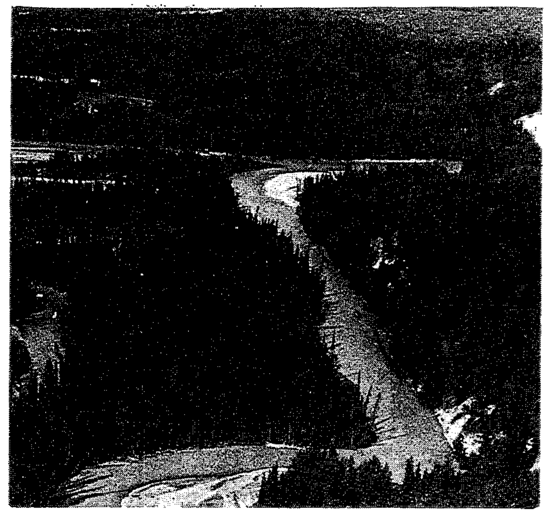


GRAND CANYON DAM SITE

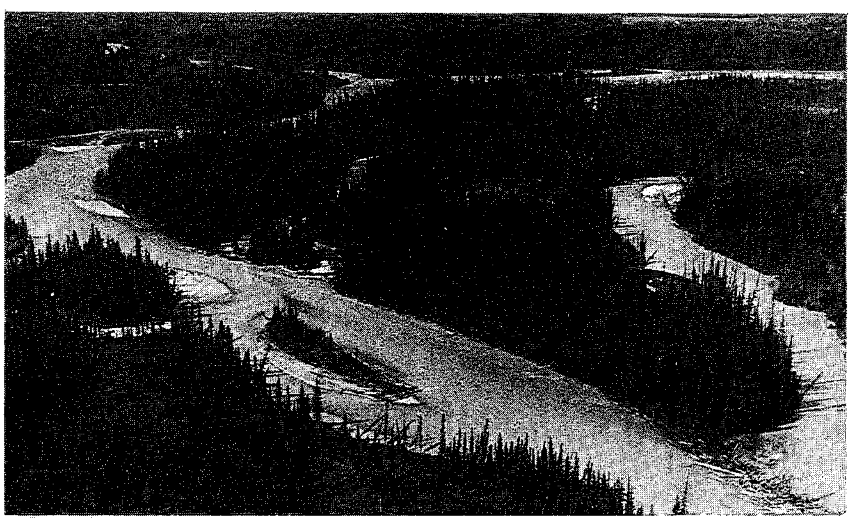
CONFLUENCE OF SMALL CREEK
MILE 182



SAMPLING SITE NEAR McLENNAN RIVER
MILE 193

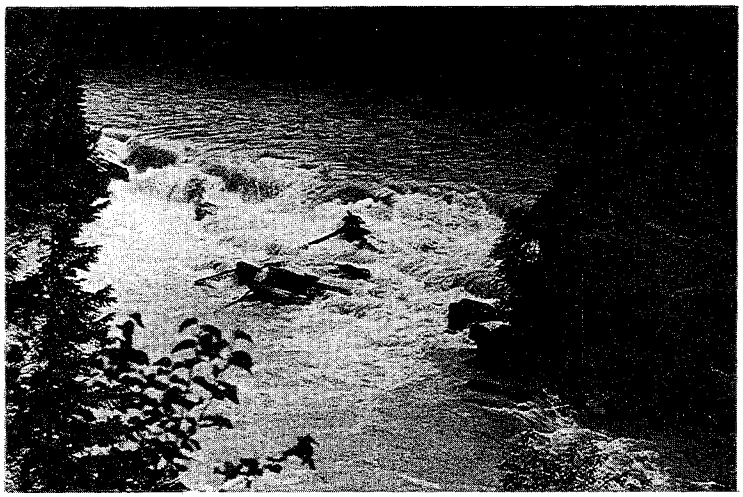


TETE JAUNE CACHE SPAWNING AREA
RIGHT CHANNEL

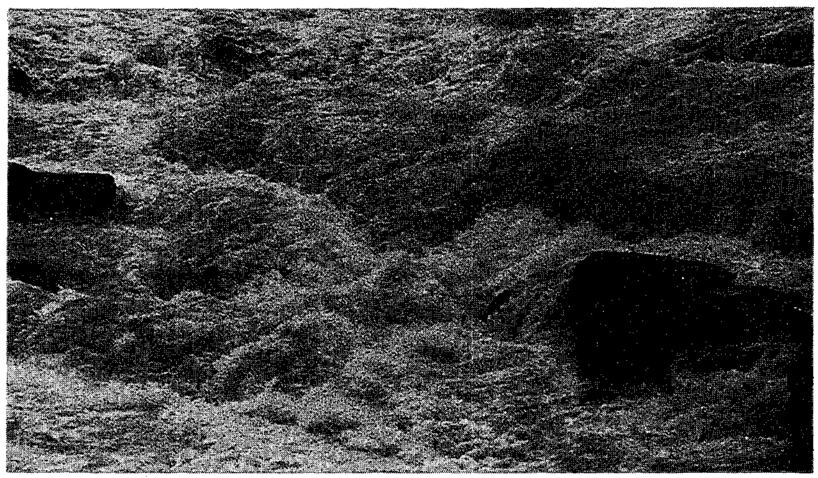


TETE JAUNE CACHE SPAWNING AREA
LEFT AND MIDDLE CHANNELS

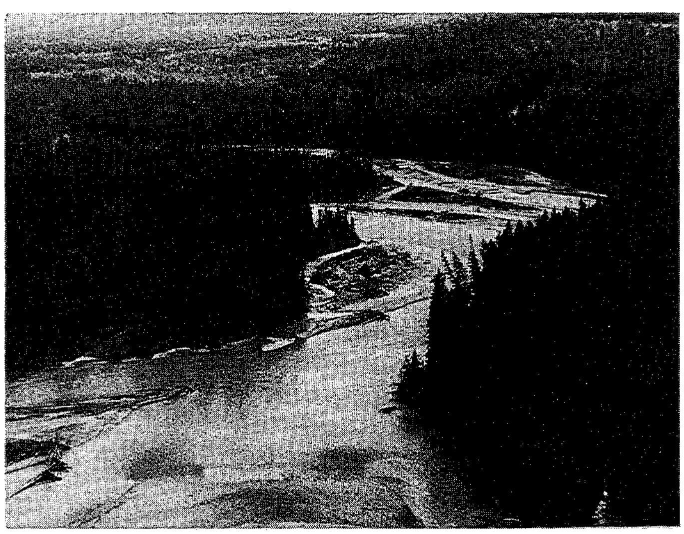
FRASER RIVER



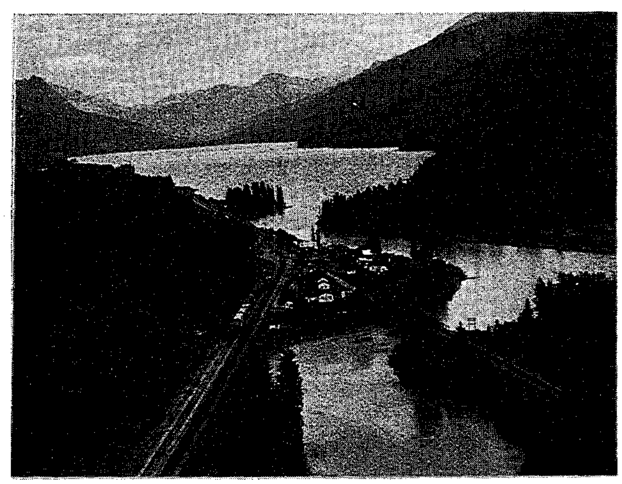
REARGUARD FALLS,
UPSTREAM LIMIT OF MIGRATION



CHINOOK AT REARGUARD FALLS



UPSTREAM FROM REARGUARD FALLS



MOOSE LAKE

SLIM CREEK (FIG. A1-4)

Slim Creek flows northeasterly for 36 miles to its confluence with the Fraser River at 32.8 miles upstream from the proposed dam site. This creek was surveyed by helicopter on August 19 and August 24, 1971; the lower section from the highway bridge upstream to about mile 5 was surveyed by jet boat on August 15, 1971.

Slim Creek is one of the major chinook salmon spawning areas in the Upper Fraser River watershed. The stream gradient to mile 10.0 is fairly steep, and the bottom in this reach is composed of coarse gravel and boulders unsuitable for spawning except for a small section near the mouth. The streambed to mile 14.8 is composed of suitable gravel. From mile 14.8 to 16.5 there is a series of rapids (Plate A1-3). From this point to Slim Lake the streambed again is composed of suitable spawning gravel. Other suitable areas are present between Slim and Tumuch lakes and upstream from the latter. In total, there are 182,221 square yards of suitable gravel capable of supporting 15,185 chinook salmon (Table A1.3).

Escapement figures (Table A1.4) indicate an average annual escapement for the period 1961 to 1971 of 964 chinook salmon. A high of 1,750 fish were counted in 1964. Two to three hundred chinook were counted on August 19 and 1,500 were counted on August 24, 1971. The Slim Creek run begins in early August, peaks in late August to early September, and ends by late September. The main spawning areas are above Tumuch Lake, between Tumuch and Slim Lake, and downstream from Slim Lake to the confluence of Everett Creek.

On August 31, 1971, juvenile spring salmon were sighted at mile 11.5. The upper portion of Slim Creek appears to be an excellent rearing stream because of the many pools, abundant streamside vegetation, logs, and hiding areas.

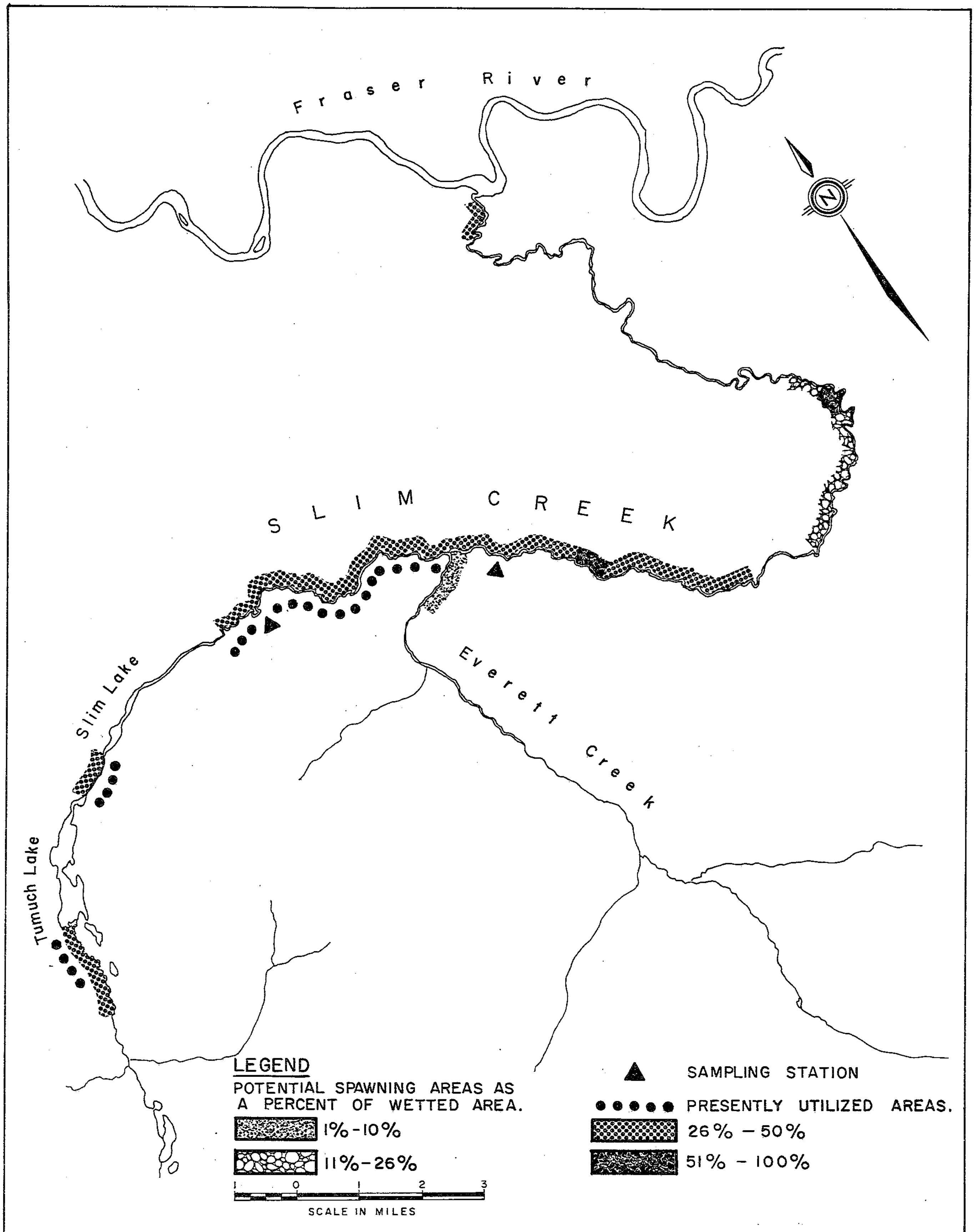


FIG. A1-4 TOTAL POTENTIAL SPAWNING AREA: SLIM CREEK

TABLE A1.3 Potential Spawning Areas: Slim Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 0.4	704	20	14,080	0	0	0
0.4 - 0.9	880	20	17,600	8,800	50	733
0.9 - 10.5	16,896	17	287,232	0	0	0
10.5 - 11.0	880	17	14,960	3,740	25	312
11.0 - 11.8	1,408	17	23,936	14,361	60	1,197
11.8 - 14.8	5,280	17	89,760	22,440	25	1,870
14.8 - 16.5	2,992	16	47,872	0	0	0
16.5 - 19.6	5,456	16	87,296	34,918	40	2,910
19.6 - 20.1	880	16	14,080	8,448	60	704
20.1 - 28.7	15,136	13	196,768	68,869	35	5,739
28.7 - 31.0	Slim L.		0	0	0	0
31.0 - 31.7	1,232	13	16,016	4,805	30	400
31.7 - 33.8	Tumuch L.		0	0	0	0
33.8 - 35.6	3,168	10	31,680	15,840	50	1,320
TOTAL:	54,912	-	841,280	182,221	-	15,185

TABLE A1.4 Chinook Salmon Escapements to Slim Creek (1961 to 1971)

Year	No. of Fish	Year	No. of Fish
1961	750	1967	650
1962	1,500	1968	750
1963	750	1969	750
1964	1,750	1970	750
1965	750	1971	1,500
1966	700	Average:	964

SLIM CREEK

RIFFLE AREA, MILE 7.0

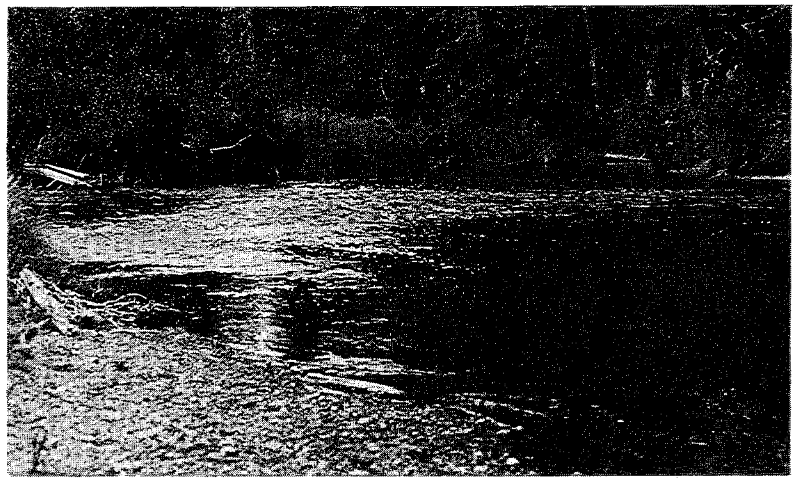
MILE 13.5

RAPIDS, MILE 15

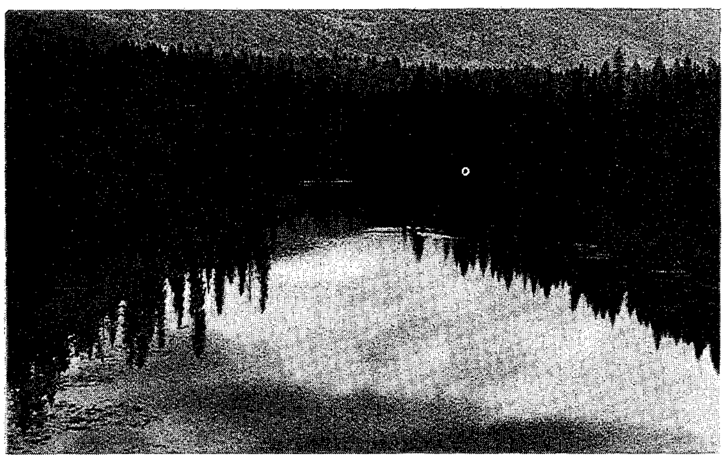
MILE 20.75

SLIM CREEK

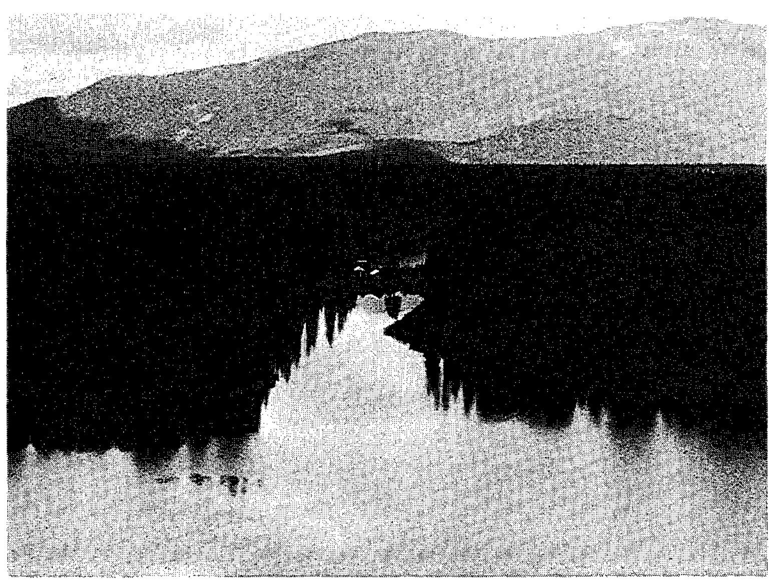
MILE 22.5



SAMPLING SITE, MILE 24.25



MILE 26.0



MILE 28,
TUMUCH LAKE
IN FOREGROUND

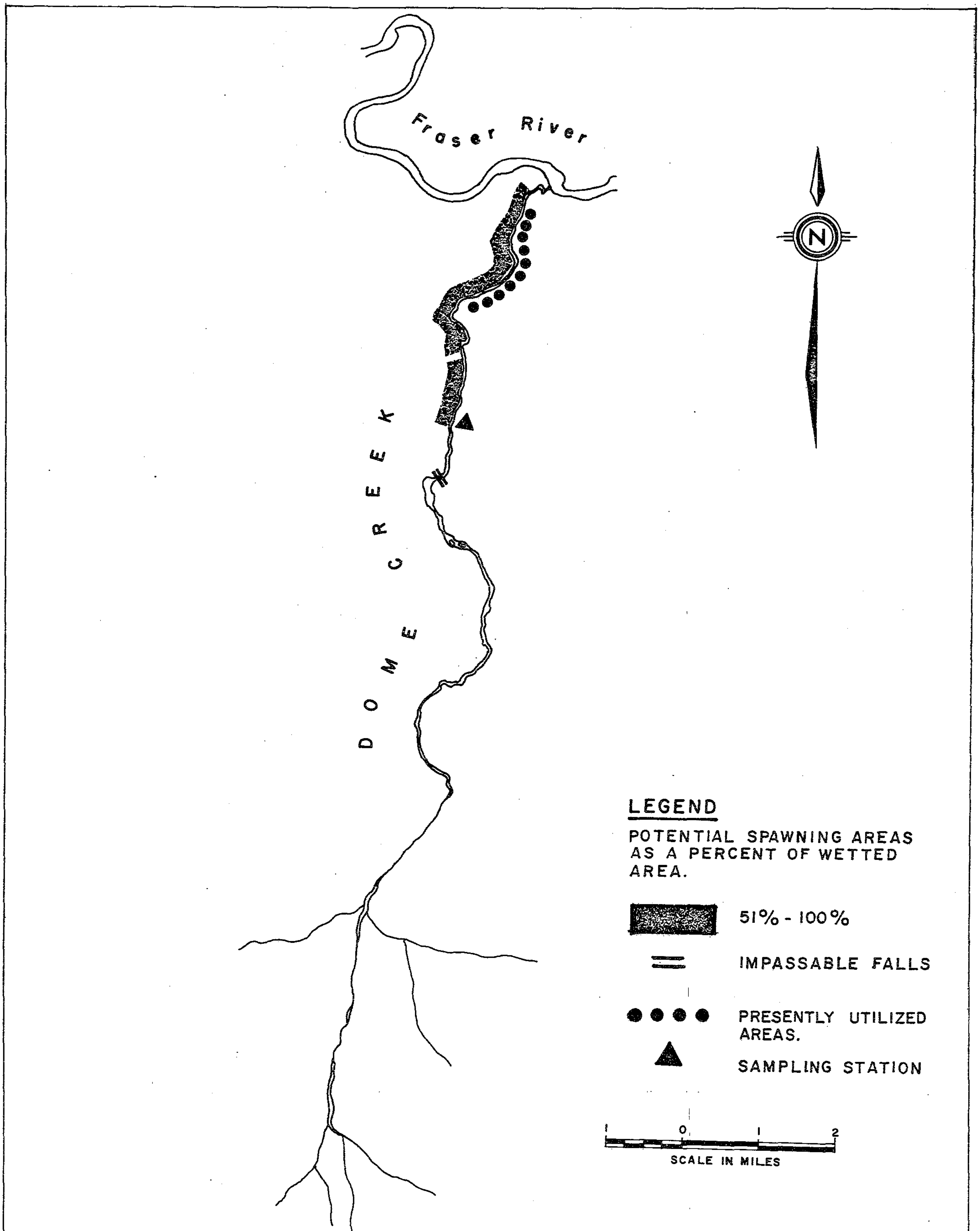


FIG. A1-5 TOTAL POTENTIAL SPAWNING AREA: DOME CREEK

DOME CREEK (FIG. A1-5)

Dome Creek flows northeasterly a distance of approximately 15 miles, entering the south bank of the Fraser River at mile 49.2. The stream is accessible to salmon to mile 4.7 where there is an 8 foot falls over an old log dam (Plate A1-5). The average stream gradient throughout this reach is 0.85%. Stream width is approximately 45 feet. The stream banks above and below the highway bridge (at about mile 4.0) have been rip-rapped to stabilize the stream channel. Sections of the stream are braided and contain as many as 4 to 5 channels.

The streambed in the first 0.3 miles is composed mainly of sand and mud, but beyond this point, to mile 2.75, is composed of suitable spawning gravel. The next 0.15 miles are canyonous and the bottom is bedrock and boulders. Above the canyon, to mile 3.8 the substrate is very satisfactory for salmon propagation. From mile 3.8 to the falls the substrate is unsuitable. Above the falls to mile 6.5, ten percent of the wetted stream area was composed of suitable spawning gravel. Upstream to the stream source, the substrate is unsuitable.

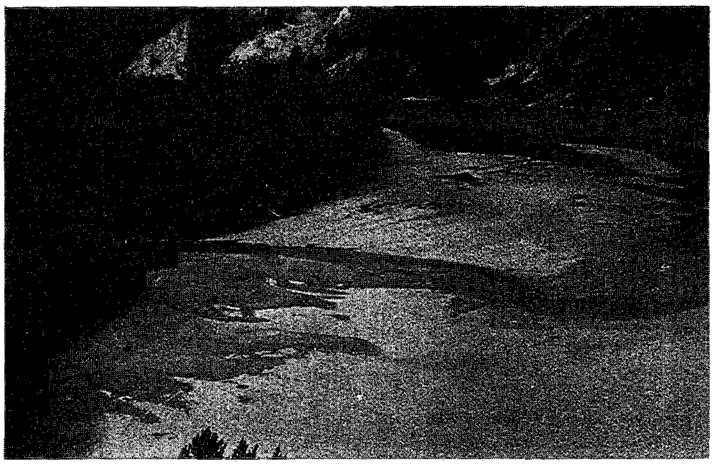
A total of 61,732 square yards of accessible spawning area is present in the lower 3.8 miles of Dome Creek (Table A1.5). Theoretically, this area could support an annual spawning population of 5,144 chinook. The potential of the area upstream from the falls is not included in the total Grand Canyon potential.

Local reports indicate that chinook salmon utilize this lower portion for spawning; the size of the run is not known. However, the sighting of salmonid juveniles in areas of the stream substantiate the fact that it is utilized.

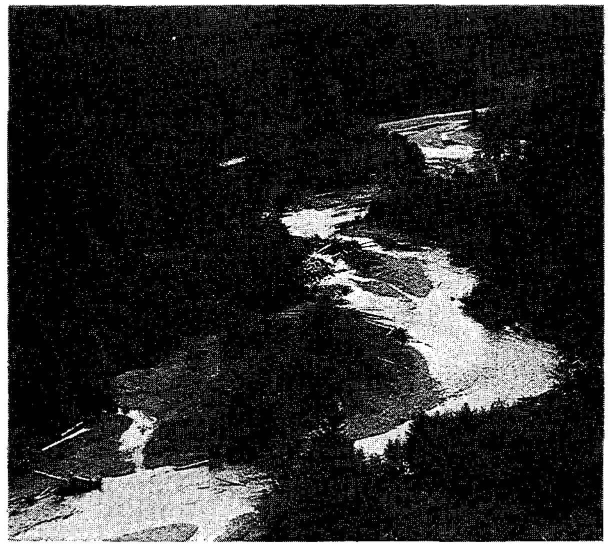
TABLE A1.5 Potential Spawning Areas: Dome Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.3	528	16	8,448	0	0	0
0.3 - 1.3	1,760	16	28,160	18,304	65	1,525
1.3 - 2.75	2,552	15	38,280	26,796	70	2,233
2.75 - 2.9	264	15	3,960	0	0	0
2.9 - 3.5	1,056	15	15,840	11,088	70	924
3.5 - 3.8	528	15	7,920	5,544	70	462
3.8 - 4.7	1,584	13	20,592	0	0	0
4.7 - 6.5	3,168	12	38,016	3,802	10	317
TOTAL:	11,440	-	161,216	65,534	-	5,461

DOME CREEK



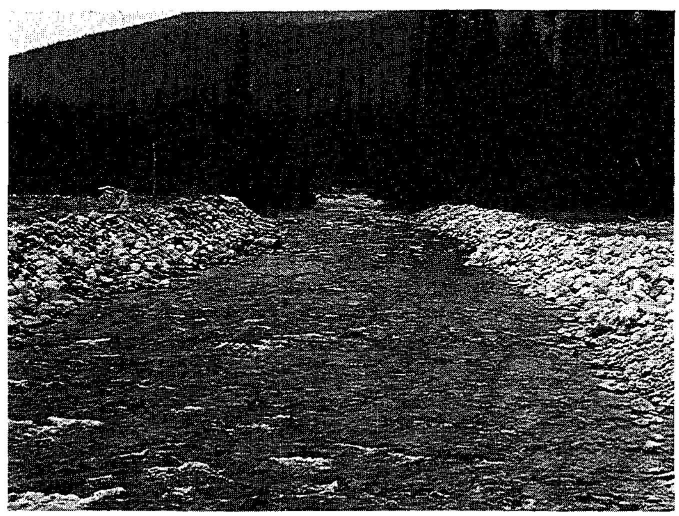
AT MOUTH



MILE 3.0

MILE 3.75

LOG DAM
MILE 5.0



ABOVE BRIDGE, MILE 4.25

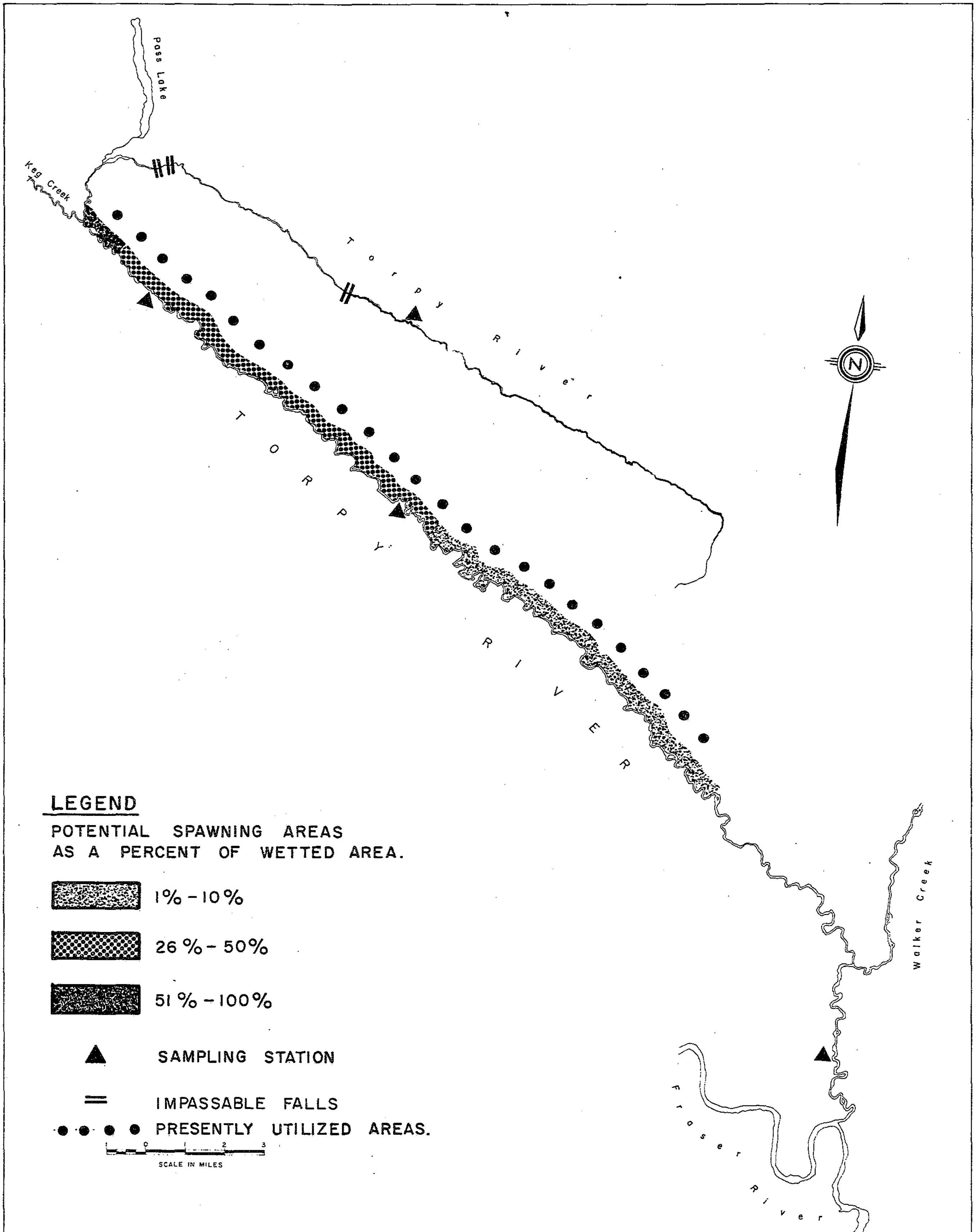


FIG. A1-6 TOTAL POTENTIAL SPAWNING AREA: TORPY RIVER

TORPY RIVER (FIG. A1-6)

The Torpy River, rising from the McGregor Mountain range, flows approximately 27 miles in a northwesterly direction, bends sharply south and east, and flows southeasterly some 50 miles to its confluence with the Fraser River at approximately mile 58.0. Aerial survey of this river was conducted on August 13, 1971, at which time 93 chinook salmon were sighted, nearly all between mile 33.0 and 46.2. The water is slightly turbid in the lower reaches but clears in the upper section of the river.

The lower section of river to mile 26.6 has a very moderate gradient; the water flow is slow and the river meanders; the stream bottom and banks are composed mainly of sand and clay. However, from mile 14.0 to 26.6 there are some scattered bars of suitable gravel, somewhat compacted by silt deposits (Plate A1-6).

From mile 26.6 to 39.0, there are many stretches of suitable spawning areas. It was estimated that 70% of the wetted stream area from mile 38.0 to 39.0 consisted of satifactory spawning gravel. The total amount of suitable spawning gravel presently accessible to chinook salmon was estimated to be 240,592 square yards, theoretically capable of supporting 20,049 chinook (Table A1.6).

Between mile 39.0 and 55.3, the gradient increases, and the stream enters a narrow canyonous area with a 10 foot falls at mile 49.3, a 15 foot falls at mile 49.6 and a 3 to 5 foot falls at mile 55.3. Above this point, the gradient again decreases and the stream flows through a meadow area that contains a small amount of suitable spawning gravel (Plate A1-7). However, because of the obstructions downstream and the low total capacity of this area, its potential was not included in the total potential estimate of the Grand Canyon basin.

Reports indicate an average annual escapement of 600 chinook to the Torpy River for the period 1961 to 1971. The main spawning areas are located in the middle portion of the river and in Keg Creek, a tributary.

Spawning commences in mid-August, peaks in early September, and is complete by late September.

TABLE A1.6 Potential Spawning Areas: Torpy River

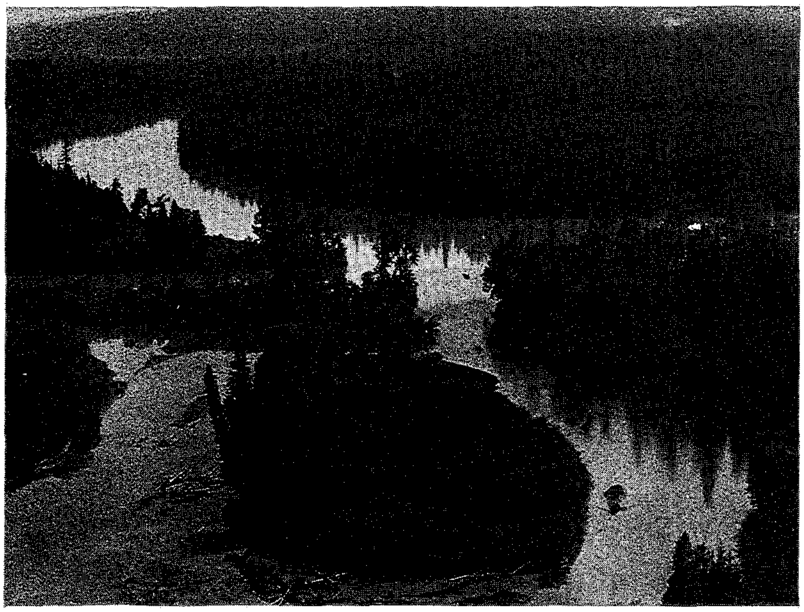
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq. yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 14.0	24,640	35	862,400	0	0	0
14.0 - 26.6	22,176	25	554,400	55,400	10	4,620
26.6 - 38.0	20,064	20	401,280	160,512	40	13,376
38.0 - 39.0	1,760	20	35,200	24,640	70	2,053
TOTAL:	68,640	-	1,853,280	240,592	-	20,049

TABLE A1.7 Chinook Salmon Escapements to the Torpy River* (1961 - 1971)

Year	No. of Fish	Year	No. of Fish
1961	250	1967	650
1962	1,500	1968	400
1963	750	1969	400
1964	600	1970	750
1965	200	1971	750
1966	350	Average:	600

* *Includes escapements to Keg Creek and Walker Creek*

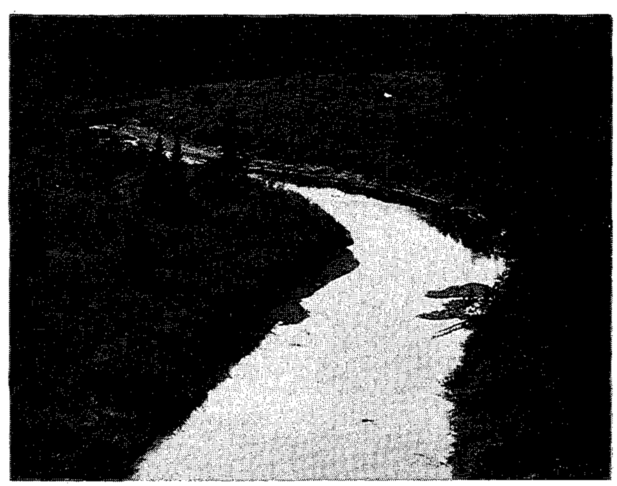
TORPY RIVER



DOWNSTREAM TO MOUTH

ONE MILE FROM MOUTH

MILE 14.25

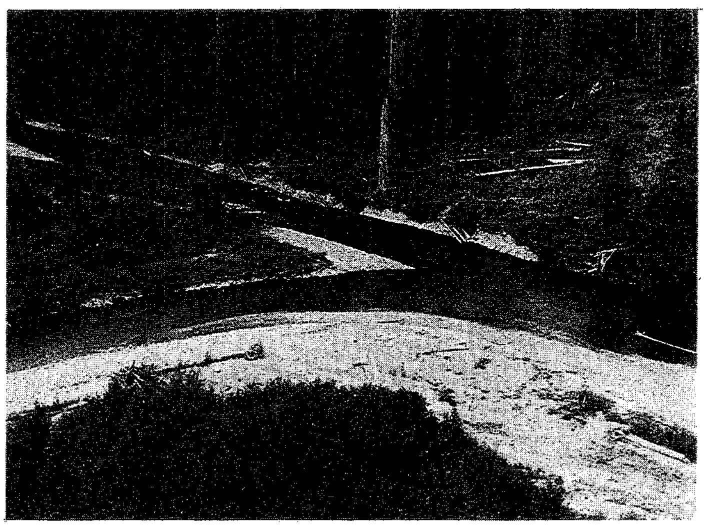


MILE 21.75

TORPY RIVER

RIFFLE AREA, MILE 30

MILE 32.5



CONFLUENCE OF KEG CREEK, MILE 46.2

MEANDERING SECTION, MILE 54

TORPY RIVER VALLEY
MILE 58.5

KEG CREEK (WEST TORPY RIVER) (FIG. A1-7)

Keg Creek flows 10 miles in a northwesterly direction to its confluence with the Torpy River at mile 46.2 on the latter. The water in this stream is very clear, although the first mile is swampy and slow-flowing and the substrate consists mainly of sand and very fine gravel. From this point, to mile 7.0, where a small tributary, Crotch Creek, enters from the west, the gradient is moderate and 30% of the substrate is composed of suitable spawning gravel (Plate A1-8). The substrate to mile 9.4 is composed of excellent spawning materials that comprise an estimated 70% of the wetted area. This entire stream section is heavily overgrown; there are windfalls and logs, and many pools between riffle areas. Rearing juvenile salmonids were visible in this portion of Keg Creek on August 14, 1971.

The lower 1.2 miles of Crotch Creek have a marginal spawning habitat; only 10% of the wetted area in this portion is composed of suitable spawning gravel (Plate A1-9). Above mile 1.2, the gradient increases, the flows are apparently unstable and most of the gravel observed appeared to be too coarse for spawning use.

Chinook escapements for Keg Creek are included with those of the Torpy River. The peak of spawning normally occurs near the middle of August and is complete by early September. The lower 9.4 miles of Keg Creek are utilized for spawning but the highest spawning activity takes place from mile 7.0 to 9.4. During the aerial survey 228 chinook were counted in Keg Creek.

The estimated amount of suitable spawning gravel present in Keg Creek is 36,960 square yards with an additional 1,056 square yards in its tributary. The total spawning capacity of the two streams is approximately 3,200 chinook salmon (Table A1.8).

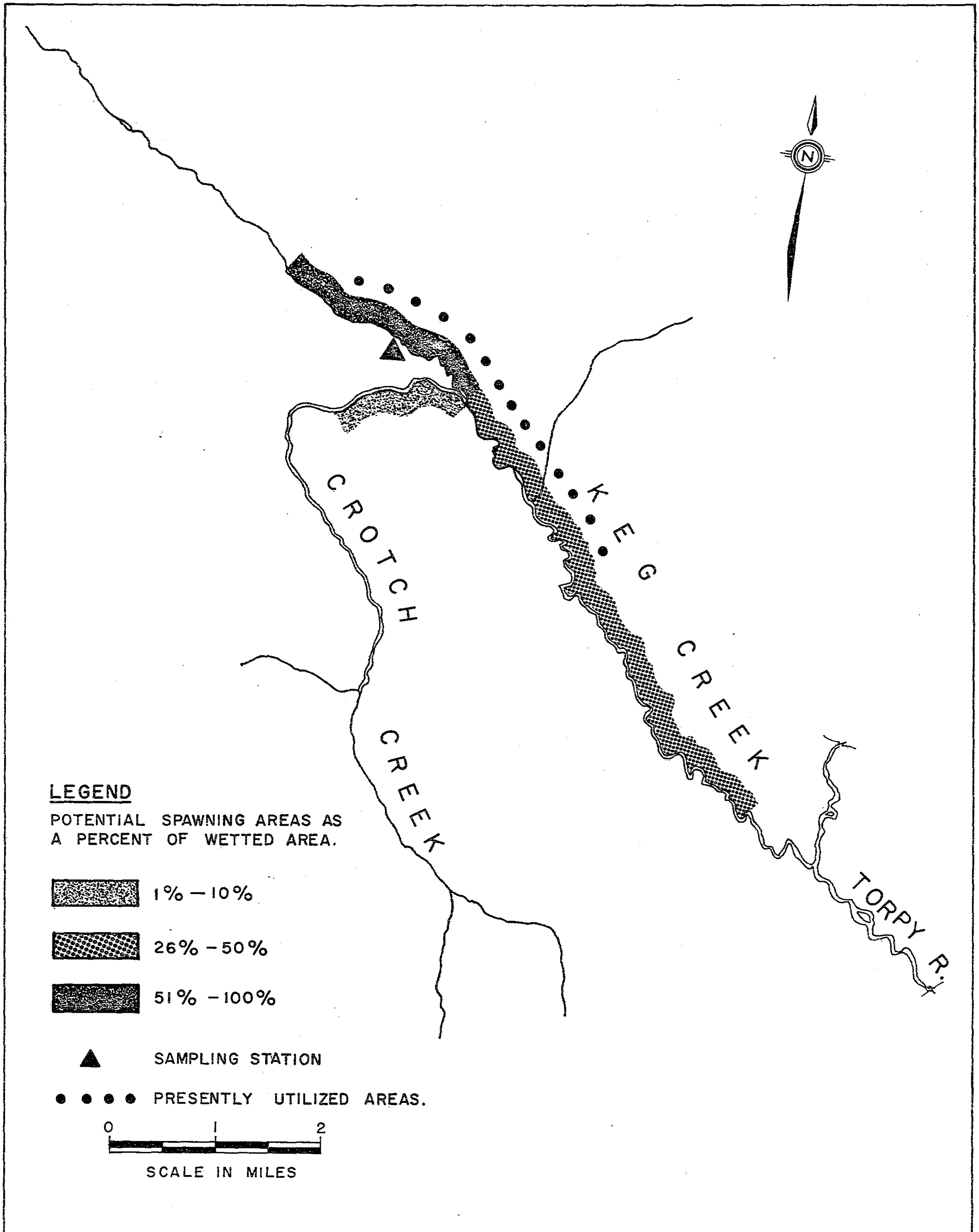


FIG. A1-7 TOTAL POTENTIAL SPAWNING AREA: KEG CREEK (WEST TORPY RIVER)

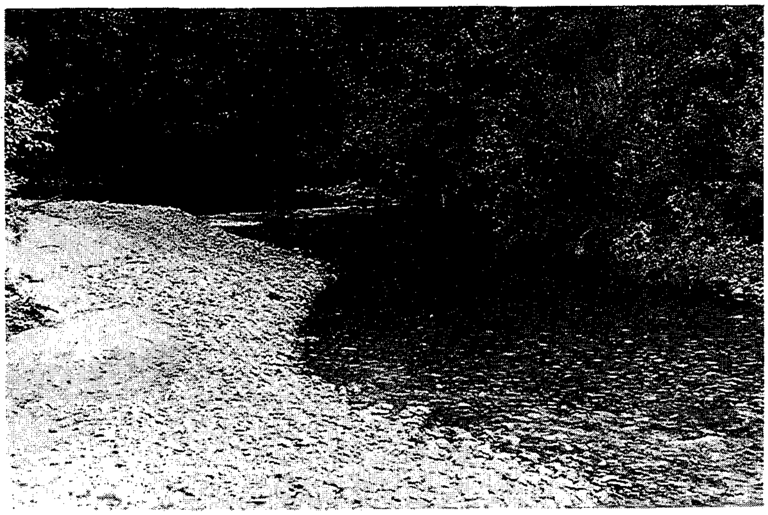
TABLE A1.8 Potential Spawning Areas: Keg Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 1.0	1,760	6	10,560	0	0	0
1.0 - 7.0	12,320	6	73,920	22,176	30	1,848
7.0 - 9.4	4,224	5	21,120	14,784	70	1,232
9.4 - Source	-	-	-	0	0	0
TOTAL:	18,304	-	105,600	36,960	-	3,080

Potential Spawning Areas: Crotch Creek

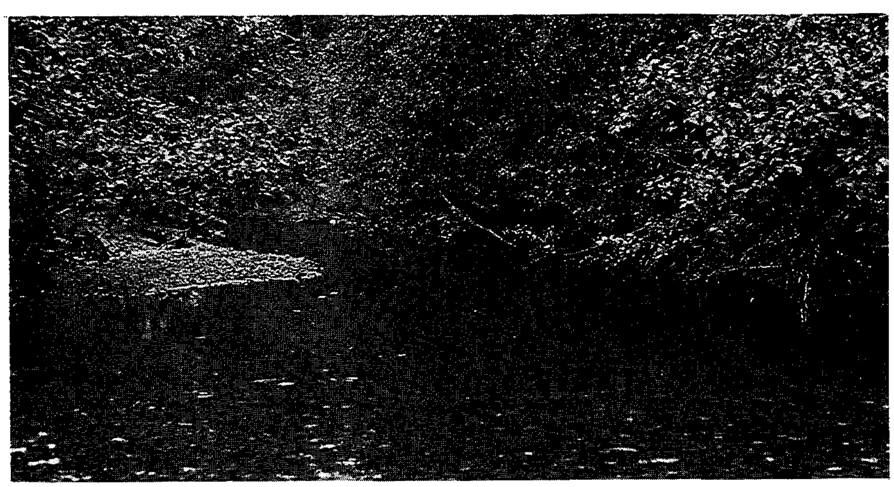
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq. yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 1.2	2,112	5	10,560	1,056	10	88
1.2 - Source	-	-	-	-	0	0
TOTAL:	2,112	-	10,560	1,056	-	88

KEG CREEK

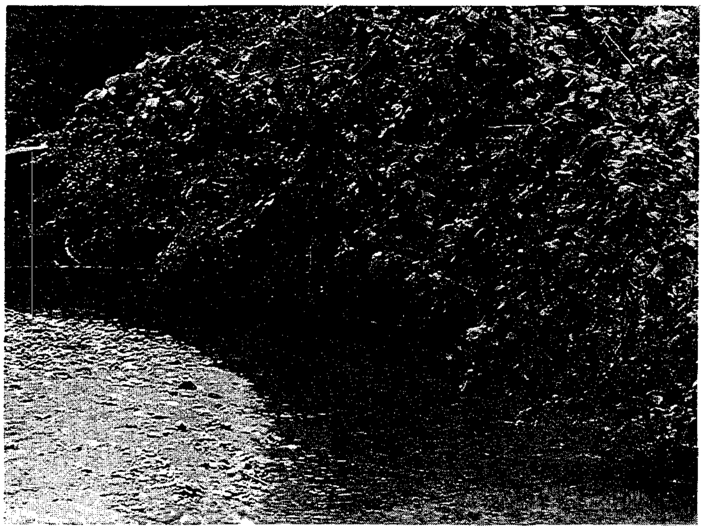


MILE 7.0

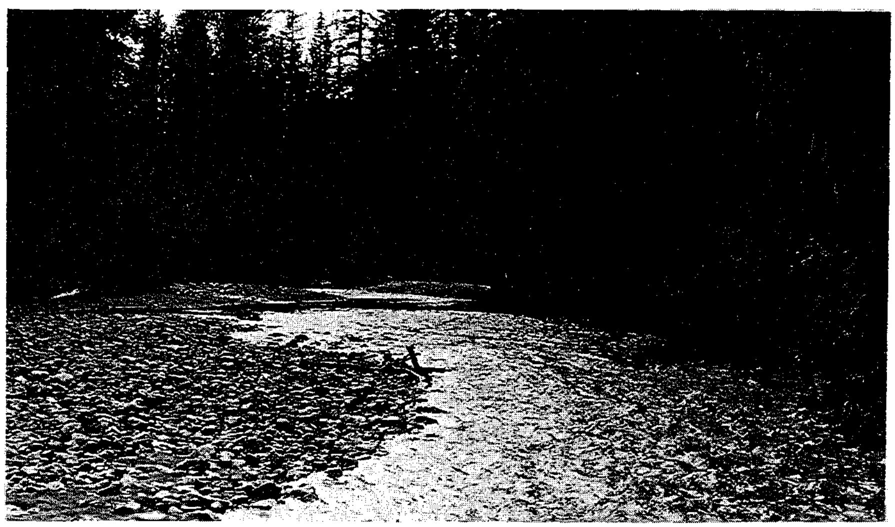
MILE 7.3



MILE 7.5



CROTCH CREEK
AT CONFLUENCE WITH KEG CREEK



CROTCH CREEK
RIFFLE AREA AT MILE 0.5

WALKER CREEK
MILE 3.0

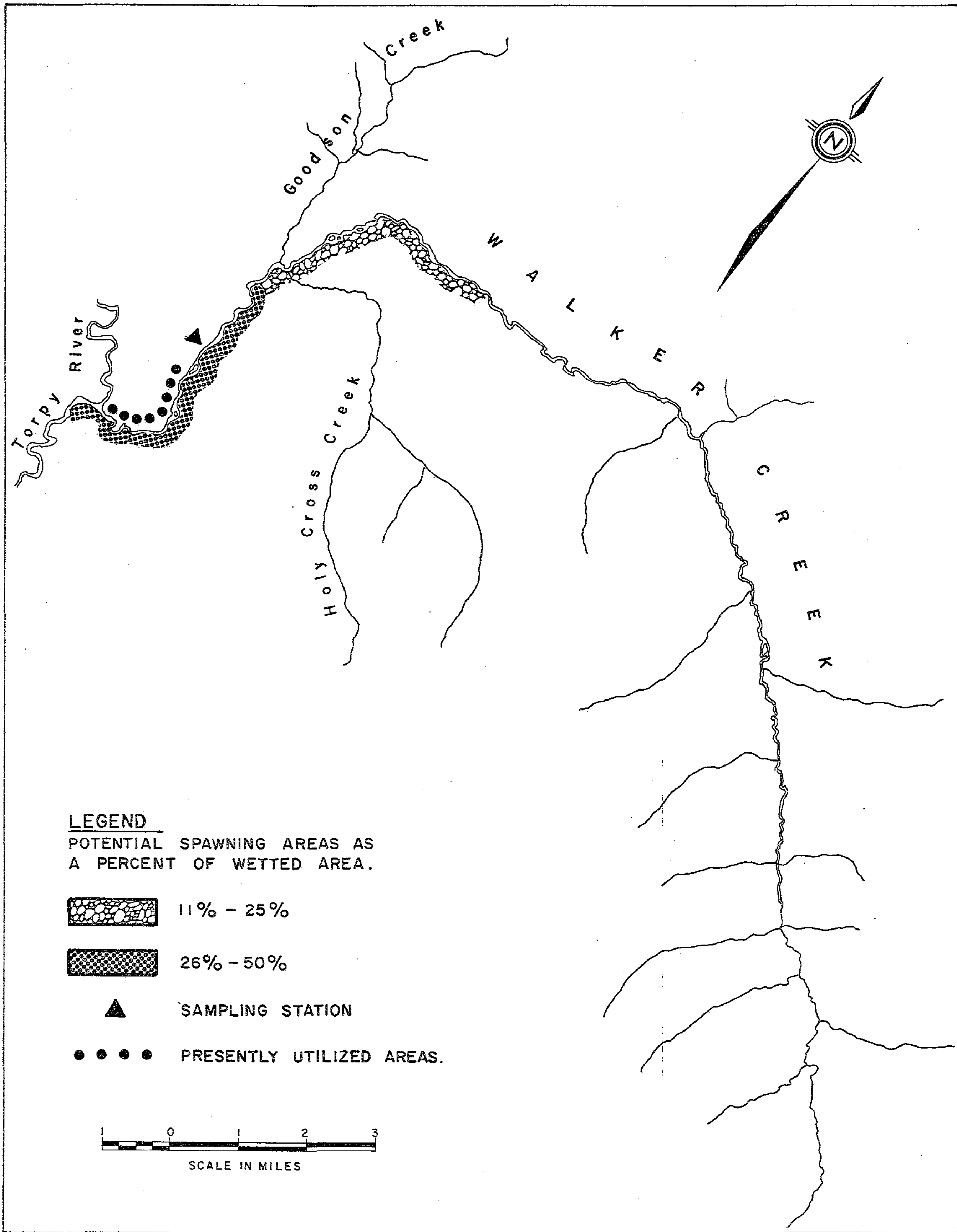


FIG. A1-8 TOTAL POTENTIAL SPAWNING AREA: WALKER CREEK

WALKER CREEK (FIG. A1-8)

Walker Creek, a tributary of the Torpy River, flows 22 miles southwesterly to its confluence with the Torpy at mile 6.0. This creek was surveyed by helicopter on August 13, 1971. The water was very clear and visibility excellent. A total of 178 chinook salmon were sighted; most were in the lower 2 miles, but some were scattered from this point to mile 7.5.

Escapement figures for this creek are included with those of the Torpy River. Records indicate that spawning takes place within the first one-half mile of this stream.

The potential spawning area in Walker Creek was estimated to be 97,460 square yards with a theoretical capacity of 8,122 chinook salmon (Table A1.9).

TABLE A1.9 Potential Spawning Areas: Walker Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of Fish)
0.0 - 4.0	7,040	20	140,800	70,400	50	5,867
4.0 - 8.1	7,216	15	108,240	27,060	25	2,225
8.1 - 22.0	24,464	7.5	183,480	0	0	0
TOTAL:	38,720	-	432,520	97,460	-	8,122

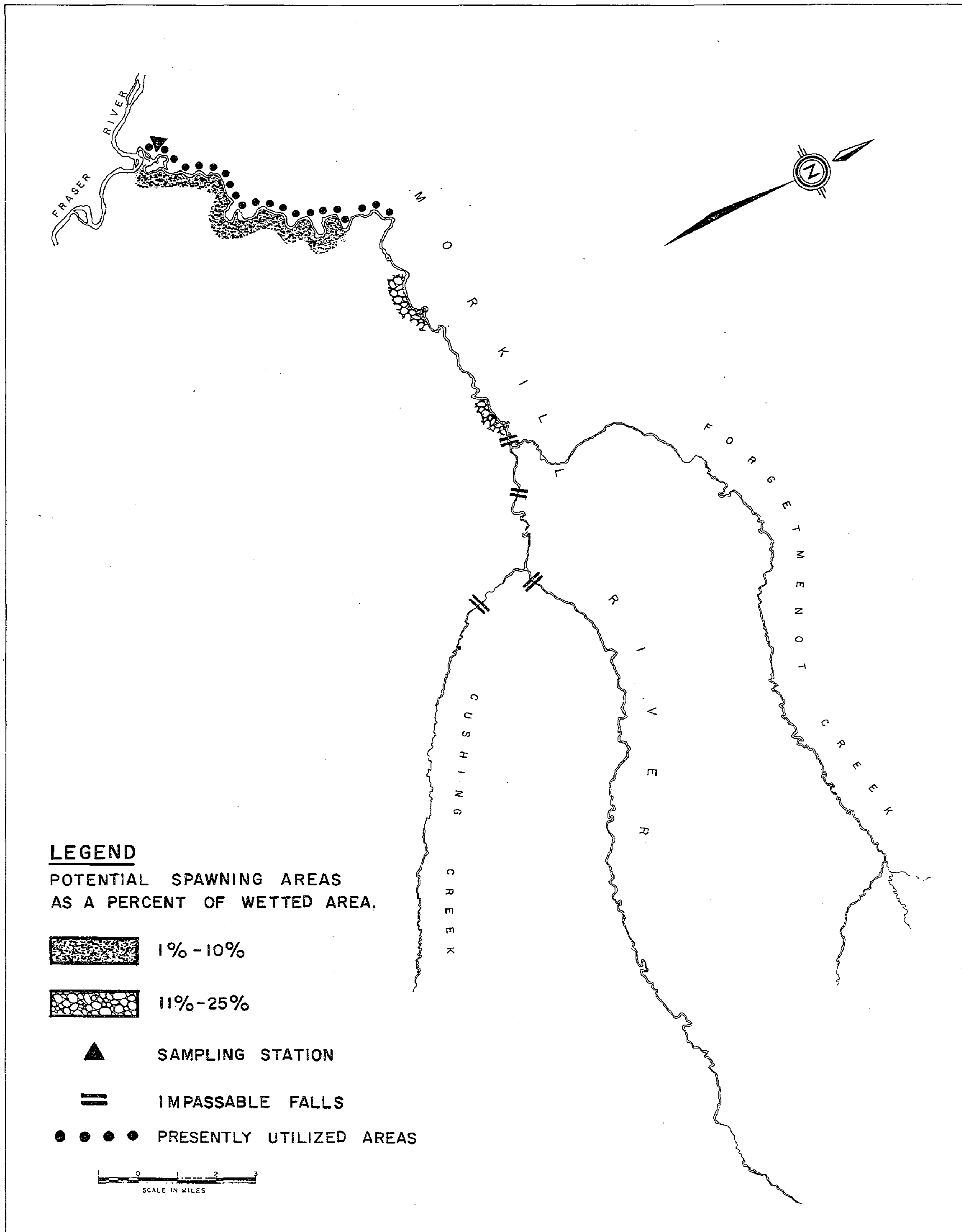


FIG. A1-9 TOTAL POTENTIAL SPAWNING AREA: MORKILL RIVER

MORKILL RIVER (FIG. A1-9)

The Morkill River, a major tributary to the upper Fraser River, flows a distance of 35 miles southwesterly to its confluence with the Fraser at mile 79.0. The stream bottom is not readily visible as the water is turbid and coloured with glacial melt. The substrate composition was determined from banks and exposed bars. The river is passable to salmon to a 50 foot falls at mile 18.5 (Plate A1-11). A second falls, approximately the same height, is at mile 20.2 and a series of falls begins at mile 21.5. The estimated potential spawning area of this stream is 64,856 square yards theoretically capable of supporting 5,405 chinook salmon annually (Table A1.10). Above the series of falls at mile 21.5 there are scattered areas of suitable spawning gravel. This potential is not included in the total Grand Canyon estimate.

Average escapement for the periods 1961 to 1970 is approximately 350 chinook salmon. Spawning commences in mid August, peaks early in September and finishes by the end of September. Spawning areas are scattered throughout the lower 10 miles of the Morkill River.

TABLE A1.10 Potential Spawning Areas: Morkill River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.00 - 9.00	15,840	30	475,200	47,520	10	3,960
9.00 - 12.25	5,720	25	143,000	0	0	0
12.25 - 13.50	2,200	25	55,000	11,000	20	917
13.50 - 16.40	5,104	20	102,080	0	0	0
16.40 - 17.60	2,112	20	42,240	6,336	15	528
17.60 - 18.15	1,584	15	23,760	0	0	0
TOTAL:	32,560	-	91,256	64,856	-	5,405

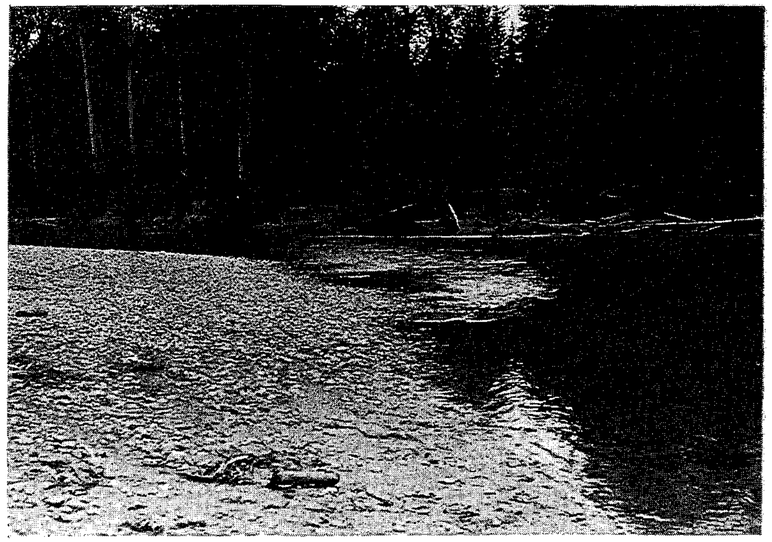
TABLE A1.11 Chinook Salmon Escapement to the Morkill River 1961-1971

Year	No. of Fish
1961	170
1962	400
1963	400
1964-1971	chinook present but not counted due to turbidity
Average*	350

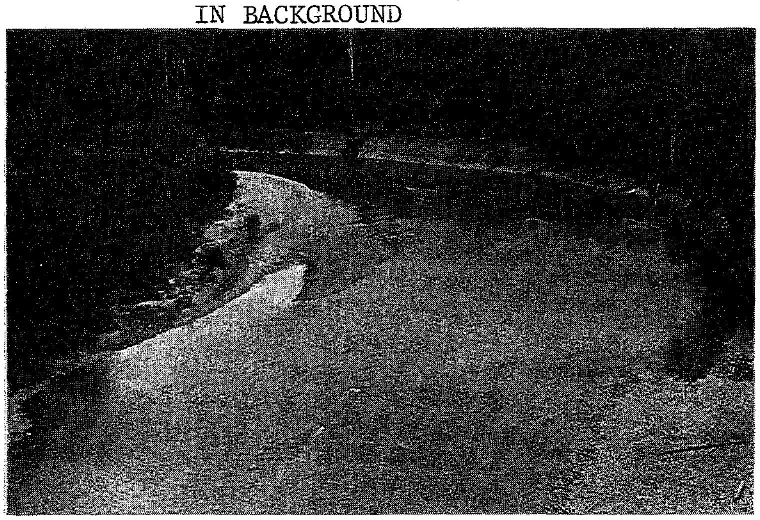
* *Calculated from years of known escapement only.*

MORKILL RIVER

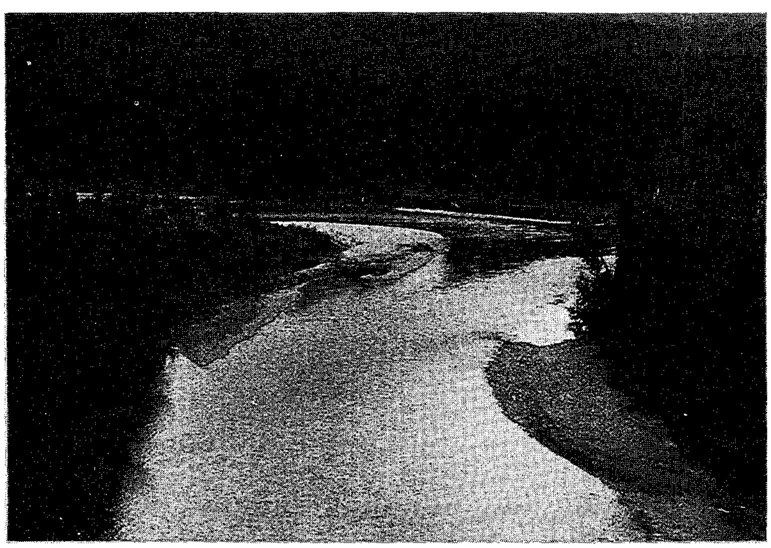
LOWER PORTION, FRASER RIVER
IN BACKGROUND



SAMPLING SITE, MILE 0.2



MILE 2.0

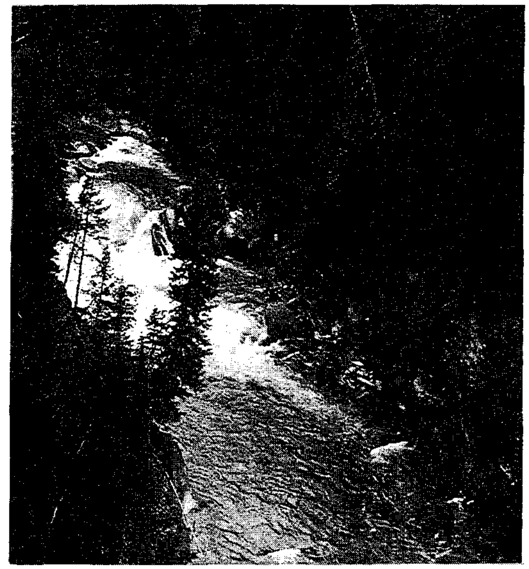


MILE 5.0

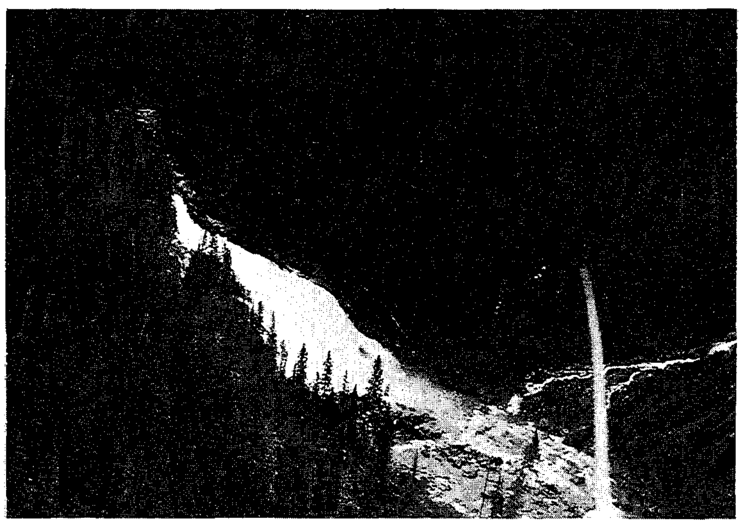
PLATE A1-10

MORKILL RIVER

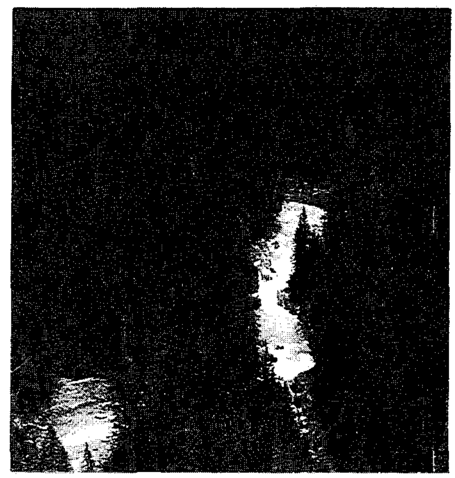
RIFFLE AREA, MILE 11



50 FT. WATERFALL, MILE 18.5



RAPIDS AND WATERFALL, MILE 20.2



FALLS, MILE 22

MILE 24

GOAT RIVER (FIG. A1-10)

The Goat River flows northwesterly for 23.1 miles to its confluence with the Fraser River at mile 94.0. Although the lower portion of the Goat River, downstream from its confluence with the Milk River, is slightly coloured because of the turbid water of the latter, the upper section is very clear. The entire length of this river is accessible to salmon; a series of rapids in a canyonous area at mile 5.0, where the river enters the Rocky Mountain Trench is considered to be passable (Plate A1-12.)

There are 35,943 square yards of suitable spawning gravel in the Goat River capable of supporting a theoretical population of 2,995 chinook salmon (Table A1.12). Most of this potential spawning gravel is situated in the lower 2.6 miles; other suitable areas are scattered throughout the middle and upper sections to mile 21.

A run of approximately fifty chinook spawn in the lower 4 miles of the Goat River. Spawning commences in mid-August, peaks in late August and is complete by mid-September. During the aerial survey on August 26, 1971, fifteen chinook salmon were spawning at mile 2.6.

MacLeod Creek, a tributary of Goat River, which enters at mile 18.9 on the latter, has approximately 422 square yards of potential spawning area at its mouth capable of supporting about 35 chinook salmon. This amount is not included in the total estimated potential of the Grand Canyon sub-basin.

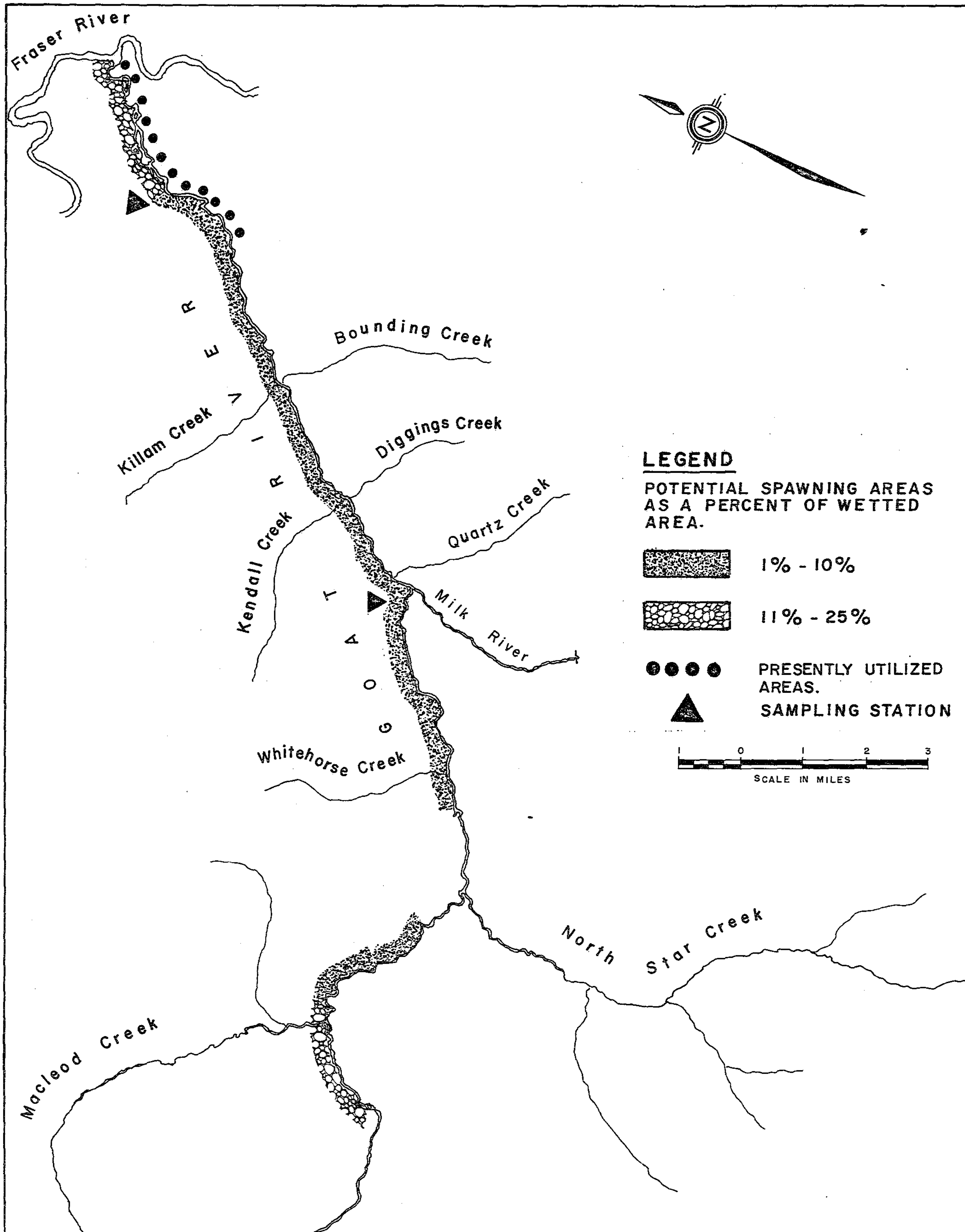


FIG. A1-10 TOTAL POTENTIAL SPAWNING AREA: GOAT RIVER

TABLE A1.12 Potential Spawning Areas: Goat River

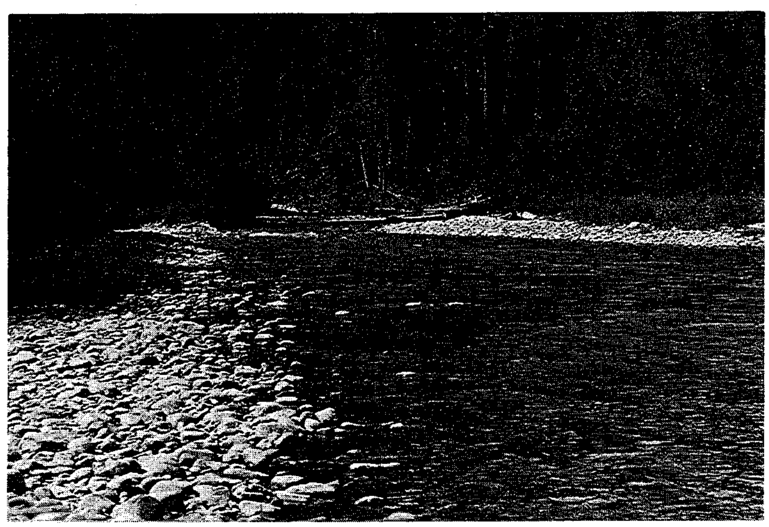
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 2.6	4,576	25	114,400	22,880	20	1,907
2.6 - 14.5	20,944	19	397,936	7,959	2	663
14.5 - 17.8	5,808	9	52,272	0	0	0
17.8 - 18.9	1,936	5	9,680	484	5	40
18.9 - 21.0	3,696	5	18,480	4,620	25	385
21.0 - 23.1	3,696	2.5	9,240	0	0	0
TOTAL:	40,656	-	602,008	35,943	-	2,995

Potential Spawning Areas: McLeod Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.6	1,056	8	8,448	422	5	35
0.6 - Source	-	-	-	0	0	0
TOTAL:	1,056	-	8,448	422	-	35

GOAT RIVER

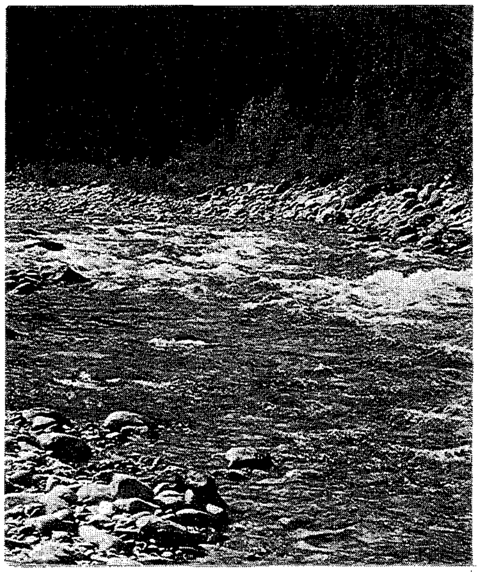
AT CONFLUENCE WITH FRASER RIVER



SAMPLING SITE, MILE 2.6

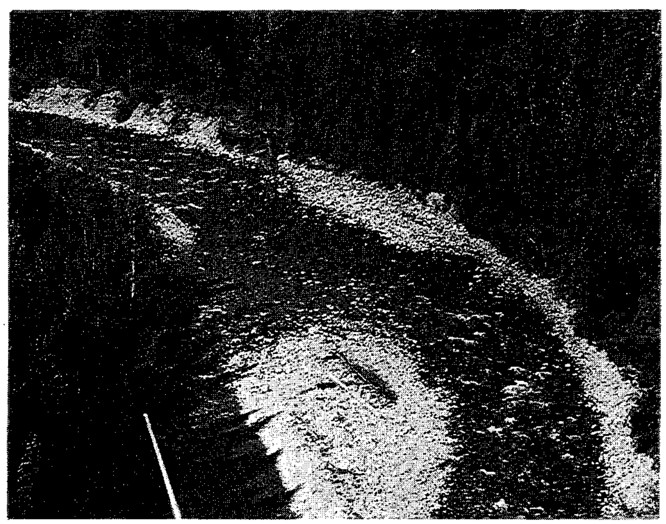
MILE 5.75

GOAT RIVER



SAMPLING SITE, MILE 9.9

MILE 14



MILE 16.3

MILE 22.5

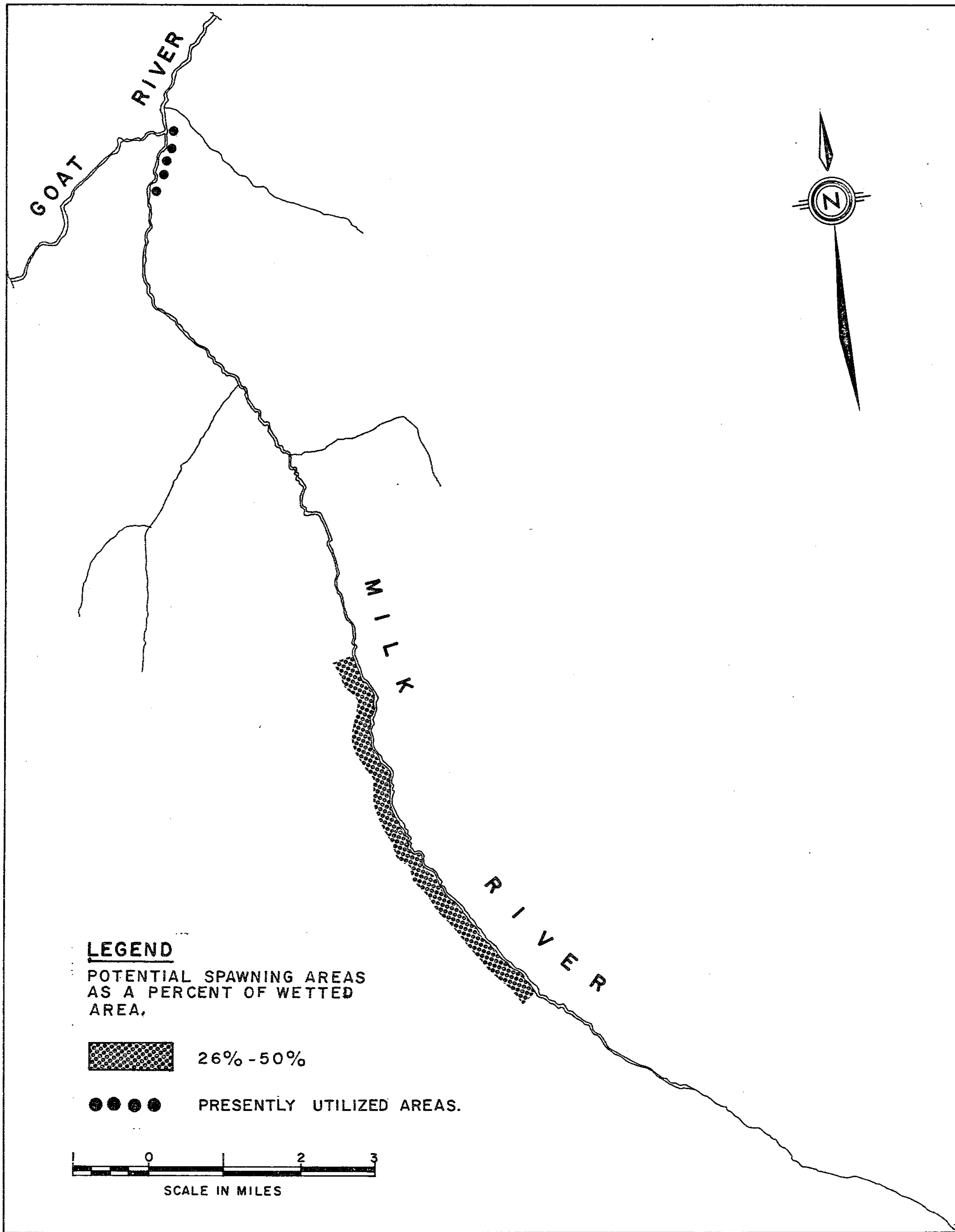


FIG. A1-11 TOTAL POTENTIAL SPAWNING AREA: MILK RIVER

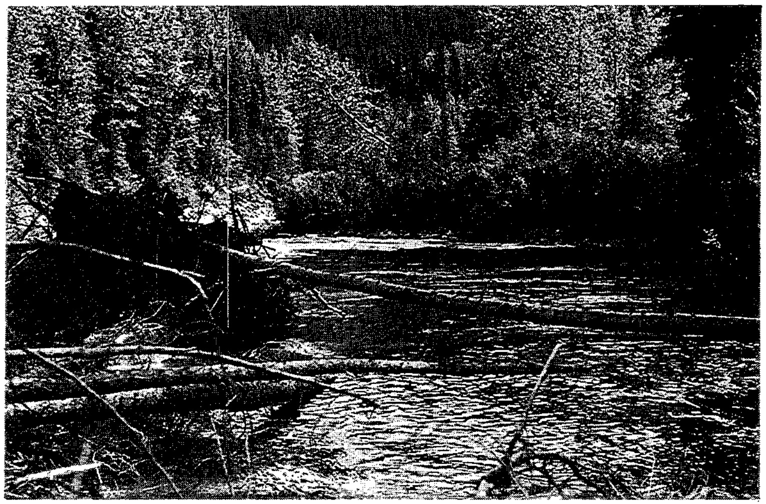
MILK RIVER (FIG. A1-11)

The Milk River flows northerly for 19 miles to its confluence with the Goat River, at mile 9.7. On August 26, 1971, the river was turbid, but the substrate composition was discernible. The gradient to mile 8.0 is steep and the streambed is composed of large rocks, boulders and bedrock. Above this point, the river flows for 5 miles through mountain meadows; the gradient decreases, and the substrate is composed of suitable spawning gravel. There is a total of 26,400 square yards of suitable gravel in this area capable of supporting 2,200 chinook salmon (Table A1.13).

At present, the Milk River has an annual escapement of about 50 chinook salmon, which reportedly spawn in the lower mile. Spawning commences in early August, peaks in late August and is complete by early September. No salmon were sighted during the aerial survey of August 26, 1971.

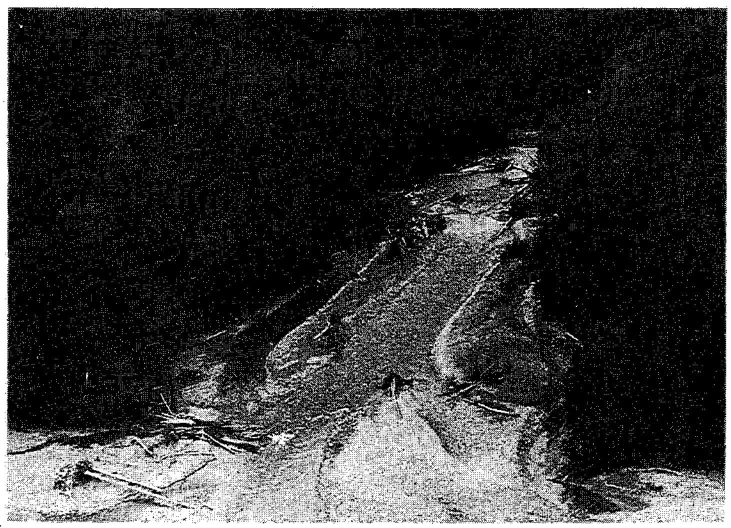
TABLE A1.13 Potential Spawning Areas: Milk River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 8.0	14,080	15	211,200	0	0	0
8.0 - 13.0	8,800	10	88,000	26,400	30	2,200
13.0 - 19.0	10,560	5	52,800	0	0	0
TOTAL:	33,440	-	352,000	26,400	-	2,200

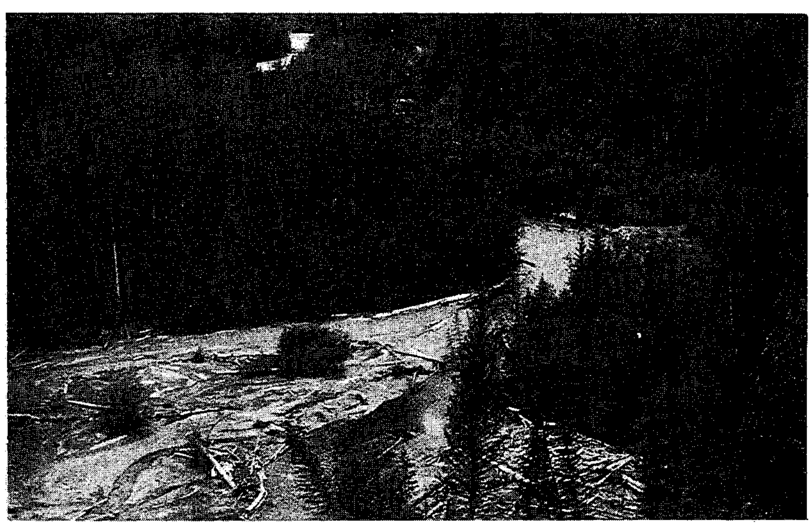


MILK RIVER AT CONFLUENCE WITH GOAT

MILK RIVER, MILE 2.5



WEST TWIN CREEK AT MOUTH



WEST TWIN CREEK,
MILE 1.5

FLEET CREEK (FIG. A1-12)

Fleet Creek flows southerly a distance of 8 miles to its confluence with the Fraser River, at mile 104, northwest of McKale River. The water is very clear and there are suitable spawning areas to mile 2.2, comprising 20 to 60% of the wetted stream area. Above mile 2.2, the stream gradient increases and the substrate becomes large rocks and boulders. A total of 10,031 square yards was estimated as potential spawning area capable of supporting 837 chinook salmon. Reports indicate that no spawning takes place in this creek; however, during the August 1971 survey, six chinook salmon were sighted in the lower mile of the creek.

TABLE A1.14 Potential Spawning Areas: Fleet Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.4	704	8	5,632	3,379	60	282
0.4 - 1.5	1,936	7	13,552	5,420	40	452
1.5 - 2.2	1,232	5	6,160	1,232	20	103
2.2 - 8.0	10,208	3	30,624	0	0	0
TOTAL:	14,080	-	55,968	10,031	-	837

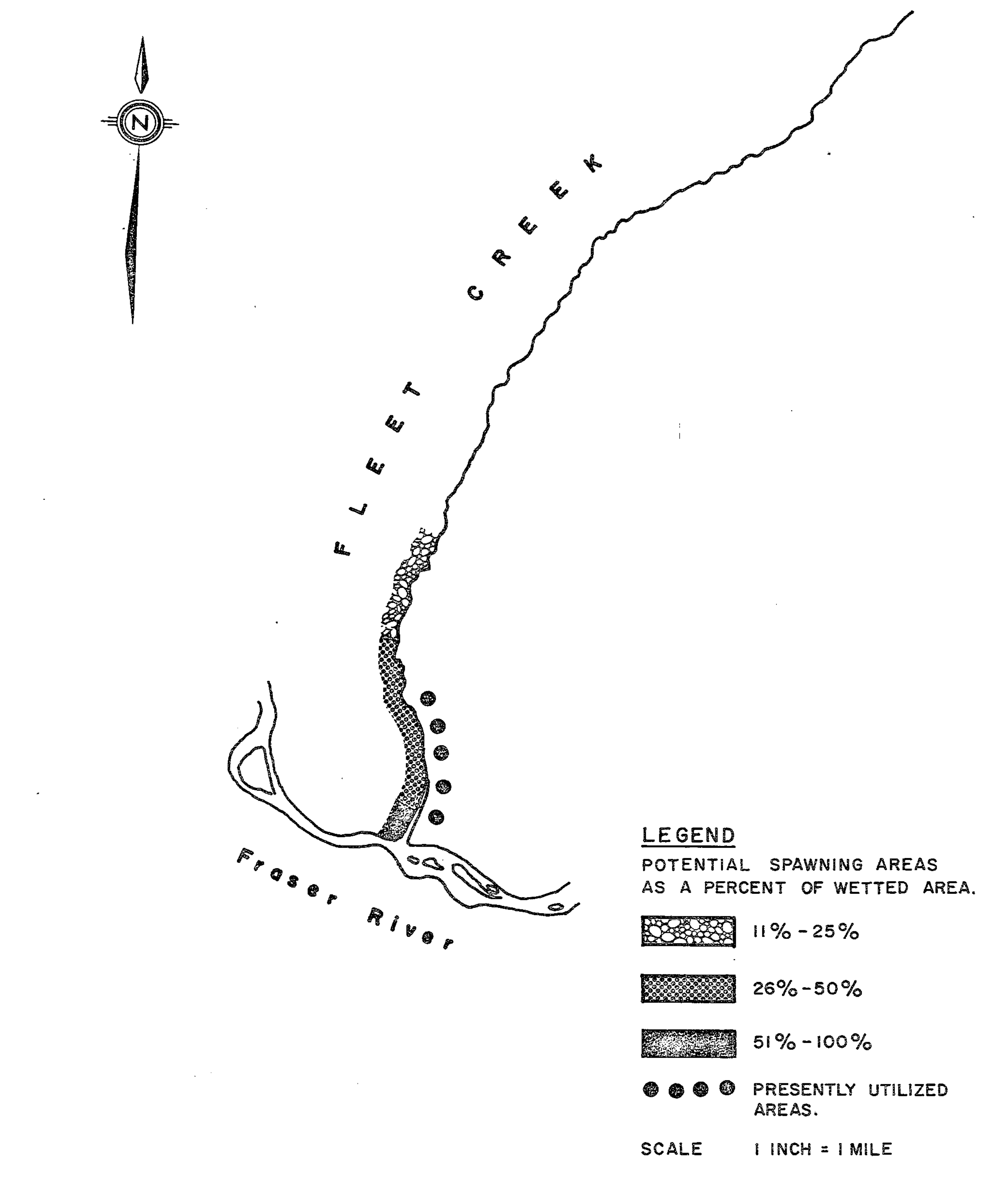


FIG. A1-12 TOTAL POTENTIAL SPAWNING AREA: FLEET CREEK

WEST TWIN CREEK (FIG. A1-13)

West Twin Creek flows easterly approximately 16.4 miles to join the Fraser River at mile 108 south of Goat River. The water is clean and clear.

The lower 2.2 miles of the stream have an estimated 8,448 square yards of suitable spawning gravel which theoretically could support an annual escapement of 704 chinook salmon (Plate A1-14).

Reports indicate that approximately 50 chinook spawn near the mouth of this creek. Spawning commences in early August, peaks in late August and ends by early September.

TABLE A1.15 Potential Spawning Areas: West Twin Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.3	2,288	15	34,320	6,864	20	572
1.3 - 2.2	1,584	10	15,840	1,584	10	132
2.2 - 16.4	24,992	5	124,960	0	0	0
TOTAL:	28,864	-	175,120	8,448	-	704

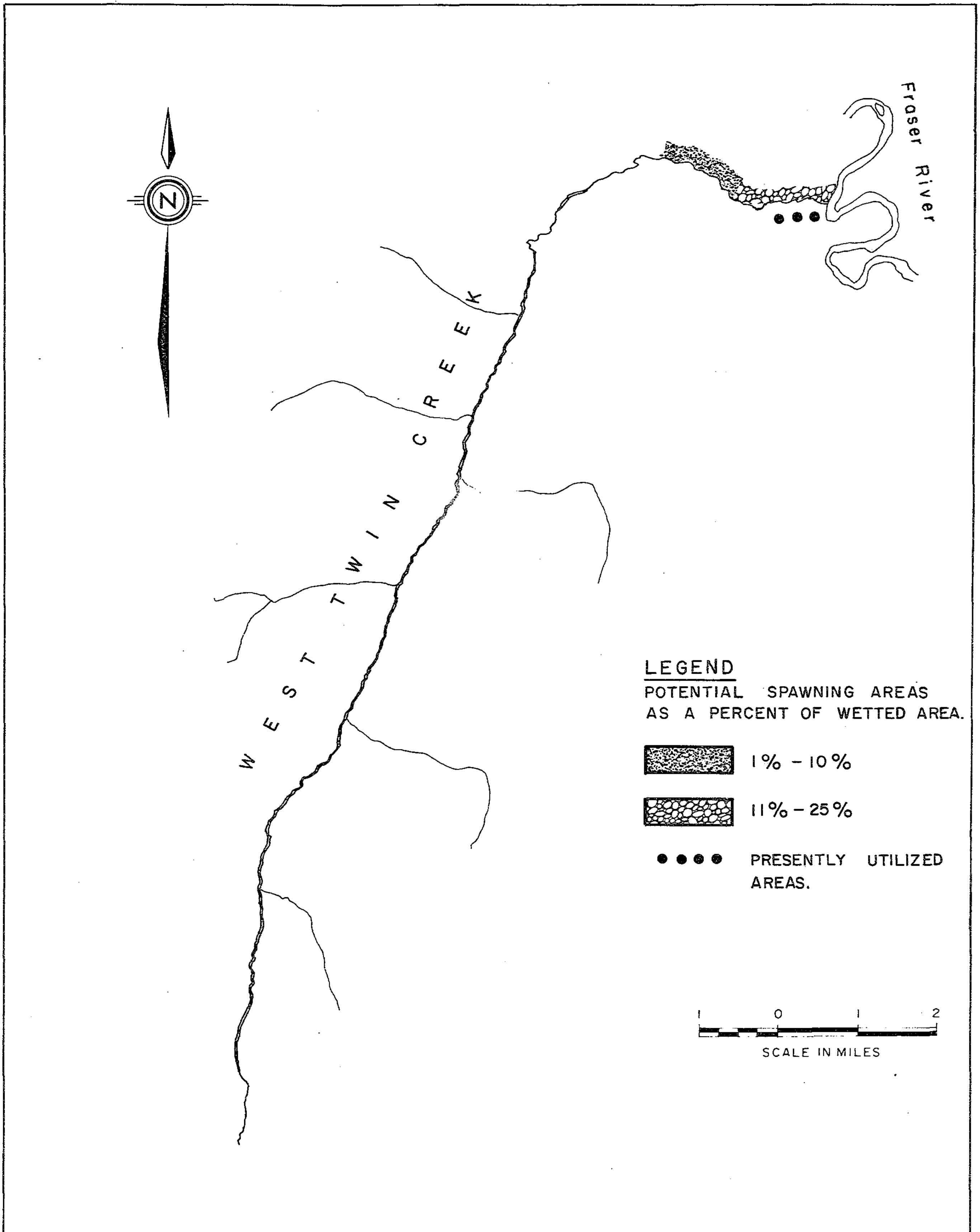


FIG. A1-13 TOTAL POTENTIAL SPAWNING AREA: WEST TWIN CREEK

DORÉ RIVER (FIG. A1-14)

The Doré River flows northeasterly a distance of 18.4 miles to its confluence with the Fraser River, at mile 130 northwest of McBride. The water was turbid with glacial melt and streambed visibility was poor. The stream gradient is steep and the streambed is composed of large rocks and boulders unsuitable for salmon spawning. However, a limited amount of suitable spawning gravel exists near the mouth of this stream, capable of supporting about 140 chinook.

At mile 6.8 the main stem branches. Neither fork has suitable spawning gravel areas (Plate A1-15).

Chinook salmon have been reported to spawn in the lower two miles of this stream.

TABLE A1.16 Potential Spawning Areas: Doré River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.00 - 0.08	150	25	3,750	1,688	45	141
0.08 - 18.40	32,243	12	386,918	0	0	0
TOTAL:	32,393	-	390 668	1,688	-	141

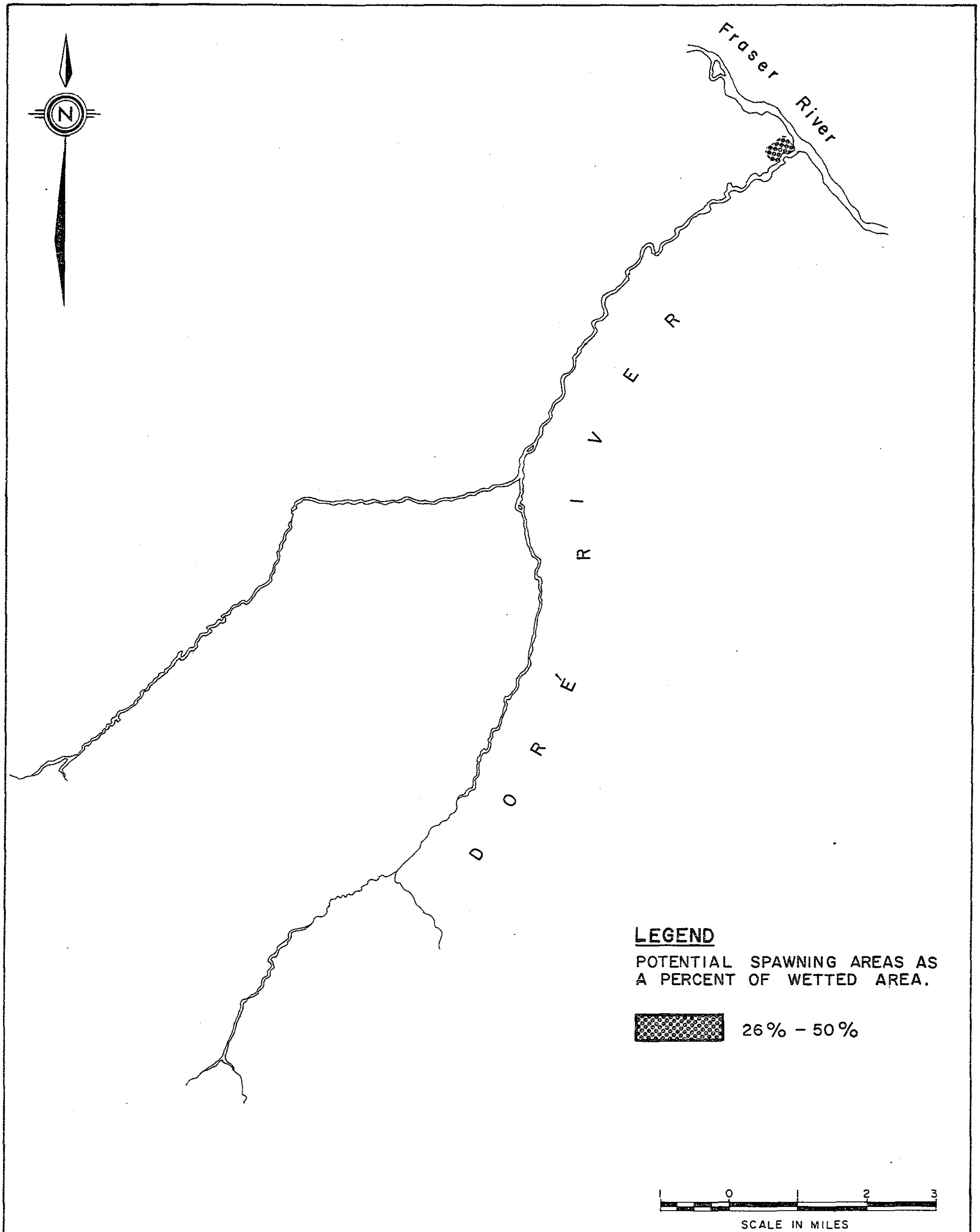
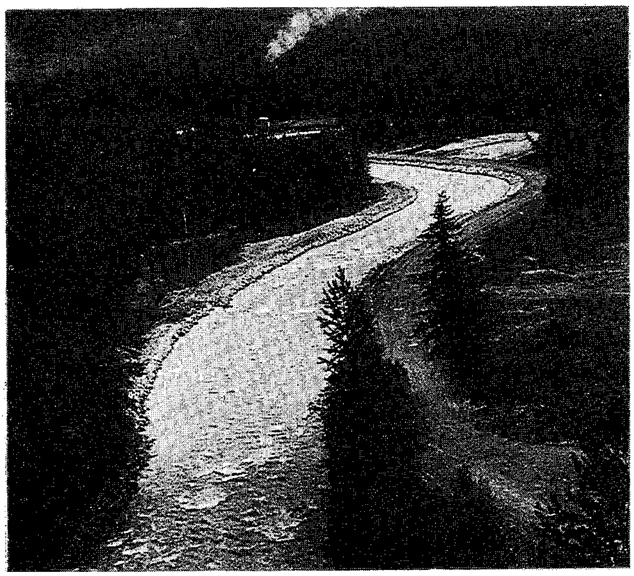
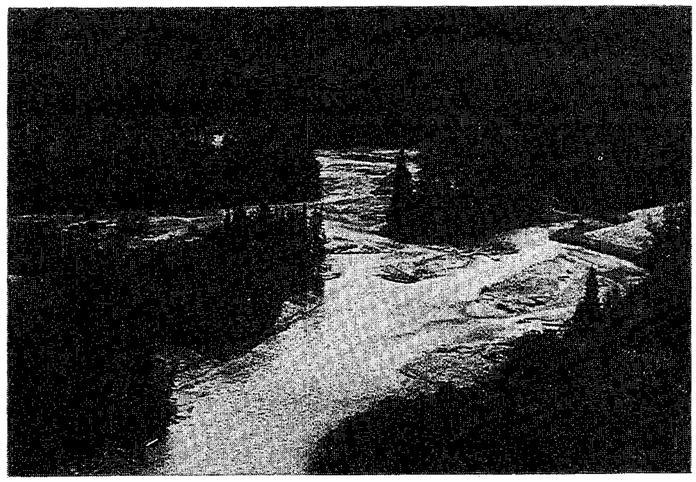


FIG. A1-14 TOTAL POTENTIAL SPAWNING AREA: DORE RIVER

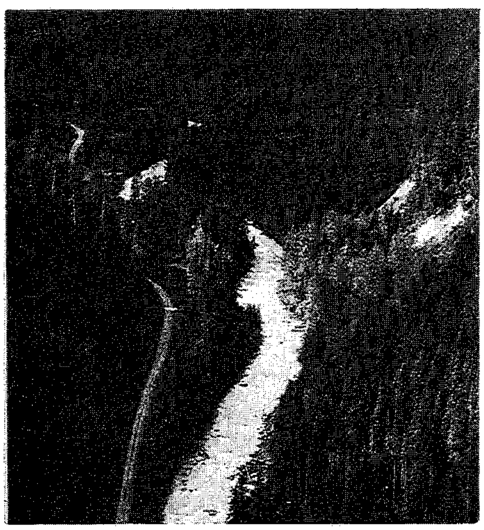
DORÉ RIVER



MILE 0.25

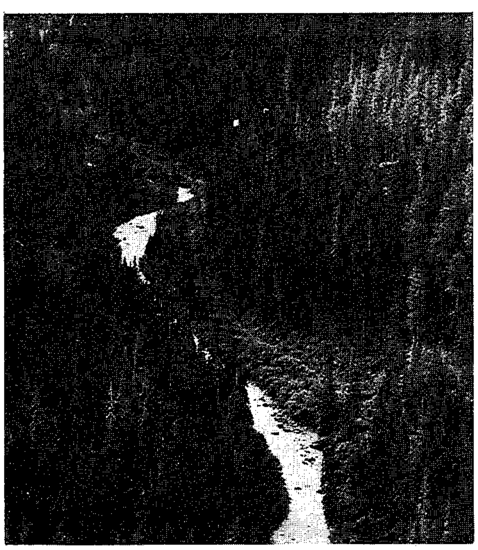


MILE 1.0



MILE 4.0

RAPIDS ON RIGHT BRANCH, MILE 8.0



LEFT BRANCH,
MILE 8.0

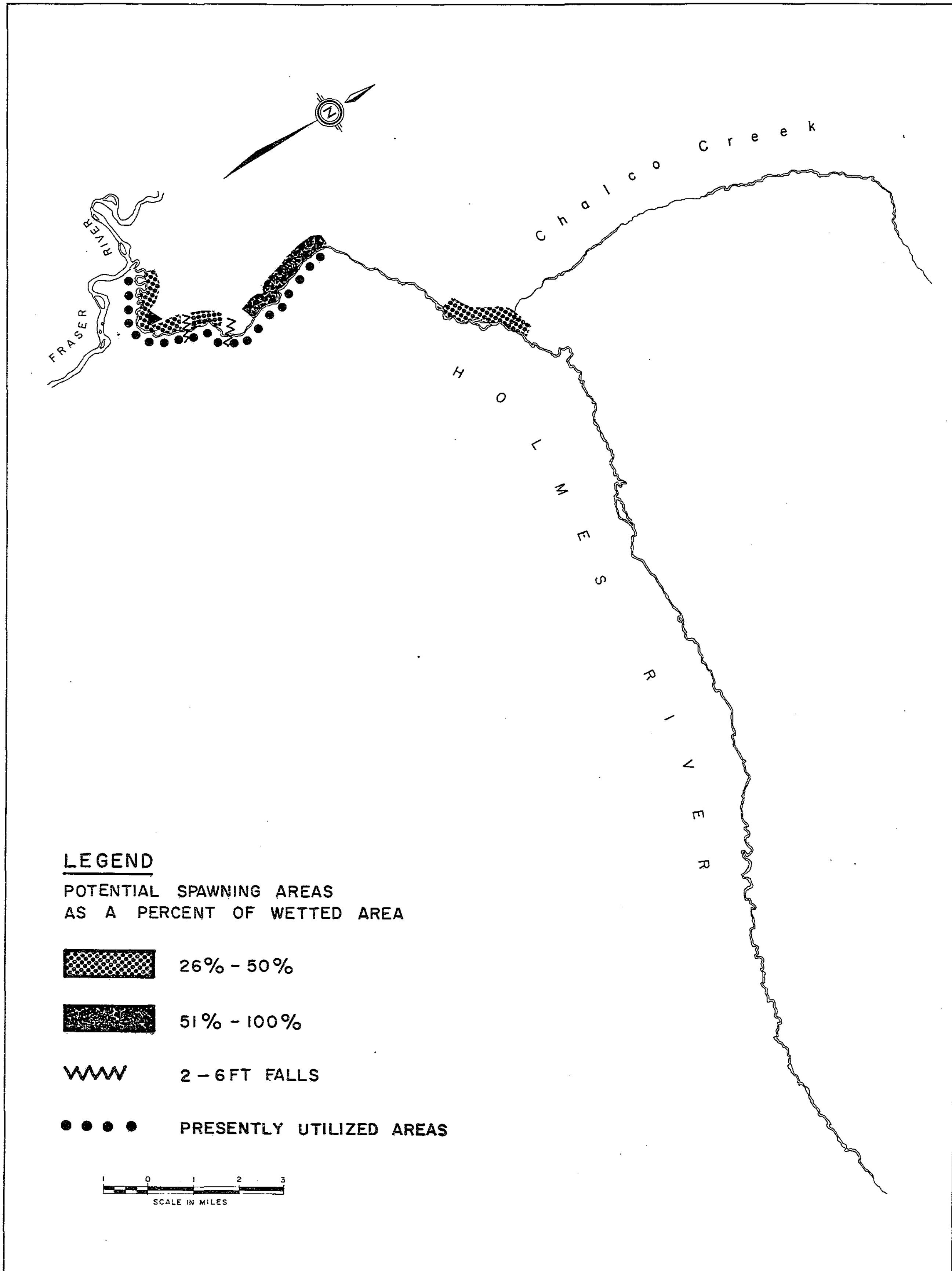


FIG. A1-15 TOTAL POTENTIAL SPAWNING AREA: HOLMES RIVER

HOLMES RIVER (FIG. A1-15)

The Holmes River flows southwesterly for 44.3 miles to its confluence with the Fraser at approximately mile 142, southeast of McBride. A six foot falls at mile 3.3 and two 3 foot falls at mile 4.3 are passable to salmon. The streambed in the lower portion, to mile 0.6, is mud and sand and has no suitable spawning areas. From here to mile 4.3, there are suitable gravel areas between the falls (Plate A1-16). Above the falls the streambed becomes large rock and boulders, but from mile 5.1 to 7.9 again contains gravel areas suitable for chinook spawning.

There are two other areas, mile 11.0 to 12.0 and mile 12.4 to 12.8, which were regarded as potential spawning areas. Above mile 12.8, the confluence of Chalco Creek, the river meanders for approximately 7 miles and the substrate is composed of fine materials unsuitable for spawning from mile 20.0 to its source, the gradient increases and the streambed is unsuitable (Plate A1-17).

There is a total of 157,766 square yards of suitable spawning gravel in the Holmes River, theoretically capable of supporting 13,148 chinook spawners.

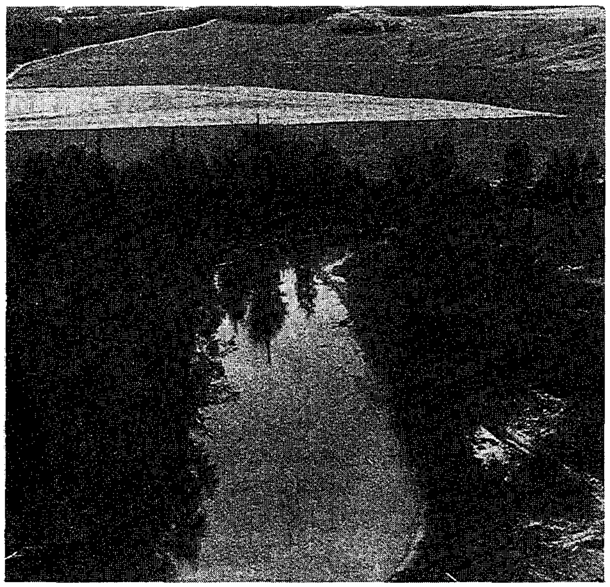
On August 26, 1971, one hundred and ninety adult chinook were sighted between mile 0.6 to 7.9. Reports indicate that the average annual escapement to the Holmes River (including escapements to Nevin and Horsey creeks) is 220 chinook salmon. Spawning commences in mid-August, peaks in early September and ends by mid-September.

On August 26, 1971 numerous juvenile chinook were also sighted in the Holmes River at the Highway 16 bridge crossing. A sample of five was collected. They ranged from 54 mm to 62 mm in length with an average of 57 mm and from 1.8 gm to 3.1 gm in weight with an average of 2.2 gm.

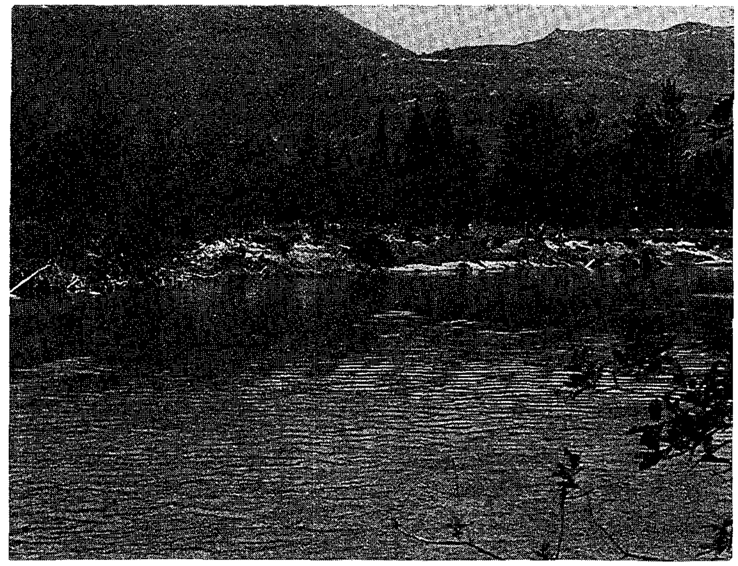
TABLE A1.17 Potential Spawning Areas: Holmes River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq. yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.6	1,056	25	26,400	0	0	0
0.6 - 4.3	6,512	25	162,800	65,120	40	5,427
4.3 - 5.1	1,408	23	32,384	0	0	0
5.1 - 7.9	4,928	23	113,344	68,006	60	5,667
7.9 - 11.0	5,456	20	109,120	0	0	0
11.0 - 12.0	1,760	20	35,200	17,600	50	1,467
12.0 - 12.4	704	20	14,080	0	0	0
12.4 - 12.8	704	20	14,080	7,040	50	587
12.8 - 44.3	55,440	10	554,400	0	0	0
TOTAL:	77,968	-	1,061,808	157,766	-	13,148

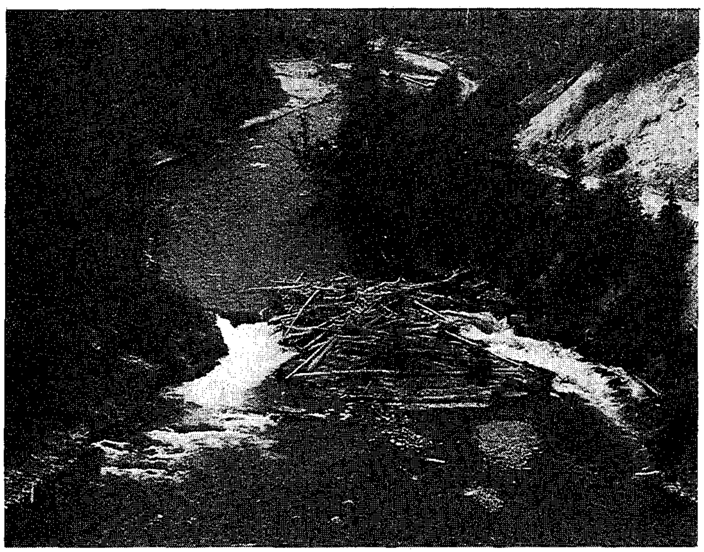
HOLMES RIVER



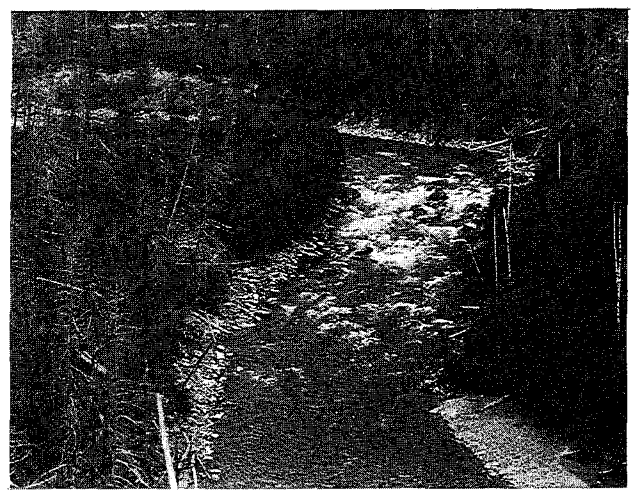
MILE 0.5



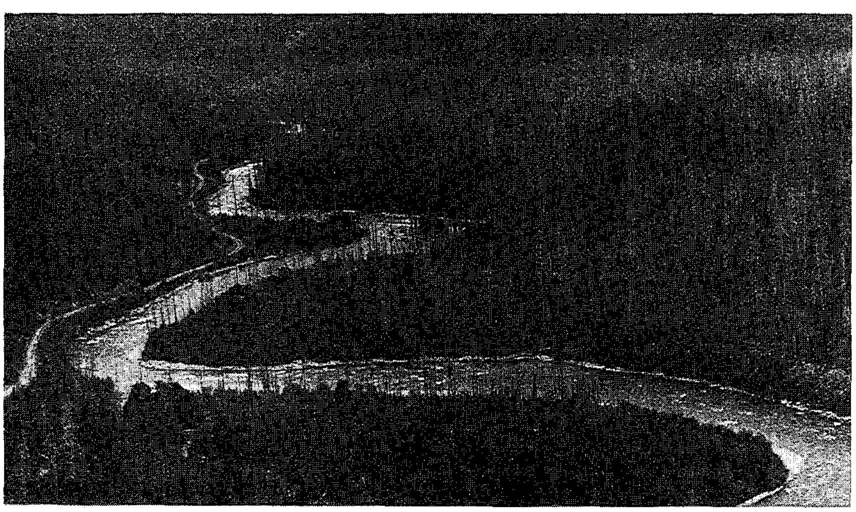
MILE 2.5



FALLS AND LOGJAM, MILE 3.3

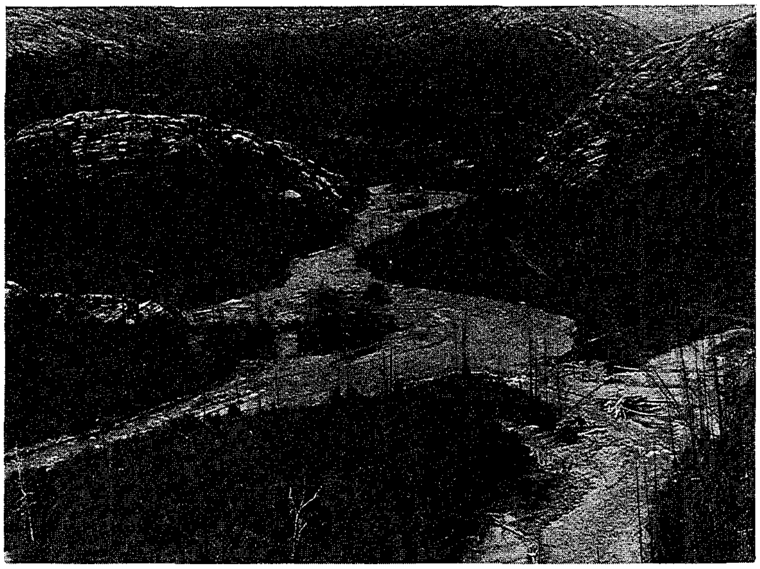


MILE 5.25



MEANDERING SECTION
MILE 9.25

HOLMES RIVER



MILE 12.7

CONFLUENCE WITH CHALCO RIVER, MILE 12.8

MILE 15.3

NEVIN CREEK

AT MOUTH

MILE 1.5

MILE 3.0

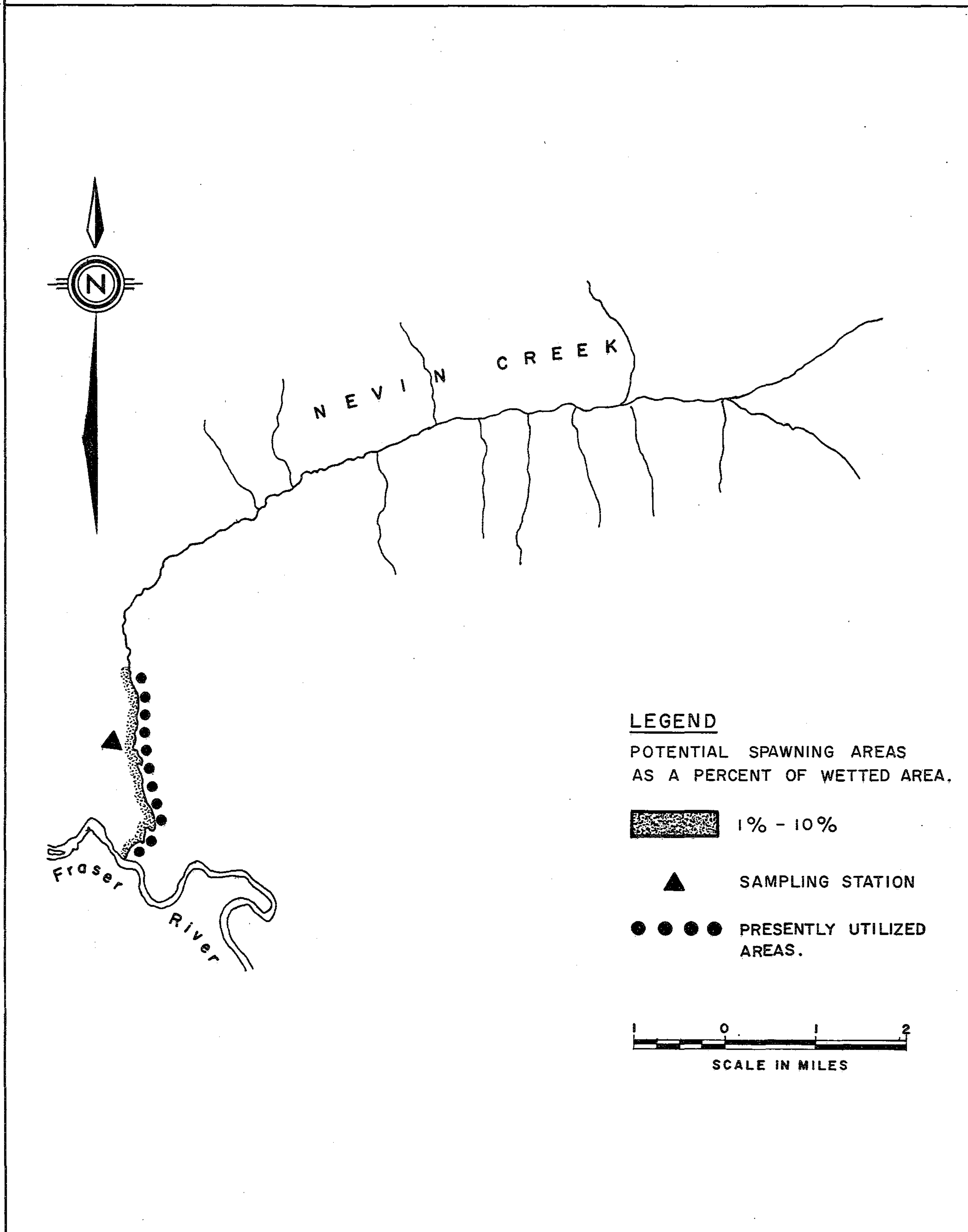


FIG. A1-16 PRESENT POTENTIAL SPAWNING AREAS: NEVIN CREEK

NEVIN (KING) CREEK (FIG. A1-16)

Nevin Creek flows in a southerly direction for 15.6 miles before entering the Fraser River at mile 150.6, north of the Raush Valley station. It is a small clear stream, heavily overgrown, with numerous windfalls and beaver dams in the lower portion. The entire creek was surveyed by helicopter on August 27, 1971, and a ground survey was made on August 29, 1971 of the area at the highway bridge. The estimated capacity of this stream is 420 chinook salmon; there are 5,034 square yards of suitable spawning gravel in the lower 2.2 miles (Plate A1-18). Accurate escapement figures for this creek are not available as they are included with those of the Holmes River. Spawning commences in mid-August, peaks early in September, is complete by the end of September, and occurs in the lower 2 miles of the stream.

During the ground survey spawning chinook salmon were sighted at mile 1.0. Several juvenile chinook salmon were also sighted at mile 1.25, two of which were collected, one 60 mm in length and the other 66 mm.

TABLE A1.18 Potential Spawning Areas: Nevin Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 2.2	3,872	13	50,336	5,034	10	420
2.2 - 15.6	23,584	6	141,504	0	0	0
TOTAL:	27,456	-	191,840	5,034	-	420

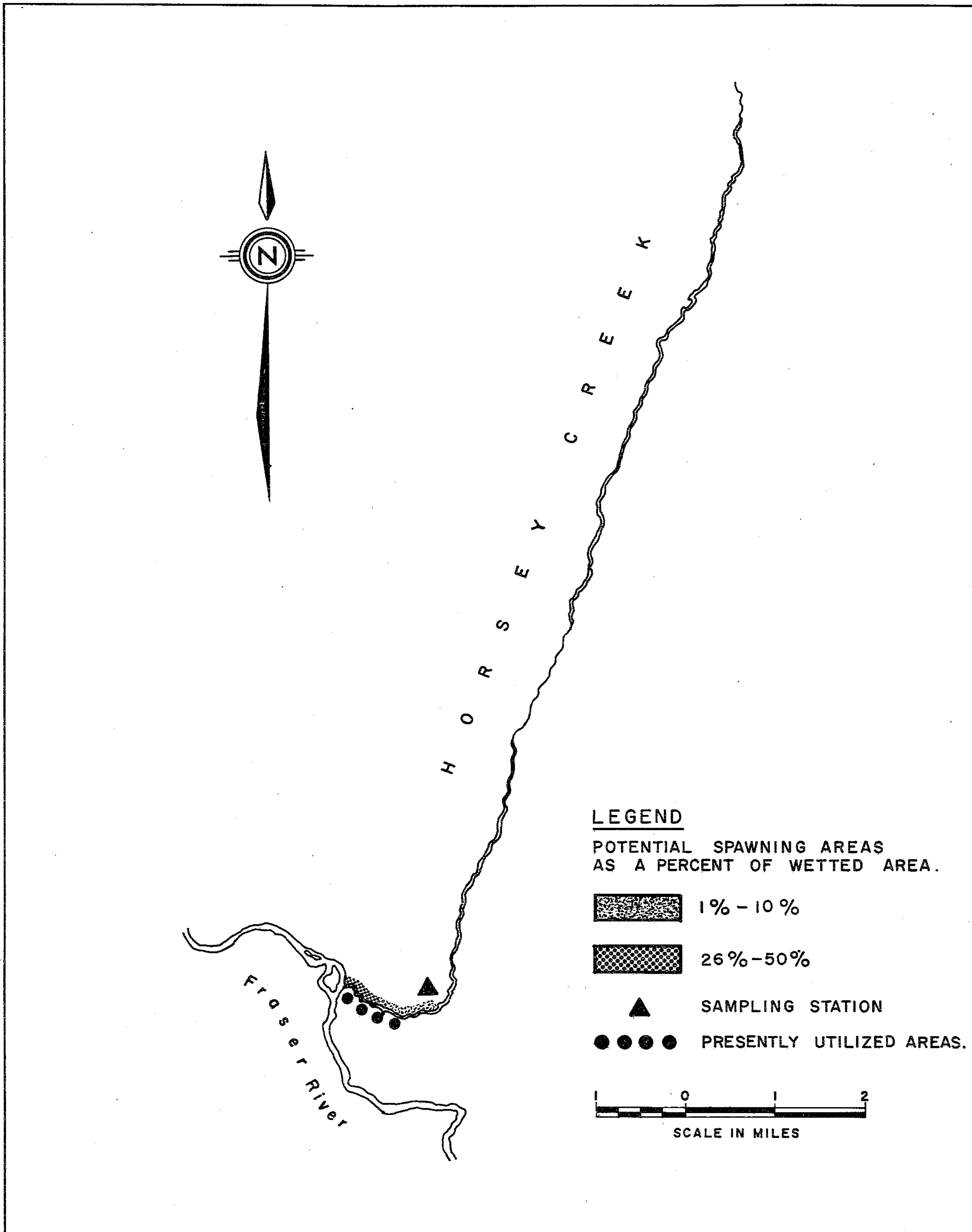


FIG. A1-17 TOTAL POTENTIAL SPAWNING AREA: HORSEY CREEK

HORSEY (HORSE) CREEK (FIG. A1-17)

Horsey Creek flows southwest a distance of 13.5 miles into the Fraser River at approximately mile 171.0. The water is slightly discoloured. At its mouth it is 40 to 50 feet wide. The lower mile of stream meanders and has moderate gradient and velocity. There is heavy stream side vegetation and many pool areas in this lower section (Plate A1-19). From mile 1.2 to the stream source, the gradient is steep and the flow rapid.

Chinook salmon utilize the lower portion for spawning but the run is very small (see escapements for Holmes River). Only 2% of the total wetted area of this stream, 3,375 square yards, contains suitable spawning gravel with an estimated capacity of 282 chinook salmon.

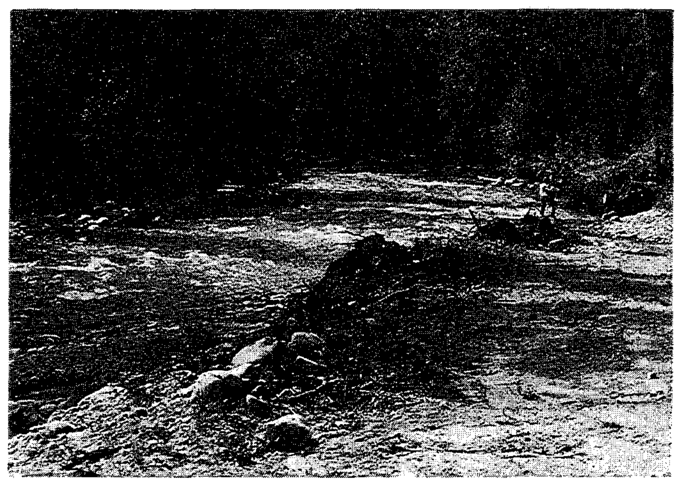
TABLE A1.19 Potential Spawning Areas: Horsey Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.00 - 0.25	440	13	5,720	2,288	40	191
0.25 - 1.20	1,672	13	21,736	1,087	5	91
1.20 - 13.50	21,648	6	129,888	0	0	0
TOTAL:	23,760	-	157,344	3,375	-	282

HORSEY CREEK

AT CONFLUENCE WITH FRASER RIVER

MILE 1.0



MILE 1.1

MILE 2.0

MCLENNAN RIVER (FIG. A1-18)

The McLennan River flows east, then north, for 30.2 miles to join the Fraser River at mile 193, two miles east of Tête Jaune Cache. The lower portion of the river was surveyed by boat on August 25, 1971; the entire river was flown by helicopter on August 27. The lower section of McLennan River meanders extensively and is very slow-moving (Plate A1-20). The first 18.5 miles of river has a mud and sand bottom and the water is heavily silted. There is an impassable falls at mile 25.0 where the river flows from the mountains onto the valley floor.

The only suitable spawning areas are located above and below the confluence of Swift Creek, at mile 18.5. Reports indicate that chinook spawn in this section of the McLennan. There are a total of 12,627 square yards capable of supporting 1,056 chinook.

TABLE A1.20 Potential Spawning Areas: McLennan River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 18.5	32,560	20	651,200	0	0	0
18.5 - 22.1	6,336	20	126,720	12,672	10	1,056
22.1 - 25.0	5,104	10	51,040	0	0	0
TOTAL:	44,000	-	828,960	12,672	-	1,056

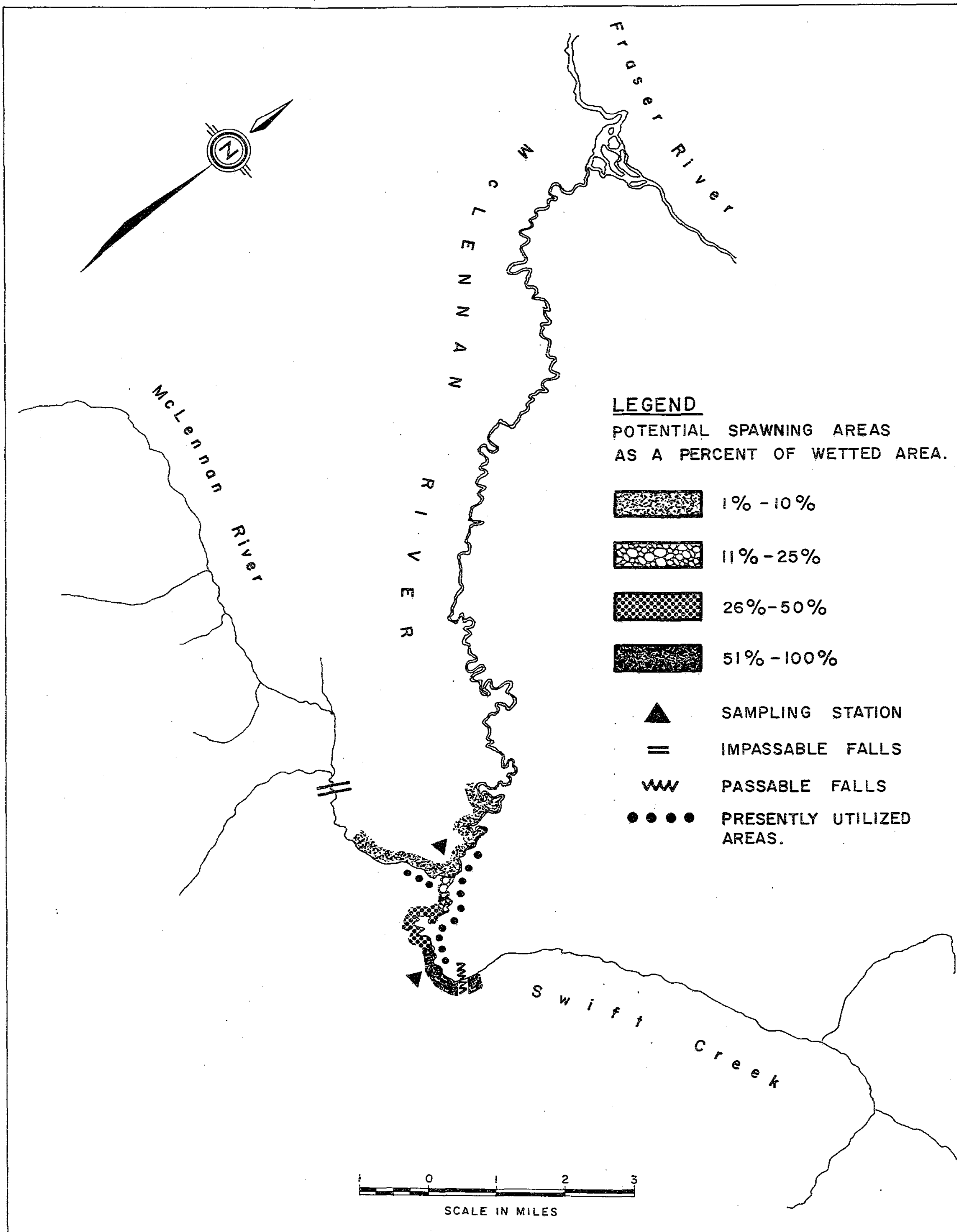


FIG. A1 - 18 TOTAL POTENTIAL SPAWNING AREA: McLENNAN RIVER

SWIFT CREEK (FIG. A1-18)

Swift Creek flows 12.7 miles southwesterly to its confluence with the McLennan at mile 18.5 on the latter. This stream was surveyed by air on August 27, 1971, and by ground on August 29. It is a clear stream with a moderate gradient to mile 2.5 where there is a small passable falls. Sections of the bank from mile 3.0 to 4.0 have been rip-rapped to prevent erosion of a road which parallels the creek in this reach (Plate A1-20).

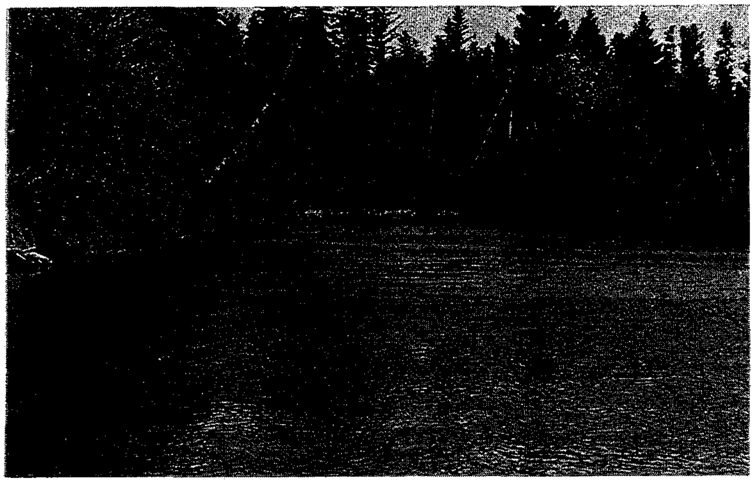
The streambed to mile 2.5 is composed of silt-free gravel suitable for spawning; above this point, the river widens and the gravel becomes coarse and unsuitable. The estimated amount of suitable spawning gravel in Swift Creek is 21,208 square yards, capable of supporting a theoretical spawning population of 1,767 chinook salmon.

On August 27, 1971, thirty-two chinook were counted in this creek between mile 0.5 and mile 1.5. The annual escapement is approximately 75 chinook salmon. Spawning is usually distributed throughout the lower portion of the stream to mile 2.5, and commences in mid-August, peaks at the end of August, and is complete by mid-September.

Juvenile spring salmon were abundant at the time of the ground survey; a sample of 8 were collected. These juvenile ranged in length from 51 to 80 mm with a mean of 64.3 mm. Weight ranged from 1.5 to 7.9 gm with an average of 3.85 gm.

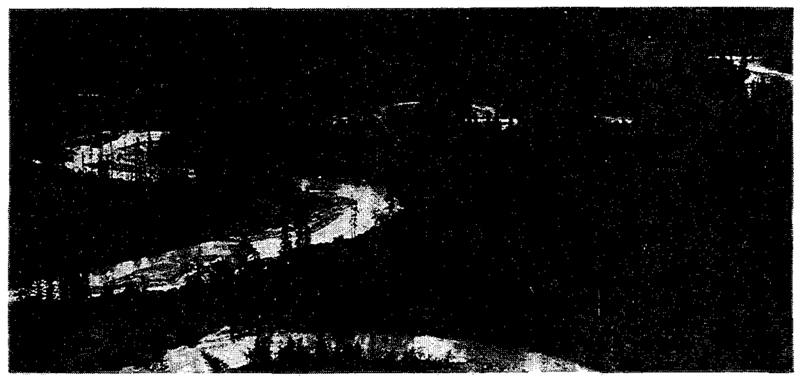
TABLE A1.21 Potential Spawning Areas: Swift Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 0.5	880	10	8,800	2,200	25	183
0.5 - 1.9	2,464	10	24,640	11,088	45	924
1.9 - 2.5	1,056	10	10,560	7,920	75	660
2.5 - 12.7	17,952	5	89,760	0	0	0
TOTAL:	22,352	-	133,760	21,208	-	1,767



McLENNAN RIVER, MILE 0.5

McLENNAN RIVER
MEANDERING SECTION
AT MILE 21.3



SWIFT CREEK, AT MOUTH

SWIFT CREEK, MILE 4.0

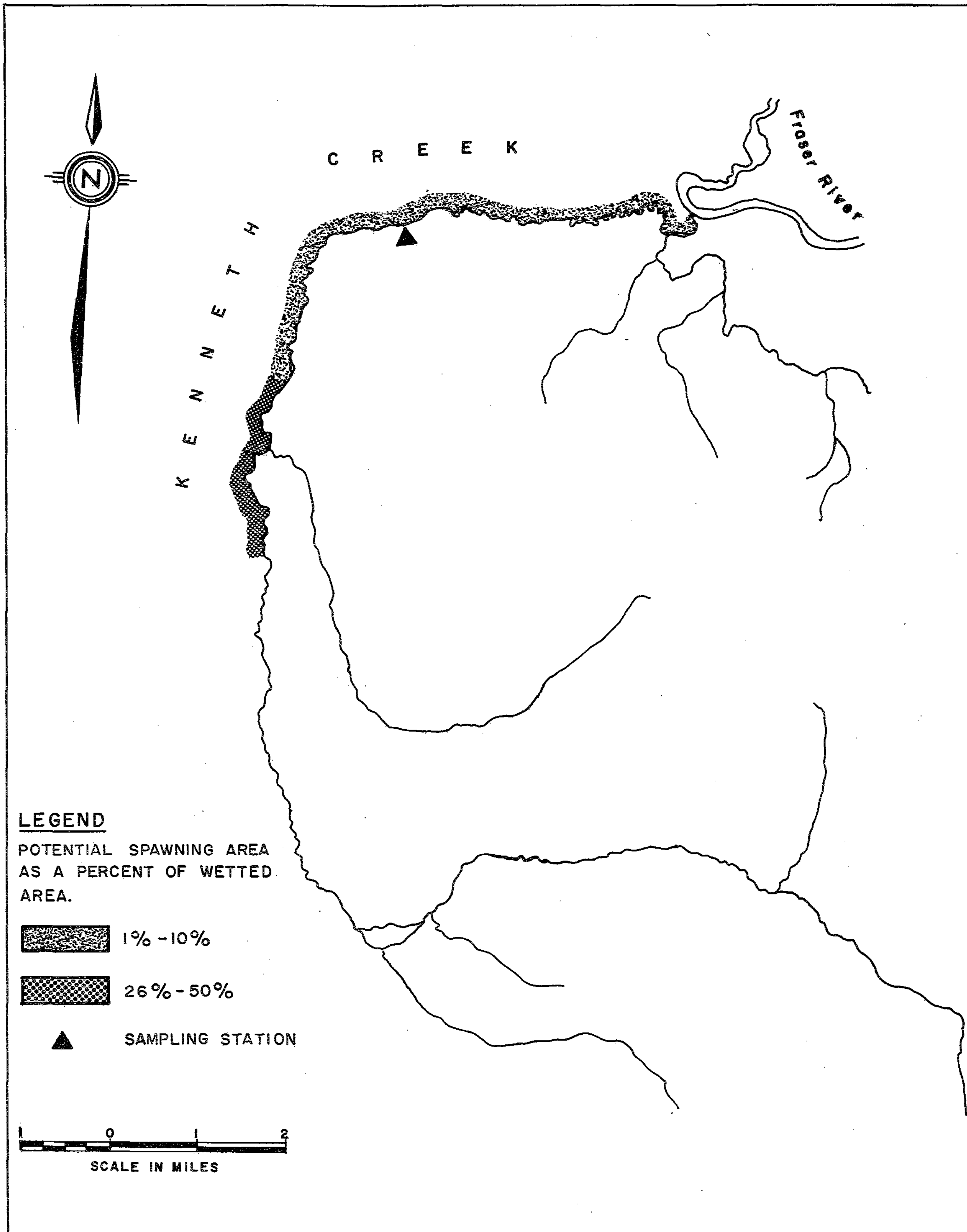


FIG. A1-19 TOTAL POTENTIAL SPAWNING AREA: KENNETH CREEK

A1.2.2 STREAMS NOT PRESENTLY UTILIZED

Twelve streams in this basin which do not presently support runs of chinook salmon are regarded as having requisite physical and chemical characteristics for salmon propagation. It should be noted, however, that all parameters of each stream were not evaluated and that conditions which are deleterious to salmon may well exist in these streams. The streams are described in upstream order from the proposed dam site at Grand Canyon.

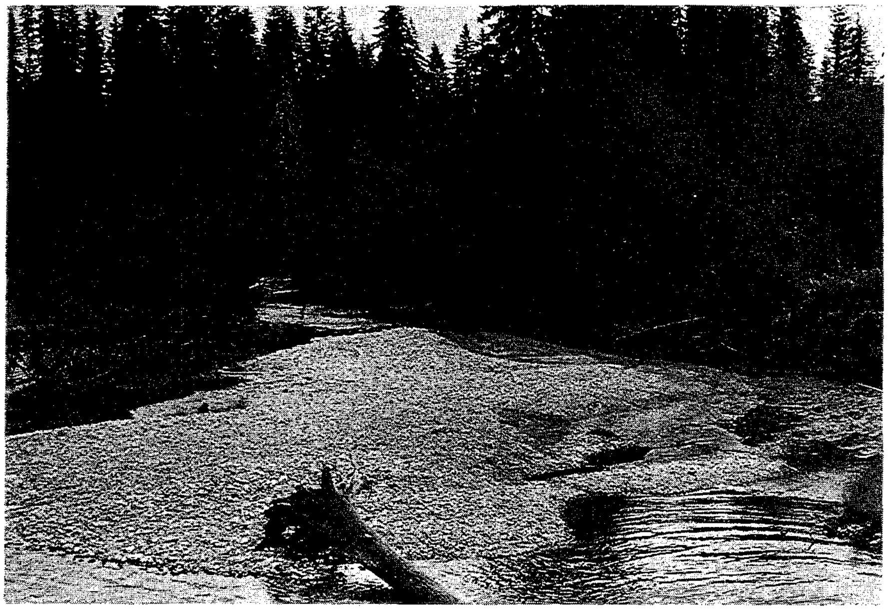
KENNETH CREEK (FIG. A1-19)

Kenneth Creek flows northerly 11.3 miles to join the Fraser River 2 miles upstream from the proposed dam site. It is a small, clear stream with a moderate gradient throughout its length. Suitable spawning areas are scattered from the mouth to mile 9.5. Silt deposits were noticeable and portions of the stream banks and bottom are composed of fine material (Plate A1-21). There are 21,384 square yards of suitable spawning gravel capable of supporting 1,781 chinook salmon.

TABLE A1.22 Potential Spawning Areas: Kenneth Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 7.1	12,496	9	112,464	11,246	10	937
7.1 - 9.5	4,224	8	33,792	10,138	30	844
9.5 - 11.0	2,640	4	10,560	0	0	0
TOTAL:	19,360	-	156,816	21,384	-	1,781

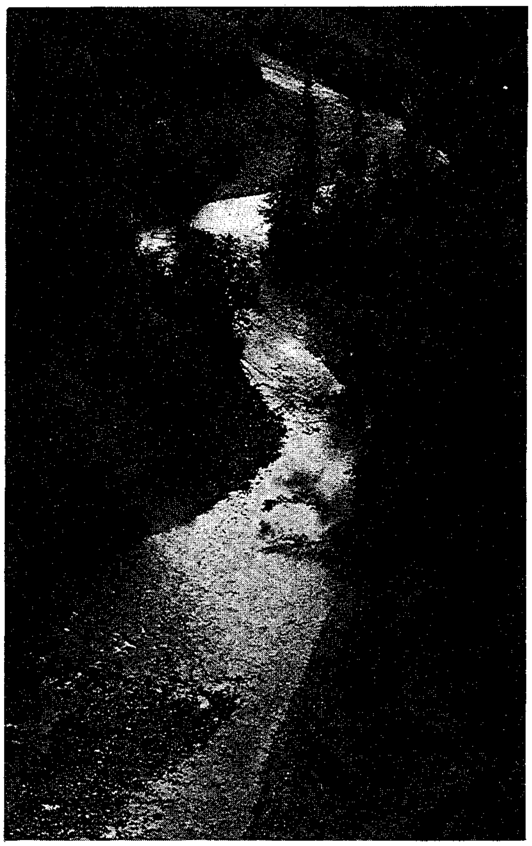
KENNETH CREEK



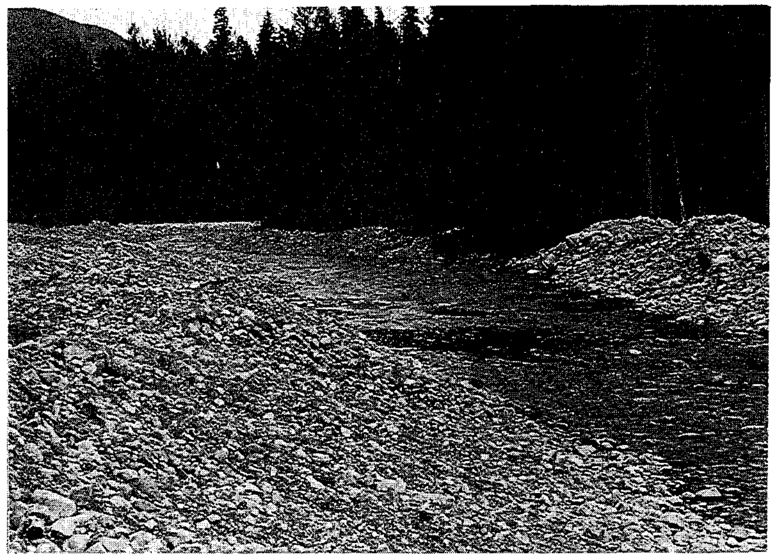
MILE 8

HIGHWAY BRIDGE SAMPLING SITE, MILE 9.0

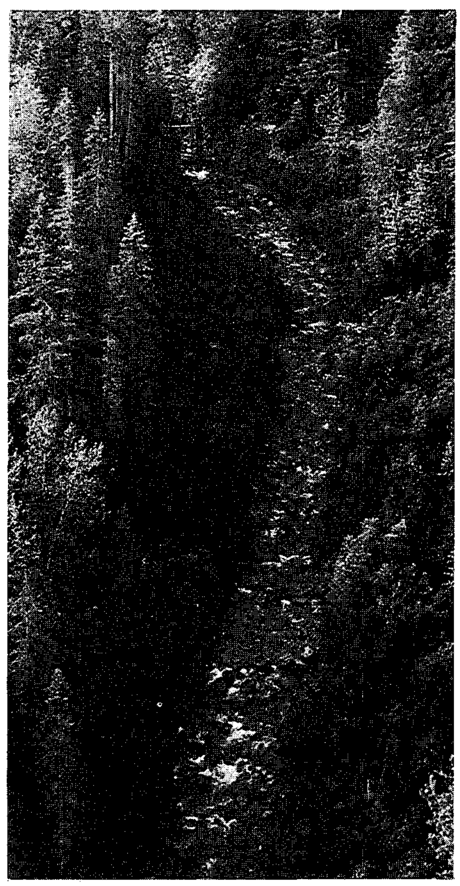
HUNGARY CREEK



MILE 1.5



UPSTREAM FROM HIGHWAY BRIDGE, MILE 3.75



MILE 4.0

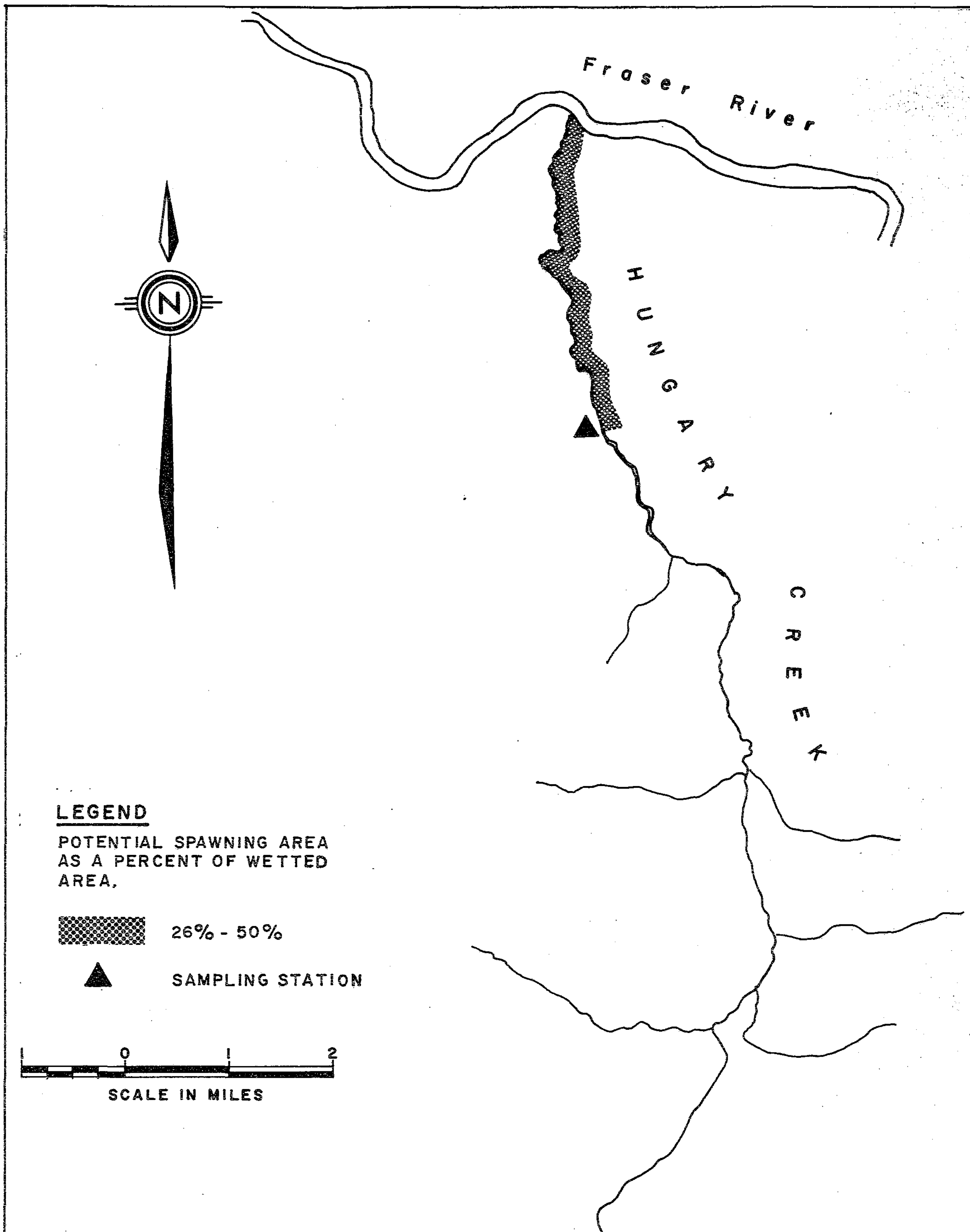


FIG. A1-20 TOTAL POTENTIAL SPAWNING AREA: HUNGARY CREEK

HUNGARY CREEK (FIG. A1-20)

Hungary Creek flows 12 miles in a northerly direction into the Fraser River, at mile 8.7. The water is very clear, the gradient is consistently moderate with few pool areas. Alder, willow and coniferous vegetation is present to the stream banks (Plate A1-22).

There is 18,480 square yards of suitable spawning gravel in the lower 3.5 miles capable of supporting about 1,540 chinook salmon. At mile 3.75 the stream passes under the highway through a culvert. Above this point the gradient increases and the substrate materials are too coarse for spawning.

TABLE A1.23 Potential Spawning Areas: Hungary Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 3.5	6,160	6	36,960	18,480	50	1,540
3.5 - 12.0	14,960	3	44,880	0	0	0
TOTAL:	21,120	-	81,840	18,480	-	1,540

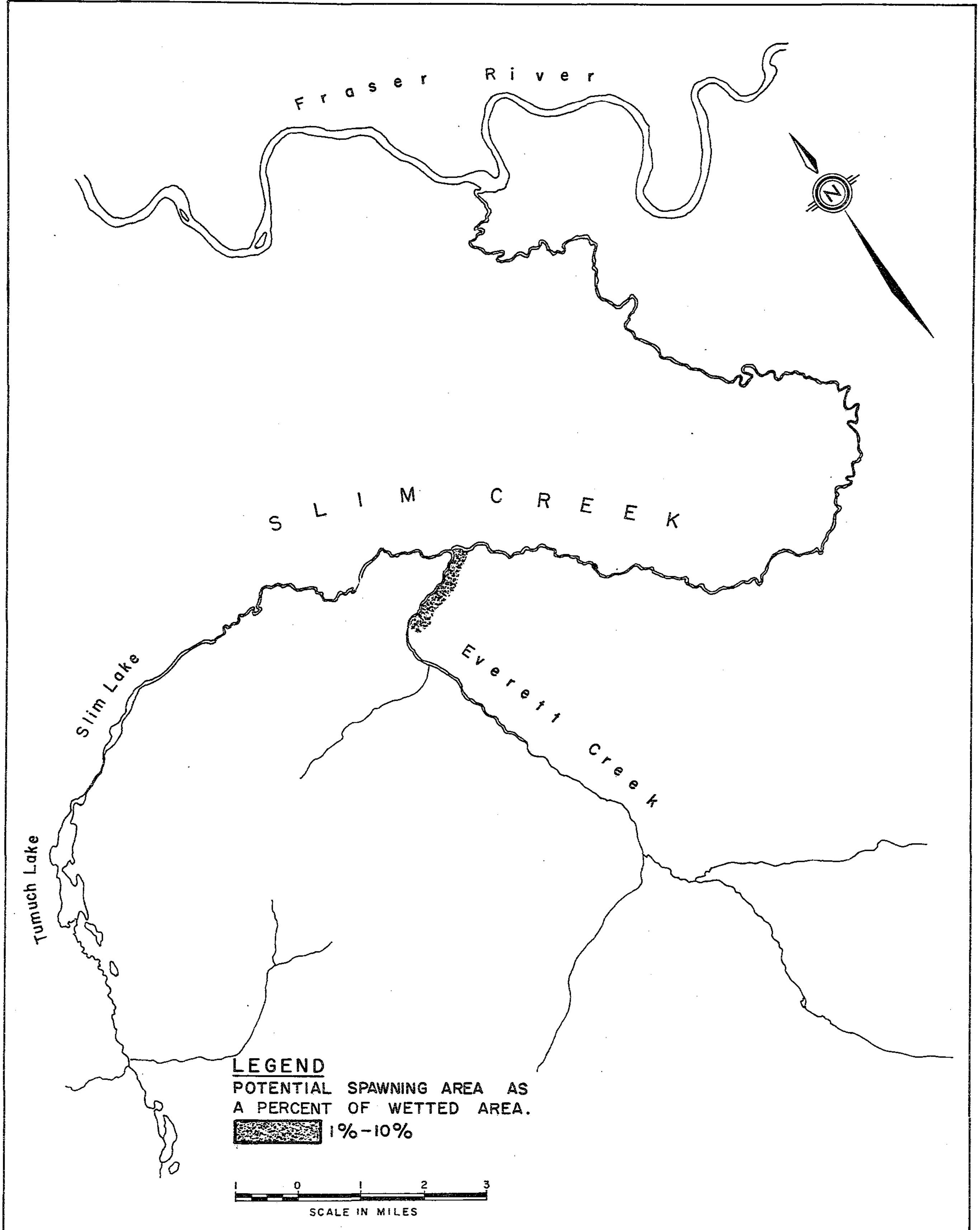


FIG. A1-21 TOTAL POTENTIAL SPAWNING AREA: EVERETT CREEK

EVERETT CREEK (FIG. A1-21)

Everett Creek flows northeasterly for 12.1 miles into Slim Creek at mile 22.1 of the latter. The water is clear; stream width averages 20 feet. Only 1,408 square yards located in the lower 0.8 mile of the streambed is composed of suitable spawning gravel. From mile 0.80 to its source, the stream gradient is steep and the substrate is composed of bedrock and boulder.

TABLE A1.24 Potential Spawning Areas: Everett Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.8	1,408	10	14,080	1,408	10	117
0.8 - 12.1	19,888	5	99,440	0	0	0
TOTAL:	21,296	-	113,520	1,408	-	117

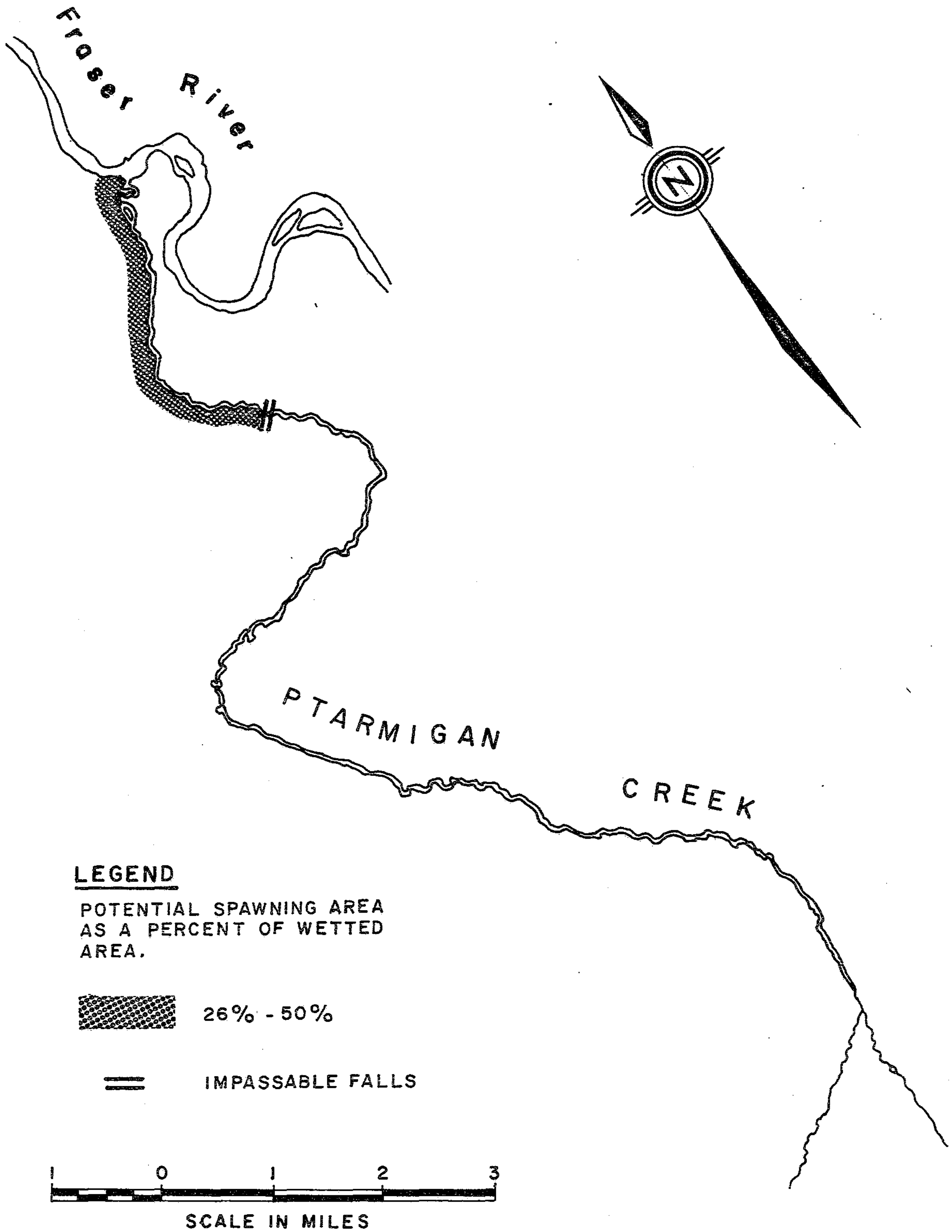


FIG. A1-22 TOTAL POTENTIAL SPAWNING AREA: PTARMIGAN CREEK

PTARMIGAN CREEK (FIG. A1-22)

Ptarmigan Creek flows northeasterly a distance of 8 miles into the Fraser River, at mile 60.4. On August 26, 1971, the water in this small stream was clear. The stream is accessible to mile 3.0 where there is a 200 foot falls upstream from a quarry (Plate A1-22). Suitable gravel areas are present in lower portions of the stream below this point. The total potential spawning area was estimated to be 21,120 square yards, capable of supporting 1,760 chinook salmon.

TABLE A1.25 Potential Spawning Areas: Ptarmigan Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 3.0	5,280	10	52,800	21,120	40	1,760
3.0 - 8.0	8,800	5	44,000	0	0	0
TOTAL:	14,080	-	96,800	21,120	-	1,760

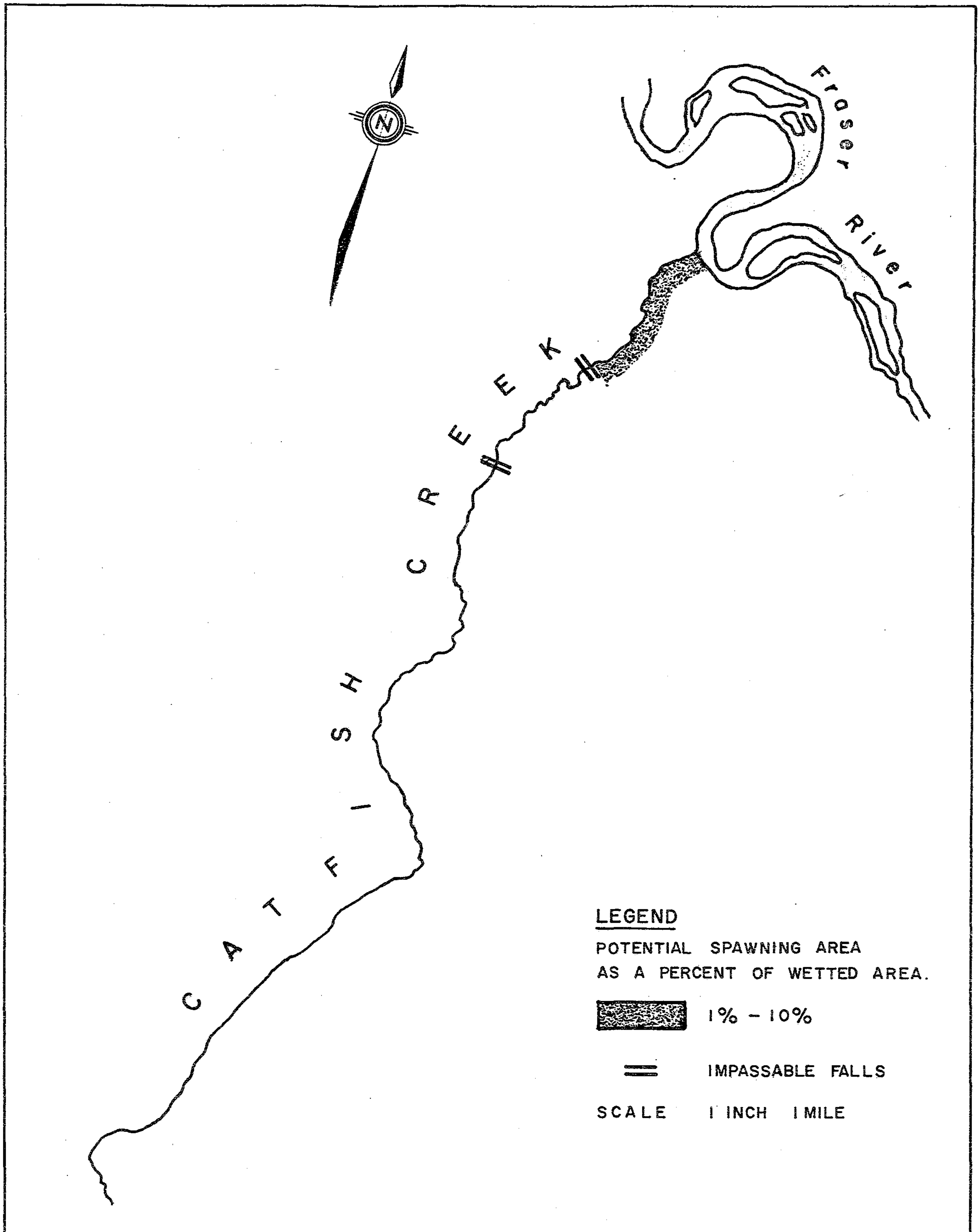


FIG. A1-23 TOTAL POTENTIAL SPAWNING AREA: CATFISH CREEK

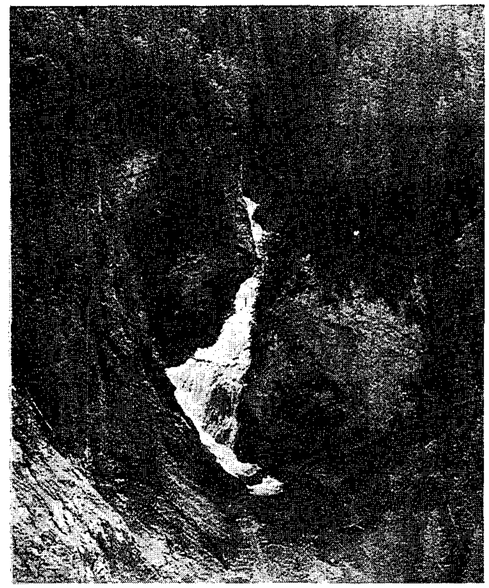
CATFISH CREEK (FIG. 1-23)

Catfish Creek flows northeast a distance of 9.4 miles to its confluence with the Fraser River at mile 75.0. There are impassable falls at mile 1.1 and 2.25. However, below the first falls there are 290 sq. yds. of suitable spawning area which theoretically could support 24 adult chinook.

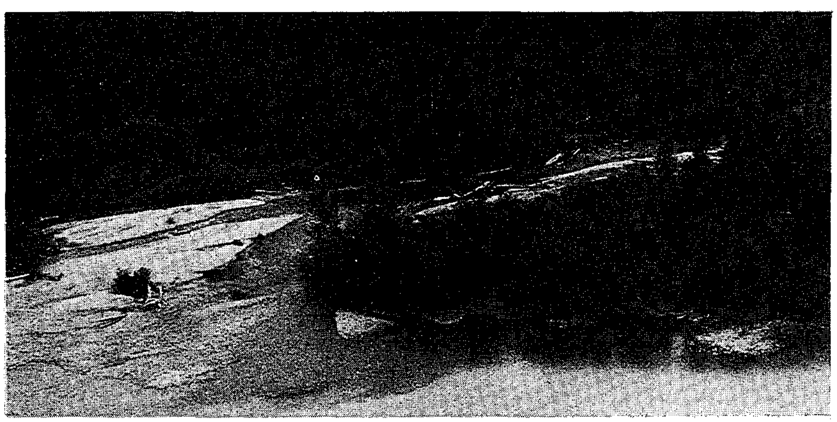
TABLE A1.26 Potential Spawning Areas: Catfish Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.1	1,936	3	5,808	290	5	24
TOTAL:	1,936	-	5,808	290	-	24

PTARMIGAN CREEK, MILE 0.5

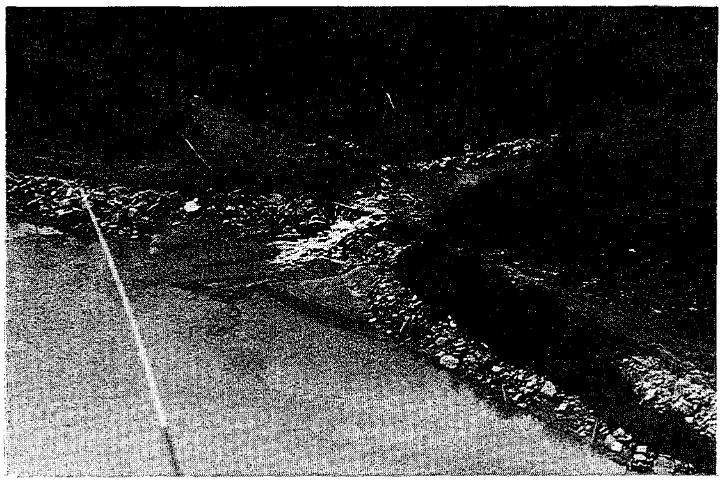


PTARMIGAN CREEK
WATERFALL, MILE 3.0

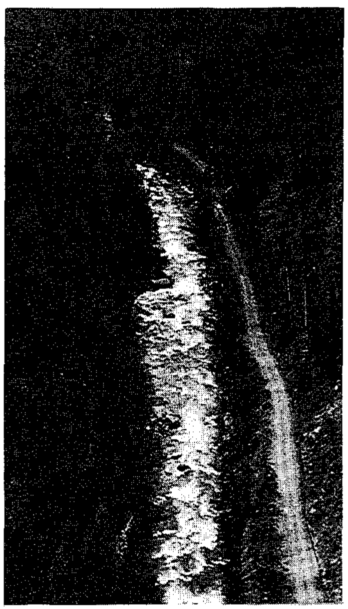


EAST TWIN CREEK, AT MOUTH

EAST TWIN CREEK
WATERFALL, MILE 1.25



EDDY CREEK, WATERFALL AT MOUTH



McKALE RIVER
RAPIDS, MILE 4.5

McKALE RIVER
MEANDERING SECTION
AT MILE 9.0

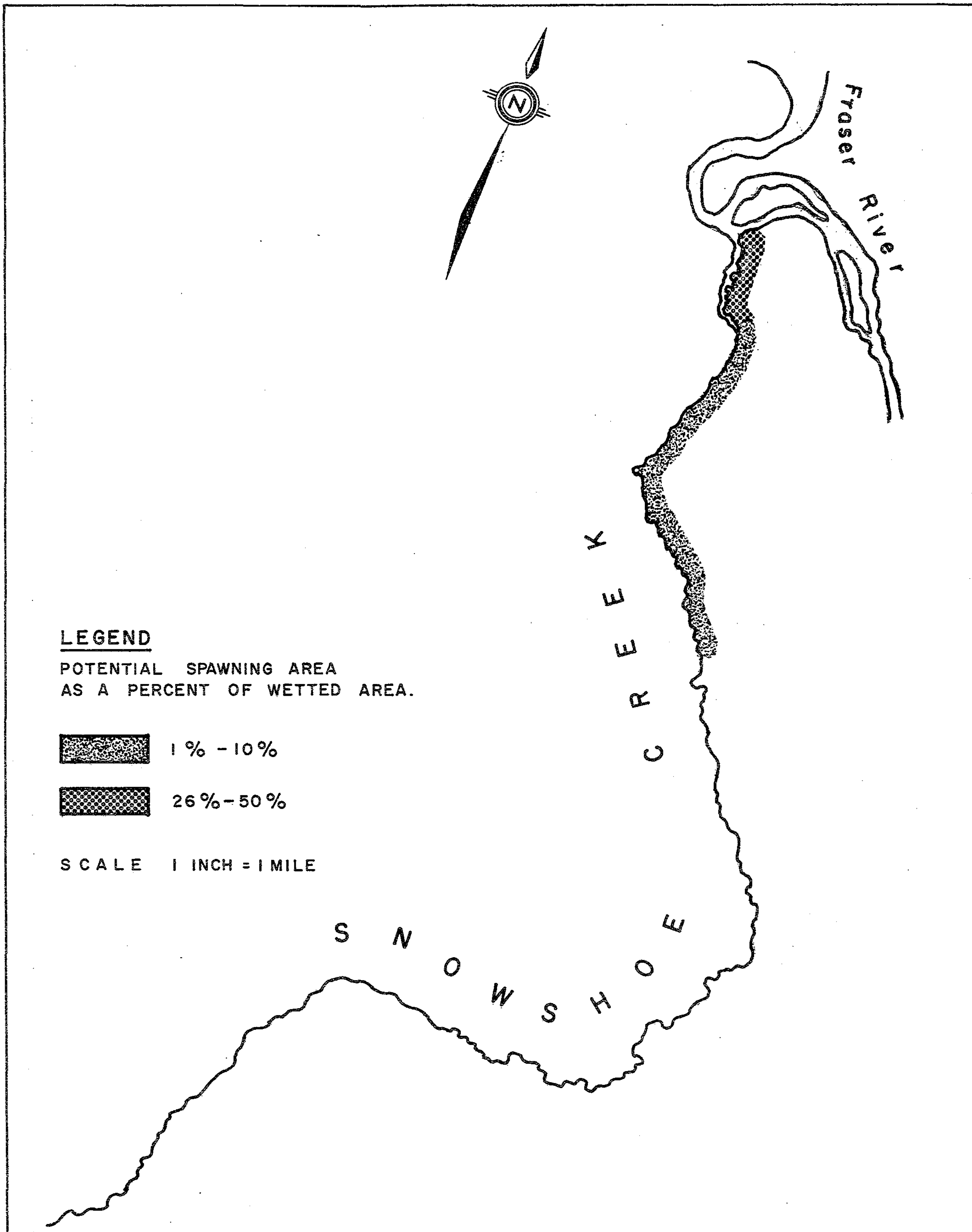


FIG. A1-24 TOTAL POTENTIAL SPAWNING AREA: SNOWSHOE CREEK

SNOWSHOE CREEK (FIG. A1-24)

Snowshoe Creek flows 12 miles in a northerly direction to its confluence with the Fraser River at mile 76.0. This creek was surveyed by helicopter on August 26, 1971 at which time the flow was very low; the water was clear.

The lower 0.5 miles of the stream has a low gradient and the streambed is composed of very coarse gravel and boulders.

The total potential spawning area is 2,860 square yards capable of supporting 239 chinook spawners.

TABLE A1-27 Potential Spawning Areas: Snowshoe Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.5	880	5	4,400	0	0	0
0.5 - 1.0	880	5	4,400	1,760	40	147
1.0 - 3.5	4,400	5	22,000	1,100	5	92
3.5 - 12.0	14,960	2.5	37,400	0	0	0
TOTAL:	21,120	-	68,200	2,860	-	239

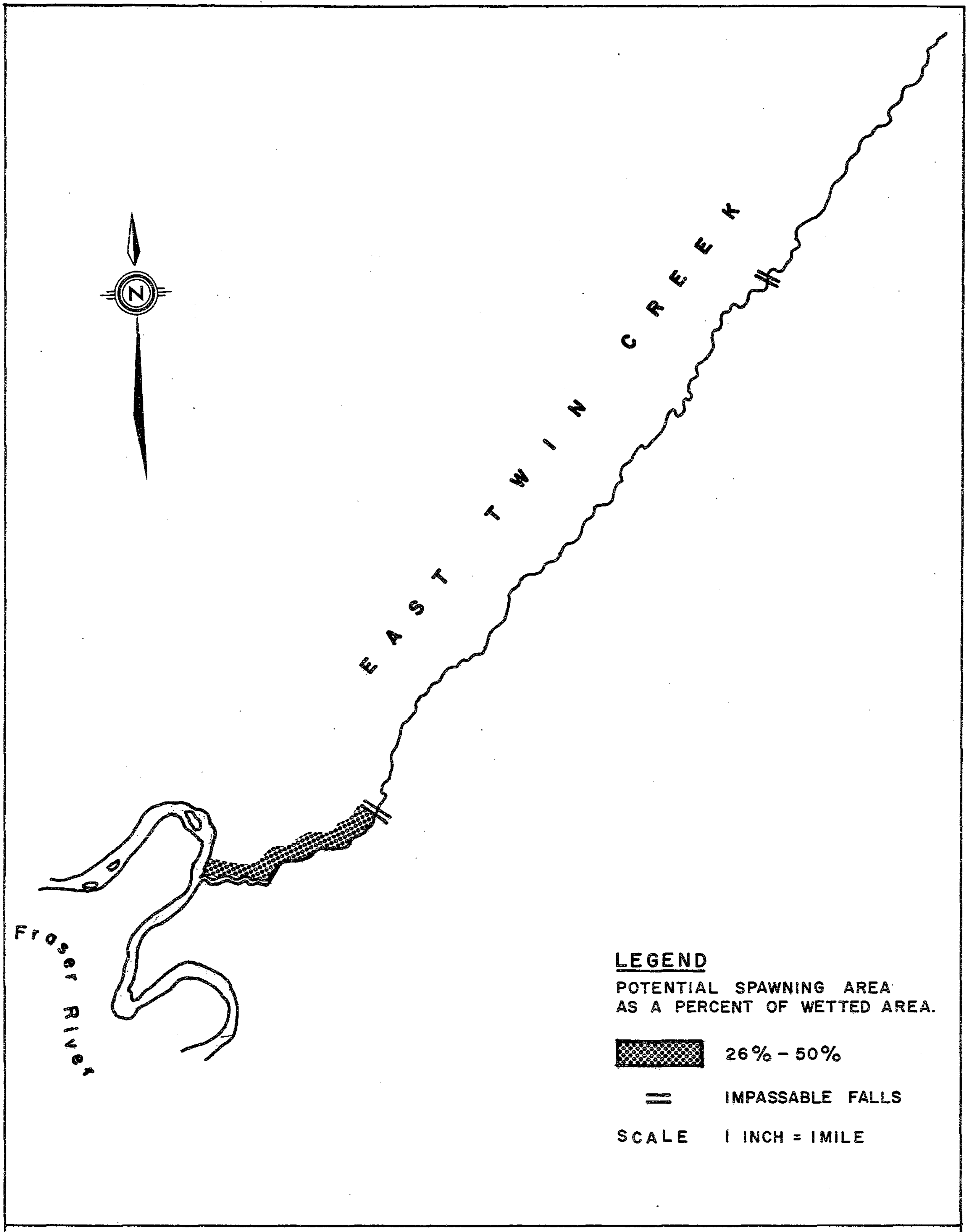


FIG. A1-25 TOTAL POTENTIAL SPAWNING AREA: EAST TWIN CREEK

EAST TWIN CREEK (FIG. A1-25)

East Twin Creek flows westerly a distance of 12.8 miles to its confluence with the Fraser River, at approximately mile 108. The water is very clear and shallow. There is a substantial quarrying operation one mile from the mouth and a falls, 200-feet high, upstream at mile 1.25 (Plate A1-23). The stream area above this falls was not surveyed. However, at approximately mile 6.5, at the mountain edge there are several falls, 40 to 50 feet high. The lower portion below the falls contains an estimated 968 square yards of suitable spawning gravel, theoretically capable of supporting 81 adult chinook.

TABLE A1.28 Potential Spawning Areas: East Twin Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.1	1,936	10	19,360	968	50	81
1.1 - 12.8	20,592	5	102,960	0	0	0
TOTAL:	22,528	-	122,320	968	-	81

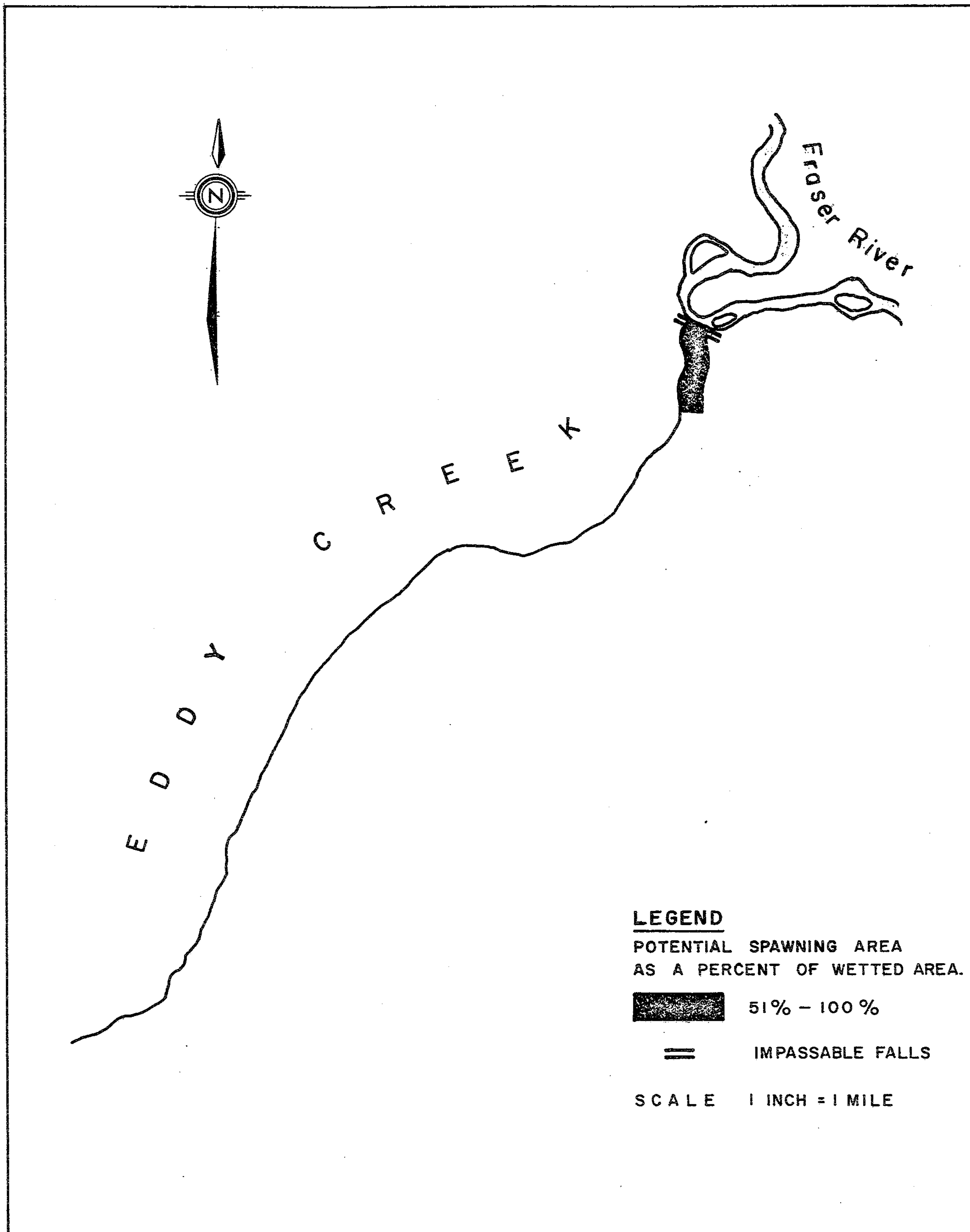


FIG. A1-26 TOTAL POTENTIAL SPAWNING AREA: EDDY CREEK

EDDY CREEK (FIG. A1-26)

Eddy Creek flows northeasterly for 6.7 miles to join the Fraser River at mile 140, southeast of McBride. There is a 10-foot falls at the mouth (Plate A1-24) above which, to mile 0.7, are 3,696 square yards of suitable spawning gravel with a theoretical chinook salmon capacity of 308 fish. From mile 0.7 to its source, the streambed is composed of rocks and boulders and is unsuitable.

TABLE A1.29 Potential Spawning Areas: Eddy Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.7	1,232	5	6,160	3,696	60	308
0.7 - 6.7	10,560	3	31,680	0	0	0
TOTAL:	11,792	-	37,840	3,696	-	308

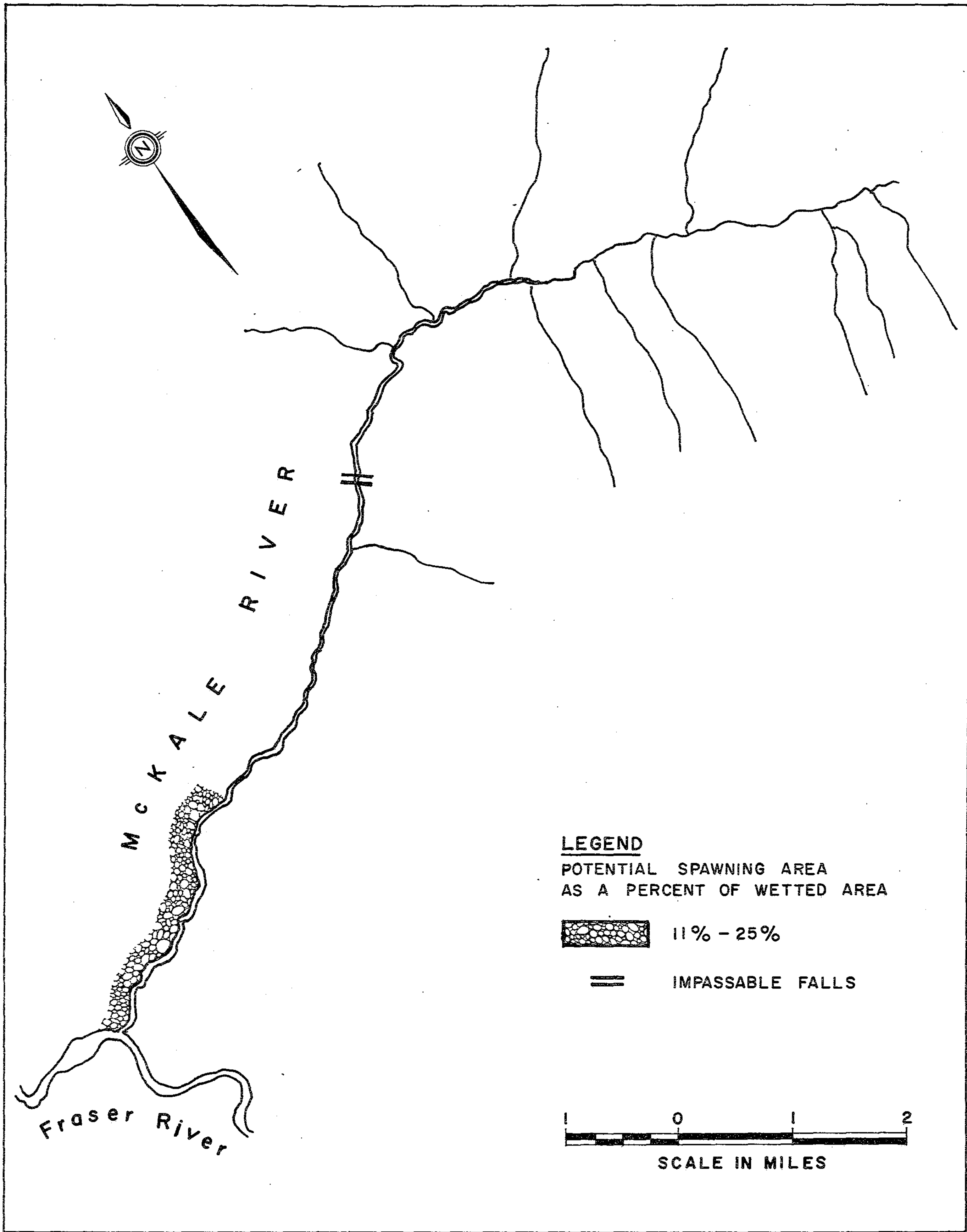


FIG. A1-27 TOTAL POTENTIAL SPAWNING AREA: McKALE RIVER

MCKALE RIVER (FIG. A1-27)

The McKale River flows southwesterly a distance of 16.5 miles to its confluence with the Fraser River at mile 120, northwest of McBride (Plate A1-24). The lower 2.5 miles of river meanders and contains suitable salmon spawning gravel. Above this point the river flows out of the mountains, the gradient increases, there is a predominance of large rubble, and the streambed becomes chiefly large rocks and boulders. At mile 5.8 is an impassable falls.

At mile 7.0 the gradient decreases, and the bottom composition is again suitable for spawning. However, this area is inaccessible to salmon because of the falls and the rapids at mile 4.5. To its source, the McKale River takes a meandering course through many channels.

The total potential spawning areas was estimated to be 13,200 square yards, capable of supporting 1,100 chinook.

TABLE A1.30 Potential Spawning Areas: McKale River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 2.5	4,400	12	52,800	13,200	25	1,100
2.5 - 5.8	5,808	10	58,080	0	0	0
TOTAL:	10,208	-	110,880	13,200		1,100

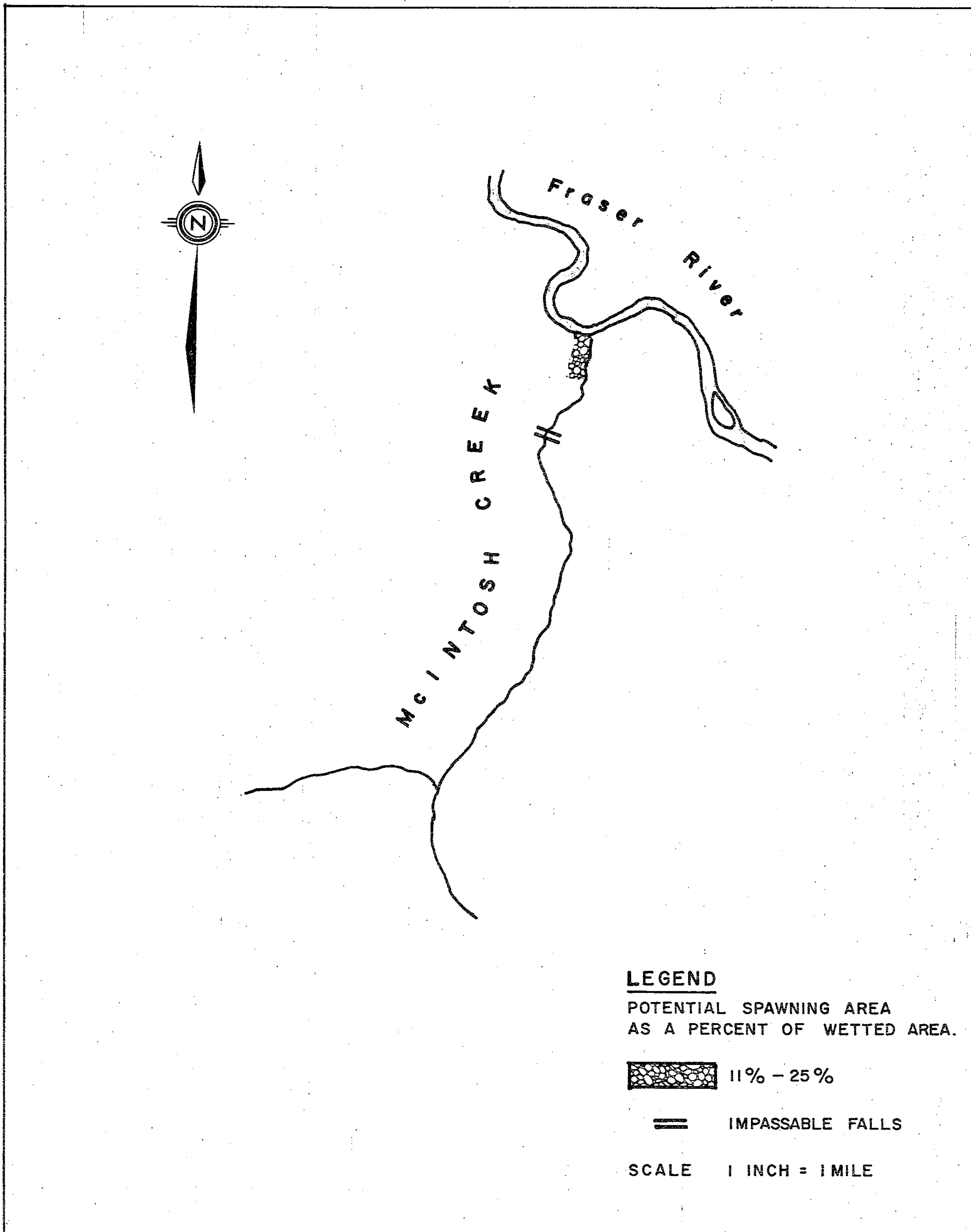


FIG. A1-28 TOTAL POTENTIAL SPAWNING AREA: McINTOSH CREEK

MCINTOSH CREEK (FIG. A1-28)

McIntosh Creek flows 4.6 miles in a northwesterly direction to the Fraser River at mile 122, northwest of McBride. The stream gradient is steep throughout its length, and the streambed is composed of large rocks and boulders. There is a 75-foot falls at mile 0.7. In the lower 0.25 miles, there are 440 square yards of suitable spawning gravel capable of supporting some 40 chinook salmon.

TABLE A1.31 Potential Spawning Areas: McIntosh Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.25	440	5	2,200	440	20	37
0.25 - 0.7	792	5	3,960	0	0	0
TOTAL:	1,232	-	6,160	440	-	37

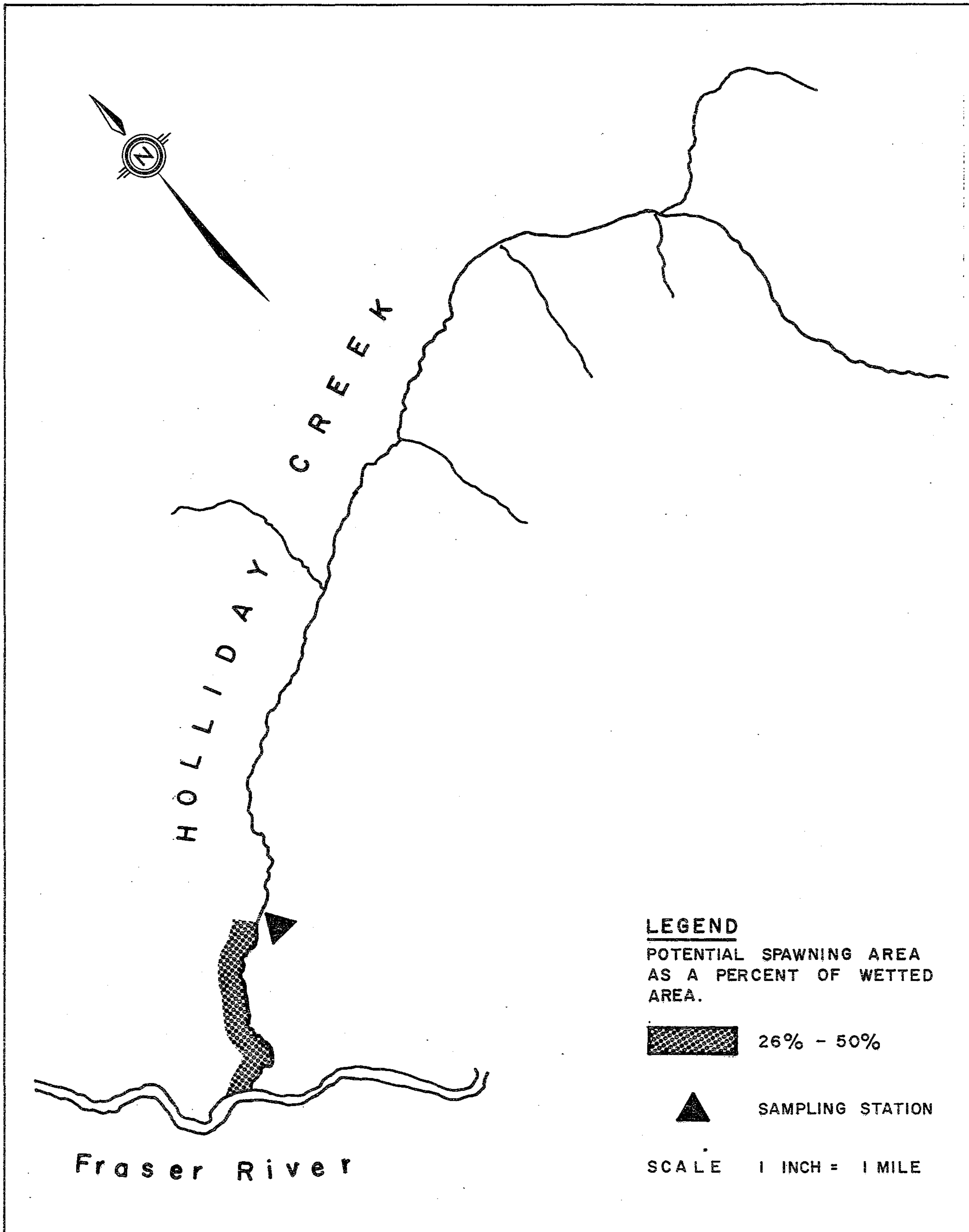


FIG. A1-29 TOTAL POTENTIAL SPAWNING AREA: HOLLIDAY CREEK

HOLLIDAY CREEK (FIG. A1-29)

Holliday Creek flows 12 miles southwest into the Fraser River at mile 156. This creek is very clear. On August 31, 1971, the flow was estimated to be 129 cfs. Above mile 1.25 to its source, the streambed is composed of coarse gravel and bedrock (Plate A1-25).

There is an estimated 5,280 square yards of suitable spawning gravel to mile 1.25, capable of supporting 440 chinook salmon.

TABLE A1.32 Potential Spawning Areas: Holliday Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.25	2,200	6	13,200	5,280	40	440
1.25 - 12.0	18,920	3	56,760	0	0	0
TOTAL:	21,120	-	69,960	5,280	-	440

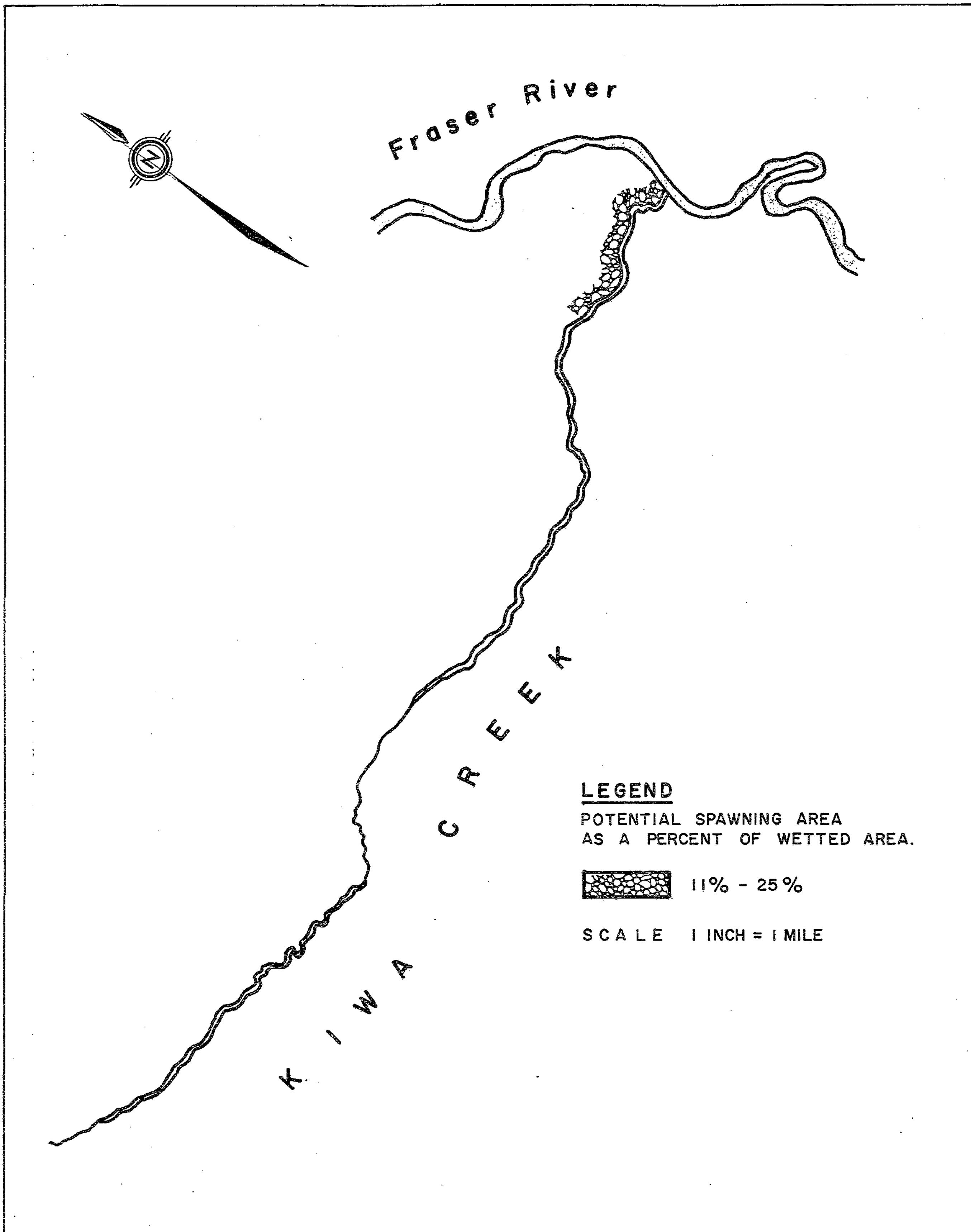


FIG. A1-30 TOTAL POTENTIAL SPAWNING AREA: KIWA CREEK

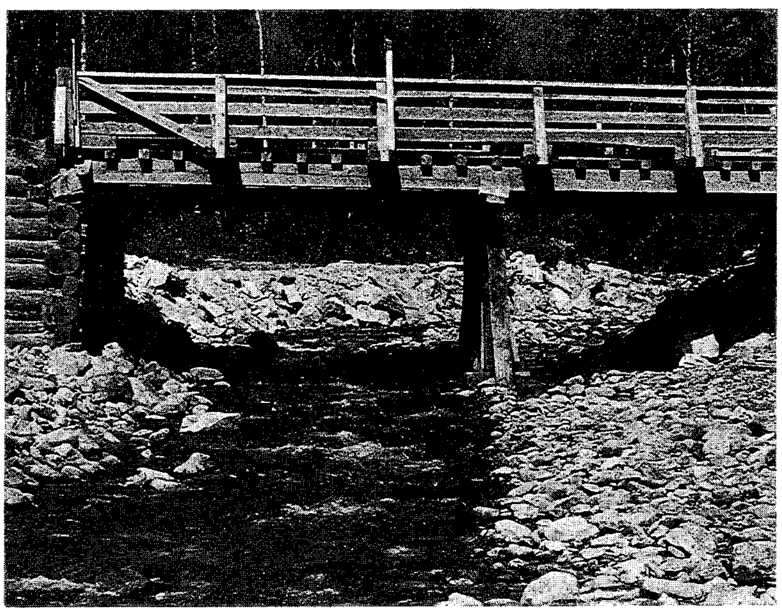
KIWA CREEK (FIG. A1-30)

Kiwa Creek flows in a northeasterly direction for 11.8 miles to its confluence with the Fraser River at mile 185. The water is slightly glacial. The gradient is moderate to mile 1.21, it then increases (Plate A1-25), and the stream bottom is composed of large rocks and boulders unsuitable for spawning. The chinook salmon spawning capacity of this stream was estimated to be 458 fish.

TABLE A1.33 Potential Spawning Areas: Kiwa Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.2	2,112	13	27,456	5,491	20	458
1.2 - 11.8	18,656	6	111,936	0	0	0
TOTAL:	20,768	-	139,392	5,491	-	458

KIWA CREEK, RAPIDS AT MILE 2



HOLLIDAY CREEK, MILE 1.25

HOLLIDAY CREEK, MILE 2.75

A1.2.3 TRIBUTARIES WITH NO POTENTIAL

Many streams in this basin are regarded as having no potential for salmon propagation due to their undesireable physical characteristics, such as steep gradients, sediment load, and turbidity. In some cases, the streams are located above Rearguard Falls or have impassable obstructions in their stream lengths or at their outlets.

Goodson and Holy Cross creeks, tributaries of Walker Creek, both have insufficient water volume, steep gradients and no suitable gravel areas.

Three tributaries of Morkill River have no salmon potential. Cushing Creek, located above the falls on Morkill, is inaccessible to salmon; it also has a steep gradient and two falls at mile 1.7. Forgetmenot Creek joins the Morkill below the falls, but has fast, rapid white-water throughout its length and a falls at mile 2.8 (Plate A1-26). Hellroaring Creek is small and shallow, with a steep gradient.

Chalco Creek, a tributary of Holmes River, has a steep gradient and a streambed composed chiefly of bedrock and boulders.

Raush River, which joins the Fraser at mile 148.0, is a slow, meandering stream, very turbid with glacial melt. The substrate was not visible; river banks were mud and sand (Plate A1-26).

Tête Creek joins the Fraser near Tête Jaune Cache. It has a very heavy silt load and the deposition of these fine materials has rendered the substrate unsuitable for spawning (Plate A1-29).

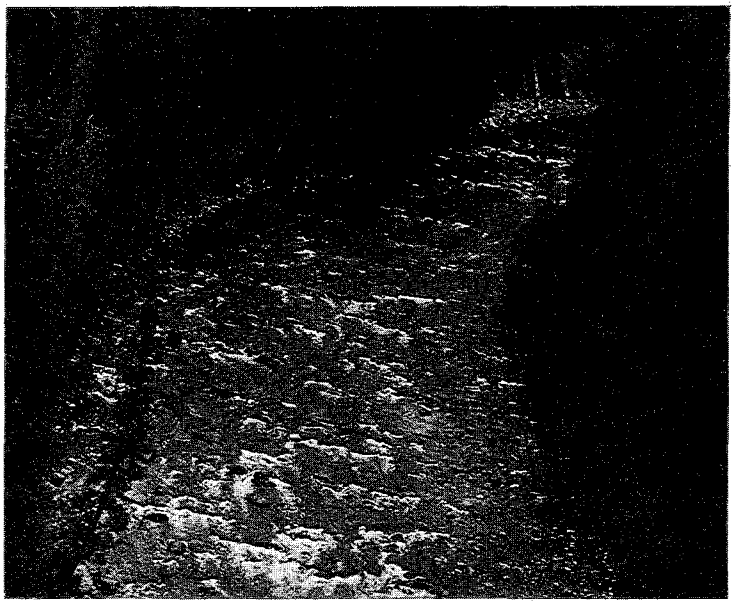
Ghita, Grantbrook and Swiftcurrent creeks, and Moose River are located upstream from Rearguard Falls (Plates A1-27,-28). All have steep gradients and turbid waters. There is a falls on Ghita Creek at mile 2.6, and an 8-foot falls at mile 0.6 on Swiftcurrent Creek.

Spittal, Driscoll, LaSalle, and Hankins creeks all have insufficient flows.

Castle Creek is very turbid. The exposed gravel bars are covered with a heavy layer of fine materials. A water sample taken August 27, 1972, had a suspended sediment level of 220 ppm (Plate A1-29).

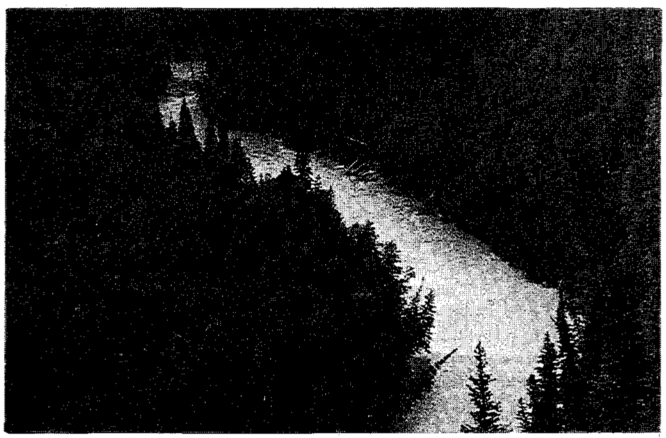
Robson River is located above Rearguard Falls and has a 20 foot falls at mile 3.1 (Plate A1-30). The water, although turbid, had a suspended sediment level of only 12 ppm. There are possible potential areas in the lower 1.8 miles but these are not accessible.

Small Creek's turbid waters meander for a great part over a wide flood plain (Plate A1-30). The high level of sediment and compacted gravel negate the suitability of this stream for salmon propagation.

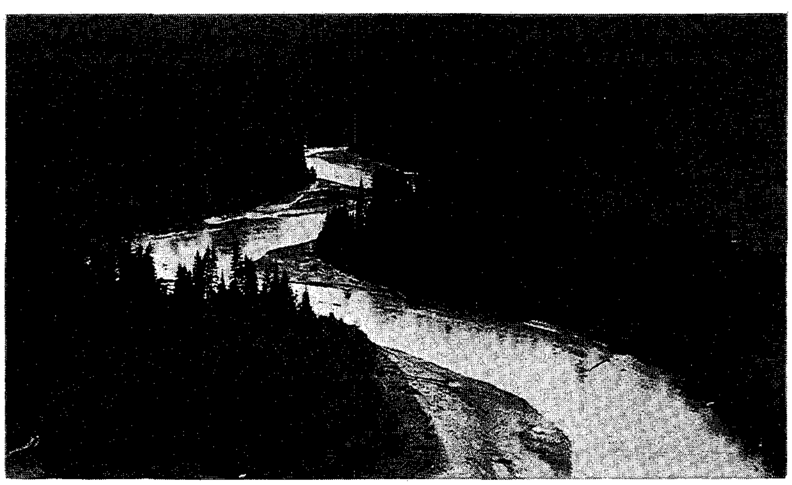


FORGETMENOT CREEK, RIFFLE AREA, MILE 1.0

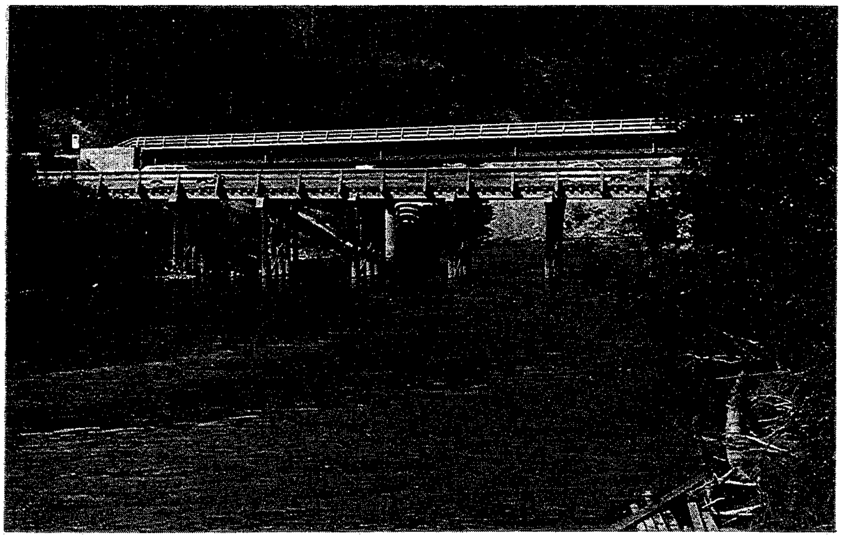
FOREGETMENOT CREEK, MILE 2.5



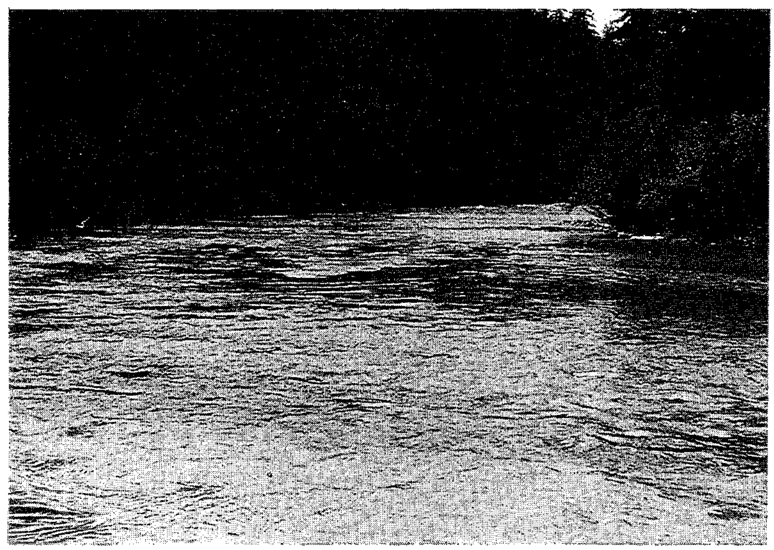
RAUSCH RIVER, MILE 1.5



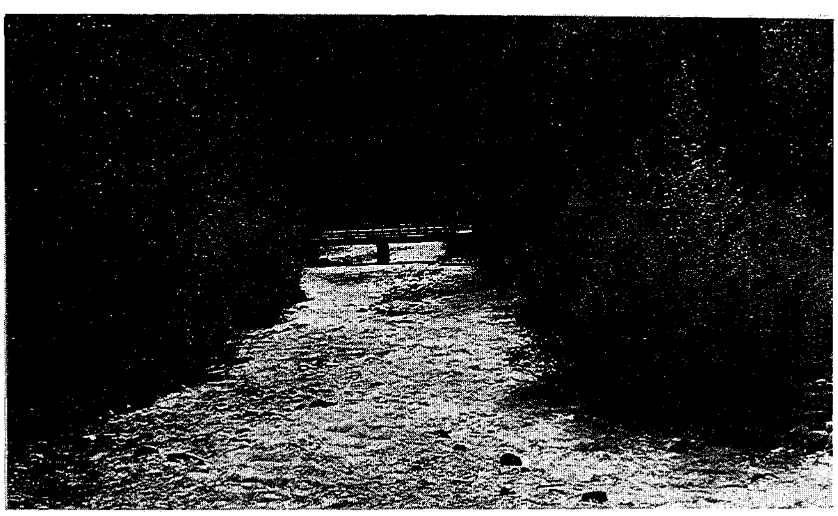
RAUSCH RIVER, MILE 9



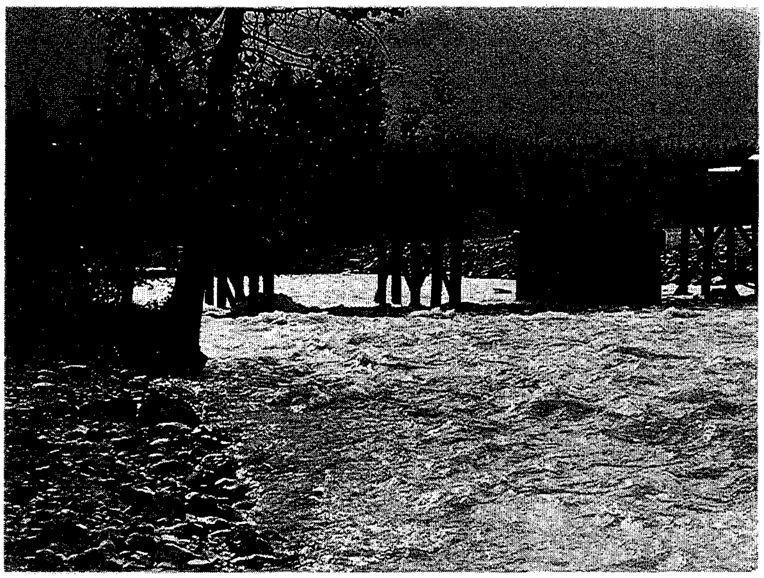
GHITA CREEK AT HIGHWAY BRIDGE



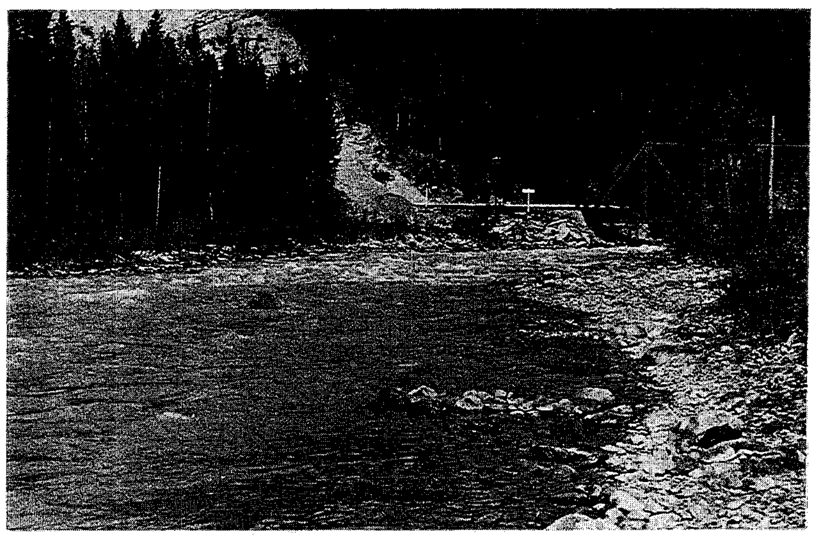
GHITA CREEK, DOWNSTREAM FROM BRIDGE



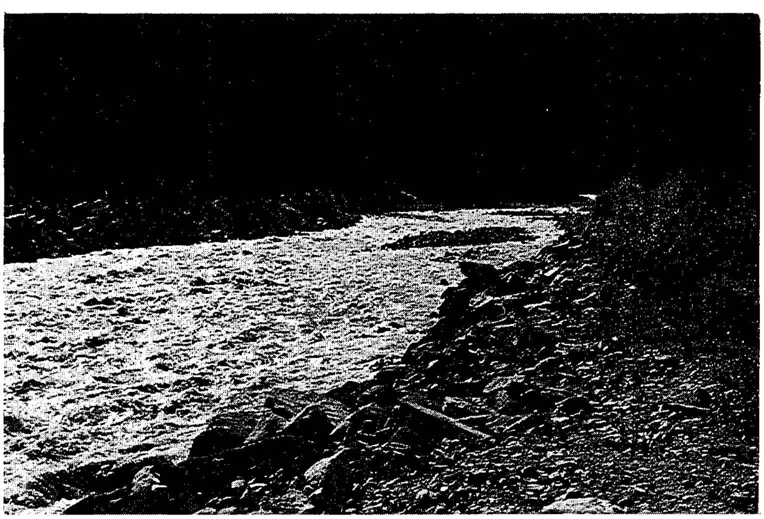
GRANTBROOK CREEK
AT HIGHWAY BRIDGE



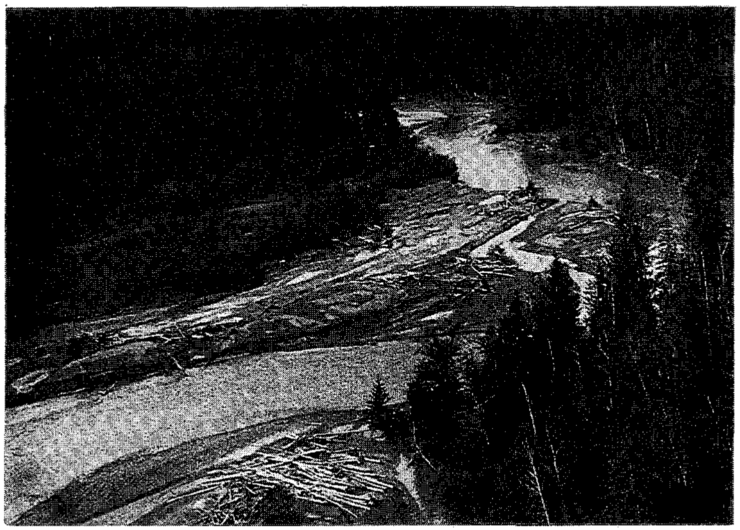
MOOSE CREEK AT BRIDGE



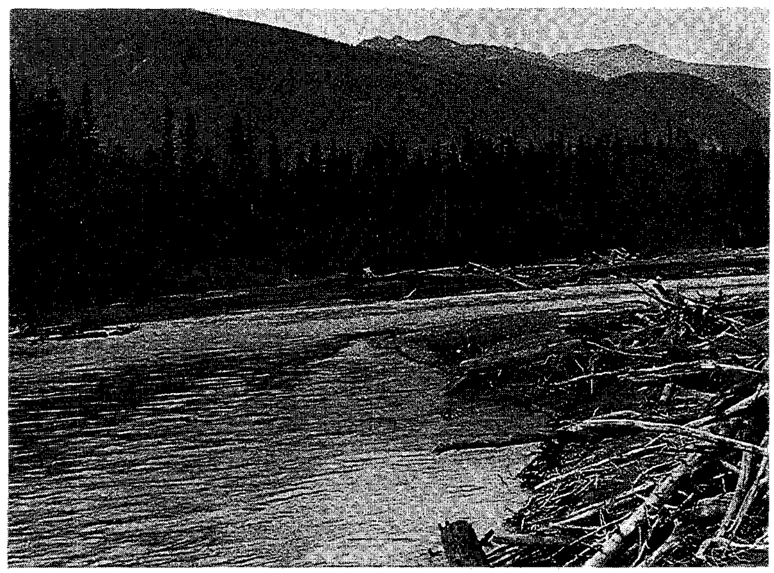
MOOSE CREEK, UPSTREAM FROM BRIDGE



SWIFT CURRENT CREEK
AT MILE 0.5



CASTLE CREEK, AT MOUTH

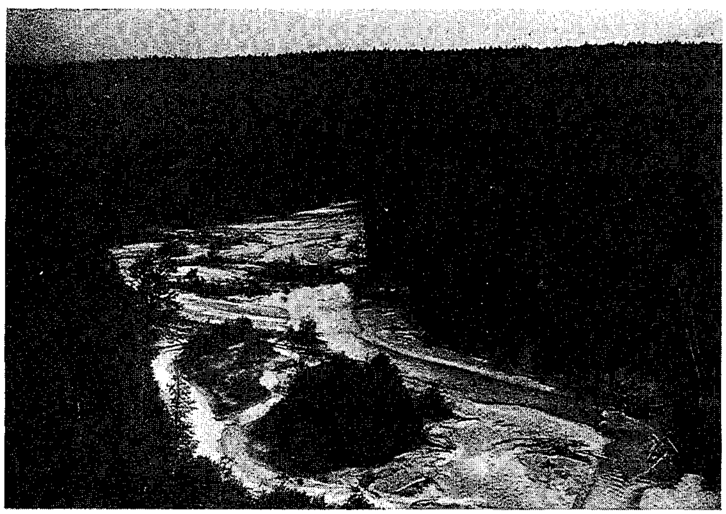


CASTLE CREEK
SAMPLING SITE
ABOVE MOUTH

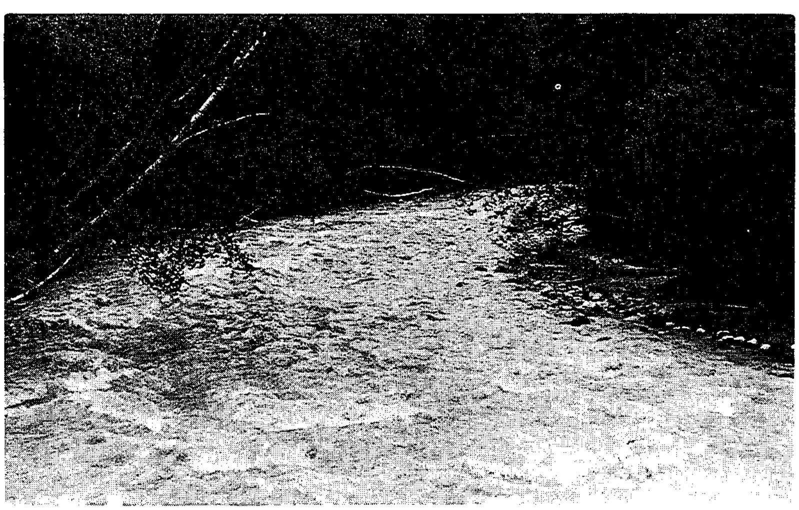
TETE CREEK
AT MOUTH

ROBSON RIVER AT MOUTH

ROBSON RIVER, MILE 3



SMALL CREEK, MILE 0.5



SMALL CREEK
MILE 1.5

A1.3 Juvenile Sampling

Length-weight relationships of juvenile chinook captured by seal-bomb technique in three streams in the Grand Canyon basin are shown in Table A1.34.

TABLE A1.34 Lengths and Weights of Chinook Juveniles Sampled

Date (1971)	Location		Length (mm)	Weight (gm)
Aug. 29	Mile 2.5 Holmes River		54	1.9
			55	1.9
			55	1.8
			59	2.4
			62	3.1
		Average:	57	2.2
Aug. 29	Mile 2.0 Swift Creek		68	4.2
			80	7.9
			69	4.9
			61	3.0
			61	3.3
			63	3.3
			61	2.7
			51	1.5
		Average:	64.3	3.85
Aug. 29	Mile 1.25 Nevin Creek		60	2.3
			66	3.1
		Average:	63	2.7

A1.4 PHYSIO-CHEMICAL MEASUREMENTS

Physical and chemical information on the streams surveyed in the Grand Canyon basin are presented in Table A1.35. Some of the streams within the basin were not sampled due to the absence of suitable streamside landing areas. All of the data is instantaneous, as continuous monitoring was not feasible. The Torpy River, Goat River and Slim Creek were the only streams sampled more than once. Sampling was carried out in late August of 1971.

The glacial waters maintained a low water temperature, averaging 54.2^{o} F., and a dissolved oxygen level of 8.7 ppm. Although slightly acidic, the average pH value of 6.8 is within the normal range for these waters. The McLennan River produced abnormally high concentration of dissolved solids (4,928 ppm) and suspended sediment (93,136 ppm). The average for the area, when these high values are omitted, is only 95.2 ppm for dissolved solids and 26.5 ppm for suspended sediment.

TABLE A1.35 Physical and Chemical Characteristics of Major Streams in the Grand Canyon Basin

STREAM	SAMPLING DATE (1971)	SAMPLING LOCATION*	DEPTH RANGE (ft.)	VELOCITY** (fps.)	FLOW VOLUME (cfs)	TEMP. (°F)	DISS. OXYGEN CONCENTRATION (ppm)	DISS. SOLIDS CONCENTRATION (ppm)	SUSPENDED SEDIMENT (ppm)	pH
CASTLE CREEK	Aug. 27	mouth	n.d.	n.d.	n.d.	44.5	n.d.	79	220	n.d.
CROTCH CREEK	Aug. 14	mouth	0.5-1.5	1.65	39	51.5	9	-	-	7.3
DOME CREEK	Aug. 31	4.0	0.5-1.0	4.22	121	54.0	9	118	3	6.1
FRASER RIVER	Aug. 25	Tete Jaune	0.5-10.0[E]	6.00	6,300	55.5	10	83	36	7.3
GOAT RIVER	Aug. 26	2.6	1.0-3.0	3.84	806	48.0	11	82	10	7.3
GOAT RIVER	Aug. 26	9.9	1.0-6.0	5.00	675	46.5	10	113	4	7.3
HORSEY CREEK	Aug. 29	1.1	1.0-4.0	5.71	642	51.5	10	72	13	7.1
HOLLIDAY CR.	Aug. 31	1.2	1.0-3.0	3.22	129	55.0	8	-	-	7.1
HOLMES RIVER	Aug. 31	2.5	1.0-4.0	2.85	1,068	53.5	9	91	11	6.2
HUNGARY CREEK	Aug. 31	3.6	0.5-1.5	3.33	67	53.0	9	114	6	7.4
KEG CREEK	Aug. 14	7.0	1.0-3.0	2.50	60	51.0	8	-	-	7.3
KENNETH CREEK	Aug. 26	4.5	0.5-1.0	1.43	27	56.0	8	143	15	7.3
McLENNAN RIVER	Aug. 27	20.7	1.0-4.0[E]	4.30	543	46.5	10	49,28	93,136	6.4
MILK RIVER	Aug. 26	Goat River confluence	0.5-1.0	3.60	162	45.0	9	109	0	7.2
MORKILL RIVER	Aug. 26	0.2	n.d.	4.30	n.d.	54.0	9	79	15	7.2
NEVIN CREEK	Aug. 29	1.3	0.5-1.0	3.60	115	51.5	9	68	46	7.1

* Distance in miles from stream mouth.
** Instantaneous velocity measured at sampling station.
n.d. Not determined due to turbidity.
E Estimated due to turbidity.

(continued)

TABLE A1.35 (cont'd) Physical and Chemical Characteristics of Major Streams in the Grand Canyon Basin

STREAM	SAMPLING DATE (1971)	SAMPLING LOCATION*	DEPTH RANGE (ft.)	VELOCITY** (fps)	FLOW VOLUME (cfs)	TEMP. (°F)	DISS. OXYGEN CONCENTRATION (ppm)	DISS. SOLIDS CONCENTRATION (ppm)	SUSPENDED SEDIMENT (ppm)	pH
ROBSON RIVER	Aug. 27	0.25	n.d.	6.14	n.d.	51.0	10	76	12	7.3
SLIM CREEK	Aug. 19	22.5	0.5-2.5	3.21	246	56.5	9	115	13	7.3
SLIM CREEK	Aug. 24	27.3	0.5-2.0	n.d.	n.d.	57.0	9	-	-	7.2
SWIFT CREEK	Aug. 29	2.0	0.5-1.5	3.33	80	53.0	9	76	3	7.1
TORPY RIVER	Aug. 13	3.2	0.5-3.5	2.05	461	68.0	9	-	-	7.2
TORPY RIVER	Aug. 13	32.1	0.5-3.5	2.78	245	67.0	9	132	16	7.2
TORPY RIVER	Aug. 31	43.3	0.5-3.5	1.14	155	59.5	8	-	-	7.3
TORPY RIVER	Aug. 31	60.0	0.5-2.5	1.25	30	64.0	9	-	-	7.2
WALKER CREEK	Aug. 13	2.5	0.5-1.5	1.88	93	62.0	8	70	2	6.95

* Distance in miles from stream mouth
** Instantaneous velocity measured at sampling station.
n.d. Not determined due to turbidity.

Appendix A2

McGREGOR RIVER BASIN

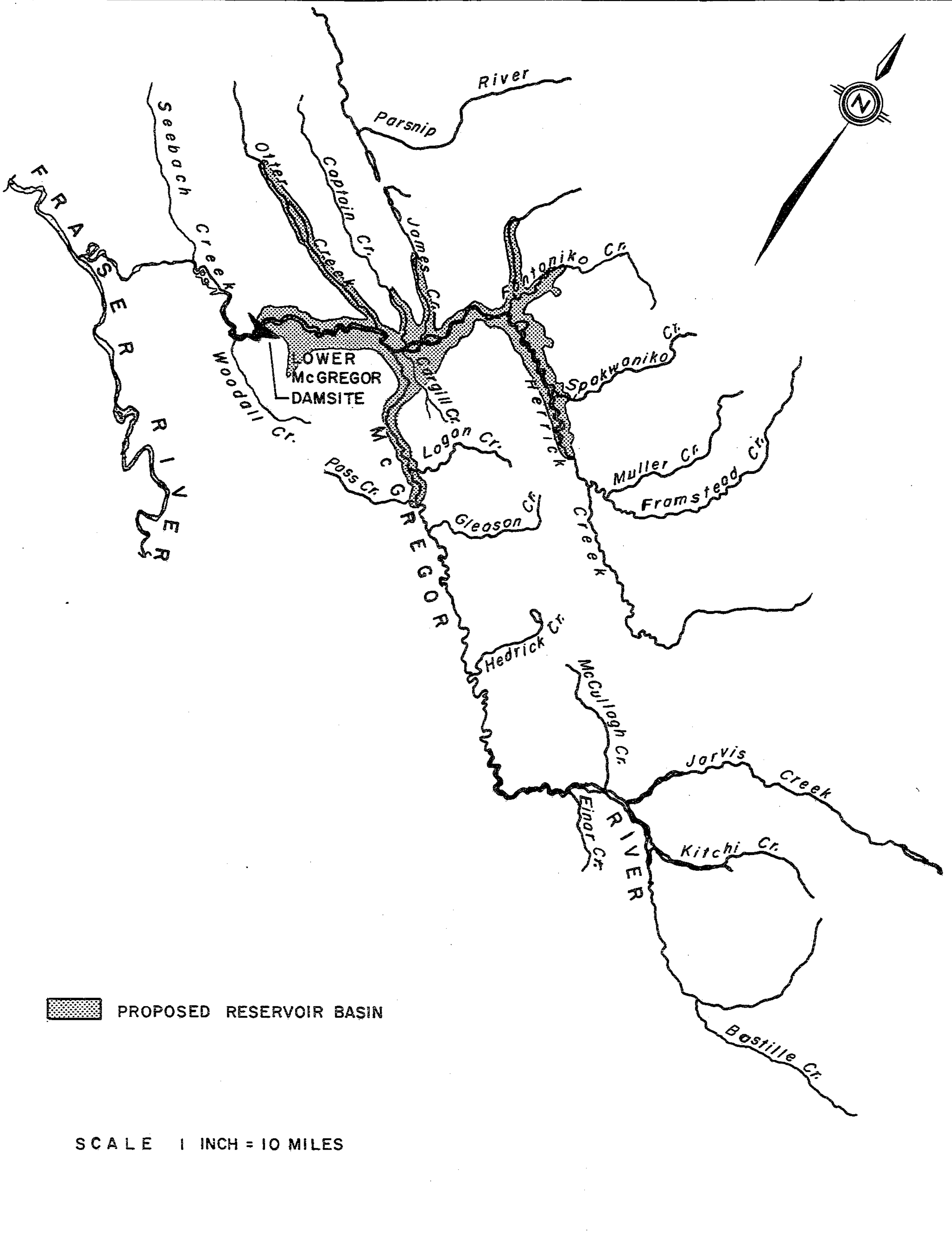


FIG. A2-1 McGREGOR RIVER BASIN

A 2 McGREGOR RIVER BASIN (FIG. A2-1)

This Section of Appendix A contains descriptions of the McGregor River drainage basin, the streams surveyed, the main stem McGregor and its major tributary, Herrick Creek. Results of the physio-chemical testing conducted during the field survey are also presented.

A2.1 DESCRIPTION OF DRAINAGE BASIN

A2.1.1 GENERAL

The McGregor River, which drains approximately 2,500 square miles, is located 360 air miles northeast of Vancouver and 50 air miles northeast of Prince George. The River rises in the Park Range of the Rocky Mountains, a few miles west of the British Columbia - Alberta border and flows northwesterly through these mountains dropping 1,000 feet in 24 miles. It then forms the boundary between the Hart Ranges to the east and the McGregor Plateau to the west, continuing northwesterly for 35 miles on a gentle, meandering gradient. At this point it plunges into a three-mile long rock walled canyon (the upper canyon), descending 150 vertical feet into a broad valley running northeast-southwest. Here Herrick Creek, the McGregor's main tributary, joins the latter. The Herrick adds approximately the same water volume as the upper McGregor, having collected the glacial waters from the southern Hart Mountains, Spakwaniko and Fontoniko creeks, and the clear waters of James and Captain creeks. James Creek drains lakes from the Arctic-Pacific Divide between the Parsnip and the McGregor drainages (northwest of the Herrick-McGregor confluence).

The McGregor River, below its confluence with Herrick Creek, flows on a gentle gradient, dropping approximately 100 feet in 11 miles as it meanders southwestward across the McGregor Plateau. Only one major tributary, the Otter, flowing from the northwest, joins the McGregor before it twists through the lower canyon, the proposed site of the System E project. The river waters do not drop very sharply through this 3.5 mile long constriction and continue southwesterly onto the Nechako Plain, gradually descending 15 miles before joining the Fraser River approximately 35 miles upstream from Prince George and some 125 miles from their source. Only three tributaries join in this reach, Seebach, flowing from the northwest, plus Woodall and Hubble, from the southeast.

A2.1.2 RESERVOIR BASIN

The proposed lower McGregor reservoir has a maximum flood elevation of 2,457 feet, extending in an octopus configuration from the lower canyon, northeast up the lower McGregor/Herrick Creek valley for 20 miles, then an additional 13 miles southeast up Herrick Creek. Appendages of this Herrick Creek leg push into the Fontoniko and Spakwaniko valleys. Further arms extend northwest: up Otter Creek, through Otter Lake, and the creek area above the lake (a total of 18 miles); up James Creek for 11 miles to Pacific and Portage Lakes, and over the divide into Arctic Lake and the Parsnip River valley. A short 6 mile leg lies northwest up Captain Creek. A long arm extends southeast through the upper canyon and along the upper McGregor River for 25 miles and completes the sprawling reservoir.

A2.1.3 SOILS

The basin has two distinct soil types: the bottom land alluvial and glacial deposits and the leached podzol soils of the upland.

The wide valleys of the McGregor, upper Otter Creek (above Otter Lake) and lower Herrick Creek, have deep deposits of sands and silts. The rivers have cut down through these deposits often exposing 10 to 50 foot high banks of unconsolidated material. The tributaries have flushed out quantities of coarse gravels and sands, which have been deposited as alluvial fans.

Even in smaller drainages, such as Captain and James creeks, there is evidence of deep sand and silt deposits. The lakes in the Pacific-Arctic Divide exhibit broken rocks along their steep shorelines. Little or no soil is present except where coarse material has been deposited by slides from the steep hill sides.

The upland podzols are thinner than the valley soils but still have copious quantities of silts, much of it from post-glacial melting. Consequently these mountain soils are rather unstable and are easily eroded.

A2.1.4 TOPOGRAPHY

The main valleys of the McGregor River Basin are broad, often two to three miles wide before they intersect the steep (40 to 60%) mountainsides which climb quickly to their summits (4,500 to 5,500 feet elevation in the west and 6,000 to 6,500 feet elevation in the east). Some wide valleys such as those of Otter, McGregor, Herrick and lower Fontoniko are not flat and contain undulating terrain. This feature is most prominent in the Cargill Creek area where the valley bottom is five miles wide. James Creek is in a deeply incised valley, less than one-quarter mile wide, with valley walls rising nearly perpendicularly to elevations exceeding 5,500 feet.

A2.1.5 CLIMATE

The McGregor River Basin lies in a moderately high rainfall area, receiving approximately 35 inches of precipitation annually, half of which falls as snow. The spring months are normally dry.

The basin experiences short warm summers and long cold winters, the temperature often dropping to minus 55 degrees F. in February. Normal summer day temperatures range from 75 to 80 degrees F. The area has less than 50 frost free days annually; both May and late August have nightly frost.

A2.1.6 ACCESS

The McGregor is navigable to the upper canyon, one mile above the Herrick-McGregor confluence, as is the upper McGregor (above this canyon) and Herrick Creek (to mile 27). In ideal water conditions, an experienced boatman with a well equipped riverboat can negotiate the rivers easily, being able to ascend 18 miles up Herrick Creek and 40 miles beyond Pass creek on the McGregor.

In low water, the lower canyon is often turbulent but presents no problem if caution is used.

The minor tributaries are unnavigable to river boats except for short distances above their mouths during high water. Otter Creek, both above and below Otter Lake, can be traversed by canoe, but the lower reaches of this creek are too steep. Captain and James creeks are not sufficiently deep most of the year for canoe travel.

A.2.2 Anadromous Stocks

The only species of anadromous fish that utilizes the McGregor River and its tributaries for spawning and rearing is the chinook salmon. Records for the past 15 years indicate that the main stem McGregor and its principal tributary, Herrick Creek, are not used as spawning grounds but as migration routes. This was corroborated during the 1971-72 field survey; no spawning salmon were sighted in the main stems of either of these rivers.

Spawning does occur in Seebach Creek (located below the proposed dam site and not surveyed) and in Otter, Captain, James and Fontoniko creeks (located upstream from the proposed dam site).

Upstream adult migration to the McGregor River basin occurs between mid-July and the end of August. The spawning period extends from the beginning of August to the end of September. Downstream juvenile migration occurs from mid-April to early June. However, there are indications that an undetermined portion of juvenile chinook rear in the McGregor and Herrick tributaries for longer periods. Chinook smolts were documented in this basin during August, 1971.

This section includes descriptions of all streams surveyed, including the main stem McGregor River and Herrick Creek. Those streams which presently support chinook salmon are discussed first, in upstream order from the mouth of the McGregor. The non-utilized streams, all of which are regarded as inaccessible to salmon are divided into those tributary to the main stem McGregor and those tributary to Herrick Creek. Streams with no salmon potential are also discussed.

A2.2.1 McGREGOR RIVER (FIG. A2-2)

The McGregor River, approximately 125 miles long, is the largest tributary of the upper Fraser River. It rises in the icefields of Mount Sir Alexander and flows northwesterly parallel to the Fraser, before turning southwesterly to join the latter approximately 35 miles northeast of Prince George.

From its confluence with the Fraser River to Woodall Creek, a distance of about 18 miles, the McGregor passes through a broad valley surrounded by forested foothills with swamp areas. Approximately two miles upstream from Woodall Creek, the river flows through a canyonous area about one-half mile long. This is the proposed lower McGregor dam site. From this point upstream to the confluence of Herrick Creek at mile 33.8, the McGregor flows through a wide valley heavily forested with second growth spruce and cottonwood, and broken by old river channels, small marshes and meadows. At the Herrick confluence, the McGregor River is broken into several channels, then narrows after three miles into a canyonous area of very turbulent water for about 3 miles. This area is believed to be the upstream migrational limit for chinook salmon as no sightings have been recorded above this point (see Plate A2-1).

From this canyon upstream some 42 miles the McGregor meanders extensively throughout a wide valley forested with spruce and cottonwoods. In this reach Logan, Pass, Gleason, Harvey and Hedrick creeks join the McGregor.

From mile 81 the McGregor River flows through a wide flood plain, which extends beyond the confluence of Einar and Jarvis creeks, to mile 98. The river narrows for the next several miles, but at the confluence of Kitchi Creek, mile 100, becomes braided for approximately 2 miles (Plate A2-2). From here to its source, the river is turbid with glacial melt.

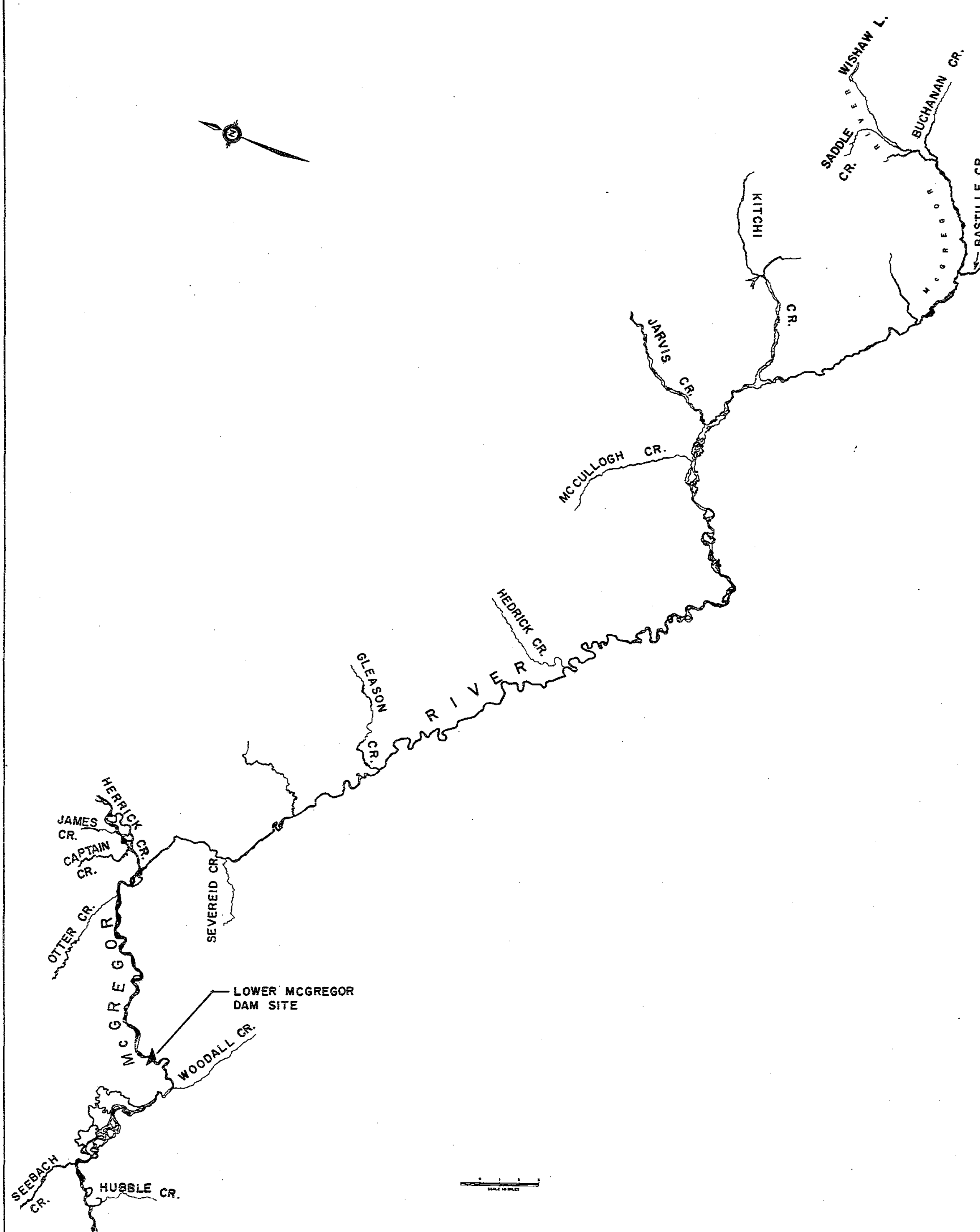
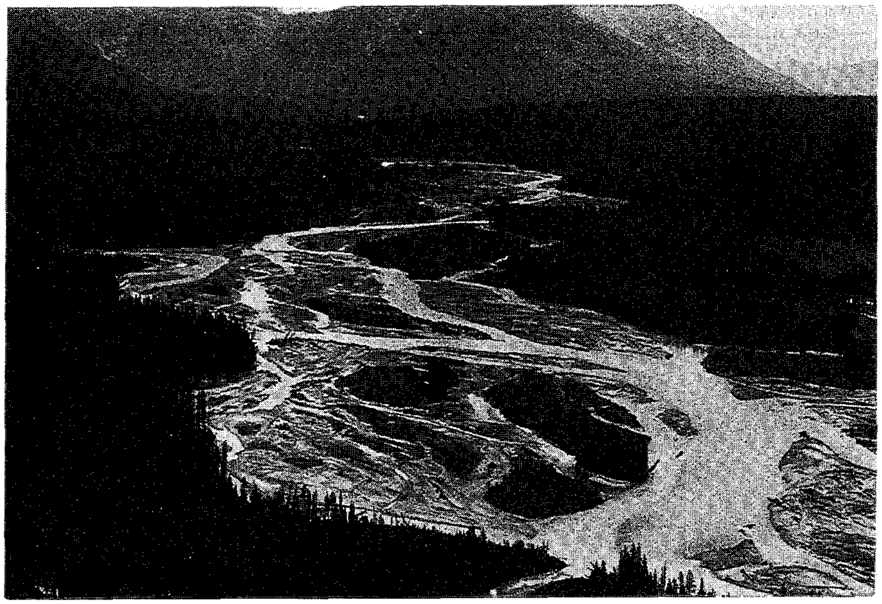


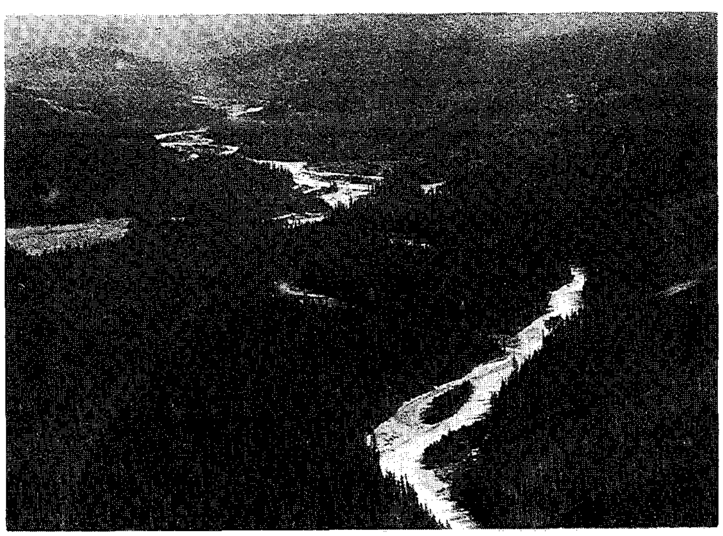
FIG. A2-2 MAIN STEM McGREGOR AND TRIBUTARIES

McGREGOR RIVER



BRAIDED AREA, MILE 95

MILE 102



MILE 109

A2.2.2 STREAMS PRESENTLY UTILIZED

Of the seventeen streams surveyed in this basin only four streams presently support salmon populations. They are, in upstream order, Otter, Captain, James and Fontoniko creeks. Otter Creek is the only McGregor River tributary; the others flow into Herrick Creek.

OTTER CREEK (FIG. A2-3)

Otter Creek is a turbid stream flowing southeasterly a distance of 26 miles into the McGregor two miles downstream from its confluence with Herrick Creek. It follows a steep-walled valley most of its length, through some swamp and sedge-meadow areas. Vegetation is mainly spruce and balsam with deciduous growth along the creek and a heavy underbrush of willow and alder.

Otter Creek is accessible to mile 2.2 where there is a 10 foot falls. To mile 2.2, the substrate is composed of large rocks and boulders, 8 inches to 2 feet in diameter. From mile 2.2 to 8.7, the gradient and velocity decreases, the stream meanders, and the substrate is composed of sand and silt. Aquatic vegetation was noted throughout this reach.

At mile 11.0 is Otter Lake, approximately 3 miles long and 0.5 miles wide (Plate A2-3). The only suitable spawning areas are at mile 8.7 (below Otter Lake) and mile 16.0 (above Otter Lake), a total of 3,630 square yards. This area is not included as part of the total potential of the McGregor River Basin (Table A2.1).

Records indicate that a run of about 25 chinook salmon spawn in the lower part of the stream; spawning commences in early August, peaks by mid-August, and ends by early September. However, no suitable spawning areas below the falls were evident during the field survey except at its confluence with the McGregor.

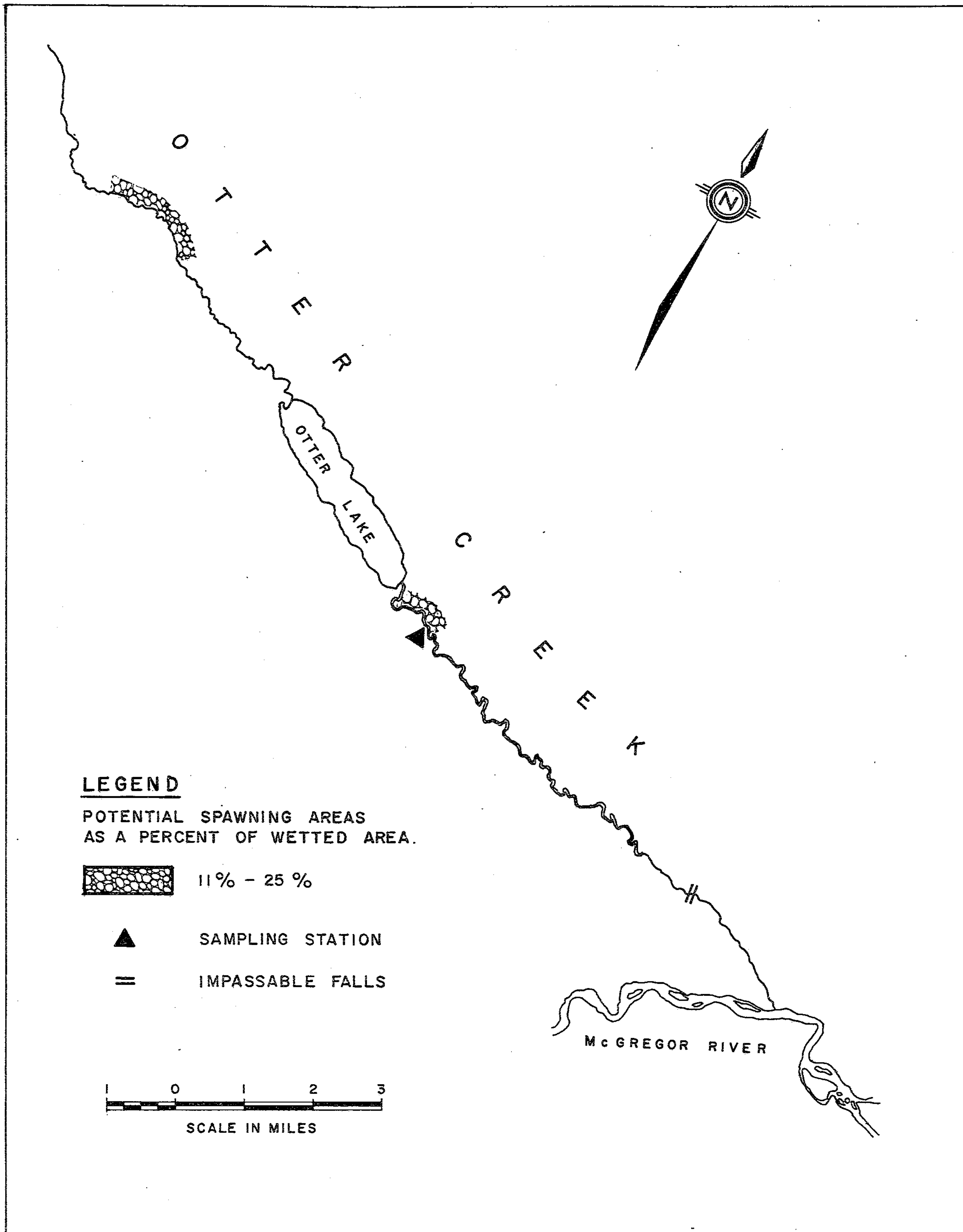
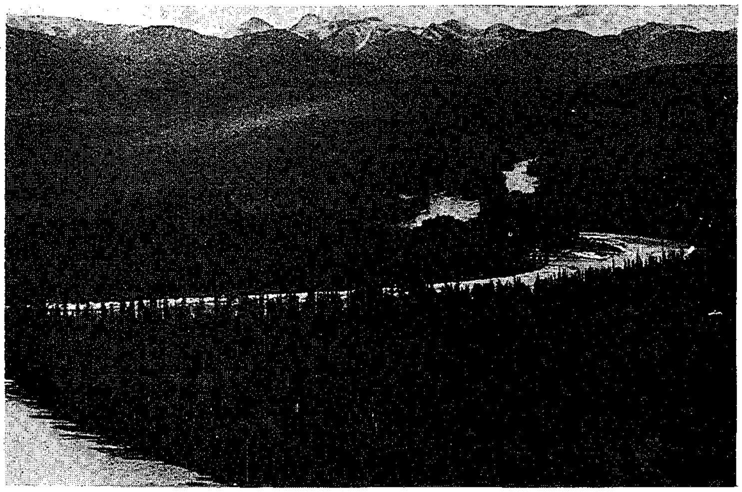


FIG. A2-3 POTENTIAL SPAWNING AREA: OTTER CREEK

TABLE A2.1 Potential Spawning Areas: Otter Creek

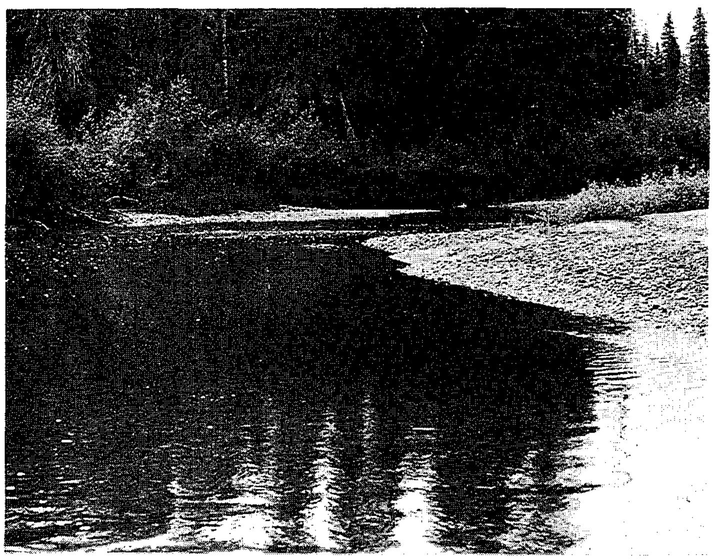
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 8.7	15,312	12	183,744	0	0	0
8.7 - 9.2	880	10	8,800	1,320	15	110
9.2 - 11.2	3,520	9	31,680	0	0	0
11.2 - 14.25	Otter L.					
14.25 - 16.0	3,080	8	24,640	0	0	0
16.0 - 17.25	2,200	7	15,400	2,310	15	193
17.25 - 26.0	15,400	4	61,600	0	0	0
TOTAL:	40,392	-	325,864	3,630	-	303

OTTER CREEK



CONFLUENCE WITH McGREGOR RIVER

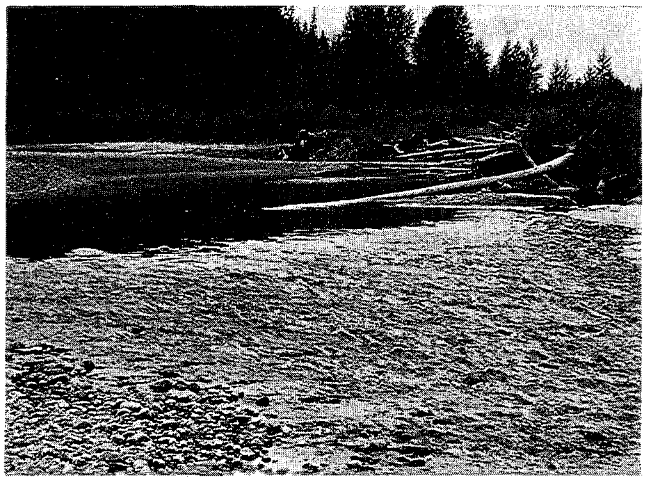
MILE 0.75



SUITABLE SPAWNING AREA, MILE 9

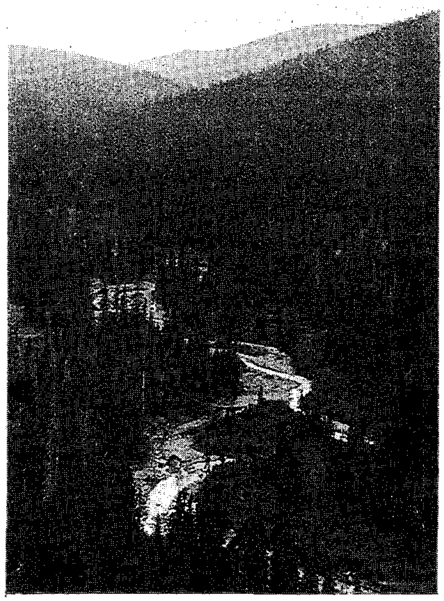
MILE 11
OTTER LAKE
IN BACKGROUND

CAPTAIN CREEK



SAMPLING STATION, AT MOUTH

MILE 8.9



MILE 10.5

MILE 12.5

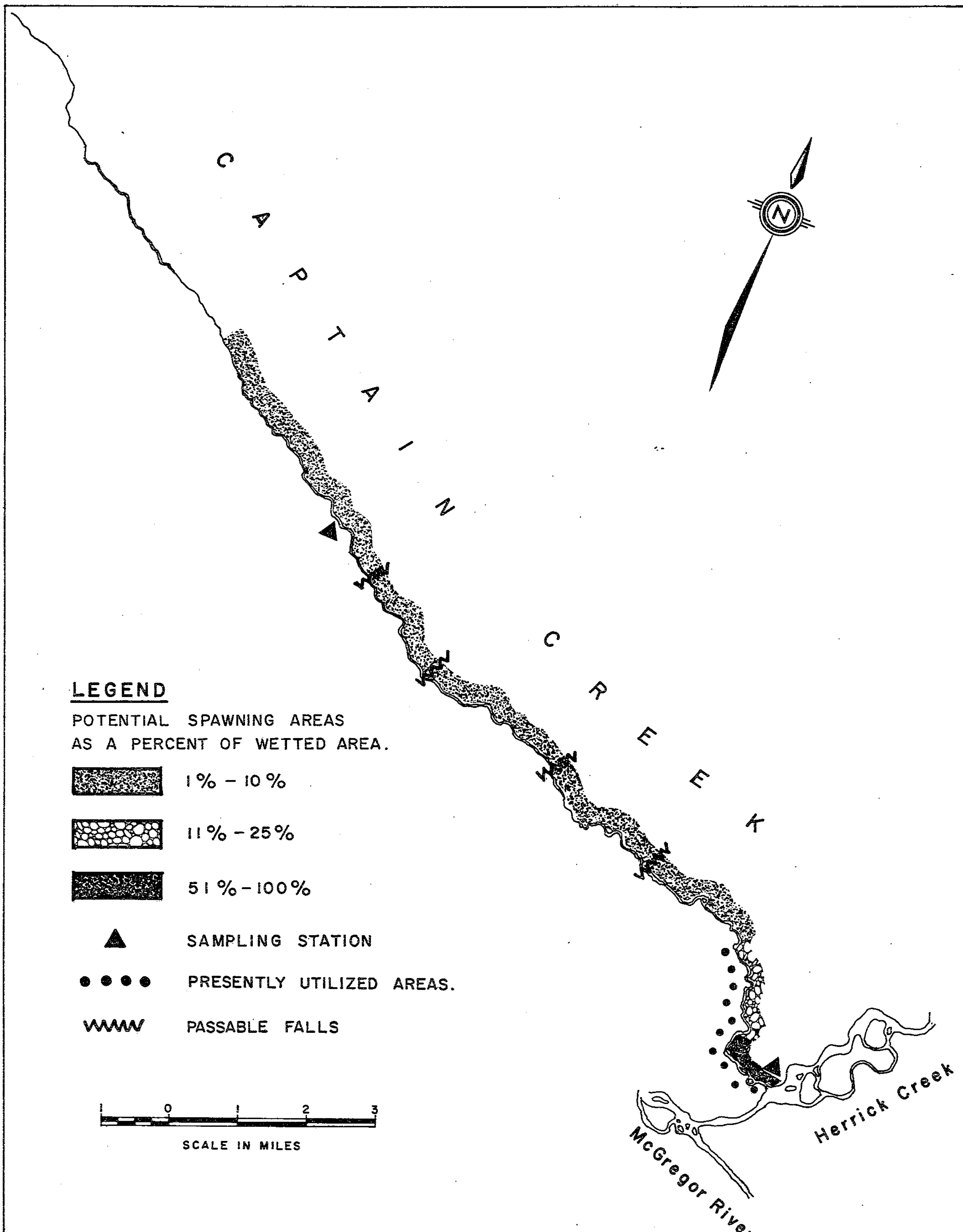


FIG. A2-4 POTENTIAL SPAWNING AREA: CAPTAIN CREEK

CAPTAIN CREEK (FIG. 2-4)

Captain Creek flows southeasterly for a distance of 22.0 miles to its confluence with Herrick Creek, at mile 1.25. It is a clear stream draining a steep sided valley forested with spruce and balsam (Plate A2-4).

The stream gradient is moderate throughout its length. However, there are small falls, less than five feet high, at mile 4.7, 6.8, 9.3, and at mile 10.7.

There are many excellent gravel bars and riffles in this stream, particularly to mile 2.75. This reach of Captain Creek has a total available spawning area of 23,848 square yards theoretically capable of supporting approximately 2,000 chinook salmon. There are suitable spawning areas also from mile 2.75 to mile 15.4 capable of supporting an additional 500 fish (Table A2-2).

TABLE A2.2 Potential Spawning Areas: Captain Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.0	1,760	12	21,120	15,840	75	1,320
1.0 - 2.75	3,080	13	40,040	8,008	20	667
2.75 - 6.25	6,160	6	36,960	3,696	10	308
6.25 - 15.4	16,104	5	80,520	2,416	3	201
15.4 - 22.1	11,792	3	35,376	0	0	0
TOTAL:	38,896	-	214,016	29,960	-	2,496

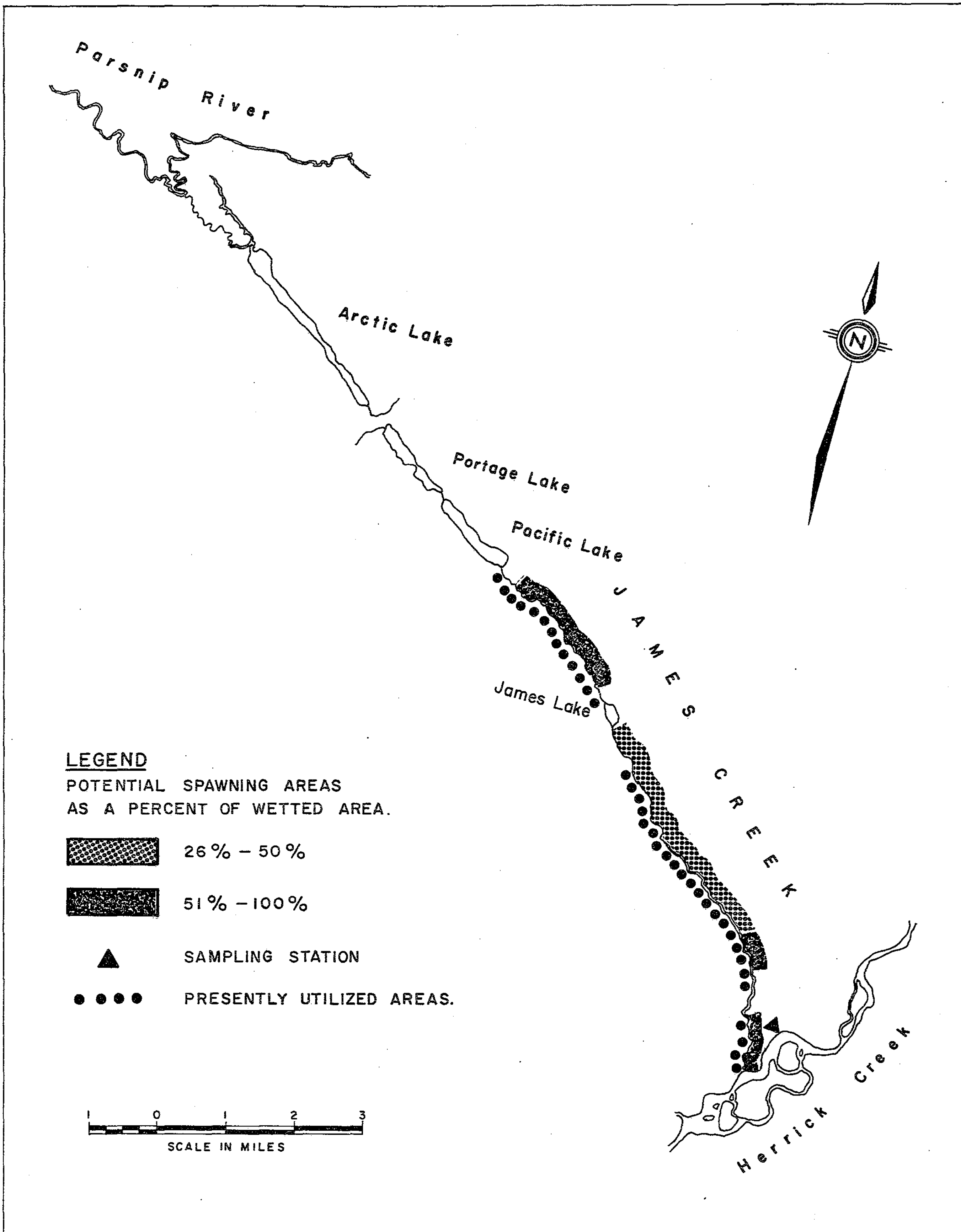


FIG. A2-5 POTENTIAL SPAWNING AREA: JAMES CREEK

JAMES CREEK (FIG. A2-5)

James Creek flows 11 miles in a southeasterly direction into Herrick Creek, at mile 2.5. Aerial reconnaissance of James Creek took place August 23, 1971, at which time the water was very clear. To mile 0.75 the streambed is composed of suitable gravel. This changes to heavier materials as the gradient increases, up to mile 1.2. From this point to the outlet of James Lake, at mile 5.5, the gradient is moderate and the substrate is composed of suitable gravel. James Lake is small (60 acres) and shallow with a mud bottom. Above the lake inlet, for about one-third of a mile, the streambed consists of mud and sand. From this point, mile 5.9, to the outlet of Pacific Lake, at mile 8.6, the stream substrate is suitable for salmon spawning (Plate A2-5).

Pacific Lake is approximately 1.5 miles long and 0.4 miles wide. There is little exposed beach as the mountains bordering the lake ascend steeply. The lake is deep and the water clear. One-eighth of a mile upstream is Portage Lake, approximately 1.25 miles long. At the time of the survey there was no flow in the stream between these two lakes.

The estimated amount of suitable spawning gravel in James Creek is 42,425 square yards, theoretically capable of supporting 3,536 chinook salmon (Table A2.3).

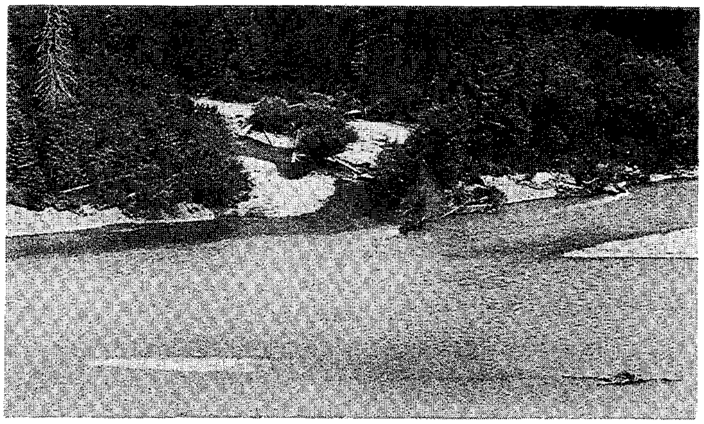
Escapement records for James Creek indicate a run of about 200 chinook salmon; distribution is scattered from the creek mouth to Pacific Lake. Spawning commences in early August, peaks in mid-August and is complete by the end of September. On August 23, 1971, one hundred and fifty chinook salmon were observed in a pool at mile 0.5.

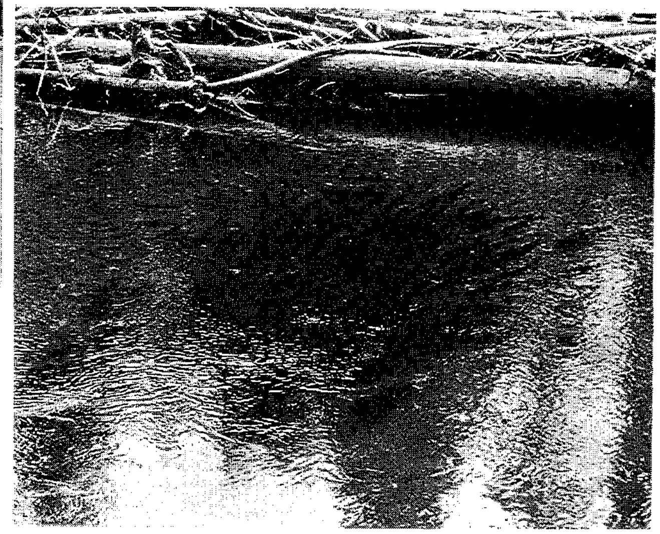
Juvenile chinook were also observed amid the protective cover of logs and debris of this pool. Three juveniles were caught; they ranged in length from 3.9 cm. to 6.0 cm., and in weight from 0.7 gm. to 3.1 gm. Spawning chinook salmon were observed immediately above James Lake.

TABLE A2.3 Potential Spawning Areas: James Creek

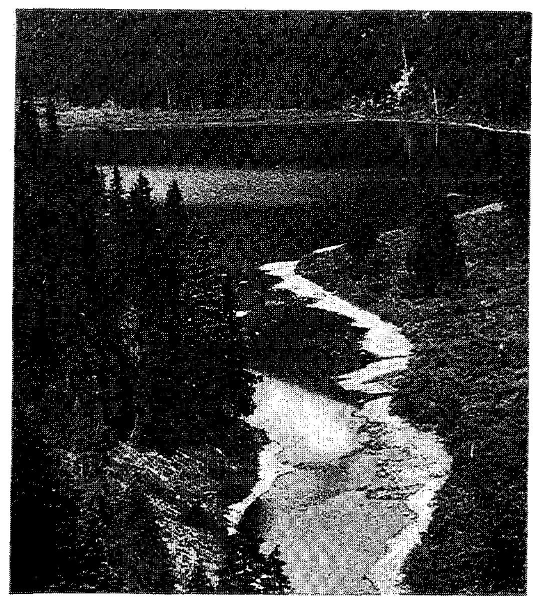
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.75	1,320	12	15,840	9,504	60	792
0.75 - 1.2	792	11	8,712	0	0	0
1.2 - 1.6	704	10	7,040	4,224	60	352
1.6 - 3.5	3,344	8	26,752	10,701	40	892
3.5 - 5.5	3,520	8	28,160	8,448	30	704
5.5 - 5.9	James Lake					
5.9 - 6.2	528	6	3,168	0	0	0
6.2 - 7.75	2,728	5	13,640	9,548	70	796
7.75 - 8.6	1,496	4	5,984	0	0	0
8.6 - 10.1	Pacific Lake					
TOTAL:	14,432	-	109,296	42,425	-	3,536

JAMES CREEK


AT CONFLUENCE WITH HERRICK CREEK


CHINOOK AT MILE 0.5


MILE 1.4


MILE 6, JAMES LAKE OUTLET


MILE 9, PACIFIC LAKE

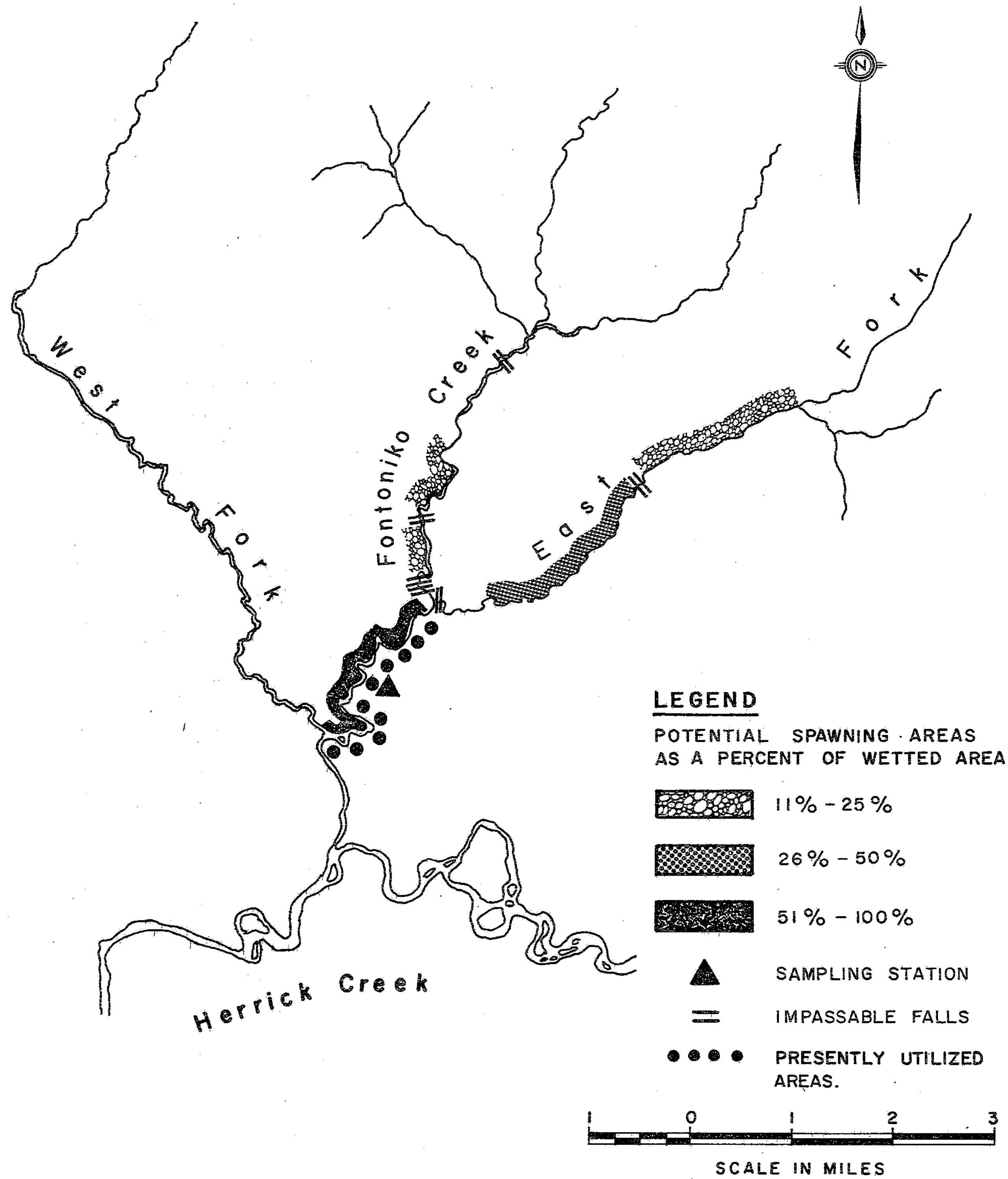


FIG. A2-6 POTENTIAL SPAWNING AREA: FONTONIKO CREEK

FONTONIKO CREEK (FIG. A2-6)

Fontoniko Creek, the largest tributary of Herrick Creek, flows 15 miles southwesterly to its confluence with Herrick at mile 10.5. It is the principal chinook spawning stream in the McGregor River basin.

It is accessible to approximately mile 4.1, at which point there are four separate falls ranging in height from 6 to 12 feet (Plate A2-6). Another falls, some 40 feet high, is at mile 5.0; further upstream at mile 7.5 is yet another falls.

Spawning occurs from mile 1.3 to mile 4.1. On August 17, 1971, 180 chinook salmon were observed in this area. This reach was estimated to contain approximately 148,000 square yards of suitable spawning gravel capable of supporting 12,300 chinook. Above this point are suitable spawning areas, but these are not included in the total potential of Fontoniko Creek.

Fontoniko has two main tributaries (Plate A2-7). The west fork, flows southeasterly into Fontoniko at mile 1.3. This fork originates from ice fields and glaciers to the northwest; the gradient is steep and the stream is turbulent throughout. The stream is so turbid that the stream bottom is barely discernible, but where visible it was composed of large rock and boulders unsuitable for spawning.

The east fork flows southwesterly to join Fontoniko at mile 4.1. It has a falls at its mouth and at mile 2.8. There are suitable spawning areas from mile 0.2 to 2.6 and from mile 2.8 to 4.5. The total amount of suitable spawning area is approximately 107,000 square yards capable of supporting about 8,900 chinook. This amount is not included in the total potential for the McGregor basin.

TABLE A2.4 Potential Spawning Areas: Fontoniko Creek

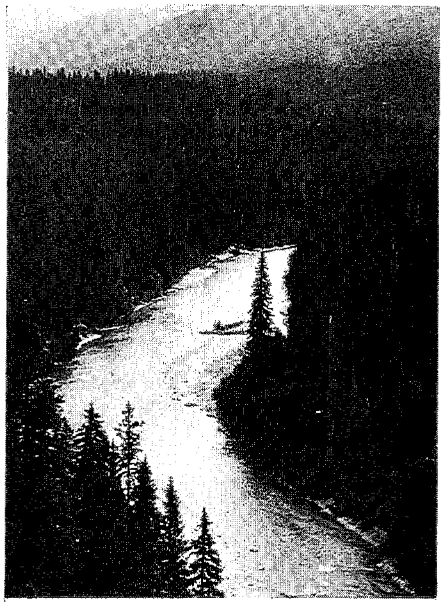
(a) main stem

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.3	2,288	60	137,280	0	0	0
1.3 - 4.1	4,928	50	246,400	147,840	60	12,320
TOTAL:	7,216	-	383,680	147,840		12,320

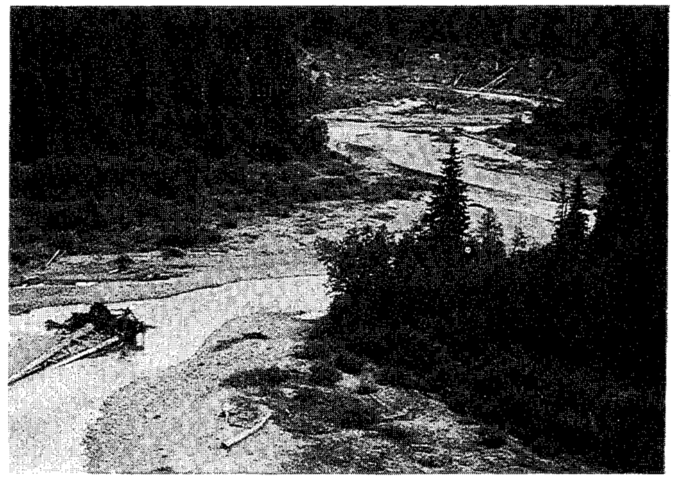
(b) East Fork

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.2	352	50	17,600	0	0	0
0.2 - 2.6	4,224	40	168,960	84,480	50	7,040
2.6 - 2.8	352	40	14,080	0	0	0
2.8 - 4.5	2,992	30	89,760	22,440	25	1,870
TOTAL:	7,920	-	290,400	106,920	-	8,910

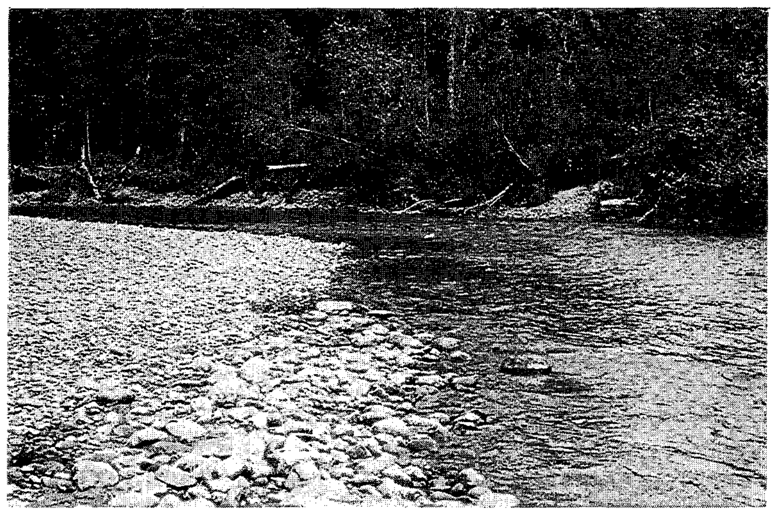
FONTONIKO CREEK



MAINSTEM, MILE 1.0

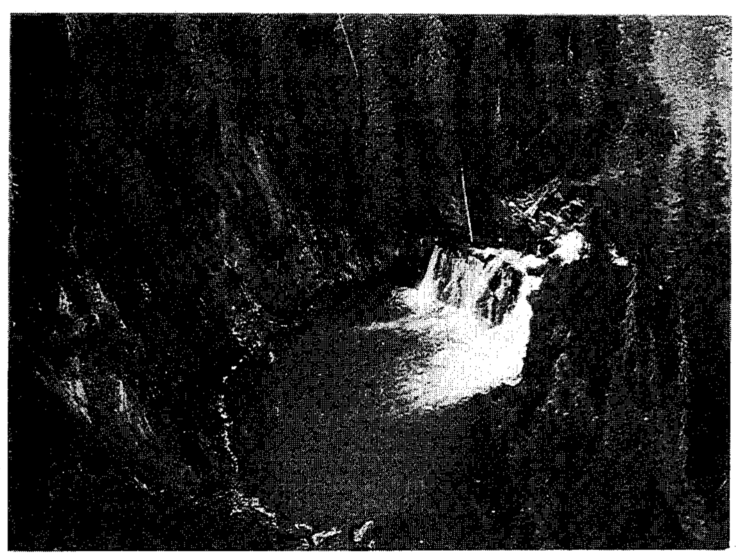


MAINSTEM, MILE 1.5



MAINSTEM, MILE 2.5

MAINSTEM FALLS,
MILE 4.1



MAINSTEM FALLS, MILE 5

FONTONIKO CREEK

MAINSTEM FALLS, MILE 7.5

WEST BRANCH, MILE 7.7

EAST BRANCH FALLS,
MILE 2.8

A2.2.3 STREAMS NOT PRESENTLY UTILIZED

Many streams in this basin which do not presently support anadromous stocks were judged to be suitable for salmon propagation on the basis of their physio-chemical parameters and the presence of suitable spawning gravel.

Those streams tributary to the McGregor River are presented first, in upstream order, and are: Logan, Pass, Gleason, Hedrick, Einar, and Jarvis creeks. The potential spawning areas of these streams are considered to be inaccessible as they are located above the canyonous area at mile 34 on the McGregor.

Herrick Creek and two of its tributaries, Muller and Framstead creeks, are also described, although the potential areas on the latter creeks are inaccessible because of the 60 foot falls at mile 27.5 on Herrick. As previously stated, Herrick Creek itself is not known to support any salmon populations.

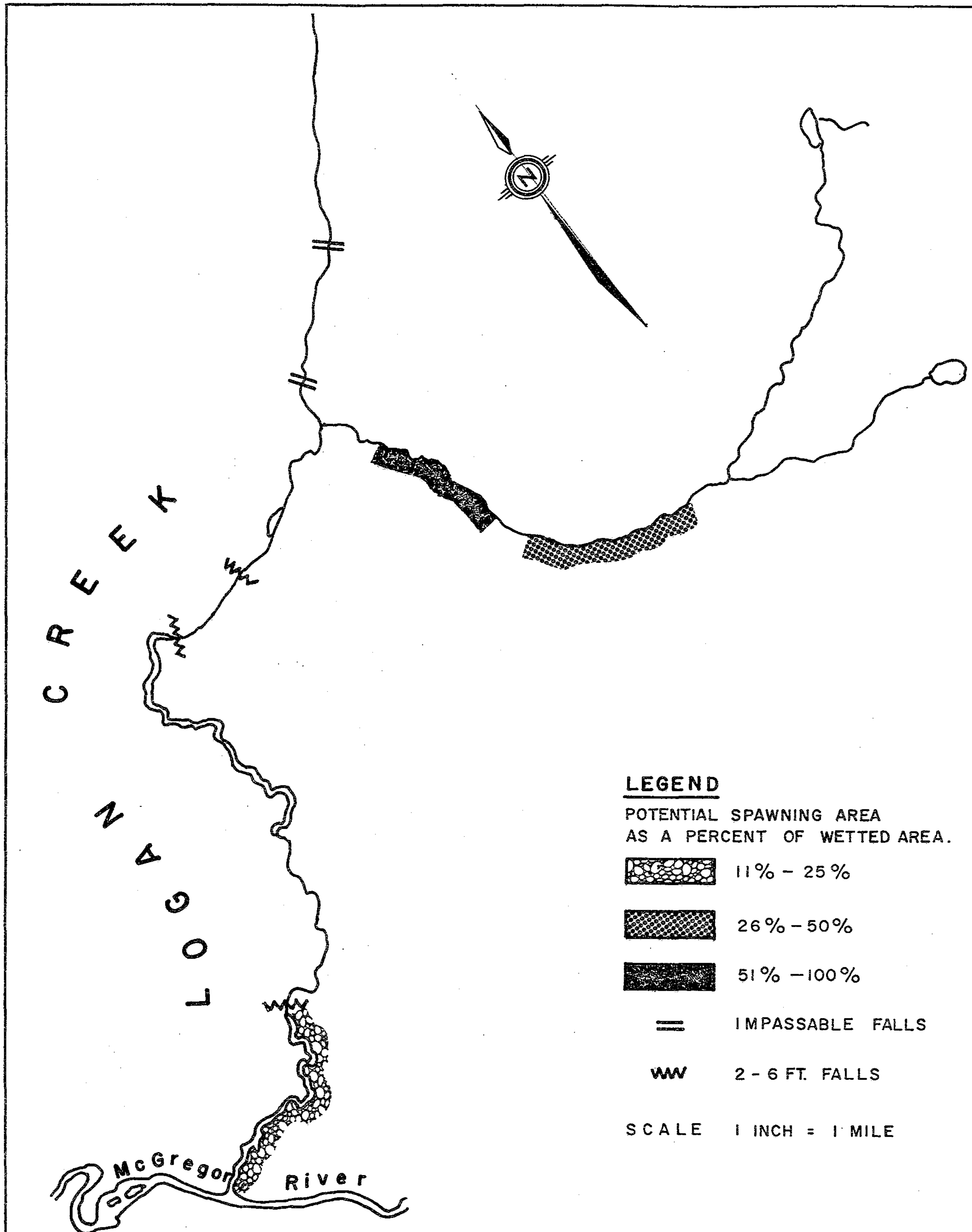


FIG. A2-7 TOTAL POTENTIAL SPAWNING AREA: LOGAN CREEK

LOGAN CREEK (FIG. A2-7)

Logan Creek flows southeasterly for a distance of about 11 miles to its confluence with the McGregor at mile 45 on the latter. At its mouth, the stream is 20 ft. wide; the lower portion is 6 inches to 2 ft. deep. This small, clear stream is accessible to salmon. However, at mile 1.5 to 1.8, there are several falls 2 to 4 ft. high; at mile 6.0 there is a 6-foot falls and at mile 7.0, a 5-foot falls (Plate A2-8).

There are suitable spawning areas to mile 1.6, from mile 8.2 to 9.2 and from mile 9.6 to 10.8; the total potential area is approximately 13,400 square yards with a theoretical spawning capacity of 1,100 chinook. At approximately mile 8.0 a small tributary enters from the northeast. It has no suitable spawning areas.

TABLE A2.5 Potential Spawning Areas: Logan Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Capacity (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.6	2,816	7	19,712	3,942	20	329
1.6 - 8.2	11,264	6	67,584	0	0	0
8.2 - 9.2	1,760	6	10,560	6,336	60	528
9.2 - 9.6	704	6	4,224	0	0	0
9.6 - 10.8	2,112	3	6,336	3,168	50	264
TOTAL:	18,656	-	108,416	13,446	-	1,121

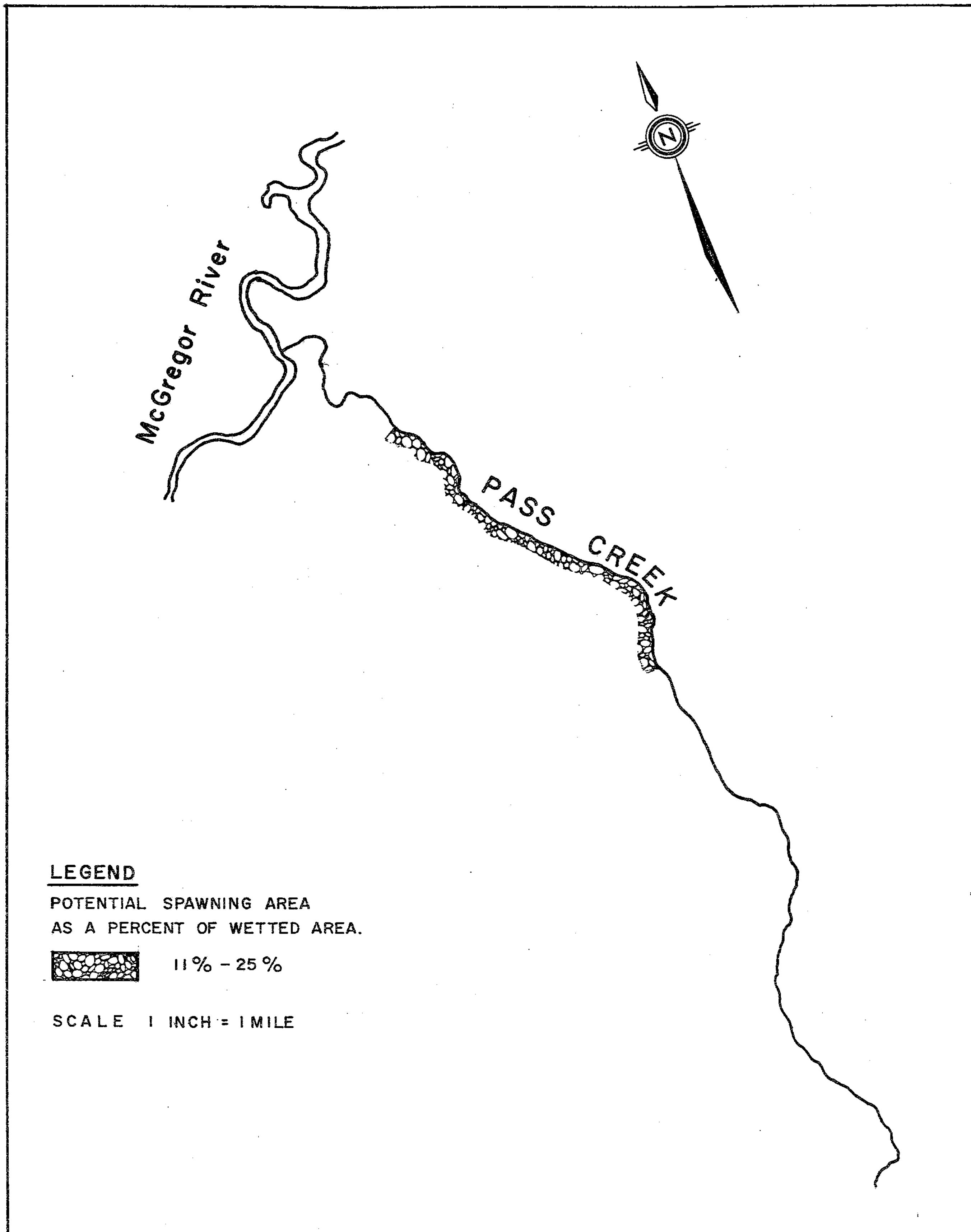


FIG. A2-8 TOTAL POTENTIAL SPAWNING AREA: PASS CREEK

PASS CREEK (FIG. A2-8)

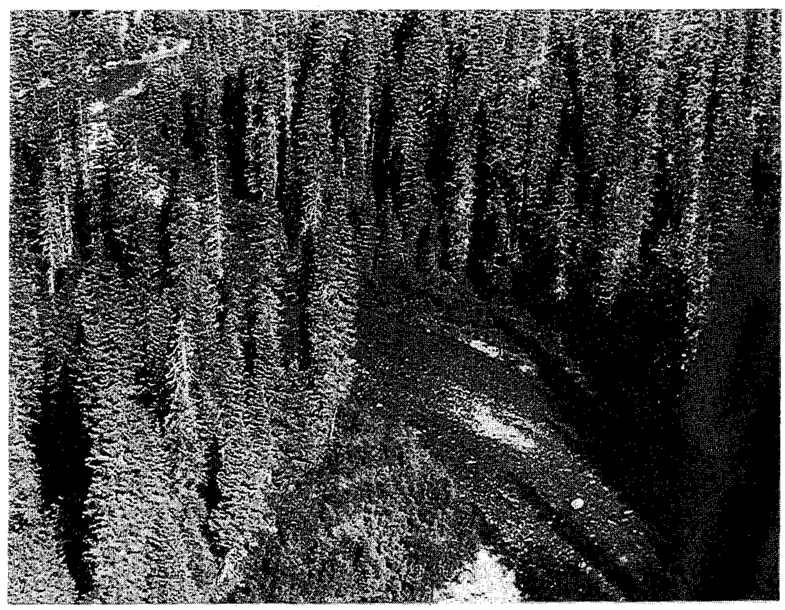
Pass Creek flows 4.7 miles northeasterly into the McGregor River, at mile 48.5. It is a clear-running stream of moderate gradient. Stream depth varies from 6 inches to one foot. To mile 1.3 the streambed is composed of sand and mud. From mile 1.3 to mile 4.1 there is a total of 4,928 square yards of suitable spawning gravel capable of supporting 411 chinook salmon.

TABLE A2.6 Potential Spawning Areas: Pass Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.3	2,288	5	11,440	0	0	0
1.3 - 4.1	4,928	5	24,640	4,928	20	411
4.1 - 4.7	1,056	3	3,168	0	0	0
TOTAL:	8,272	-	39,248	4,928	-	411

LOGAN CREEK

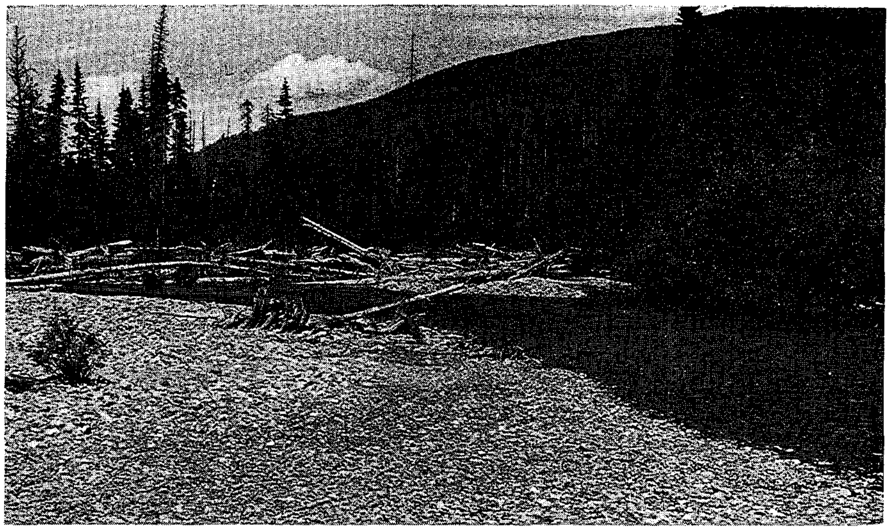
MILE 1.5



MILE 5.3

MILE 6.5

GLEASON CREEK



AT MOUTH

MILE 2.5

MILE 5.7

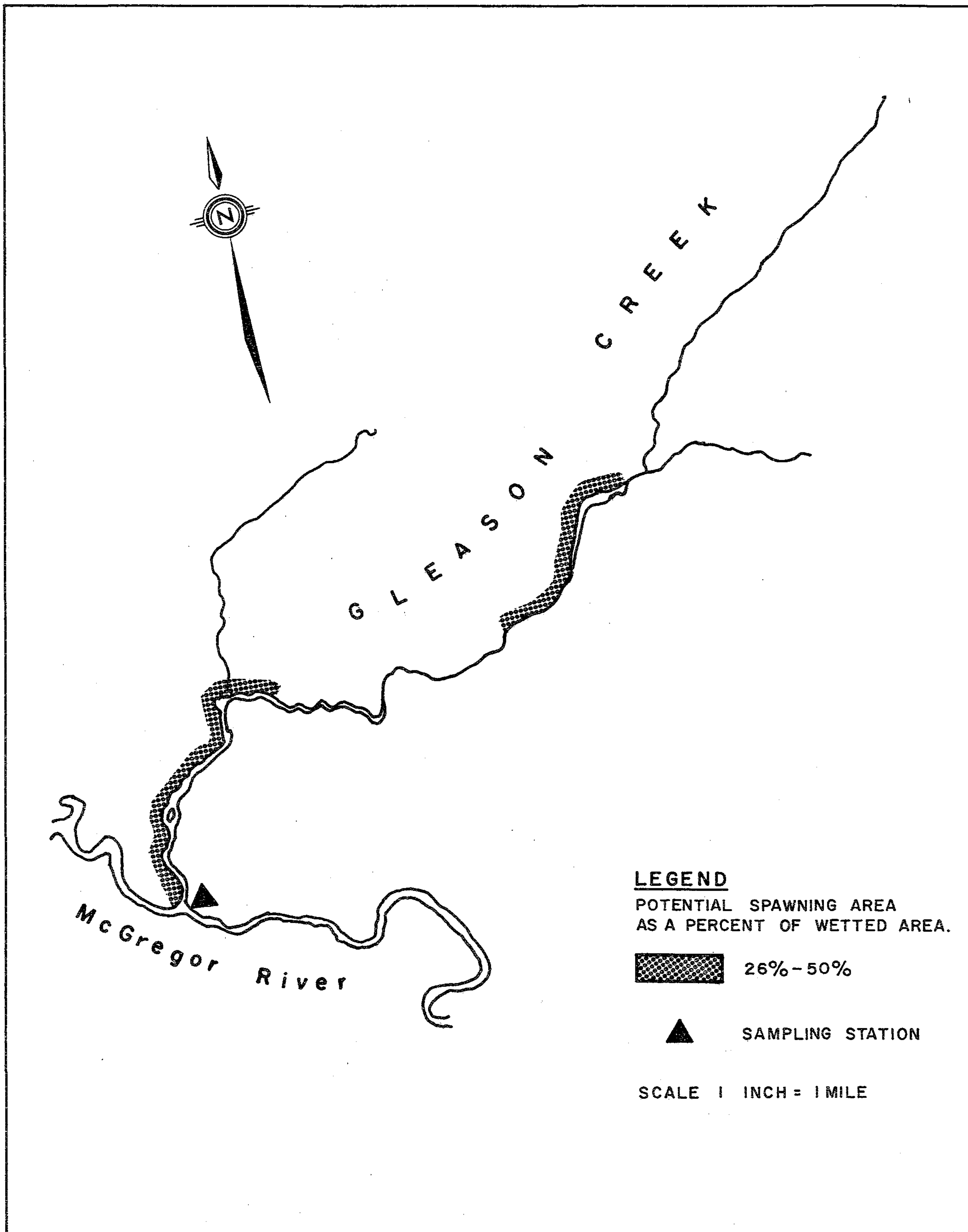


FIG. A2-9 TOTAL POTENTIAL SPAWNING AREA: GLEASON CREEK

GLEASON CREEK (FIG. A2-9)

Gleason Creek flows southerly 9.1 miles into the McGregor River at approximately mile 52 of the latter. On August 19, 1971, the creek water was clear. The lower 2 miles of stream has a moderate gradient with suitable spawning gravel, 1 to 6 inches in diameter. From mile 2.0 to 4.0, the gradient increases, and the streambed is composed of gravel over 8 inches and boulders. Above mile 4.0 the stream passes through mountain meadows to mile 5.6; in this reach the gravel is suitable for spawning (Plate A2-9). From mile 5.6 to the stream source the stream gradient increases and the substrate becomes unsuitable for spawning.

The estimated potential spawning area of Gleason Creek is 22,528 square yards theoretically capable of supporting 1,877 chinook salmon.

TABLE A2.7 Potential Spawning Areas: Gleason Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 2.0	3,520	8	28,160	14,080	50	1,173
2.0 - 4.0	3,520	7	24,640	0	0	0
4.0 - 5.6	2,816	6	16,896	8,448	50	704
5.6 - 9.1	6,160	3	18,480	0	0	0
TOTAL:	16,016	-	88,176	22,528	-	1,877

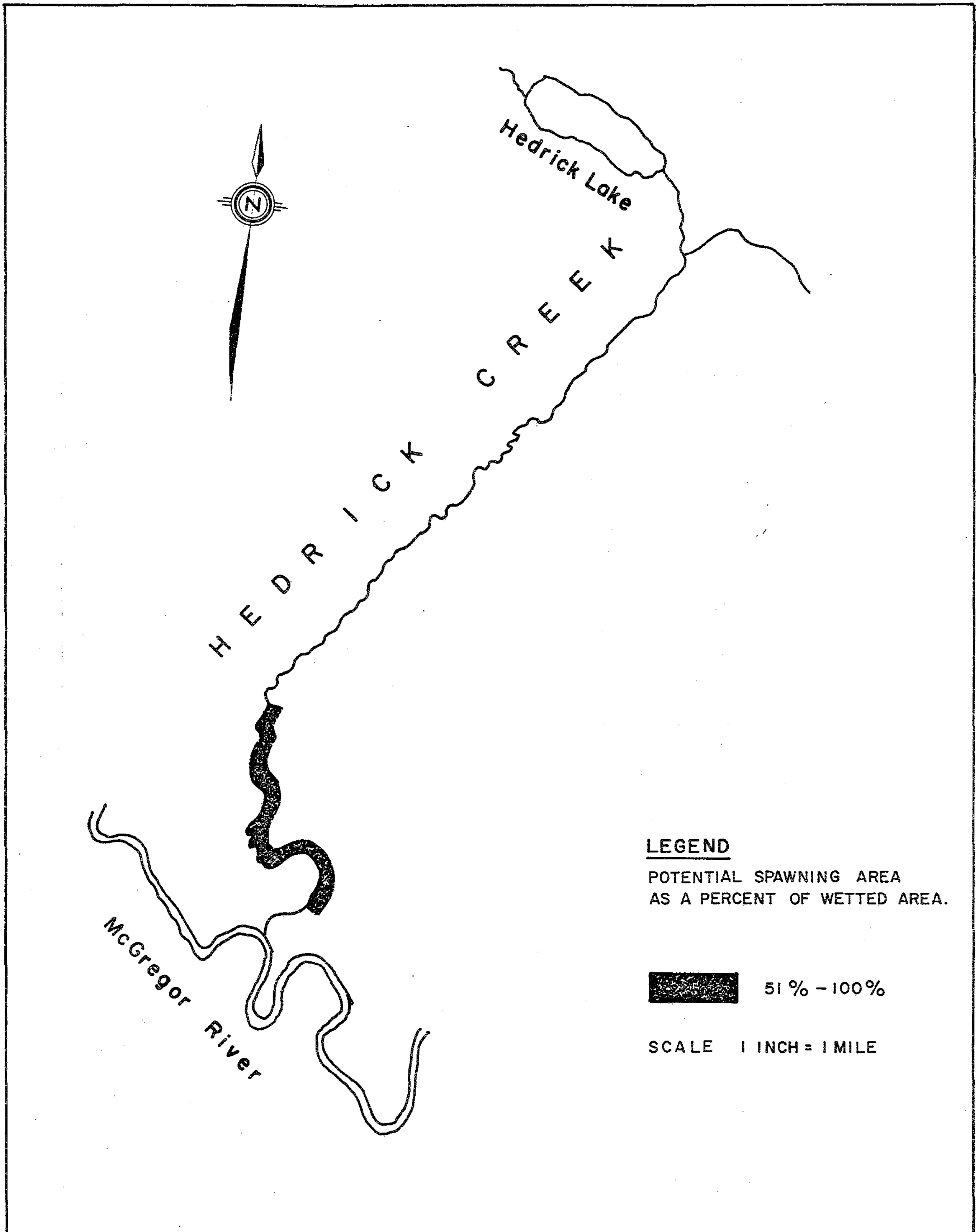


FIG. A2-10 TOTAL POTENTIAL SPAWNING AREA: HEDRICK CREEK

HEDRICK CREEK (FIG. A2-10)

Hedrick Creek flows 8 miles southwesterly to its confluence with the McGregor River, at approximately mile 69. This creek was surveyed on August 28, 1971. It is a small, clear stream with a moderate gradient to mile 2.2. From this point to its source the gradient is steep and the stream is unsuitable for salmon spawning. The substrate in the lower area, to mile 0.2, is composed of sand and mud, but from mile 0.2 to 2.2 are many potential salmon spawning areas. Hedrick Creek contains a total of 19,430 square yards of suitable spawning gravel, capable of supporting 1,619 chinook salmon.

Physio-chemical parameters were not measured as a helicopter landing was not possible.

TABLE A2.8 Potential Spawning Areas: Hedrick Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.2	352	10	3,520	0	0	0
0.2 - 1.8	2,816	10	28,160	16,896	60	1,408
1.8 - 2.2	704	9	6,336	2,534	60	211
2.2 - 8.0	10,208	4.5	45,936	0	0	0
TOTAL:	14,080	-	83,952	19,430	-	1,619

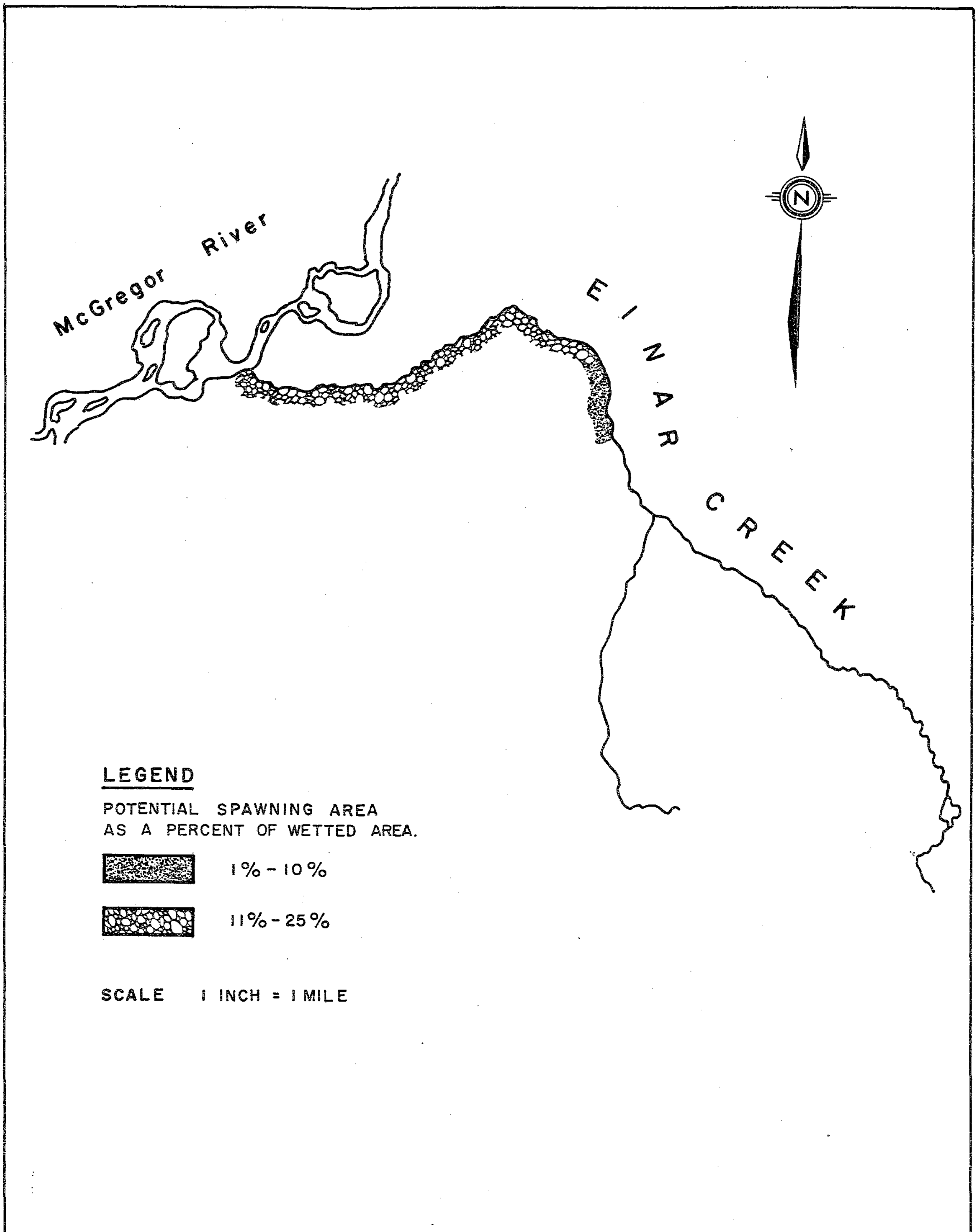


FIG. A2-11 TOTAL POTENTIAL SPAWNING AREA: EINAR CREEK

EINAR CREEK (FIG. A2-11)

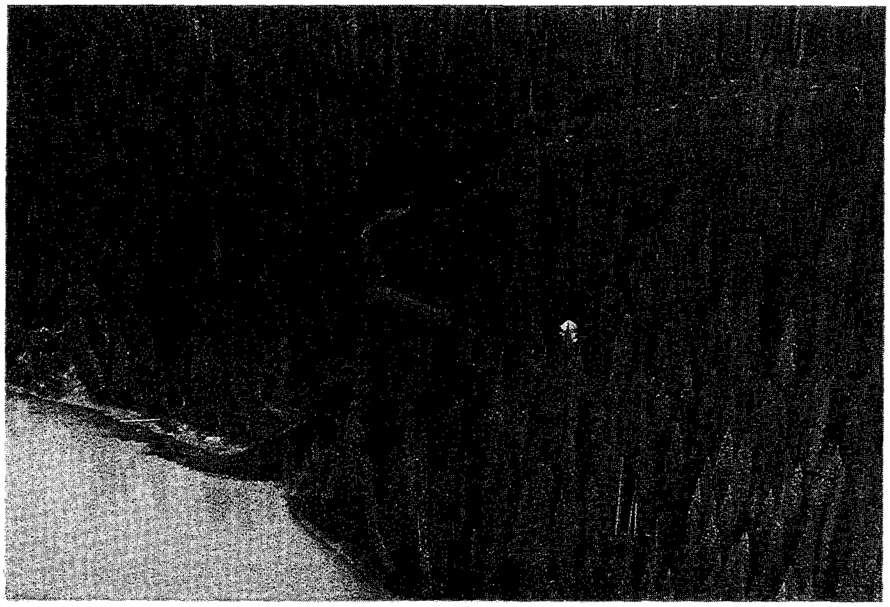
Einar Creek flows 7.2 miles northwesterly to its confluence with the McGregor River, at mile 89.

The stream is small and clear, with suitable gravel to mile 3.25. The estimated total suitable spawning area is 7,040 square yards, theoretically capable of supporting 587 chinook salmon.

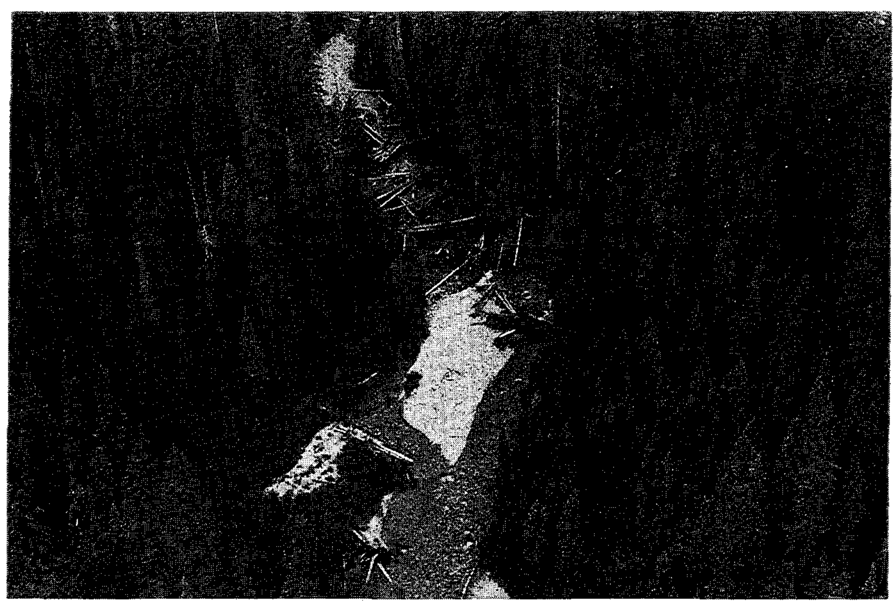
TABLE A2.9 Potential Spawning Areas: Einar Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 2.75	4,840	7	33,880	6,776	20	565
2.75 - 3.25	880	6	5,280	264	5	22
3.25 - 7.2	6,952	3	20,856	0	0	0
TOTAL:	12,672	-	60,016	7,040	-	587

HEDRICK CREEK



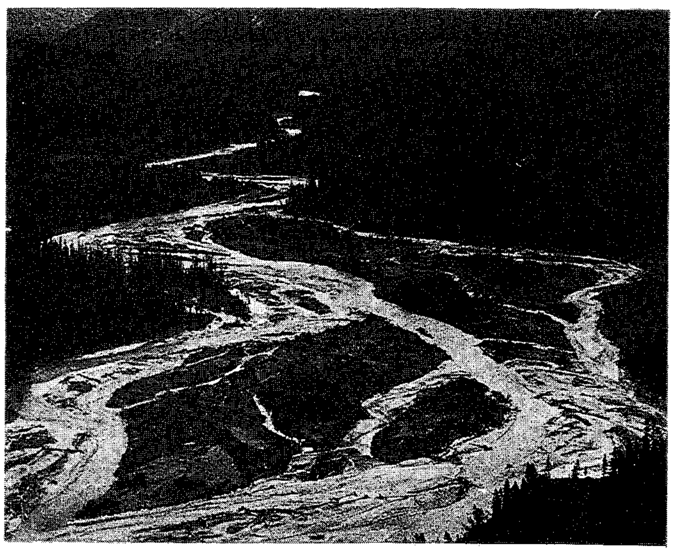
AT MOUTH



MILE 1.5

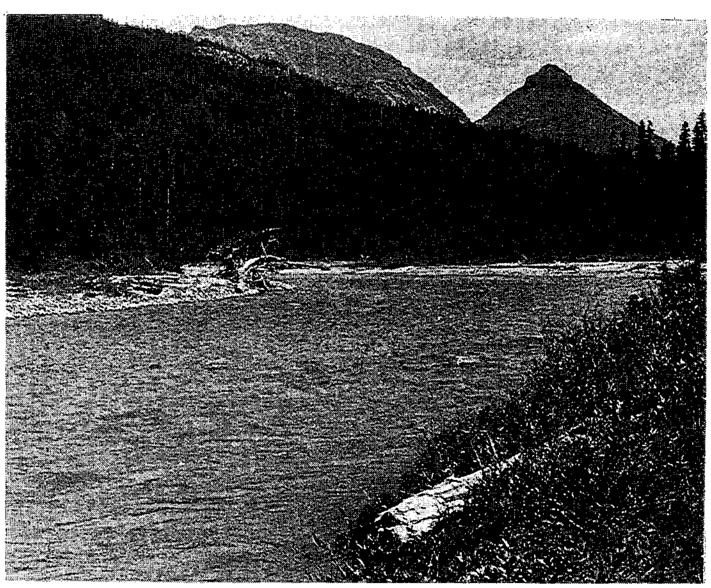
JARVIS CREEK

AT MOUTH



BRAIDED SECTION, MILE 3

MILE 11.5



MILE 13

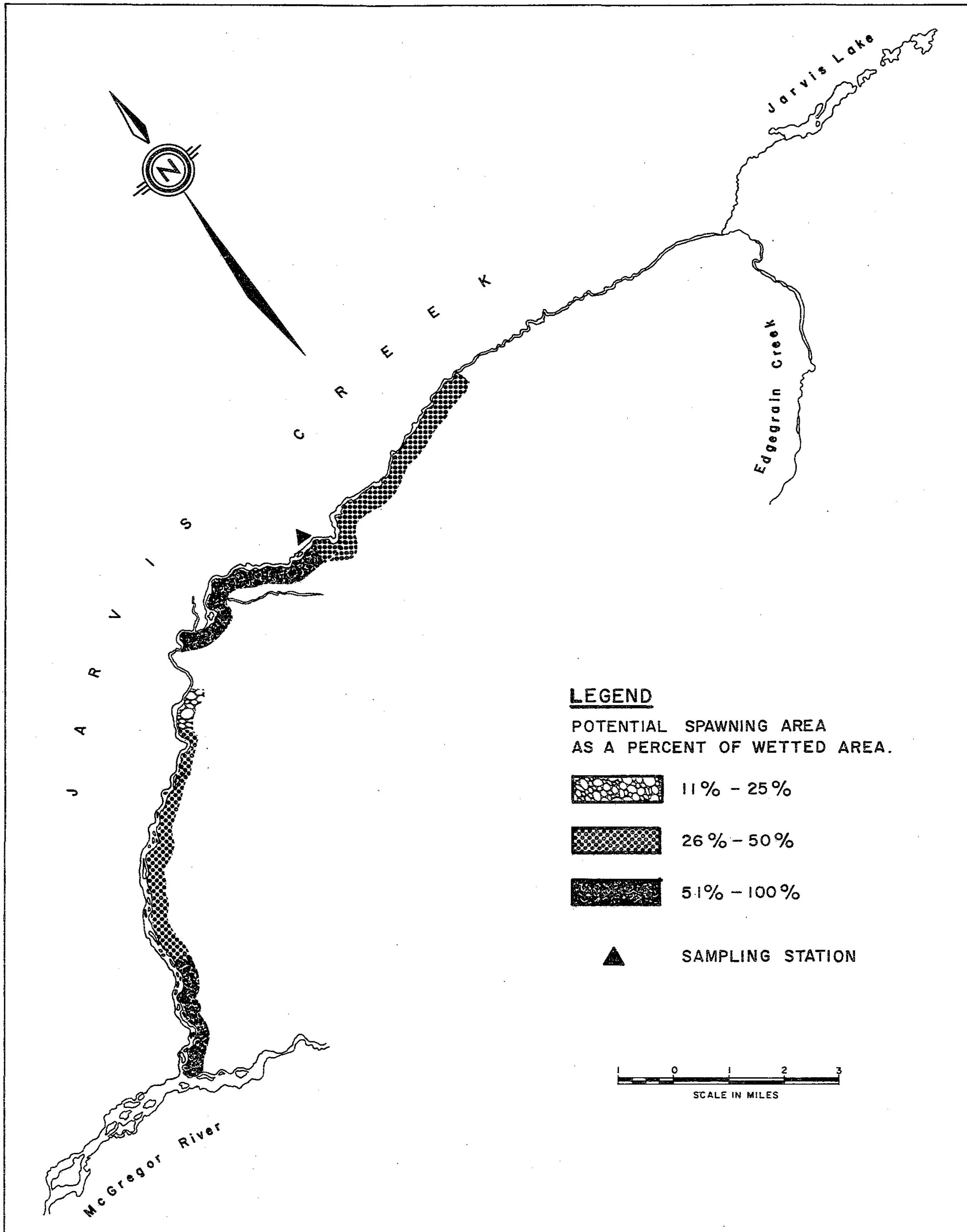


FIG. A2-12 TOTAL POTENTIAL SPAWNING AREA: JARVIS CREEK

JARVIS CREEK (FIG. A2-12)

Jarvis Creek flows in a southwesterly direction for 24.7 miles to its confluence with the McGregor River at mile 96. The lower reaches of this stream consist of a side flood plain where the stream flows through several channels (Plate A2-11).

Visibility of the stream bottom was poor and the amount of suitable spawning gravel was estimated from the composition of exposed bars and stream banks; silt deposits were very noticeable around the boulders edging the stream. The total estimated spawning area is 341,484 square yards, capable of supporting 28,457 chinook salmon.

TABLE A2.10 Potential Spawning Areas: Jarvis Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 2.25	3,960	30	118,800	71,280	60	5,940
2.25 - 4.9	4,664	30	139,920	62,964	45	5,247
4.9 - 6.9	3,520	30	105,600	36,960	35	3,080
6.9 - 7.8	1,584	30	47,520	7,128	15	594
7.8 - 9.0	2,112	30	63,360	0	0	0
9.0 - 12.4	5,984	30	17,952	107,712	60	8,976
12.4 - 17.0	6,336	25	158,400	55,440	35	4,620
17.0 - 24.7	13,552	12.5	169,400	0	0	0
TOTAL:	41,712	-	820,952	341,484	-	28,457

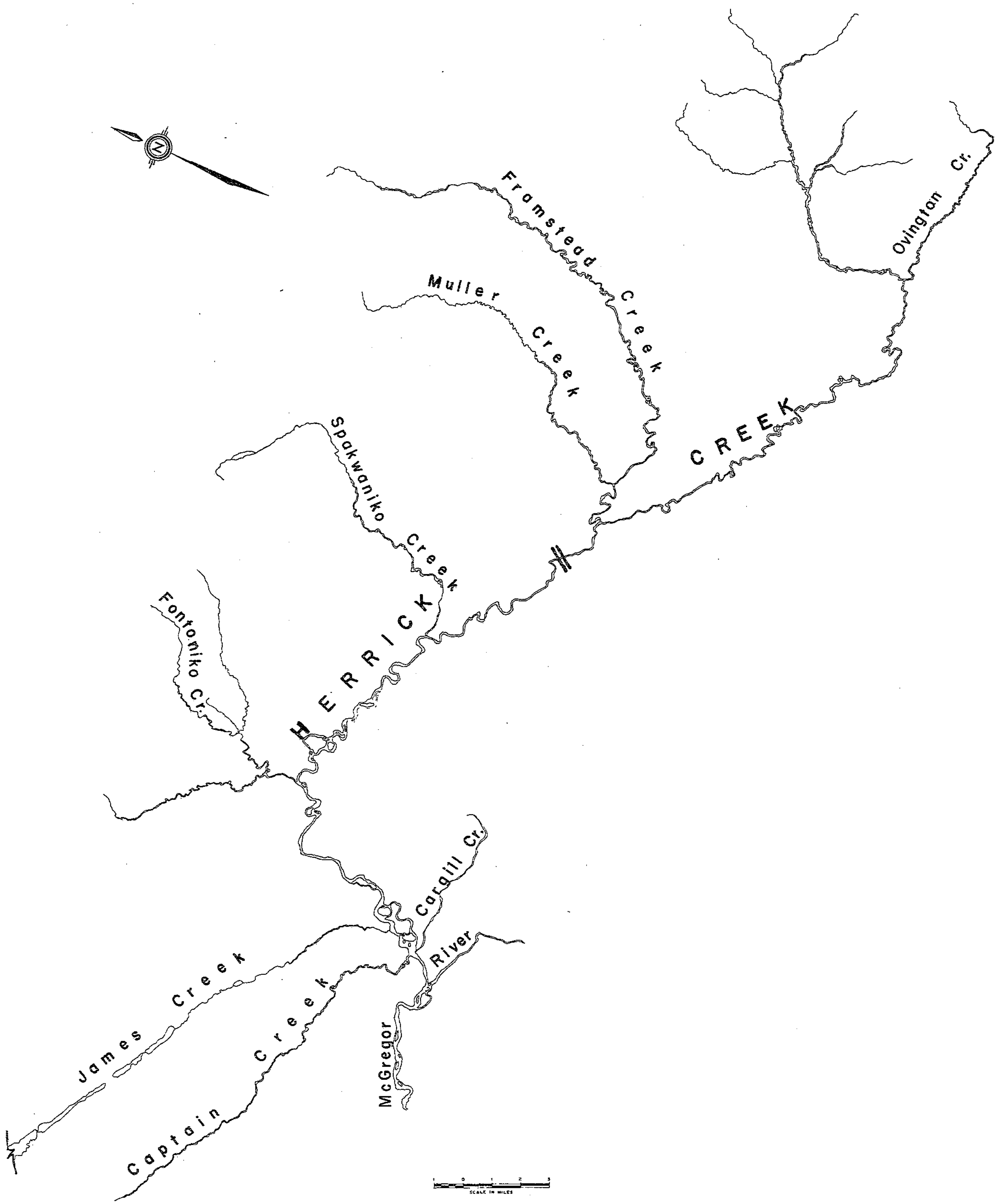


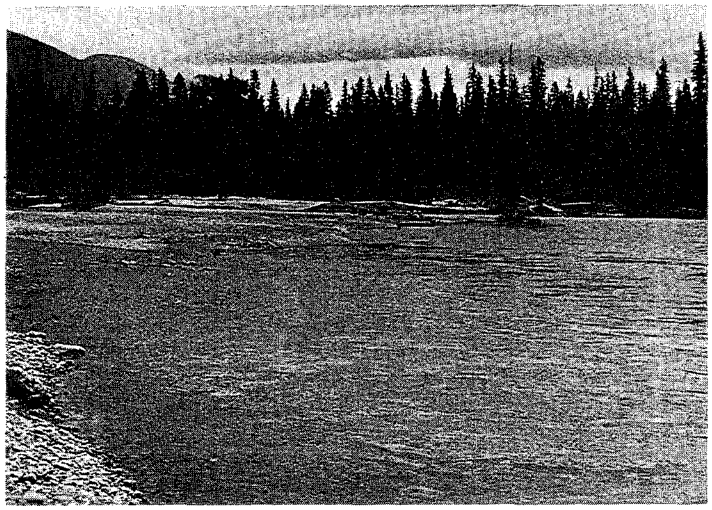
FIG. A2-13 HERRICK CREEK AND TRIBUTARIES

HERRICK CREEK (FIG. A2-13)

Herrick Creek is the north fork of the McGregor River. It flows through a two-mile wide valley, for approximately 64 miles in a southwesterly direction to its confluence with the McGregor approximately 34 miles from the mouth of the latter. Herrick is passable to salmon to about mile 27.5 where there is a 60 foot falls (Plate A2-12).

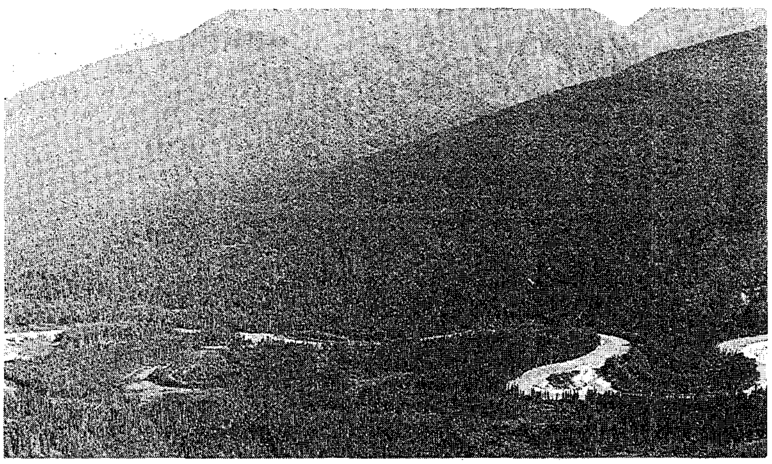
Herrick Creek is turbid and the streambed is not discernible. As a result no accurate estimate of the amount of suitable spawning gravel was made. It is generally accepted that no spawning occurs in Herrick Creek and that it is used only as a migrational route. However, the physical and chemical characteristics of Herrick Creek measured near the mouth of James Creek are similar to those of the Fraser River at the Tête Jaune spawning grounds.

HERRICK CREEK

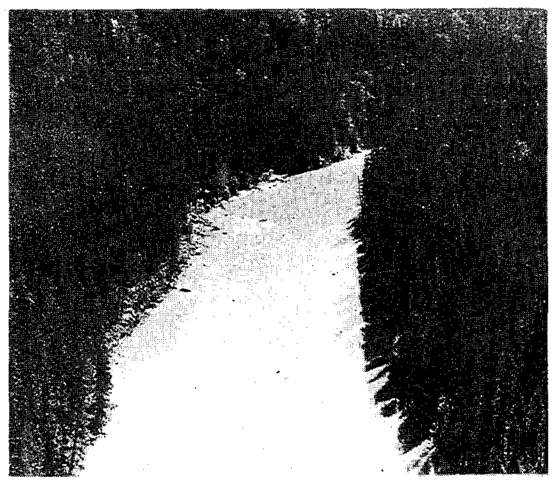


MILE 2.3

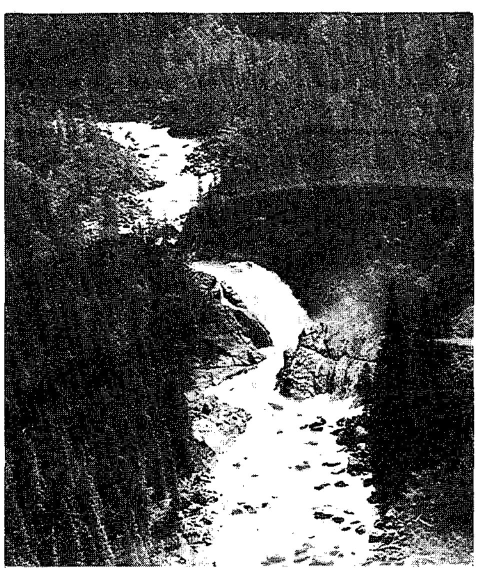
MILE 12.3



MILE 16.8



MILE 22.3



WATERFALL, MILE 27.5

RAPIDS, MILE 26.3

FRAMSTEAD CREEK (FIG. A2-14)

Framstead Creek flows southwesterly for a distance of 36.4 miles to its confluence with Herrick Creek at approximately mile 30 on the latter. There is a 10 foot falls at the creek mouth.

On August 19, 1971, the water was exceptionally clear. The stream gradient is moderate to mile 22, after which it increases and the substrate is composed of very large boulders and bedrock unsuitable for salmon spawning. In the lower reaches of the stream are many excellent spawning areas. However, access to these areas is obstructed by a 10 foot falls at mile 7.5, two falls at mile 16.0, and mile 20.2, and at mile 23.4 the stream rises 75 ft. over a series of falls (Plate A2-13).

The estimated potential spawning area in Framstead Creek is 381,818 square yards, capable of supporting a theoretical escapement of 31,818 chinook salmon. Only that portion of potential area to mile 7.5 is included in the inaccessible potential for the McGregor basin.

TABLE A2.11 Potential Spawning Areas: Framstead Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 7.5	13,200	28	369,600	221,760	60	18,480
7.5 - 9.0	2,640	28	73,920	29,568	40	2,464
9.0 - 11.0	3,520	28	98,560	24,640	25	2,053
11.0 - 12.1	1,936	23	44,528	26,717	60	2,227
12.1 - 14.0	3,344	17	56,848	5,684	10	474
14.0 - 14.2	352	17	5,984	4,488	75	374
14.2 - 16.3	3,696	17	62,832	15,708	25	1,309
16.3 - 20.2	6,864	13	89,232	26,770	30	2,231
20.2 - 22.0	3,168	12	38,016	15,206	40	1,267
22.0 - 24.3	4,048	10	40,480	0	0	0
24.2 - 25.9	2,816	10	28,160	11,264	40	939
25.9 - 36.4	18,480	5	92,400	0	0	0
TOTAL:	64,064	-	1,000,560	381,805	-	31,818

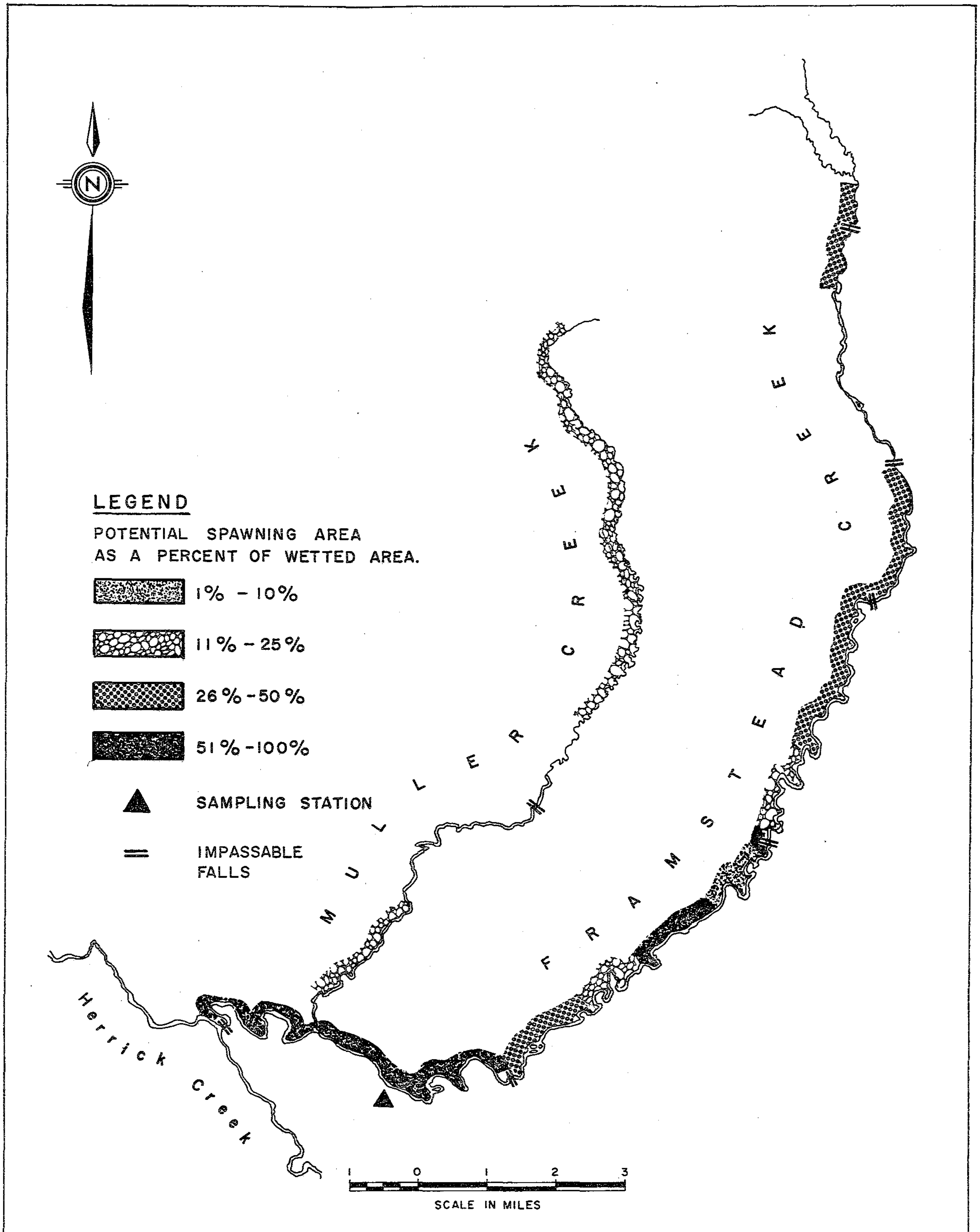


FIG. A2-14 TOTAL POTENTIAL SPAWNING AREA: FRAMSTEAD AND MULLER CREEKS

MULLER CREEK (FIG. A2-14)

Muller Creek flows southwesterly 16.1 miles into Framstead Creek at approximately mile 2.5 of the latter. It is not accessible because of the falls on Herrick Creek at mile 27.5 and at the mouth of Framstead Creek.

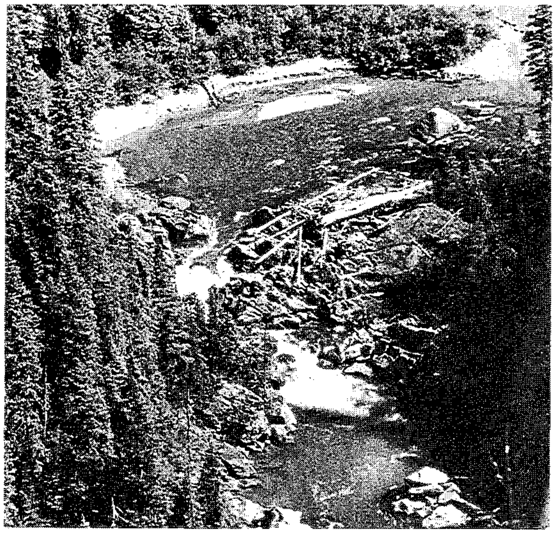
On August 19th, 1971, the water of this creek was clear. Muller Creek itself is passable for a distance of 5.5 miles at which point the stream drops a vertical distance of about 100 feet over a series of falls (Plate A2-14). Suitable spawning areas exist from mile 0.5 to 2.3, as well as above the falls from mile 7.3 to 15.0.

There is a total potential capacity of approximately 2,044 chinook in an estimated spawning area of 24,526 square yards. Only that portion of the stream below the falls at mile 5.5 is included in the inaccessible potential figures of the McGregor Basin.

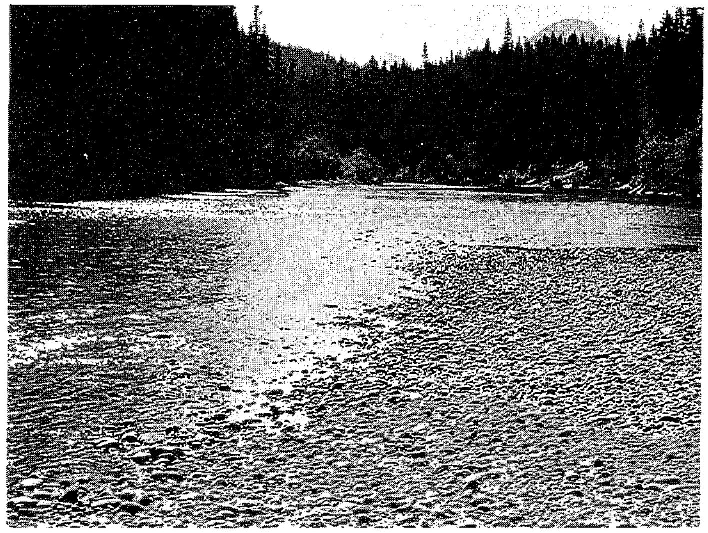
TABLE A2.12 Potential Spawning Areas: Muller Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
0.0 - 0.5	880	13	11,440	0	0	0
0.5 - 2.3	3,168	13	41,184	10,296	25	858
2.3 - 5.7	5,984	12	71,808	0	0	0
5.7 - 7.3	2,816	8	22,528	0	0	0
7.3 - 15.0	13,552	7	94,864	14,230	15	1,186
15.0 - 16.1	1,936	4	7,744	0	0	0
TOTAL:	28,336	-	249,568	24,526	-	2,044

FRAMSTEAD CREEK

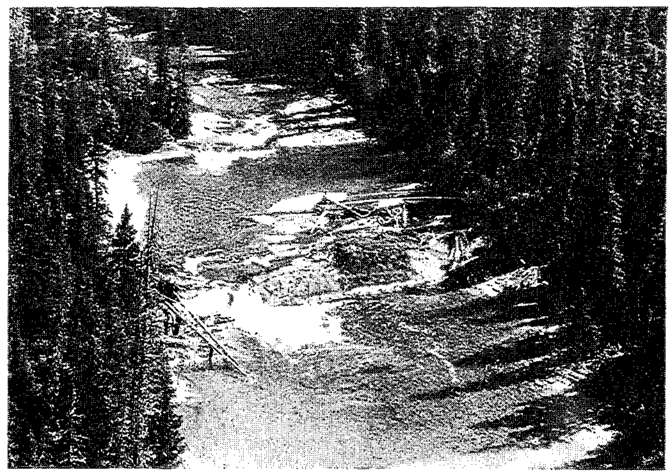


AT MOUTH



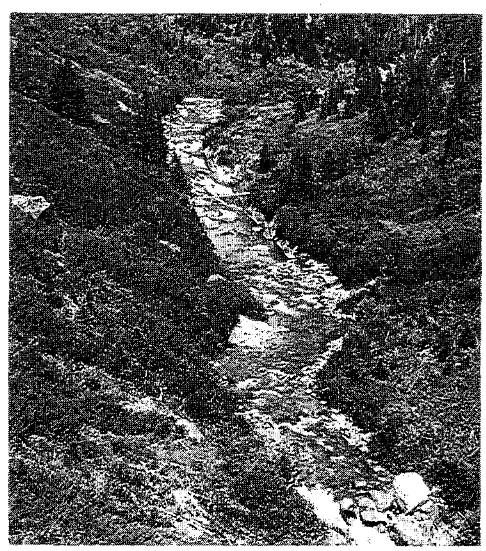
SAMPLING SITE, MILE 4.5

MILE 9.0



MILE 21.0

MILE 27.0



MILE 23.8

MULLER CREEK

AT MOUTH

MILE 3.3

WATERFALL, MILE 5.5

MILE 7.5

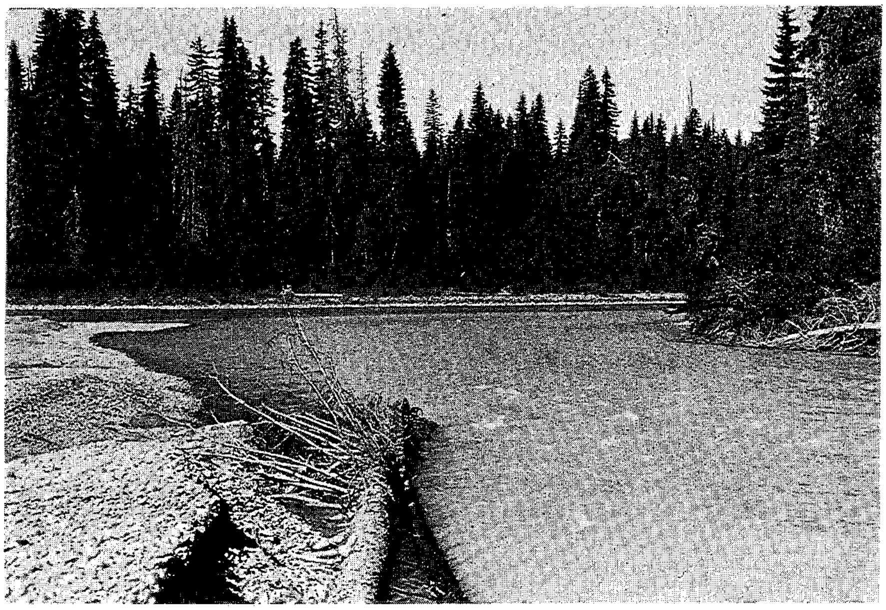
A.2.2.4 TRIBUTARIES WITH NO POTENTIAL

Spakwaniko and Kitchi creeks are regarded as having no salmon propagation potential. Spakwaniko Creek flows southwesterly for 13.1 miles to its confluence with Herrick Creek at approximately mile 20 on the latter. A canyonous area at mile 1.5, extending some 200 yards, and having a 75 foot falls, blocks salmon migration (Plate A2-15). At the time of the survey on August 19, 1971, this creek was very turbid with glacial melt and the composition of the substrate could not be determined. Exposed areas had noticeable silt deposits intermixed with the gravel.

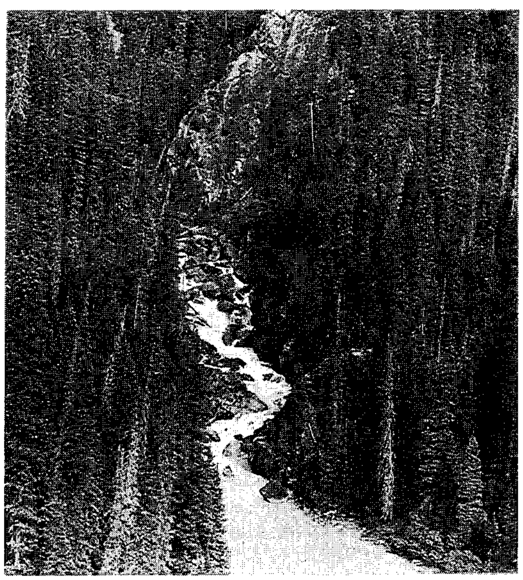
Kitchi Creek flows 12.25 miles in a westerly direction to its confluence with the McGregor River, at mile 100. The lower reaches of Kitchi Creek consist of broad flood plain with several channels (Plate A2-16). This stream was extremely turbid and the streambed was not visible.

Other streams in this basin were documented during the field survey as having no potential: Barbara, Bastille and Buchanan creeks contain no suitable gravel areas and have precipitous stream gradients; Cargill, Deafy and Severeid creeks have insufficient discharge levels; Harvie and Idol creeks have low levels of fast water; the streambed of McCullagh Creek is composed of boulders and large rock.

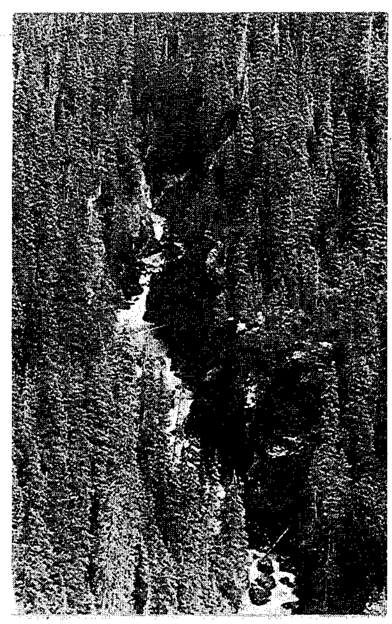
SPAKWANIKO CREEK



SAMPLING SITE AT MOUTH

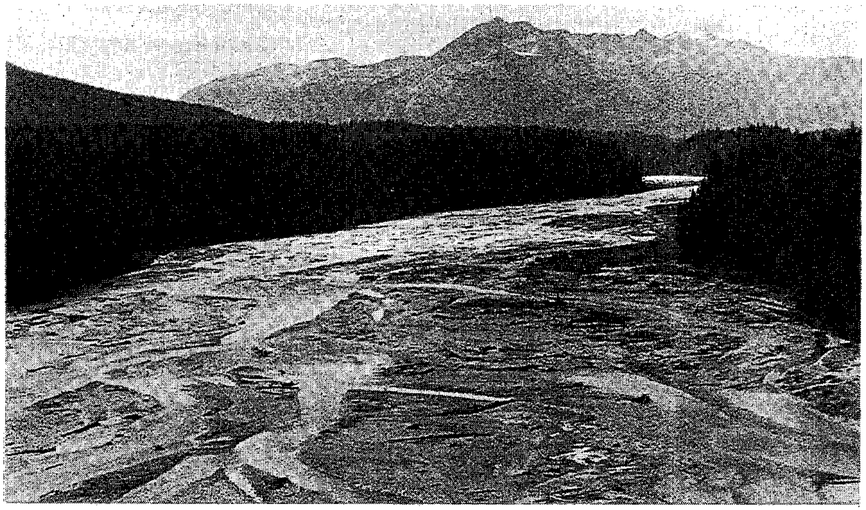


FALLS, MILE 1.5



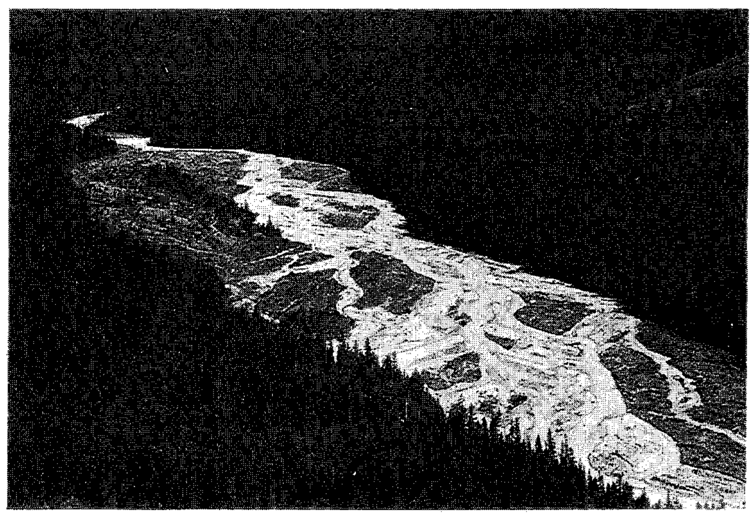
RAPIDS, MILE 1.8

KITCHI CREEK

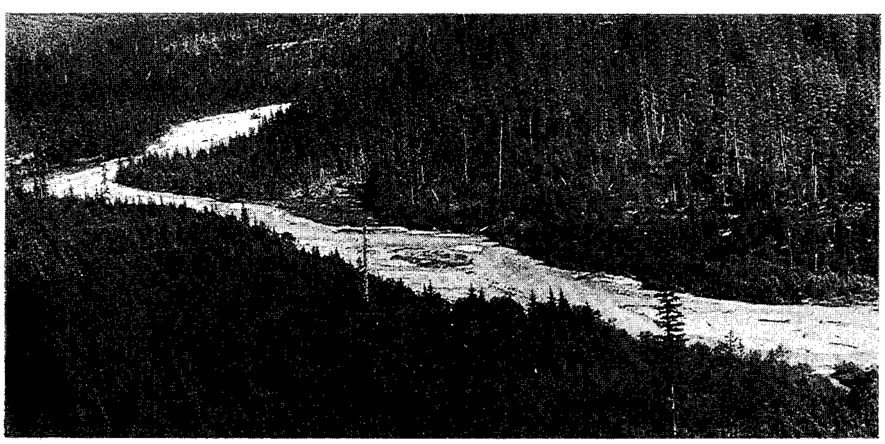


BRAIDED SECTION, MILE 2

MILE 7.3



BRAIDED AREA, MILE 5.3



MILE 8.0

A2.3 PHYSIO-CHEMICAL MEASUREMENTS

A summary of the physical and chemical parameters of the streams surveyed in the McGregor River basin are described in Table A2-13. The topography of the basin precluded extensive sampling as suitable helicopter landing sites were limited.

Eight streams were sampled; Captain Creek was tested at two sites. The water depth varied from 0.5 to 3.5 feet and current velocity ranged from 1.12 to 6.50 fps. Discharge volumes were extremely widespread, ranging from 18 to 1770 cfs. Water temperatures ranged from 45.5 degrees F. for streams of glacial origin, such as Jarvis Creek, to 64.5 degrees F. for lake-fed streams, such as Otter Creek.

Surface water dissolved oxygen concentrations ranged from 7 to 11 ppm, well above the lower tolerance limit for salmonids. Hydrogen ion concentrations (pH) were uniform, ranging from 7.1 to 7.4. The level of suspended sediment ranged from 2 to 45 ppm.

TABLE A2.13 Physical and Chemical Characteristics of Major Streams in the McGregor River Basin

STREAM	SAMPLING DATE (1971)	SAMPLING LOCATION*	DEPTH RANGE (ft.)	VELOCITY** (fps)	FLOW VOLUME (cfs)	TEMP. (°F)	DISS. OXYGEN CONCENTRATION (ppm)	DISS. SOLIDS CONCENTRATION (ppm)	SUSPENDED SEDIMENT (ppm)	pH
CAPTAIN CR.	Aug. 16	13.1	0.5-1.0	1.63	18.3	58.5	7	110	2	7.2
CAPTAIN CR.	Aug. 17	mouth	0.5-1.5	1.12	58.0	59.5	8	-	-	7.2
FONTONIKO CR.	Aug. 17	2.4	0.5-3.5	3.86	278.0	52.5	10	65	6	7.2
JAMES CR.	Aug. 17	0.5	0.5-1.5	1.37	52.1	57.0	9	116	6	7.2
OTTER CR.	Aug. 16	9.0	0.5-1.5	1.52	48.6	64.5	8	62	11	7.2
FRAMSTEAD CR.	Aug. 19	4.4	0.5-1.5	4.26	375.0	56.5	9	103	11	7.4
GLEASON CR.	Aug. 19	mouth	0.5-2.5	3.95	178.0	50.0	10	-	-	7.4
HERRICK CR.	Aug. 23	near James Creek	n.d.	3.57	1,770.0	51.0	9	87	21	7.1
JARVIS CR.	Aug. 28	13.1	n.d.	4.90	833.0	45.5	11	70	3	7.2
KITCHI CR.	Aug. 28	1.0	n.d.	6.50	743.0	51.0	9	66	45	7.3

* Distance in miles from stream mouth.
** Instantaneous velocity measured at sampling station.
n.d. Not determined due to excessive turbidity.

APPENDIX A3

CARIBOO RIVER BASIN

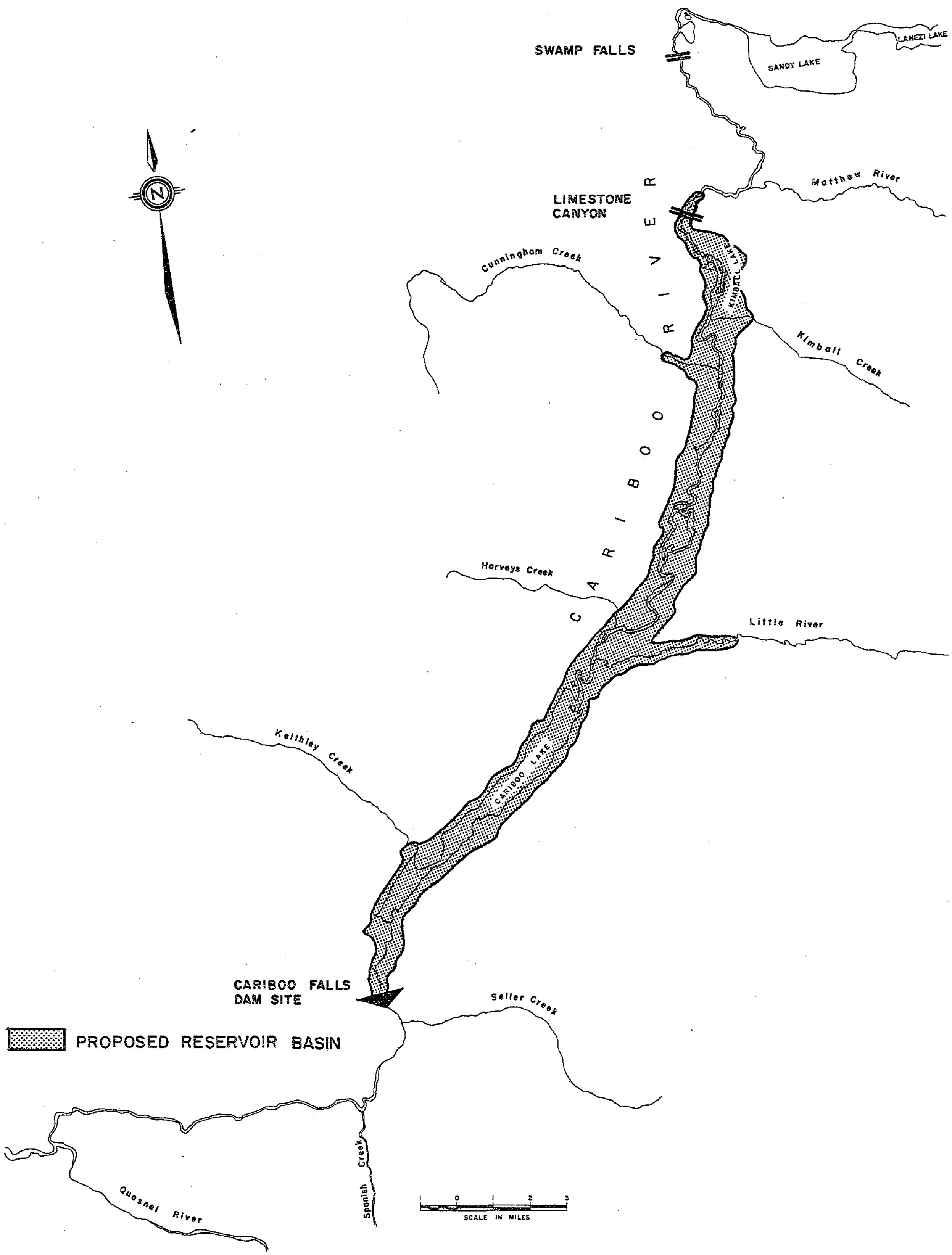


FIG. A3-1 CARIBOO RIVER BASIN

A 3 CARIBOO RIVER BASIN (FIG. A3-1)

This section of Appendix A contains a description of the Cariboo River drainage basin, the main stem Cariboo and the field survey stream evaluations. A summary of the water quality parameters is presented in section A3.3.

A3.1 DESCRIPTION OF DRAINAGE BASIN

A3.1.1 GENERAL

The Cariboo River drainage is 250 air miles northeast of Vancouver. Rising in the Cariboo Mountains, the river drains Isaac, Lanezi, and Sandy lakes in Bowron Provincial Park and flows in a southwesterly direction across the Quesnel Highland for thirty miles to Cariboo Lake and then an additional 14 miles to its confluence with the Quesnel River at Quesnel Forks. In total, the Cariboo River drains approximately 1,400 square miles. The river gradient is variable. From the Park Lakes it drops 400 feet in 10 miles before reaching Kimball Lake. This section has two fast water areas: Swamp Falls (0.75 miles south of Unna Lake) and Limestone Canyon (8 miles south of Unna Lake). The river gradient then lessens substantially, dropping only 75 feet in 20 miles before entering Cariboo Lake. From the outlet of this lake, the Cariboo River descends 350 feet in 14 miles before intersecting the Quesnel River. The river is bordered by Columbia rain forest along most of its length grading towards Cariboo parklands below Cariboo Lake.

A3.1.2 RESERVOIR BASIN

The proposed reservoir basin stretches from a narrow walled canyon 2.5 miles south of the Cariboo Lake outlet and extends northeast through Cariboo Lake, and up the Cariboo River to Limestone Canyon, some 40 miles above the dam site. The lower three miles of the Little River would also be inundated.

A3.1.3 SOILS

Two major soil types are evident in the Cariboo Valley: the lowlands, below 2,700 ft. and the uplands, above this elevation.

The flat (usually less than 1% slope) lowlands bordering the upper Cariboo River above Cariboo Lake are composed of various sands, silts, and gravels which have been deposited by the annual water fluctuation. During high water, the river banks are breached and the turbid water, having picked up silt and sand in the spring torrents, flows over a large area of the lowland. With the receding waters, the finer material is deposited on the flood plains. Consequently, the dynamic action of the river builds up soils in some areas and erodes in others; soil fertility is continually rejuvenated by new deposition each year. However, new river courses are cut through the highly erodable sands and silts.

These lowlands also contain outwash fans such as the fans created along the upper Cariboo River by Little River and Cunningham, Harvey, and Kimball creeks and on Cariboo Lake at the mouth of Frank and Keithley creeks. These areas have a greater proportion of gravel for the light silts have been washed into the main stem river or Cariboo Lake. Consequently, these fans are better drained than the alluvial silt.

The Cariboo River downstream from Cariboo Lake is not turbid. The suspended matter has settled in the lake and the river contributes no deposits to the lowlands. Without the lubricating properties of silt, the river tends to erode whatever fine material is in the low areas. This process is accelerated by the greater water velocities caused by the steeper gradient. The flood plain is narrow as the steep upland areas rise almost directly from the river.

The uplands, generally with a slope over 20%, are composed of thin podzol soils which have formed under the wet belt coniferous forest.

A3.1.4 TOPOGRAPHY

The area from the proposed dam site to within one mile of Cariboo Lake has steep, mountainous sides rising (20 to 50%) from the river. On the east, the terrain remains precipitous rising to 4,700 feet; on the west, a bench is intercepted at approximately 3,000 ft. elevation.

The balance of the basin is generally characterized by a flat, wide (one-half mile to one and one-quarter mile) valley with steep sides (often 60 to 70%). The valley floor is at 2,700 ft. elevation and the surrounding mountains are approximately 6,000 to 6,500 ft. The valley walls are broken where the tributaries enter via their steeply incised valleys.

Approximately 80% of the basin is composed of the wide valley floor and Cariboo Lake, while the remaining 20% is composed of precipitous tree-covered mountainsides. Above Kimball Lake the basin terminates and the broad valley narrows sharply to enter the 300 foot deep Limestone Canyon.

A3.1.5 CLIMATE

The basin is situated in the interior wet belt. The precipitation ranges from 20 to 40 inches in the Cariboo Lake area to 40 to 60 inches eastward up the valley into the Cariboo Mountains. Most of the rain in the Cariboo Lake area falls in the summer. Further upstream, however, the precipitation is evenly distributed through summer, fall, and winter. Spring in the entire basin is normally dry. The total precipitation is nearly equally divided between rain and snow.

The basin exhibits a cool temperature regime with long cold winters and short warm summers. Although summer temperatures may rise to 90 degrees F. they normally do not exceed 75 to 85 degrees F. Autumns occur early; the first frost in most years is in late August. Long stretches of sub-zero weather occur in the winter, often as cold as minus 50 degrees F. Springs are late; the ice does not leave Cariboo Lake until mid-May.

A3.1.6 ACCESS

The Cariboo River below Cariboo Lake is unnavigable. However, the upper Cariboo River is easily navigable by riverboat up to Limestone Canyon except during low water when boats not equipped with either an outboard motor-lift or a jet-type drive may have difficulties. None of the tributaries are navigable. Cariboo Lake is easily navigable by small boat, although it has a deficiency of sheltered coves. Rudimentary boat launching sites exist at the south end of the lake.

A3.2 ANADROMOUS STOCKS

No records exist regarding salmon utilization of the Cariboo River and its tributaries above the proposed dam site. It is believed that until 1971 the chute at mile 14 on the Cariboo, effectively blocked migration (Plate A3-1). However, during the 1971-1972 survey, chinook salmon were observed near the mouth of Kimball Creek.

Six tributaries of the Cariboo River above the proposed project were surveyed, four of which are regarded as having gravel areas suitable for chinook spawning. Little River, Keithley and Cunningham creeks are situated below the migration obstruction at mile 42.8 on the Cariboo, whereas Matthew River is upstream from it and is thus considered totally inaccessible. These tributaries are discussed in upstream order. Section A3.2.3 discusses those tributaries regarded as having no potential for salmon propagation.

A3.2.1 CARIBOO RIVER (FIG. A3-2)

The Cariboo River, from its confluence with the Quesnel to the outlet of Cariboo Lake, a distance of 16.6 miles, has an average gradient of 0.6% and flows through a deep, narrow valley. From the proposed dam site at mile 14, to Cariboo Lake, the average gradient is about 0.2%. The substrate throughout this 16 mile section is composed almost entirely of coarse gravel boulders. A chute-type falls at mile 14 presents an area of difficult ascent although a rock-cut fishway has been constructed. Except for a limited amount at the Lake outlet, no suitable spawning area is available in this reach of the river (Plate A3-1). Cariboo Lake is 7.7 miles long.

For 15 miles upstream from the north end of Cariboo Lake to the outlet of Kimball Lake, the river meanders through a flat narrow valley marked with old river channels, marshes and islands. In this reach the substrate composition becomes more suitable for spawning. Specifically, that section of river from mile 30.9 to the mouth of Kimball Creek contains scattered areas of suitable spawning gravel (Plate A3-2).

Upstream from the confluence of Kimball Creek to Kimball Lake, there is little suitable spawning area as the river banks are primarily composed of mud and sand. Above Kimball Lake the river gradient increases and the streambed is composed of very coarse gravel and boulders. A canyonous area (Limestone Canyon) is situated several miles above Kimball Lake and is considered to be the upstream limit of migration (Plate A3-3). Throughout this reach, the substrate of the Cariboo River is made up of boulders and bedrock.

The bottom composition of the upper Cariboo River is not directly discernible due to the glacial turbidity in the stream above Cariboo Lake. The nature of the substrate areas discussed above was based on the composition of the exposed bars and banks of the river.

The Cariboo River and its tributaries above Swamp Falls at mile 50.3, were not surveyed as construction of fish passage facilities to bypass the

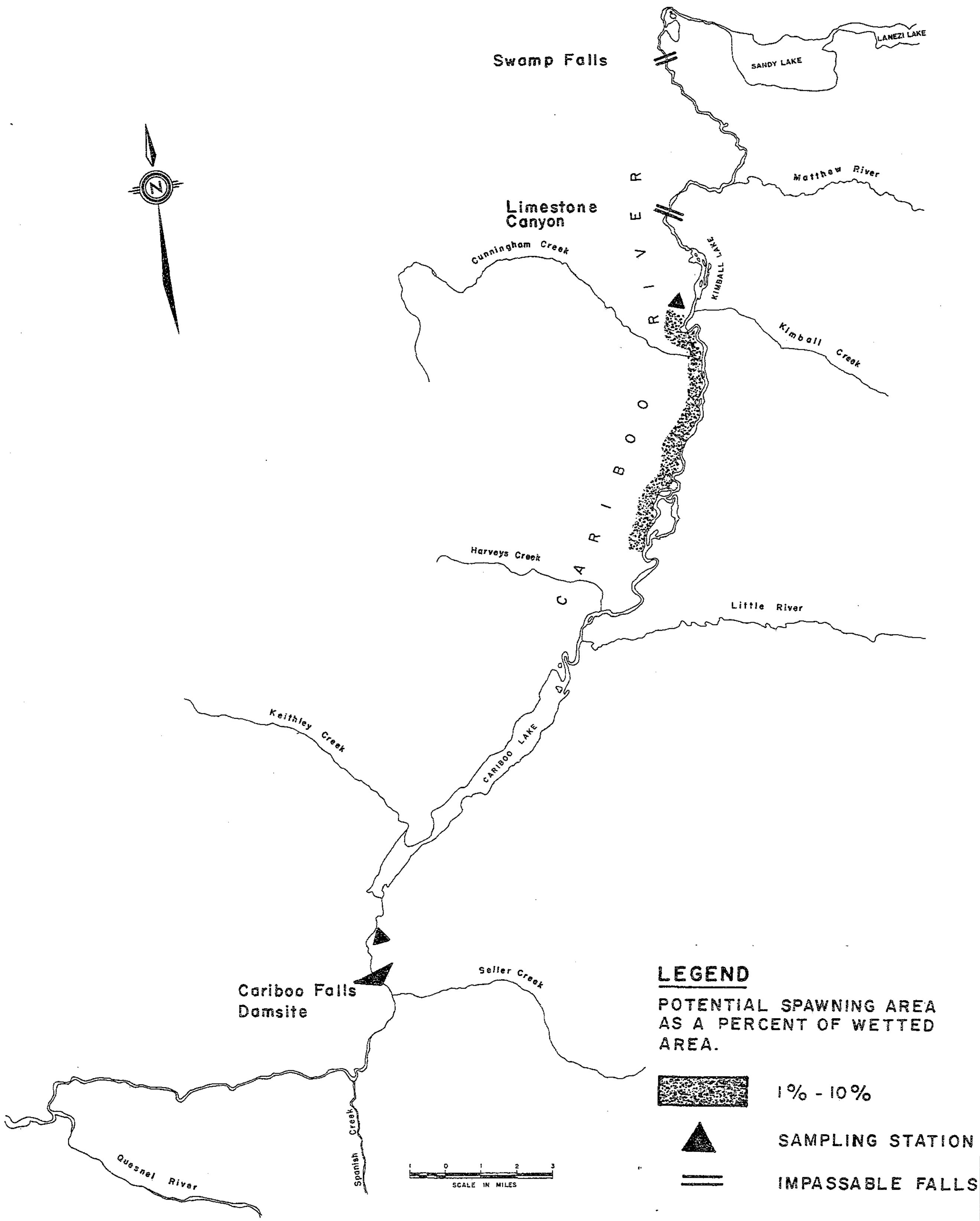


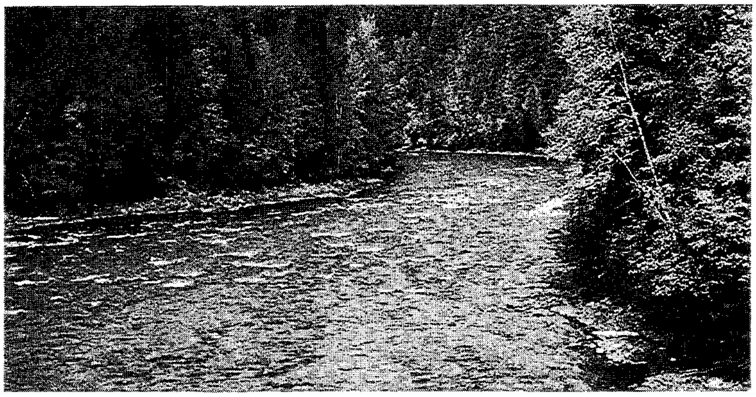
FIG. A3-2 TOTAL POTENTIAL SPAWNING AREA: CARIBOO RIVER chute in Limestone Canyon and Swamp Falls was not considered feasible.

Table A3.1 shows the spawning potential of the Cariboo River. There are 25,564 square yards of suitable spawning area capable of supporting a theoretical population of 2,130 chinook salmon.

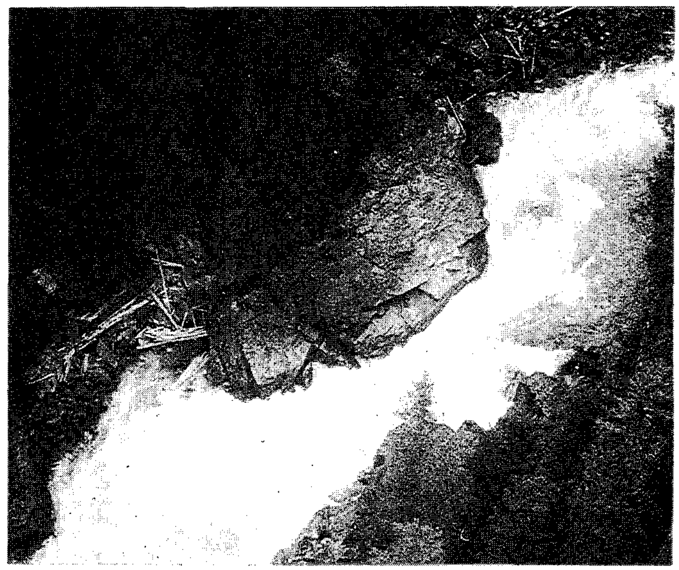
TABLE A3.1 Potential Spawning Areas: Cariboo River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning (sq.yds.)	Potential Area (%)	Spawning Capacity (no. of fish)
Damsite to 16.6	4,576	50	228,800	0	0	0
16.6 - 24.3	Cariboo L.					
24.3 - 30.9	11,616	45	522,720	0	0	0
30.9 - 39.2	14,608	35	511,280	25,564	5	2,130
39.2 - 57.7	32,560	30	976,800	0	0	0
TOTAL:	63,184	-	2,230,800	25,564	-	2,130

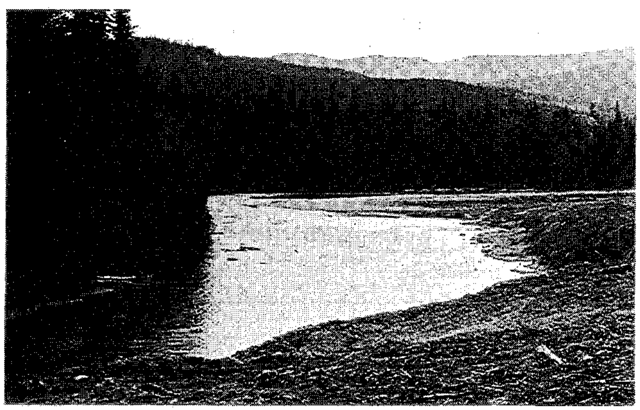
CARIBOO RIVER



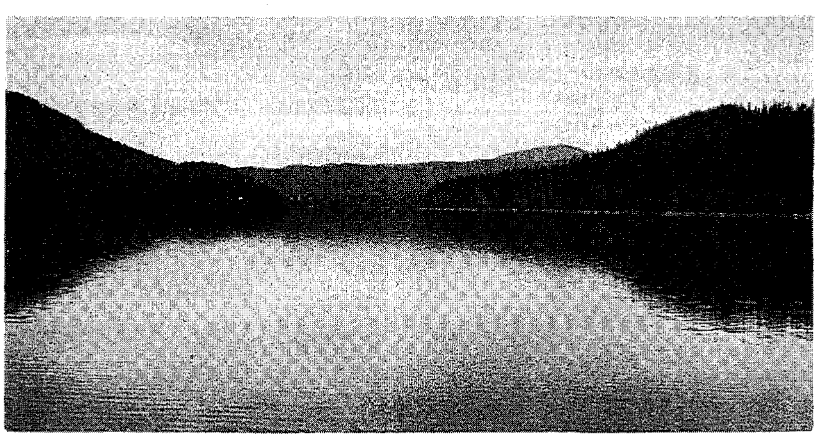
MILE 10



CARIBOO FALLS, MILE 14, ROCK-CUT
FISHWAY ON WEST BANK

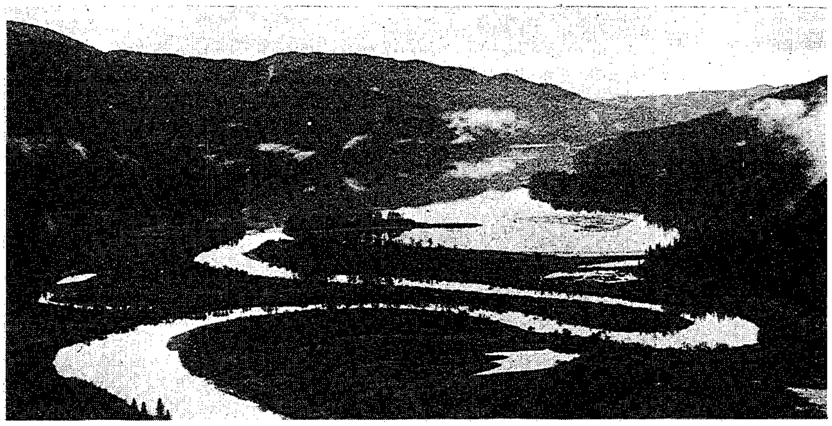


MILE 15.5

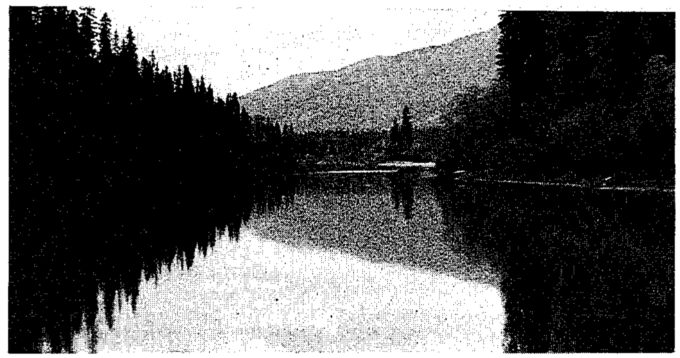


MILE 21.3, CARIBOO LAKE

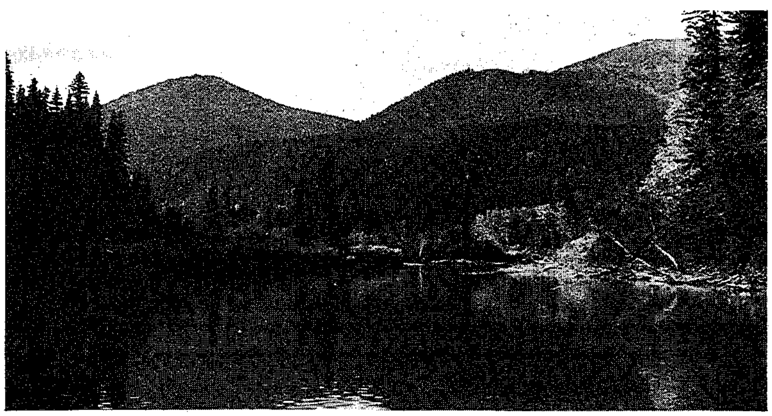
CARIBOO RIVER



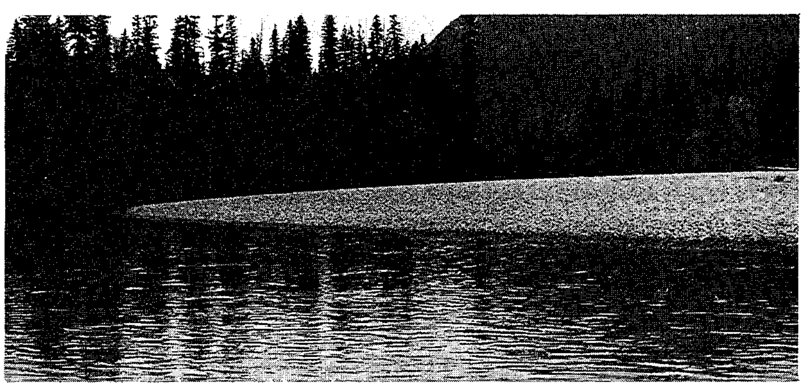
MILE 24.5, CARIBOO LAKE
IN BACKGROUND



MILE 28.8



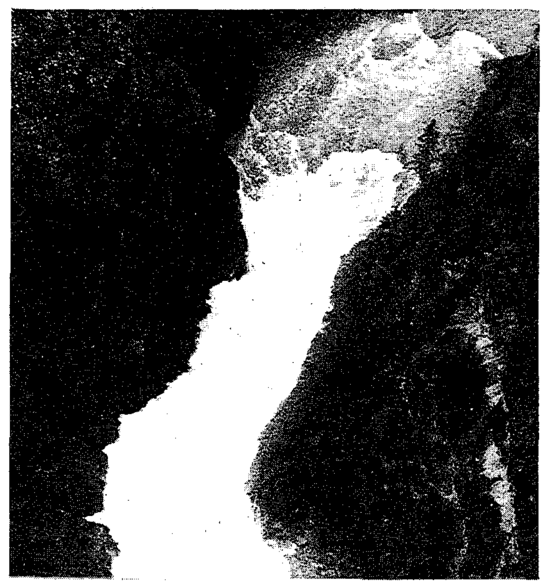
MILE 31.8



POTENTIAL SPAWNING SITE
MILE 36.3

CARIBOO RIVER

MILE 39.3, KIMBALL LAKE

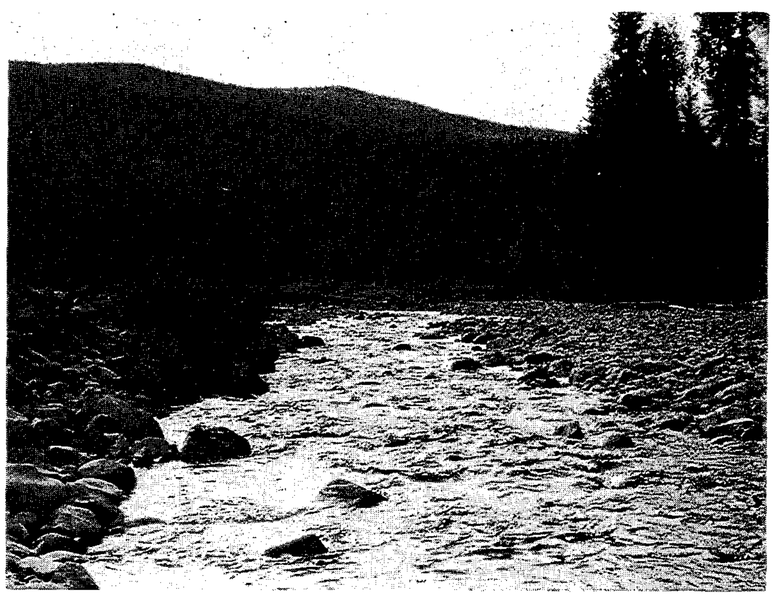


LIMESTONE CANYON, MILE 42.8
UPSTREAM LIMIT OF MIGRATION

MILE 50.3, SWAMP FALLS

KEITHLEY CREEK

AT HIGHWAY BRIDGE



MILE 0.6

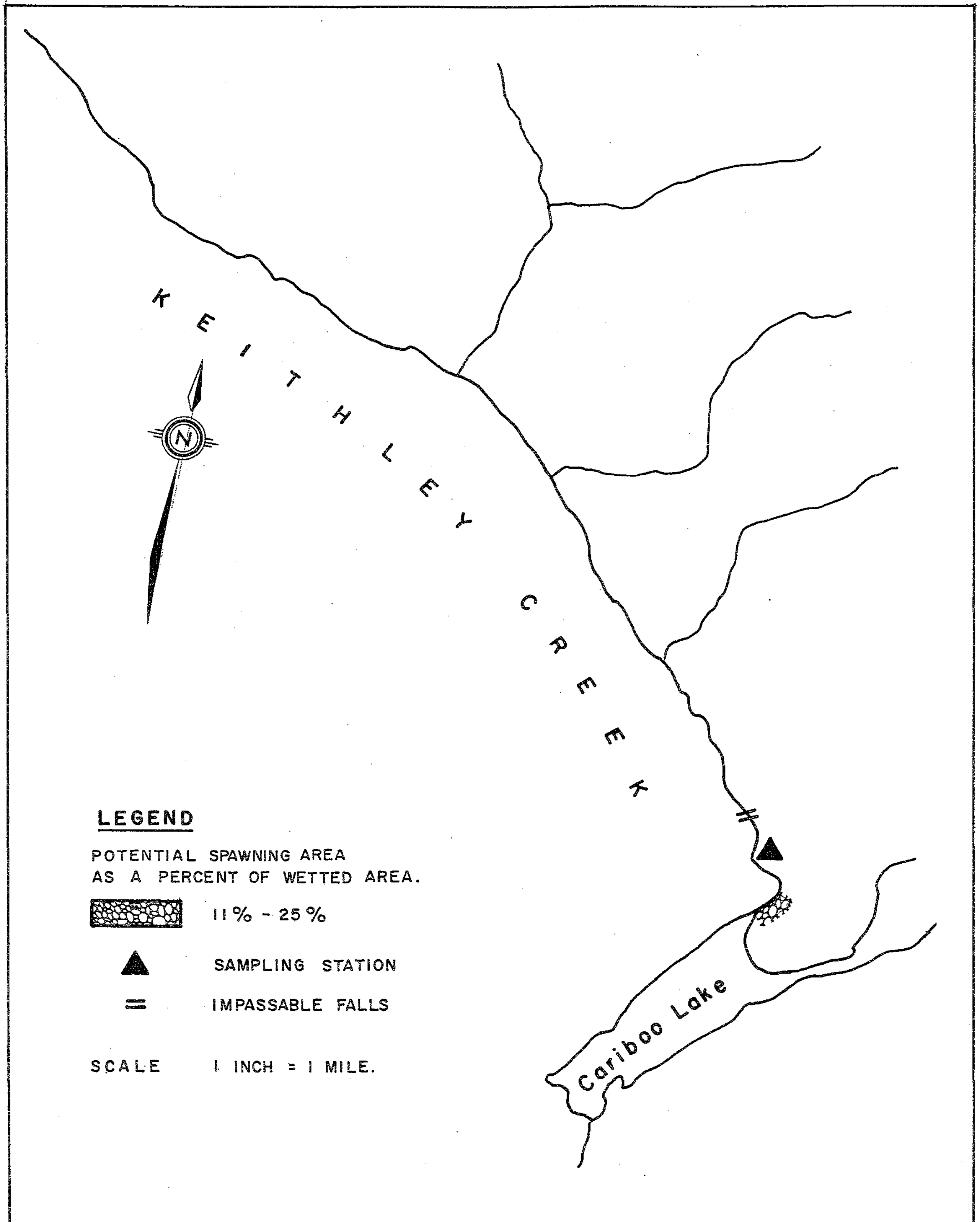


FIG. A3-3 TOTAL POTENTIAL SPAWNING AREA: KEITHLEY CREEK

A3.2.2 STREAMS NOT PRESENTLY UTILIZED

KEITHLEY CREEK (FIG. A3-3)

Keithley Creek flows southeasterly for 9 miles into the west side of the lower portion of Cariboo Lake, below the narrows. The estimated discharge of this creek on September 27, 1971 was 100 cfs.

At the creek mouth is an extensive gravel fan. Only that portion to approximately mile 0.11 contains suitable spawning gravel, estimated to be 726 square yards, capable of supporting some 60 chinook salmon (Plate A3-4).

From here to its source, the stream gradient is steep and the bottom is composed of coarse gravel and boulders. The creek is only accessible to mile 0.75, an impassable falls.

TABLE A3.2 Potential Spawning Areas: Keithley Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.11	194	15	2,904	726	25	61
0.11 - 9.0	15,646	7	109,525	0	0	0
TOTAL:	15,840	-	122,429	726	-	61

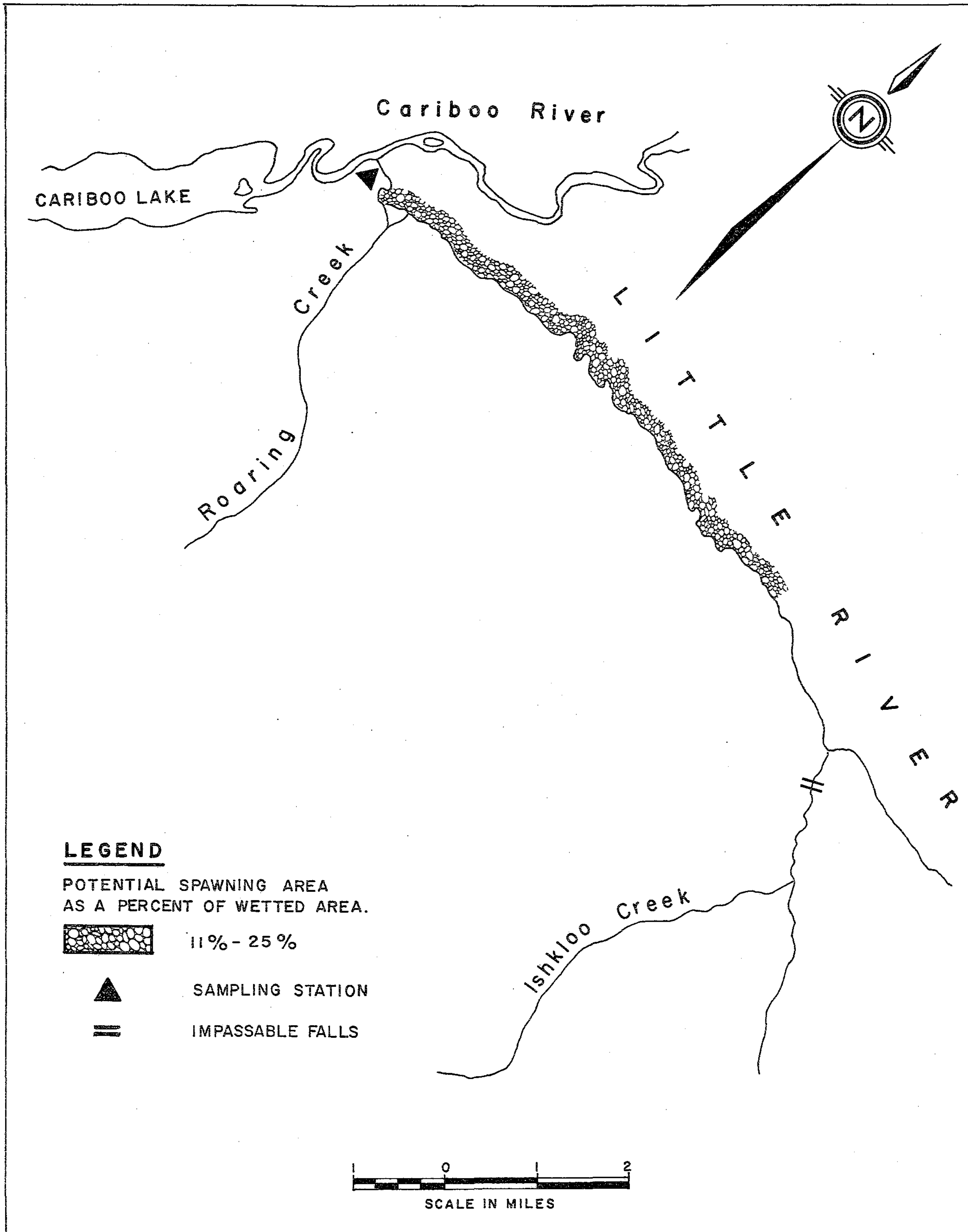


FIG. A3-4 TOTAL POTENTIAL SPAWNING AREA: LITTLE RIVER

LITTLE RIVER (FIG. A3-4)

Little River, the most suitable tributary of the Cariboo River for salmon propagation, flows westerly for 18.75 miles to join the Cariboo River, 2 miles upstream from Cariboo Lake. The water is clear and bottom visibility is excellent. On October 1, 1971, the volume of flow was estimated to be 37.5 cfs.

The substrate composition for the first 0.9 mile of stream is sand and mud. From this point upstream to mile 7.6 the stream bottom is composed of gravel suitable for salmon spawning. The average gradient in this reach is 0.5%.

Above this point to its source, Maeford Lake, the gradient increases, with a mean of 3.3%, the flow is swift and broken, and the bottom consists of coarse gravel and boulders. At mile 8.5 is a canyonous area (Plate A3-5).

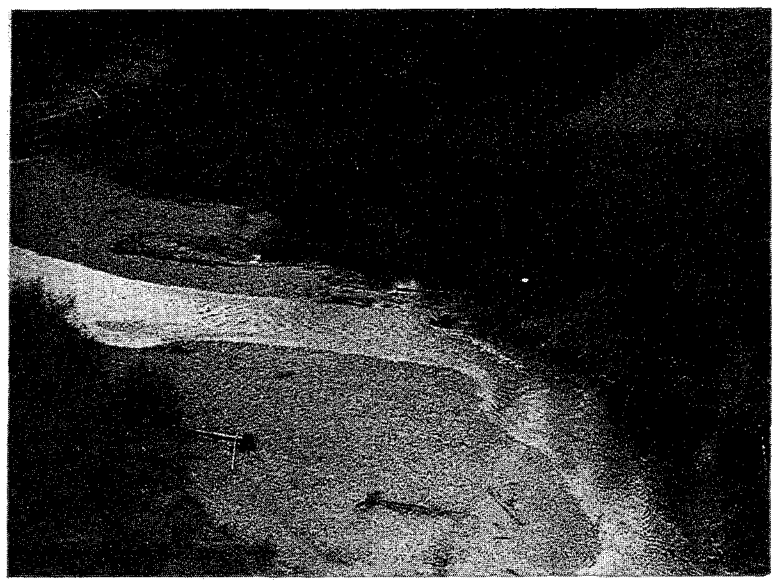
The Little River appeared to be an excellent rearing stream because of the presence of many pools, streamside cover, and stream debris of logs and windfalls. The latter provide protection for juvenile salmonids from predators during the critical fresh water rearing stage. The estimated chinook salmon spawning capacity of the Little River is 2,457 fish, based on the estimated available spawning area of 29,480 square yards.

TABLE A3.3 Potential Spawning Areas: Little River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.9	1,584	15	23,760	0	0	0
0.9 - 7.6	11,792	10	117,920	29,480	25	2,457
7.6 - 13.3	10,032	5	50,160	0	0	0
TOTAL:	23,408	-	191,840	29,480	-	2,457

LITTLE RIVER

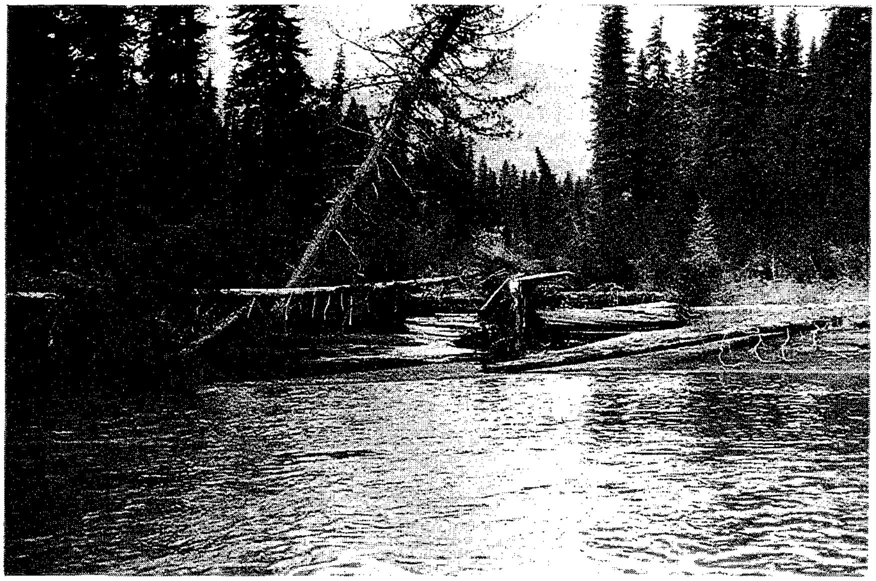
AT MOUTH



SUITABLE SPAWNING GRAVEL, MILE 5.0

FALLS, MILE 8.5

CUNNINGHAM CREEK



AT MOUTH

NEAR MOUTH

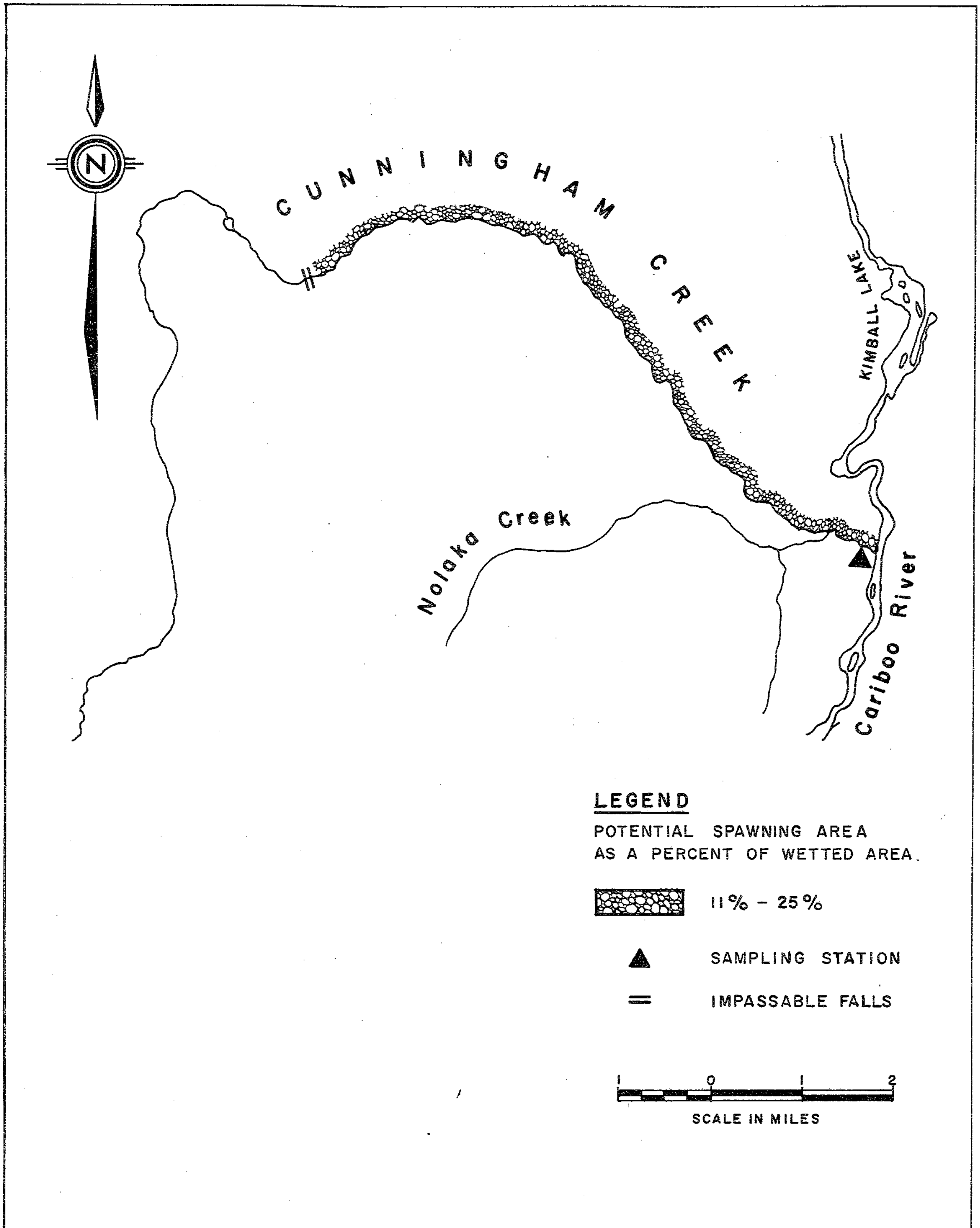


FIG. A3-5 TOTAL POTENTIAL SPAWNING AREA: CUNNINGHAM CREEK

CUNNINGHAM CREEEK (FIG. A3-5)

Cunningham Creek flows north, then southeasterly, 16.5 miles to its confluence with the Cariboo River, 12.6 miles upstream from the Cariboo Lake inlet. It is a very small, clear-running stream; on October 1, 1971 estimated discharge at the mouth was 6 cfs.

This creek is accessible to mile 8.2, an impassable falls. The mean gradient of this 8 mile reach is 2.3%; the substrate throughout is suitable for spawning. There is an estimated 18,040 square yards of spawning area, capable of supporting 1,500 chinook.

TABLE A3.4 Potential Spawning Areas: Cunningham Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 8.2	14,432	5	72,160	18,040	25	1,503
8.2 - 16.5	14,608	3	43,824	0	0	0
TOTAL:	29,040	-	115,984	18,040	-	1,503

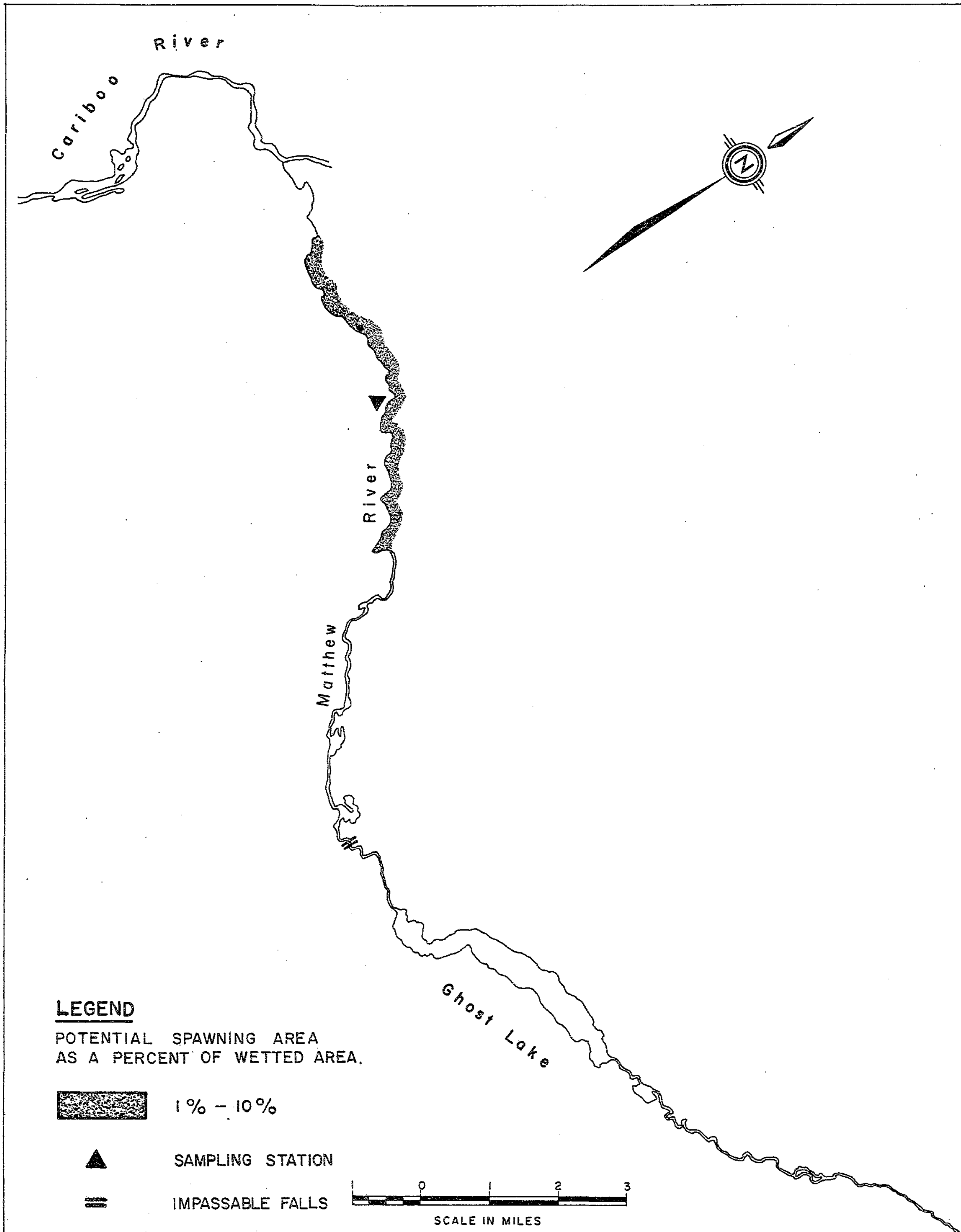


FIG. A3-6 TOTAL POTENTIAL SPAWNING AREA: MATTHEW RIVER

MATTHEW RIVER (FIG. A3-6)

The Matthew River flows westerly for 28.9 miles through Ghost Lake to join the Cariboo River approximately 21 miles upstream from Cariboo Lake. The river is passable to salmon for about 12 miles to a 50 ft. falls below Ghost Lake. The water is slightly turbid and the gradient to the falls is moderate. The gravel composing the exposed bars was silty and compacted.

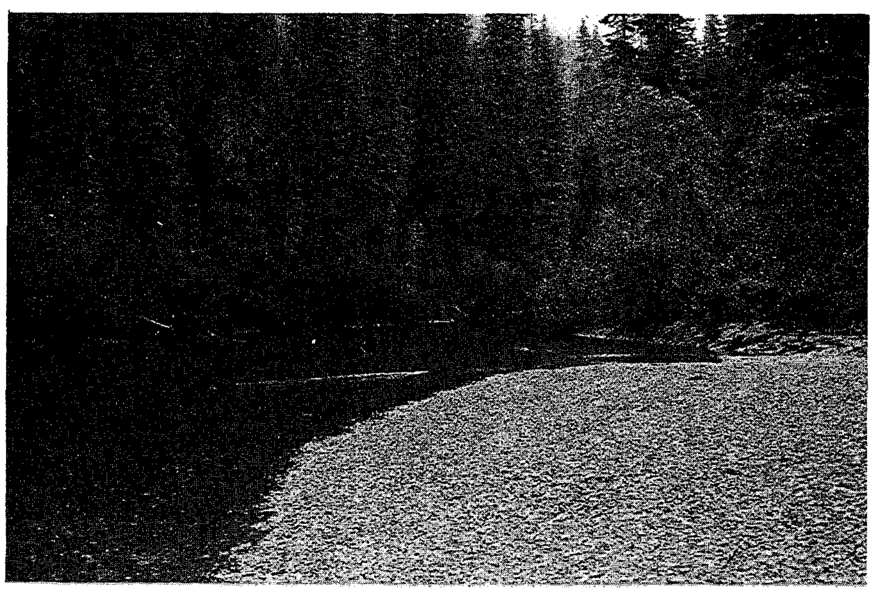
Matthew River is situated above Limestone Canyon and its potential areas are regarded as inaccessible. However, there are 15,048 square yards of suitable spawning gravel theoretically capable of supporting 1,254 chinook salmon. This amount has not been included in the total potential capacity of the Cariboo River basin.

TABLE A3.5 Potential Spawning Areas: Matthew River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.5	2,640	15	39,600	0	0	0
1.5 - 7.2	10,032	15	150,480	15,480	10	1,254
7.2 - 12.0	8,448	12	101,376	0	0	0
12.0 - 14.1	3,696	10	36,960	0	0	0
14.1 - 18.2	Ghost Lake					
18.2 - 28.9	18,832	5	94,160	0	0	0
TOTAL:	43,648	-	422,576	15,480	-	1,254

MATTHEW RIVER

MILE 0.5



SAMPLING SITE, MILE 4.5

A3.2.3 TRIBUTARIES WITH NO POTENTIAL

More than sixteen streams in this basin were listed during the survey as having no potential for chinook salmon propagation. Many are located upstream from Limestone Canyon and Swamp Falls and, therefore, are completely inaccessible and were not surveyed. These include Babcock, Betty Wendle, de Witte Reed, Harold, Kilakuai creeks and Isaac River. Streams tributary to Keithley Creek (such as French, Little Snowshoe and Snowshoe creeks) are located above the falls at mile 0.75 on Keithley; others, such as Four Creek, have little water and a steep gradient.

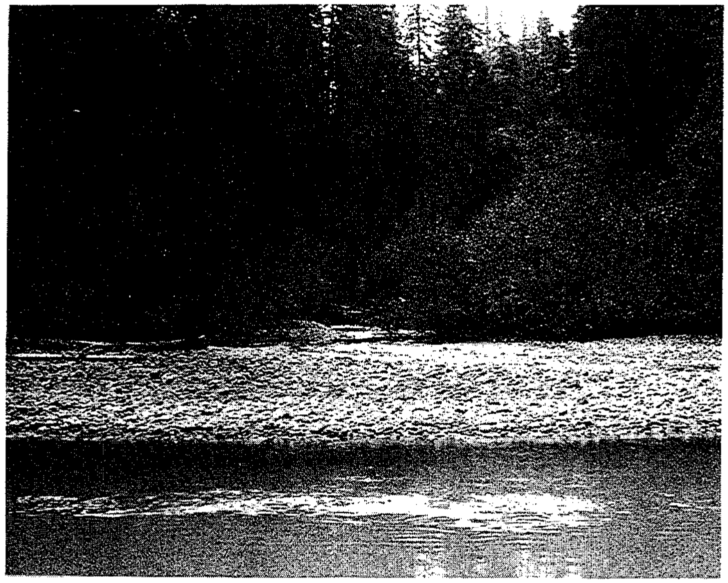
Tributaries of Little River are similarly unsuitable: Roaring Creek has insufficient flow; Ishkloo is steep and also has an impassable falls at mile 0.5, and Barkers Creek, which flows into Ishkloo, has insufficient flow.

Harveys Creek, which joins the Cariboo River northeast of Cariboo Lake, had a flow of only 2-3 cfs when surveyed on Octlber 1, 1971.

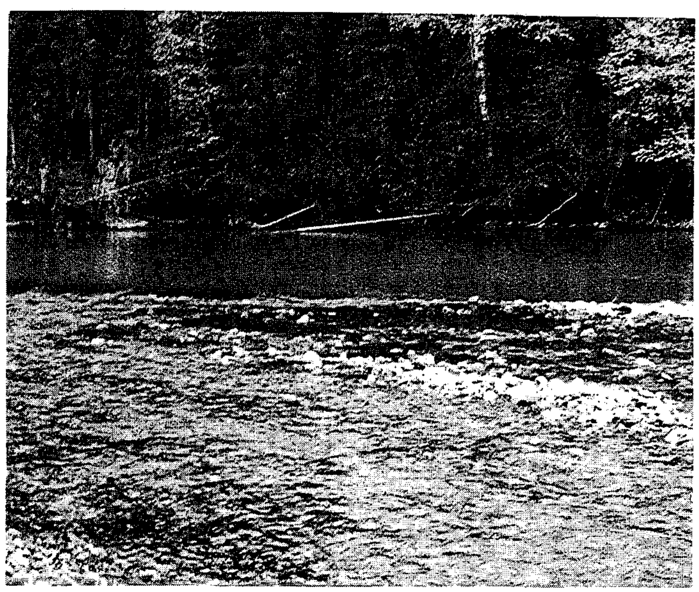
Kimball Creek flows westerly 8 miles to its confluence with the Cariboo River, 0.5 miles downstream from the Kimball Lake outlet. It is a small, clear, non-turbid stream, about 15 feet wide at its mouth. However, when surveyed (October, 1971) discharge was estimated to be 4 cfs. Kimball Creek also has an alluvial gravel fan at its mouth which further disperses this small flow (Plate A3-8).

Although these streams are generally regarded to have no spawning potential, some of them, for example Harveys and Kimball creeks, may be considered important for two reasons. They enhance the rearing capacity of the Cariboo River system and as adult sockeye have been observed below Cariboo Falls they may serve as potential sockeye salmon spawning areas.

KIMBALL CREEK



GRAVEL FAN AT MOUTH



NEAR MOUTH

A3.3 PHYSIO-CHEMICAL MEASUREMENTS

The physical and chemical parameters of the five streams surveyed within the upper Cariboo River basin and those of the Cariboo River itself are shown in Table A3.6. Only those streams regarded as suitable for salmon propagation were evaluated in detail. All parameters were within the established tolerance limits for salmonid production.

TABLE A3.6 Physical and Chemical Characteristics of Major Streams in the Cariboo River Basin

STREAM	SAMPLING DATE (1971)	SAMPLING LOCATION*	DEPTH RANGE (ft.)	VELOCITY** (fps)	FLOW VOLUME (cfs)	TEMP. (°F)	DISS. OXYGEN CONCENTRATION (ppm)	DISS. SOLIDS CONCENTRATION (ppm)	SUSPENDED SEDIMENT (ppm)	pH
CARIBOO RIVER	Oct. 1	Kimball Lake	n.d.	1.5	800	45.5	9	59,64	5,4	6.9
CARIBOO RIVER	Oct. 3	15.6	1.0-5.0	3.0	1,000	50.0	8	65,55	0,0	7.0
CUNNINGHAM CR.	Oct. 1	mouth	0.5-1.5	0.6	6	40.0	9	-	-	7.1
KEITHLEY CR.	Sept. 27	0.6	0.2-1.0	4.3	65	37.5	11	59	5	6.8
KIMBALL CR.	Oct. 1	mouth	0.2-0.8	0.85	6	48.0	10	-	-	7.3
LITTLE RIVER	Oct. 1	mouth	0.5-1.25	0.85	28	41.0	8	-	-	7.2
MATTHEW RIVER	Oct. 3	4.5	0.75-2.25	2.27	272	47.0	9	-	-	6.9

* Distance in miles from stream mouth.
** Instantaneous velocity measured at sampling station.
n.d. Not determined due to glacial turbidity.

Appendix A4

CLEARWATER RIVER BASIN

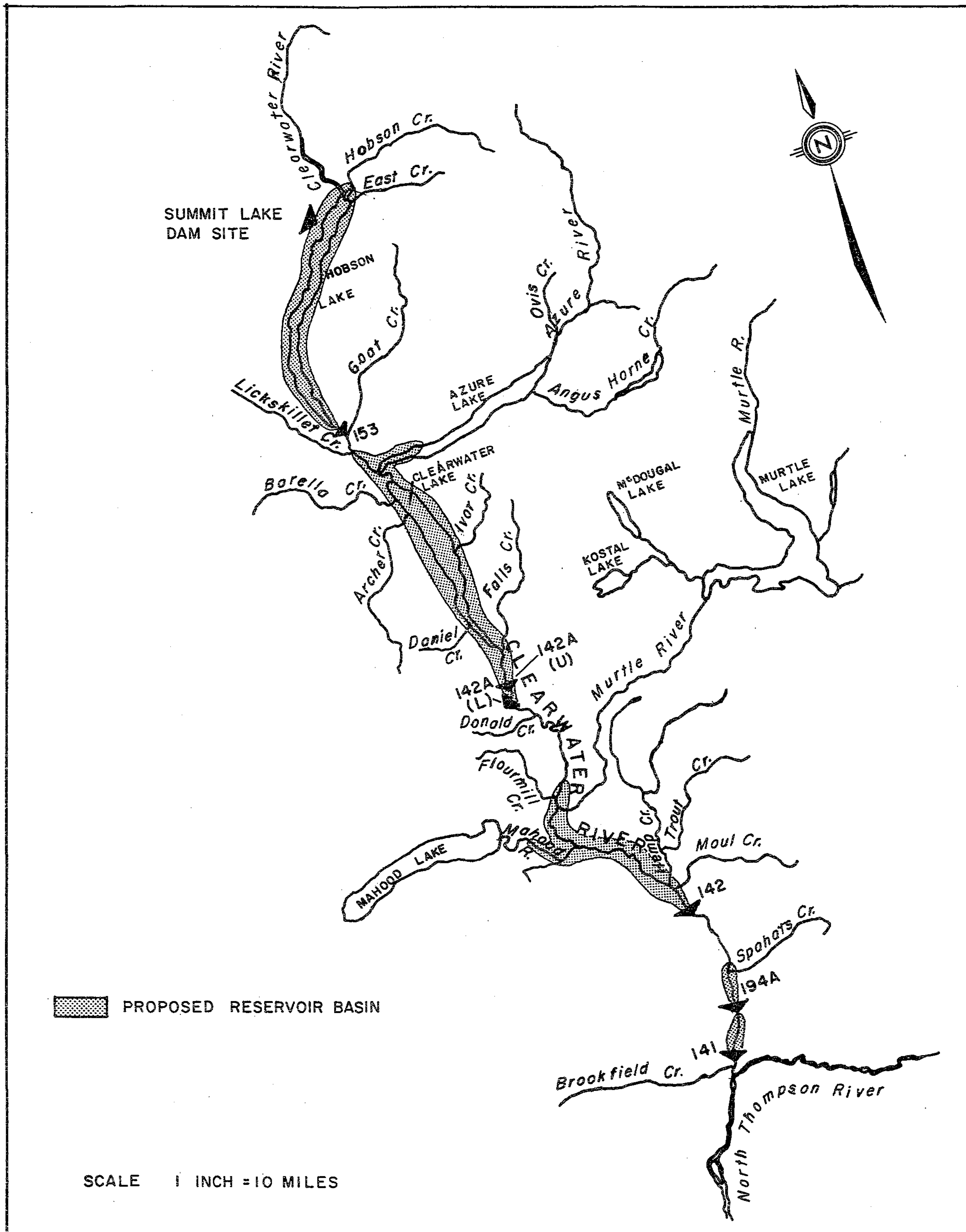


FIG. A4-1 CLEARWATER RIVER BASIN

A 4 CLEARWATER RIVER BASIN (FIG. A4-1)

Appendix A 4 contains descriptions of the Clearwater drainage basin, the main stem river and its tributaries. The results of a juvenile sampling study, and a swim and jet-boat survey are presented, as well as the results of the physical and chemical measurements taken.

A4.1 DESCRIPTION OF DRAINAGE BASIN

A4.1.1 GENERAL

The Clearwater River system originates in the Columbia Mountains and is typical of the majority of the Fraser River headwater streams. The main part of the watershed is located 240 air miles northeast of Vancouver. Creeks flow from mountains and glaciers, which range to 9,000 ft. in elevation, and feed into four large lakes, Hobson, Azure, Clearwater and Murtle. Draining the southwestern part of the watershed these lakes act as settling basins between the glacial headwater flows and the main stem Clearwater. Streams flow through the rolling Fraser Plateau into Mahood Lake, the fifth of the large lakes in the system.

The Clearwater is approximately 100 miles long and flows southerly to its confluence with the North Thompson River. The upper section of river is braided, meandering over a wide valley before entering the scoured basin holding the blue glacial water of Hobson Lake. Below this lake, the river flows at a gentle gradient for about 4,000 ft. to the head of a narrow rock-walled canyon, where it begins a rapid descent and, in a distance of four miles, falls some 600 ft. to the level of Azure Lake, at about 2,300 feet elevation. Azure Lake, also glacier fed, is perpendicular to the main stem Clearwater and narrows to a river for less than a mile before emptying into the same. Immediately below this confluence is Clearwater Lake, some 15 miles long. At its outlet is an unnavigable falls 20 ft. high. Three and a half miles below the lake, at the proposed lower Clearwater-Azure dam site (142A-L), the river turns to the west, passes over a 10 ft. waterfall, then flows southeast another 5.5 miles to enter a contorted section known as Horseshoe Bend. Murtle River, the largest and longest tributary, drawing its water from Murtle Lake, flows southwesterly over several falls, the most famous of which is 450 ft. high Helmcken Falls, near the Clearwater River confluence. Five miles downstream, the Mahood River flows easterly from Mahood Lake at 2,066 ft. in elevation, and passes over two falls on its short three mile drop to the Clearwater River. The remaining tributaries, Hemp, Moul and Spahats, all join the Clearwater from the east in the lower 24 miles.

A4.1.2 RESERVOIR BASINS

A series of five major dams are planned to utilize and control the drainage of the Clearwater River. The uppermost dam, at the outlet of Hobson Lake, would raise the present level of Hobson Lake by 70 ft. and extend the upper reach of the lake two to three miles.

Three miles below the base of Clearwater Lake is the Clearwater-Azure project site (142A), comprised of two dams, the upper and lower, separated by 3,500 feet. As the reservoir reaches its maximum height at 2,375 feet, the level of Clearwater Lake would increase until the small portion of the river between it and Azure Lake would be inundated resulting in a continuous lake pushing a few miles into the upper Azure River. This reservoir would extend completely to the Hobson Lake dam site (153).

Inundation from the Hemp Creek dam (142) will develop to the 2,000 ft. level and extend up the Clearwater River to above Murtle River. Three-quarters of Mahood River below Mahood Lake would be inundated; Hemp Creek would also be flooded for approximately five miles upstream from its mouth.

The two lower damsites, Granite Canyon (194A) and Clearwater (141), respectively six miles and two and one-half miles upstream from the confluence of the North Thompson River, are low-head run-of-river plants which will not produce reservoirs of any substantial size. The flooding that does result is only on the main stem Clearwater.

A4.1.3 SOILS

The entire basin is classified under a mountainous soil type, with the principal associated soils including lithosol, alpine meadow, podzol, grey wooded and peat.

In the south are alpine meadows and to the north are high peaks, numerous glaciers and icefields. Hobson Lake, situated in a glacially scoured basin, has deposited downstream of its outlet large quantities of glacial, outwash sands and and gravels intermixed with silt to depths exceeding 400 ft. on an irregular bedrock surface. The thick coniferous forest cover combined with moderate to heavy rainfall causes a leached, acid soil to form under this overstory. The streams have washed sand and gravel to their outlets forming alluvial fans. In many cases the river beds have been worn down to old basaltic lava flows resulting in the formation of numerous waterfalls.

A4.1.4 TOPOGRAPHY

The Clearwater River drainage is part of the Interior Plateau, divided into the Quesnel Highland north of Mahood Lake and the Shuswap Highland to the south. The basin is characterized by broad, rounded mountains (to 7,000 ft. elevation) separated by deep valleys (1,500 ft. elevation).

The upper Clearwater drainage is dominated by a backdrop of high, glaciated mountains and glacially formed U-shaped valleys and lake basins. The glacial origin of these lake basin formations accounts for the large number of hanging valleys and waterfalls. The system below Clearwater Lake is dominated by extensive volcanic flows through which the main stem of the river and many of the tributary streams have cut deep gorges which again results in spectacular waterfalls in the lower portions of the Clearwater system. The steep-sloped valley and the narrow benches marking old river levels as much as 900 feet above the existing valley floor typify these volcanic formations.

A4.1.5 CLIMATE

The changing topography of the Clearwater River basin has a definite influence on the climate of this region. Winters are often severe, with heavy snowfall exceeding 100 inches. Frost free days number 100 in the lower section to less than 50 north of Clearwater Lake. From its headwaters to its mouth, the Clearwater River passes through five zones of decreasing rainfall. Sixty to one hundred inches fall annually in the region north of the middle of Hobson Lake. Clearwater and Murtle lakes lie in a zone receiving 30-40 inches annually, whereas near the mouth, south from Spahats Creek, precipitation drops to 15-20 inches per year. April is normally the driest month, but from July through September frequent rain and thunderstorms occur. The mean daily January temperature ranges from 0-10 degrees F. while that for July is less than 55 degrees F. in the Hobson Lake area, and 60-65 degrees F. near the outlet of the Clearwater River.

A4.1.6 ACCESS

The lower Clearwater River, except for short portions during high water in early summer, is unsafe for navigation from the falls at the outlet of Clearwater Lake downstream to the North Thompson River. The waterway between Clearwater Lake and Hobson Lake is extremely dangerous, and no attempt should be made at any time to traverse its rapids. The large lakes are navigable, with boat facilities at the Clearwater Lake campground for a 64-mile round trip on Clearwater and Azure Lakes. Most of the tributaries contain insufficient water for boat travel and follow steep gradients to the Clearwater River. The mountainous terrain along the river valley limits road access and limits boat launching to a few definite locations.

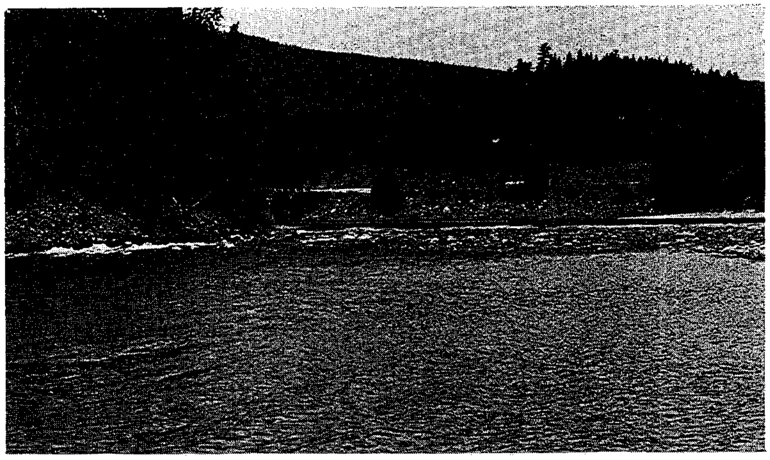
A4.2 Anadromous Stocks

Chinook and coho salmon utilize the Clearwater River and its tributaries for spawning and rearing. Chinook migration occurs from mid-August to the end of September. Spawning takes place from September 1 to October 15. Juvenile migration begins in early April, peaks in late April or early May. Coho spawning is from the beginning of October to mid-November.

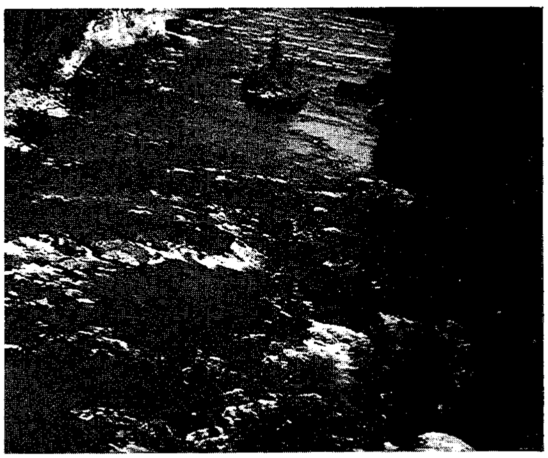
Present and potential chinook spawning areas of the Clearwater system which are located above the proposed projects are discussed in this Section. The streams are divided into three categories: streams presently utilized, those not presently utilized but regarded as containing potential spawning areas, and streams with no potential.

Of the tributaries surveyed only one, Mahood River, presently supports chinook salmon. However, Brookfield Creek, which is located downstream of the Clearwater dam site, also supports a run of coho. Seven streams were regarded as having suitable spawning areas, and thus a potential for salmon propagation. However, only one, Hemp Creek, is accessible; four streams are located above obstructions on the lower Clearwater River, and two, located above Hobson Lake, are considered to be inalterably inaccessible.

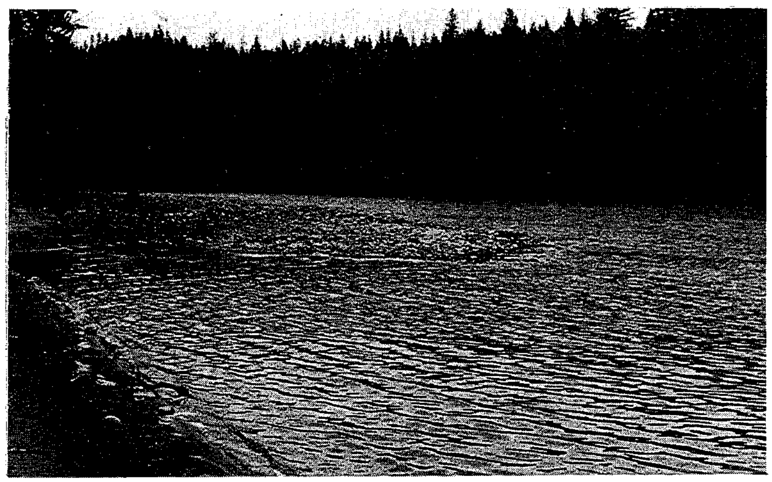
CLEARWATER RIVER



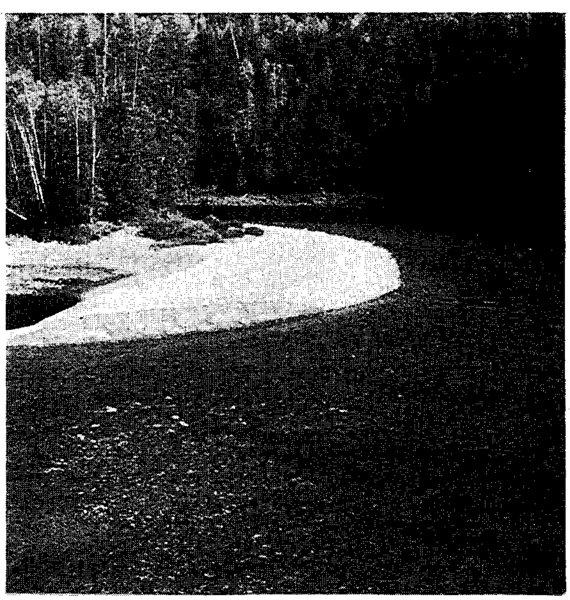
CHINOOK SPAWNING AREA
BELOW HWY. 5 BRIDGE



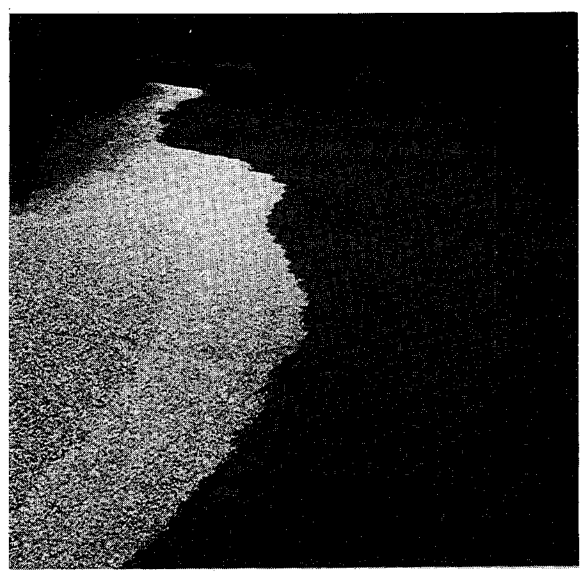
CANYON AREA, MILE 5



SOCKEYE SPAWNING AREA
ABOVE BROOKFIELD CREEK



SUITABLE GRAVEL, MILE 8



SUITABLE SPAWNING GRAVEL, MILE 13

A4.2.1 CLEARWATER RIVER

The Clearwater River from its mouth to its source, including Clearwater and Hobson Lakes, is some 104 miles long. To facilitate its description the river will be divided into the Lower, Middle, and Upper portion. The Lower River encompasses that portion from the mouth to the outlet of Clearwater Lake; the Middle Clearwater, the section from the northern end of Clearwater Lake to the Hobson Lake outlet; the Upper River, the reach from the Hobson Lake inlet to the Clearwater River source.

A4.2.1.1 LOWER CLEARWATER RIVER

One mile upstream from the Clearwater and North Thompson confluence, where Brookfield Creek joins the Clearwater, there is suitable spawning gravel on the west side of the River for a distance of approximately 0.25 miles. Here the Clearwater is some 200 ft. wide. Silt deposits were visible, intermixed with the gravel substrate but the shallow gravel areas were relatively silt-free (Plate A4-1).

The total suitable spawning area in this section of the River was estimated to be 2,948 square yards which presently supports about 250 sockeye salmon and, reportedly, a few chinook.

In the reach from mile 1.25 to mile 8.0, which includes a mile long granite bedrock canyon between mile 5.0 and 6.0, the substrate of the Clearwater River is composed of large boulders and bedrock unsuitable for salmon spawning.

Between mile 8.0 and mile 13.0, there are several suitable spawning areas consisting of gravel bars located in shallow side channels and in wide braided areas of the river (Plate A4-1). The substrate in these areas is composed of gravel ranging in diameter from 2 to 6 inches; water depth varies from 1 to 3 feet. At the time of the survey, the water velocity was about two fps. The streamside vegetation is small trees and shrubs. A total of 36,960 square yards of suitable spawning area exist in this section of the river.

Mile 13.0 to mile 15.0 is unsuitable with bedrock and boulders and with fairly turbulent flow. A passable chute, some 300 yds. long is located at mile 13.5.

Just below the mouth of Hemp Creek at mile 15.0, Clearwater River widens to 500 ft. and divides into 3 channels for a distance of 0.13 miles (Plate A4-2). All three channels are from one to two feet deep, with sufficient velocities, and substrates composed of two to six inch gravel. As much as 85% of the wetted area in this section is composed of suitable gravel, for a total of 10,067 square yards of potential spawning area. From the mouth of Hemp Creek, upstream for 3 miles the river substrate is unsuitable for chinook propagation.

One of the three major chinook salmon spawning areas of the Clearwater River is situated at mile 18.13. This 4 mile long area, known as Whitehorse Bluffs, is made up of wide, shallow channels with numerous riffle areas, composed of suitable spawning gravel (Plate A4-2). The Clearwater River first flows in an easterly direction for 2 miles and then turns southerly for 2 miles. With the exception of three large pool areas, this reach of river varies in depth from 2 to 4 feet, with velocities of 1.0 to 2.5 fps. The average width of the river, excluding the numerous islands, is about 300 feet. Very little silt is intermixed with the gravel although silt deposits are quite noticeable with the gravel in low velocity back channels.

It was estimated that this four mile section contained a total of 240,768 square yards of suitable spawning area, capable of theoretically supporting 20,064 chinook salmon (Fig. A4-2).

From Whitehorse Bluffs to approximately mile 31.0 no suitable spawning areas exist. This includes that area where the Mahood and Murtle rivers join the Clearwater at mile 24.3 and mile 29.

Two miles above the mouth of the Murtle River, for approximately one mile, the Clearwater becomes very braided and scattered areas of spawning gravel are present. The water depth in these areas is one to three feet.

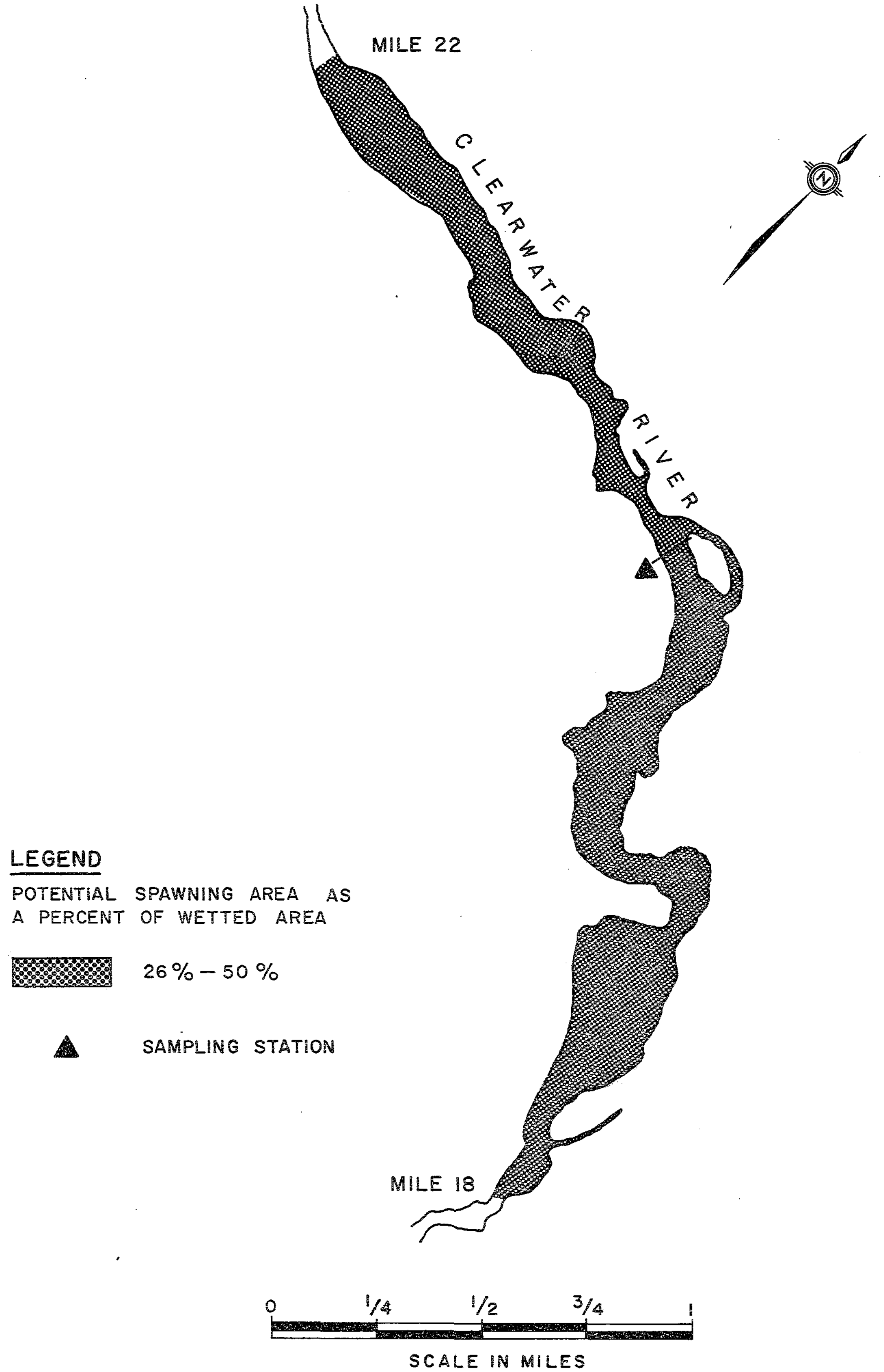
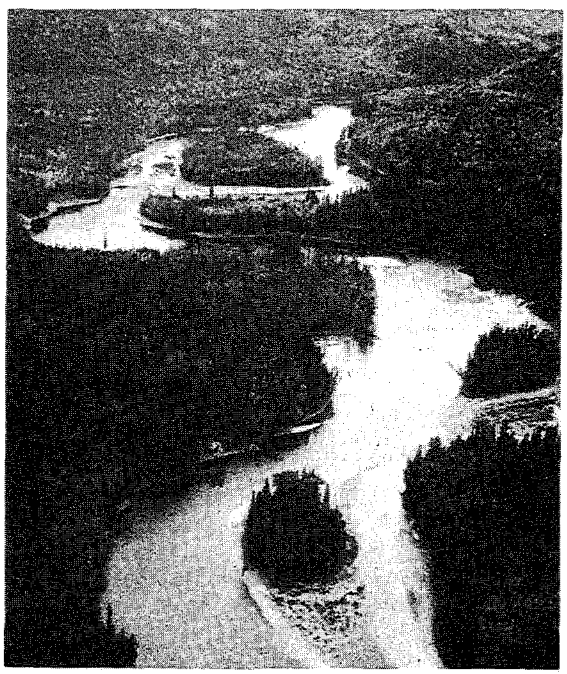


FIG. A4-2 TOTAL POTENTIAL SPAWNING AREA: WHITEHORSE BLUFFS, LOWER CLEARWATER RIVER

CLEARWATER RIVER

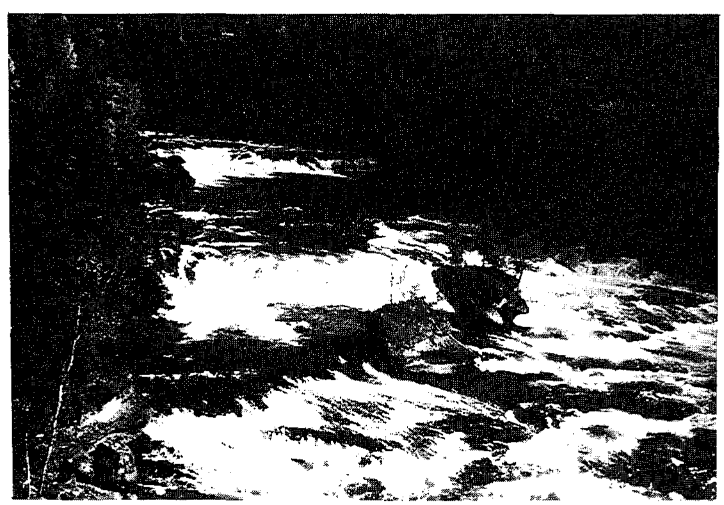
MILE 13.5, PASSABLE CHUTE

MILE 15, SPAWNING AREA
BELOW HEMP CREEK



MILE 18, WHITEHORSE BLUFFS
MAJOR SPAWNING AREA

CANYON, MILE 27.5



CLEARWATER FALLS
MILE 29

Suitable spawning area was estimated to be 11,440 square yards.

From approximately mile 32.0 to mile 35.0 the river narrows, velocity increases and the stream bottom becomes boulders and bedrock with no spawning gravel.

Horseshoe Bend, the second major spawning area in the Clearwater River is located at mile 35.0, and extends for a distance of 3 miles (Plate A4-3). The Clearwater River, fast flowing above and below this area, widens and becomes shallower, within the Horseshoe. The water velocity decreases, depth varies from 1 to 3 feet, and average width is 250 feet. Fifty percent of the substrate is composed of suitable spawning gravel, and the total suitable spawning area in this section of river was estimated to be 211,200 square yards (Fig. A4-3).

At mile 40.0, a steep rapid area with a vertical drop of approximately 20 feet marks the upstream limit of salmon migration. On September 18, 1972, this chute area was observed and, over a fifteen minute period, 25 unsuccessful jumping attempts by chinook salmon were recorded. From the "chute" to the outlet of Clearwater Lake, at mile 45.0, the substrate is unsuitable.

At the Lake outlet is a falls approximately 20 feet high (Plate A4-4). Because of these two obstructions the remainder of the Clearwater, including tributaries above this area, are presently inaccessible to salmon. However, as fish passage facilities are feasible for this type of obstruction, that portion of the river and tributaries from the Clearwater Lake inlet to above the Azure Lake outlet was surveyed.

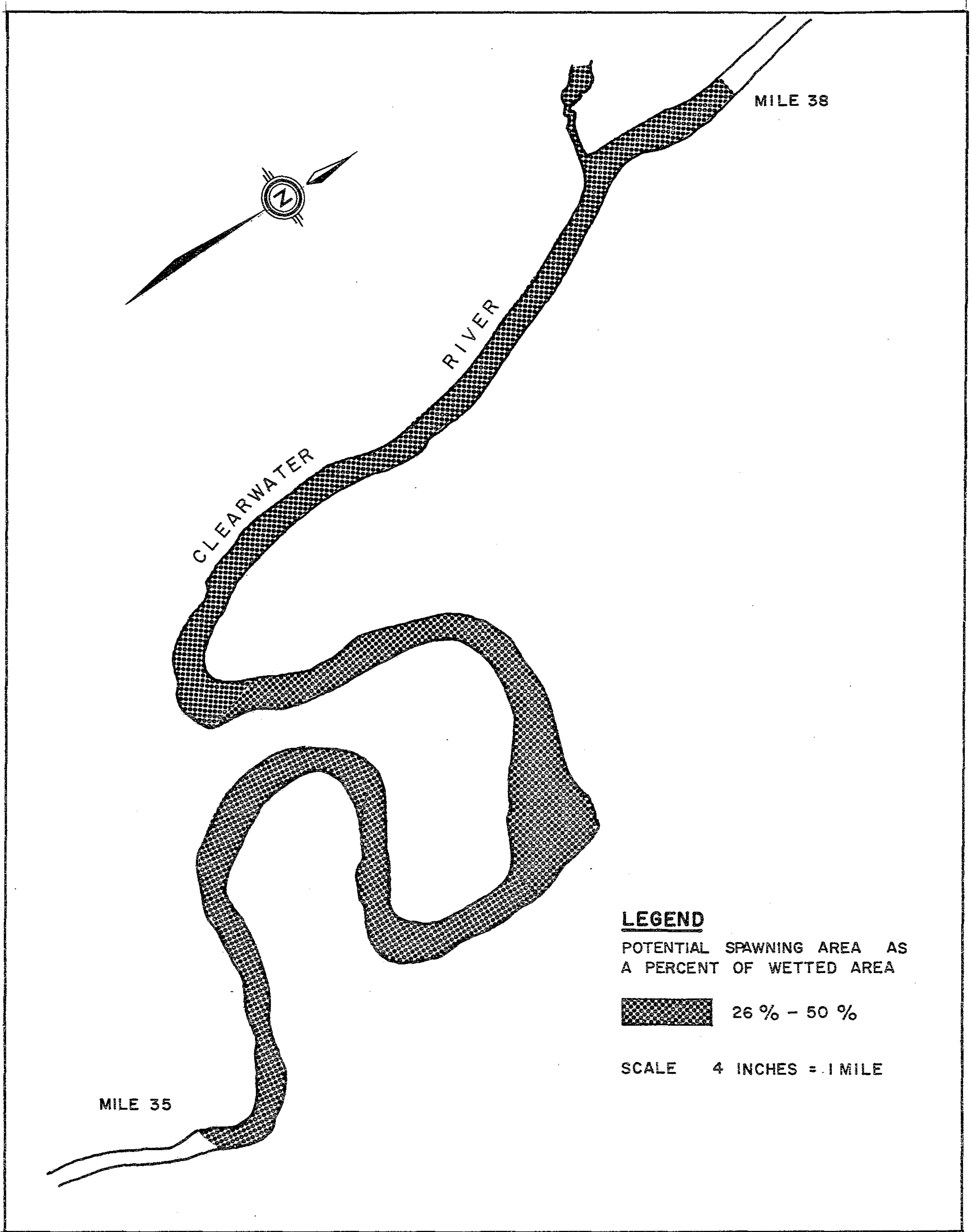
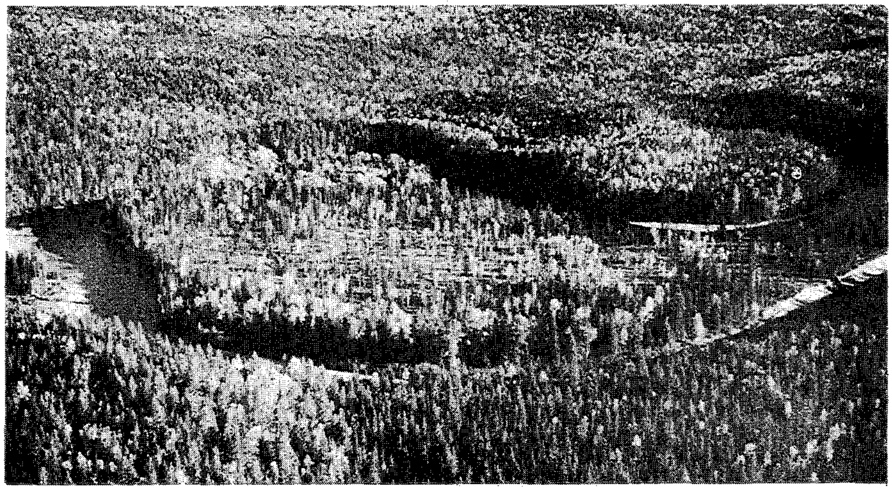
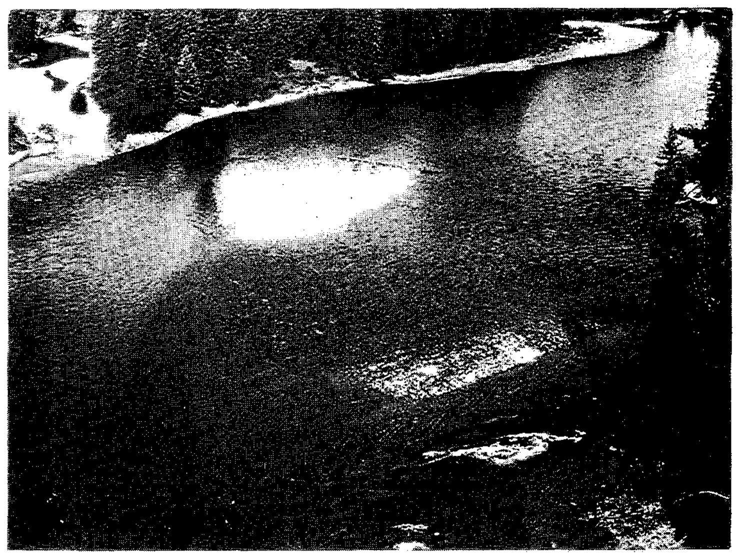


FIG. A4-3 TOTAL POTENTIAL SPAWNING AREA: HORSESHOE BEND, LOWER CLEARWATER RIVER

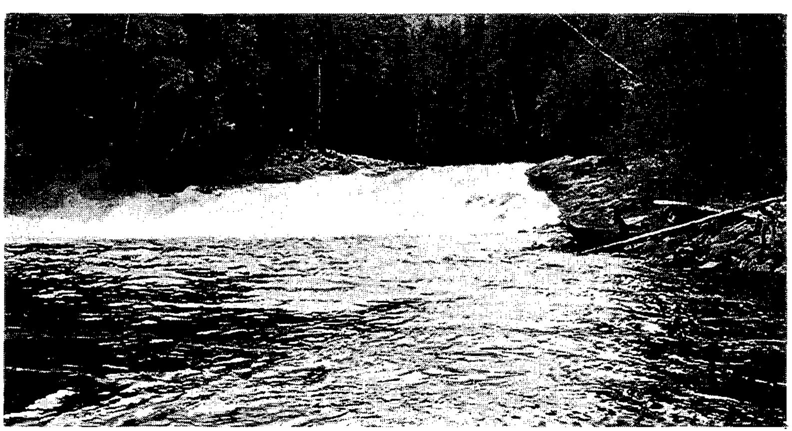
CLEARWATER RIVER



MILE 35, HORSESHOE BEND
MAJOR SPAWNING AREA



MILE 31.5



CHUTE, MILE 40
UPSTREAM LIMIT OF MIGRATION

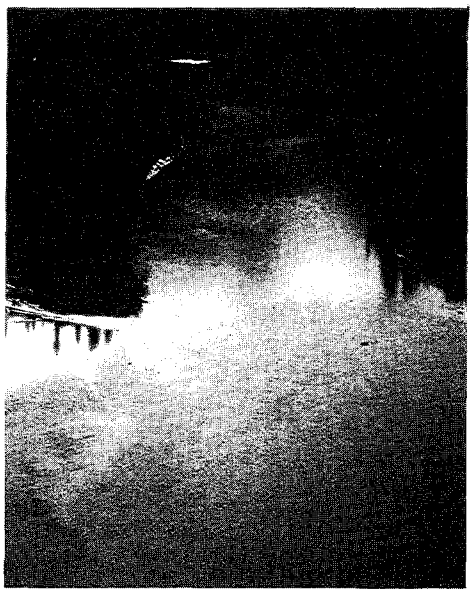
TABLE A4.1 Potential Spawning Areas: Lower Clearwater River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 1.0	1,760	60	105,600	0	0	0
1.0 - 1.25	440	67	29,480	2,948	10	246
1.25 - 8.0	11,880	53	629,640	0	0	0
8.0 - 13.0	8,800	60	528,000	36,960	7	3,080
13.0 - 15.0	3,520	70	246,400	0	0	0
15.0 - 15.13	228	50	11,440	10,067	88	839
15.13 - 18.13	5,280	75	396,000	0	0	0
18.13 - 22.13	7,040	90	633,600	240,768	38	20,064
22.13 - 31.0	15,611	55	858,616	0	0	0
31.0 - 32.0	1,760	65	114,400	11,440	10	953
32.0 - 35.0	5,280	70	369,600	0	0	0
35.0 - 38.0	5,280	80	422,400	211,200	50	17,600
38.0 - 45.0	12,320	50	616,000	0	0	0
TOTAL:	79,199	-	4,961,176	513,383	-	42,782

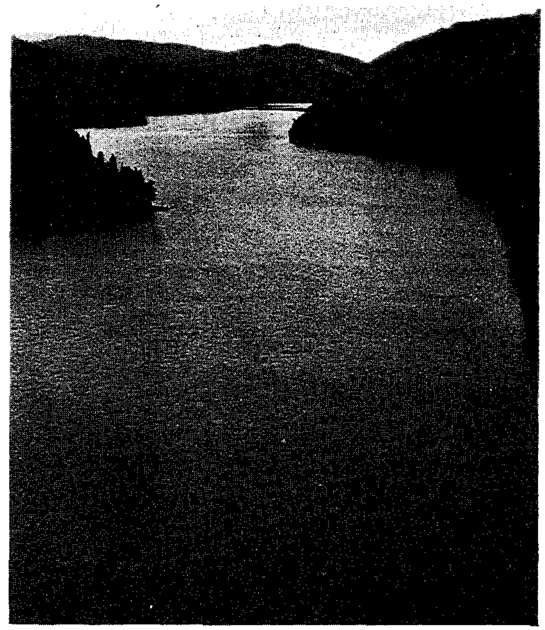
Clearwater Lake is approximately 15 miles long and 1.5 miles wide. Both shorelines are relatively steep, rising at 30% and higher gradients. Vegetation is predominantly fir forest on the east with spruce, cedar, and fir on the west. Beaches are situated at the mouths of some 30 small streams which for the most part drop precipitously into the lake. Some of these creeks flow through a low gradient over the last few hundred yards before reaching the lake and have formed alluvial deltas (Plate A4-4).

CLEARWATER RIVER

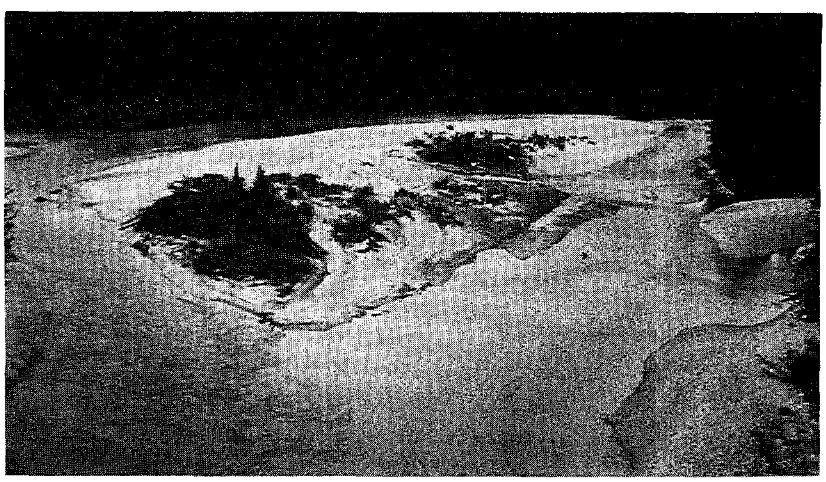
FALLS AT OUTLET OF CLEARWATER LAKE,
MILE 45



MILE 60, NORTH END OF
CLEARWATER LAKE



CLEARWATER LAKE



MILE 61
SUITABLE SPAWNING AREA

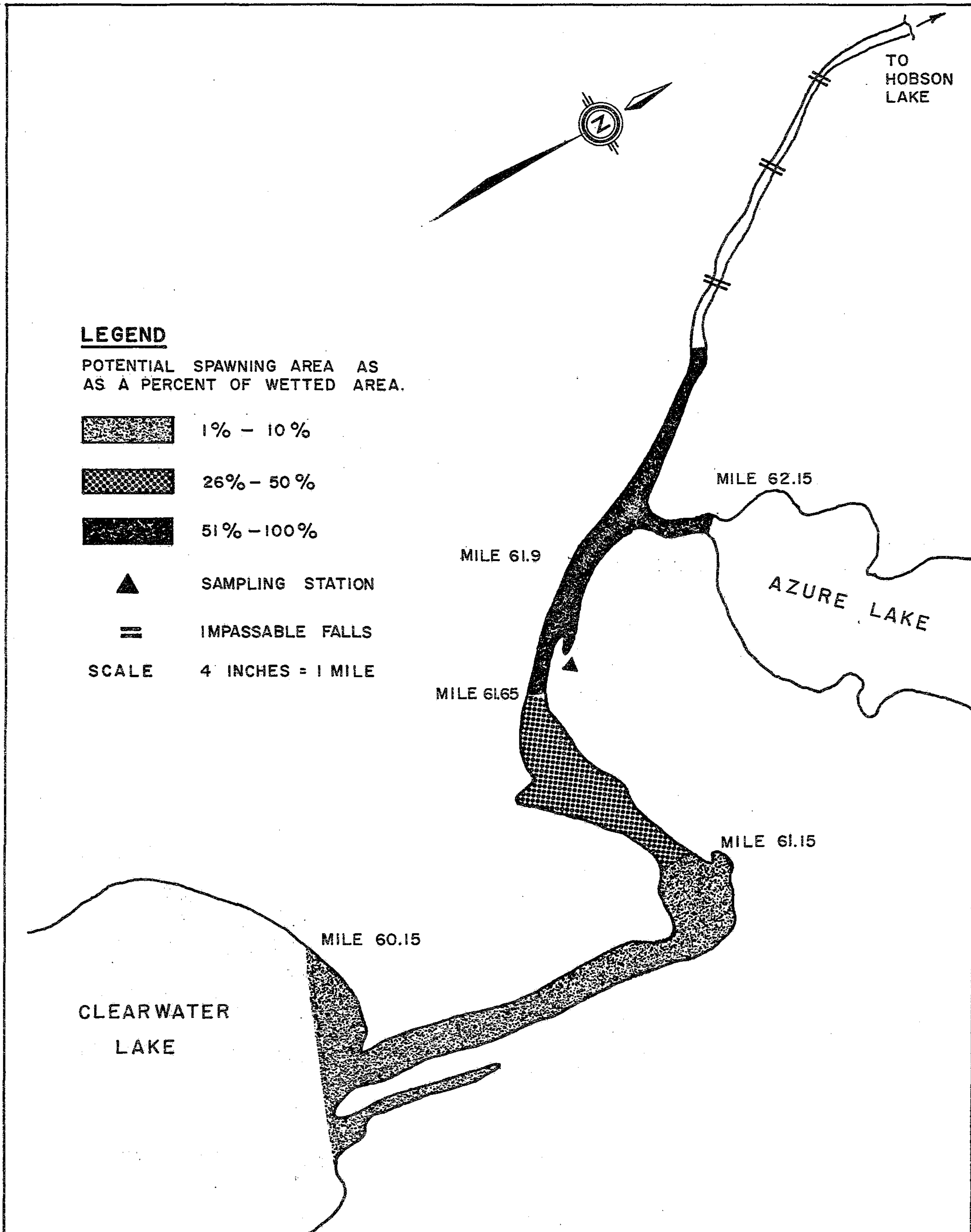


FIG. A4-4 TOTAL POTENTIAL SPAWNING AREA: MIDDLE CLEARWATER RIVER

A4.2.1.2 MIDDLE CLEARWATER RIVER

This portion of the River, between Clearwater and Hobson Lake, is approximately 7 miles long. At the Clearwater Lake inlet, the river is about 200 ft. wide. The confluence of the Lower Azure River is 2 miles upstream from the Lake inlet. The lower mile is deep and slow moving; the streambed is composed of sand and silt. However, there are suitable gravel areas at, and one mile upstream of, the lake inlet (Plate A4-4). The stream banks in this reach consist of fine soil materials. The upper mile is braided; the river becomes shallower and the water velocity increases. The west bank is composed of soil; the right bank, coarse gravel and rock. The size of streambed materials varies considerably. The proportion of wetted stream area composed of suitable gravel ranges from 30 to 75%. A total of 55,176 square yards of suitable gravel, capable of supporting 4,598 chinook salmon is present in this 2 mile stretch of river (Fig. A4-4). Included in this figure is the potential spawning area of the Lower Azure River.

From the Lower Azure River, at mile 62.0, to the outlet of Hobson Lake, a distance of approximately 5 miles, the gradient of the Clearwater River increases markedly in a series of chutes, rapids and waterfalls. The maximum river gradient is located here with a total drop of 465 feet in 7 miles (Plate A4-5). This area is impassable to anadromous fish and marks the absolute limit of migration in the Clearwater River. No suitable spawning areas are present in this portion of the Middle Clearwater River.

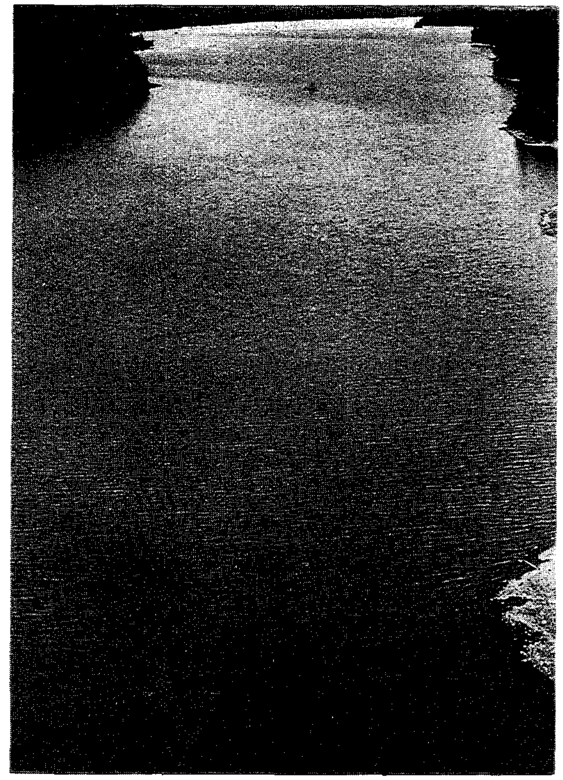
A4.2.1.3 UPPER CLEARWATER RIVER

Although inaccessible to salmon, this portion of the Clearwater River to its source, including Hobson Lake and its tributaries, was examined to complete the survey of the Clearwater River watershed.

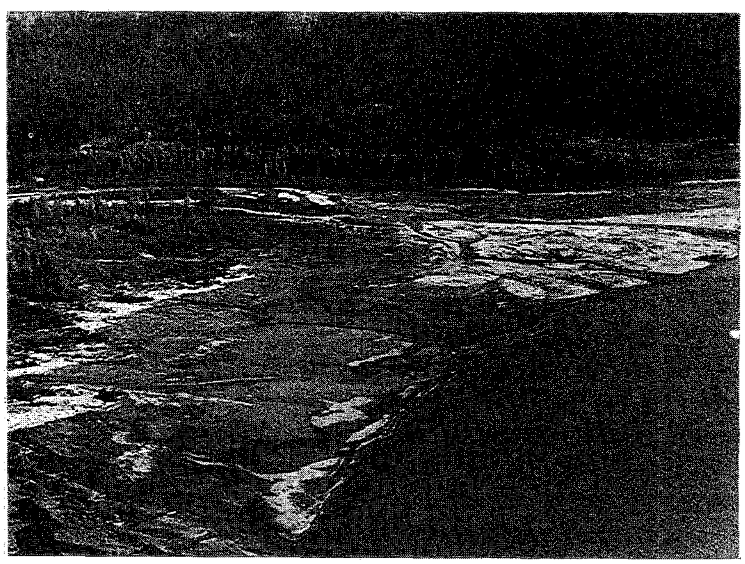
Hobson Lake, 15 miles long and approximately 0.75 miles wide, is a turbid glacial lake. The shoreline is steep and forested to the water's edge except for small deltas at the mouths of tributary streams. Hobson and East creeks drain into the upper end of the lake from the north and east, respectively.

CLEARWATER RIVER

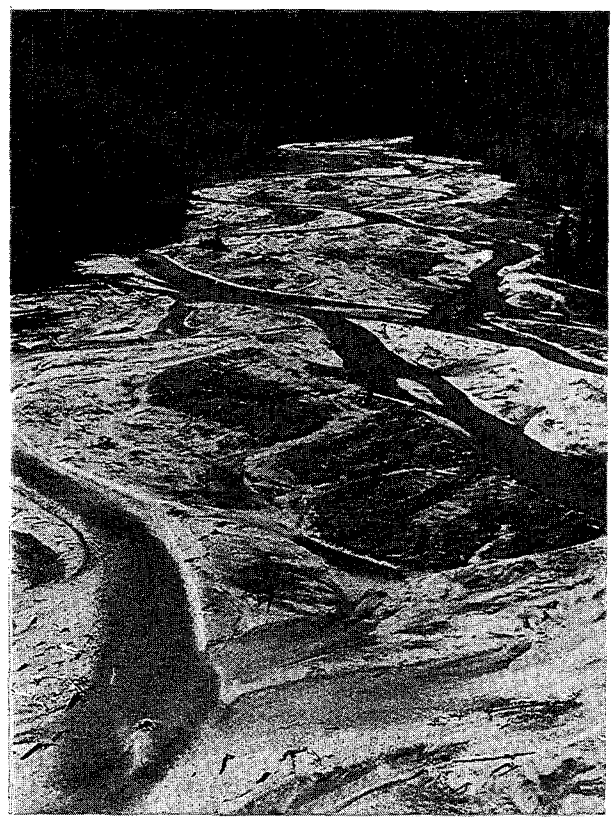
CHUTE AT MILE 65



HOBSON LAKE



MILE 82, NORTH END OF HOBSON LAKE



BRAIDED UPPER SECTION OF RIVER

Their deltas join to form a silty, sand shoreline backed by swamp lowlands.

The Upper Clearwater River flows southerly for 19 miles, into the northwest end of Hobson Lake. The river is braided (Plate A4-5) and meanders through glacial deposits. It is fed by numerous tributaries which originate in snow fields and glaciers and carry a high load of suspended solids (glacial flour) making the river very turbid. The lower 5 miles consists of an alluvial plain which is poorly drained and supports typical marsh vegetation. The stream bottom is compacted, silted gravel; the flow is unstable. From this point to its source the river becomes very turbulent as the gradient steepens. The Upper Clearwater River is not suitable for salmon propagation.

TABLE A4.2 Potential Spawning Areas: Middle Clearwater River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
60.15 - 61.15	1,760	65	114,400	8,008	7	667
61.15 - 61.65	880	60	52,800	16,368	31	1,364
61.65 - 61.90	440	50	22,000	14,300	65	1,192
61.90 - 62.15	440	50	22,000	16,500	75	1,375
62.15 - 66.92	8,395	30	251,856	0	0	0
TOTAL:	11,915	-	463,056	55,176	-	4,598

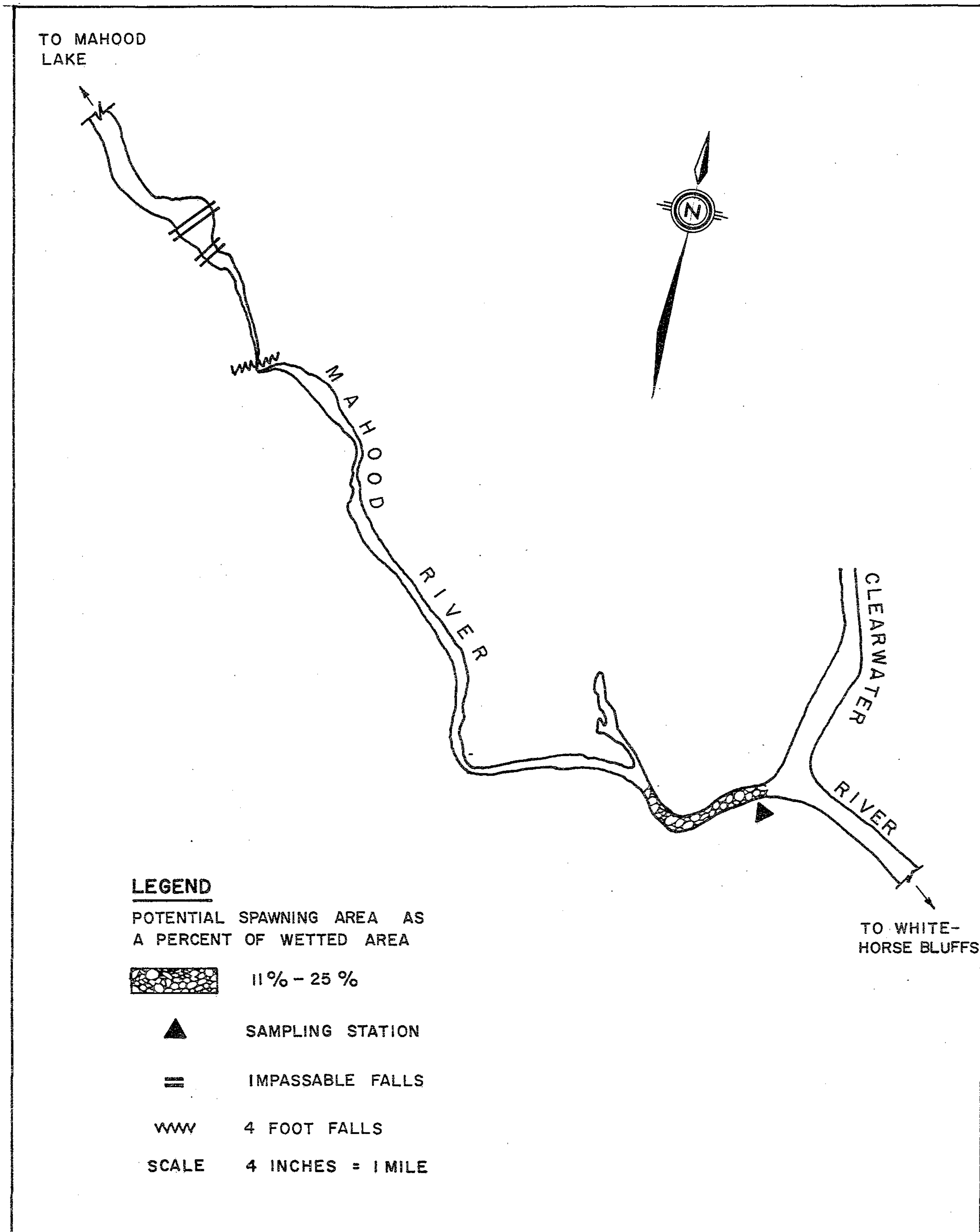


FIG. A4-5 TOTAL POTENTIAL SPAWNING AREA: MAHOOD RIVER

A4.2.2 STREAMS PRESENTLY UTILIZED

Only two streams feeding the Clearwater River presently support chinook salmon populations: Brookfield Creek and Mahood River.

BROOKFIELD CREEK

Brookfield Creek flows southwesterly into the Clearwater River at mile 1.0. It is a narrow, shallow creek, averaging 15 feet in width and 6 inches in depth. It is approximately 3 miles long with abundant streamside vegetation and suitable gravel areas to a steep-walled canyon at mile 2.0. Records indicate that a run of about 75 coho spawn in this creek annually.

As this creek is situated downstream from the proposed Clearwater dam site salmon migration will not be blocked; no estimate of potential capacity was made.

MAHOOD RIVER (FIG. A4-5)

The Mahood River flows southeasterly for 3 miles from its source, Mahood Lake, to its confluence with the Clearwater River, at mile 24.3. At its mouth, the Mahood River is approximately 90 feet wide and the substrate is composed of coarse gravel and boulders. One hundred yards above its mouth, to mile 0.25, portions of the substrate are composed of suitable spawning gravel. In this section, the river depth ranges from one to two feet and the average width is about 75 feet. In the next 0.75 miles deep pools interrupt the rapid flow of the river. The substrate in this reach is unsuitable for salmon spawning.

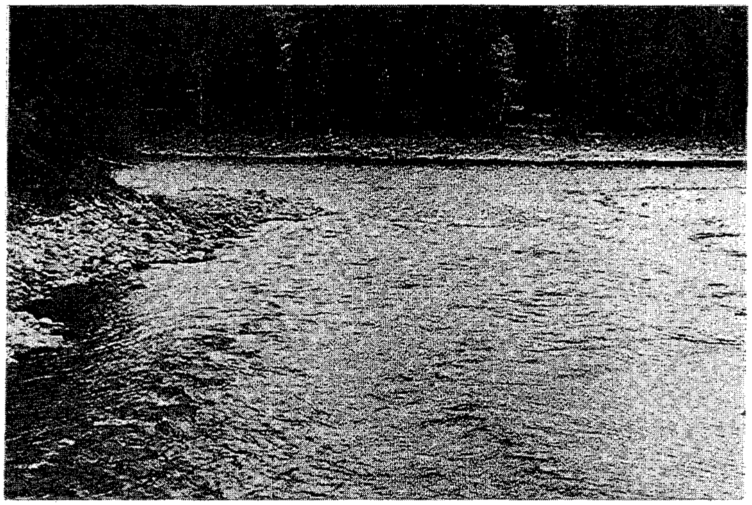
At mile 1.3 there is a 4 foot falls above which the Mahood narrows and steepens. For the next 0.3 miles the river is characterized by falls and rapids. At mile 1.55 and 1.62 are Goodwin and Sylvia falls, each approximately 50 feet high (Plate A4-6). Approximately one mile above Sylvia Falls is the outlet of Mahood Lake. The substrate in this area is lava and bedrock.

The total amount of suitable spawning area in Mahood River was calculated to be 2,530 square yards.

TABLE A4.3 Potential Spawning Areas: Mahood River

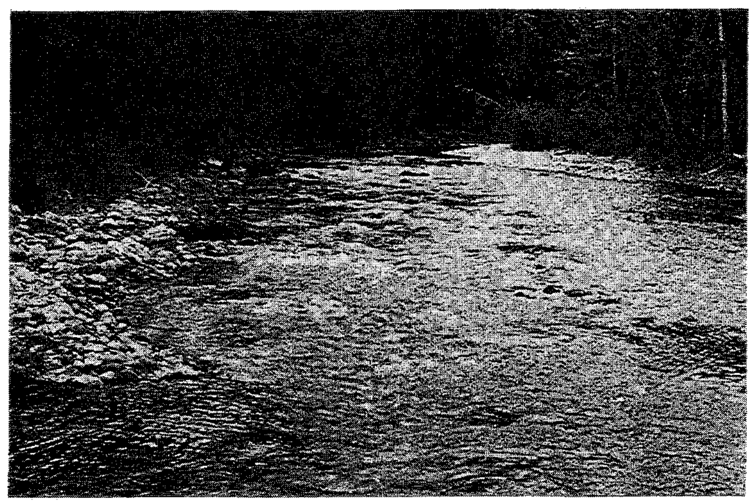
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.25	440	25	11,000	2,530	23	211
0.25 - 3.0	4,840	7	33,880	0	0	0
TOTAL:	5,280	-	44,880	2,530	-	211

MAHOOD RIVER



CONFLUENCE WITH CLEARWATER

GOODWIN FALLS
MILE 1.5



MAJOR SPAWNING AREA
UPSTREAM FROM MOUTH

SYLVIA FALLS
MILE 1.6

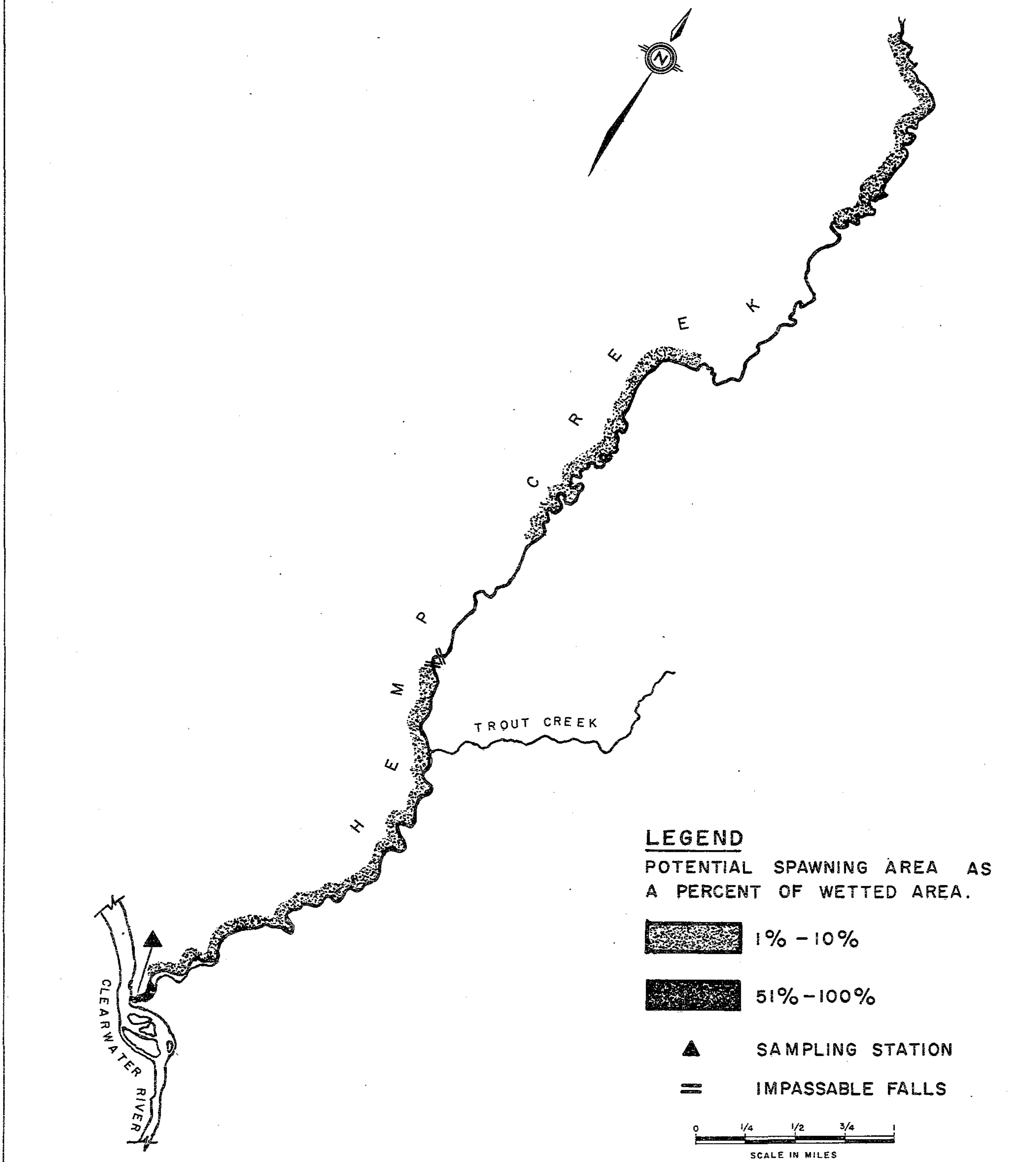


FIG. A4-6 TOTAL POTENTIAL SPAWNING AREA: HEMP CREEK

A4.2.3 STREAMS NOT PRESENTLY UTILIZED

In the Clearwater drainage basin there are seven tributaries which do not presently support salmon runs, but which contain suitable spawning and rearing areas. Of these, only one, Hemp Creek, is accessible. Four streams, Archer, Barella and Ovis creeks and the Azure River are located above the obstructions in the Lower Clearwater River.

Hobson and East creeks are situated above Hobson Lake and are inalterably blocked to salmon migration. Although their descriptions are included herein, the potential capacity of these two creeks is not included in the total potential figures for the Clearwater basin.

HEMP CREEK (FIG. A4-6)

Hemp Creek flows in a southerly direction for 16 miles and enters the Clearwater River at mile 15.4 on the right bank. Most of the gravel in the lower portion of this stream was over 8 inches in diameter. Noticeable amounts of algae were present on the substrate materials. The substrate on the bends was smaller and suitable for spawning. There is excellent cover for rearing purposes throughout the entire stream, with an abundance of trees and overhanging vegetation.

The first 200 yards of stream bottom is suitable for spawning but water depth is shallow and the area is exposed (Plate A4-7). To mile 3.12, only 5% of the wetted area consisted of suitable spawning gravel.

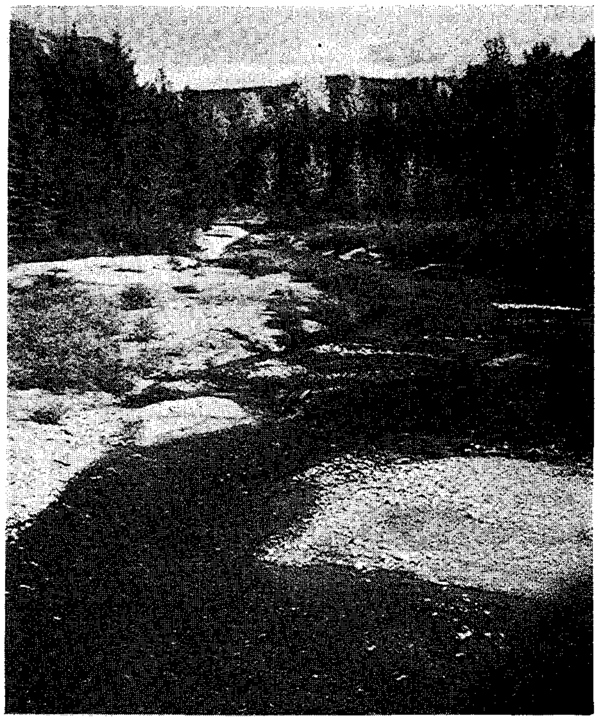
At this point, at mile 3.12, above the confluence of Hemp and Trout creeks, there is a 30 foot falls, above which, for approximately one mile, is a canyonous area. The creek then passes through a lowland marsh and meanders extensively for 2 miles, and the stream depth increases to about 3 feet. In this reach only 5% of the wetted area is suitable for spawning but there is excellent rearing habitat throughout. From mile 6.12 to mile 8.12 is a canyonous area above which the creek flows through an agricultural area for 1.5 miles. In this section 10% of the wetted area was suitable for spawning. Above mile 9.62 Hemp Creek becomes narrow and shallow and is unsuitable for salmon propagation.

A total of 2,956 square yards of suitable spawning gravel exist below the falls; the suitable area above the falls is not sufficient to warrant construction of fish passage facilities and is not included in final potential quantities.

TABLE A4.4 Potential Spawning Areas: Hemp Creek

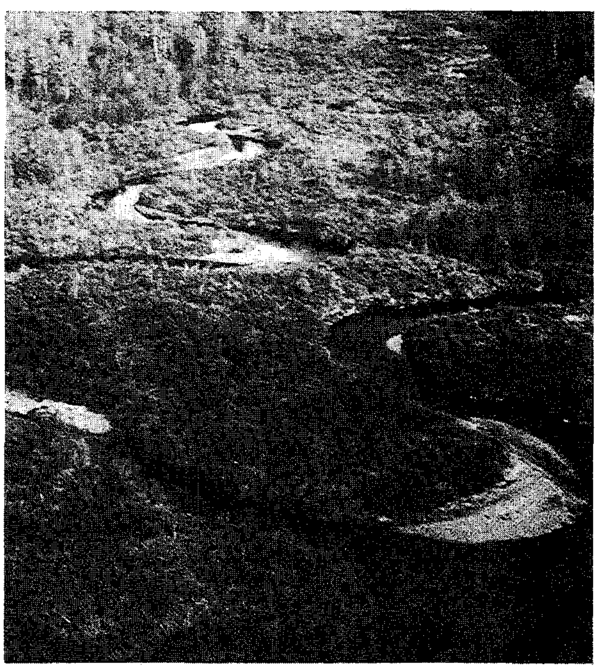
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.12	211	5	1,056	844	80	70
0.12 - 3.12	5,280	10	52,800	2,112	4	176
3.12 - 4.12	1,760	4	7,040	0	0	0
4.12 - 6.12	3,520	6	21,120	1,056	5	88
6.12 - 8.12	3,520	4	14,080	0	0	0
8.12 - 9.62	2,640	5	13,200	1,188	9	99
9.62 - 16.62	12,320	5	61,600	0	0	0
TOTAL:	29,251	-	170,896	5,200	-	433

HEMP CREEK

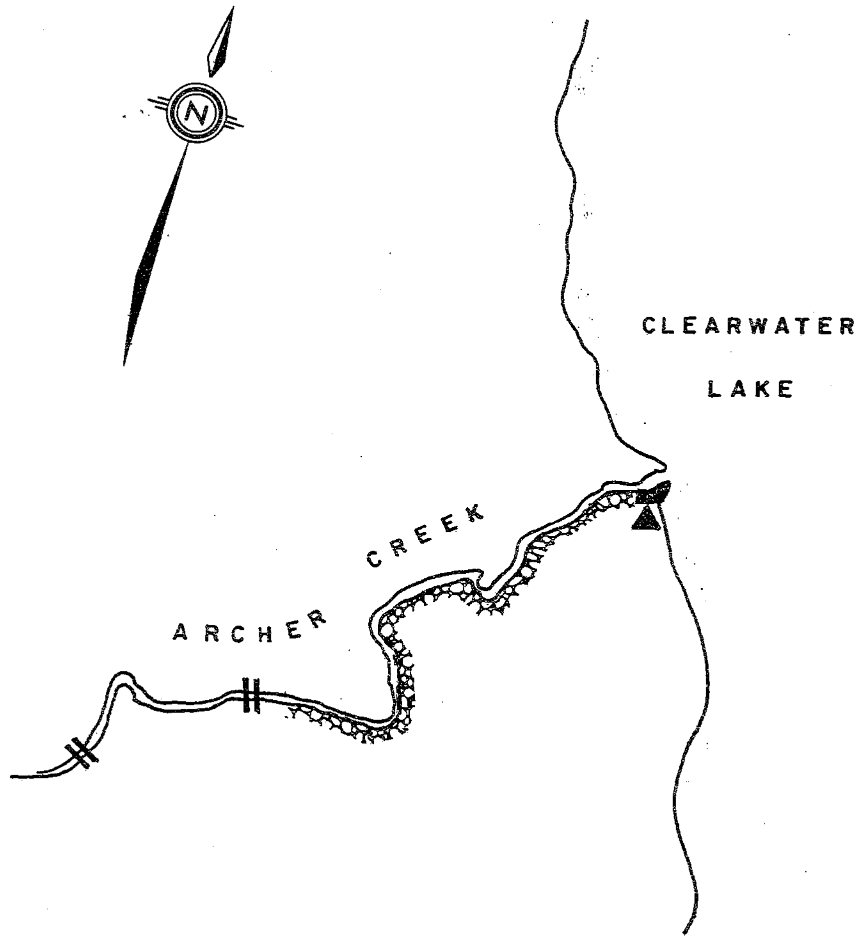


UPSTREAM FROM MOUTH

30-Foot Falls, Mile 3.12



MILE 4.1



LEGEND

POTENTIAL SPAWNING AREA AS A PERCENT OF WETTED AREA

11% – 25%

51% – 100%

SAMPLING STATION

IMPASSABLE FALLS

SCALE 4 INCHES = 1 MILE

FIG. A4-7 TOTAL POTENTIAL SPAWNING AREA: ARCHER CREEK

ARCHER CREEK (FIG. A4-7)

Archer Creek flows into the west side of Clearwater Lake, 12 miles above the lake outlet. At its mouth, Archer Creek is 35 feet wide with an average depth of one foot. Very suitable spawning areas exist to mile 0.2 (Plate A4-8). Above this point, to mile 0.75, the stream averages 25 feet in width; the bottom composition is mainly mud and silt. However, a small portion of the wetted area consisted of suitable spawning gravel.

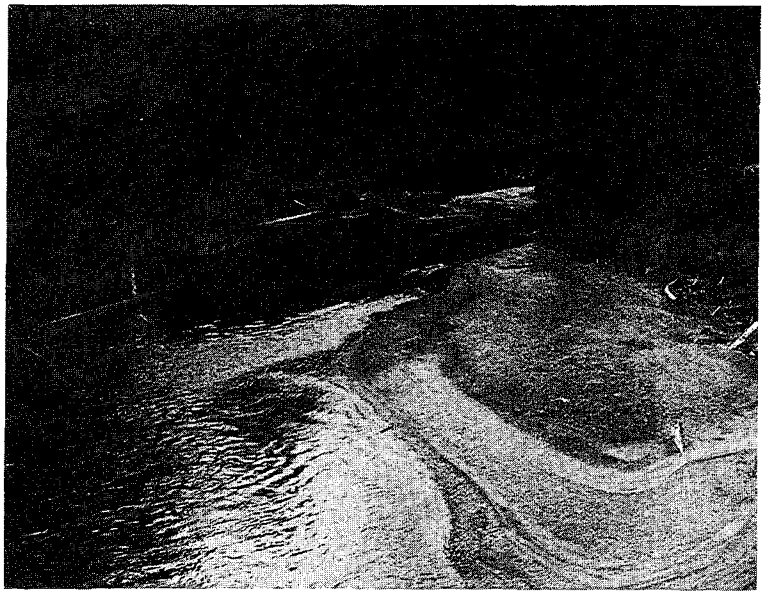
From mile 0.75 to mile 2.0, the stream flows through a narrow canyon. At mile 2.0 is a 25 foot falls above which are no suitable gravel areas.

Total suitable spawning area was estimated to be 1,983 square yards, capable of supporting a theoretical population of 165 salmon.

TABLE A4.6 Potential Spawning Areas: Archer Creek

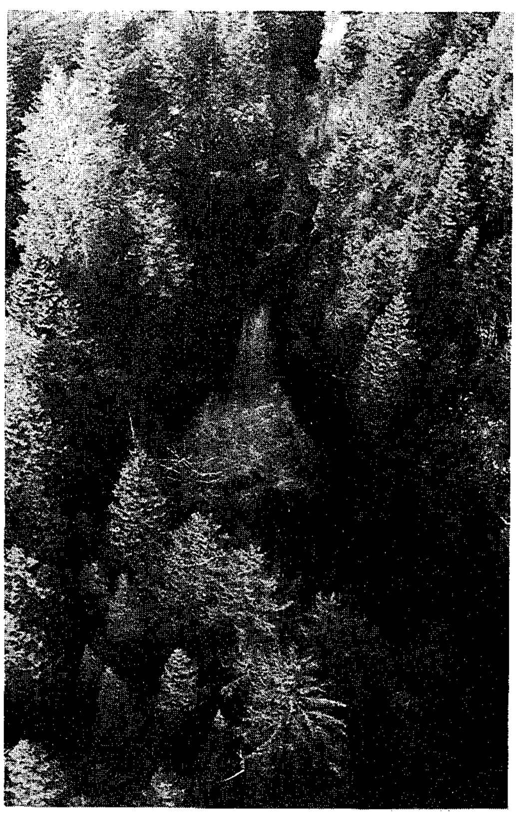
Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.02	35	12	422	338	80	28
0.02 - 0.75	1,285	8	10,278	1,645	16	137
0.75 - 8.00	12,760	3	38,280	0	0	0
TOTAL:	14,080	-	48,980	1,983	-	165

ARCHER CREEK



AT MOUTH

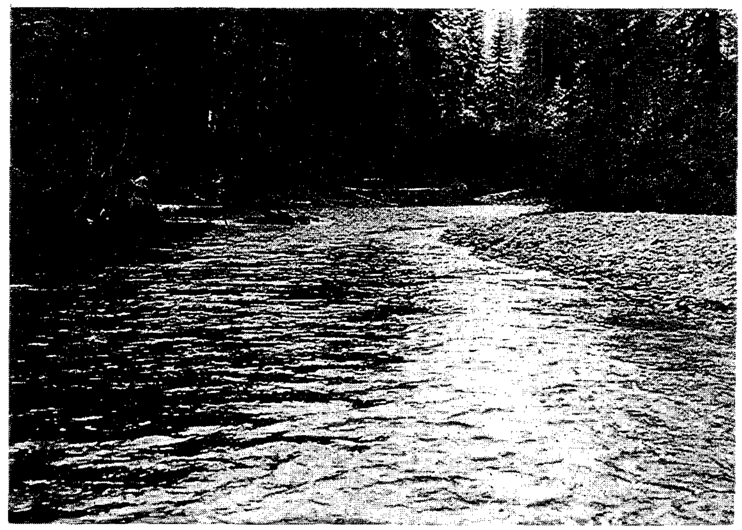
SUITABLE SPAWNING AREA
UPSTREAM FROM MOUTH



FALLS, MILE 2

BARELLA CREEK

AT MOUTH



REARING AREA
UPSTREAM FROM MOUTH

CANYON AREA

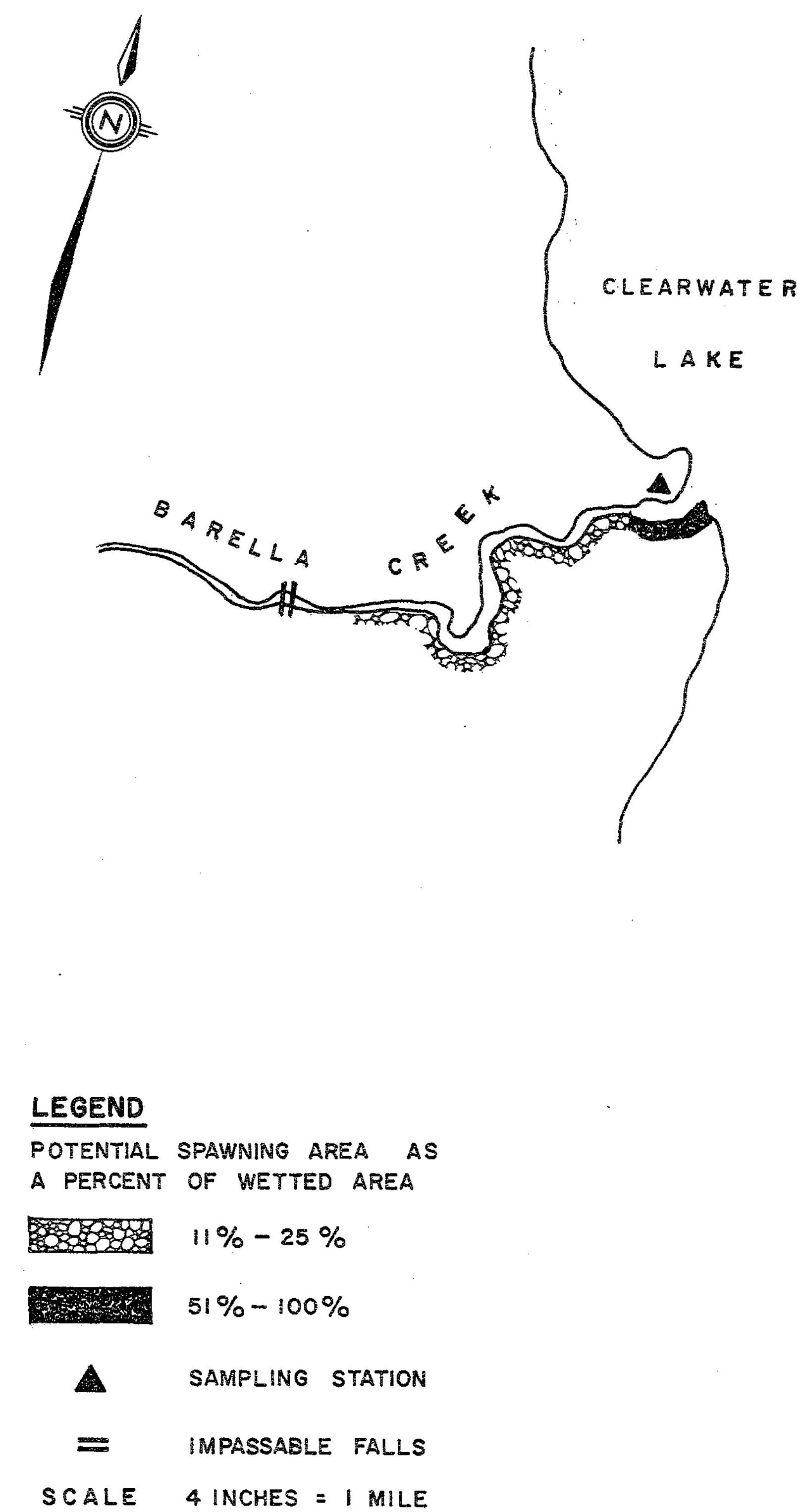


FIG. A4-8 TOTAL POTENTIAL SPAWNING AREA: BARELLA CREEK

BARELLA CREEK (FIG. A4-8)

Barella Creek flows easterly for 15 miles and drains into the west side of Clearwater Lake, approximately 14 miles above its outlet, and north of Archer Creek. At the mouth it is 50 feet wide. Seventy-five percent of the wetted area to mile 0.13 is composed of suitable spawning gravel; to mile 0.3, the proportion of suitable area decreases to 20%. Above mile 0.3 there is a long canyonous area with no suitable spawning areas (Plate A4-9).

The amount of suitable spawning area is 3,404 square yards, capable of supporting 284 spawners.

TABLE A4.6 Potential Spawning Areas: Barella Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.13	229	16	3,661	2,746	75	229
0.13 - 0.3	299	11	3,291	658	20	55
0.3 - 0.7	11,792	5	58,960	0	0	0
TOTAL:	12,320	-	65,912	3,404	-	284

AZURE RIVER (FIG. A4-9)

That portion of the Azure River which joins the Clearwater at the outlet of Azure Lake has been included in the description of the Middle Clearwater River.

Azure Lake is approximately 15 miles long and 0.5 miles wide with an area of 7,680 acres. The shoreline is steep, with gradients of 30% to 70% and

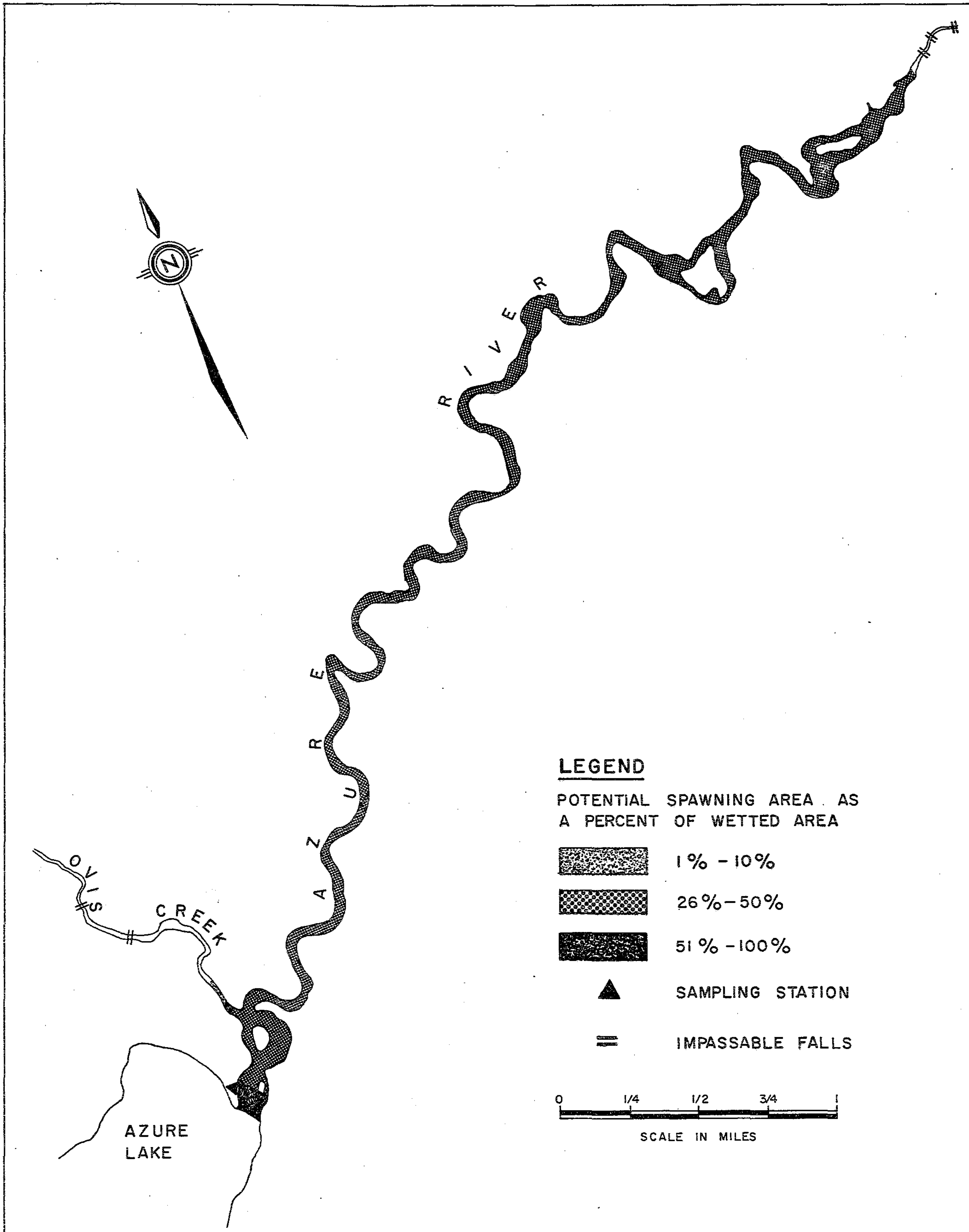


FIG. A4-9 TOTAL POTENTIAL SPAWNING AREA: AZURE RIVER (UPPER) and OVIS CREEK is heavily forested to the water's edge. There are approximately thirty streams, small and intermittent, which drop precipitously into the lake. None were considered to contain suitable salmon habitat.

The Azure River, above Azure Lake, flows southwesterly for some thirty miles. To mile 0.13, the river is 75 to 90 feet wide, averages 2 feet in depth, and contains excellent spawning gravel. To mile 5.13, the river meanders; it is braided and about 3 feet deep (Plate A4-10). Suitable spawning gravel is confined to the bends, with sand and fine gravel comprising the remainder of the stream bed materials.

Above mile 5.13, the gradient increases and the river becomes an impassable series of falls. At mile 5.38, there is a 25 ft. falls, above which the Azure River divides into two branches. The left fork contains two falls, 40 feet and 80 feet high, while the right fork has one falls, about 100 feet high. Above these falls no suitable spawning areas exist.

The total potential spawning area in the lower 5.13 miles is 79,240 square yards, theoretically capable of supporting 6,603 chinook.

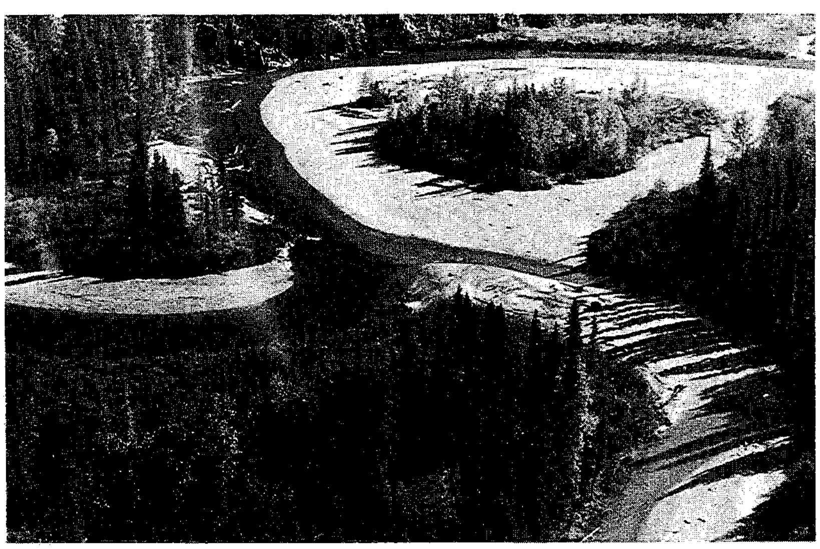
TABLE A4.7 Potential Spawning Areas: Upper Azure River

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	Potential Spawning Area (%)	Spawning Capacity (no. of fish)
Lake Inlet 0.0 - 0.13	229	25	5,720	5,320	93	443
0.13 - 5.13	8,800	30	264,000	73,920	28	6,160
5.13 - 30.0	43,771	5	218,856	0	0	0
TOTAL:	52,800	-	488,576	79,240	-	6,603

AZURE RIVER

ABOVE MOUTH

AZURE LAKE



CONFLUENCE OF OVIS CREEK

OVIS CREEK (FIG. A4-9)

Ovis Creek flows southerly some 12 miles to join the Azure River, 300 yards from the mouth of the latter (Plate A4-10). There is suitable spawning gravel to mile 0.5, beyond which the stream gradient increases markedly. Ovis Creek is 50 feet wide and 2 to 3 feet deep in this lower reach. There is 1,197 square yards of suitable spawning area, capable of supporting 100 chinook.

TABLE A4.8 Potential Spawning Areas: Ovis Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.5	880	17	14,960	1,197	8	100
0.5 - 12.0	20,240	6	121,440	0	0	0
TOTAL:	21,120	-	136,400	1,197	-	100

HOBSON CREEK

Hobson Creek flows westerly, then southerly for approximately 12 miles into Hobson Lake at a point east of the mouth of the Clearwater River. At its mouth, Hobson Creek is about 40 feet wide and an average of 2 feet deep. Suitable spawning gravel comprises 40% of the wetted area in the lower 300 yards (Plate A4-11). Above mile 0.17, the creek narrows, the gradient increases and the stream becomes an impassable series of falls. Hobson Creek was estimated to contain 1,560 square yards of suitable spawning gravel. This potential capacity, however, is inalterably inaccessible.

TABLE A4.9 Potential Spawning Areas: Hobson Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.17	299	13	3,890	1,556	40	130
0.17 - 12.0	20,821	4	83,283	0	0	0
TOTAL:	21,120	-	87,173	1,556	-	130

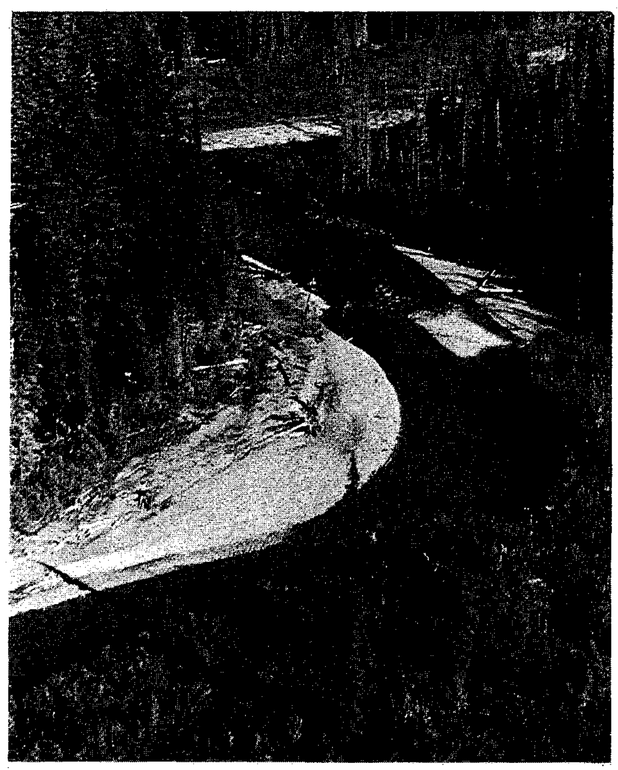
EAST CREEK

East Creek flows westerly 10 miles into Hobson Lake directly south of Hobson Creek. At its mouth, this shallow stream is 40 feet wide, but to mile 1.0 the creek narrows to an average of 20 feet and meanders through a low valley. Above mile 1.0 East Creek becomes steep, and bedrock and boulders comprise the stream bottom. To mile 1.0 East Creek has 2,215 square yards of suitable spawning gravel which is not accessible and therefore not included in the total potential capacity for the Clearwater basin.

TABLE A4.10 Potential Spawning Areas: East Creek

Stream Section (miles)	Length (yds.)	Average Width (yds.)	Wetted Area (sq.yds.)	Potential Spawning Area (sq.yds.)	(%)	Spawning Capacity (no. of fish)
0.0 - 0.13	229	13	2,974	714	24	60
0.13 - 1.0	1,531	7	10,718	1,501	14	125
1.0 - 10.0	15,840	4	63,360	0	0	0
TOTAL:	17,600	-	77,052	2,215	-	185

EAST CREEK, MILE 0.25



HOBSON CREEK
MAJOR GRAVEL
AREA AT MOUTH

A4.2.4 TRIBUTARIES WITH NO POTENTIAL

Streams were judged to have potential capacity for salmon propagation on the basis of two criteria: physio-chemical parameters, including streambed composition, and accessibility. Many of the streams in the Clearwater basin are unsuitable because they fail to comply with one or more of the above criteria.

Because of the volcanic origin of the basin below Clearwater Lake, many tributaries flow through deep narrow gorges, at steep gradients with turbulent flow and contain many waterfalls. Streambeds are composed of large boulders and bedrock. Spahats, Moul and Donald creeks typify this type of inaccessible and non-productive stream. Murtle River is blocked to migration by Helmcken Falls, 450 feet high, one mile from its mouth. In the 22 miles between Helmcken Falls and Murtle Lake are five other falls ranging from 20 to 110 feet in height. Trout and Lonespoon creeks, although accessible, have gradients in excess of 5% and consequently contain no suitable gravel. Deer and Mink creeks do not have sufficient flows to support salmon. The above named tributaries are all located below the chute on the Clearwater River at mile 40.

Other streams situated above this chute area, upstream to Hobson Lake, including tributaries of Azure Lake, also failed to meet the criteria for potential salmon propagation. Falls, Angus Horne, and Lickskillet creeks have waterfalls at or near their outlets; Goat, Ivor and Daniel creeks have steep gradients and contain no suitable spawning gravel, and Donkey Creek has insufficient flow.

As noted previously, streams above Hobson Lake and tributary to it, are unsuitable due to the numerous obstructions below Hobson Lake. Such streams as Goat, Tighe, Hamany Hall, Summit, Hobson and East creeks are included in this group. These streams, except for Hobson and East creeks, are further regarded as non-productive because of their steep gradients and lack of spawning gravel.

A4.3 Swim and Boat Surveys of Chinook Abundance and Spawning Areas

In conjunction with the aerial survey of the Clearwater system to determine its potential capacity, the abundance, and spatial and temporal distribution of adult salmon was recorded during a jet-boat and a swim survey of the Clearwater and Mahood rivers. Those river sections where chinook salmon spawning has been recorded were surveyed: the Clearwater from its mouth to mile 4.0, and from mile 11.0 to 35.0 was examined by jet-boat and by swimmers; the lower section of the Mahood River was swam.

During a swim survey September 13, 1972 of the Clearwater River from mile 24.3 (Mahood River confluence) downstream to below the Whitehorse Bluffs area, a distance of 6 miles, 225 adult chinook salmon were counted. These fish were moving upstream or holding in pool areas. Very few were engaged in spawning activity. Large numbers of rainbow trout and white fish, both juveniles and adults were also evident.

On September 14th, the Mahood River was floated and ten adult chinook were sighted below the falls at mile 0.75, and two were seen near the mouth. A small number of chinook juveniles were also sighted, as were substantial numbers of adult and juvenile rainbow trout and white fish.

On September 16, 1972, the Clearwater River from Whitehorse Bluffs downstream to the chute at mile 13 was floated by the swimmers again. At Whitehorse Bluffs, 3 chinook were digging redds; two miles downstream, two chinook were observed, but from this point downstream to mile 13, no adult fish were sighted.

Approximately 2000 juvenile chinook were observed on the west bank of the Clearwater River, below the chute in a 0.25 mile long section of the river.

On September 17, 1972, the lower 4 miles of the Clearwater River were surveyed by boat. From the mouth of Brookfield Creek to the bridge at Clearwater station, 250 sockeye were spawning.

On September 20, a five mile portion of the Clearwater River from the chute (mile 40) downstream to Horseshoe Bend, was floated. One hundred and seventy-five adult chinook were counted; several hundred rainbow trout were also present. Six of the chinook were digging redds, the remainder appeared to be holding.

The same area was surveyed by boat on September 22, from Lonespoon Creek down to Deer Creek, through the Horseshoe Bend area. One hundred and four chinook were counted on the route downriver, and 105 on the return trip. The majority of these were in the Horseshoe Bend area spread over the riffle areas, and were spawning.

The sockeye spawning area at Brookfield Creek was observed again on September 30. At this time no spawning activity was taking place and only four spawned out sockeye were present. This would indicate that spawning had ended.

On October 2, a total of 110 actively spawning chinook salmon were counted in the lower 0.25 miles of the Mahood River. These fish appeared larger in size than the Clearwater chinook.

On October 5, no juveniles were present in that reach of the Clearwater below mile 13.

The majority of the chinook observed in the system were occupying the major spawning grounds. There were 600 fish at Whitehorse Bluffs, 750 at Horseshoe Bend, and 20 chinook in an area 0.5 miles downstream from the mouth of Mahood River.

Peak spawning occurs between late September and early October for chinook and around mid-September for sockeye.

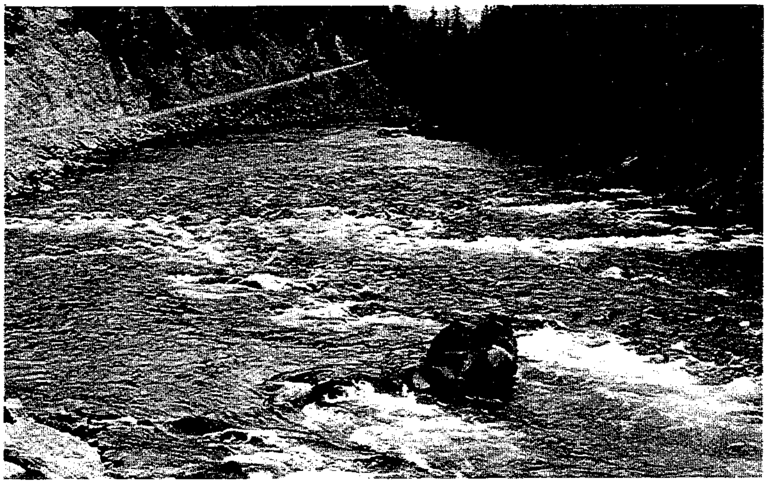
A4.4 Juvenile Chinook Sampling Survey

A sampling of the juvenile salmonids was undertaken in an effort to determine abundance, distribution and timing of downstream migration as well as to determine the condition, length-weight relationships and age of the juveniles sampled. Samples were obtained using beach seine and electro-fishing techniques at sites on Hemp Creek and on Clearwater River. Each site was sampled twice, the second sample taken 7 days after the first.

It was only possible to establish four beach seine stations, two each at mile 8 and mile 11 on the Clearwater; other areas did not have adequate access. In addition, three areas were sampled with an electro-fish shocker; mile 8 and mile 15 on the Clearwater, and mile 0.25 on Hemp Creek (Plate A4-12).

On September 12 and 14, beach seining captured 136 juvenile chinook in 5 sets at the four Clearwater stations. On October 5, four sets produced only 40 juvenile chinook. Visual observations indicated a decline in juvenile chinook abundance at these sites. Electro-fishing produced 25 juveniles in 3 attempts on the Clearwater, and 15 juveniles in one attempt on Hemp Creek.

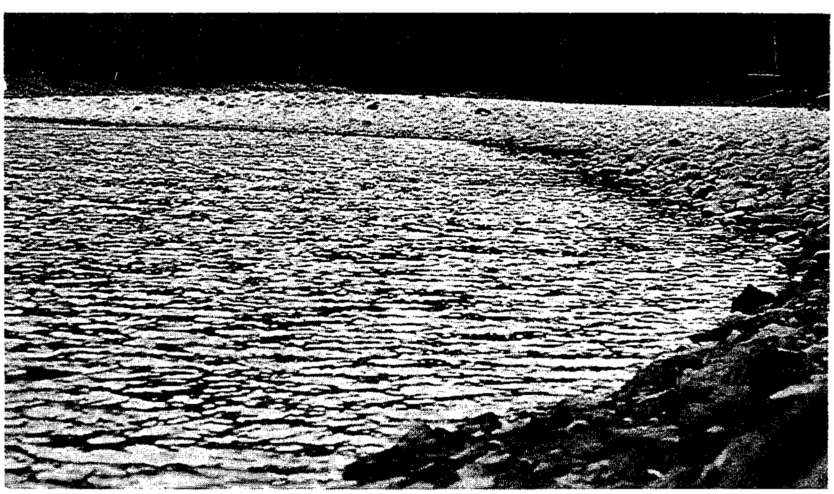
Scales from each juvenile sampled were analyzed to determine age. The results indicate that all were fry of the year, that is, emergence had occurred that spring.



ELECTROFISHING SITE, MILE 13
CLEARWATER RIVER

ELECTROFISHING SITE, MILE 1
HEMP CREEK

JUVENILES CAUGHT BY BEACH SEINE
AT MILE 8, CLEARWATER RIVER



BEACH SEINE SITE, MILE 11
CLEARWATER RIVER

The length-weight relationships detailed in Table A4.11 are summarized below.

Sampling Summary

Stream	Sample Size	Length Range (mm)	Average Length (mm)	Weight Range (gm)	Average Weight (gm)
Clearwater River	75	47-75	59	1.2-5.15	2.66
Hemp Creek	15	52-71	60	1.71-5.95	3.11

The presence of fry-of-the-year in the Clearwater and Hemp Creek during September indicates that not all chinook fry migrate seaward after a 90 day rearing period. It is speculated that the decrease in juvenile abundance at the sampling sites resulted from downstream migration of the fry during the sampling period.

TABLE A4.11 Lengths and Weights of Chinook Juveniles Sampled

Date (1972)	Location	Time	Sampling Method	Length (mm.)	Weight (gm.)	Number Sampled	Number of fish Captured
Sept. 12	Mile 8 Clearwater R.	1745	BS*	71	4.522	2	2
				56	2.315		
Sept. 12	Mile 8 Clearwater R.	1815	BS*	49	1.389	6	12
				54	1.892		
				57	2.297		
				59	2.400		
				60	2.440		
				74	5.144		
Sept. 12	Mile 8 Clearwater R.	1845	BS*	51	1.603	9	40
				55	1.800		
				57	2.121		
				57	2.312		
				58	2.392		
				66	3.488		
				70	4.037		
				64	3.003		
				71	4.400		
					Total:	17	54
			Average:	60	2.797		

* BS Beach Seine

TABLE A4.11 (cont'd.)

Lengths and Weights of Chinook Juveniles Sampled

Date (1972)	Location	Time	Sampling Method	Length (mm.)	Weight (gm.)	Number Sampled	Number of fish Captured
Sept. 14	Mile 11 Clearwater R.	1800	BS*	47	1.200	8	22
				53	1.721		
				50	1.487		
				50	1.609		
				59	2.713		
				60	2.730		
				64	3.430		
				57	2.277		
Sept. 14	Mile 11 Clearwater R.	1830	BS*	59	2.517	15	50
				57	2.107		
				62	2.740		
				56	2.165		
				51	1.470		
				54	1.880		
				58	2.214		
				59	2.700		
				50	1.560		
				55	1.962		
				53	1.894		
				60	2.649		
				65	3.449		
				65	3.333		
				75	4.742		
					Total:	23	72
			Average:	57	2.371		

* BS Beach Seine

TABLE A4.11
(cont'd.)

Lengths and Weights of
Chinook Juveniles Sampled

Date (1972)	Location	Time	Sampling Method	Length (mm.)	Weight (gm.)	Number Sampled	Number of fish Captured
Sept. 14	Mile 8 Clearwater R.	1200	EF**	49	1.454	12	12
				60	2.449		
				61	2.735		
				62	2.896		
				56	1.989		
				61	2.636		
				66	3.450		
				63	3.028		
				68	3.990		
				66	3.780		
				70	4.186		
				75	5.167		
					Total:	12	12
			Average:	63	3.146		
Sept. 14	Mile 15 Clearwater R.	1345	EF**	56	2.161	3	3
				54	2.307		
				53	1.876		
					Total:	3	3
			Average:	54	2.114		

** EF Electrofishing

TABLE A4.11
(cont'd.)

Lengths and Weights of
Chinook Juveniles Sampled

Date (1972)	Location	Time	Sampling Method	Length (mm.)	Weight (gm.)	Number Sampled	Number of fish Captured
Sept. 15	Mile 0.25						
	Hemp Creek	1230	EF**	52	1.711	15	15
				54	2.059		
				54	2.108		
				56	2.415		
				60	2.856		
				59	2.906		
				55	2.604		
				63	3.660		
				59	2.954		
				64	3.444		
				68	3.942		
				59	2.755		
				64	3.890		
				62	3.367		
				71	5.950		
					Total:	15	15
			Average:	60	3.108		

** EF Electrofishing

TABLE A4.11 (cont'd.) Lengths and Weights of Chinook Juveniles Sampled

Date (1972)	Location	Time	Sampling Method	Length (mm.)	Weight (gm.)	Number Sampled	Number of fish Captured
Sept. 16	Mile 12.5						
	Clearwater R.	1530	EF**	57	2.124	10	10
				55	1.910		
				55	1.831		
				57	2.059		
				59	2.408		
				56	2.320		
				60	2.648		
				65	3.576		
				68	4.018		
				70	4.290		
					Total:	10	10
			Average:	60	2.718		
Oct. 5	Mile 14						
	Clearwater R.	1600	BS*	53	1.726	3	3
				58	2.558		
				61	2.951		
		1645		57	2.128	2	2
				64	3.424		
		1700		58	2.317	5	5
				54	2.308		
				63	2.937		
				61	2.890		
				61	3.414		
					Total:	10	10
			Average:	59	2.665		

* BS Beach Seine
** EF Electrofishing

A4.3 PHYSIO-CHEMICAL MEASUREMENTS

A summary of the physical and chemical characteristics of the streams in the Clearwater River basin surveyed in 1972 are described in Tables A4.12 and A4.13. Analysis of water chemistry was conducted using a Hach water analysis field kit.

Water depth varied from 0.5 to 5.5 feet and was estimated by eye at the sampling station. Water velocity measurements were also variable, from 2.8 to 6.1 fps. Water temperatures ranged from 36.0 to 53.0 degrees F. The dissolved oxygen concentration of the surface and sub-surface water ranged from 7 to 12 ppm and 5 to 10 ppm respectively. Suspended sediment levels ranged from less than one ppm to 94 ppm. Hydrogen ion concentration (pH) varied from 6.8 to 8.05, within the tolerance range for salmon.

The results of the chemical analysis of the streams are summarized below:

total alkalinity	30.00 - 75.00 ppm	manganese	0.00 - 1.10 ppm
color (apparent)	0.00 - 18.00	nitrate nitrogen	0.00 - 10.00 "
carbon dioxide	0.80 - 4.00 ppm	nitrite nitrogen	<0.01 - 1.00 "
chloride	2.50 - 5.00 ppm	pH	6.80 - 8.05 "
chromium	0.015- 0.03 ppm	orthophosphate	0.70 - 1.60 "
copper	0.02 - 0.08 ppm	metaphosphate	0* - 0.8 "
calcium hardness	10.00 - 40.00 ppm	sulfate	4.00 - 23.00 "
total hardness	15.00 - 85.00 ppm	silica	2.40 - 4.50 "
iron	0.00 - 0.36 ppm	turbidity	0 JTU**

* negative value, assume meter read 0 ppm

** Jackson Turbidity Units

TABLE A4.12 Physical characteristics of major streams in the Clearwater River Basin.

STREAM	SAMPLING DATE (1972)	SAMPLING LOCATION*	DEPTH RANGE (ft.)	VELOCITY** (fps)	AIR TEMP. (°F)	WATER TEMP. (°F)	SURFACE DISSOLVED OXYGEN (ppm)	SUB-SURFACE DISSOLVED OXYGEN (ppm)	SUSPENDED SEDIMENT CONCENTRATION (ppm)	DISSOLVED SOLIDS CONCENTRATION (ppm)
ARCHER CREEK	Oct. 4	mouth	0.5-1.5	2.80	47.0	36.0	12	10	2.0	49
AZURE RIVER	Oct. 3	mouth	0.5-3.0	3.70	53.0	42.0	8	5	23.0	48
BARELLA CR.	Oct. 4	mouth	0.5-1.5	4.20	45.0	37.0	10	8	2.0	22,27
CLEARWATER R.	Oct. 5	Whitehorse Bluffs	1.5-5.5	6.10	53.0	47.0	7	6	0.6	66
MIDDLE CLEARWATER R.	Oct. 3	1.0	0.5-4.5	3.30	44.0	47.0	9	8	2,1	45,56
DEER CREEK[1]	Sept. 21	0.06	0.5-1.0	5.00	47.0	44.0	11	8	10,6	60,62
FALLS CREEK[1]	Sept. 21	mouth	0.5-1.5	4.70	47.0	44.0	10	8	5,2	47,50
HEMP CREEK	Sept. 15	mouth	0.5-3.0	4.40	58.0	53.0	12†	-	-	-
LONESPOON CR.[1]	Sept. 21	0.06	0.5-1.5	4.20	47.0	44.0	11	8	82,94	46,55
MAHOOD RIVER	Sept. 23	mouth	0.5-3.5	3.10	41.0	51.5	9	8	0.6,1	74,77

* Distance in miles from stream mouth.
** Instantaneous velocity measured at sampling station.
† Sample taken at mile 10.
1 Sampled after heavy rainfall.

TABLE A4.13 Chemical Analysis of Major Streams in the Clearwater River Basin

	SAMPLING DATE (1972) (HOUR)	SAMPLING LOCATION*	WATER TEMP. (^0F)	TOTAL ALKALINITY (ppm)	CARBON DIOXIDE (ppm)	CHLORIDE (ppm)	CHROMIUM (ppm)	COPPER (ppm)	CALCIUM HARDNESS (ppm)	TOTAL HARDNESS (ppm)	COLOUR (colour units)
ARCHER CR.	Oct. 4 (1300)	mouth	36	30	2.0	-	-	.04	15	15	18
AZURE RIVER	Oct. 3 (1600)	mouth	42	50	2.0	-	-	.07	30	45	0
BARELLA CR.	Oct. 4 (1200)	mouth	37	40	2.0	-	-	.02	10	15	0
CLEARWATER R.	Sept. 23 (1400)	at Mahood confluence	47†	50	4.0	2.5	.025	-	35	50	0
MIDDLE CLEARWATER R.	Oct. 4 (1100)	0.25	47	50	2.0	-	-	.08	20	30	0
DEER CREEK	Sept. 21 (1530)	0.06	44	-	-	-	-	-	-	-	10
FALLS CREEK	Sept. 21 (1615)	mouth	44	-	-	-	-	-	-	-	0
HEMP CREEK	Sept. 21 (1400)	10.0	46.5	75	0.8	5	.015	-	30	85	0.6
LONESPOON CR.	Sept. 21 (1600)	mouth	44	-	-	-	-	-	-	-	0
MAHOOD RIVER	Sept. 23 (1500)	mouth	51.5	50	0	2.5	.03	-	40	55	0
MURTLE R.	Sept. 21 (1500)	2.0	-	50	-	-	-	-	10	15	0

* Distance in miles from stream mouth.
† Taken at Whitehorse Bluffs.

TABLE A4.13 (cont'd) Chemical Analysis of Major Streams in the Clearwater River Basin

	IRON (ppm)	MANGANESE (ppm)	NITRATE NITROGEN (ppm)	NITRITE NITROGEN (ppm)	pH	ORTHO-PHOSPHATE (ppm)	META-PHOSPHATE (ppm)	SULFATE (ppm)	SILICA (ppm)	TURBIDITY (JTU)
ARCHER CREEK	0	0	0	-	6.9	.70	0**	4	4.5	0
AZURE RIVER	0	0	0	-	6.9	1.6	0.8	23	2.5	0
BARELLA CR.	0	0	0	-	6.8	.95	0**	8	3.8	0
CLEARWATER R.	.03	0.7	10	<.01	8.05	-	-	-	3.1	0
MIDDLE CLEARWATER R.	0	0	0	-	7.4	1.5	0**	9	2.4	0
DEER CREEK	-	-	-	-	7.65	-	-	-	-	0
FALLS CREEK	-	-	-	-	7.45	-	-	-	-	0
HEMP CREEK	.36	0.1	3	1	7.8	-	-	-	5	0
LONESPOON CREEK	-	-	-	-	7.65	-	-	-	-	0
MAHOOD RIVER	.03	1.1	2.5	<.01	7.65	-	-	-	4.3	0
MURTLE RIVER	-	-	-	-	7.33	-	-	-	-	0

** Negative value, assumed meter reading was zero.
JTU Jackson Turbidity Units.

Appendix A5

WATER QUALITY SURVEY

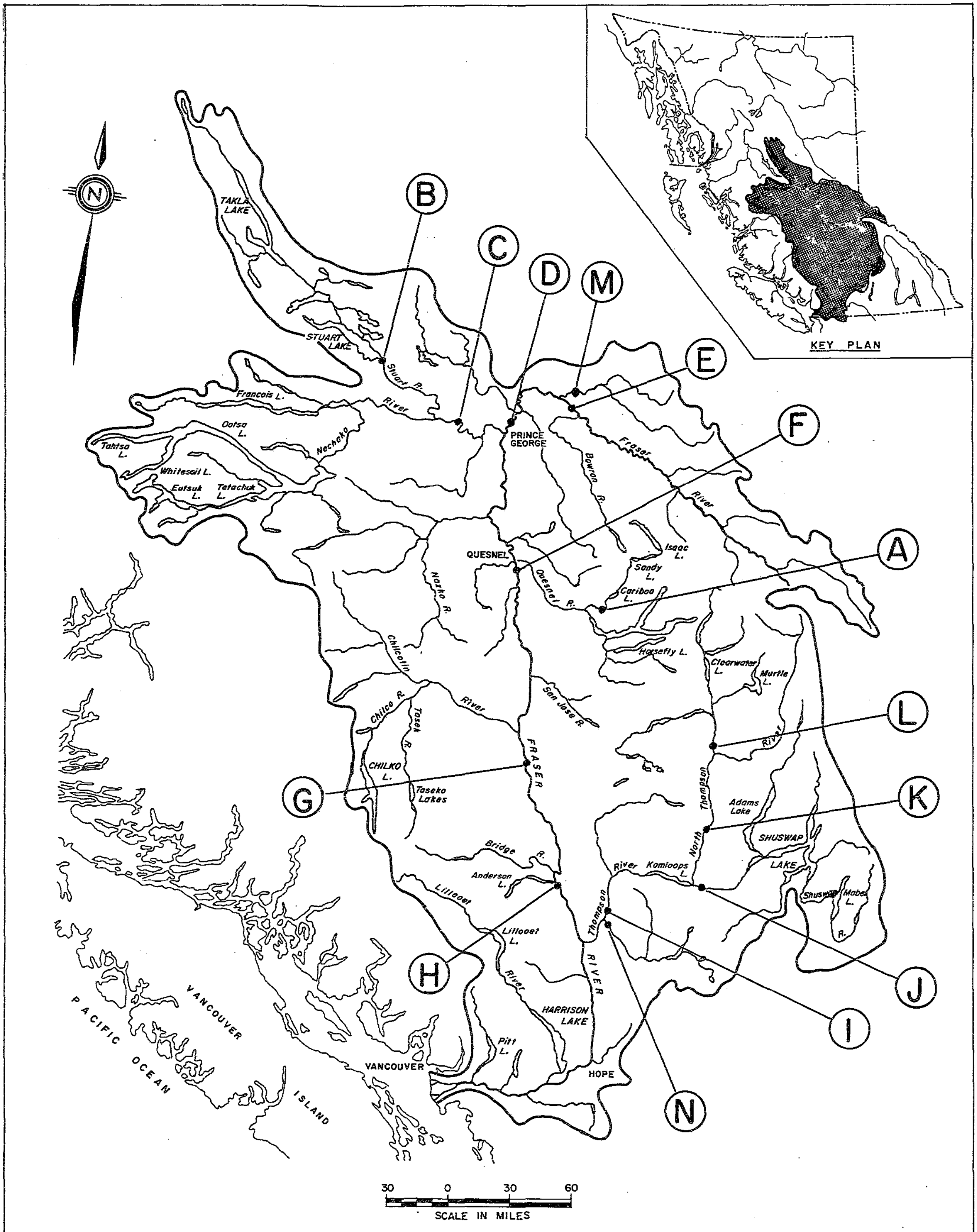


FIG. A5-1 SAMPLING SITES OF WATER QUALITY SURVEY, FRASER RIVER BASIN

A 5 WATER QUALITY SURVEY

This portion of Appendix A presents and analyzes the results of the water quality sampling program conducted in 1972 on the Fraser River and its major tributaries. Where possible, the results are compared to other studies and analyses.

The water quality parameters obtained were used as guidelines to estimate the impact of the various components of System E upon the water quality of the Fraser system and the effects any changes in that quality would have on the salmon stocks of the system.

A5.1 SAMPLING PROCEDURE

Initially, thirteen sampling sites were chosen. A fourteenth on the Nicola River was added several weeks later. Sampling began May 12, 1972 and was completed by August 27, 1972. Two weeks were required to visit all fourteen sites (one tour) covering a total distance of 2,000 miles. A total of eight tours were completed.

The sampling pattern commenced in the Prince George area, proceeded south down the Fraser River to Quesnel, east to the Cariboo River, then south to Lytton, north to Spences Bridge, Kamloops, and to the Clearwater River. Five sampling sites were located on the Fraser River, three on the Thompson system, and one on each of the remaining six rivers. Each site, identified by a letter and shown in Figure A5-1, is listed below:

A	Cariboo River near Likely
B	Stuart River at Fort St. James
C	Nechako River at Isle Pierre Ferry
D	Fraser River at Shelley
E	Fraser River at Hansard
F	Fraser River at Quesnel
G	Fraser River near Gang Ranch
H	Fraser River near Lillooet
I	Thompson River near Spences Bridge

J	South Thompson River near Kamloops
K	North Thompson River at McLure Ferry
L	Clearwater River near Clearwater
M	McGregor River northwest of Hansard
N	Nicola River near Spences Bridge

At each site, three samples of running water were collected in plastic, one-liter bottles from a depth of six inches at a point near the shore. One sample was warmed to near 23^{o} centigrade and analyzed at the site with a Hach DR-EL "Direct Reading" portable engineer's kit for the following: total alkalinity, colour, turbidity, iron, manganese, nitrate, nitrite, orthophosphate, metaphosphate, fluoride, dissolved oxygen and pH. River temperatures were obtained six inches beneath the surface at time of sampling. In addition, colour photographs of each sampling site were taken to record changing water levels during the survey period.

Two samples were stored at 3^{o} centigrade in ice and shipped by air to the Pacific Environment Institute in West Vancouver where biological oxygen demand (BOD) and conductance tests were performed. Three shipments were made during each complete sampling tour. Samples reached the laboratory the day of shipment.

During May, samples from sites B, C, D, F, H, I, J, and K were analyzed for only temperature, biological oxygen demand, specific conductance, nitrates, nitrites, and dissolved oxygen. Samples obtained during the third to eighth tours were analyzed completely.

A5.2 RESULTS OF THE CHEMICAL ANALYSIS

The sampling stations are grouped in the following geographical regions (Fig. 5-2).

Upper Fraser River Basin

(A) Grand Canyon Basin - site E
(B) McGregor River Basin - site M
(C) North Fraser Area - sites B, C, and D

Central Fraser System

(A) Cariboo River Basin - site A
(B) Middle Fraser Area - sites F, G, and H

Thompson River Basin

(A) Clearwater River Basin - site L
(B) North Thompson System - site K
(C) Thompson/South Thompson - sites J, I, and N

No sampling was conducted in the Lower Fraser Area as changes in water quality resulting from the proposed System E development were not considered likely to persist this far downstream. No sampling was conducted in the Quesnel River area (shown on map as "B" in Central Fraser).

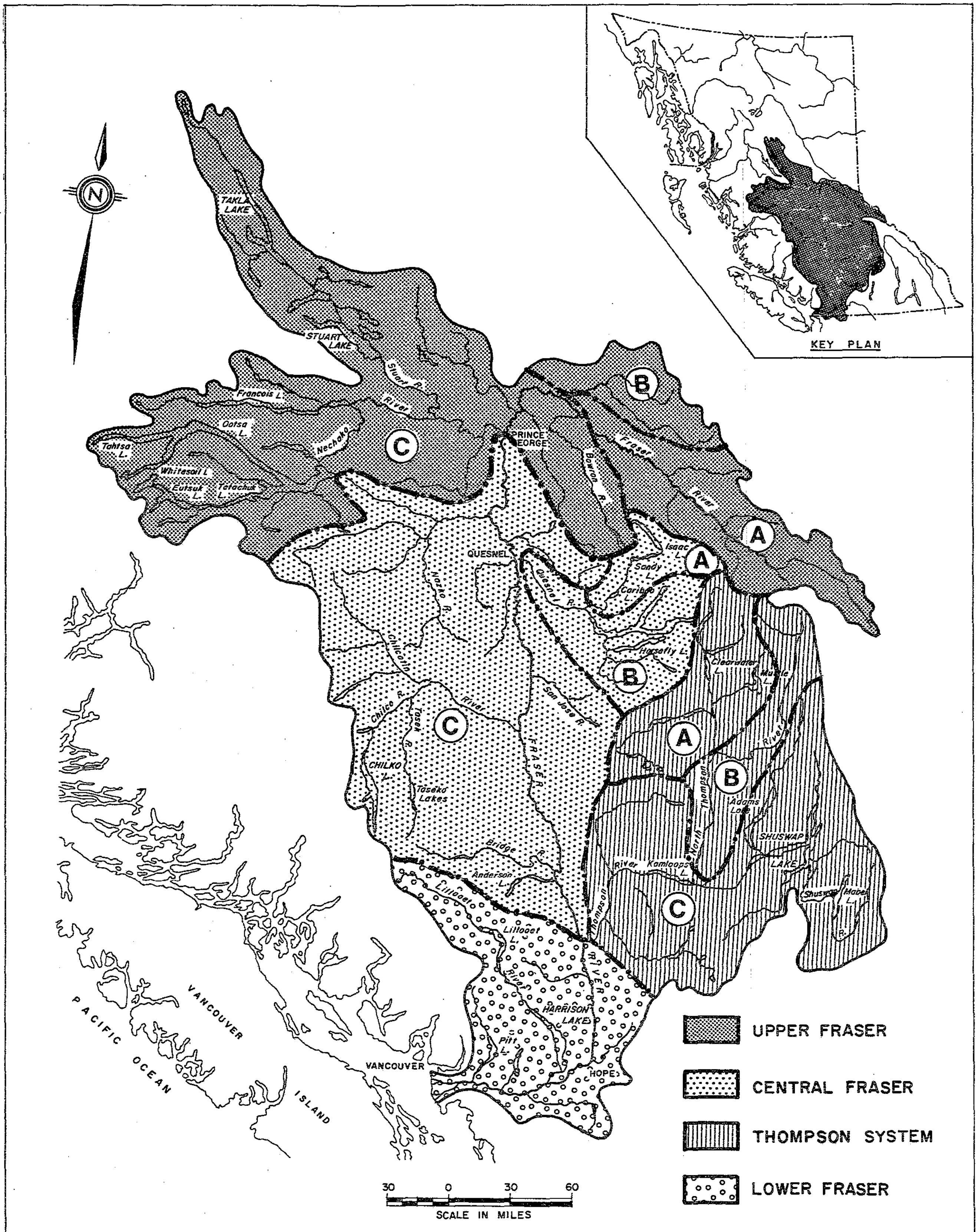


FIG. A5-2 GEOGRAPHICAL REGIONS OF THE FRASER RIVER DRAINAGE BASIN

A5.2.1 UPPER FRASER RIVER BASIN

A5.2.1.1 GRAND CANYON BASIN

The sampling for the Grand Canyon Basin was conducted on the south bank of the Fraser River at Hansard, just downstream of the confluence of the Bowron River. The results of the chemical analysis at this site are shown on Table A5.1.

A5.2.1.2 McGREGOR RIVER BASIN

The sampling site chosen on the McGregor River was approximately seven miles upstream from its confluence with the Fraser River below Hansard. The site was reached by crossing the Hansard bridge and driving the Church road to its end at the river.

The results of the chemical analysis at this site are shown in Table A5.2.

TABLE A5.1 Chemical Analysis of Fraser River Water at Sampling Site E (Hansard Bridge Crossing)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 14 (1830)	5.3	60	320	4.0	0.0	0.0	0.0	104	0.35	0.0	9	7.4	0.18	0.0	108
May 27 (1600)	9.7	60	60	–	0.28	0.10	0.0	113	0.19	0.0	6	7.9	0.23	0.24	28
June 10 (2100)	10.6	50	200	–	–	0.05	0.0	81	0.10	0.0	6	7.6	0.22	0.18	83
June 25 (0900)	11.4	55	110	n/d	0.15	0.05	0.0	78	0.15	0.0	9	8.2	0.07	0.08	50
July 8 (1400)	12.5	55	85	1.8	0.05	0.02	0.0	22	0.14	0.0	9	7.9	0.13	0.02	40
July 22 (1630)	13.9	60	70	n/d	0.12	0.03	0.0	132	0.14	0.0	9	8.1	0.17	0.10	35
August 6 (1300)	14.5	60	85	1.1	0.0	0.03	0.0	137	0.12	0.0	8	8.1	0.14	0.0	27
August 20 (1700)	14.5	70	80	2.7	0.10	0.0	0.0	149	0.12	0.0	9	8.35	0.05	0.06	38

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.2 Chemical Analysis of McGregor River Water at Sampling Site M
(seven miles upstream from Fraser R. confluence)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 28 (1100)	5.6	60	122	-	0.15	0.05	0.0	113	0.30	0.0	9	7.6	0.18	0.0	55
June 10 (1000)	8.4	55	210	4.0	-	0.05	0.0	73	0.20	0.0	6	8.1	0.41	0.0	80
June 25 (1300)	9.2	55	140	n/d	0.10	0.10	0.0	81	0.16	0.0	9	8.0	0.10	0.0	65
July 8 (1900)	9.5	60	98	2.0	0.0	0.03	0.0	21	0.14	0.0	10	8.3	0.11	0.19	42
July 22 (2030)	12.0	65	40	n/d	0.15	0.03	0.0	112	0.12	0.0	9	8.2	1.0	0.60	12
August 6 (1100)	12.0	65	32	0.6	0.08	0.02	0.0	137	0.13	0.0	9	8.2	0.03	0.15	20
August 20 (1030)	12.0	70	30	2.6	0.0	0.03	0.0	135	0.11	0.0	9	8.1	0.04	0.03	15

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

A5.2.1.3 NORTH FRASER AREA

Three sampling sites were chosen in this area: one on the main stem Fraser at Shelley, downstream of the mill; and two on tributary streams, the Nechako River at the Isle Pierre Ferry Landing and the Stuart River, one mile east of the Highway 27 bridge at Fort St. James. The results of the chemical analysis for these sites are shown in Tables A5.3, A5.4, and A5.5.

TABLE A5.3 Chemical Analysis of Fraser River Water at Sampling Site D (Shelley)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 14 (1030)	4.7	–	–	<3	–	–	–	124	0.43	0.0	10	–	–	–	–
May 27 (0900)	8.1	–	–	–	–	–	–	113	0.30	0.0	11	–	–	–	–
June 10 (0900)	9.5	25	220	1.0	–	0.05	0.0	70	0.24	0.0	11	7.9	0.17	0.03	100
June 24 (1000)	10.3	55	175	n/d	0.05	0.05	0.0	84	0.16	0.0	9	8.0	0.12	0.03	68
July 8 (0900)	12.5	55	120	1.9	0.0	0.02	0.0	18	0.14	0.0	9	8.3	0.23	0.0	45
July 22 (1200)	13.9	60	50	n/d	0.10	0.03	0.0	124	0.11	0.0	9	8.1	0.07	0.13	32
August 5 (0900)	13.9	60	70	0.7	0.05	0.02	0.0	141	0.15	0.0	8	8.2	0.10	0.0	34
August 19 (1700)	15.0	70	90	2.8	0.0	0.0	0.0	53	0.12	0.0	8	8.32	0.06	0.03	43

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.4 Chemical Analysis of Nechako River Water at Sampling Site C (Isle Pierre Ferry Landing)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 13 (1830)	5.0	-	-	<3	-	-	-	80	0.18	0.0	9	-	-	-	-
May 26 (1400)	11.1	-	-	-	-	-	-	85	0.11	0.0	8	-	-	-	-
June 9 (1500)	15.0	50	20	2.0	-	0.03	0.0	52	0.10	0.0	9	7.6	0.07	0.0	3
June 23 (1500)	15.0	50	50	1.5	0.20	0.0	0.0	70	0.08	0.0	8	8.1	0.10	0.10	10
July 7 (1600)	15.6	45	15	1.6	0.10	0.03	0.0	16	0.08	0.0	8	7.9	0.70	1.50	5
July 21 (1500)	16.7	40	40	n/d	0.20	0.02	0.0	80	0.10	0.0	8	8.1	0.16	0.0	12
August 4 (1000)	17.5	45	55	0.5	0.21	0.01	0.0	85	0.11	0.0	8	8.1	0.05	0.05	8
August 18 (1430)	17.5	40	35	3.0	0.0	0.01	0.0	95	0.08	0.0	7	7.8	0.10	0.0	8

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.5 Chemical Analysis of Stuart River Water at Sampling Site B (one mile east of highway 27 bridge)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 13 (1500)	9.7	–	–	<3	–	–	–	102	0.20	0.0	9	–	–	–	–
May 26 (1030)	9.5	–	–	–	–	–	–	68	0.17	0.0	10	–	–	–	–
June 9 (1000)	11.4	45	12	1.0	–	0.04	0.0	63	0.10	0.0	8	7.8	0.04	0.04	2
June 23 (1030)	13.9	50	35	3.6	0.3	0.03	0.0	79	0.11	0.0	9	7.7	0.09	0.0	9
July 7 (1200)	13.1	45	0	2.3	0.15	0.03	0.0	16	0.07	0.0	9	7.8	0.16	0.0	0
July 21 (1200)	15.6	50	5	n/d	0.15	0.02	0.0	97	0.05	0.0	9	8.3	0.04	0.03	0
August 4 (1400)	18.6	50	15	1.1	0.15	0.03	0.0	109	0.09	0.0	8	8.0	0.02	0.03	3
August 18 (1100)	17.8	50	25	3.5	0.0	0.0	0.0	101	0.11	0.0	7	8.2	0.03	0.12	0

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

A5.2.2 CENTRAL FRASER SYSTEM

A5.2.2.1 CARIBOO RIVER BASIN

The Cariboo River was sampled on the north bank at the highway bridge north of Likely, three miles below the proposed dam site. The results of chemical analysis are shown on Table A5.6.

TABLE A5.6 Chemical Analysis of Cariboo River Water at Sampling Site A (highway bridge north of Likely)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 12 (2100)	4.7	60	62	<3	0.20	0.0	0.0	112	0.16	0.0	9	7.4	0.05	0.05	18
May 30 (1000)	8.1	55	205	n/d	-	0.0	0.0	76	0.24	0.0	8	7.5	0.17	0.28	80
June 13 (1230)	8.6	45	65	1.0	-	0.04	0.0	58	0.15	0.0	6	7.3	0.03	0.04	25
June 27 (1100)	10.3	50	15	3.0	0.10	0.05	0.0	122	0.13	0.0	10	7.7	0.07	0.06	1
July 11 (1000)	11.7	50	10	n/d	0.0	0.02	0.0	83	0.11	0.0	9	8.2	0.10	0.24	0
July 25 (1100)	13.9	50	5	1.7	0.10	0.02	0.0	114	0.10	0.0	9	8.2	0.10	0.0	0
August 8 (0800)	15.6	55	0	0.3	0.0	0.03	0.0	108	0.10	0.0	9	8.1	0.05	0.0	0
August 22 (0800)	15.3	50	0	1.2	0.13	0.0	0.0	103	0.10	0.0	9	8.15	0.03	0.13	0

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

A5.2.2.2 MIDDLE FRASER AREA

This area includes the Fraser River and its tributaries downstream from Prince George to Lytton, exclusive of the Quesnel River System. Three sites were chosen in this area, all on the main stem Fraser: two miles downstream from Quesnel on the west bank; on the east bank, one-half mile downstream from the bridge to Gang Ranch (about 15 miles below the Chilcotin River confluence with the Fraser); and on the east bank, one-half mile downstream from Lillooet.

The chemical analysis of samples taken at these sites is shown on Tables A5.7, A5.8, and A5.9.

TABLE A5.7 Chemical Analysis of Fraser River Water at Sampling Site F (two miles south of Quesnel)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 16 (1330)	6.7	–	–	–	–	–	–	–	0.44	0.0	11	–	–	–	–
May 29 (1500)	11.7	–	–	n/d	–	–	–	92	0.20	0.0	6	–	–	–	–
June 12 (1530)	–	50	400	5.7	–	0.05	0.0	64	0.29	0.0	10	7.6	0.55	–	170
June 26 (1300)	12.8	55	200	3.4	0.1	0.05	0.0	159	0.17	0.0	8	8.1	0.25	0.0	78
July 10 (1500)	12.8	50	165	n/d	0.0	0.0	0.0	94	0.16	0.0	9	8.2	0.15	0.0	60
July 24 (1200)	15.6	50	120	0.9	0.0	0.02	0.0	124	0.14	0.0	8	8.2	0.20	0.05	50
August 7 (1300)	17.5	50	90	0.5	0.0	0.04	0.0	125	0.12	0.0	8	8.2	0.07	0.06	33
August 21 (1400)	16.7	65	75	1.2	0.1	0.01	0.0	124	0.13	0.0	8	8.3	0.08	0.05	42

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.8 Chemical Analysis of Fraser River Water at Sampling Site G (near Gang Ranch bridge)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 17 (1100)	7.5	70	515	-	0.0	0.24	1.2	-	0.55	0.0	11	7.7	0.45	0.0	163
May 31 (1100)	11.7	55	390	n/d	-	0.08	0.5	90	0.35	0.0	8	8.0	0.25	0.15	160
June 14 (1200)	10.3	50	550	5.7	-	0.20	0.0	64	0.31	0.0	10	8.4	0.71	0.15	240
June 28 (1300)	13.4	55	290	0.9	0.0	0.05	0.0	150	0.20	0.0	9	8.35	0.37	0.07	105
July 12 (1330)	12.8	50	190	n/d	0.0	0.02	0.0	97	0.19	0.0	9	8.4	0.28	0.10	75
July 26 (0900)	15.6	55	130	1.5	0.12	0.03	0.0	142	0.15	0.0	8	8.35	0.18	0.12	52
August 8 (1800)	18.4	55	90	0.2	0.1	0.10	0.0	123	0.15	0.0	8	8.2	0.11	0.04	43
August 22 (1830)	17.3	55	90	0.7	0.1	0.0	0.0	124	0.15	0.0	8	8.15	0.08	0.16	47

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.9 Chemical Analysis of Fraser River Water at Sampling Site H (one half mile below Lillooet)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 18 (1130)	6.4	43.5	-	-	-	-	-	-	0.25	0.0	10	-	-	-	-
June 1 (0900)	11.7	53.0	-	n/d	-	-	-	89	0.31	0.0	11	-	-	-	-
June 15 (1300)	10.6	51.0	650	0.5	-	0.10	0.0	66	0.38	0.0	11	7.7	-	-	320
June 29 (1300)	13.4	56.0	290	0.9	0.0	0.05	0.0	139	0.22	0.0	9	8.3	0.24	0.01	120
July 13 (1000)	13.6	56.5	240	n/d	0.0	0.05	0.0	99	0.20	0.0	9	8.4	0.28	0.10	95
July 26 (1900)	16.4	61.5	160	3.4	0.05	0.03	0.0	130	0.16	0.0	9	8.2	0.15	0.03	75
August 10 (1000)	18.4	65.0	120	0.7	0.05	0.02	0.0	124	0.17	0.0	8	8.1	0.08	0.09	55
August 23 (1530)	17.8	64.0	90	0.7	0.0	0.02	0.0	122	0.15	0.0	9	8.3	0.13	0.0	35

CU Colour units.
JTU Jackson Turbidity Units
† Microhms per cm.
nd Not detectable.

A5.2.3 THOMPSON RIVER BASIN

A5.2.3.1 CLEARWATER RIVER BASIN

The Clearwater River sampling site was located on the east bank, three miles upstream from its confluence with the North Thompson River and one-half mile above the proposed Clearwater dam site. The results of the chemical analysis are shown on Table A5.10.

TABLE A5.10 Chemical Analysis of Clearwater River Water at Sampling Site L (three miles north of Highway 5 bridge)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 22 (1000)	5.3	50	220	2.0	0.20	0.05	0.0	84	0.26	0.0	7	7.6	0.25	0.0	110
June 4 (1200)	7.8	40	18	n/d	–	0.0	0.0	73	0.13	0.0	8	7.8	0.14	0.19	10
June 17 (1130)	7.8	30	0	0.8	–	0.0	0.0	49	0.14	0.0	8	7.4	0.07	0.0	0
July 2 (1400)	10.0	35	5	1.7	0.05	0.03	0.0	87	0.10	0.0	10	8.0	0.07	0.01	3
July 15 (1100)	10.6	30	10	1.1	0.05	0.0	0.0	65	0.12	0.0	10	8.2	0.07	0.0	0
July 29 (1700)	14.7	35	0	1.4	0.13	0.03	0.0	64	0.05	0.0	10	8.0	0.02	0.06	0
August 12 (1100)	14.5	40	0	n/d	0.03	0.02	0.0	86	0.11	0.0	10	8.0	0.02	0.06	0
August 26 (1230)	15.3	40	0	1.3	0.10	0.0	0.0	81	0.10	0.0	9	8.1	0.02	0.0	0

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

A5.2.3.2 NORTH THOMPSON SYSTEM

The North Thompson River was sampled on the east bank, 35 miles north of its confluence with the South Thompson at the McLure Ferry landing. The results of the chemical analysis are shown on Table A5.11.

TABLE A5.11 Chemical Analysis of North Thompson River Water at Sampling Site K (McLure Ferry Landing)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 21 (1300)	8.1	–	–	2.0	–	–	–	80	0.17	0.0	7	–	–	–	–
June 3 (0900)	8.4	–	–	n/d	–	–	–	61	0.15	0.0	5	–	–	–	–
June 18 (1000)	8.6	30	40	0.8	–	0.03	0.0	65	0.11	0.0	9	7.7	0.13	0.21	19
July 3 (1200)	11.4	35	20	1.8	0.05	0.03	0.0	80	0.10	0.0	9	7.9	0.18	0.05	5
July 16 (1100)	12.0	30	25	1.3	0.0	0.03	0.0	68	0.11	0.0	9	8.0	0.05	0.02	15
July 29 (1200)	13.9	35	0	1.6	0.18	0.02	0.0	57	0.10	0.0	9	7.8	0.08	0.06	0
August 12 (1400)	14.2	35	35	0.5	0.05	0.02	0.0	70	0.11	0.0	9	7.9	0.02	0.11	18
August 26 (1500)	16.4	35	15	0.9	0.1	0.02	0.0	75	0.11	0.0	9	8.0	0.02	0.02	3

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

A5.2.3.3 THOMPSON/SOUTH THOMPSON SYSTEM

This area includes the Thompson and South Thompson rivers and their tributaries, excluding the North Thompson system. Three sampling locations were selected in this area, one on each of the Thompson, South Thompson, and Nicola rivers.

The South Thompson River water was sampled on the north bank, two miles upstream from its confluence with the North Thompson. The Thompson River sampling site was located on the east bank near Spences Bridge, 100 yards upstream from its confluence with the Nicola River. The Nicola River was sampled 100 yards upstream from its confluence with the Thompson on the south bank. The chemical analysis of these samples is shown in Tables A5.12, A5.13, and A5.14.

TABLE A5.12 Chemical Analysis of South Thompson River Water at Sampling Site J (two miles upstream from Highway 5 bridge)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conduc-tance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 21 (0900)	9.5	-	-	2.0	-	-	-	98	0.13	0.0	7	-	-	-	-
June 3 (0930)	9.5	-	-	n/d	-	-	-	82	0.15	0.0	5	-	-	-	-
June 18 (1600)	11.4	30	4	0.6	-	0.0	0.0	54	0.07	0.0	6	7.7	0.16	0.0	0
July 3 (1500)	11.4	30	0	1.6	0.0	0.03	0.0	98	0.07	0.0	10	7.7	0.13	0.0	0
July 16 (1900)	14.5	30	10	0.7	0.05	0.03	0.0	69	0.07	0.0	9	8.1	0.12	0.0	0
July 30 (1900)	16.7	30	2	1.6	0.20	0.02	0.0	60	0.11	0.0	9	7.7	0.03	0.03	2
August 13 (1400)	18.4	35	0	0.5	0.03	0.01	0.0	72	0.07	0.0	9	8.1	0.02	0.0	0
August 27 (1100)	19.7	40	0	1.7	0.05	0.0	0.0	79	0.08	0.0	9	8.2	0.02	0.04	0

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.13 Chemical Analysis of Thompson River Water at Sampling Site I (upriver from the confluence with the Nicola River)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
May 18 (1500)	7.0	–	–	–	–	–	–	–	0.11	0.0	10	–	–	–	–
June 1 (1200)	10.0	–	–	n/d	–	–	–	77	0.16	0.0	11	–	–	–	–
June 15 (1600)	10.3	40	150	0.9	–	0.05	0.0	41	0.17	0.0	9	7.8	0.23	0.08	70
June 29 (1500)	12.5	35	30	1.0	0.20	0.05	0.0	93	0.11	0.0	9	8.0	0.15	0.0	13
July 13 (1800)	13.9	30	30	n/d	0.0	0.02	0.0	66	0.11	0.0	9	7.8	0.13	0.50	10
July 27 (1600)	16.1	35	0	0.4	0.10	0.02	0.0	88	0.07	0.0	10	8.0	0.16	0.19	0
August 10 (1300)	17.0	40	0	0.3	0.18	0.02	0.0	84	0.10	0.0	9	7.9	0.04	0.11	5
August 24 (1000)	17.2	35	12	0.7	0.03	0.0	0.0	86	0.08	0.0	9	7.9	0.03	0.05	2

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

TABLE A5.14 Chemical Analysis of Nicola River Water at Sampling Site N (upriver from its confluence with the Thompson R.)

Sampling Date (1972) and Time	Water Temp. (°C)	Total Alkalinity (ppm)	Colour (cu)	Bio. Oxygen Demand (ppm)	Flouride (ppm)	Iron (ppm)	Manganese (ppm)	Specific Conductance (†)	Nitrate Nitrogen (ppm)	Nitrite Nitrogen (ppm)	Diss. Oxygen (ppm)	pH	Ortho-Phosphate (ppm)	Meta-Phosphate (ppm)	Turbidity (JTU)
June 29 (1800)	13.9	55	150	1.5	0.05	0.05	0.0	144	0.14	0.0	8	7.8	0.32	0.16	60
July 13 (1630)	14.2	50	70	n/d	0.0	0.03	0.0	90	0.12	0.0	9	8.2	0.17	0.07	25
July 27 (1400)	18.4	65	8	1.7	0.2	0.02	0.0	167	0.08	0.0	9	8.3	0.85	0.30	8
August 10 (1500)	20.0	85	5	0.7	0.18	0.02	0.0	157	0.09	0.0	8	8.42	0.06	0.04	6
August 24 (0800)	17.0	100	15	1.0	0.21	0.0	0.0	214	0.04	0.0	9	8.44	0.03	0.09	2

CU Colour units.
JTU Jackson Turbidity Units

† Microhms per cm.
nd Not detectable.

A5.3 Comparison of Results

In addition to the water quality results obtained during the sampling program, data collected over several years is available from other sources. Most notable is the Water Quality Directorate of Environment Canada, whose sampling, conducted with more sophisticated methods than those utilized by the Fisheries Service, is less extensive geographically, less intensive in time, and does not include a record of dissolved oxygen content. However, results from such agencies are very useful in extending and substantiating the data obtained in the 1972 study. Unless noted, water quality data quoted below which was not obtained in the 1972 Fisheries' sampling program are from the Water Quality Directorate files. Geographical areas for which comparison data from other sources was not available are not included.

A5.3.1 NORTH FRASER AREA

The Water Quality Directorate has been sampling water quality of the Fraser River at Shelley for several years. Some results of that sampling program are plotted on Figures A5-3 and A5-4 together with Fisheries Service 1972 data.

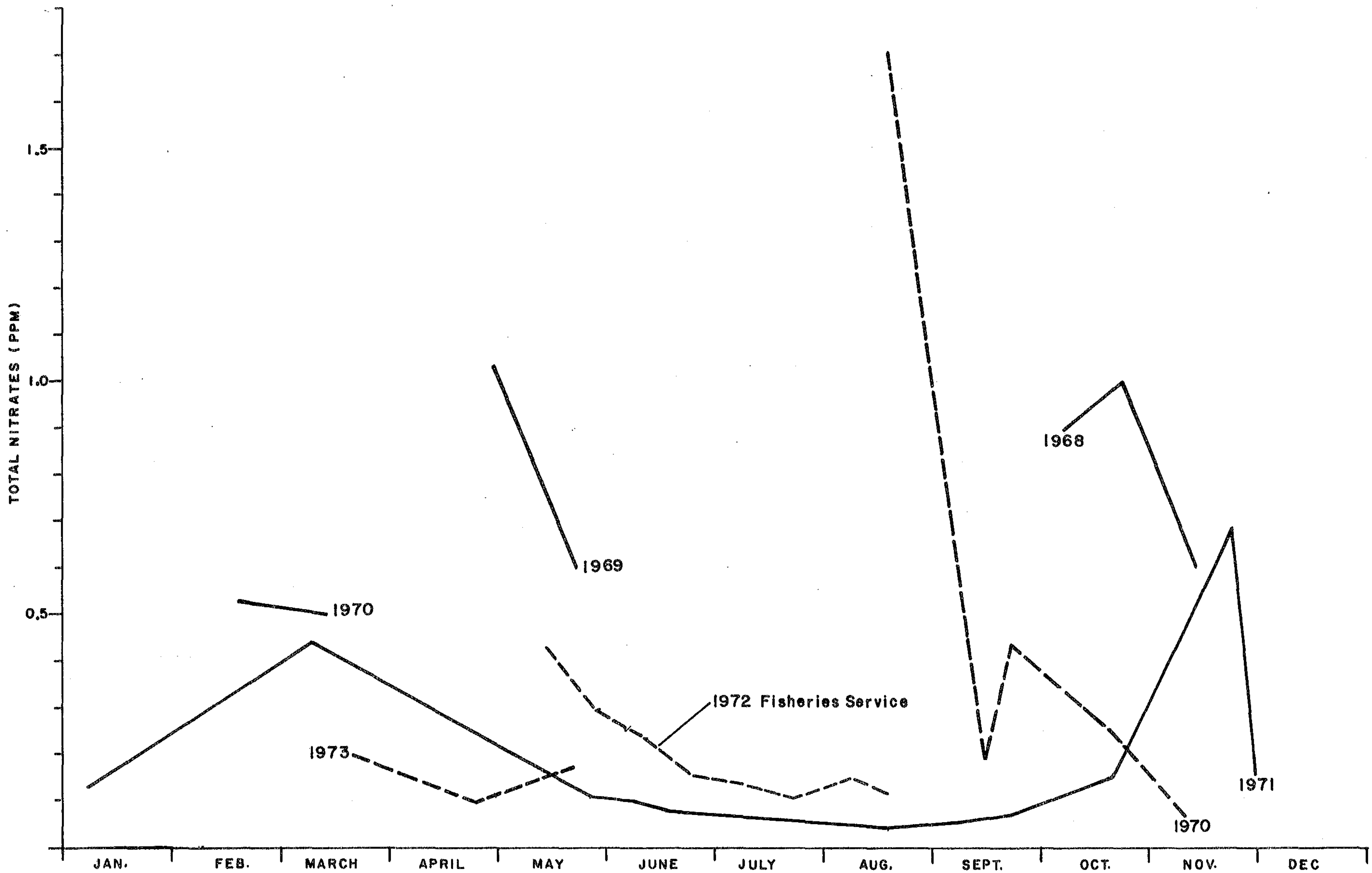


FIG. A5-3 . COMPARISON OF NITRATE VALUES OF THE FRASER RIVER AT SAMPLING SITE D (SHELLEY)

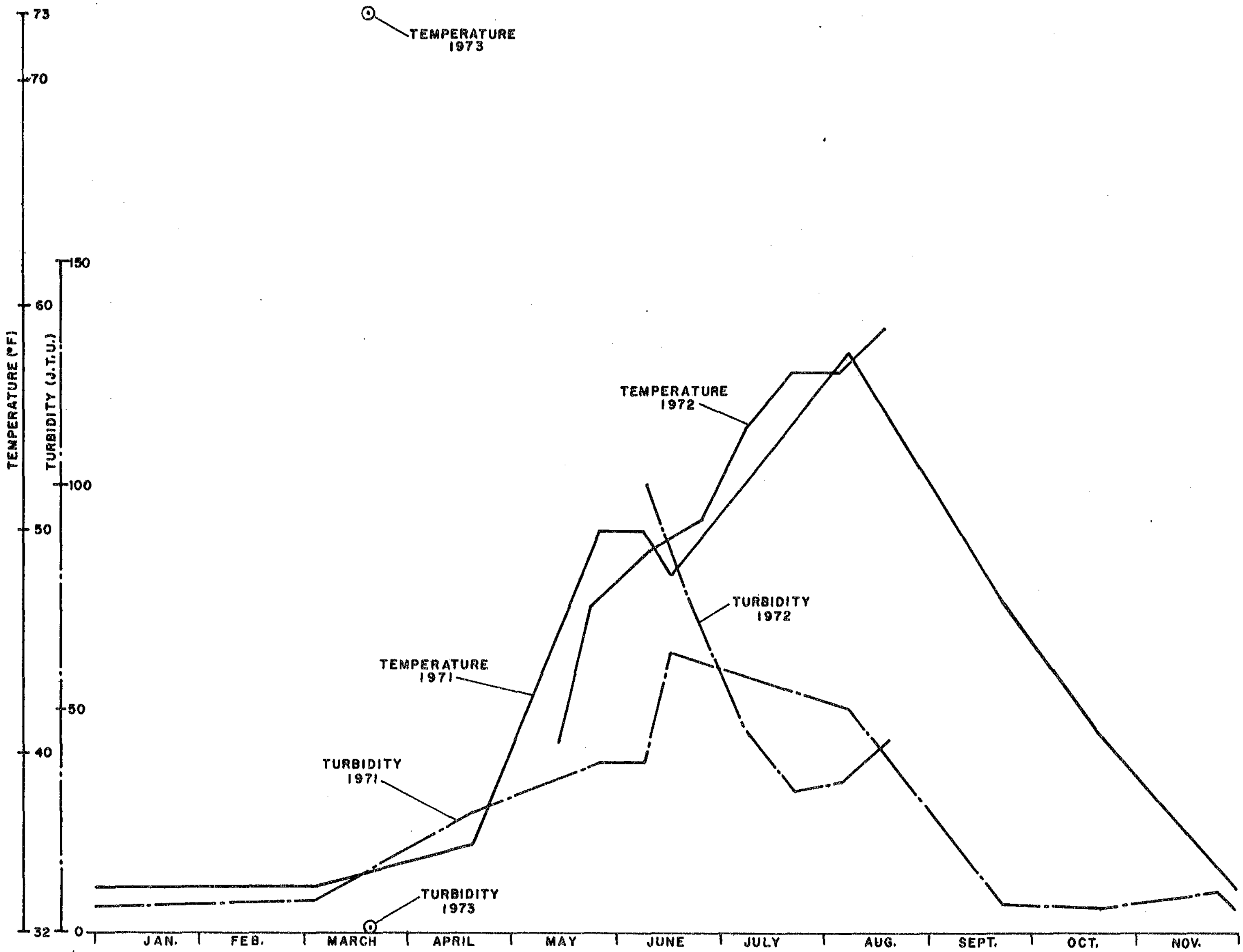


FIG. A5-4 COMPARISON OF TEMPERATURES AND TURBIDITY VALUES OF THE FRASER RIVER AT SAMPLING SITE D (SHELLEY).

A5.3.2 THOMPSON/SOUTH THOMPSON SYSTEM

Applicable data taken at Spences Bridge by the Water Quality Directorate are compared to Fisheries Service data in Figures A5-5 to A5-7.

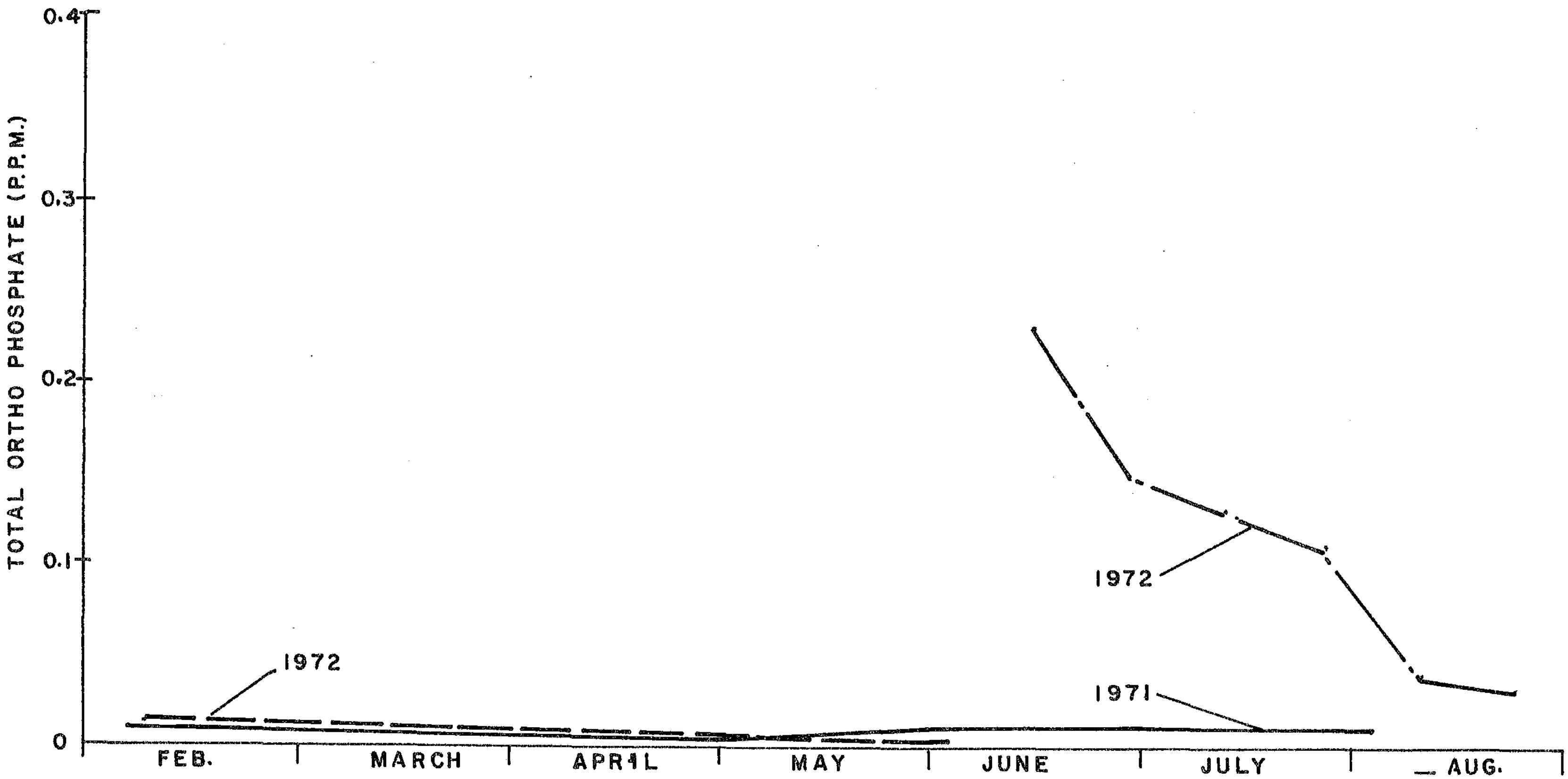


FIG. A5-5 COMPARISON OF PHOSPHATE VALUES OF THE THOMPSON RIVER AT SAMPLING SITE I (SPENCES BRIDGE).

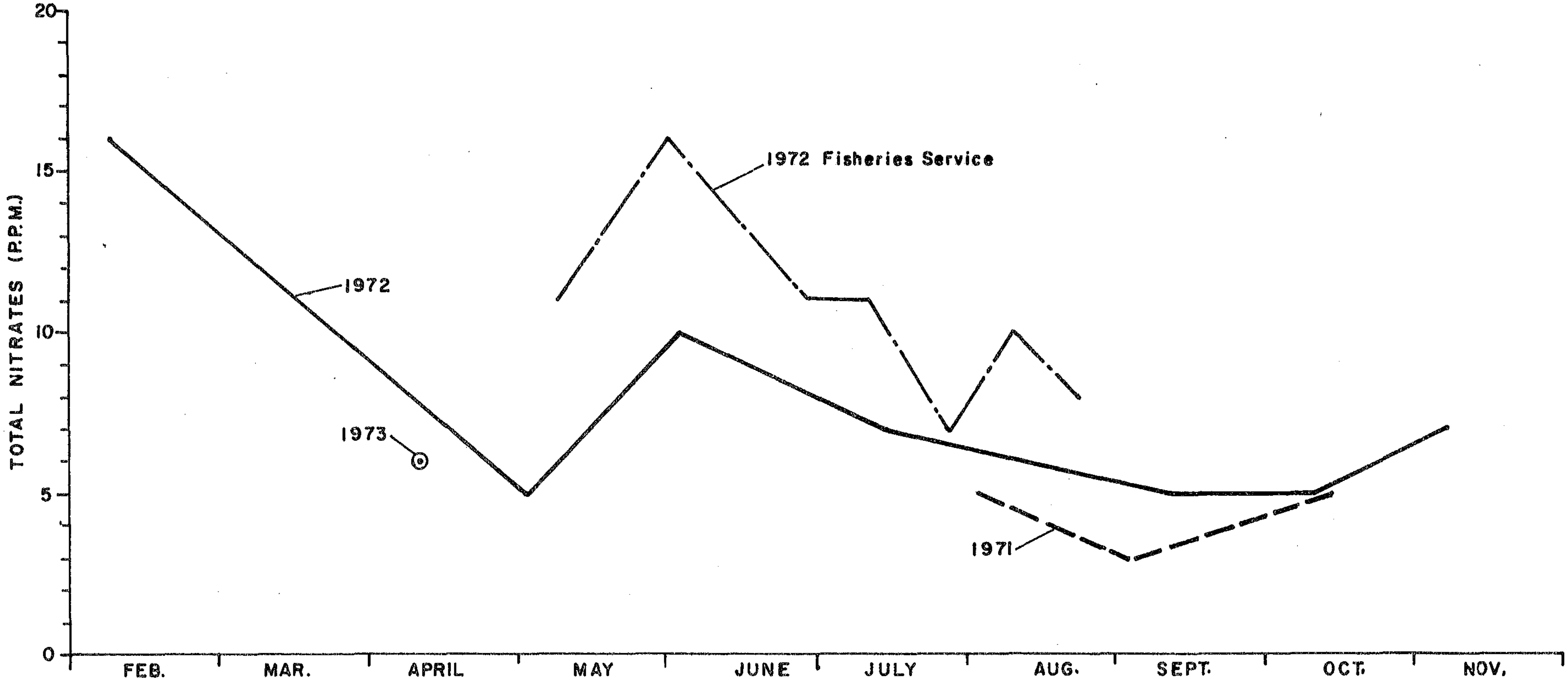


FIG. A5-6 COMPARISON OF NITRATE VALUES OF THE THOMPSON RIVER AT SAMPLING SITE I (SPENCES BRIDGE).

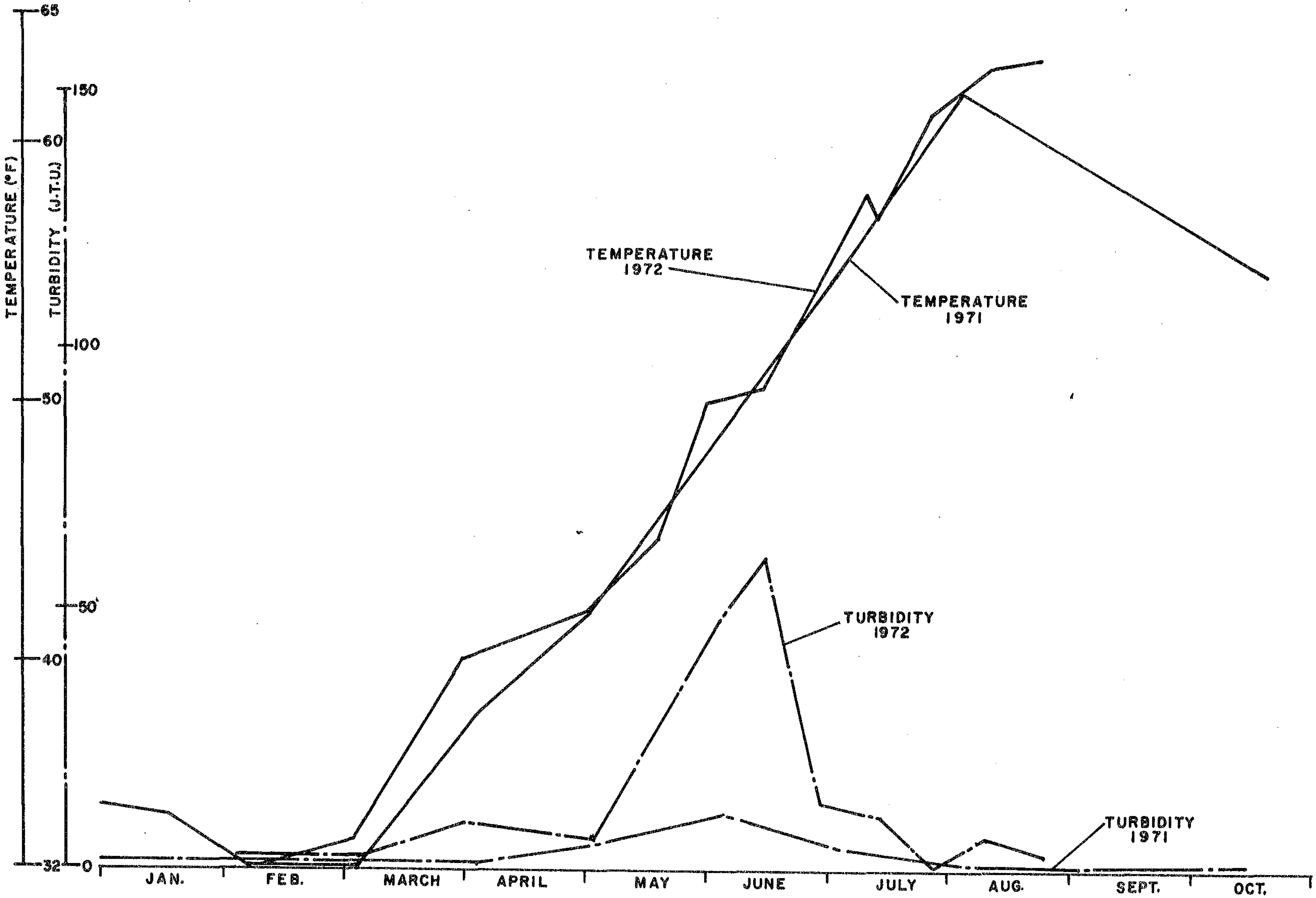


FIG. A5-7 COMPARISON OF TEMPERATURES AND TURBIDITY VALUES OF THE THOMPSON RIVER AT SAMPLING SITE I (SPENCES BRIDGE).

A5.4 ASSESSMENT OF WATER QUALITY CHARACTERISTICS

A5.4.1 UPPER FRASER RIVER BASIN

A5.4.1.1 GRAND CANYON BASIN

The most significant relationship found in the water quality data taken at Hansard was that between phosphates, nitrates, dissolved oxygen (D.O.), and turbidity. These factors are plotted on Figure A5-8. It will be noted that during the June 1972 freshet the dissolved oxygen content and nitrate level dropped as phosphate levels rose. These reactions appear to be independent of changes in turbidity.

It would be expected that moderate to high levels of turbidity during the freshet would cause a reduction in light penetration and algal production. As a result, the concentrations of phosphates and nitrates should increase (as their uptake by algae is reduced) and the dissolved oxygen level may drop as a result of reduced photosynthesis. However, the drop in measured nitrates during the freshet indicates that primary (algae) production may have increased rather than decreased during this period. The corresponding rise in phosphates may demonstrate that this nutrient was being supplied at a rate in excess of the assimilative capacity of the increased primary producers.

This implies that before the freshet, primary production was limited by a lack of phosphates which, when supplied by the freshet inflow, caused primary production to expand, depleting the nitrate supply. Such a situation would be expected to result in an increase in dissolved oxygen. However, the dissolved oxygen level dropped significantly at this time, indicating that oxygen-consuming secondary producers or decomposing organic material may have increased at a rate faster than the primary producers.

If the former assessment is correct, there are important ramifications for a proposed impoundment at this site. An impoundment provides a more stable and productive environment for algae than does a free-flowing stream. In addition, the reduced water velocity permits much of the suspended sediment to settle

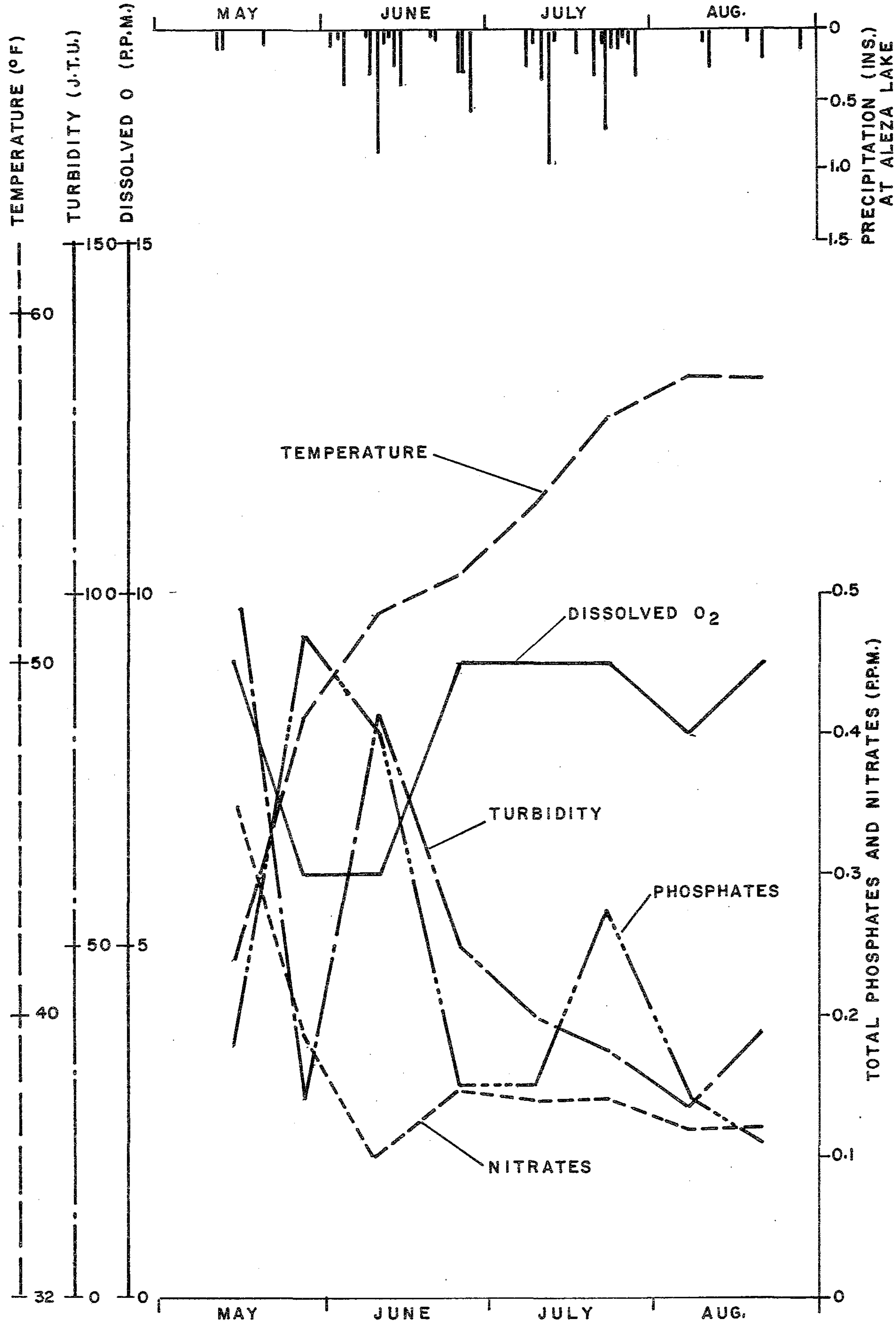


FIG. A5-8 WATER QUALITY PARAMETERS OF THE FRASER RIVER AT SAMPLING SITE E (HANSARD).

out in the reservoir. Increased water clarity would, in the presence of nutrients, encourage algae production and photosynthesis. The abundant supply of food and oxygen could ensure an increasing secondary activity. Therefore, whereas a phosphate input to the free-flowing Fraser River causes an increase in production which is simply interesting, the same input into a reservoir could accelerate eutrophication.

In recognition of this difference in receiving bodies of water, the U.S. Department of the Interior's Committee on Water Quality Criteria made the following recommendations (in part) with regard to nutrient additions to fresh water: "The naturally occurring ratios and amounts of nitrogen (particularly NO_3 and NH_4) to total phosphorus should not be radically changed... As a guideline, the concentration of total phosphorus should not be increased to levels exceeding 0.10 ppm in flowing streams or 0.05 ppm where streams enter lakes or reservoirs". (1968, p.56)

The total phosphate level measured at Hansard in 1972 varied from 0.11 ppm to 0.47 ppm - well above the "guideline" levels noted above. However, the "available" proportion of total phosphates varies considerably between locations, depending largely upon the other elements present in the water. In particular, if iron is present, the addition of sulphates or manganese oxide tends to greatly increase the available phosphates. The Fraser River at Hansard was found to contain significant amounts of iron, but no tests were carried out for sulphates or manganese oxide. The tests conducted for ionic manganese (not detectable below 1.0 ppm) did not show any manganese at Hansard but did give readings as high as 1.2 ppm downstream in the Central Fraser Area.

A5.4.1.2 McGREGOR RIVER BASIN

The water quality of the McGregor River underwent changes during the 1972 freshet which were similar to those found for the Fraser River at Hansard (Fig. A5-9). Specifically, when the phosphate level rose, the dissolved oxygen content and nitrate level dropped. These changes were accompanied by a rise in turbidity with the freshet; the lowered dissolved oxygen and elevated phosphate levels could be explained by a reduction in algal production and photosynthesis. This does not explain, however, the co-incident drop in nitrates.

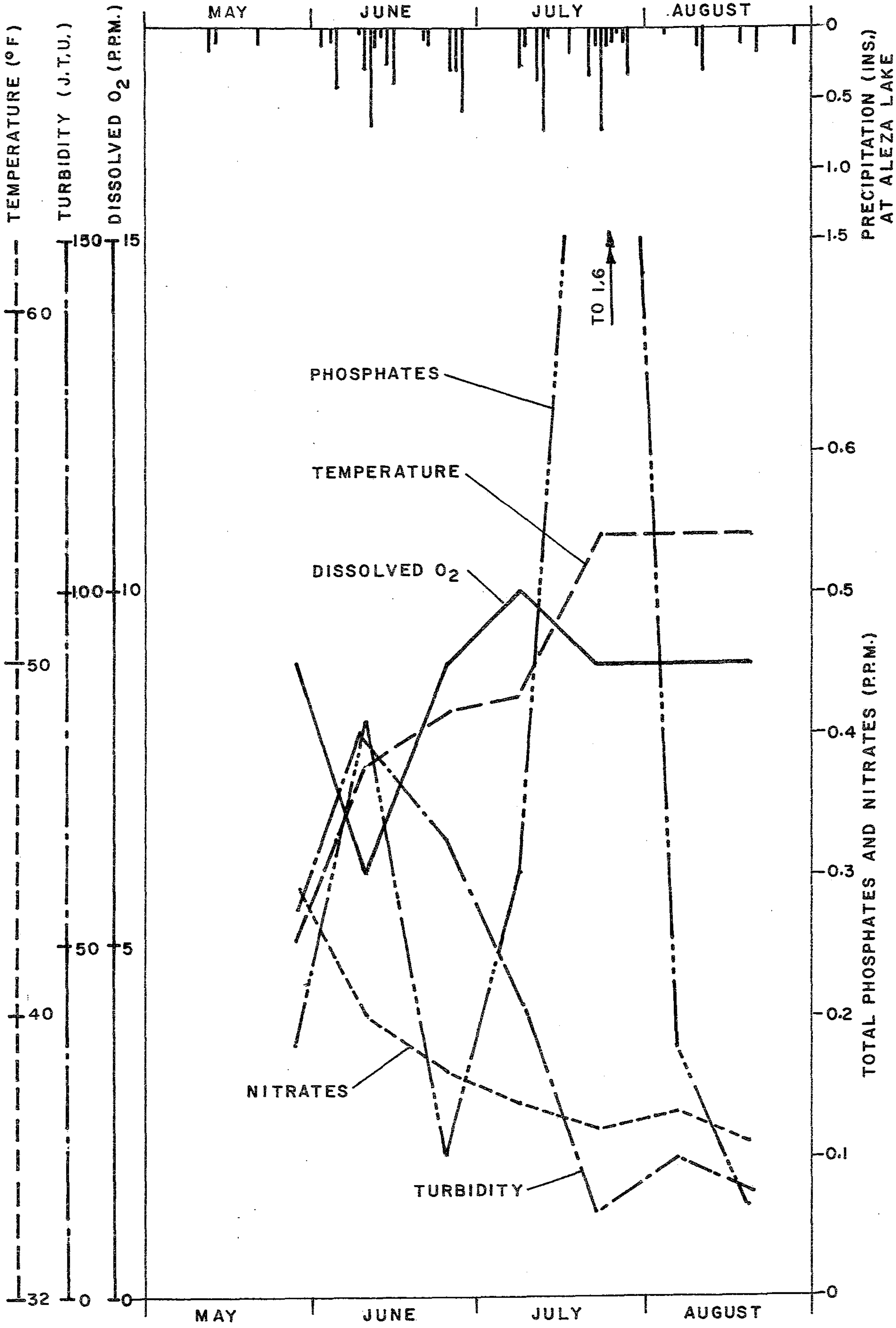


FIG. A5-9 WATER QUALITY PARAMETERS OF THE McGREGOR RIVER AT SAMPLING SITE M.

The McGregor watershed is similar to the upper Fraser watershed above Hansard, and winter logging (a probable source of phosphate input during spring breakup) occurs in both systems. It may be assumed that a reaction similar to that described for the Hansard site may also be taking place on the lower McGregor. However, the data do not clearly support this assumption, and no conclusions can be drawn at this time.

It was also noted that a relatively high B.O.D. reading of 4 ppm was recorded at the McGregor site during the freshet when the dissolved oxygen dropped to 6 ppm. Although such a situation is not conclusive, it provides evidence of increased secondary production or organic decomposition.

As nutrient input from logging activities would occur below the proposed Lower McGregor dam, there should be no problem with excessive fertilization of the reservoir. However, the same amount of nutrients supplied to the Lower McGregor river after damming would result in an intense concentration in the smaller river; it is possible that this will result in a serious reduction of dissolved oxygen levels.

A second very large increase in phosphate level was recorded in late July although no response was found among the other parameters measured. This high reading and a moderately high phosphate reading in early July are correlated with a heavy rainfall after a week or more of dry weather. It is possible that such a rainfall could wash new logging debris into the stream and cause temporary high values. This is in contrast to the freshet period when the high overland discharge due to snow melt should persist for several weeks and includes the nutrient source from an entire winter's logging. As a result, the elevated phosphate level during the freshet is considered to be more serious than the higher level measured in July - particularly as the dissolved oxygen and nitrate levels showed no response to the July phosphate rise.

A5.4.1.3 NORTH FRASER SYSTEM

As shown in Figure A5-10, the dissolved oxygen level of the Fraser River at Shelley remained high during the 1972 freshet in contrast to the reaction upstream at Hansard and on the McGregor River. The nitrate level dropped throughout the freshet, possibly indicating increased primary production. The first measurement of phosphates was taken on June 10 at the height of the freshet, and it cannot be definitely stated that the phosphate levels at Shelley were not elevated before the freshet. However, as the June 10 phosphate values at Hansard and McGregor were about the highest recorded, it may be inferred that the phosphates were largely taken up by algae by the time the water reached Shelley. A large production of algae by the time the river reached Shelley could explain the high dissolved oxygen level at that point.

Figures A5-11 and A5-12 show the 1972 sample results of the Nechako River at Isle Pierre and the Stuart River at Fort St. James. Both sites showed a slight drop in nitrate content as the freshet passed. This is probably due to increased primary production in these clear rivers as the water warmed. The dissolved oxygen levels remained high in both streams and were consistently close to saturation at the temperatures noted.

A high level of phosphates (2.2 ppm) was recorded in early July on the Nechako at Isle Pierre. This may be explained by the fact that this measurement was taken on the first day of rain after more than a week of dry weather. Reliable sources in Prince George indicate that the Nechako basin above Isle Pierre is highly utilized for cattle grazing and that islands in the middle of the Nechako have large deposits of cow manure. In addition, farms in the Vanderhoof area are irrigated and very heavily fertilized. It is believed that these factors, particularly the fertilizer aspect, serve to explain the very high July phosphate readings.

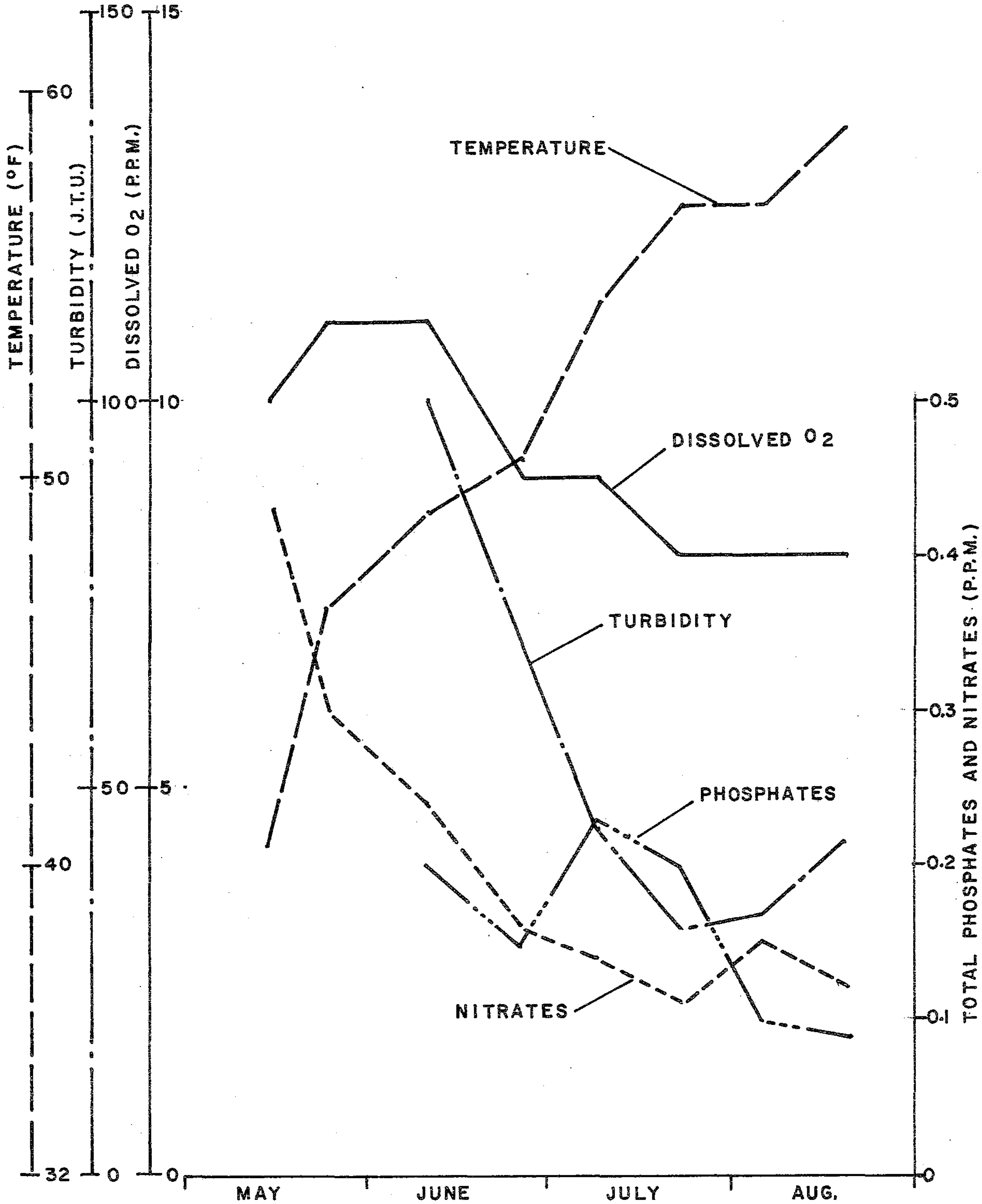


FIG. A5-10 WATER QUALITY PARAMETERS OF THE FRASER RIVER AT SAMPLING SITE D (SHELLEY).

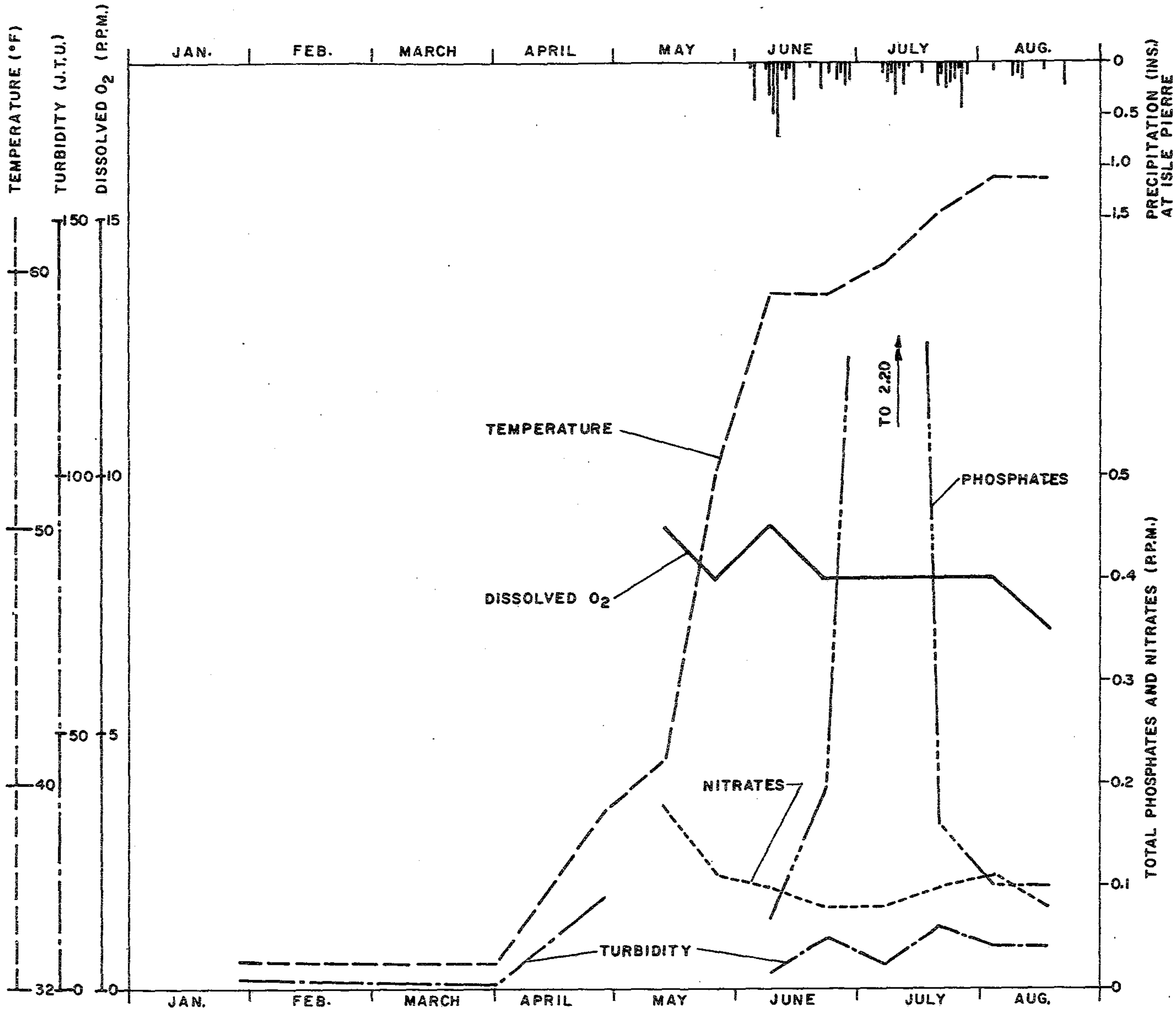


FIG. A5-11 WATER QUALITY PARAMETERS OF THE NECHAKO RIVER AT SAMPLING SITE C (ISLE PIERRE).

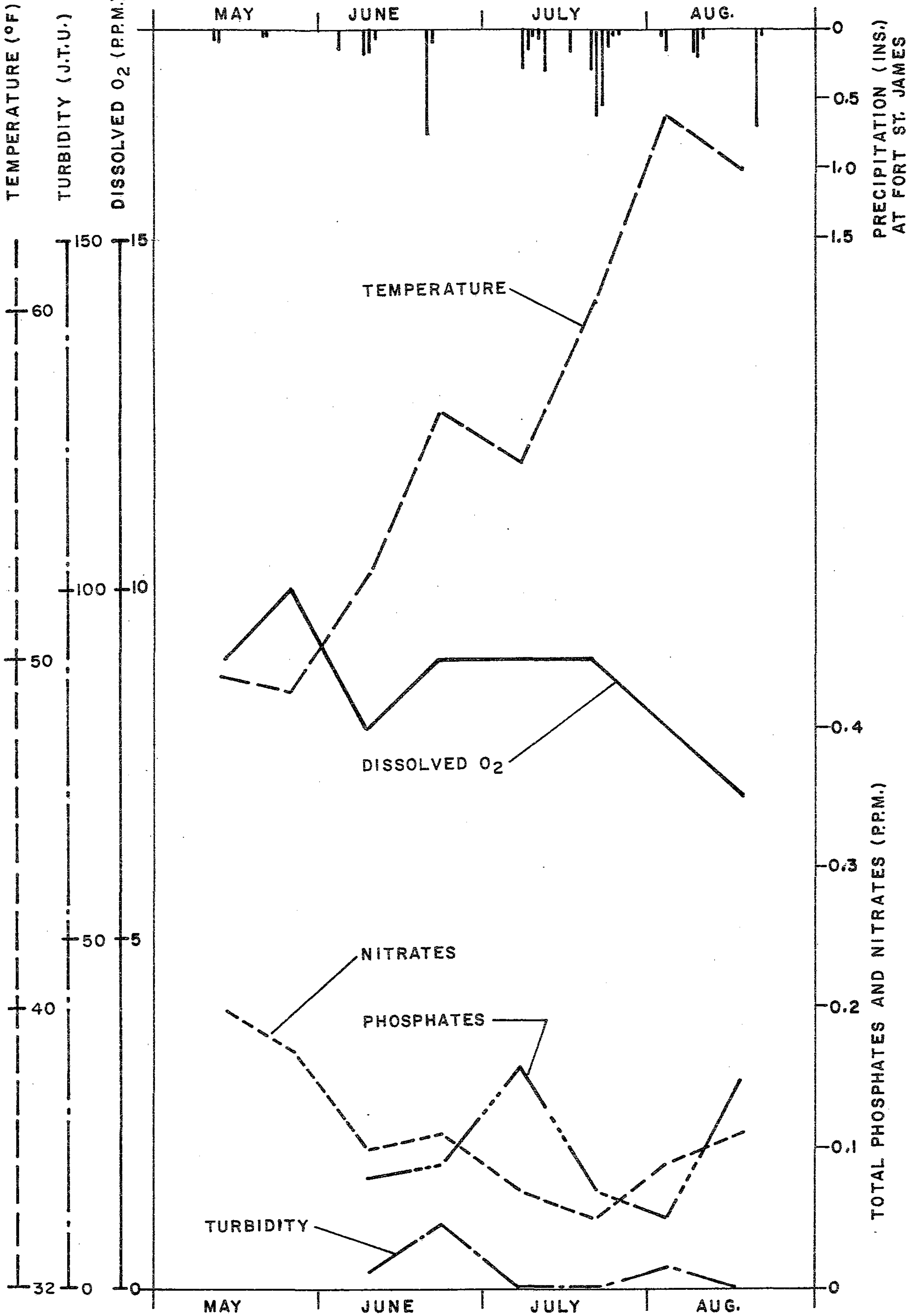


FIG. A5-12 WATER QUALITY PARAMETERS OF THE STUART RIVER AT SAMPLING SITE B (FORT ST. JAMES).

A5.4.2 CENTRAL FRASER SYSTEM

A5.4.2.1 CARIBOO RIVER BASIN

The results of the 1972 sampling program of the Cariboo River near Likely are shown in Figure A5-13. At this site, the rising turbidity during the freshet appears to have reduced algal production temporarily, resulting in an increase in measureable phosphates and nitrates, and a slight short-term drop in dissolved oxygen. A subsequent small rise in phosphates in July probably is related to a heavy rainfall following a two-week dry period. The information available does not suggest that any unusual water quality changes will result from impoundment of this water.

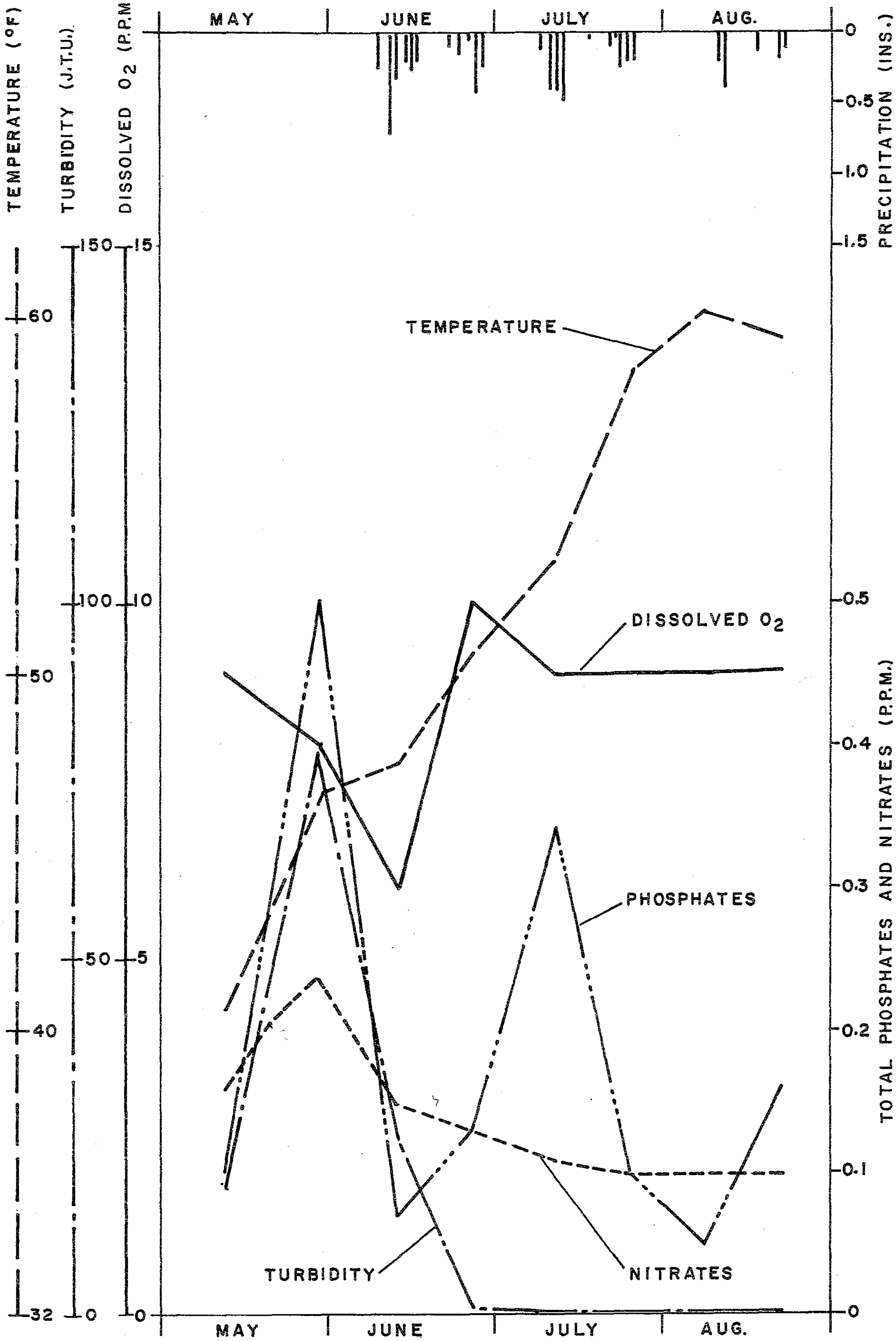


FIG. A5-13 WATER QUALITY PARAMETERS OF THE CARIBOO RIVER AT SAMPLING SITE A (LIKELY).

A5.4.2.2 MIDDLE FRASER AREA.

The major results of the sampling carried out on the Fraser River at Quesnel are shown in Figure A5-14. Phosphates and turbidity were not measured during the rising part of the freshet. Accordingly, the low dissolved oxygen level of 6 ppm on May 29, which occurred in mid-afternoon on a sunny day when D.O. levels at Shelley, Isle Pierre, and the Cariboo River were high, cannot be explained with the data available at the Quesnel site. However, a high turbidity reading of 170 JTU was later recorded at this site, and 160 JTU was recorded just downstream in late May. It may thus be assumed that high turbidity at the Quesnel site resulted in a low level of photoshythesis and, hence, low dissolved oxygen content.

The main water quality parameters measured in the Fraser River near Gang Ranch are shown in Figure A5-15. The fluctuations in nutrient levels may be attributed to changes in algal production caused by varying levels of turbidity. A similar relationship is shown in the data obtained from the Fraser River near Lillooet (Fig. A5-16).

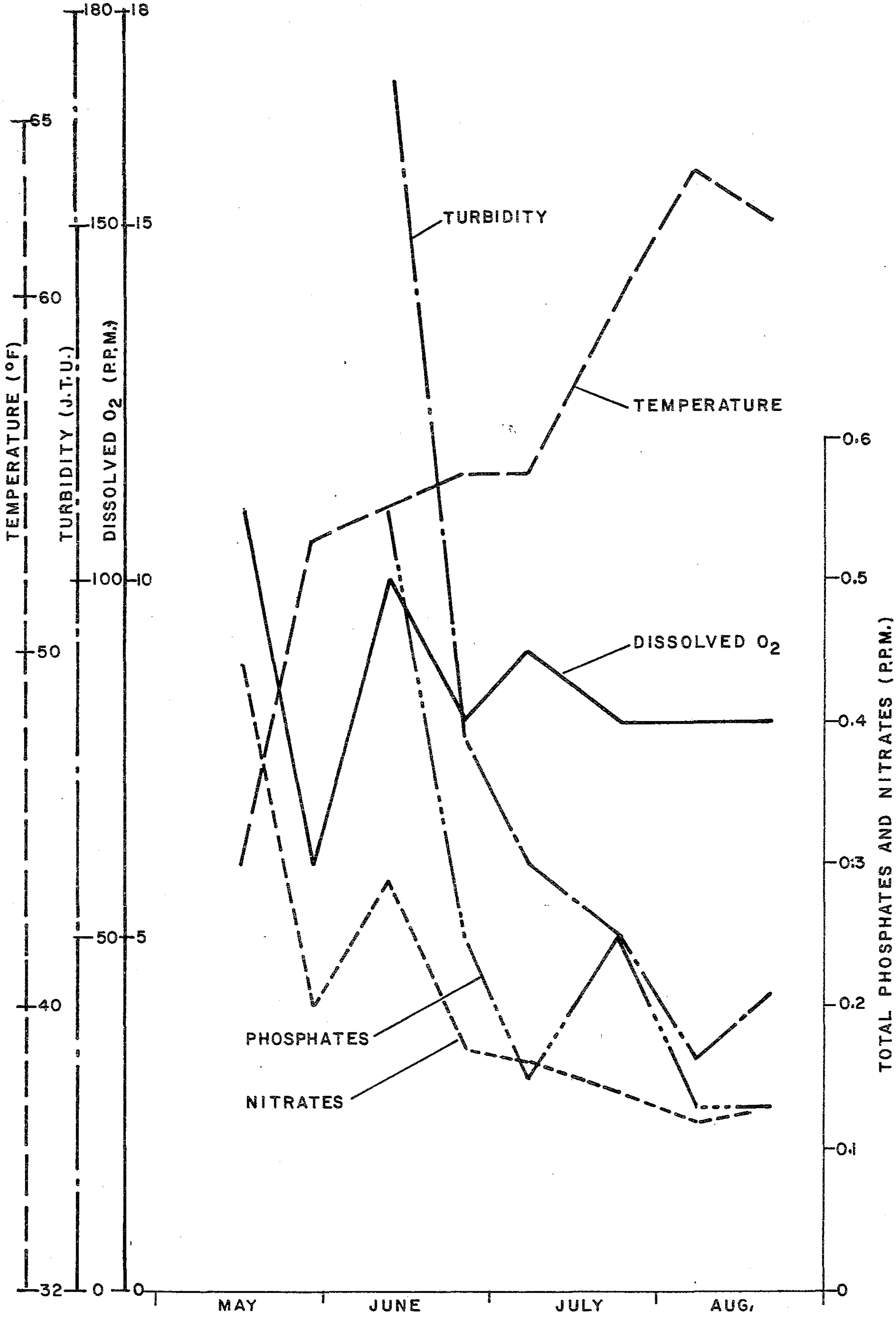


FIG. A5-14 WATER QUALITY PARAMETERS OF THE FRASER RIVER AT SAMPLING SITE F (QUESNEL).

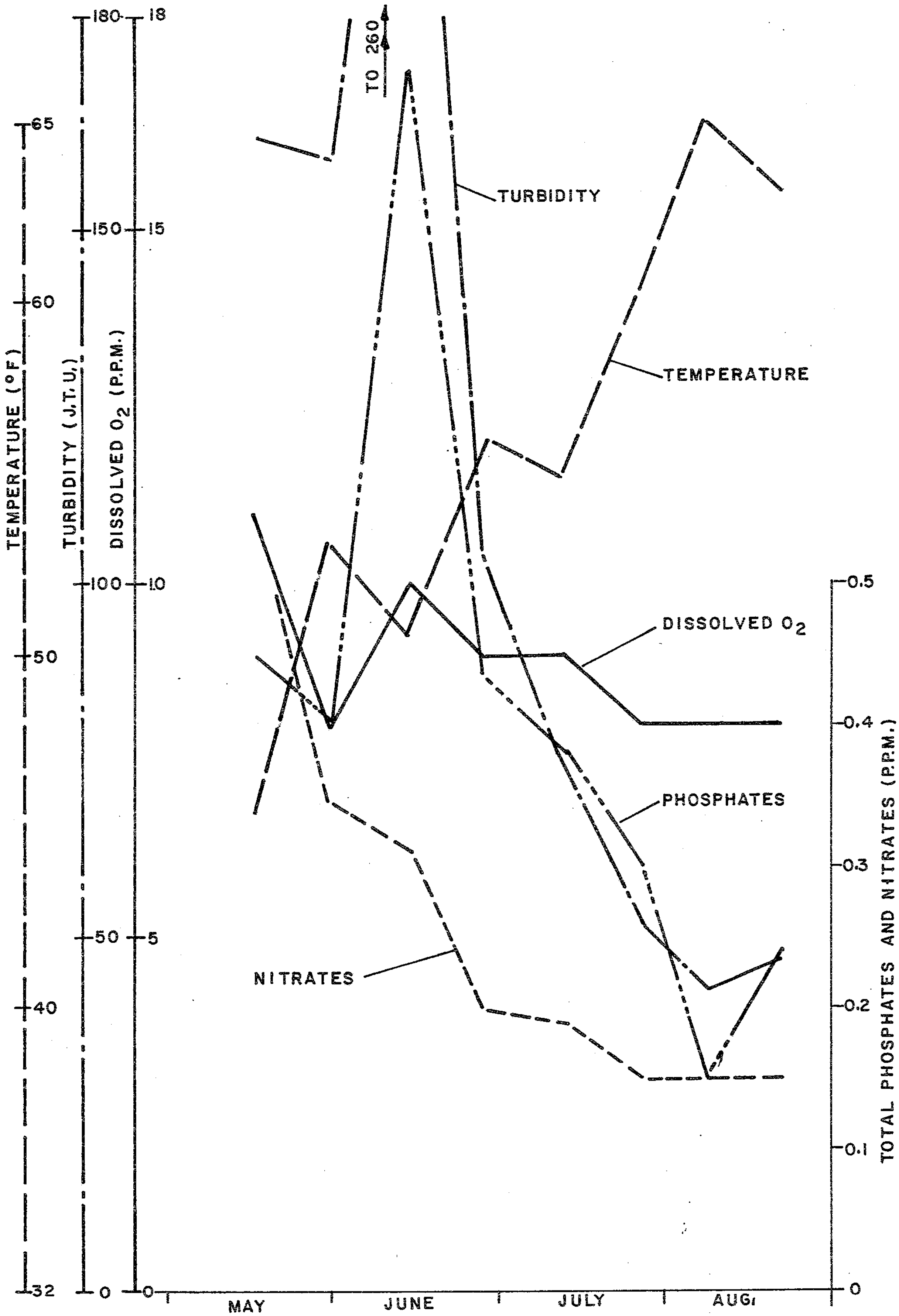


FIG. A5-15 WATER QUALITY PARAMETERS OF THE FRASER RIVER AT SAMPLING SITE G (GANG RANCH).

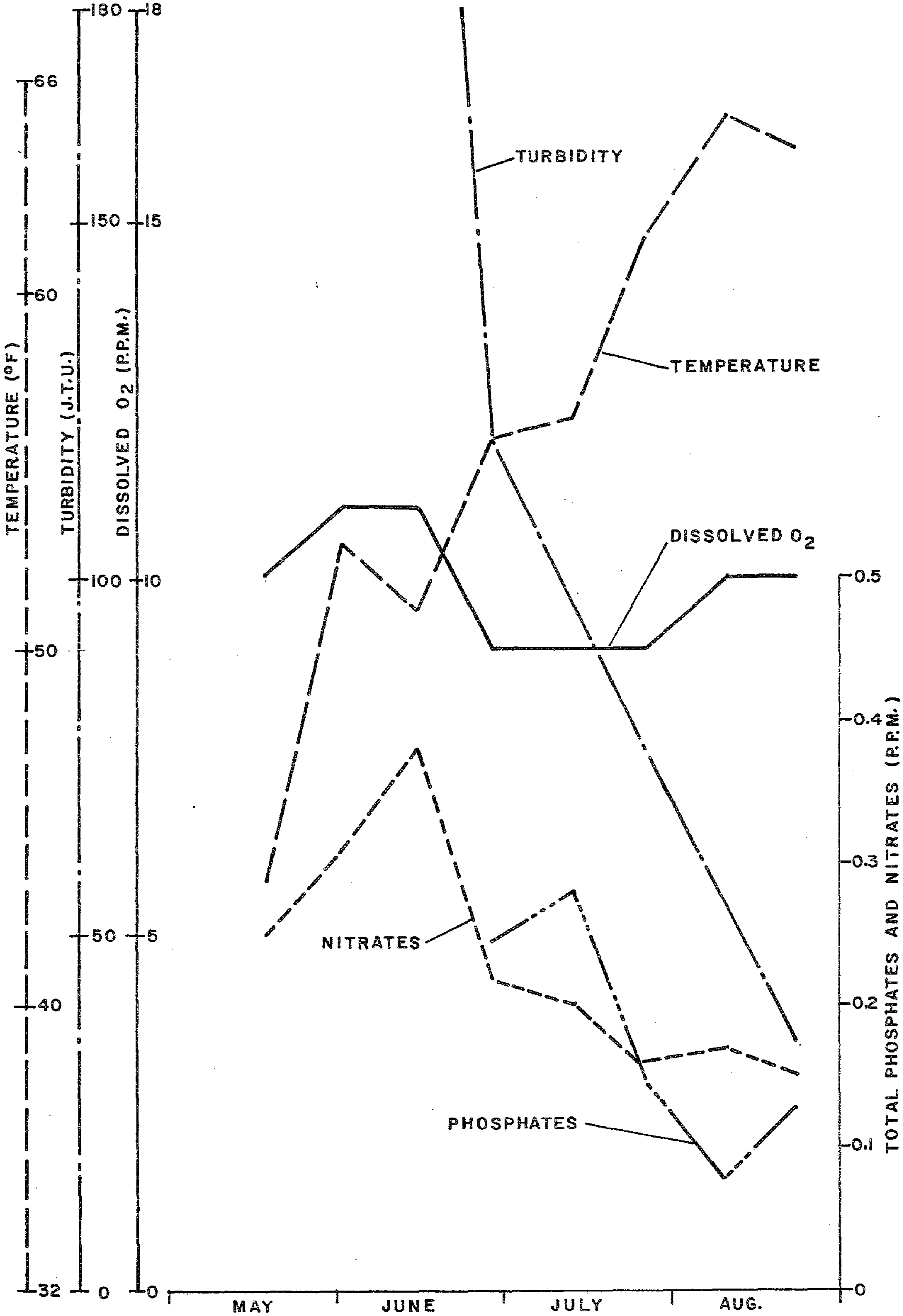


FIG. A5-16 WATER QUALITY PARAMETERS OF THE FRASER RIVER AT SAMPLING SITE H (LILLOOET).

A5.4.3 THOMPSON RIVER BASIN

A5.3.3.1 CLEARWATER RIVER

The sampling on the Clearwater River was not begun until the height of the freshet and changes in water quality previous to peak cannot be detailed. The first sample taken showed high turbidity (110 JTU). The resultant decrease in algal production, the high nutrient levels, and the low dissolved oxygen content shown in Figure A5-17 are confirmatory.

The range of dissolved oxygen and temperatures noted are within optimal ranges for salmonids. No unusual values were noted for the other parameters measured.

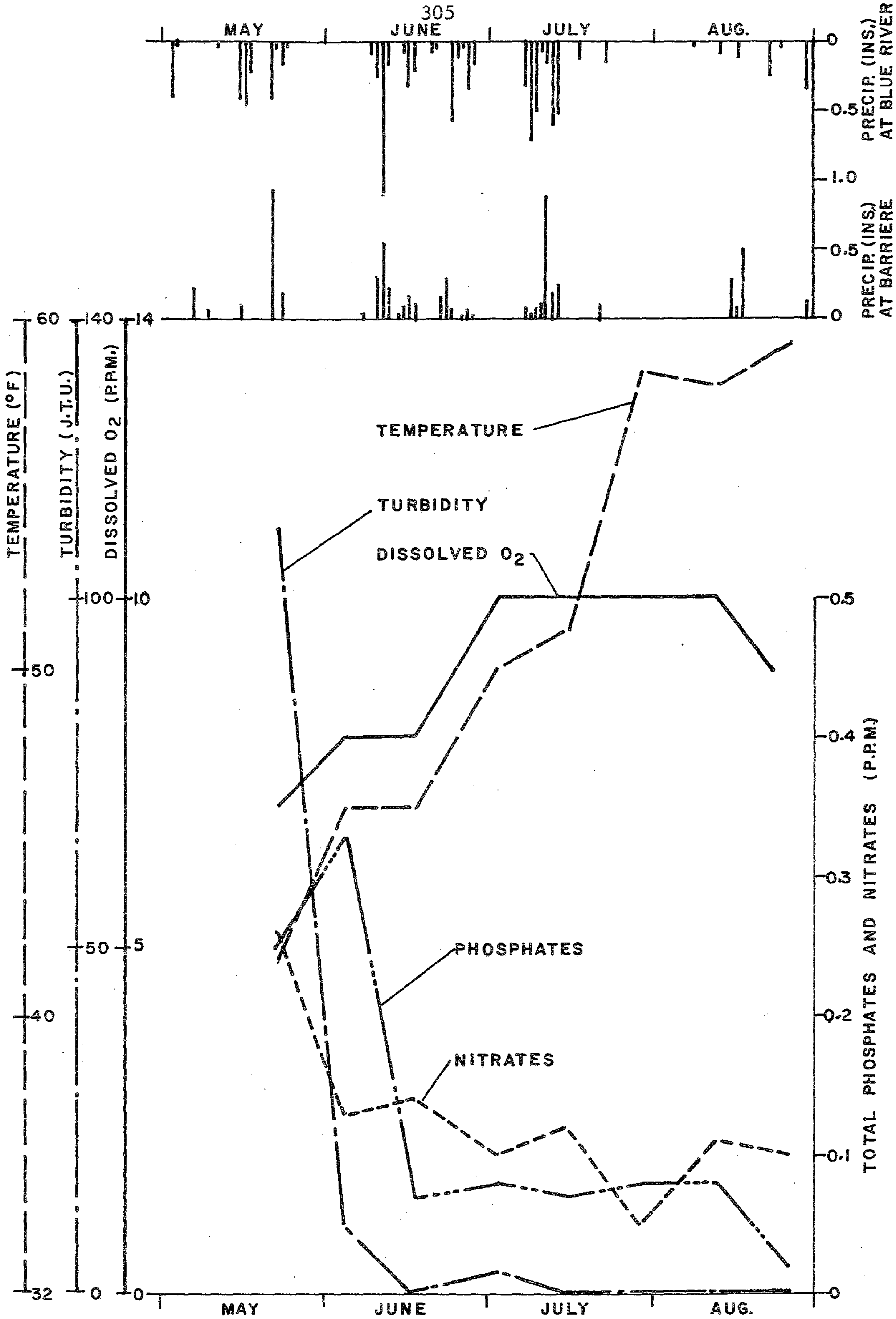


FIG. A5-17 WATER QUALITY PARAMETERS OF THE CLEARWATER RIVER AT SAMPLING SITE L (CLEARWATER).

A5.4.3.2 NORTH THOMPSON SYSTEM

Water quality data obtained from the North Thompson River at McLure are plotted on Figure A5-18. The most notable feature of this information is a dissolved oxygen reading of 5 ppm on June 3 at the height of the North Thompson freshet. If a reading of 5 ppm dissolved oxygen is possible without evidence of organic pollution in the North Thompson in spite of dilution by a well oxygenated inflow from the Clearwater, a development which would lower the dissolved oxygen content of the Clearwater River must be viewed as potentially dangerous to all anadromous fish populations which migrate through the lower North Thomson River. It is conceivable that the effect may extend as far downstream as Kamloops Lake if the Clearwater River water quality is sufficiently degraded.

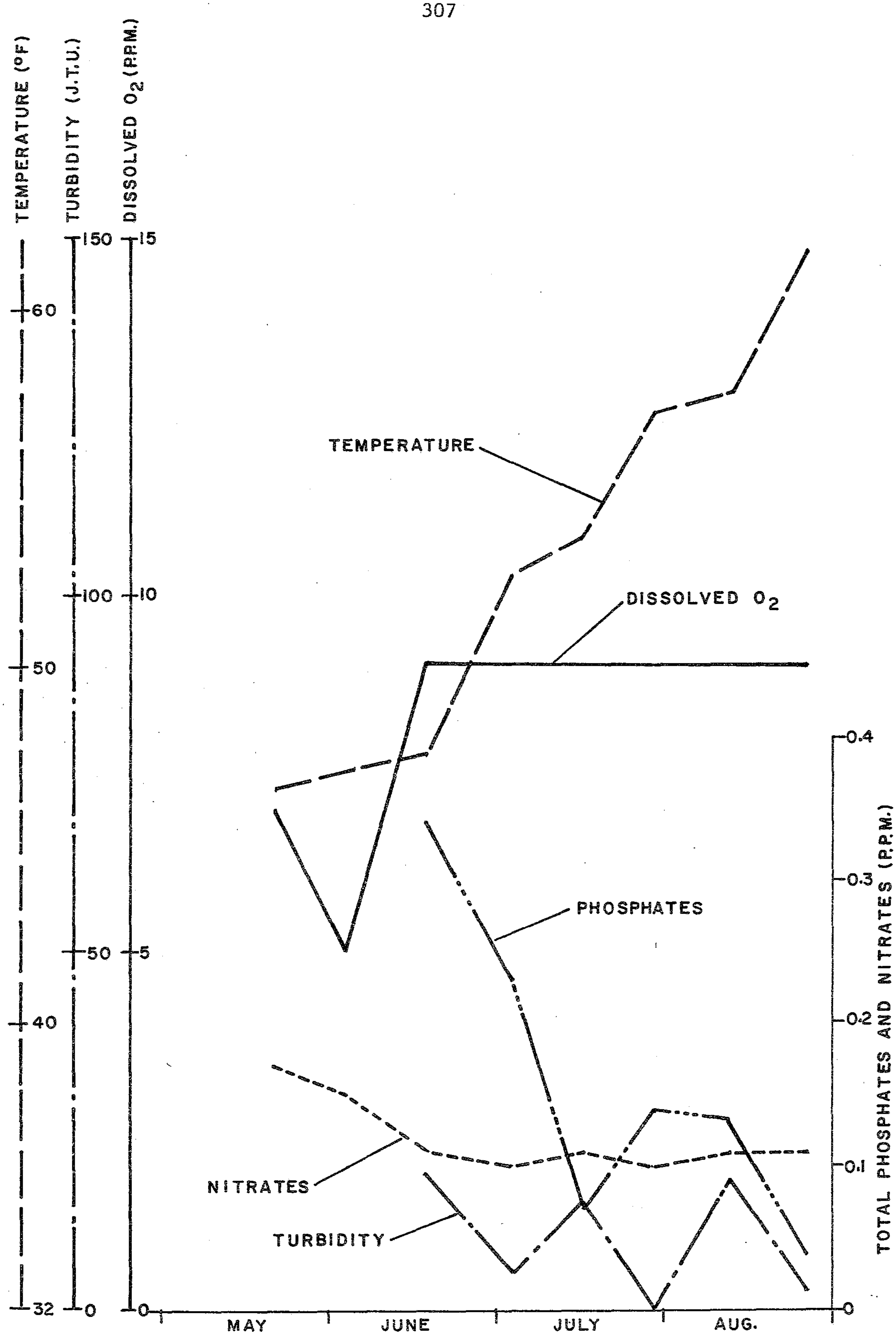


FIG. A5-18 WATER QUALITY PARAMETERS OF THE NORTH THOMPSON RIVER AT SAMPLING SITE K (McLURE)

A5.4.3.3 THOMPSON/SOUTH THOMPSON SYSTEM

As shown in Figure A5-19, the dissolved oxygen of the South Thompson River dropped to 5 ppm on June 3. This is the same date that a similar value was found in the North Thompson at McLure. Judging from the negligible turbidity noted for the South Thompson on later dates, it may be assumed that this low D.O. level was not the result of reduced photosynthesis in a turbid river. Because the B.O.D. was not detectable on June 3, a temporary pollution problem is not suspected.

This sample was taken at 9:30 a.m. when the dissolved oxygen level can be expected to be slightly depressed as sunlight has been acting on the algae for only a short period of time. However, on May 21 a reading of 7 ppm was taken at 9:00 a.m., and on July 16 and 30 readings of 9 ppm were taken at 7:00 p.m. It is likely that time of day was not a particularly important factor.

Sampling on the Thompson River was conducted just upstream from its confluence with the Nicola River at Spences Bridge. The results are shown in Figure A5-20; information for the Nicola River is shown in Figure A5-21. The inter-relationships of the various factors plotted are very similar for both sites, indicating a similarity of land usage close to the sampling locations.

At both sites, fluctuations in nutrient levels during the spring are apparently related to turbidity levels. The phosphate values were quite high and were most pronounced in the Nicola River.

The dissolved oxygen remained high throughout the sampling period. Although the freshet values were not recorded on the Nicola, it is considered probable that they compared favourably with Thompson River levels. The temperature of the Thompson River remained within an acceptable range for salmonids, but the Nicola River water temperature rose to 68° F in mid-August, a level which may indicate less than desirable conditions for early migrating adult salmon.

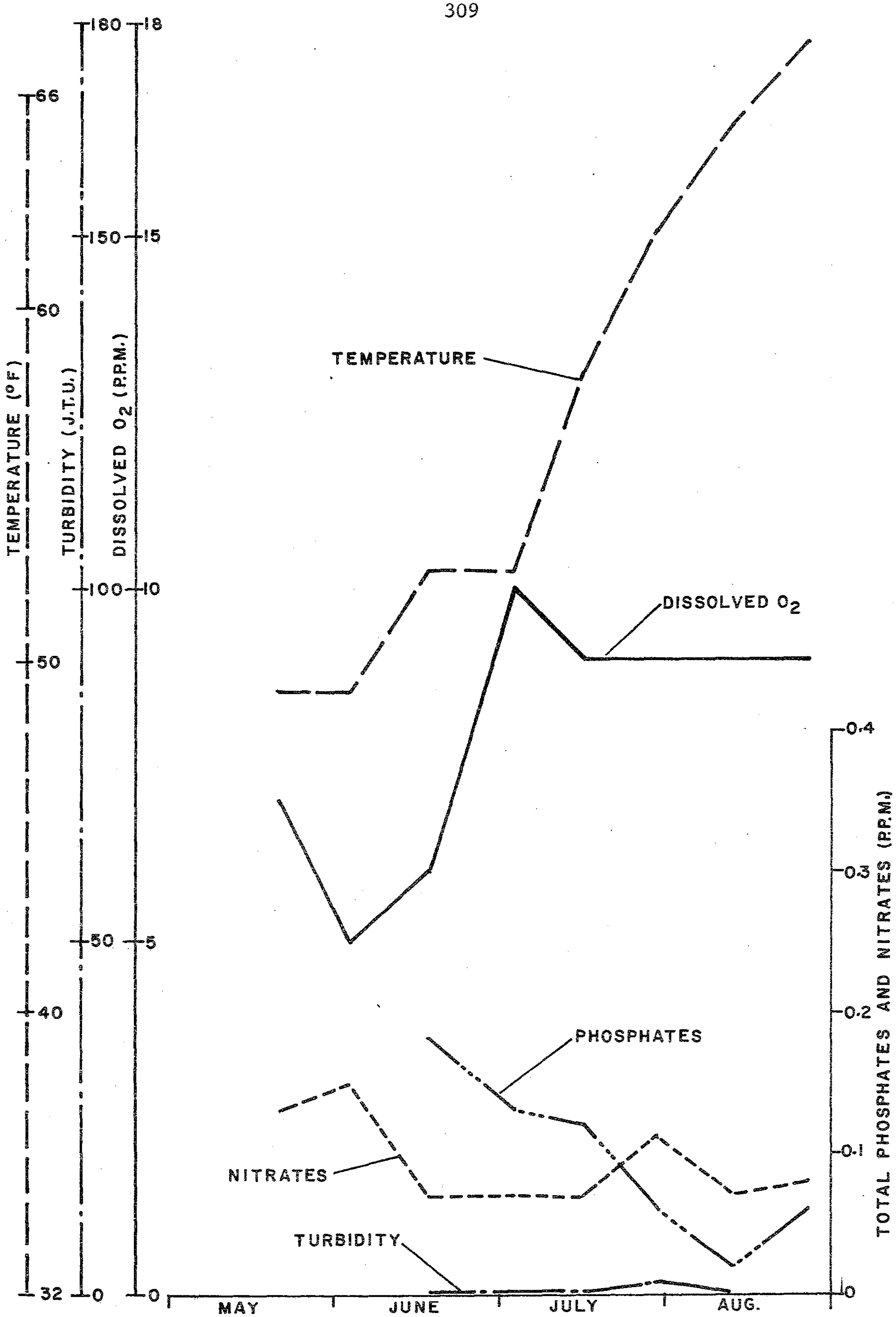


FIG. A5-19 WATER QUALITY PARAMETERS OF THE SOUTH THOMPSON RIVER AT SAMPLING SITE J (KAMLOOPS).

The most significant fluctuation in measured parameters was a large rise in metaphosphates at both sites in late July. The maximum level in the Nicola was twice that of the Thompson value. The fact that the South Thompson and North Thompson water exhibited consistent moderate levels of phosphates during the July period, narrows the area of phosphate input to the Nicola River and to the Thompson River between Kamloops and Spences Bridge.

In this area, both the Nicola and Thompson river basins are heavily utilized for fertilized, irrigated, agricultural purposes and for cattle raising. These uses should contribute high phosphate inputs to the streams, and a short, intensive rain of less than one-quarter of an inch a few days before the July 27 sampling (after a period of dry weather) may have resulted in an exceptional contribution of nutrients.

The introduction of any System E project is not likely to have an effect on the water quality of the Thompson River as far downstream as Spences Bridge, with the possible exception of a small beneficial reduction in summer temperatures.

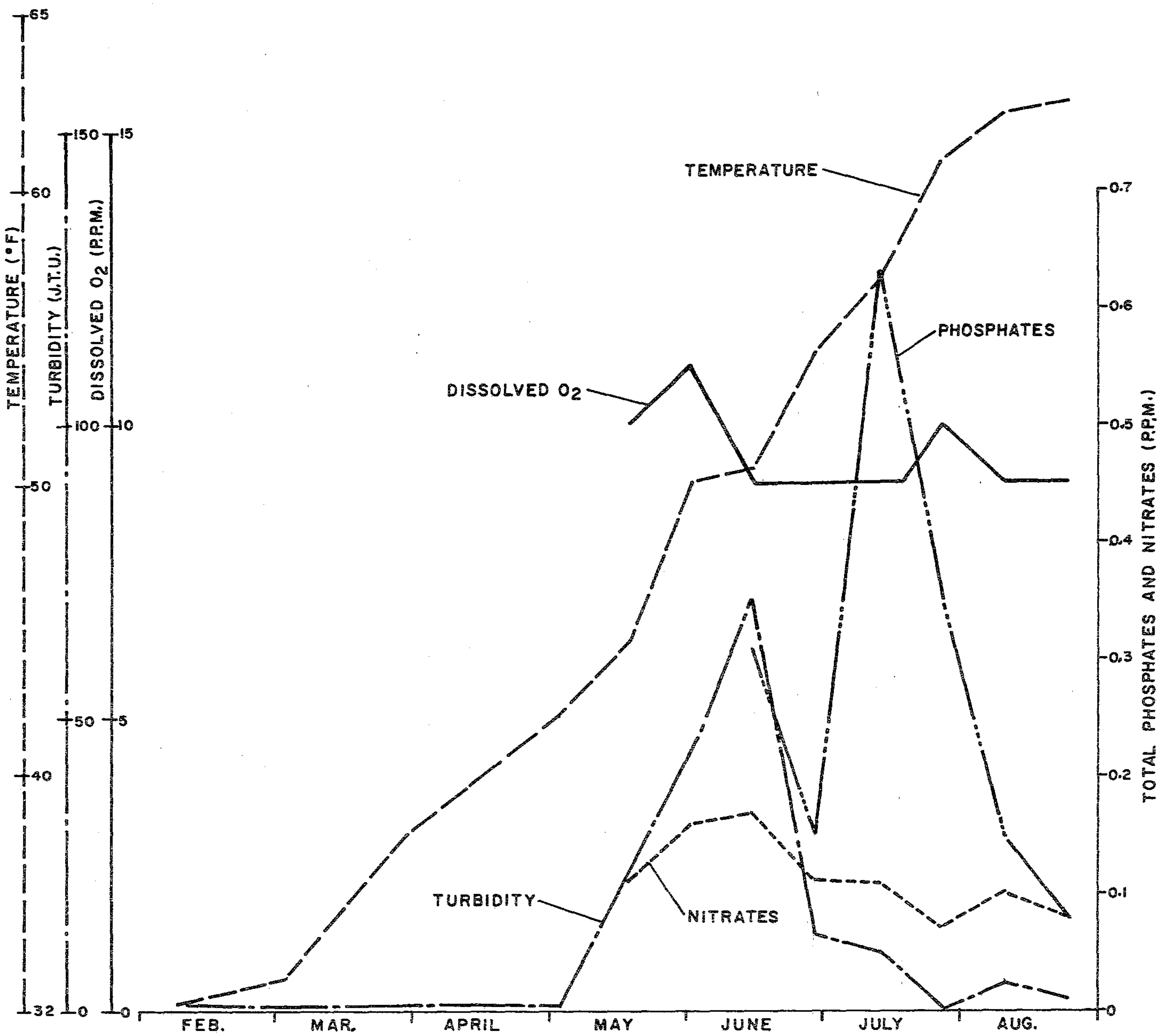


FIG. A5-20 WATER QUALITY PARAMETERS OF THE THOMPSON RIVER AT SAMPLING SITE I (SPENCES BRIDGE).

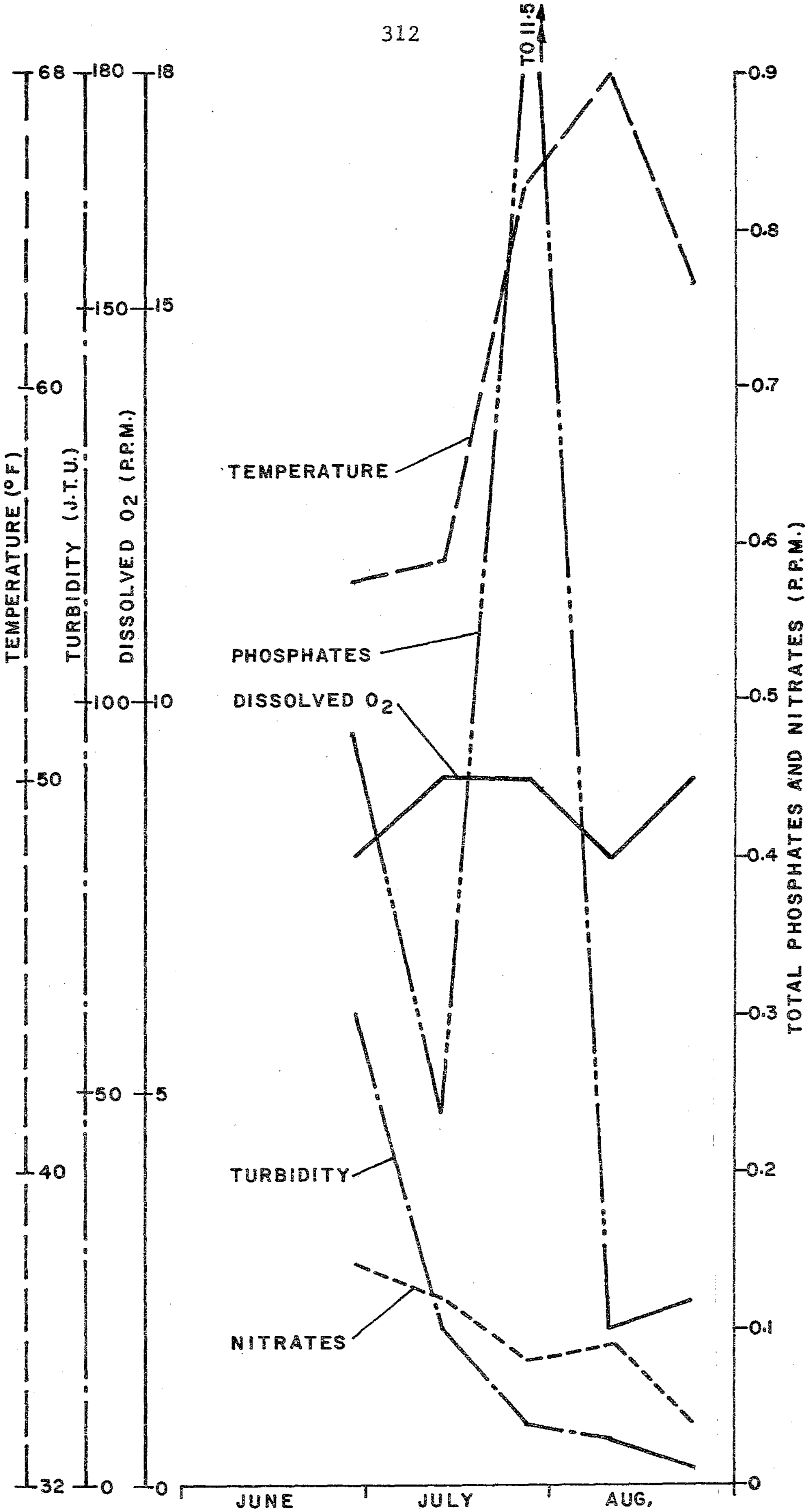


FIG. A5-21 WATER QUALITY PARAMETERS OF THE NICOLA RIVER AT SAMPLING SITE N (SPENCES BRIDGE.

A5.5 Discussion

The methodology and intensity of sampling undertaken in 1972 does not permit detailed analysis of the cause and effect relationships associated with fluctuations in nutrient levels lower than 1.0 ppm. The trends within the 1.0 to 2.2 ppm range are considered valid, and high nutrient levels (2.2 ppm at Isle Pierre) may have very positive implications. The results, however, do provide a reliable overview of the absolute values and seasonal ranges in temperature, dissolved oxygen, heavy metals, and turbidity. Unquestionably, there is a very urgent need for a more intensive and comprehensive on-going monitoring program in the Fraser system to provide an adequate understanding of the implications of future water and land-use developments.

A5.6 Conclusions

(1) Concentrations of iron and manganese do not appear to be inordinately high in the upper Fraser watershed. There is no information available to support an assumption that the proposed System E development would result in increasing these levels.

(2) With the exception of the Nicola, river water temperatures during the summer of 1972 were well within an acceptable range for rearing and migrating salmonids.

(3) Values of pH were within desirable ranges for salmonids, although a tendency toward alkalinity was noted.

(4) Relatively low dissolved oxygen values during the freshet were recorded near the Grand Canyon dam site, in the North Thompson River below its confluence with the Clearwater, and in the South Thompson two miles east of Kamloops. Low dissolved oxygen levels at Grand Canyon coincided with high phosphate levels and may indicate a potential for reservoir eutrophication in this area. The cause(s) of low dissolved oxygen content in the North and South Thompson rivers were not identified.

(5) Very high phosphate inputs were recorded during mid-summer on the Nechako, Nicola, and Thompson River above Spences Bridge.

(6) Turbidity ranged widely but maximum levels did not exceed those commonly tolerated by salmonids.

Appendix B

Evaluation of the Fraser River Salmon Resource Affected by System E Developments

APPENDIX B

EVALUATION OF THE FRASER RIVER SALMON RESOURCE AFFECTED BY SYSTEM E DEVELOPMENTS

The impact of the proposed System E development on the Pacific salmon indigenous to the Fraser River system was assessed in four categories: losses to the commercial fishery, losses to recreationalists, preservation values associated with the resource, and the implications of losses to the Indian food fishery. A detailed description of the analytic techniques utilized is contained in Chapter V.

The recreational values applied were determined from a questionnaire survey. Appendix B1 presents a review of the concepts of recreational evaluation and the rationale for choosing the direct questioning technique. Appendix B2 outlines the interview techniques employed and contains a copy of the pertinent portion of the questionnaires and of the transformation questionnaire utilized to enable comparison of Year 1 and Year 2 survey data. Appendix B3 presents the mean recreational values obtained from survey data. Appendix B4 provides a list of references on recreational evaluation.

B1 A REVIEW OF CONCEPTS AND SOME APPLIED DEVELOPMENTS FOR COMPREHENSIVE EVALUATION OF RECREATION

Traditionally, evaluation techniques in the area of recreation and/or aesthetics, when applied to the fishery resource, have been specific activity and direct use oriented. Consequently, while the value of sport fishing activity has been treated on a number of occasions and by a variety of methods, other direct uses, such as viewing, have been seldom quantified. Furthermore, values associated with uncertain future use have, to the best of the writer's knowledge, remained virtually unquantified in empirical studies.

B1.1 TRADITIONAL METHODS OF RECREATION EVALUATION

The most common and most maligned subject for evaluation in the common goods area is sport fishing. Traditionally, three general methods of evaluation have been used - often yielding very different products.

B1.1.1 ASSESSMENT OF EXPENDITURES

A common method of deriving a recreational "value" has been by adding up the amounts people spend in sport fishing - either per angler, per angler day, per fish, or whatever. The theory is that in the absence of price, a proxy for price may be the amounts people spend to get to and participate in the activity. In fact, this begs a number of questions concerning what the product is, how proximate people are to the activity, how easy is access, and so on. These problems raise serious questions as to the technique's appropriateness as an accurate means of determining net economic value. The technique can be used, however, to measure the revenue generated to the private sector in a given area and will produce a "Chamber of Commerce" type figure. As noted, however, it will only yield an accurate measure of net economic value to society of a given impact or enhancement decision under very special circumstances.

B1.1.2 TRANSFER COST APPROACH

A second "indirect" method of getting at sport fish values zeros in on the critical distance factor that the "expenditure" method fails to handle adequately. It argues that if one looks at the "average expenditure" of a trip to a fishing site in each of a series of concentric geographical zones, and compares that with the number of participants in each zone, adjusted for differing population, a curve can be constructed that plots numbers of participants (on the x axis) against cost of the trip (on the y axis). This technique is used by many economists to approximate a demand curve for sport fishing at a particular site, and possesses a fairly strong measure of credibility in the evaluation of options at a single site. It proves cumbersome, however, in the simultaneous evaluation of multiple sites (although, within limits, not impossible) and breaks down where user populations are concentrated very close to site.

B1.1.3 DIRECT QUESTION APPROACH

Another method, also in general use, is to ask directly, "What would you pay?", "How much would I have to pay you?", "What is it worth relative to some observable market reference point?", or some variation of this theme. The major drawback to this approach concerns whether you can get a relevant answer to a hypothetical question. If you believe you can, the direct method is better from almost all points of view than the "expenditure" method and better in some ways than the "transer cost" approach.

First, you are able to better define the product you are seeking. For instance, the practitioner of one of the other two methods must decide whether he has "sky", "Sunday drives" or what, mixed into his observed "sport fishing" expenditures. This may not be important if you are valuing the "activity". It becomes critical, however, if you are evaluating the resource - fish.

Second, the direct method probably handles "close to" evaluation best, where site is proximate to users and access easy. This point has been noted earlier.

Third, both the "direct" and "transfer cost" methods can define a demand curve ("the amounts of a product that users will take at each of a series of possible prices"). The expenditure method cannot.

B1.2 Preservation Value Concepts

An additional value, not associated with direct use, and which is characterized herein as "preservation value" has been synthesized by Arrow and Fisher (forthcoming). They argue that if development involves irreversible transformation of the environment, and one assumes conditional uncertainty about future benefits and costs, the relationship between expected benefits and costs of development will have to be adjusted to account for the loss of environmental options it entails. This argument is based on the assumption that individuals will adjust their perceptions as to benefits in period two on the basis of development-environment tradeoffs reached in period one, hence introducing a form of conditional uncertainty into decision making. They further state that the effect of such uncertainty will be to adjust the benefit-cost calculation against development. They generalize that if net benefits are not totally clear, investment should be adjusted downward, for over-investment is irreversible, but under-investment is not. This argument remains clear of assumption of risk aversion. Preservation values can, however, only be claimed where the product loss is irreversible over project life, and where the product is relatively unique.

B1.3 Comprehensive Evaluation and the Search for a Uniform Measuring Technique - Exchange Value

In view of the above considerations, five criteria that the present study-approach should meet were established.

(1) The technique should be capable of considering <u>direct use</u>, <u>indirect use</u>, and <u>preservation value</u> where relevant.

(2) The technique should be capable of deriving market exchange values, or their shadow price equivalents in the public goods sector.

(3) The technique should enable a respondent to indicate his command over future, as well as present resources where irreversibility is present.

(4) Problems concerned with revealing of preference should be reduced by depersonalizing the question to some extent.

(5) The technique should enable the respondent to consider the presentation of recreation-aesthetics as a "product" a relevant presentation.

On this basis, it was decided that a direct questioning approach would best meet these criteria. Respondents were presented with a range of public services purchased on their behalf by local government and then asked to assign "relative values" to specific recreational opportunities.

N.B.: A question of "option value" was also asked in the survey. It subsequently became clear that its inclusion in final results would have resulted in double counting. Consequently, it was not added into final totals and has not been discussed in this Appendix.

B2 RECREATIONAL EVALUATION - FIELD PROGRAM

B2.1 Program Inception

The aquatic recreation survey program related to the Fraser River and its estuary, initiated in the spring of 1971, was carried out in the Lower Mainland of British Columbia in that year, and continued in the summer of 1972 in the Interior.

A preliminary questionnaire was prepared in early spring 1971, and finalized after a pilot study of households in the Vancouver area and Fisheries Service personnel. Piloting was constrained by the necessity of entering the field by June 1, 1971.

B2.2 Sample Selection

In 1971, a target of 1,500 households to be interviewed in the Lower Mainland was set based on the man-years available to the project and average estimated interviewing time. The population of each municipality was obtained and a consistent percentage of each population was identified for interview. In the smaller municipalities, a minimum of 50 households were interviewed.

In 1972, the study area encompassed the Interior regions of the Fraser drainage basin. The number of households chosen per area was determined by relating interviewer time to manpower available. It was determined that a minimum of 15 households would need to be covered in the smaller areas. The areal referent groups were determined by using local telephone books of each main city or town, and including those smaller towns listed in each telephone book as belonging to that particular area. (See Table B2.1 for a complete listing of municipalities selected and total populations of these areas.) A target of 1,000 households was established in year 2.

Respondents were selected by a computer-generated sampling technique. Anticipating changes in telephone numbers and addresses, approximately four times the number of respondents required for an areal sample were selected for each municipality in the Lower Mainland. Due to a higher rate of response expected in its more sparsely populated area, three times the number required in the Interior were selected.

Names were obtained from the Greater Vancouver Criss-Cross Directory for 1971, and from individual municipal telephone books for 1972 as no directories were available for the latter. The random numbers were coded and fed into the computer in such a manner that they could be broken down into a row by column matrix from which names could be derived in the directories. They were then entered on lists according to survey areas.

At this point, an introductory letter was mailed to persons selected from the random listings advising them that they would be contacted shortly by the Department of Environment. Approximately 10 percent of the letters mailed were returned undelivered. A slightly higher level of "non-deliveries" was recorded in the larger Lower Mainland municipalities.

TABLE B2.1 Sample Areas and Populations

1971 Sample	Population 1970*	Population 1971**
Maple Ridge	23,000	24,476
New Westminster	40,000	42,835
North Vancouver	91,525	89,708
Port Coquitlam	19,000	19,560
Port Moody	11,000	10,778
Vancouver City	450,000	456,256
White Rock	10,300	10,349
Burnaby	129,700	125,660
Coquitlam	55,000	53,230
Delta	41,500	45,860
Richmond	67,000	62,121
West Vancouver	37,000	36,440
	1,071,525	1,075,874
1972 Sample		
Ashcroft		1,916
Cache Creek		1,013
Chase		1,212
Clinton		905
Enderby		1,158
Kamloops≠		26,162
- Avola		315
- Barriere		668
- Blue River		545
- Clearwater		401
- Little Fort		122
- Savona		508
- Spences Bridge		163

TABLE B2.1 (cont'd)

Lillooet & Lytton≠	2,008
- Bralorne	531
- Shalalth	127
Merritt	5,289
Quesnel	6,252
Prince George≠	33,101
- Giscombe	477
- Hixon	454
- Red Rock	267
100 Hile House	1,120
Salmon Arm	7,793
Valemount & McBride	1,351
Vanderhoof	1,653
Williams Lake	4,072
	99,583
Vancouver	456,256
	555,839

≠ 1966 most recent figures available for towns listed beneath major cities.

* 1970 estimated populations used in 1971 sample were taken from Municipal Statistics, 1971.

** 1971 population figures obtained from preliminary census, Statistics Canada.

B2.3 Pre-Testing Contacts

Approximately one week after mailing of the introductory letters, the interviewers telephoned prospective respondents and arranged an appointment time with members of the household, age fourteen and over. The letter proved most useful in identifying the Department and the purpose of the survey, and accounted for a generally positive telephone response. In the Lower Mainland area, the rate of acceptance was lower as people tended to be more skeptical, too busy, more apathetic, etc. There was also some difficulty when interviewers visited homes at the appropriate appointment times and found no one home. This occurred with approximately 2.6 percent of the total sample but was minimized to some extent when interviewers phoned and reminded householders of their upcoming appointment prior to the interview.

In the Lower Mainland, the acceptance rate from telephone calls was 34 percent, indicating that 3,504 actual phone contacts were made. In 1972, a higher acceptance rate of 45 percent was achieved, with approximately 2,772 phone calls being made (see Table B2.2). Over the two-year period, interviewers were unable to contact approximately 23 percent of the sample selected. This was mainly due to persons moving out of the area, letters being returned, and telephone numbers being disconnected.

TABLE B2.2 Initial Contacts Made By Interviewers

Total Names Selected		Unable to Contact*		Total Contacts		Appts. Accepted		Not Wishing To Be Interviewed	
No.	%	No.	%	No.	%	No.	%	No.	%
1971									
Lower Mainland/									
4,550	100	1,046	23	3,504	100	1,191	34	2,313	66
1972									
Interior B.C./									
3,600	100	828	23	2,772	100	1,275	45	1,497	55

* Includes underlivered introductory letters.
/ Yearly average. Data taken from telephone lists and summaries of summer staff.

B2.4 INTERVIEWERS' SCHEDULE

Each respondent was asked to fill out the individual section of the questionnaire dealing with aquatic recreational evaluation. The interviewers assisted in interpretation where necessary.

In each of the two years the survey was conducted, there were seven interviewers. An average of 88 households were interviewed per week in 1971, and 122 households interviewed weekly in 1972. The lower figure in 1971 resulted from more time being spent by interviewers in telephoning for interviews due to a generally lower rate of response on initial telephone contacts. A total of 2,002 individuals were interviewed in Year 1, and 1972 in Year 2 (Table B.3).

TABLE B2.3 Recreation Questionnaire - Summary of Interviews

1971	HOUSEHOLDS VISITED	INDIVIDUALS INTERVIEWED
Vancouver	398	703
White Rock	50	67
West Vancouver	50	84
Surrey	85	155
Richmond	60	100
Port Moody	50	82
Port Coquitlam	50	92
Delta	52	91
Coquitlam	54	103
Burnaby	114	221
Maple Ridge	52	79
New Westminster	50	71
North Vancouver	85	154
Sub-Total	1,150	2,002

TABLE B2.3 (cont'd)

1972	HOUSEHOLDS VISITED	INDIVIDUALS INTERVIEWED
Salmon Arm	50	106
Chase	17	32
Enderby	20	40
Lillooet	55	55
Lytton	40	55
100 Mile House	43	75
Clinton	46	73
Ashcroft	40	76
Cache Creek	47	90
Merritt	48	88
Prince George	152	276
Valemount	30	54
McBride	30	41
Williams Lake	60	98
Quesnel	60	91
Vanderhoof	30	52
Kamloops	171	313
	939	1,615
Vancouver	290	357
Sub-Total	1,229	1,972
1971 - 72 TOTAL	2,379	3,974

B2.5 General Discussion of Questionnaire

Municipal expenditures for the most recent year available (1968) were calculated and used as a reference for respondents to value water related recreational opportunities along the Fraser River. Although the questionnaire was modified in the second year of the survey, this crucial base question remained the same for both years.

In the second year, the individual part of the questionnaire was revised for use in the interior regions along the Fraser River system. Respondents were asked to separate out the "fish" value from their total activity value and to vary their total "fish" value as the number of fish in the system were hypothetically changed. This latter evaluation yields a revenue curve. The critical portions of the two questionnaires follow.

B2.5.1 QUESTIONNAIRE - YEAR 1

4. a) The following list shows average municipal expenditure per household in your area during 1968. You may not agree with this allocation. For instance, you may feel that more should have been spent on education and less on public works. Or you may believe the opposite. If you agree with this allocation or are neutral, proceed to Question 4(b). If you disagree with this allocation, assume you are the decision-maker and change the numbers shown to suit your personal preferences, entering the new numbers to the right in the spaces provided. You can reduce some items to zero if you wish. Alternatively, you can increase items as much as you wish.

MUNICIPALITY OF DELTA

Areas of Expenditure	Dollars per Household	Your New Value ($ per Household)
Education	203.25	________
Public Works	72.69	________
Protection to Persons and Property (building inspector, coroner, police, etc.)	37.64	________
General Government (executive, legislative, administrative)	34.29	________
Social Assistance (care of aged and blind, children's aid, etc.)	31.70	________
Community Services such as Parks, Recreation Programs, Libraries, Community Centres, etc.	21.91	________
Fire Protection	16.09	________
Utilities (deficits) and Debt Charges	14.75	________
Sanitation and Waste Removal	11.10	________
Public Health and Hospital Care (medical, dental, allied services)	7.47	________
Other (appropriation for reserves and provision for allowances, contributions to reserve funds, contributions to general capital and loan fund, joint or special projects, and miscellaneous)	82.34	________

4. b) Just as these services are provided to the community by local government, so other "services", or if you prefer, "opportunities", are provided by the water environment of the Fraser River and its estuary. Some of the opportunities are recreational. Others are more aesthetic or environmental. A number of these opportunities are listed below. For each opportunity, please place your assessment of its value in the appropriate space. While you should refer to the allocation of city expenditures in Question 4(a), it should be used as a reference point only. You may place any value you feel appropriate in the spaces provided.

	YOUR VALUES ($ per household)
(a) Activities involving personal/human contact with water (swimming, scuba diving, etc.) at ocean beaches	________
(b) Activities involving personal/human contact with water (swimming, scuba diving, etc.) on Burrard Inlet	________
(c) The enjoyment derived from viewing and thinking about the marine environment (fish, water fowl, marine vegetation, the water itself).	________
(d) Indirect activities such as picnicking, hiking and sunbathing that are carried out in areas on, adjacent to, or in view of the water.	________
(e) Stream, lake and sand bar fishing	________
(f) Salt water fishing	________

B2.5.2 QUESTIONNAIRE - YEAR 2.

4. The following list shows the value of the goods and services purchased by your municipality on your behalf. They are presented as dollars per household. You may not agree with this allocation; for instance, you may feel that more should have been spent on education and less on public works, or vice-versa. If you agree with this allocation or are neutral, proceed to the opposite page. If you disagree with this allocation, assume you are the decision maker and change the numbers shown to suit your personal preferences, entering the new numbers to the right in the spaces provided. You can reduce some items to zero if you wish. Alternatively, you can increase items as much as you wish.

TOWN OF WILLIAMS LAKE

Areas of Expenditure	Dollars per Household	Your New Value ($ per household)
Education	307.41	________
Community Services such as Parks, Recreation Programs, Libraries, Community Centres, etc.	103.18	________
Public Works	71.13	________
General Government (executive, legislative, administrative)	65.83	________
Sanitation and Waste Removal	60.40	________
Social Assistance (care of aged and blind, children's aid, etc.)	36.26	________
Fire Protection	35.07	________
Protection to Persons & Property (building inspectors, coroner, police, etc.)	30.83	________
Public Health & Hospital Care (medical, dental, allied services)	2.08	
Other (appropriations for reserves and provision for allowances, contributions to reserve funds, contributions to general capital and loan fund, joint or special projects and miscellaneous)	4.78	________
Utilities (deficits) & Debt Charges	less than 0.50	________

5. Just as these services are provided to the community by local government, so other "services", or if you prefer, "opportunities", are provided by the water environment of the Fraser River and its estuary. Some of the opportunities are recreational; others are more aesthetic or environmental. A number of these opportunities are listed below. For each opportunity, please place your assessment of its value in the appropriate space. You should refer to the allocation of city expenditures on the opposite page as a reference point. You may place any value you feel appropriate in the spaces provided, however.

	Your Annual Values ($ per household)
a) Swimming	________
b) Boating	________
c) Fishing	________
d) Viewing and other recreation (picnicking, hiking, etc.) next to the water	________

e) If you do not presently participate in some of the activities listed above, you, your family or your friends may, nevertheless, wish to use it in the future. Would you please indicate what additional value, if any, you associate with "knowing the resource is there" for use, even though you may not presently use it.

Knowing the resource "is there" for use ________

f) Some people associate a value with environmental resources even though they don't expect to "use" them, simply because they feel they should be preserved. Please place any value that you associate with "preservation" below.

Preservation value ________

6. What total value (referring to Question 5) would you allocate to all the recreational and aesthetic opportunities associated with the aquatic environment in the Fraser system? This number need not be the total of those given above. ________

7. Now we would like to direct your attention to one particular part of the Fraser life system - fish. Referring to your answers on the previous page, we would like you to indicate what part of those values you associate with fish. For each category shown below, you may write in any portion of your previous values from 0 to the full amount, depending on how important fish are to you in each. You can start by putting your fishing value derived in Question 5 in the space marked "fishing".

ANNUAL VALUES RELATED TO THE FISH RESOURCES OF THE RIVER

Fishing	________
Boating	________
Viewing, etc.	________
Keeping the option for future use open	________
Preservation value	________
Total Fish Resource Value (add above)	________

8. To this point we have been considering present levels of fish abundance. As a final question, we would like to know how the value you associate with fish in the Fraser system will change as the number of fish in the system change. In the spaces below enter your total fish resource value in the "present numbers" space, and put 0 in the "no fish" space. Place whatever values you feel are appropriate in the other spaces.

Less Fish		Present Numbers of Fish	More Fish	
10% less	_____		10% more	_____
One-quarter less	_____		One-quarter more	_____
One-half less	_____		One-half more	_____
Three-quarters Less	_____	____________	Three-quarters more	_____
No fish	_____		Three times as many	_____

B2.5.3 TRANSFORMATION QUESTIONNAIRE.

4. The following list shows the value of the goods and services purchased by your municipality on your behalf. They are presented as dollars per household. You may not agree with this allocation; for instance, you may feel that more should have been spent on education and less on public works, or vice-versa. If you agree with this allocation or are neutral, proceed to the opposite page. If you disagree with this allocation, assume you are the decision maker and change the numbers to the right in the spaces provided. You can reduce some items to zero if you wish. Alternatively, you can increase items as much as you wish.

CITY OF VANCOUVER

Areas of Expenditure	Dollars per Household	Your New Value ($ per household)
Education	314.54	________
Social Assistance (care of aged and blind, children's aid, etc.)	261.70	________
Protection to Persons and Property (building inspectors, coroners, police, etc.)	141.19	________
Community Services such as Parks, Recreation Programs, Libraries, Community Centres, etc.	70.16	________
Fire Protection	68.64	________
Public Works	48.10	________
Sanitation and Waste Removal	46.72	________
General Government	38.24	________
Public Health and Hospital Care (medical, dental, allied services)	27.18	________
Utilities (deficits) and Debt Charges	22.36	________
Other (appropriations for reserves and provision for allowances, contributions to reserve funds, contributions to general capital and loan fund, joint or special projects, and redevelopment of Downtown and substandard areas)	112.14	________

4. b) Just as these services are provided to the community by local government, so other "services", or if you prefer, "opportunities", are provided by the water environment of the Fraser River and its estuary. Some of the opportunities are recreational; others are more aesthetic or environmental. A number of these opportunities are listed below. For each opportunity, please place your assessment of its value in the appropriate space. You should refer to the allocation of city expenditures on the opposite page as a reference point. You may place any value you feel appropriate in the spaces provided, however.

	Your Annual Values ($ per household
(a) Activities involving personal/human contact with water (swimming, scuba diving, etc.) at ocean beaches.	________
(b) Activities involving personal/human contact with water (swimming, scuba diving, etc.) on Burrard Inlet.	________
(c) The enjoyment derived from viewing and thinking about the marine environment (fish, water fowl, marine vegetation, the water itself).	________
(d) Indirect activities such as picnicking, hiking and sunbathing that are carried out in areas on, adjacent to, or in view of the water.	________
(e) Stream, lake and sand bar fishing.	________
(f) Salt water fishing.	________

5. What total value (referring to Question 4.b) would you allocate to all those recreational pursuits associated with the aquatic environment in the Lower Mainland? This number need not be the total of those given above.

____

6. We would now like to redirect your attention to parts (c) and (d) of question 4b on the previous page. In question 4b, you associated dollar values with items (c) and (d). Now we would like you to take the total value you associated with items (c) and (d) - ($ c and d) - and divide this value among the following categories. You may place any portion of your total value figure in each category shown below, depending upon how important you feel each category is.

Total value of (c) and (d) __________

(a) Viewing and other recreation (picnicking, hiking, etc.) next to the water. __________

(b) If you do not presently participate in some of the activities listed on the previous page (question 4b), you, your family, or your friends may nevertheless wish to use it in the future. Would you please indicate what portion of the value, if any, you associate with "knowing the resource is there for use", even though you may not presently use it.

Knowing the resource "is there" for use __________

(c) Some people associate a value with environmental resources even though they don't expect to "use" them, simply because they feel they should be preserved. Please place any value that you associate with "preservation" below.

Preserving nature value __________

B3 MEAN RECREATIONAL VALUES

As a standard of comparison, the recreational activity values derived from the System E questionnaire are presented in parametric, rather than non-parametric form.

TABLE B3.1 Mean Recreational Activity Values Per Household - Zone 1

Activity	$ per annum
swimming at ocean beaches*	303
swimming in Burrard Inlet	272
viewing, picknicking, hiking, etc.	235
stream, lake and bar fishing	264
saltwater fishing	267
Total Annual Mean Value	$1,341

* Defined as the area from the North Arm jetty to the U.S. border

TABLE B3.2 Mean Recreational Activity Values Per Household - Zone 2

Activity	$ per annum
swimming	65
boating	60
fishing	79
viewing, picknicking, etc.	107
Total Annual Mean Value	$311

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