SUSITNA
HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

RESPONSE OF AQUATIC HABITAT SURFACE AREAS TO MAINSTEM DISCHARGE IN THE YENTNA RIVER CONFLUENCE TO TALKEETNA REACH OF THE SUSITNA RIVER

PREPARED BY

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

EWT&A

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

DRAFT REPORT
APRIL 1985
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SUSITNA HYDROELECTRIC PROJECT

RESPONSE OF AQUATIC HABITAT SURFACE AREAS TO MAINSTEM DISCHARGE IN THE YENTNA RIVER CONFLUENCE TO TALKEETNA REACH OF THE SUSITNA RIVER

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Under Contract To:

Harza-Ebasco Susitna Joint Venture

Prepared For:

Alaska Power Authority

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This study was conducted under contract to Harza-Ebasco Susitna Joint Venture. Funding was provided by the Alaska Power Authority in conjunction with environmental impact assessment studies for the proposed Susitna Hydroelectric Project.

The aerial photographs were taken by Air Photo Tech with photograph printing and enlargements by North Pacific Aerial Surveys. Bill Ashton, Sharon Klinger-Kingsley and Steve Bredthauer did the field checking of the habitat type designations. Jack Bolke, Rick Bennett and Len Story digitized the wetted surface areas and Debbie Stephens assisted in data analysis. Steve Bredthauer, Woody Trihey and Carl Schoch provided many useful review comments. Orlando Paraoan and Mark Cordery drafted the figures and Barb Estus typed the report.

1.0 INTRODUCTION

The proposed Susitna Hydroelectric Project will alter the natural streamflow regimes of the Susitna River. In general, with-project flows will be lower than natural flows during the summer and higher during the winter. These altered flows will affect the amount and seasonal availability of aquatic habitats present in the river.

This report presents the results of three studies which examined the response of wetted surface areas to changes in mainstem discharge in the Yentna River Confluence to Talkeetna reach of the Susitna River (River Mile (RM) 28.5 to River Mile 98) (hereafter referred to as the lower river). The three studies were: 1) to define similar morphologic segments and assess the change in wetted surface area of the lower river (RM 28.5 to RM 98) in response to change in flow; 2) identification, mapping, and surface area determination of aquatic habitat types in selected study areas in the lower river and evaluating the surface area response to discharge for these habitat types; and 3) an evaluation of the morphologic stability of islands and side channels in the study areas using aerial photography taken during the period 1951 to 1983. The scope of this study is to present the results of the three subjects described above for natural flow conditions. Subsequent reports will detail the effects of the with-project flow regime on these three subjects.

Previous work on the Susitna River has used aerial photography for aquatic habitat analysis. Klinger and Trihey (1984) measured wetted surface areas of aquatic habitat types in the Susitna River between Talkeetna and Devil Canyon (RM 98 to RM 149) and evaluated changes in wetted surface area as a response to mainstem discharge. Their study provided background and served as basis from which sections of this particular study were developed. The work of Klinger and Trihey (1984) has shown that repeatable, visual identification of the wetted surface areas associated with different aquatic habitat types can be made by various observers. Secondly, it was shown that accurate surface area measurements can be obtained by digitizing the aerial photography. The ability to achieve both these goals is essential for the successful completion of a study such as the present one. To adequately interpret the result of surface area measurements, an evaluation must be made of the relative stability of channels and islands in the study area. For this reason, the morphologic assessment was performed.

five = Intro

This report consists of four sections. Section 2 describes the wetted surface area response to discharge for the entire lower river between Talkeetna and the Yentna River confluence. Section 3 presents results of delineating aquatic habitat types and measuring their surface area response to discharge in selected representative areas. Section 4 addresses the relative stability of the channels and islands in the selected representative areas. The results of this evaluation will provide some limits within which the surface area response data can be interpreted and will indicate to what extent extrapolations can be made from them. Section 5 combines the results and discusses their applicability to the lower river. All mainstem flows referenced in this report are based on the U.S. Geological Survey streamflow gage at Sunshine (No. 15292780).

2.0 MORPHOLOGICAL CLASSIFICATION AND WETTED SURFACE AREA DETERMINATION

2.1 Lower River Segments

The purpose of this study was to provide an initial estimate of changes in wetted surface area in response to changes in discharge in the lower Susitna River. The lower river was divided into 5 segments based on river morphology and hydrology (Figure 2.1). The segments are described below and are delinated on photographs in Exhibit A.

Explain a little more

Segment I: RM 98.5 to RM 78

This segment extends from the Chulitna River confluence downstream to the head of the side channel complex just upstream of Montana Creek. The river is braided, with the main channel meandering through a wide gravel floodplain. Large expanses of gravel bars are exposed at low flows. The channel is constricted to a single channel at the Parks Highway Bridge (RM 83.8). Significant tributaries in this segment include Birch Creek, Trapper Creek, Sunshine Creek, and Rabideux Creek. A total of six side channel complexes were identified.

Segment II: RM 78 to RM 51

This segment extends from the side channel above Montana Creek to the head of Delta Islands where the river splits into two main channels. The morphology in segment II is complex, with a total of 9 side channel complexes along the floodplain margin, and two additional side channel complexes located within mid-channel islands. Significant tributaries in this segment include Montana Creek, Goose Creek, Sheep Creek, Caswell Creek and the Kashwitna River.

Segment III: RM 51 to RM 42.5

This segment encompasses the Delta Islands reach where two main channels exist, one on the east and one on the west. A total of five side channel complexes exist in this segment, with a major complex between the two main channels. The segment ends where the two main channels rejoin. Significant tributaries in this segment include Little Willow Creek and Willow Creek.

Segment IV: RM 42.5 to RM 28.5

This segment extends from the lower end of the Delta Islands to the confluence with the Yentna River. The reach is characterized by a braided pattern, with seven side channel complexes. The Deshka River enters the upper end of this reach. Kroto Slough branches off from this segment, and extends to the Yentna River.

Segment V: RM 28.5 to RM 0

This segment extends from the Yentna River, which contributes approximately 40 percent of the total flow of the Susitna River, to Cook Inlet. The segment is primarily a split-channel configuration down to RM 19, the head of Alexander Slough. The Susitna River has two channels from RM 19 to Cook Inlet, with the main channel on the east side. The west channel is primarily an overflow channel. Its upper section dewaters at low flow, while the lower segment is fed by Alexander Creek. Other tributaries entering this segment include Anderson Creek and Fish Creek.

2.2 Morphological Classifications

Two main morphological classifications were identified within the segments, with subclassifications recognized for purpose of future discussion but were not differentiated in this analysis.

What are the sub classifications referred to?

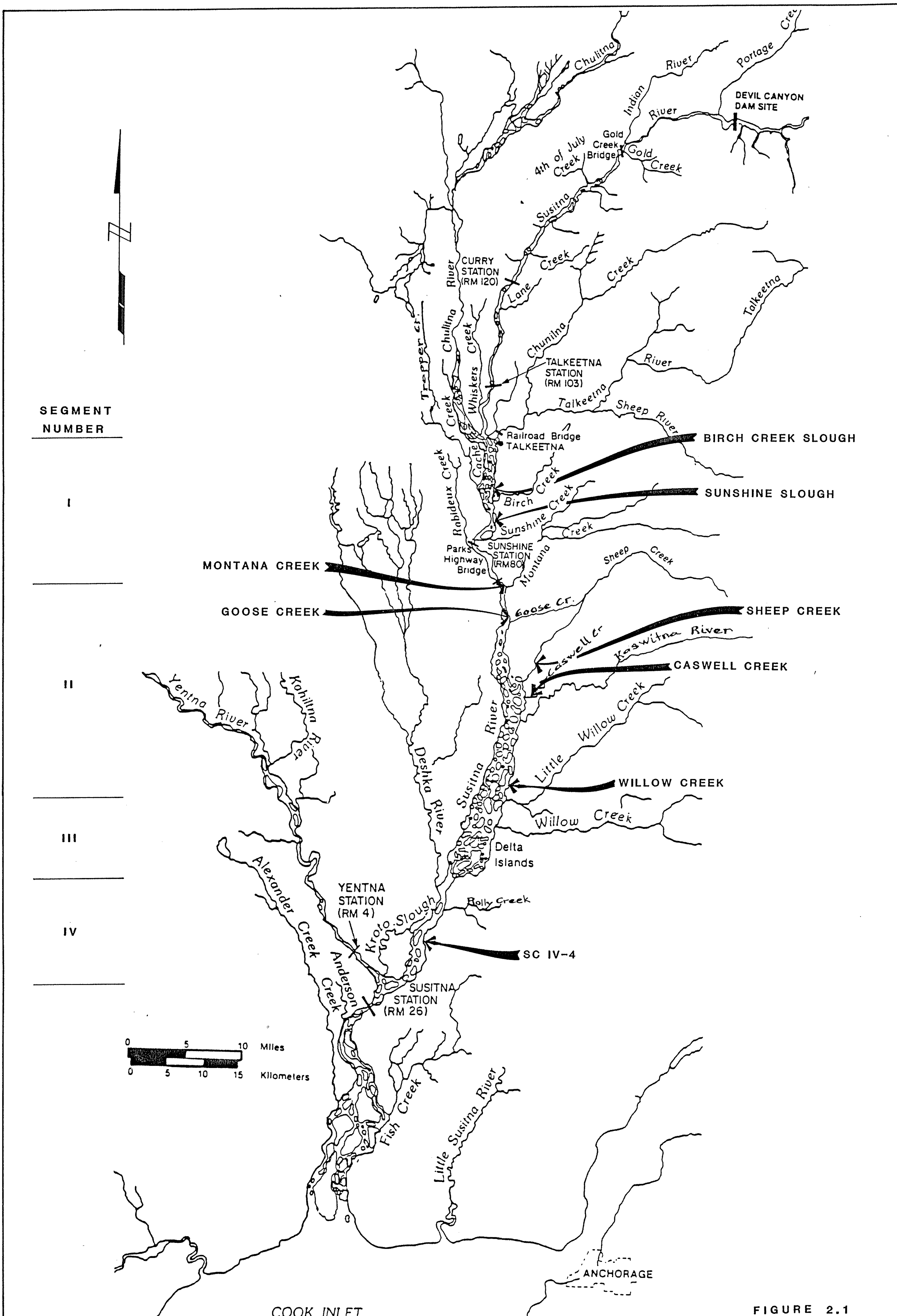

FIGURE 2.1

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STUDY SITE LOCATION MAP

LOWER SUSITNA RIVER

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X - Breached
- Not breached
O - Possible

	Minor	Intermed	Major
75,000	X	X	X
59,100	-	X	X
36,600	-	O	X
21,000	-	O	X
13,900	-	-	X

Could have two other classification

Mainstem Channel is that portion of the river floodplain between the vegetated boundaries, including the wide gravel floodplain and isolated vegetated islands in mid-channel. Two subclassifications are:

1. Mainstem river - the thalweg channel and main subchannels.

2. Alluvial island complexes - areas of broad gravel islands with numerous subchannels which dewater as flow decreases.

Side Channel Complexes consist of one or more channels flowing among a group of vegetated islands. These complexes are usually located along the edge of the mainstem river, but in areas such as the Delta Islands may occur in the middle of the river. Channels within the side channel complexes are classified within one of these groups. These groups are differentiated by the presence or absence of overtopping flow in the photography used in this analysis (see Section 2.3). Once a classification is determined for a channel, the channel will have that classification throughout the range of mainstem flows. This classification is based solely on overtopping flows and does not consider potential habitat characteristics of the channel.

1. Major side channels are overtopped at mainstem flows of 13,900 cfs and lower and may dewater at their upstream berms just prior to freezeup or maintain flow throughout the winter. Major side channels tend to be, but are not limited to, the outside-most channel of a complex, closest to the edge of the floodplain. These channels may collect groundwater seepage and tributary flow.

How are channels breaching between 13,900 & 21,100 cfs. classified?

2. Intermediate side channels dewater at their upstream berm in the mainstem flow range of 21,100 cfs to 59,100 cfs. After their upstream berm dewaters, some intermediate channels maintain turbid water to a mainstem flow of 21,100 cfs or less, while the turbid water of others is dissipated by groundwater and/or surface water inflow. Other intermediate side channels dewater the complete length of the channel before the mainstem flow decreases to 21,100 cfs. Intermediate side channels may be extensions of tributaries once their upper berms dewater.

3. Minor side channels dewater at their upstream berm at mainstem flows above 59,100 cfs and tend to ~~be dewatered the complete length of the channel~~ dry up completely at mainstem flows of 36,600 cfs.

2.3 Photography

Black and white aerial photography at a scale of 1" = 2,000' was obtained of the lower Susitna River at five mainstem discharges (Table 2.1).

TABLE 2.1. DATES AND DISCHARGE AT WHICH AERIAL PHOTOGRAPHY WAS OBTAINED

Date	Discharge at Sunshine	Remarks
8-27-84	75,200 cfs	Typical July-August natural flow
8-27-83	59,100 cfs	Typical July-August flow during project operation.
9-6-83	36,600 cfs	Transitional natural flow and project operation flow during May and September.
9-16-83	21,100 cfs	High winter flow during project operation.
10-25-83	13,900 cfs	Low winter flow during project operation.

Photo mosaics were prepared from each set of photography for river Segments 1 through 4. Segment 5 was not included due to inflow from the Yentna River and tidal influences which were assumed to mask changes in habitat surface areas due to projection operation.

Boundaries of each subsegment (mainstem or side channel complex) were defined. Each island and gravel bar was numbered and its boundary delineated. The total area of the segment was determined. Areas of islands and gravel bars were subtracted from the total area to obtain wetted surface area of the subsegment. Channels which extended through an island complex were delineated. Backwater areas were also included, but isolated pockets of water left when the water level dropped were not digitized, as these areas were not considered usable habitat.

Surface areas were digitized using a HP-9845 computer. Individual measurements were replicated 2-4 times and the average value used. All measurements were adjusted for a common scale due to minor scale differences between flights. The September 16, 1983 set of photography was used as the base and all measurements adjusted to match that scale.

2.4 Results

Segment I

The response of the wetted surface area in SC I-5 to mainstem discharge is indicative of a side channel complex with a mix of major, intermediate, and minor side channels (Figure 2.2 and Table 2.2). The rate of decrease in wetted surface area increases with decreasing mainstem discharge. SC I-4, a side channel complex with few intermediate and minor side channels and no major side channels, has a slight change in wetted surface area with decreasing mainstem discharge (Figure 2.2). For SC I-1 and SC I-2 the slight rise in wetted surface area at 13,900 cfs is due to the problem of delinating the edge of water with the ice cover in the photographs.

Segment II

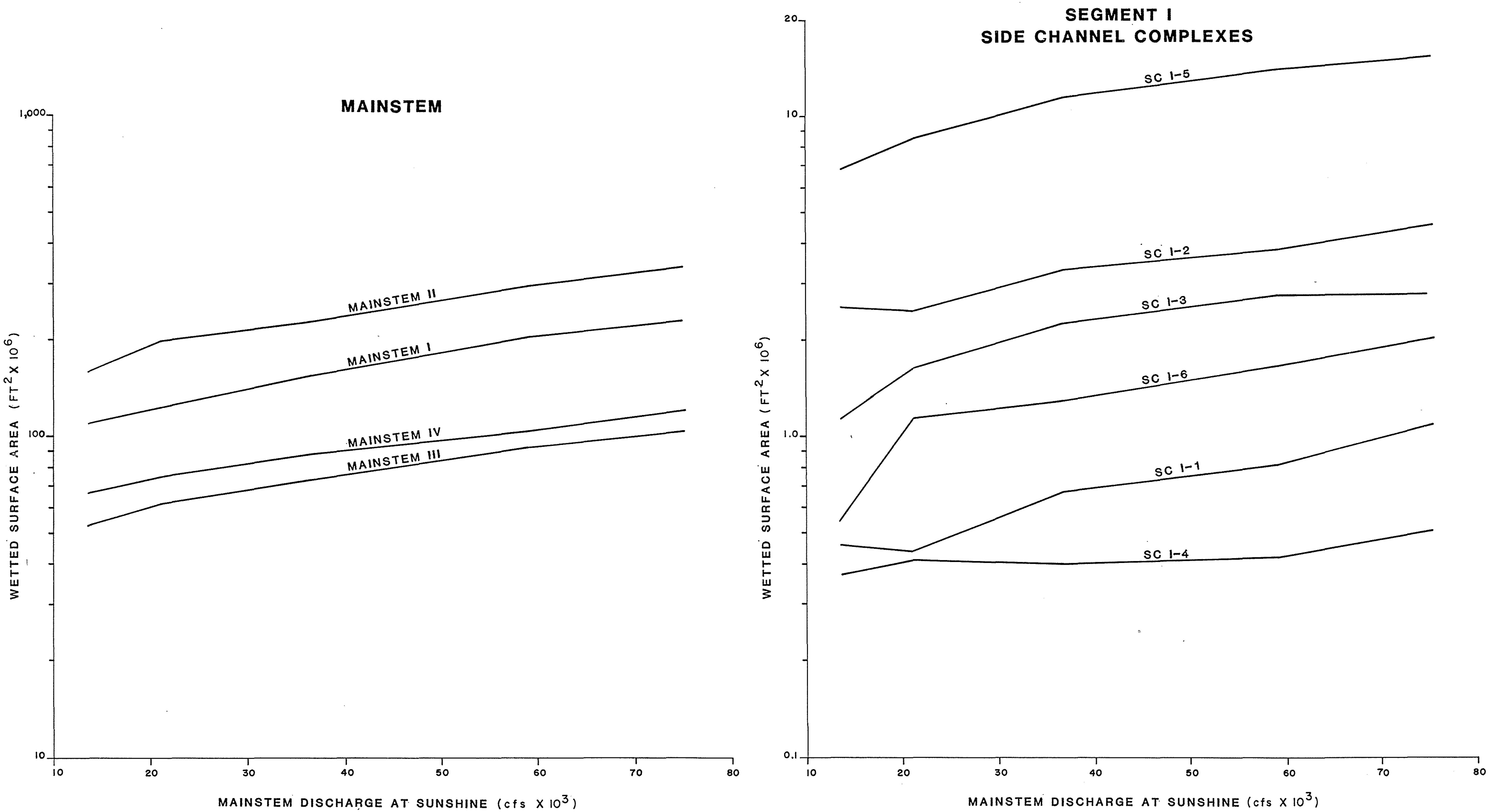
SC II-6 is a large side channel complex with many minor and intermediate channels (Figure 2.3). The sharp drop in wetted surface area at 21,100 cfs is due to dewatering of many intermediate channels. SC II-1 shows the wetted surface area response of a side channel complex with no major channels and a few intermediate channels. SC II-9 consists of intermediate channels which rapidly dewater at mainstem discharges below 59,100 cfs (Figure 2.3). At SC II-8 the wetted surface area at 75,200 cfs and 59,100 cfs are approximately equal, but due to slight local scale changes in the air photos the wetted surface ara at 59,200 cfs digitized slighty larger.

Segment III

SC III-2 has many minor and intermediate channels. The rate at which intermediate channels are dewatering increases below 36,600 cfs, indicated by the increased slope of the wetted surface area response curve (Figure 2.4). In contrast, the rate at which intermediate channels dewater in SC III-5 is greater between 59,100 cfs and 36,600 cfs than between 36,600 cfs and 21,100 cfs (Figure 2.4). This is probably due to the wider shallower channels of SC III-5.

Segment IV

SC IV-5 and SC IV-7 are side channel complexes with one intermediate side channel and no major or minor side channels (Figure 2.4). SC IV-1 and SC IV-2 are side channel complexes with many minor and intermediate side channels and no major side channels. The slope of the wetted surface area response curve is steeper because the channels in SC IV-1 and SC IV-2 are generally wide and shallow whereas the channels in SC IV-5 and SC IV-7 are generally deep and narrow.



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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: MAINSTEM AND SEGMENT I SIDE CHANNEL COMPLEXES

FIGURE 2.2

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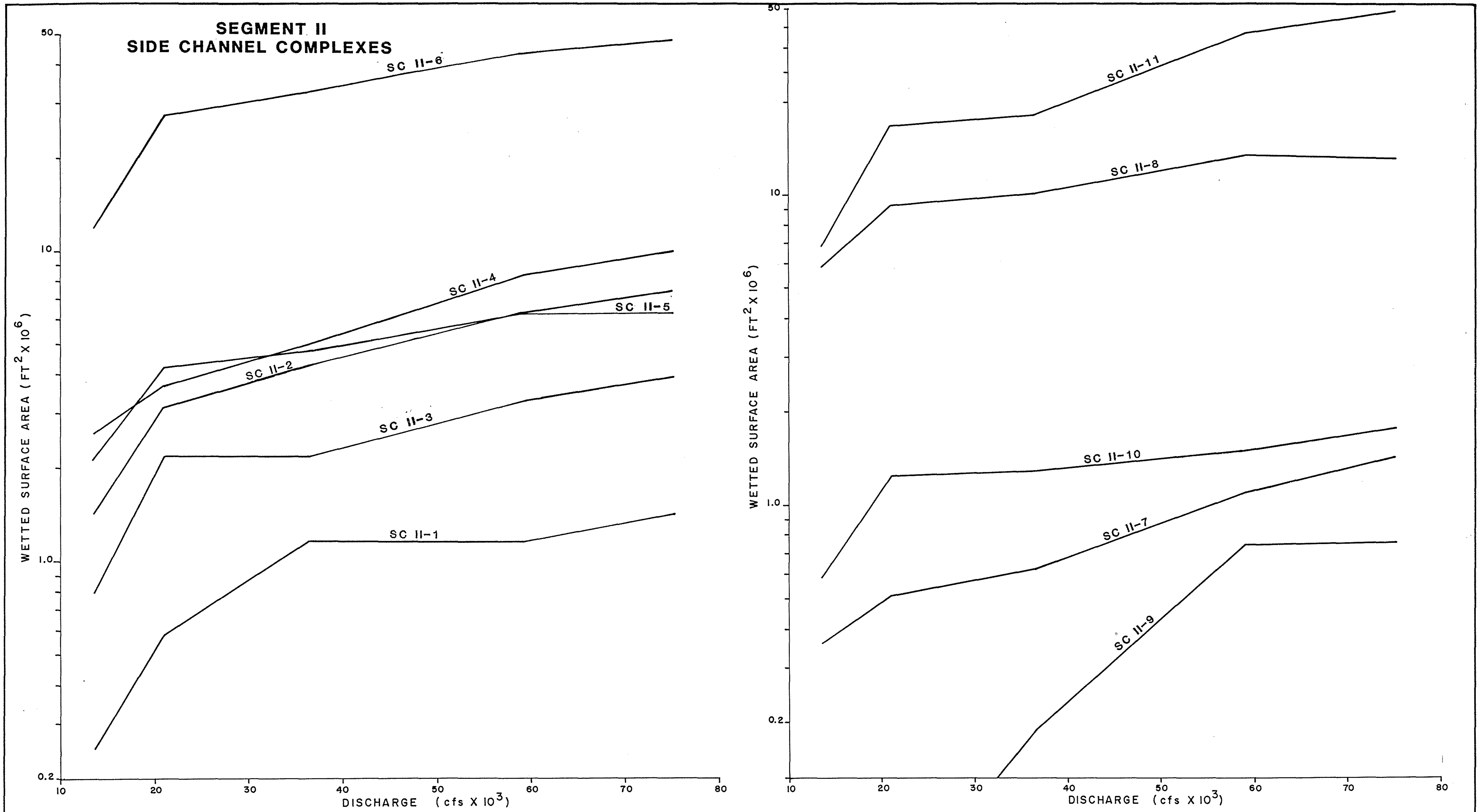
TABLE 2.2. CHANGES IN WETTED SURFACE AREA WITH FLOW IN THE YENTNA RIVER CONFLUENCE TO TALKEETNA REACH OF THE SUSITNA RIVER

Date	8-27-84		8-27-83		9-6-83		9-16-83		10-25-83	
Flow(cfs) @ Sunshine	75,200		59,100		36,600		21,100		13,900	
Subsegment	WSA[1] (10^6 sq ft)	Percent of Subsegment Area[2]	WSA (10^6 sq ft)	Percent of Subsegment Area	WSA (10^6 sq ft)	Percent of Subsegment Area	WSA (10^6 sq ft)	Percent of Subsegment Area	WSA (10^6 sq ft)	Percent of Subsegment Area
Mainstem I	230	70.6	203	62.8	156	48.2	123	38.1	110	34.1
SC I-1[3]	1.10	23.6	0.82	17.3	0.67	14.1	0.44	9.3	0.46	9.8
SC I-2	4.66	14.4	3.83	11.8	3.31	10.2	2.47	7.6	2.52	7.8
SC I-3	2.84	41.0	2.76	40.0	2.27	32.9	1.63	23.6	1.14	16.6
SC I-4	0.51	36.8	0.42	30.2	0.40	28.6	0.41	29.9	0.37	26.5
SC I-5	15.6	29.7	14	26.7	11.5	21.9	8.47	16.2	6.84	13.0
SC I-6	2.06	25.9	1.67	20.9	1.29	16.2	1.14	14.3	0.55	6.9
Total SC I	28.2	26.6	23.5	22.2	19.4	18.3	14.6	13.8	11.9	11.2
Mainstem II	339	63.4	292	64.2	229	50.3	199	43.8	160	35.2
SC II-1	1.41	13.5	1.16	11.2	1.16	11.2	0.58	5.6	0.25	2.4
SC II-2	7.42	25.6	6.33	21.8	4.27	14.7	3.12	10.8	1.41	4.9
SC II-3	3.90	27.5	3.20	22.5	2.38	16.8	2.39	16.8	0.79	5.5
SC II-4	9.95	17.6	8.34	15.5	4.97	8.5	3.69	6.5	2.59	4.6
SC II-5	6.24	31.7	6.22	39.7	4.77	28.0	4.20	24.6	2.13	12.5
SC II-6	42.6	27.3	42.8	27.4	32.1	20.5	27.1	17.3	11.9	7.6
SC II-7	1.46	23.6	1.10	17.8	0.63	10.2	0.51	8.2	0.36	5.8
SC II-8	13.1	24.1	13.5	24.9	10.1	18.7	9.25	17.0	5.88	10.8
SC II-9	0.76	11.5	0.74	11.3	0.19	3.0	0.00	0.0	0.00	0.0
SC II-10	1.79	38.6	1.50	32.5	1.29	27.9	1.25	27.0	0.59	12.8
SC II-11	39.5	18.7	33.1	15.7	18.1	8.6	16.8	7.9	6.84	3.2
Total SC II	128	22.5	123	21.7	78.5	13.9	68.9	12.2	32.7	5.8
Mainstem III	103	79.3	91.9	70.7	74.7	57.5	61.9	47.7	52.4	40.3
SC III-1 (3)	11.8	29.2	11.4	28.1	10.4	25.6	7.54	18.6	6.28	15.5
SC III-2	16.0	20.8	14.1	17.9	11.5	14.6	6.91	8.8	4.59	5.8
SC III-3	47.8	16.5	46.3	16.0	38.2	13.2	27.6	9.5	26.6	9.2
SC III-4	7.18	31.6	7.23	31.8	5.34	23.5	3.87	17.0	3.11	13.7
SC III-5	1.75	21.2	1.34	16.5	0.57	6.9	0.47	5.7	0.33	4.0
Total SC III	84.5	19.2	81.8	18.6	66.0	15.0	46.4	10.5	40.9	9.3
Mainstem IV	120	82.0	103	69.8	87.5	59.5	75.0	51.1	66.3	45.2
SC IV-1	4.15	22.4	2.94	15.8	1.52	8.2	1.05	5.6	0.62	3.3
SC IV-2	2.98	41.7	2.32	32.5	1.72	24.1	1.31	18.3	0.53	7.4
SC IV-3	12.9	23.2	12.6	22.6	10.5	18.9	8.16	14.7	5.84	10.5
SC IV-4	9.25	29.2	8.08	25.5	6.64	20.9	4.76	15.0	2.80	8.8
SC IV-5	0.86	28.6	0.82	27.1	0.74	24.4	0.38	12.4	0.13	4.4
SC IV-6	30.4	35.7	26.8	31.5	22.0	25.9	17.2	20.2	12.2	14.4
SC IV-7	0.77	29.2	0.77	29.1	0.66	25.2	0.36	13.7	0.14	5.4
Total SC IV	61.3	30.2	54.3	26.7	43.8	21.5	33.2	16.3	22.3	10.9



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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: SEGMENT II SIDE CHANNEL COMPLEXES

FIGURE 2.3

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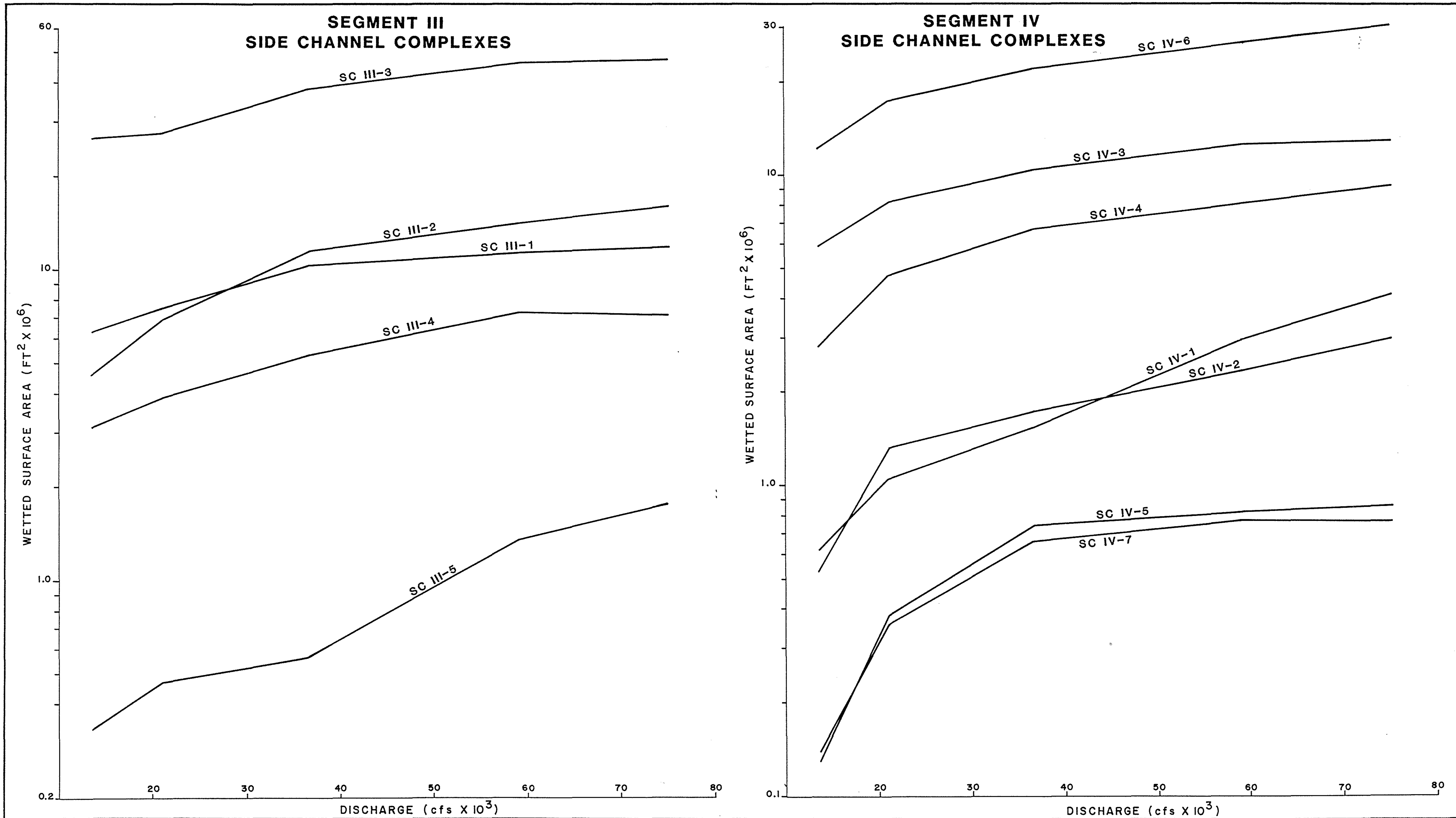

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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: SEGMENT III AND IV SIDE CHANNEL COMPLEXES

FIGURE 2.4

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2.5 Discussion

The response of wetted surface area to discharge for side channel complexes is generally indicative of the mix of major, intermediate and minor side channels within a specific side channel complex and the cross-sectional shape of those side channels. For example, when the mainstem discharge decreases from 75,200 cfs to 59,100 cfs side channel complexes with relatively few minor side channels and relatively deep narrow intermediate side channels have little or no decrease in wetted surface area. As the mainstem discharge decreases from 59,100 cfs to 21,100 cfs the rate of decrease in wetted surface area, as indicated by the slope of the wetted surface area response curves in Figures 2.2 through 2.4, indicates the mix of intermediate and major side channels and their cross-sectional shape. For example, side channel complexes with wide shallow intermediate side channels will have a steeper sloping line in Figures 2.2 through 2.4 than will a side channel complex with predominately narrow deep channels.

As the mainstem discharge decreases to 13,900 cfs intermediate channels have dewatered completely or are substantially smaller than at 21,100 cfs. The wetted surface area at 13,900 cfs was difficult to digitize because the aerial photographs were taken after ice had covered low velocity areas. Therefore the wetted surface area for the 13,900 cfs aerial photography is probably underestimated for most side channels and overestimated for a few side channels.

3.0 HABITAT DELINEATION AND SURFACE AREA MEASUREMENTS FOR SELECTED STUDY AREAS

3.1 Study Sites

The lower Susitna River encompasses an extensive area of braided channels and islands. Rather than mapping and digitizing the total wetted surface area of the lower river as done for the middle river (Klinger & Trihey, 1984), representative areas were chosen in the lower river for which habitat types would be mapped and wetted surface areas measured (Figure 2.1). Eight representative areas were selected which exhibited the different morphologic patterns and contained the various types of aquatic habitat present in the lower river (Table 3.1).

TABLE 3.1. REPRESENTATIVE AREAS FOR THE LOWER SUSITNA RIVER

Area Name	Inclusive River Miles
SC IV-4	32.5 - 36.0
Willow Creek (SC III-1)	49.0 - 52.0
Caswell Creek	64.0
Sheep Creek	66.1
Goose Creek (SC II-4)	68.5 - 72.5
Montana Creek & SC II-1	77.0 - 78.0
Sunshine Slough (SC I-5)	84.0 - 86.5
Birch Creek Slough	88.5 - 93.0

SC IV-4

Side channel complex SC IV-4 is located between approximately RM 32.5 and RM 36 on the east bank of the Susitna River. This representative area has two major side channels that remain breached at mainstem discharges as low as 13,900 cfs. One intermediate side channel is no longer breached between 21,100 and 13,900 cfs. Several smaller intermediate and minor side channels exist. Most become dewatered as mainstem discharge drops from 59,100 to 21,100 cfs.

Willow Creek (SC III-1)

SC III-1 extends from RM 49 to RM 52. Willow Creek enters the side channel complex at approximately RM 49, while Little Willow Creek enters at RM 50.5. This representative area has one main major side channel flowing through the upper two-thirds of the complex with a major side channel branching off and continuing through the rest of the complex. Several intermediate side channels exist. Little Willow Creek flows into an intermediate channel which has clear tributary water as mainstem stage decreases and/or tributary flow increases.

Caswell Creek

Caswell Creek is a tributary entering a side channel of the Susitna River at approximately RM 64. The upstream end of this side channel is dewatered at mainstem discharges below 37,000 cfs. When this occurs the tributary mouth extends approximately 800 feet downstream.

Sheep Creek

Sheep Creek is a tributary entering a side channel of the Susitna River at RM 66.1. Backwater effects due to side channel stage range from no effect at low mainstem discharges (13,900 cfs), to a backwater zone of approximately 5,000 feet at a mainstem discharge of 52,000 cfs.

Goose Creek (SC II-4)

Goose Creek Side Channel, located between RM 68.5 and RM 72.5, is a large side channel complex. The complex has one main intermediate side channel and numerous smaller intermediate and minor side channels. Goose Creek enters the main intermediate side channel of the side channel complex at approximately RM 72.

Montana Creek (SC II-1)

SC II-1 extends from RM 77 to RM 78 with Montana Creek entering SC II-1 at its downstream extent. SC II-1 is a relatively small side channel complex with one main intermediate side channel and several smaller intermediate and minor side channels. Montana Creek has a relatively steep gradient resulting in no backwater area until mainstem flows increases to approximately 38,000 cfs.

Sunshine Slough (SC I-5)

Sunshine Side Channel complex is located between RM 84 and RM 86.5 on the east bank of the Susitna River. The side channel complex consists of one major side channel, two main intermediate side channels and several smaller intermediate and minor side channels. Only the major channel conveys water throughout the flow range investigated. The other channels become side sloughs, contain isolated ponded water, or dewater completely at 13,900 cfs. Sunshine Creek flows into the major side channel at a point approximately 8,000 feet upstream from the point where the side channel adjoins the mainstem Susitna.

Birch Creek Slough

Birch Creek Slough is a single channel extending from approximately RM 88.5 to RM 93 on the east bank of the Susitna River. Birch Creek enters the side channel at a point slightly less than a mile upstream from its juncture with the Susitna. Birch Creek Slough was chosen as a study site to be representative of single channel sites in the river.

3.2 Habitat Type Designations

Aquatic habitats associated with the lower Susitna River were classified into eight general categories: mainstem, primary side channel, secondary side channel, turbid backwater, clearwater, side slough, tributary mouth, and tributary. These categories represent physical characteristics of the habitat type visually discernable from aerial reconnaissance or examination of aerial photography. As such these do not necessarily convey any specific biological significance nor do they indicate specific geographical locations. In some instances, transformation of one habitat type into another may occur as river stage increases or decreases.

Characteristics used to delineate the eight aquatic habitat types are described below. These descriptions represent physical attributes of the habitat type during ice-free conditions. These physical attributes are visually recognizable during helicopter reconnaissance flights.

Mainstem habitats represent the mainstem river, consisting of the thalweg channel, major subchannels and alluvial island complexes. This habitat type was, in most cases, outside the boundaries of the control areas used to define representative areas.

Primary side channel habitats are those channels which normally convey streamflow throughout the entire year. They exhibit characteristics similar to middle Susitna River mainstem habitat types, as described by Klinger and Trihey (1984). They are characterized by turbid glacial water, high velocities, and few mid-channel gravel bars.

Secondary side channel habitats also have turbid water, but exhibit characteristics of the middle river side channels. For example, there are mid-channel gravel bars and riffles or water surface features that indicate slower-moving, shallower water.

Like ?

Can these be related back to definitions on page 4?

Turbid backwater habitats are non-breached channels containing turbid water. They have non-vegetated upper thalwegs that are overtopped during periods of moderate to high mainstem discharge. They represent a transitional habitat type between breached secondary side channel habitats and non-breached clearwater or side slough habitats. Because of their large size with respect to the locally available supply of clear water, considerable time is required for these areas to become clearwater habitats after the upstream berm dewaters. Some channels may dewater completely without becoming ~~transitioning to~~ clearwater habitat.

Are these areas backwater?

Clearwater areas are non-breached channels containing clear water which dewater completely at a mainstem discharge of 13,900 cfs or higher. These channels have non-vegetated upper thalwegs that are overtopped during periods of moderate to high mainstem discharge. Upwelling and local surface runoff appear to supply water to these areas at mainstem flows above 13,900 cfs. At 13,900 cfs and lower these areas are dewatered.

Side slough habitats contain clear water. Upwelling and local surface runoff appear to supply sufficient clear water to these areas to maintain wetted areas at a mainstem discharge of 13,900 cfs. Side sloughs also have non-vegetated upper thalwegs that are overtopped at moderate to high mainstem discharges.

Tributary mouth habitats are clear water habitats that exist between the downstream extent of a clear-water plume and upstream into the tributary, to the upper extent of the backwater influence. The surface area depends on the discharge of both the tributary and mainstem.

Tributary habitat exists upstream of the tributary mouth habitat. In this analysis, tributary habitat was measured only to the boundary of the digitized photo enlargement. Tributary habitat may increase dramatically when the tributary flows into a non-breached side channel and the clear tributary flows through the side channel to join the Susitna River.

At Willow Creek sidechannel, a very small side channel was flowing in to tributary mouth.

Non-wetted areas were classified as gravel bars or vegetated islands. Wetted areas that were not contiguous and connected to a side channel or mainstem were considered "ponded water" and their surface area was incuded in the mesurement of gravel bars. Areas which were within the river corridor but were not relevant to the analysis were classified as "background".

3.3 Methods

3.3.1 Field Methods

Black and white aerial photography at a scale of 1 inch = 2,000 feet was obtained of the lower Susitna River at five mainstem discharges as measured at the USGS Sunshine gage.

Helicopter mapping flights were conducted over the eight representative areas at mainstem discharges similar to those at which the aerial photography was obtained (Table 3.2). During these flights, aquatic habitat types were identified and their locations mapped on blue-line prints made from 1 inch = 500 feet enlargements of the study area. Gravel bars and dewatered streambank areas were sketched on the bluelines along with the boundaries of the various habitat types.

Aren't these more easily obtained from aerial photos?

TABLE 3.2. DATES AND SUSTINA RIVER DISCHARGE (AS MEASURED AT SUNSHINE) AT WHICH AERIAL PHOTOGRAPHY WAS OBTAINED AND HELICOPTER MAPPING FLIGHTS WERE FLOWN

Aerial Photography		Mapping Flight	
Date	Instantaneous Discharge (cfs)	Date	Mean Daily Discharge (cfs)
08/27/84	75,200	08/27/84	81,600
08/27/83	59,100	07/24/84	52,000
		08/22/84	56,300
09/06/83	36,600	08/31/84	38,000
09/16/83	21,100	09/11/84	23,600
10/25/83	13,900	10/13/84	12,100

3.3.2 Office Procedure

Habitat Type Delinations

Photo enlargements at a scale of 1 inch = 500 feet were prepared for each of the eight representative areas at each of the five discharges. Aquatic habitat boundaries that had been mapped on the blueline prints during the helicopter reconnaissance flights were transferred to acetate overlays on these enlargements.

External boundaries of the representative area to be included in the surface area analysis (hereafter referred to as control areas) were defined on each enlargement. Control area boundaries were established using features identifiable on all five sets of photography. In some cases, a given enlargement was broken into more than one control area to accommodate the size of the digitizer tablet used in the analysis. Control areas served as an index of quality control. Surface areas of the individual elements within each control area were summed and compared to the total surface area of the control area. This insured that no habitat elements were left undigitized.

Digitizing

Boundaries were drawn around each wetted and non-wetted habitat element on each enlargement for each of the five flows. Individual area elements were identified as to habitat type and assigned unique sequential identifier numbers. Channels which contained water at the 75,200 cfs flow were assigned unique identifier numbers that were used for the same channel at lower flows. Gravel bars and vegetated islands were assigned unique numbers for a given photo enlargement.

Surface area determinations were made using an HP-9845 computer and area measurements were calculated and displayed to an accuracy of 0.0049 inches. This represents an accuracy of 2.5 feet for photography at a scale of 1" = 500'. The total surface area of a control area was digitized. Individual habitat areas within that control area were then digitized and their areas summed for comparison to the control area. Replicate measurements were made for each area digitized to ensure repeatability within five percent. Comparisons between summed individual areas and the total control area were considered acceptable if the difference was less than five percent.

Analysis Procedures

Each individual surface area measurement entered into the data base had an identifier number that allowed identification by discharge, representative area, habitat type, and specific area identification number. In this way, data may be displayed by study area, by tracking a specific channel, or using a variety of other formats.

Due to weather conditions such as ceilings and wind at the time ~~of~~ the aerial photography flights were flown, the different sets of photographs were obtained at slightly different scales. To allow direct comparisons, the September 16, 1983, 21,100 cfs set of photography was chosen as a base and correction factors were determined to standardize measurements to a common scale.

3.4 Results

3.4.1 General

The general response for total wetted surface in all representative areas is a decrease with decreasing mainstem discharge (Figures 3.1 - 3.4). The representative areas are described below and the habitat type designations are shown on aerial photographs in Exhibit B. Mainstem, primary and secondary side channel surface area decreases with decreasing discharge. The response of wetted surface area for tributaries varies depending on tributaries juncture with the mainstem or side channel.

The amount of clearwater wetted surface area increases with decreasing mainstem flow. As mainstem discharge decreases many channels ~~transition~~ change from side channels ~~through~~ to turbid backwaters ~~and~~ to clearwater areas to gravel bars. The discharge at which the change occurs varies for each side channel complex. Some channels ~~transition~~ change directly from side channel to side slough skipping turbid backwater and maintain a base winter flow. Turbid backwater wetted surface area increases with decreasing discharge as the heads of side channels dewater, then decreases as channels change to clearwater areas or dewater completely at lower discharges.

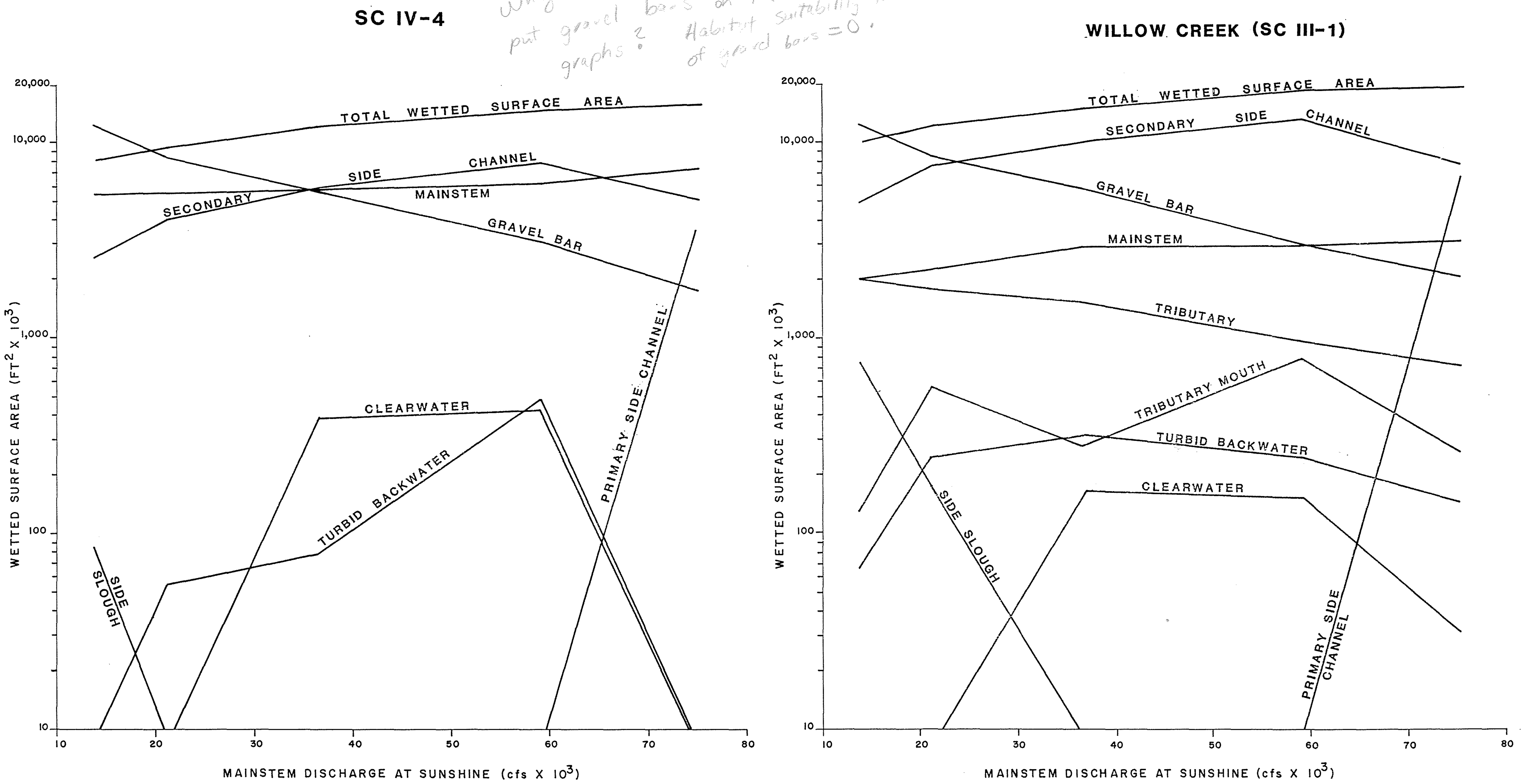
noun, not a verb

3.4.2 Study Sites

SC IV-4

The slight change in mainstem wetted surface area with changing mainstem discharge is due to the close proximity of the mainstem thalweg to the side channel complex (Figure 3.1). Therefore, there is access to the side channel complex at low flows. Secondary side channel surface area decreases with decreasing discharge below 59,100 cfs as secondary side channels dewater or become turbid backwaters, clear water areas, and side sloughs. The increase in secondary side channel area from 75,200 cfs to 59,100 cfs is due to the transformation of a primary side channel to a secondary side channel. Turbid backwaters and clearwater areas form as the discharge decreases from 75,200 cfs to 59,100 cfs. As the discharge decreases to 36,600 cfs turbid backwaters typically transition from turbid water to clearwater as intragravel flow flushes the turbid water out thus

Even if the discharge remained at 59,100 cfs the turbid backwaters would eventually become clear. Backwaters are very transitional in being turbid or clear, Why do you always put gravel bars on these graphs? Habitat suitability for fish of gravel bars = 0.



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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: SC IV-4 AND WILLOW CREEK

FIGURE 3.1

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

TABLE 3.3. WETTED SURFACE AREAS AND PERCENT OF TOTAL WETTED SURFACE AREA BY HABITAT TYPE AT FIVE MAINSTEM DISCHARGES FOR SELECTED REPRESENTATIVE AREAS

	Mainstem		Primary Side Channel		Secondary Side Channel		Turbid Backwater		Clearwater	
Discharge at Sunshine (cfs)	WSA[1] (ft² x 10³)	Percent of Total WSA	WSA (ft² x 10³)	Percent of Total WSA	WSA (ft² x 10³)	Percent of Total WSA	WSA (ft² x 10³)	Percent of Total WSA	WSA (ft² x 10³)	Percent of Total WSA
			SC IV-4							
75,200	7470	46.4	3510	21.8	5090	31.6	--	--	--	--
59,100	6270	41.6	--	--	7900	52.4	491	3.3	427	2.8
36,600	5880	47.6	--	--	5990	48.5	79.4	0.6	386	3.1
21,100	5510	57.3	--	--	4050	42.1	55.4	0.6	--	--
13,900	5450	67.1	--	--	2580	31.8	--	--	--	--
			WILLOW CREEK (SC III-1)							
75,200	3420	17.6	6870	35.4	7930	40.9	145	0.7	31.7	0.2
59,100	2990	16.2	--	--	13300	72.1	247	1.3	153	0.8
36,600	2970	19.3	--	--	10100	65.7	320	2.1	169	1.1
21,100	2270	17.8	--	--	7700	60.3	249	1.9	178	1.4
13,900	2030	20.2	--	--	5020	50.0	67.9	0.7	--	--
			CASWELL CREEK							
75,200	--	--	143	23.4	343	56.2	--	--	--	--
59,100	--	--	--	--	402	77.3	--	--	--	--
36,600	--	--	--	--	259	66.4	--	--	--	--
21,100	--	--	--	--	73.4	35.0	--	--	--	--
13,900	--	--	--	--	53.7	31.6	--	--	--	--
			SHEEP CREEK							
75,200	--	--	--	--	319	25.9	--	--	--	--
59,100	--	--	--	--	309	23.4	--	--	--	--
36,600	--	--	--	--	336	24.5	--	--	--	--
21,100	--	--	--	--	158	14.9	--	--	--	--
13,900	--	--	--	--	116	11.6	--	--	--	--
			GOOSE CREEK (SC II-4)							
75,200	8120	48.0	--	--	7840	46.3	416	2.5	--	--
59,100	7040	49.2	--	--	6340	44.3	178	1.2	62.9	0.4
36,600	3590	37.2	--	--	4240	43.9	338	3.5	334	3.5
21,100	943	13.9	--	--	4650	68.6	35.7	0.5	147	2.2
13,900	--	--	--	--	2880	48.7	15.0	0.3	--	--
			MONTANA CREEK (SC II-1)							
75,200	5000	68.9	--	--	1740	24.0	16.3	0.2	--	--
59,100	4580	72.1	--	--	1120	17.6	118	1.9	173	2.7
36,600	3890	76.7	--	--	590	11.6	--	--	273	5.4
21,100	3320	81.6	--	--	--	--	425	10.4	--	--
13,900	1920	62.3	--	--	859	27.9	--	--	--	--
			SUNSHINE CREEK (SC I-5)							
75,200	9520	37.8	5860	23.3	9480	37.6	261	1.0	--	--
59,100	8840	36.2	5720	23.4	9160	37.5	179	0.7	87.7	0.4
36,600	7460	40.0	--	--	10300	55.3	448	2.4	--	--
21,100	6800	47.9	--	--	6330	44.5	660	4.6	8.9	0.1
13,900	5540	52.7	--	--	3350	31.9	95.8	0.9	--	--

TABLE 3.3. WETTED SURFACE AREAS AND PERCENT OF TOTAL WETTED SURFACE AREA BY HABITAT TYPE AT FIVE MAINSTEM DISCHARGES FOR SELECTED REPRESENTATIVE AREAS (Continued)

	Side Slough		Tributary Mouth		Tributary		Gravel Bar			Incremental Change
Discharge at Sunshine (cfs)	WSA[1] ($ft^2 \times 10^3$)	Percent of Total WSA	WSA ($ft^2 \times 10^3$)	Percent of Total WSA	WSA ($ft^2 \times 10^3$)	Percent of Total WSA	Area ($ft^2 \times 10^3$)	Percent of Total Area	Total Wetted Surface Area ($ft^2 \times 10^6$)	Of Total WSA of Given Discharge from Next Lower Discharge (Percent)
					SC IV-4					
75,200	--	--	--	--	--	--	1750	3.6	16.07	6.5
59,100	--	--	--	--	--	--	3140	6.5	15.09	22.3
36,600	--	--	--	--	--	--	5700	11.7	12.34	28.3
21,100	--	--	--	--	--	--	8520	17.5	9.62	18.5
13,900	85.4	1.0	--	--	--	--	12400	25.5	8.12	--
					WILLOW CREEK (SC III-1)					
75,200	--	--	260	1.3	732	3.8	2080	2.0	19.39	5.1
59,100	--	--	784	4.2	973	5.2	2950	2.9	18.45	20.0
36,600	--	--	284	1.8	1540	10.0	5870	5.7	15.38	20.5
21,100	--	--	558	4.3	1800	14.1	8680	8.5	12.76	27.0
13,900	762	7.6	131	1.3	2040	20.3	12600	12.3	10.05	--
					CASWELL CREEK					
75,200	--	--	71.7	11.7	51.8	8.5	183	5.5	0.61	17.3
59,100	--	--	104	20.0	16.6	3.2	247	7.4	0.52	33.3
36,600	--	--	25.3	6.5	101	25.9	402	12.1	0.39	85.7
21,100	13.1	6.2	45.3	21.5	76.4	36.4	582	17.5	0.21	23.5
13,900	13.2	7.8	--	--	102	60.0	611	18.4	0.17	--
					SHEEP CREEK					
75,200	--	--	352	28.6	581	45.8	162	1.1	1.25	-5.7
59,100	--	--	649	49.2	362	27.4	249	1.6	1.32	-3.6
36,600	--	--	349	25.5	681	49.7	213	1.4	1.37	29.2
21,100	--	--	19.8	1.9	883	83.3	508	3.3	1.06	6.0
13,900	--	--	10.4	1.0	875	87.5	573	3.8	1.00	--
					GOOSE CREEK (SC II-4)					
75,200	--	--	39.0	0.2	517	3.1	5700	6.2	16.93	18.3
59,100	--	--	141	1.0	553	3.9	9570	10.4	14.31	48.1
36,600	651	6.7	66.1	0.7	445	4.6	13500	14.8	9.66	42.5
21,100	471	6.9	30.4	0.4	501	7.4	16000	17.5	6.78	14.7
13,900	751	12.7	--	--	2260	38.2	18100	19.7	5.91	--
					MONTANA CREEK (SC II-1)					
75,200	--	--	132	1.8	372	5.1	2170	10.0	7.26	14.3
59,100	--	--	131	2.1	226	3.6	2970	13.7	6.35	25.3
36,600	--	--	10.9	0.2	309	6.1	4140	19.0	5.07	24.6
21,100	41.4	1.0	27.0	0.7	260	6.4	5370	24.7	4.07	32.1
13,900	29.8	9.7	7.5	0.2	168	5.5	6430	29.6	3.08	--
					SUNSHINE SLOUGH (SC I-5)					
75,100	--	--	57.9	0.2	7.7	0.1	5920	5.5	25.19	3.2
59,100	361	1.5	76.2	0.3	--	--	7580	7.1	24.42	31.0
36,600	335	1.8	37.6	0.2	61.2	0.3	12700	11.9	18.64	31.2
21,100	338	2.4	--	--	73.5	0.5	16900	15.8	14.21	35.2
13,900	1390	13.2	--	--	134	1.3	22000	20.6	10.51	--

forming clearwater areas. Clearwater habitat disappears at 21,100 cfs because the areas present at 36,600 cfs dry up but no new ones are formed by the heads of other side channels dewatering or turbid backwaters clearing up. Below 21,100 cfs the turbid backwaters transition to side sloughs.

Willow Creek Side Channel Complex

The area of secondary side channel increases as mainstem discharge decreases from 75,200 cfs to 59,100 cfs because the primary side channel transitions to a secondary side channel (Figure 3.1). Tributary surface area increases with decreasing discharge because the head of side channels dewater with decreasing mainstem discharge and the tributary extends down the side channels. With decreasing mainstem discharge tributary mouth surface area fluctuates depending on the tributary discharge. Turbid backwater area increases with decreasing discharge as the heads of more side channels become dewatered at 36,600 cfs. Turbid backwaters transition to side sloughs and gravel bars from 21,100 cfs to 13,900 cfs.

Caswell Creek

Tributary and tributary mouth wetted surface areas vary depending on both mainstem and tributary discharge (Figure 3.2). Between 21,100 cfs and 13,900 cfs the tributary area increases because the head of the side channel dewaters and the tributary extends down the side channel.

Sheep Creek

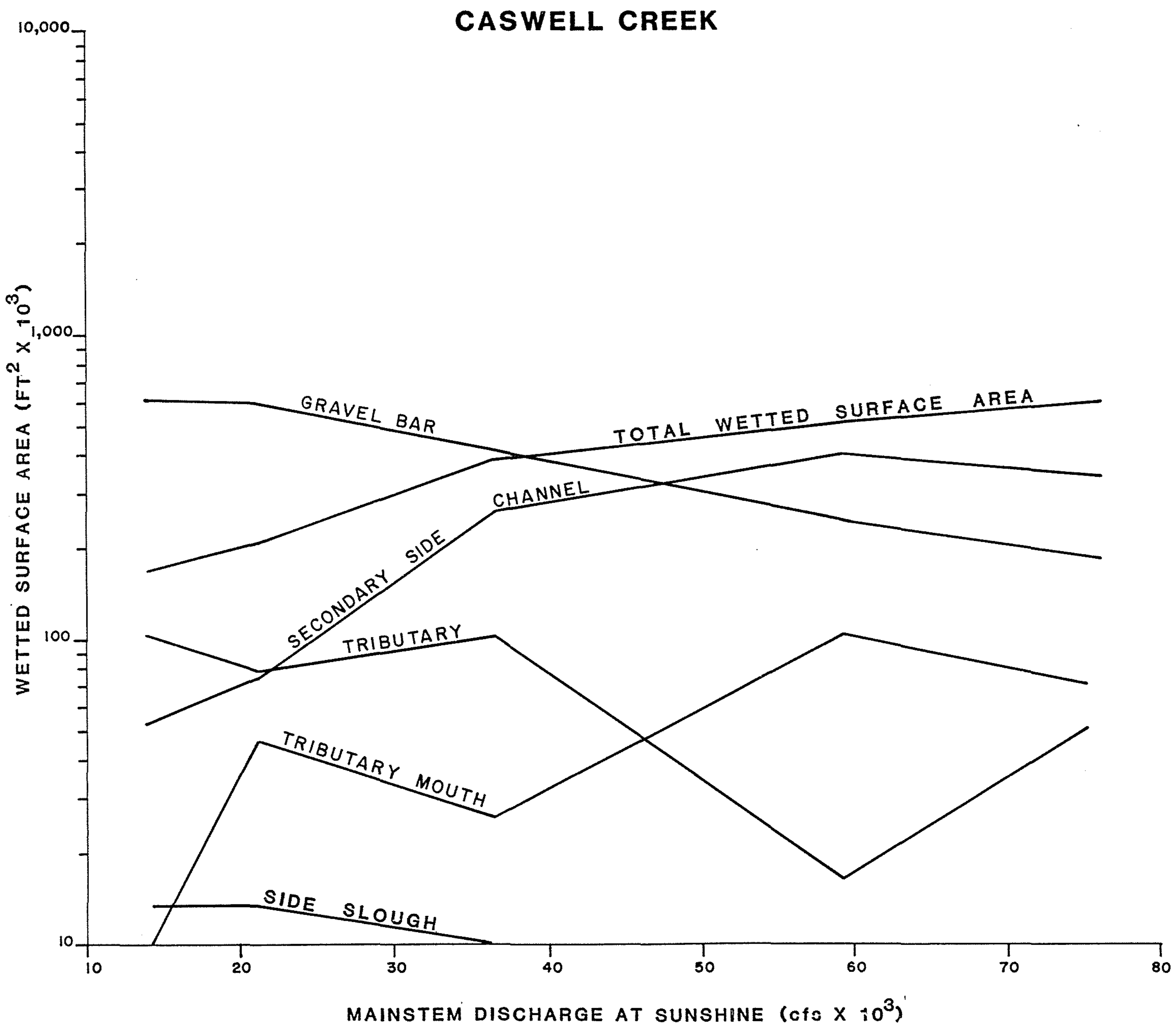
Tributary mouth surface area dramatically decreases with decreasing mainstem discharge because of the flat gradient of Sheep Creek (Figure 3.2). As mainstem discharge decreases, the side channel into which Sheep Creek flows has less flow resulting in less backwater effects. Tributary area increases as the tributary mouth area decreases, however the total wetted surface area stays approximately the same. The slight rise in wetted surface area with decreasing flow is because of slight differences between the 1983 and 1984 photography.

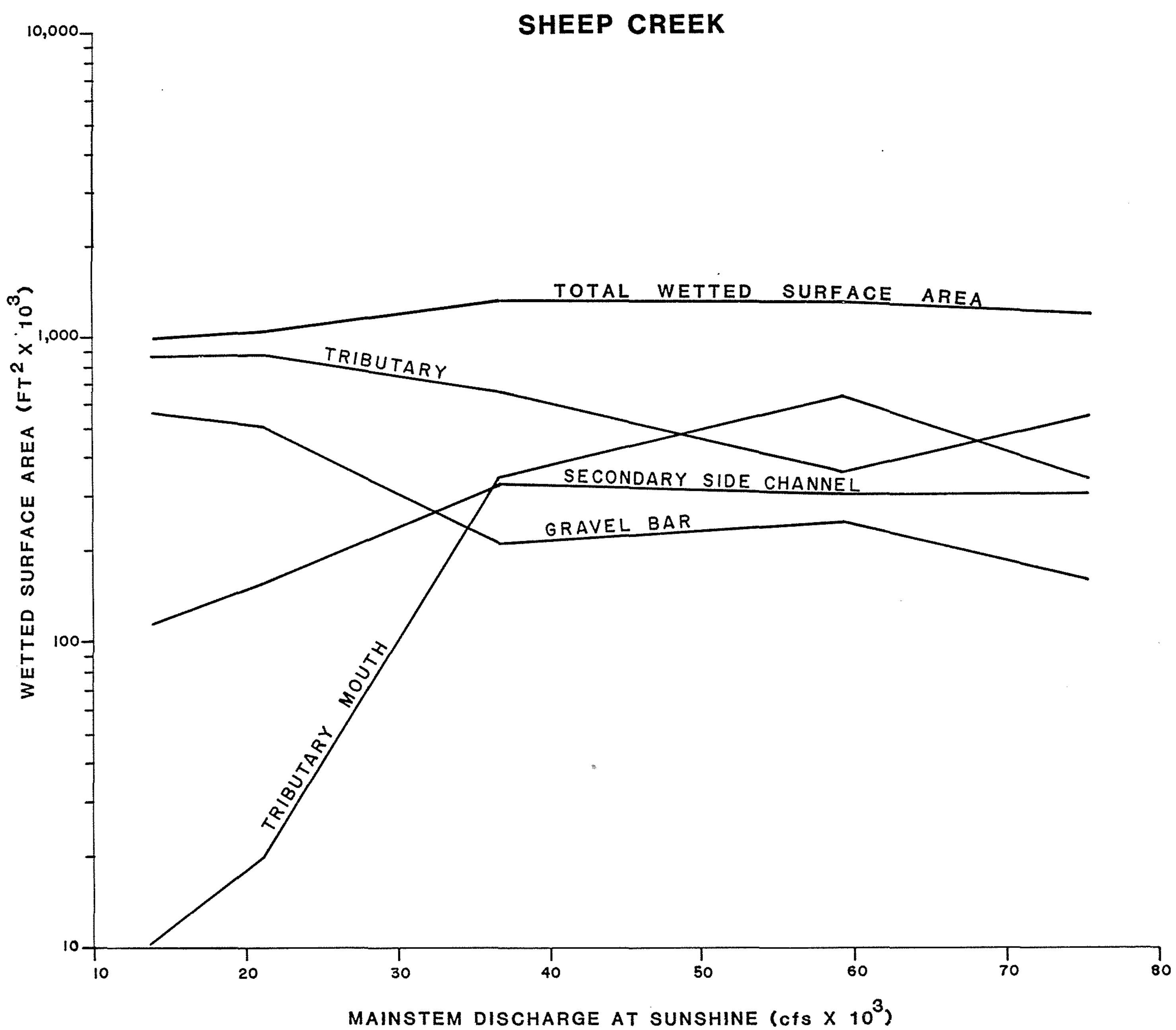
Goose Creek (SC II-4)

Mainstem surface area drops off sharply at lower flows as gravel bars enlarge and mainstem habitat within the representative area becomes secondary side channel habitat (Figure 3.3). This is because the mainstem thalweg is on the west side of the river floodplain and the side channel complex is on the east side. Tributary surface area increases at 13,900 cfs because the head of the side channel becomes dewatered and the side channel into which the tributary flows becomes an extension of the tributary. Tributary mouth area is low at 75,200 cfs relative to 59,100 cfs due to the rainstorms prior to the 75,200 cfs aerial photography. The heavy rain resulted in higher tributary flow which therefore lessened the backwater effect due to mainstem stage for this steep gradient tributary. Turbid backwater surface area increases between 59,100 and 36,600 cfs as various channels become dewatered at their upper berms and then decreases below 36,600. Clearwater areas appear at 59,100 cfs, increase in surface area at 36,600 cfs, and then decrease at lower discharges. Side sloughs appear at 36,600 cfs, decrease in surface area slightly at 21,100 cfs and then increase at 13,900 cfs as turbid backwaters transform to side sloughs.

Montana Creek (SC II-1)

Mainstem surface area decreases only slightly as mainstem discharge decreases from 75,200 cfs to 21,000 cfs because Montana Creek is next to the main low water channel (Figure 3.3). At 13,900 cfs, part of the mainstem area dewaters creating a secondary side channel.





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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: CASWELL CREEK AND SHEEP CREEK

FIGURE 3.2

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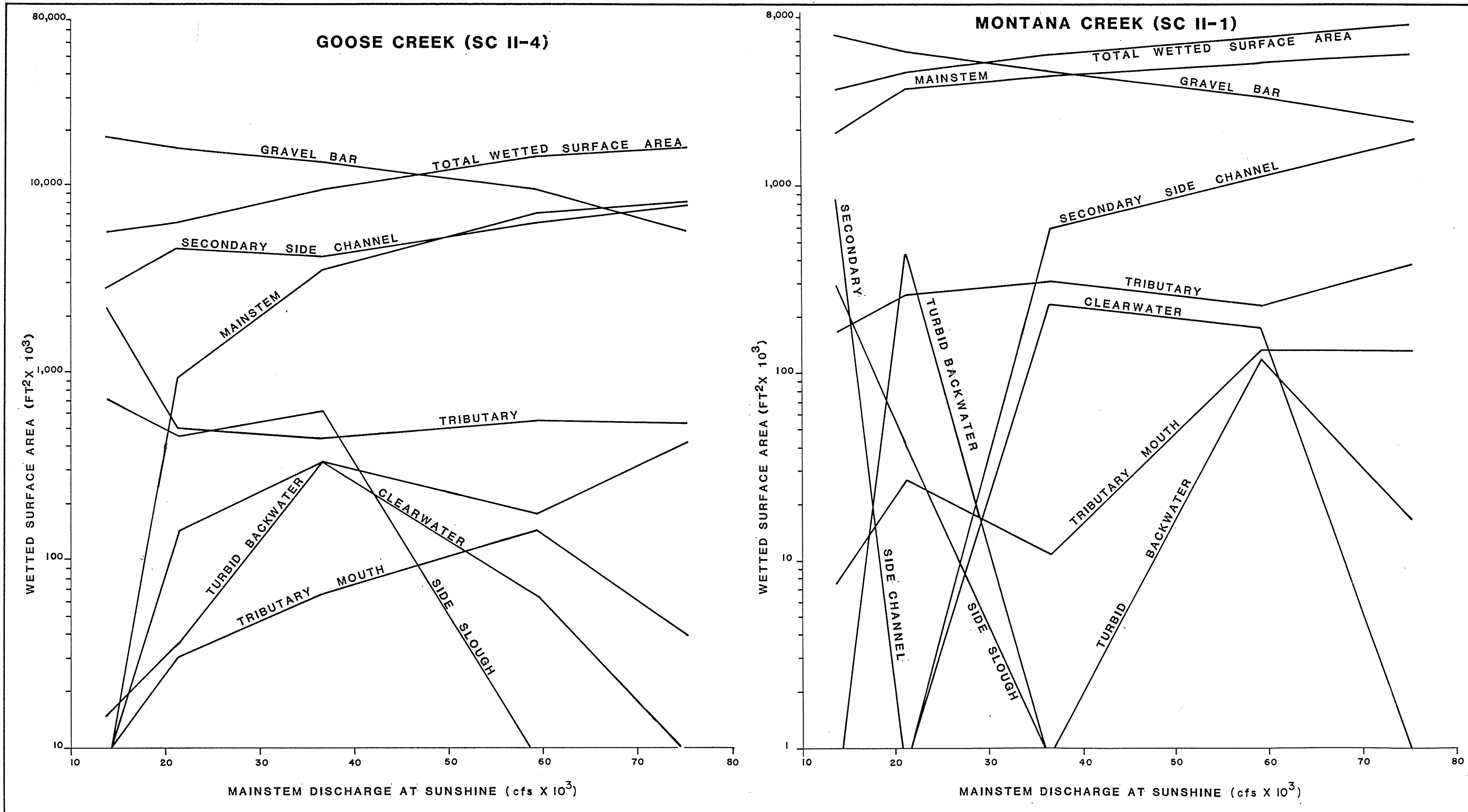

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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: GOOSE CREEK AND MONTANA CREEK

FIGURE 3.3

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Secondary side channels transition to turbid backwaters at 21,100 cfs. The turbid backwater goes to side slough at 13,900 cfs.

Sunshine Slough (SC I-5)

Mainstem surface area stays fairly constant because the side channel complex is next to the low water channel (Figure 3.4). From 21,100 cfs to 13,900 cfs some mainstem area becomes secondary side channel. Primary side channel stays relatively constant from 75,200 cfs to 59,100 cfs then transitions to secondary side channel at 36,600 cfs. With decreasing discharge secondary side channels become turbid backwaters, clearwater areas, side sloughs or gravel bars. Tributary area decreases at 59,100 cfs because the tributary discharge was relatively low at the time of photography, increasing tributary mouth habitat extending to the edge of the control area.

Birch Creek Slough

Birch Creek Slough is a single, isolated channel, fed by Birch Creek and groundwater inflow. This differentiates it from the other side channel complex study areas. Birch Creek Slough is long, narrow, and meandering. It flows through a vegetated area for its entire length with vegetation extending down to and overhanging much of the bank. The combination of the narrow channel, overhanging vegetation, and shadows in the photography made detection of water's edge and the edge of vegetation very difficult. For this reason, delination and digitizing of habitat type surface areas was not done on Birch Creek Slough. However, a verbal description of the slough and its responses to the mainstem stage that were noted during the helicopter overflights are discussed below.

The head of Birch Creek Slough becomes dewatered between mainstem discharges of 59,100 and 36,600 cfs. A road crosses the slough approximately 1,000 feet downstream from the head of the slough.

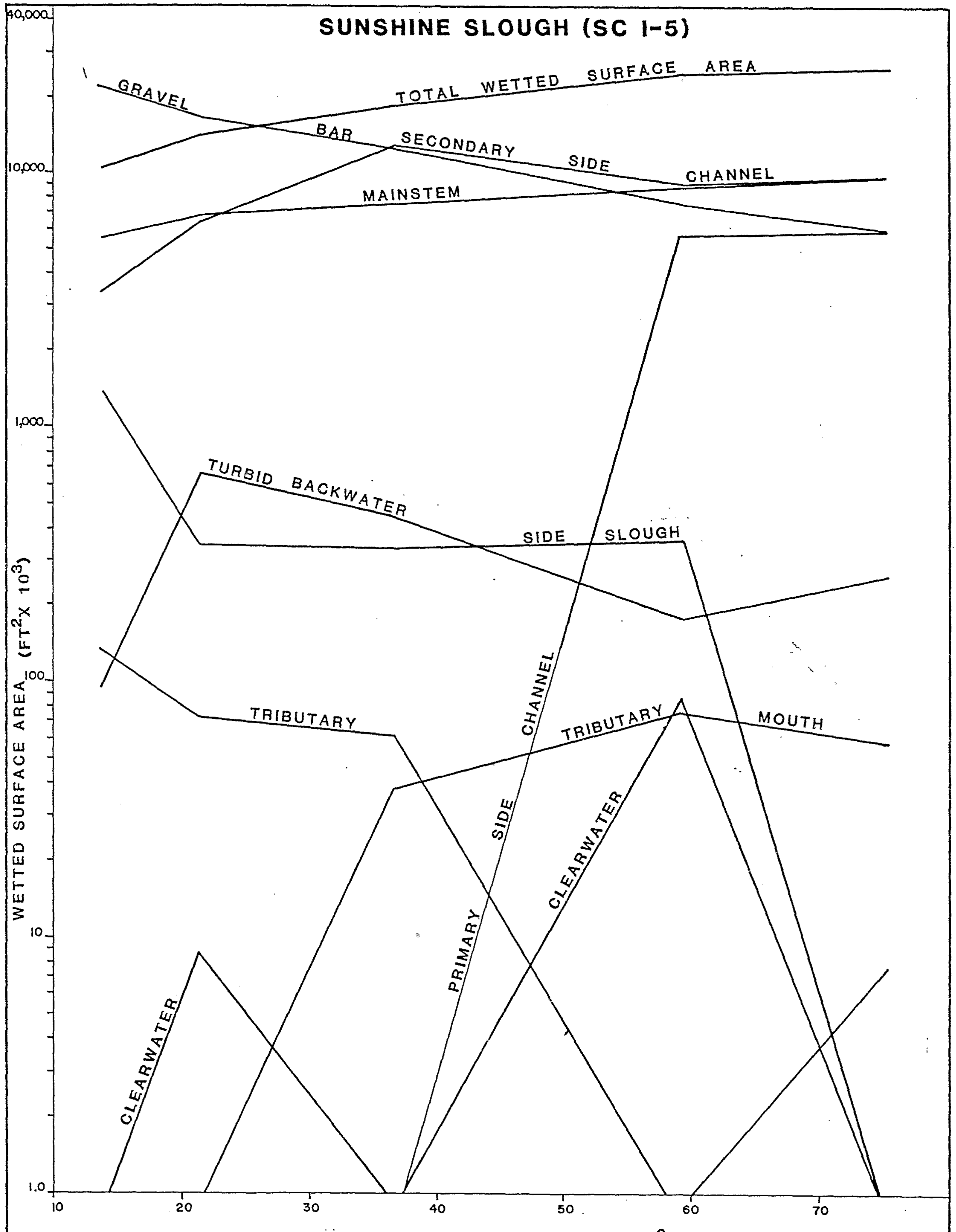

FIGURE 3.4

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SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE LOWER SUSITNA RIVER: SUNSHINE SLOUGH

PREPARED FOR: HARZA-EBASCO SUSITNA JOINT VENTURE

The upper portion of the slough contains numerous beaver dams which form a series of impounded pools. These do not appear to have significant flow through them as evidenced by stagnant-appearing water, and early ice formation. During reconnaissance surveys, no evidence of spawning was seen in these upper areas in contrast to the lower reaches of the slough where salmon spawning was observed on August 31, 1984 and carcasses were seen on October 10, 1984. The lower reaches of the slough are characterized by a pool-riffle type of habitat which appears to provide suitable habitat for spawning. The beaver dams appear to provide a barrier to upstream movement of salmon in the slough and limit fish utilization to the downstream areas.

Birch Creek enters Birch Creek Slough approximately 5000 feet upstream from the mouth of the slough. During periods when the upstream end of the slough is overtopped and the slough is flowing turbid water, Birch Creek provides clear water habitat downstream to the mouth. As mainstem stage drops and the slough is no longer breached, the slough becomes a clearwater habitat. Backwater effects of the mainstem are reduced and the tributary habitat of Birch Creek extends down to the mouth of the slough.

Always clear in 1984 - Slough never turbid.

3.5 Discussion

Definitions for aquatic habitat types used in this study represent a set of visually recognizable, streamflow-dependent physical characteristics that do not restrict the occurrence of a particular habitat type to fixed geographic locations. An example of the flow-dependent nature of these definitions are side slough, clearwater area, turbid backwater and side channel habitats. The berms at the heads of side channels may become dewatered as the mainstem discharge decreases, forming a turbid backwater habitat. As the discharge continues to decrease the turbid backwater may remain a turbid backwater or become a clearwater area or a side slough depending on the local influence of upwelling, channel length and channel slope. Clearwater areas form as remnant wetted areas remaining after the berm becomes dewatered. These areas clear due to settling out of suspended particles or due to some intragravel flow. They eventually dewater completely. Side sloughs are clear water habitats in which the flow is maintained by upwelling and surface water runoff. When mainstem discharge increases and river stage rises, the berm at the head of the side channel is overtopped. Turbid mainstem flows into the overflow channel and replaces the former, clearwater habitat with deeper, faster-flowing, turbid water. The aquatic habitat type at this location then fits the definition of side channel habitat.

The surface area response curves for the representative areas in the lower river appear at first very complex without clear trends. This is a function of the complexity of many of these representative areas each containing numerous individual channels. Within a side channel complex, for example, various channels or groups of channels have different breaching discharges. A typcial sequence for a channel is to transition from a secondary side channel to a turbid backwater then become a clear water area and finally dewater. Another sequence may show a secondary side channel becoming a side slough, or remaining a secondary side channel throughout the flow range. In combination the loss of a given habitat type in one channel may be replaced by the gain of that or another habitat type in another channel which is at a different point in the same or in a different sequence.

Surface area responses are a function of streamflow and channel geometry. Previous work by Klinger and Trihey (1984) has shown the repeatability and usefulness of wetted surface area mapping on the Susitna River from RM 101 to RM 149, a single channel and split channel river. The repeatability of wetted surface area measurements ~~are~~ is dependent on stable channel geometry. Differences in channel morphology were noted between the 1983 aerial photographs and the river in 1984. This difference was first observed during the helicopter overflight on July 24, 1984 at a flow rate (52,000 cfs) less than the flow rate of the aerial photography (59,100 cfs). After field mapping the wetted surface area for the 59,100 cfs photography, the delineations were field checked on August 22, 1984, at 56,300 cfs. Between the dates of original mapping and checking, a peak flow of 82,000 cfs occurred. By the time of the later field checking, some of the gravel bars had increased in size and changed location.

Even though channels of lower river side channel complexes display gravel bar shifting on a relatively short time scale as a result of moderate high flow events, as described above, the wetted surface area response to discharge generally is repeatable and, within the precision of this work, useful in further analysis of relative changes of habitat area in response to changes in flow.

4.0 MORPHOLOGIC RESPONSE OF SIDE CHANNEL COMPLEXES

4.1 General

Braided rivers are dynamic systems whose channel shapes change from year to year and high flow to high flow. As the river channel shifts across the floodplain, some gravel bars form, become vegetated and increase in size while other bars and/or islands erode. The purpose of this assessment is to quantify the natural change in vegetated island shapes in the representative areas studied in Section 3.0.

The rate of change or shifts in thalweg position or in erosional changes is very difficult to determine between successive sets of photography. Changes could occur at a constant, uniform rate or they could be the result of sudden, brief episodes occurring at a given point somewhere between the photo dates.

Establishment and growth of vegetation on gravel bars provides some indication of a period of relative stability. However, due to the time period between photo dates, periods of stability with vegetation growth may be interspersed with periods of high erosion. Therefore, it is difficult to interpolate between sets of photos where an obvious trend is not evident.

In some reaches of the river the main low water channels have been shifting from the west side of the floodplain to the east side; in other reaches the low water channels are shifting from east side to west side. In some areas, the low water channel has been shifting from a single channel low water channel to a split channel low water channel. As the channel meander moves down valley, areas which have been stable for a relatively long time (islands with tall cottonwoods) are being eroded away.

During the photo analysis it was noted most of the channel change occurred outside of the study areas themselves but some of these changes affected the study areas. A significant change that occured in the side channels was log jams. As relatively stable islands are eroded the trees fall into the river and are swept downstream. Jams may form at the heads of a side channel creating a low velocity area where sand and silts deposit. Over time these areas may aggrade thereby raising the elevation of the berm at the head of the side channel and increasing the discharge required to overtop it.

4.2 Methods

There are eleven sets of complete aerial photographic coverage of the lower river. For evaluating the morphologic change, four sets of photography were selected ranging from 1951 to 1983. The photography was obtained July 3, 1951, August 31 and September 16, 1983. The 1962 and 1963 photography covered complementary portions of the river, therefore only one date was used to obtain complete coverage of the river.

The photographs were taken at different flows, therefore only relatively large morphologic changes such as aggradation or erosion of vegetated islands and relative position of major channels were compared. Detailed changes in channel cross-sectional shape, breaching discharges or debris jam position could not be discerned from the photographs.

Since the photography was taken at different scales, changes were delineated by scaling off of stable features in the photographs. The imprecision of this method has no serious effect on studying the relative morphologic change. The changes were delineated on the September 16, 1983 photography. The August 24, 1980 photography was used to evaluate trends and shifts in trends but was not included in the figures because of the slight differences from the September 16, 1983 photography.

4.3 Site Specific Descriptions

SC IV-4

Between 1964 and 1980, the west mainstem low water channel shifted towards the west bank. The east mainstem low water channel between 1980 and 1983 started eroding gravel bars on the west side of the side channel complex downstream of Hooligan Side Channel (Figure 4.1). The bar at the head of Hooligan Side Channel has grown since 1951. Within the side channel complex itself major changes are an increase in size and vegetation of small gravel bars. Since 1951 a small island downstream of the ADF&G Eagles Nest study site has eroded away.

Willow Creek (SC III-1)

The width of the main channel through the study area has decreased from 1951 to 1983. Gravel bars in the channel are increasing in size and becoming vegetated (Island A, Figure 4.2). The gravel bars in the northwest corner of the study site are becoming more stable and vegetated. The entrance to the side channel complex from the east mainstem channel increased in size from 1962 to 1980. The channel at the mouth of Willow Creek has remained relatively stable since 1951.

Caswell Creek

The creek channel has been relatively stable from 1951 to 1983 (Figure 4.3). Since 1951 the side channel at the mouth of Caswell Creek has been shifting to the west away from Caswell Creek. This has caused an increase in the length of the low water channel from the creek mouth to the side channel.

LEGEND
VEGETATED BANKS:
1951 ————
1962 ┬┬┬┬┬┬┬

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:
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ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

EWT&A

COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: SC IV-4

FIGURE 4.1

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

PREPARED BY:

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EWT&A

LEGEND

VEGETATED BANKS:

1951

1962

FIGURE 4.2

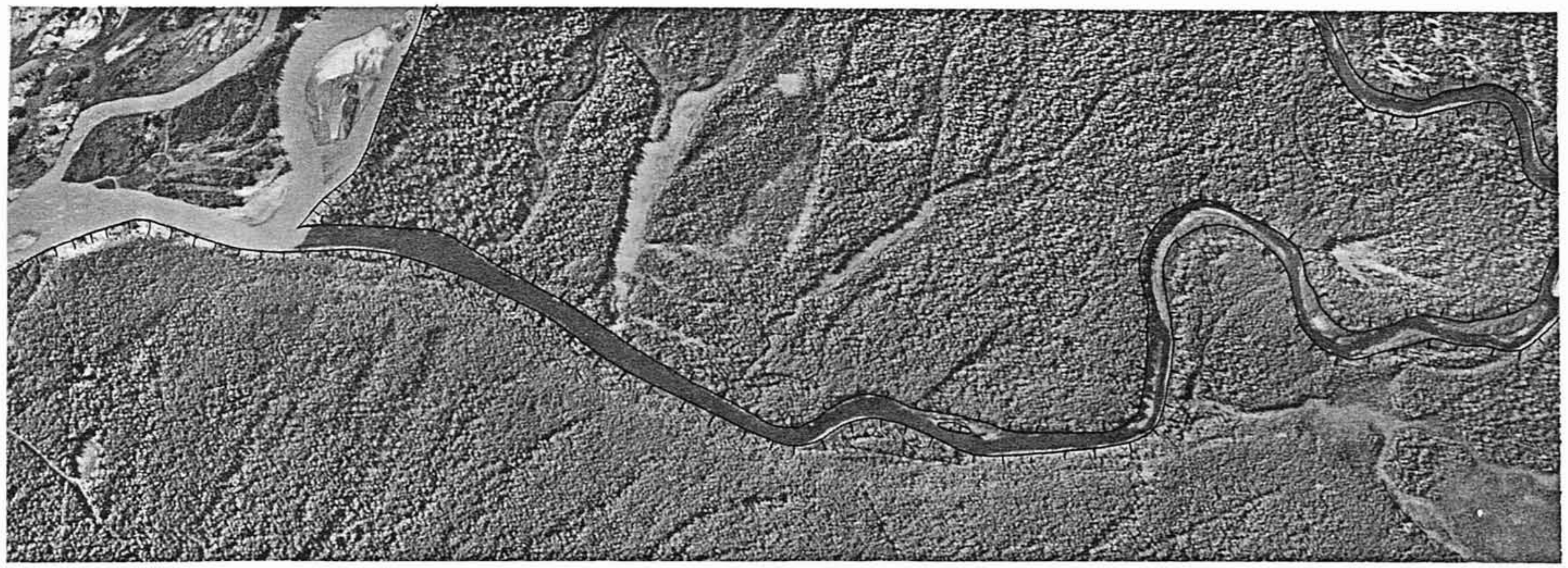
DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



SHEEP CREEK

CASWELL CREEK

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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E. WOODY TRIHEY & ASSOCIATES

COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: SHEEP CREEK AND CASWELL CREEK

FIGURE 4.3

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

Sheep Creek

In 1951 the majority of the flow was on the east side of river floodplain. From 1980 to 1983 the majority of flow shifted from the east side of the river to the west side of the river away from the mouth of Sheep Creek. Sheep Creek is now flowing into a side channel of the mainstem which may continue decreasing in size under natural conditions (Figure 4.3).

Goose Creek (SC II-4)

The Goose Creek Side Channel Complex has been on the inside of a thalweg meander for most of the period 1951 to 1983. Erosion is limited, with the dominant process being deposition on and around gravel bars and islands, with vegetation covering these newly stable areas. Island A (Figure 4.4) was a slightly vegetated gravel bar in 1951 with the extent of vegetation increasing as the bar became more stable. In 1951 the head of side channel B was a diverse set of gravel bars (Figure 4.4). Since 1951 the head of the side channel has become more stable and decreased the amount of water that could enter this channel. Between 1963 and 1980 a debris jam formed near the mouth of Goose Creek diverting a portion of the creek flow into side channel C (Figure 4.4).

Can't find?

Montana Creek (SC II-1)

The side channel complex has aggraded since 1951, especially near the creek mouth (Figure 4.5). The mouth of Montana Creek shifted in the upstream direction between the 1951 and 1962 photographs, shifted downstream between 1962 to 1980 and upstream again between 1980 to 1983 (Figure 4.5). The island near the upstream end of the east side channel has become more vegetated since 1951. The interior of the side channel complex is relatively stable with limited aggradation and vegetation growth.

Sunshine Slough (SC I-5)

Sucker Side Channel has become narrower with vegetation encroaching on the channel (Figure 4.6). The islands near the ADF&G Sunrise and Sunset study sites have become more stable, transitioning from gravel bars to vegetated islands from 1951 to 1984 (Figure 4,6). The head of Beaver Dam Slough has become more stable. The main channel has shifted slightly east so it impinges on the side channel complex and has caused relatively rapid erosion at point A (Figure 4.6). Debris jams within the side channel complex are causing areas of aggradation, increasing the stability of the gravel bars.

where?

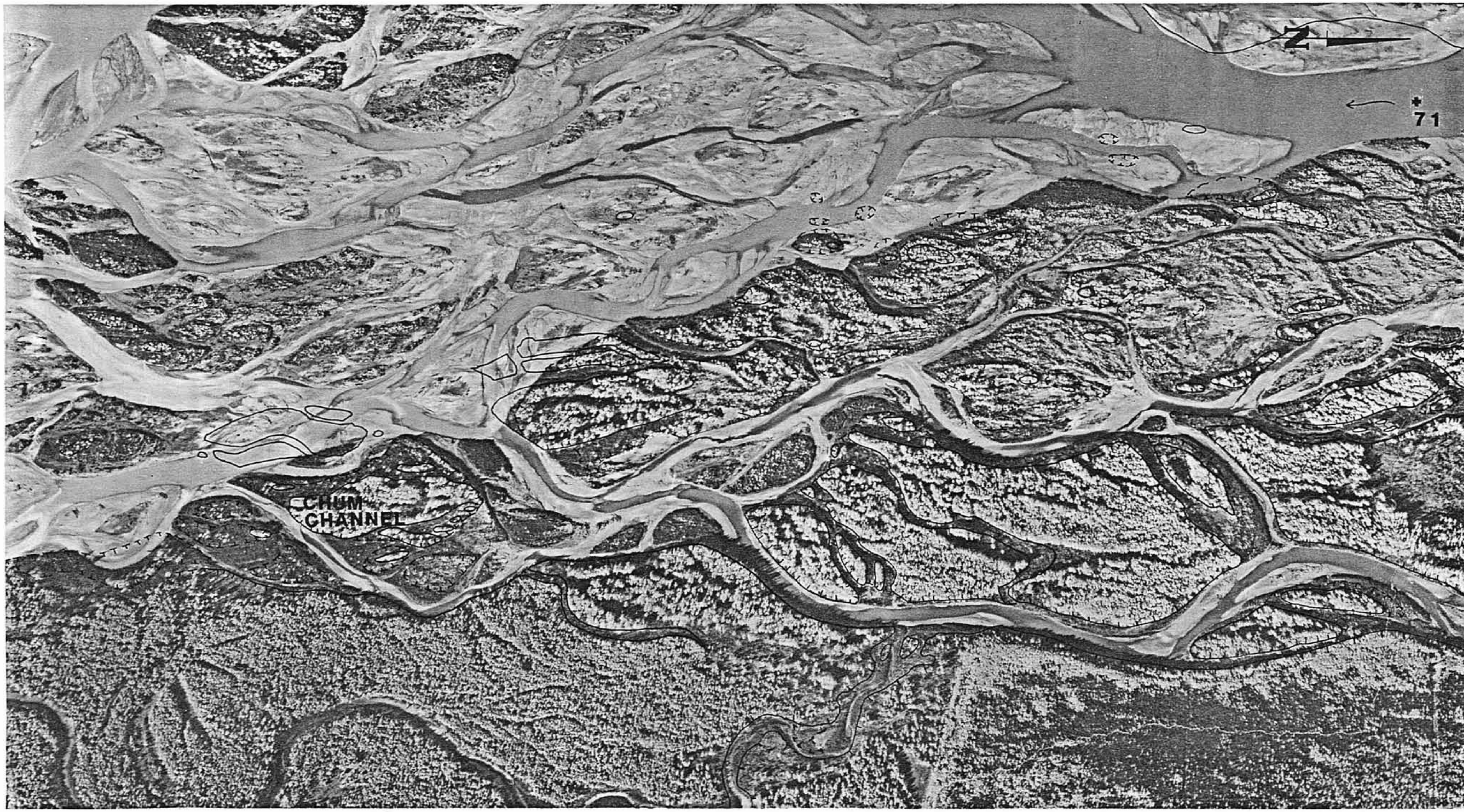
Birch Creek

The upstream end of the slough is on the outside and slightly upstream end of a thalweg meander in a relatively stable area. The slough itself is stable, with little or no change since 1951. The downstream end of the slough is on the inside of thalweg meander. Islands at the slough mouth have eroded away between 1951 and 1962 (Figure 4.7). Since 1962 the slough confluence with the mainstem has been into a side channel. The frequency of flushing flows through the slough is affected by a road across the slough to access a timber sale area (Figure 4.7).

4.4 Results and Discussion

In general the representative areas evaluated in this report are stable. Individual bars and islands along the perimeter of each representative area may be eroding or aggrading as the mainstem channels shift location. However, the central portion of the side channel complexes are stable.

Dramatic changes in channel position and form may occur whenever the river reaches bankfull stage. At bankfull stage gravel in the active floodplain scours and fills as bed material is moved down valley. The main



LEGEND

VEGETATED BANKS:

1951 ————

1962 ┬┬┬┬┬┬

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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E. WOODY TRIHEY & ASSOCIATES

COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: GOOSE CREEK 1 of 2

FIGURE

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND
VEGETATED BANKS:
1951
1962

DATE OF PHOTOGRAPHY: 9/16/83
GRAPHIC SCALE: 1000 500 0 1000 FT

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COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: GOOSE CREEK 2 of 2

FIGURE 4.4

PREPARED FOR:
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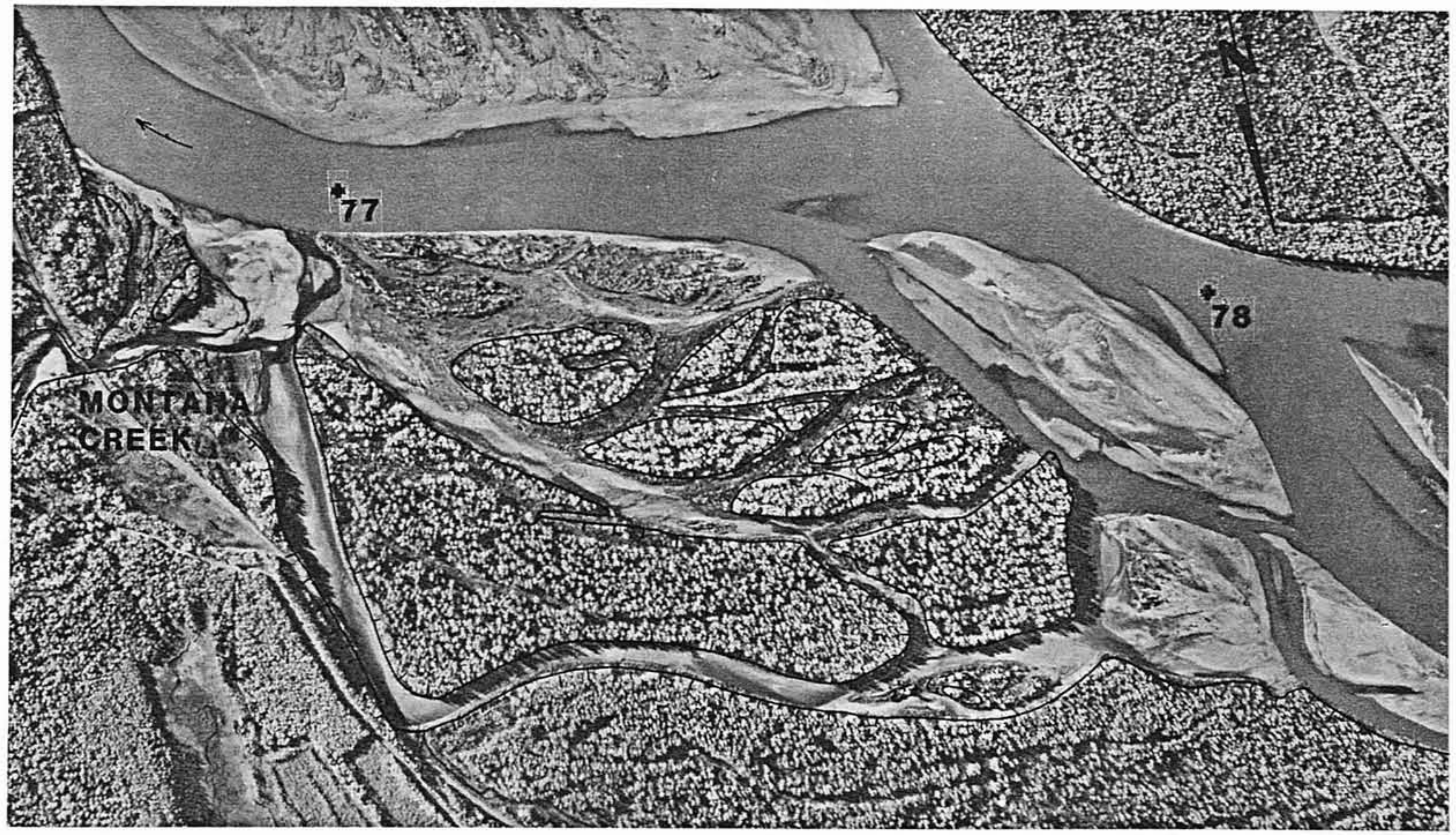

LEGEND
VEGETATED BANKS:
1951
1962

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: MONTANA CREEK

FIGURE 4.5

PREPARED FOR:

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9/16/83

LEGEND
VEGETATED BANKS:
1951
1962

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COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: SUNSHINE SLOUGH 1 of 2

FIGURE 4.6

PREPARED FOR:
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SUSITNA JOINT VENTURE

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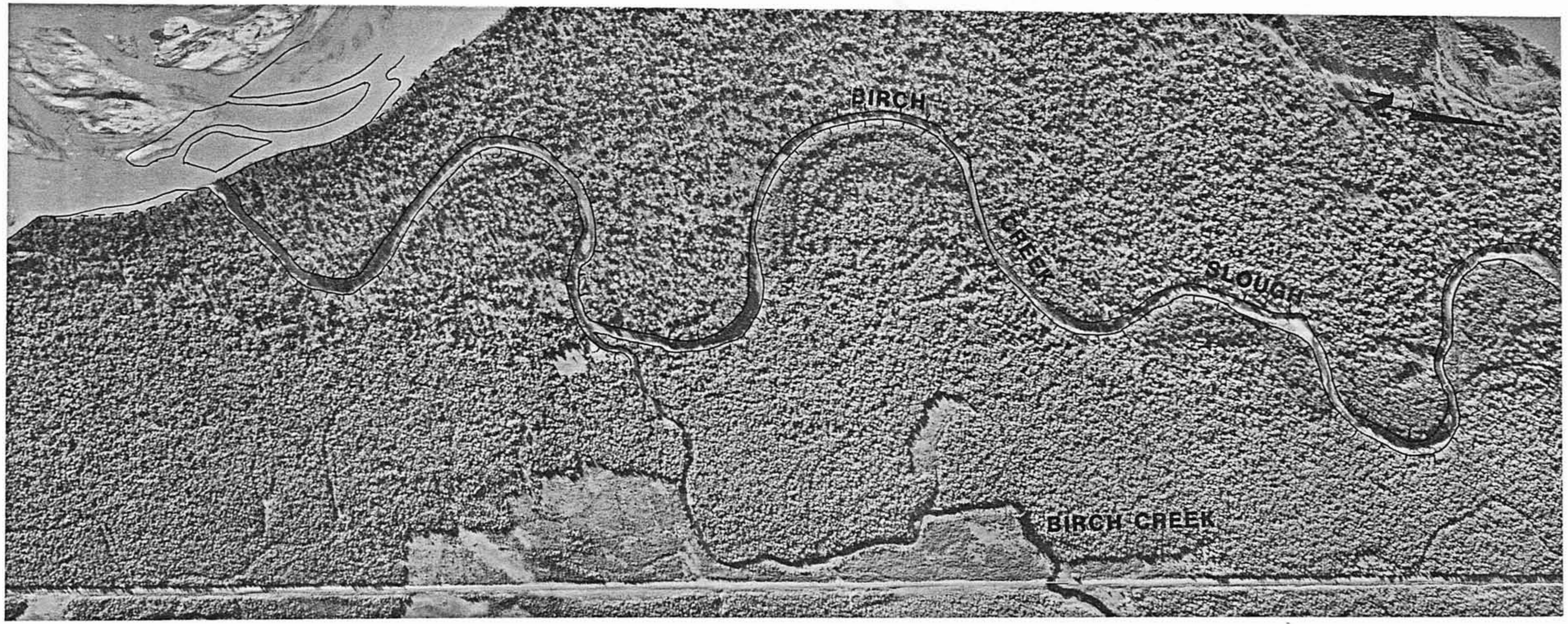
COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: SUNSHINE SLOUGH 2 of 2

FIGURE 4.6

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND
VEGETATED BANKS:
1951
1962

DATE OF PHOTOGRAPHY: 8/27/83
GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:
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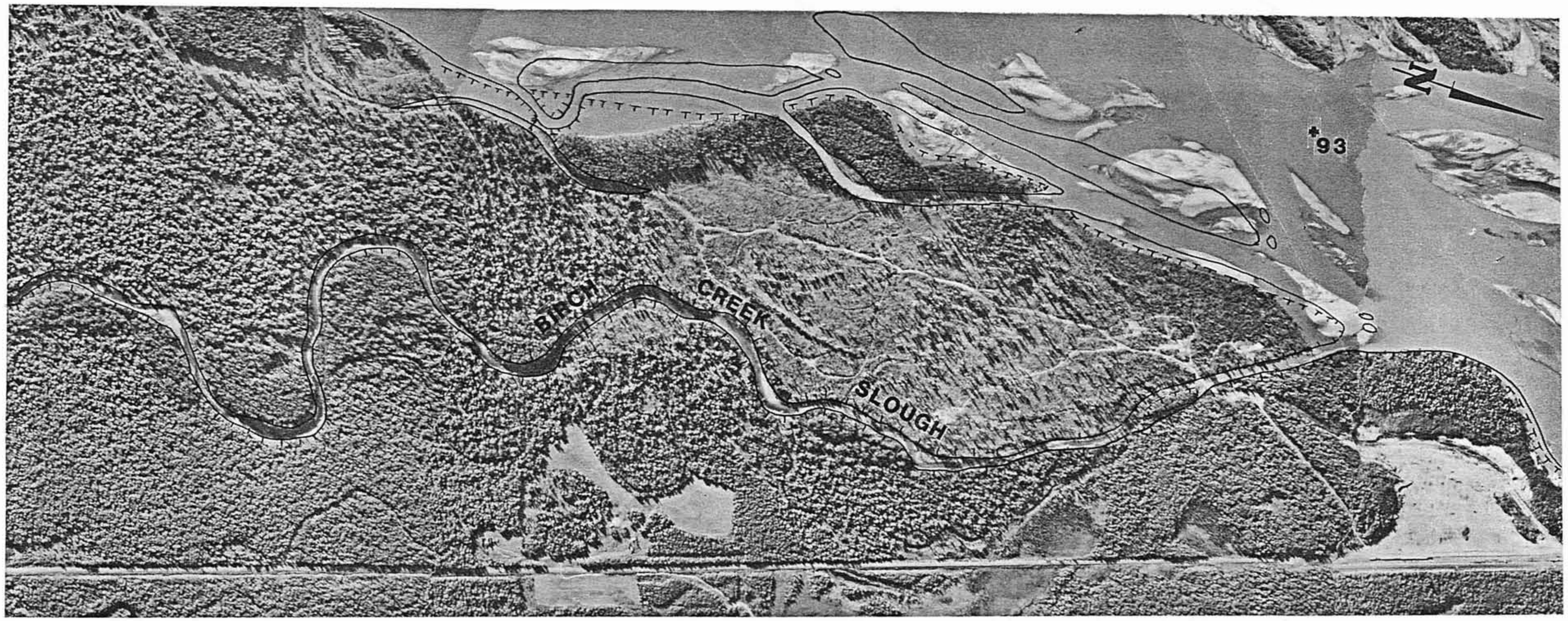
COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: BIRCH CREEK SLOUGH 1 of 2

FIGURE 4.7

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE



LEGEND
VEGETATED BANKS:
1951
1962

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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COMPARISON OF VEGETATED RIVERBANKS AND ISLANDS 1951, 1962 and 1983: BIRCH CREEK SLOUGH 2 of 2

FIGURE 4.7

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

channel may change its location dramatically, intercepting other channels at different locations causing them to readjust. In general, the geometric shape of the main channel remains uniform as it changes location within the floodplain. Minor channels respond to processes such as main channel and major side channel changes of location, debris jam formation and local sediment movement.

Debris jams influence the meandering pattern of major subchannels, while they may control the overtopping discharge of side channels. Debris jams form, increase and decrease in size during floods approaching bankfull stage. When the debris jams increase in size they can increase the overtopping discharge for a side channel.

5.0 COMBINED EVALUATION OF LOWER RIVER SIDE CHANNEL COMPLEXES

5.1 General

The response of wetted surface areas are affected by factors in addition to discharge, including: channel cross-sectional shape, channel gradient, stability of the channel bed, and whether the wetted surface area was delineated on the rising or falling limb of the hydrograph. The response of individual channels within a side channel complex is similar for both the middle river and lower river. However, the response of an entire side channel complex will be different than for a given section of the middle river. The difference is due to the combination of major, intermediate and minor channels providing replacement wetted surface areas as the mainstem discharge decreases. The influence of each of these factors is detailed below.

5.2 Channel Morphology

The morphology of channels within side channel complexes (e.g. the cross-sectional shape, gradient of the channel and bed material) controls the manner in which the channels respond to changes in discharge. For example, the rate of change of wetted surface area for decreasing discharge will be greater for a wide shallow channel than for a narrow deep channel. In a plot of discharge vs. wetted surface area, a steep line will generally indicate a side channel complex with more numerous gravel bars and fewer narrow deep channels than does a line with a flatter slope. An exception occurs when the mean streambed elevation of the channels of a particular side channel complex are high relative to other side channel complexes. These complexes dewater at a higher discharge, such as at SC II-9 (Figure 2.3).

Goose Creek Side Channel Complex contains predominately wide shallow minor channels, some of which become dry at 59,100 cfs. The intermediate side channels transform to turbid backwaters and side sloughs at 36,600 cfs and dry up at 21,100 cfs. In contrast, SC IV-4 is an example of a side channel complex with many relatively narrow deep channels which predominately start dewatering below 36,600 cfs.

These two side channel complexes have approximately the same total wetted surface area at 75,200 cfs - 16.07 million square feet for SC IV-4 as compared to 16.93 million square feet for Goose Creek (Table 3.3). However, the total wetted surface area for Goose Creek is 9.66 million square feet at 36,600 cfs, whereas SC IV-4 has 12.34 million square feet at 36,600 cfs.

Side channel gradient controls the rate at which a channel may transition from turbid backwater to clear water area and the size of the remaining wetted area. Given the same upstream berm elevation, channel length and relative position in a side channel complex, a channel with a steeper gradient will have more water in the lower portions of channel than would a flatter gradient channel. This is due to the backwater effect of the mainstem on the downstream end of the channel.

What

Deeper water?

5.3 Aerial Photography

Air photo interpretation is highly dependent on the quality of the photography. Although each set of photographs obtained in this study were generally clear and complete, the time of day, date, and prevailing weather conditions at the time the aerial photographic missions were flown affected the extent to which detailed riverine features were visible. The 13,900 cfs photographs, obtained on October 25, 1983, were taken after ice had begun to form along the river and a light snowfall had covered the ground. This made determination of the water's edge more difficult.

The remainder of the photography was obtained in late August through mid-September. At this time of the year combination of sun angle and well-developed deciduous foliation resulted in extensive shadows along the south shorelines. These shadows sometimes obscured the water's edge and made surface area delineations difficult. This was the reason Birch Creek Slough was dropped from our analysis. The shadows made it impossible to accurately delineate the change in wetted surface area with discharge.

There were problems encountered using aerial photography from two different years and in delineating the 1983 photography using ground truthing obtained in 1984. Most of the problems dealt with 1984 observations of gravel bars of larger sizes and in different locations than in the 1983 photography.

Whether the photographs were taken on a rising, falling or steady stage influences the habitat type found, specifically whether a given channel is a clearwater area or turbid backwater. On a rising stage an intermediate side channel could be a clearwater area or side slough if there has been sufficient time between periods of overtopping flow for the channel water to clear up. On a falling limb an intermediate side channel could be a turbid backwater if the aerial photography were taken immediately after the berm dewatered. If the channel was influenced by upwelling then as the discharge continued to drop, the turbid backwater would transition to a side slough. If it was not influenced by upwelling, the channel would remain a turbid backwater until the water cleared by settling out of the sediment. This was noticed at SC IV-4 between the 36,600 cfs and 21,100 cfs photographs.

The following is a description of the flow regimes when the aerial photographs were taken.

Date	Discharge (cfs) at Sunshine	Flow Regime
08/27/84	75,200	a rapidly falling stage
08/27/83	59,100	at or near a peak stage
09/06/83	36,600	a slowly falling stage
09/16/83	21,100	a slowly falling stage near base flow
10/25/83	13,900	a slowly falling stage near base flow, some local ice effects

5.4 Summary

In general, the habitat surface area response curves for the lower river study areas appear different than those for the middle river (as presented in Klinger and Trihey, 1984). Both differences and certain similarities exist between the lower river and the middle river which help explain the surface area responses. The middle river is a single or split channel river whereas the lower river is a braided channel with many more channels present in a given length of the river than for the same length in the middle river. This results in somewhat of a buffering or damping effect on the habitat type surface area response for the given length of the lower river. The net loss or gain of a given habitat type within a length of the lower river viewed as a whole may be minor. In contrast, with one or a few channels in a given length of the middle river, this buffering effect is not possible and the surface area response curves are more directly linked to changes in discharge. Looking at isolated channels within lower river side channel complexes reveals similar processes occurring as in middle river channels.

The concept of braided rivers providing a relatively stable amount of wetted surface area for a range of discharges is supported by a detailed study of New Zealand braided rivers (Mosley, 1982). Mosley (1982) found for braided rivers in New Zealand that the surface area associated with shallow, slow water remained relatively constant over a wide range of flows, even though the physical location changed. This is because braided rivers are composed of numerous channels with a range in sizes and overtopping discharges, thus providing a more stable wetted surface area response to changes in discharge than a single-thread channel.

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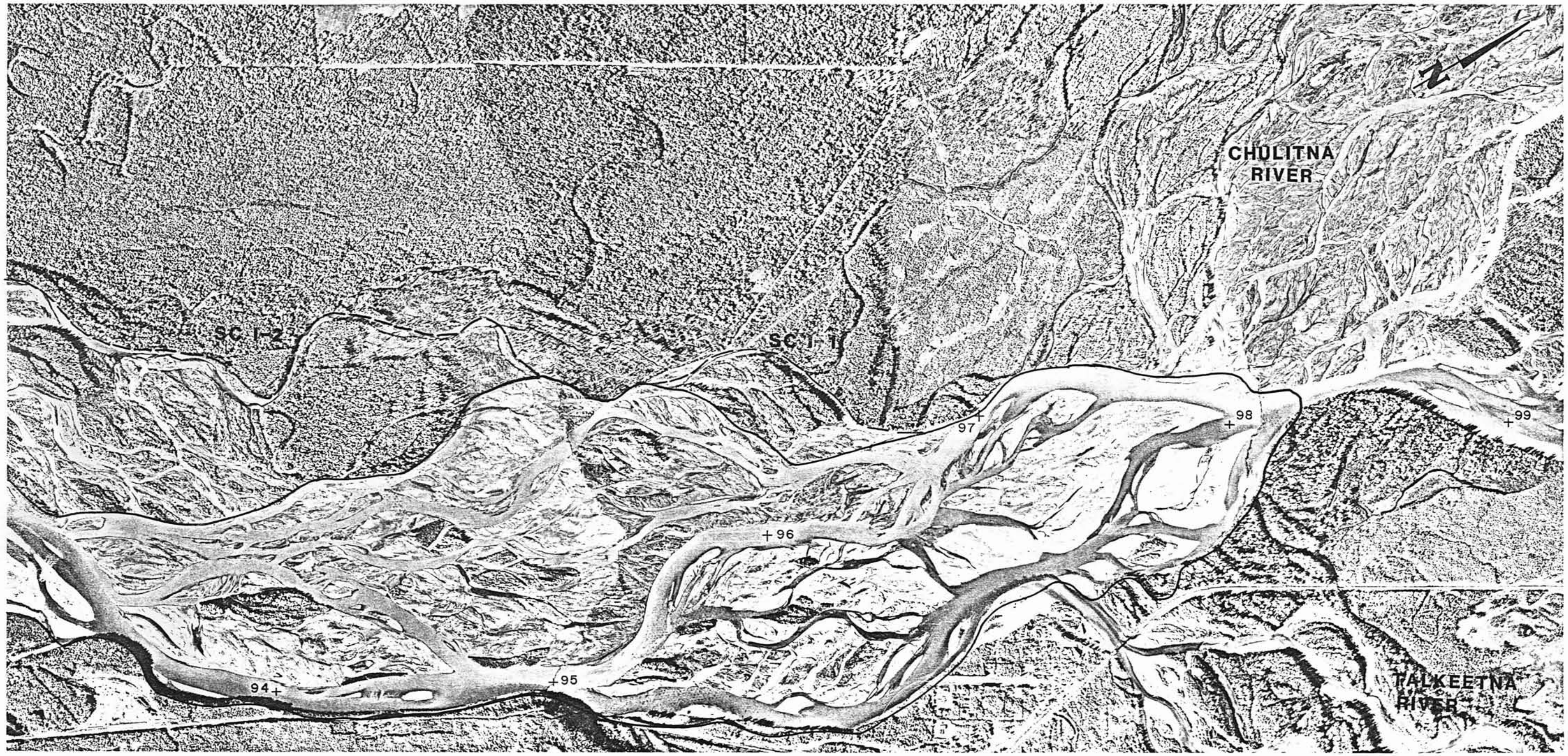
Klinger, S. and E.W. Trihey. 1984. Response of aquatic habitat surface areas to mainstem discharge in the Talkeetna to Devil Canyon reach of the Susitna River, Alaska. E. Woody Trihey and Associates. Report for Alaska Power Authority, Susitna Hydroelectric Project, Anchorage, Alaska. Document No. 1693. 1 Volume.

Mosley, M.P. 1982. Analysis of the Effect of Changing Discharge on Channel Morphology and Instream Uses in a Braided River, Ohau River, New Zealand. Water Resources Research. Vol. 18, No. 4 Pages 800-812.

EXHIBIT A

Aerial Photograhpy Showing Mainstem and Side Channel Morphologic Classification of the Lower Susitna River.



DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

R&M CONSULTANTS, INC.

ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

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FIGURE A-1

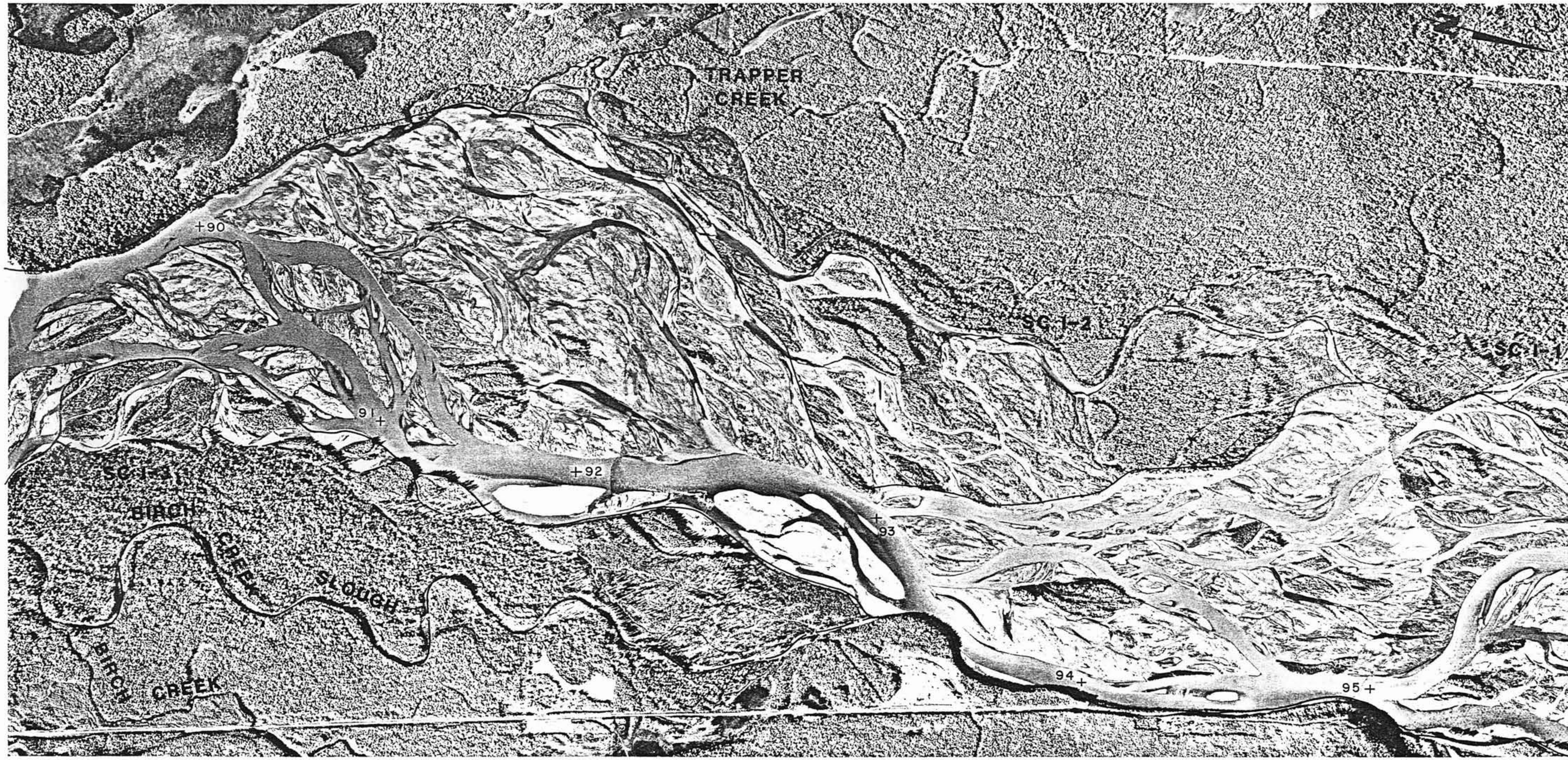
MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 94 TO 99

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 90 TO 95

FIGURE A-2

PREPARED FOR:

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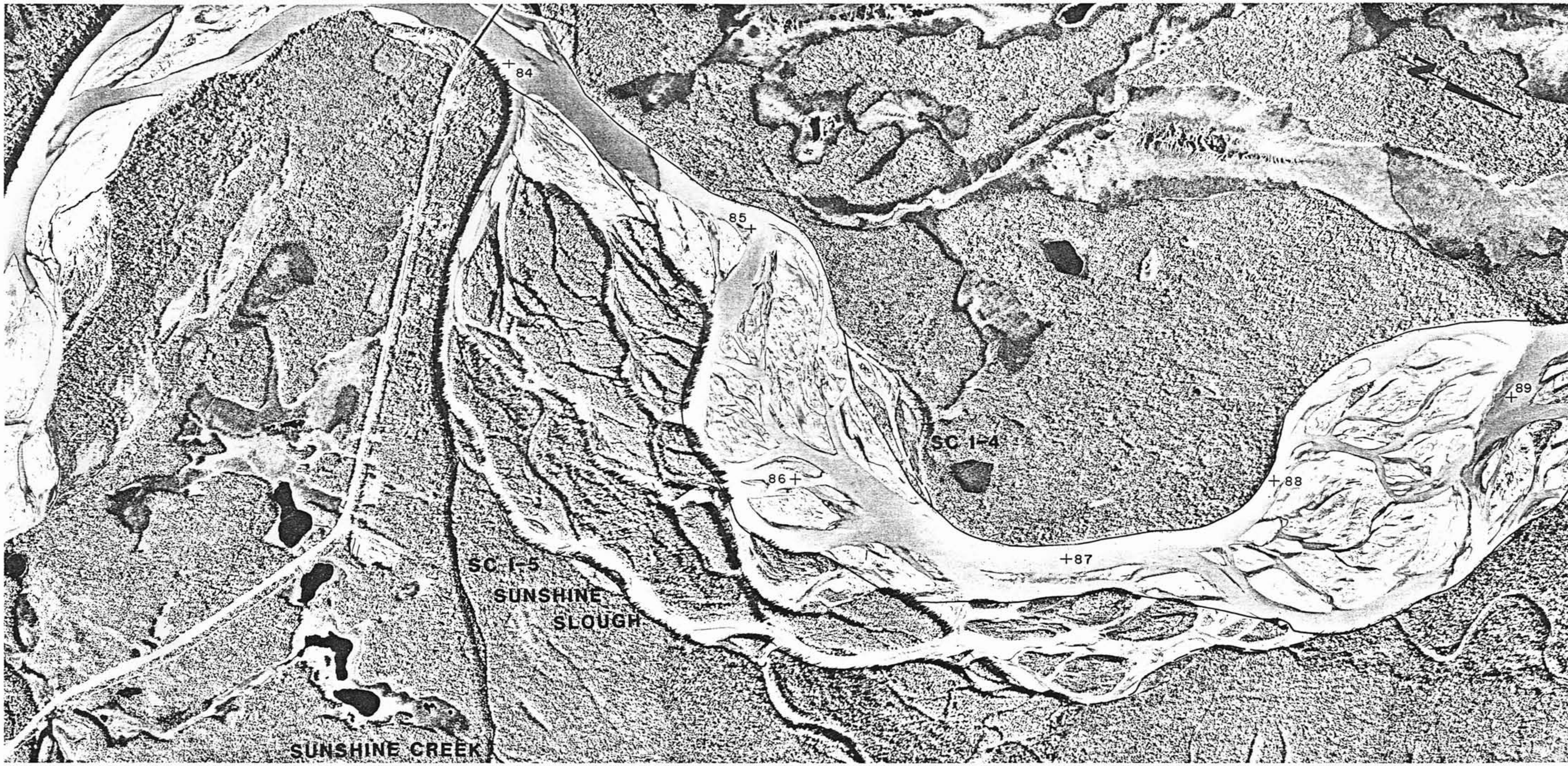
SUSITNA JOINT VENTURE



DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 84 TO 89

FIGURE A-3

PREPARED FOR:

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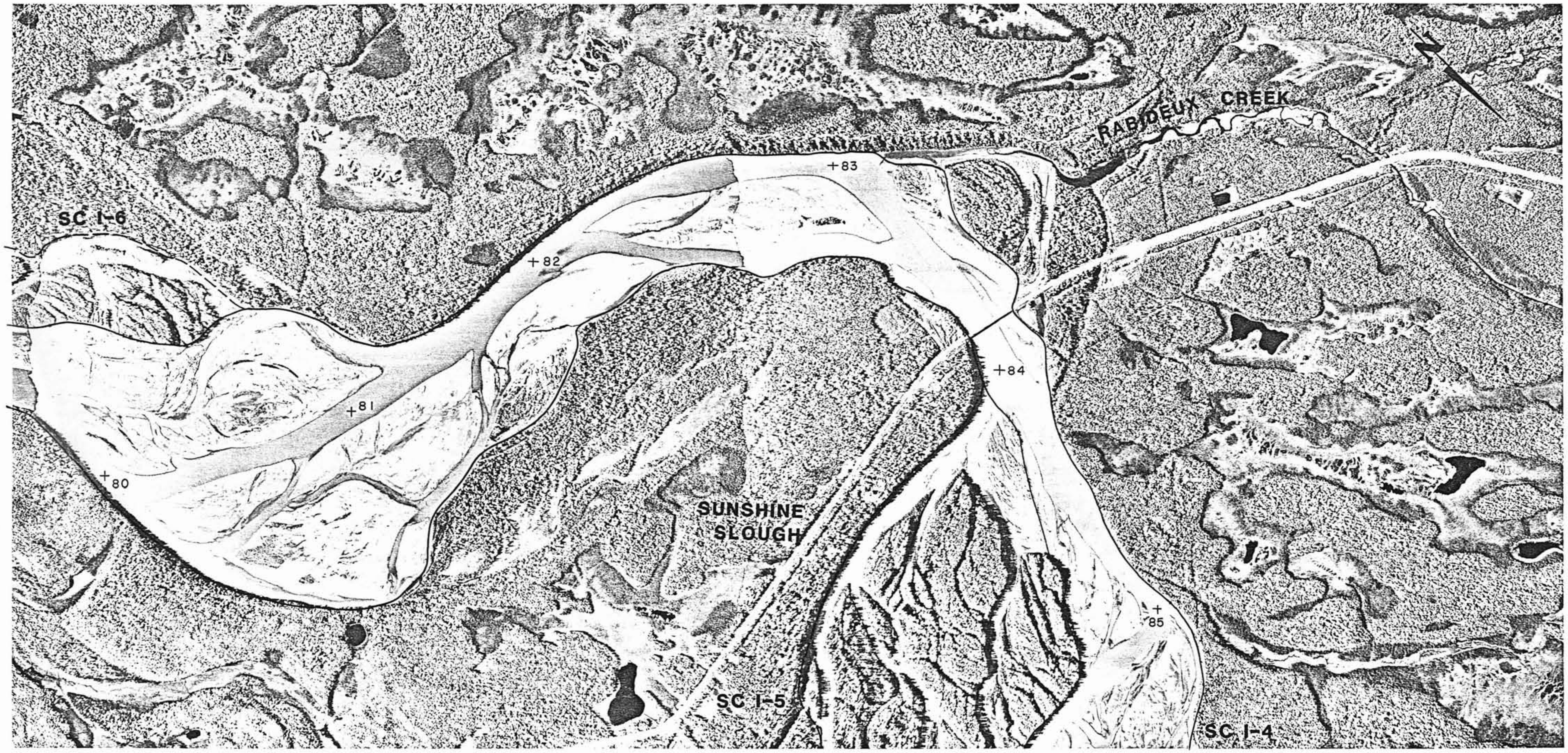
SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

2000 1000 0 2000 4000

SCALE IN FEET

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

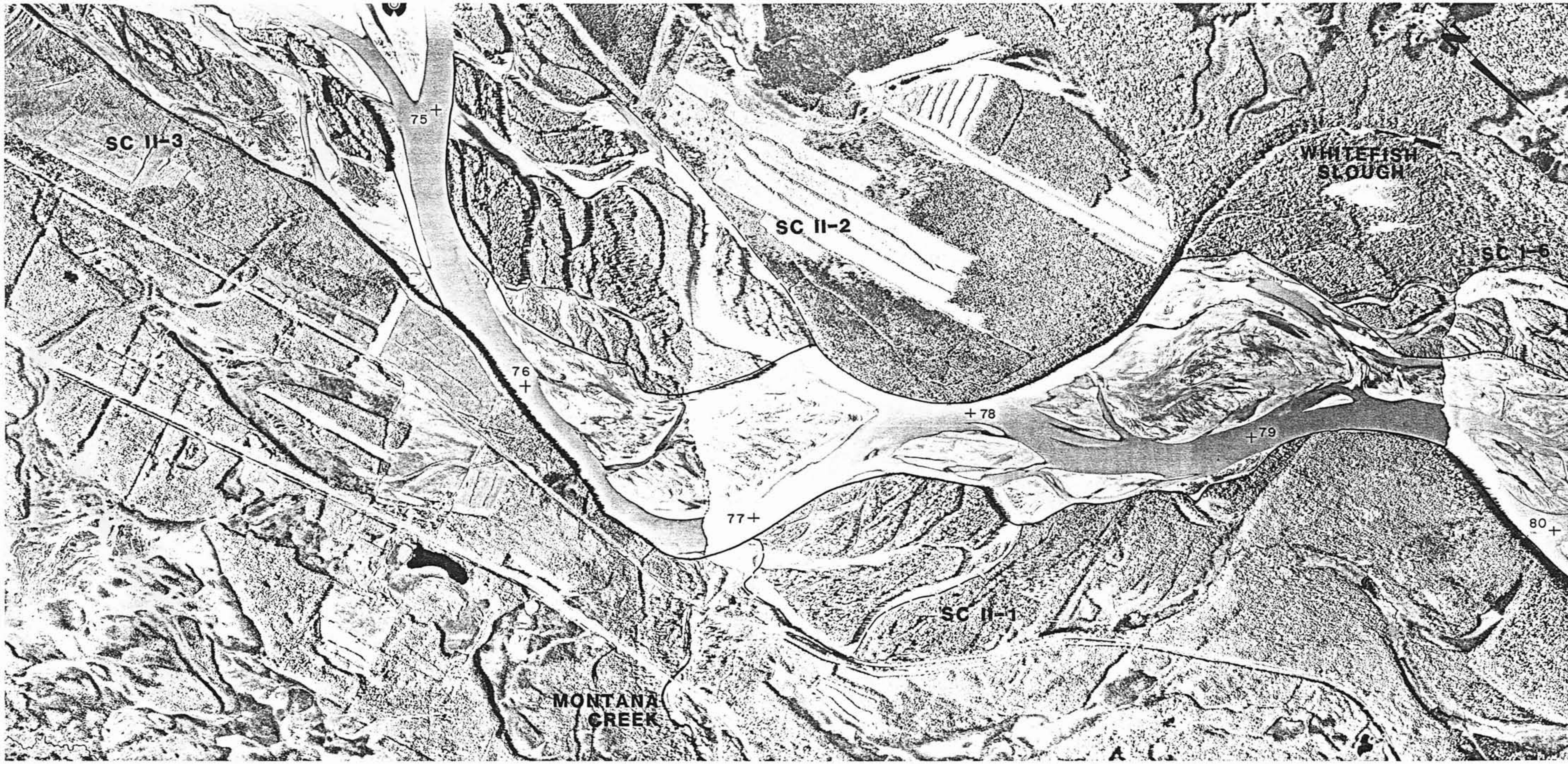
RIVER MILE 80 TO 85

FIGURE A-4

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 75 TO 80

FIGURE A-5

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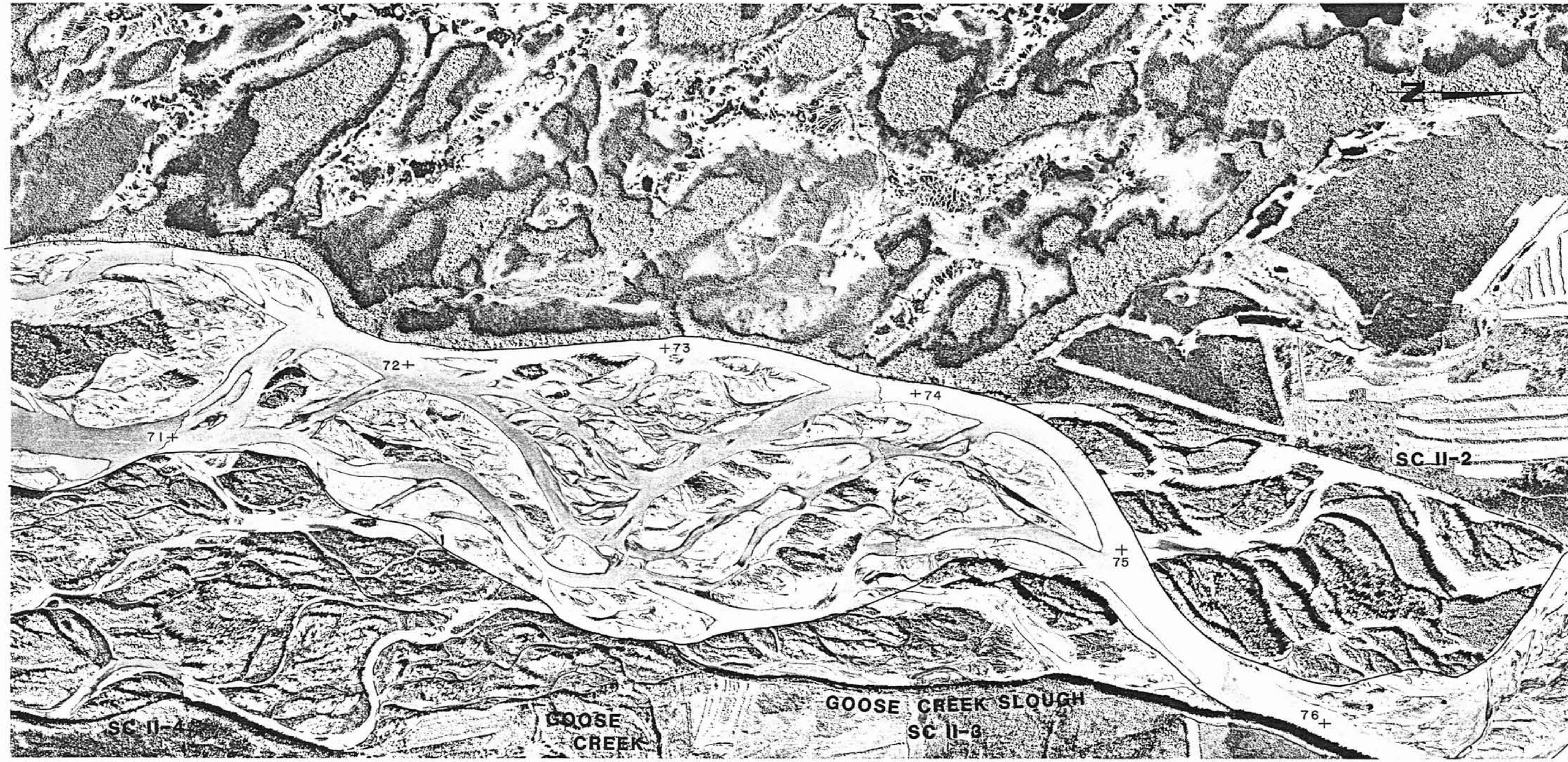
SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

2000 1000 0 2000 4000

SCALE IN FEET

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 71 TO 76

FIGURE A-6

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

2000 1000 0 2000 4000

SCALE IN FEET

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 67 TO 72

FIGURE A-7

PREPARED FOR:

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SUSITNA JOINT VENTURE

LOWER SUSITNA RIVER

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 63 TO 69

FIGURE A-8

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

KASHWITNA RIVER

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 59 TO 65

FIGURE A-9

PREPARED FOR:

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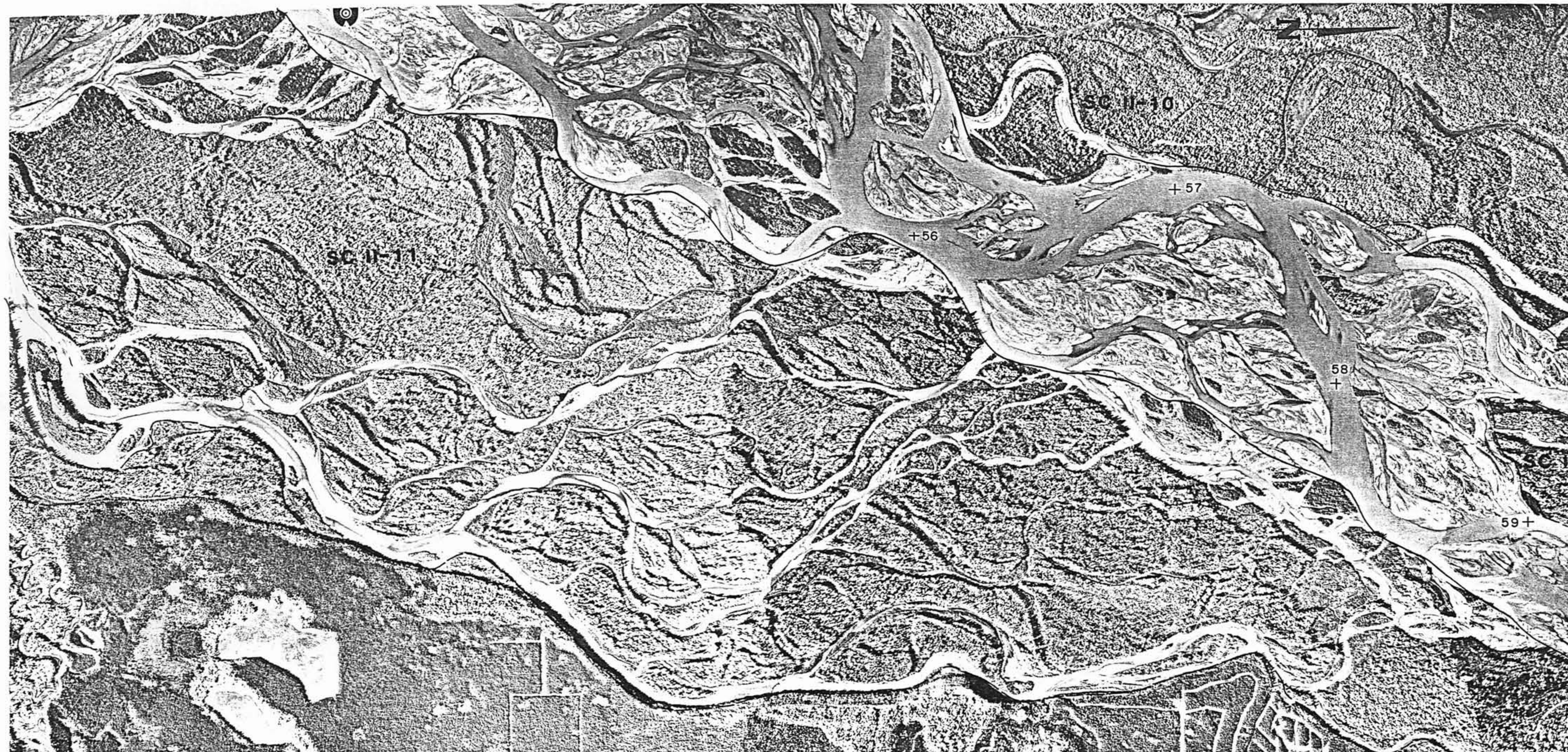
SUSITNA JOINT VENTURE



DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000
SCALE IN FEET

PREPARED BY:
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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION
RIVER MILE 56 TO 59

FIGURE A-10

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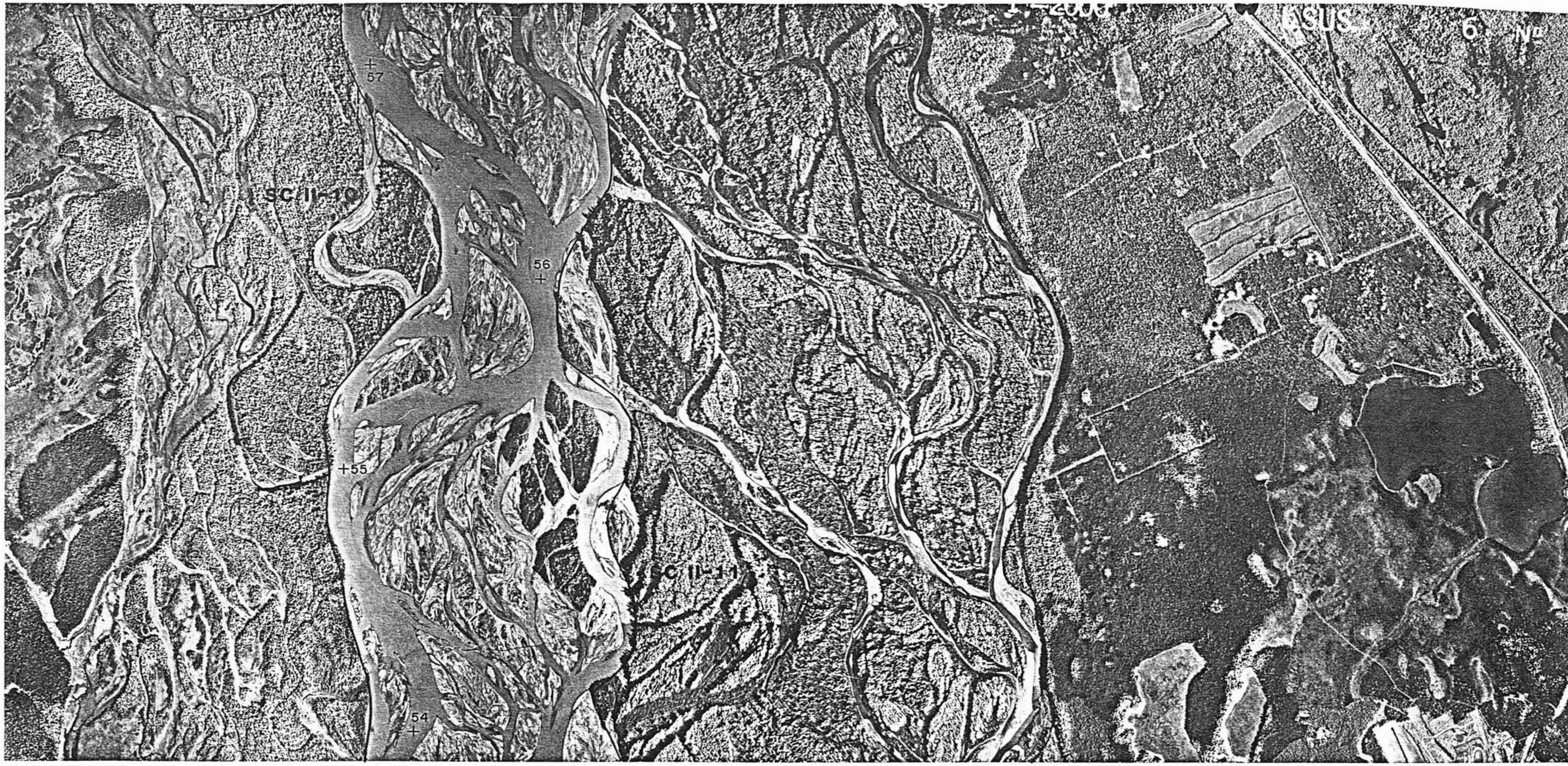
HARZA-EBASCO
SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

R&M CONSULTANTS, INC.

ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

EWT&A

E. WOODY TRIHEY & ASSOCIATES

MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

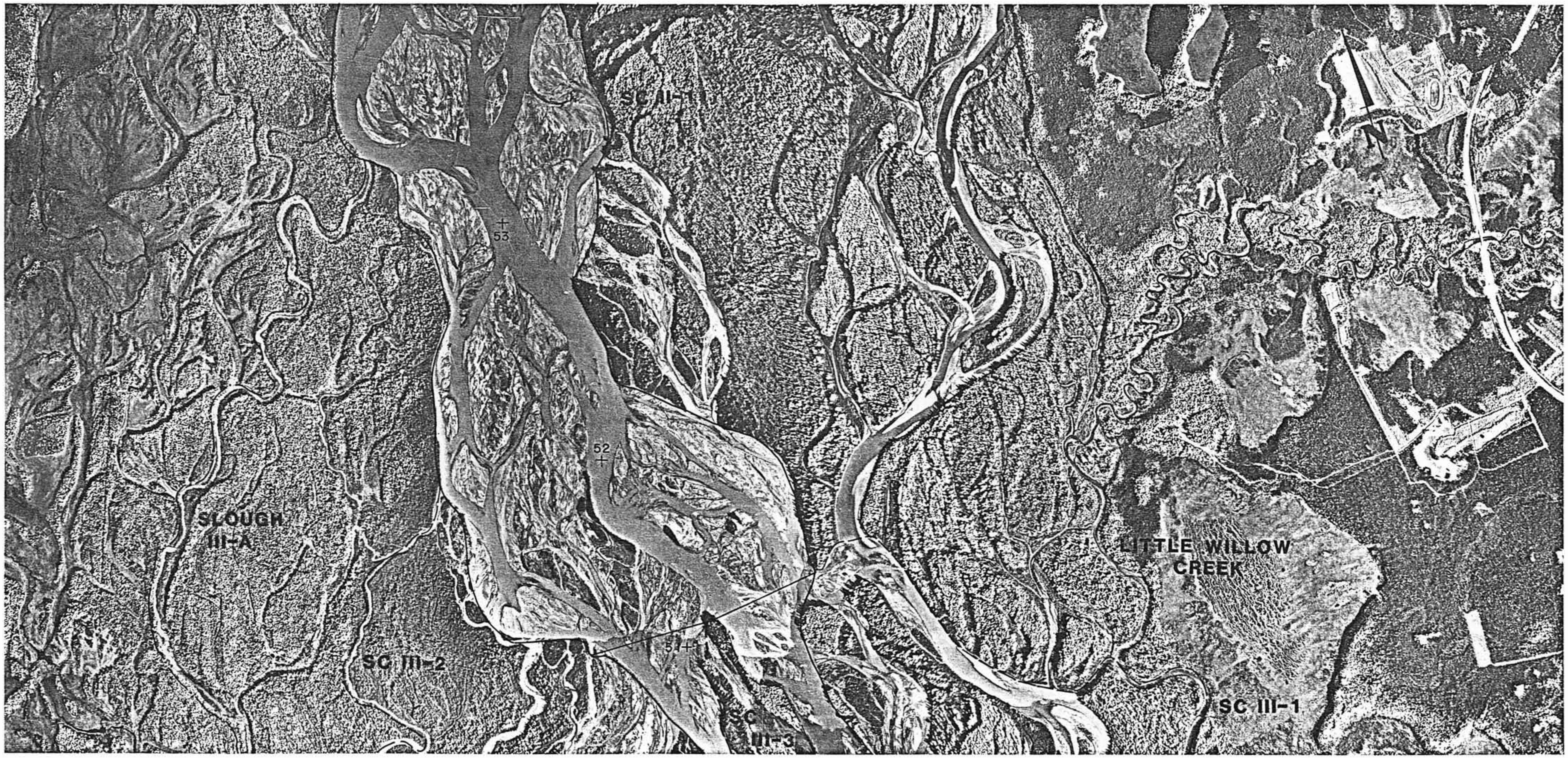
RIVER MILE 54 TO 57

FIGURE A-11

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



2000 1000 0 2000 4000

SCALE IN FEET

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

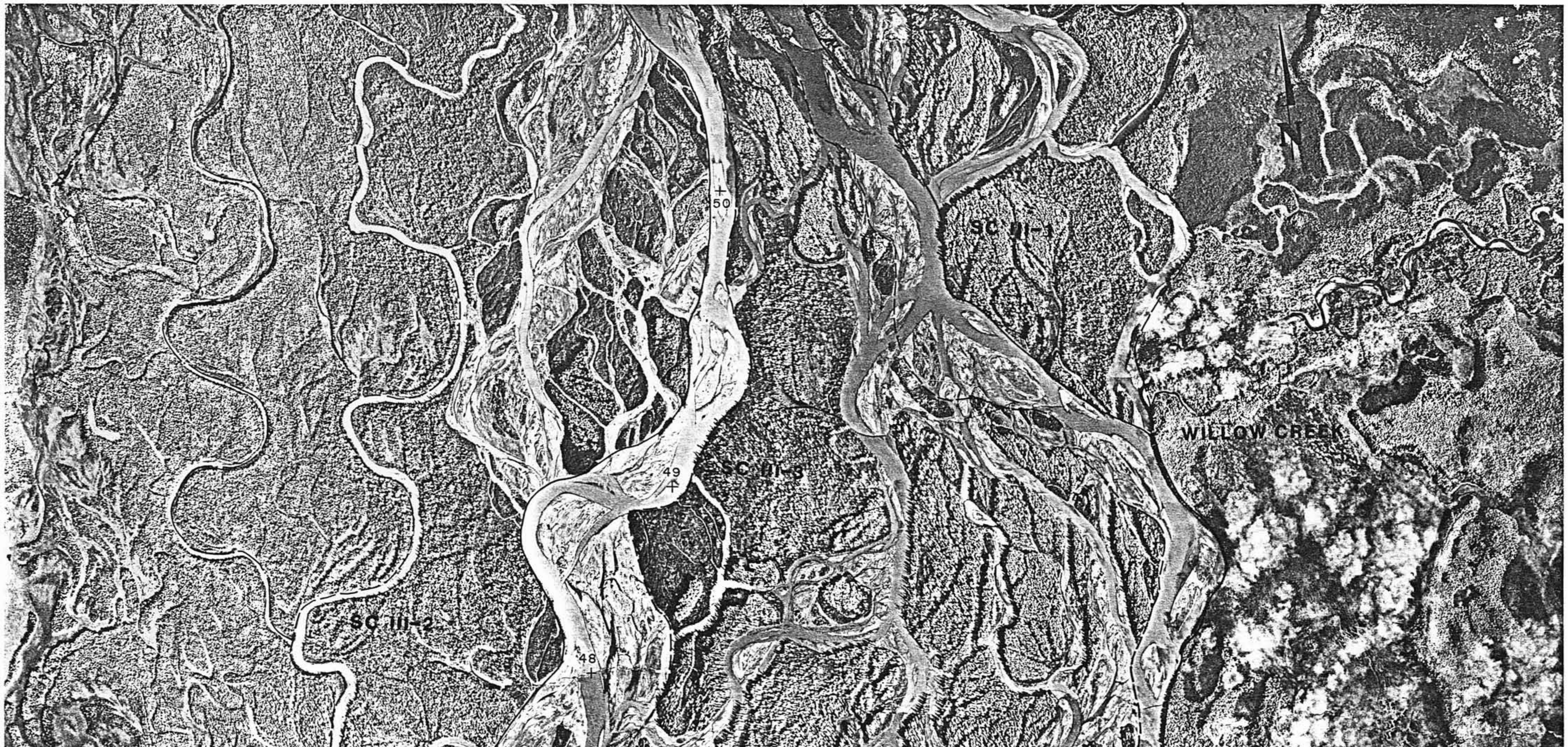
RIVER MILE 51 TO 53

FIGURE A-12

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



2000 1000 0 2000 4000

SCALE IN FEET

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 48 TO 50

FIGURE A-13

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 45 TO 47

FIGURE A-14

PREPARED FOR:

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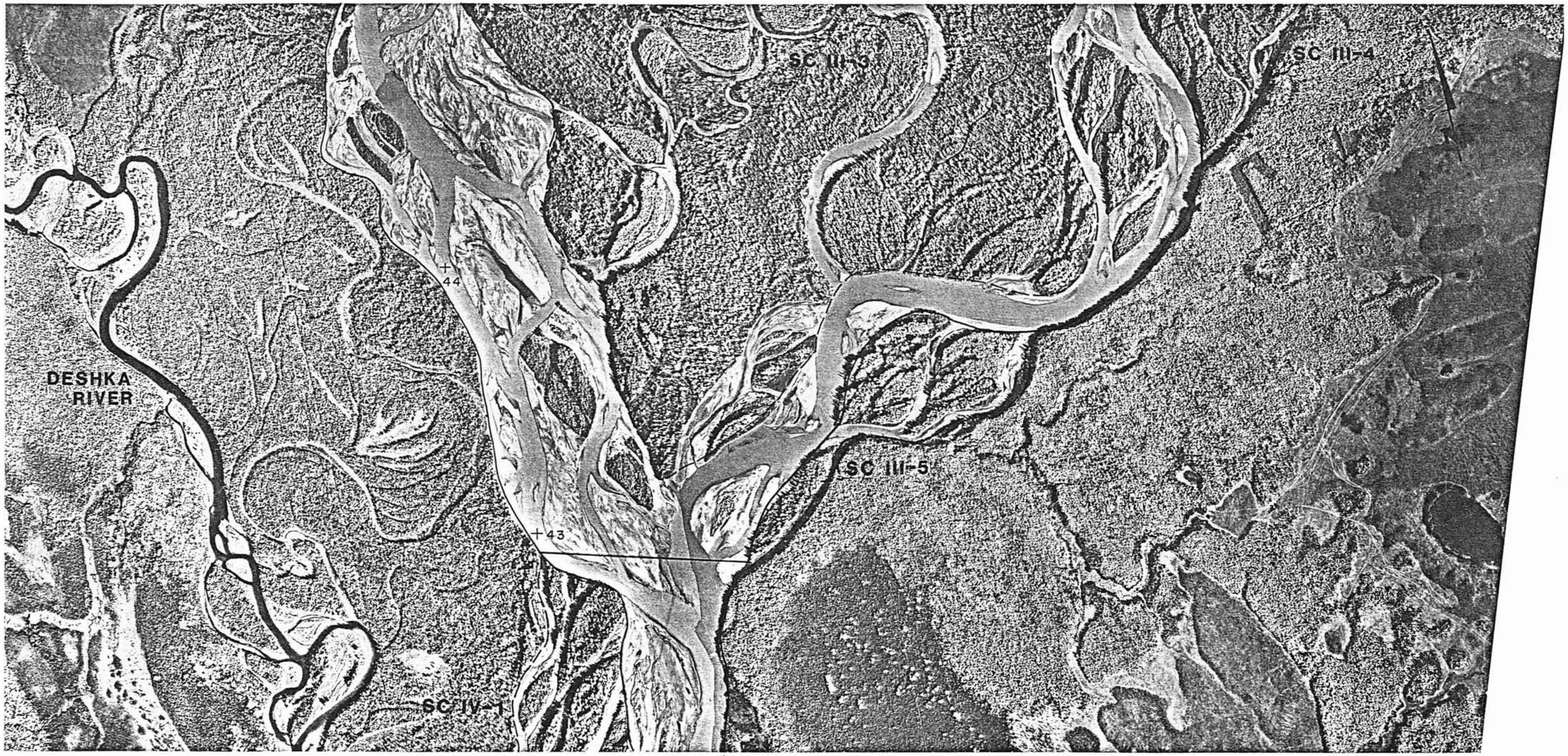
SUSITNA JOINT VENTURE



DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

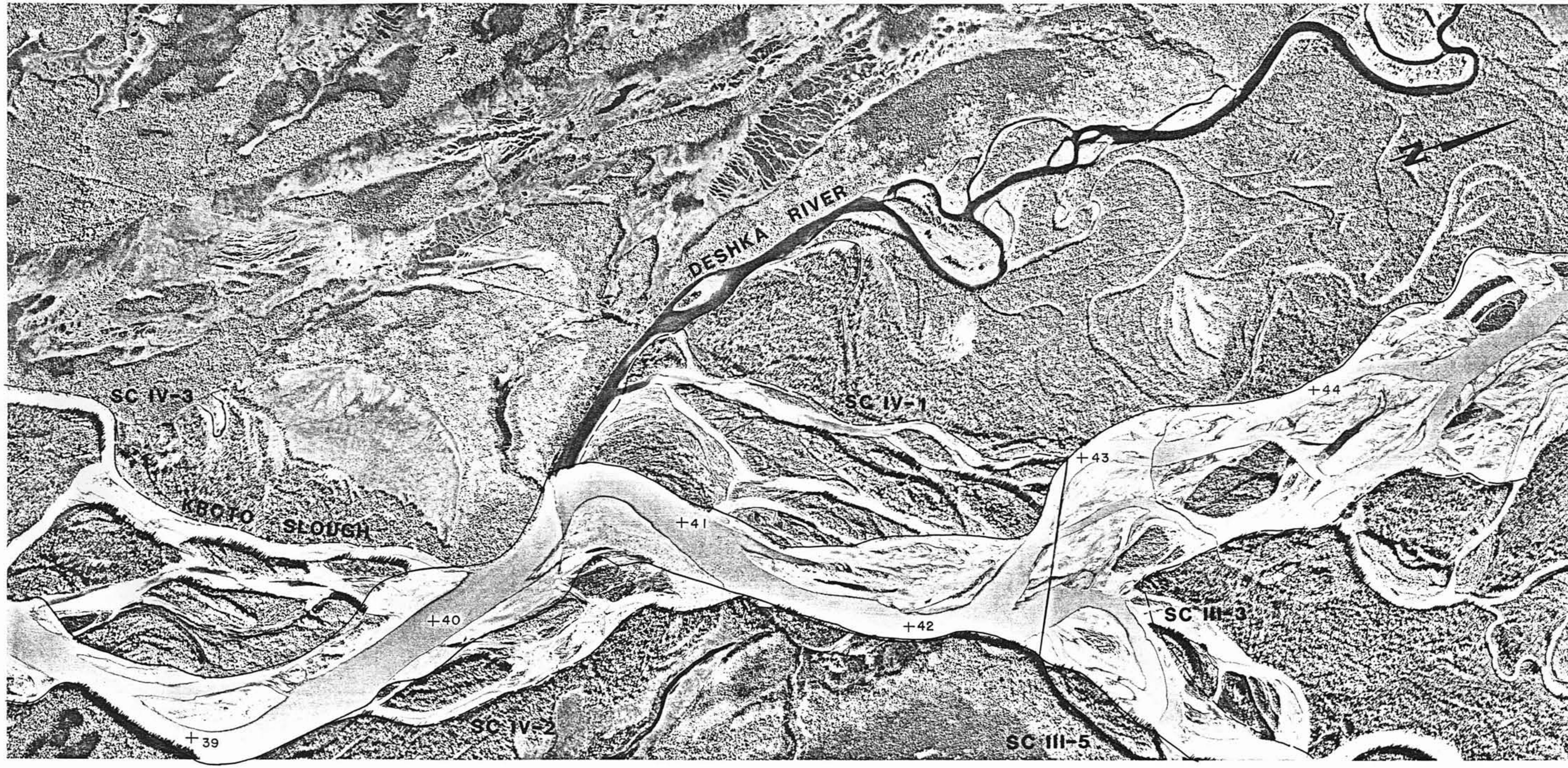
RIVER MILE 43 TO 44

FIGURE A-15

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 39 TO 44

FIGURE A-16

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

2000 1000 0 2000 4000

SCALE IN FEET

PREPARED BY:

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FIGURE A-17

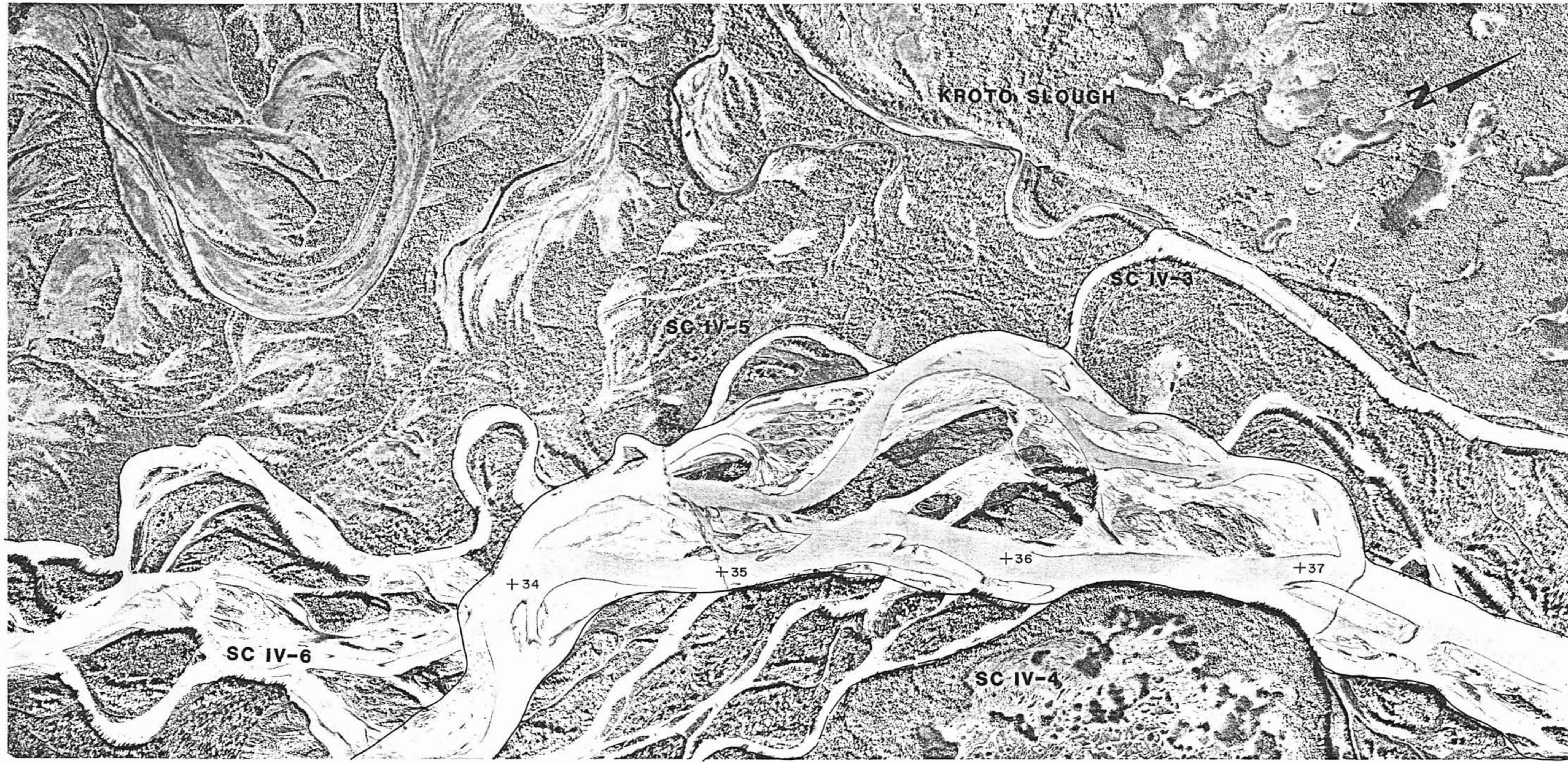
MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 36 TO 41

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



2000 1000 0 2000 4000

SCALE IN FEET

LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 34 TO 37

FIGURE A-18

PREPARED FOR:

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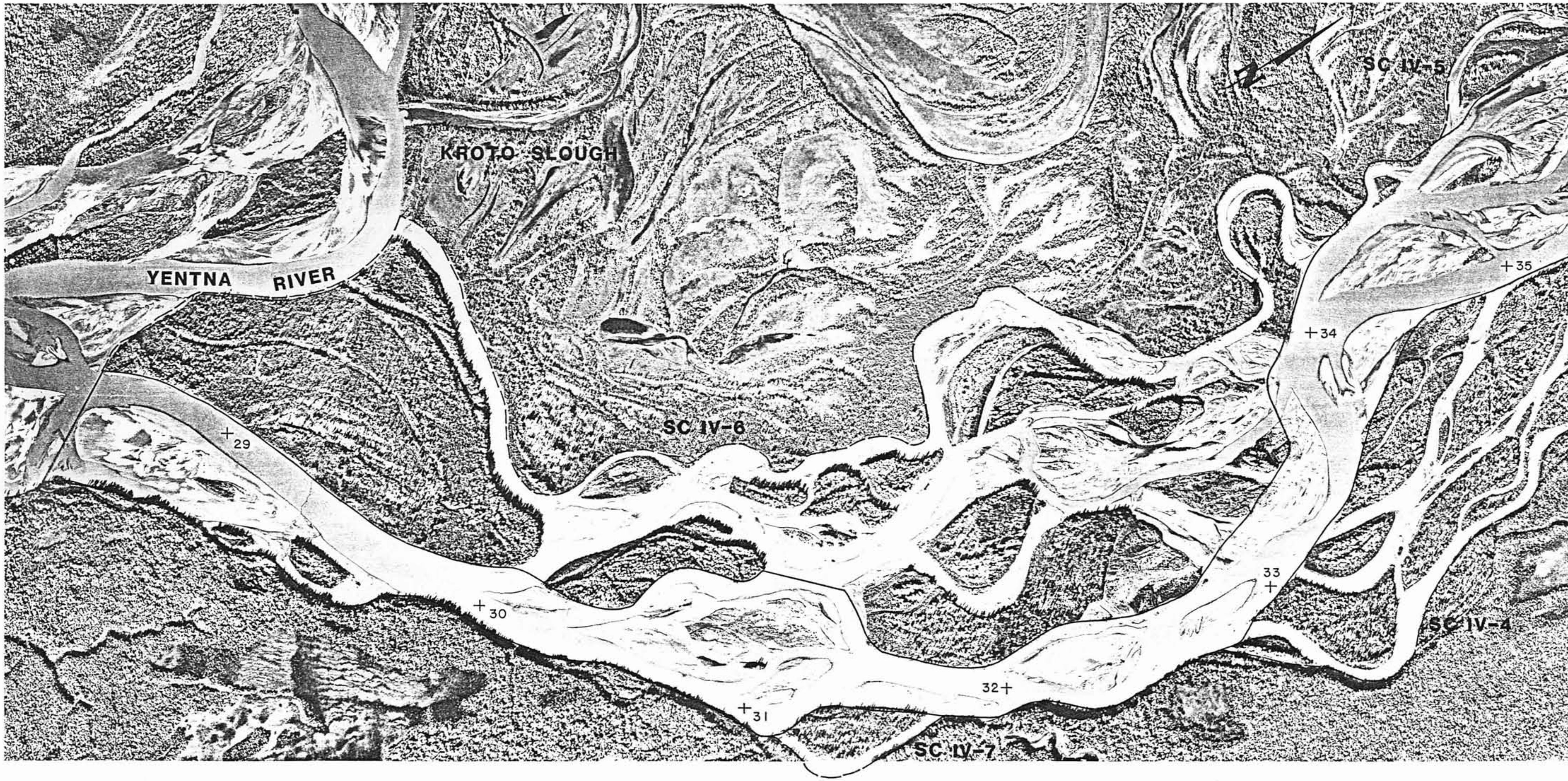
SUSITNA JOINT VENTURE



LOWER SUSITNA RIVER

DISCHARGE AT SUNSHINE: 21,100 cfs

DATE OF PHOTOGRAPHY: SEPTEMBER 16, 1983

PREPARED BY:

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MAINSTEM AND SIDE CHANNEL MORPHOLOGIC CLASSIFICATION

RIVER MILE 29 TO 35

FIGURE A-19

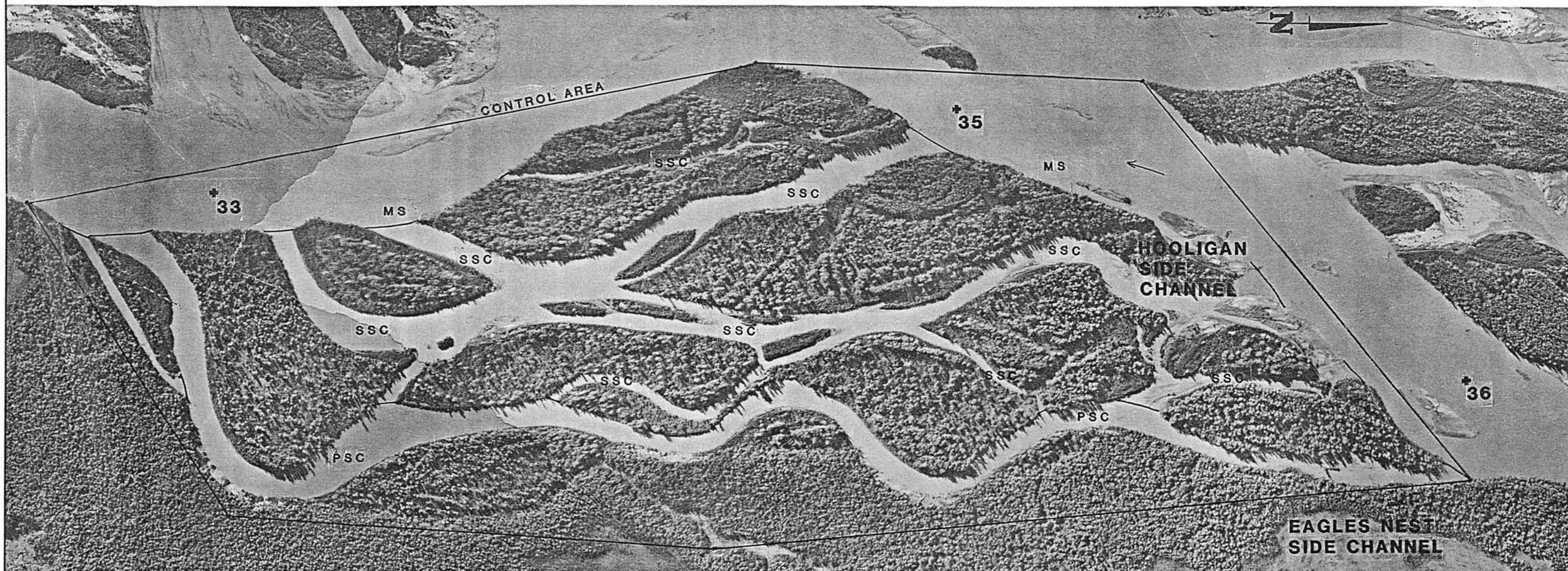
PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

EXHIBIT B

Aerial Photography for Selected Representative Areas Showing Habitat Types at Selected Mainstem Discharges.



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		✦	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:
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EWT&A

SC IV-4

DISCHARGE AT SUNSHINE: 75,200 cfs

FIGURE B-1

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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SC IV-4

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-2

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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EWT&A

SC IV-4

DISCHARGE AT SUNSHINE: 36,600 cfs

FIGURE B-3

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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SC IV-4

DISCHARGE AT SUNSHINE: 21,100 cfs

FIGURE B-4

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND			
MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		◆	RIVER MILE

DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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SC IV-4

DISCHARGE AT SUNSHINE: 13,900 cfs

FIGURE B-5

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

PREPARED BY:

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EWT&A

E. WOODY TRIHEY & ASSOCIATES

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		•	RIVER MILE

FIGURE B-6

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

PREPARED BY:

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LEGEND

MS	MAINSTEM
PSC	PRIMARY SIDE CHANNEL
SSC	SECONDARY SIDE CHANNEL
TB	TURBID BACKWATER
CW	CLEAR WATER AREA
SS	SIDE SLOUGH
TM	TRIBUTARY MOUTH
T	TRIBUTARY
◆	RIVER MILE

FIGURE B-7

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

PREPARED BY:

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ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

EWT&A

E. WOODY TRIHEY & ASSOCIATES

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		•	RIVER MILE

FIGURE B-8

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

PREPARED BY:

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LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		•	RIVER MILE

FIGURE B-9

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

PREPARED BY:

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LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

FIGURE B-10

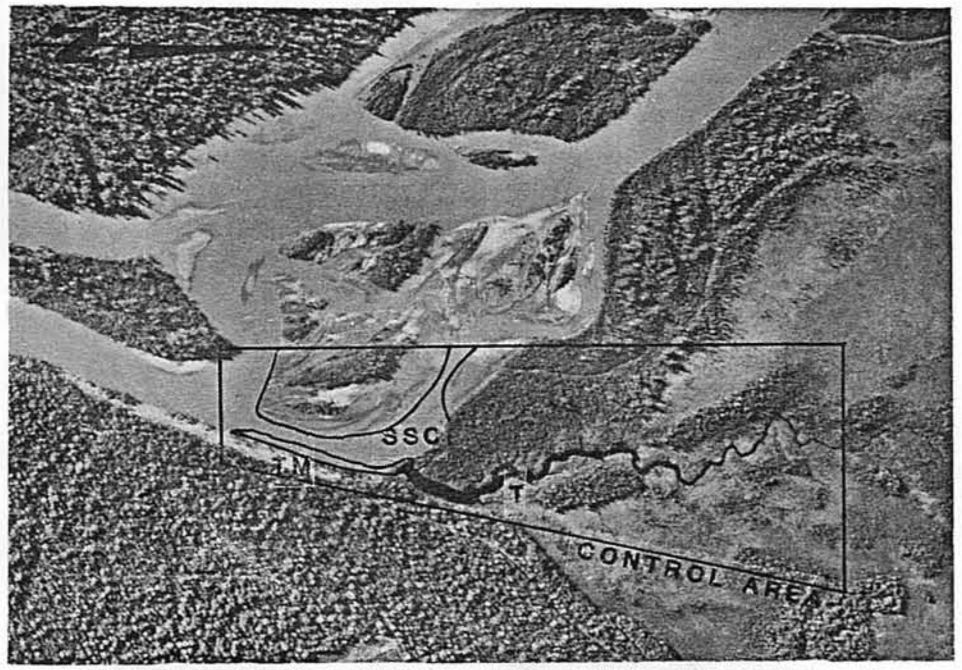
DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

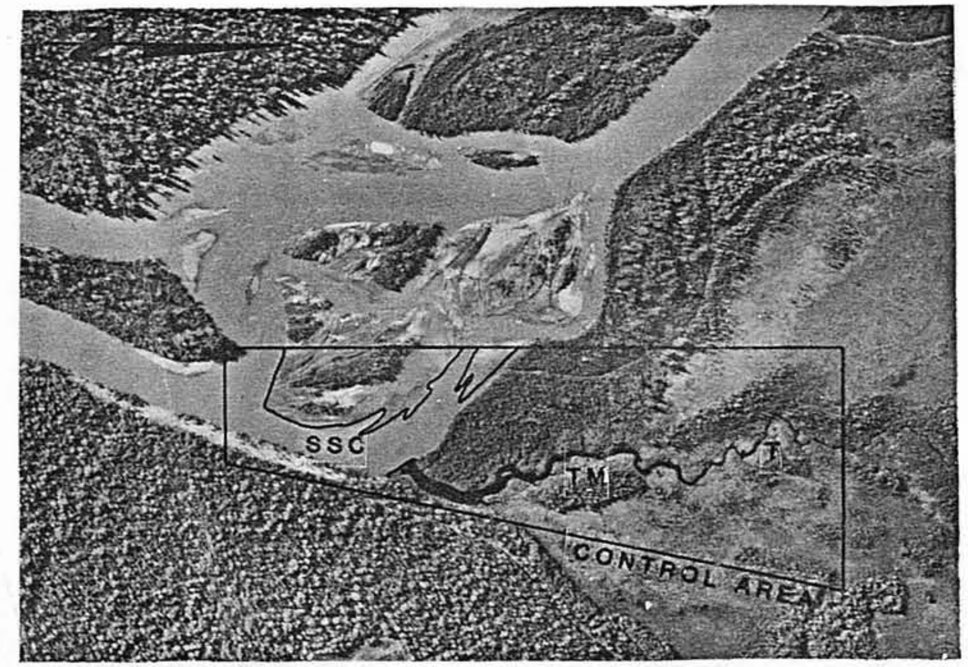
PREPARED FOR:

HARZA-EBASCO

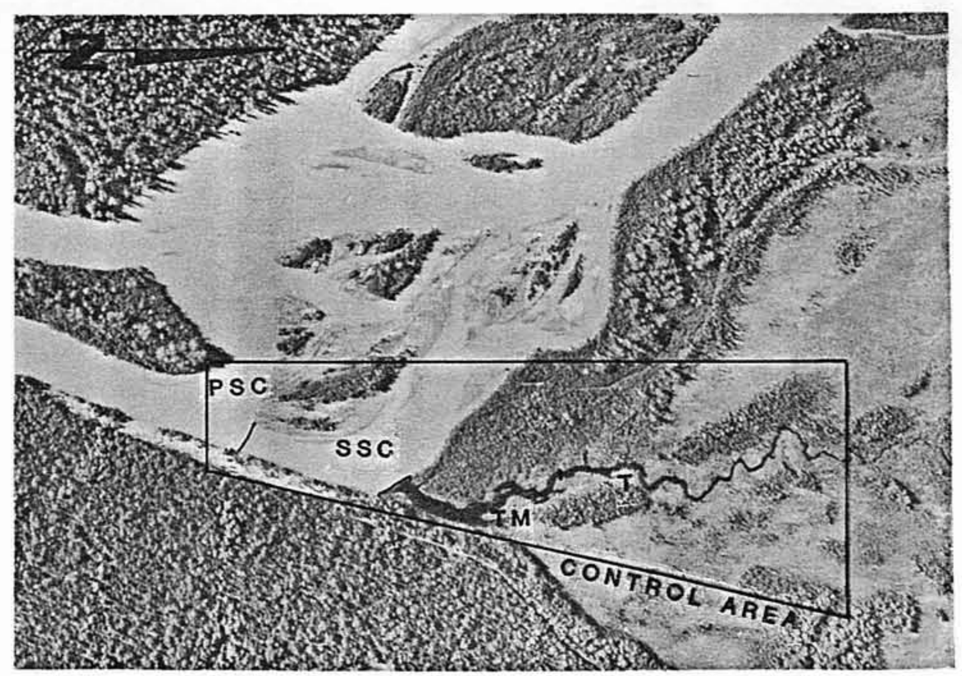
SUSITNA JOINT VENTURE



WETTED SURFACE AREA FOR 36,600 cfs



WETTED SURFACE AREA FOR 59,100 cfs



WETTED SURFACE AREA FOR 75,200 cfs

DATE OF PHOTOGRAPHY: 8/27/84

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

LEGEND

MS	MAINSTEM	SS	SIDE SLOUGH
PSC	PRIMARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
SSC	SECONDARY SIDE CHANNEL	T	TRIBUTARY
TB	TURBID BACKWATER	◆	RIVER MILE

PREPARED BY:

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E. WOODY TRIHEY & ASSOCIATES

CASWELL CREEK

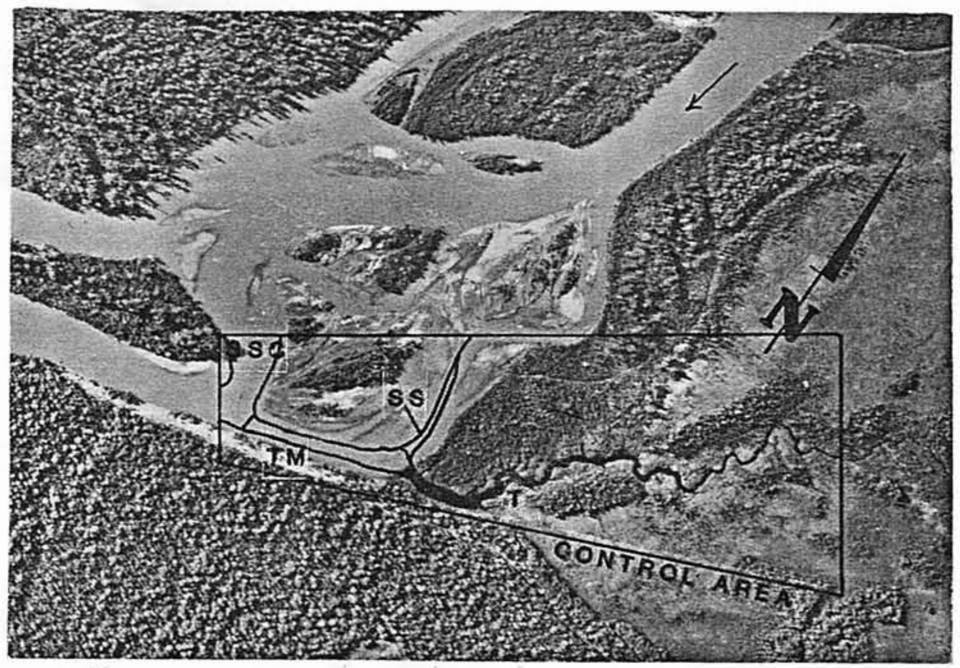
DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-11

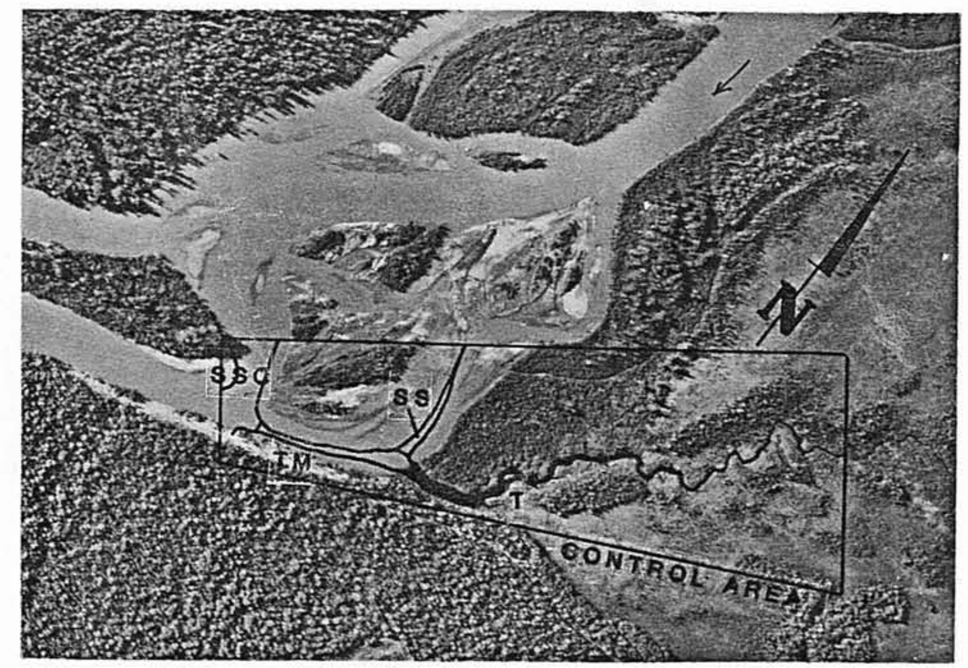
PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



WETTED SURFACE AREA FOR 21,100



WETTED SURFACE AREA FOR 13,900

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		◆	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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E. WOODY TRIHEY & ASSOCIATES

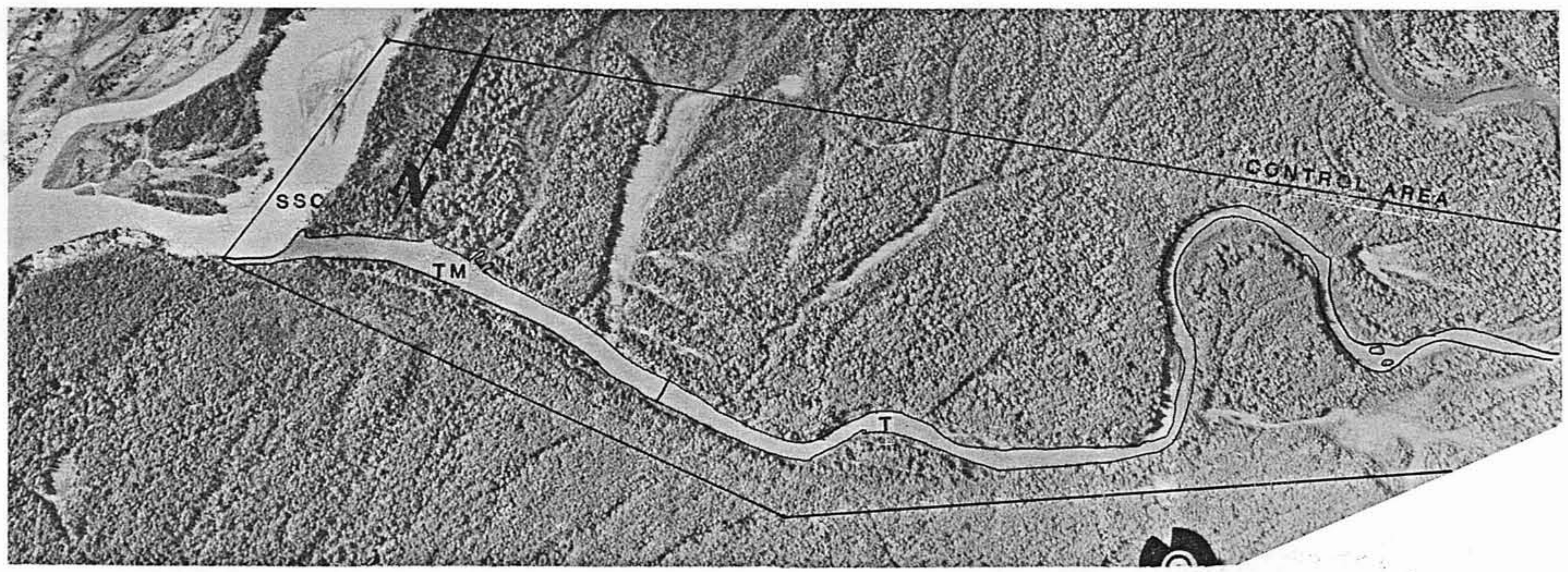
CASWELL CREEK

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-12

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		◆	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

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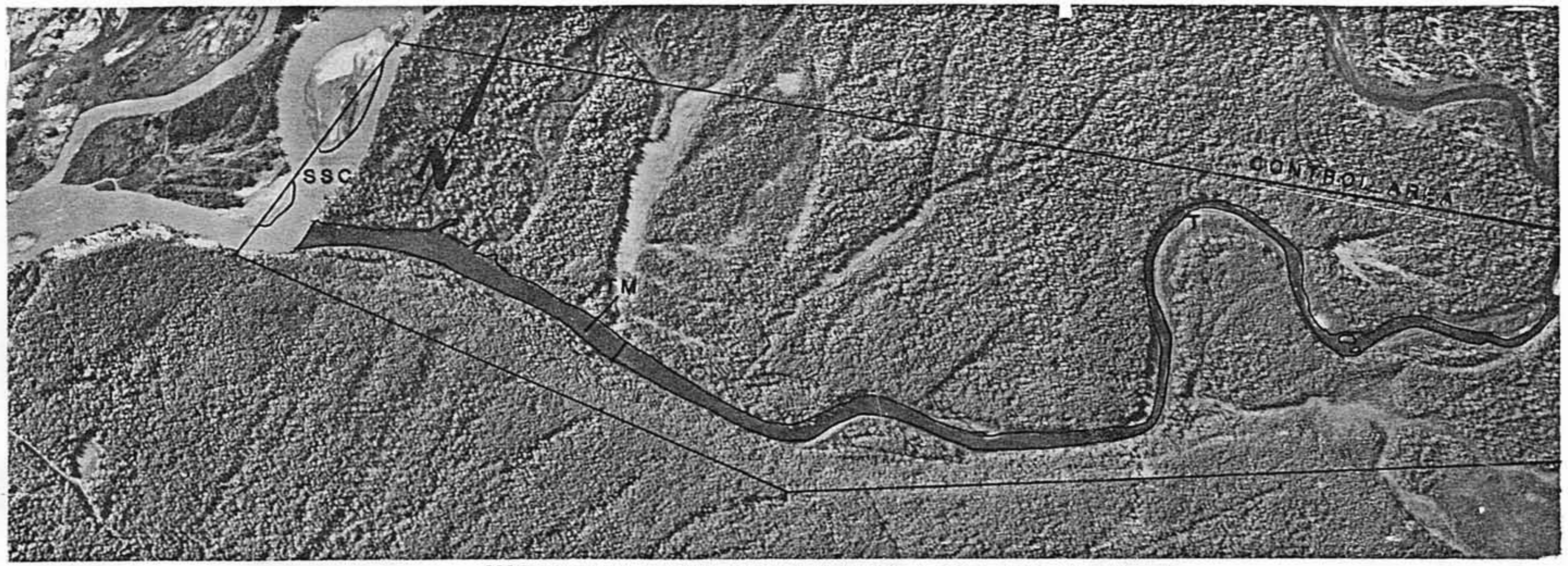
FIGURE B-13

SHEEP CREEK

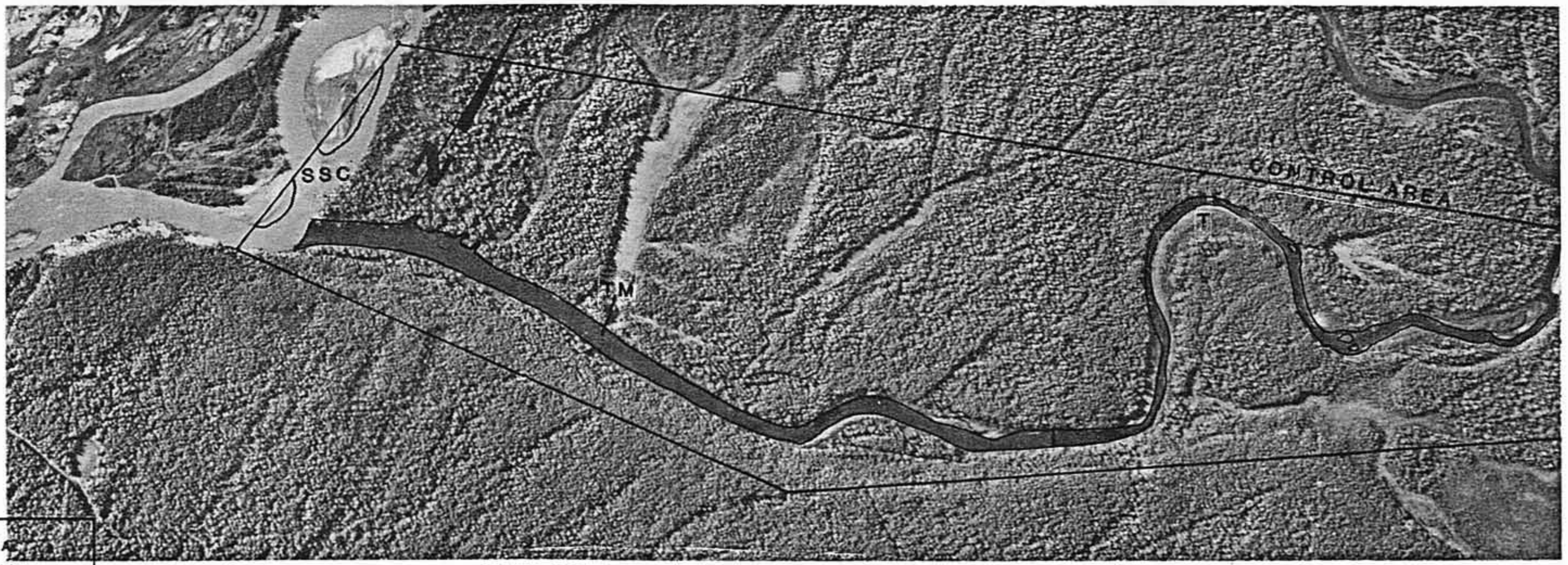
DISCHARGE AT SUNSHINE: 75,200 cfs

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE



WETTED SURFACE AREA FOR 59,100 cfs



WETTED SURFACE AREA FOR 36,600 cfs

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		◆	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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SHEEP CREEK

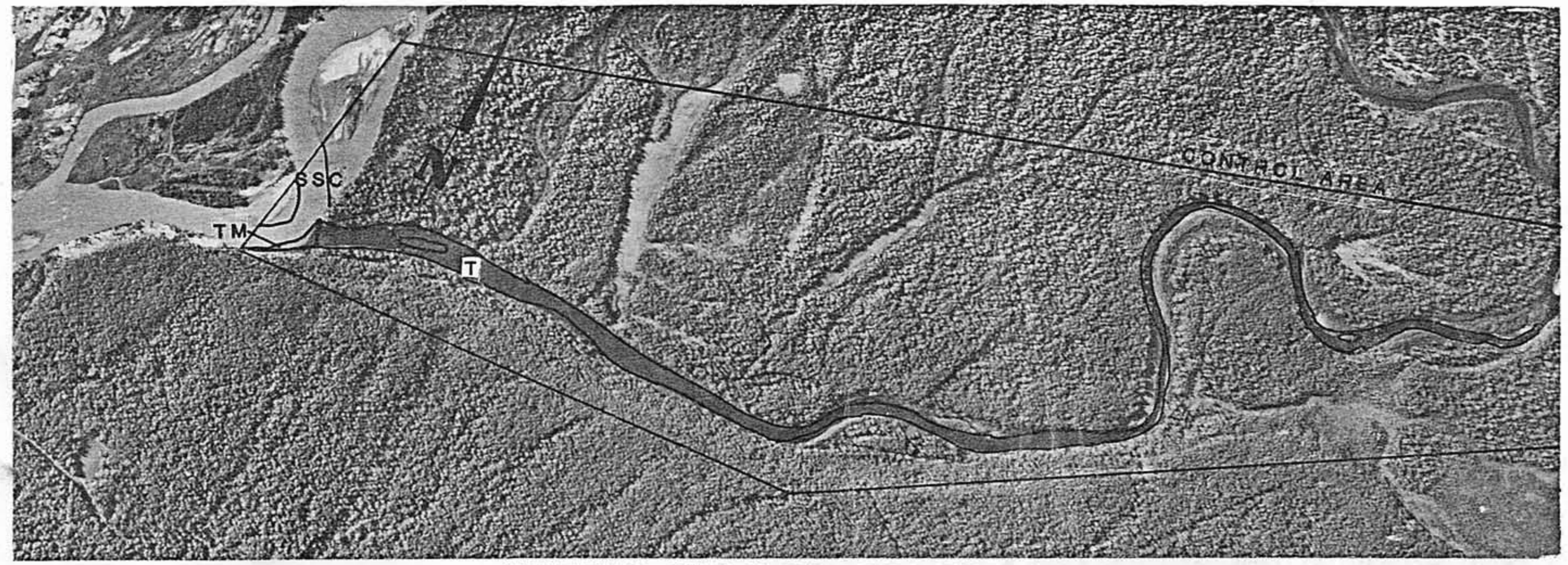
DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-14

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



WETTED SURFACE AREA FOR 21,100 cfs

WETTED SURFACE AREA FOR 13,900 cfs

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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FIGURE B-15

SHEEP CREEK

DISCHARGE AT SUNSHINE: 59,100 cfs

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND

MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
* RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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GOOSE CREEK 1 of 2

DISCHARGE AT SUNSHINE: 75,200 cfs

FIGURE B-16

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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GOOSE CREEK 2 of 2

DISCHARGE AT SUNSHINE: 75,200 cfs

FIGURE B-16

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND
MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
+ RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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GOOSE CREEK 1 of 2

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-17

PREPARED FOR:
HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
+ RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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GOOSE CREEK 2 of 2

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-17

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

- MS MAINSTEM
- PSC PRIMARY SIDE CHANNEL
- SSC SECONDARY SIDE CHANNEL
- TB TURBID BACKWATER
- CW CLEAR WATER AREA
- SS SIDE SLOUGH
- TM TRIBUTARY MOUTH
- T TRIBUTARY
- * RIVER MILE

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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GOOSE CREEK 1 of 2

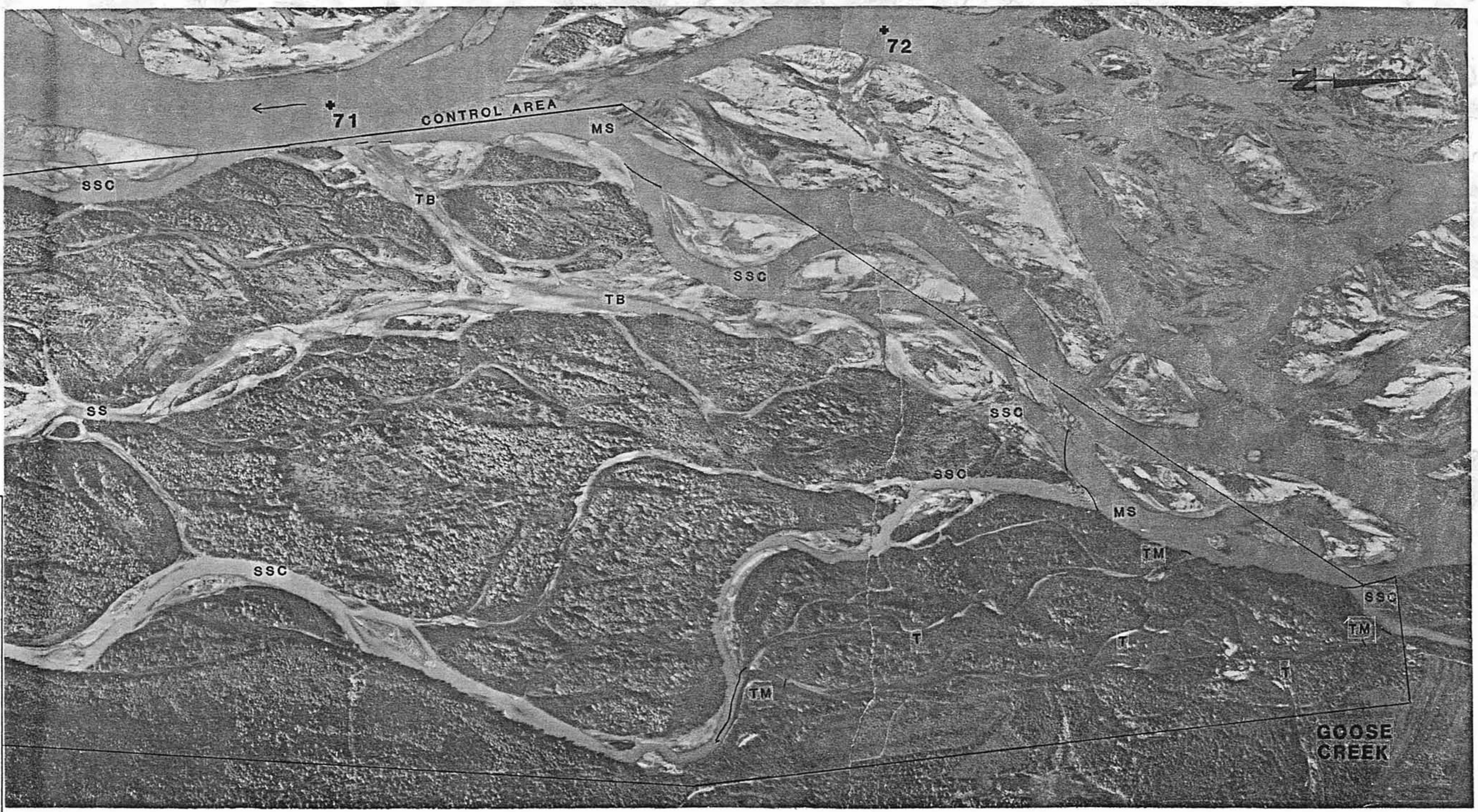
DISCHARGE AT SUNSHINE: 36,600 cfs

FIGURE B-18

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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EWT&A

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GOOSE CREEK 2 of 2

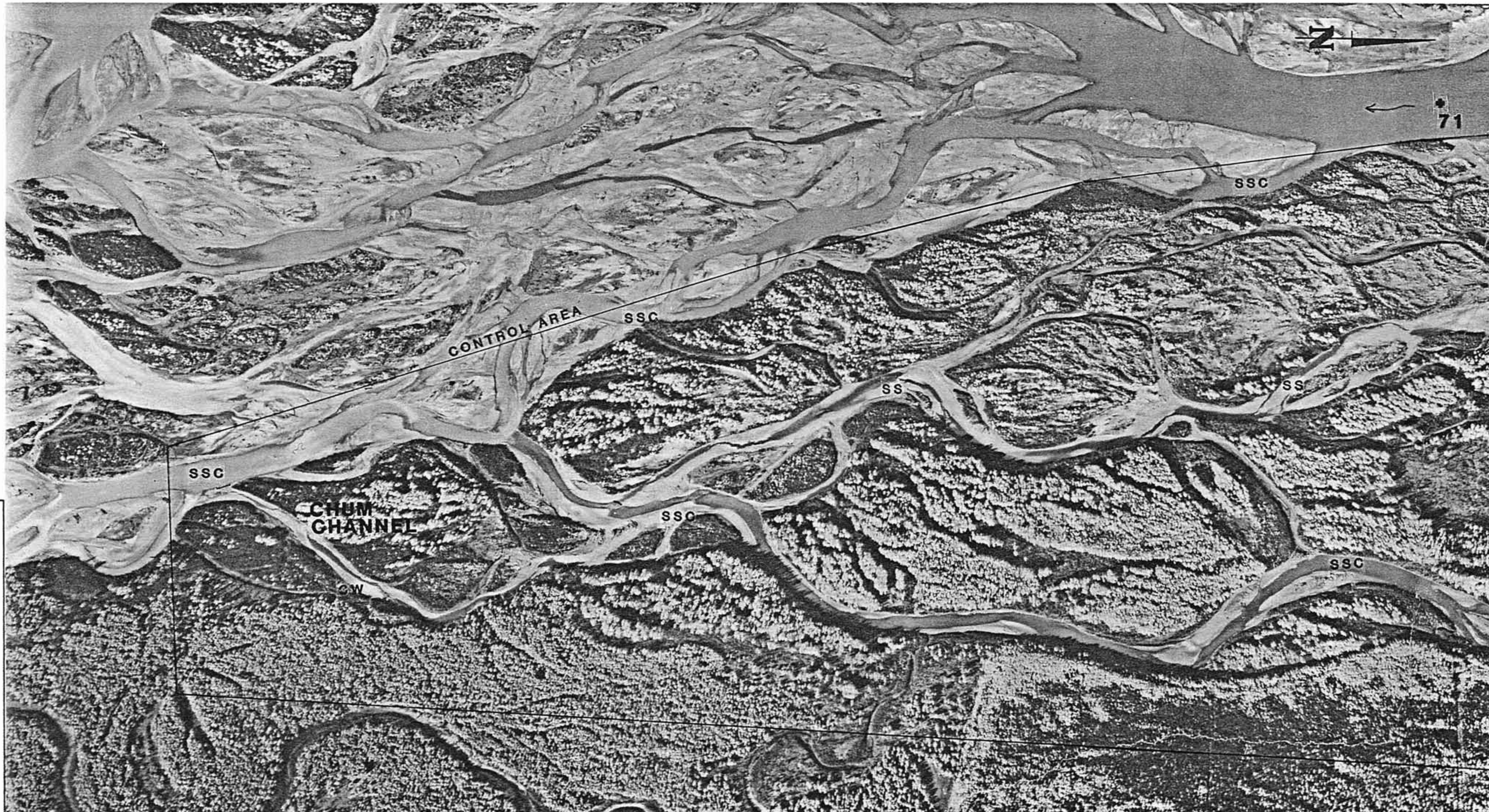
DISCHARGE AT SUNSHINE: 36,600 cfs

FIGUREB-18

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND

MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
◆ RIVER MILE

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

EWT&A
E. WOODY TRIHEY & ASSOCIATES

GOOSE CREEK 1 of 2

DISCHARGE AT SUNSHINE: 21,100 cfs

FIGURE B-19

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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E. WOODY TRIHEY & ASSOCIATES

GOOSE CREEK 2 of 2

DISCHARGE AT SUNSHINE: 21,100 cfs

FIGURE B-19

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND
MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
◆ RIVER MILE

DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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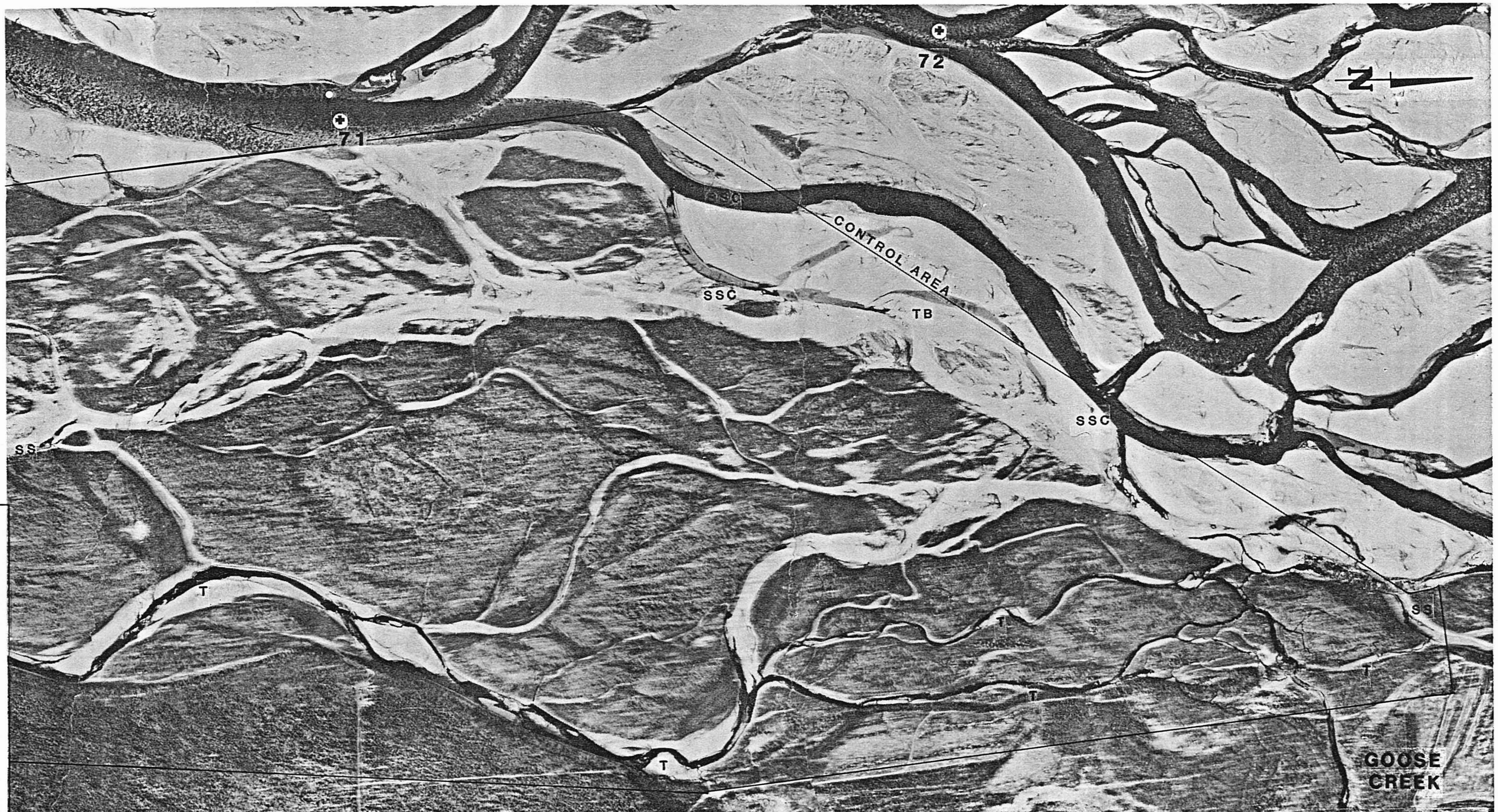
GOOSE CREEK 1 of 2

DISCHARGE AT SUNSHINE: 13,900 cfs

FIGURE B-20

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		✚	RIVER MILE

DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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E. WOODY TRIHEY & ASSOCIATES

GOOSE CREEK 2 of 2

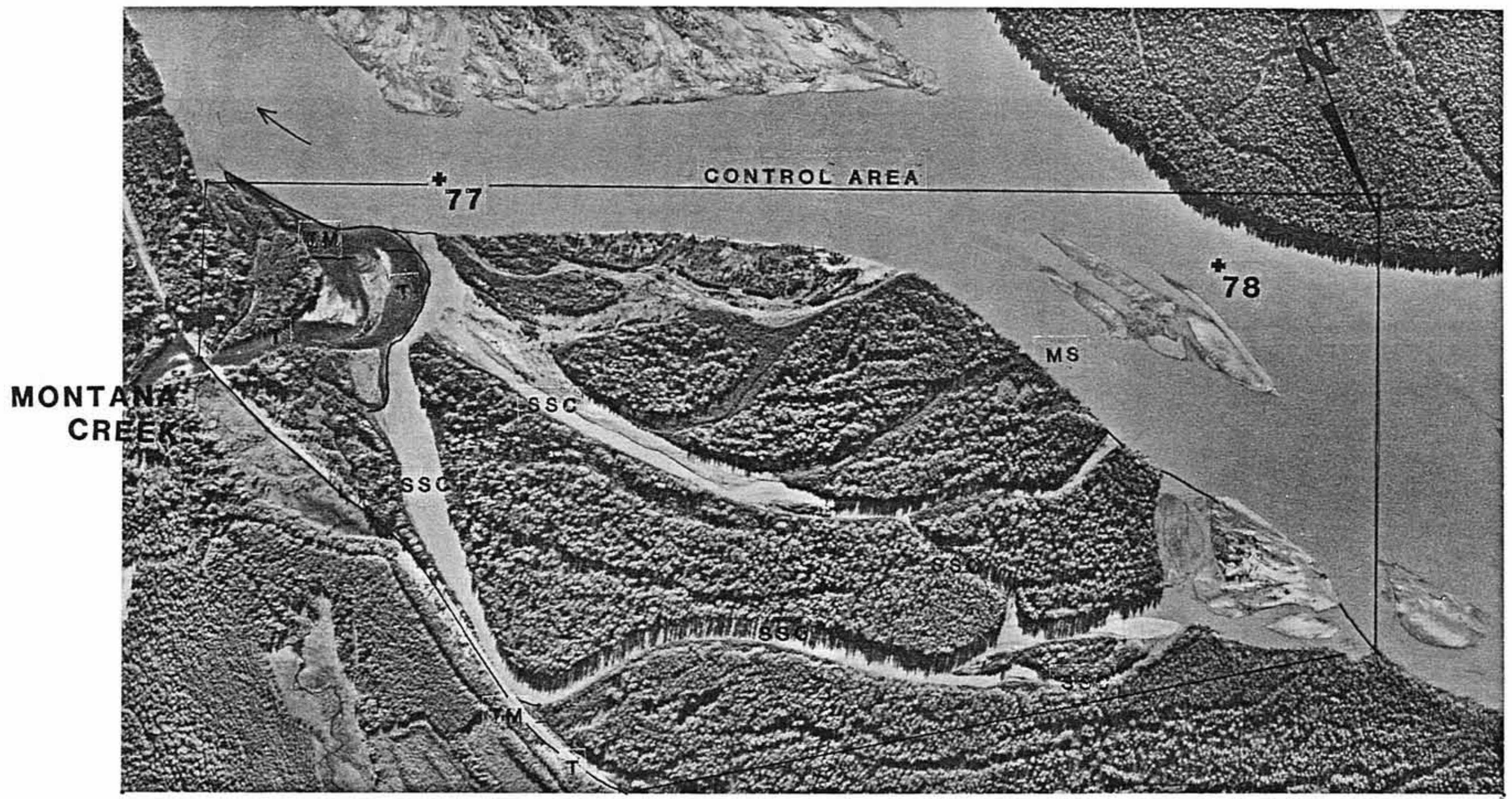
DISCHARGE AT SUNSHINE: 13,900 cfs

FIGURE B-20

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND			
MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		✦	RIVER MILE

DATE OF PHOTOGRAPHY: 9/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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E. WOODY TROREY & ASSOCIATES

MONTANA CREEK

DISCHARGE AT SUNSHINE: 75,200 cfs

FIGURE B-21

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

MONTANA
CREEK

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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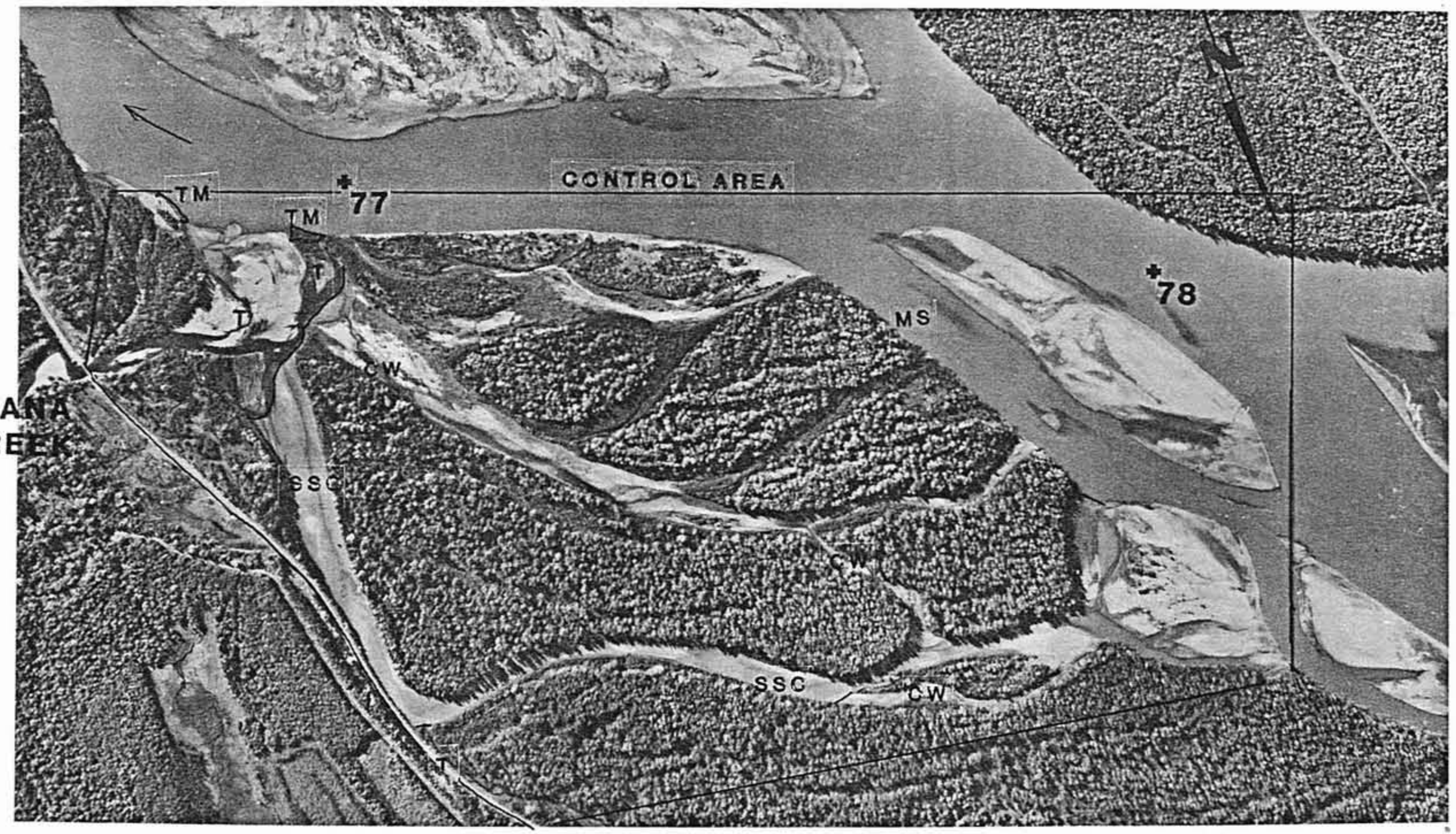
MONTANA CREEK

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-22

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		✦	RIVER MILE

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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E. WOODY TRIHEY & ASSOCIATES

MONTANA CREEK

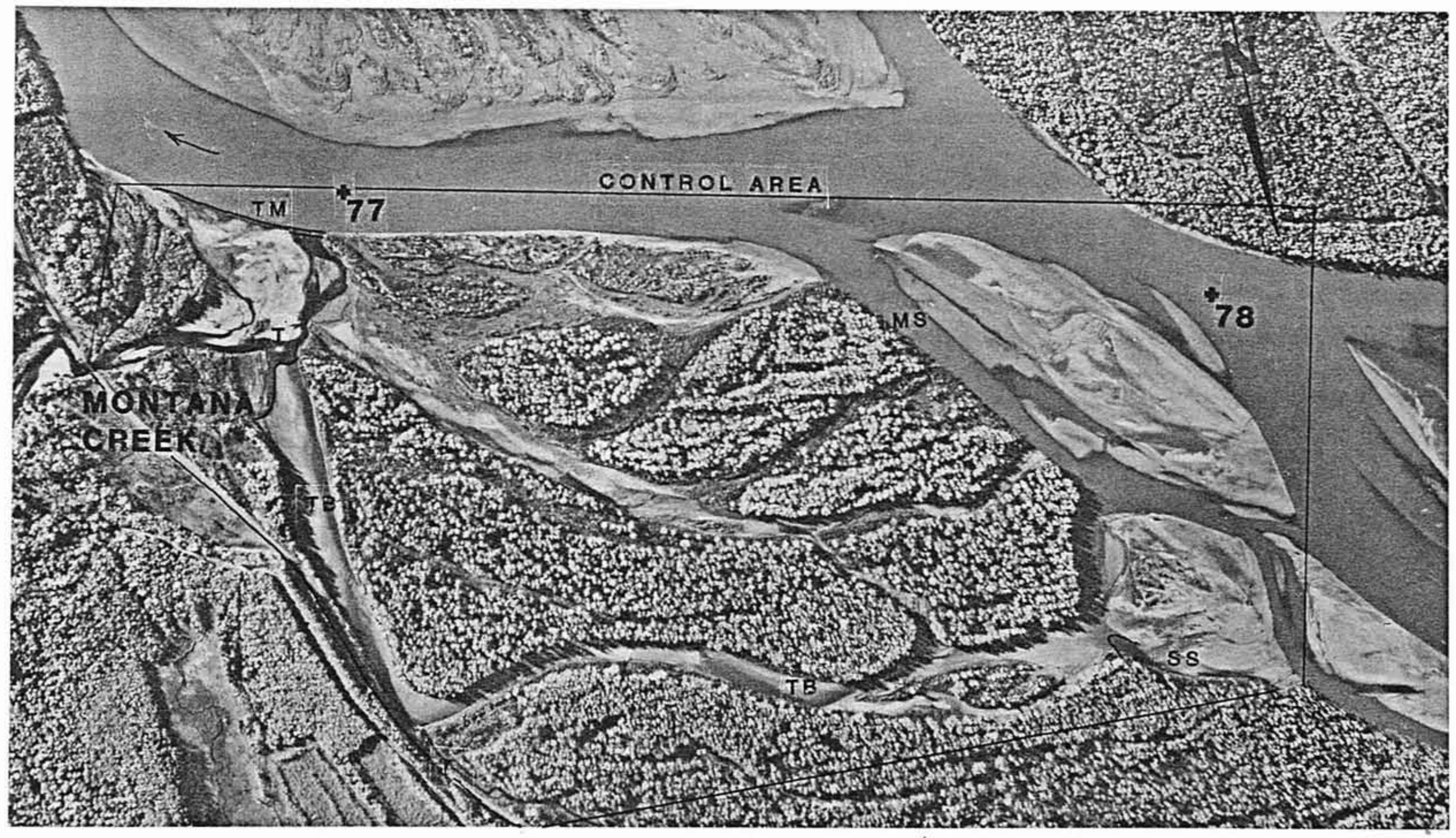
DISCHARGE AT SUNSHINE: 36,600 cfs

FIGURE B-23

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		✦	RIVER MILE

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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MONTANA CREEK

DISCHARGE AT SUNSHINE: 21,100 cfs

FIGURE B-24

PREPARED FOR:

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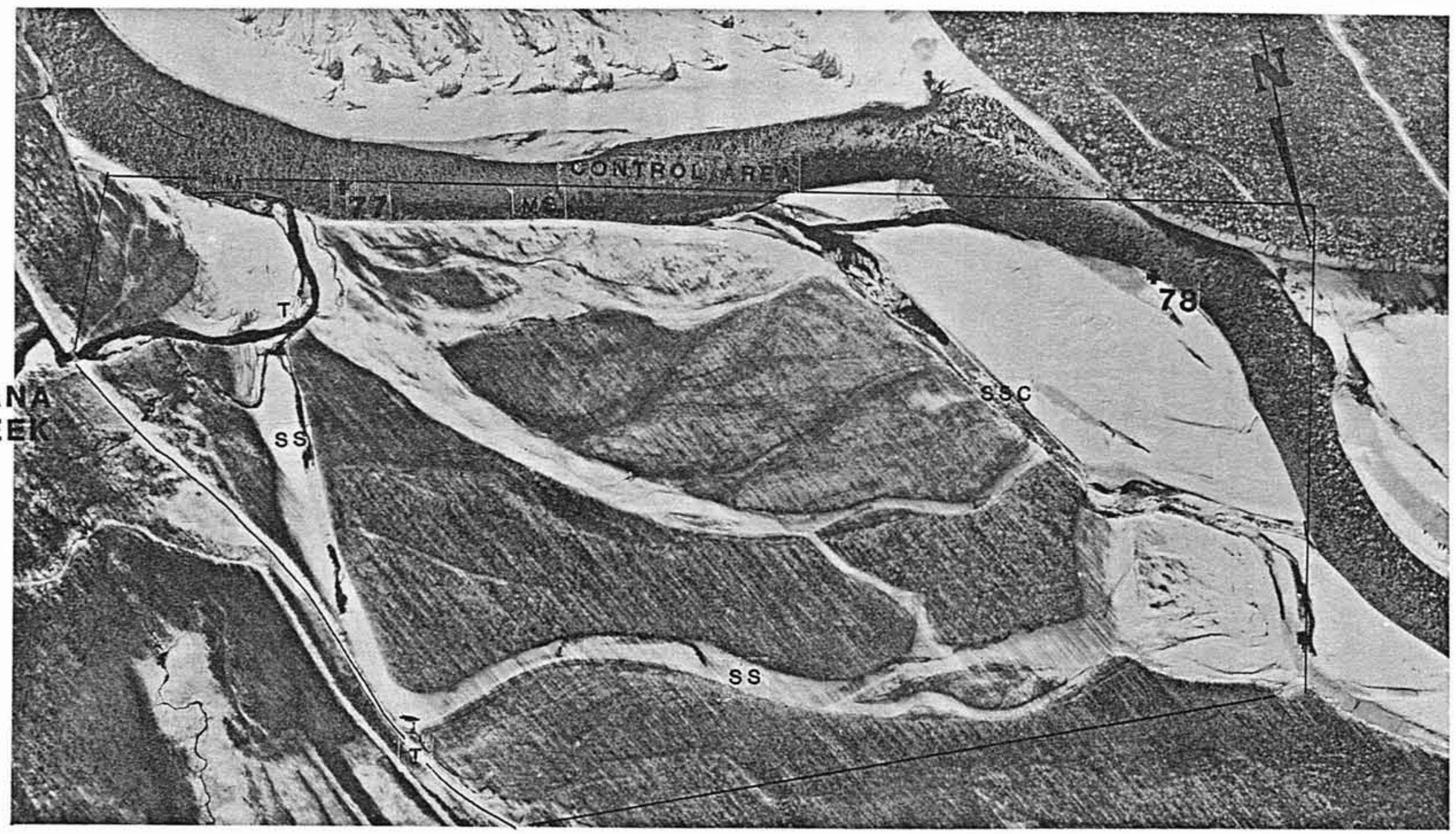
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		◆	RIVER MILE

DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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EWT&A

E. WOODY TRIHEY & ASSOCIATES

MONTANA CREEK

DISCHARGE AT SUNSHINE: 13,900 cfs

FIGURE B-25

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		*	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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EWT&A
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SUNSHINE SLOUGH 1 of 2

DISCHARGE AT SUNSHINE: 75,200 cfs

FIGURE B-26

PREPARED FOR:

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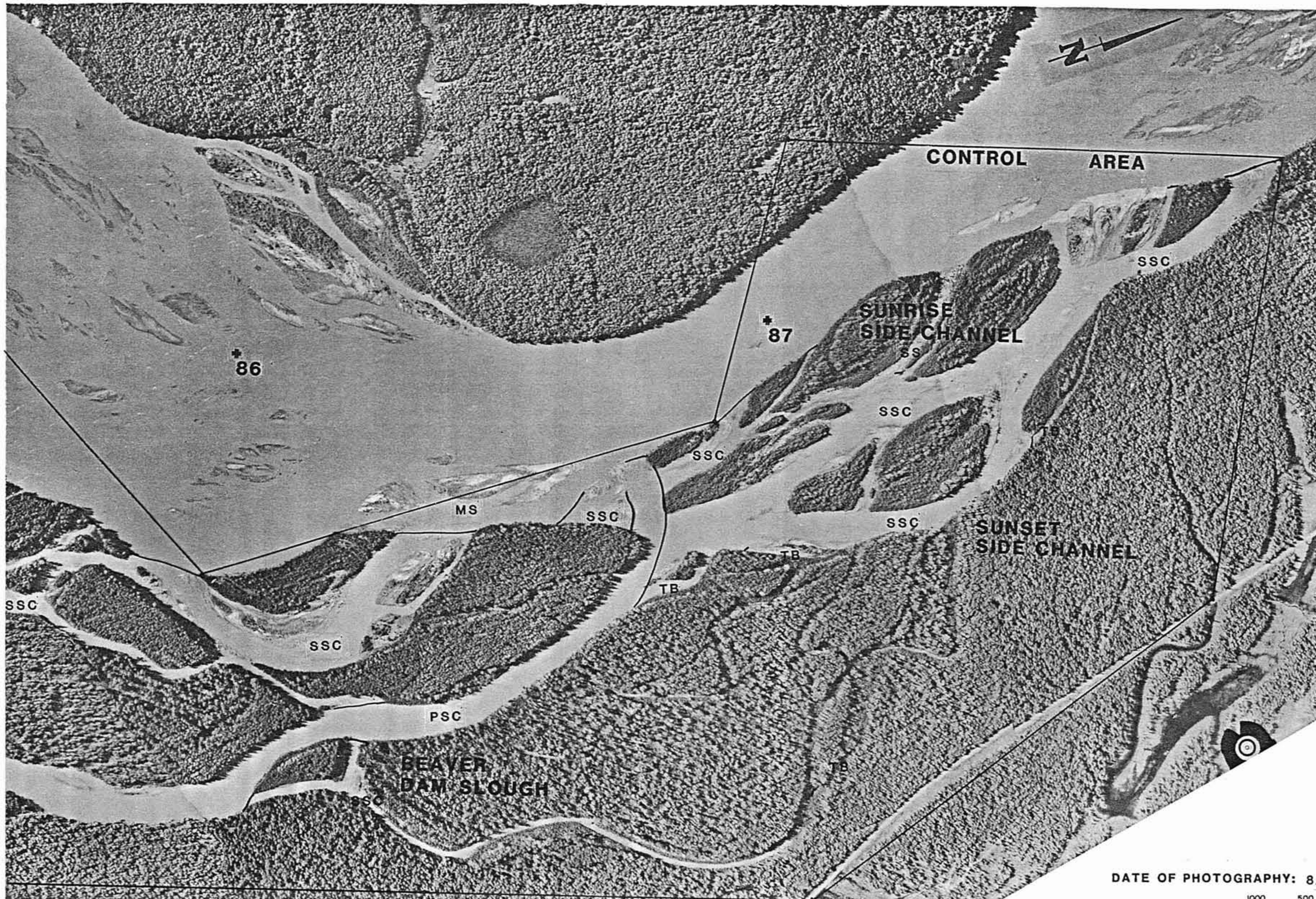
SUSITNA JOINT VENTURE



LEGEND
MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
✦ RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/84

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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ENGINEERS GEOLOGISTS HYDROLOGISTS SURVEYORS

EWT&A

E. WOODY TRIHEY & ASSOCIATES

SUNSHINE SLOUGH 2 of 2

DISCHARGE AT SUNSHINE: 75,200 cfs

FIGURE B-26

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND

- MS MAINSTEM
- PSC PRIMARY SIDE CHANNEL
- SSC SECONDARY SIDE CHANNEL
- TB TURBID BACKWATER
- CW CLEAR WATER AREA
- SS SIDE SLOUGH
- TM TRIBUTARY MOUTH
- T TRIBUTARY
- + RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

PREPARED BY:

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SUNSHINE SLOUGH 1 of 2

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-27

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		+	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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SUNSHINE SLOUGH 2 of 2

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-27

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND

MS	MAINSTEM
PSC	PRIMARY SIDE CHANNEL
SSC	SECONDARY SIDE CHANNEL
TB	TURBID BACKWATER
CW	CLEAR WATER AREA
SS	SIDE SLOUGH
TM	TRIBUTARY MOUTH
T	TRIBUTARY
+	RIVER MILE

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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EWT&A

E. WOODY TRIHEY & ASSOCIATES

FIGURE B-28

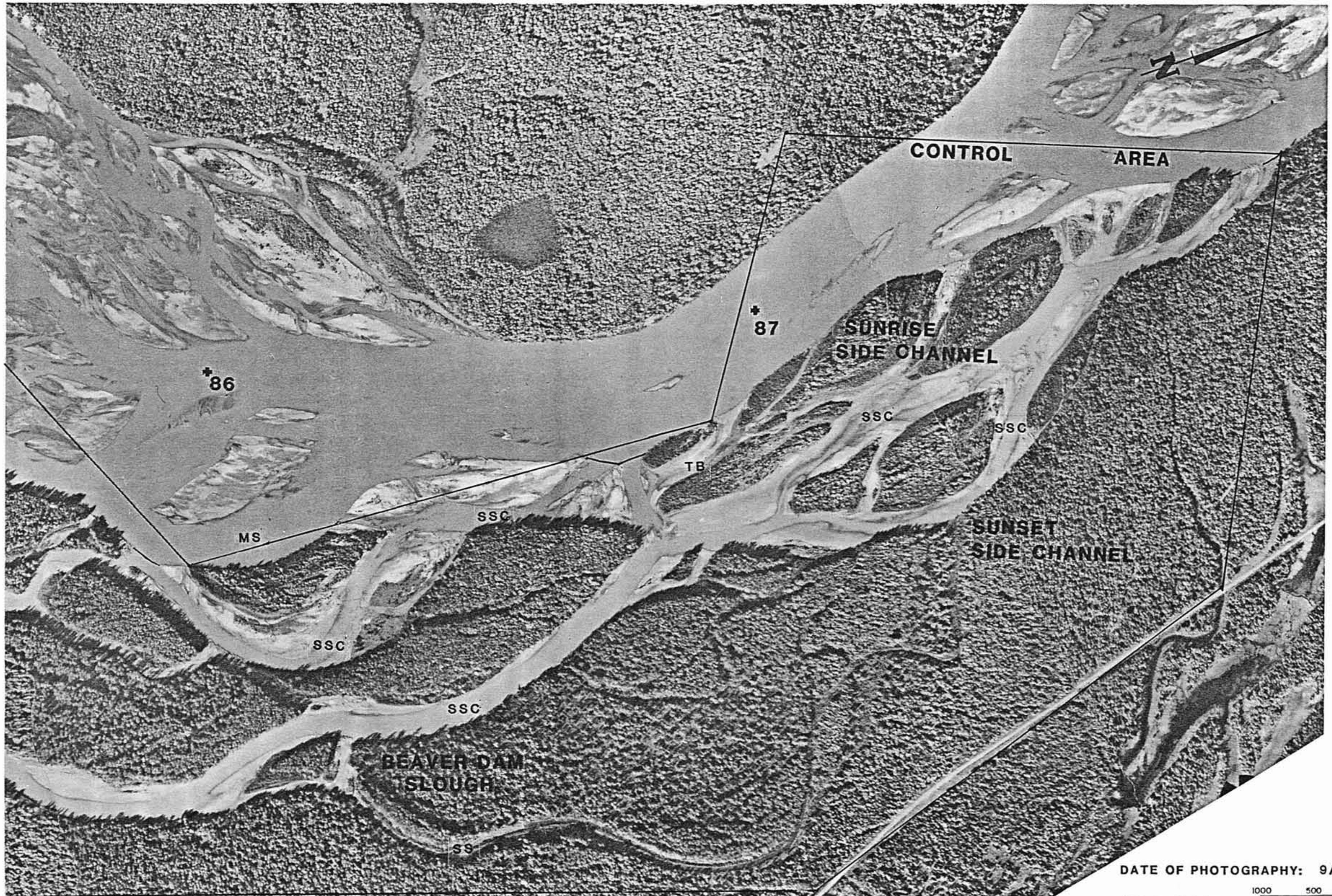
SUNSHINE SLOUGH 1 of 2

DISCHARGE AT SUNSHINE: 36,600 cfs

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND

- MS MAINSTEM
- PSC PRIMARY SIDE CHANNEL
- SSC SECONDARY SIDE CHANNEL
- TB TURBID BACKWATER
- CW CLEAR WATER AREA
- SS SIDE SLOUGH
- TM TRIBUTARY MOUTH
- T TRIBUTARY
- ✦ RIVER MILE

DATE OF PHOTOGRAPHY: 9/6/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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F. WOODY TRIHEY & ASSOCIATES

FIGURE B-28

SUNSHINE SLOUGH 2 of 2

DISCHARGE AT SUNSHINE: 36,600 cfs

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE

LEGEND

MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
+ RIVER MILE

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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SUNSHINE SLOUGH 1 of 2

DISCHARGE AT SUNSHINE: 21,100 cfs

FIGURE B-29

PREPARED FOR:

HARZA-EBASCO
SUSITNA JOINT VENTURE

LEGEND
MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
+ RIVER MILE

DATE OF PHOTOGRAPHY: 9/16/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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EWT&A
E. WOODY TRIHEY & ASSOCIATES

SUNSHINE SLOUGH 2 of 2

DISCHARGE AT SUNSHINE: 21,100 cfs

FIGURE B-29

PREPARED FOR:
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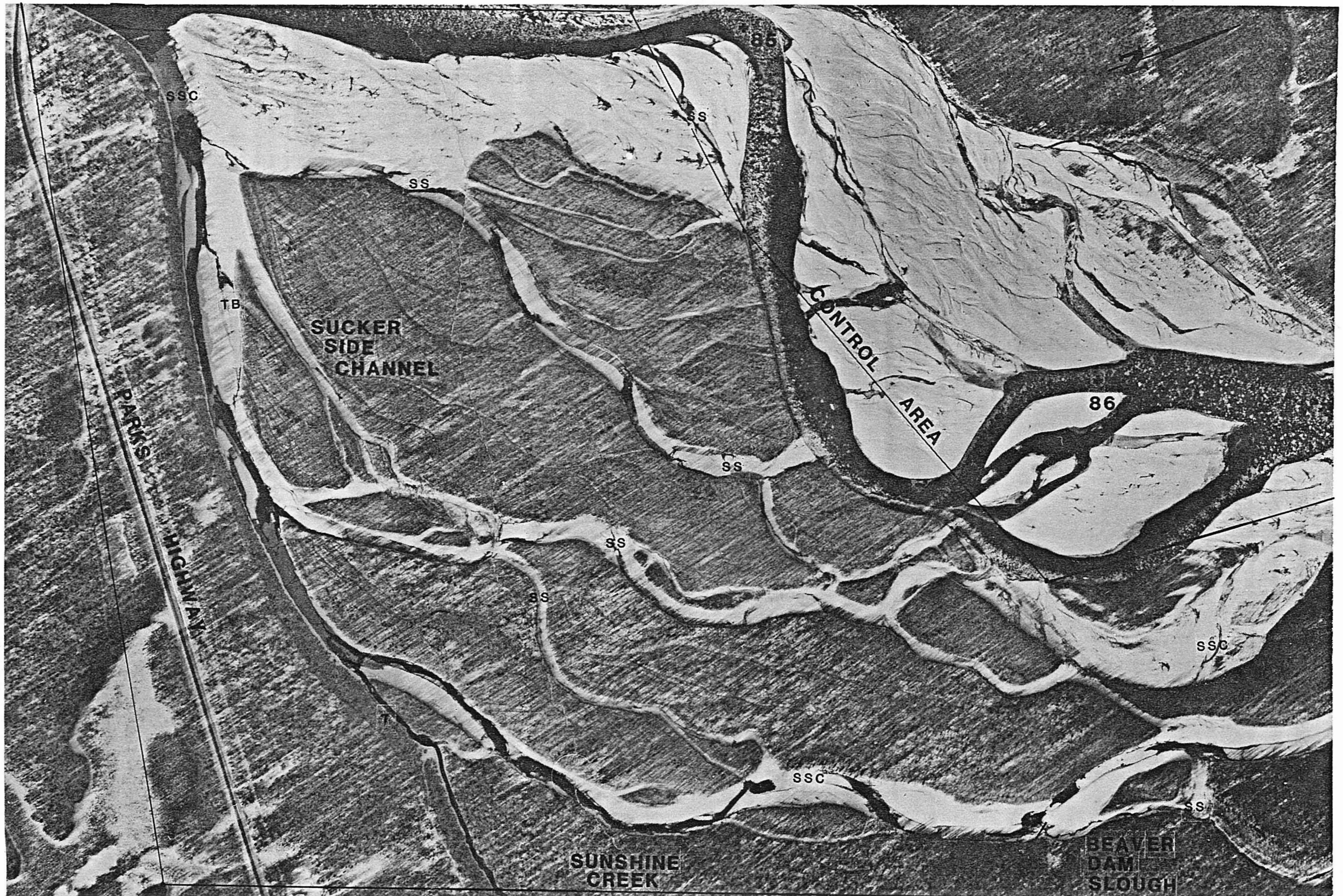
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	CW	CLEAR WATER AREA
PSC	PRIMARY SIDE CHANNEL	SS	SIDE SLOUGH
SSC	SECONDARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
TB	TURBID BACKWATER	T	TRIBUTARY
		◆	RIVER MILE

DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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SUNSHINE SLOUGH 1 of 2

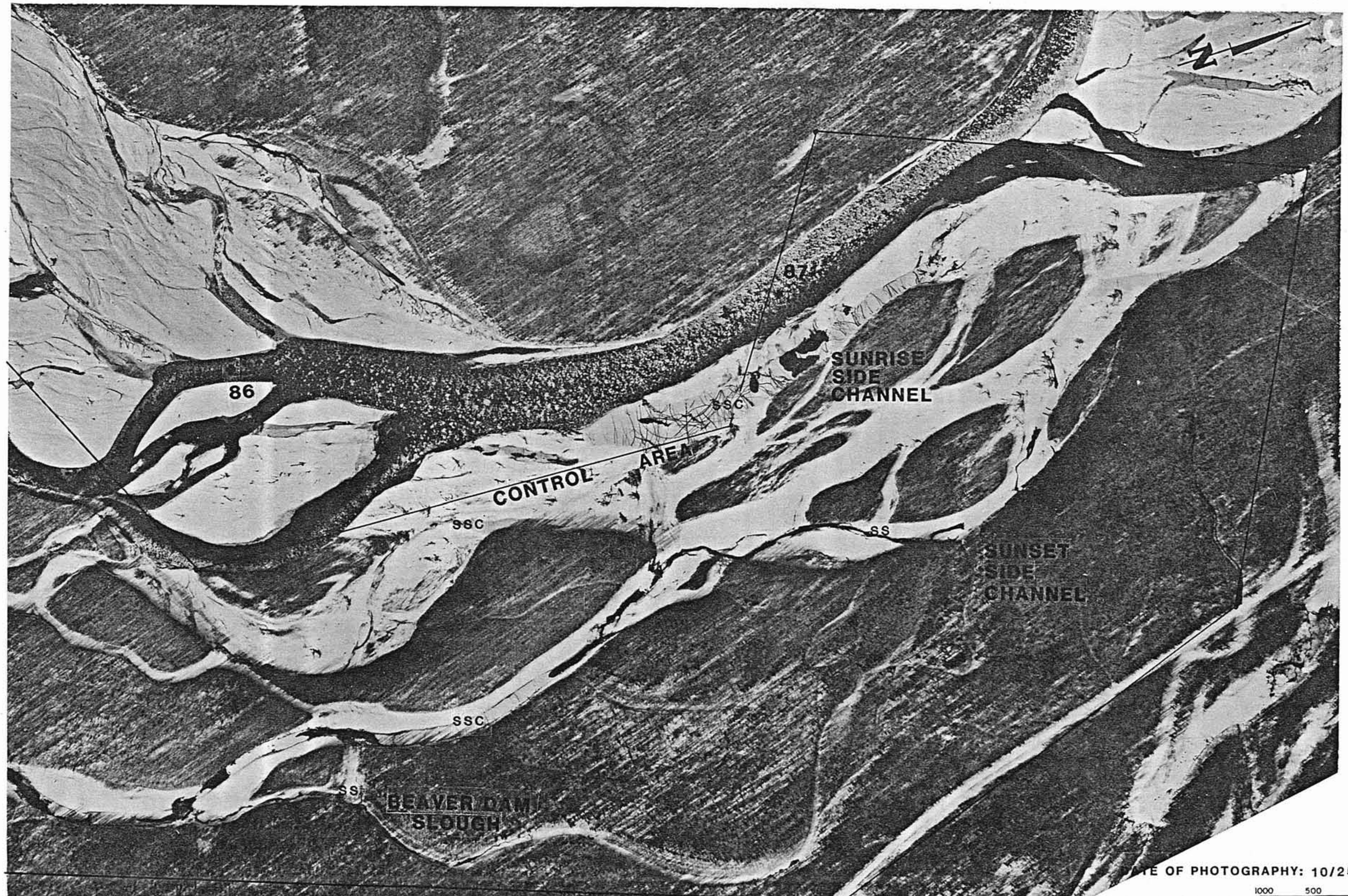
DISCHARGE AT SUNSHINE: 13,900 cfs

FIGURE B-30

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



DATE OF PHOTOGRAPHY: 10/25/83

GRAPHIC SCALE: 1000 500 0 1000 FT

LEGEND

MS MAINSTEM
PSC PRIMARY SIDE CHANNEL
SSC SECONDARY SIDE CHANNEL
TB TURBID BACKWATER
CW CLEAR WATER AREA
SS SIDE SLOUGH
TM TRIBUTARY MOUTH
T TRIBUTARY
◆ RIVER MILE

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EWT&A

E. WOODY TRIHEY & ASSOCIATES

SUNSHINE SLOUGH 2 of 2

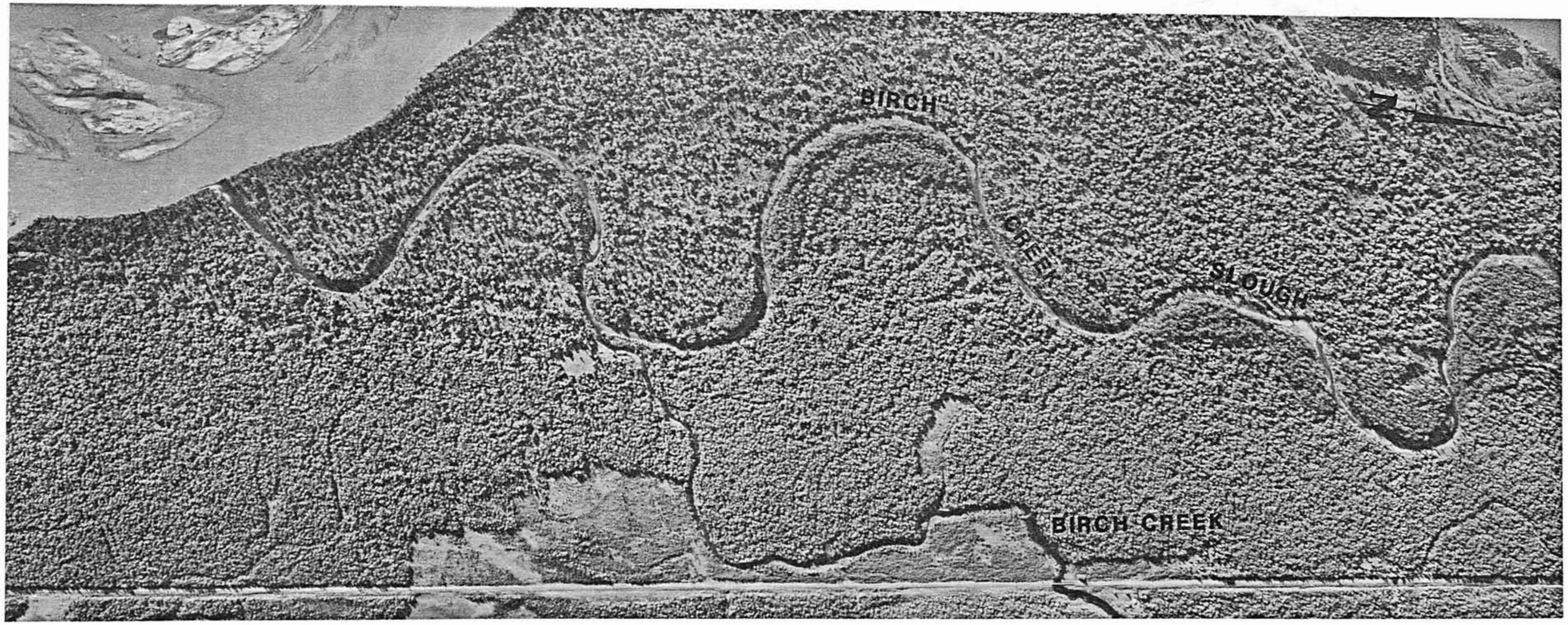
DISCHARGE AT SUNSHINE: 13,900 cfs

FIGURE B-30

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	SS	SIDE SLOUGH
PSC	PRIMARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
SSC	SECONDARY SIDE CHANNEL	T	TRIBUTARY
TB	TURBID BACKWATER	•	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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BIRCH CREEK SLOUGH 1 of 2

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-31

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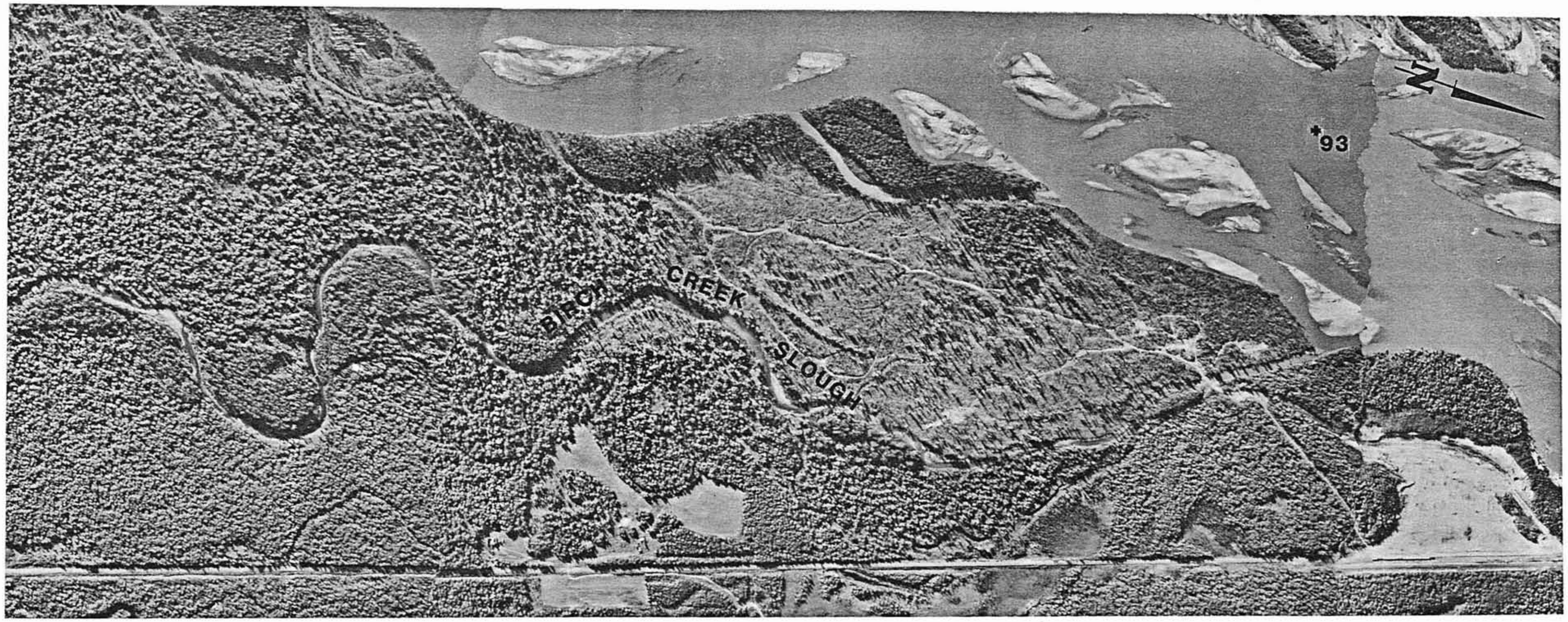
HARZA-EBASCO
SUSITNA JOINT VENTURE



LEGEND

MS	MAINSTEM	SS	SIDE SLOUGH
PSC	PRIMARY SIDE CHANNEL	TM	TRIBUTARY MOUTH
SSC	SECONDARY SIDE CHANNEL	T	TRIBUTARY
TB	TURBID BACKWATER	•	RIVER MILE

DATE OF PHOTOGRAPHY: 8/27/83

GRAPHIC SCALE: 1000 500 0 1000 FT

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EWT&A

E. WOODY TRIHEY & ASSOCIATES

BIRCH CREEK SLOUGH 2 of 2

DISCHARGE AT SUNSHINE: 59,100 cfs

FIGURE B-32

PREPARED FOR:

HARZA-EBASCO

SUSITNA JOINT VENTURE