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SUSITNA
HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

ASSESSMENT OF ACCESS BY SPAWNING SALMON INTO TRIBUTARIES OF THE LOWER SUSITNA RIVER

PREPARED BY

R&M CONSULTANTS, INC.

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

DRAFT REPORT
MARCH 1985
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SUSITNA HYDROELECTRIC PROJECT

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Report By:

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Under Contract To:

Harza-Ebasco Susitna Joint Venture

Prepared For:

Alaska Power Authority

DRAFT REPORT
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ACKNOWLEDGEMENTS

The initial airphoto assessment was done by Carl Schoch. Field data were collected by Steve Bredthauer, Chip Green and Bill Ashton. Debbie Stephens assisted in data analysis and figure preparation. Steve Bredthauer and Carl Schoch contributed many useful editoral comments. Orlando Paraoan and Mark Cordery drafted the figures and Barb Estus typed the report. Information regarding the timing of adult salmon migrations in the lower Susitna River and the use of lower river tributaries by spawning salmon was obtained from Alaska Department of Fish and Game SuHydro reports.

1.0 INTRODUCTION

The proposed Susitna Hydroelectric Project will alter the natural flow regime of the Susitna River by increasing winter flows and decreasing summer flows. Previous studies have evaluated the effects of the proposed Susitna project on the morphologic stability and fish access conditions at tributary mouths and side sloughs within the Talkeetna to Devil Canyon reach of the Susitna River (R&M, 1982; Trihey, 1983; and Sautner, Vining and Rundquist, 1984).

This report provides an assessment of the potential effects of the with-project flow regime downstream of the Chulitna-Susitna-Talkeetna confluence on three areas: 1) the change in backwater zones (low velocity fishery holding areas) at tributary mouths; 2) access by adult salmon into tributaries; and 3) morphologic stability of the tributary mouths. The assessment is based on visual evaluation of aerial photographs, observations from helicopter overflights at selected lower river discharges, available U.S.G.S. streamflow data, and on-site field measurements made during a period of low streamflows.

Within this report, the term backwater zone and holding area are used interchangeably. Section 2 describes the natural flow regime, the timing of upstream salmon migrations and a general discussion of the effects a typical with-project flow regime might have on tributary mouth stability, adult salmon access into tributaries and the availability of holding areas. Section 3 describes the methods used in the analysis, and section 4 summarizes the results of the analysis. Exhibit A presents a location map and aerial photos of each tributary, a brief description of fisheries use of, and potential with-project effects at each study site.

2.0 OVERVIEW OF EXISTING SYSTEM

2.1 Basin Overview

The Susitna River drainage basin is located in the southcentral region of Alaska. It is bordered on the west and north by the Alaska Range, on the east by the Copper River lowlands and the Talkeetna mountains, and on the south by Cook Inlet (Figure 2.1). The basin lies within two climatic zones and covers an area of 19,600 square miles. The upper basin (the portion of this basin above Devil Canyon) is in the continental zone, with the lower basin in the transitional zone. Continental climate is characterized by large diurnal and annual temperature variations, low precipitation, low humidity and mean annual temperatures in the range of 15-25° F. Transitional climate is characterized by diurnal and annual temperature variations moderated by maritime influences, higher precipitation than continental climatic zones and mean annual temperatures in the range of 25-35°F (Hartman and Johnson, 1978). The mountainous areas of both climatic zones typically have higher precipitation values than valley areas.

2.2 Fisheries

The Susitna River contributes significantly to the Cook Inlet commercial salmon harvest and sport fishing opportunities for residents of the Matanuska-Susitna Borough and Anchorage (Barrett et al, 1984). Important commercial and sport fisheries include five species of Pacific salmon: chinook, chum, sockeye, pink and coho. The primary salmon spawning areas within the lower Susitna Basin appear to be the clearwater tributaries such as Willow Creek and the Deshka River (Barrett et al, 1984). Backwater areas in lower river side channels, sloughs, and the adjoining tributaries themselves, are thought to provide important rearing areas for juvenile salmon and holding areas for adults. Timing of the adult salmon migration varies by species and from year to year. The rate of upstream migration by adult salmon appears to be retarded by mainstem

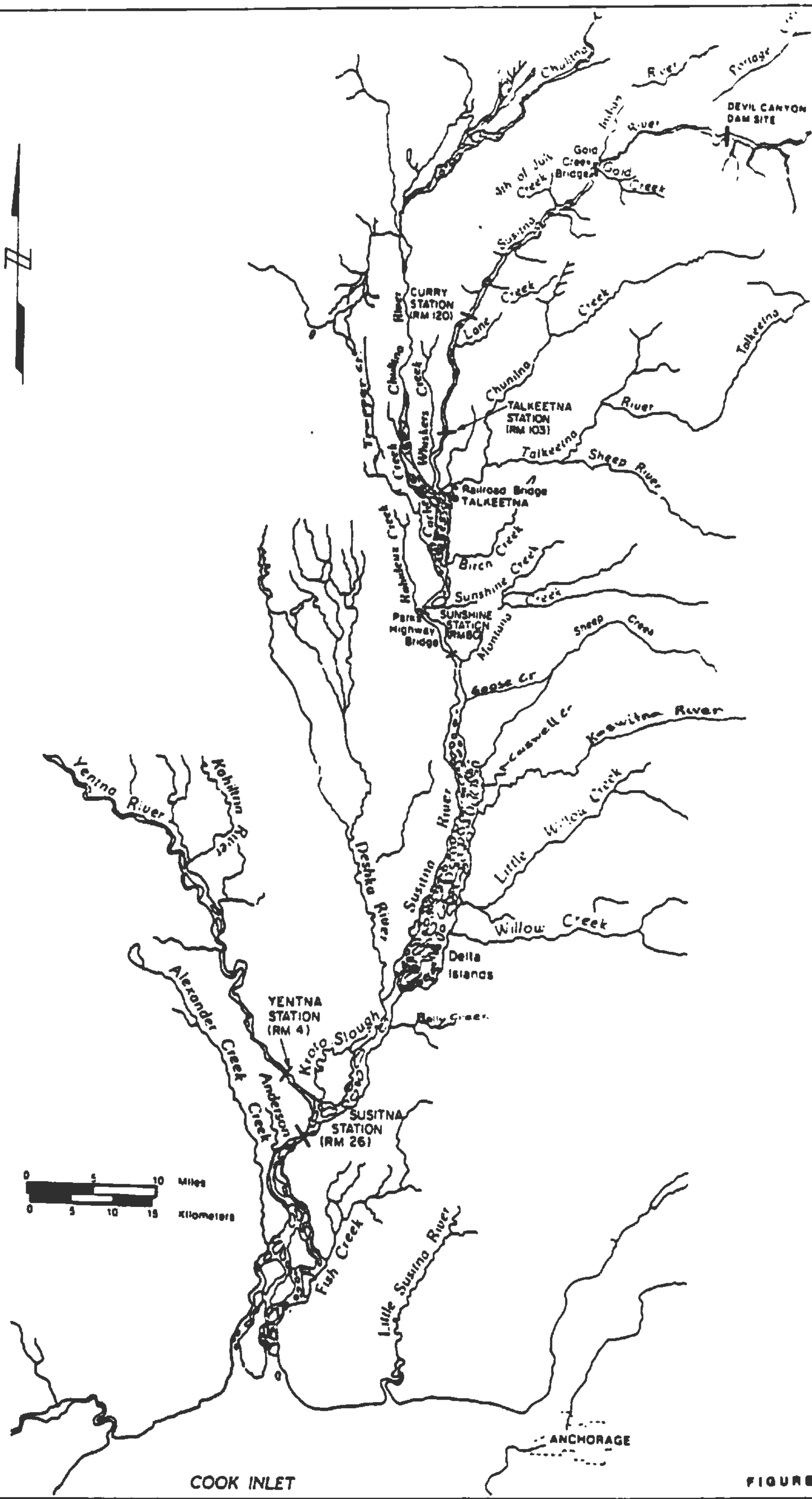

FIGURE 2.1

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ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

SUSITNA RIVER AND MAJOR TRIBUTARIES FROM MOUTH TO DEVIL CANYON

PREPARED FOR:

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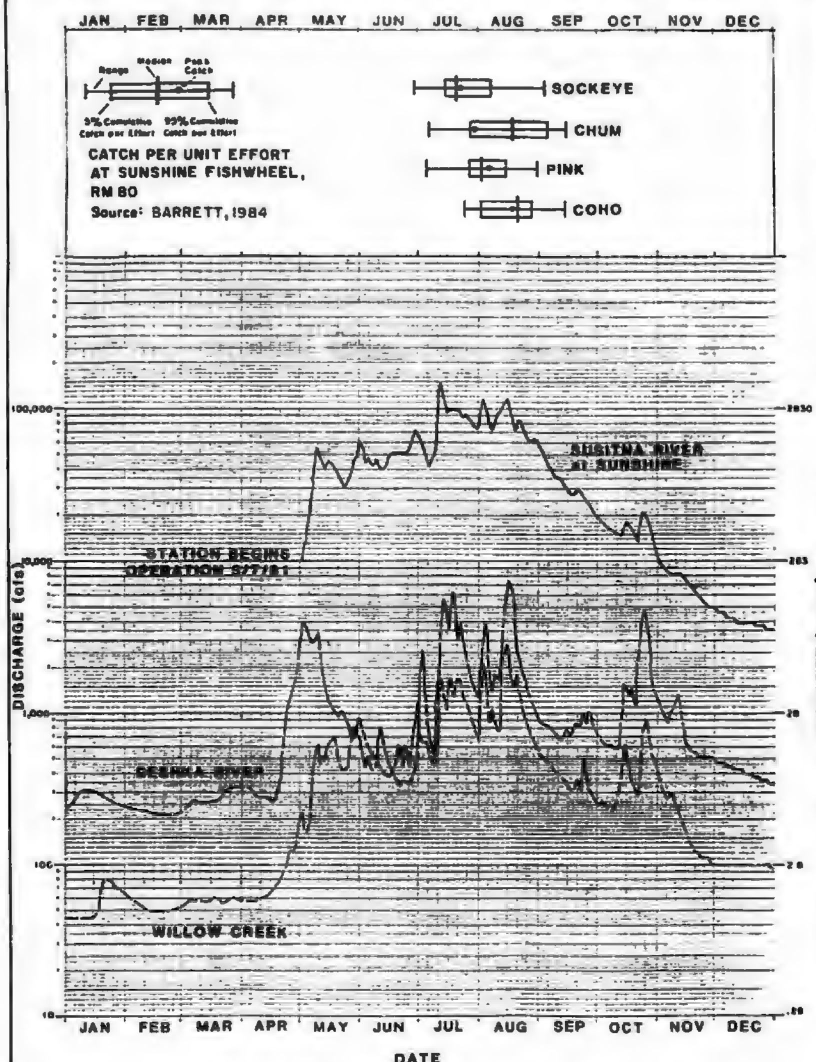
flows above 80,000 cfs (Barrett et al, 1984 and 1985). Timing of the upstream migration for five species of Pacific salmon are presented in Figures 2.2 through 2.4 based on 1981-83 unit effort fishwheel catches for Sunshine station (RM 80). Typically chinook reach Sunshine station in early June, followed by sockeye, pink, chum and coho salmon.

Low velocity backwater areas near tributary mouths are often used as holding areas by adult salmon during upstream migration. Pink and chum salmon have been observed spawning in the interface reach of some of the lower river tributaries (Barrett et al, 1985). Tributaries in the lower Susitna River are predominantly used for spawning by pink, coho and chum salmon, with some tributaries having runs of chinook and sockeye (Appendix 7, Barrett et al, 1985). The greatest numbers of fish in the tributaries during 1984 occurred from late July through August (Appendix 7, Barrett et al, 1985).

2.3 Natural Flow Regime

2.3.1 Mainstem Susitna River

The Talkeetna to Devil Canyon reach of the Susitna is primarily a single channel and split channel river. At its confluence with the Chulitna River the channel pattern changes from a split channel to a braided channel. This change in channel morphology is primarily due to the increased input of sediment from the Chulitna River, additional flow from the Chulitna and Talkeetna Rivers, and a flatter channel gradient. The Susitna River contributes 43 percent of the annual flow at the Chulitna-Susitna-Talkeetna confluence, with the Chulitna and Talkeetna contributing 39 percent and 18 percent, respectively. During the summer, the Susitna River's average contribution ranges from a high of 51 percent in May to a low of 39 percent in July (Table 2.1).



DISCHARGE DATA FROM USGS (1982, 1983)

FIGURE 2.2

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SALMON MIGRATION TIMING AT SUNSHINE AND DISCHARGE FOR SUSITNA RIVER AND SELECTED TRIBUTARIES, 1981

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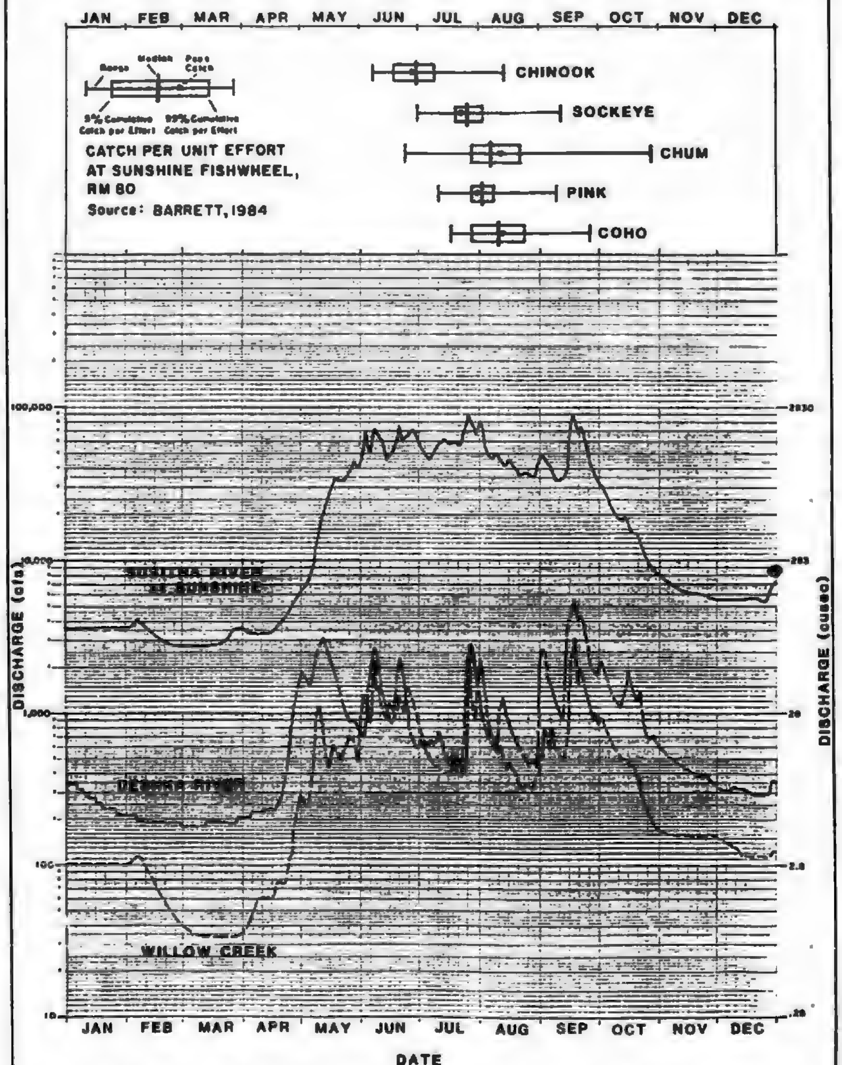

DISCHARGE DATA FROM USGS (1983, 1984)

FIGURE 2.3

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SALMON MIGRATION TIMING AT SUNSHINE AND DISCHARGE FOR SUSITNA RIVER AND SELECTED TRIBUTARIES, 1982

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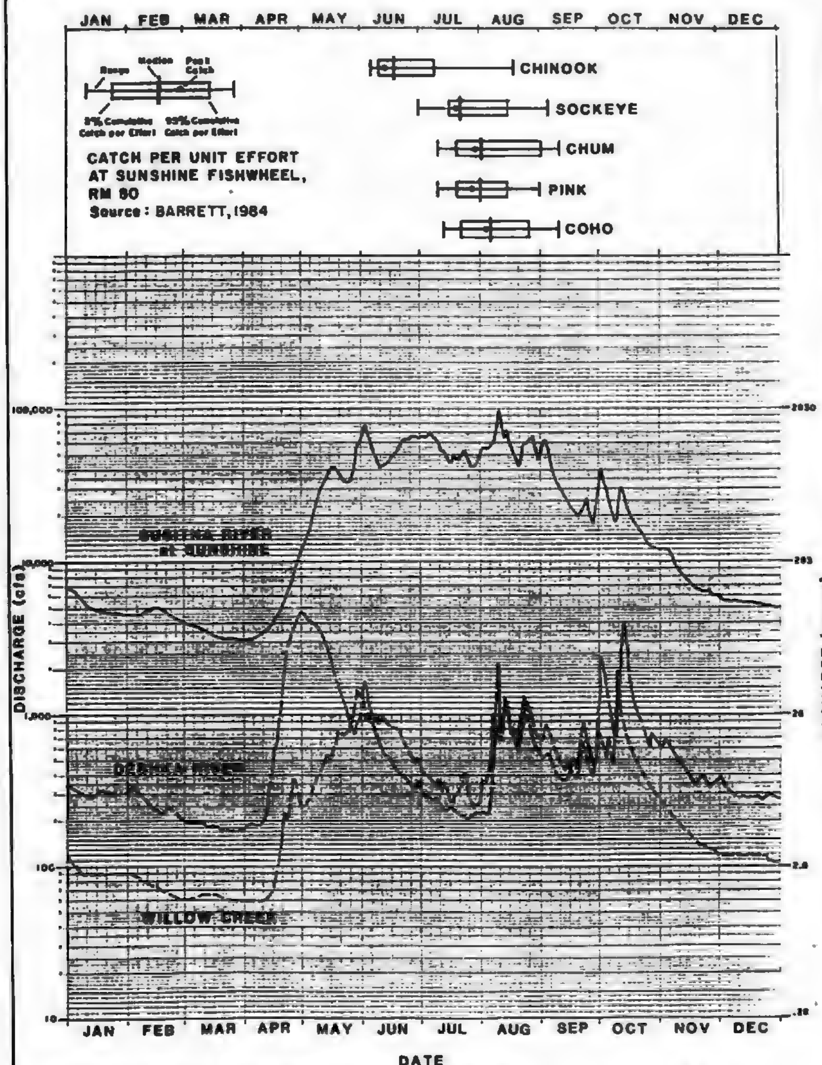

DISCHARGE DATA FROM USGS (1984 & Preliminary Data)

FIGURE 2.4

PREPARED BY: R&M CONSULTANTS, INC.

SALMON MIGRATION TIMING AT SUNSHINE AND DISCHARGE FOR SUSITNA RIVER AND SELECTED TRIBUTARIES, 1983

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The mean daily flows for the Susitna River at the Sunshine gage, approximately 20 miles downstream from the three rivers confluence, are also presented in Figures 2.2 through 2.4, along with the migration timing information for 1981, 1982 and 1983. The initial rise in mainstem discharge in the spring results from snowmelt in the lower basin during late April or early May. As the snowmelt runoff decreases, streamflow in the clearwater tributaries declines (refer to Deshka River and Willow Creek in Figures 2.2 through 2.4). While the streamflow contribution from glacier melt to the mainstem Susitna and its glacially fed tributaries increases. A good example of a clearwater tributary flow decreasing while the mainstem flow remains high occurred during June and July 1983 (Figure 2.4). The influence of glaciers on the mainstem flow regime is more pronounced below the Chulitna-Susitna-Talkeetna confluence than in the middle river.

Glaciers cover 5 percent of the basin area above the Gold Creek streamgage increasing to 10 percent of the basin area at the Sunshine streamgage. The increase is due to the Chulitna and Talkeetna Rivers having 27 and 7 percent, respectively, of their basin area as glaciers. The percentage of the lower river flow contributed by the Chulitna increases during July and August due to its larger percentage of glacierized basin area and lower basin rainstorms (Table 2.1). The influence of the Chulitna and Talkeetna Rivers decreases the relative importance of the middle Susitna River for maintaining summer baseflow in the lower river. By mid-September cold air temperatures at high elevations cause a decrease in the streamflow contribution from glacier melt and increases the importance of fall rain storms in maintaining lower river streamflows.

2.3.2 Lower Susitna River Tributaries

Tributaries to the Susitna River below Talkeetna generally fall within two classifications: Susitna Basin lowland streams and streams

TABLE 2.1

RELATIVE CONTRIBUTION OF FLOWS
AT CHULITNA-SUSITNA-TALKEETNA CONFLUENCE
(PRE-PROJECT)

	Flow Contribution by (cfs)			Total Flow D/S(cfs)	Percent Flow by		
	Chulitna(1)	Talkeetna(1)	Susitna(1)	Talkeetna	Chulitna	Talkeetna	Susitna
October	4859	2537	5639	13035	37%	20%	43%
November	1994	1187	2467	5648	35%	21%	44%
December	1457	838	1773	4068	36%	21%	43%
January	1276	671	1454	3401	37%	20%	43%
February	1095	565	1236	2896	38%	19%	43%
March	976	492	1114	2582	38%	19%	43%
April	1158	557	1368	3083	38%	18%	44%
May	8511	4176	13317	26004	33%	16%	51%
June	22540	11910	27928	62378	36%	19%	45%
July	26330	10390	23853	60573	44%	17%	39%
August	22190	9749	21479	53418	42%	18%	40%
September	11700	5853	13171	30760	38%	19%	43%
Annual	8748	4086	9567	22401	39%	18%	43%

(1) Discharge data from U.S.G.S. records up to September, 1981.

Source: Brabets and Drage, 1982.

originating in the Talkeetna Mountains. During basin wide summer storms, the amount of runoff per unit area generally increases as the basin size decreases. Smaller tributaries generally have a more rapid and pronounced response to rainstorms than larger tributaries or the mainstem Susitna River.

The Susitna lowlands are covered with birch and white spruce forests on the better drained sites, with black spruce trees and sphagnum bogs on the poorly drained sites. The area is relatively flat, with low hills to the south and mountains to the west ranging in elevation up to 8,000 feet. Lowland streams have relatively flat channel gradients and numerous meanders. Snowmelt in late April to early May causes high spring streamflows. Tributary flow typically declines during the summer while responding to rainfall which at times causes short term peak flows. Lakes and bogs retard runoff from summer storms causing lower peak flows of longer duration. Hence lower river tributaries with lakes and bogs are generally buffered from flashy spiked flow events. Streamflow in lowland tributaries are not influenced by glacial melt. The Deshka River near Willow (USGS Station No. 15294100) provide an example of streamflows for a lowland tributary, Figures 2.2 through 2.4.

Streams originating in the Talkeetna Mountains have alpine vegetation covering the portion of the basin above approximately 2,000 feet, with forests of birch and white spruce on better drained sites, and black spruce trees and sphagnum bogs on the poorly drained sites. The streams have relatively steep channel gradients in the mountains and transition to relatively flat channel gradients and meanders in the lowlands. Snowmelt in late April to early May causes high spring streamflows. Tributary flows typically decline during the summer while responding to rainfall which at times causes short term peak flows. Willow Creek near Willow (USGS Station No. 15294005) provide an example of a Talkeetna Mountain stream, Figures 2.2 through 2.4.

2.4 Potential Effects of an Altered Lower River Flow Regime

2.4.1 General

The effect of the altered flow regime of the middle Susitna River caused by the project will be dampened on the lower Susitna River by the major tributaries - the Chulitna River (RM 98), the Talkeetna River (RM 97) and the Yentna River (RM 28). With-project flows in the lower river are expected to be higher than natural flows during the winter and lower than natural flows during the summer. With-project flows will increase the return period for a given magnitude flood. For instance, the natural flow two-year return period flood for natural conditions at Sunshine will have a return period of approximately ten years during project operation (Bredthauer and Drage, 1982). This analysis was based on one of several possible with-project flow regimes and is presented to illustrate the effect of the proposed project on the frequency of channel forming floods occurring in the lower Susitna River.

Project induced reductions of mid-summer mainstem discharge may potentially affect adult salmon access into lower Susitna River tributaries by: 1) decreasing the size of backwater areas available to migrating salmon for resting or holding areas near tributary mouths; 2) decreasing the water depth in the tributary mouth causing insufficient depth for adult salmon to enter the tributary; and 3) a change in the morphologic stability of the tributary mouth or adjoining slough/side channel thereby inhibiting access into the tributaries during periods of low tributary flow.

2.4.2 Holding Areas

One principal affect of with-project flows on tributaries will be a reduction in the size and depth of low velocity backwater areas near the tributary mouths. Quantification of this effect is complicated because the upstream extent of these backwater areas varies as a function of mainstem stage, channel geometry and tributary flow. The decrease in mainstem and side channel water surface elevations in the lower Susitna River caused by project operation will vary depending on the shape of the channel cross-section. For a given change in discharge the stage change will be greater at a confined channel section such as at the Parks Highway Bridge (the location of the USGS Sunshine stream gage) than at a wide, braided channel section, such as the Delta Islands, where a small increase in stage greatly increases the channel cross-sectional area.

The change from natural flows on the lower river caused by project operation will generally result in increased flows in the late fall and winter, lower flows during the summer, and nearly equal flows in spring and early fall. During extremely dry years, with-project flows may exceed natural flows in late summer and early fall. The general effects of the altered flow regime on the size of backwater areas are shown in Table 2.2 for various tributary flow conditions. During with-project summer flow conditions when tributary flows are higher than average long term tributary flows, the size of backwater areas at tributary mouths will decrease (↓) (Table 2.2). During with-project summer flow conditions when tributary flows are less than average long term tributary flows, the size of backwater areas may increase (↑), have no change (-), or decrease (↓) (Table 2.2) depending upon the relative percentages of which with-project flows and tributary flows are lower. The nature and degree of change of the backwater area at each tributary is a function of channel gradient, the runoff characteristics of the basin (such as percentage of basin as forest, lakes or bogs, thereby causing slower time to peak and lower peak flows) and whether the tributaries join the mainstem directly or through a side channel.

TABLE 2.2 CHANGE IN SIZE OF TRIBUTARY BACKWATER AREAS DUE TO WITH-PROJECT FLOWS

		MAINSTEM WITH-PROJECT FLOW		
		HIGHER LATE FALL FLOW	TRANSITION PERIOD MAY & SEPT FLOW	LOWER SUMMER FLOW
TRIBUTARY FLOW	ABOVE AVERAGE	△ — ▽	— ▽	▽
	AVERAGE	△	—	— ▽
	BELOW AVERAGE	△	— ▽	△ — ▽

SIZE OF BACKWATER AREAS AT TRIBUTARY MONTHS,

△ INCREASES,

— IS APPROXIMATELY THE SAME, OR

▽ DECREASES,

DEPENDING ON TRIBUTARY FLOWS AND MAINSTEM WITH-PROJECT FLOWS.

2.4.3 Tributary Access

Tributaries enter the lower Susitna River either in side channels or sloughs or directly into the mainstem. The affect of the altered flow regime on fish access into tributaries entering in side channels or sloughs depends on the with-project flow relative to the mainstem discharge required to overtop the head of the side channel or slough. Overtopping discharges measured at Sunshine range from less than 13,900 cfs at Willow Creek to 36,600 cfs at Kroto Slough. For the with-project flow regime being used in this analysis, on an average weekly basis 36,600 cfs will be exceeded 95 percent of the time from June 24 to August 11 (Harza-Ebasco, 1984). For the tributaries which enter the mainstem directly the upstream extent of the backwater will decrease, as will the depth of flow.

2.4.4 Tributary Mouth Stability

Morphologic stability of the tributary mouths in side channels and sloughs depends on the peak flow of either the mainstem or the tributary. Where deposition of sediment carried downstream by the tributaries presently occurs it would likely occur somewhat closer to the tributary mouth under with-project flow as a result of the upstream extent of backwater in the tributary being reduced. Since the flows in the tributaries will not be affected by project operation, tributary peak flows will continue to transport material from the tributary.

3.0 STUDY PLAN DESIGN AND METHODS

The objective of this evaluation is to determine whether alteration of the lower Susitna River flow regime by the proposed Susitna Hydroelectric Project is likely to affect the availability of holding areas for adult salmon near tributary mouths, access by adult salmon into tributary streams for spawning or morphologic stability of the tributary mouths. The ability of fish to pass through a given stream reach is primarily a function of the species of fish and life stage being considered, environmental stresses the fish are exposed to during migration, water depth and velocity in the passage reach, length of the passage reach and availability of resting areas. Passage criteria most often considered are water depth, water velocity and passage reach length.

Previous passage criteria used for evaluating access and passage conditions in the middle Susitna River (RM 98.0 to RM 152.0) include a set of curves developed for adult chum salmon (Sautner, Vining and Rundquist, 1984). Passage ability was rated as a function of water depth and reach length. The middle river curves were developed for slough spawners from field measurements, literature values and professional judgement of ADF&G, Woodward Clyde and E.W. Trihey & Associates personnel. Water velocity was assumed to be less than 2.0 fps, and two generalized channel types were defined.

Passage criteria for the lower Susitna River needed to include the five Pacific salmon, therefore the passage criteria used are those recommended by Thompson (1972) and applied by Trihey (1983) for the middle Susitna River tributaries Indian River and Portage Creek (Table 3.1). The procedures used for evaluating tributary access in the lower Susitna River include: initial airphoto assessment of the conditions at the tributary mouth, field checking of the airphoto assessment during low flow conditions, and taking spot measurements at locations where passage may be a problem.

TABLE 3.1 DEPTH AND VELOCITY CRITERIA FOR SUCCESSFUL UPSTREAM MIGRATION OF ADULT SALMON (FROM THOMPSON, 1972)

Fish Species	Minimum Depth (ft)	Maximum Velocity (fps)
Chinook salmon	0.8	8
Coho salmon	0.6	8
Chum salmon	0.6	8
Pink salmon	0.6	7
Sockeye salmon	0.6	7

The lowest with-project average weekly flows estimated for the period June 3 to September 15 is 21,500 cfs at Sunshine (Harza-Ebasco, 1984). The September 16, 1983 aerial photography, with a flow at Sunshine of 21,100 cfs, was selected for the initial airphoto assessment and as the photo base for this report. These photos show reasonable worst case passage conditions since the mainstem flowrate is lower than the expected with-project flows and the tributary flows are also low. The photos were examined for sand bars, riffle areas and continuous water at tributary mouths and in side channels leading from the mainstem to the tributary mouths. Tributaries with potential access problems were identified for follow-up aerial reconnaissance and on-site field measurements. Depending on the tributary, field checking consisted of helicopter overflights (Deshka River), boating up the side channel to the tributary mouth (Sunshine Creek), walking along the side channel to the tributary mouth (Trapper Creek), and taking depth-velocity measurements at potentially critical passage reaches (Goose Creek).

4.0 RESULTS AND CONCLUSIONS

4.1 General

This assessment of access conditions at fifteen lower Susitna River tributaries found five locations that may presently restrict the movement of adult salmon (Table 4.1). Specific site evaluations are presented in Exhibit A with oblique and vertical air photos showing the tributary confluence with the mainstem and an air photo mosaic showing the area surrounding the tributary mouth. The head of Kroto Slough becomes dewatered at mainstem flow of approximately 38,000 cfs, but there is still access into the lower part of the slough from the Yentna River. Potential access problems exist at Rolly Creek due to a debris jam near the mouth, at Caswell and Trapper Creeks because of shallow depths in an unstable side channel leading from the tributary mouth to the mainstem and in some reaches of Montana Creek where the water velocities may be excessive.

The affect of the proposed project on the flow regime of the lower Susitna River will be dampened by the influence of the major tributaries: the Chulitna, Talkeetna, Deshka, and Yentna Rivers. Effects of the altered lower river flows on access conditions at tributary mouths will be further masked by the dynamic variations of a braided river and the natural response of the tributaries to summer rain storms. Figure 4.1 compares average weekly natural flows for a representative year, 1983, with flows during project operation. This example is one of several possible with-project flow regimes and is presented to illustrate the potential changes in lower river flow regime.

Based on the tributary evaluations provided in Exhibit A, it can be concluded that access by adult salmon into tributaries of the lower Susitna River should not be inhibited by with-project flows in the 25,000 to 30,000 cfs range. The size of backwater areas will be affected (as shown in Table 2.2), however the degree of change is difficult to quantify due to the natural variability of tributary flows. Tributary mouths should become more stable with with-project flows although the natural variation in a braided river will make quantification of this change difficult.

4.2 Holding Areas

Project affects on the extent of backwater areas vary depending on the season, precipitation, the channel gradient and location of the tributary mouth (in a side channel or the mainstem). The channel cross-section will determine the amount the mainstem stage drops for a specified decrease in flow. For example, the lowest median average flow at Sunshine during the four week period June 3 to June 30 drops from 59,400 cfs under natural conditions to 34,900 cfs under weekly with-project conditions (1996 load) (Harza-Ebasco, 1984). This change in streamflow causes a decrease in stage of 1.9 feet at the USGS Sunshine gage, whereas at Willow Creek (RM 49.1) and Caswell Creek (RM 64.0) the decrease in channel stage for the same decrease in flow are 0.7 and 1.1 feet, respectively. Using the stage change at Sunshine to determine the change in channel stage at other locations on the river may be misleading. Where possible, stage-discharge curves developed at or near the tributary mouths should be used to determine the potential effect of with-project flows on stage. At 21,100 cfs the upstream extent of backwater is slight or nonexistent at each study site except the Deshka River. In the flow range of 35,000 to 60,000 cfs in June and July the change in backwater extent may be severe at Sheep Creek due to the relatively flat tributary channel gradient(Table 5.1). For most of the other tributaries there will be a moderate change in backwater extent.

4.3 Tributary Access

At confluences of tributaries with the mainstem or side channels typically there is a low water channel. Tributaries identified during the initial air photo assessment having potential access problems had water depths ranging from 0.4 to 3.0 feet at 17,800 cfs (Table 4.1). Exhibit A describes where the water depths were measured. Three creeks have

4.1 SUMMARY OF POTENTIAL EFFECTS ON WITH-PROJECT FLOWS ON TRIBUTARIES OF THE LOWER SUSITNA RIVER

Tributary	River Mile	Tributary Mouth in Side Channel	Tributary Mouth in Mainstem	Summary of Adult Salmon Usage of Stream Interface Reach, 1984(1): Passage	Summary of Adult Salmon Usage of Stream Interface Reach, 1984(1): Spawning	Passage Conditions Near Tributary Mouth: Water Depth (ft)	Passage Conditions Near Tributary Mouth: For Discharge at Sunshine (cfs)	Effects of With-Project Flows On Fisheries Access Into Tributaries at 21,100 cfs (2): Problem	Possible Problem	No Problem	Effects of With-Project Flows On Holding Areas (3): Severe Change	Moderate Change	Slight Change	Morphologic Stability Of Tributary Mouth (4): Present	With-Project
Alexander Cr	9.1	x		Not Surveyed		--	--			x		x		Good	Good
Kroto Sl	36.3	x		Not Surveyed		dry	38,000	x					N/A	Good	Good
Rolly Cr	39.0		x	--	--	4.4	43,300		x			x		Good	Good
Deshka R	40.6		x	Ch S P Co	--	--	--			x		x		Fair	Fair
Willow Cr	49.1	x		S P Ch Co	P Ch	2.8	17,800			x			x	Good	Good
L Willow Cr	50.5	x		Ck S P CH Co	P	1.5	17,800			x		x		Good	Good
Kashwitna R	61.0	x		P Ch	--	--	--			x			x	Fair	Fair
Caswell Cr	64.0	x		Ck S P Ch Co	P Ch	0.4	17,800		x			x		Fair	Fair/Good
Sheep Cr	66.1	x		S P Ch Co	P	3.0	17,800			x	x			Good	Good
Goose Cr	72.0	x		Ck S P Ch Co	P	0.4	--		x				x	Fair	Fair/Good
Montana Cr	77.0		x	Ck P Ch Co	P Ch	1.1	17,800		x				x	Poor	Poor/Fair
Rabideux Cr	83.1		x	Ck S P Ch Co	--	--	--			x		x		Fair	Good
Sunshine Cr	85.1	x		Ck S P Ch Co	P Ch	1.5	22,600			x		x		Good	Good
Birch Cr	89.2		x	Ck S P Ch Co	P	--	--			x		x		Fair	Fair/Good
Trapper Cr	91.5	x		Ck S P Ch Co	P Ch	0.6	20,700		x			x		Fair	Fair

Definitions:

1 The interface reach is first third mile from mouth up the tributary. Source Barrett, et al, 1985. Ck = chinook, S = sockeye, P = pink, Ch = chum, and Co = coho.

2 Problem - There is an existing problem with fish access.

Possible Problem - There is the potential for access problems depending on low tributary flows, debris jams or channel changes

No Problem - No problem with access currently exists.

3 Severe Change - The extent of backwater area could be severly reduced by with-project flows during June and July.

Moderate Change - The extent of backwater area could be moderately reduced by by with-project flows during June and July.

Slight Change - The extent of backwater area could be slightly reduced by with-project flows during June and July.

4 Good - No change in tributary mouth morphology since 1951

Fair - Some change in tributary mouth morphology since 1951

Poor - Change in tributary mouth morphology from 1951 to present.

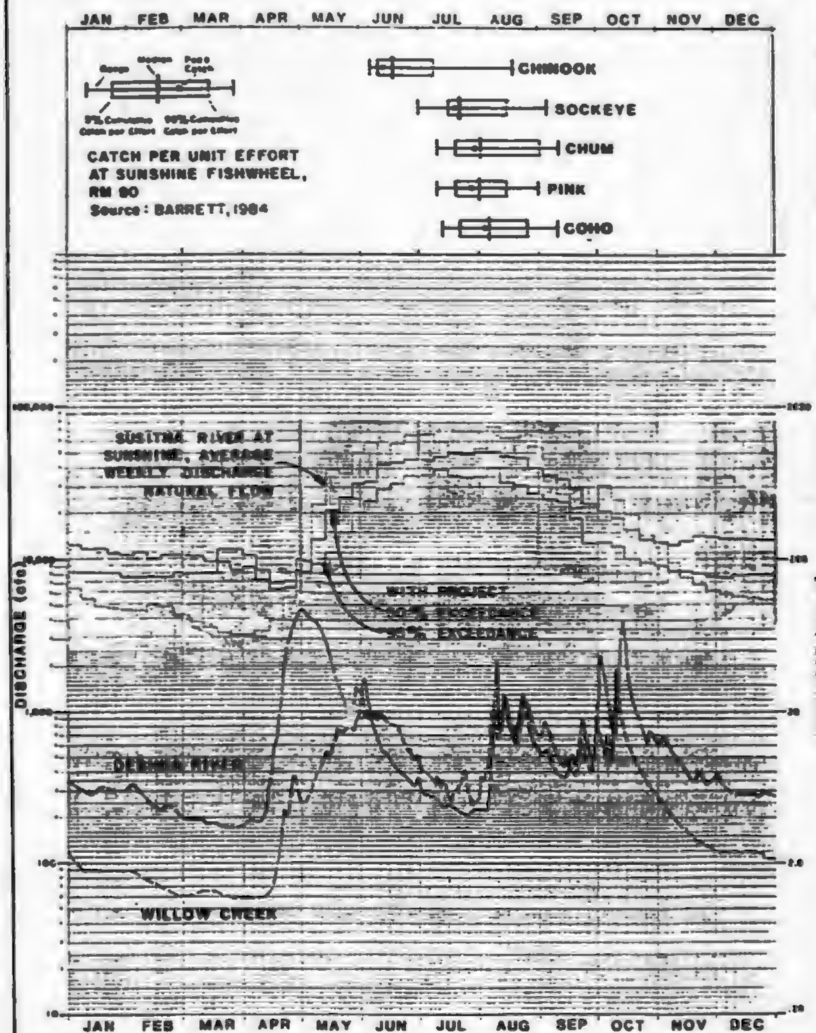
water depths less than the recommended depth (Table 4.1). Caswell Creek was measured at 17,800 cfs, below the 21,100 cfs considered the base low flow and well below the 30,000 to 35,000 cfs range for low with-project flows mid-June through September. For with-project flows there shoud be sufficient water depth for access. Below 20,000 to 23,000 cfs the head of Goose Creek side channel becomes dewatered and water depths in the side channel are dependent on tributary flows. The shallow water depths were measured during a non-overtopped condition. Water depths during overtopped periods should be sufficient for access. Shallow depths in Trapper Creek were measured during a non-overtopped condition when the water depth was dependent on tributary flows. During overtopped periods there should be sufficient water depth for access.

Site specific quantification of with-project water depths available for adult salmon access into lower river tributaries is not considered necessary because the measured and estimated water depths at 21,100 cfs are sufficient for passage. This flow rate is exceeded 100 percent of the time during the period June 3 to September 15 (Figure 4.1). With-project flows may have an effect on the upstream extent of backwater areas at the tributary mouths, however the decrease in size of these areas is not expected to cause access problems.

4.4 Tributary Mouth Stability

Due to the relatively low gradients of the tributary streams, it is not anticipated there will be down cutting of the channel bed at the confluence, which could result in problems with perched tributaries.

Currently only one tributary mouth is morphologically unstable. Since 1951 the side channel upstream of Montana Creek has grown in size and become more stable. However, the creek mouth continues to shift its location from year to year. The general effect of with-project flows will be to reduce the frequency of the channel-forming flows, thereby slightly increasing the stability of the side channels.



DISCHARGE DATA FROM USGS (1984 & Preliminary Data)

FIGURE 4.1

SALMON MIGRATION TIMING AT SUNSHINE AND DISCHARGE FOR SUSITNA RIVER AND SELECTED TRIBUTARIES, 1983

R&M CONSULTANTS, INC.

PREPARED FOR: HARZA-EBASCO SUSITNA JOINT VENTURE

6.0 REFERENCES

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EXHIBIT A EVALUATION OF SELECTED LOWER SUSITNA RIVER TRIBUTARIES

The following are descriptions of the hydrology and fisheries use of selected lower Susitna River tributaries. These descriptions are based on initial aerial photo evaluation of access problems, field data collected to confirm the evaluation, and analysis of the potential effect of with-project flows on backwater areas and morphologic stability of the tributary mouth. The fisheries use of the tributary mouths for spawning or passage is from "Appendix 7 - Adult Salmon Lower Susitna River Spawning Surveys," by Levesque and Seagren (Barrett, et al. 1985). Depths reported for tributaries are passage depths where cross-sections were measured and maximum depth where only spot measurements were made. Passage depth is the average of the mean depth and the maximum depth (Sautner, Vining and Rundquist, 1984). Aerial photographs (at 1" = 500') of each study site are provided for a flow at Sunshine of 21,100 cfs except for Caswell and Sheep Creeks, where the lowest flow at which aerial photography is available is at 59,100 cfs. The tributaries are given in upstream order. Tributary locations are marked on the lower Susitna River aerial mosaics (at 1"=2000').

Alexander Creek

Alexander Creek (Figure A-1 and A-2) originates in the Susitna lowlands and flows southeast to the Susitna River. The flow regime is similar to the Deshka River (Figure 2.2, 2.3 and 2.4), except that flow from Alexander Lake will result in a higher baseflow during dry summers and during the winter. The creek is a popular fishing stream. Year-around residents live just upstream from the confluence with the Susitna River (Photo A-1). There is boat access at 21,100 cfs (at Sunshine) from Cook Inlet up the west channel. Potential fish access is up this side channel or through the east channel then through a slough (RM 6) to the west channel. The affect of with-project flows on the morphologic stability of the tributary mouth and fisheries access into the tributary will be minimal due to the flow contribution from the Yentna River. Fisheries use of Alexander Creek was not reported in Appendix 7 (ADF&G, 1985).

PHOTO A-1

Looking upstream at the mouth of Alexander Creek (RM 9.1). In the foreground is Alexander Slough flowing from right to left. Photo taken 9/11/84 discharge at Sunshine 23,600 cfs, discharge at Susitna Station 51,400 cfs.

LOWER SUSITNA RIVER

TRIBUTARY ACCESS STUDY

STUDY SITE LOCATION MAP

FIGURE A-1

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT 16, 1983
SCALE 1"=2000
SHEET 27 OF 28
DATE 2-7-84

HARZA-EBASCO

PREPARED BY:
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

ALEXANDER CREEK

FIGURE A-2

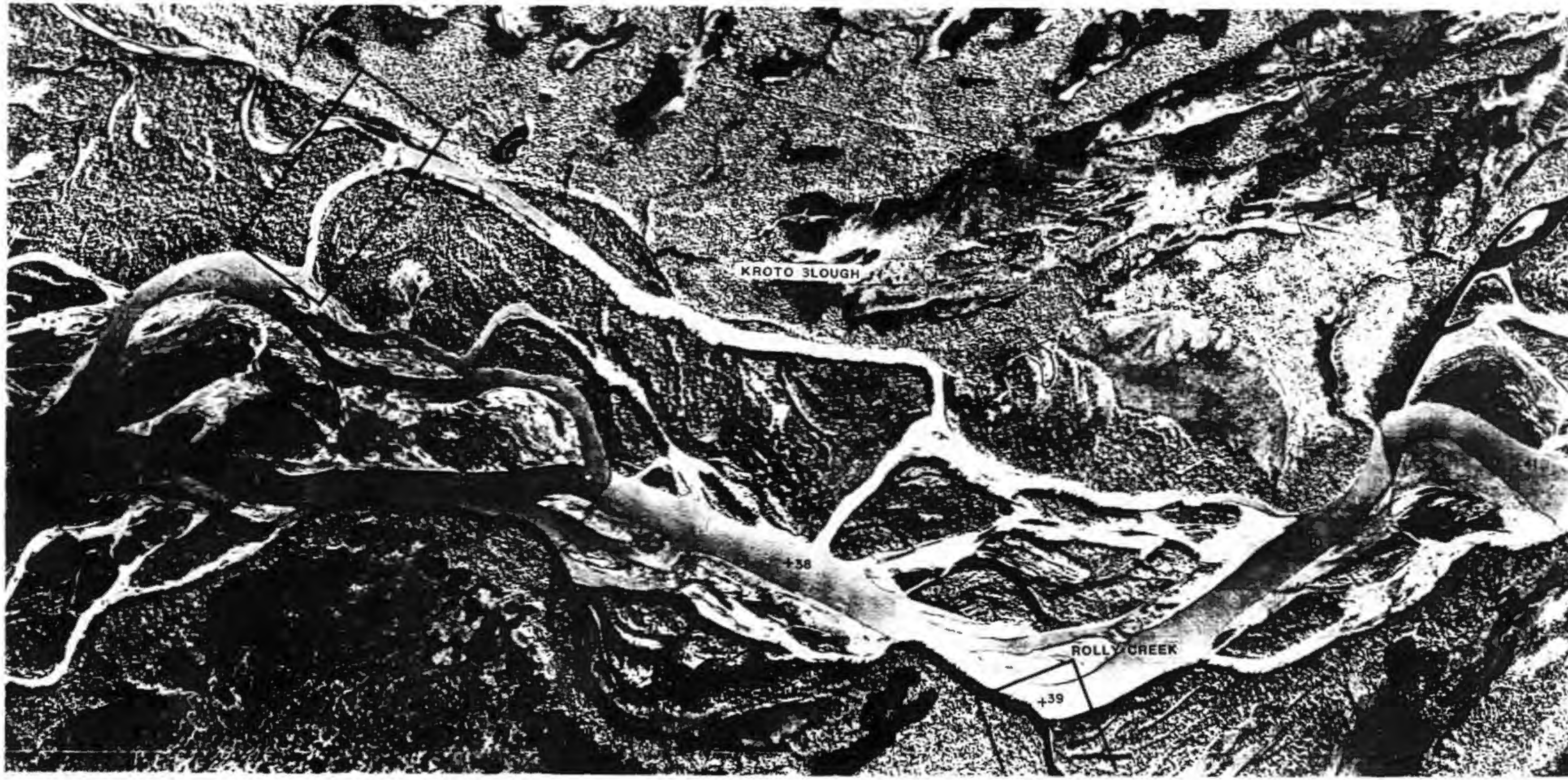
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Kroto Slough

Kroto Slough flows from Kroto Side Channel to the Yentna River. Below mainstem flows of 38,000 cfs the head of Kroto Slough becomes dewatered (Figure A-3). Flow into the upstream end of the slough is entirely dependent on side channel flows, although small lowland tributaries enter along the slough. The side channel typically has water until a few weeks prior to freezeup. There is a controlling berm at the head of the slough (point A, Figure A-4). An ADF&G Resident-Juvenile study site (point B, Figure A-4) studied the effect of change in stage on several habitat parameters. Passage by the upstream berm is uncertain at natural flows below 38,000 cfs, which usually occur during early May and late August. The gravel bar at the mouth of the slough will tend to become more stable due to the lower magnitude of the annual flood peak under with-project conditions (Photo A-2). The head of Kroto Slough may be used by sockeye and coho salmon to access Whitsol Creek, and by chinook and coho salmon to access Fish Creek.

PHOTO A-2

Looking downstream at Kroto Slough (RM 36.3), flow is from bottom to top of photo. Gravel bar in center of photo overtops at approximately 38,000 cfs. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16, 1983 SCALE 1"=2000' SHEET 18 OF 28 DATE 2-7-84
FIGURE A-3	R&M / HARZA-EBASCO

PREPARED BY:
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100 cfs

KROTO SLOUGH

FIGURE A-4

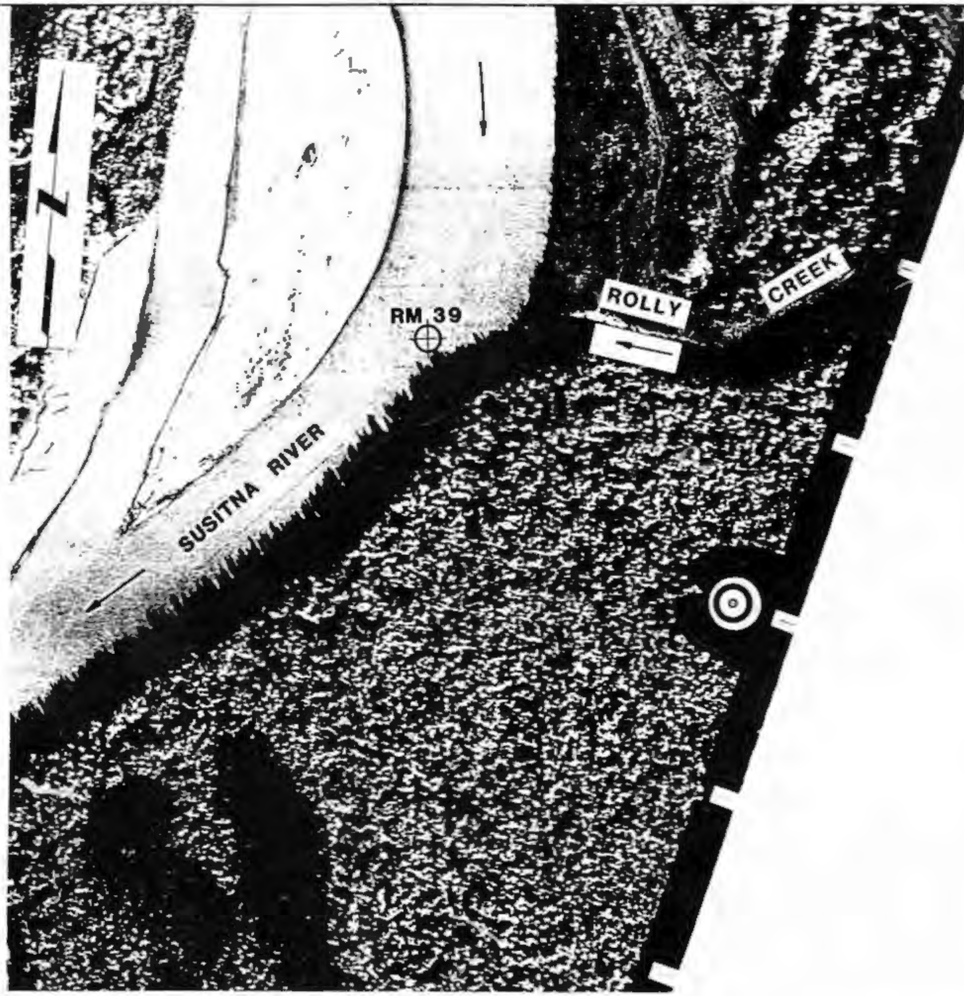
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Rolly Creek

The headwaters of Rolly Creek are in the Susitna lowlands in the Nancy Lake area. The flow regime is similar to the Deshka River (Figure 2.2, 2.3 and 2.4), but would have higher baseflow due to the influence of the lakes in the basin. A log jam which formed in 1984 near the confluence with the mainstem may affect fish access to Rolly Creek (Figure A-3, A-5 and Photo A-3). With-project flows will reduce the backwater zone, but should not affect the access or morphologic stability of the tributary mouth. Chinook and coho salmon spawn upstream.

PHOTO A-3

Looking upstream at Rolly Creek (RM 39.0). The Susitna River mainstem is in the foreground flowing from left to right. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



PREPARED BY:
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

ROLLY CREEK

FIGURE A-5

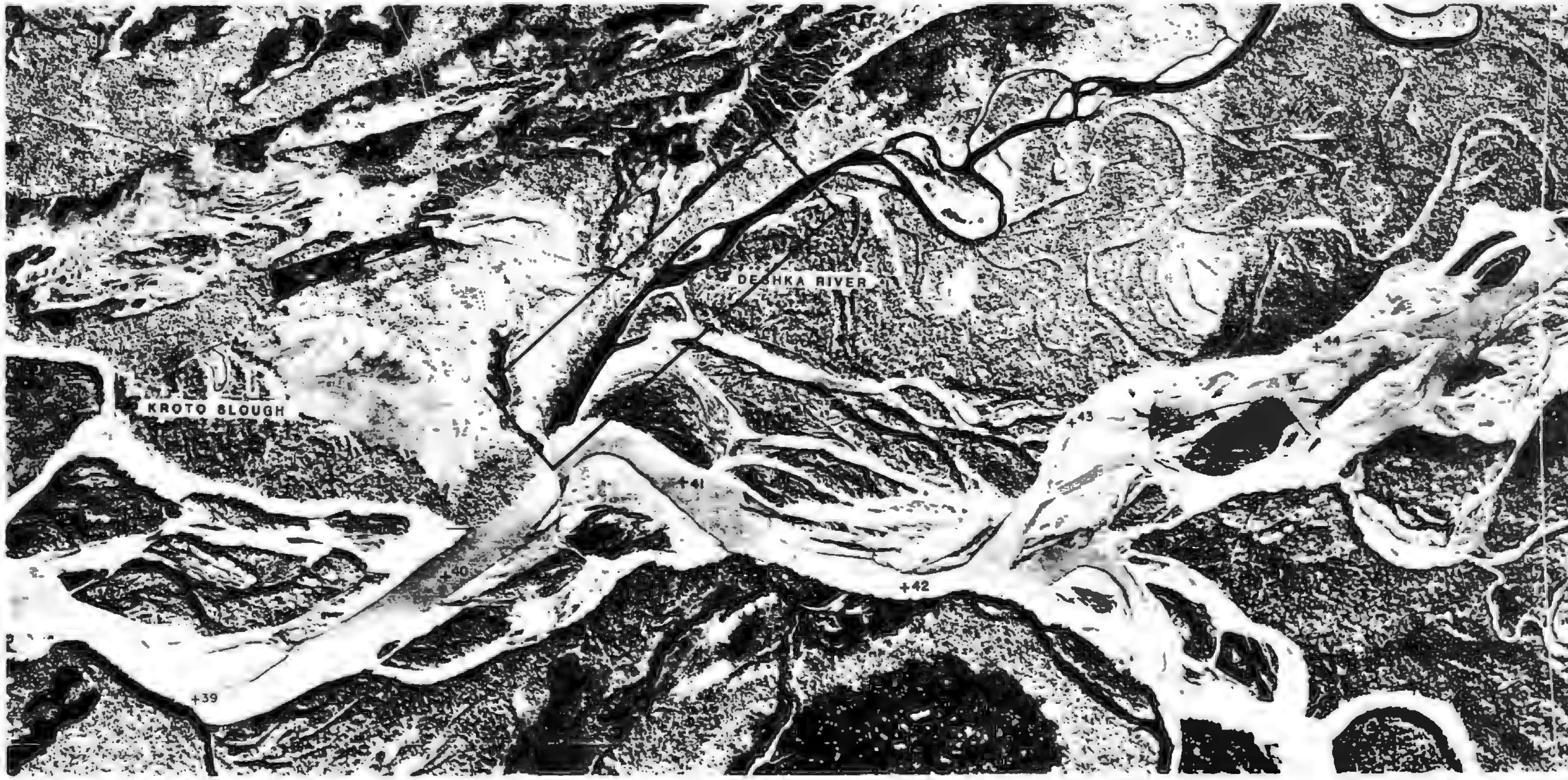
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Deshka River

The Deshka River originates in the Susitna lowlands and flows southeast to the Susitna River (Figure A-6). Since October 1978, the USGS has maintained a continuous recording discharge station 7.9 miles upstream on the Deshka River from its confluence with the Susitna River (Figures 2.2, 2.3 and 2.4). After the Yentna River, the Deshka River is the second largest tributary below Talkeetna. Backwater extended approximately 6,000 feet upstream from the confluence while the mainstem discharge was 23,600 cfs. There is sufficient depth to allow fish access at 21,100 cfs, so with-project flows should not affect access. Island A (Figure A-7) has actively increased in size since 1951, although recently it has started eroding. With-project flows will decrease the size of the backwater zone. The reduction in size, however, depends on many factors, primarily mainstem stage and magnitude of tributary flow. The tributary mouth may become more stable because of slightly lower peak mainstem flows. The erosion rate of Island A may decrease. Chinook, sockeye, pink and coho salmon spawn in the upstream habitats.

PHOTO A-4

Looking upstream at the mouth of the Deshka River (RM 40.6). The Susitna River mainstem flows from right to left in the foreground. Photo taken 8/31/84, discharge at Sunshine 38,000 cfs.



LOWER SUSITNA RIVER

TRIBUTARY ACCESS STUDY

STUDY SITE LOCATION MAP

FIGURE A-6

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT 16, 1983
SCALE 1" = 2000'
SHEET 17 OF 20
DATE 2-7-84

HARZA-EBASCO
SUSITNA JOINT VENTURE

PREPARED BY
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100 cfs

FIGURE A-7

DESHKA RIVER

PREPARED FOR
HARZA-EBASCO
SUSITNA JOINT VENTURE

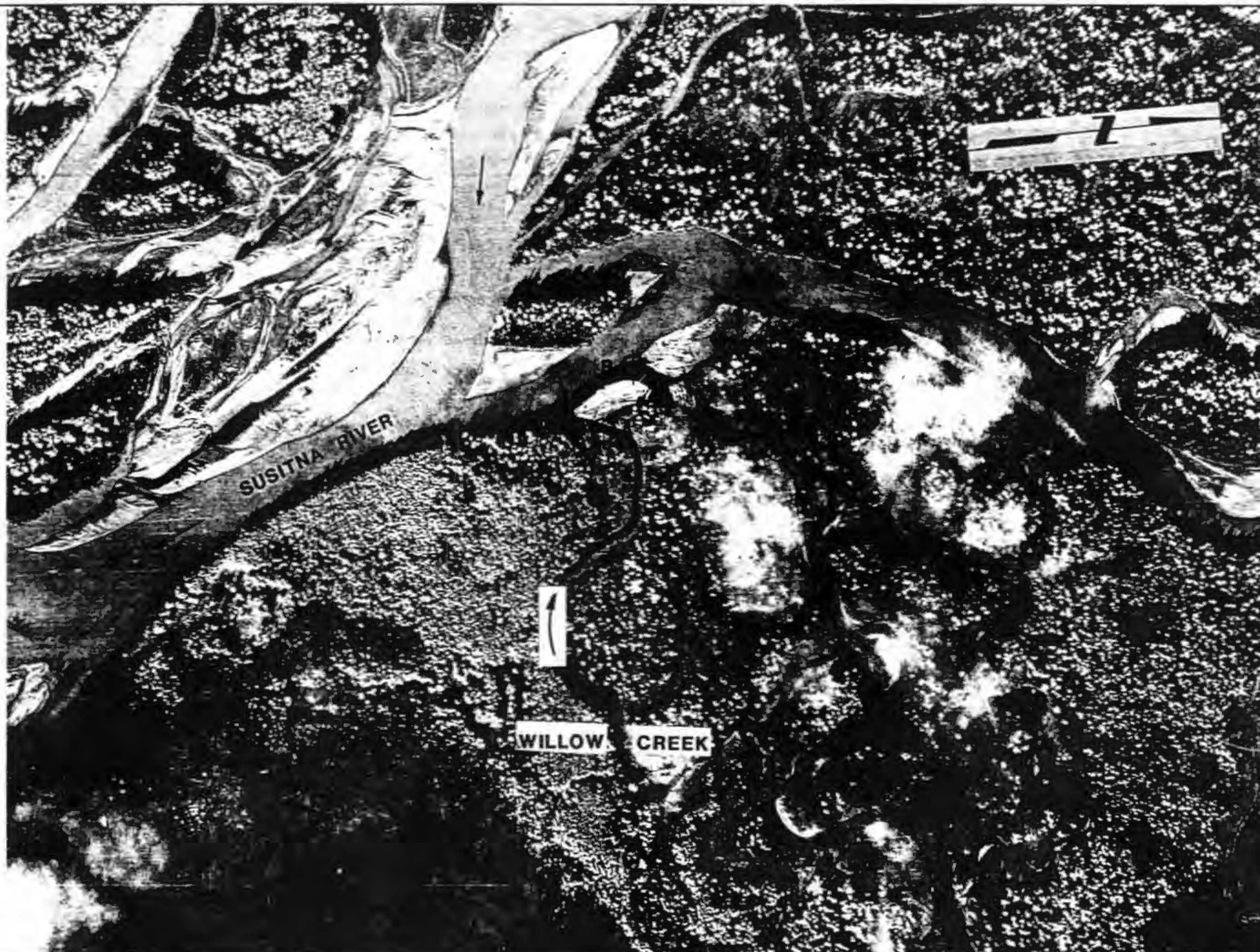
Willow Creek

Willow Creek originates in the Talkeetna Mountains and flows west through the Susitna lowlands to the Susitna River (Figure A 8). Since June 1978, the USGS has maintained a continuous recording discharge station on Willow Creek approximately 15 miles upstream from its confluence with the Susitna River (Figures 2.2, 2 3 and 2.4). Water depths at 21,100 cfs are sufficient to allow passage from the mainstem into Willow Creek. At a flow of 17,800 cfs, the passage depth was 2.8 feet and 1.9 feet at cross-sections A and B, respectively (Figure A 9). These cross-sections are at or near the shallowest depth in the reach. The mean velocity was 2.4 per second for a depth of 2.8 feet at A, and 3.0 fps for the maximum depth of 2.2 feet at B. The substrate ranged from sand to sandy gravel at both A and B. With-project flows may cause reduced backwater zones, but should not affect access or morphologic stability of the tributary mouth. Pink and chum salmon were observed spawning in the tributary just upstream of the mouth of Willow Creek in 1984 (Barrett et al, 1985). Chinook, sockeye, chum and coho salmon spawn in the upstream habitats.

PHOTO A-5

Looking upstream at Willow Creek confluence (RM 49.1). Willow Creek flows from lower right to the center of the photo. Photo taken 8/31/84, discharge at Sunshine 38,000 cfs.

LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16,1983 SCALE 1" = 2000' SHEET 14 OF 29 DATE 2-7-84
FIGURE A-8	HARZA-EBASCO



PREPARED BY:
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100 cfs

WILLOW CREEK

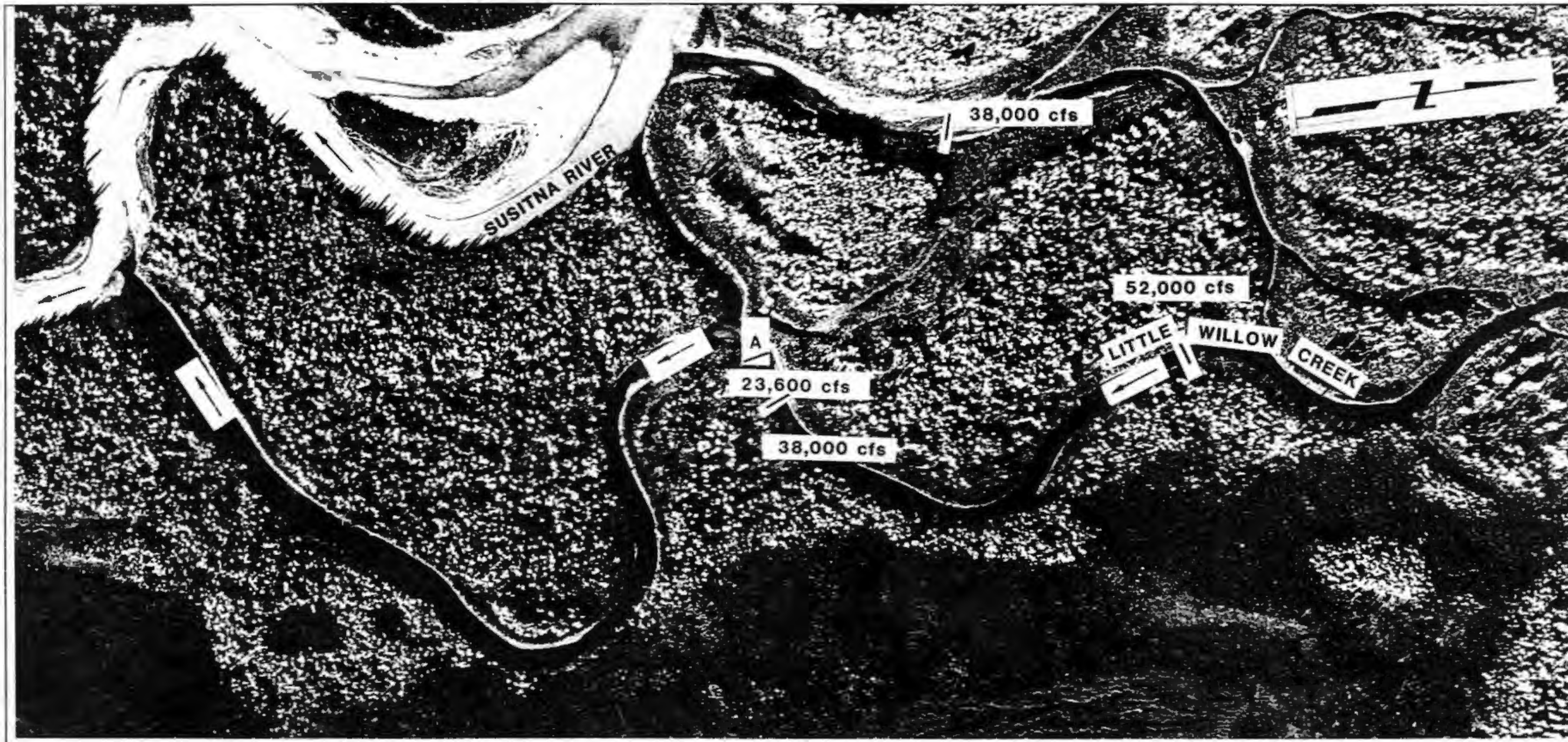
FIGURE A-9

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Little Willow Creek

Little Willow Creek originates in the Talkeetna Mountains and flows west through the Susitna lowlands to the Susitna River (Figure A-10 and A-11). The flow regime is similar to Willow Creek (Figures 2.2, 2.3 and 2.4). Water depths for a mainstem flow of 21,100 cfs are sufficient to allow passage from the mainstem to Little Willow Creek. At a flow of 17,800 cfs, the passage depth was 1.5 feet at cross-section A (Figure A-11) and the mean velocity was 2.0 feet per second at the maximum depth 1.6 feet. The substrate was a silty sand with some gravel covered with a layer of silt-clay. Access to Little Willow Creek is through a side channel from the Susitna River. At a flow of 17,800 cfs there were no apparent shallow riffles which would impede the passage of fish into the side channel. The extent of backwater at 23,600, 38,000 and 52,000 cfs are marked in Figure A-11. With-project flows may cause reduced backwater zones, but should not affect access or morphologic stability of the tributary mouth. Pink salmon were observed near point A during 1984 (Barrett et al, 1985). Chinook, sockeye, pink, chum and coho salmon spawn in the upstream habitats.

LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16, 1983 SCALE 1" = 2000 SHEET 13 OF 28 DATE 2-7-84
FIGURE A-10	R&M HARZA-EBASCO



PREPARED BY:
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

LITTLE WILLOW CREEK

FIGURE A-11

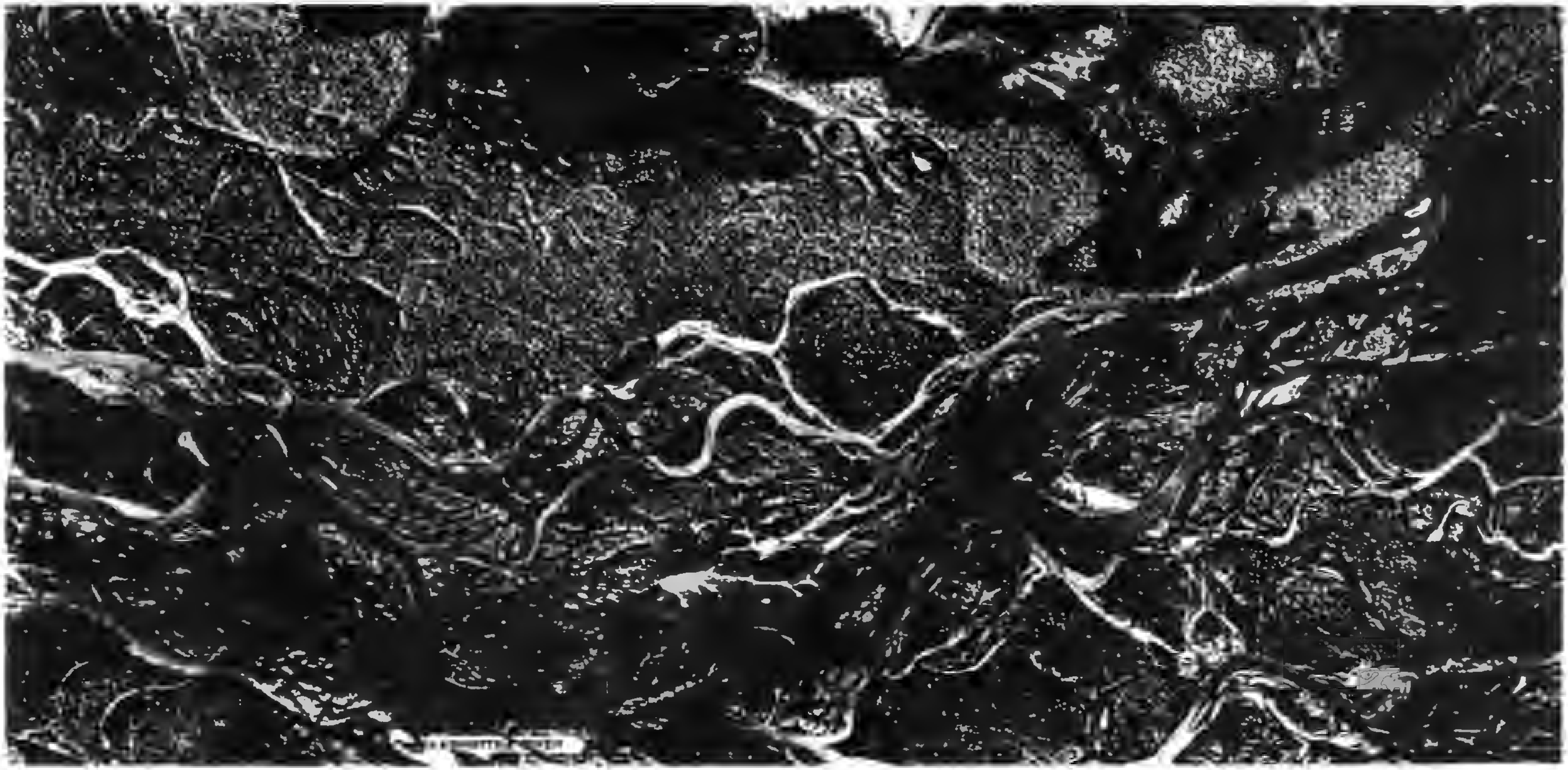
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Kashwitna River

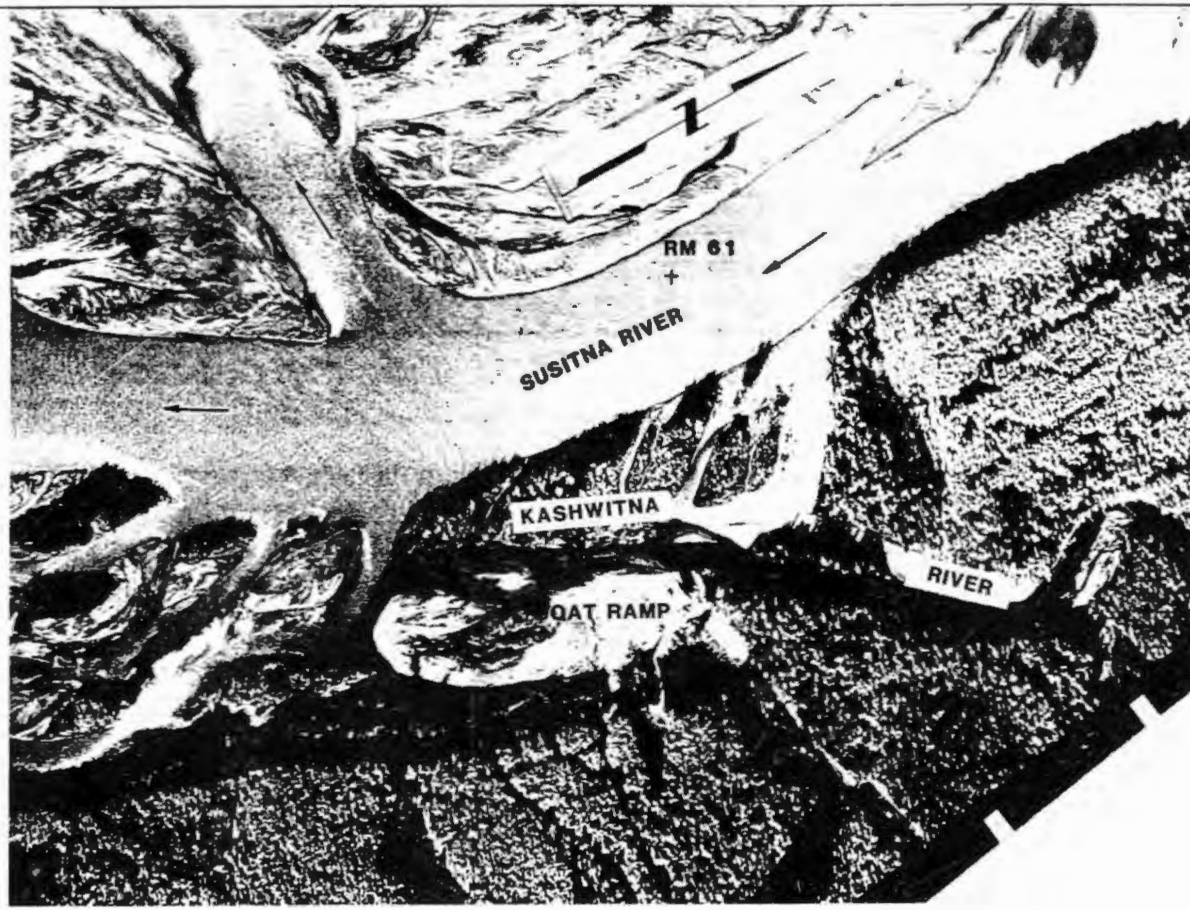
The Kashwitna River originates in the Talkeetna Mountains and flows west through the Susitna lowlands to the Susitna River (Figure A-12). Glacier melt in the headwaters results in a higher baseflow during July and August than other east bank tributaries without glaciers. The river responds to summer rains in a manner similar to Willow Creek. Fisheries access is through a side channel from the mainstem (Figure A-13). This channel provides boat access from the boat landing in the Kashwitna River to the mainstem (Photo A-6). With-project flows will decrease the size of the backwater zone. The reduction in size depends on many factors, primarily mainstem stage and magnitude of tributary flow. The bar to the west of the boat ramp has been increasing in size since 1951. The rate of growth of the bar may slow down with with-project flows. Chinook, pink, chum and coho spawn in upstream habitats.

PHOTO A-6

Looking upstream at the Kashwitna River (RM 61.0). Susitna Landing boat ramp is on the gravel bar in the top center to lower right. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP FIGURE A-12	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16, 1983 SCALE 1" = 2000' SHEET 10 OF 26 DATE 2-7-84 R&M | HARZA-EBASCO



PREPARED BY:

R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

KASHWITNA RIVER

FIGURE A-13

PREPARED FOR:

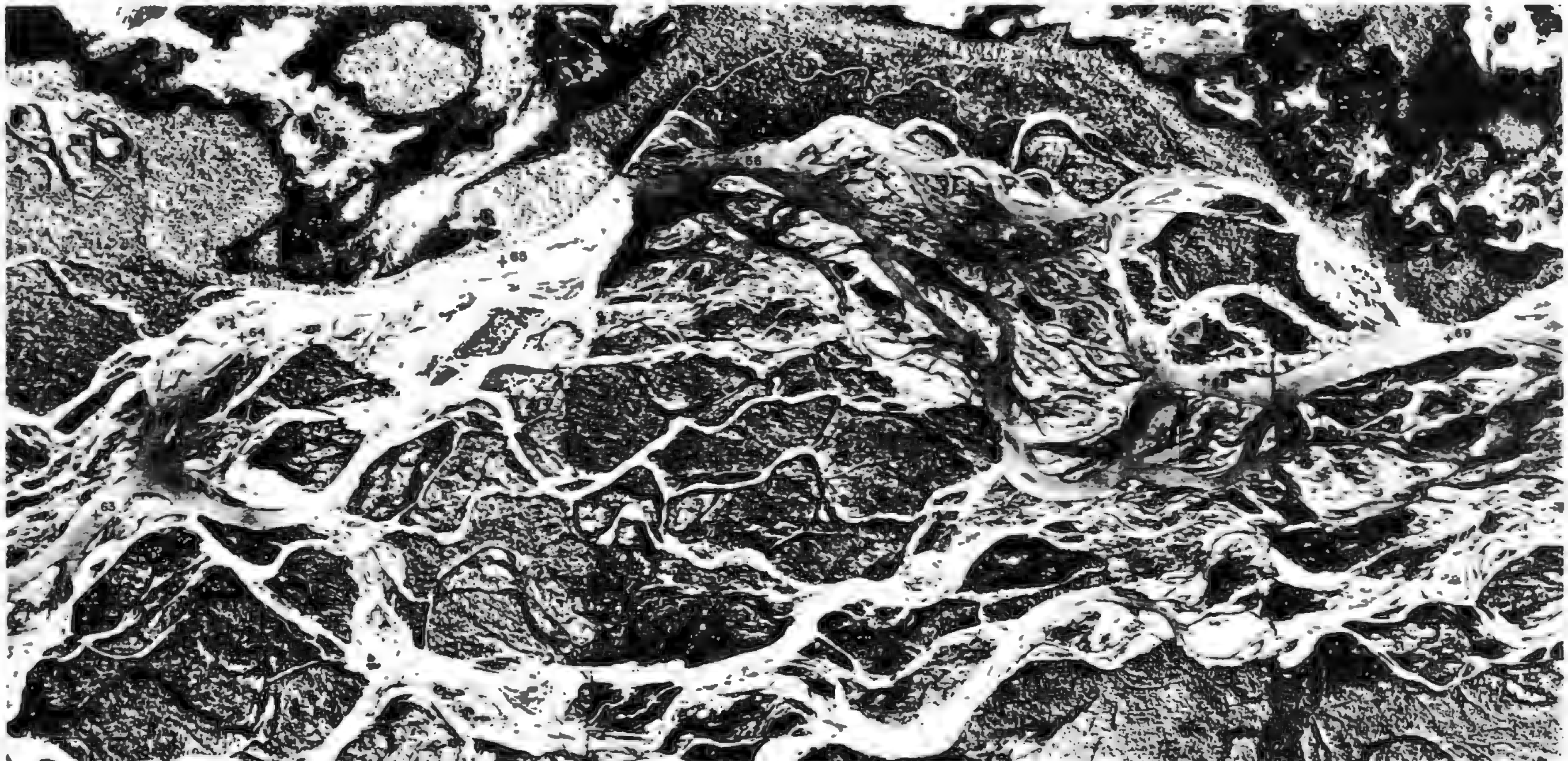
HARZA-EBASCO
SUSITNA JOINT VENTURE

Caswell Creek

The headwaters of Caswell Creek are in the Susitna River lowlands in the Caswell Lake area (Figure A-14). Caswell Creek has lower peak flows after rainfall events than does Deshka River or Willow Creek due of the influence of lakes in the basin. Baseflow during the winter and during dry summers would be relatively higher due to the influence of Caswell Lake. Water depths for flow at Sunshine of 21,100 cfs would be sufficient in the creek and at the creek mouth to allow fish passage. Channel A (Figure A-15) is dewatered at approximately 36,600 cfs thereby extending the tributary mouth approximately 800 feet to the southwest (Photo A-7). The low water mouth is a mobile bed of silt and sand which changes with each high flow event. During our site visit (September 27, 1984, 17,800 cfs) there was a water depth of 0.2 to 0.4 feet for a length of 10 to 20 feet at the mouth. Water velocities were low, 0.2 to 0.6 fps. There could be difficulty in passage due to shallow depths. At 21,100 cfs there would be sufficient depths and velocities to ensure passage. With-project flows will affect the extent of backwater up Caswell Creek. However, the area which would change would be 600 to 800 feet upstream from the tributary mouth. The stability of the tributary mouth would not be affected by with-project flows. The shape of the side channel immediately downstream of the tributary mouth changes with each high flow and will continue to change shape under with-project conditions. Pink and chum salmon were observed spawning in the tributary just upstream of the mouth. Chinook, sockeye, pink, chum and coho salmon spawn in upstream habitats.

PHOTO A-7

Caswell Creek (RM 64.0) flows from right to left. This photo shows the side channel below the creek mouth. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



CASWELL CREEK

SHEEP CREEK

LOWER SUSITNA RIVER

TRIBUTARY ACCESS STUDY

STUDY SITE LOCATION MAP

FIGURE A14

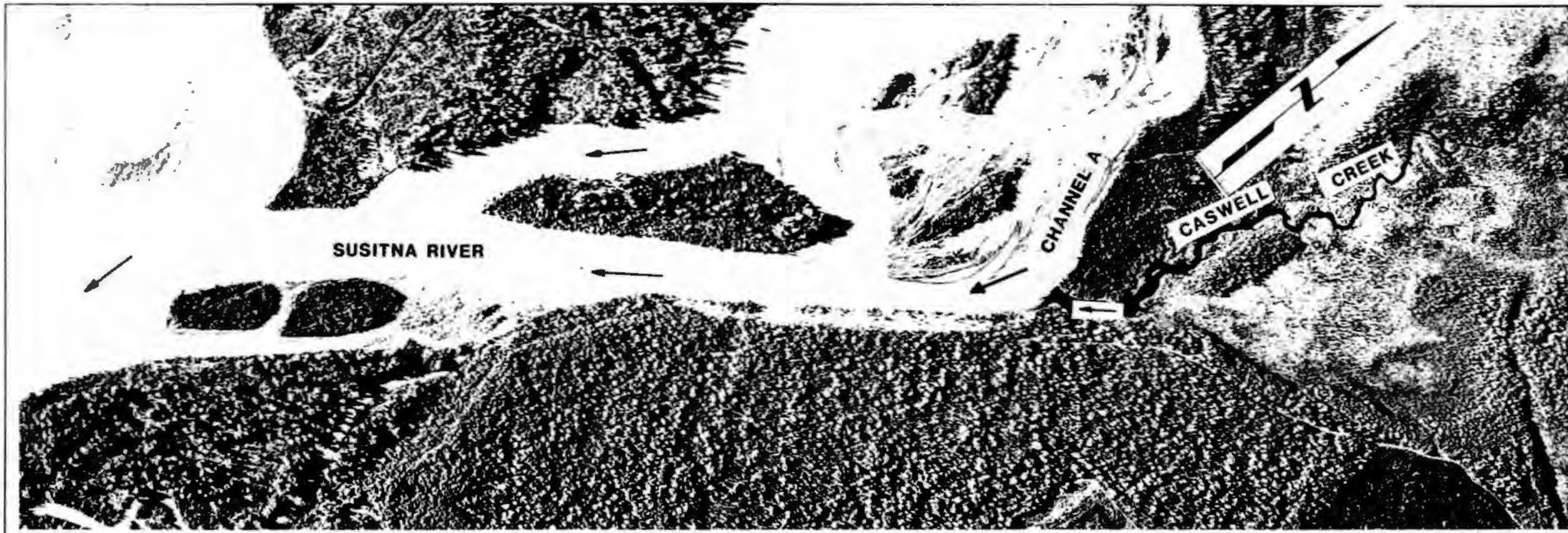
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT 16, 1983
SCALE 1"=2000'
SHEET 9 OF 29
DATE 2-7-84

R&M

HARZA-EBASCO



PREPARED BY:
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: AUG. 27th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 59,100 cfs

CASWELL CREEK

FIGURE A-15

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Sheep Creek

Sheep Creek originates in the Talkeetna Mountains and flows west through the Susitna River lowlands to the Susitna River. As Sheep Creek leaves the mountains, a secondary channel flows to Goose Creek. The percentage of water going to Goose Creek varies, depending on natural channel shifting and man-made diversions at the confluence of the two creeks. The flow regime is similar to Willow Creek (Figures 2.2, 2.3 and 2.4). The small area of glaciers in the headwaters will maintain a marginally higher baseflow during July and August than that at Willow Creek.

The aerial photo (Figure A-16) is 59,100 cfs, as the area was not covered in the 21,100 cfs photography. At 21,100 cfs there is a continuous water course in the side channel downstream from Sheep Creek (Photo A-8). Backwater in the tributary occurs at mainstem discharges above 23,000 cfs (Photo A-8 and Figure A-16). At 52,000 cfs the backwater zone extends approximately 5,000 feet up Sheep Creek. The extent of backwater for three different flows at Sunshine are marked in Figure A-16. The effect of with-project flows will be limited to reduced backwater zones, and will not affect access or morphologic stability of the tributary mouth. Pink salmon were observed to spawn just upstream of the tributary mouth. Chinook, sockeye, chum and coho spawn in upstream habitats.

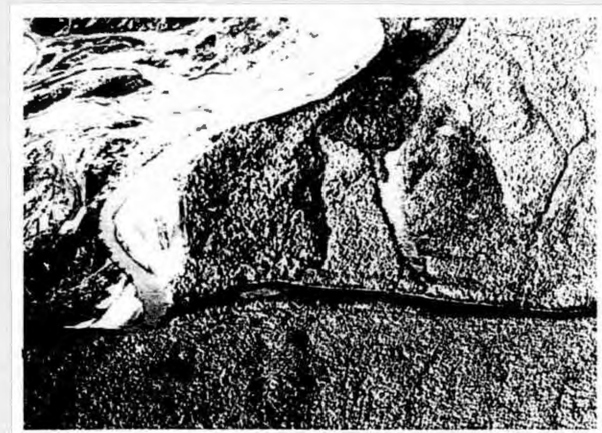
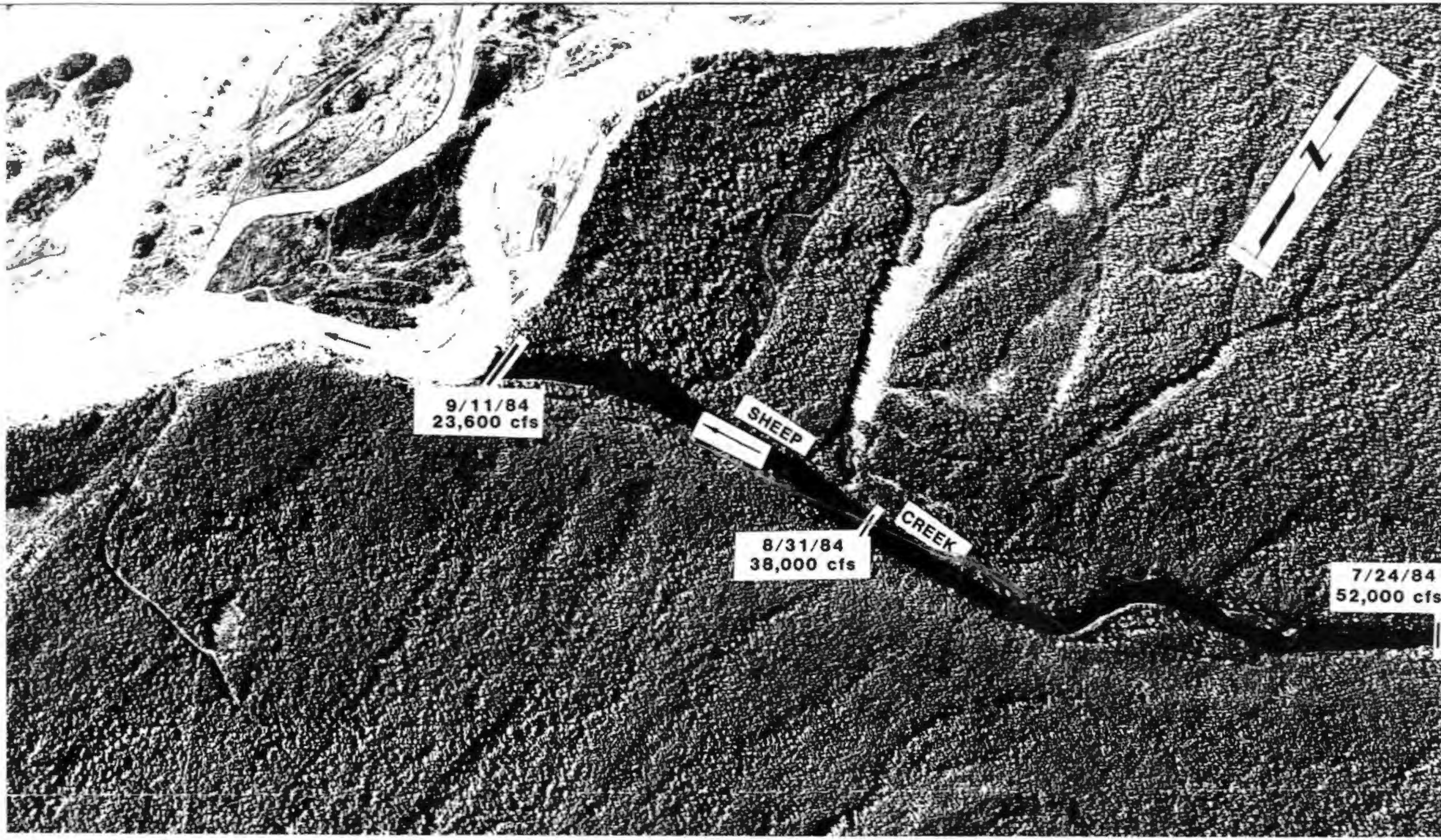


PHOTO A-8

Sheep Creek (RM 66.1) flows from right to left. Sheep Creek side channel flows from top to lower left. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



PREPARED BY:

R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: AUG. 27th, 1983

SCALE: 1" = 500'

DISCHARGE at SUNSHINE: 59,100 cfs

SHEEP CREEK

FIGURE A-16

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

Goose Creek

Goose Creek originates in the foothills of the Talkeetna Mountains and flows west through the Susitna River lowlands to the Susitna River (Figure A-17 and A-18). The channel starts as Sheep Creek leaves the mountains. The percentage of water entering Goose Creek from Sheep Creek varies, depending on natural channel shifting and man made diversion. The flow regime is similar to Willow Creek (Figures 2.2, 2.3 and 2.4). Goose Creek splits into four main channels, with two flowing into the mainstem of the Susitna River and two flowing into a side channel (Photo A-9). The side channel overtops between 20,000 and 23,000 cfs, with the actual overtopping flow varying from year to year due to channel changes and debris accumulating at the head of the side channel. When the side channel is overtopped, there is sufficient water depth and low water velocities to ensure fish passage into Goose Creek. Water depths and velocities were measured in the side channel downstream of the tributary mouth when the berm was not overtopped. At cross-section A (Figure A-18) the critical section had a water depth of 1.0 feet, a velocity of 4.6 fps and a reach length of 20 feet. Section B (Figure A-19) had a critical section water depth of 1.2 feet, a velocity of 4.6 fps and a reach length of 20 feet. The discharge in the side channel was 39 cfs during these measurements. The shallowest water depth, 0.4 feet, was at Section C (Figure A-19), with a water velocity of 0.9 fps and a reach length of 50 feet. During with-project flows, Sunshine flows will exceed 24,000 cfs 95 percent of the time from June 3rd to September 8th. Pink salmon were observed to spawn near the tributary mouth. Chinook, sockeye, pink, chum and coho salmon spawn in upstream habitats.

Since most of the adult inmigration occurs during the period when the side channel berm is overtopped (June 3 to September 8), there is little chance of fish passage problems. The slight change in stage with with-project flows will slightly alter the backwater in the channels flowing into the mainstem, but should not severely affect potential holding areas. The tributary mouth has changed considerably since 1951 due to bedload

moving down Goose Creek and elevating the old mouth where it joins a side channel at point A (Figure A-21). From point A water flows both to the north and to the southwest. The event which caused the change in the mouth was probably a storm in upper Sheep Creek basin which caused a channel change, diverting most of the water down Goose Creek.

PHOTO A-9

Looking upstream at the confluence of Goose Creek and Goose Creek side channel (RM 72.0). Goose Creek flows from top right towards bottom center. The side channel was barely overtopped at 23,600 cfs, at Sunshine on 9/11/84.

LOWER SUSITNA RIVER

TRIBUTARY ACCESS STUDY

STUDY SITE LOCATION MAP

FIGURE A-17

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY SEPT 16, 1983
SCALE 1"=2000'
SHEET 8 OF 70
DATE 2-7-84

R&M

HARZA-EBASCO

LOWER SUSITNA RIVER **TRIBUTARY ACCESS STUDY** **STUDY SITE LOCATION MAP**	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16, 1983 SCALE 1"=2000' SHEET 7 OF 26 DATE 2-7-84
FIGURE A-18	R&M HARZA-EBASCO

PREPARED BY:

R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983

SCALE: 1" = 500'

DISCHARGE at SUNSHINE: 21,100 cfs

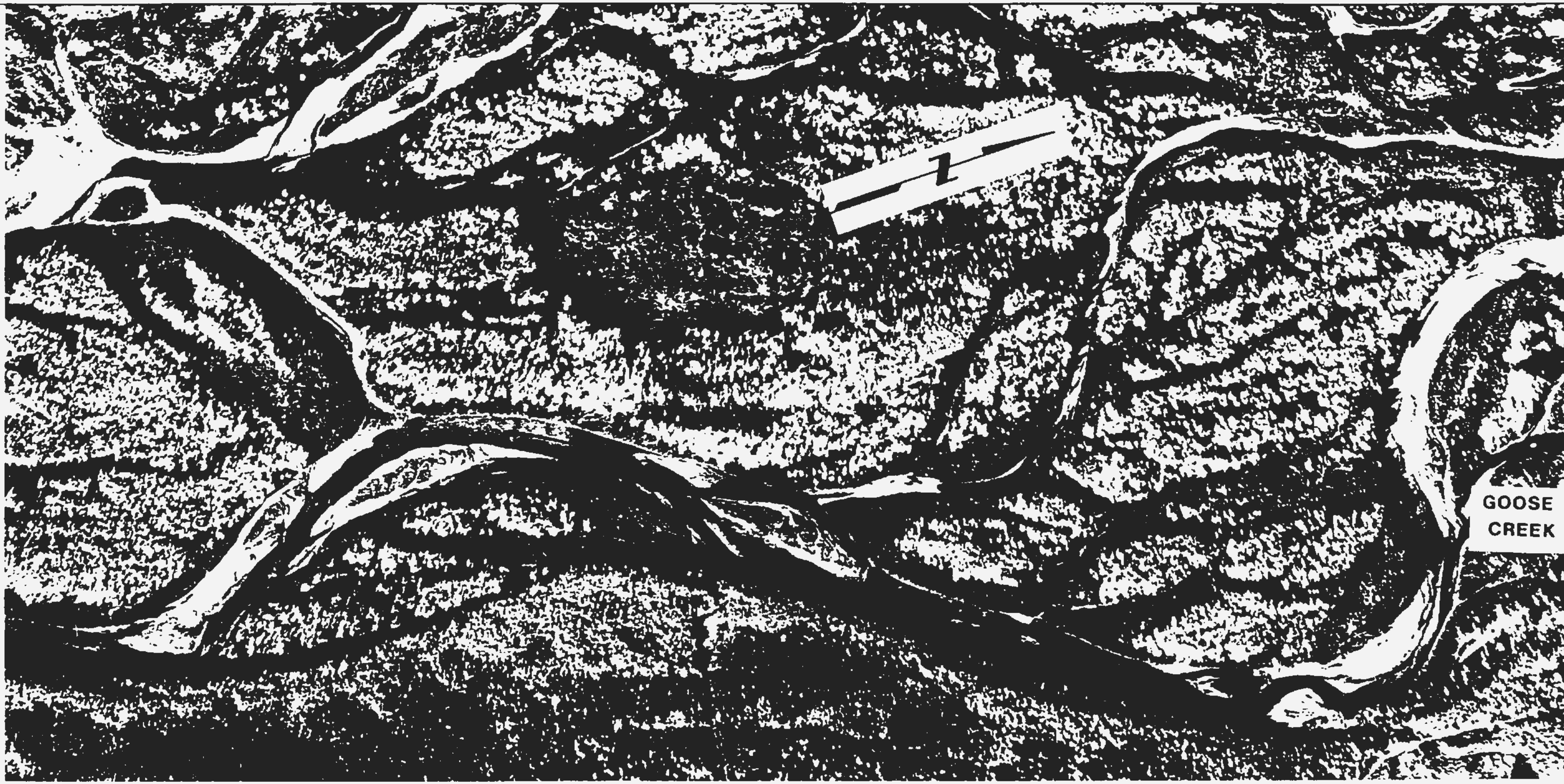
GOOSE CREEK A

FIGURE A-19

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



PREPARED BY
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100 cfs

GOOSE CREEK B

FIGURE A-20

PREPARED FOR
HARZA-EBASCO

PREPARED BY
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 600'
DISCHARGE at SUNSHINE: 21,100cfs

GOOSE CREEK C

FIGURE A-21

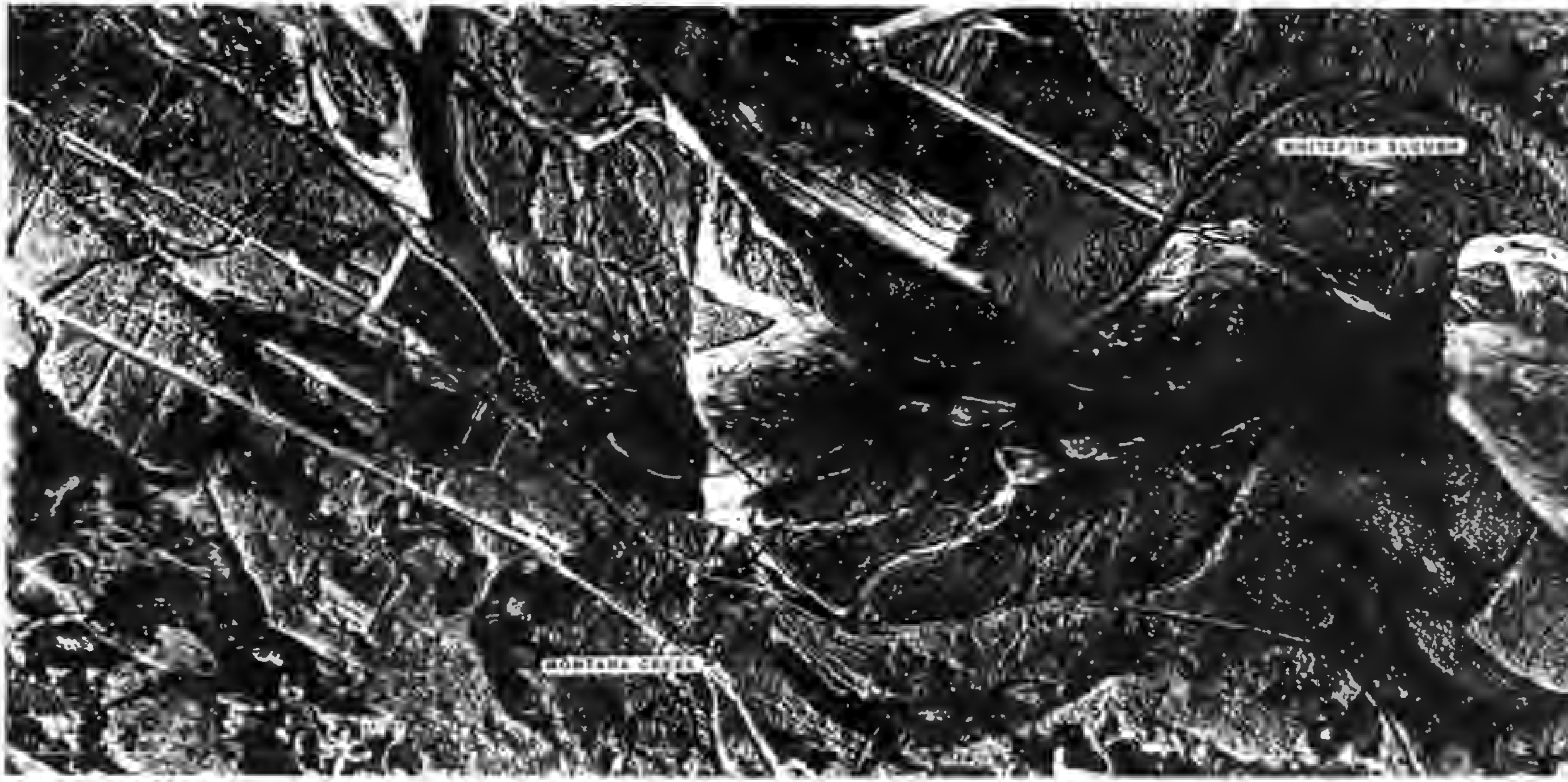
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Montana Creek

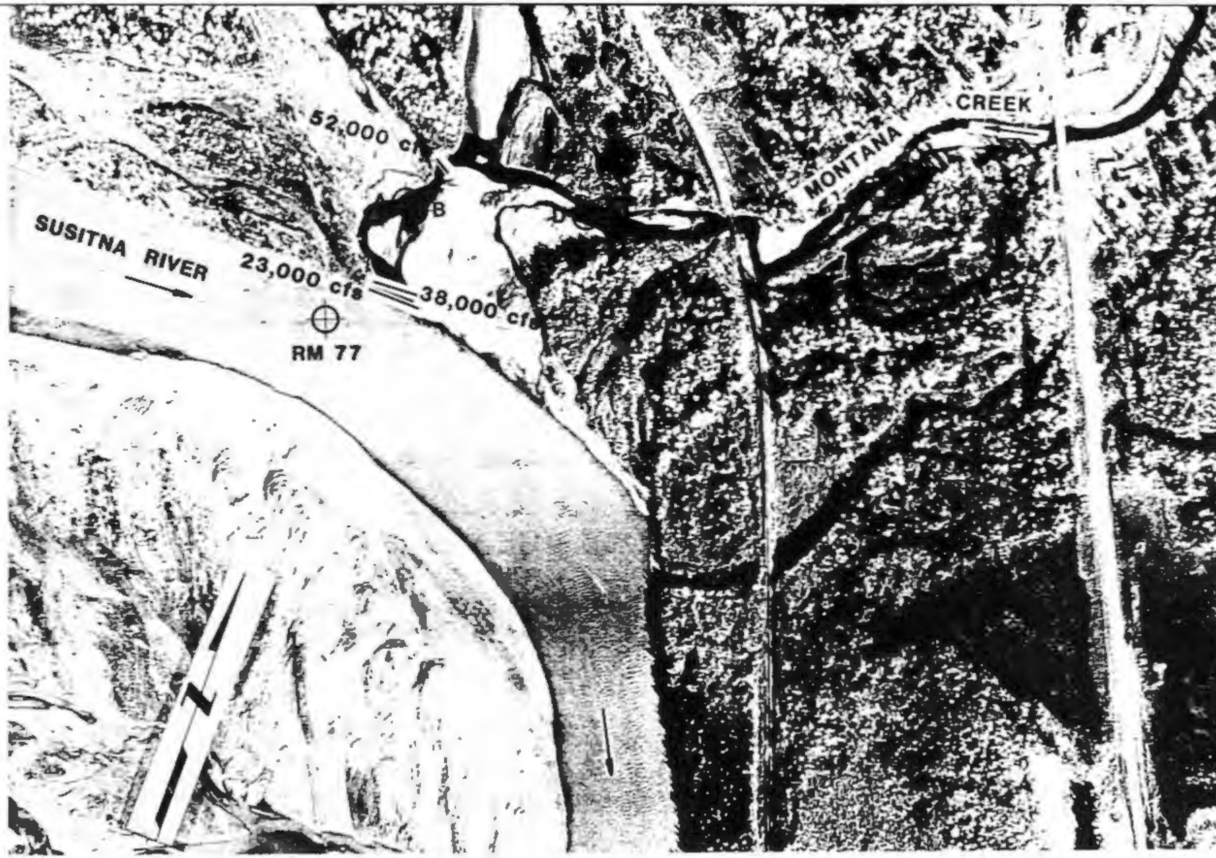
Montana Creek originates in the Talkeetna Mountains and flows west through the Susitna lowlands to the Susitna River (Figure A-22). The flow regime is similar to Willow Creek (Figures 2.2, 2.3 and 2.4). Water depths during 21,100 cfs are sufficient to allow passage from the mainstem to Montana Creek. Depending on the fish species and life stage, water velocities within the tributary may partially block fish passage (Figure A-23). During the past 30 years the sandbars at the confluence of Montana Creek and the Susitna have become more vegetated and morphologically stable. However, the morphology of the channel between measurement sites A and B and the confluence change each year (Figure A-23 and Photo A-10). At point A and B the water depth and velocity were 1.8 feet and 3.1 fps, and 1.2 feet and 2.8 fps, respectively. At point C the water depth and velocity were 1.3 feet and 7.1 fps, while at point D they were 1.1 feet and 3.2 fps. Montana Creek has a relatively steep gradient, with essentially no backwater zone at mainstem flows of up to 38,000 cfs, and with 600 feet of backwater at 52,000 cfs. The side channels entering Montana Creek from the north are overtopped between 38,000 cfs and 52,000 cfs. The effect of with-project flows will be limited to slightly reduced backwater zones, and will not affect access or morphologic stability of the tributary mouth. Pink and chum salmon were observed spawning just upstream from the tributary mouth. Chinook and coho salmon spawn in upstream habitats.

PHOTO A-10

Montana Creek (RM 77.0) flows from right to left center. The Susitna River mainstem flows from upper left to lower left. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPH SEPT 16, 1983 SCALE 2000 SHEET 6 OF 20 DATE 2-7-84
FIGURE A-22	R&M HARZA-EBASCO



PREPARED BY
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

MONTANA CREEK

FIGURE A-23

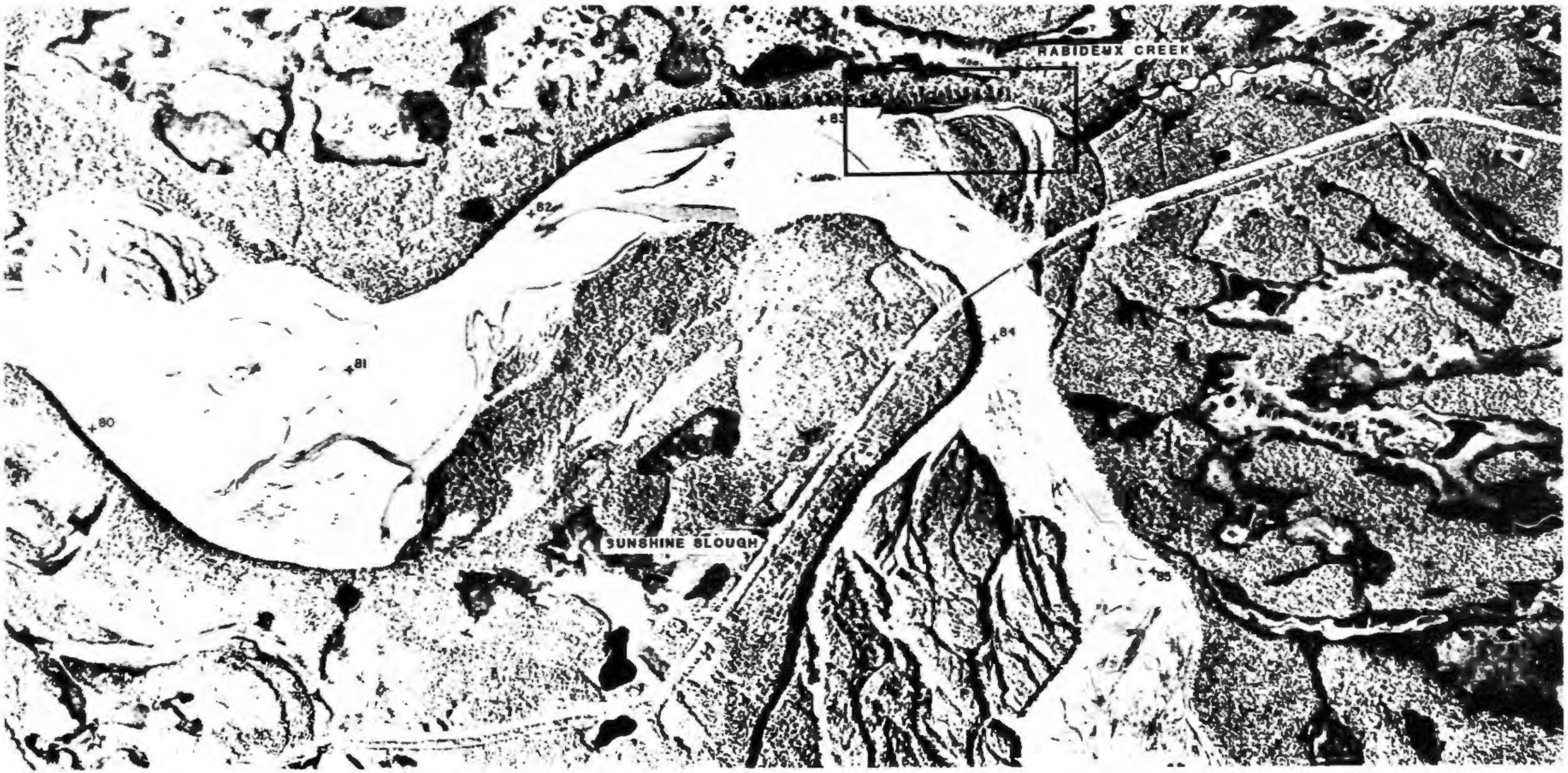
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Rabideux Creek

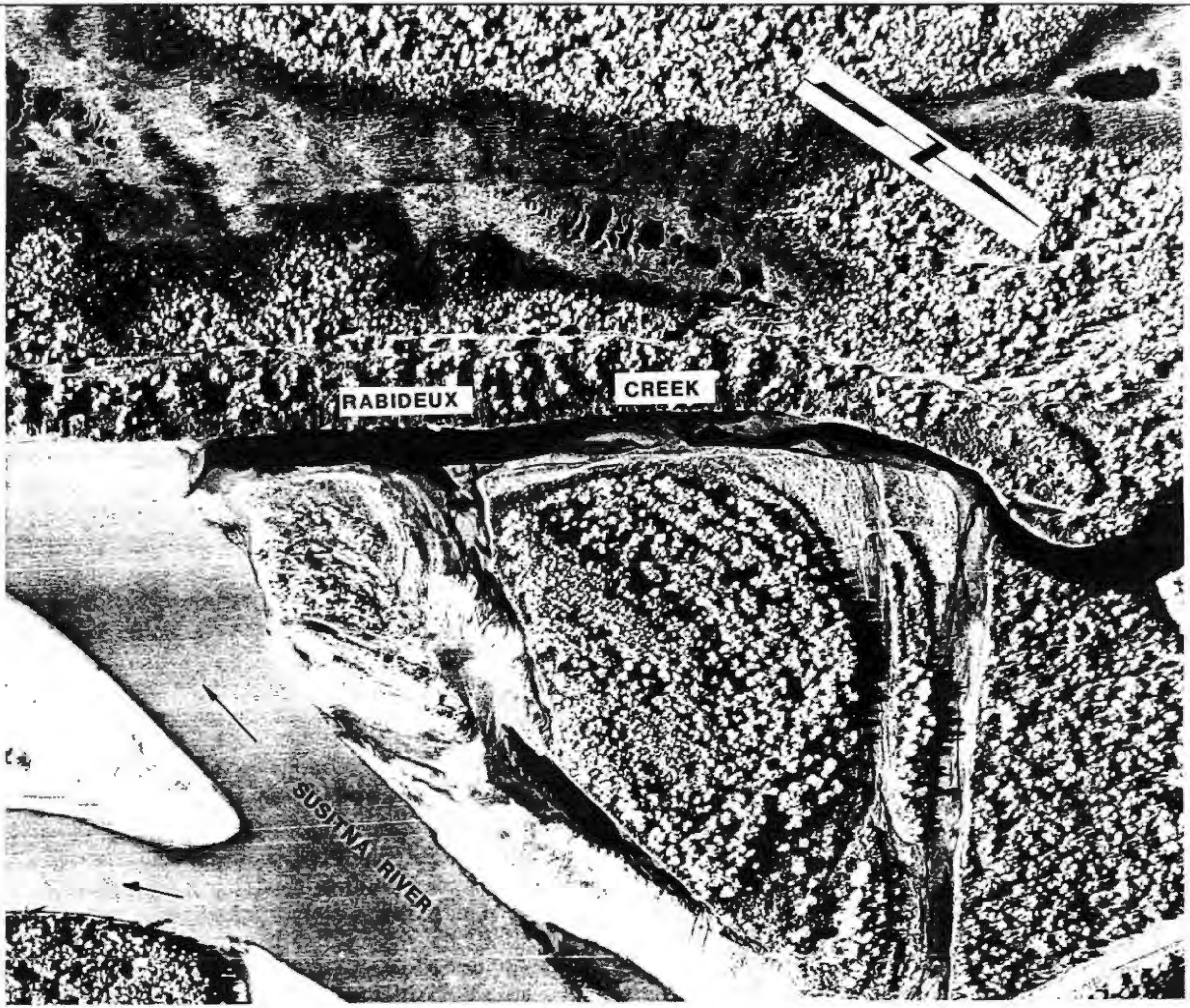
Rabideux Creek originates in the Susitna lowlands and flows southeast to the Susitna River (Figure A-24). The flow regime is similar to the Deshka River (Figures 2.2, 2.3 and 2.4). At 21,100 cfs passage appears feasible. There is one reach that may provide problems. The bar at the mouth changes shape year to year, depending on the high flows from Rabideux Creek (Figure A-25 and Photo A-11). The confluence with the Susitna River has been morphologically stable since 1951. The effect of with-project flows will be limited to reducing the backwater zones and will not affect access or morphologic stability of the tributary mouth. Chinook, sockeye, pink, chum and coho salmon spawn in upstream habitats.

PHOTO A-11

Looking upstream at Rabideux Creek (RM 83.1). The Susitna River mainstem flows from center right to bottom center. Photo taken 8/31/84, discharge at Sunshine 38,000 cfs.



LOWER SUSITNA RIVER	ALASKA POWER AUTHORITY **SUSITNA HYDROELECTRIC PROJECT**
TRIBUTARY ACCESS STUDY **STUDY SITE LOCATION MAP**	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16, 1983 SCALE: 1" = 2000' SHEET: 5 OF [illegible] DATE: 2-7-84
FIGURE A-24	R&M CONSULTANTS, INC. / HARZA-EBASCO SUSITNA JOINT VENTURE



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R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100 cfs

RABIDEUX CREEK

FIGURE A-25

PREPARED FOR:
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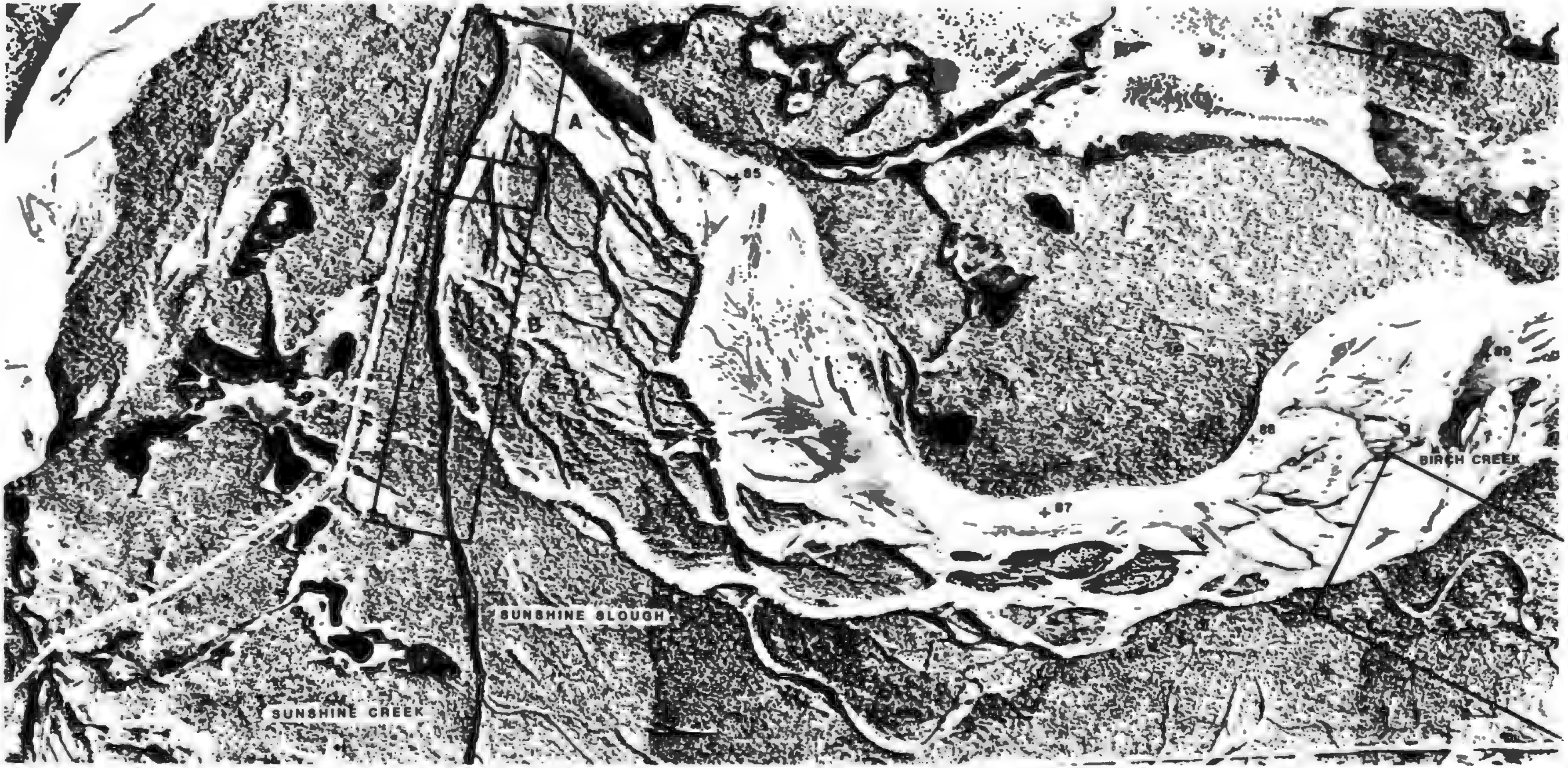
SUSITNA JOINT VENTURE

Sunshine Creek

Sunshine Creek originates in the Susitna River lowlands and flows southwest to the Susitna River (Figure A-26). The affect of the many lakes in the basin is to flatten out the peak flows from rainfall events and to maintain a relatively higher baseflow, as compared to a basin without lakes. At a mainstem flow of 21,100 cfs, the mouth of Sunshine Creek extends down a side channel (from point A to point B, Figure A-27 and A-28) to Sunshine Slough. During the site visit of September 19, 1984, 1.5 feet was the critical maximum depth in the low water channel from the mainstem Susitna River to the mouth of Sunshine Creek. The affect of with-project flows will be to reduce the magnitude of flood flows causing morphologic changes in Sunshine Slough. The slough would tend to become more stable. The extent of the backwater area may be reduced by with-project flows, but this would not affect access conditions. The tributary mouth has been relatively stable since 1951, and should not be affected by with-project flows. Pink and chum salmon were observed spawning just upstream of the tributary mouth during 1984. Chinook, sockeye, pink, chum and coho spawn in the upstream habitats.



LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16,1983 SCALE 1" = 2000' SHEET 4 OF 28 DATE 2-7-84
FIGURE A-26	R&M · HARZA-EBASCO

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DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100 cfs

SUNSHINE CREEK A

FIGURE A-27

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SUSITNA JOINT VENTURE

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DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

SUNSHINE CREEK B

FIGURE A-28

PREPARED FOR:

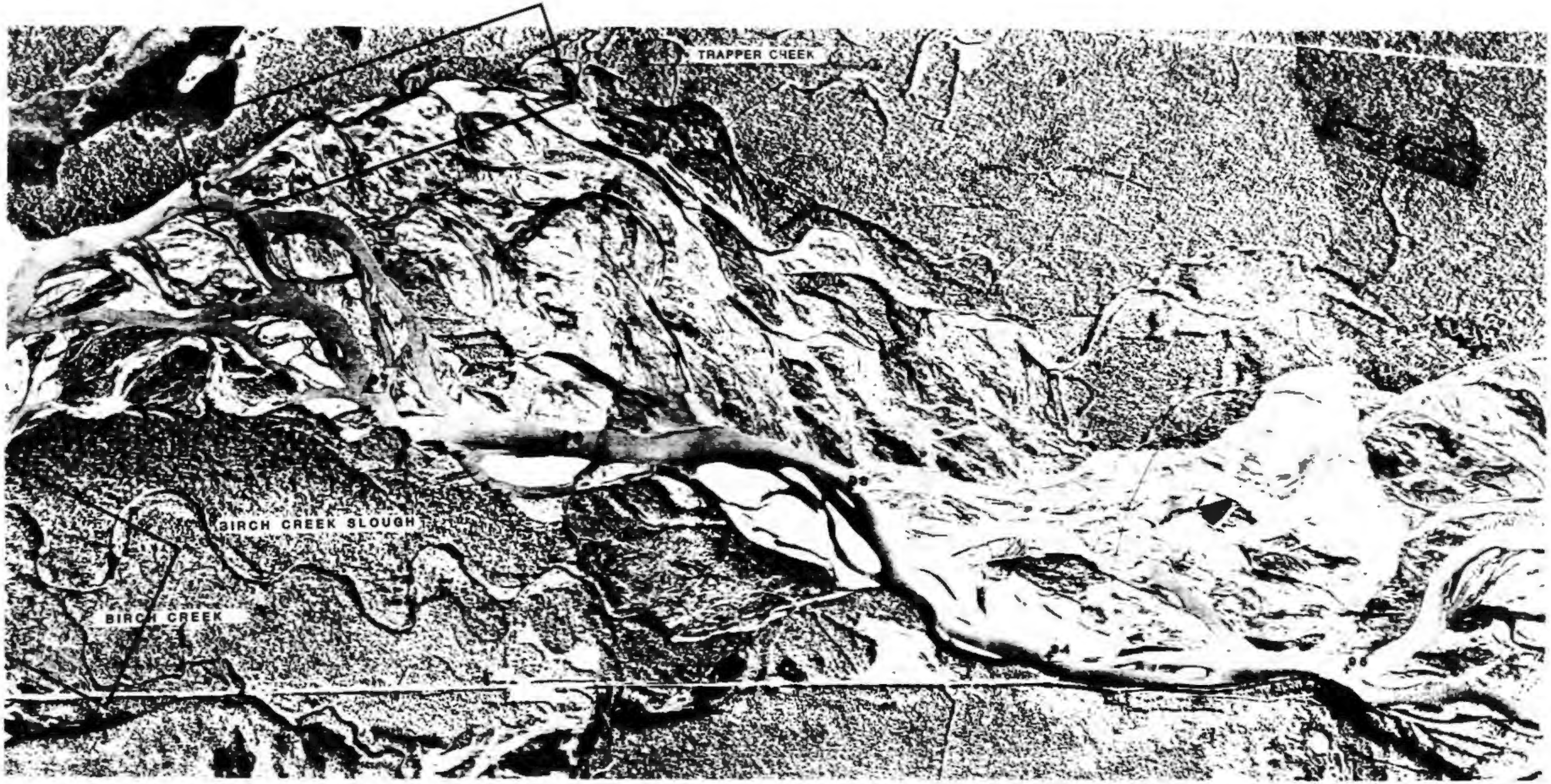
HARZA-EBASCO
SUSITNA JOINT VENTURE

Birch Creek

Birch Creek originates in the Susitna River lowlands and flows southwest to the Susitna River (Figure A-26 and A-29). The affect of the many lakes in the basin, especially Fish Lake, is to flatten out the peak flows from rainfall events and to maintain a relative high baseflow, as compared to a basin without lakes. Birch Creek (Figure A-30) flows into Birch Creek Slough, which flows into one of the mainstem channels (Photo A-12). Birch Creek Slough has sufficient water for fish access at 21,100 cfs. The extent of the backwater area in Birch Creek Slough may be reduced at with-project flows, but this would not affect access conditions. Between 1951 and 1974 an island between the mouth of Birch Creek Slough and the mainstem Susitna has eroded away. Since 1974 the tributary mouth has been relatively stable and should not be affected by with-project flows. Pink salmon were observed spawning near the mouth of Birch Creek and in Birch Creek Slough below the confluence in 1984. Chinook, sockeye, pink, chum and coho salmon spawn in upstream habitats.

PHOTO A-12

Looking upstream with Birch Creek Slough (RM 89.2) flowing from center right to center. Photo taken 9/11/84, discharge at Sunshine 23,600 cfs.



LOWER SUSITNA RIVER TRIBUTARY ACCESS STUDY STUDY SITE LOCATION MAP	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
	LOWER SUSITNA RIVER DATE OF PHOTOGRAPHY SEPT 16, 1983 SCALE 1" = 2000' SHEET 3 OF 28 DATE 2-7-84
FIGURE A-29	R&M / HARZA-EBASCO

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R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

BIRCH CREEK

FIGURE A-30

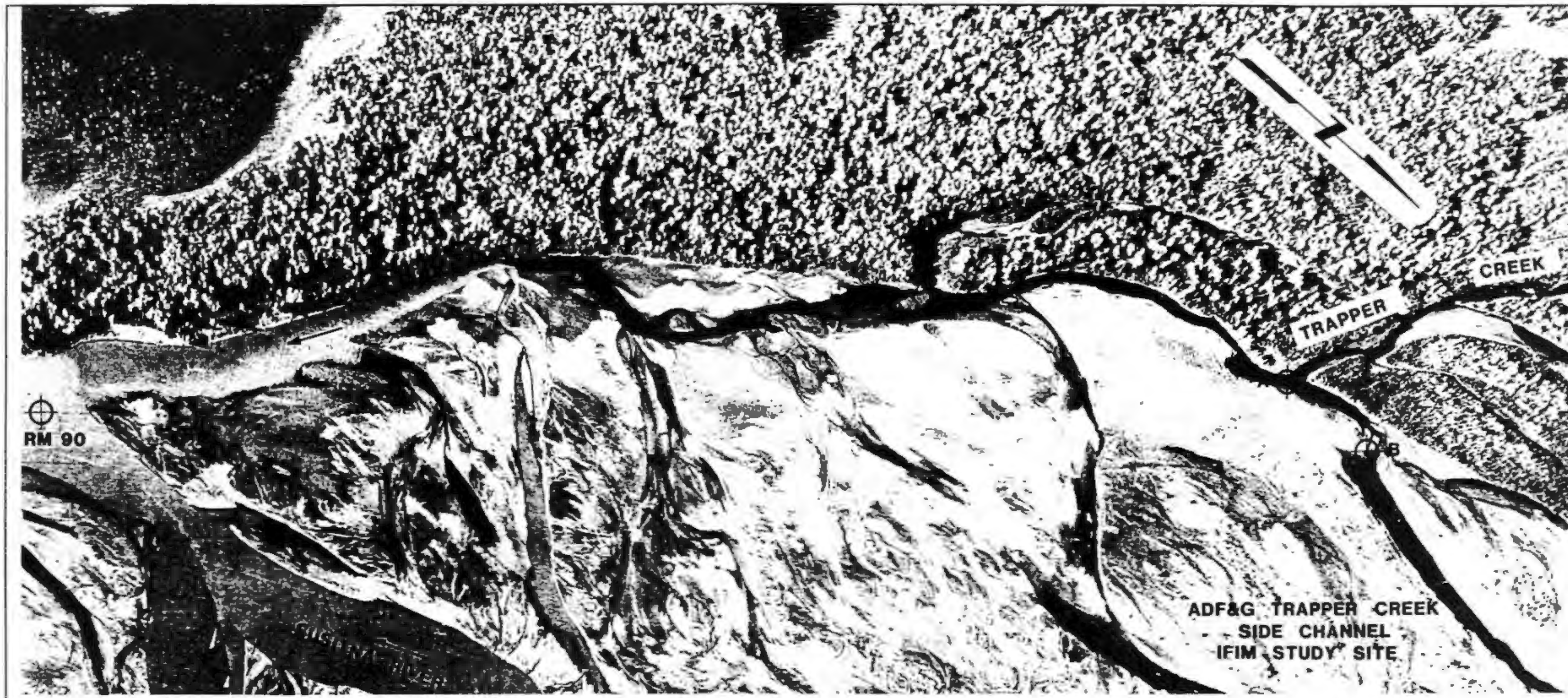
PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

Trapper Creek

Trapper Creek originates in the Susitna lowlands and flows southeast to the Susitna River (Figure A-29). The flow regime is similar to that of the Deshka River, but has a smaller magnitude of flow (Figures 2.2, 2.3 and 2.4). At 21,100 cfs, Trapper Creek extends down a side channel to the mainstem Susitna River. The channel is transitory, with its shape and water depth varying from year to year, depending on the magnitude of the peak flow that year. Photo A-13 shows how the channel changed shape from 1983 to 1984 (Figure A-31). During the field visit of September 18, 1984, the channel shape was different from that shown in the aerial photo. Measured critical maximum depths varied between 0.4 and 0.6 feet. At 21,100 cfs fish were able to access both Trapper Creek and the ADF&G IFIM Trapper Creek study site (Figure A-31). Since 1951 the main channel of the Susitna River has shifted from the west side to the east side of the flood plain, increasing the length of the side channel from the mouth of Trapper Creek to the Susitna River. The effect of with-project flows will be to reduce the magnitude of the flood flows causing morphologic changes in the channel downstream of Trapper Creek. The channel would tend to become relatively more stable and the vegetation may encroach on the channel. The backwater zones will be reduced by with-project flows, but this should not affect access conditions. Pink and chum salmon were observed spawning just upstream of the tributary mouth during 1984. Chinook, sockeye, pink, chum and coho salmon spawn in upstream habitats.

PHOTO A-13

Looking upstream at Trapper Creek Side Channel ADF&G IFIM Study Site, Trapper Creek (RM 91.5) flows from center left to bottom center. Photo taken 8/31/84, discharge at Sunshine 38,000 cfs.



PREPARED BY:
R&M CONSULTANTS, INC.

DATE OF PHOTOGRAPHY: SEPT. 16th, 1983
SCALE: 1" = 500'
DISCHARGE at SUNSHINE: 21,100cfs

TRAPPER CREEK

FIGURE A-31

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SUSITNA JOINT VENTURE