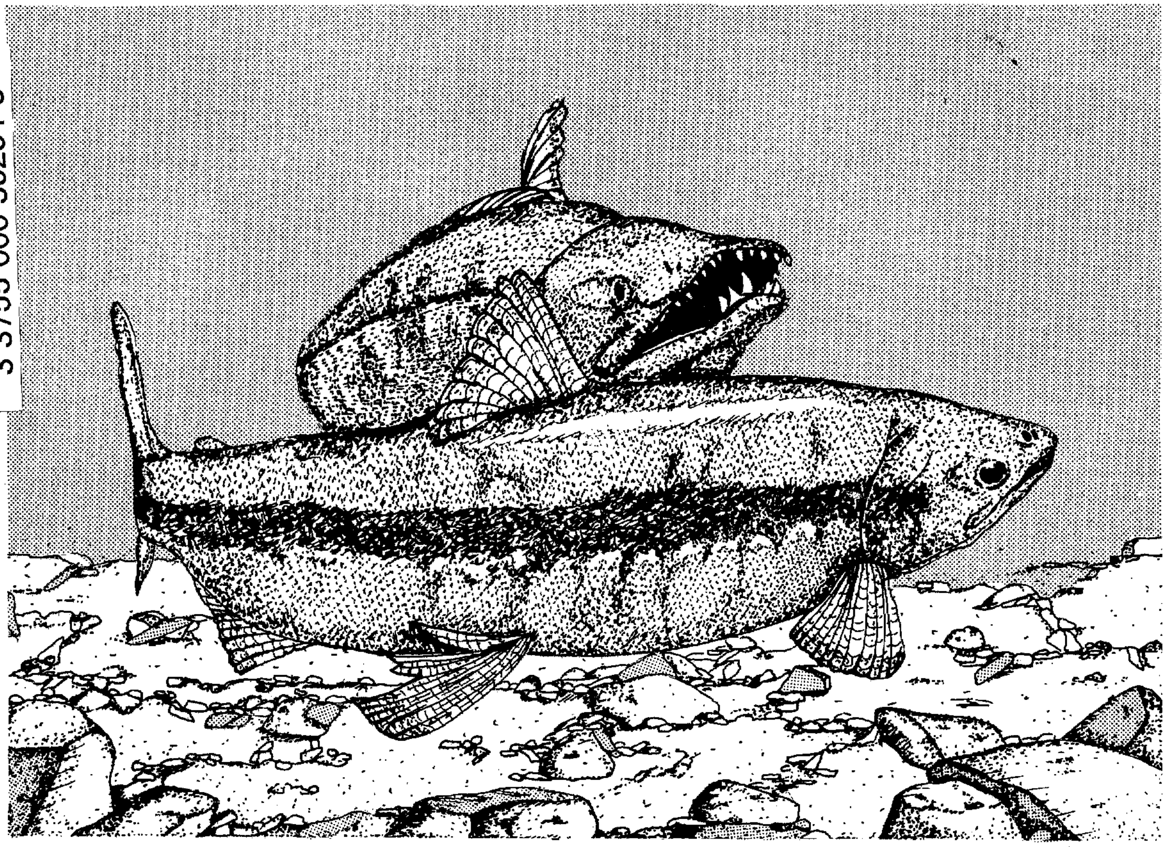

SUSITNA HYDRO AQUATIC STUDIES
PHASE II BASIC DATA REPORT

Volume 5: Upper Susitna River
Impoundment Studies 1982

SUSITNA HYDRO AQUATIC STUDIES
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Volume 5: Upper Susitna River Impoundment Studies 1982

-by-

ALASKA DEPARTMENT OF FISH AND GAME
Susitna Hydro Aquatic Studies
2207 Spenard Road
Anchorage, Alaska 99503
1983

PREFACE

This report is part of a five volume presentation of the fisheries, aquatic habitat, and instream flow data collected by the Alaska Department of Fish and Game (ADF&G) Susitna Hydroelectric (Su Hydro) Feasibility Aquatic Studies Program during the 1981-82 (October-May) ice-covered and 1982 open water (May-October) seasons. It is one of a series of reports prepared for the Alaska Power Authority (APA) and its principal contractor, Acres American (Acres), by the ADF&G and other contractors to evaluate the feasibility of the proposed Susitna Hydroelectric Project. This report is intended for data transmittal to other Susitna Hydroelectric Feasibility Study participants. A preliminary draft was circulated for review in February.

The topics discussed in Volumes Two through Five are illustrated in Figure A. Volume One presents a synopsis of the information contained in the other four volumes. Volume Two also includes a comparison of 1981 and 1982 adult anadromous fisheries data.

An ADF&G data analysis report will include an analysis of the pre-project fishery and habitat relationships derived from this and related reports prepared by other study participants. A review draft will be circulated to study participants in May 1983. The final report will be submitted to the APA on June 30, 1983 for formal distribution to study participants, state and federal agencies, and the public. Also scheduled for completion on June 30, 1983 is the first draft of the ADF&G 1982-83 ice-covered season basic data report. It will include a presentation of 1982-83 incubation and other fishery and habitat data.

These and other ADF&G reports (1974, 1976, 1977, 1978, 1979, 1981a, b, c, d, e, f, 1982) and information reported by others will be summarized and analyzed by the Arctic Environmental Information and Data Center (AEIDC) to evaluate post-project conditions within the overall study area of the proposed project (Figure B). Woodward Clyde

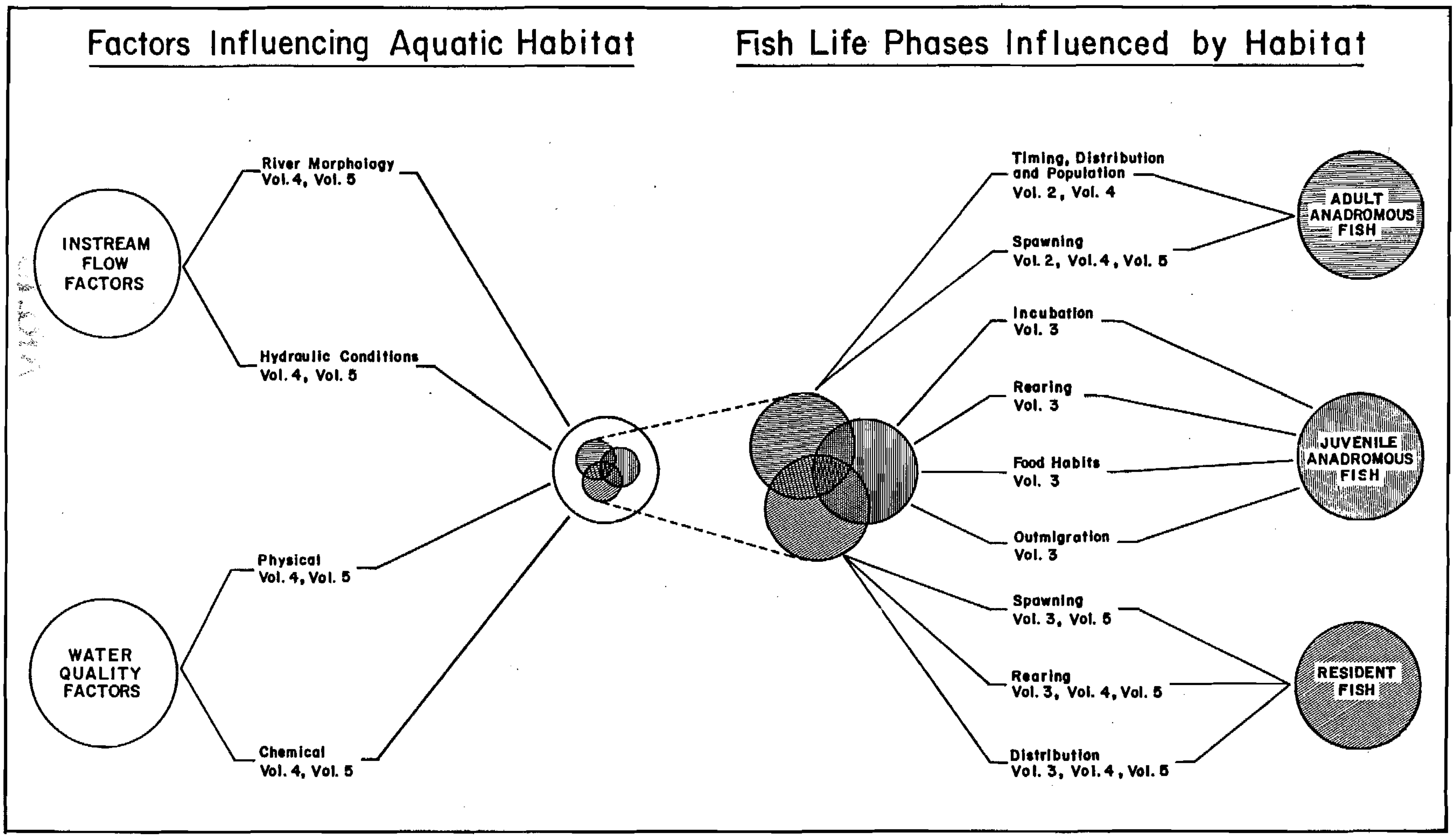

Figure A. Integration of and relationships among the program elements presented in Volumes Two through Five.

Consultants will, in turn, use this information to support the preparation of the Federal Energy Regulatory Commission License Application for Acres.

The five year (Acres 1980) ADF&G Su Hydro Aquatic Studies program was initiated in November 1980. It is subdivided into three study sections: Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH).

Specific objectives of the three sections are:

1. AA - determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area (Figure B);

2. RJ - determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area; and

3. AH - characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

The 1981-82 ice-covered and 1982 open-water ADF&G study areas (Figures C and D) were limited to the mainstem Susitna River, associated sloughs and side channels, and the mouths of major tributaries. Portions of tributaries which will be inundated by the proposed Watana and Devil Canyon reservoirs were also evaluated. Descriptions of study sites are presented in each of these volumes including the ADF&G reports (ADF&G 1981a, b, c, d, e, f).

The Susitna River is approximately 275 miles long from its sources in the Alaska Mountain Range to its point of discharge into Cook Inlet. Its drainage encompasses an area of 19,400 square miles. The mainstem

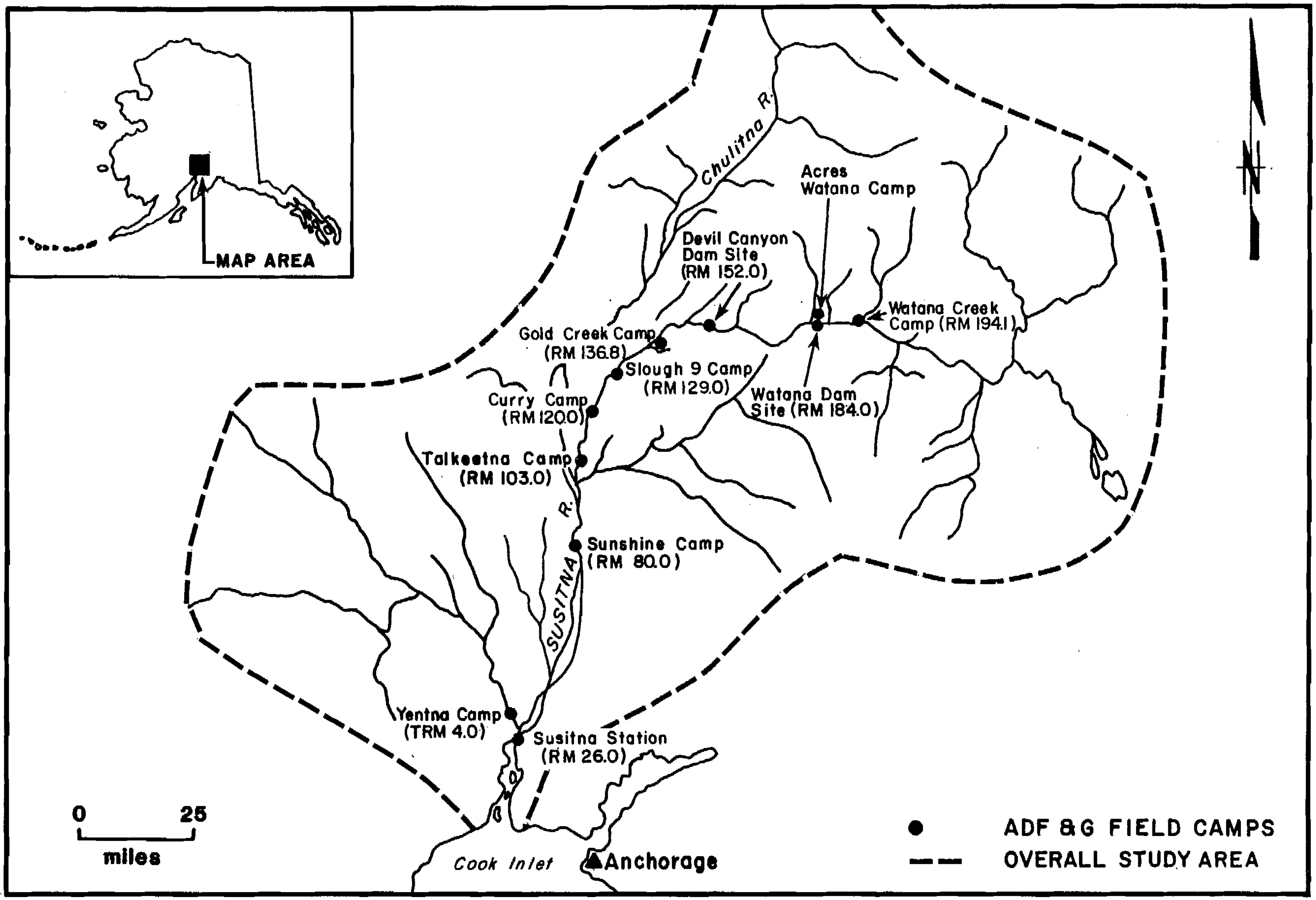

Figure B. Overall study area of the Susitna Hydroelectric Feasibility Study Program.

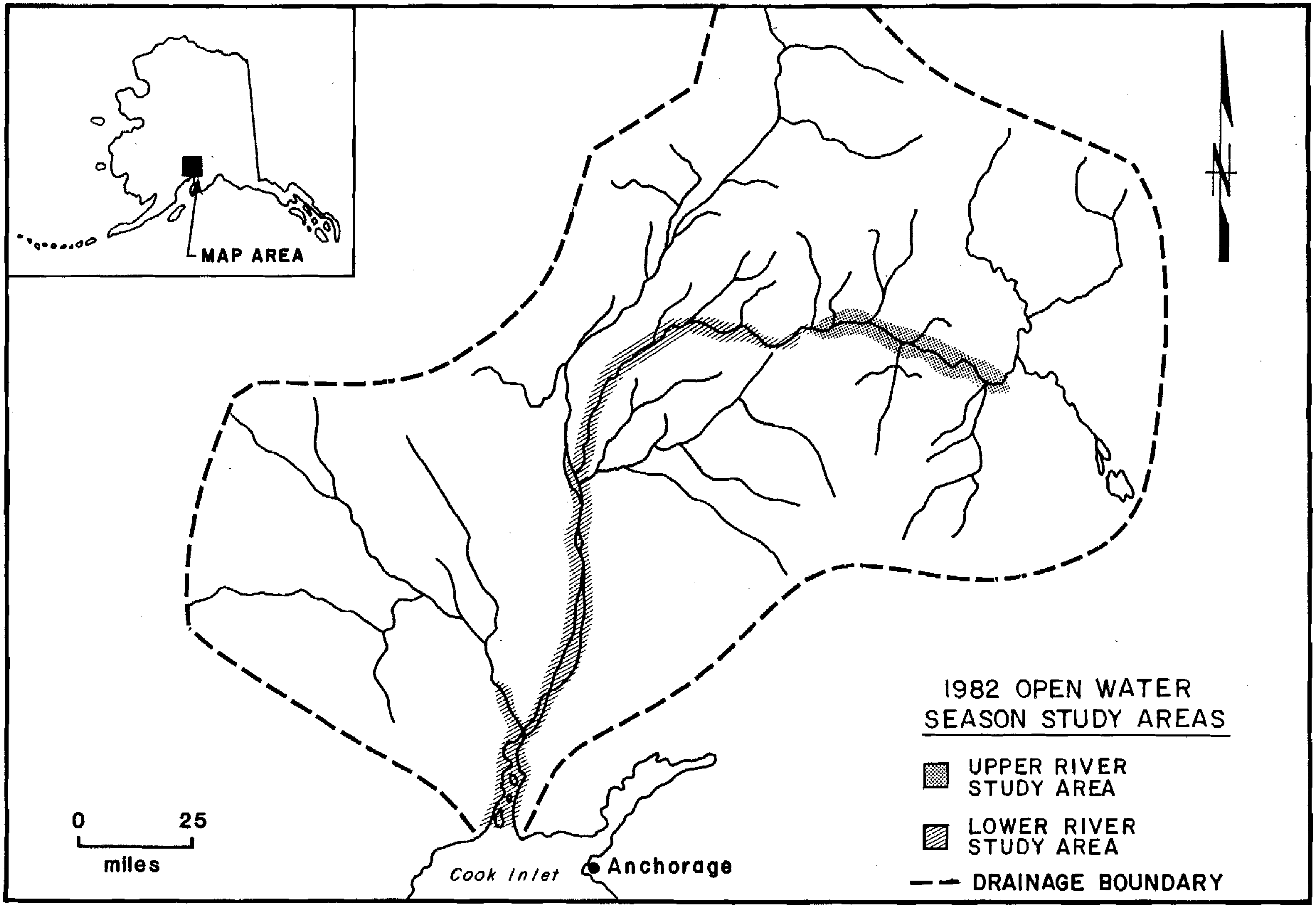

Figure C. 1982 ADF&G open water season (May through October) study area.

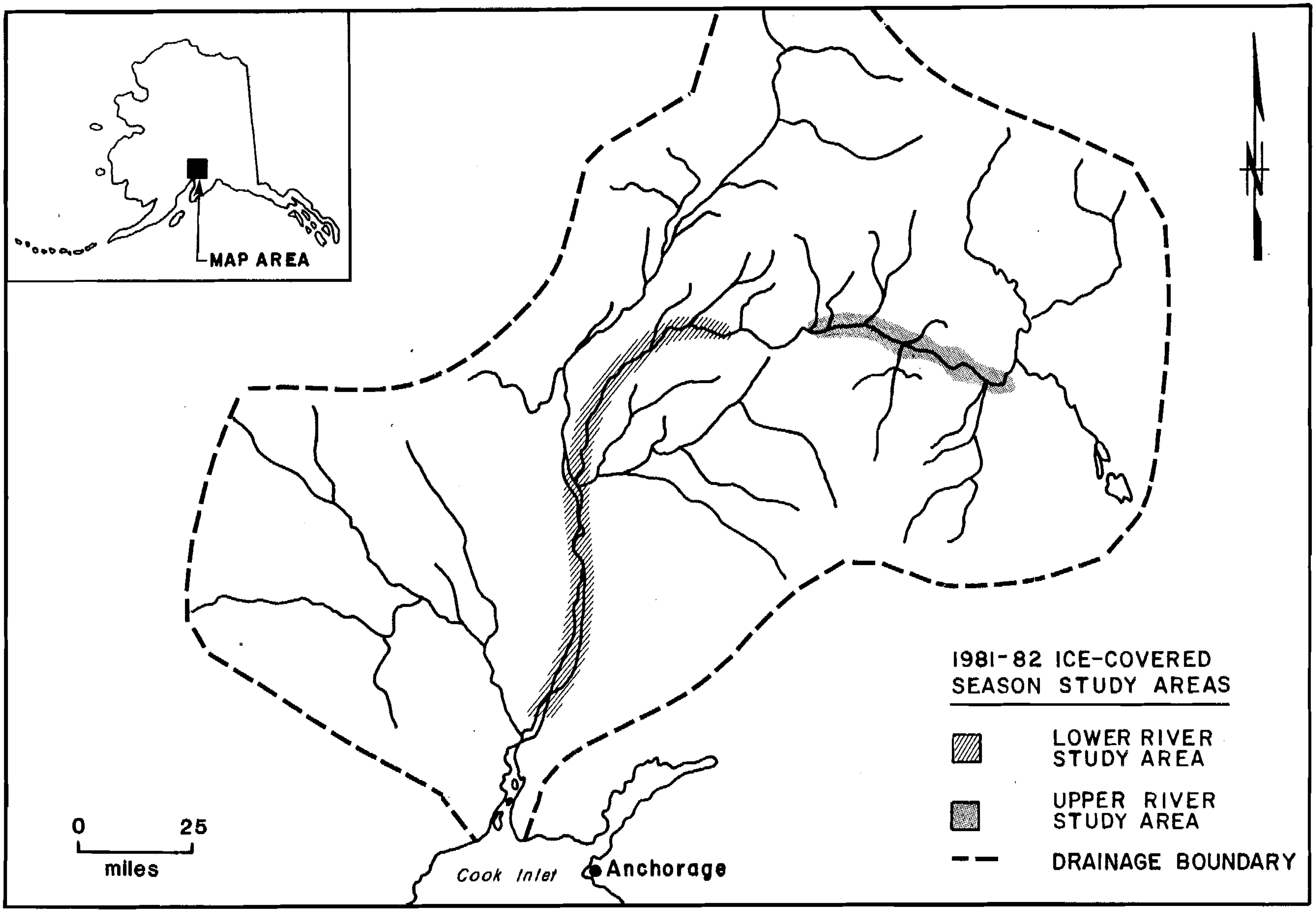

Figure D. 1981-82 ADF&G ice-covered season (October through May) study area.

and major tributaries of the Susitna River, including the Chulitna, Talkeetna and Yentna rivers, originate in glaciers and carry a heavy load of glacial flour during the ice-free months (approximately May through October). There are many smaller tributaries which are perennially clear.

Questions concerning these reports should be directed to:

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We would like to express our gratitude to all the people and organizations that provided information or assistance to the Impoundment Study Program during the past year.

We appreciate the support services provided by Acres American, Inc., Air Logistics, Akland Helicopter, R&M Consultants, Inc. and the U.S. Geological Survey.

Appreciation is also extended to the Alaska Power Authority for funding this project and to T. Trent, L. Bartlett, R. Dieryck, K. Watson, R. Logan, L. Heckart, M. Mills and other staff of the ADF&G for their administrative services support.

1. INTRODUCTION

This volume is a presentation and discussion of the habitat and fishery data collected from the proposed Susitna Hydroelectric Project impoundment study area (Figure 5-1-1) during 1982. Habitat data contained in this volume are also summarized with similar data collected from the Cook Inlet to Devil Canyon reach of the Susitna River in Appendices 4A and D of Volume 4.

1.1 General Objectives

Impoundment study area investigations were initiated in 1981 by a joint Aquatic Habitat and Instream Flow (AH), and Resident and Juvenile Anadromous Fish (RJ) study team to provide the basis for:

1) assessing the impacts of transforming the existing lotic environment within the boundaries of the proposed Watana and Devil Canyon reservoirs into one that is lentic; and

2) determining whether alternative aquatic habitats are available in the area adjacent to the proposed reservoirs to sustain grayling populations at levels presently existing in the proposed impoundment areas.

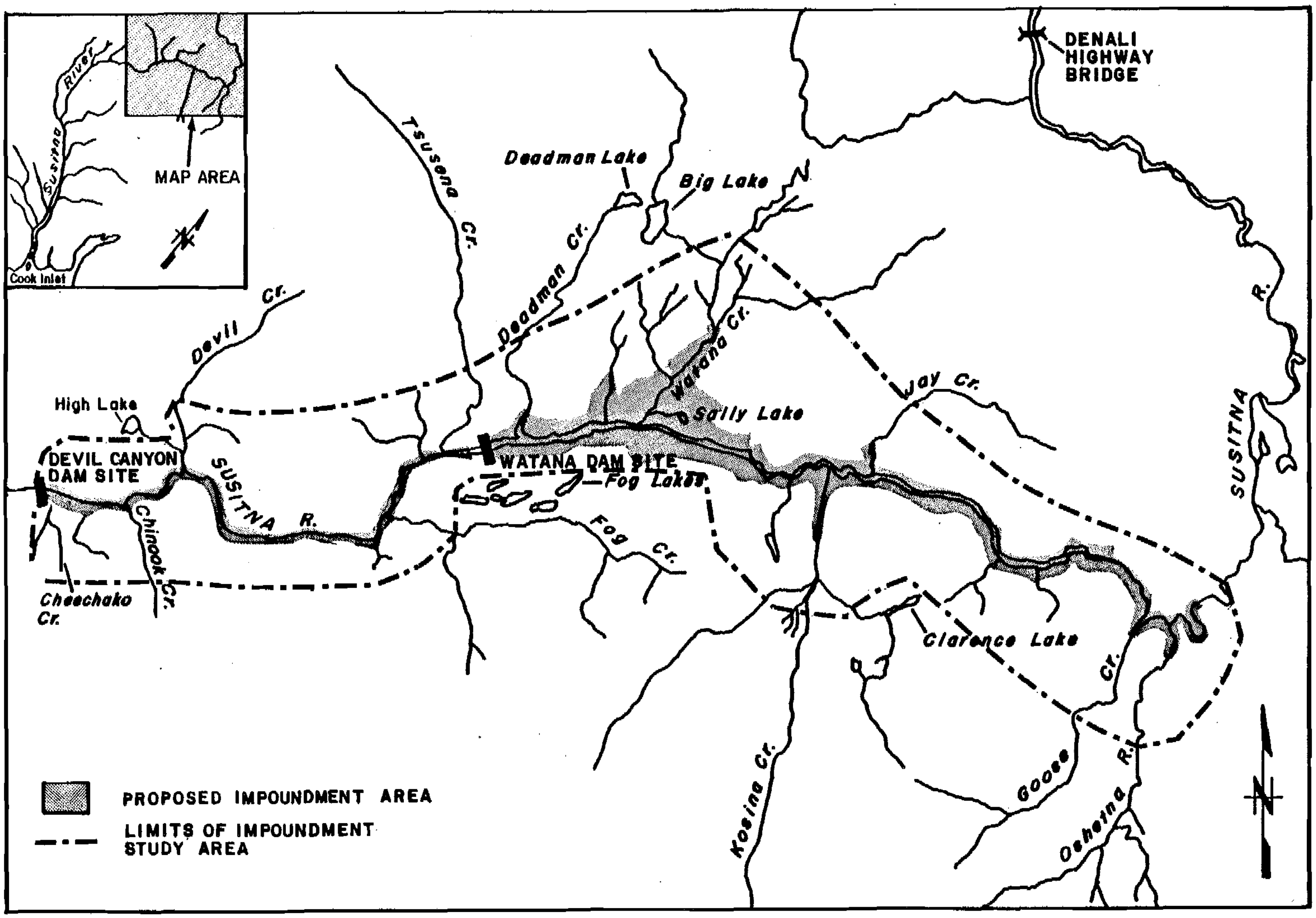


Figure 5-1-1. Proposed impoundment study area, 1982.

To achieve the first goal, data were collected with the objectives of determining:

1) which habitats within the impoundment study area are utilized by various fish species on a seasonal basis;

2) the physical and chemical characteristics of these habitats; and

3) the seasonal distribution and abundance of fish populations within the proposed impoundment areas.

The second goal was not pursued during the 1981 studies because of limited manpower resources.

Investigations were therefore continued in 1982 to:

1) collect additional habitat and fishery data to more accurately characterize the fish populations and the physical and chemical characteristics of their seasonal habitats within the boundaries of the proposed reservoirs to further meet goal number one; and

2) collect habitat and fishery data to determine whether the tributary reaches immediately upstream of the impoundment boundaries contains similar habitat to that presently found

below the proposed impoundment elevation (PIE) and if these upstream reaches presently support fish populations.

1.2 Aquatic Habitat Investigations

To meet objectives one and two above, the following six tasks were pursued by the Aquatic Habitat and Instream Flow Investigations Group:

1) Measure the range of physical and chemical characteristics of tributary and mainstem Susitna River habitats within the boundaries of the proposed reservoirs;

2) Quantify the stream length and surface area of selected tributaries which would be inundated by the proposed Devil Canyon and Watana reservoirs;

3) Examine the physical and chemical characteristics of selected tributary habitats immediately upstream of the PIE;

4) Identify and evaluate the physical and chemical characteristics which appear to be influencing the utilization and suitability of habitats associated with the various life stages of Arctic grayling;

5) Evaluate the physical and chemical characteristics of Sally Lake; and

6) Identify and evaluate aquatic habitats within the impoundment study area that are presently utilized by adult anadromous fish species.

1.3 Resident Fisheries Investigations

The specific tasks for the 1982 season resident fisheries studies within the impoundment study area included the following:

1) Determine the distribution, abundance and migratory habits of Arctic grayling;

2) Determine the distribution and relative abundance of selected resident fish species in the Susitna River;

3) Determine the abundance of lake trout and Arctic grayling in Sally Lake;

4) Record biological information on selected resident fish populations to provide information on survival and growth to eventually support an analysis of fish production within the reservoir study area; and

5) Identify Arctic grayling spawning and rearing locations within the impoundment and adjacent study areas.

These data and the previous habitat data will provide much of the necessary information to ultimately evaluate the impacts of the reservoir on the areas to be inundated. Further analysis of these data to address the major goals of this study will be included in the Fisheries and Habitat Relationships report (see Preface).

1.4 Background

The upper Susitna River basin from Devil Canyon to the Oshetna River is a remote wilderness area of high aesthetic and recreational value. Mountainous terrain dominates the area with elevations ranging from approximately 900 feet near the basin floor of Devil Canyon to 8,000 feet in some areas of the glaciated terrain in the Oshetna River basin. The landscape varies from treeless alpine tundra at higher elevations to low lying areas dominated by black spruce frequently interspersed with muskeg bogs. Occasional stands of cottonwood, birch and aspen are often found throughout the area, especially at lower elevations.

According to projections by Acres American (Acres 1982) the two proposed impoundments would inundate approximately 84 miles of the mainstem Susitna River. This would include most of the reach of the Susitna River from the proposed Devil Canyon dam site (RM 152.0) upstream to a point approximately five miles above the confluence of the Susitna and Oshetna rivers (RM 239.0). An approximate one mile reach of the Susitna River immediately downstream of the proposed Watana Dam site will not be inundated. The combined surface area of these two reservoirs would be approximately 45,800 acres. The proposed Devil Canyon Dam would create an impoundment 26 miles long with a surface area of 7,800 acres. The maximum probable flood elevation is projected at 1,466 feet mean sea level (MSL) with a normal operating pool level of 1,455 feet MSL. The proposed Watana Dam (RM 184.0) would create an impoundment that would extend 55 miles upstream from the dam and cover 38,000 acres. The maximum probable flood elevation of this impoundment is projected at 2,200.5 feet MSL with a normal operating pool level of 2,185 feet MSL (Acres 1982).

Prior to initiation of the 1981 Susitna River Hydroelectric Aquatic studies, fisheries and aquatic habitat data for this area consisted of various preliminary environmental assessments (U.S. Fish & Wildlife Service 1952, 1954, 1957, 1959a, b, 1960, 1965; ADF&G 1978). These studies define species composition and highlight selected habitat locations and issues of particular concern, but because of their limited scope, were unable to quantitatively examine resident fish populations and their relationships to the aquatic environments.

2. METHODS

2.1 Study Design

The 1982 Aquatic Studies program in the proposed impoundment study area was conducted during the open water field season (May-October) on a monthly basis with field activities lasting from 14 to 18 days per month. Additional field trips were conducted in late April and early May to determine timing, location, and extent of Arctic grayling spawning activities. These trips lasted from three to six days.

Boundaries of the proposed impoundments were defined to differentiate between habitats above and below the proposed impoundment elevations (PIE) and to help establish the overall study area. The boundaries for the proposed Devil Canyon and Watana reservoirs were based on maximum probable flood elevations of 1,466 and 2,200.5 feet MSL, respectively.

The 1982 impoundment study area included the aquatic habitat within the boundaries of the proposed Devil Canyon and Watana reservoirs and a five mile study reach immediately upstream of the PIE of selected tributaries (Figure 5-1-1). The study area was further divided into three categories grouped by habitat type including tributary, mainstem Susitna River (including mainstem sloughs) and lake locations. Those portions of tributaries, the mainstem Susitna River and lakes investigated during 1982 that lie within the proposed impoundment boundaries were designated as habitat evaluation locations. Specific study sites within these habitat evaluation locations were designated as habitat evaluation sites.

Eleven tributary streams were chosen as habitat evaluation sites during 1982, including the eight major tributary streams within the proposed impoundment area that were studied during 1981 (Fog, Tsusena, Deadman, Watana, Kosina, Jay, and Goose Creeks and the Oshetna River). In addition, habitat evaluation locations were established on three streams (Cheechako, Chinook and Devil) within Devil Canyon that were examined for the first time this year.

Each tributary habitat evaluation location consists of the mouth and the tributary upstream to the PIE. The mouth encompasses that area of the Susitna River which is influenced by the tributary stream flow (the clear/turbid water mixing zone), and that area of the tributary which is influenced by the rise and fall of the Susitna River.

All tributary habitat evaluation locations were divided into reaches of stream according to habitat types or by using other physical characteristics as reference points (e.g., pools, cliffs, tributary streams). These points were then assigned a tributary river mile (TRM) to assist in identifying various reaches of the streams.

The Oshetna River and Kosina Creek, the two largest tributaries in the proposed impoundment areas, were divided into three distinct habitat types: (1) the mouth (confluence habitat); (2) the major pools and (3) the riffle areas. The delineation of the major pool/riffle areas was based subjectively on streamflow velocities and depths determined by visual observations. Clearly defined habitats characterized by deeper water and relatively moderate to low stream velocities were designated as pool habitat evaluation sites. Reaches of stream between pools characterized by shallower water and higher stream velocities were designated as riffle habitat evaluation sites. Beginning at the PIE, and moving downstream, each pool and riffle was assigned a letter and corresponding TRM for identification.

Due to its length, the proposed impoundment reach of Watana Creek, 11.9 miles, could not be effectively sampled in its entirety. Therefore, representative reaches of each habitat type encountered were sampled. These sections included both the East Fork and West Fork from their confluence to the PIE, and a two-mile section between TRM 4.0 and TRM 6.0.

The mainstem Susitna River habitat evaluation location consists of that portion of the mainstem Susitna River affected directly by the proposed Devil Canyon and Watana reservoir (RM 152 to 239). Since it was not feasible to regularly sample all of this area, seven habitat evaluation sites were selected for study within this reach. Four mainstem slough habitats (Watana, Kosina, and Upper and Lower Jay Creek sloughs) were also examined to obtain baseline data on resident fish species present and to conduct a general evaluation of the aquatic habitat available in these areas.

Sally Lake was selected for study as a lake habitat evaluation location during 1982. The entire lake was included in the Sally Lake habitat evaluation location. No other lakes within the proposed impoundment boundaries were studied during 1982.

2.2 Aquatic Habitat Investigations

Aquatic Habitat data referred to in this section were collected according to procedures presented in the Procedures Manual (ADF&G 1982a) and Volume 4 unless indicated otherwise.

2.2.1 Topographical and General Physical Characteristics of Aquatic Habitats

Elevations at the mouths of tributaries, and water surface areas were determined from blue-line maps (scale 1":400', with 10' contour intervals) developed by R&M Consultants, Inc., North Pacific Aerial Photos and Air Photo Tech (1978 - 1982). Stream gradients and the length of proposed inundated tributary reaches were determined from blue-line maps (scale 1":1000', 1981) developed by Acres American and North Pacific Aerial Photos, Inc. Drainage basin areas were determined from US Geological Survey (USGS) topographical maps (1:63360 series). The surface area measurements, stream gradients and stream lengths were derived from the appropriate maps utilizing a Numonics 2400 electronic graphics calculator (digitizer). Surface area measurements were based on the stream channel boundaries displayed on the respective map and are representative of the discharge at the time the 1":400' blueline maps were initially drafted. Therefore, these measurements may not be accurate at present and should only be considered an approximation of the actual surface area.

Stream widths and depths were visually estimated in the field and should only be considered as a gross approximation of these characteristics as observed during the 1982 sampling period.

Substrate compositions were visually assessed and categorized according to the size classification scheme outlined in the 1982 ADF&G Procedures Manual (ADF&G 1982a).

2.2.2 Water Quality

General water quality parameters (dissolved oxygen, pH, specific conductance, water temperature, and turbidity) were measured at least once per month during the open water field season at designated tributary, mainstem and lake sampling sites. These sites were selected as being representative of those habitat evaluation locations under study. Tributary sites were located immediately above the mouth of Fog, Tsusena, Deadman, Watana, Kosina, Jay and Goose Creeks and the Oshetna River. Mainstem Susitna River sites were located immediately above the confluence of the above-mentioned tributaries and the Susitna River with the exception of Jay Creek, where the sampling site was located immediately above the confluence of Upper Jay Creek Slough and the Susitna River. Sally Lake was sampled once a month at a site at the west end of the lake. Sites one mile above the PIE of selected tributaries were sampled once during the field season. Additional sites at other minor tributaries and within tributary study sections not mentioned above were sampled at irregular intervals. Sampling incidence varied among all sites due to sampling priority and/or proximity to base camp.

Dissolved oxygen saturation levels were determined from dissolved oxygen concentration, water temperature, and site elevation using an oxygen saturation nomograph (Wetzel 1975).

Ryan Model J-90 thermographs were placed near the mouth of Tsusena, Watana, Kosina and Goose Creeks and the Oshetna River to continuously monitor surface water temperatures. These tributaries were selected as thermograph sites based on their importance in providing surface water temperature data for grayling habitat evaluations and to support proposed reservoir modeling plans of project engineers.

Mean, minimum and maximum temperatures were calculated for each two hour period for each thermograph temperature record using methods described in Volume 4, Section 2.2.1.1.2. From these calculated temperatures, daily mean, minimum and maximum temperatures were computed for each thermograph temperature record. Mean monthly temperatures were also calculated for all streams. However, due to incomplete data sets on some streams resulting from thermograph malfunctions, only those means which were calculated from at least 75% of the total possible monthly observations during the sample period were compared.

2.2.3 Discharge

Discharge data were collected to obtain baseline data to support proposed reservoir modeling plans of project engineers and to determine relative differences in discharge for comparisons of fisheries habitat in tributaries under study.

Monthly tributary discharges were measured with a Price AA flow meter when water velocities and depths permitted wading. Fog, Tsusena, Watana, Jay and Goose Creek discharges were measured in the tributary reach upstream of the mouth. Discharge data in Deadman Creek were collected approximately three miles above the mouth because of hazardous sampling conditions in the lower reaches of the stream. Sampling sites were selected on the basis of channel morphology, substrate size, stream velocities and water depths.

2.2.4 Lake Mapping and Morphometric Data

A depth contour map of Sally Lake was developed by plane table methods (Plate 5-2-1) using procedures similar to those presented in Lind (1974). Depth profiles were obtained utilizing a depth sounder (Lowrance, Model LRG-1510B) mounted on an outboard powered boat travelling at constant speed between points on specified transects. These profiles were recorded on a printout and used to determine placement of depth contours on the map.

Plate 5-2-1   Plane table techniques used for mapping of Sally Lake.

The surface area of Sally Lake was determined by polar planimetry (Lind 1974). All other data associated with lake morphometry were derived according to procedures described in Wetzel (1975).

2.3 Resident Fisheries Investigations

The majority of tributary habitat evaluation locations were sampled in their entirety at least once a month. All sampling conducted above the mouths of the eight major tributaries was by and hook and line. Assorted spinners and flies, both wet and dry, were used. Mainstem habitat locations were sampled for two consecutive 24 hour periods each month. Sampling gear utilized at the mainstem sites and tributary mouths included trotlines, gillnets and hook and line. Sally Lake was sampled as time, work load, and transportation availability permitted. Hook and line, variable mesh gillnets and hoop nets were deployed at various locations in Sally Lake.

A detailed discussion on methodology of quantitative data collection and sampling techniques is provided in the Procedures Manual (ADF&G 1982a). Descriptive data (i.e., observation of juveniles, non-quantified habitat observations, fish behavior) were recorded daily in field notebooks for future reference.

A standard tagging and recapture scheme was used to study seasonal migrations and generate population estimates for selected resident fish species. All resident fish species over 135 millimeters (mm) fork length (FL) and in good condition after capture were tagged using international orange Floy anchor tags inserted just posterior of the dorsal fin (Plate 5-2-2).

Population estimates generated from the 1981 field data provided a preliminary estimate of grayling populations in the proposed impoundment areas. Many biases associated with these estimates have been identified. These include: lack of randomness of recapture effort, heterogeneity within the populations (catch rates are not the same and tagged/recapture ratios vary within the segments of the population), the population is not closed geographically (immigration and emigration do occur), and time changes affect the estimate.

In order to address some of these biases in the estimates, several changes in the study design and the analytical procedures have been implemented.

It was assumed that the probability of fish captured in pool and riffle habitats within Kosina Creek and the Oshetna River would differ substantially. This assumption was based on the wide variations in habitat characteristics that exist between pool and riffle habitats in these two streams. Therefore, Kosina Creek and the Oshetna River were divided into the pool and riffle reaches described previously so that the population estimates can address each of these sub-areas separately.

Secondly, the data base has been stratified by length classification based on the age-length relationship for the entire study area. Examination of the specific age classes for differences in the tagged/re-

Plate 5-2-2 Arctic grayling implanted with Floy anchor tag.

capture ratios can provide an indication of the amount of bias due to heterogeneity.

Finally, the actual statistical methods employed for calculating the population estimates and their confidence levels have been changed. The 1981 estimates were generated using a Schnabel multiple census estimator while the 1982 estimates employ an adjusted Petersen single census estimator. A detailed description of the estimator is given in Appendix 5A.

Therefore the population estimates in this volume address these biases.

Instantaneous survival rates for Arctic grayling are calculated using catch, length, and age data from the effectively sampled portion of the population. The resulting rate can be applied to the entire population, since fishing mortality is insignificant and natural mortality is the only factor influencing the survival rate. The actual statistical method is provided in Appendix 5A.

3. RESULTS

3.1 Tributary Habitat and Fisheries Investigations

3.1.1 Aquatic Habitat Investigations

General habitat characteristics of the eleven tributary habitat evaluation locations in the impoundment study area are presented below. Specific information on the topographical features of each stream is presented in Tables 5-3-1 and 5-3-2. A stream gradient profile of the impoundment study area identifying fish passage barriers is presented in Figure 5-3-1. Maps of the proposed inundated reach of the eleven tributary habitat evaluation sites, including the adjacent zone of the mainstem Susitna River, are presented in Appendix 5B, Figures 5-B-1 to 5-B-11.

3.1.1.1 General Stream Descriptions

Cheechako Creek

Cheechako Creek drains into the Susitna River from the south at river mile 152.4, approximately one half mile upstream of the proposed Devil Canyon dam site (Appendix Figure 5-B-1). It is the most downstream major tributary to the Susitna River within the proposed impoundment study area. Approximately the first 1.7 miles of the tributary would be inundated by the proposed Devil Canyon impoundment.

Table 5-3-1. Topographical features of selected tributaries of the proposed Devil Canyon impoundment[a], 1982.

Tributary	Susitna River Mile	Geographic Code At Confluence With Susitna	Approximate Elevation At Confluence With Susitna (ft MSL)	Size of Drainage Basin (sq mi)	Characteristics of Tributary Reach to be Inundated			Gradient of Tributary Immediately Above PIE	
					Length (mi)	Surface Area (acres)	Gradient (ft/mi)	1-Mile (ft/mi)	5-Mile (ft/mi)
Cheechako Creek	152.4	S32N01E33CCB	920	36.4	1.7	---	321	N/A	N/A
East Fork	N/A	N/A	1620[b]	N/A	N/A	N/A	N/A	331	338
West Fork	N/A	N/A	1620[b]	N/A	N/A	N/A	N/A	344	267
Chinook Creek	157.0	S31N02E06CAC	1065	22.4	1.3	3.4	308	357	203
Devil Creek	161.4	S32N02E34AAC	1200	73.6	1.5	7.7	176	344	203
Fog Creek	176.7	S31N04E16DBB	1375	147.2	1.3	11.2	72	158	100
Tsusena Creek	181.3	S32N04E36ADB	1435	144.5	0.4	5.4	82	45	111

a Proposed Impoundment Elevation (PIE) - 1466 Feet MSL
b Elevation at Confluence of Tributary Forks
--- Data Unavailable

Table 5-3-2. Topographical features of selected tributaries of the proposed Watana impoundment[a], 1982.

Tributary	Susitna River Mile	Geographic Code At Confluence With Susitna	Approximate Elevation At Confluence With Susitna (ft MSL)	Size of Drainage Basin (sq mi)	Characteristics of Tributary Reach to be Inundated			Gradient of Tributary Immediately Above PIE	
					Length (mi)	Surface Area (acres)	Gradient (ft/mi)	1-Mile (ft/mi)	5-Mile (ft/mi)
Deadman Creek	186.7	S32N05E26CDB	1515	175.1	2.7	24.5	253	53	62
Watana Creek	194.1	S32N06E25CCA	1550	174.8	8.5	70.5	60[b]	N/A	N/A
East Fork	N/A	N/A	2060[c]	N/A	1.2	6.1	113	103	98
West Fork	N/A	N/A	2060[c]	N/A	2.1	10.4	67	65	59
Kosina Creek	206.8	S31N08E15BAB	1670	400.2	4.5	79.7	118	125	90
Jay Creek	208.5	S31N08E13BCC	1695	61.8	3.5	15.7	143	158	95
Goose Creek	231.3	S30N11E32DBC	2060	103.9	1.2	10.6	114	141	125
Oshetna River	233.4	S30N11E34CCD	2110	555.0	2.2	43.1	41	61	60

[a] Proposed Impoundment Elevation (PIE) - 2200.5 Feet MSL
[b] Watana Creek below forks
[c] Elevation at Confluence of Tributary Forks

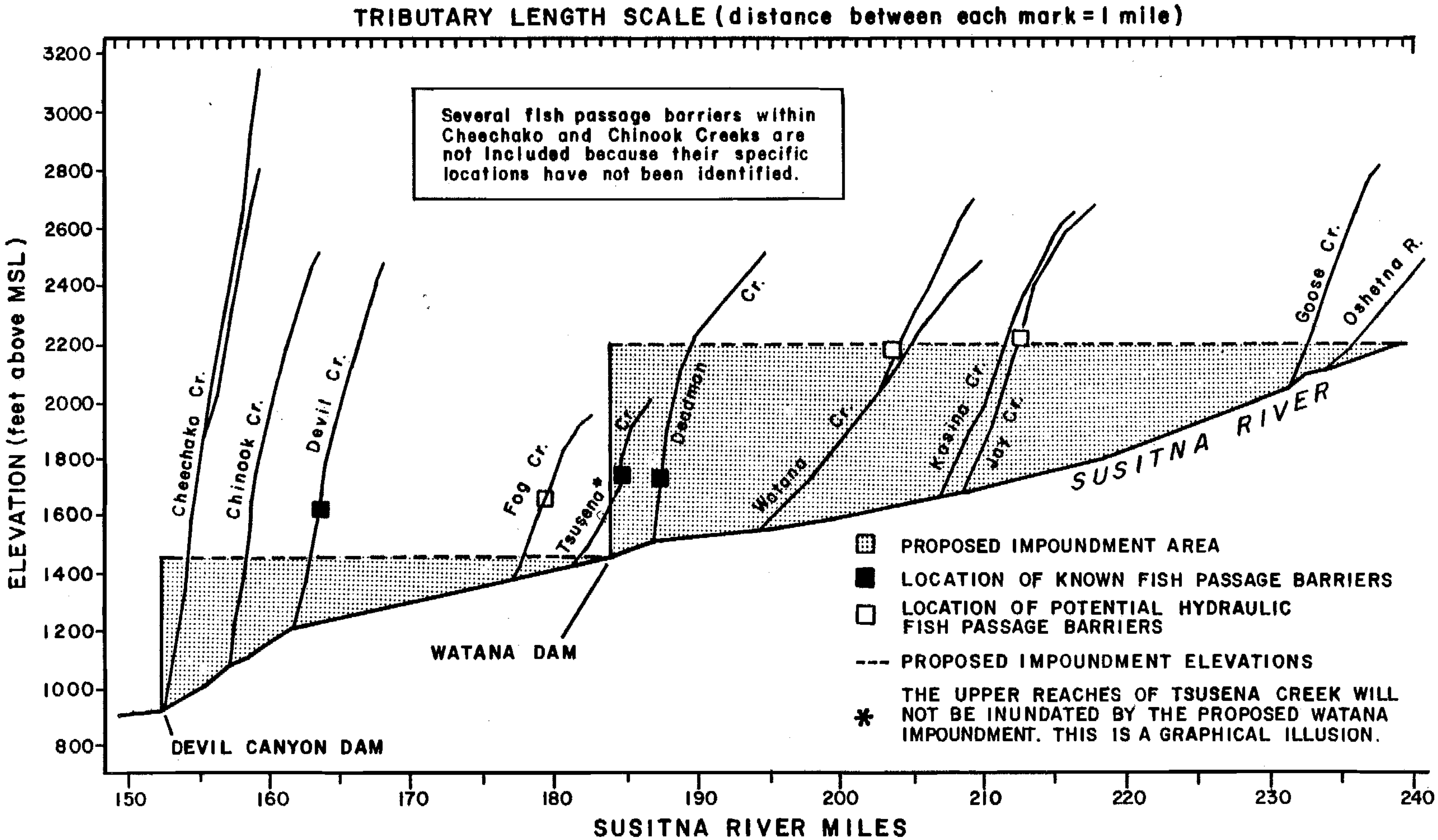


Figure 5-3-1. Gradient profile of the Susitna River and the major tributaries within the proposed impoundment areas. Profile includes the five mile reach of each tributary immediately above the PIE and identifies known and potential fish passage barriers.

The steepness of the terrain and time constraints limited ground surveys of this tributary to the vicinity of the mouth. Aerial surveys were conducted from the tributary mouth upstream for a distance of approximately three miles.

Cheechako Creek is a high gradient clearwater stream originating on the north slope of the Talkeetna Mountains. It flows in a northerly direction for approximately 10 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 36 square miles. The stream forks approximately 2.2 miles upstream from the mouth forming an east and a west fork. A small lake drains into the system near the headwaters of the west fork. The upper reaches of the east and west forks flow through open tundra areas with habitat consisting predominantly of riffle areas with relatively high streamflow velocities. The lower reach of the stream is confined to a deep, steep-walled canyon and the habitat consists predominately of rapids and small waterfalls with a few isolated deep pools.

The reach of stream which would be inundated by the proposed impoundment has a gradient of 321 feet per mile. This relatively high stream gradient results in high streamflow velocities with long stretches of turbulent, cascading whitewater areas interspersed with a few relatively large deep pools. The narrow stream channel, situated in a deep "V" shaped canyon, is between 20-30 feet wide with depths between 2-4 feet. Substrate is composed mainly of large boulder and cobble with smaller rubble and gravel confined to pool areas.

During the open water field season a clearwater plume of Cheechako Creek, approximately 60 feet long and 10 feet wide, extended downstream into the Susitna River. This area provided good, although limited, salmon spawning habitat. Substrate in this area consisted mainly of gravel and streamflow velocities were moderate. Limited numbers of chinook salmon were observed utilizing this habitat for spawning during late summer (refer to Volume 2). Prior to this observation, an unconfirmed report that this tributary was utilized by salmon was included in: Progress Report 1957 Field Investigations Devil Canyon Dam Site One Reservoir Area, Susitna River Basin (USFWS 1959a).

Chinook Creek

Chinook Creek drains into the Susitna River from the south at river mile 157.0, approximately five miles upstream of the Devil Canyon dam site (Appendix Figure 5-B-2). The first 1.3 miles of stream would be inundated by the proposed Devil Canyon impoundment.

The steepness of the terrain and time constraints prevented ground surveys; however, aerial surveys of the stream were conducted upstream from the mouth to approximately TRM 4.0.

Chinook Creek is a clearwater stream which originates from several small drainages on the north slope of the Talkeetna Mountains. It flows north for approximately 10 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 22 square miles. The stream is mostly confined to a deep V-shaped canyon characterized by steep gradients and high streamflow velocities throughout most of its reach. Several waterfalls and rapids, which may constitute velocity barriers to fish, exist both above and below the PIE.

The reach of stream which would be inundated by the proposed impoundment winds through a steep, narrow canyon with a stream gradient of 308 feet per mile. This steep gradient results in high streamflow velocities with large areas of whitewater and few pools. Stream widths vary from 20-30 feet with average depths of 2-4 feet. Substrate consists mainly of large boulder and small cobble. Salmon have been observed spawning approximately one half mile upstream from the mouth during 1982. However, areas of suitable salmon spawning habitat are limited to a few pools where gravel substrate and moderate streamflows are available. The USFWS (1959a) reported unconfirmed sitings of salmon spawning in this creek.

Devil Creek

Devil Creek drains into the Susitna River from the north at river mile 161.4, approximately nine miles upstream of the proposed Devil Canyon dam site (Appendix Figure 5-B-3). The first 1.5 miles of this stream would be inundated by the proposed Devil Canyon impoundment.

Because access to the area is limited due to the steepness of the terrain, ground surveys were only conducted once in the lower mile of the stream. Aerial surveys were conducted from the mouth of the tributary to approximately TRM 5.0.

Devil Creek is a clearwater stream originating from various drainages in a mountainous region immediately south of the Alaska Range. The stream flows generally south for approximately 15 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 74 square miles. Several small lakes drain into the stream along its course. A large waterfall, approximately 100 feet in height, is located two miles upstream from the mouth and divides the stream into two distinct reaches. The reach above the falls flows through open tundra areas and is characterized by relatively low stream gradients. The reach of stream below the falls is situated in a deep steep-walled canyon characterized by higher stream gradients.

The reach of stream which would be inundated by the proposed impoundment is characterized by high streamflow velocities, turbulent whitewater areas and relatively large, deep pools. The stream gradient in this reach is 176 feet per mile. Substrate is composed predominantly of large boulder and cobble with smaller rubble and gravel being confined mainly to pool areas. Stream widths range from 30-40 feet with average depths between 2-4 feet. Some of the large pool areas observed were in excess of five feet deep. These large, deep pools were found to be the preferred habitat for the limited numbers of resident Dolly Varden which were observed in this reach of the stream.

Fog Creek

Fog Creek flows into the Susitna River from the southeast at river mile 176.7 (Appendix Figure 5-B-4). The mouth of the stream is located approximately 24 miles upstream of the proposed Devil Canyon dam site. The first 1.3 miles of stream would be inundated by the proposed Devil Canyon impoundment.

The stream was sampled from the mouth to TRM 0.5 on a monthly basis during the open water field season. The reach upstream of TRM 0.5 was not sampled because it is located on native land claims and permission for access was denied. Aerial surveys were conducted from the mouth upstream for a distance of approximately ten miles.

Fog Creek is a clearwater stream which originates on the north slope of the Talkeetna Mountains. It flows in a general northwest direction for approximately 20 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 147 square miles. The headwaters of the stream flow over steeply sloping terrain for several miles before reaching the foothills of the Talkeetna Mountains where the terrain becomes less steep. From this point the stream meanders over the tundra terrain for several miles prior to entering a deep "V" shaped canyon. Within this reach, a system of five large lakes drain into the stream approximately six miles upstream from the mouth. Below this reach much of the stream winds through a deep, narrow, steep gradient canyon to a point approximately one mile from its mouth where the gradient begins to decrease.

The reach of stream which would be inundated has a relatively low gradient of 72 feet per mile. Stream habitat consists predominantly of shallow riffles with few pools. Stream widths range from 50-75 feet and average depths are 2-3 feet. Substrate consists mainly of rubble and cobble. Most of the stream within the study area is confined to one stable channel, although braided channels occur in a few areas near the mouth. During periods of high discharge many backwater areas were present in this reach. Studies in 1981 (ADF&G 1981a) indicated that resident fish species utilized these backwater areas when they were available.

Tsusena Creek

Tsusena Creek drains into the Susitna River from the north at river mile 181.3 (Appendix Figure 5-B-5). It is the most upstream major tributary to the Susitna River that would be affected by the proposed Devil Canyon impoundment. It is located 29 miles upstream of the proposed Devil Canyon dam site. The first 0.4 miles of stream would be inundated by the proposed impoundment.

Ground surveys of the reach to be inundated were conducted on a monthly basis during the open water season. Additional sampling was conducted twice in areas approximately 1-2 miles upstream of the mouth. Aerial surveys were conducted from the tributary mouth to approximately TRM 10.

Tsusena Creek is a clearwater stream originating in steep, mountainous terrain on the southern edge of the Alaska Range. The stream flows south for approximately 30 miles from its source to its confluence with the Susitna River and has a total drainage basin area of approximately 144 square miles. One major tributary, Clark Creek, enters the stream approximately six miles above the mouth. There are no major lakes accessible to fish within the drainage basin. Below its headwaters the stream flows across a region of open tundra of relatively moderate gradient. A large waterfall, located approximately three miles upstream from the mouth, divides the stream into an upper and lower area. The stream is situated in a deep "V" shaped canyon for approximately two miles in the area adjacent to the falls. Below this area the stream valley broadens and gradient decreases to its confluence with the Susitna.

Due mainly to the extreme upstream location of Tsusena Creek in the proposed Devil Canyon impoundment, it will only be affected upstream from the mouth for a distance of 0.4 miles. In this reach the stream is approximately 75-100 feet wide with habitat consisting primarily of shallow riffles with a few small pools approximately 2-3 feet in depth. Substrate consists of large cobble and boulder embedded in sand (Plate 5-3-1) with small gravel confined mainly to pool areas. The stream channel splits near the mouth resulting in the formation of two separate channels at its confluence with the Susitna River which are approximately 150 feet apart separated by a large gravel bar.

In 1981, a clear water plume from Tsusena Creek was observed to extend approximately 0.5 miles downstream into the Susitna River during periods of high discharges which followed heavy precipitation events. Many grayling were caught in this area during the 1981 open water field season. Discharges in 1982 were reduced from those observed in 1981 as was the clearwater plume. Relatively fewer grayling were also caught

Plate 5-3-1 Typical substrate found in Tsusena and Kosina Creeks (ruler in photograph is 12 inches).

downstream of the mouth in 1982 as compared to 1981. This reduced catch may have resulted from the reduction of this type of habitat.

Deadman Creek

Deadman Creek enters the Susitna River from the north at river mile 186.7, approximately 2.7 miles upstream of the proposed Watana dam site (Appendix Figure 5-B-6). It is the lowermost tributary habitat evaluation location in the proposed Watana impoundment area. The stream would be inundated upstream from the mouth for 2.7 miles.

Because of a deep canyon and large waterfall in the vicinity of TRM 0.5, the stream was divided into an upper and lower study reach for sampling purposes. Only the lower 0.3 miles of stream below the canyon was sampled regularly during the 1982 open water field season. A one mile section immediately above the falls was sampled on two occasions before sampling was suspended because of limited success in catching fish in this whitewater reach. The reach of stream within the canyon, approximately one half mile in length, was not sampled due to its inaccessibility.

Deadman Creek is a clearwater stream originating in an open tundra region just south of the Denali Highway. The stream flows south for approximately 40 miles from its source to its confluence with the Susitna River and has a total drainage basin area of 175 square miles. A large lake, Deadman Lake, is located approximately 16 miles upstream from the mouth. The drainage basin above Deadman Lake is drained by several smaller streams which converge to form the main channel of Deadman Creek. Below the outlet of the lake the stream habitat consists of long riffles, turbulent whitewater and occasional areas of deep, slow flowing, placid water with low stream gradients.

The reach of stream which would be inundated is confined mostly to a deep, narrow canyon and has a relatively steep gradient of 253 feet per mile. This reach is characterized by high streamflow velocities and turbulent whitewater areas resulting in few pools with little cover for fish. Channel widths vary from 75-100 feet with depths of 3-5 feet. Substrates consist mostly of large boulder and cobble. A large waterfall, which is presently a barrier to upstream fish migration, is located 0.6 miles upstream from the mouth. The proposed Watana impoundment would inundate the waterfall and allow fish migration between the upper areas of Deadman Creek, Deadman Lake, and the Susitna River.

Watana Creek

Watana Creek drains into the Susitna River from the north at river mile 194.1, approximately 10 miles above the proposed Watana dam site (Appendix Figure 5-B-7). The total length of stream that would be inundated by the proposed reservoir is 11.9 miles. This reach extends 8.5 miles upstream from its mouth to its confluence with the east and west forks, and 1.3 and 2.1 miles of each fork respectively.

Time and personnel limitations precluded sampling of this entire reach. Because of this, three sections of the stream were selected as study reaches to be used as index areas during the regular sampling season (as described earlier in this report; see Methods Section 2.1.) These sections were sampled as stream turbidity levels allowed. Aerial surveys were conducted upstream from the mouth to approximately five miles up each fork.

Watana Creek originates in a region of open tundra just south of the Denali Highway. It has a drainage basin area of 175 square miles. It is generally a clearwater stream but is often turbid in summer due mainly to runoff from melting permafrost and other unstable soils in upstream areas. The main fork of Watana Creek (east fork) flows generally south for approximately 23 miles from its source to its confluence with the Susitna River. The west fork, approximately 12 miles in length, joins the east fork 8.5 miles upstream from the mouth.

Several lakes are located in the drainage basin. Many of these are small, shallow lakes situated on the tundra. One large unnamed lake drains into the east fork and another relatively large lake, Big Lake, drains into the west fork. Sally Lake, 63 acres in size, drains into Watana Creek approximately one mile upstream from the mouth.

The east and west fork vary considerably in terms of habitat within the habitat evaluation location. The east fork is confined to a well defined stream channel with steep canyon walls and the gradient (112 feet/mile) is almost twice that of the west fork (67 feet/mile). Small waterfalls on the east fork may hinder upstream movement of fish. Several large, deep pools are interspersed between the predominant riffle areas. Stream habitat in the west fork consists mainly of long, shallow riffle areas with few pools. Substrates differ within and between forks primarily as a function of local stream velocities. Gravel and rubble, often embedded in sand, is prevalent in riffle and pool areas where streamflow velocities are moderate to slow. Cobble and boulder is more common in areas of higher streamflow velocities. Stream widths on each fork vary between 30 and 50 feet with average depths of 2-3 feet.

Below the confluence of these two forks, changes in the habitat of Watana Creek occur gradually. Within this reach to the mouth, stream valley walls become steeper although the floor widens. Stream channel width generally increases and stream gradient decreases. Stream widths in this reach vary from 40-60 feet with average depths of 2-4 feet. The shallow pool-riffle type habitat present in the forks persists in this lower reach. However, because of the increased volume of water and widening of the stream channel, it becomes less defined. Substrate differs little from substrate described earlier in the forks. Unstable soils, due mainly to melting permafrost, result in higher stream turbidities within this reach. This condition prevailed in the lower 3-4 miles of Watana Creek throughout the 1982 field season.

Kosina Creek

Kosina Creek enters the Susitna River from the south at river mile 208.6, approximately 24 miles upstream from the proposed Watana dam site

(Appendix Figure 5-B-8). The proposed reservoir would inundate 4.5 miles of the stream.

The habitat evaluation location was sampled monthly during the open water field season. Sampling was also conducted once during July on the 1.5 mile reach of stream immediately above the PIE. Aerial surveys were conducted on the main fork of Kosina Creek upstream from the mouth for approximately 10 miles. Aerial surveys were also conducted along Gilbert Creek to Clarence Lake and on other selected major tributaries of Kosina Creek.

Kosina Creek is a relatively large clearwater stream which originates in steep mountainous terrain just south of the Talkeetna Mountains. It flows generally north for approximately 35 miles from its source to its confluence with the Susitna River and has a drainage basin size of 400 square miles. Several major tributaries drain into Kosina Creek along its course. Two of these tributaries, Terrace (TRM 15.5) and Gilbert (TRM 5.8) Creeks, drain large lake systems which presently support populations of Arctic grayling and lake trout. Several other lakes are located on the tundra plateau above the valley floor and are drained by small high gradient streams. These lakes do not appear to be accessible to fish.

The stream habitat in Kosina Creek varies considerably along its course. In the upper reaches, the creek flows through broad valleys of glacial origin having relatively moderate streamflow velocities. Meandering braided channels are common in this area. Approximately ten miles upstream from the mouth the gradient increases and the stream becomes confined to a V-shaped valley. Long, fast flowing riffle areas are the dominant habitat type in this middle reach of the stream.

The reach of stream below its confluence with Gilbert Creek is characterized by long stretches of high velocity riffle areas interspersed with numerous large, deep, slow flowing pools (Plate 5-3-2). These pools are generally located against cliffs, high banks or in areas behind large boulders. The pools are as large as 50 by 150 feet and up to 8-10 feet in depth. Substrate in the pools consists of varying proportions of cobble, rubble and boulder usually embedded in sand. Substrate in the riffle areas consists mainly of cobble and boulder. The stream channel is frequently braided in this reach. Stream widths are often in excess of 200 feet and depths average 3-5 feet.

Jay Creek

Jay Creek enters the Susitna River from the north at river mile 208.5, approximately 23 miles upstream of the proposed Watana dam site (Appendix Figure 5-B-9). It would be inundated upstream for 3.5 miles by the proposed impoundment.

Sampling of the habitat evaluation location was conducted monthly during the open water field season. Additional sampling was conducted twice on the first mile of stream located immediately above the PIE. Aerial surveys were conducted upstream from the mouth to approximately TRM 8.0.

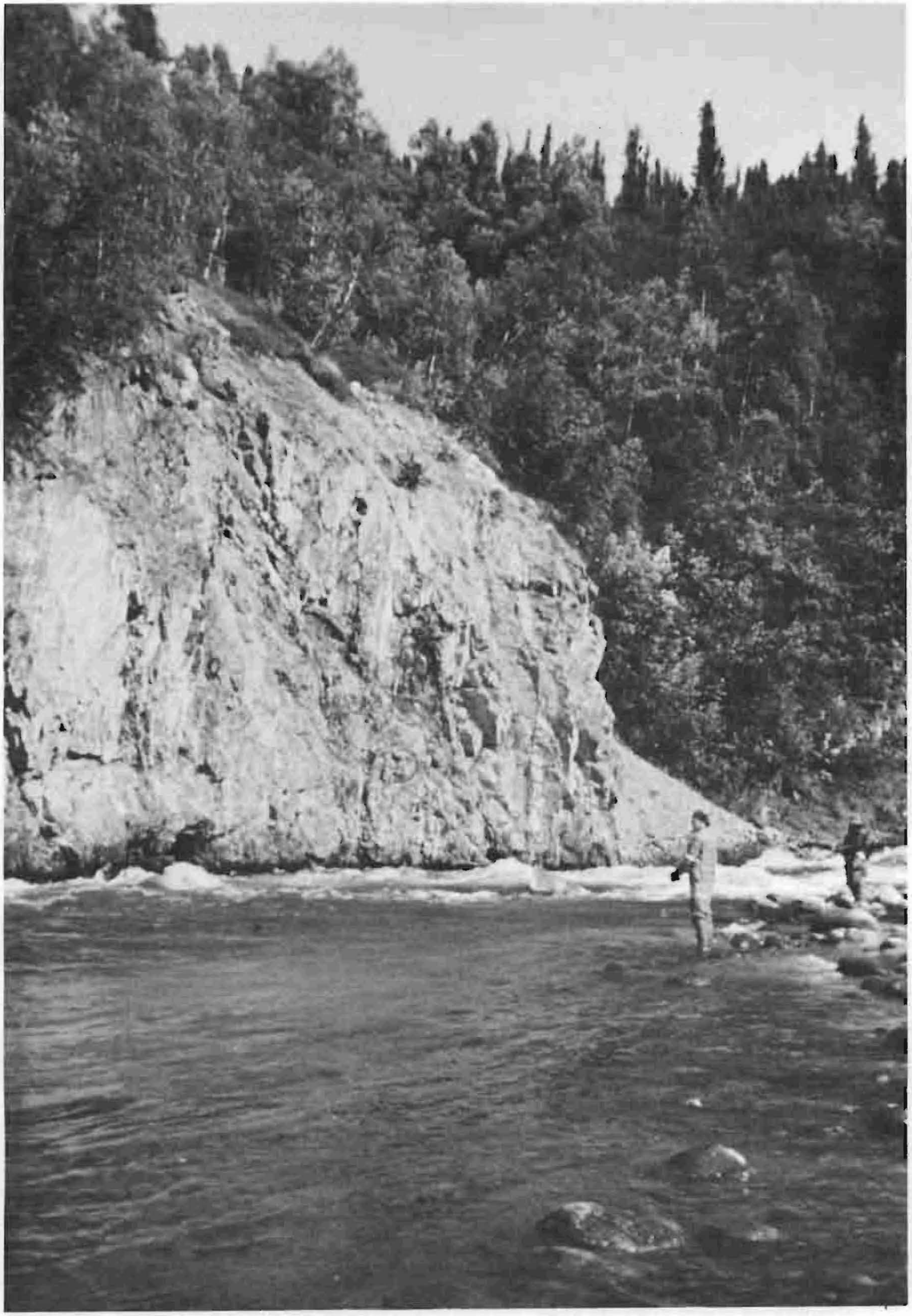


Plate 5-3-2 A typical, large, deep pool located below the Proposed Impoundment Elevation (PIE) in Kosina Creek.

Jay Creek is a clearwater stream originating in a gently sloping region of open tundra just north of the Susitna River. It flows in a general northwest direction for approximately 12 miles and then flows southwest for 8 miles to its confluence with the Susitna River. It has a relatively small drainage basin of approximately 62 square miles. One major unnamed fork, approximately 9 miles in length enters the stream eight miles upstream from the mouth of Jay Creek. The stream habitat of Jay Creek is generally characterized by moderate streamflows and alternating pool/riffle areas. Lentic environments in the drainage basin are limited to a few very small tundra ponds scattered throughout the area.

The stream reach which would be inundated is mostly confined to a deep, narrow canyon and has a stream gradient of 143 feet per mile. Streamflows are moderate and the habitat consists mainly of riffle areas interspersed with numerous small pools mostly situated behind boulders or against cliffs. Stream widths vary from 40-60 feet with average depths of 2-3 feet. Substrate consists of gravel, cobble and rubble often embedded in sand. Although the stream is generally clear, unstable soils in upstream areas often result in landslides during periods of moderate to heavy precipitation which can rapidly increase the turbidity of the stream. The stream channel itself is stable. The channel splits approximately 100 feet above its confluence with the Susitna River resulting in the formation of two distinct channels at the mouth. Due to the relatively low discharge of Jay Creek during the 1982 field season, the clear water plume area at the confluence with the Susitna River was small and confined to the immediate proximity of the mouth.

Goose Creek

Goose Creek drains into the Susitna River from the south at river mile 231.3, approximately 47 miles upstream of the proposed Watana dam site (Appendix Figure 5-B-10). The stream would be inundated upstream for 1.2 miles by the proposed impoundment.

Sampling was conducted monthly on the habitat evaluation location. A one mile section of stream immediately above the PIE was also sampled once during the season. The stream was not surveyed beyond this point.

Goose Creek is a relatively small clearwater stream with a drainage basin area of 104 square miles. The stream originates in a steeply sloping region of open tundra south of the Susitna River and flows in a general northerly direction for approximately 20 miles to its confluence with the Susitna River. The stream habitat consists predominantly of long riffle areas of moderate streamflow velocity and few pools. The stream is generally confined to one channel, although braided channels occur occasionally in the upper reaches. Busch Creek, the only major tributary to Goose Creek, drains into the stream approximately 15 miles upstream from the mouth. Numerous smaller tributaries drain into the creek along its course to the mouth. Several small lakes are located in the upper reaches of the drainage basin.

The stream channel below the PIE is narrow and shallow throughout most of the reach and has a gradient of 114 feet per mile. Stream widths vary from 30 to 50 feet and depths average 2 to 3 feet. Long riffle areas dominate the habitat although deeper runs with lower streamflow velocities occur in a few areas. Substrate consists mainly of rubble, cobble and boulder in the riffle areas. Deeper areas with slower flows have substrates consisting mainly of gravel and rubble.

Oshetna River

The Oshetna River drains into the Susitna River from the south at river mile 233.4, approximately 50 miles above the proposed Watana dam site (Appendix Figure 5-B-11). It is the uppermost major tributary that would be affected by the proposed Watana Impoundment. The stream would be inundated upstream for 2.2 miles by the proposed impoundment.

Sampling was conducted monthly on the habitat evaluation location. Ground surveys were conducted on the first mile of stream located immediately above the PIE. Aerial surveys were conducted from the mouth upstream to approximately TRM 7.0.

The mainstem Oshetna River flows in a general northerly direction for approximately 50 miles from its source to its confluence with the Susitna River. It originates in steep mountainous and glacial terrain south of the Susitna River at elevations approaching 7,000 feet. It drains an area of 555 square miles. It is the only tributary to be influenced by glacial activity which gives the water a blue-green appearance due to the light load of glacial flour present in the stream during the summer months.

Three major rivers drain the upper reaches of this relatively large drainage basin. These consist of the Black River, the Little Oshetna River, and the reach of the Oshetna River above its confluence with the Little Oshetna River, hereafter referred to as the Upper Oshetna River. These three streams are similar in morphology. They all flow through relatively flat, U-shaped, glaciated valleys having frequently braided stream channels. All three drainages are presently affected to some extent by glacial activity. Two of the major lakes located in the Oshetna River drainage basin, Black Lake and Crater Lake, are both within the Black River drainage. Several smaller lakes are also present within the Little and Upper Oshetna drainages.

The reach of stream below the confluence of the Black River is confined to a "V" shaped valley with steeply rising valley walls and is characterized by a relatively high stream gradient. Several large lakes are situated on the tundra plateau above the valley floor in this area with small, high-gradient outlet streams connecting them to the Oshetna River.

Stream gradient begins to decrease approximately five miles above the mouth and the stream channel becomes meandering. The stream habitat in this reach consists mostly of long riffle areas (Plate 5-3-3) with moderate streamflow velocities. Several large, rather shallow pools are present in the lower two miles of stream and many small pool type habitats are located behind boulders in the stream. Substrate consists mainly of cobble and boulder in the riffle areas with rubble and gravel

Plate 5-3-3 Typical habitat of the Oshetna River, long riffle areas with moderate stream flow velocities.

found more often in pool type habitats. Stream widths range from 100 to 125 feet with average depths of 3 to 5 feet.

3.1.1.2 Water Quality

3.1.1.2.1 Instantaneous Water Quality

Instantaneous water quality and air temperature data for all tributary habitat evaluation sites are presented in Appendix Tables 5-C-1 to 5-C-17 (refer also to Volume 4 Appendix D). Graphical representations of the range, mean and median values for each parameter at each habitat evaluation site are presented in Figures 5-3-2 to 5-3-7. Due to the limited number of observations made at each site, and the variations in daily sampling times, a comparison of ranges, means and medians between sites is not valid. Therefore, these data only provide a general overview of the water quality characteristics of streams which were investigated.

Instantaneous water temperature observations for all tributary evaluation sites ranged from 0.1°C in the Oshetna River on May 5, 1982 to 14.8°C recorded in Goose Creek on July 28, 1982 (Figure 5-3-2).

The lowest instantaneous dissolved oxygen concentration of 9.6 mg/l was observed in Goose Creek on June 27, 1982, Watana Creek on June 24, 1982 and in the Oshetna River on July 19, 1982. Corresponding instantaneous surface water temperatures for those streams were generally at their highest when these low oxygen concentrations were observed. Highest

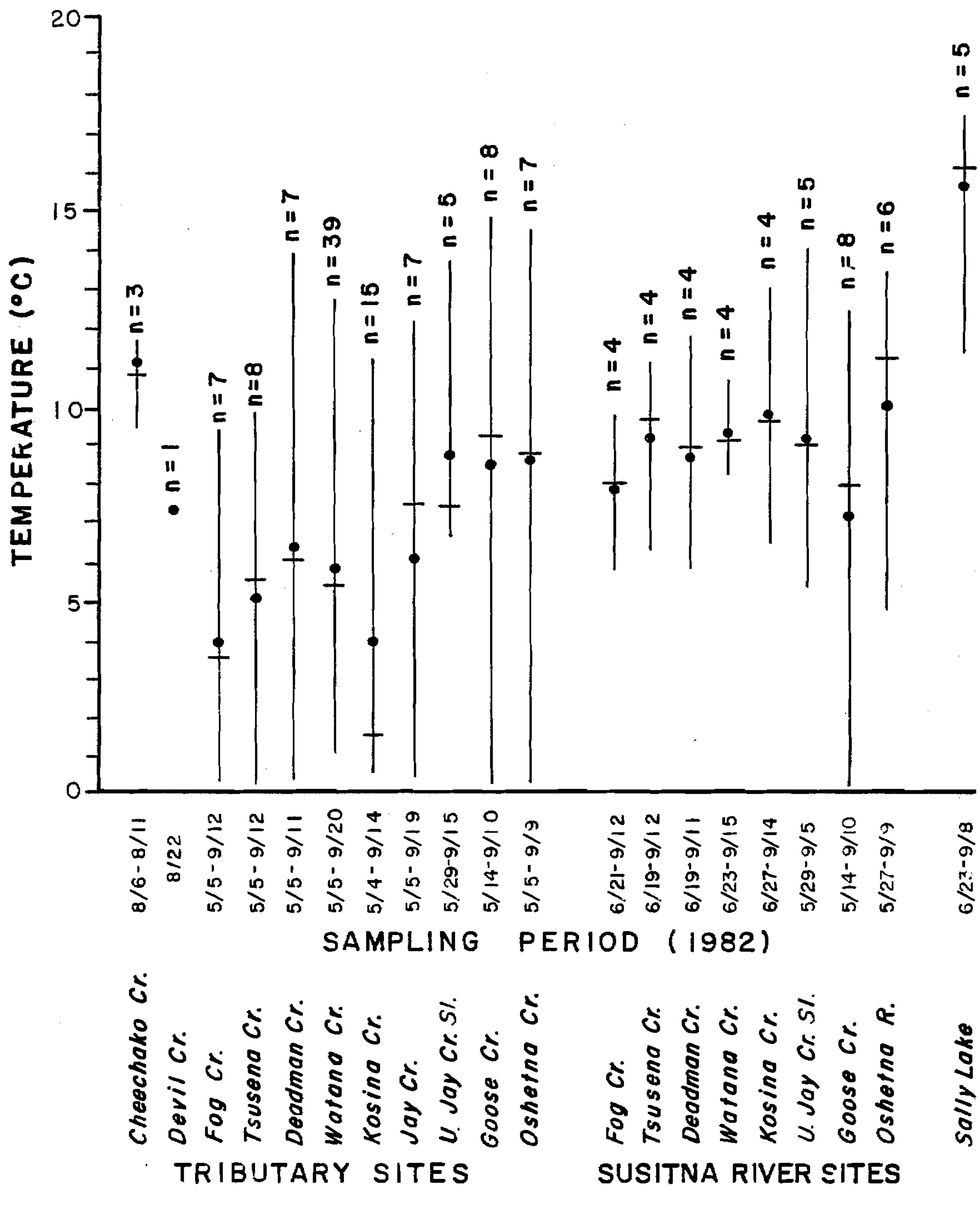


Figure 5-3-2. Mean (•), range (|) and median (—) instantaneous surface water temperatures recorded at selected habitat evaluation sites within the proposed impoundment areas during the 1982 open water field season (n = the number of observations).

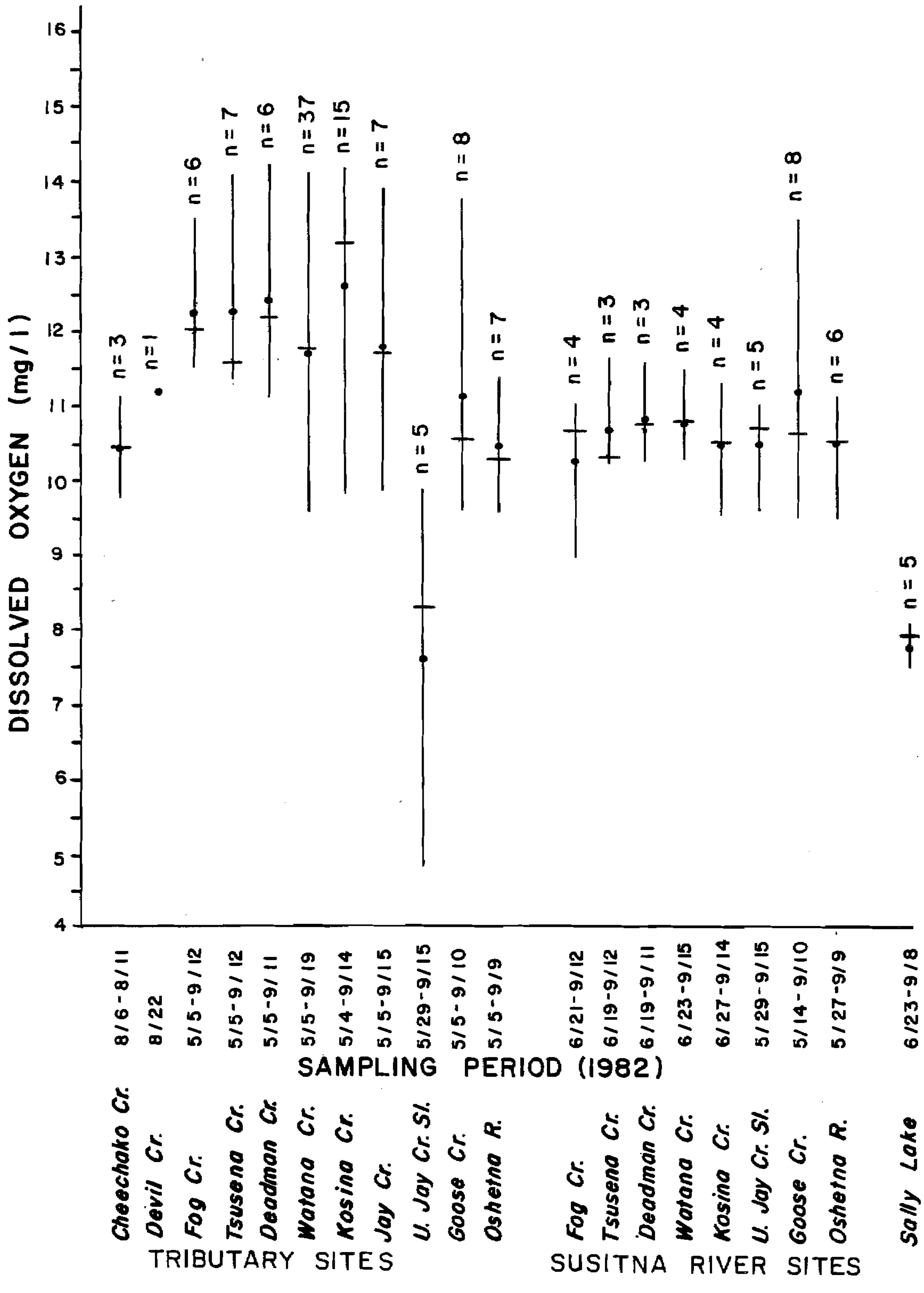


Figure 5-3-3. Mean (•), range (|) and median (—) dissolved oxygen concentrations recorded at selected habitat evaluation sites within the proposed impoundment areas during the 1982 open water field season (n = the number of observations).

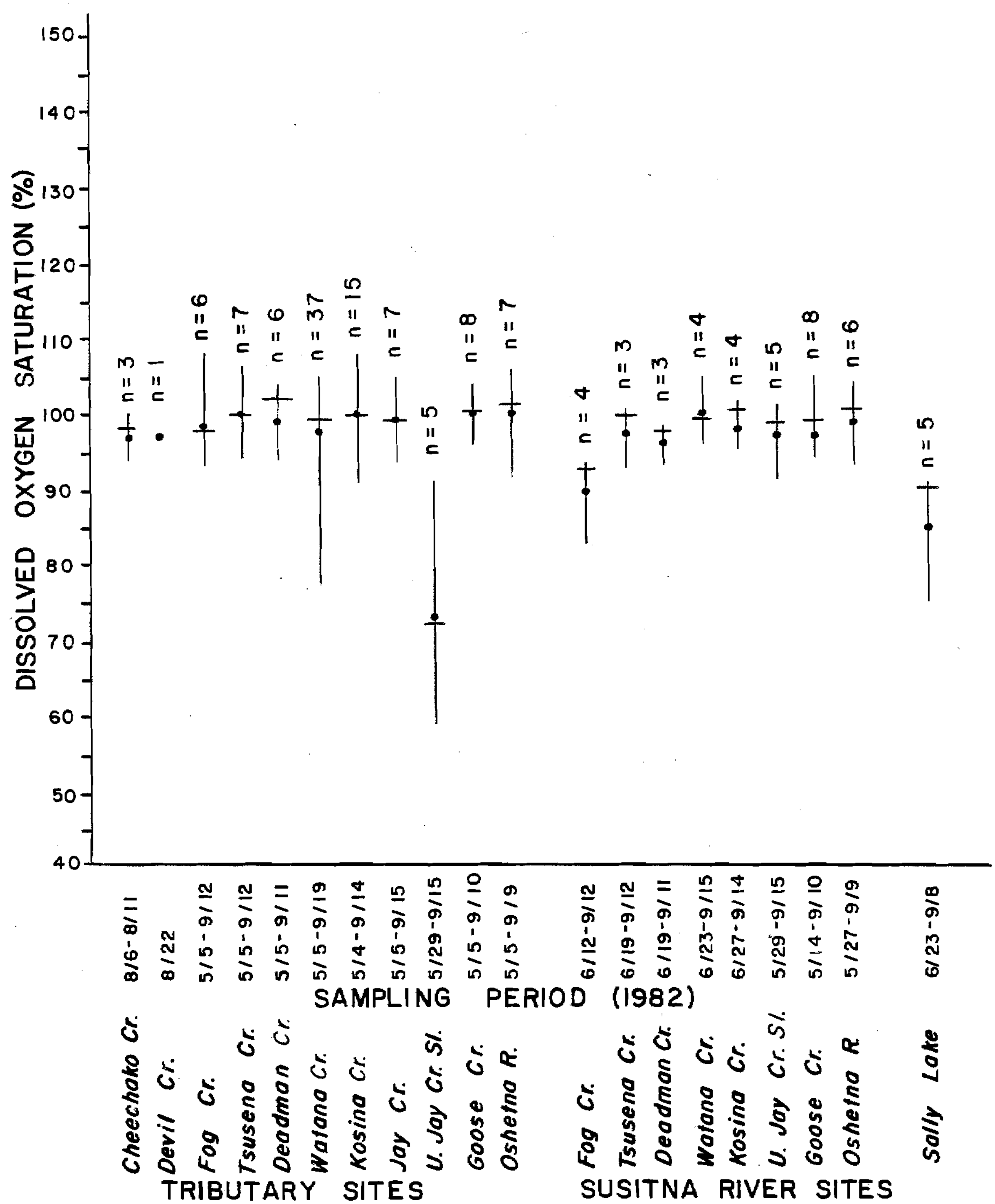


Figure 5-3-4. Mean (•), range (|) and median (—) dissolved oxygen saturation values recorded at selected habitat evaluation sites within the proposed impoundment areas during the 1982 open water field season (n = the number of observations).

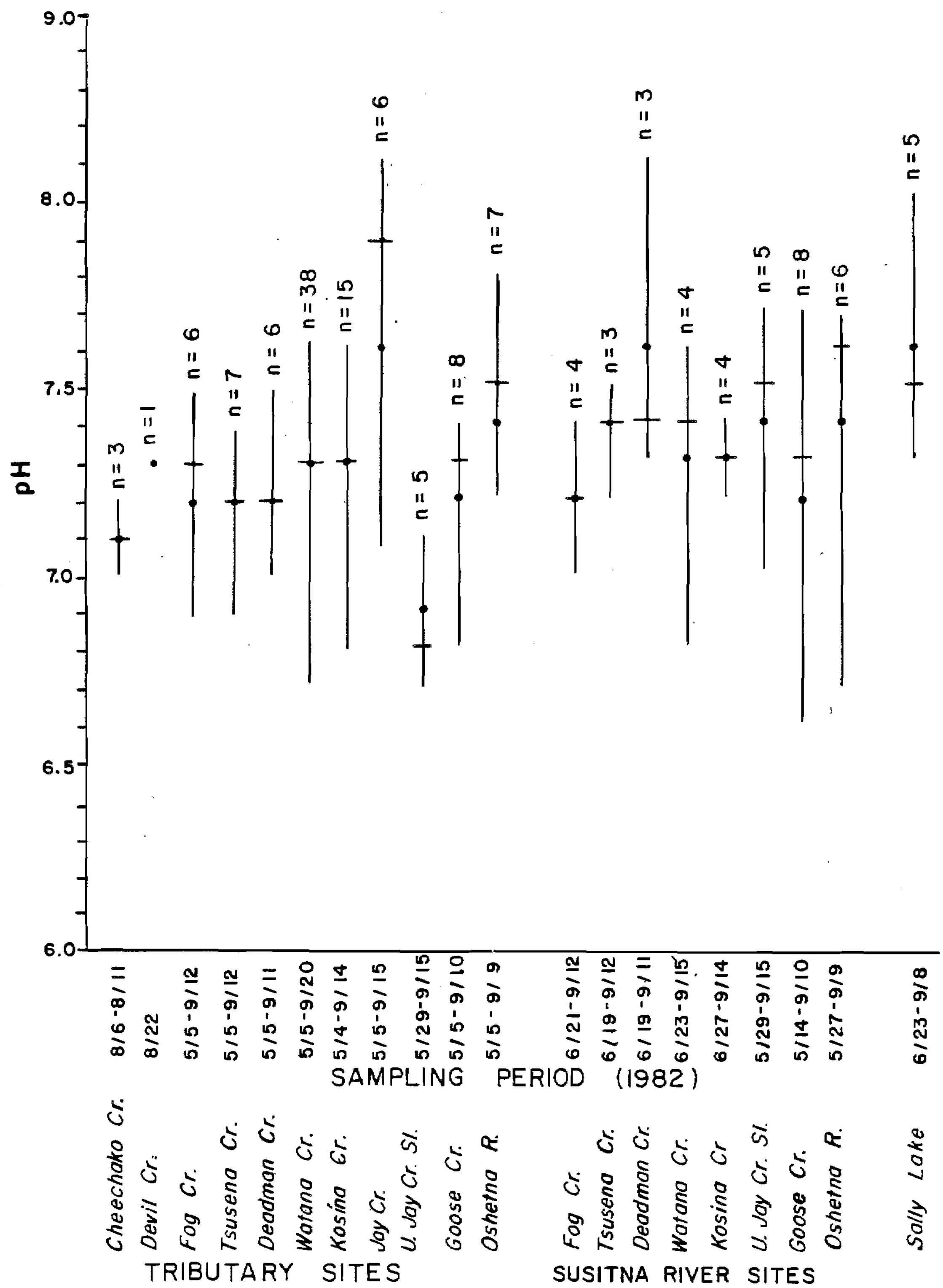


Figure 5-3-5. Mean (•), range (|) and median (—) pH values recorded at selected habitat evaluation sites within the proposed impoundment areas during the 1982 open water field season (n = the number of observations).

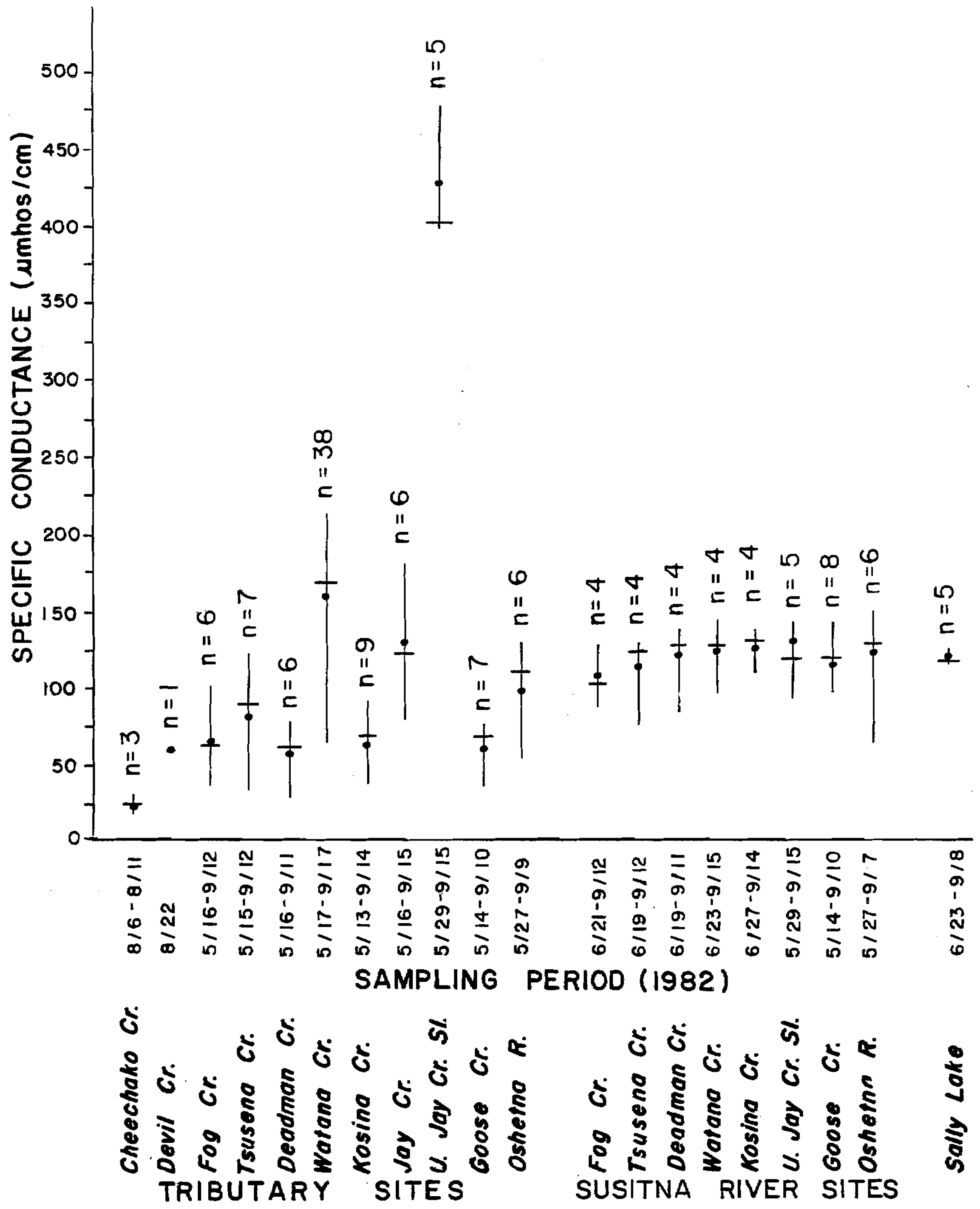


Figure 5-3-6. Mean (•), range (|) and median (—) specific conductance values recorded at selected habitat evaluation sites within the proposed impoundment areas during the 1982 open water field season (n = the number of observations).

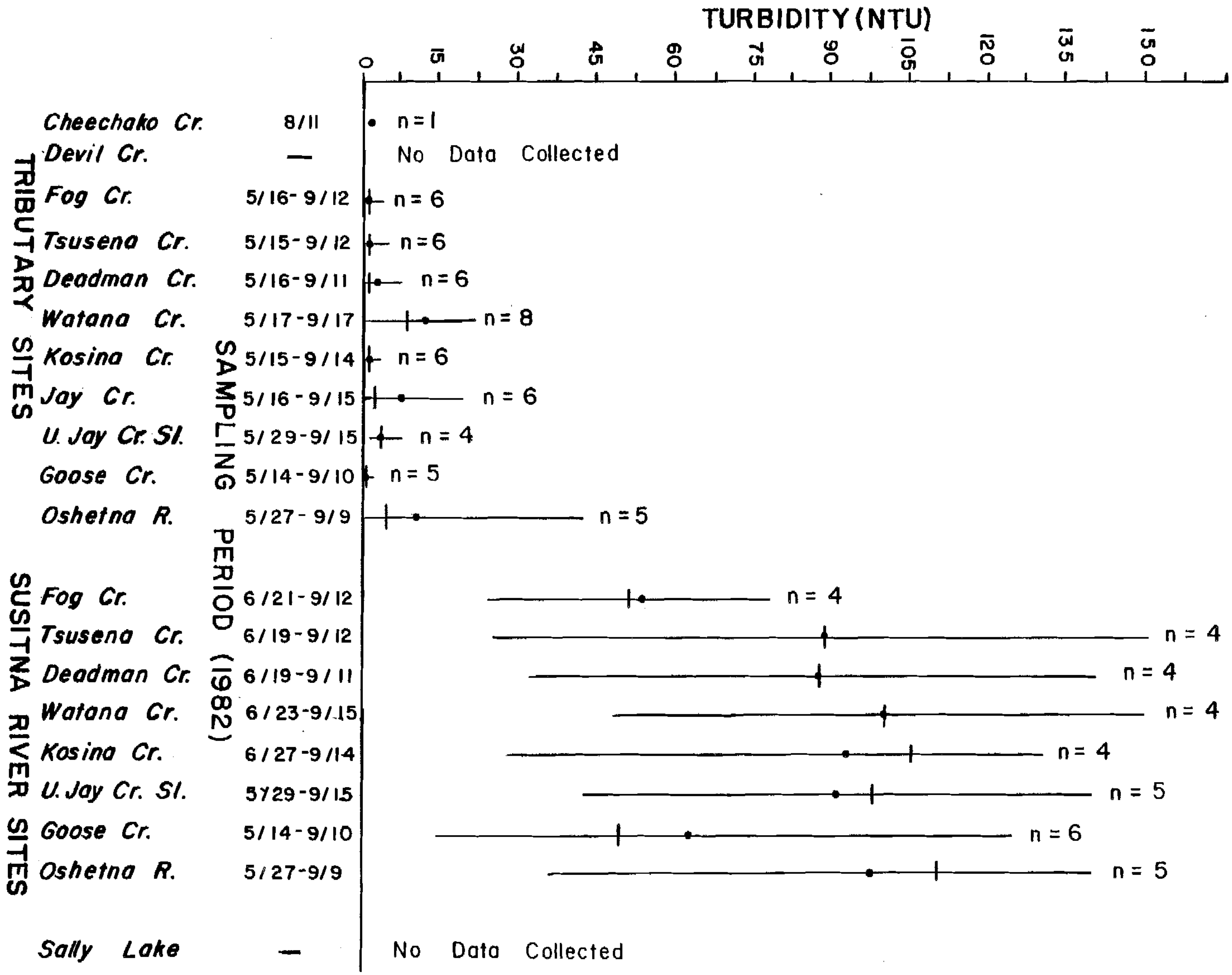


Figure 5-3-7. Mean (•), range (|) and median (—) turbidity values recorded at selected habitat evaluation sites within the proposed impoundment areas during the 1982 open water field season (n = the number of observations).

dissolved oxygen concentrations, 14.2 mg/l, occurred in Deadman Creek on May 5, 1982 when water temperature was only 0.8°C (Figure 5-3-3).

Percent dissolved oxygen saturation in surface water at all tributary habitat evaluation sites ranged from 77% in Watana Creek to 108% in Fog and Kosina Creek (Figure 5-3-4).

Values of pH in all tributary evaluation sites ranged from 6.7 in Watana Creek to 8.1 in Jay Creek (Figure 5-3-5).

Specific conductances, expressed in umhos/cm, were measured in all tributary habitat evaluation sites. Values ranged from 22 umhos/cm in Cheechako Creek to 212 umhos/cm in Watana Creek (Figure 5-3-6).

Observed turbidities, expressed in NTUs, ranged from less than 1 NTU in at least one site on each tributary to 42 NTUs in the Oshetna River (Figure 5-3-7).

3.1.1.2.2 Continuous Surface Water Temperature

Surface water temperatures were continuously recorded in five selected clearwater tributaries to the Susitna River at sites located immediately above each tributary mouth from June 19, 1982 through October 16, 1982. Because of occasional thermograph malfunctions, several gaps in the data occur.

Daily minimum, maximum and mean values for each stream during the sampling period are graphically presented in Figures 5-3-9 through 5-3-13. A comparison of temperature values among streams is presented in Figure 5-3-8. Tabular continuous surface water temperatures are listed in Volume 4, Part 1, Appendix 4C, Tables 4-C-20 through 4-C-24 (ADF&G 1983a).

Tributary surface water temperatures ranged from 0°C to 16.5°C during the sampling period. Mean monthly surface water temperatures were lowest in Tsusena Creek in June (6.4°C), July (8.2°C), August (8.4°C), and September (5.5°C), and in Kosina Creek in October (0.7°C). Highest mean monthly surface water temperatures occurred in Watana Creek in June (8.7°C), in Goose Creek in July (11.6°C) and August (10.8°C), in the Oshetna River in September (6.2°C) and in Watana (1.2°C) and Tsusena Creeks (1.2°C) in October (Figure 5-3-8).

3.1.1.3 Discharge

Discharge measurements were taken on selected tributaries during the months of August and September, 1982. Fog, Tsusena, Watana, Jay and Goose Creeks were sampled once during each sampling period. Discharge on Deadman Creek was measured only during the August sampling period. Frequency of sampling on all streams was limited because of personnel constraints and difficult sampling conditions due to high water.

Discharge increased in all streams sampled from the August to the September sampling periods. August discharge measurements among streams

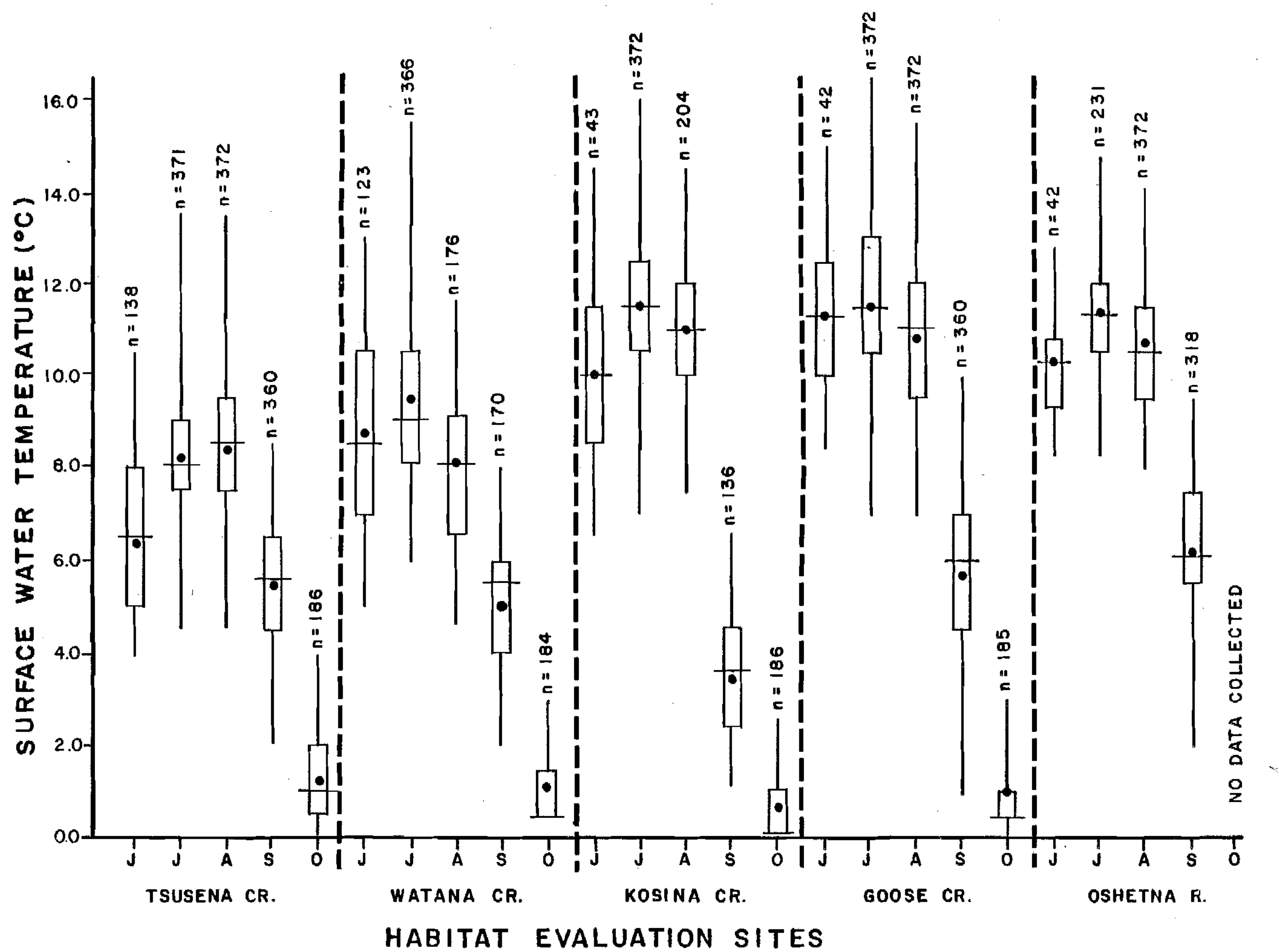


Figure 5-3-8. Monthly thermograph data summary, mean (•), range (|) and 25th, 50th (median), and 75th percentiles (⊟), for selected habitat evaluation sites within the proposed impoundment areas from June through October, 1982 (n = the number of two hour interval observations taken each month at each site).

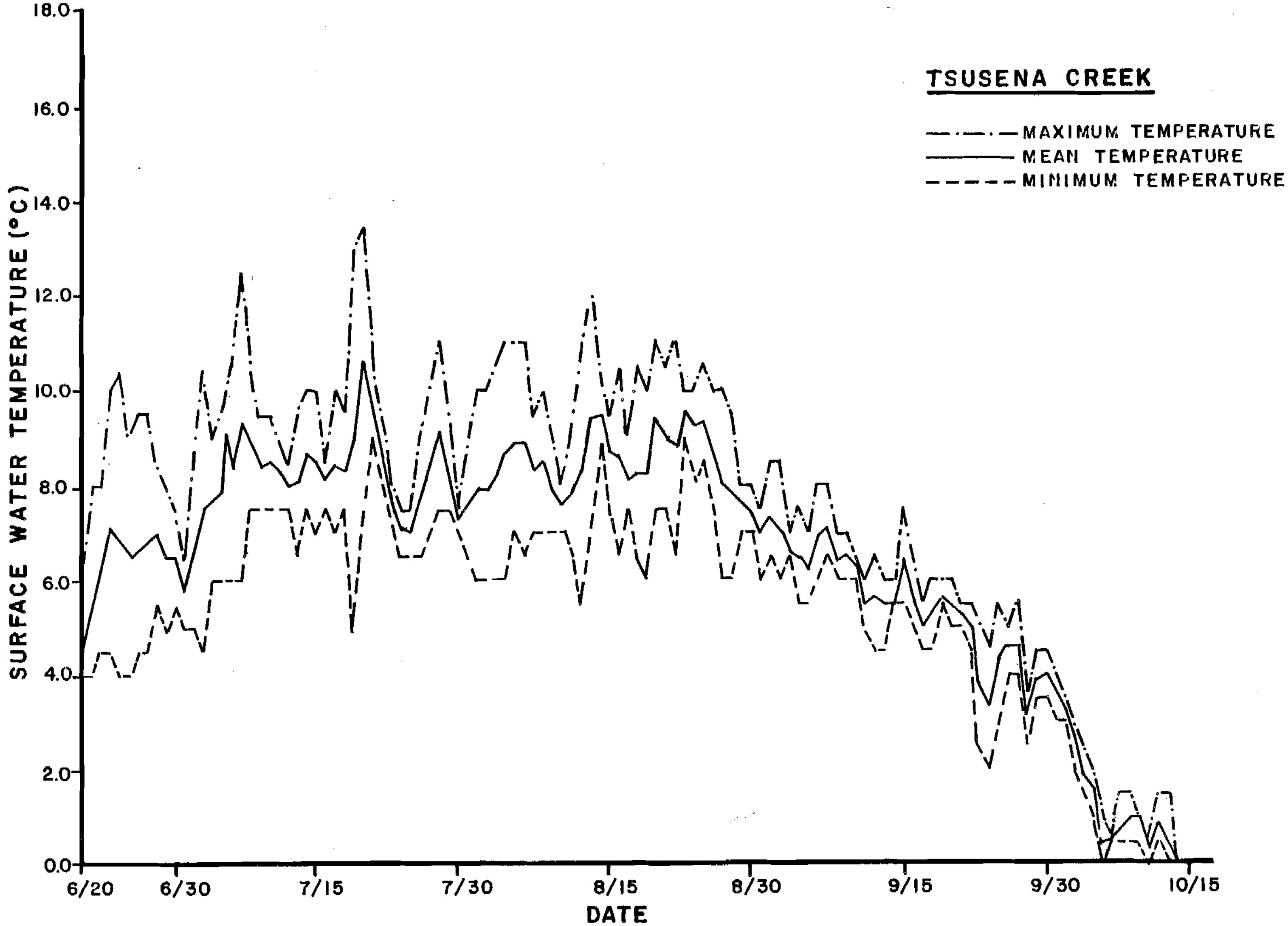


Figure 5-3-9. Daily thermograph data summary for Tsusena Creek, RM 181.3, GC S32N04E36ADB, June 20 through October 15, 1982.

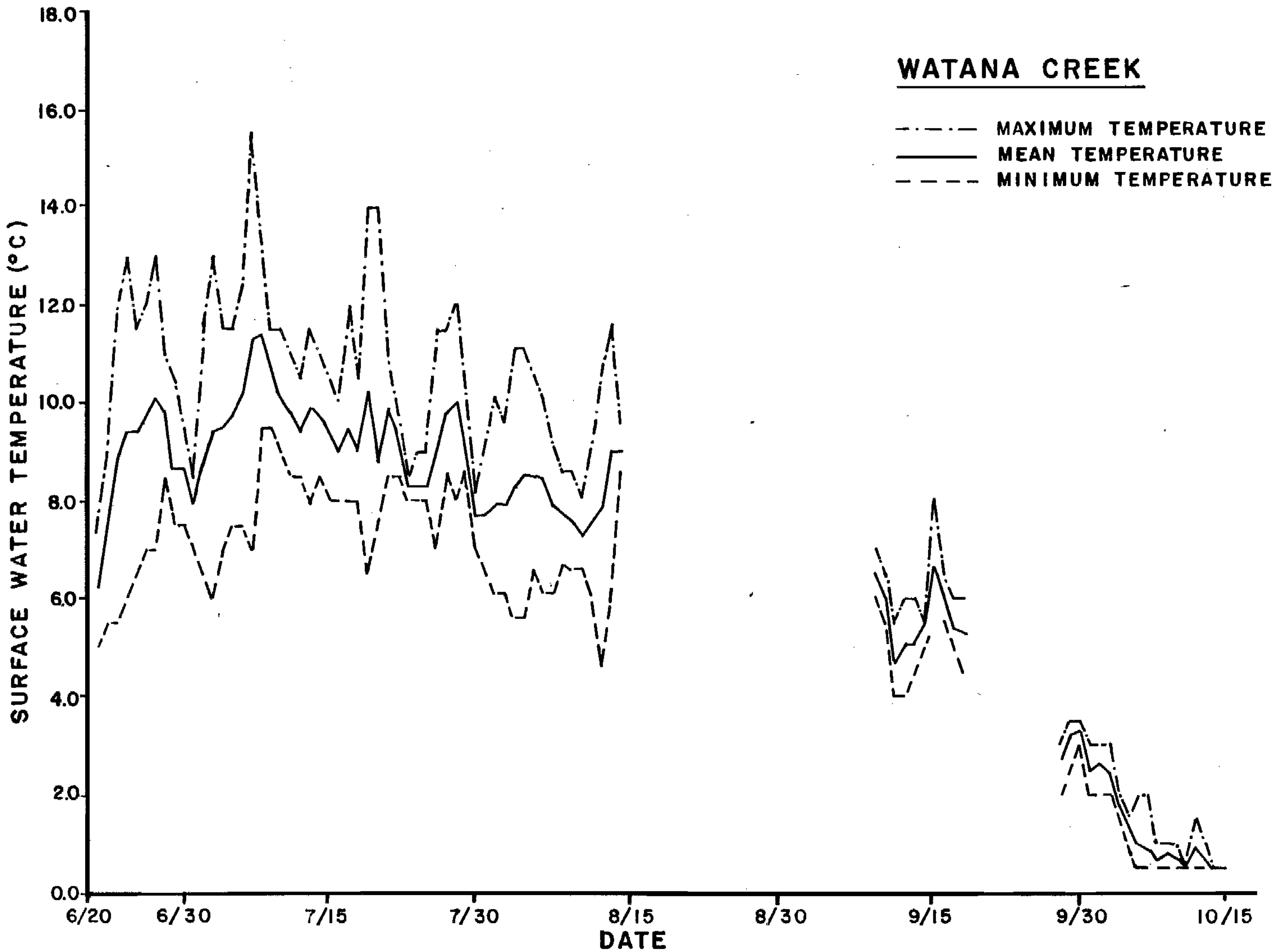


Figure 5-3-10. Daily thermograph data summary for Watana Creek, RM 194.1, GC S32N06E25CCA, June 21 through August 14, September 9 through September 18 and September 28 through October 15, 1982.

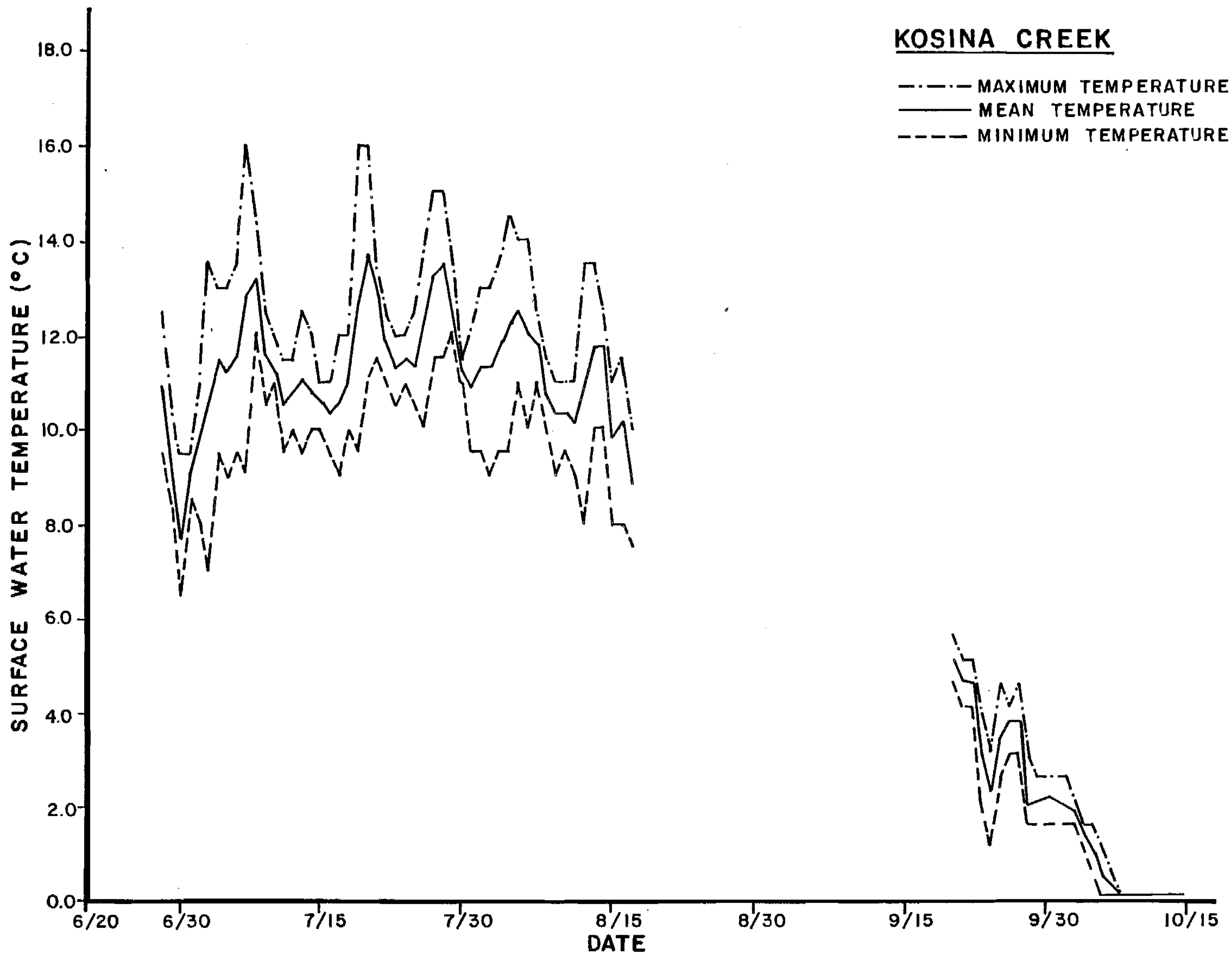


Figure 5-3-11. Daily thermograph data summary for Kosina Creek, RM 206.8, GC S31N08E15BAB, June 28 through August 17 and September 20 through October 15, 1982.

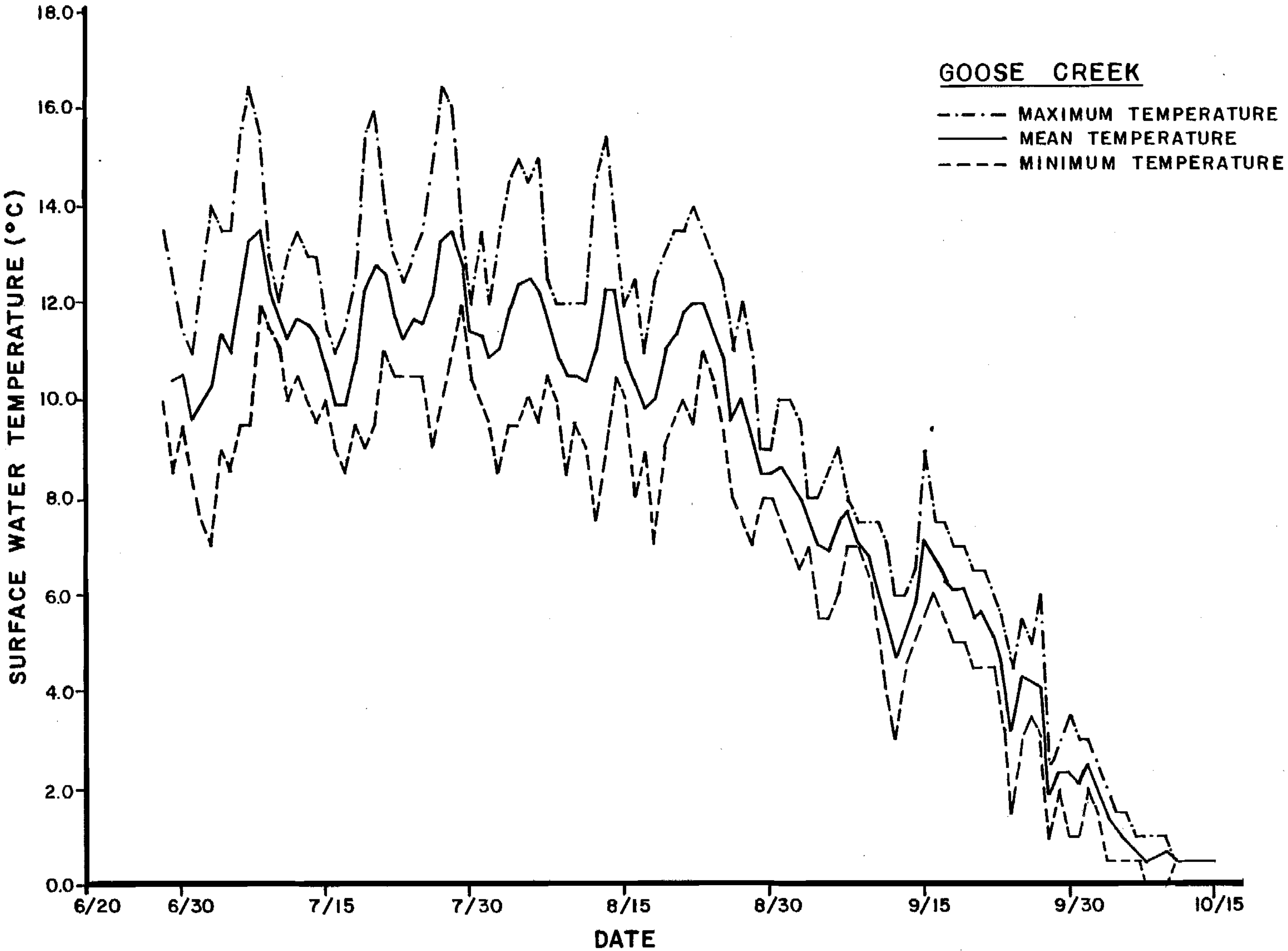


Figure 5-3-12. Daily thermograph data summary for Goose Creek, RM 231.3, GC S30N11E32DBC, June 28 through Ocotber 15, 1982.

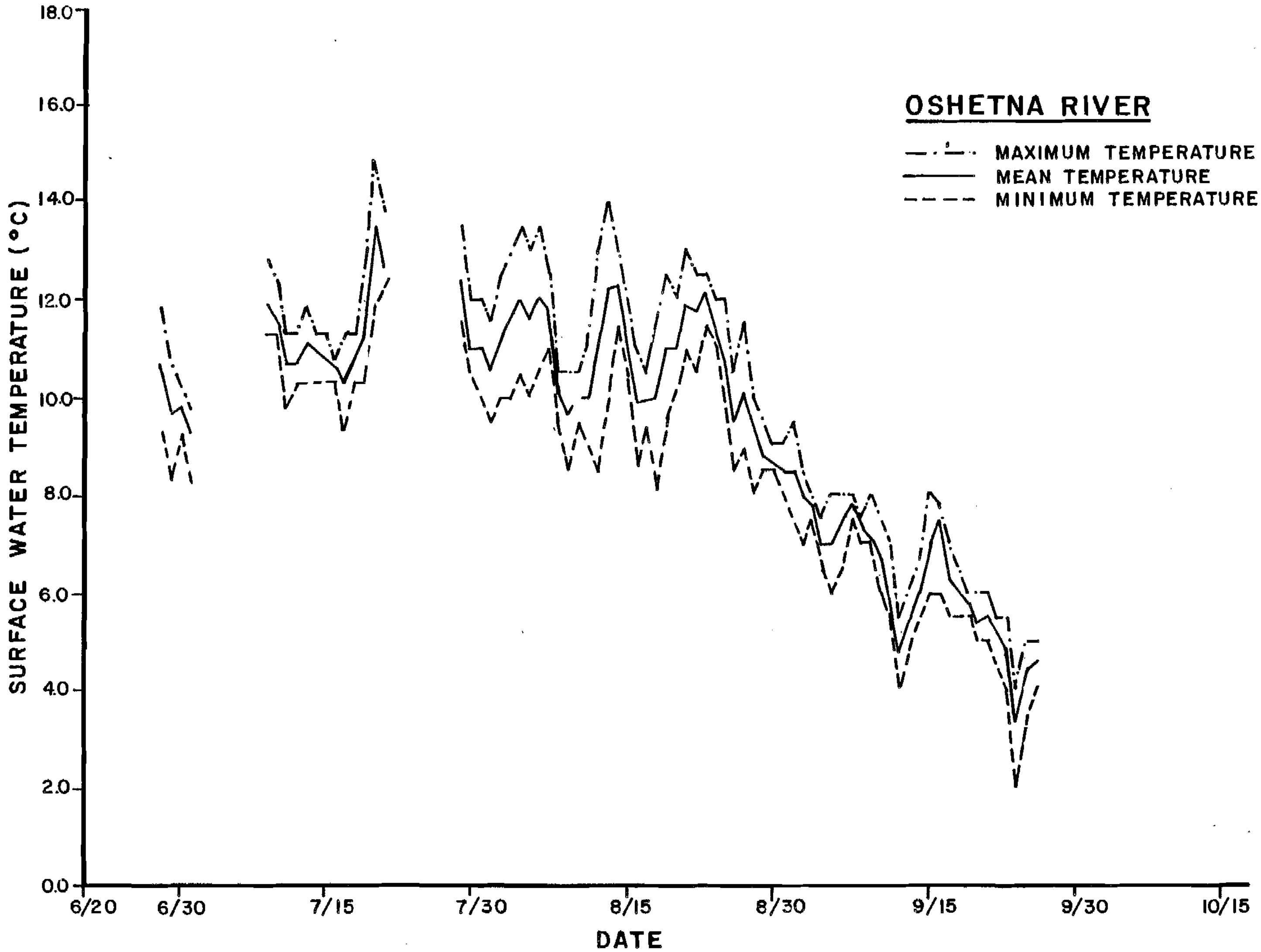


Figure 5-3-13. Daily thermograph data summary for the Oshetna River, RM 233.4, GC S30N11E34CCD, June 28 through July 1 and July 9 through September 26, 1982.

ranged from 61 cfs in Jay Creek to 330 cfs in Tsusena Creek. September measurements ranged from 150 cfs in Goose Creek to 557 cfs in Watana Creek. Individual stream discharge measurements are presented in Table 5-3-3 (refer also to Volume 6, Appendix A).

3.1.2 Resident Fisheries Investigations

3.1.2.1 Arctic Grayling

Distribution and Abundance

Arctic grayling (*Thymallus arcticus* Pallas) were captured at all tributary habitat evaluation locations, except Chinook Creek, during the 1982 Aquatic Studies of the proposed impoundment areas.

Four thousand three hundred and sixty-seven Arctic grayling over 135 mm fork length were captured. Table 5-3-4 lists the grayling catch by location and month. Only hook and line catches are listed as other gear types contributed less than 1% (33) of the total catch.

The total habitat evaluation location catch was 3782 Arctic grayling in 408 angler hours, giving a catch rate of 9.3 Arctic grayling per angler hour for the entire summer study. Arctic grayling catches, angler hours and catch rates are listed in Tables 5-3-5 and 5-3-6 and illustrated in Figures 5-3-14 and 5-3-15. Arctic grayling catch per hour ranged from a low of 0.0 to a high of 29.6.

Table 5-3-3. Discharge data on selected tributaries within the proposed impoundment study area, 1982.

Tributary[a]	Date (1982)	Discharge (cfs)
Fog Creek	8/15	269
	9/12	307
Tsusena Creek	8/16	330
	9/12	363
Deadman Creek	8/21	228
Watana Creek	8/15	229
	9/19	557
Jay Creek	8/12	61
	9/19	154
Goose Creek	8/19	79
	9/10	150

a All discharges were taken in proximity of the mouth with the exception of Deadman Creek where it was taken approximately three miles upstream from the mouth.

Table 5-3-4. Arctic grayling hook and line catch by location and month, Proposed Impoundment Areas, 1982.

Location	May	June	July	August	September	Total
Oshetna River	10	-	288	243	172	713
Goose Creek	-	38	91	76	2	207
Jay Creek	3	79	130	108	4	324
Kosina Creek	37	232	491	604	320	1684
Watana Creek	-	128	175	208	36	547
Deadman Creek	1	40	51	110	1	203
Tsusena Creek	7	10	29	26	7	79
Fog Creek	-	1	5	17	2	25
Totals	58	528	1260	1392	544	3782
Others in Proposed Impoundments	7	4	-	2	-	13
Sally Lake	-	3	-	33	-	36
A.P.I.E. [a] (1m) (5 Creeks)	-	-	428	50	25	503
Totals	65	535	1688	1477	569	4334

[a] Above proposed impoundment elevation.

Table 5-3-5. Arctic grayling hook and line catch and effort by tributary and month for the mouths of the eight major tributary habitat evaluation location, Proposed Impoundment Areas, 1982.

Location		May	June	July	August	Sept.	Total
	Catch	6	-	12	20	6	44
Oshetna	Hours	1.5	-	0.75	1.0	1.5	4.75
River	Catch/Hours	4.0	-	16.0	20.0	4.0	9.3
	Catch	-	12	13	2	0	27
Goose	Hours	-	1.0	1.0	0.75	0.25	3.0
Creek	Catch/Hours	-	12.0	13.0	2.7	0.0	9.0
	Catch	3	17	25	2	0	47
Jay	Hours	0.5	1.0	1.0	0.25	0.5	3.25
Creek	Catch/Hours	2.5	17.0	25.0	8.0	0.0	14.5
	Catch	21	38	74	54	46	233
Kosina	Hours	3.0	2.5	2.5	2.25	5.0	15.25
Creek	Catch/Hours	7.0	6.5	29.5	24.0	9.2	15.3
	Catch	-	-	-	-	-	-
Watana	Hours	-	-	-	-	-	-
Creek	Catch/Hours	-	-	-	-	-	-
	Catch	1	38	11	47	1	98
Deadman	Hours	1.0	5.0	0.75	1.75	0.25	8.75
Creek	Catch/Hours	1.0	7.6	14.7	26.9	4.0	11.2
	Catch	7	10	29	26	7	79
Tsusena	Hours	2.0	5.0	3.0	2.0	1.0	13.0
Creek	Catch/Hours	3.5	2.0	9.7	13.0	7.0	6.1
	Catch	0	0	1	0	0	1
Fog	Hours	0.5	1.0	0.25	0.5	0.5	2.75
Creek	Catch/Hours	0.0	0.0	4.0	0.0	0.0	0.4
	Catch	38	115	165	151	60	529
TOTAL	Hours	8.5	15.5	9.25	8.5	9.0	50.75
	Catch/Hours	4.5	7.4	17.8	17.8	6.7	10.4

- not sampled.

Table 5-3-6. Arctic grayling hook and line catch and effort by tributary and month for the eight major tributary habitat evaluation locations in their entirety, Proposed Impoundment Areas, 1982.

Location		May	June	July	August	Sept.	Total
	Catch	10	-	288	243	172	713
Oshetna	Hours	2.5	-	21.25	22.0	18.25	64.0
River	Catch/Hours	4.0	-	13.60	11.1	9.4	11.1
	Catch	-	38	91	76	2	207
Goose	Hours	-	8.75	6.75	12.75	7.0	35.25
Creek	Catch/Hours	-	4.3	13.5	6.0	0.3	5.9
	Catch	3	79	130	108	4	324
Jay	Hours	0.5	10.5	12.0	9.5	2.75	35.25
Creek	Catch/Hours	1.5	7.5	10.8	11.4	1.5	9.2
	Catch	37	232	491	604	320	1684
Kosina	Hours	11.5	28.75	31.5	38.0	52.75	162.5
Creek	Catch/Hours	3.2	8.1	15.6	15.9	6.1	10.4
	Catch	-	128	175	208	36	547
Watana	Hours	-	18.5	18.0	13.5	16.75	66.75
Creek	Catch/Hours	-	6.9	9.7	15.4	2.2	8.2
	Catch	1	40	51	110	1	203
Deadman	Hours	1.5	9.0	4.5	4.75	2.25	22.0
Creek	Catch/Hours	0.7	4.4	11.3	23.1	0.4	9.2
	Catch	7	10	29	26	7	79
Tsusena	Hours	2.0	5.0	3.0	2.0	1.0	13.0
Creek	Catch/Hours	3.5	2.0	9.7	13.0	7.0	6.1
	Catch	0	1	5	17	2	25
Fog	Hours	0.5	3.0	1.25	1.5	2.5	8.75
Creek	Catch/Hours	0.0	0.3	4.0	11.3	0.8	2.9
	Catch	58	528	1260	1392	544	3782
TOTAL	Hours	8.5	83.5	98.25	104.0	103.25	407.5
	Catch/Hours	4.5	6.3	12.8	13.4	5.3	9.3

- not sampled.

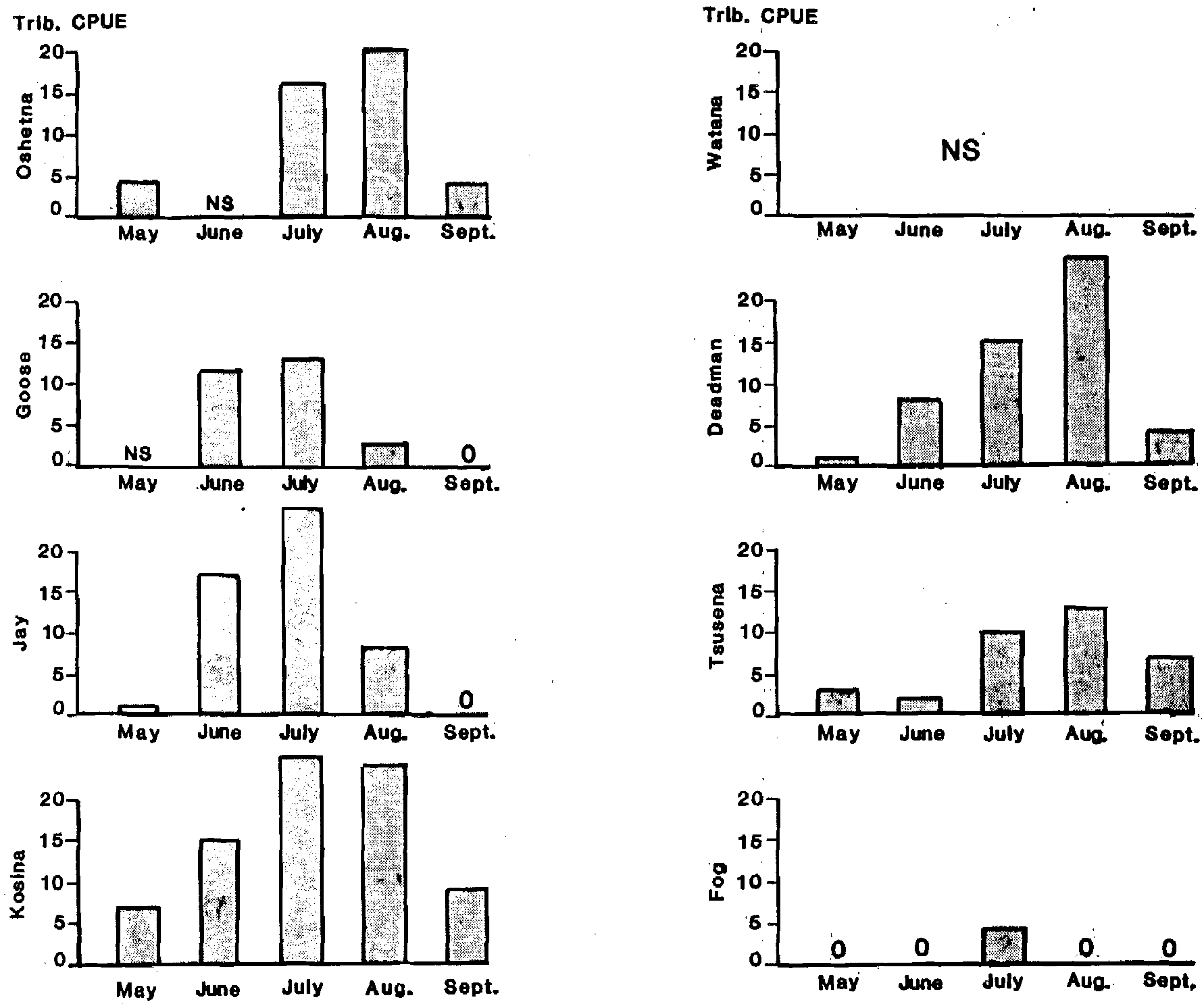


Figure 5-3-14. Arctic grayling hook and line CPUE for the mouths of the eight tributary habitat evaluation location, proposed Impoundment Areas, 1982. (NS = Not Sampled)

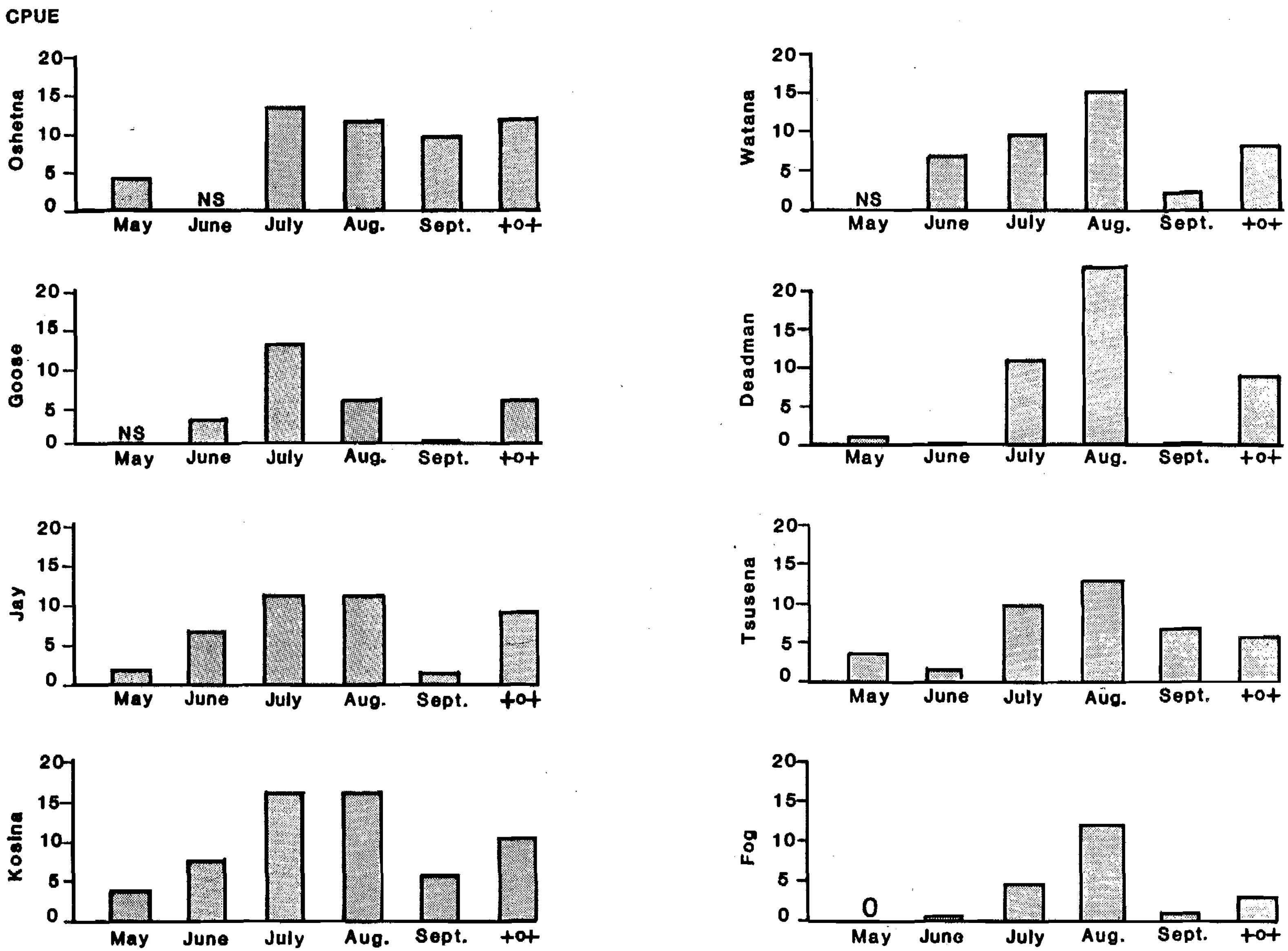


Figure 5-3-15. Arctic grayling hook and line CPUE for the eight tributary habitat evaluation locations in their entirety, Proposed Impoundment Areas, 1982. (NS = Not Sampled)

Age, Length, Sex

Two hundred and eighty-two Arctic grayling taken by hook and line were aged by scale analysis. These fish ranged from Age I to Age IX. Age V Arctic grayling were dominant, comprising 31% of the total sample (Table 5-3-7 and Figure 5-3-16).

Lengths were taken from all Arctic grayling sampled. Lengths ranged from 120 mm to 420 mm, with the 310 mm to 329 mm Arctic grayling occurring most frequently (22%) (Table 5-3-8 and Figures 5-3-17 and 5-3-18).

The age-length relationship shown in Figure 5-3-19 is calculated from the ages and lengths taken from a subsample of 282 Arctic grayling. Age-length comparisons between the tributaries themselves and against the overall combined sample were also made. No apparent differences were found (Figure 5-3-20). From the same subsample, an age-length comparison of males versus females was calculated (Figure 5-3-21). Other than the 17 mm difference in mean lengths (males 328 mm versus females 311 mm) no other differences were apparent.

Two hundred sixty-three Arctic grayling were sampled for sex composition. Males comprised 53.6% of the sample and the overall ratio of males to females was 1.2 males:1 female (Figure 5-3-22).

During the upstream spawning migration, 50 Arctic grayling were necropsied for sex determination and sexual maturity; 26 males and 24 females. All males 330 mm and over and females 320 mm and over were found to be

Table 5-3-7. Arctic grayling age-length composition, Proposed Impoundment Areas, 1982.

Age	Total No. Fish Sampled	Mean Length(mm)	Range (mm)	% of Sample
I	5	147	115-170	2
II	12	202	170-230	4
III	26	255	220-295	9
IV	55	292	270-335	20
V	88	320	280-345	31
VI	59	344	310-360	21
VII	25	367	345-395	9
VIII	9	393	375-395	3
IX	3	415	410-420	1
Total	282	313	115-420	100

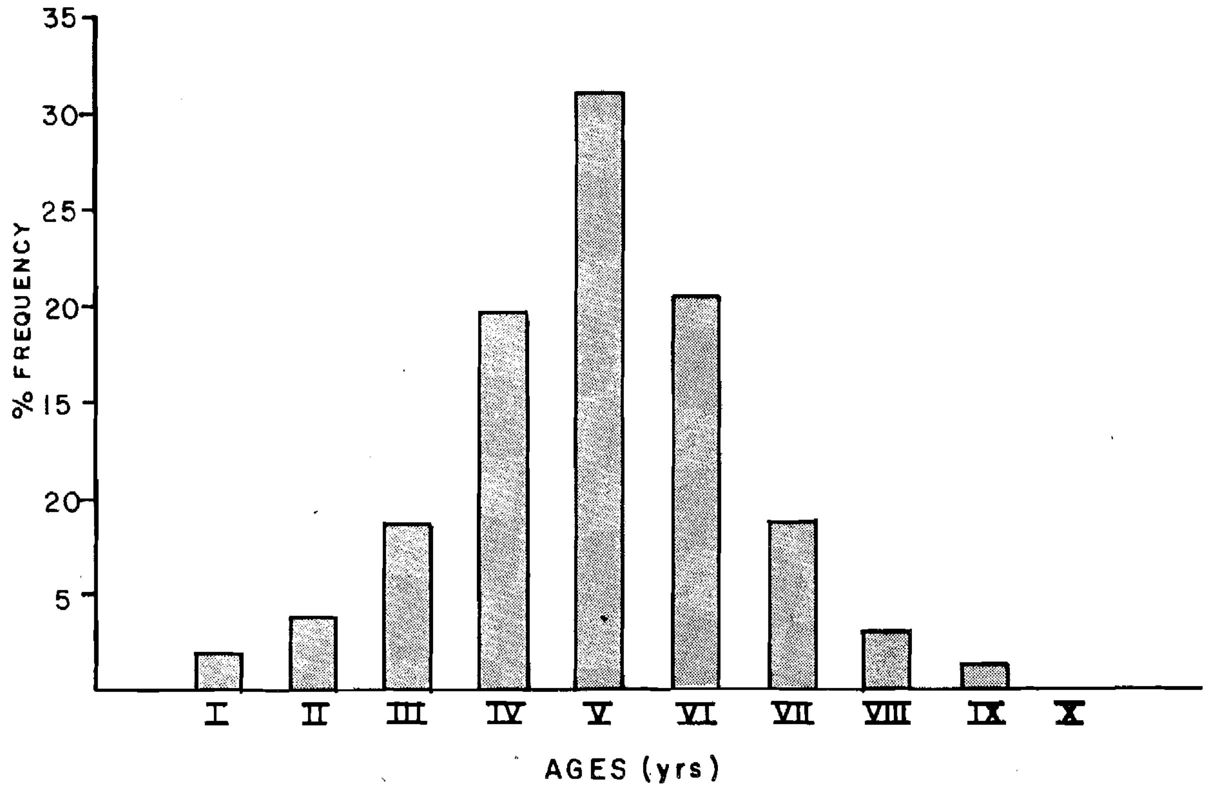


Figure 5-3-16. Arctic grayling age frequency composition, proposed Impoundment Areas, 1982.

Table 5-3-8. Arctic grayling length-frequency by tributary, Proposed Impoundment Areas, 1982, catch data.

			Catch (Numbers/Percent)			Fork	Oshetna	Goose	Jay
Kosina	Watana	Deadman	Tsusena	Fog	Total				
Length (mm)	River	Creek	Creek	Creek	Creek	Creek	Creek	Creek	
less than 200	1/0[a]	10/0	11/4	12/1	10/1	15/8	3/8	1/4	53/1
200-209	5/1	2/1	6/2	8/1	2/0	3/2	0/0	0/0	26/1
210-219	2/0	1/0	1/0	11/1	2/0	9/5	1/1	0/0	27/1
220-229	10/1	4/1	2/1	27/2	5/1	9/5	1/1	0/0	58/1
230-239	20/2	2/1	6/2	31/2	11/2	16/8	1/1	0/0	87/2
240-249	25/3	8/3	12/4	38/2	4/1	13/1	1/1	3/12	104/3
250-259	29/3	8/3	9/3	52/3	11/2	15/8	3/3	2/8	129/3
260-269	36/4	8/3	5/2	56/3	10/2	11/6	2/2	3/9	131/3
270-279	35/4	5/2	18/6	77/4	15/3	15/8	2/2	0/0	167/4
280-289	56/6	14/5	16/5	102/6	18/3	13/7	2/2	0/0	221/5
290-299	76/9	25/9	12/4	125/7	32/6	14/7	2/2	0/0	286/7
300-309	86/10	29/11	25/8	147/8	33/6	6/3	0/0	2/8	328/8
310-319	111/13	29/11	38/12	202/11	43/8	12/6	9/9	1/4	445/11
320-329	96/11	30/11	34/11	196/11	67/12	18/9	10/10	5/20	456/11
330-339	92/11	27/10	37/12	180/10	67/12	11/6	12/12	1/4	427/10
340-349	63/7	30/11	27/9	172/10	74/14	4/2	12/12	2/8	384/9
350-359	41/5	22/8	21/7	123/7	53/10	4/2	15/15	0/0	279/7
360-369	44/5	16/6	12/4	92/5	29/5	5/3	11/11	0/0	209/5
370-379	19/2	9/3	5/2	58/3	20/4	2/1	5/5	3/12	121/3
380-389	7/1	6/2	6/2	29/2	23/4	1/0	4/4	1/4	77/2
390-399	17/2	1/0	4/1	17/1	10/2	0/0	4/4	1/4	54/1
over400	8/1	0/0	2/1	10/1	6/1	1/0	2/2	0/0	29/1
n=	879	276	309	1765	545	197	102	25	4098
mean=	315	320	317	319	332	271	341	322	320
range=	190-420	200-395	140-420	175-420	120-420	130-400	180-410	175-395	120-420

[a] Catch data (numbers/percent)

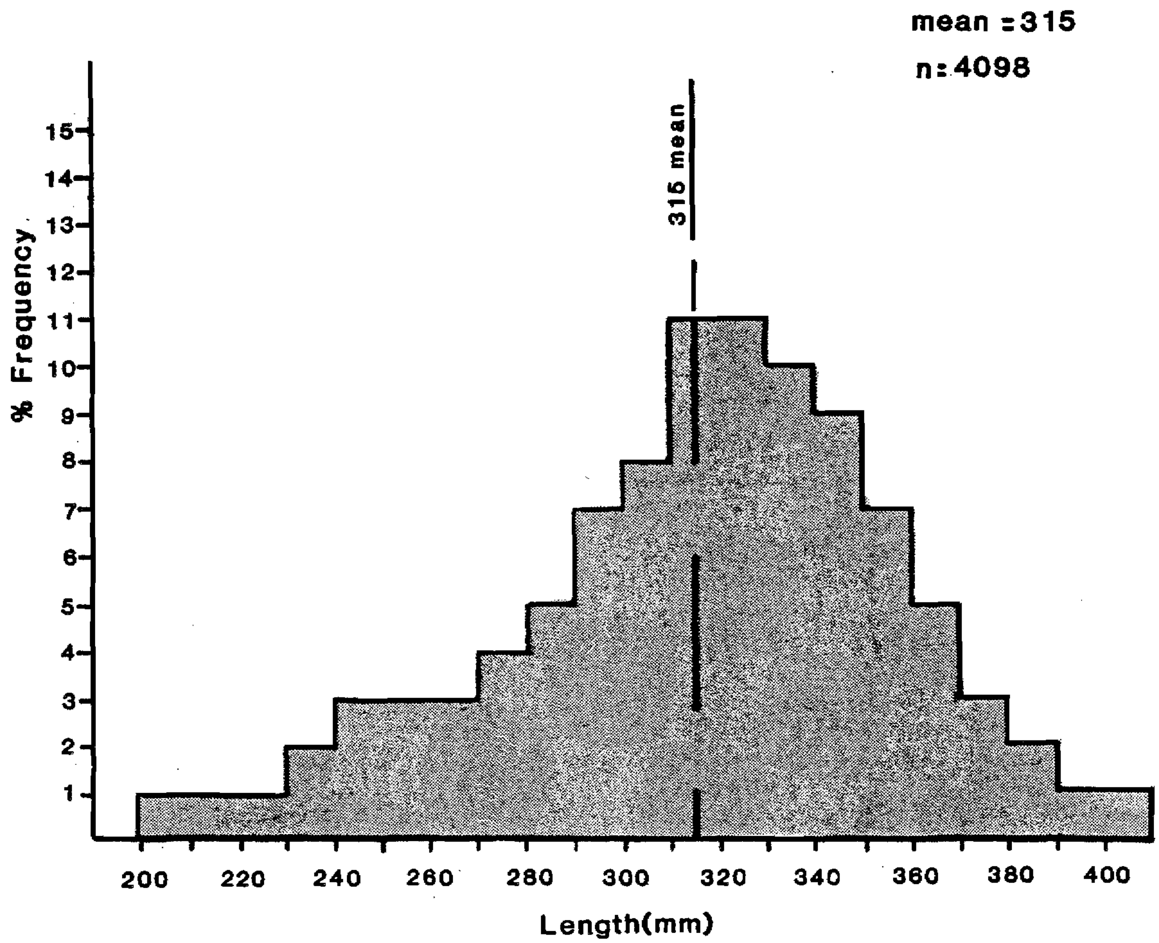


Figure 5-3-17. Arctic grayling length frequency composition for all tributaries combined, Proposed Impoundment Areas, 1982.

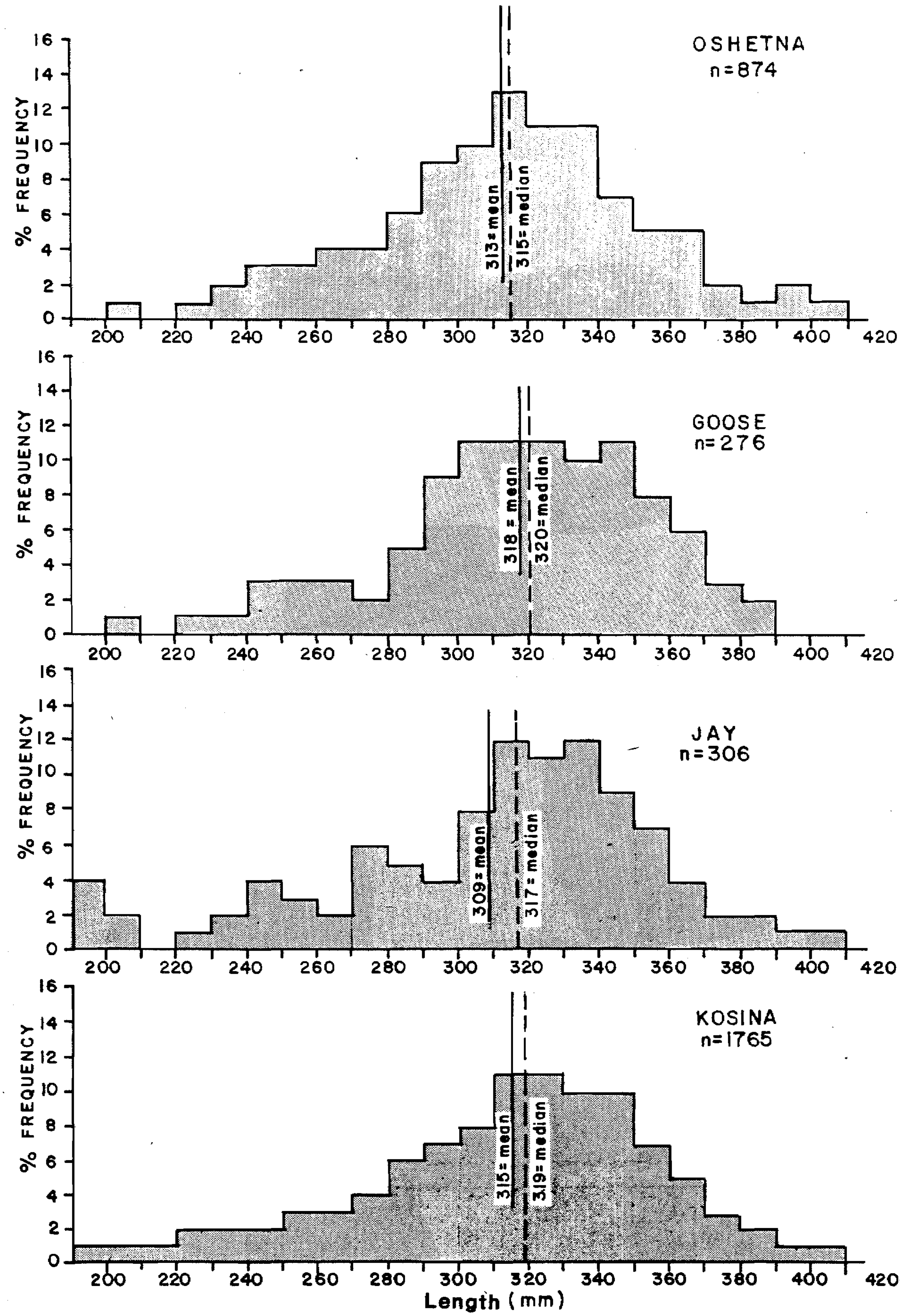


Figure 5-3-18. Arctic grayling length frequency composition by tributary, Proposed Impoundment Areas, 1982.

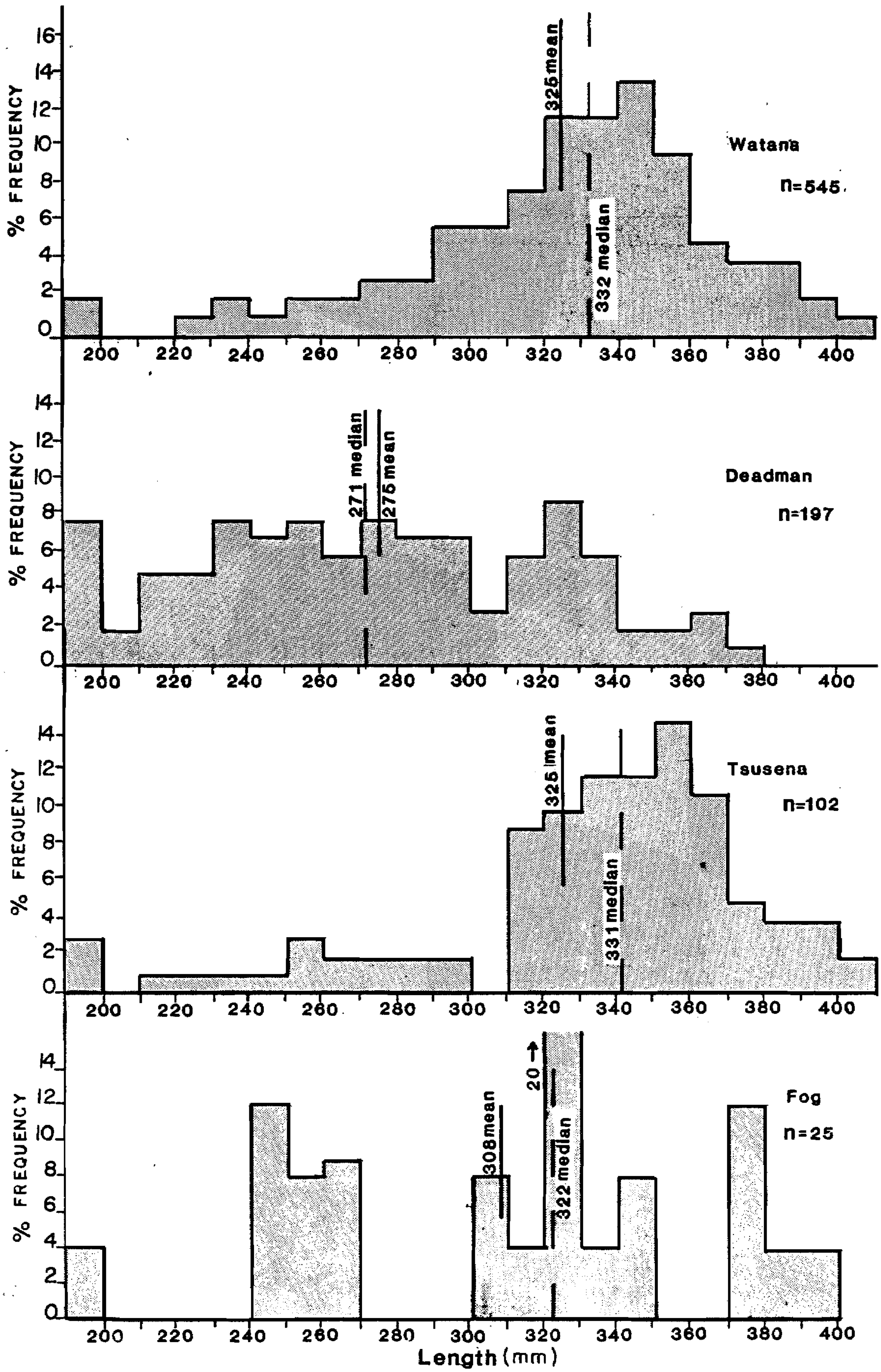


Figure 5-3-18. (continued).

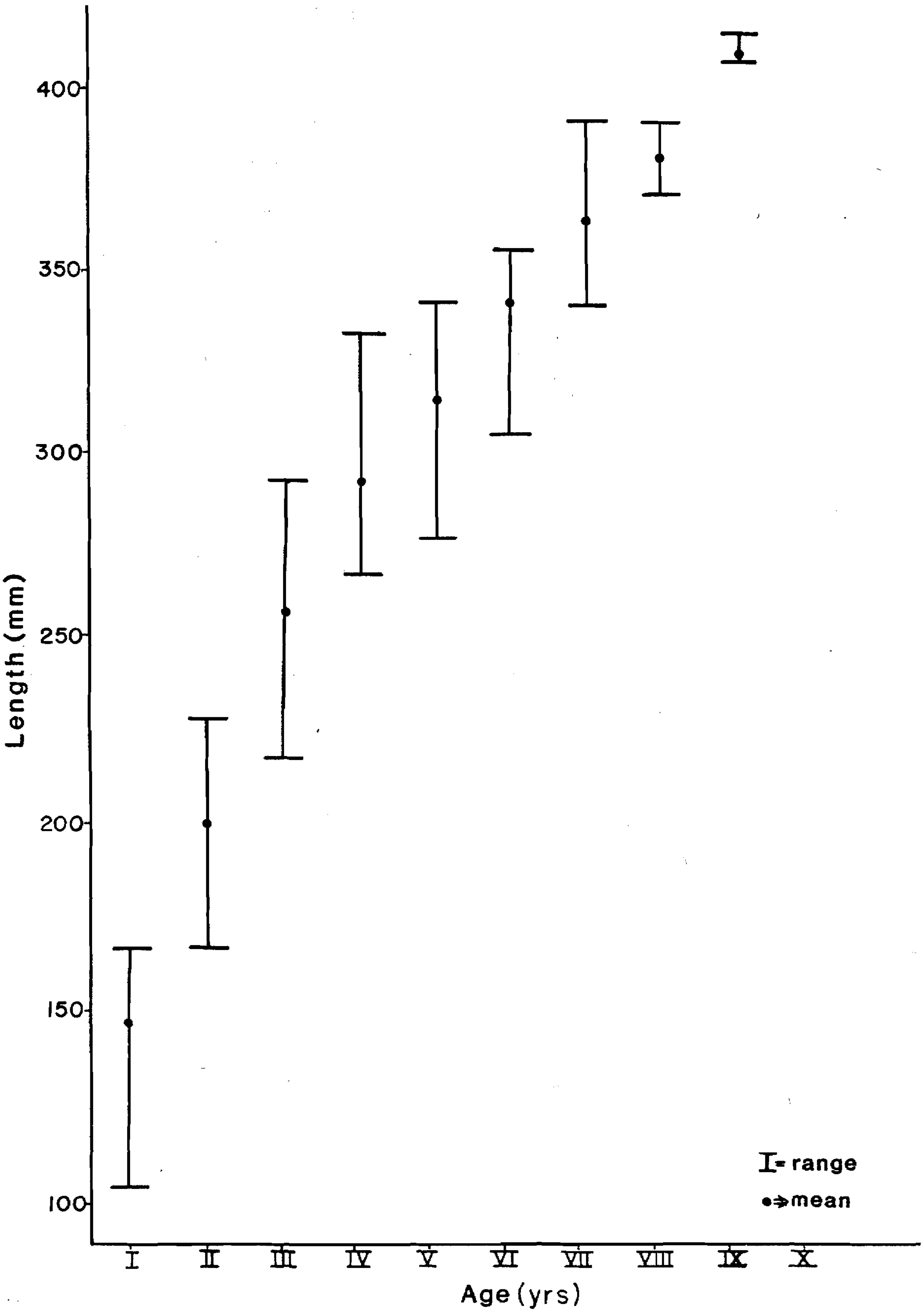


Figure 5-3-19. Arctic grayling age-length relationship for all tributaries combined, Proposed Impoundment Areas, 1982.

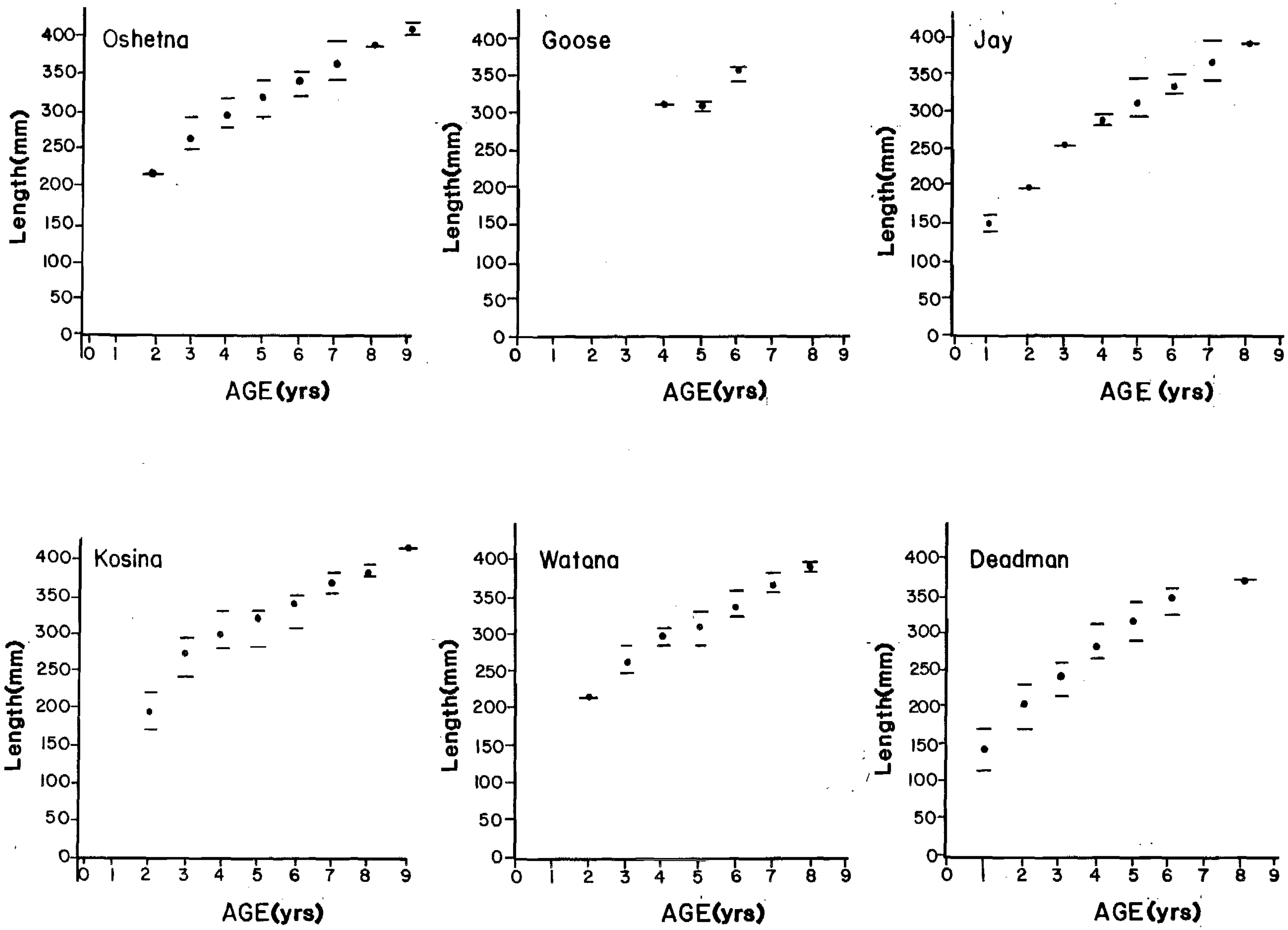


Figure 5-3-20. Arctic grayling age-length distribution, Proposed Impoundment Areas, 1982. (•mean, - range)

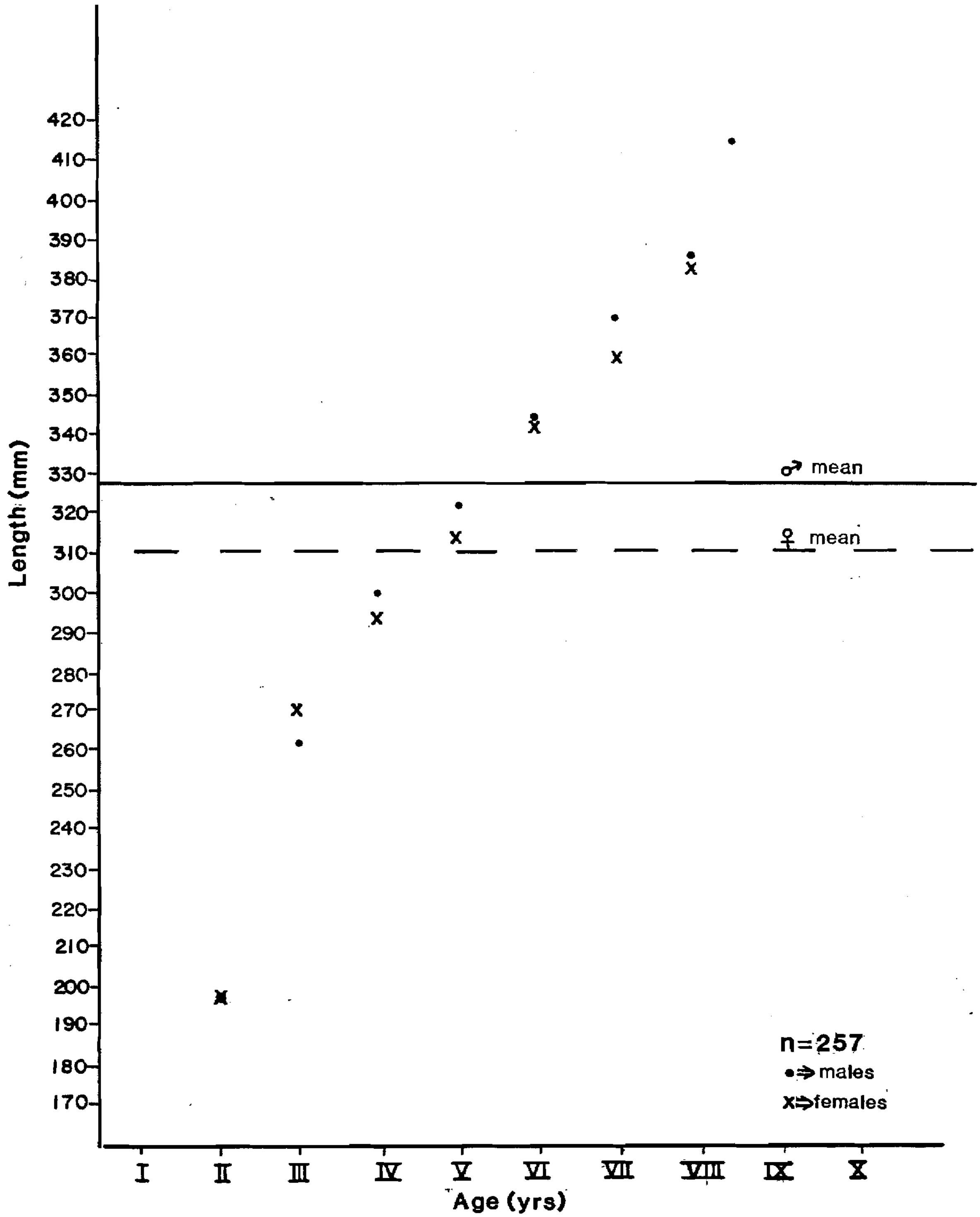
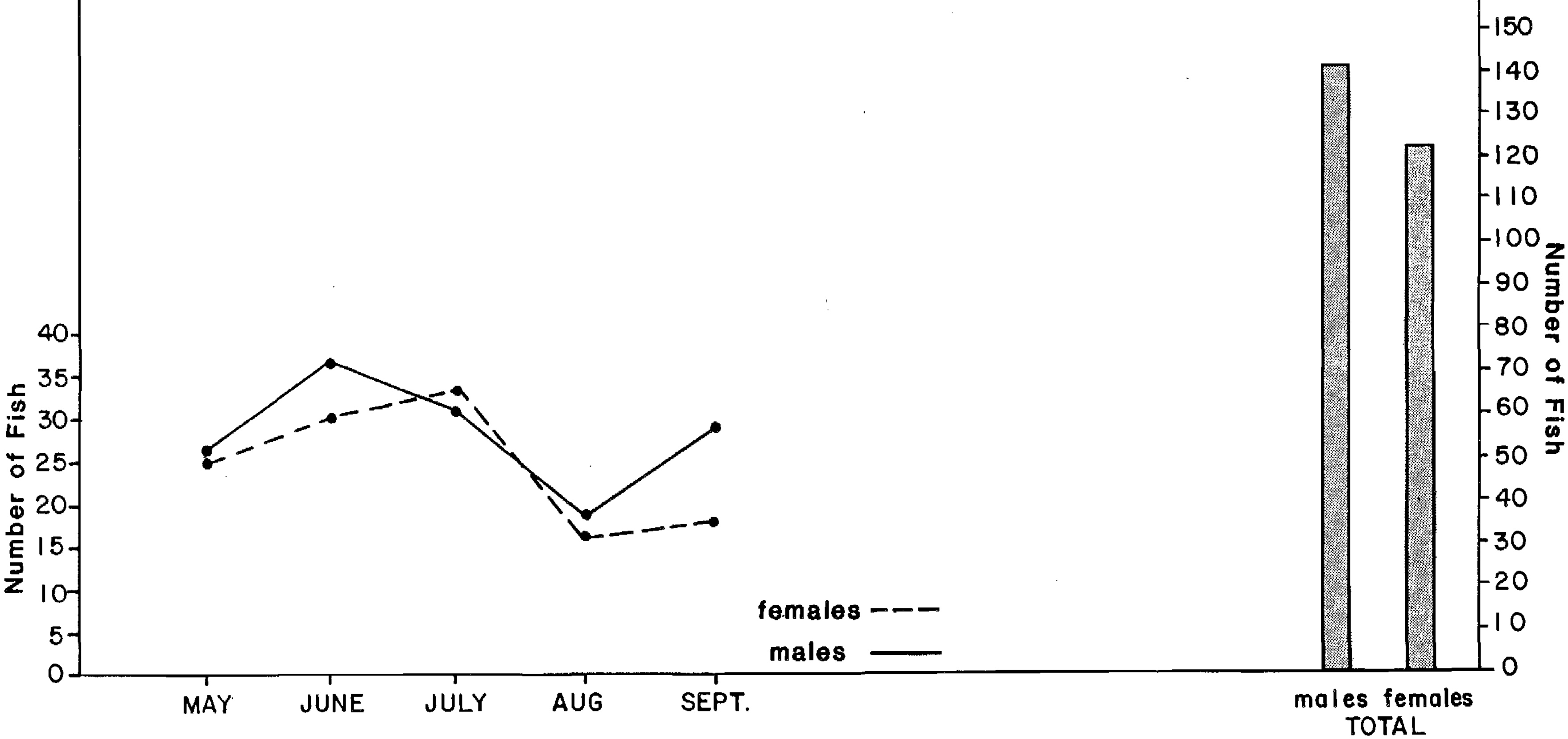


Figure 5-3-21. Arctic grayling age-length relationship, males vs females, Proposed Impoundment Areas, 1982.

MAY	JUNE	JULY	AUG.	SEPT.	TOTAL	
26	37	31	18	29	141	- male
25	30	33	16	18	122	- female
1.04	1.23	0.94	1.13	1.61	1.16	- male/female



Figures 5-3-22. Arctic grayling sex composition by month, Proposed Impoundment Areas, 1982.

sexually mature, while inversely, all males under 330 mm and females under 320 mm were found to be nonspawners or sexually immature. No overlap occurred when lengths of spawning versus nonspawning fish were compared. However, age classes of spawning fish did overlap. Both Age IV and V grayling were found sexually mature and immature depending on their length (Figure 5-3-23).

The instantaneous survival rate was calculated by two methods, using age versus catch and length versus catch. The resulting rates were very similar, being 39.2% and 40.5%, respectively (Figure 5-3-24).

Tagging/Recapture (Migration)

Four thousand sixteen Arctic grayling were tagged during 1982 studies, 3,560 within the proposed impoundment areas and 456 in selected tributary streams above the PIE (Table 5-3-9). Of these 4,016 tagged Arctic grayling, 335 were subsequently recaptured, of which 320 of these (95.5%) were recaptured within the same stream where they were tagged. The majority of these recatpured grayling (67%) were caught at their initial point of tagging within the same stream from 1-100 days later. Movement both upstream and downstream followed the expected pattern with most of the upstream movement occurring in early summer and the downstream movement occurring in the early fall (Table 5-3-10).

Fifteen Arctic grayling were recaptured within tributary streams other than the stream where they were originally tagged, two moving to another

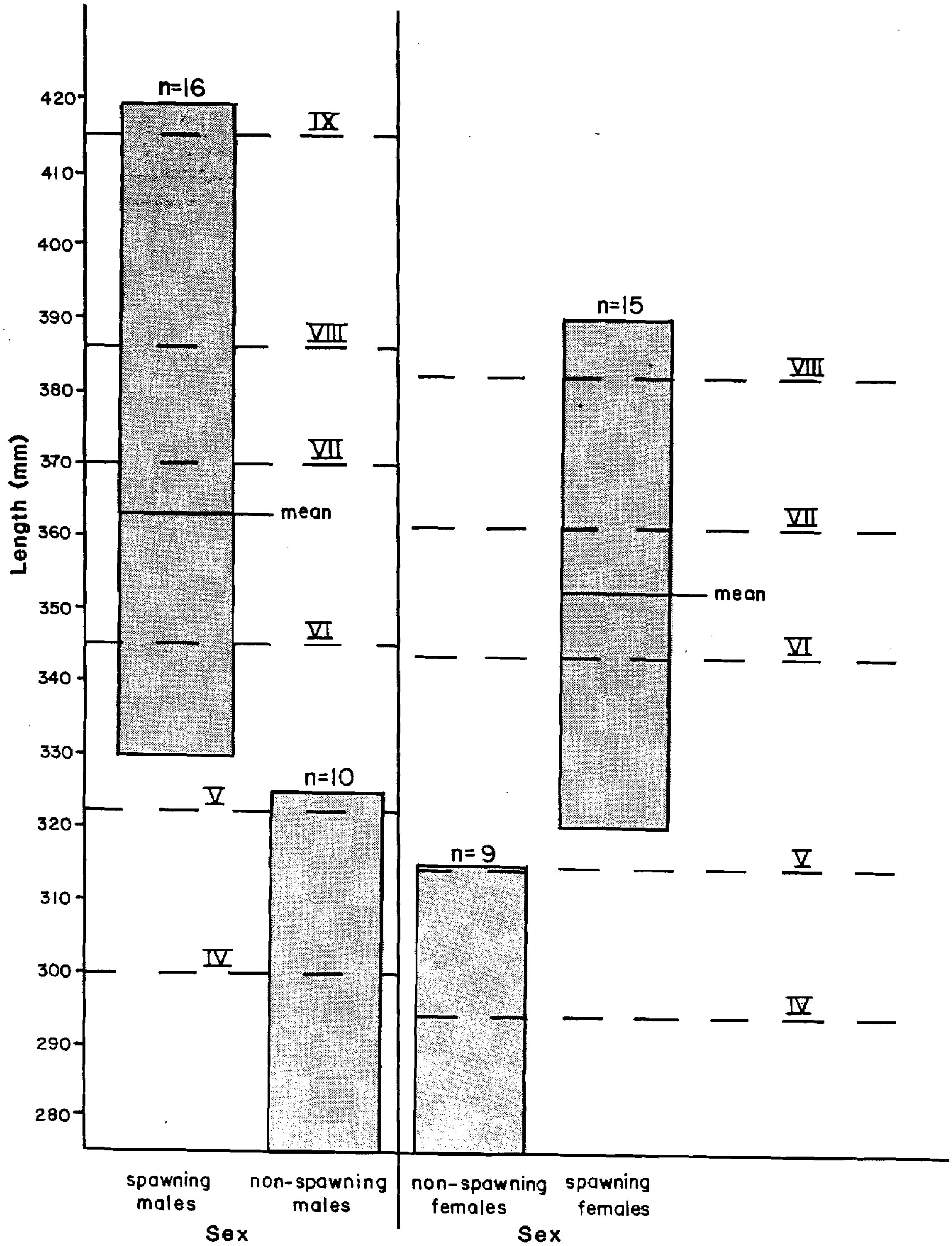


Figure 5-3-23. Arctic grayling length vs. sexual maturity relationship by sex, Proposed Impoundment Areas, 1982.

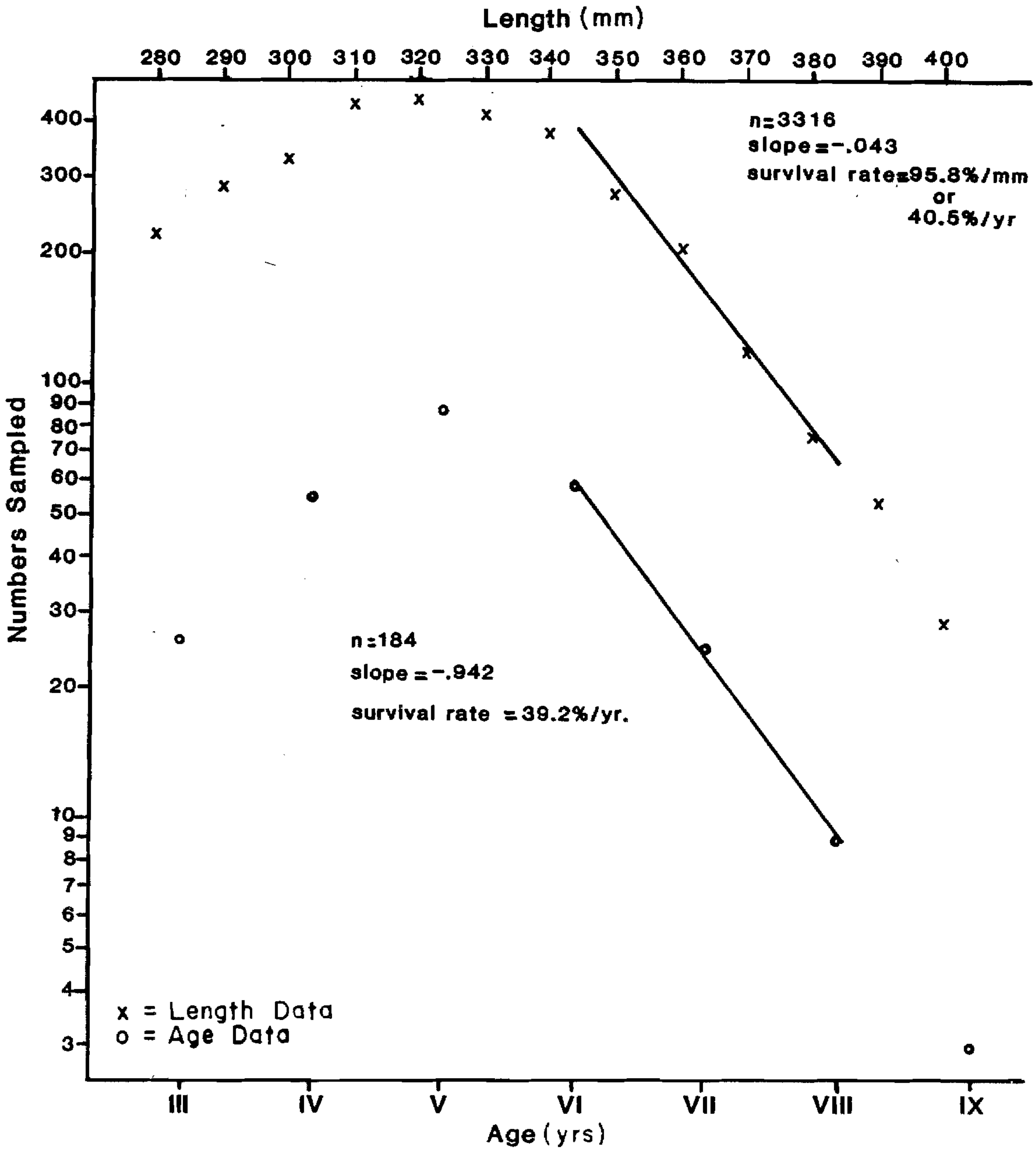


Figure 5-3-24. Arctic grayling instantaneous survival rate curves, Proposed Impoundment Areas, 1982.

Table 5-3-9. Arctic grayling tagged by location and month, Proposed Impoundment Areas, 1982.

Location	May	June	July	August	September	Total
Oshetna River	0	0	275	233	154	662
Goose Creek	0	34	87	76	1	198
Jay Creek	0	53	123	105	4	285
Kosina Creek	16	207	479	589	300	1591
Watana Creek	1	103	163	205	36	508
Deadman Creek	0	33	45	102	1	181
Tsusena Creek	0	10	28	26	2	66
Fog Creek	0	1	5	17	2	25
Others Within Impoundment	4	4	0	2	0	10
Sally Lake	0	3	0	31	0	34
Total	21	448	1205	1386	500	3560
APIE[a] (5 creeks, 1 mile each)	0	0	382	50	24	456
Total	21	448	1587	1436	524	4016

[a]Above proposed impoundment elevations.

Table 5-3-10. Arctic grayling intrastream movement by tributary and month as demonstrated by recoveries of 1982 tagged fish, Proposed Impoundment Areas, 1982.

Tagging Location	Tagging Month	No. Recaptures	Movement No. Up	Movement No. Down	Movement No. Same	(Range) Miles Moved	Days at Large
Oshetna	June	-	-	-	-	-	-
River	July	37	3	5	29	-0.4-+0.3	32-51
	August	6	1	0	5	0.0-+0.2	18-19
	Sept.	0	0	0	0	-	-
Goose	June	9	1	0	8	0.0-+1.0	33-62
Creek	July	8	0	0	8	0.0	28-29
	August	2	0	1	1	-0.2-0.0	1-29
	Sept.	0	0	0	0	-	-
Jay	June	10	1	6	3	-1.1-+0.1	33-49
Creek	July	10	1	4	5	-0.7-+0.1	16
	August	3	3	0	0	+0.2-+0.4	27-37
	Sept.	0	0	0	0	-	-
Kosina	June	38	5	13	20	-1.6-+2.2	31-100
Creek	July	94	10	19	65	-2.7-+2.1	18-68
	August	27	1	11	15	-2.3-+0.4	1-45
	Sept	9	0	6	3	-2.1-0.0	5-19
Watana	June	19	1	1	17	-1.0-+1.0	28-85
Creek	July	28	1	0	27	0.0-+1.0	17-25
	August	3	0	1	2	-4.4-0.0	33
	Sept	0	0	0	0	-	-
Deadman	June	3	1	0	2	0.0-+0.3	29-57
Creek	July	7	4	3	0	-0.2-+0.2	28
	August	0	0	0	0	-	-
	Sept.	0	0	0	0	-	-
Tsusena	June	2	1	0	1	0.0-+0.1	29-58
Creek	July	1	1	0	0	+0.1	29
	August	4	0	0	4	0.0	29
	Sept.	0	0	0	0	-	-

stream up the Susitna River and 13 to another stream down the Susitna. These fish were at large from 2-123 days and moved from 1.7-30.2 miles with averages of 50 days and 13.2 miles (Table 5-3-11).

Of the 2,619 Arctic grayling tagged during 1981 studies, 350 (13.4%) were recaptured during 1982 studies. Three hundred and eight (88%) of these fish returned to their original tagging stream. Forty-two (12%) of the 1981 tagged grayling recaptured were found in streams other than those in which they were tagged, 25 moving to another stream down the Susitna and 17 moving to another stream up the Susitna (Table 5-3-12). One Arctic grayling tagged on June 21, 1981 in Jay Creek (RM 208.5) was recaptured by a sportfisherman on June 22, 1982 in Salt Creek, a small tributary to Tyone Lake. This represents an upstream movement of approximately 75 miles in one year.

Population Estimates

Population estimates based on data collected in July and August were calculated for each of the eight major tributary habitat evaluation locations. Recapture information indicates that grayling movement is at a minimum during these months; 1,205 grayling were tagged and only 2 of the 185 recaptured had moved out of their original habitat evaluation location by August.

The population estimates provided in Table 5-3-13 are for the eight major tributary habitat evaluation locations in their entirety, with the exception of Deadman Creek where only the section studied below the

Table 5-3-11. Arctic grayling interstream movement by location as demonstrated by recoveries of 1982 tagged fish, Proposed Impoundment Areas, 1982.

Tagging Location	Tagging TRM	Tag No.	Date Tagged	Days at Large	Recovery Location	Recovery TRM	Total Miles Moved
Oshetna R.	1.7	11727	9/9	2	Kosina Cr.	1.9	30.2
Goose Cr.	0.0	007405	6/18	102	Kosina Cr.	0.0	24.5
Goose Cr.	0.0	007408	6/18	38	Kosina Cr.	0.1	24.6
Jay Cr. Slough		007021	5/29	86	Kosina Cr.	2.6	4.4
Jay Cr.Slough		007023	5/29	123	Watana Cr.	8.5	23.0
Jay Cr.	0.0	007478	6/24	34	Watana Cr.	4.3	18.7
Jay Cr.	3.0	009405	7/27	49	Kosina Cr.	0.0	4.7
Jay Cr.	2.1	009438	7/27	49	Kosina Cr.	0.6	4.4
Kosina Cr.	0.0	04852	6/23	34	Jay Cr.	0.0	1.7
Kosina Cr.	2.0	009162	7/24	3	Jay Cr.	0.8	4.5
Watana Cr.	8.5	009656	7/28	44	Tsusena Cr.	1.5	22.8
Watana Cr.	0.4	007414	6/28	49	Tsusena Cr.	0.1	13.3
Deadman Cr.	0.0	007061	6/19	29	Tsusena Cr.	0.0	5.4
Deadman Cr.	0.0	007067	6/19	85	Fog Cr.	0.4	10.4
Deadman Cr.	0.3	007437	7/18	28	Tsusena Cr.	0.1	5.8

Table 5-3-12. Arctic grayling interstream movement by location as demonstrated by recoveries of 1981 tagged fish during 1982, Proposed Impoundment Areas, 1982.

Tagging Location	Recapture Location	Numbers Recaptured
Oshetna River	Oshetna River	65
Goose Creek	Goose Creek	36
Goose Creek	Jay Creek	5 [a]
Goose Creek	Oshetna River	1
Goose Creek	Kosina Creek	1 [a]
Jay Creek	Jay Creek	36
Jay Creek	Goose Creek	3 [a]
Jay Creek	Kosina Creek	8
Jay Creek	Watana Creek	1
Jay Creek	Tyone Lake	1 [a]
Kosina Creek	Kosina Creek	124
Kosina Creek	Deadman Creek	5
Kosina Creek	Goose Creek	1 [a]
Kosina Creek	Watana Creek	1
Kosina Creek	Kosina Slough	1
Kosina Slough	Kosina Slough	1
Kosina Slough	Kosina Creek	3
Kosina Slough	Watana Creek	1
Watana Creek	Watana Creek	16
Deadman Creek	Deadman Creek	7
Deadman Creek	Kosina Creek	1
Deadman Creek	Fog Creek	1
Deadman Creek	Oshetna River	1 [a]
Deadman Creek	Tsusena Creek	1
Tsusena Creek	Tsusena Creek	20
Tsusena Creek	Oshetna River	1 [a]
Tsusena Creek	Jay Slough	1
Tsusena Creek	Kosina Creek	2
Tsusena Creek	Watana Creek	1
Fog Creek	Fog Creek	3
Fog Creek	Goose Creek	1 [a]
		350

308 returned to same stream
42 changed streams
[a] through Vee Canyon

Table 5-3-13. Arctic grayling population estimates by tributary habitat evaluation location, Proposed Impoundment Areas, 1982.

Location	Population Estimate [a]	Grayling/ Mile	Grayling/ Acre
Oshetna River	2426	1103	56
Goose Creek	949	791	90
Jay Creek	1592	455	101
Kosina Creek	5544	1232	69
Watana Creek	3925	324	44
Deadman Creek [c]	734	1835	273
Tsusena Creek [d]	1000		
Fog Creek [d]	176	440	
Totals	16,346	664	

[a] correction factor included.

[b] 95%.

[c] Includes only that part of Deadman Creek below falls

[d] 1981 estimates.

falls is included. Insufficient data were obtained at Tsusena and Fog Creeks during 1982, so the 1981 population estimates have been used. (Actual data used for population estimates is listed in Table 5-3-14). Population estimates range from a low of 176 Arctic grayling in the Fog Creek habitat evaluation location to a high of 5,544 Arctic grayling in the Kosina Creek habitat evaluation location, with a total estimate of 16,346 for the eight major tributary habitat evaluation locations combined. Estimates of numbers of Arctic grayling per mile ranged from a low of 324 in Watana Creek to a high of 1,232 in Kosina Creek, with an average of 664 for the 24.5 miles of tributary waters to be impounded. Densities ranged from 44 to 273 Arctic grayling per acre of stream.

Population estimates were also calculated for each age class present in the sample. The capture/recapture probability for Arctic grayling Age IV and less was found to be significantly lower than for the older fish, Age V-IX (Table 5-3-15). A correction factor of 1.2951 was calculated based on the ratio of the sum of the population estimates for each age class versus the population estimate for all age classes combined.

Spawning

The first Arctic grayling were observed at the mouths of tributaries on May 13, 1982 but none were observed upstream until May 26, 1982. Surveys were not comprehensive, but spawning Arctic grayling were found in four locations; three pools at TRM 1.4, 1.2 and 0.1 on Kosina Creek, and one pool at TRM 2.1 on the Oshetna River. Characteristics of these pools were similar, including low water velocity, three to six foot

Table 5-3-14. Data used for Arctic grayling population estimates, Proposed Impoundment Areas, 1982.

Stream	Reach	No. Marked July (M)	No. Recaptured August (R)	No. Caught August (C)
Oshetna River	Pools	82	15	115
	Riffles	184	16	108
	Mouth	7	1	20
Goose Creek	all	87	8	74
Jay Creek	all	123	10	108
Kosina Creek	Pools	209	32	337
	Riffles	195	24	213
	Mouth	73	13	82
Watana Creek	East Fork	28	6	58
	West Fork	73	13	82
	Middle Section	61	8	68
Deadman Creek	all	45	8	110
Tsusena Creek	all	28	1	26
Fog Creek	all	5	0	17

$$N = \frac{(M+1)\ (C+1)}{(R+1)}$$

Table 5-3-15. Arctic grayling population estimates by age class, Proposed Impoundment Areas, 1982.

Age	Length (mm)	No. Marked in July (M)	% R/M	No. Recaptured in August (R)	No. Caught in August (C)	N
I	(less than 175)	5	3.3	0	2	1955
II	(176-231)	86		3	82	
III	(232-278)	226	4.4	10	222	4602
IV	(279-307)	263	8.8	23	263	2904
V	(308-331)	321	13.7	44	342	2454
VI	(332-356)	204	23.5	48	270	1134
VII	(357-377)	81	19.8	16	107	521
VIII	(378-399)	27	25.7	7	41	180
IX	(more than 400)	8		2	8	
						13,750
Totals		1221		153	1337	10,617

$$\frac{\text{total each age estimate}}{\text{total estimate}} = \frac{13{,}750}{10{,}617} = 1.2951 \text{ correction factor}$$

depths, and a large area of small (sand to 1" gravel) substrate. Arctic grayling were also observed at this time in the tributaries below these pools, but none were found further upstream.

Juveniles

Juvenile Arctic grayling were observed in all of the eight major tributaries sampled, both above and below the PIE. Scattered individuals and small schools (less than 25) were observed along the banks of the tributaries in side channels, backwater areas, pool edges and small sloughs. Characteristics of these areas were low water velocity, shallow (less than one foot) depth and abundant cover consisting of large rocks and vegetation. Large concentrations of juveniles were found early in the summer at tributary mouths and throughout the summer in clear water sloughs off the mainstem Susitna River just above and below Jay Creek at RM 208.7 and 208.1 and below Watana Creek at RM 193.5. These sloughs generally have springs as their source and periodically are completely cut off from the Susitna.

3.1.2.2 Dolly Varden

Dolly Varden were found to be more widely distributed in the proposed impoundment areas than past studies have shown, with observations being made in Cheechako, Devil, Watana, Jay and upper Deadman Creeks. Habitat occupied by Dolly Varden in these streams varied significantly from that occupied by Arctic grayling, with most observations occurring in "plunge pool" type habitats.

A total of 16 Dolly Varden were captured. All were of the resident stunted or dwarf variety with lengths ranging from 120 mm to 205 mm (Plate 5-3-4).

3.2 Mainstem Habitat and Fisheries Investigations

3.2.1 Aquatic Habitat Investigations

Mainstem Susitna River Aquatic Habitat investigations within the impoundment study area included general water quality data collection at designated sites, mapping of general habitat characteristics at selected habitat evaluation sites, and identification of slough habitats within the study area during 1982. Aerial surveys were conducted on the entire mainstem study reach to generally evaluate the habitat characteristics of this area. Time, personnel constraints, and study priorities did not permit a more in depth assessment of the mainstem habitat during 1982.

3.2.1.1 General Characteristics of Mainstem Study Area

The mainstem Susitna River habitat evaluation location consists of the reach of the Susitna River within the impoundment study area (RM 152 to RM 239). This reach was divided into two study reaches corresponding to the proposed impoundment it was located in. The Devil Canyon study reach extends for 32 miles from the Devil Canyon dam site (RM 152.0) to the Watana dam site (RM 184.0) and has a gradient of approximately 18 feet/mile. The Watana study reach extends for 55 miles from

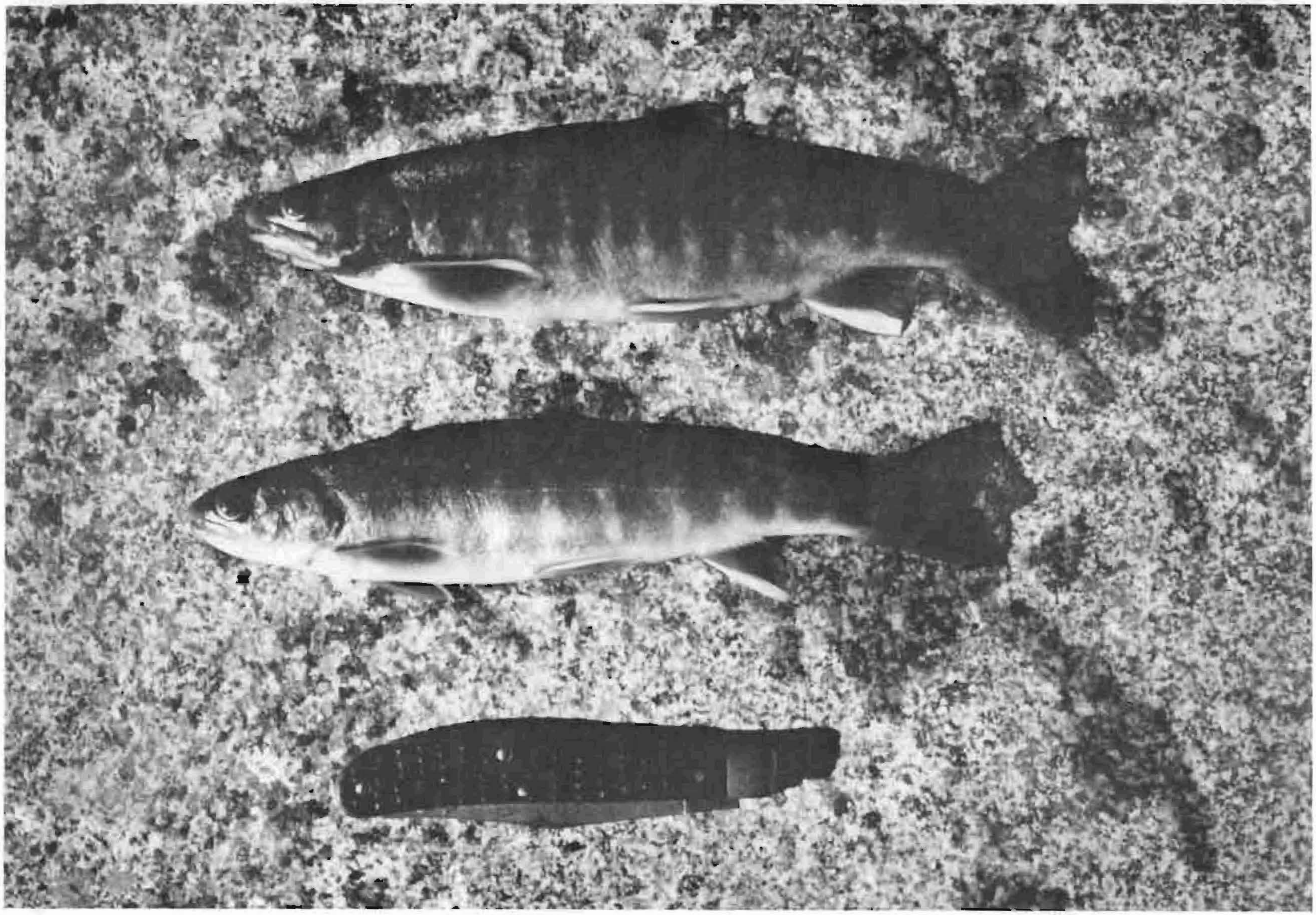


Plate 5-3-4   Male and female resident Dolly Varden found in Devil Creek.

the Watana dam site (RM 184.0) to a point approximately five miles above the confluence of the Oshetna and Susitna Rivers (RM 239.0). The gradient in this study reach is approximately 13 feet/mile. The stream channel in this reach is not as confined as in the Devil Canyon reach and often splits into two or more channels. Streamflow velocities are generally lower than those in the Devil Canyon reach.

The seven mainstem sites where fish sampling was conducted were mapped to show the general characteristics of these sites. These maps are presented in Appendix Figures 5-D-2 to 5-D-8. The legend for these maps is presented in Appendix Figure 5-D-1.

3.2.1.2 Water Quality

Instantaneous water quality and air temperature data collected at all mainstem and slough sites are presented in Appendix Tables 5-C-18 to 5-C-27. Graphical representations of the range, mean and median values for each water quality parameter for each habitat evaluation site are presented in Figures 5-3-2 to 5-3-7. Due to the limited number of observations made at each site, and the variations in daily sampling times, a comparison of ranges, means and medians between sites is not valid. Therefore, these data only provide a general overview of the water quality characteristics of streams which were investigated.

The lowest instantaneous surface water temperature recorded in the Susitna River was 0.1°C above Goose Creek on May 14, 1982, while the highest temperature of 13.6°C was observed above Jay Creek Slough on June 24, 1982 (Figure 5-3-2).

Mainstem instantaneous dissolved oxygen concentrations ranged from 9.0 mg/l above Fog Creek on August 15, 1982 to 13.5 mg/l above Goose Creek on May 14, 1982 (Figure 5-3-3).

Percent dissolved oxygen saturation values at Susitna River evaluation sites varied from 83% above Fog Creek to 105% above Goose and Watana Creeks (Figure 5-3-4).

Observed pH values ranged from 6.6 above Goose Creek to 8.1 above Deadman Creek (Figure 5-3-5).

Specific conductance observations at all mainstem Susitna River evaluation sites ranged from 59 umhos/cm above the Oshetna River to 144 umhos/cm above Oshetna River (Figure 5-3-6).

Turbidities for the mainstem varied considerably over the course of the sampling period and among sampling sites. Observed turbidities varied from 14 NTUs above Goose Creek on May 14, 1982 to 150 NTUs recorded above Watana Creek on August 16, 1982 and Tsusena Creek on July 26, 1982 (Figure 5-3-7).

3.2.1.3 Discharge

Daily USGS provisional discharge data for the mainstem Susitna River at gaging station No. 15291500 near Cantwell (USGS 1982) was used to construct a corresponding Susitna River hydrograph (Figure 5-3-25). During the 1982 open water field season, the minimum discharge, 1,400 cfs, occurred on May 1, 1982, while the maximum discharge, 24,100 cfs, occurred on June 21, 1982. Mean discharge for this period was 12,400 cfs.

3.2.1.4 Mainstem Slough Habitats

Aquatic habitat investigations during the 1982 field season in the proposed impoundment areas have identified four major mainstem slough areas. These four areas are referred to as Watana Creek Slough (RM 193.5), Kosina Creek Slough (RM 205.6), Lower Jay Creek Slough (RM 208.1), and Upper Jay Creek Slough (RM 208.7). These sloughs are located in spring fed overflow channels adjacent to the mainstem Susitna River. Limited water quality data was collected only at Upper and Lower Jay Creek Sloughs and is presented in Appendix Tables 5-C-23 and 5-C-24.

In addition to the slough areas identified in the field, six additional areas which may classify as mainstem slough habitats were identified from color aerial photos (scale 1" = 2000') of the proposed impoundment areas. Four of these sites are located 3-4 miles below the mouth of Fog Creek; one site is located approximately five miles below the mouth of Kosina Creek; and the last site is located approximately three miles

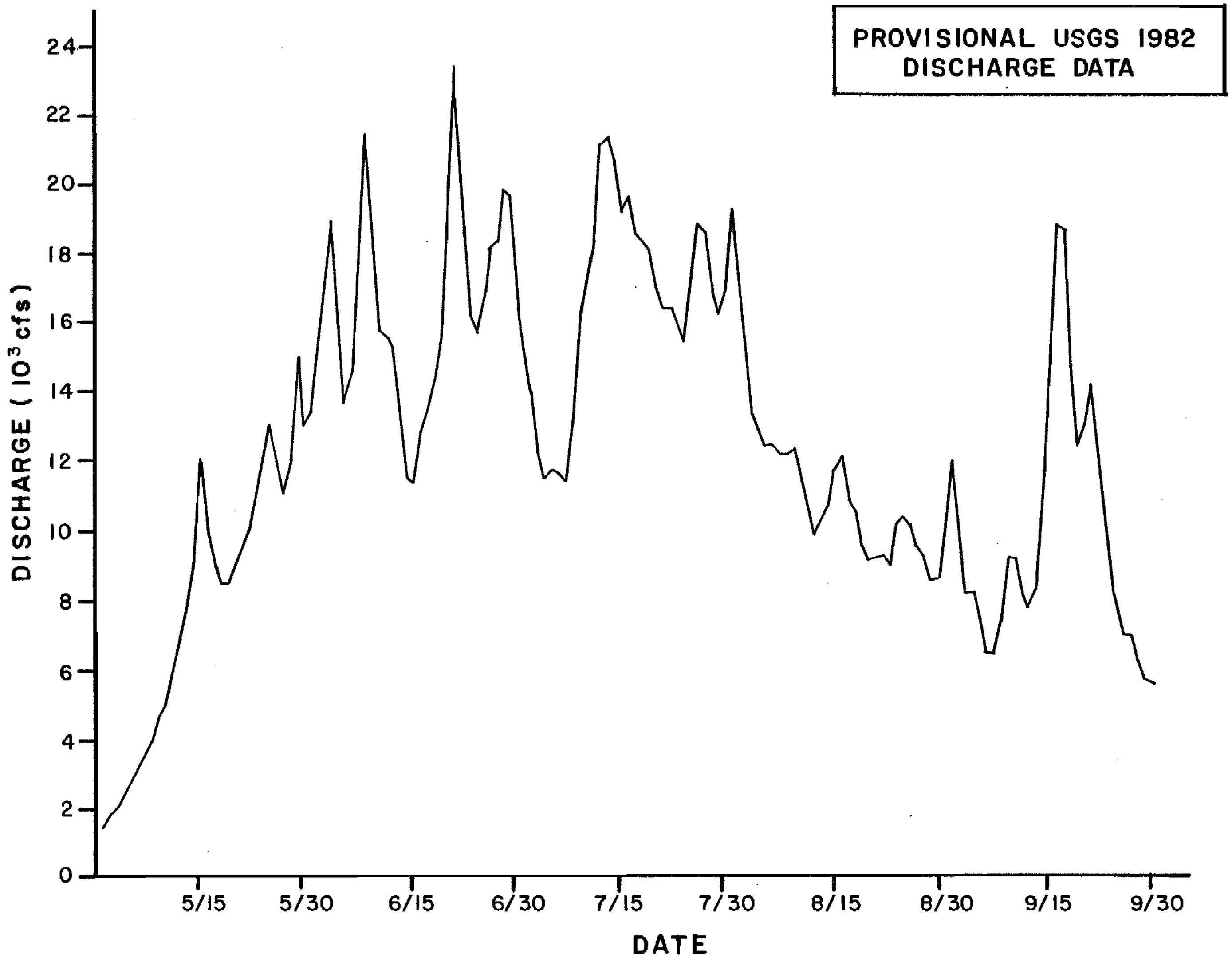


Figure 5-3-25. Susitna River hydrograph at Vee Canyon, RM 223.3 (USGS gaging station No. 15291500), from May 1 through September 30, 1982 (USGS 1982).

above the mouth of Jay Creek. These slough habitats have not been verified by ground surveys at present.

3.2.2 Resident Fisheries Investigations

3.2.2.1 Burbot

Distribution and Abundance

Burbot (*Lota lota* L.) were captured at all of the seven mainstem habitat evaluation sites. One hundred and eighty-five trotline sampling days produced a total catch of 135 burbot. Burbot catches per trotline day ranged from 0.6 to 3.5 with the mean being 0.7. Table 5-3-16 lists the burbot catch and catch rates by mainstem site and month.

Age, Length, Sex

A subsample of 63 burbot were aged by otolith analysis. These fish ranged from age IV to age X. Age V was the dominant age class, comprising 43% of the sample (Figure 5-3-26).

Lengths were taken from all burbot captured. Lengths ranged from 178 mm to 740 mm with the 350 mm to 450 mm burbot occurring most frequently (59%). The mean and median lengths were 438 mm and 415 mm respectively (Figure 5-3-27).

Table 5-3-16. Burbot catch and catch per trotline day by mainstem site and month, Proposed Impoundment Areas, 1982.

Mainstem Site	Catch (numbers/(catch per trotline day) May	June	July	August	September	Total
1	--.--	--.--	3/(0.8)	6/(1.5)	7/(1.8)	16(1.3)
2	--.--	--.--	3/(0.8)	1/(0.3)	0/(0.0)	4/(0.3)
3	--.--	8/(2.0)	3/(0.8)	--.--	--.--	11/(1.4)
3A	--.--	--.--	--.--	6/(1.5)	7/(1.8)	13/(1.6)
4	--.--	5/(1.3)	10/(2.5)	7/(1.8)	2/(0.5)	24/(1.5)
5	--.--	4/(1.0)	2/(0.5)	4/(1.0)	2/(0.5)	12/(0.8)
Watana Creek Mouth	7/(3.5)	17/(0.6)	9/(0.3)	13/(0.4)	9/(0.4)	55/(0.5)
Total	7/(3.5)	34/(0.8)	30/0.6)	37/(0.7)	27/(0.6)	135/(0.7)

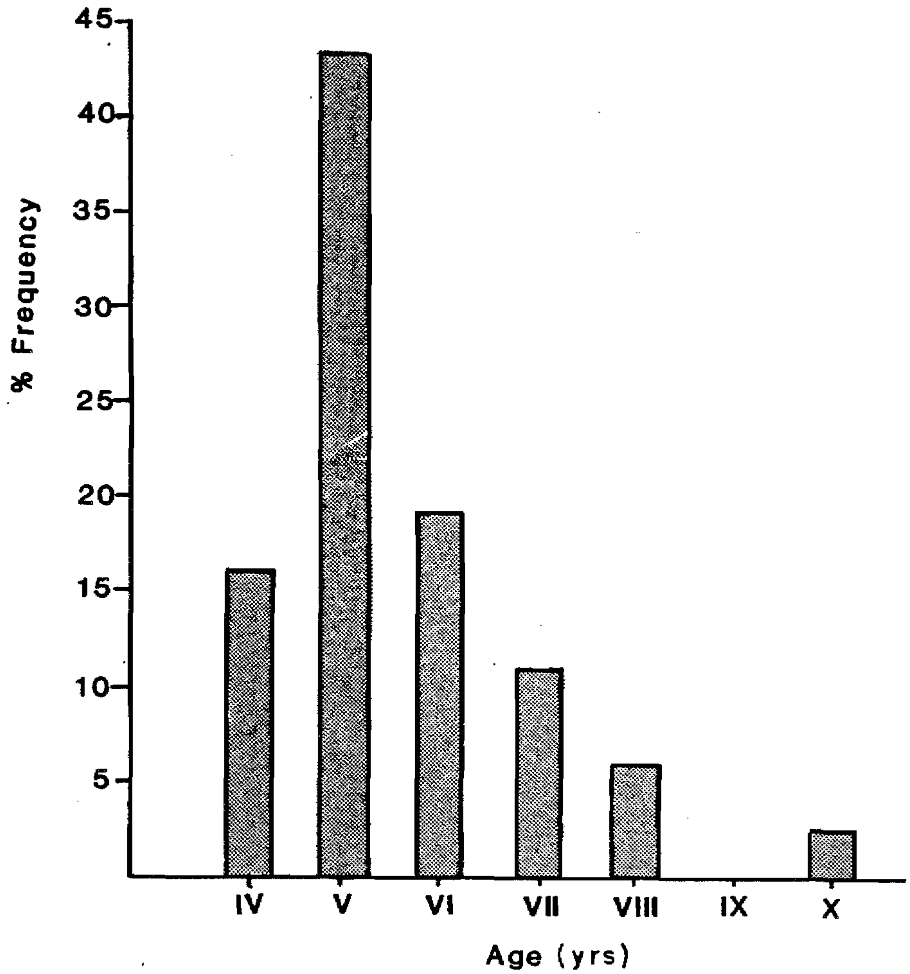


Figure 5-3-26. Burbot age-frequency composition, Proposed Impoundment Areas, 1982.

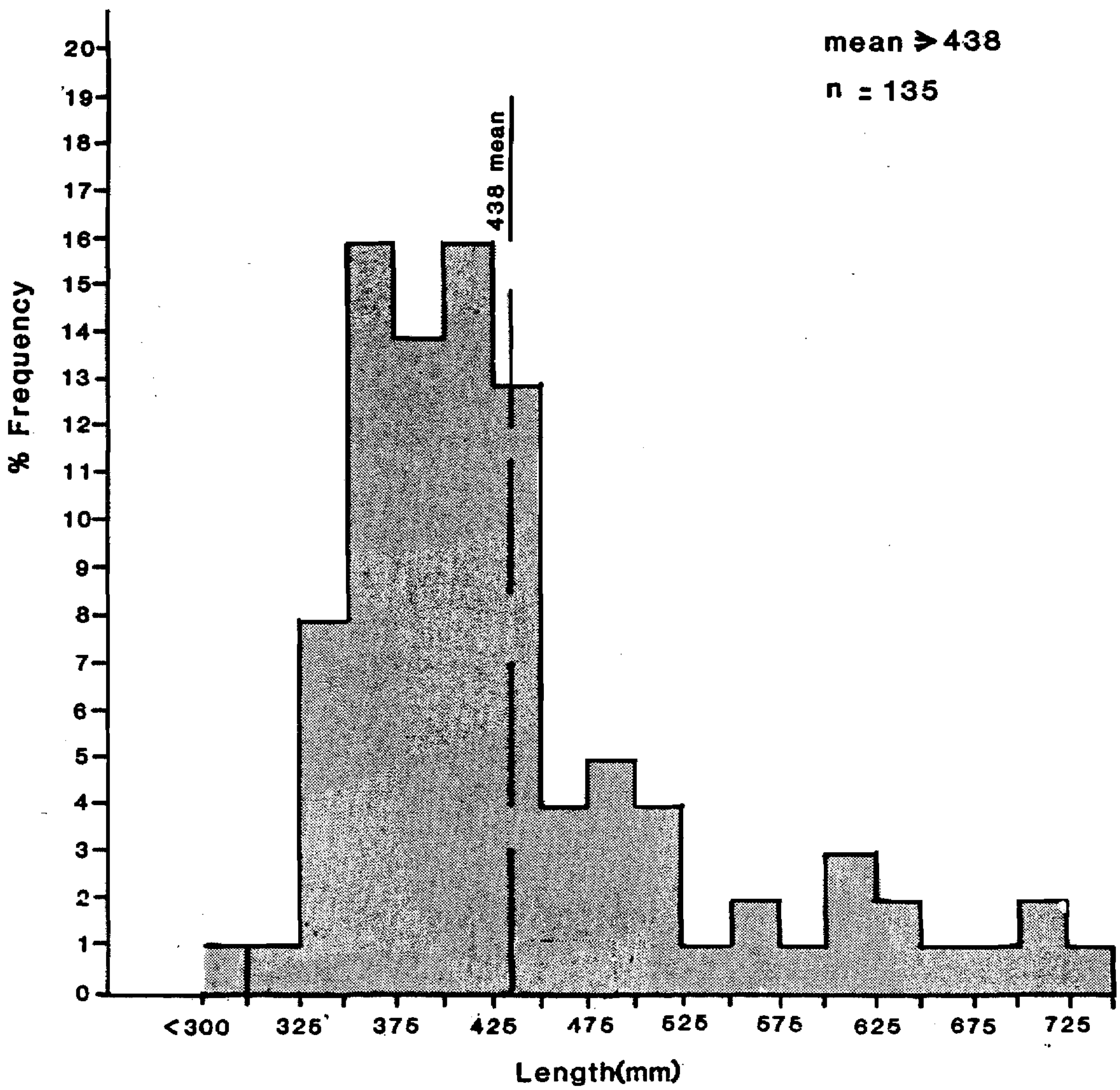


Figure 5-3-27. Burbot length frequency composition, Proposed Impoundment Areas, 1982.

Of the sixty-three burbot that were examined for sex determination; 31 were males and 32 were females (Table 5-3-17). The age-length relationships shown in Figures 5-3-28 and 5-3-29 are calculated for the entire subsample and as a comparison between males and females.

Tagging/Recapture

Sixty-nine burbot were tagged at mainstem sites during 1982 studies, the majority at the Watana Creek site (Table 5-3-18). Three of these burbot were recaptured from 27-42 days later at their original point of tagging. Of the 23 burbot tagged during 1981 studies, four were recaptured during 1982 studies. All were at large from 11-13 months and were captured at their original point of tagging.

3.2.2.2 Longnose Sucker

Distribution and Abundance

Longnose suckers (Catostomus catostomus Forster) were captured at four of the seven mainstem habitat sites. All of the 66 suckers were captured by gillnets. The majority (53) were taken at the Watana Creek site. Longnose sucker catches by month and site are given in Table 5-3-19.

Table 5-3-17. Burbot age, length and sex frequency, Proposed Impoundment Areas, 1982.

Age	Total No. Fish Sampled	Mean Length(mm)	Range of Lengths	Males No./%	Females No./%
IV	10	361	330-385	6/60	4/40
V	27	388	290-445	12/44	15/56
VI	14	444	340-540	7/50	7/50
VII	7	471	420-575	3/43	4/57
VIII	4	611	55-670	2/50	2/50
XI	0	-	-	-	-
X	1	675	-	1/100	0/0
Total	63	424	290-670	31/49	32/51

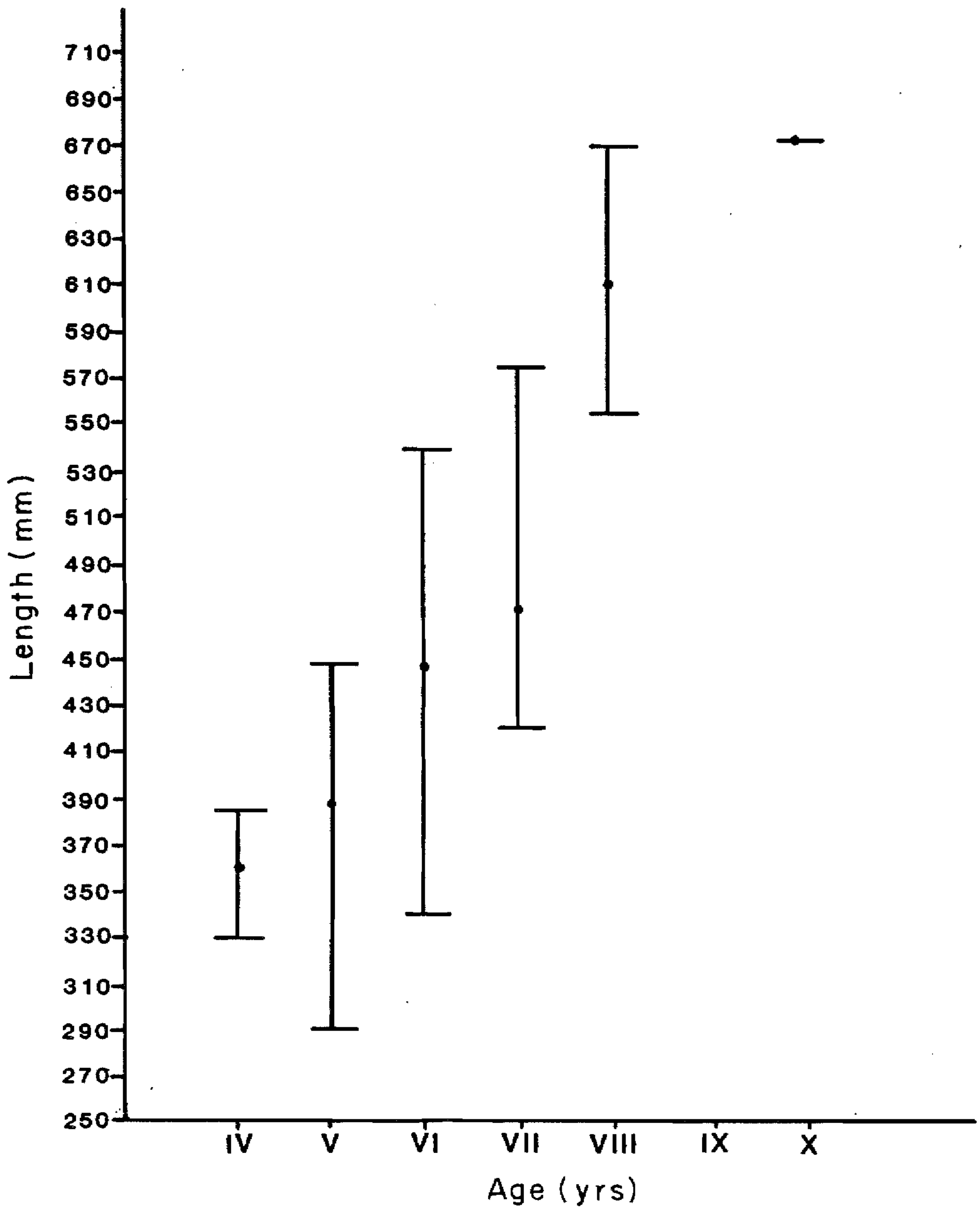


Figure 5-3-28. Burbot age-length relationship, Proposed Impoundment Areas, 1982. (˙ = mean, I = range)

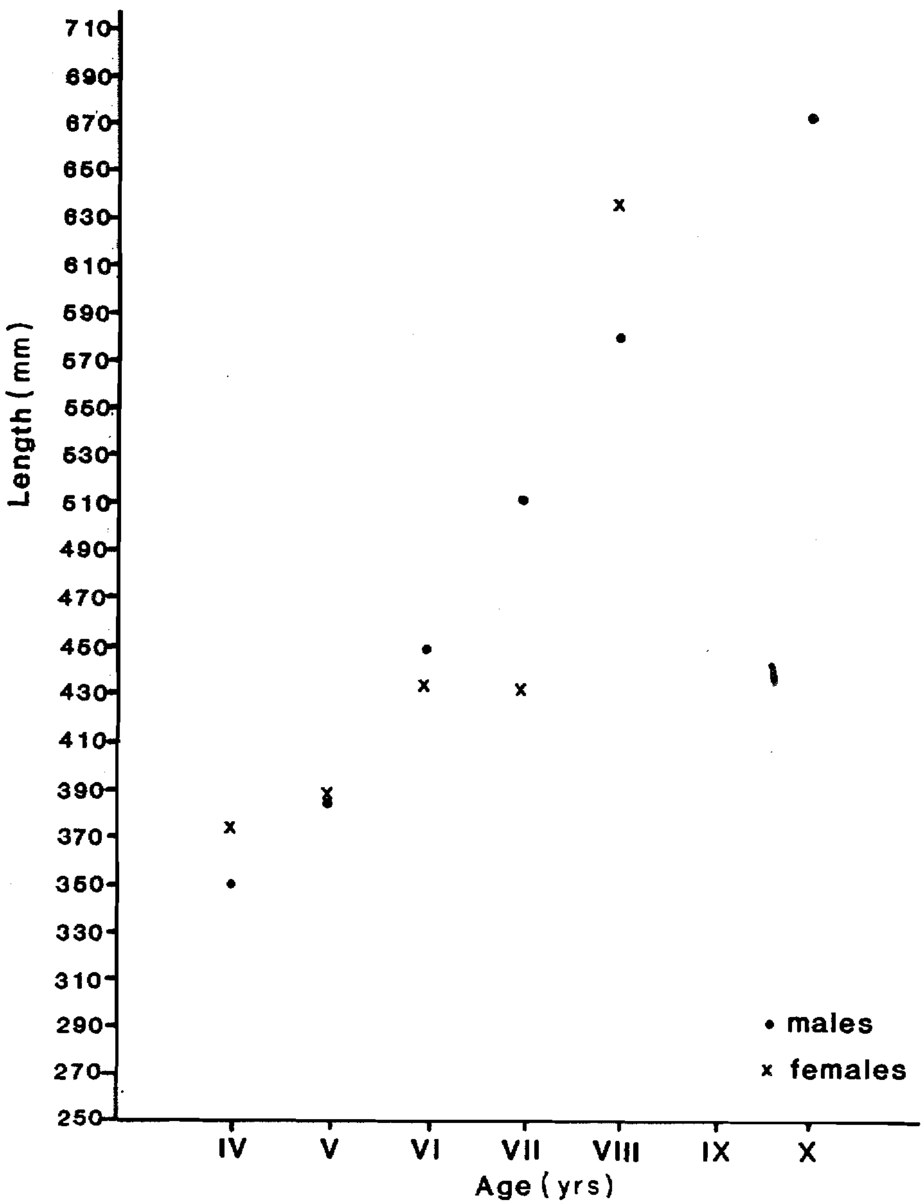


Figure 5-3-29. Burbot age-length relationship, males vs. females, Proposed Impoundment Areas, 1982.

Table 5-3-18. Burbot tagged by mainstem site and month, Proposed Impoundment Areas, 1982.

Mainstem Site	Catch					
	May	June	July	August	Sept.	Total
1	-	-	3	5(1)	3	11
2	-	-	1	1	0	2
3	-	3	2	-	-	5
3A	-	-	-	5	3	8
4	-	1	8	2	0	11
5	-	3	4	1	2	10
Watana Creek Mouth	1	6	2(1)	9(1)	4	22
Total	1	13	20	23	12	69

( ) number of recaptures

Table 5-3-19. Longnose sucker catches by mainstem site and month, Proposed Impoundment Areas, 1982.

Mainstem Site	Catch					
	May	June	July	August	Sept.	Total
1	-	-	0	0	0	0
2	-	-	0	0	0	0
3	-	0	0	-	-	0
3A	-	-	-	2	0	2
4	-	0	0	7	0	7
5	-	0	0	4	0	4
Watana Creek Mouth	11	12	21	3	6	53
TOTAL	11	12	21	16	6	66

Age, Length, Sex

Lengths were taken from 58 longnose suckers. These lengths ranged from 210 mm to 495 mm with the 410 mm to 429 mm suckers occurring most frequently (31%) (Figure 5-3-30).

Due to the limited sample size, no age or sex determinations were made.

Spawning

Longnose suckers in spawning condition were captured at the Watana Creek mainstem site during May and early June. By late June, all suckers sampled had already spawned.

Tagging/Recapture

Fifty longnose suckers were tagged during 1982 studies, the majority (41) at the Watana Creek mainstem site. Two of these fish were subsequently recaptured at their original point of tagging.

Of the 97 suckers tagged during 1981 studies, two were recaptured in 1982. Both were captured at their original point of tagging.

3.2.2.3 Other Species

In addition to burbot and longnose suckers, three other species of resident fish were captured by gillnets at mainstem sites, including 21

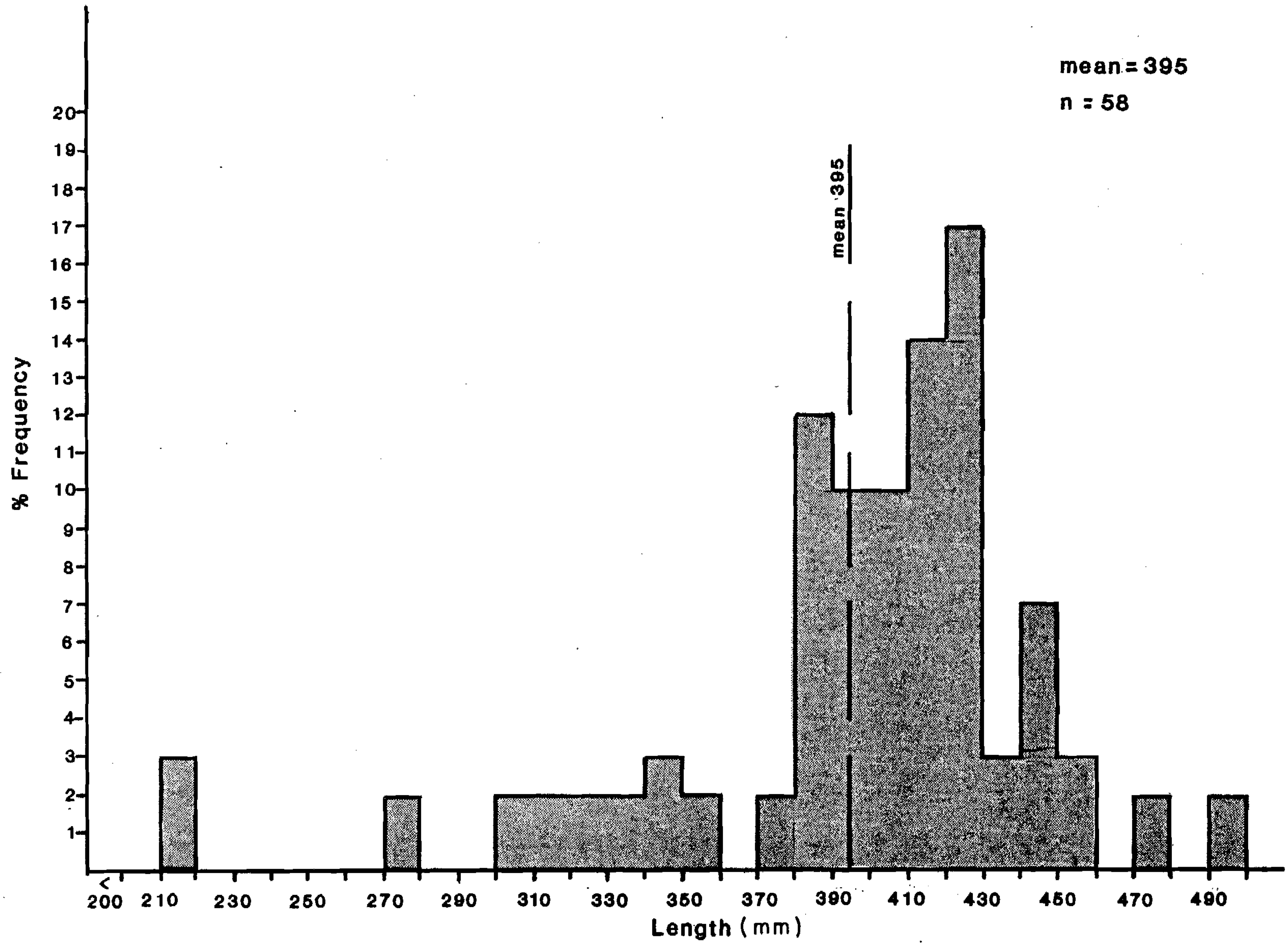


Figure 5-3-30. Longnose sucker length frequency composition, Proposed Impoundment Areas, 1982.

Arctic grayling, five round whitefish (Prosopium cylindraceum Pallas) and one humpback whitefish (Coregonus pidschian). The grayling were captured throughout the summer at the Watana Creek mainstem site only. The single humpback whitefish was captured in July at RM 208.1. The five round whitefish were captured at the Watana Creek mainstem site in July and August and were all sexually mature and in a prespawning condition.

3.3 Lake Habitat and Fisheries Investigations

3.3.1 Aquatic Habitat Investigations

Time and personnel constraints restricted lake sampling efforts to Sally Lake, the largest lake within the proposed impoundment boundaries, during 1982. Morphometric date for Sally Lake is presented in Table 5-3-20. A contour map of the lake is presented in Figure 5-3-31. Depth area and depth volume curves are presented in Figures 5-3-32 and 5-3-33, respectively.

3.3.1.1 General Characteristics of Sally Lake

Sally Lake, a clear, oligotrophic tundra lake, is situated on a plateau approximately two miles east of the mouth of Watana Creek at an elevation of 2025 feet (Plate 5-3-5). The lake is irregular in shape with a total surface area of 63 acres and a maximum depth of 27 feet. It appears to be spring-fed as there are no streams of significant size

Table 5-3-20. Sally Lake morphometric data, 1982.

Morphometric Parameter	Estimate
Surface area	63 acres
Volume	736 acre-feet
Maximum depth	27.0 feet
Mean depth	11.6 feet
Shoreline length	10,450 feet
Maximum length/orientation, main axis	3,100 feet/NW-SE
Maximum width/orientation	950 feet/NE-SW

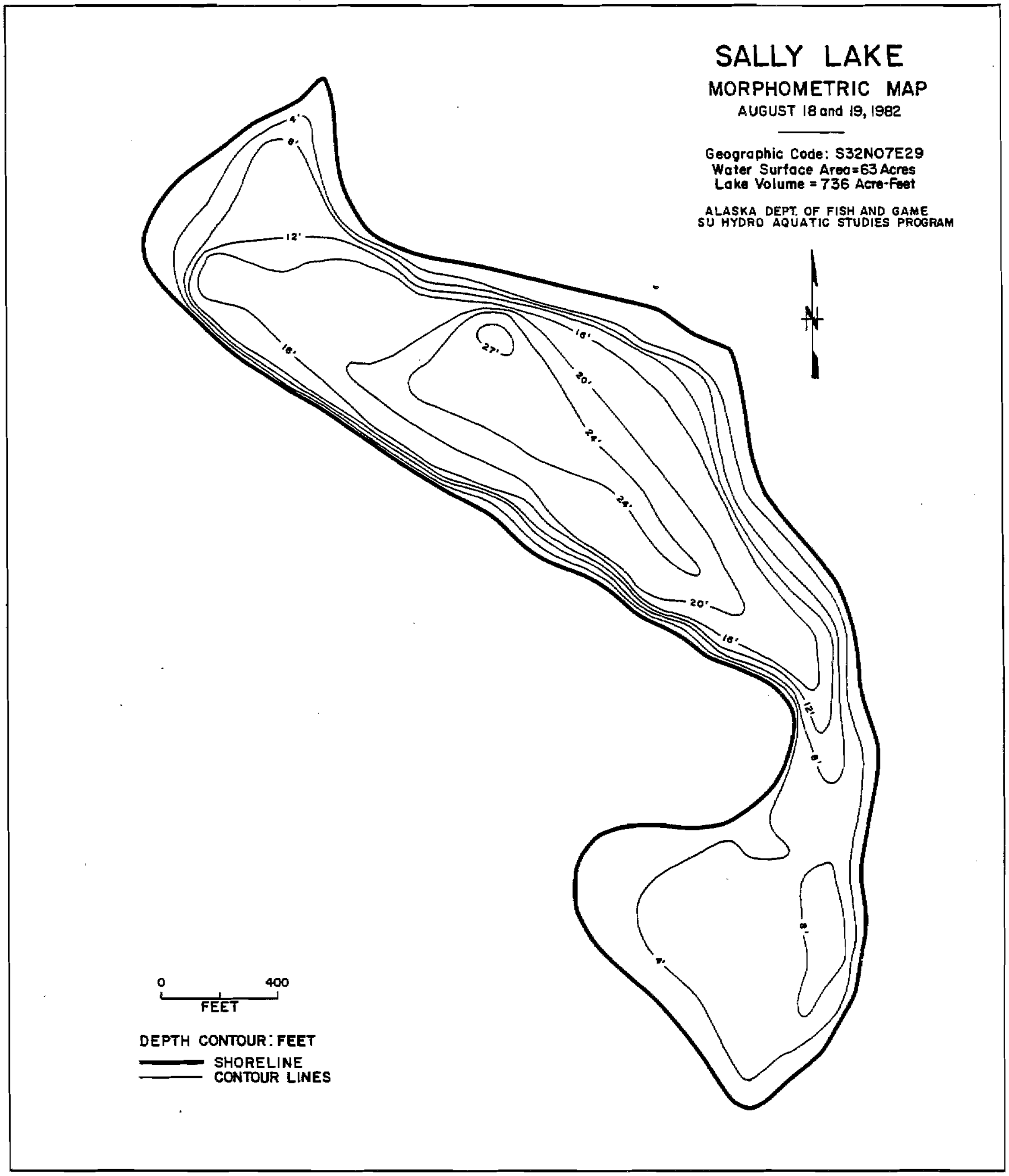


Figure 5-3-31. Sally Lake, morphometric map, GC S32N07E29.

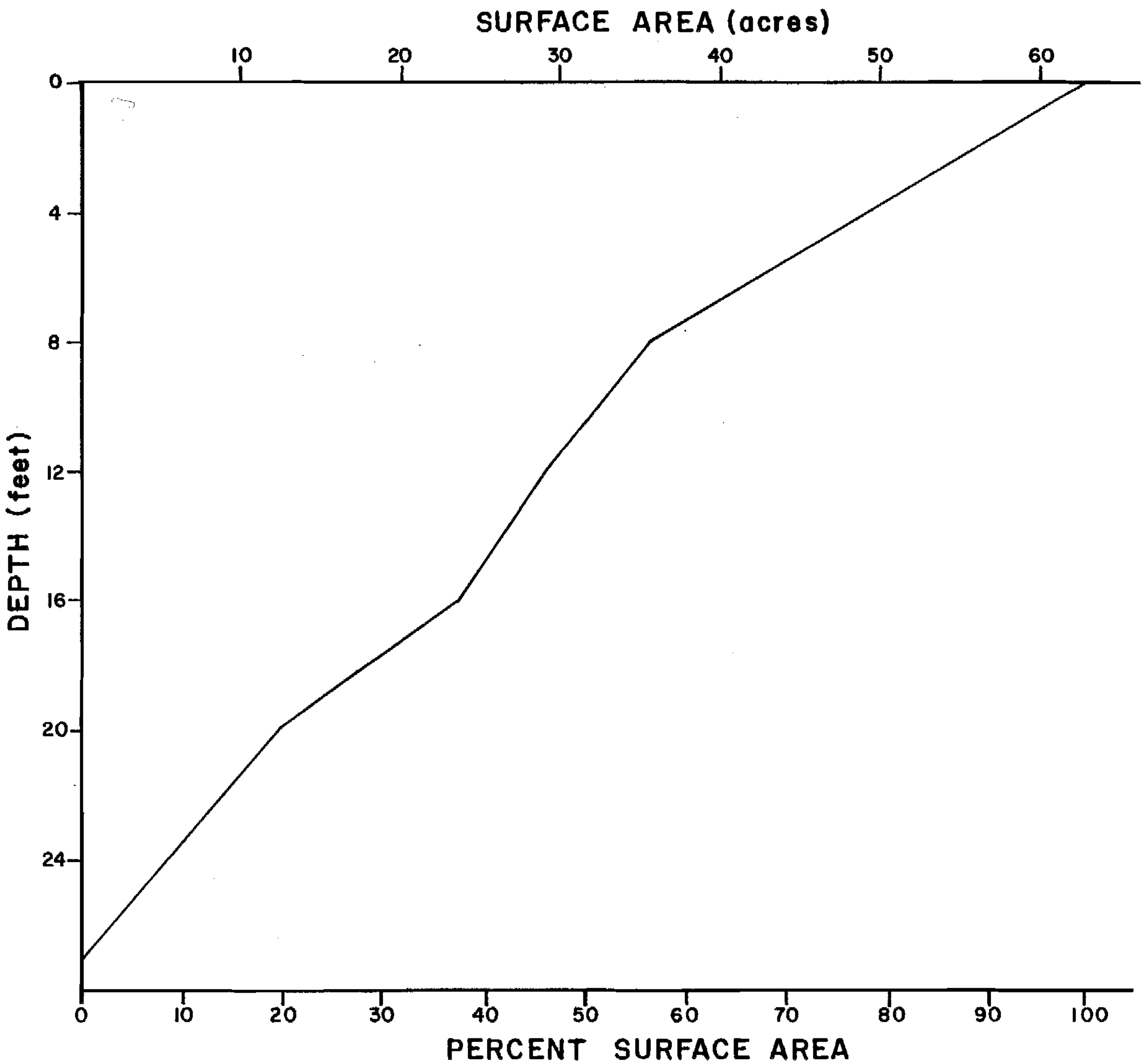


Figure 5-3-32. Hypsographic (depth-area) curve of Sally Lake, GC S32N07E29, (August, 1982).

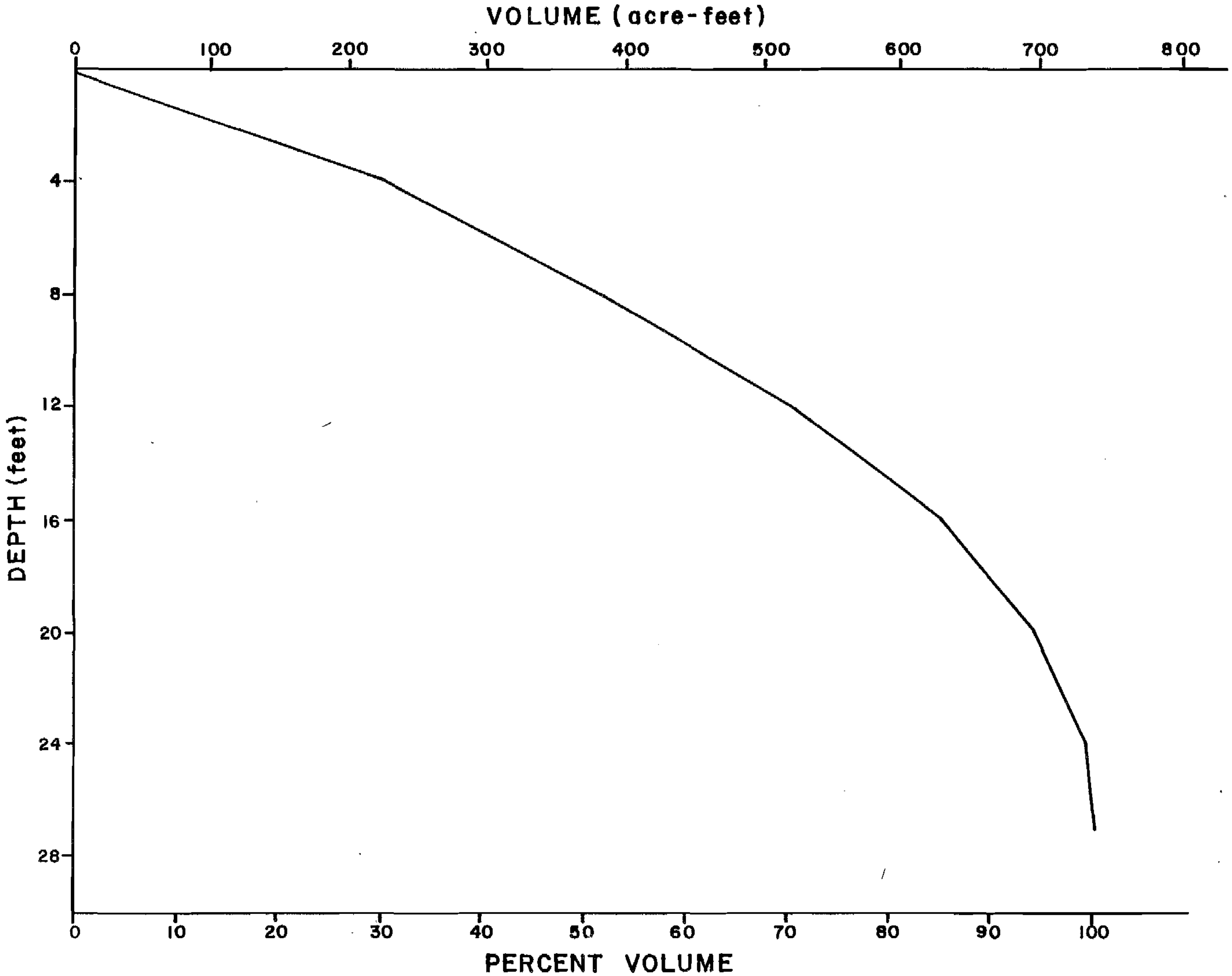


Figure 5-3-33. Depth-volume curve of Sally Lake, GC S32N07E29 (August, 1982).

Plate 5-3-5   Aerial view of Sally Lake from north to south.

entering it. The lake drains from the north end into a stream which empties into Watana Creek approximately two miles away. The entire lake would be inundated by the proposed Watana Reservoir.

The lake can be divided into two geomorphologically distinct areas. The southern end of the lake (approximately 20 acres) is a shallow bowl shaped basin with average depths of four feet. This is an area of relatively high littoral productivity and is characterized by extensive growths of submerged aquatic vegetation. Some emergent macrophytes are present near the shoreline areas. The northern section of the lake (approximately 40 acres) is in a deep V-shaped basin which slopes steeply from the shoreline resulting in a poorly developed littoral zone. Water depths toward the middle of this section are in excess of twenty feet. Submerged aquatic vegetation grows sporadically throughout the shallower depths of this area. Emergent macrophytes are limited to the littoral areas.

3.3.1.2 Water Quality

General water quality data were collected on a monthly basis at a site located at the west end of the lake. These data are presented in Appendix Table 5-C-28. Ranges of individual parameters are presented in Figures 5-3-2 through 5-3-7.

3.3.2 Resident Fisheries Investigations

3.3.2.1 Lake Trout

Thirty-two lake trout (*Salvelinus namaycush* Walbaum) were captured by hook and line, hoop nets and gillnets at Sally Lake. Lengths ranged from 260 mm to 490 mm with the mean being 419 mm. No age or sex determinations were made with this limited sample size.

Due to the high incidence of mortality associated with even the most minimal handling, only 20 of these lake trout were tagged. One tagged lake trout was subsequently recaptured, however this did not provide enough data to allow a viable population estimate.

3.3.2.2 Arctic Grayling

Forty-two Arctic grayling were captured by hook and line and hoop nets at Sally Lake. Lengths ranged from 220 mm to 325 mm with the mean being 263 mm. No age or sex determinations were made with this limited sample size.

Thirty-five grayling were tagged of which two were subsequently recaptured. No population estimate was made due to the insufficient recapture data.

4. DISCUSSION

4.1 Tributary Habitat and Fisheries Investigations

4.1.1 Water Quality

4.1.1.1 Instantaneous Water Quality

Ranges of water quality parameters monitored in tributaries in the proposed impoundment areas during 1982 are comparable to values observed during the 1981 season (ADF&G 1982b). With the exception of turbidity levels, no major differences are apparent in the water quality among tributary sampling sites. Preliminary water quality data collected above the PIE of selected tributaries indicates that there is no significant difference in water quality above and below the PIE.

Of the water quality parameters which were monitored, only turbidity appeared that it might influence the distribution and abundance of fish among and within tributaries. Turbidity levels in most tributaries remained relatively low during the open water season. Arctic grayling were found throughout these clearwater habitats and were generally not found in the turbid water of the mainstem Susitna River. Other fish species such as sucker, burbot and whitefish, which are present in most turbid water areas, were not generally found to reside in the clearwater tributaries. These preferences in habitat may be associated with differences in turbidity levels between mainstem and tributary habitats.

Relatively high turbidity levels were recorded in the lower reaches of Watana Creek during most of the sampling season. These turbid water conditions, resulting from melting permafrost in upstream areas, reduced the effectiveness of hook and line sampling for Arctic grayling. The low catch rates associated with these turbid water conditions resulted in the suspension of grayling sampling efforts in this area. It is unknown whether these low catch rates are attributable to the ineffectiveness of the sampling technique or a reduced population of grayling due to the turbid water environment.

4.1.1.2 Continuous Surface Water Temperatures

Lowest mean monthly surface water temperatures during most of the 1982 open water field season occurred in Tsusena Creek. These lower temperatures may partially explain why few fish were captured from this stream during the field season. Low surface water temperatures may reduce catch per unit effort and may also be a contributing factor for the seemingly low populations of grayling in this stream.

As expected, the degree of fluctuation in diel and seasonal water temperatures was found to be partially dependent upon volume and depth of water among streams. In streams with low discharge, such as Goose Creek, diel and seasonal surface water temperature fluctuations are relatively large when compared with the buffered temperature patterns of a larger volume, deeper stream such as the Oshetna River. Stream surface water temperatures in the study area may also be significantly affected by contributing lakes, glaciers, residual snowpacks, local precipitation and topography.

4.1.2 Discharge

Discharge was measured twice, once during August and once during September, in selected tributaries above Devil Canyon. In all tributaries, discharge was lower during August than it was during September. This was most likely the result of lower precipitation levels which occurred during August (2.29 inches) then during September (3.97 inches) (R&M Consultants, 1982). In addition, the mean discharge of the Susitna River for August, 1982 was determined to be 66% of the mean historical August discharge for the years 1962 through 1972 and 1980 through 1982, inclusive (USGS 1978, 1980, 1981 in press, and 1982 provisional data in press). Thus discharges measured in tributaries during August, 1982 may also be considerably lower than the historical August mean discharge for these tributaries. If this is true, the discharges obtained in the tributaries during August may be considered as a good estimate of the August base flows of these tributaries.

September stream discharge levels increased in all tributaries over levels recorded during the August sampling period. Percent increase of discharge ranged from 14% in Fog Creek to 143% in Watana Creek. The variable degree of percent increase among streams measured can be attributed to the timing of individual stream sampling during the period (Table 5-3-3) and differential stream runoff resulting from the localized precipitation falling within the impoundment areas (R&M Consultants, 1982). Generally, September stream discharges taken later in the sampling period had a higher percent increase over their August discharge measurements than those taken earlier in September. This was due mainly to increased precipitation over the duration of the September sampling period.

A review of preliminary discharge data for the Susitna River indicates that these data can be used to determine relative changes in tributary discharge. The hydrograph of the Susitna River at RM 233 (Figure 5-3-25) shows that the discharge of the Susitna River was declining when the low discharge levels were recorded at the tributary sites during August. In addition, the fluctuations shown on the Susitna River hydrograph during the period which parallels the September tributary discharge sampling period corresponds to the increase of the September tributary measurements over the August measurements. The large percent increase in stream discharges recorded in Goose, Jay and Watana Creeks, were taken at a corresponding peak or on a rising arm of the Susitna River hydrograph, while small discharge increases recorded in Fog and Tsusena Creeks were taken at a corresponding low point. Stage/discharge relationships on tributaries above Devil Canyon need to be further evaluated to more accurately define the relationship of these streams to the mainstem Susitna River and to estimate their individual contribution to the proposed Devil Canyon and Watana Reservoirs.

Low discharge levels can contribute to hook and line sampling success by: 1) increasing the proportion of stream accessible to sampling; 2) concentrating fish in a reduced number of deeper areas; 3) decreasing overall stream velocities; and 4) in some cases, reducing stream turbidities.

Hook and line sampling success for Arctic grayling was generally higher during low discharge periods than during high discharge periods during 1982. However, the poor sampling efficiency of hook and line techniques for the younger age class grayling, precluded an accurate assessment of the abundance and distribution of these age classes. Therefore, it is unknown if the decrease in utilizable habitat resulting from decreased discharge, combined with the territorial nature of the Arctic grayling (Vascotto and Morrow 1973), cause increased displacement of the smaller, less territorial grayling during these periods. Younger age class grayling displaced into submarginal habitat during low flow periods, may be more susceptible to disease and predation, possibly affecting year class strength.

4.1.3 Stream Gradient

A review of the general habitat characteristics of tributaries within the impoundment study area indicates that stream gradient appears to be the most important topographical feature affecting the lotic habitats. Other stream characteristics, including channel morphology, water velocities and substrate type are directly influenced by stream gradient. High gradient streams in the impoundment study areas generally have larger substrates, more narrow and shallow stream channels, higher water velocities and are more likely to contain fish passage barriers than low gradient streams.

An evaluation of the gradient of individual streams indicates that there is relatively little change in gradient between the reach of stream below the PIE and a five mile reach immediately above the PIE on most streams. Accordingly, the habitat of these individual tributary reaches is also similar except for obvious habitat differences due to changes in gradient which occur within Deadman and Kosina Creek above and below the PIE.

The greatest difference in stream gradient above and below the PIE, along with the greatest change in habitat, occurs in Deadman Creek. The stream abruptly changes from a meandering, low gradient (62 feet/mile), relatively slow flowing, wide, deep stream with many pools above the PIE to a high gradient (253 feet/mile) stream characterized by high velocity whitewater areas with very few pool areas below the PIE. The low gradient section above the PIE supports some of the largest grayling in the impoundment study area, while the habitat below is more suited for the smaller, younger age classes of grayling.

Kosina Creek, unlike Deadman Creek, has no abrupt change in stream gradient but does have substantial habitat differences in the stream reaches above and below the PIE due to an inconspicuous change in gradient pattern. The section of Kosina Creek from five miles above the PIE downstream to the PIE is characterized by a constant increase in stream gradient resulting in a uniform riffle type habitat interspersed with a few shallow pools. The contrasting, step-like, decreasing stream gradient below the PIE to the mouth results in an alternating pool/riffle pattern of habitat types. Large deep pools are formed in the low gradient sections while riffle areas dominate the higher gradient reaches. This diversity in the habitat below the PIE probably provides the best overall grayling habitat within the impoundment study area.

Stream gradient below the PIE, along with impoundment pool elevation and tributary mouth elevation will determine the extent to which an individual stream will be inundated by the proposed reservoirs. Since pool levels of the proposed Devil Canyon and Watana impoundments will annually vary 28 and 105 feet respectively, a drawdown zone of varying size will occur around the perimeter of each reservoir. This area will be in a constant state of flux between flooding and dewatering depending upon seasonal fluctuations in reservoir water levels. The length of a tributary stream affected by the drawdown zone will depend on the depth of the drawdown and the tributary reach gradient within the elevation limits of the drawdown. Affected tributary lengths within the proposed Watana impoundment will be longer than those in the proposed Devil Canyon reservoir because of deeper drawdowns and the lower overall stream gradients of tributaries associated with the proposed Watana impoundment.

Grayling eggs spawned within the reservoir drawdown zones in early spring, when pool levels are rising, may be adversely affected by the flooding of this habitat. Conversely, whitefish and burbot eggs spawned during the autumn and winter months of the year may be dessicated due to receding reservoir water levels during this period.

4.1.4 Fish Passage Barriers

Several existing or potential fish passage barriers (waterfalls or stream velocity barriers) have been identified both above and below the PIE within the proposed impoundment study area. Existing waterfalls which constitute a barrier to upstream fish migration have been identified in the steeper, more narrow sections of Cheechako, Chinook, Devil, Tsusena and Deadman Creeks. A small falls on Watana Creek may also limit upstream movement of fish. Areas where possible fish passage barriers may occur due to high stream velocities have been identified on Cheechako, Chinook, Fog and Jay Creeks. Some of these high stream velocity areas may only be temporary barriers during periods of high discharge.

The locations of these barriers are presented by TRM in the respective tributary reach maps in Appendix 5B. These barriers are also shown in relation to their overall stream gradient in Figure 5.3.1. The exact location of the numerous barriers in Cheechako and Chinook Creek were not documented during 1982. Further investigations will be conducted on these streams during 1983 to document the location and extent of present barriers.

The only complete barrier to upstream fish migration identified below the PIE is the approximately 100 foot waterfall located on Deadman Creek at TRM 0.6 (Figure 5-B-6). The proposed Watana impoundment would permanently inundate the falls and allow fish migration between the upper areas of Deadman Creek, Deadman Lake and the Susitna River. A population of relatively large grayling presently exists in the reach of Deadman Creek immediately above the falls. If fish from the Susitna River gain access to the habitat above the falls it may have an adverse effect on the large grayling above the falls due to increased competition. This could result in a gradual reduction of the age class structure and size of grayling in this area.

High waterfalls exist above the PIE on Devil and Tsusena Creeks at TRM 2.1 and 3.1, respectively (Figures 5-B-3 and 5-B-5). These falls will, not be inundated by the proposed Devil Canyon impoundment, therefore limiting the amount of stream habitat available to Susitna River fish utilizing the lower reaches of these streams. The length of free-flowing stream habitat which would be accessible to Susitna River fish will be reduced 71 and 13 percent on Devil and Tsusena Creeks, respectively. This would leave 0.6 and 2.7 miles of stream accessible to Susitna River fish on Devil and Tsusena Creeks, respectively. Aerial surveys on Devil Creek revealed that fish species, probably Arctic grayling, are present above the falls. It is not known if fish are present above the falls on Tsusena Creek.

Preliminary aerial surveys of Cheechako and Chinook Creeks indicate that several possible fish passage barriers, both waterfalls and stream velocity barriers, may exist in the steep, extensive whitewater reaches of each stream above and below the PIE. Although some of these barriers would be inundated by the proposed Devil Canyon impoundment, several barriers to fish passage may still exist immediately above the PIE on each stream. It was not determined if fish are present in the upper reaches of these streams. Therefore, the affects of the inundation of these barriers on the resident fish populations are not known.

A small waterfall located in the east fork of Watana Creek at TRM 9.4 (Figure 5-B-7), may be a periodic fish passage barrier depending upon discharge. Grayling were found above this falls during the summer when discharge was relatively low. However, the falls appeared to be a barrier to upstream fish migration at this time. It is possible that these fish may be permanent residents in the area above the falls or they may have ascended the falls during a period when discharge would permit upstream migration beyond the falls.

Possible fish passage velocity barriers in Fog Creek are restricted to the turbulent, whitewater areas located within a steep, narrow canyon above the PIE at TRM 2.7 (Figure 5-B-4). It is not known if fish in the lower reach of this stream have access to the habitat above this canyon. Although grayling and Dolly Varden have been found above the canyon in the Fog Lakes system, these fish are probably part of a resident lake population and their presence above the canyon does not necessarily indicate that Susitna River fish are able to migrate above the canyon.

A deep, narrow canyon immediately above the PIE on Jay Creek at TRM 3.8 (Figure 5-B-9) may inhibit upstream movement of fish during periods of high stream velocities resulting from high discharge. This condition was observed by ADF&G personnel during 1981 when no fish were observed in this area. However, adult grayling were sighted above this canyon during this year's study indicating that the canyon is not a permanent barrier to all fish. Since there are no apparent overwintering habitat areas for grayling within the Jay Creek basin, these sightings indicate that the apparent velocity barriers in the canyon identified in 1981 are not permanent and that Susitna River fish at least have periodic access to the reach of stream above the canyon.

No other apparent barriers to fish migration were identified on those portions of tributaries in the proposed impoundment study areas which were surveyed during the 1982 season.

4.1.5 Salmon Spawning Habitat

Cheechako and Chinook Creeks, located within lower Devil Canyon are the only two tributaries within the proposed impoundment areas that are presently known to be utilized by spawning salmon. Studies conducted by ADF&G during 1981 and 1982 indicate that salmon do not have access to areas above Devil Canyon (ADF&G 1981b, 1983b). The constricting river channel of Devil Canyon apparently creates velocity barriers to salmon which inhibit further upstream migration of these fish. Salmon in the Susitna River have presently been documented as far upstream as RM 157.0.

The best salmon spawning habitat on either of these streams was located in the clearwater plume of Cheechako Creek which extended downstream of its mouth into the Susitna River. This area, approximately 60 feet long and 10 feet wide, provided good, although limited salmon spawning habitat. Substrate consisted mainly of gravel and streamflow velocities were moderate. Limited numbers of chinook salmon utilized this habitat for spawning during late summer.

Preliminary surveys on Cheechako and Chinook Creeks indicate that salmon utilize only a small portion of the habitat above the mouth. Most of the lower reach on each of these streams is characterized by turbulent, high velocity whitewater areas and spawning habitat appears to be limited. Access to upper reaches of the stream is limited due to fish passage barriers which result from the steep gradients in this area.

Additional information on salmon utilizing these streams is presented in the ADF&G Adult Anadromous Report (1983b).

During construction of the Watana Dam at RM 184.0, river velocities in the Devil Canyon area are expected to decrease sufficiently to allow salmon to migrate upstream of Devil Canyon (Acres 1982). Adult salmon will subsequently have access to Devil, Fog and Tsusena Creeks. Of these three streams, Fog Creek has the greatest potential for providing new salmon spawning habitat. The Fog Lakes system may support a large number of sockeye and coho salmon fry if adults are able to gain access into this area. Salmon spawning habitat on Tsusena and Devil Creek is more limited.

4.1.6 Arctic Grayling Population Estimates

During the course of the 1982 Aquatic Studies, biases and assumptions relating to the population estimates of Arctic grayling were identified. These biases fall into two general categories, those caused by behavior or other attributes of the biology of the fish and those caused by the sampling technique. Table 5-4-1 lists the major biases.

The major bias associated with the behavior and biology of Arctic grayling, and probably the largest bias in the population estimate, is heterogeneity, the variance in individual capture probabilities. The smaller fish (less than 300 mm) have a much smaller probability of capture than the larger fish. One reason for this is that hook and line methods are more selective for the larger fish. Another closely related reason is an aspect of Arctic grayling behavior, strong territoriality. The largest and strongest fish occupy the most advantageous positions at the head of the pool while the smaller fish are pushed farther downstream to the extreme foot of the pool or even out of the pool (Morrow 1980). Our observations confirm this and, additionally, have found that the larger grayling in each area are caught first, raising the probability of recapture for larger fish even more. This bias tends to greatly underestimate the population estimates for the smaller age classes. Therefore, by stratifying our data as to age class, a relative correction factor based on this bias was calculated and applied to the population estimates, as the age class structures of the eight tributaries is similar. This alleviates most of the bias for age classes with a sufficient sample size. A method to sample all segments of the population sufficiently to assign probabilities of capture and recapture to the Age IV and under grayling will be required if this portion of the population is to be included in the overall estimates.

Table 5-4-1. Biases, corrections and assumptions which affect the 1982 Arctic grayling population estimates, Proposed Impoundment Areas, 1982.

Bias:	Lack of randomness of mark or recapture effort.
Correction:	Stratification of habitat location by habitat type.
Assumption:	Random mark and recapture effort.
Bias:	Unequal recapture probability due to time between censusing.
Correction:	Use of single census estimator.
Assumption:	Time does not affect recapture probability.
Bias:	Population is open geographically.
Correction:	Use of July and August data only; period of minimal movement.
Assumption:	Population is closed geographically.
Bias:	Heterogeneity; variance in the probability of capture and recapture between age classes.
Correction:	Stratification by age class for entire population, develop correction factor for populations.
Assumption:	Population estimates limited to Age IV and older fish due only to insufficient sample sizes of smaller fish.

One of the sampling technique biases concerns time between censusing. Varying environmental factors such as temperature, turbidity and flows may alter the probabilities of recapture. By using a single census estimator as opposed to a multiple census estimator, these variances can be reduced. Minimal variations in flow and turbidity were encountered during censusing in July and August and temperatures were similar, all being in the normal summer range. No differences in capture probability versus temperatures in the normal range have been observed.

Time also affects the degree to which the Arctic grayling population is open or closed geographically. Tag return data shows maximum movement, both within and between streams, occurs during May and June as Arctic grayling are entering the tributaries and in September when they are out migrating. By using data from July and August, the period of minimal movement, this bias is also greatly reduced.

Another of the sampling technique biases is lack of randomness of mark and recapture effort which affects the probability of recapture. More effort was expended in areas suspected of harboring high densities of Arctic grayling (pool habitat) as opposed to areas suspected of harboring few fish (riffle habitat). This tends to raise the recapture probability in the pool habitat which in turn lowers the total population estimate of pools and inversely, lowers the recapture probability in the riffle habitat, which raises the total population estimate. Therefore, by stratifying the habitat location into pool and riffle habitat types, the amount of this bias is reduced. However, some bias may still occur between strata due to non-random differences in sampling effort.

Sampling problems associated with the individual tributary habitat evaluation locations which bias the population estimates are discussed on a stream by stream basis along with the estimates generated and their relative accuracy.

Oshetna River

The Oshetna River, one of the two largest tributaries in the proposed impoundment areas, presented sampling problems due to its size. Stratification of the river into pool and riffle habitat types allowed all seven of the pools (all located along the east bank) to be sampled in their entirety. Sampling was conducted from both banks, however, due to the width (100-125 feet) of the stream, sampling of the entire riffle reaches was not possible.

The relatively low gradient (41 feet/mile) and the presence of numerous boulders in midstream allow for abundant areas of utilizable habitat that are outside hook and line effective sampling range. The average depth of 3-5 feet combined with the higher flows in the riffle reaches also reduces hook and line effectiveness. For these reasons, the population estimate generated for the riffle reaches reflect the absolute minimum, which in turn means the total population estimate for the Oshetna River should be regarded as being substantially low.

Population estimates for the 2.2 miles of the Oshetna River to be impounded are:

Arctic grayling population estimate = 2426
95% Confidence interval = 1483-4085
Arctic grayling/mile = 1103
Arctic grayling/acre = 56 (pools = 1759, riffles = 36)

Goose Creek

Goose Creek, one of the smaller streams in the proposed impoundment areas, presented few sampling problems. With a width of 30-50 feet and an average depth of 2-3 feet, the entire stream could be sampled effectively from either bank. High velocities in some riffle reaches, associated with Goose Creeks relatively steep gradient (114 feet/mile), slightly lowered sampling efficiency, but for the majority of the stream this was not a problem. No stratification of the stream into pool and riffle habitat types was deemed necessary as clear delineation between the two types was impossible. Since the entire stream was of a similar habitat type, index points were chosen and data was kept for the reaches between these points. Catches and catch rates were similar between the index reaches. For these reasons, population estimates generated for Goose Creek should be regarded as accurate.

Population estimates for the 1.2 miles of Goose Creek to be impounded are:

Arctic grayling population estimate = 949
95% Confidence interval = 509-1943
Arctic grayling/mile = 791
Arctic grayling/acre = 90

Jay Creek

Jay Creek, the smallest stream studied in the proposed impoundment areas presented few sampling problems. With a width of 30-50 feet and average depths of 2-3 feet, the entire stream could be effectively sampled from either bank. A gradient of 143 feet/mile and the resultant higher velocity lowered the efficiency in sampling some of the pocket water habitat. Extreme fluctuations in turbidity, common in this stream, also lowered sampling efficiency. No stratification by habitat types could be accomplished as even minimal fluctuations in discharge would alter an areas classification. Index points were chosen and data was kept for the reaches between these points. Catches and catch rates were comparable between the index reaches. For these reasons, population estimates generated for Jay Creek should be regarded as being slightly low.

Population estimates for the 3.5 miles of Jay Creek to be impounded are:

Arctic grayling population estimate = 1592
95% Confidence interval = 903-3071
Arctic grayling/mile = 455
Arctic grayling/acre = 101

Kosina Creek

Kosina Creek, one of the two largest tributaries in the proposed impoundment areas, presented numerous sampling problems. With an average width of 125-150 feet, much of the stream could not be sampled. Average depths of 3-6 feet and high flows associated with a relatively steep gradient (114 feet/mile) combined to further lower our sampling effectiveness. Sampling could only be conducted from the west bank as much of the east bank is sheer rock cliffs. The stream is also braided with numerous large islands and sidechannels. Stratification by pool and riffle habitat type was deemed necessary and easily accomplished. Pool areas are easily distinguished from riffle areas in this stream based on flow and area. The pools are extremely large, in some cases reaching completely across the stream channel. Effective sampling of the entire pool area was not always possible. For these reasons, the population estimate generated for both the riffle and pool areas of Kosina Creek should be regarded as being the absolute minimum, with the correct estimate possibly being many factors higher.

Population estimates for the 4.5 miles of Kosina Creek to be impounded are:

Arctic grayling population estimate = 5544
95% Confidence interval = 3792-8543
Arctic grayling/mile = 1232
Arctic grayling/acre = 69 (pools = 2985, riffles = 28, mouth =770)

Watana Creek

Watana Creek, the stream with the longest reach to be inundated by the proposed impoundment (11.9 miles), presented sampling problems associated with this length. As it was not feasible to sample this entire reach, visual surveys were conducted and based on width, depth, pool/riffle ratios and turbidity, three distinct habitat reaches were identified: from the mouth upstream to the forks, the East Fork and the West Fork. By sampling representative sections of each habitat reach, the corresponding population estimate generated could be extrapolated to the entire reach. Limited sampling conducted outside the study areas produced comparable catches and catch rates.

Widths ranging from 40-60 feet and depths from 2-4 feet allow effective sampling from both banks. The East Fork and the reach of Watana Creek below the Forks has the unique characteristic of daily turbidity fluctuations caused by areas of thawing permafrost resulting in very unstable soil conditions. As the day progresses, rising turbidity levels greatly reduce sampling effectiveness. Velocities have little effect on sampling effectiveness as Watana Creek has a low gradient (60 feet/mile) and velocities are relatively low.

For these reasons, the population estimate generated for the West Fork (2.1 miles, low turbidity) should be regarded as accurate, while the East Fork and the reach below the Forks (9.8 miles, high turbidity) should be regarded as being quite low. Therefore, Watana Creeks total population estimate should be regarded as being quite low.

Population estimates for the 11.9 miles of Watana Creek to be inundated are:

Arctic grayling population estimates = 3925

(Below forks = 2615, West Fork = 994, East Fork = 316)

95% Confidence interval = 1880-6973

Arctic grayling/mile = 324

Arctic grayling/acre = 44

Deadman Creek

Deadman Creek, an average sized stream relative to the other streams in the proposed impoundment areas, presented sampling problems due to its size and gradient. Thick underbrush and rock cliffs on the west bank allowed sampling from the east bank only. With an average width of 60-80 feet and depth of 3-6 feet, the entire stream cannot be effectively sampled from one bank. Extremely high velocities and turbulent water conditions, the result of the steep gradient (253 feet/mile), also limits hook and line effectiveness. The Arctic grayling are limited to one large pool and scattered pocket water areas. Also, during August, the majority of our catch (approximately 90%) was of small Arctic grayling (less than 275 mm) that were not present in the stream in these numbers during July. Recapture information from 1981 and 1982 indicate a significant amount of migration both into and out of Deadman Creek occurs throughout the summer. For this reason, the population estimate generated for Deadman Creek should be regarded as being high.

Population estimates for the 0.3 mile study area on Deadman Creek below the falls are:

Arctic grayling population estimates = 734
95% Confidence interval = 394-1502
Arctic grayling/mile = 1835
Arctic grayling/acre = 273

Tsusena Creek

Tsusena Creek, another average sized stream relative to the other streams in the proposed impoundment areas, presented few sampling problems. Although excellent habitat is present within the 0.4 miles of stream to be impounded, few Arctic grayling utilize this area. Almost all of the Arctic grayling are found at the mouth and in the extensive clearwater plume extending down the Susitna River. Both of these areas can be sampled effectively in their entirety. This year, with the low discharges, the plume was greatly reduced in size and depth and few fish were captured. With only one recapture occurring, a population estimate could not be generated.

Fog Creek

Fog Creek, another average sized stream in the proposed impoundment areas, presented few sampling problems. With an average width of 50-70 feet and depth of 2-3 feet, the stream could be effectively sampled from either bank. The entire reach sampled contained no large pools and is basically one long riffle. Very little Arctic grayling habitat is present which is reflected by the total summer catch of 25 Arctic grayling. With this small of a sample, a population estimate could not be generated.

The 1982 total population estimate for Arctic grayling in the 24.6 miles of major tributary streams to be impounded is 1.6 times higher than the 1981 estimate (16,346 vs. 10,279). Although, the 1981 estimate gave a good preliminary indication of the relative abundance of Arctic grayling, the estimate itself contained many of the biases previously discussed which have been eliminated from the 1982 estimate.

The 1982 estimates generally encompass a larger area of each stream and more effort than the 1981 estimates. For example, in 1981, the first mile of Kosina Creek was sampled in its entirety and the upper 3.5 miles was sampled only at selected sites. The population estimate generated by this data (2,787) was applied to the entire 4.5 miles. In 1982, the entire 4.5 miles was sampled and the population estimate of 5,544 reflects this increased effort. For this reason, many of the 1982 estimates are higher than the 1981 estimates.

In 1981, large concentrations of grayling were found at the mouths of Goose, Deadman, and Tsusena Creeks, where the high water levels of the Susitna and the tributaries created large areas of prime habitat. The low water levels encountered in 1981 reduced and, at times, completely eliminated this habitat, resulting in lower catches and lower estimates. Table 5-4-2 compares the 1981 and 1982 total population estimates and estimates by stream.

Table 5-4-2. Arctic grayling population estimates, 1981 versus 1982, Proposed Impoundment Areas, 1982.

Tributary	1981	1982
Oshetna	2017	2426
Goose	1327	949
Jay	1089	1592
Kosina	2787	5544
Watana	--	3925
Deadman	979	734
Tsusena	1000	--
Fog	176	--
Total Estimate	10,279	16,346

The values generated for population estimates (numbers/mile) are reflective of the relative abundance of Arctic grayling in the stream and can be used in this sense as a relative comparison between streams. They do not take into account the surface area of the stream and, therefore, cannot be used alone to compare the streams. Examination of the density of fish expressed as numbers per unit area of streambed available may provide an indication of habitat quality and availability. For example, the Arctic grayling/mile values generated for Kosina and Jay Creeks of 1,232/mile and 455/mile, respectively, can be compared as to the relative abundance of Arctic grayling in the two streams. This does not take into account the fact that the average width of Kosina Creek is four times larger than Jay Creek (146 feet vs. 37 feet). Therefore, when the surface area is taken into account, the density of Arctic grayling in Jay Creek is 1.5 times that of Kosina (101/acre vs. 69/-acre). Although Kosina Creek has the large pools with excellent habitat, this lower density is indicative of the large reaches of poor habitat in the riffles. Inversely, Jay Creek does not have the large pools that Kosina Creek has but instead has a larger proportion of bank cover and "edge" conditions which contribute to this higher density.

4.1.7 Arctic Grayling Spawning and Juveniles

In 1982, the majority of spawning occurred during late May and early June, about two weeks later than in 1981. This corresponds with a two week difference in breakup which reflects that water temperatures and spring flooding may be key factors in initiating Arctic grayling spawning. Spent and spawning grayling were captured in streams where water temperatures ranged from 2.3°C to 5.8°C. This coincides with the findings of Tack (1973) and Alt (1976) who feel that temperatures around 4°C trigger Arctic grayling spawning in interior and western Alaska. Observations of the violent nature of ice-out in 1982 in these tributaries indicate that it is very doubtful that Arctic grayling enter the streams and spawn before ice-out.

Newly hatched Arctic grayling (20-30 mm) were first observed in mid June and were found both above and below the PIE. Although no Arctic grayling were observed above the PIE while spawning was occurring, the presence of newly hatched fish in these areas would tend to confirm that spawning does take place there.

Small schools (less than 25) of young of the year Arctic grayling were observed in the tributaries throughout the summer, from the mouth to the upstream limit of our studies. They frequently occupied areas of low water velocity with abundant cover. Large concentrations of both newly hatched and young of the year Arctic grayling were observed in mainstem slough areas immediately below the mouth of Jay, Kosina and Watana Creeks. The presence of young of the year Arctic grayling can be attributed to the fact that the sloughs are all spring fed and are excellent rearing habitat. These sloughs are generally sidechannels of the Susitna River during May and early June. Although spawning may occur here, the presence of newly hatched Arctic grayling may be because juvenile Arctic grayling are helpless in water currents for two weeks after hatching (Nelson, 1954) and probably have been washed down from the tributaries.

4.1.8 Arctic Grayling Migration

Through analysis of tagging/recapture data, it appears that the majority of Arctic grayling return to the same stream year after year, in many cases returning to the same specific area within the stream. A small but significant number (12% of the 1982 recaptures of 1981 tagged fish) have been found to migrate to the other streams within the impoundment areas. This migration seems to be random in direction as similar numbers of fish migrate to other streams both up and down the Susitna River.

Interstream movement of Arctic grayling during the 1982 sampling season differs from that found between years with the predominant direction of movement (90% of the recaptured fish) being down the Susitna River. The majority of these fish were recaptured at the mouths of other tributary streams, so the total extent of this movement may be even larger.

The reasons for these interstream movements are not known at this time. Territorial displacement may be a major factor, suggesting that the population is limited by available summer habitat. Continued sampling for recaptures both within and outside the proposed impoundment areas will help determine the actual extent of these movements.

Intrastream migration is generally a seasonal event. After spawning in late May, a large number of Arctic grayling move up the tributaries to their summer habitat. During mid-summer, movement of Arctic grayling is at a minimum with the majority of the fish being sedentary. Finally, an outmigration of Arctic grayling begins in late-August or September. This migration was observed earliest in the smaller streams. Extremes of physical factors (i.e., late breakup, discharge, temperatures) may alter this basic time schedule, but the pattern of mainstem to tributary and intrastream movement has remained the same.

4.2 Mainstem Habitat and Fisheries Investigations

4.2.1 Water Quality

Ranges of water quality parameters monitored at Susitna River mainstem sampling sites during 1982 are comparable to values observed during the 1981 season (ADF&G 1982b). No major differences are apparent in the range of water quality parameters among the various sampling sites.

Of the water quality parameters monitored, only turbidity appeared to influence the seasonal distribution and abundance of fish species in the mainstem. High turbidity values in the mainstem during the warmer months may have selectively excluded some fish species such as Arctic grayling which prefer to reside in the clear water tributaries (Tack 1980). However, it is generally assumed that grayling utilize the mainstem habitat for overwintering when turbidity levels have decreased significantly.

4.2.2 Mainstem Slough Habitats

Mainstem slough habitats in the proposed impoundment areas are relatively small compared to available slough habitats in the Susitna River below Devil Canyon. They generally flow clear except during periods of high water when they are affected by the turbid flow of the Susitna River. Water quality data collected at slough sites during 1982 was limited to Upper and Lower Jay Creek Slough. These data show that conductivity levels are significantly higher in these slough habitats compared to levels in the mainstem or tributaries indicating that they are probably spring fed (Appendix 5C, Tables 1-27).

Preliminary investigations indicate that these sloughs appear to be a commonly utilized habitat of resident juvenile fish in the area. Juvenile Arctic grayling, sucker, and whitefish have been found to utilize these sloughs during the summer months. A juvenile burbot was also found in Upper Jay Creek slough on one occasion. Few adult fish have been observed in these slough habitats.

4.2.3 Resident Fish Species

One element of the 1981 Plan of Study for the mainstem habitat location was to identify and determine the relative abundance of the fish species that inhabit the mainstem Susitna River at the tributary mouths. In 1982, the allocation of a riverboat to the impoundment studies greatly increased sampling mobility. An attempt was made to document the relative abundance of species which utilize those areas of the Susitna River not affected by the tributaries. This was accomplished by selecting mainstem sites away from the tributary mouths and utilizing trotlines and gillnets. Five species of fish were captured including burbot, longnose sucker, Arctic grayling, round whitefish and humpback whitefish.

Burbot could be captured at almost any point along the banks of the Susitna River. The major limiting factor was water velocity, with the burbot preferring the low velocity areas associated with back eddies and side channels. Limited recapture information tend to confirm findings of Morrow (1980) that these fish generally are sedentary and do not migrate during the summer months.

Longnose suckers were captured in the mainstem Susitna River in large pools and at the mouths of tributary streams. While mature adults were caught exclusively at the mouths of suspected spawning streams, only subadults and juveniles were captured at mainstem sites and sloughs not affected by the tributaries. Although recapture data on longnose suckers was limited, the findings generally agree with other studies of longnose sucker populations in Alaska. The juveniles apparently drift out of the tributaries, rear in the mainstem, and then return as adults to the tributaries to spawn. The adults often remain in the vicinity of the tributary mouth for much of the summer (Morrow 1980). Large concentrations of juvenile fish were observed in the mainstem sloughs.

Both round and humpback whitefish were captured during the fall at or near the mouths of tributary streams. No information on their summer range in the proposed impoundment area has been collected. Juvenile whitefish have been observed at the mouths of tributary streams and in mainstem sloughs.

Arctic grayling were captured in the mainstem Susitna only near the mouths of tributary streams. These fish were generally subadults which were not large enough to defend a territory in the stream itself.

4.3 Lake Habitat and Fisheries Investigations

Thirty-one lentic habitats have been identified within the boundaries of the proposed Devil Canyon and Watana impoundments (Acres 1982). Twenty-seven of these habitats are less than five acres in size. Preliminary aerial surveys of many of these lakes revealed that most of them are relatively small, isolated and shallow. Therefore, it is assumed that most are not capable of supporting fish populations. Due to limited time and personnel, lake sampling efforts during 1982 were limited to Sally Lake, the largest lake within the proposed impoundment boundaries. More effort should be directed toward other lentic habitats in 1983 to verify the presence or absence of fish in these areas.

4.3.1 Resident Fish Species

In 1982, an attempt was made to estimate the fish population of Sally Lake. The original study plan was to utilize large hoop nets and hook and line sampling to capture fish. Gill nets were excluded as a 67% mortality rate was encountered during 1981 gill net sampling.

The hoop nets were not as effective as had been anticipated with an average catch rate of only 0.68 lake trout per day. The trap itself was found to be large enough but the 25 foot leads (wings) were much too short. Traps with 100 foot leads may have been more effective. In addition, the mesh size used in the trap was too large to effectively capture Arctic grayling; individuals were occasionally gilled.

Hook and line sampling was the most effective method with a catch rate of 0.76 lake trout per hour. The use of this method allows the entire lake to be sampled, as opposed to the stationary hoop nets. The major drawback of hook and line sampling is the time involved; hoop nets can be set and then checked daily whereas hook and line sampling requires the actual presence of biologists for extended lengths of time.

Experimental use of a wide angle vertical sonar proved that fish could be distinguished and counted, but because of the shallow depth, the area of the lake which could be sampled by a transect is extremely small, necessitating a large number of transects to be made. Also, a large portion of the bottom of Sally Lake is covered with large aquatic plants extending, in some cases, all the way to the surface. These plants effectively mask any recording of fish present. Therefore, in 1982, a study program utilizing more hoop nets with longer leads and more sampling time should result in a large enough sample size to generate a population estimate. In addition, the use of side scan sonar as an alternative method will be tested.

The recapture of 2 of 35 tagged lake trout provides an idea of the order of magnitude of the population. It is generally believed that the population of lake trout is below 1,000 fish. The Arctic grayling population is believed to be somewhat larger, possibly in the vicinity of 5,000 fish. These estimates are based on observations of large schools and the relatively small size of the fish.

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APPENDIX A

Statistical Analysis

POPULATION ESTIMATES

Adjusted Petersen Single Census Method (Ricker, 1975 pg. 78)

$$N = \frac{(M+1)(C+1)}{R+1}$$

where:

N size of population at time of marking

M number of fish marked

C catch or sample taken for census

R number of recaptured marks in the sample

CONFIDENCE LIMITS

Confidence Limits For Variables (x) Distributed In a Poisson Frequency Distribution, For Confidence Coefficients (=1-P) of 0.95. (Ricker, 1975 pp. 78, 343)

For 1-P = 0.95 $x+1.92 \pm 1.960\sqrt{x+1.0}$

MORTALITY AND SURVIVAL

MORTALITY (EVERHART ET AL. 1976, pp. 104-109)

$$N_t = No\ e^{-Zt}$$

and

$$Z = -\ln S \text{ or alternatively } S = {}^{1}/e^{Z}$$

where:

N_t is number of fish at time t

N_o is number of fish at time equal o

Z is the force of total mortality

and

S is survival

APPENDIX B

Maps of the proposed impoundment area of selected tributaries and the adjacent Susitna River within the impoundment study area.

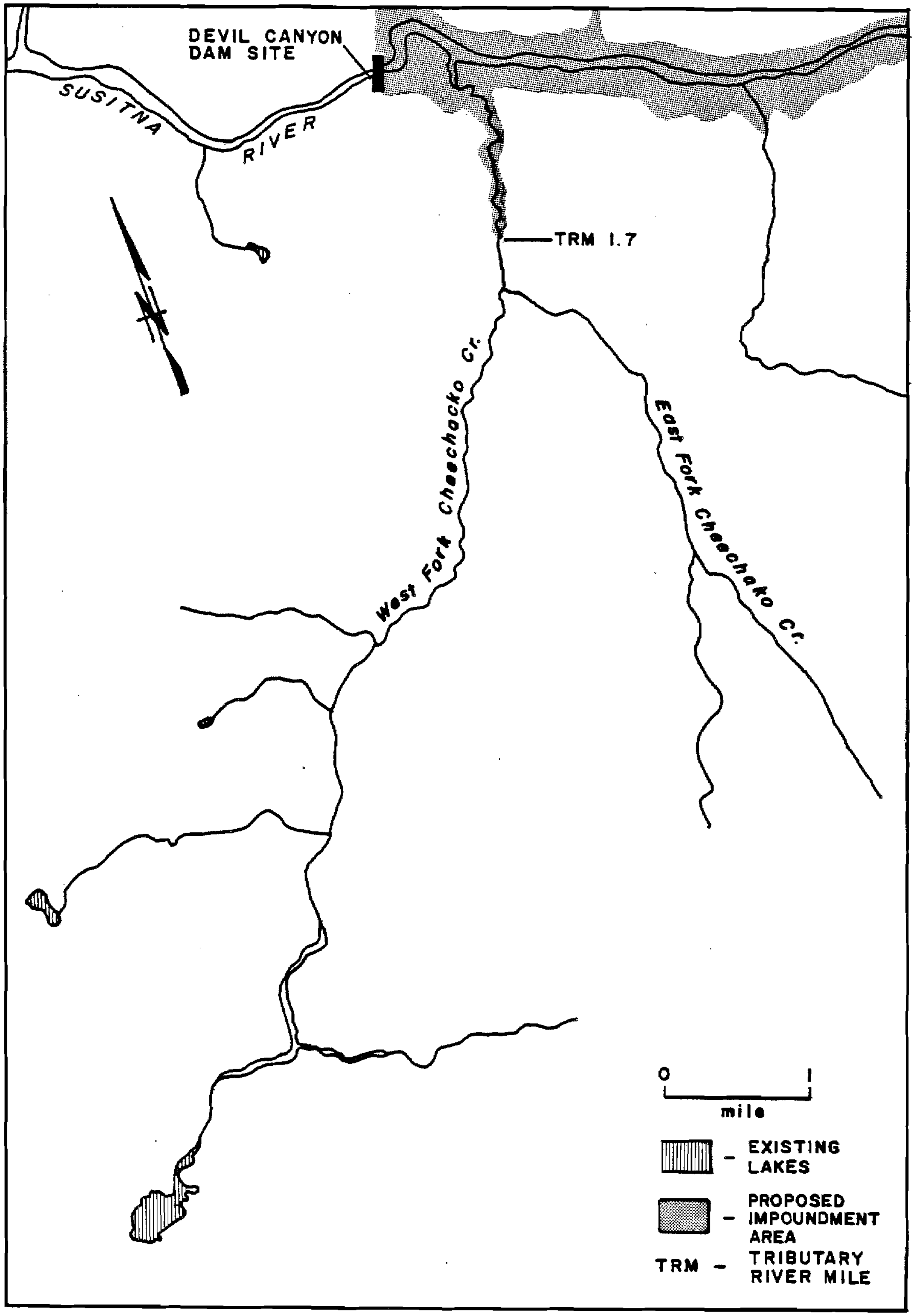

Figure 5-B-1. Proposed Devil Canyon impoundment area of Cheechako Creek, RM 152.4, and adjacent Susitna River.

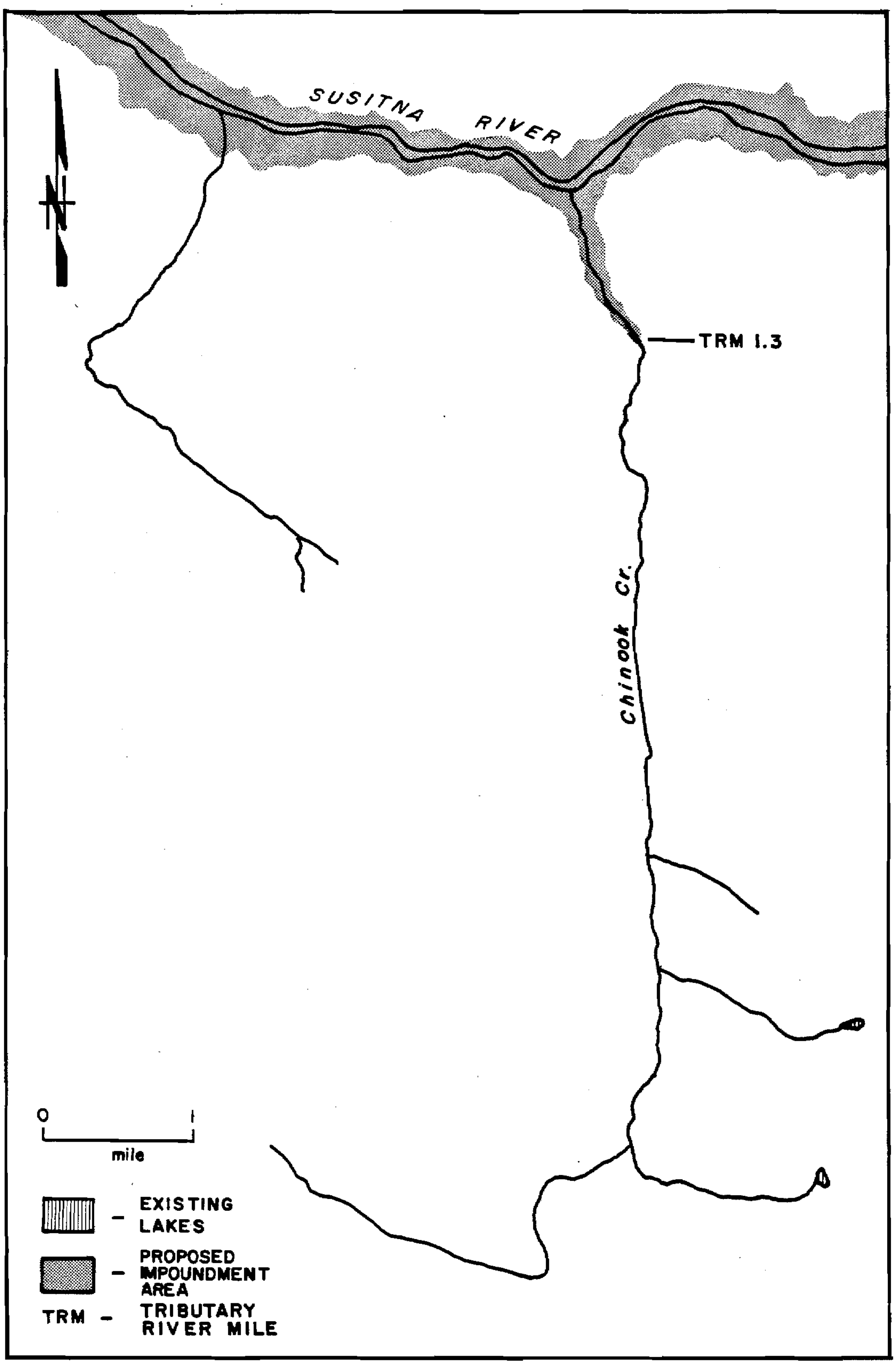

Figure 5-B-2. Proposed Devil Canyon impoundment area of Chinook Creek, RM 157.0, and adjacent Susitna River.

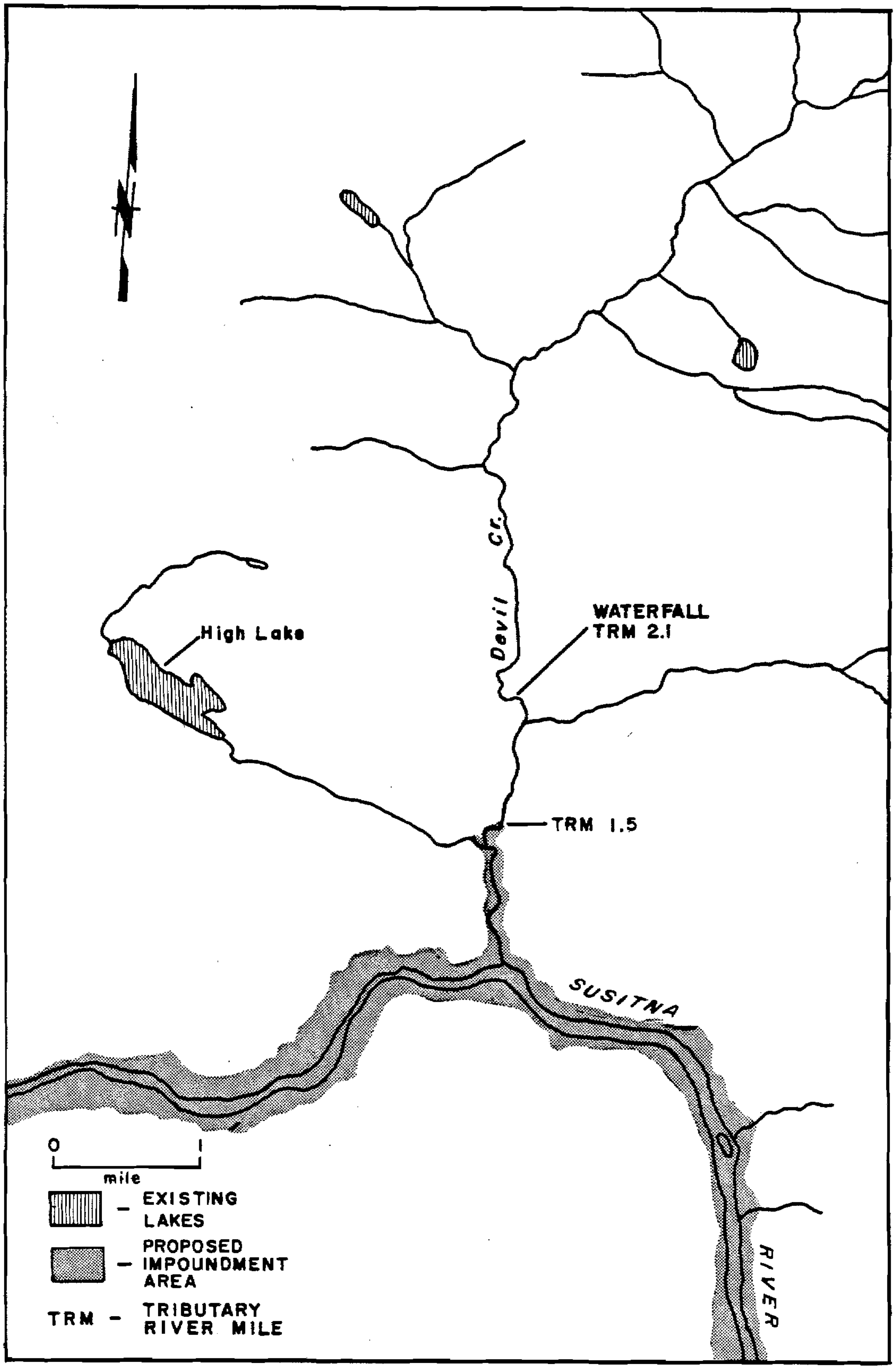

Figure 5-B-3. Proposed Devil Canyon impoundemnt area of Devil Creek, RM 161.4, and adjacent Susitna River.

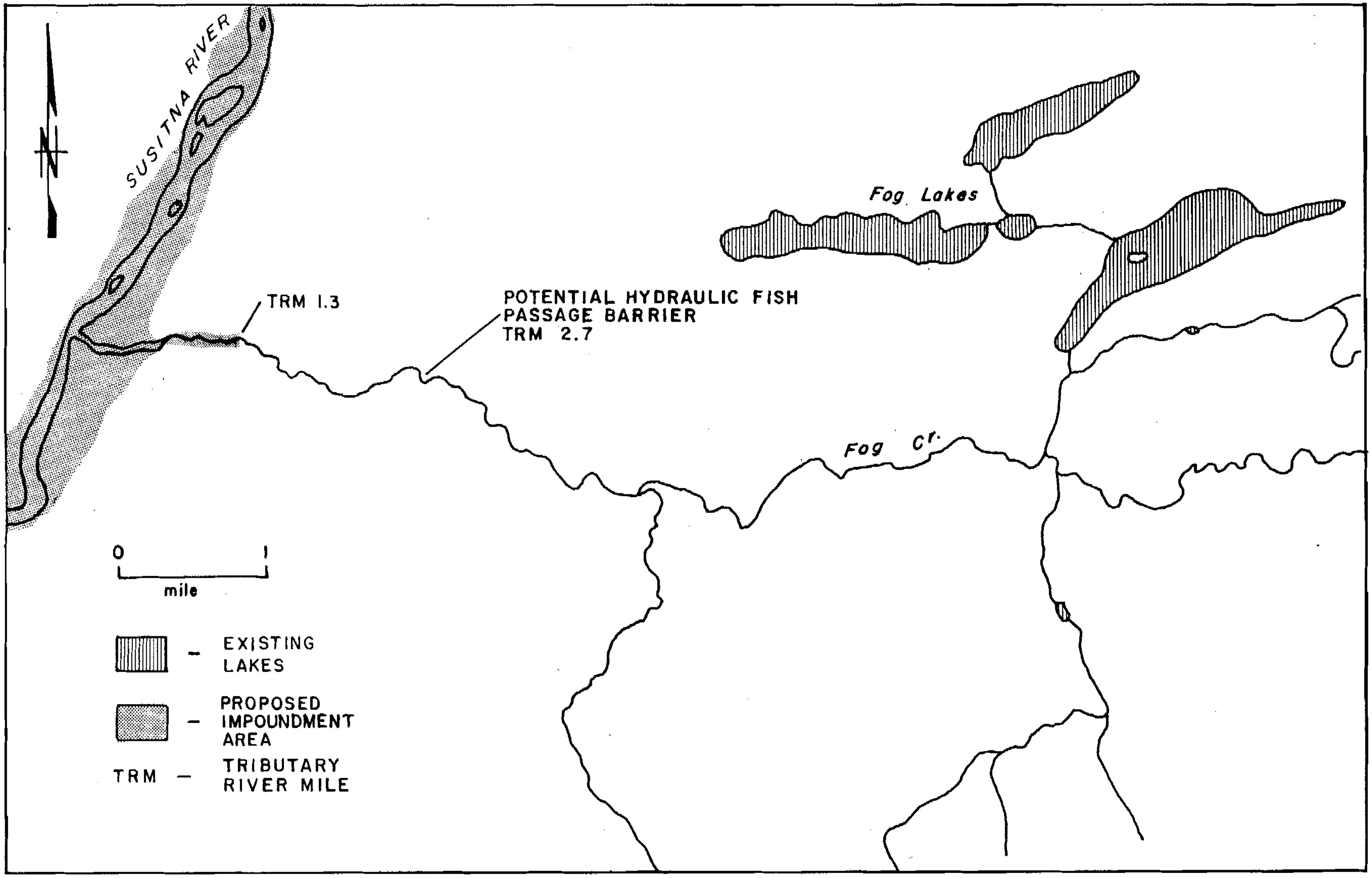

Figure 5-B-4. Proposed Devil Canyon impoundment area of Fog Creek, RM 176.7, and adjacent Susitna River.

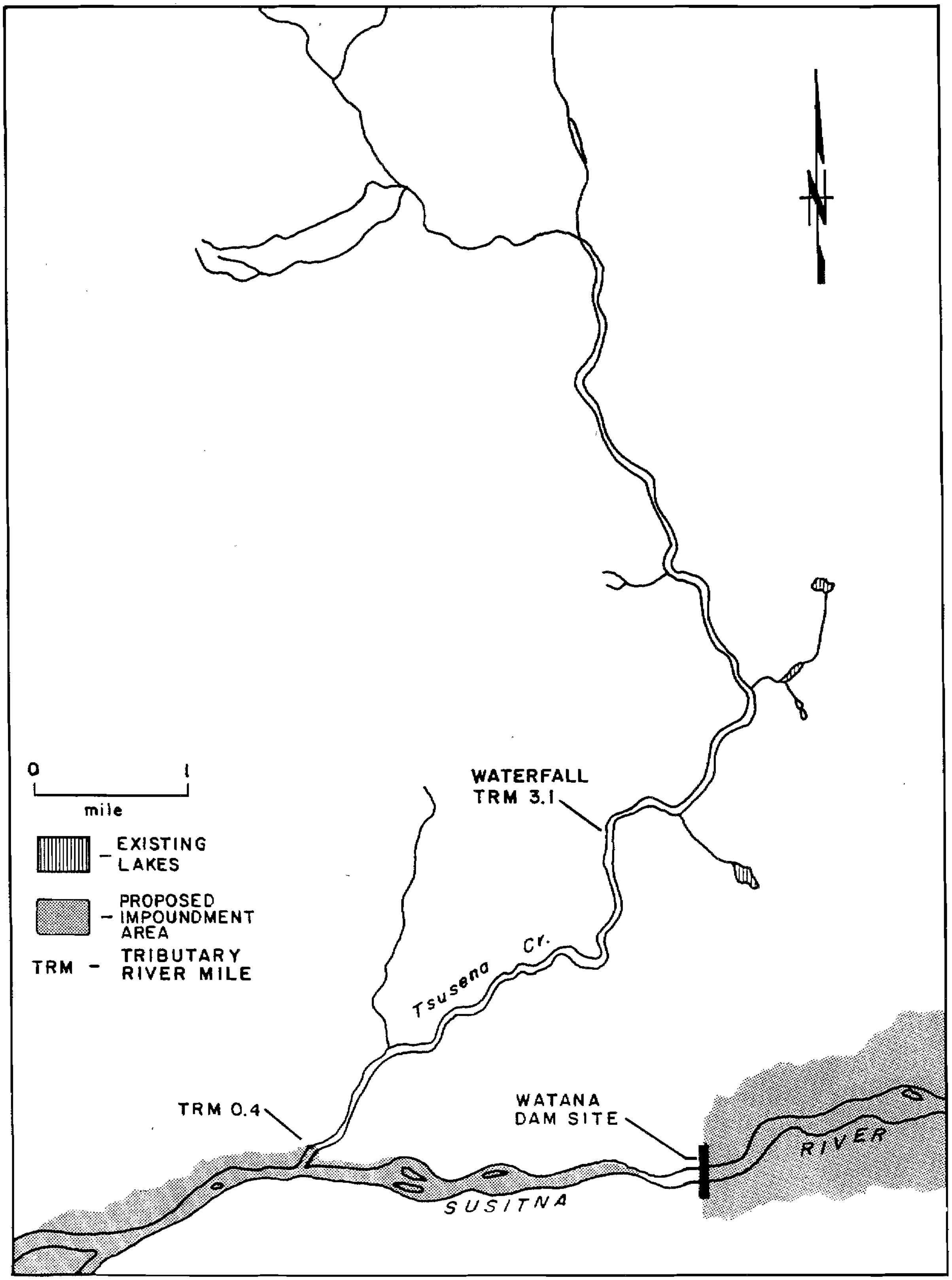

Figure 5-B-5. Proposed Devil Canyon impoundment area of Tsusena Creek, RM 181.3, and adjacent Susitna River.

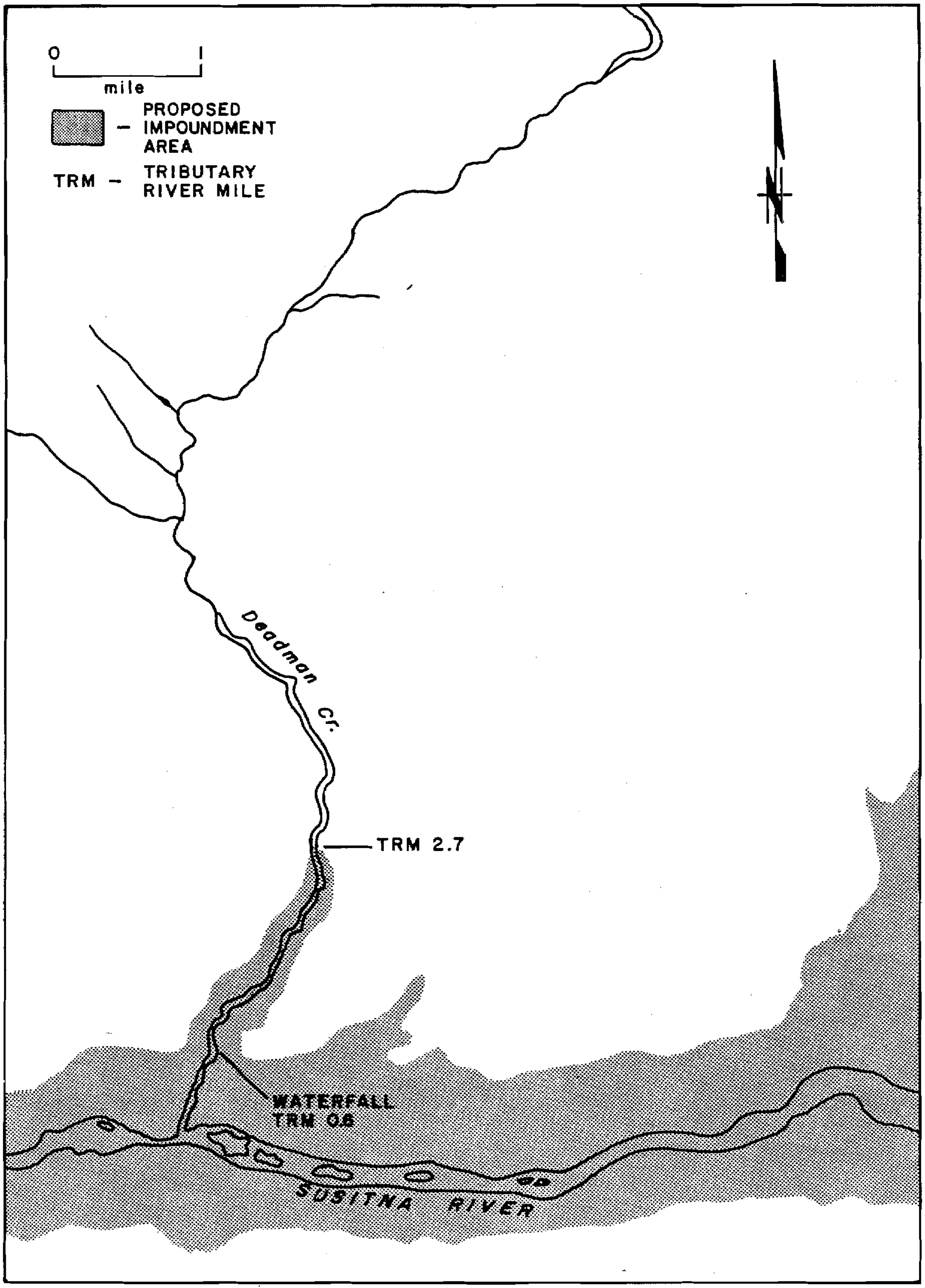

Figure 5-B-6. Proposed Watana impoundment area of Deadman Creek, RM 186.7, and adjacent Susitna River.

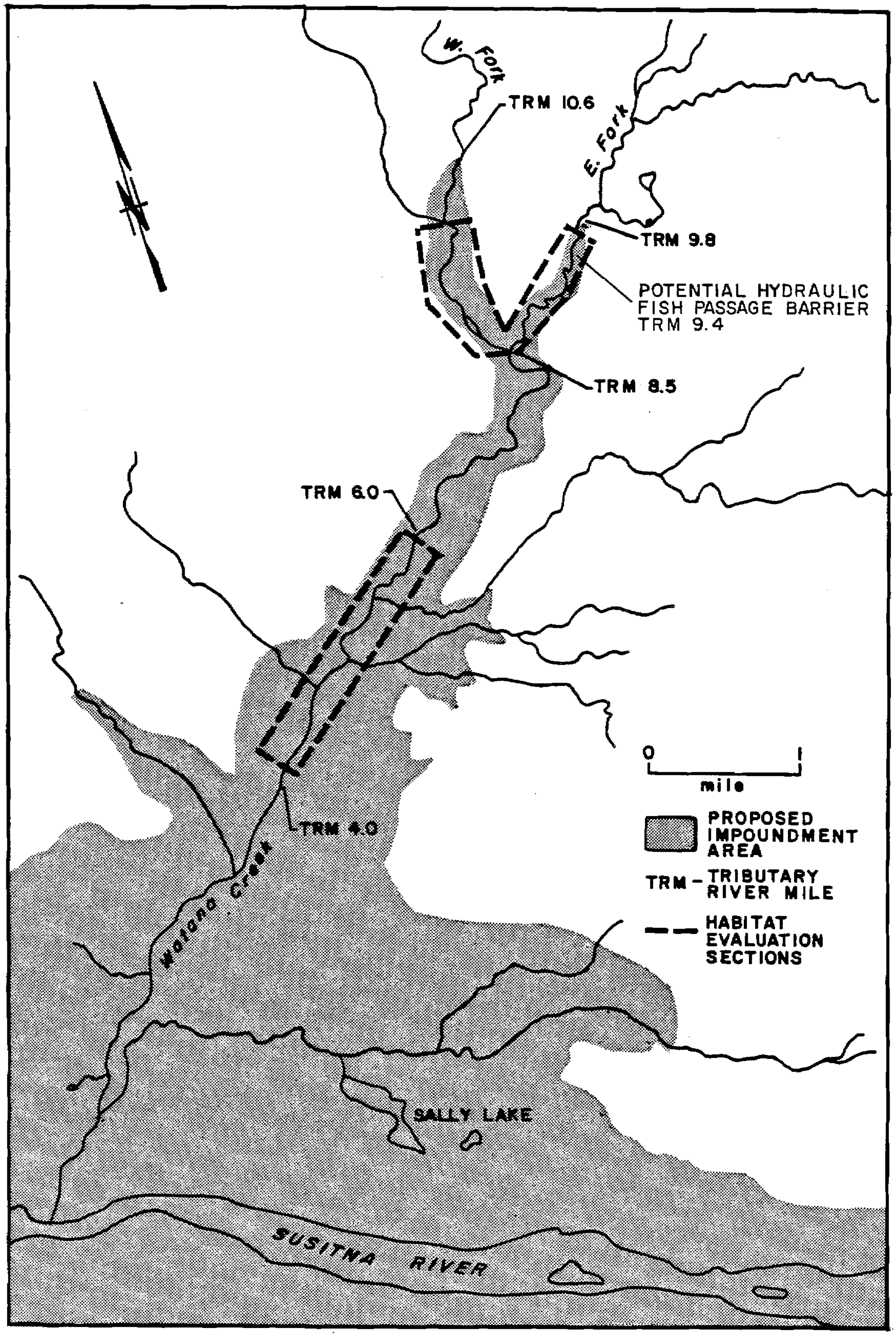

Figure 5-B-7. Proposed Watana impoundment area of Watana Creek, RM 194.1, and adjacent Susitna River.

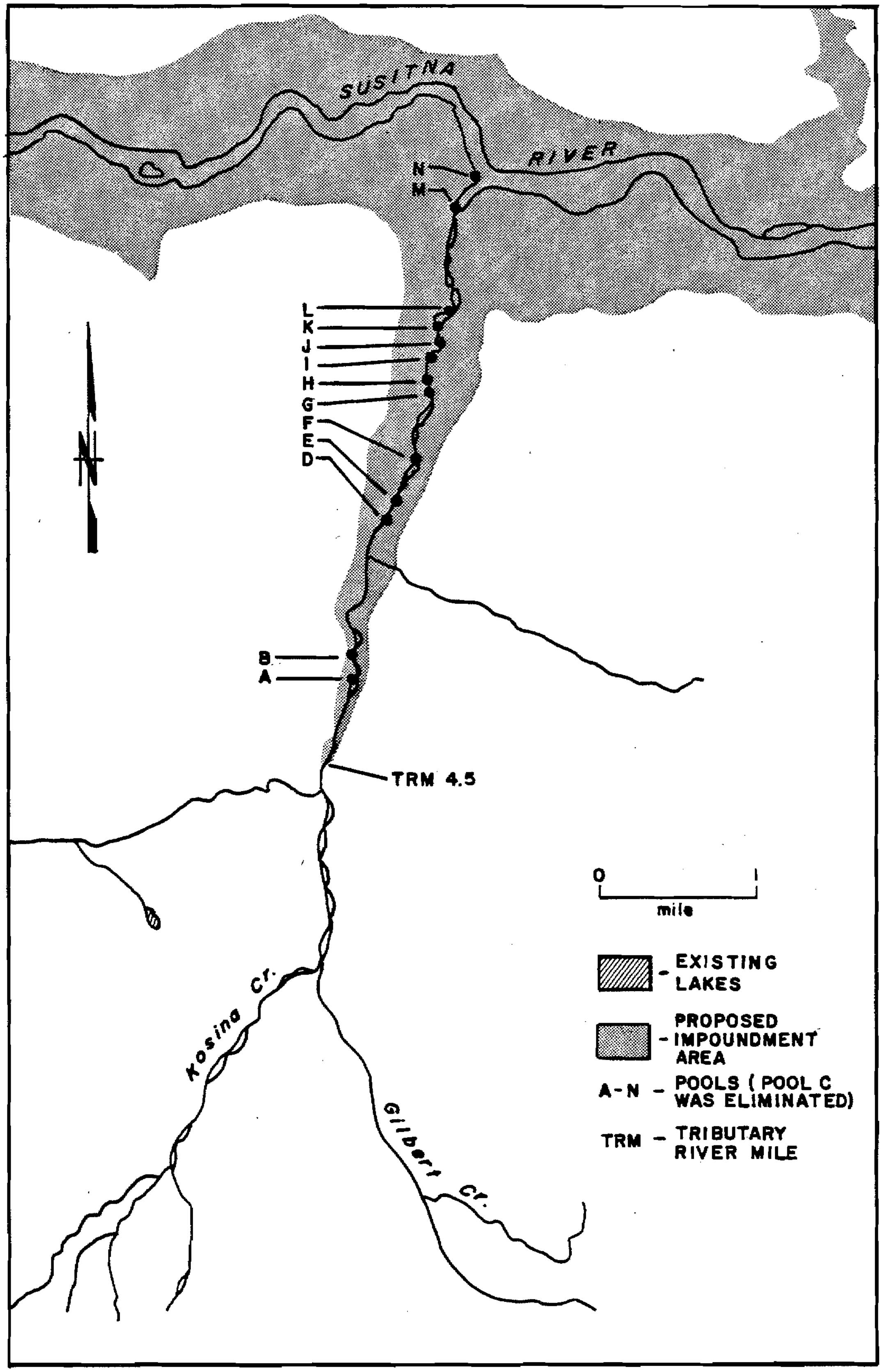

Figure 5-B-8. Proposed Watana impoundment area of Kosina Creek, RM 206.8 and adjacent Susitna River.

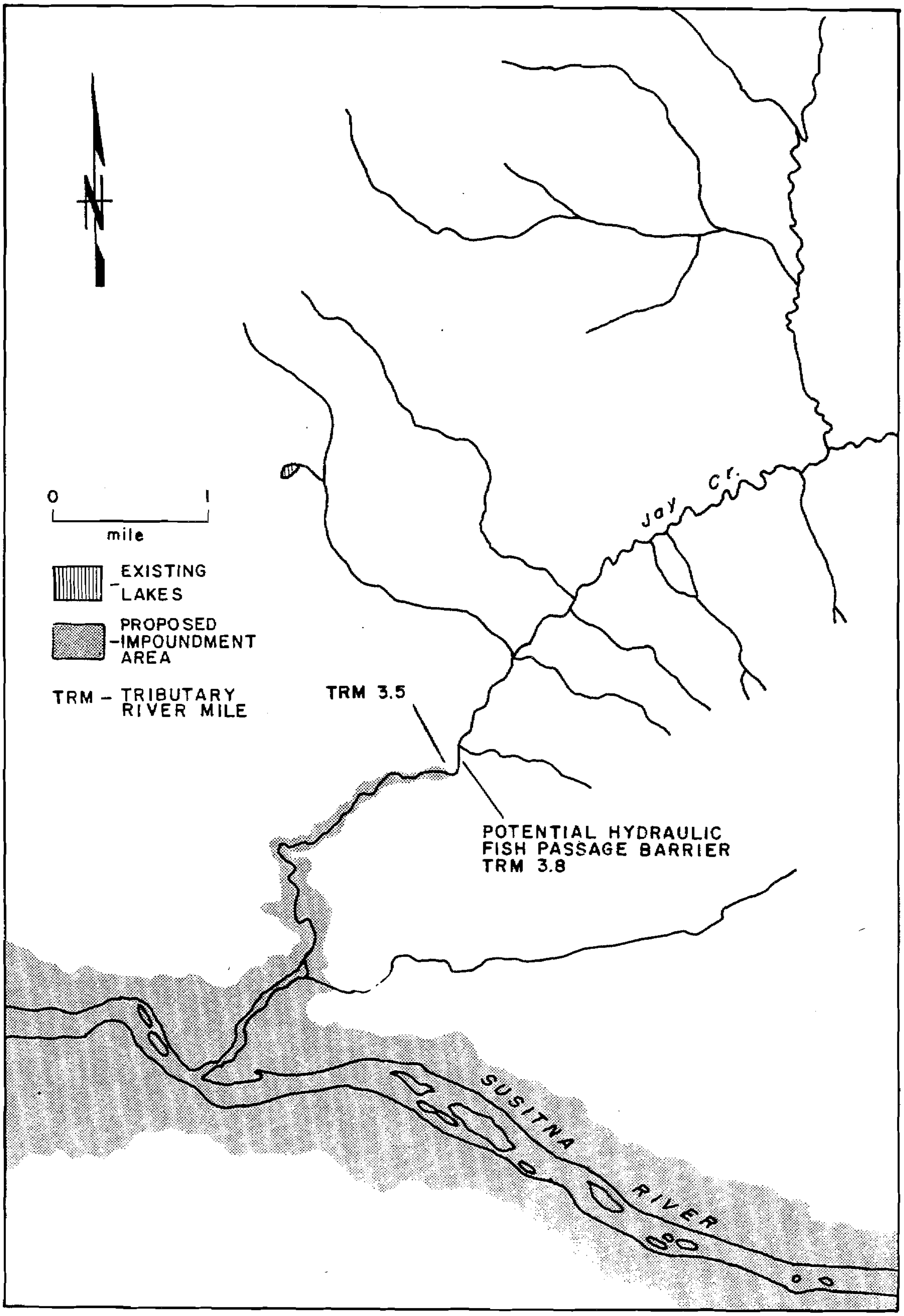

Figure 5-B-9. Proposed Watana impoundment area of Jay Creek, RM 208.5, and adjacent Susitna River.

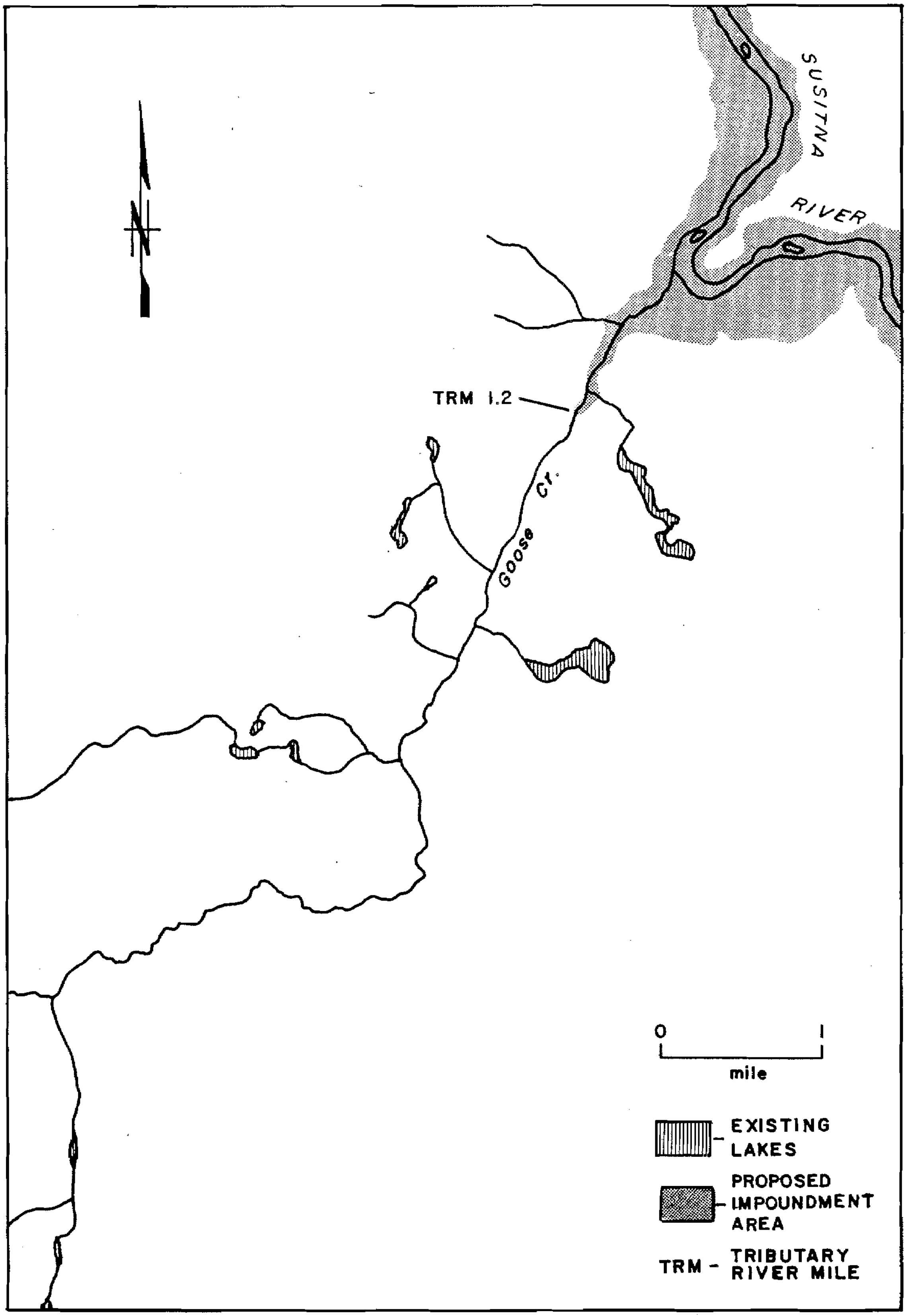

Figure 5-B-10. Proposed Watana impoundment area of Goose Creek, RM 231.3, and adjacent Susitna River.

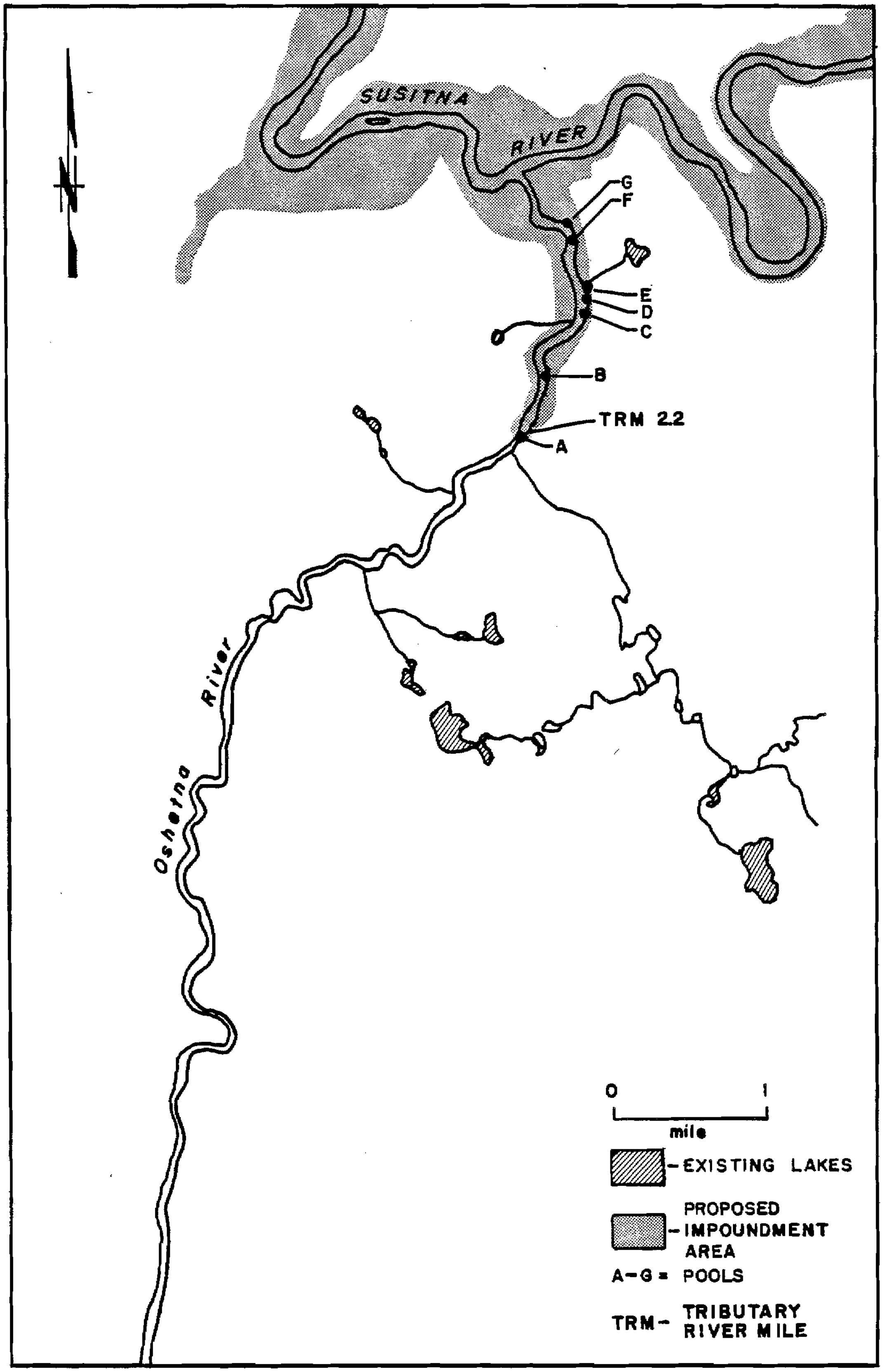

Figure 5-B-11. Proposed Watana impoundment area of the Oshetna River, RM 233.4, and adjacent Susitna River.

APPENDIX C

Selected water quality data for habitat evaluation sites within the impoundment study area.

Table 5-C-1. Selected tributary water quality data collected immediately above the mouth of Cheechako Creek, RM 152.4, GC S32N01E33CCB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C		Turbidity (NTU)
						Air	Water	
820806	1525	9.8	94	7.0	30	----	11.6	--
820808	1555	10.4	98	7.2	23	----	10.8	--
820811	1430	11.1	100	7.0	22	17.0	9.4	1

-- Data available

Table 5-C-2. Selected tributary water quality data collected immediately above the mouth of Devil Creek, RM 161.4, GC S32N02E34AAC, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C		Turbidity (NTU)
						Air	Water	
820822	0930	11.2	97	7.3	57	9.6	7.4	--

-- Data unavailable

Table 5-C-3. Selected tributary water quality data collected immediatley above the mouth of Fog Creek, RM 176.7, GC S31N04E16DBB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820505	1530	13.2	97	7.4	--	4.7	1.1	--
820516	1345	13.5	97	7.5	37	11.0	0.4	4
820528	1630	11.8	93	7.1	63	6.0	3.5	3
820621	1130	11.6	94	6.9	50	10.8	4.5	2
820718	1130	11.5	100	7.2	65	14.8	7.5	1
820815	1300	----	---	---	99	15.8	9.4	1
820912	1155	12.4	108	7.5	83	8.1	3.6	1

-- Data unavailable

Table 5-C-4. Selected tributary water quality data collected immediatley above the mouth of Tsusena Creek, RM 181.3, GC S32N04E36ADB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820505	1500	14.0	104	7.3	---	4.7	1.4	--
820515	1705	13.8	100	7.4	121	7.8	0.3	5
820528	1420	12.2	94	6.9	96	7.0	2.6	1
820619	1140	11.4	95	7.0	33	18.2	5.3	2
820718	1430	11.6	103	7.2	57	15.8	7.9	1
820728	1600	11.3	105	7.2	61	----	9.9	--
820816	1210	----	---	---	97	15.8	7.9	1
820912	1415	11.6	98	7.4	87	10.2	5.9	1

-- Data unavailable

Table 5-C-5. Selected tributary water quality data collected immediatley above the mouth of Deadman Creek, RM 186.7, GC S32N05E26CDB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820505	1430	14.2	104	7.3	--	4.8	0.8	--
820516	1245	13.8	100	7.4	61	----	0.5	7
820528	1330	12.7	94	7.0	53	5.8	0.9	2
820619	1310	11.2	95	7.0	28	17.8	6.1	7
820718	1010	11.1	103	7.5	59	10.6	9.6	1
820816	1645	----	---	---	75	16.8	13.9	1
820911	1225	11.7	100	7.1	66	9.1	6.6	1

-- Data unavailable

Table 5-C-6. Selected tributary water quality data collected one mile above the PIE on Deadman Creek, TRM 3.7, GC S32N05E13BBB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820720	0910	10.3	104	6.8	56	19.4	11.9	1

Table 5-C-7. Selected tributary water quality data collected immediatley above the mouth of Watana Creek, RM 194.1, GC S32N06E25CCA, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C		Turbidity (NTU)
						Air	Water	
820505	1420	14.1	102	7.5	---	4.8	0.1	--
820517	1200	13.1	100	7.4	82	8.0	1.9	17
820525	2130	10.1	77	6.7	101	4.7	2.2	--
820526	1620	11.3	93	7.1	104	11.5	4.9	25
820620	1800	11.7	99	7.0	63	12.8	5.7	8
820623	1830	9.9	97	7.4	108	21.8	11.9	7
820624	1800	9.6	99	7.4	114	24.1	12.7	--
820628	0915	10.4	94	7.4	103	18.2	8.5	--
820718	1700	10.8	102	7.6	151	----	9.8	20
820726	0950	12.1	105	7.2	122	13.8	7.0	8
820729	1200	11.0	100	7.6	163	15.0	9.1	--
820811	0700	12.5	105	7.3	169	8.0	6.2	--
820812	0800	12.8	104	7.5	191	4.8	4.0	1
820813	0740	11.9	99	7.5	195	6.4	5.4	--
820814	0700	11.0	100	7.6	194	----	8.3	--
820815	0730	12.2	105	7.6	200	9.6	7.0	--
820816	0720	----	---	---	206	7.0	6.0	--
820817	0820	10.4	90	7.4	184	9.0	6.8	--
820818	0700	11.9	100	7.3	186	6.8	5.9	--
820819	0615	12.5	104	7.4	188	1.6	5.1	--
820820	0730	12.0	101	7.5	191	7.6	6.0	--
820821	0730	11.5	99	7.4	191	8.4	6.5	--
820822	0650	11.7	98	7.5	198	2.8	5.4	--
820823	0730	10.1	90	7.5	202	11.4	8.0	--
820824	0740	11.3	99	7.5	206	----	7.1	--

-- Data unavailable

Table 5-C-7. Continued.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C		Turbidity (NTU)
						Air	Water	
820825	0700	11.0	97	7.2	211	8.4	7.7	--
820826	0730	11.4	99	7.4	212	7.1	6.6	--
820909	0645	11.8	98	7.1	164	6.4	5.1	--
820910	0730	11.9	97	7.2	172	4.8	4.7	--
820911	0730	13.2	102	7.2	176	3.6	3.1	--
820912	0730	13.2	104	7.2	183	1.8	3.0	--
820913	0800	12.5	100	7.3	169	4.8	3.9	--
820914	0730	12.1	100	7.0	118	6.4	4.7	--
820915	0745	11.8	98	7.2	104	9.6	5.0	--
820916	0800	11.4	95	7.3	105	5.8	5.3	--
820917	0730	12.4	100	7.2	124	3.2	4.0	9
820918	0745	12.7	100	7.1	134	3.0	3.6	--
820919	0745	10.4	85	7.2	147	7.1	4.6	--
820920	0745	----	---	7.3	147	4.2	3.8	--

-- Data unavailable

Table 5-C-8. Selected tributary water quality data collected within the two mile study section of Watana Creek, TRM 5.0, GC S32N07E17BAD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820626	1600	9.9	95	7.4	96	26.0	10.9	--
820729	1300	11.4	105	7.2	142	14.5	9.0	--
820825	1240	11.1	102	7.6	184	----	8.5	--

-- Data unavailable

Table 5-C-9. Selected tributary water quality data collected in the East Fork Watana Creek, TRM 9.2, GC S33N07E34CCA, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820825	1200	10.7	98	7.6	80	----	8.1	--

-- Data unavailable

Table 5-C-10. Selected tributary water quality data collected in the West Fork Watana Creek, TRM 9.6, GC S33N07E34CCA, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820825	1235	11.2	102	7.7	193	----	8.2	--

-- Data unavailable

Table 5-C-11. Selected tributary water quality data collected immediately above the mouth of Kosina Creek, RM 206.8, GC S31N08E15BAB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820504	1630	14.1	108	7.2	--	4.7	1.8	--
820504	1800	14.1	107	7.1	--	----	1.5	--
820505	1130	14.1	104	7.6	--	4.3	0.8	--
820505	1230	13.5	100	7.5	--	----	1.1	--
820505	1630	13.8	104	7.6	--	----	1.4	--
820505	1930	14.0	104	7.5	--	0.4	1.0	--
820513	1200	13.4	97	7.4	89	2.8	0.6	--
820515	1200	12.6	94	7.3	79	7.8	1.5	2
820516	1200	13.2	98	7.5	68	----	1.2	--
820526	1400	11.8	91	6.8	43	12.0	2.3	2
820623	1200	10.1	93	7.3	37	21.0	9.0	3
820627	1030	9.9	94	7.1	39	20.1	10.0	--
820726	1205	11.0	106	7.3	68	17.8	11.2	1
820812	1130	11.0	100	7.3	70	13.2	8.4	1
820914	1335	11.9	104	7.2	62	11.8	6.8	1

-- Data unavailable

Table 5-C-12. Selected tributary water quality data collected one mile above the PIE on Kosina Creek, TRM 5.5, GC S30N08E04CBD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820724	0945	11.0	106	7.2	61	15.8	10.1	2

Table 5-C-13. Selected tributary water quality data collected immediately above the mouth of Jay Creek, RM 208.5, GC S31N08E13BCC, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820505	1315	13.9	100	7.8	---	4.8	0.3	--
820516	1100	13.4	98	7.6	77	10.0	0.6	14
820529	1000	12.0	94	7.1	60	10.0	2.9	37
820624	1600	9.9	98	8.1	103	27.2	12.1	19
820726	1125	11.7	105	8.0	158	19.2	8.1	2
820812	1200	11.3	99	7.7	178	14.4	6.9	1
820915	1510	10.7	97	7.9	120	15.8	8.2	3

-- Data unavailable

Table 5-C-14. Selected tributary water quality data collected immediately above the mouth of Goose Creek, RM 231.3, GC S30N11E32DBC, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820505	1345	13.3	100	7.4	--	4.9	0.5	--
820514	0800	13.8	100	7.1	47	2.5	0.2	1
820618	1430	11.2	97	6.8	34	11.0	6.1	2
820621	1630	10.0	104	7.3	65	17.0	14.0	1
820627	1200	9.6	96	7.2	48	22.3	12.0	--
820728	1500	9.7	103	7.3	77	----	14.8	--
820818	1645	9.7	100	7.4	69	17.2	13.0	1
820910	1425	11.2	98	7.2	68	10.6	6.6	1

-- Data unavailable

Table 5-C-15. Selected tributary water quality data collected one mile above the PIE on Goose Creek, TRM 2.2, GC S29N11E07CCA, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820621	1850	10.2	107	7.2	59	15.4	13.2	1

Table 5-C-16. Selected tributary water quality data collected immediately above the mouth of the Oshetna River, RM 233.4, GC S30N11E34CCD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820505	1400	14.3	105	7.7	---	4.9	0.1	--
820527	1400	11.4	92	7.2	56	10.8	3.4	5
820627	1135	10.2	94	7.3	50	19.6	8.7	42
820719	1650	9.6	101	7.5	99	23.0	14.4	6
820728	1440	10.2	106	7.5	115	----	13.9	--
820820	1805	10.4	106	7.8	114	19.2	12.8	2
820909	1540	11.0	98	7.4	128	10.2	7.1	1

-- Data unavailable

Table 5-C-17. Selected tributary water quality data collected one mile above the PIE on the Oshetna River, TRM 3.2, GC S29N11E16ACC, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820719	1700	9.9	105	7.6	98	24.8	14.5	2

Table 5-C-18. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Fog Creek, RM 176.7, GC S31N04E16DBB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820621	1135	10.7	93	7.0	84	10.8	7.3	66
820718	1140	10.6	94	7.2	92	14.6	8.6	36
820815	1315	9.0	83	7.2	110	15.8	9.7	85
820912	1150	11.0	91	7.4	128	8.1	5.7	24

Table 5-C-19. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Tsusena Creek, RM 181.3, GC S32N04E36ADB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820619	1200	10.2	93	7.2	73	18.8	8.8	38
820718	1440	10.3	99	7.5	122	16.6	11.0	140
820816	1200	----	---	---	119	15.8	10.3	150
820912	1410	11.7	100	7.5	127	10.2	6.2	25

-- Data unavailable

Table 5-C-20. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Deadman Creek, RM 186.7, GC S32N05E26CDB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820619	1315	10.2	93	7.3	80	17.8	8.7	38
820718	1000	10.7	98	8.1	136	10.6	9.0	135
820816	1650	----	--	---	116	16.8	10.8	140
820911	1220	11.5	97	7.4	136	9.1	5.8	33

-- Data unavailable

Table 5-C-21. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Watana Creek, RM 194.1, GC S32N06E25CCA, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820623	1000	10.3	98	7.2	92	17.0	10.6	48
820726	1010	11.5	105	6.8	117	16.0	9.0	150
820812	1030	10.8	99	7.5	138	12.4	9.1	100
820915	1645	10.7	96	7.6	128	13.0	8.2	100

Table 5-C-22. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Kosina Creek, RM 206.8, GC S31N08E15BAB, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820627	1100	9.5	95	7.4	108	21.0	13.0	130
820726	1055	11.0	102	7.3	116	17.6	9.4	130
820812	1130	10.0	98	7.2	133	13.2	9.5	80
820914	1330	11.3	97	7.3	134	11.8	6.3	28

Table 5-C-23. Selected water quality data collected in Lower Jay Creek Slough, RM 208.1, GC S31N08E11DCD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820814	1130	6.4	70	7.3	358	----	16.5	--

-- Data unavailable

Table 5-C-24. Selected water quality data collected in Upper Jay Creek Slough, RM 208.7, GC S31N08E13BCD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820529	1430	4.8	59	6.8	452	10.6	6.6	1
820624	1620	6.3	65	7.0	398	27.2	13.6	--
820726	1110	8.7	77	6.7	473	19.2	7.5	7
820812	1145	8.3	72	6.8	396	14.0	6.6	4
820915	1455	9.9	91	7.1	401	15.8	8.7	3

-- Data unavailable

Table 5-C-25. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Upper Jay Creek Slough, RM 208.7, GC S31N08E13BCD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820529	1515	10.8	91	7.0	89	10.2	5.3	42
820624	1615	9.6	99	7.5	96	27.2	13.9	46
820726	1120	11.0	101	7.7	115	19.3	9.0	130
820812	1145	11.5	98	7.0	139	14.0	9.4	140
820915	1450	10.7	96	7.7	124	15.0	8.0	98

Table 5-C-26. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and Goose Creek, RM 231.3, GC S30N11E32DBC, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820514	0930	13.5	98	7.3	10	2.5	0.1	14
820514	1200	13.0	94	7.2	83	3.5	0.2	66
820618	1440	10.6	95	7.0	95	11.0	7.1	33
820630	1245	9.5	94	7.4	93	22.0	11.4	---
820721	1640	10.4	105	7.5	116	17.0	12.4	125
820728	1500	10.5	102	7.7	124	----	11.2	---
820818	1650	10.3	95	6.6	113	17.2	8.7	110
820910	1440	11.4	99	7.2	138	10.6	6.0	32

-- Data unavailable

Table 5-C-27. Selected mainstem water quality data collected immediately above the confluence of the Susitna River and the Oshetna River, RM 233.4, GC S30N11E34CCD, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820527	1405	11.1	93	7.1	59	11.0	4.7	36
820627	1130	9.5	99	7.6	122	19.6	13.4	140
820719	1645	10.2	104	7.5	128	23.0	12.6	140
820728	1445	10.5	103	7.7	125	----	11.6	---
820820	1810	10.4	100	7.7	122	19.2	10.5	110
820909	1550	11.1	96	6.7	144	10.2	6.3	43

-- Data unavailable

Table 5-C-28. Selected water quality data collected in Sally Lake, GC S32N07E29, 1982.

Date	Time	DO (mg/l)	DO (% sat)	pH	Spec. Cond. (umho/cm)	Temp. - °C Air	Temp. - °C Water	Turbidity (NTU)
820623	1500	8.0	90	7.3	111	----	16.9	--
820729	1240	8.1	89	7.5	122	15.2	16.0	--
820819	1600	7.5	82	7.5	114	18.8	15.7	--
820822	1330	8.0	91	7.7	113	20.6	17.4	--
820908	1710	7.6	75	7.0	113	9.8	11.3	--

-- Data unavailable

APPENDIX D

Planimetric maps of selected Susitna River habitat evaluation sites within the impoundment study area.

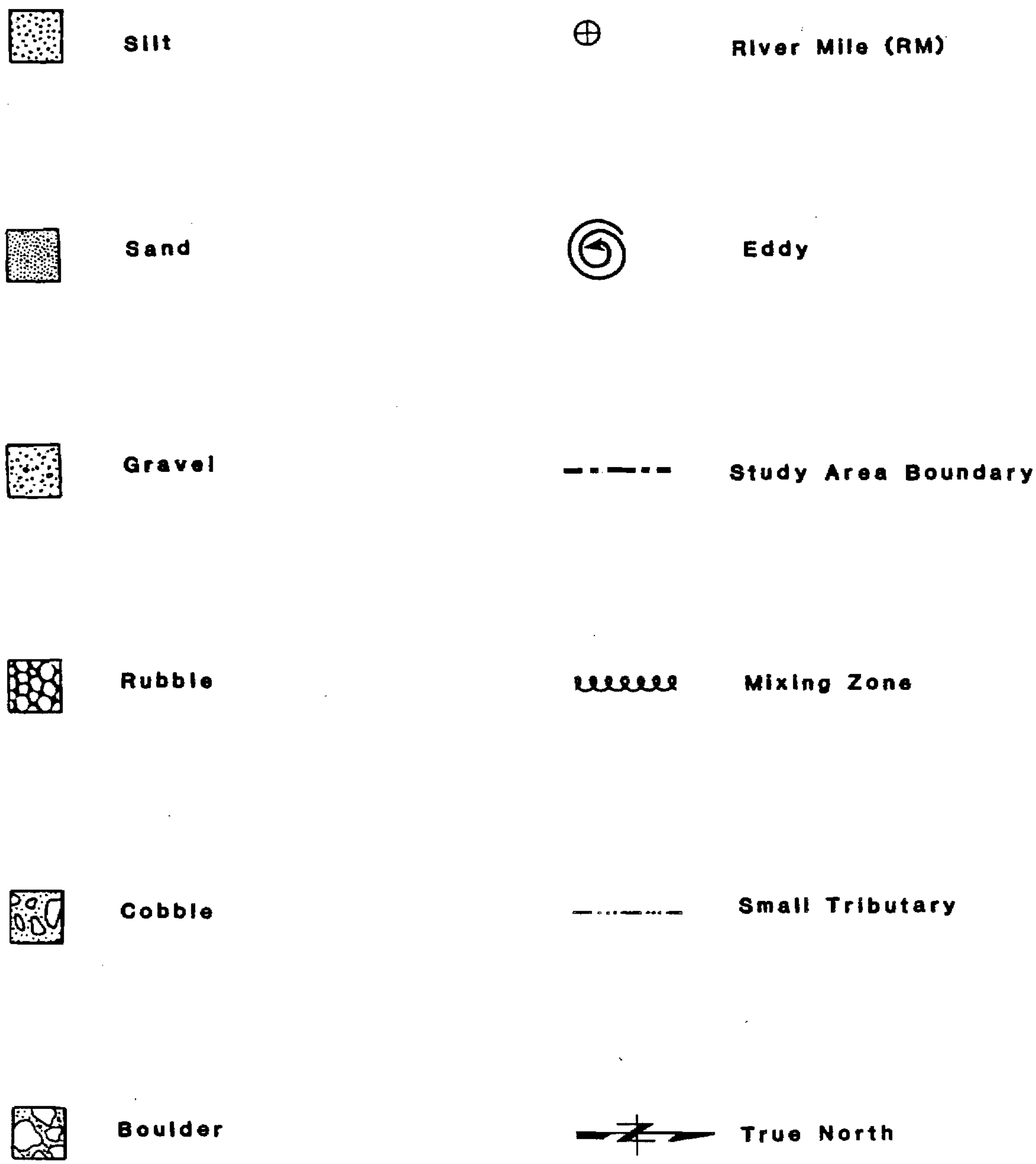

Figure 5-D-1. Planimetric map symbol legend for selected mainstem Susitna River habitat evaluation sites, Proposed Impoundment Areas, 1982.

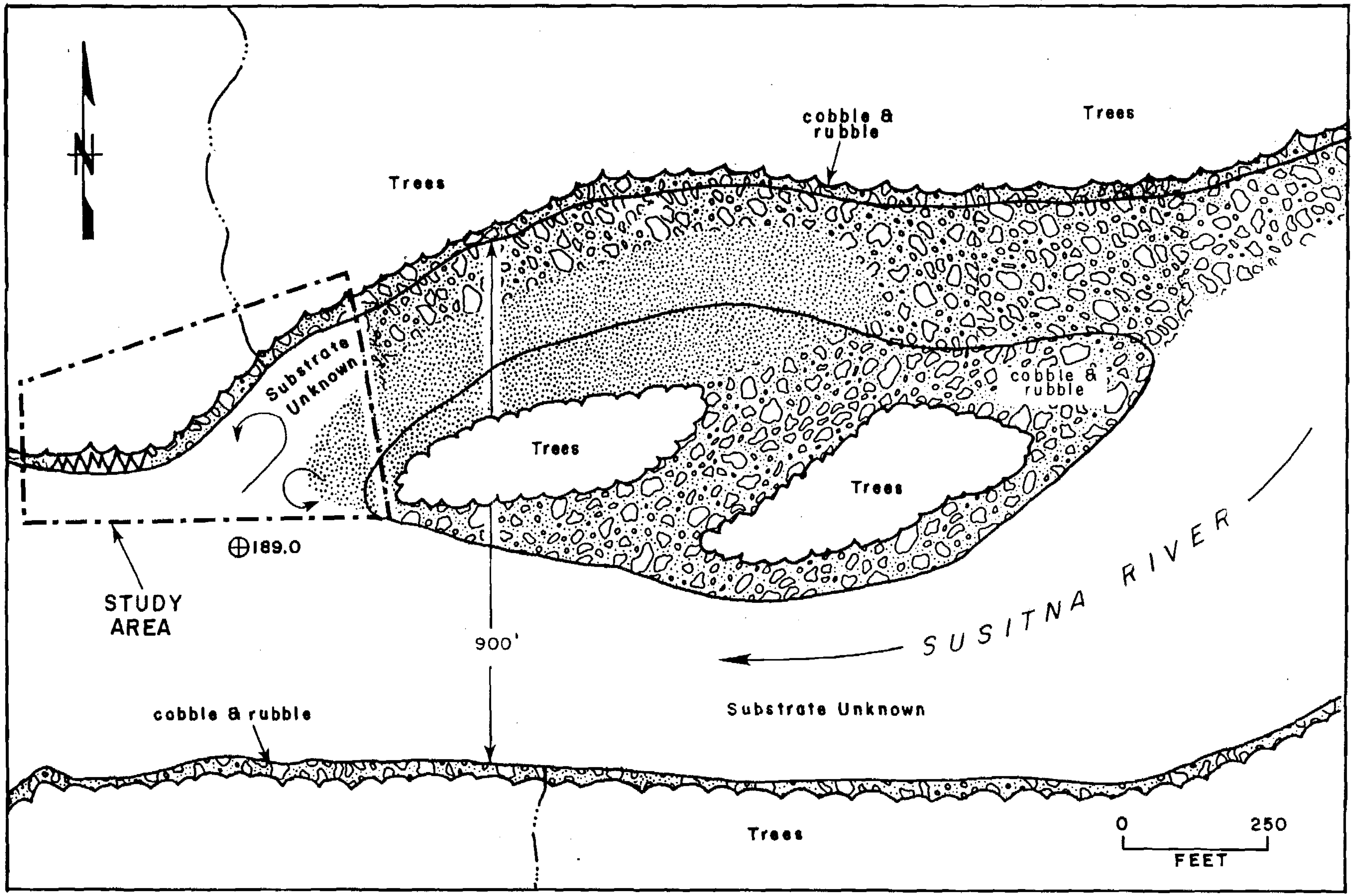

Figure 5-D-2. Mainstem Susitna River habitat evaluation site No. 1, RM 189.0, GC S32N06E31ABC.

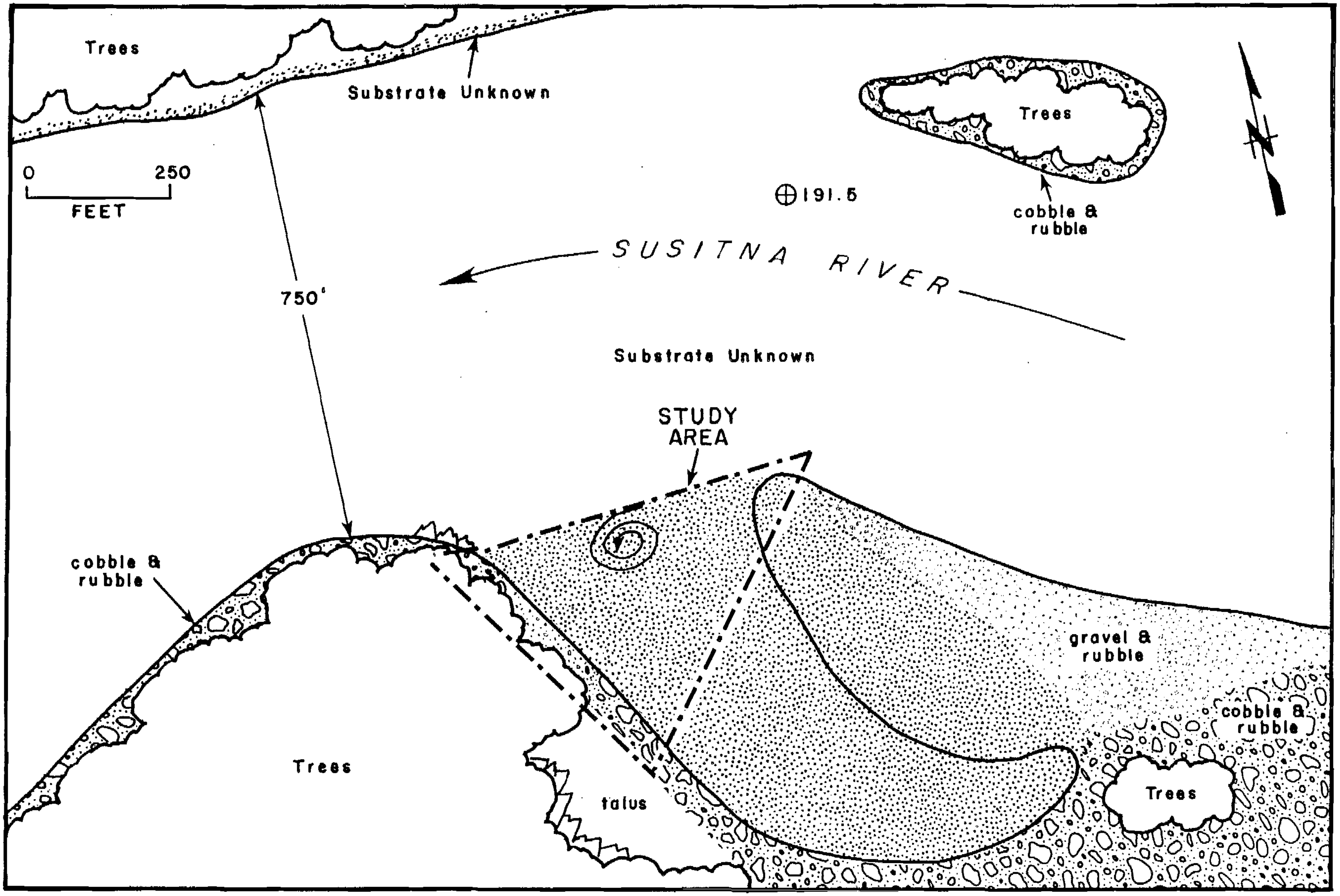

Figure 5-D-3. Mainstem Susitna River habitat evaluation site No. 2, RM 191.5, GC S32N06E28CAC.

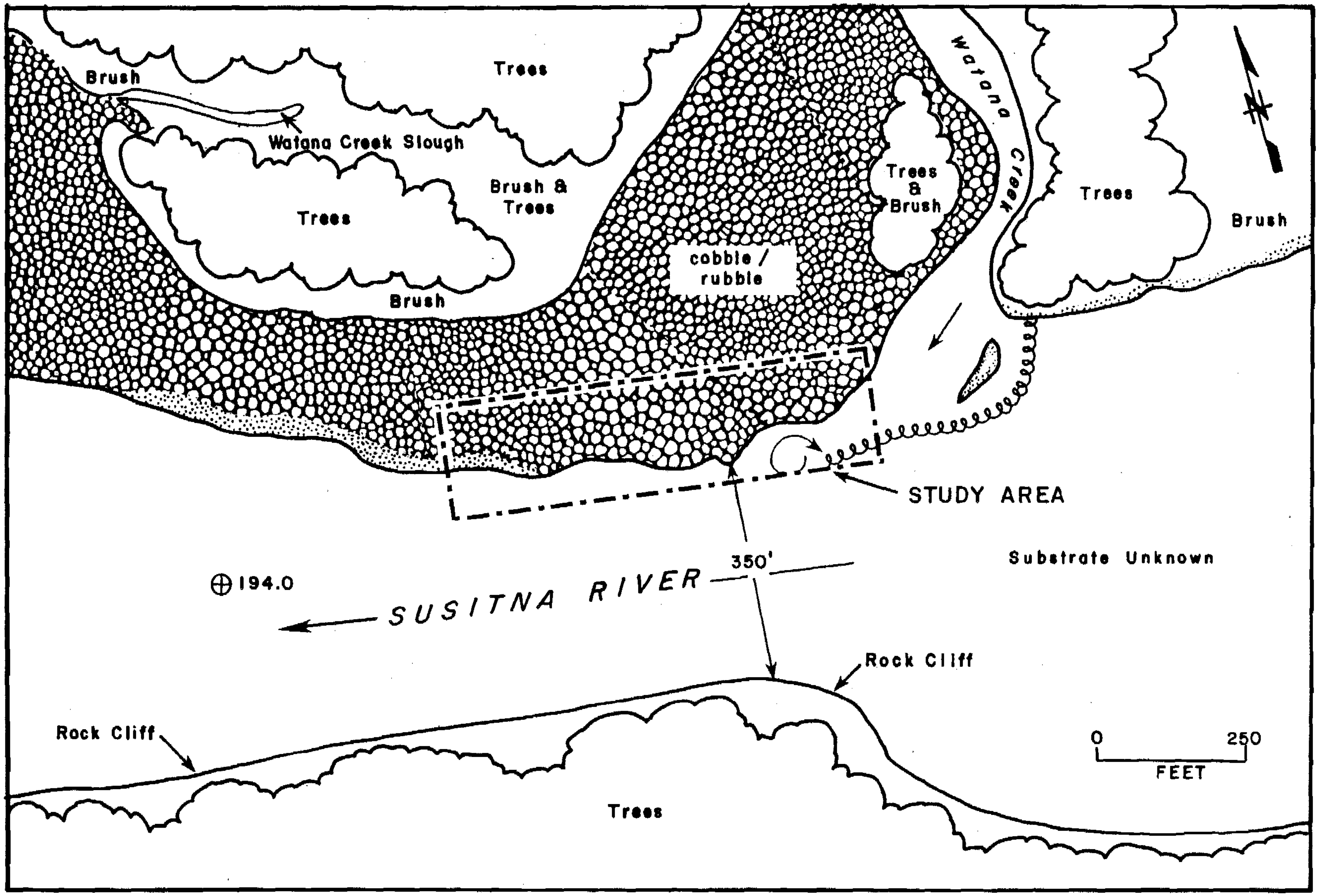

Figure 5-D-4. Mainstem Susitna River habitat evaluation site at Watana Creek, RM 194.1, GC S32N06E25CCA.

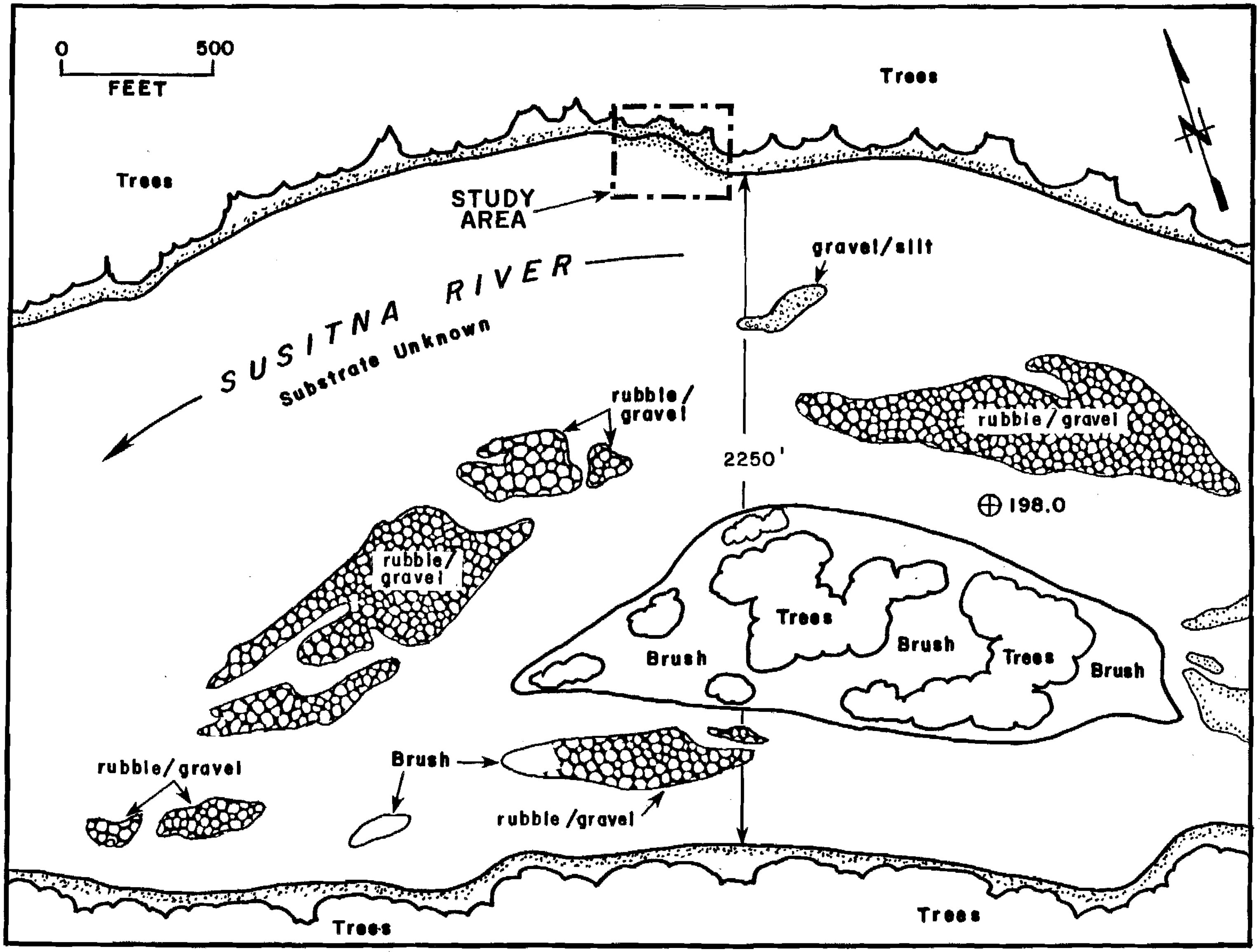

Figure 5-D-5. Mainstem Susitna River habitat evaluation site No. 3, RM 197.8, GC S32N07E33DBC.

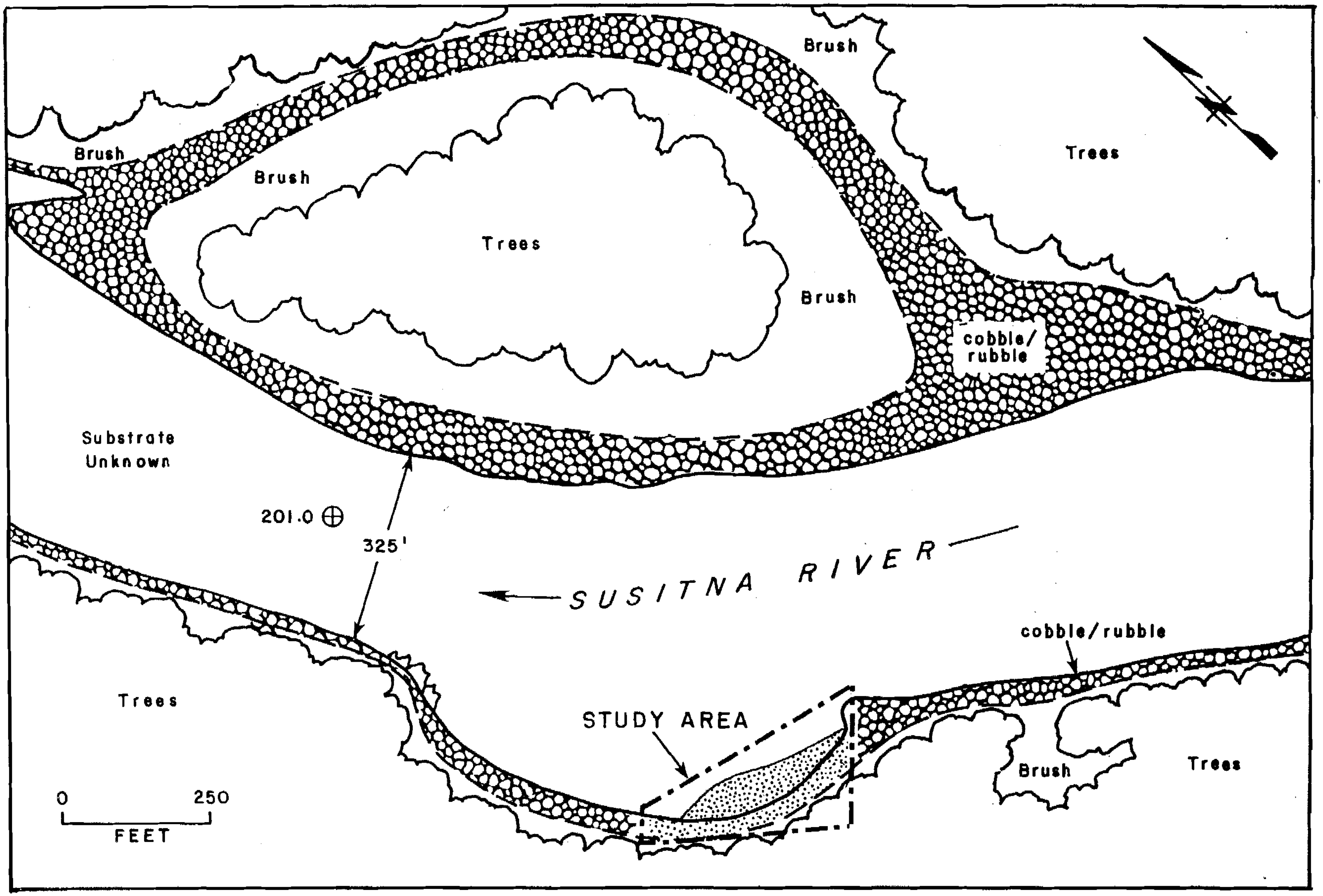

Figure 5-D-6. Mainstem Susitna River habitat evaluation site No. 4, RM 201.2, GC S31N07E12BCB.

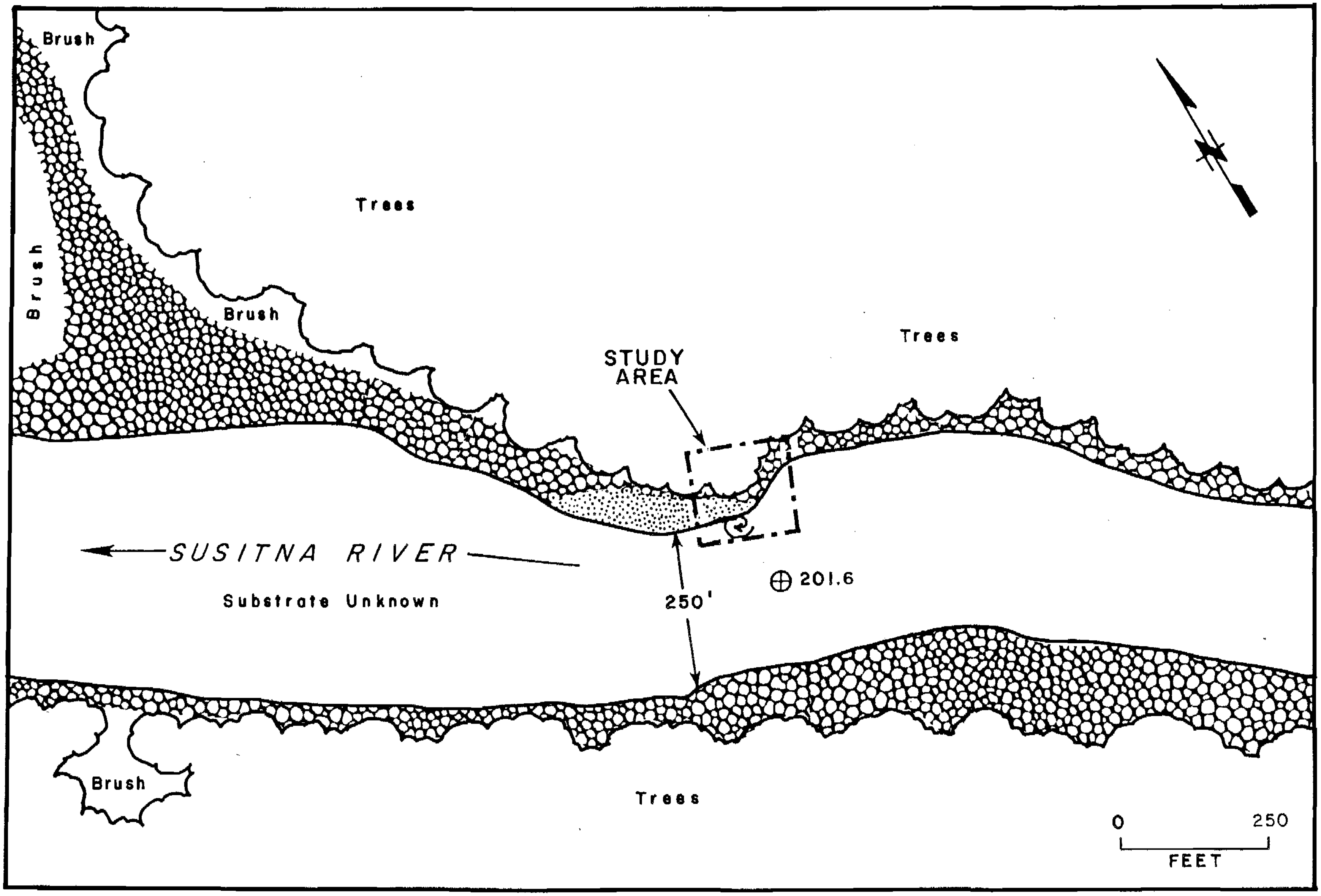

Figure 5-D-7. Mainstem Susitna River habitat evaluation site No. 3A, RM 201.6, GC S31N07E12BDB.

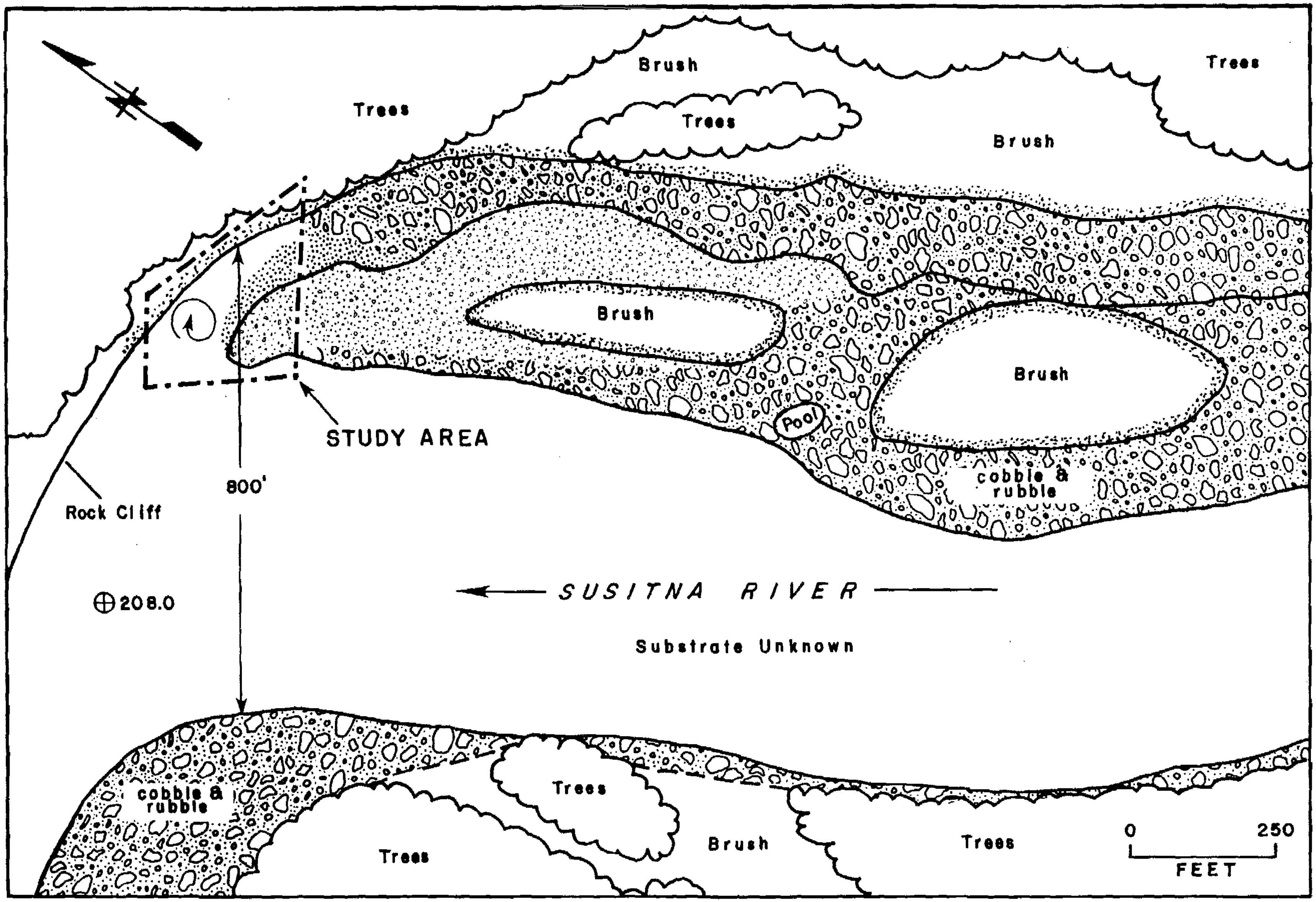

Figure 5-D-8. Mainstem Susitna River habitat evaluation site No. 5, RM 208.1, GC S31N08E11DCD.