Preliminary Assessment of Access by Spawning Salmon to Side Slough Habitat above Talkeetna

Draft Report

by

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INTRODUCTION

The proposed Susitna hydroelectric project will alter the existing streamflow, sediment and thermal regimes of the river. Each of these have a direct influence on the quality and/or quantity of fish habitat available throughout the year. It is proposed that post project streamflows at Gold Creek be reduced during summer and increased during winter. Suspended sediment, turbidity and water temperatures are expected to follow similar patterns (Acres 1982).

Although mainstem spawning areas have been documented within the Talkeetna to Devil Canyon reach, the most intensively used spawning areas are located in tributary streams and side sloughs (ADF&G 1981a). Of these, side-slough habitats are in the greatest jeopardy of being adversely effected by reduced streamflows during the inmigration and spawning period. Natural flows at Gold Creek commonly range between 18,000 and 25,000 cfs during late August and early September. A controlled flow of no less than 12,000 cfs at Gold Creek is proposed by the Alaska Power Authority.

Because of the magnitude of the proposed streamflow reductions during the inmigration and spawning period, the availability, as well as the quality of existing side-slough spawning habitat is of concern.

The primary purpose of this paper is to present a preliminary analysis of the influence mainstem discharge has on access to spawning areas in the side sloughs above Talkeetna. The paper has been prepared at the request of the Alaska Power Authority and in cooperation with the Alaska Department of Fish and Game Su Hydro Aquatic Studies Group.

The field data used in the analysis are both limited and provisional. Continuing analysis of these and other 1982 data by the Su Hydro Aquatic Studies Group will provide a more reliable indication of the range of mainstem discharges that are necessary for providing access to the side sloughs. The ADF&G report is scheduled for June 1983. Until the remainder of the 1982 data are analyzed by ADF&G, the statements presented in this paper regarding the streamflows necessary for chum salmon to gain access to the side sloughs must be viewed as the provisional opinion of the author.

To assist with understanding the limitations of the specific focus of this paper four general categories of fish habitat which exist along the Susitna River between Talkeetna and Devil Canyon, are identified and an introductory description is presented of the physical processes which interact to provide side-slough habitat. The sequence in which these topics are addressed is diagrammed in Figure 1. Much of the discussion presented in this paper is unsupported at this time, by data or analyses. However, it is believed that the data collected during the 1982 field season and that which could be collected during 1983 will substantiate these hypotheses and provide a basis for quantifying their associated relationships.

SUSITNA RIVER FISHERY RESOURCES

The Susitna River basin supports populations of five Pacific salmon species (chinook, sockeye, coho, chum, and pink), one additional anadromous salmonid (Bering cisco), an anadromous osmerid (eulachon), and several resident species (Arctic grayling, rainbow trout, burbot, Dolly Varden, round whitefish, humpback whitefish, longnose sucker, threespine stickleback, arctic lamprey, and sculpin. Rainbow trout, grayling, Dolly Varden and burbot are the principal resident species contributors to the Susitna River sport fishery (Mills 1982). The rainbow, grayling and Dolly Varden fishery is primarily located in the clear water tributaries whereas burbot are generally found in the Susitna River.

The five species of Pacific salmon which inhabit the Susitna basin utilize a variety of habitats to different degrees on a seasonal basis (Figure 2). Habitat utilization is implied by the relative abundance of a particular species/life stage in a certain habitat. Degree of utilization (high, medium, or low) was determined from the FERC License Application Exhibit E Draft Report (Acres 1982). Sockeye and chum salmon originating in the Susitna basin are the most important contributors to the total upper Cook Inlet commercial salmon harvest. Coho and pink salmon are of lesser commercial value. Commercial harvest of chinook has been very limited, because regulations

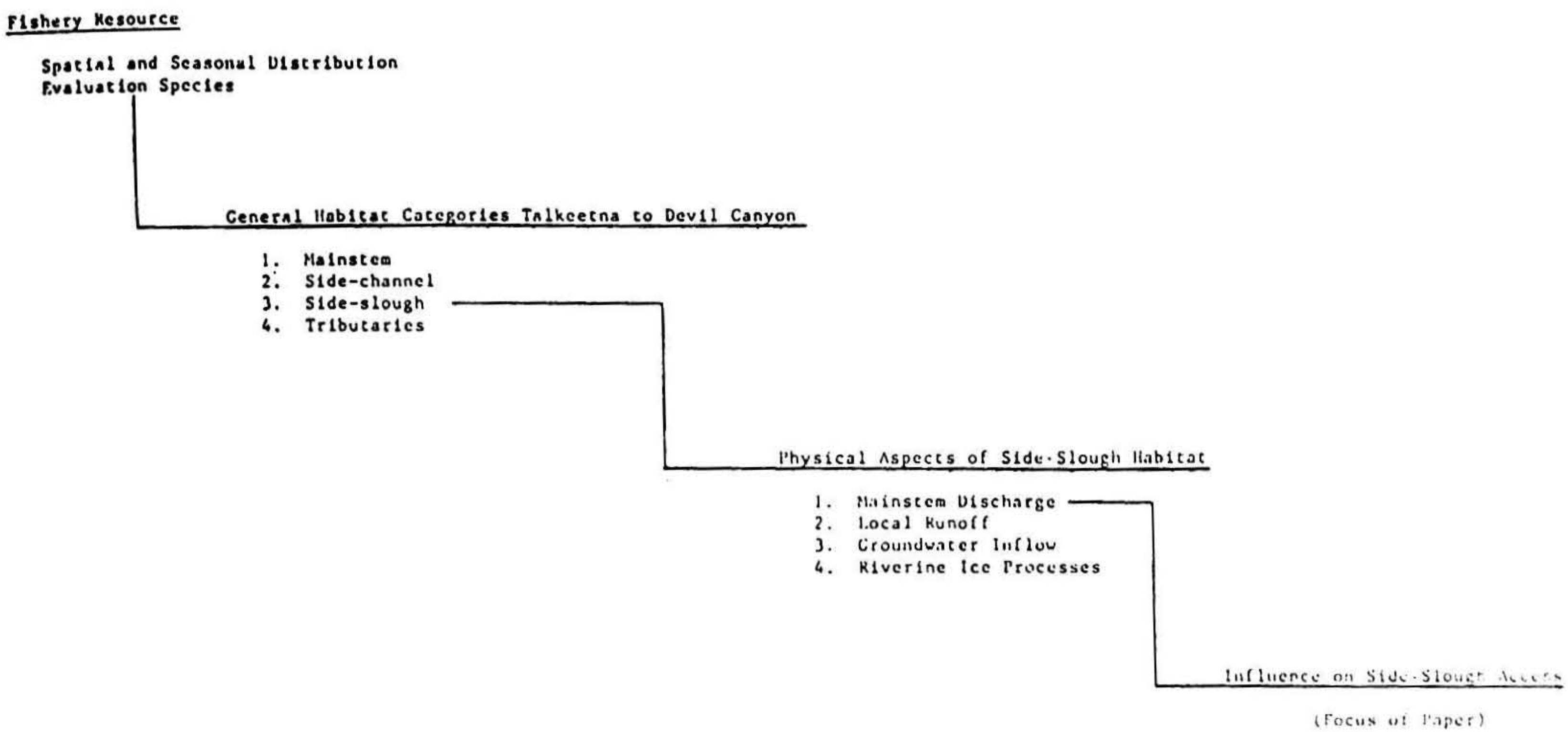
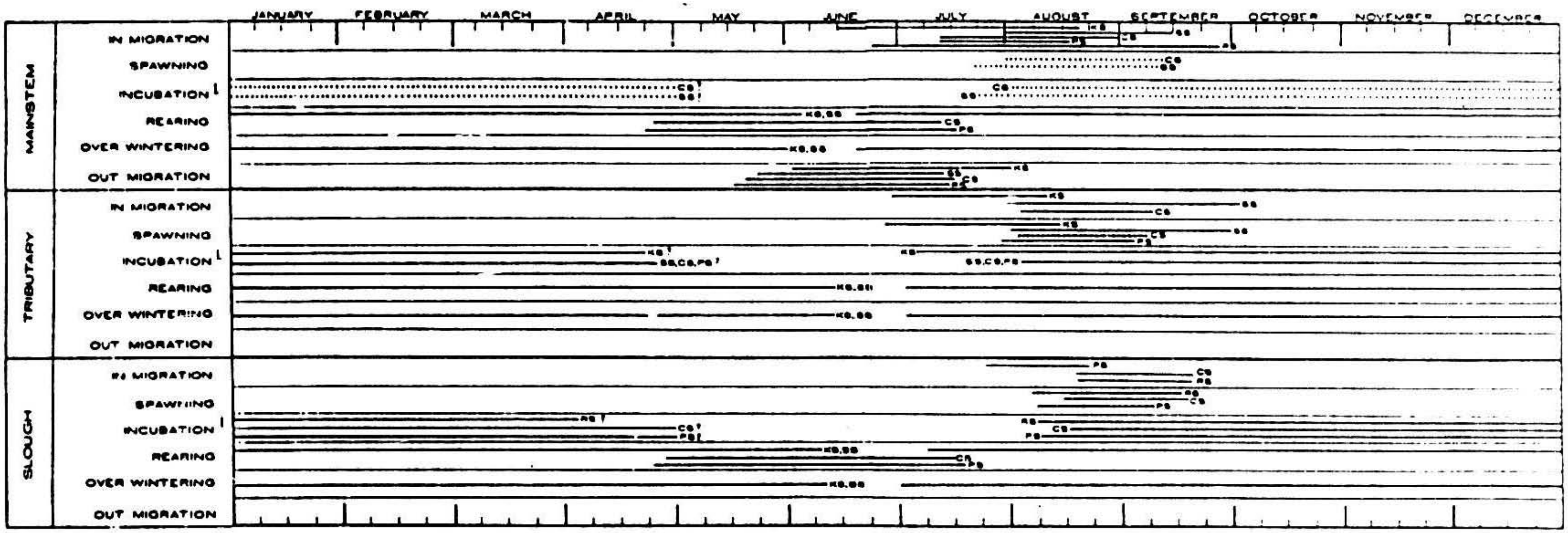


Figure 1. Schematic Diagram of Information Flow

FIGURE 2. PROVISIONAL PERIODICITY CHART FOR THE SUSITNA RIVER SALMON, TALKEETNA TO DEVIL CANYON *



* DEVELOPED FROM PROVISIONAL DATA GATHERED BY ADF&G THROUGH DECEMBER, 1981

l END OF INCUBATION PERIOD DETERMINED FROM WOODWARD AND CLYDE (1982) SPECIES ACCOUNTS.

LEGEND

KS - CHINOOK SALMON	——— HIGH UTILIZATION
SS - COHO SALMON	——— MEDIUM UTILIZATION
CS - CHUM SALMON	.... LOW UTILIZATION
PS - PINK SALMON	
RS - SOCKEYE SALMON	

prevent commercial fishing for chinook until most of the run has entered natal streams. However, chinook salmon are a very important sport fish in the lower Susitna drainage, and are harvested in a local subsistence fishery at Tyonek. Therefore Susitna River chinook stocks might be considered to hold a relative overall rank in the Susitna basin at least equal to pink and coho salmon.

Selection of an evaluation species and life stages to represent the life stages of species which utilize a particular habitat type during each season of the year is an essential step in assessing impacts and developing mitigation plans. Various species and life stages have different critical life requirements and respond differently to habitat alterations. A change in habitat conditions that benefits one species or life stage may adversely affect another and mitigation plans which favor one species may discriminate against another. The selection of an evaluation species provides a mechanism to prioritize seasonal habitat requirements thereby reducing such potential conflicts. An evaluation species can be selected after the initial baseline studies and impact assessments have identified the dominant species and existing habitats most vulnerable to potential impacts throughout the year. For the purposes of this report, species within the Susitna River with high regional visibility and commercial, sport, subsistence, or aesthetic value were given priority by the author. Those species within this category whose habitat is thought most sensitive to project effects were rated higher than those species whose habitat was not considered as vulnerable (Table 1).

The five species of Pacific salmon were identified as evaluation species for the Susitna River below Devil Canyon based on information presented to date in the aquatic studies baseline reports, preliminary impact assessments, and their commercial, sport and subsistence harvest contributions,

Since the greatest changes in existing physio-chemical characteristics of fish habitats are expected to occur in the reach between Talkeetna and Devil Canyon, the fishery resource using that portion of the river was considered to be the most concern. Because of differences in habitat location and seasonal habitat requirements, not all salmon species are expected to be equally affected by the proposed project. Of the five species of salmon which inhabit the Talkeetna to Devil Canyon reach chum and sockeye salmon appear to be the most vulnerable. This is due to their dependence on slough habitats for spawning, incubation and early rearing (ADF&G 1981a, 1981b, 1981c, 1982). Of the two species, chum salmon appear to be the dominant species (ADF&G 1981b). Chinook and coho salmon, while having a greater commercial and sport value than chum salmon, may not be as adversely impacted by the project. These species are principally tributary spawners and rear in clearwater areas such as the mouths of sloughs and tributaries (ADF&G 1981a, b, c, 1982). Post-project conditions in the mainstem may provide replacement habitat to offset potential loss of mainstem rearing areas. While some pink salmon spawn in slough habitats in the reach between Talkeetna and Devil Canyon, the majority of these fish utilize tributary habitats (ADF&G 1981a). A limited data base regarding the other life history phases of resident species precludes their prioritization with respect to side-slough habitat utilization.

GENERAL HABITAT CATEGORIES

For the purpose of this report fish habitat in the Talkeetna to Devil Canyon reach of the Susitna can be divided into four general categories: mainstem, side channel, side-slough, and tributary habitats. Each general habitat category contains a spectrum of physical attributes rather than a specific set of uniform characteristics.

Mainstem habitat consists of those portions of the Susitna River which normally convey streamflow throughout the year. Both single and multiple channel reaches are included in this habitat category. In general this habitat category is characterized by high-velocity streamflows and well armoured streambeds. Substrates generally consist of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sand. Suspended sediment concentrations and turbidity are high from late May through early October due to the influence of glacial melt water. Streamflows recede, and the water appreciably clears in the early to mid fall before an ice cover forms on the river in late November or December. Groundwater and tributary inflow appear to be inconsequential contributors to the overall characteristics of this habitat category. Seasonal temperatures of the mainstem river respond primarily to air temperature and solar radiation. Mainstem surface water appears to establish mainstem intragravel water temperatures.

Table 1. Evaluation Species and Life Stages for Side Slough Habitats in the Talkeetna to Devil Canyon Reach.

- Chum Salmon
    - . Returning adults;
    - . Spawning adults;
    - . Incubating embryos and pre-emergent fry;
    - . Emergent fry;
    - . Outmigrant juveniles.
- Sockeye Salmon
    - . Returning adults;
    - . Spawning adults;
    - . Incubating embryos and pre-emergent fry;
    - . Emergent fry;
    - . Outmigrant juveniles.
- Chinook Salmon
    - . Rearing juveniles.
- Coho Salmon
    - . Rearing juveniles.
- Pink Salmon
    - . Returning adults;
    - . Spawning adults;
    - . Incubating embryos and pre-emergent fry;
    - . Emergent fry;
    - . Outmigrant juveniles.
- Resident Species
    - . Limited data base precludes identification of relevant life stage.

Side channel habitat consists of those portions of the Susitna River which normally convey streamflow during the open water season but which become appreciably dewatered during periods of low flow. The controlling streambed elevations at the upstream entrance to the side channels are less than the water surface elevations of the mean monthly flows for June, July and August. Side-channel habitats are characterized by shallower depths, lower velocities and smaller streambed materials than mainstem habitats. In general the streamflow, sediment, and thermal regimes of the side channel habitats reflect attenuated mainstem conditions. Tributary and groundwater inflow may prevent some side-channel habitats from becoming completely dewatered when mainstem flows recede. However, the presence of these limited inflows could conceivably not be considered a critical component of side-channel habitat. A winter ice cover, similar to that which forms on the mainstem, generally exists in the side channels. Groundwater inflow and upwelling retained open leads in some side- channel areas throughout the winters of 1974-75 and 1981-82 (Barrett 1975a, b, c and Trihey 1982).

Side-slough habitats are found in spring-fed perched overflow channels which only convey glacial meltwater from the mainstem during median summer and high flow periods. At intermediate and low-flow periods the side sloughs convey clear water from small tributaries and/or upwelling groundwater (ADF&G 1981c, 1982). The controlling streambed/streambank elevations at the upstream end of the side sloughs are slightly less than the water surface elevations of the mean monthly flows for June, July, and August. Side sloughs generally exist along the edge of the flood plain, separated from the mainstem by well-vegetated bars. An exposed alluvial berm often separates the head of the slough from mainstem or side channel flows where as the water surface elevation of the river generally causes a backwater to extend well up into the slough from its lower end (ADF&G 1981c, 1982). It is important to note that, even though a substantial backwater exists, hydraulically the sloughs function very much like small stream systems. Several hundred feet of the slough channel often conveys water independent of mainstem backwater effects.

Except when the discharge in the mainstem river is sufficient to have overtopped the upper end of the slough, surface water temperatures in the side sloughs appear to be independent of those in the mainstem river (ADF&G 1981c, 1982). Surface water temperatures in the side-sloughs during summer months are principally a function of air temperature, solar radiation, and the temperature of the local runoff. During winter months surface water temperatures are strongly influenced by upwelling groundwater. The large deposits of alluvium through which the upwelling water flows appears to act as a buffer or thermal reservoir; attenuating summer temperatures and providing very stable winter temperatures.

Tributary habitat consists of the full complement of hydraulic and morphologic conditions which occur in the tributaries. Their seasonal streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology and climate of the tributary drainage. The physical attributes of tributary habitat do not appear to be dependent on mainstem conditions except at the tributary mouth where mainstem discharge influences access into the tributary and the tributary extends a clear water plume into the mainstem (ADF&G 1981c, 1982).

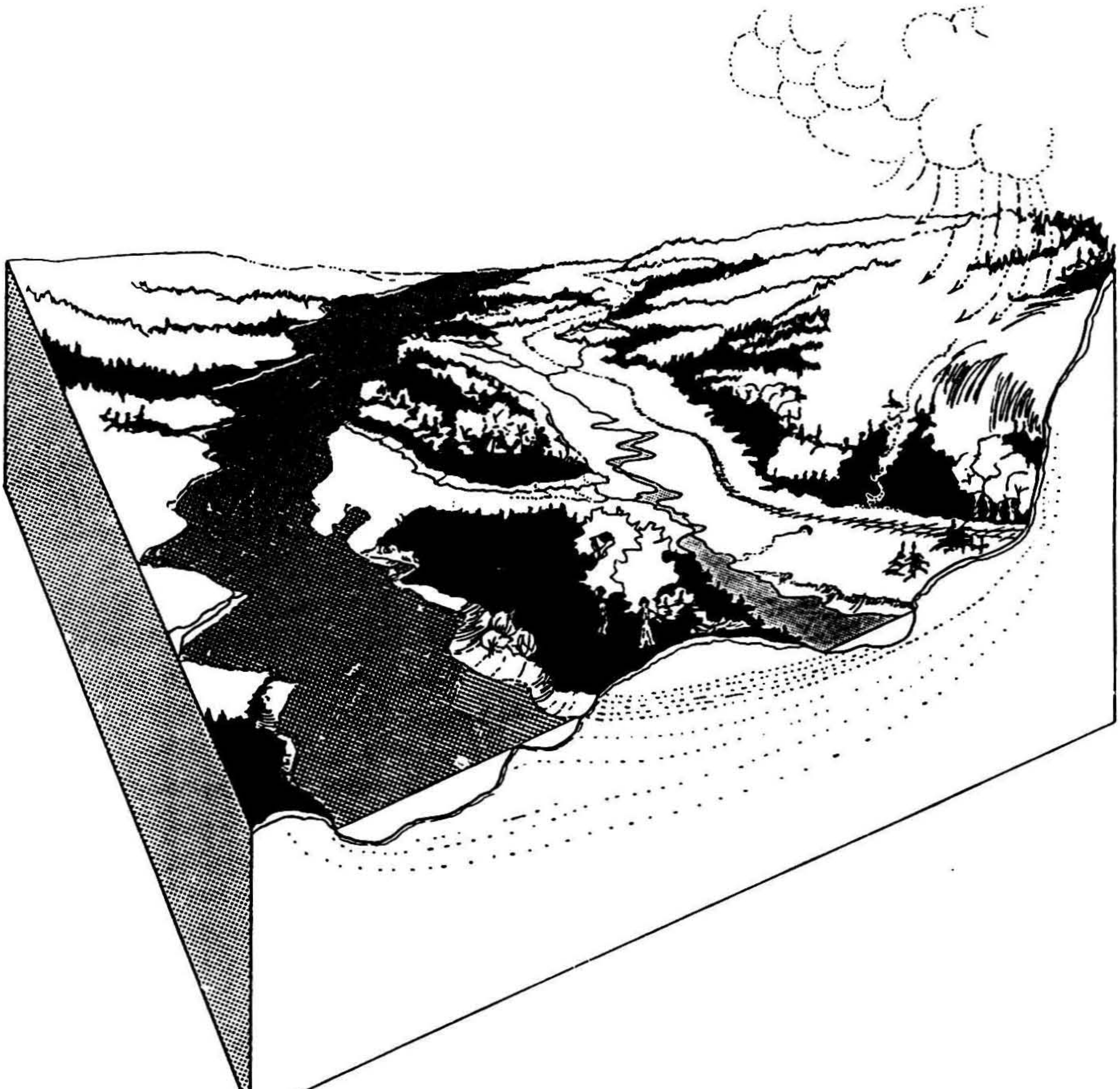
PHYSICAL ASPECTS OF SIDE-SLOUGH HABITAT

The physical characteristics of side-slough habitat appear to be dependent upon the interaction of four principal factors: discharge of the mainstem Susitna River, surface runoff patterns from the adjacent catchment area, local groundwater inflow and riverine ice processes. These factors are thought to interact to varying degrees during different seasons of the year to provide a very unique type of fish habitat along the margins of the Susitna River (Figure 3). Side-slough habitat is predominately utilized by chum and sockeye salmon, although chinook, coho and pink salmon also inhabit the side sloughs at some time during their fresh water life history. Resident species are also found in these areas.

Mainstem Discharge

Two ways in which the amount of streamflow in the mainstem Susitna River can influence habitat conditions in the side sloughs are: 1) it causes a backwater effect at the mouth of the slough which creates a special type of slough habitat and facilitates access into the slough (ADF&G 1981c, 1982); and 2) it provides the dominant sediment transport mechanism in the slough. Streambed elevations at the lower entrance to the side sloughs are generally lower than the stage (water surface elevation) in the adjoining mainstem channel. Thus the stage of the mainstem causes a hydraulic plug which impedes

Figure 3. Artists sketch of a side slough and adjacent Susitna River (courtesy of AEIDC).



the flow of clear water from the mouth of the slough and forms a clear backwater zone that may extend several hundred feet upstream into the slough.

As mainstem discharge increases, the depth and size of the backwater zone at the mouth of the slough continues to increase. At some point, the stage in the mainstem river becomes high enough that turbid glacial flow from the mainstem enters the slough at its upstream end. Depending upon the magnitude of the mainstem discharge, flow within the slough may rapidly increase from less than 10 cfs to more than 500 cfs (ADF&G 1982, R&M 1982). These periodic high flows tend to flush out detrital material and fine sediments which have accumulated near the mouth of the slough. Occasionally high flows transport sands and silts into the slough from the mainstem; however, the overall effect of these periodic overtoppings is generally thought to result in a net transport of fines out of the slough. During spring break up very large, short duration flows pass through the side sloughs. Periodically breakup flows are apparently of such magnitude that they can remove debris and beaver dams, redistribute streambed gravels and, at times, alter the thalweg profile or alignment of the slough.

Local Runoff

During those portions of the year when mainstem streamflows are high enough to cause a backwater effect at the mouth of the slough, but not high enough to overtop the slough at the head end, the principal sources of streamflow within the slough (slough flow) are thought to be from local surface runoff and groundwater upwelling. Summer rainstorms appear to have a major influence on the amount of clear water flow in side-sloughs during July and August. In general local surface runoff may contribute a greater portion of the clear water flow to side-slough than does groundwater upwelling during the ice-free period of the year. However, a subset of side sloughs also exist which depend predominantly on ground water throughout the year (ADF&G 1981c, 1982).

Unseasonably dry weather during August of 1982 resulted in the second lowest mean monthly discharge in 33 years of record at Gold Creek. Average daily streamflows fluctuated between 12,000 and 14,000 cfs for 14 days. The mean monthly flow was 15,270 in comparison to the long term average monthly flow of 22,200 cfs. During this time, groundwater inflow to small tributary streams and upwelling within the side-slough itself was the most significant factor in maintaining sloughflow. It is hypothesized that, during a more normal year, local runoff would have provided the greatest source of clear water to the side sloughs.

Groundwater Inflow

Although it is thought that groundwater upwelling normally contributes a lesser amount of water to the total clear water flow in the side sloughs than does surface runoff, it is believed to be essential for attracting adult salmon into those spawning areas which are not likely to freeze during winter. During winter months, groundwater inflow and upwelling most likely provide nearly all of the slough flow. Field work conducted during the winters of 1974-75 and of 1981-82 indicate that elevated surface and intragravel water temperatures exist in upwelling areas throughout the winter (Barrett 1975a, b, c and Trihey 1982). Groundwater inflow also results in stable water surface elevations and a discontinuous ice cover. By mid-winter the mainstem river is frozen over and nearly all tributary flow has ceased. Yet substantial portions of the side sloughs remain ice free. Even if winter air temperatures become cold enough to cause an ice cover to form over the side sloughs substrates are not expected to freeze.

Upwelling water appears to flow from beneath the streambed into the slough in a near vertical direction. Besides preventing substrates from freezing, upwelling is also thought to prevent deposits of silts and sands from suffocating developing embryos which are within the underlying streambed gravels. The general direction of the upwelling flow is also believed to keep the embryos oxygenated during the incubation period. Oxygen being supplied from beneath the streambed should avoid the problems which are normally associated with the deep silt mantle spread over spawning areas.

Ice Processes

Ice processes in the mainstem river are important in maintaining the character of the slough habitat. Besides reworking substrates and flushing debris and beaver dams from the sloughs which could otherwise be potential barriers to upstream migrants, ice processes are also considered important for maintaining the groundwater upwelling in the side sloughs. The increased stage associated with a winter ice cover on the Susitna makes it possible for approximately the same hydraulic head to exist between mainstem and an adjacent side-slough during low winter flows as exists during normal summer flow (Figure 4).

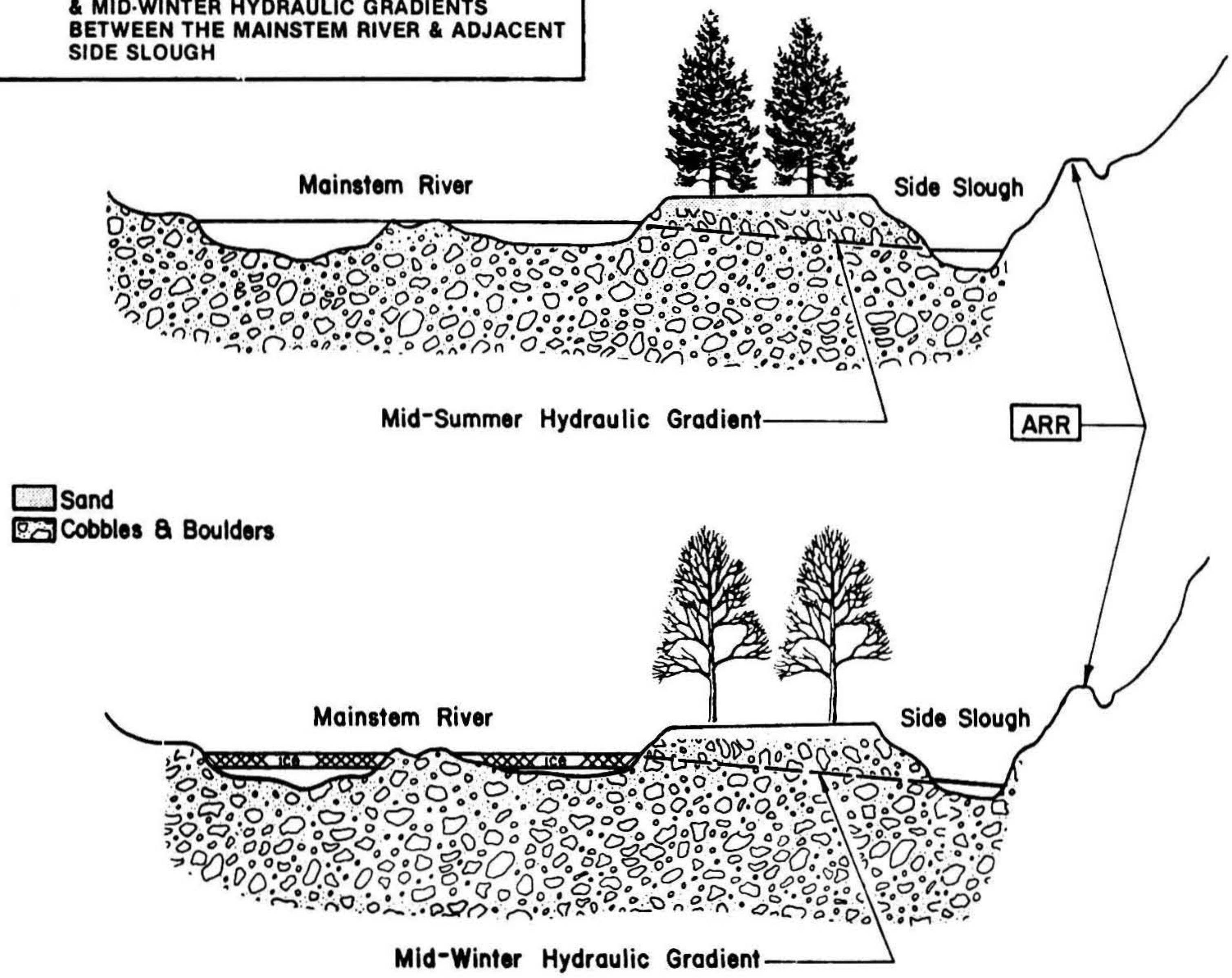
For example, the river stage observed during mid-winter 1981-82 associated with the ice cover formation on the Susitna River appeared very similar to the water surface elevation associated with summer discharges of 18,000 to 19,000 cfs.

Apparently, the higher stage caused by ice makes it possible for approximately the same hydraulic head to exist between the mainstem and an adjacent side-slough during the winter as exists during late summer. The alluvial deposits which form gravel bars and islands between the mainstem river and side sloughs are highly permeable making it possible for water from the river to flow downgradient through the alluvium and into the sloughs. Although the origin of the water which upwells in the side sloughs is unknown at this time, (it may be from a discontinuous local aquifer or it may be from the mainstem river) it is likely that the stage of the mainstem river provides the principal driving mechanism for the upwelling in the side sloughs.

SIDE SLOUGH ACCESS

The remainder of this paper addresses only one element of the preceding discussion: the effect of mainstem discharge on chum salmon access into the side sloughs during the spawning season. Slough 9 has been selected as the focal point for this analysis. In general, upstream access into Slough 9 appears to be more difficult than the average entrance condition encountered by adult spawners at those sloughs between Talkeetna and Devil Canyon in which spawning occurs. Upstream access into Slough 9 is apparently better than

Figure 4. COMPARISON OF CONCEPTUAL MID-SUMMER & MID-WINTER HYDRAULIC GRADIENTS BETWEEN THE MAINSTEM RIVER & ADJACENT SIDE SLOUGH



access to Slough 16B or 19; but far more difficult than access into Whiskers Slough or Slough 8A. It is therefore believed to be a reasonable index of entrance conditions into Sloughs 20 and 21.

The thalweg and water surface profiles which define entrance conditions for Slough 9 on August 24, 1982 are presented in Figure 5. The mainstem discharge at Gold Creek was 12,500 cfs and flow in Slough 9 was 3 cfs. The profiles originate in the Susitna River approximately 1000 feet downstream from the mouth of the slough (cross section 128.4W1) and continue up the slough terminating with the streambed elevation at the upstream entrance to the slough. The profile is 7250 feet in length, and reflects a difference in elevation of approximately 15 feet between the downstream (mouth) and the upstream (head) ends of the slough. The uppermost area of Slough 9 (thalweg station 34+00 head) has an average streambed gradient of 18.6 ft/mi; whereas the average gradient of the lower 2900 ft of the slough (thalweg station 56+00 - 23+00) is 5.6 ft/mi. The average gradient of the river through this reach is 10.9 ft/mi (R&M 1982).

Although high velocities have been identified as blocking the upstream migration of spawning fish in some Alaskan rivers, entrance conditions and associated backwater effects in the lower portions of the side sloughs in the Talkeetna to Devil Canyon reach make it nearly impossible for velocity barriers to exist at these locations. Thus the ease at which adult salmon can enter the side sloughs from the mainstem Susitna appears to be primarily a function of depth.

The depth of flow at the mouth of Slough 9 is a function of the water surface elevation of the mainstem and the discharge from the slough. Data obtained during the 1981 and 1982 field seasons indicate that the flow from Slough 9 is quite small unless the mainstem has entered its head end (Table 2). On the basis of these data 3 cfs was selected as being typical of the mid-summer clearwater flow from Slough 9.

A staff gage was installed at the entrance to Slough 9, and numerous gage height readings were recorded through September. The staff gage was installed in the deepest water available in the passage reach so that it would not

Table 2. A comparison of Slough 9 streamflow measurements with the average daily mainstem discharge at Gold Creek.

Date	Sloughflow (cfs)	Mainstem (cfs)
6/24/81	2.9*	16,600
7/21/81	714.0*	40,800
9/30/81	1.5*	8,000
10/14/81	1.2*	7,290
6/23/82	182.0#	No Record
7/15/82	108.0#	25,600
7/20/82	28.5#	22,900
8/25/82	3.4*	13,400
9/4/82	8.4*	14,400
9/9/82	3.0#	13,400
9/18/82	232.0*	26,800
9/20/82	145.0*	24,000

* ADF&G 1981c and 1982.
\# R&M Consultants 1982.

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Table 3. Comparison of water surface elevations (WSEL) at the entrance to Slough 9 and the average daily mainstem discharge at Gold Creek, 1982.

Date	WSEL* (ft)	Gold Creek Discharge (cfs)	Date	WSEL (ft)	Gold Creek Discharge (cfs)
8/24/82	590.03	12,500	9/05/82	590.16	13,600
8/25/82	590.19	13,400	9/06/82	589.91	12,200
8/26/82	590.24	13,600	9/07/82	589.84	11,700
8/27/82	590.04	12,900	9/16/82	594.09	32,500
8/28/82	589.98	12,400	9/17/82	593.71	32,000
8/29/82	589.91	12,200	9/18/82	592.86	26,800
9/02/82	590.82	16,000	9/19/82	592.37	24,100
9/03/82	590.51	14,600	9/20/82	592.36	24,000
9/04/82	590.42	14,400	9/29/82	589.98	12,400

* ADF&G gages 129.2 W1A and W1B.

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dewater before the reach. As a result gage height readings are 0.3 ft. greater than the controlling depth at the mouth of the slough. Water surface elevations were determined for each staff gage reading and compared to the average daily mainstem discharge at Gold Creek (Table 3). A plot of these data indicates the relationship between mainstem discharge and the water surface elevation in the mouth of Slough 9 is well defined for the range of streamflows from 11 to 33,000 cfs (Figure 6).

To evaluate the influence of mainstem discharge on fish passage, backwater profiles were determined for the 2200 foot reach near the mouth of Slough 9 for incremental levels of mainstem discharge and a constant sloughflow of 3 cfs (Figure 7). Two potential problem areas exist for adult salmon entering Slough 9; a 125 foot reach approximately 400 feet downstream from the mouth of the slough, and a 280 foot reach from 620 to 900 feet upstream of the mouth. The approximate length and average depth within the two critical passage reaches were determined for each backwater profile (Table 4).

Upstream passage into Slough 9 by adult chum salmon would not appear to be restricted when mainstem discharges were 18,000 cfs or higher. Access becomes increasingly more difficult as mainstem discharge decrease. At streamflows of 12,000 cfs and less an acute access problem exists.

Table 4. Entrance conditions at the mouth of Slough 9 for various mainstem flows at Gold Creek and sloughflow of 3 cfs.

Mainstem Discharge (cfs)	Slough 9 WSEL (ft)	Passage Reach A		Passage Reach B	
		Average Depth (ft)	Reach Length (ft)	Average Depth (ft)	Reach Length (ft)
10,000	589.50	0.1	125	0.20	280
12,000	589.90	0.4	125	0.20	240
14,000	590.35	0.85	125	0.20	200
16,000	590.85	1.35	125	0.25	140
18,000	591.25	1.75	125	0.30	80
20,000	591.60	2.10	125	0.50	30
22,000	591.90	2.40	125	0.6	10

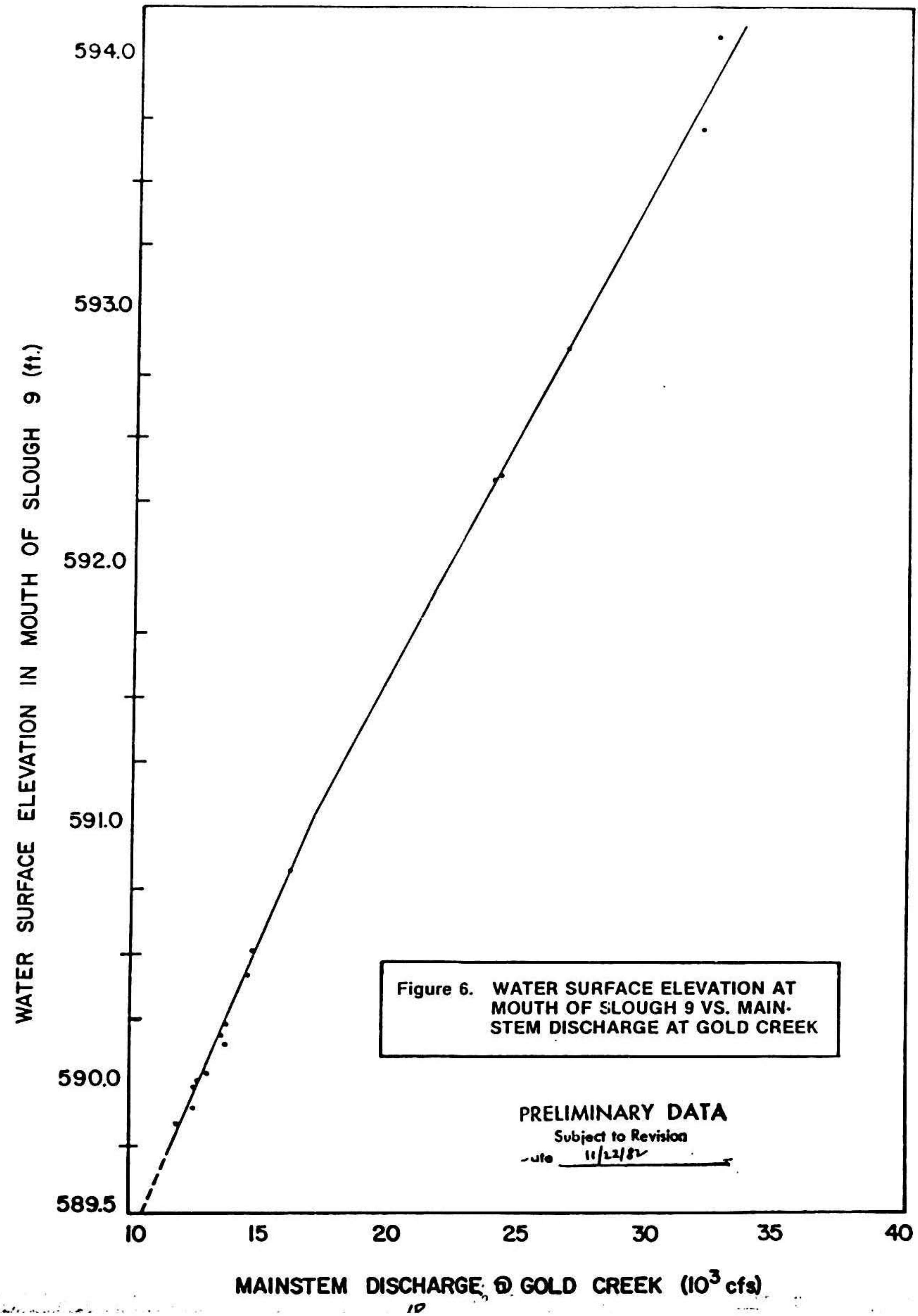

Figure 6. WATER SURFACE ELEVATION AT MOUTH OF SLOUGH 9 VS. MAINSTEM DISCHARGE AT GOLD CREEK

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Date 11/22/82

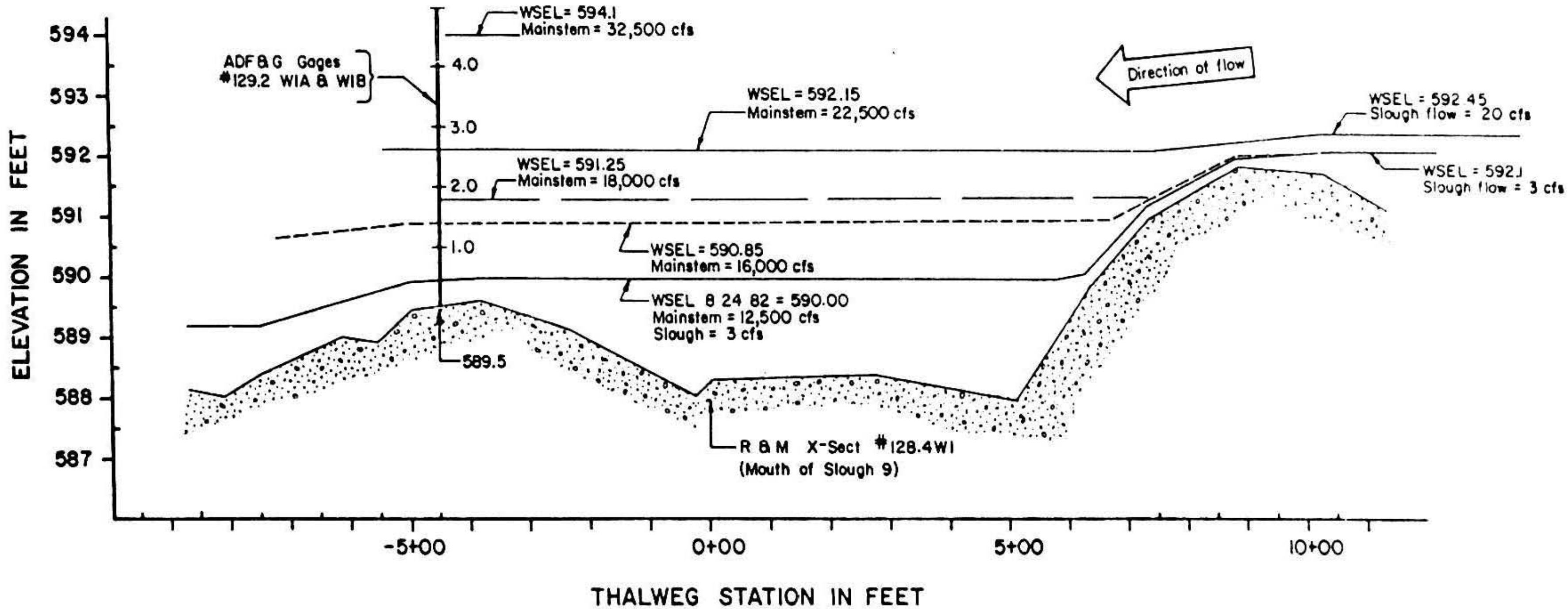

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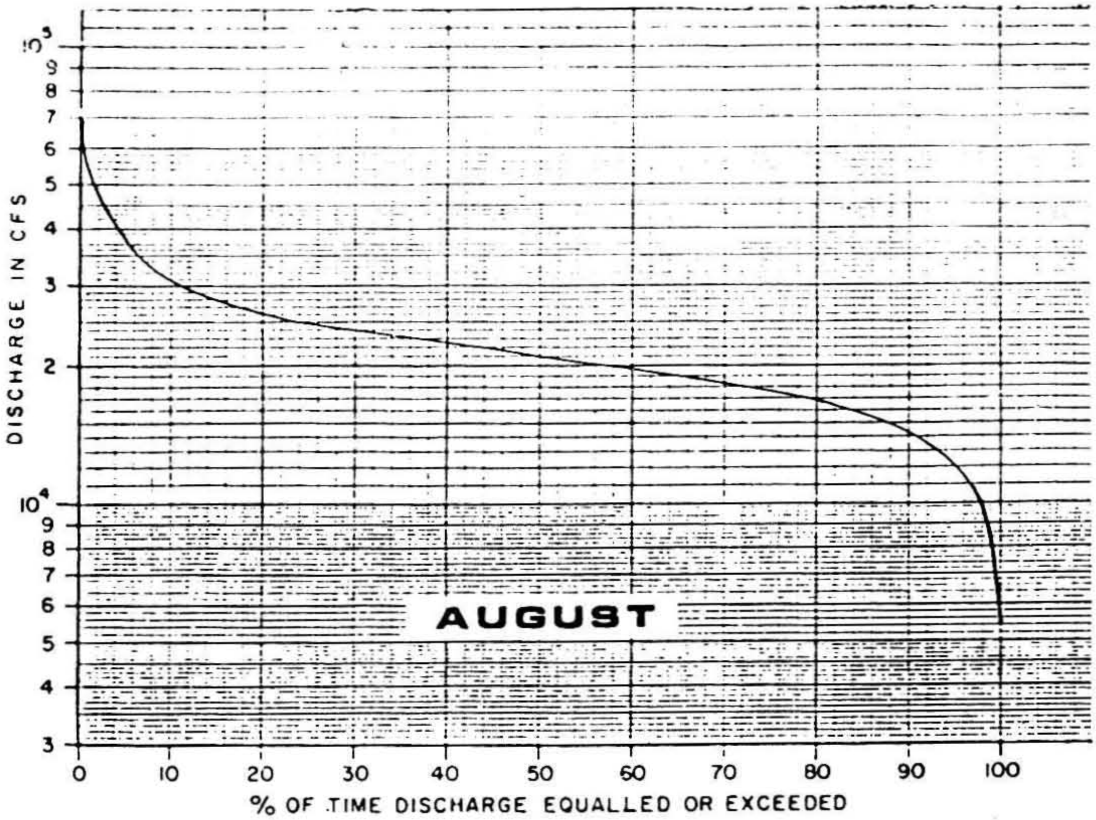
Figure 7. Backwater Profiles at the Entrance to Slough 9 for Selected Mainstem Streamflows at Gold Creek.

These statements are, in part, substantiated by field observations made the morning of August 24, 1982. A foot survey was conducted to assess spawning conditions in the lower 5000 ft of Slough 9 (refer Fig. 5). The mainstem discharge was 12,500 cfs and no appreciable backwater zone was present in the mouth of the slough.

Several chum salmon were grounded in shallow water near the entrance to the slough. Depths were measured at numerous points in the area where fish were grounded at the entrance to the slough. A few isolated depths of 0.5 ft were measured, but the most representative depth at the entrance to the slough was 0.2 ft. Approximately 500 feet upstream several chum salmon were actively digging redds along both banks of the slough. Further upstream between station 15+00 and 20+00 chum salmon were observed actively digging three redds in upwelling areas along the west bank of Slough 9. (A total of twenty fish were counted). Between August 19 and 24, streamflows ranged between 12,200 and 13,300 cfs. This would tend to indicate that the shallow depths at the downstream entrance to the slough were not a complete blockage for upstream migrants.

Between August 30 and September 3 mainstem discharge at Gold Creek fluctuated between 16 and 18,000 cfs; the result of rather typical fall rains. Streamflow data are not available for Slough 9 during this period, although it is known that the mainstem of 18,000 cfs did not breach the head of the slough. On September 5 another ground survey was conducted of spawning conditions in Slough 9. Many more chum salmon were observed in the slough than were observed August 24, and active redds were located as far up the slough as station 37+00. From these observations it can be concluded that a short term rise in mainstem stage in conjunction with an increase in sloughflow can provide adequate conditions for adult spawners to reach spawning areas mid-way into the sloughs.

The range of entrance conditions most likely to exist at Slough 9 during the chum salmon inmigration and spawning period was determined from a comparison between streamflow duration curves (Figure 8) and the information summarized in Table 4. Under preproject streamflows passage into Slough 9 by adult spawners would seldom be a problem during August. Average daily streamflows



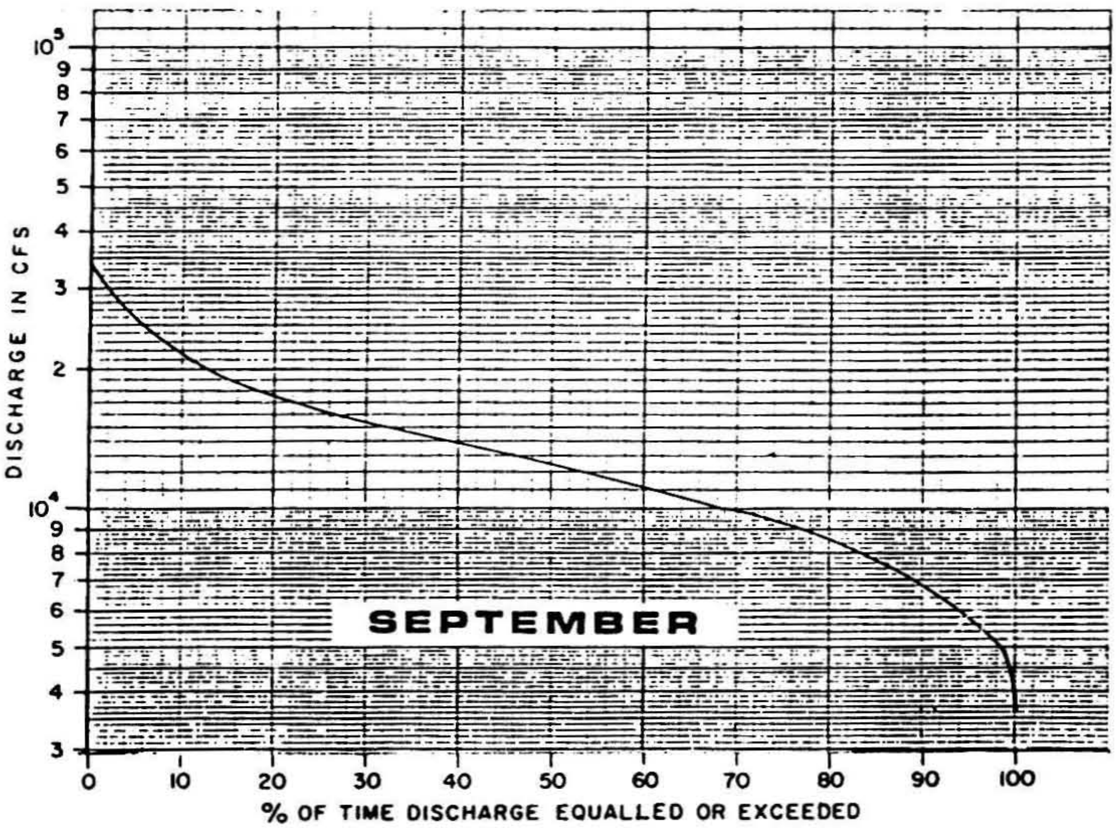


Figure 8. August and September Average Daily Streamflow Duration Curves for the Susitna River at Gold Creek.

equal to or greater than 18,000 cfs have occurred 70% of time during 33 years of record. Adult passage could become limiting during September since streamflows in equal to or greater than 16,000 cfs have only occurred about 25% of the time, and mainstem flows of 12,000 cfs or greater only occurred 54% of the time. A more refined evaluation of access to the side sloughs during the inmigration and spawning period could be obtained from a flow duration curve specifically developed for the mid-August to mid-September period.

The range of entrance conditions most likely to exist under postproject flows was determined from a comparison between proposed average monthly streamflows during various project phases (Table 5), and the information summarized in Table 4. It is anticipated that adult spawners will experience considerable difficulty in gaining access to traditional spawning areas in the side sloughs under the proposed filling and operational flows. However, these proposed streamflows may be sufficient to provide some potential for rectifying impacts. Additional information and analysis will provide a more refined understanding of the daily or weekly fluctuations in mainstem stage and slough discharge that might be expected under various postproject scenarios. This knowledge will be instrumental in better quantifying impacts and evaluating alternative mitigation proposals.

Table 5. Comparison of average monthly pre- and proposed postproject streamflows at Gold Creek.

Month	Streamflow (cfs)			
	Preproject	Filling[a]	Watana[b]	Watana/Devil[c]
January	1500	1000	9700	10600
February	1200	1000	9000	10200
March	1100	1000	8300	9300
April	1400	1000	7700	8100
May	13200	6000	10400	8700
June	27800	6000	11400	9900
July	24400	6480	9200	8400
August	22200	12000[d]	13400[d]	12600[d]
September	13300	9300[d]	9800[d]	10500[d]
October	5800	2000	8000	7800
November	2600	1000	9200	9600
December	1800	1000	16700	11300

[a] Filling streamflows are target minimum values; actual streamflows during filling will typically be greater.
[b] Operation of Watana dam only.
[c] Operation of Watana and Devil Canyon dams.
[d] Includes a controlled flow of no less than 12,000 cfs from mid August to mid September.

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