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ALASKA DEPARTMENT OF FISH AND GAME

SUSITNA HYDRO AQUATIC STUDIES

REPORT NO. 6

ADULT SALMON INVESTIGATIONS
MAY - OCTOBER 1984

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PREFACE

The Susitna River is the largest watershed in the Cook Inlet basin encompassing about 19,400 square miles from its origin in the Alaska Mountain Range to its discharge into Upper Cook Inlet (Figure A).

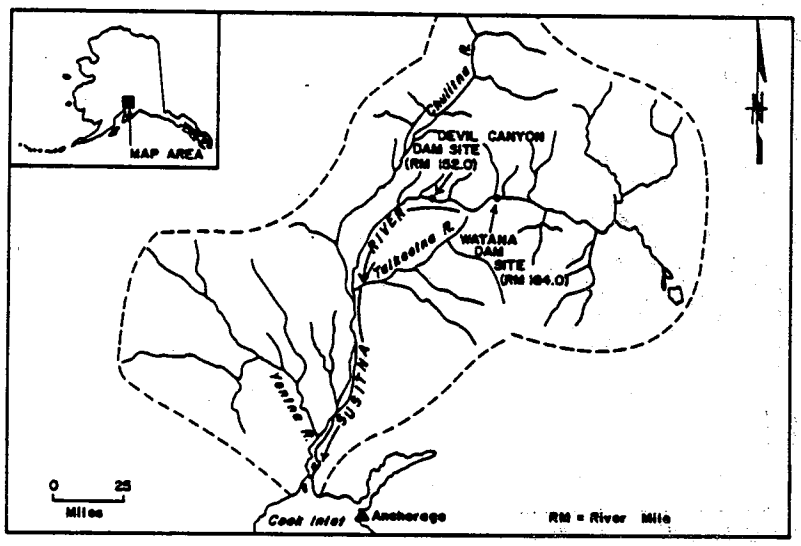

Figure A. Susitna River drainage, 1984.

The Alaska Power Authority (APA) proposes construction of two hydroelectric dams at Watana and Devil Canyons on the upper Susitna River (Figure A). The Alaska Department of Fish and Game (ADF&G) has been contracted by APA to assess the fishery resources that might be impacted by the proposed hydroelectric project. The APA-ADF&G contract, initiated in November 1980, is still in effect.

This is one of a series of ADF&G reports for 1984 that will be submitted to APA. This document addresses the adult anadromous fish investigations contracted for the Susitna River open water period of May through October, 1984 and specifically covers the following Pacific salmon species:

Pacific Salmon	Oncorhynchus sp.
Chinook Salmon	O. tshawytscha
Sockeye Salmon	O. nerka
Pink Salmon	O. gorbuscha
Chum Salmon	O. keta
Coho Salmon	O. kisutch

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1.0 OBJECTIVES

The fourth consecutive year of study of the Susitna River adult salmon populations in association with proposed hydroelectric development at Watana and Devil Canyon was completed in 1984. The primary emphasis of the 1984 study were to quantify mainstem escapements and to define spawning locations. More explicitly, the objectives, by river reach, were:

A. Lower River (Intertidal at RM 0.0 to the Chulitna River confluence at RM 98.6).

1. define the abundance, timing and stock characteristics of sockeye, pink, chum and coho salmon escapements to the Susitna River at Flathorn (RM 22) and Sunshine (RM 80) stations and into the Yentna River (RM 28) at Yentna Station (TRM 04); additionally, evaluate the same parameters for chinook salmon at Sunshine Station;

2. define timing, distribution and extent of salmon spawning in Susitna River slough, main channel, side channel and stream mouth habitats upstream of Yentna River.

B. Middle River (Chulitna River confluence at RM 98.6 to upper Devil Canyon at RM 161.0).

1. define the abundance, timing and stock characteristics of chinook, sockeye, pink, chum and coho salmon escapements to the Susitna River at Talkeetna (RM 103) and Curry (RM 120) stations;

2. define timing, distribution and extent of salmon spawning in main channel, side channel, stream and slough habitats; additionally, to determine the average resident time (observed residence) of sockeye and chum salmon in middle-reach sloughs.

2.0 METHODS

2.1 Main Channel Escapement Monitoring

In 1984, salmon escapements were monitored at five mainstem locations on the Susitna and Yentna rivers (Figure 1). In the lower Susitna River reach, a tagging site was operated at Flathorn Station, a sonar site at Yentna Station on the Yentna River and a second tagging site at Sunshine Station between Montana Creek and the George Parks Highway bridge. In the middle Susitna River reach, a tagging station was operated at Talkeetna Station and another at Curry Station. With the exception of Flathorn Station, a new tagging site this year, the other four monitoring stations were at the same river mile locations in 1984 as in 1981 through 1983.

The five lower- and middle-river escapement monitoring stations in 1984 were operated according to the schedule in Table 1. Flathorn and Sunshine stations each had four fishwheels in operation. At Yentna Station, two side scan sonars (SSS) and two fishwheels were run concurrently. In the middle reach, four fishwheels at Talkeetna Station and two fishwheels at Curry Station were used. The specific placement sites of the 16 fishwheels and two sonars at the five sampling stations can be found in Appendix 2.

Table 1. Operation schedules at main channel Susitna and Yentna rivers escapement monitoring stations, 1984.

Station	Location		Period	
	River	River Mile	Begin	End
Flathorn	Susitna	20	6/29	9/3
Yentna	Yentna	04	7/1	9/5
Sunshine	Susitna	80	6/4	9/10
Talkeetna	Susitna	103	6/3	9/11
Curry	Susitna	120	6/9	9/14

The two sonars operated in 1984 at Yentna Station were 1980 Model Side Scan Sonar Counters (Bendix Corporation). The sonar installation and operating procedures were in accordance with the manufacturer's operational manual (Bendix Corporation 1980). Except for occasional

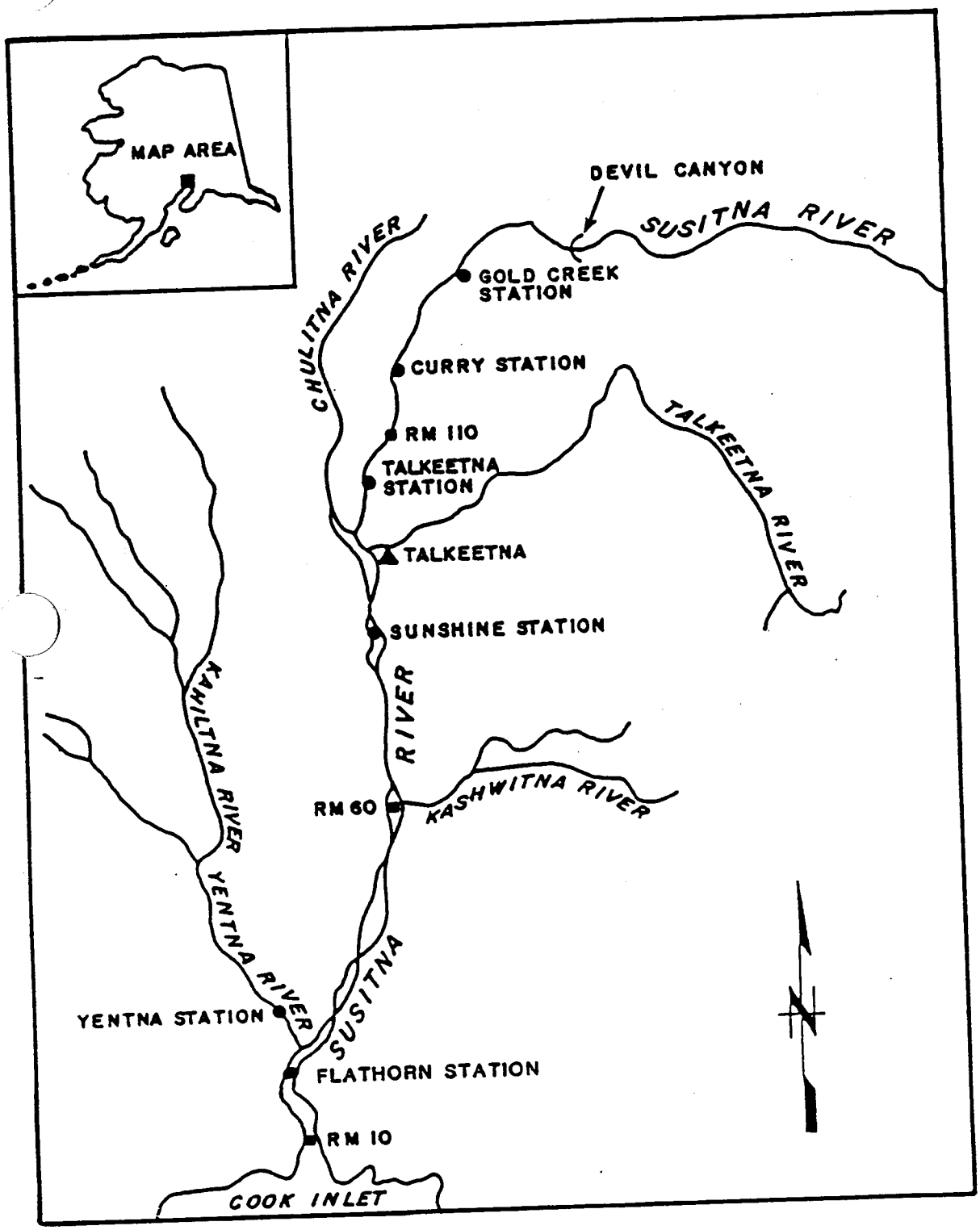

Figure 1. Susitna River basin map showing field stations and major glacial streams, 1984.

heavy-debris flow periods associated with extreme high water, the two sonar counters at Yentna Station were run continuously, 24 hours per day, through the season. The two fishwheels, one near each sonar off the north and south Yentna River banks, were operated a minimum of 12 hours daily during the season for apportioning the sonar counts by species and for tag recovery data from Flathorn Station. Detailed sonar monitoring and apportioning methodology is described by Barrett et al. (1984).

All fishwheels were designed by ADF&G Su Hydro staff (ADF&G 1981, 1982). The fishwheels at Flathorn, Sunshine, Talkeetna and Curry stations were run 24 hours per day except for occasional down time for maintenance, debris problems and high catches that exceeded manpower capabilities. Each fishwheel was checked four or more times daily. Salmon catches were tagged and released, except for the following, which were not tagged:

1. fish that visually appeared lethargic or stressed;
2. post-spawning condition fish;
3. fish previously tagged;
4. 90% of the pink salmon at Flathorn and Sunshine stations, and 50% of the pink salmon caught at Talkeetna and Curry stations;
5. chinook salmon at Flathorn Station, and chinook salmon less than 351 mm in fork length at the other three stations.

All recaptured fish were checked for species identification and tag type, color and number before being released.

In 1984, two tag types were used. All chinook salmon were tagged with Petersen discs. The other species were tagged with Floy FT-4 spaghetti tags. The exception was at Curry Station where Petersen disc tags were used for all species. A percentage of the tags used at all the tagging stations were numbered to determine migrational travel time. The methodology used to implant the Petersen and spaghetti tags can be found in ADF&G (1981).

At each sampling station on the Susitna and Yentna rivers, an age, fork length and sex composition sample was collected daily for the following number of each species regardless of size:

1. chinook salmon--30 consecutively caught fish, except at Sunshine Station, where the sample was 30 consecutively caught fish from both the east and west bank fishwheels;
2. sockeye salmon--30 consecutively caught fish, except at Flathorn Station, where the sample was 30 consecutively caught fish from both the east and west channels;

3. pink salmon--30 consecutively caught fish;

4. chum salmon--20 consecutively caught fish;

5. coho salmon--20 consecutively caught fish.

The procedures followed in 1984 for collecting salmon age, length and sex samples can be found in ADF&G (1982).

On August 22, 1984, 25 coho salmon were collected at Sunshine Station for a fecundity study. The collection procedures used for sampling fecundity can be found in Barrett et al. (1984).

2.2 Spawning Ground and Tag Recovery Surveys

Drainage-wide surveys of pre-selected chinook spawning areas were conducted cooperatively by ADF&G Region II Sport Fish Division and ADF&G Su Hydro. The surveyed areas have been routinely monitored for chinook since 1976 (ADF&G 1981). The 1984 surveys were performed from helicopter, fixed-wing airplane, raft and by foot, depending on access. Between mid-July and mid-August, most lower-river areas were surveyed once and most middle-river areas were surveyed twice.

The next two subsections outline additional 1984 salmon spawning ground and tag recovery survey work by ADF&G Su Hydro staff, specific to river reach.

2.2.1 Lower Reach

The mouths of lower-reach streams listed in Table 2 were surveyed weekly for salmon presence (by foot and occasionally by helicopter) from July 21 to October 7, 1984. A "stream mouth" began at the confluence and extended one-third mile into the reach.

Table 2. Lower reach Susitna River stream mouths surveyed weekly from July 21 to October, 7, 1984.

Stream	River Mile	Stream	River Mile
Unnamed Creek	31.7	Fish Creek	31.2
Whitsol Creek	35.2	Rolly Creek	39.0
Willow Creek	49.1	Little Willow Creek	50.5
Grays Creek	59.5	Kashwitna River	61.0
Caswell Creek	64.0	Sheep Creek	66.1
Goose Creek	72.0	Montana Creek	77.0
Rabideux Creek	83.1	Sunshine Creek	85.1
Birch Creek	89.2	Trapper Creek	91.5
Cache Creek	95.5		

Mainstem and slough habitats above RM 28 were surveyed weekly from August 21 to October 17 by helicopter. Suspected salmon-spawning areas were checked by foot and boat between scheduled surveys and classified as spawning areas if one or more of the following conditions were met:

1. visual identification of one or more actively mating pairs of fish;

2. presence of one or more distinct redds;

3. confirmed presence of live eggs by intragravel sampling.

The mouths of the streams listed in Table 2, and confirmed mainstem and slough salmon-spawning habitats in the lower reach were mapped and described in terms of channel morphology, substrate composition and ground water presence.

Precise evaluations of substrates at stream mouths were performed as time permitted using a McNeil sampler and sieves. Substrates were sampled for eggs by excavation with a shovel or backpack-mounted Homelite water pump and screen.

2.2.2 Middle Reach

Salmon-spawning surveys were conducted between July 21 and October 14. Specific chinook surveys were made between July 21 and August 18 of all suspected middle-reach spawning streams. Each stream was generally surveyed twice by helicopter or on foot to the upper limit of fish migration.

All sloughs and streams of suspected adult salmon use were surveyed weekly from August 6 to October 11. Sloughs were surveyed on foot over their entire distance, and streams to standard index markers. Exceptions were Indian River (RM 138.6) and Portage Creek (RM 148.9), in which the entire reaches accessible to salmon were surveyed. Three streams located in Devil Canyon: Cheechako Creek (RM 152.4), Chinook Creek (RM 157.0) and Devil Creek (RM 161.0) were similary surveyed.

Observed residence data was taken for chum and sockeye at three-day intervals from sloughs Moose (RM 123.5), A' (RM 124.6), 8A (RM 125.1) and 11 (RM 135.3). Observers used polarized glasses and polarized 7 x 35 Bushnell binoculars to detect and identify tagged chum and sockeye from Curry Station. Observers recorded sighting date, tag number, species, location in the slough and activity of each tagged salmon.

Main channels and side channels were surveyed weekly by helicopter from August 27 to October 13. Criteria presented in Section 2.2.1 were used to identify spawning sites.

Tag recovery surveys were conducted in conjunction with spawning ground surveys by recording numbers of live tagged and untagged fish of each species.

Egg retention sampling of sockeye and chum salmon carcasses was conducted at sloughs during escapement surveys. The sample size was based on fish availability and time. An incision was made in the abdomen of each fish and retained eggs were counted by hand.

2.3 Data Analysis

2.3.1 Escapement Monitoring by SSS Counter

The SSS counters operated at Yentna Station had a counting range of 60 feet, which was divided into 12 equal sectors. Counts for individual sectors were registered hourly on a printer. The printer tapes were edited in the field and rechecked in the office to eliminate debris counts (Barrett et al. 1984).

The daily fish counts by each SSS counter at Yentna Station were apportioned by species based on the composition of the catch by the fishwheel operating on the same day off the same bank. When the daily fishwheel catch was less than 150 fish, the SSS counts were apportioned according to the cumulative fishwheel catch for the succeeding number of days required to reach a 150 fish threshold catch sample.

2.3.2 Tag and Recapture Estimates

Salmon escapements to Flathorn, Sunshine, Talkeetna and Curry stations were estimated using the modified Petersen model by Ricker (1975). The exception was for jack chinook salmon measuring less than 351 mm. Barrett et al. (1984) discuss the procedure for calculating the jack chinook salmon escapements, the assumptions and suitability of the Petersen model and the calculation of the associated 95 percent confidence limits.

2.3.3 Escapement Timing

Salmon escapement timings were calculated for each species by station based on fishwheel catches. Species migration at a sampling station was defined to have started, reached a midpoint and ended on the date when 5, 50 and 95 percent of the cumulative station fishwheel catch-per-unit-effort (CPUE) was attained.

Escapement timings by salmon species are presented graphically as fishwheel CPUE curves, smoothed by the von Hann linear filter method (BMDP 1981).

2.3.4 Age Samples

Standard scale analysis techniques (Clutter and Whitesel 1956) were used to determine the ages of migrating salmon. The Gilbert-Rich notation is used to describe salmon ages.

2.3.5 Slough Escapements

Sockeye and chum salmon escapements to individual sloughs above RM 98.6 were calculated using spawner abundance data adjusted by average fish

observed residence (Cousens et al. 1982). Two exceptions to this method were: 1) when a peak escapement count for a slough was less than 15 live and dead fish and 2) when only one spawning ground survey was made. Total slough escapements in these cases were calculated using the following formula:

$$x = \frac{A}{B}(T)$$

where x = estimated escapement of Slough x

A = sum of escapements to all sloughs having peak counts ≥ 50 fish

B = sum of peak counts of all sloughs having peak counts ≥ 50 fish

T = single highest fish count at Slough x.

Pink salmon escapements to sloughs above RM 98.6 were adjusted by multiplying the peak live and dead survey counts by a factor of 1.2. This correction factor assumes that 80 to 90 percent of the spawning population was present at the peak of the escapement count (Cousens et al. 1982).

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APPENDIX 1

ADULT SALMON

LOWER SUSITNA RIVER SPAWNING SURVEYS

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INTRODUCTION

The proposed hydroelectric project may impact fish resources in the lower Susitna River through changes in flow, water quality and temperature in the slough, side channel, main channel, and stream mouth habitats. Information on the distribution, timing and magnitude of salmon spawning in these habitats is necessary to assess impacts and to plan appropriate mitigation measures.

OBJECTIVES

1) Identify distribution, timing and abundance of salmon spawning in main channel, side channel, slough and stream mouth habitats of the lower Susitna River (RM 28.0 - 98.6).

2) Identify the general habitat characteristics of those areas utilized by spawning salmon.

Anadromous fish species addressed in this report are:

Pacific Salmon	Oncorhynchus sp
Chinook salmon	O. tshawytscha
Sockeye salmon	O. nerka
Pink salmon	O. gorbuscha
Chum salmon	O. keta
Coho salmon	O. kisutch

METHODS

Mainstem and Slough Habitats

An aerial survey from RM 26.0 to 96.0 was conducted by R & M Consultants on March 18, 1983 (Coffin 1983). The open water leads observed during that survey were mapped as possible salmon spawning sites (Figure 1). No attempt was made to distinguish between velocity and warm water leads. Salmon, particularly chum, often select warm water upwelling areas for spawning (Vining et al. 1985; Bakkala 1970; Kogl 1965).

Aerial surveys in the lower-river study reach (Figure 2) were conducted weekly from August 21 to October 17, 1984 to locate salmon spawning sites (Plate 1). Suspected spawning sites identified from the air, were resurveyed on foot to verify spawning. Verification was determined through visual observation of salmon redds (Plate 2) and/or locating salmon eggs in the substrate with standard egg pumping equipment (Plate 3). Spawning areas were mapped with the species, numbers of live and dead salmon, number of redds and upwelling noted. More detailed methods can be found in Barrett et al. (1985).

Stream Mouth Habitats

Seventeen lower-river stream mouths between RM 28 and 98.6 were surveyed weekly from July 21 to October 1, 1984 (Table 1). The primary objectives of these surveys were to determine the distribution, timing and magnitude of salmon spawning.

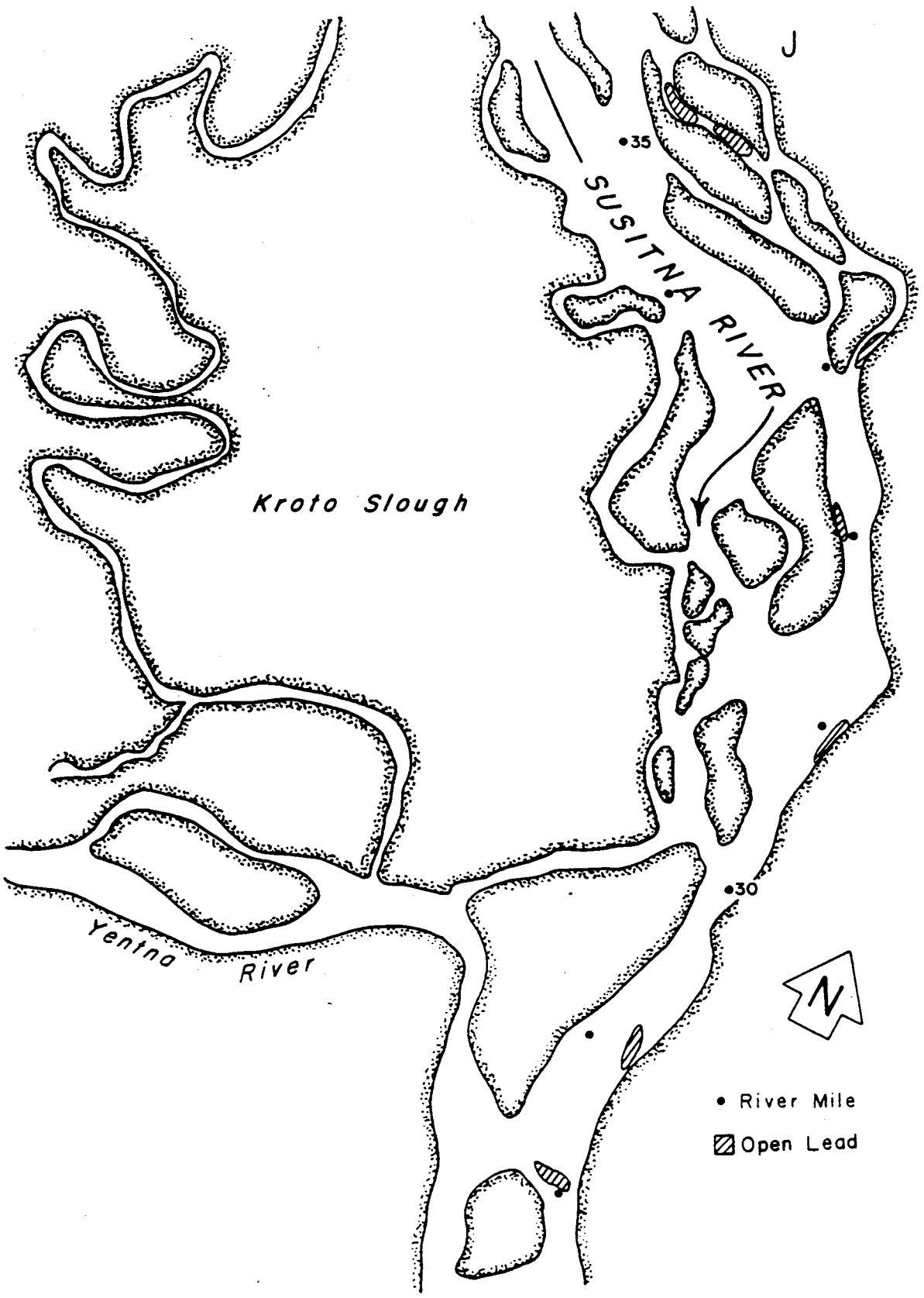


Figure 1. Lower Susitna River (RM 28.0 - 98.6) illustrating open leads observed on March 18, 1983.

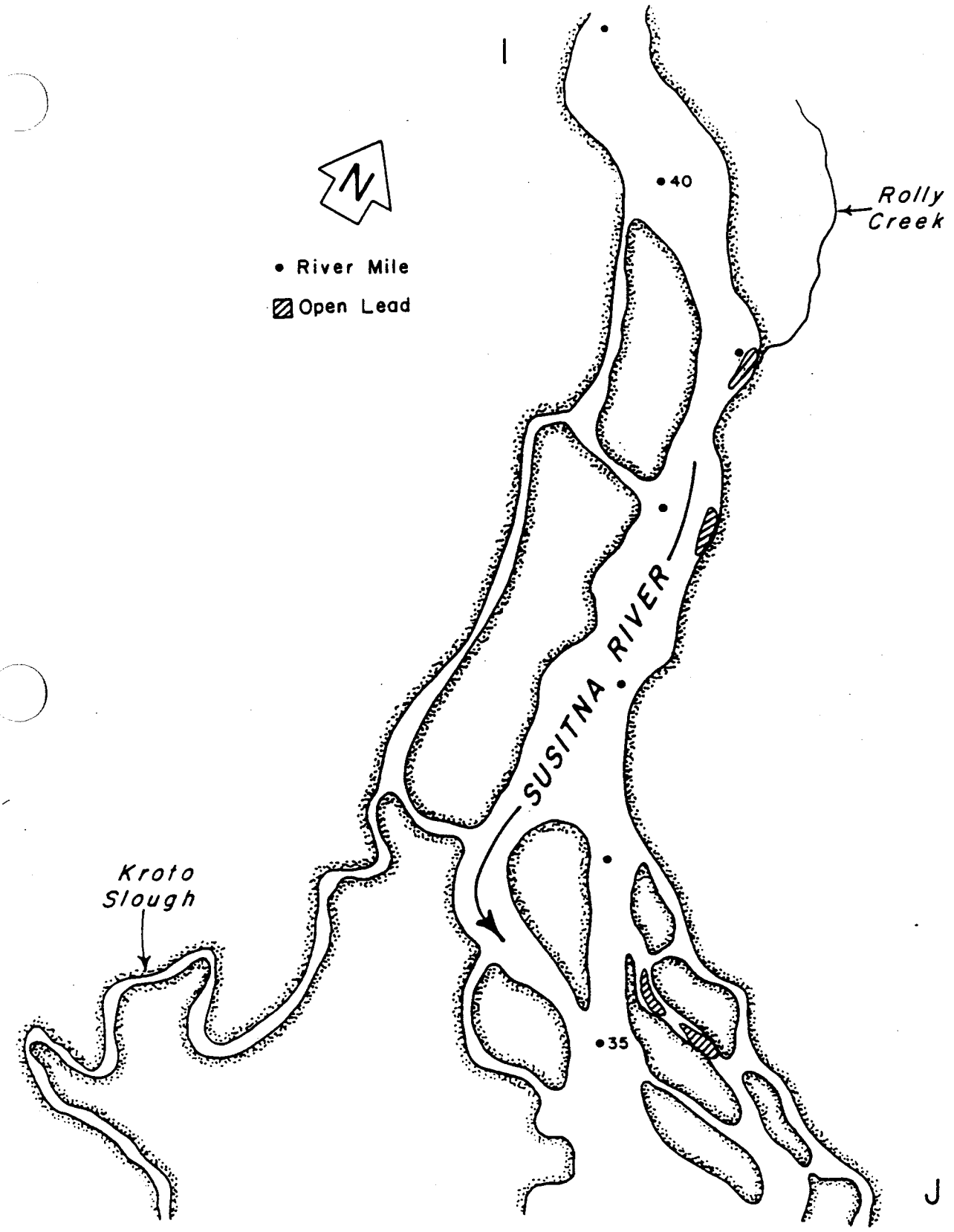
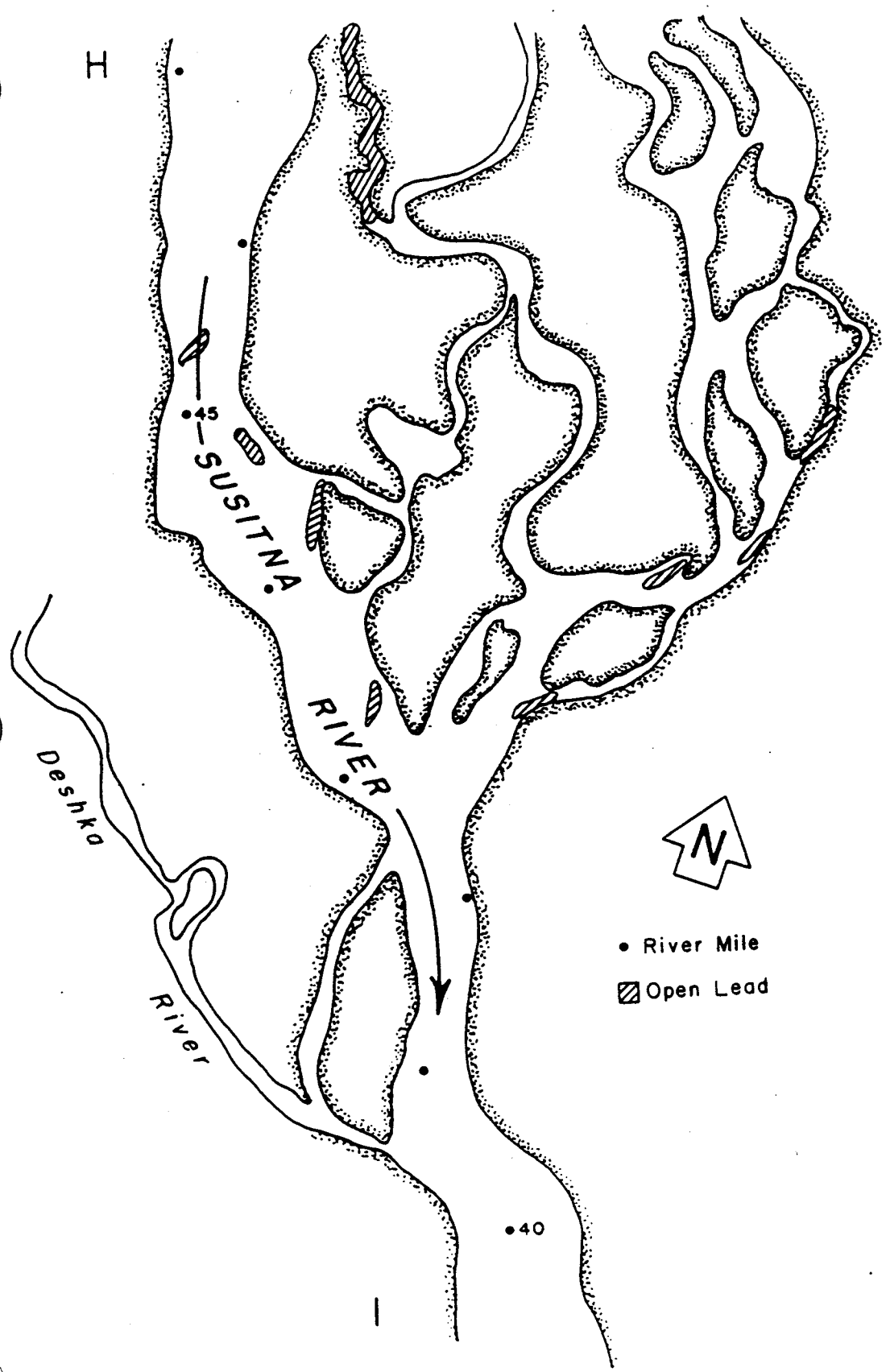


Figure 1 (cont.) Lower Susitna River (RM 28.0 - 98.6) illustrating open leads observed on March 18, 1983.



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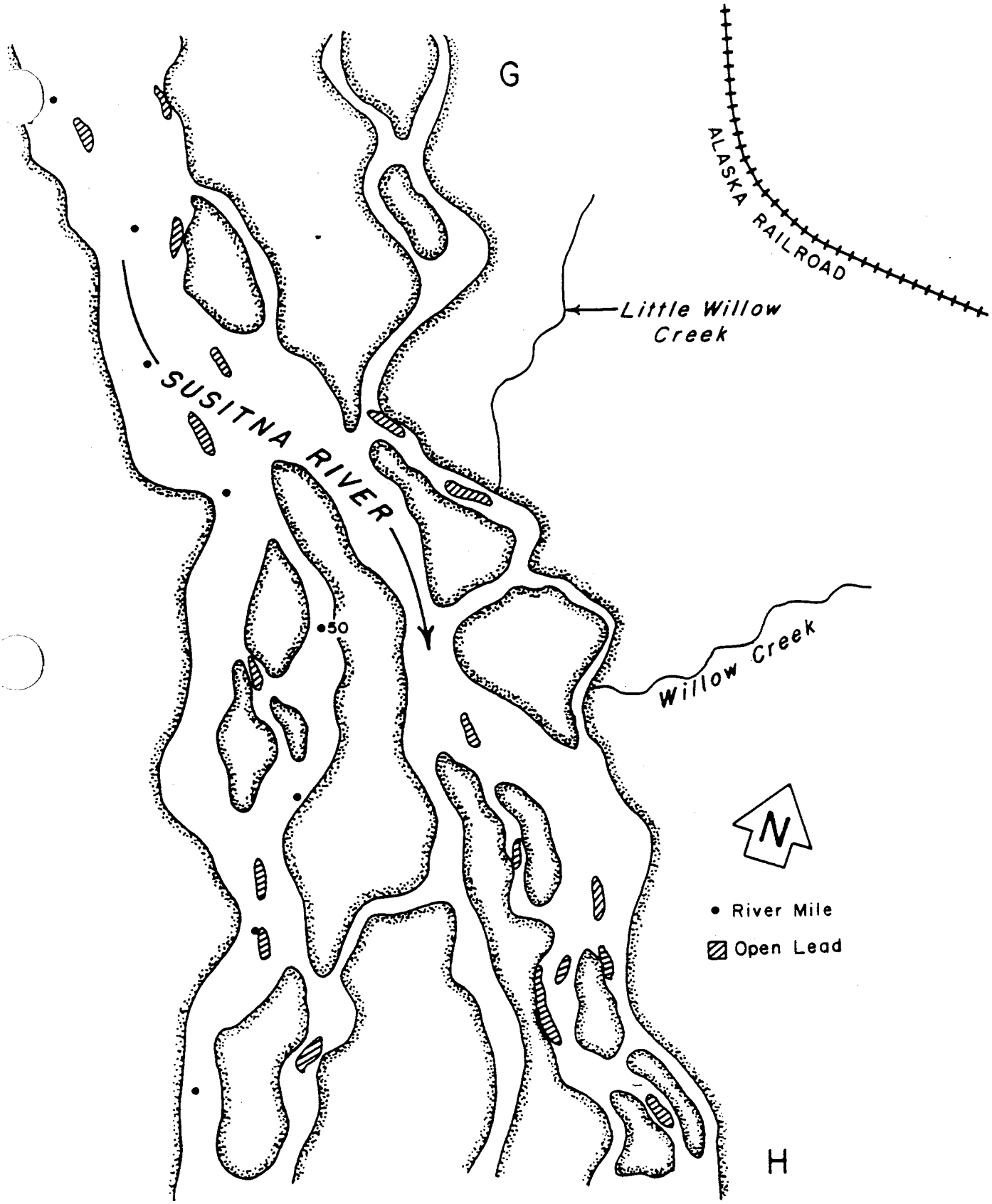

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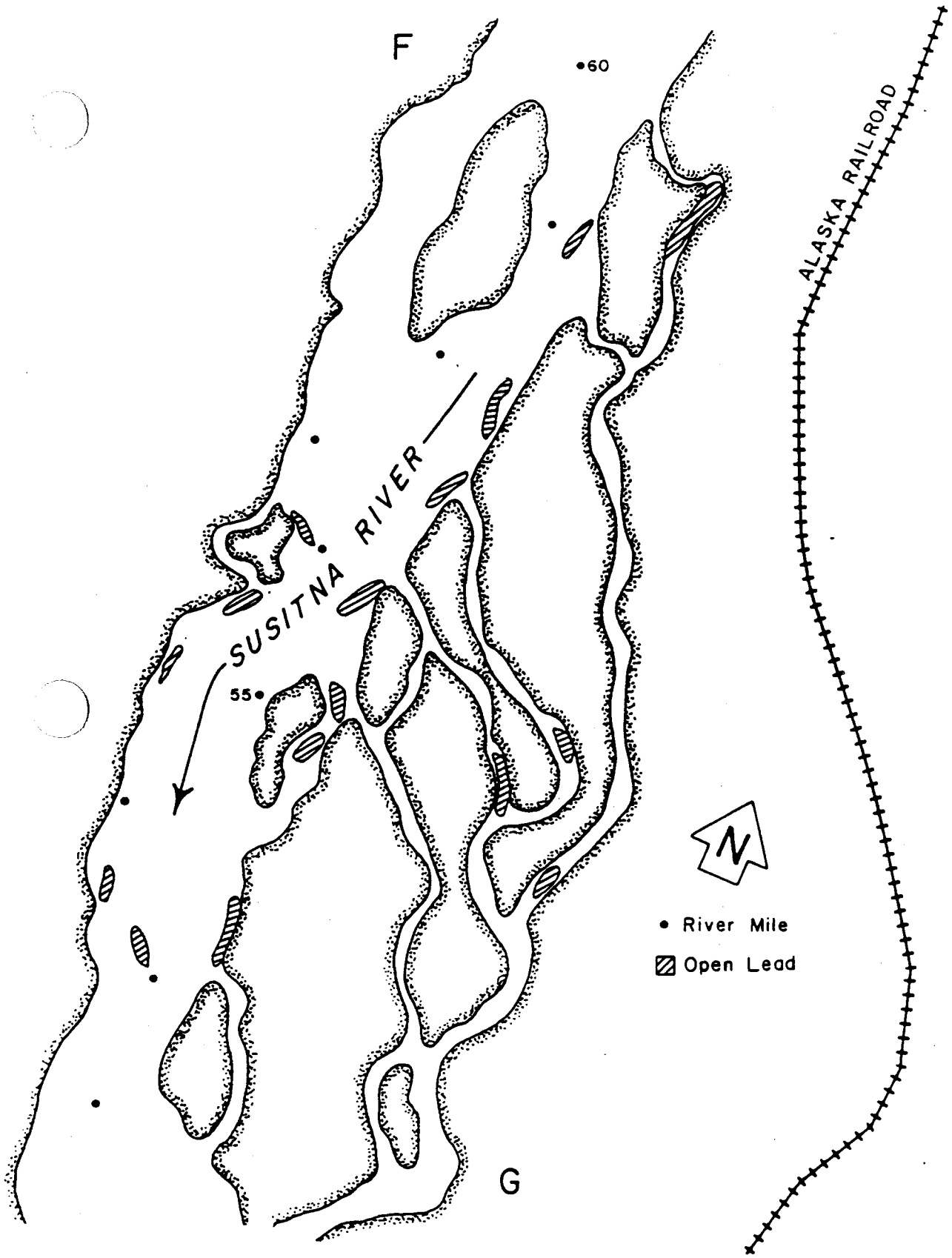

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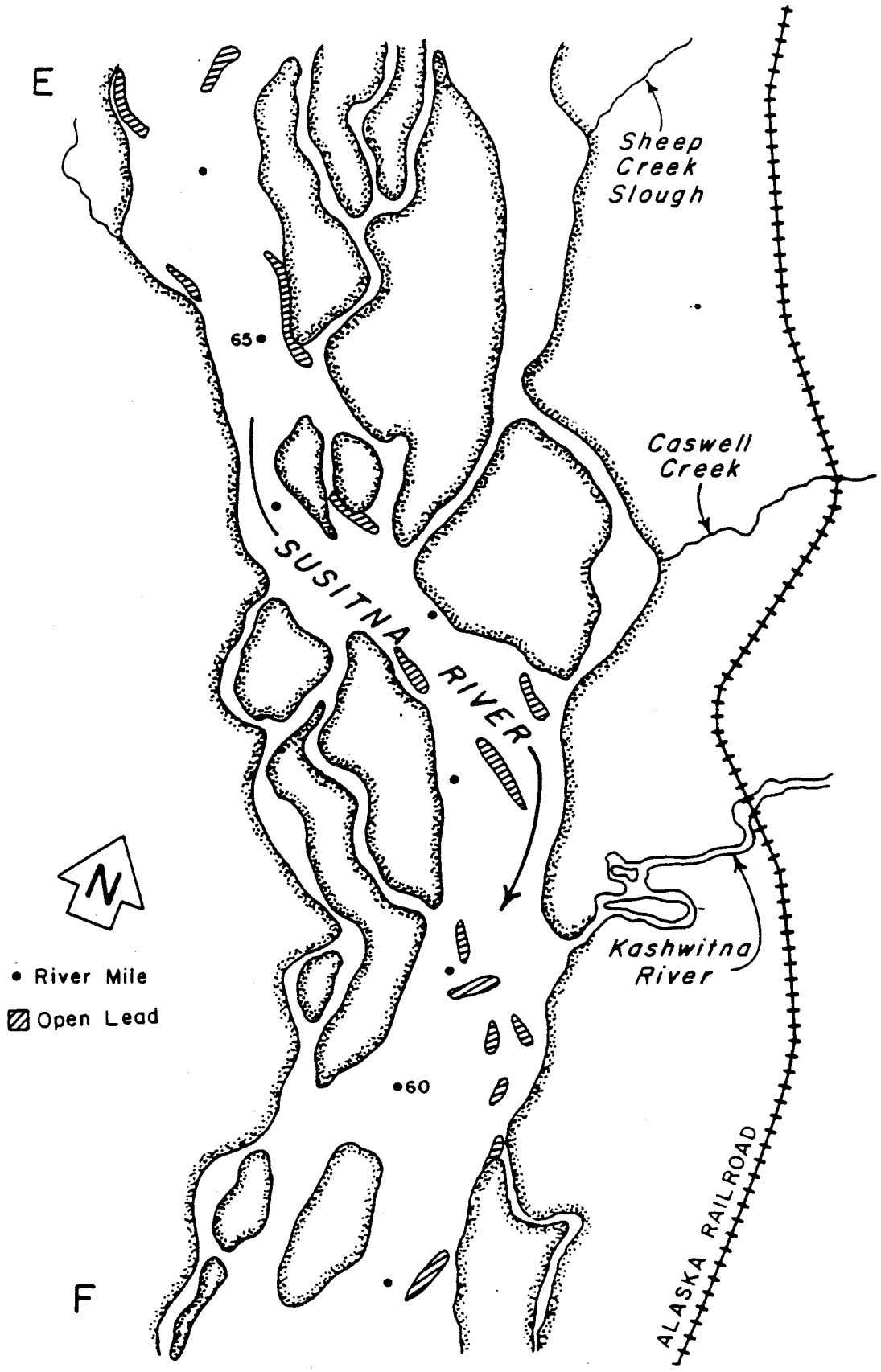

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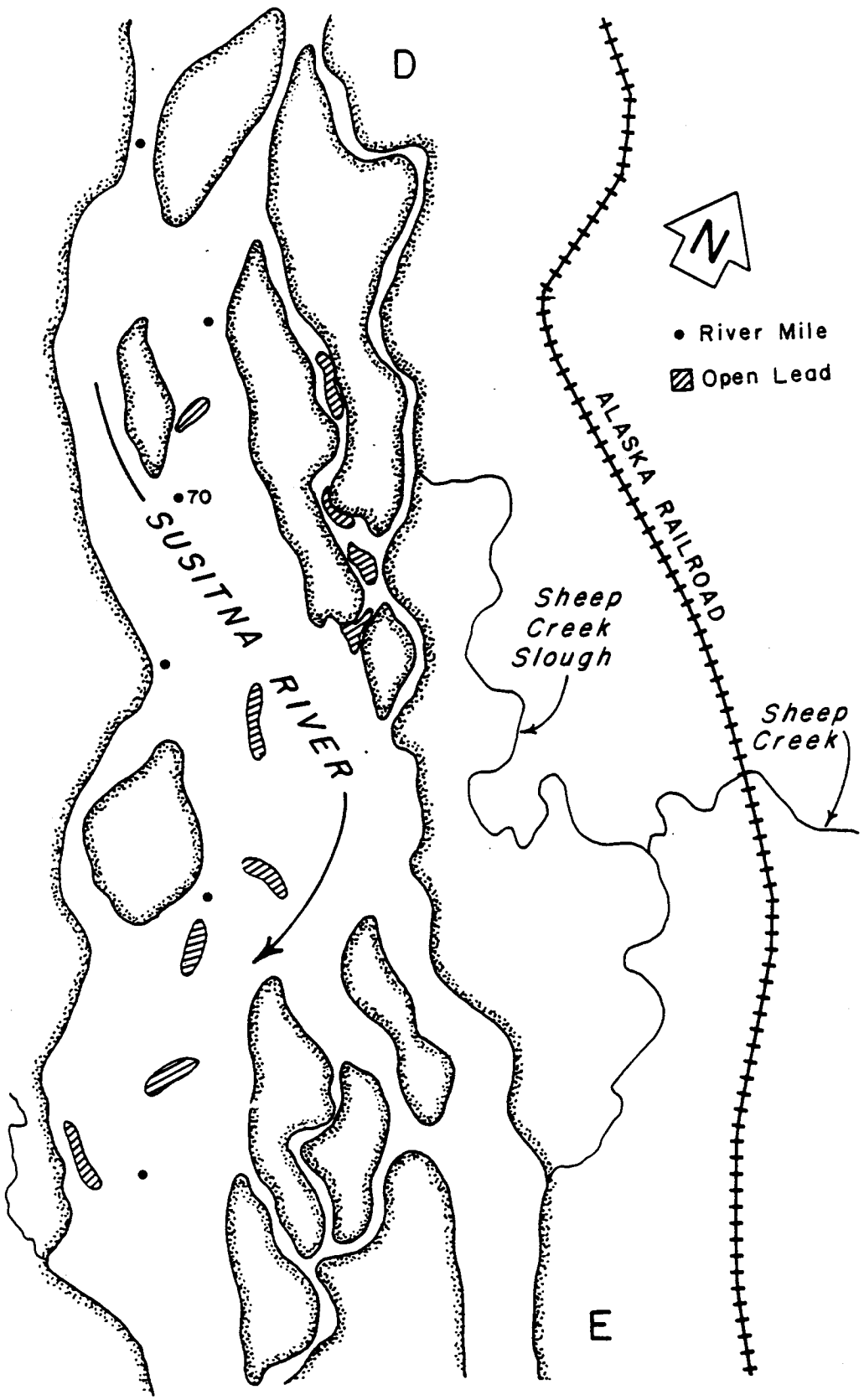

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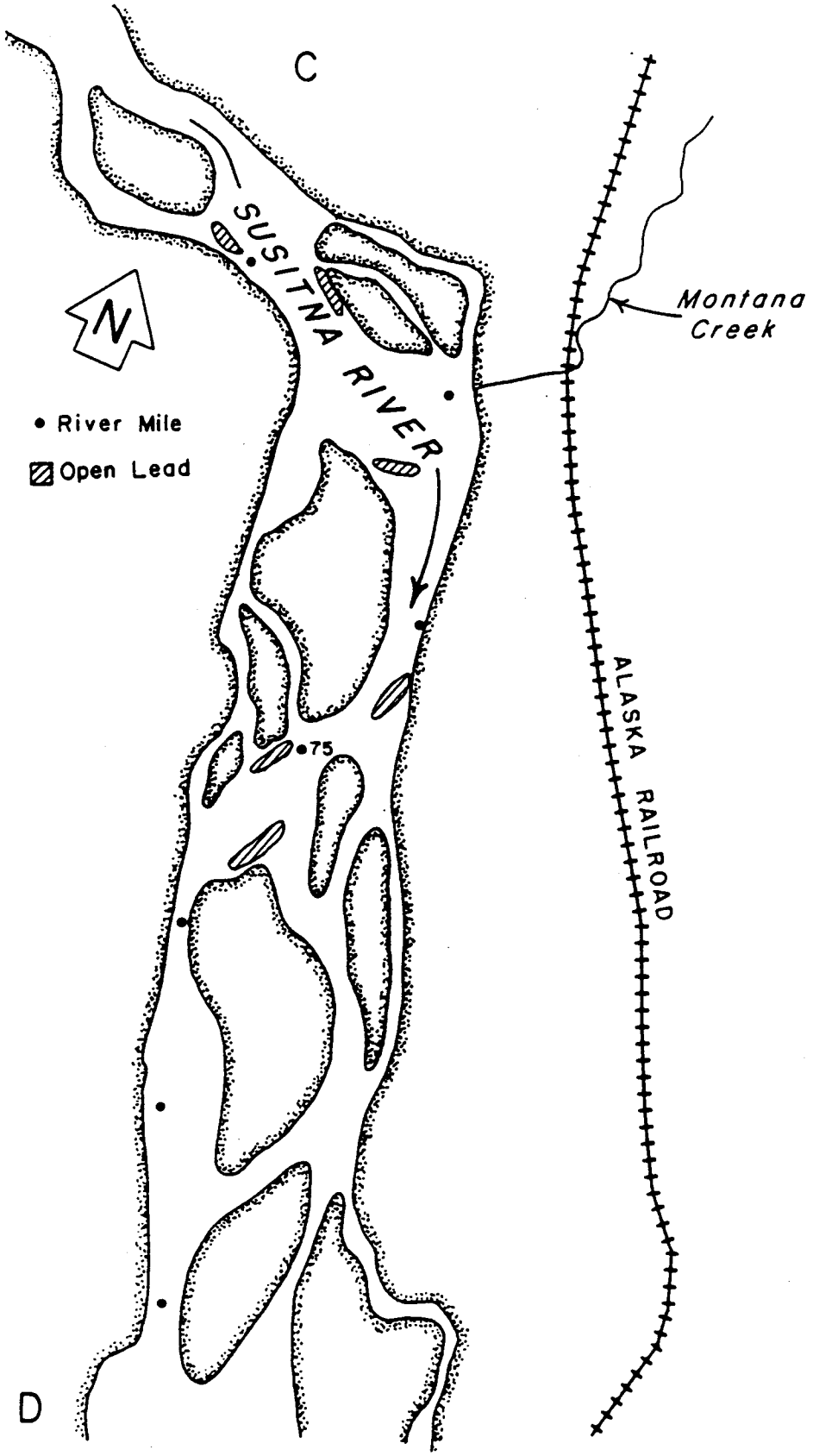

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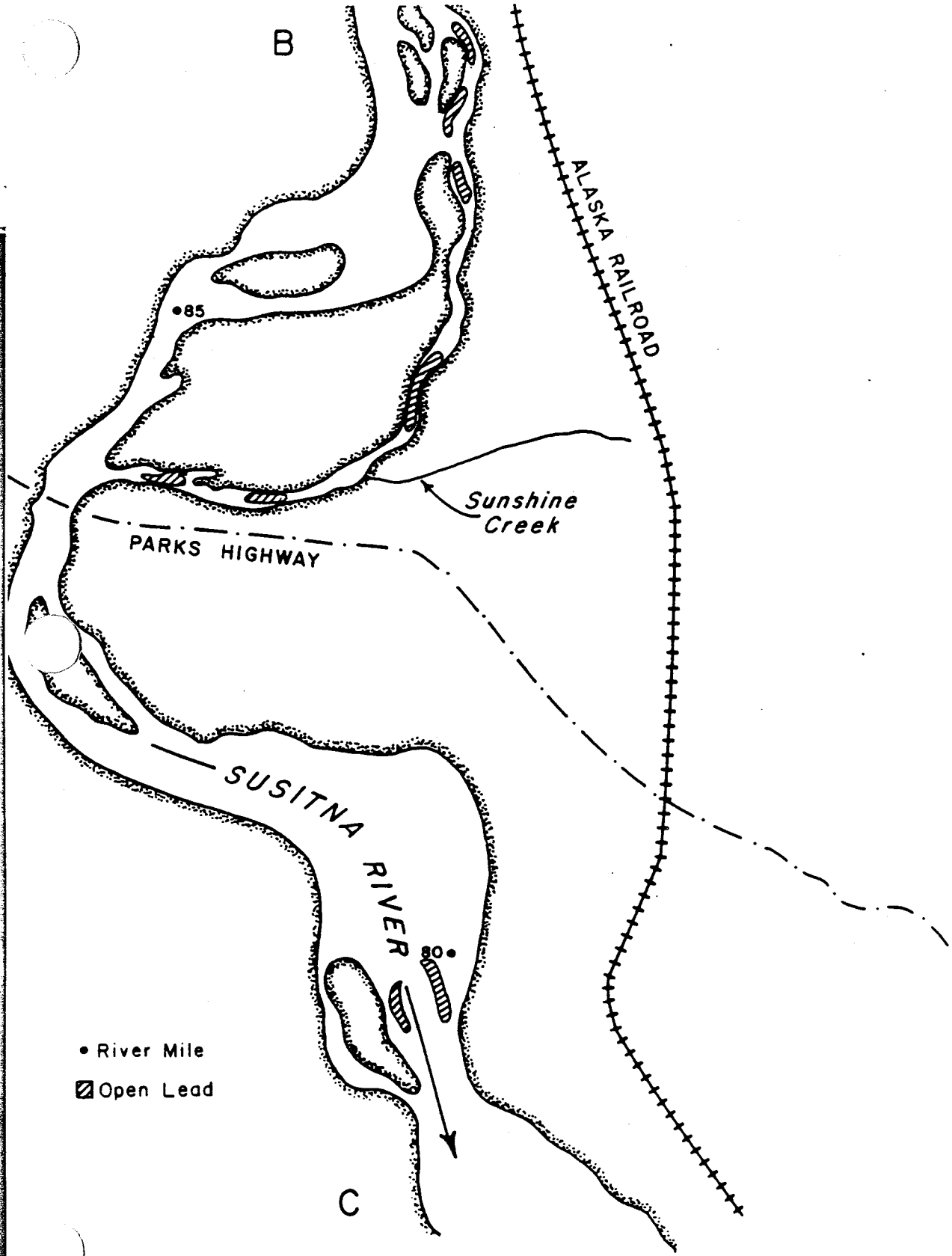

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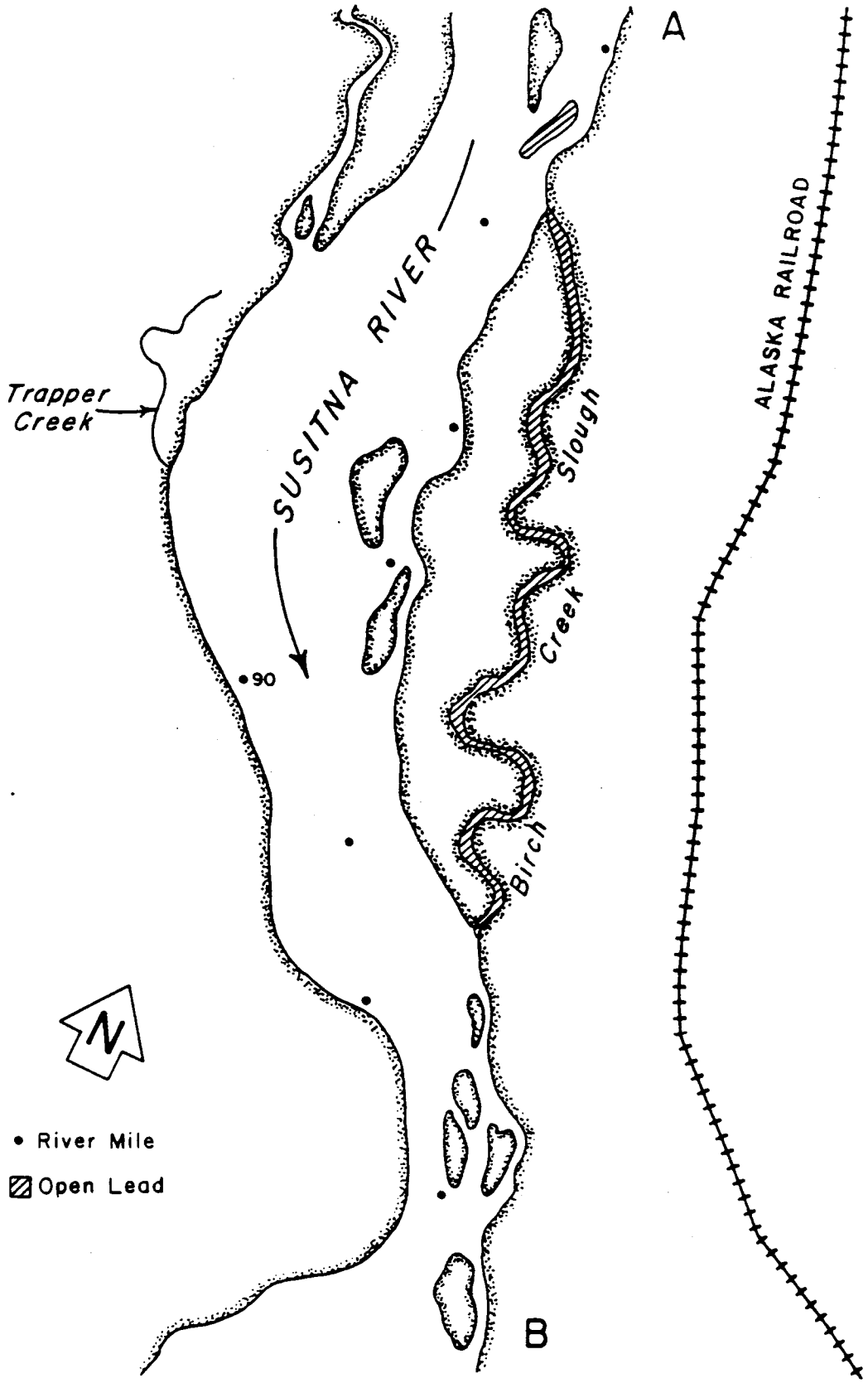

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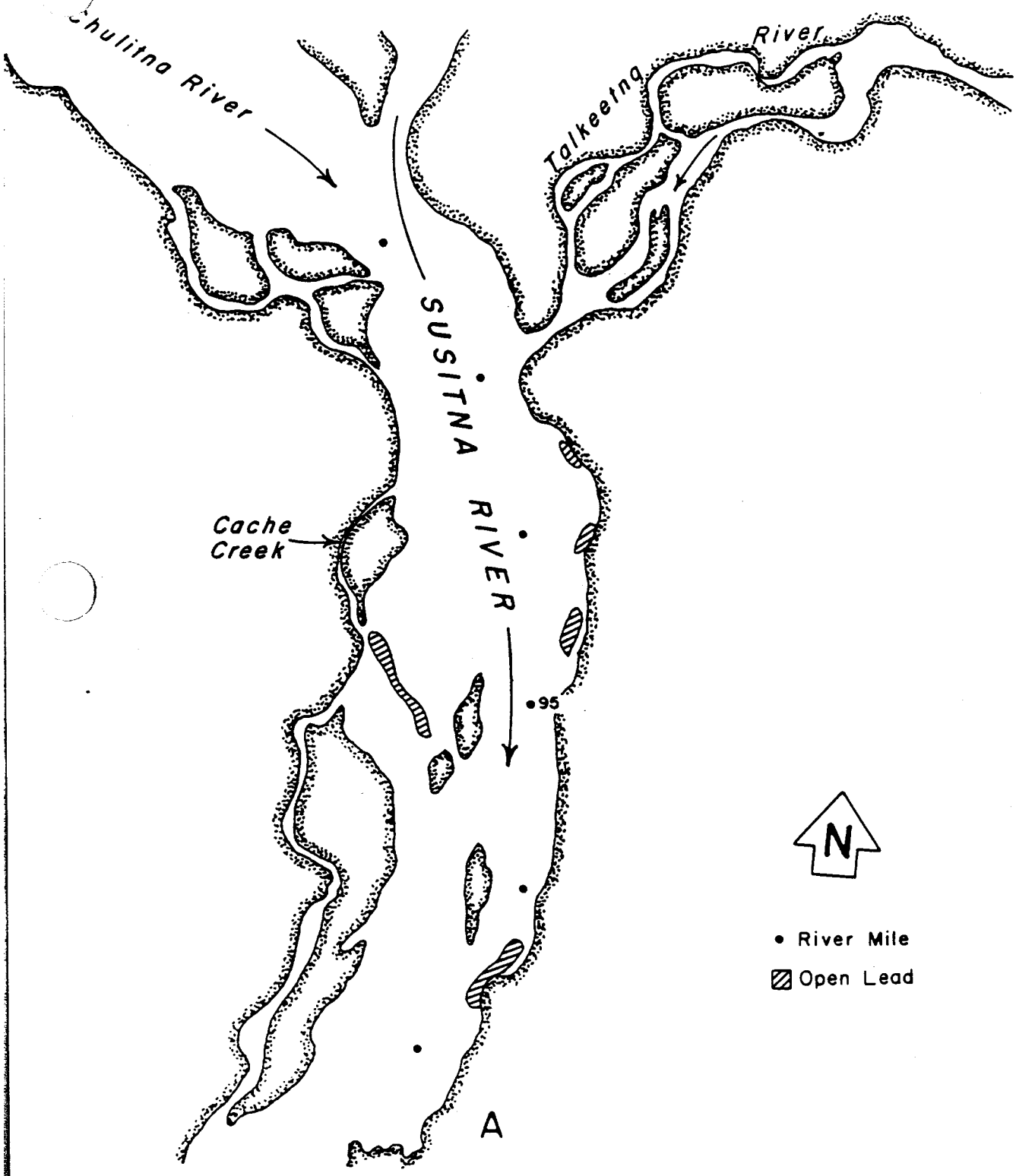

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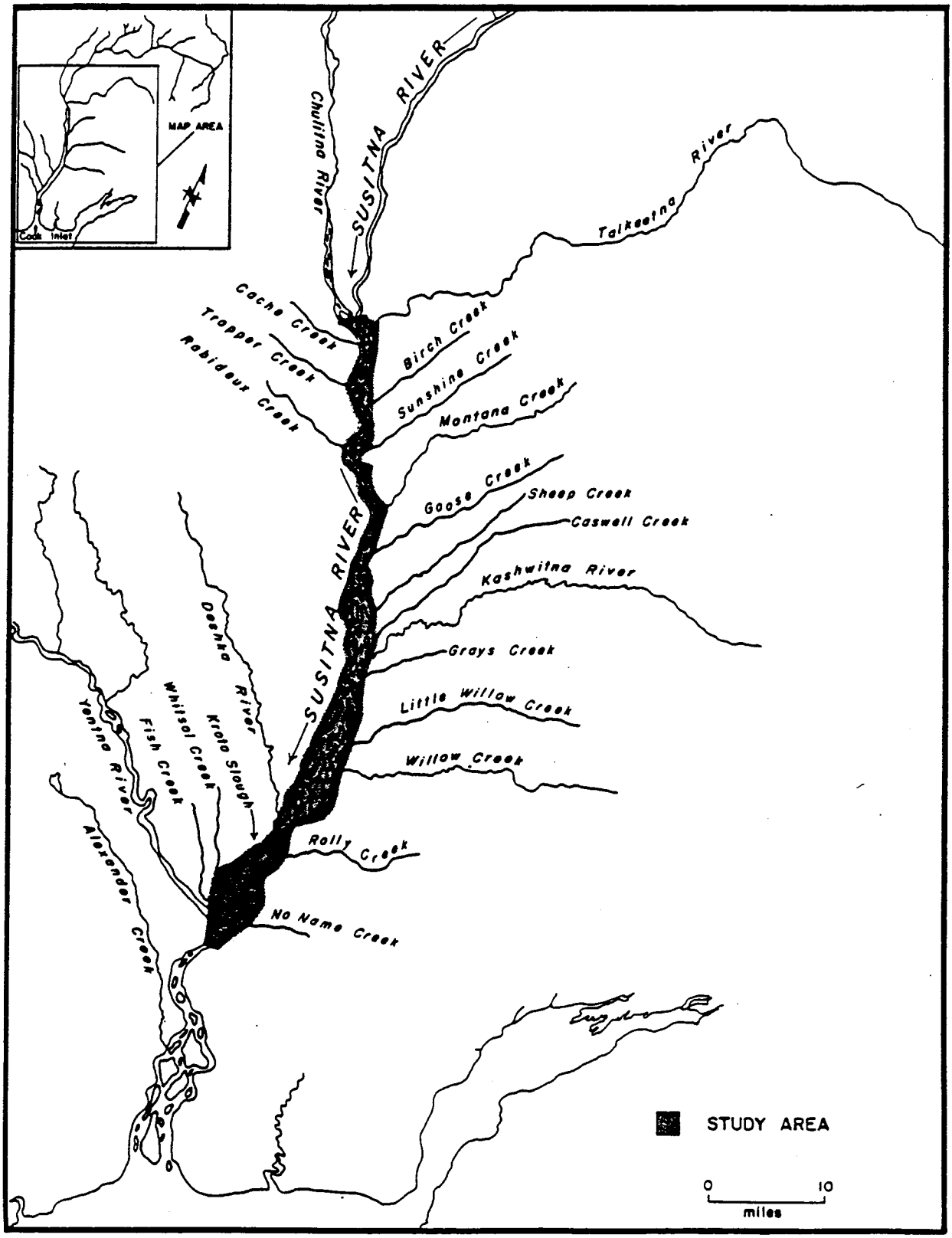


Figure 2. Lower Susitna River salmon spawning area (RM 28.0 - 98.6), 1984.

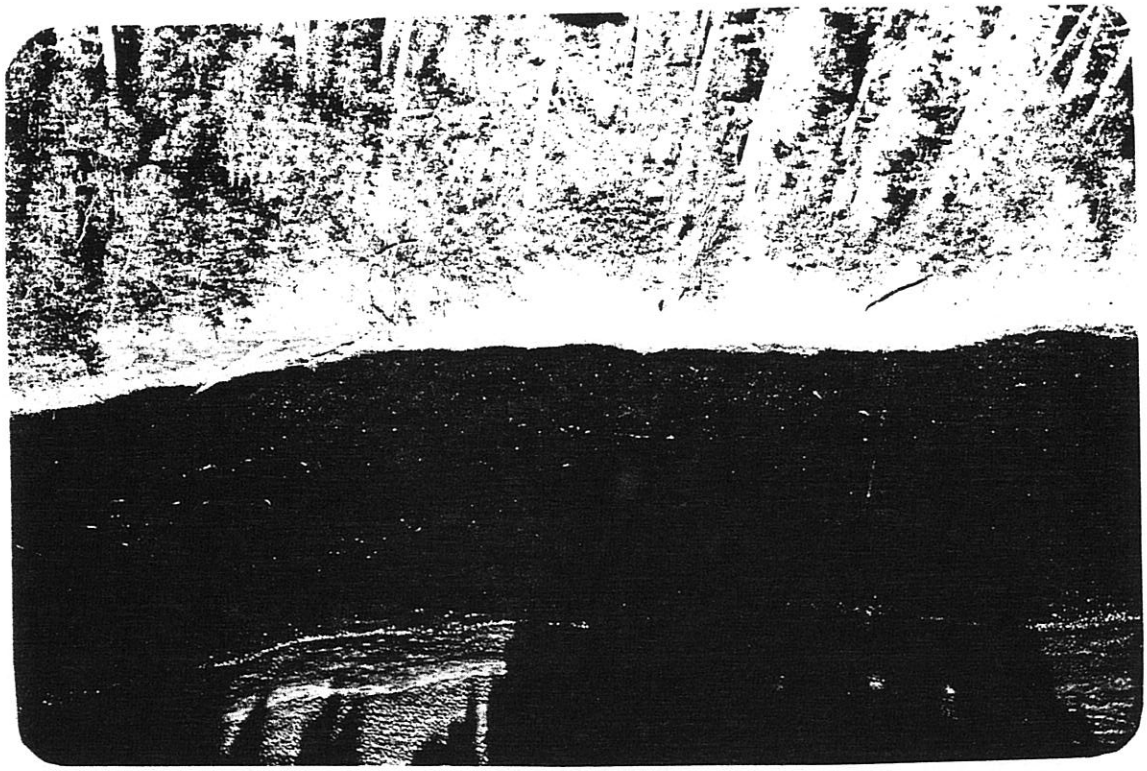


Plate 1. Aerial view of a salmon spawning area illustrating redds, 1984.

Plate 2. Ground view of a salmon redd, 1984.

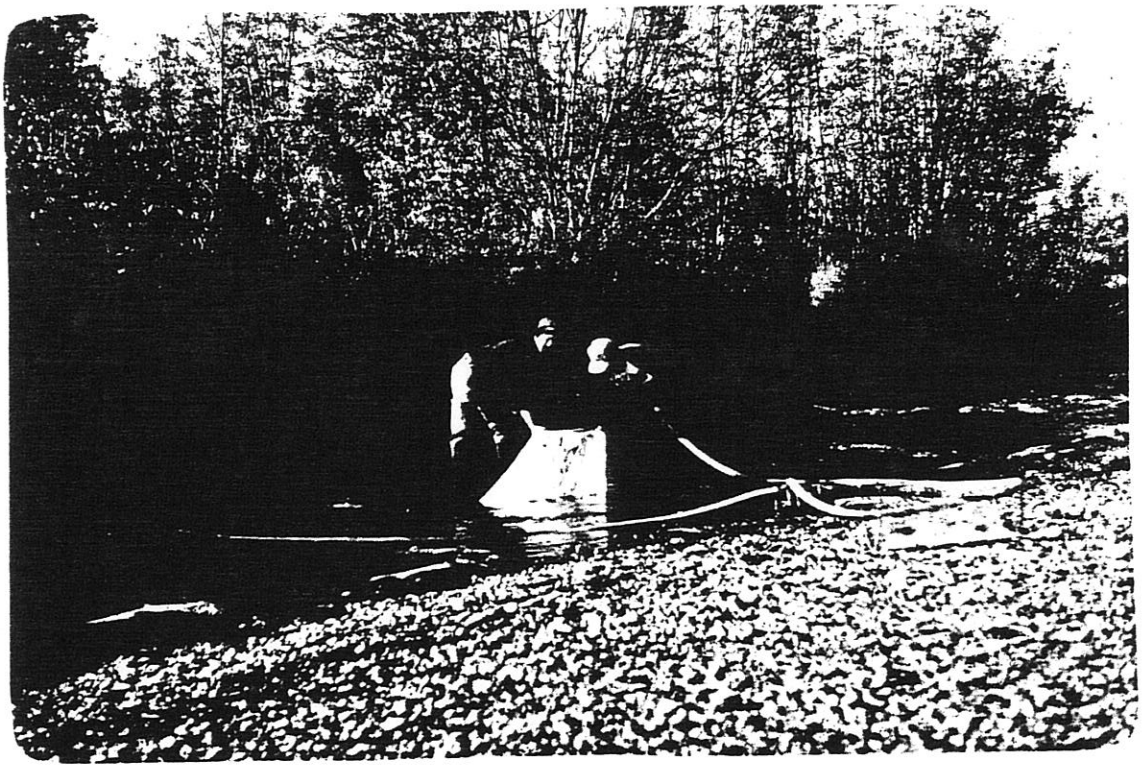


Plate 3. Egg pumping a salmon area to verify the presence of eggs, 1984.

Table 1. Lower Susitna River stream mouths surveyed weekly from July 21 to October 1, 1984.

Stream	River Mile	Stream	River Mile
Unnamed Creek	31.7	Fish Creek	31.2
Whitsol Creek	35.2	Rolly Creek	39.0
Willow Creek	49.1	Little Willow Cr.	50.5
Grays Creek	59.5	Kashwitna River	61.0
Caswell Creek	64.0	Sheep Creek	66.0
Goose Creek	72.0	Montana Creek	77.0
Rabideux Creek	83.1	Sunshine Creek	85.1
Cache Creek	95.5		

The term stream mouth refers to the segment of stream extending from its confluence with the Susitna River mainstem, side-channel or slough to a distance one-third mile upstream. Data recorded during each weekly survey included the species and number of salmon present and if spawning was observed. To determine if spawning occurred the following criteria were used:

1) visual identification of one or more actively mating fish pairs;
2) one or more distinct redds;
3) confirmed presence of live eggs by intragravel sampling.

Surface substrate was assessed in accordance with standard procedures (ADF&G 1983d).

A profile of each stream mouth was developed by measuring the depth, at two foot intervals, along one or two transects. Stream mouth profiles were determined for two Susitna River discharges.

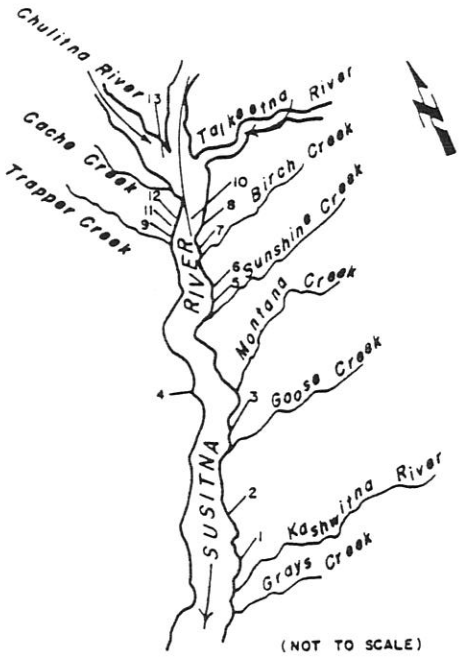
RESULTS AND DISCUSSION

Mainstem Habitats

The Susitna River mainstem is comprised of main-channel and side-channel habitats. Sautner et al. (1984) describes the main channel habitat in the middle reach of the Susitna River as being characterized by high water velocities and well-armored streambeds. Main-channel habitat downstream of the Chulitna River confluence has different characteristics than similar habitat in the middle reach. The main channel in the lower reach is highly braided and in places, not easily distinguishable. Main channel substrates in the lower river are generally less armored and less stable than those of the middle river. As a result, the morphological character of main-channel habitats in the lower river often changes during high mainstem discharges. Side-channel habitat is characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the main channel river (Sautner et al. 1984). Side channels in the lower river are often difficult to distinguish from the braided main-channel habitats. Side-channel habitats have generally narrower channels that are separated from the main channel by stable vegetated islands. For the purposes of this study, however, both main channel and side-channel habitats have been classified as mainstem habitats since our ability to distinguish between the two habitat types on the basis of their physical and hydraulic characteristics was limited.

Survey conditions prior to late September were poor due to high water and turbidity levels. As a result, earlier surveys may not have documented all of the spawning activity present. A flood in early September eliminated signs of spawning prior to that time. Lower water and turbidity levels beginning in late September improved visibility conditions which increased the frequency and accuracy of spawning observations.

Twelve mainstem spawning sites were identified in 1984 (Figure 3). Chum salmon spawned in 11 of these sites and coho salmon spawned at two. The other salmon species were not observed spawning in the mainstem. Maps and habitat descriptions of the 12 spawning sites can be found in Appendix A.



Site Number	Location: River Mile[1/]	Location: Legal	Observed Upwelling	Species	Observed Fish Observed: Number of Redds	Observed Fish Observed: Live	Observed Fish Observed: Dead	Spawning Observation Date
1	62.1R	S21N05W12AAC	Upwelling	Chum	5	2	6	10/09
2	71.6R	S22N05W13DBD	B. Seepage[3/]	Chum	4	4	0	10/09
3	73.9C	S23N05W24DAB	Open Lead	Chum	7	0	3	10/10
4	79.2L	S23N05W35ADA	B. Seepage[3/] Open Lead	Chum	7	18	7	10/08
5	87.0R	S24N05W01BDA	Open Lead	Chum	48	173	0	09/28
6	87.5R	S25N05W36DBD	Open Lead	Coho	3	5	0	09/25
7	88.7R	S25N05W25BCA	B. Seepage[3/]	Chum	11	23	0	10/09
8	90.1R	S26N05W13BCB	None	Chum	19	41	27	10/09
9	92.0C-94.5L	S25N05W15DAB S25N05W02DAA	Upwelling	Chum	98	538	257	09/23
				Coho		98	19	10/10
10	95.0C	S26N05W36BCD	None	Chum	1	3	0	09/27
11	95.5C[2/]	S26N05W36CBA	None	Chum				09/27
12	95.8C[2/]	S26N05W36BCB	None	Chum				09/27
13	98.0La	S26N05W14DCD	Upwelling	Chum	11	27	0	10/09
	98.0Lb	S26N05W22AAC	None	Chum	7	12	0	10/09
	98.0Lc	S26N05W22ABA	None	Chum	7	10	0	10/09
	98.0Ld	S26N05W15CCB	None	Chum	26	67	0	10/09

1/ Looking upstream: R-right bank; C-center; L-left bank.
2/ Data was combined in the field with an adjacent slough site
3/ Bank Seepage

Figure 3. Mainstem salmon spawning areas identified in the lower Susitna River between RM 28.0 and 98.6, 1984.

The majority of mainstem spawning was documented from late September until mid-October, just prior to freeze up. High mainstem discharges and turbidity in early September limited our ability to observe earlier spawning activity. Based on the escapement counts at mainstem sites, it is likely that the peak of chum salmon spawning occurred during the first two weeks of September. Chum salmon spawning was essentially over by the second week of October. From the limited data available, it appears that the peak of coho spawning in mainstem sites occurred around the second week of October.

A conservative estimate of between 2,600 to 3,900 chum salmon spawned at mainstem sites in the lower Susitna River. This represents between 0.3 to 0.5 percent of the 1984 Susitna River escapement (Barrett et al. 1985). Observed residence studies conducted in 1983 and 1984 have determined that a peak count represents about 50 percent of a spawning escapement. The highest fish count (live and dead) for mainstem sites was probably not made at the peak spawning period due to high mainstem discharges and turbidity. Using this assumption, an expansion factor of three was used to determine the upper limit of the range (Barrett et al. 1985). Coho salmon exhibited a range of 200 to 400 fish spawning in two mainstem sites. This is between 0.1 to 0.2 percent of the 1984 Susitna River escapement.

The majority of the chum salmon spawning occurred at: Trapper Creek side channel (RM 90.3L); Sunset side channel (RM 87.0R); the Chulitna River mouth (RM 98.6L) and Circular side channel (RM 75.0L). Collectively, these sites supported 90 percent of the spawning while the other eight sites had the remaining 10 percent, based on survey counts. Trapper Creek side channel had 96 percent of the coho salmon spawning while Sunset side channel had the remaining four percent, based on survey counts. Surveys conducted by the Aquatic Habitat and Instream Flow Study of the Susitna Hydro Project indicated that several of these sites may have had more utilization than our survey counts indicate (Bigler 1985a).

Upwelling (Plate 4), bank seepage (Plate 5) or open leads in winter were observed at 10 of the 12 spawning sites. The major chum salmon spawning sites and the two coho salmon spawning sites all had associated upwelling or bank seepage. It is likely that some degree of upwelling occurs at the remaining sites although it was not detected during our surveys. Other studies have shown that chum salmon select upwelling areas in which to spawn (Vining et al. 1985; Bakkala 1970; Kogl 1965).

Slough Habitats

Slough habitats can be divided into two types: upland sloughs and side sloughs. The main difference between the two types is that the upstream end of an upland slough does not connect with the mainstem even at high mainstem discharges (Sautner et al. 1984). A feature that distinguishes side slough habitat from side-channel habitat is that side sloughs usually convey clear water from small tributaries and/or upwelling groundwater in an unbreached condition (Sautner et al. 1984). All of the slough salmon spawning sites located in this study fall in the side slough category.

Plate 4. Example of upwelling associated with slough and side channel spawning areas, 1984.

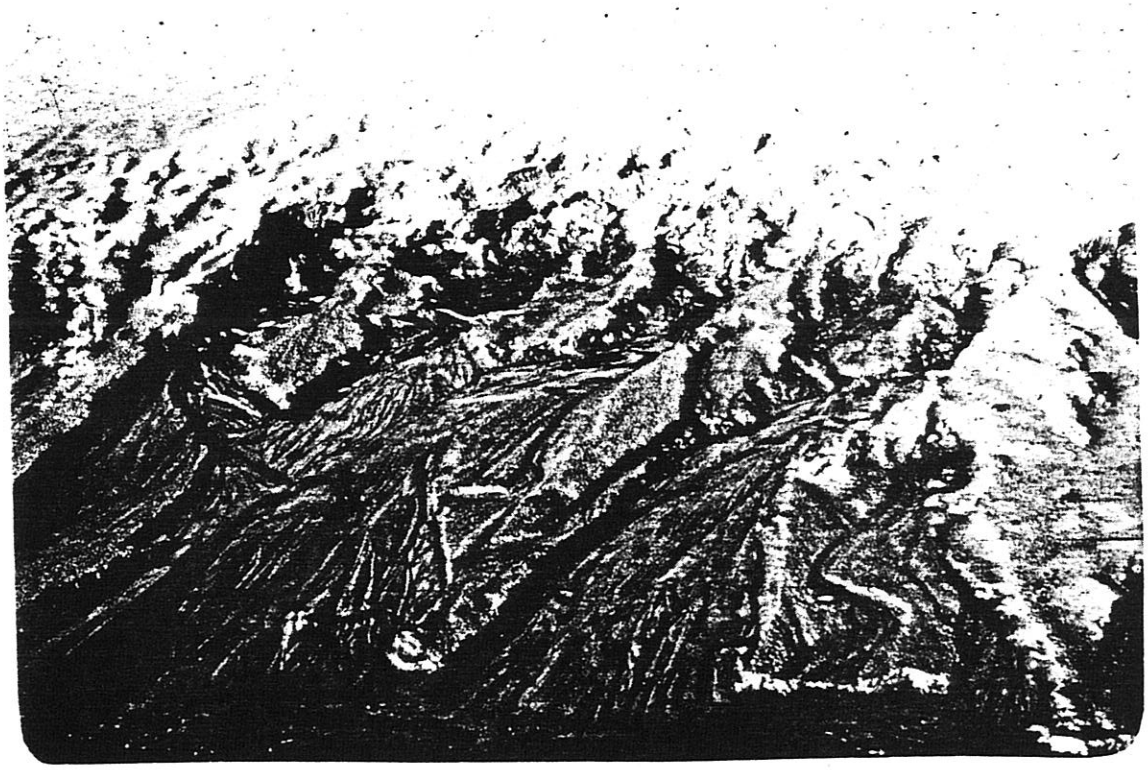


Plate 5. Example of bank seepage associated with slough and side channel spawning areas, 1984.

Survey conditions encountered in slough surveys were similar to those encountered in the mainstem. Survey conditions improved as mainstem discharges fell in late fall, which increased the frequency and accuracy of spawning observations.

Spawning was observed in six sloughs (Figure 4), five of which were used by chum salmon and one by coho salmon. The other salmon species were not observed spawning in lower-river sloughs. Maps and habitat descriptions of the six sloughs can be found in Appendix A.

Slough spawning by chum and coho salmon was documented in late September and early October as visibility improved just prior to freeze up. It is probable that earlier spawning occurred that was not observed due to high mainstem discharges and turbidity. The peak of spawning in lower-river slough sites appears to follow a pattern similar to the mainstem. Peak chum salmon spawning probably occurred the first two weeks of September and was essentially over by the second week in October. Similarly, the peak coho salmon spawning, in the single slough site, occurred during the second week of October.

Using procedures outlined in Barrett et al. (1985), it was estimated that 700 to 1,000 chum and 10 to 20 coho spawned in slough sites in the lower river. Both of these ranges are less than 0.1 percent of the Susitna River escapement.

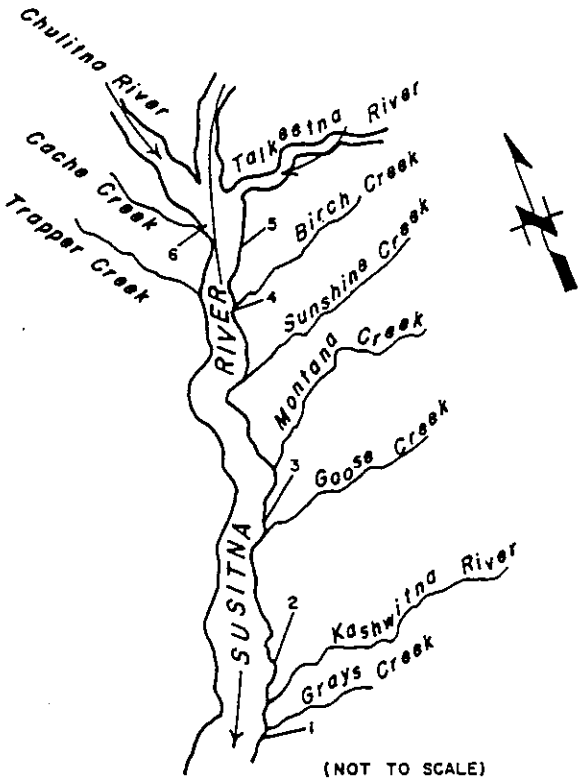
Most of the spawning occurred at Cache Creek Slough (RM 96.0L) and Musher Slough (RM 95.2R). Collectively, these sloughs supported 90 percent of the spawning while the other three sloughs supported the remaining 10 percent as determined by spawning ground counts. The only slough found to have spawning coho salmon was Rustic Wilderness Slough (RM 57.0R), in which six fish and nine redds were observed.

Four sloughs, in which salmon spawned, had associated upwelling, bank seepage or were identified as an open lead area. Cache Creek Slough, which had most of the chum salmon spawning, had no visible upwelling or bank seepage. Cache Creek flows into the slough and probably provides adequate intragravel flows that attracted the spawning.

Stream - Mouth Habitats

Descriptions of individual stream-mouth habitat characteristics and a summary of adult salmon use is provided in Appendix B. Also included in Appendix B are maps depicting the spawning areas within each stream mouth. Additional habitat and stream-mouth depth profiles are provided in Appendix D.

The Deshka River was not specifically included in the survey program because high densities of sport fishermen use the stream mouth, and water depths and lack of clarity thwarted definitive results. Historically, chinook, sockeye, pink and coho salmon have spawned in this drainage (ADF&G 1982b).



Site Number	Location: River Mile[1/]	Location: Legal	Observed Upwelling	Observed Fish Observed: Species	Number of Redds	Live	Dead	Spawning Observation Date
1	57.0R	S21N05W25CCD	Upwelling	Coho	9	6	0	10/13
2	63.2R	S21N05W01DCD	Upwelling	Chum	3	4	0	10/11
3	74.5R	S23N05W19BCB	Open Lead	Chum	12	0	16	10/08
4	89.5R	S25N05W24BBC	None	Chum	4	12	0	10/09
5	95.2R	S26N05W36ADB	B. Seepage[2/]	Chum	41	84	52	09/28
6	96.0L	S26N05W35ABB	None	Chum	4	160	--	09/27

1/ Looking upstream: R-right bank; C-center; L-left bank.
2/ Bank seepage

Figure 4. Slough salmon spawning areas identified in the lower Susitna River between RM 28.0 and 98.6, 1984.

Chinook Salmon

The chinook migration at Sunshine Station was essentially complete 15 days prior to the first survey on July 21 (Barrett et al. 1985). Therefore, assessment of spawning and passage in stream mouths was not representative of the entire migration.

Chinook salmon used five stream mouths for either passage to upstream spawning areas or as holding areas prior to continuation of their Susitna River migration. The most important were Birch and Montana creeks (Table 2 and Appendix Table C-3). Twenty-six of the 39 fish counted were at these stream mouths.

Table 2. Chinook salmon peak counts of stream mouths between RM 28.0 and 98.6 in order of contribution, 1984.

Stream	River Mile	Date	Number Counted Live	Dead	Total	Percent Contribution	Spawning Observed
Birch Creek	89.2	8/9	13	3	16	41.0	no
Montana Creek	77.0	8/14	4	6	10	25.6	no
Rabideux Creek	83.1	7/7	8	0	8	20.5	no
Goose Creek	72.0	7/27	3	0	3	7.8	no
Caswell Creek	64.0	8/6	1	1	2	5.1	no
	TOTAL		29	10	39	100.0	

Chinook were documented in lower-river stream mouths from July 23 to August 21 (Appendix Table C-3). Sport fish harvests and fishwheel catches at Sunshine Station indicate chinook salmon are generally abundant in the lower river and probably stream mouths beginning in early June (ADF&G 1983a).

Chinook did not spawn in the five stream mouths they occupied (Appendix Table B-1).

The Deshka River, not included in the lower river survey program, was a major chinook-producing system. Spawning probably did not occur in the mouth of the Deshka because a 1984 assessment of the substrate indicate a composition of primarily silt and sand, which is not preferred by chinook for spawning (Burner 1951). Passage through the mouth of the Deshka River began in May and probably ended, as in other lower-river stream mouths, sometime in August.

Sockeye Salmon

Sockeye salmon were observed in eight of 17 lower-river streams surveyed between July 23 and October 1 (Appendix Table C-3). All sockeye observed during these surveys were second-run fish. First-run sockeye had completely passed Sunshine Station by June 28 and were known to spawn above RM 28 in only the Fish Creek drainage (Talkeetna River System) (Barrett et al. 1985).

Sockeye salmon utilized eight lower-river stream mouths for either passage or holding. Most (88%) of the 608 sockeye were observed in Willow, Birch, Goose and Fish creeks (Table 3). Sockeye were present in stream mouths from July 23 to September 1 (Appendix Table C-3).

Ashton and Trihey (1985) reported possible fish access problems into several lower-river streams at with-project flows. Sockeye occupied three of these areas: Goose and Rabideaux creeks and Fish Creek, which enters Kroto Slough. A combined 25 percent of the sockeye were observed at these stream mouths (Table 3).

Table 3. Sockeye salmon peak counts in stream mouths between RM 28.0 and 98.6 in order of contribution, 1984.

Stream	River Mile	Date	Number Counted Live	Dead	Total	Percent Contribution	Spawning Observed
Willow Creek	49.1	8/21	210	2	212	35.2	no
Birch Creek	89.2	7/29	174	0	174	28.9	no
Goose Creek	72.0	7/27	74	0	74	12.3	no
Fish Creek	31.2	8/17	68	1	69	11.5	no
Sunshine Creek	85.1	8/3	42	0	42	6.9	no
Little Willow Cr	50.5	8/21	11	1	12	2.0	no
Cache Creek	95.5	8/15	12	0	12	2.0	no
Rabideux Creek	83.1	7/29	7	0	7	1.2	no
	TOTAL		598	4	608	100.0	

High Susitna River discharges have been associated with alterations in salmon migration behavior, either slowing or stopping upstream movement (ADF&G 1983c; Barrett et al. 1984, 1985). Stream mouths increase in area during high discharges due to Susitna River backwater effects and probably were more important as holding areas during these periods. Ashton and Trihey (1985) identified five stream mouths, in which sockeye were observed, where with-project flows may moderately decrease the backwater area. These were Birch, Fish, Sunshine, Little Willow and Rabideaux creeks.

Sockeye salmon were not observed spawning in any lower-river stream mouths (Appendix Table B-1). Although the Deshka River was not included in the survey program, there was probably no spawning at the mouth of this river because the substrate was primarily a silt-sand composition, not suitable for spawning (Burner 1951).

Pink Salmon

Lower-river streams supported most of the Susitna River basin pink salmon spawning in 1984. Approximately 60 percent of the 3.6 million Susitna River pink escapement spawned in lower-river streams between Flathorn and Sunshine stations excluding the Yentna River (Barrett et al. 1985).

In 1984, pink salmon used 12 lower-river stream mouths for either passage to upstream spawning areas or as holding areas during their Susitna River migration (Table 4 and Appendix Table C-3). A total of 5,941 fish were counted in these streams during peak surveys. Most (76%) were in Willow, Sunshine and Birch creeks. Pinks were observed in stream mouths from July 28 to September 9, and were most abundant during the first two weeks of August. Passage did not appear to be a problem at natural flows, but may be restricted during with-project flows at Caswell, Goose, Montana and Trapper creeks, which collectively accounted for 12 percent of the fish counted in stream mouths.

Table 4. Pink salmon peak counts in stream mouths between RM 28.0 and 98.6 in order of contribution, 1984.

Stream	River Mile	Date	Number Counted			Percent Contribution	Spawning Observed
			Live	Dead	Total		
Willow Creek	49.1	8/6	2,871	0	2,871	48.3	yes
Birch Creek	89.2	8/9	889	15	904	15.2	yes
Sunshine Creek	85.1	8/10	750	16	766	12.9	yes
Little Willow Cr	50.5	8/21	287	125	412	6.9	yes
Goose Creek	72.0	7/31	279	3	282	4.7	yes
Trapper Creek	91.5	7/28	234	0	234	4.0	yes
Sheep Creek	66.1	8/13	209	?	211	3.6	yes
Montana Creek	77.0	8/14	170	12	182	3.1	yes
Rabideux Creek	83.1	8/17	35	0	35	0.6	no
Caswell Creek	64.0	8/20	26	3	29	0.5	yes
Cache Creek	95.5	8/22	14	0	14	0.2	yes
Grays Creek	59.5	8/20	1	0	1	0.0	no
	TOTAL		5,765	176	5,941	100.0	

An estimated 4,500 to 9,000 pinks spawned in 10 of the 12 occupied stream mouths (Table 5). Most (75%) of the spawning occurred in Willow, Sunshine and Birch creeks. Specific spawning locations within each stream mouth are provided in Appendix B. All spawning occurred between July 28 and September 8 and peaked during the first two weeks of August.

Table 5. Abundance of pink salmon spawners in lower-river stream mouths, 1984.

Stream	River Mile	Number of Spawners 2-100	101-250	251-500	501-1,000	1,001-2,000
Willow Creek	49.1					X
Little Willow Cr.	50.5				X	
Caswell Creek	64.0	X				
Sheep Creek	66.1		X			
Goose Creek	72.0		X			
Montana Creek	77.0		X			
Sunshine Creek	85.1					X
Birch Creek	89.2					X
Trapper Creek	91.5		X			
Cache Creek	95.5	X				

Pink salmon spawned in gravel-rubble substrates at the 10 stream mouths. This was consistent with the results of previous Susitna River studies (ADF&G 1983b).

Historically, pink salmon have used the mouth of the Deshka River for passage and possibly as a holding area (ADF&G 1982). Spawning probably does not occur in this stream mouth because the substrate was primarily comprised of silt and sand, not the preferred spawning substrate for salmon (ADF&G 1983b).

Chum Salmon

The lower river, between Flathorn and Sunshine stations excluding the Yentna River, supported about three percent of the 1984 chum salmon spawning in the Susitna River basin (Barrett et al. 1985).

Chum salmon utilized 10 stream mouths for either passage to upstream spawning areas or as holding areas during migration (Table 6 and Appendix Table C-3). Goose, Willow and Sheep creeks were the most important of those, with 72 percent of the fish. Chum were present in lower-reach stream mouths from July 27 to September 24. Peak abundance was in the last week of August and the first week of September.

Ashton and Trihey (1985) predicted potential fish-access problems into Caswell, Goose, Montana and Trapper creeks at with-project flows. Fifty-three percent of the chum were located in these stream mouths (Table 6).

Table 6. Chum salmon peak counts in lower reach stream mouths in order of contribution, 1984.

Stream	River Mile	Date	Number Counted Live	Dead	Total	Percent Contribution	Spawning Observed
Goose Creek	72.0	8/14	280	1	281	36.8	no
Willow Creek	49.1	8/6	157	0	157	20.6	yes
Sheep Creek	66.1	8/13	111	0	111	14.6	no
Trapper Creek	91.5	8/8	46	0	46	6.0	yes
Montana Creek	77.0	8/14	41	0	41	5.4	yes
Sunshine Creek	85.1	8/30	37	0	37	4.8	yes
Caswell Creek	64.0	8/13	33	1	34	4.5	yes
Cache Creek	95.5	8/15	28	0	28	3.7	no
Little Willow Cr	50.5	8/3	15	0	15	1.9	no
Rabideux Creek	83.1	7/29	13	0	13	1.7	no
	TOTAL		761	2	763	100.0	

Fifteen percent of the count was attributed to Sheep Creek, where access may be severely affected at with-project flows.

Chum salmon spawned in five lower-river stream mouths (Table 7). Total number of spawners was in the range of 100 to 225 fish. Most were at Caswell Creek. Spawning occurred from the second week of August through the third week of September and reached a peak during the last week of August and first week of September.

Table 7. Abundance of chum salmon spawners in lower-river stream mouths, 1984.

Stream	River Mile	Number of Spawners 2-25	26-50	51-75
Willow Creek	49.1	X		
Caswell Creek	64.0			X
Montana Creek	77.0		X	
Sunshine Creek	85.1	X		
Trapper Creek	95.5		X	

All identified chum spawning at mouth areas occurred in primarily gravel-rubble substrates (Appendix B). These findings were consistent with other ADF&G Su Hydro studies (ADF&G 1983b).

Chum may have used the Deshka River mouth as a holding area, but there was no evidence of spawning there. The substrate was a silt-sand composition unsuitable for spawning (ADF&G 1983b). There is no documentation of this species spawning upstream in the Deshka River drainage (ADF&G 1982).

Coho Salmon

Lower-river streams supported about 50 percent of the 1984 Susitna River basin-wide coho salmon spawning (Barrett et al. 1985).

Coho salmon utilized eleven stream mouths for either passage or as holding areas (Table 8 and Appendix Table C-3). Most (84%) of the 1,430 fish counted were in Willow Creek. Coho occupied stream mouths from August 6 to September 27. Peak abundance occurred in the third week of August.

Of the stream mouths utilized by coho salmon, Whitsol, Caswell, Goose and Montana creeks may have restricted access at with-project flows (Ashton and Trihey 1985). Those streams accounted for about 12 percent of the coho peak survey counts at lower reach stream mouths.

Coho salmon did not spawn in any of the 17 lower-river stream mouths surveyed (Appendix Table B-1). Historically, the Deshka River has been utilized for passage and holding (ADF&G 1982). It was unlikely that coho spawned here because the substrate was comprised of mainly silt and sand, unsuitable for spawning (Burner 1951).

Table 8. Coho salmon peak counts in stream mouths between RM 28.0 and 98.6 in order of contribution, 1984.

Stream	River Mile	Date	Number Counted Live	Dead	Total	Percent Contribution	Spawning Observed
Willow Creek	49.1	8/22	1,196	2	1,198	83.8	no
Montana Creek	77.0	9/14	50	0	50	3.5	no
Caswell Creek	64.0	8/6	44	0	44	3.1	no
Whitsol Creek	35.2	9/20	30	0	30	2.0	no
Sheep Creek	66.1	8/13	21	0	21	1.5	no
Rabideux Creek	83.1	9/26	9	12	21	1.5	no
Trapper Creek	91.5	9/15	21	0	21	1.5	no
Goose Creek	72.0	8/29	19	0	19	1.3	no
Cache Creek	95.5	9/15	13	0	13	0.9	no
Little Willow Cr	50.5	8/29	10	0	10	0.7	no
Sunshine Creek	85.1	9/16	3	0	3	0.2	no
	TOTAL		1,416	14	1,430	100.0	

SUMMARY

Mainstem Habitats

Mainstem habitat is comprised of both main-channel and side-channel habitats. Due to the braided configuration and somewhat unstable nature of the lower Susitna River, it is sometimes difficult to distinguish between the two habitat types. In 1984, 12 mainstem spawning sites were identified. Chum and coho salmon were the only species observed spawning in the mainstem. Chum salmon utilized 11 of the areas while coho salmon spawned in only two. Poor visibility conditions due to high mainstem discharges and turbidity limited documentation of spawning prior to late September. Using survey counts, it is likely that chum salmon spawning peaked during the first two weeks in September, while coho salmon spawning peaked around the second week in October. A conservative estimate of between 2,600 and 3,900 chum salmon and 200 to 400 coho salmon spawned in mainstem sites in the lower Susitna River during 1984. Upwelling, bank seepage or open leads were observed at 10 of the 12 spawning sites.

Slough Habitats

All of the slough habitats found to contain spawning salmon in the lower Susitna River were in side sloughs. Alteration of channel morphology at high discharges may change a slough site to a side channel site. Poor visibility limited the accuracy of surveys until after late September. Six slough spawning sites were located in the lower river, five of these sites were used by chum salmon and one by coho salmon. It appears that the timing of spawning in the sloughs follows a similar pattern to that of the mainstem. Chum salmon probably peak during the first two weeks of September with coho salmon peaking during the second week of October. Between 700 to 1,000 chum salmon and 10 to 20 coho salmon are estimated to have spawned in sloughs. Only four of the sloughs were observed to have upwelling, bank seepage or open leads. Cache Creek may be providing adequate intragravel flow in one of the remaining sites.

Stream Mouth Habitats

Seventeen lower-river stream mouths were surveyed for adult salmon from July 21 to October 1. Pink salmon were most widely distributed, occupying 12 stream mouths and chinook occupying only five. Coho, chum and sockeye were observed in 11, 10 and 8 stream mouths, respectively. Salmon were present in stream mouths from July 23 to September 27.

Only pink and chum salmon spawned in lower-river stream mouths in 1984. Approximately 4,500 to 9,000 pinks spawned in 10 stream mouths. Five stream mouths supported in the range of 100 to 225 chum spawners. Pinks spawned from July 28 to September 8. The peak occurred during the first two weeks of August. Chum salmon spawned from the second week of August through the third week of September. Peak spawning occurred during the last week of August and first week of September.

Both pink and chum salmon selected gravel-rubble substrates for spawning. Neither species spawned in silt-sand substrates. This was consistent with previous ADF&G Su Hydro study results (ADF&G 1983b).

Historically, chinook, sockeye, pink and coho salmon have passed through the Deshka River stream mouth enroute to upstream spawning areas (ADF&G 1982). Examination of the stream-mouth revealed a silt-sand substrate and therefore, it was concluded that salmon did not spawn here.

and/or upwelling groundwater. These clear water inflows are essential contributors to the existence of this habitat type. The water surface elevation of the Susitna River generally causes a backwater area to extend well up into the slough from its lower end. Even though this substantial backwater area exists, the sloughs function hydraulically very much like small stream systems and several hundred feet of the slough channel often conveys water independent of mainstem backwater effects. At high discharges, the water surface elevation of the mainstem river is sufficient to overtop the upper end of the slough. Surface water temperatures in the side sloughs during summer months are principally a function of air temperature, solar radiation, and the temperature of the local runoff.

Stream Habitat: Consists of full complement of hydraulic and morphologic conditions that occur in the streams. Their seasonal flow, sediment, and thermal regimes reflect the integration of the hydrology, geology, and climate of the stream drainage. The physical attributes of stream habitat are not dependent on mainstem conditions.

Upland Slough Habitat: Differs from side-slough habitat in that the upstream end of the slough does not interconnect with the surface waters of the main-channel Susitna River or it side channels even at high mainstem discharges. These sloughs are characterized by the presence of beaver dams and an accumulation of silt covering the substrate resulting from the absence of mainstem scouring discharges.

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