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# SUSITNA HYDROELECTRIC PROJECT

# EVALUATION OF ALTERNATIVE FLOW REQUIREMENTS

Report by
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Prepared for
Alaska Power Authority

Final Report
October 1984

**NOTICE**

**ANY QUESTIONS OR COMMENTS CONCERNING THIS REPORT SHOULD BE DIRECTED TO THE ALASKA POWER AUTHORITY**

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SUSITNA HYDROELECTRIC PROJECT

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FLOW REQUIREMENTS

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# 1.0 INTRODUCTION

## 1.1 LICENSE APPLICATION FLOW CASES

### 1.1.1 Range of Flows

The flow cases analyzed in the License Application for the Susitna Project ranged from the operational flow that would produce the maximum amount of usable power and energy benefits from the project, referred to as Case A, to the one which would result in minimum flow-related impacts on the downstream fishery resources relative to natural conditions, referred to as Case G. Eight additional flow scenarios were analyzed between these two extremes. The monthly flow requirements at Gold Creek for each of these cases are presented in the License Application, Table B.54.

### 1.1.2 Selection of Case C

To determine the net economic value of the energy and power produced by the Susitna Hydroelectric Project, the mathematical model known as OGP (Optimized Generation Planning) was used to determine the present worth of the long-term (1993-2051) production costs of supplying the Railbelt energy needs by various alternative means of generation. The analysis was performed for the best "without Susitna" (all thermal) option as well as for the "with Susitna" option using the ten flow cases mentioned above. The results of the "with Susitna" analysis are presented in Table B.57 of the License Application. The results of this analysis can be summarized as follows: as summer flows are increased for environmental reasons the net power and energy benefits decrease. This decrease in net benefits becomes more pronounced as minimum summer flows are increased above those required in Case C.

Based upon the instream flow studies conducted up to the time of the license submittal, it was concluded that for flows of the Case A magnitude, severe impacts would occur to the existing fish populations, particularly in the middle river, and these impacts could not be mitigated except by compensation through construction and operation of hatcheries. Case C requirements minimized these impacts through control and timing of flow releases. The August 1 to September 15 minimum flow of 12,000 cfs was the primary focus of Case C and was intended to provide access into side slough spawning habitat. With August flows in the 12,000 cfs range (Case C), salmon can access a number of traditional spawning sloughs. To further insure that salmon could obtain access to slough spawning areas at a flow of 12,000 cfs, a series of habitat alterations were incorporated into the mitigation plan presented in the License Application.

Cases A, A1, and A2 do not allow mitigation of the impacts caused by the changed flows through habitat alteration. Based on economic analysis and the fishery analysis, it was judged that the loss in net energy and power benefits for Case C was acceptable, while the loss associated with Case C1 was on the borderline between acceptable and unacceptable. The potential decrease in mitigation costs associated with higher flows would not offset the loss in net energy benefits. Thus, Case C was selected as the flow case presented in the License Application.

## 1.2 Refined Flow Cases

### 1.2.1 Power and Energy

#### 1.2.1.1 Project Operation

The Power Authority's goal is to operate the project to maximize power and energy benefits within environmental and operational constraints. Environmental constraints include maximum and minimum downstream flows (termed flow requirements) and maximum rates of change of flow. Operational constraints include: a minimum reservoir level, a maximum reservoir level which if exceeded results in a prespecified operating procedure, maximum output of the turbines, minimum turbine output, and system electrical energy demand.

Generally, the project would be operated to store high summer flows when energy demands are low and then releasing these flows in winter when energy demands are high. To maximize the power and energy benefits of the project, the reservoir should be close to, or at, the normal maximum operating level at the beginning of October of each year and close to, or at, the minimum operating level at the end of April of each year. This permits greater power and energy generation in the months from October to April when energy is most valuable. During this period, energy would be generated in direct proportion to the system electrical demand. This is accomplished in average and high flow years by discharging water from the reservoir to match weekly or monthly target reservoir water levels and in lower flow years by producing a specified minimum energy in each weekly or monthly period. The target water levels and minimum energy production are established based on the historic streamflow record. The natural inflow to the reservoir and the water taken out of storage to meet the target reservoir elevations are used to produce energy during each specified time interval. In low flow years, if the energy produced by meeting the target reservoir water levels is less than the minimum energy production, additional water is withdrawn from storage to provide the minimum prescribed energy. The minimum energy is determined using a dry hydrological sequence with a specified frequency of occurrence. The end of this dry period corresponds to the beginning of the spring snow melt runoff period by which time the reservoir is drawn down to its minimum elevation.

From May to September, the target reservoir elevation is increased from one time step to the next to store the summer flows for release the following winter. Water levels are established so that the energy produced remains a fixed proportion of the system energy demand for each time step with the objective that the reservoir is at or close to the normal maximum operating level at the end of September. Further, it is desirable to avoid premature filling of the reservoir because this would result in release of water with less energy producing benefits. Minimum flow requirements during summer may be greater than the flow resulting from normal energy production. When this occurs, energy production is increased up to the system energy demand until the minimum flow requirements are met. Since only usable energy can be produced, the remainder of any minimum flow requirement after the power house flow is subtracted is made up by releases from the fixed cone valves. As in winter operation, summer reservoir operation is required to produce a minimum specified energy during each time interval.

#### 1.2.1.2 Power and Energy Flow Case

An operational flow regime (P-1) was established to provide a basis for an economic comparison of alternative flow regimes resulting from various environmental constraints. Case P-1 maximizes power and energy benefits of the project irrespective of environmental considerations. Project benefits are optimized based on two objectives. In minimum flow years, the project would operate to minimize the thermal capacity requirements in the railbelt system. In all other years, the project would operate to take advantage of the most efficient operation of thermal generating units. To achieve these objectives, the project would operate to permit thermal energy generation at a constant level throughout the year. In terms of reservoir operation, this is accomplished by subtracting the annual energy available from the project from the total annual energy demand. The remaining energy is assumed to be distributed uniformly through the year and would be generated by thermal and other hydro plants. For each time interval, the Susitna project would provide the difference between the system energy demand and the constant thermal energy production. This strategy is subject to the added consideration that the October to April energy is limited by the usable storage and natural reservoir inflow. This limitation could result in two periods of constant thermal generation: an October to April period and a May to September period. The October to April period would require a higher level of constant thermal energy generation because of the reservoir storage limitations.

Case P-1 flows average 9,700 cfs at Gold Creek during the October to April period. Beginning in October, flows are gradually increased, reaching a peak in December. From January through May, flows gradually decrease. Maximum December flows at Gold Creek could reach as high as 14,000 cfs but more often would be approximately 12,000 cfs. During the winter, minimum flows are rarely less than 7,000 cfs. Flows less than 7,000 cfs occur only in unusually low flow years at the end of the winter period.

The average flow during summer operation (May-September) is the same as in winter. During this period, however, flow variability is much greater than during winter operation. During high flow years, the monthly or weekly average discharge at Gold Creek might approach 20,000 cfs in May, June or July. In August and September when the reservoir is more likely to be full, discharge at Gold Creek could exceed 20,000 cfs. In low flow years, the flow at Gold Creek could be as low as 4,500 cfs for extended periods. Summer flow would be less than 7,000 cfs about 30 percent of the time.

### 1.2.2 Environmental Cases

The environmental flow scenarios presented in the License Application contained flow constraints to satisfy particular habitat needs during specific time periods. These constraints focused on species, habitat, and timing criteria thought at that time to be important or critical. The constraints were derived to satisfy limited resource management objectives. For example, the environmental flow components of Case C were designed to maintain suitable conditions for upstream migration of adult salmon during the early summer and provide access to side sloughs by chum salmon for spawning during August and September. This approach failed to consider any flow constraints to protect chum incubation.

Results of several additional studies and analyses have become available since submittal of the License Application. These new data have allowed the Power Authority to develop more detailed and refined environmental flow requirements to meet specific management objectives. The Power Authority has evaluated eight new environmental Cases. Each new Case is an expansion or refinement of Case C in the License Application. However, where Case C (Table 1) was a combination of power demand flows over the entire year with minimum environmental flow requirements only for critical times, the new cases establish weekly minimum and maximum environmental flows for an entire year. (See Table 2 for relationship of calendar weeks to water weeks.) The minima and maxima are limits within which the project is constrained to operate if stated management objectives are to be achieved. Actual flows within these limits will depend on operational criteria aimed at maximizing the power and energy benefits of the project.

Table 1

SUSITNA HYDROELECTRIC PROJECT
WEEKLY MEAN FLOWS AT GOLD CREEK
FOR FLOW CASE C

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum(1) | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 5,000 | | 40 | 6,000 | |
| 15 | 5,000 | | 41 | 6,000 | |
| 16 | 5,000 | | 42 | 6,000 | |
| 17 | 5,000 | | 43 | 6,400(3) | |
| 18 | 5,000 | | 44 | 11,100(4) | |
| 19 | 5,000 | | 45 | 12,000 | |
| 20 | 5,000 | | 46 | 12,000 | |
| 21 | 5,000 | | 47 | 12,000 | |
| 22 | 5,000 | | 48 | 12,000 | |
| 23 | 5,000 | | 49 | 12,000 | |
| 24 | 5,000 | | 50 | 11,900(5) | |
| 25 | 5,000 | | 51 | 7,400(6) | |
| 26 | 5,000 | | 52 | 6,000(7) | |
| 27 | 5,000 | | 1 | 5,000 | |
| 28 | 5,000 | | 2 | 5,000 | |
| 29 | 5,000 | | 3 | 5,000 | |
| 30 | 5,000 | | 4 | 5,000 | |
| 31 | 5,700(2) | | 5 | 5,000 | |
| 32 | 6,000 | | 6 | 5,000 | |
| 33 | 6,000 | | 7 | 5,000 | |
| 34 | 6,000 | | 8 | 5,000 | |
| 35 | 6,000 | | 9 | 5,000 | |
| 36 | 6,000 | | 10 | 5,000 | |
| 37 | 6,000 | | 11 | 5,000 | |
| 38 | 6,000 | | 12 | 5,000 | |
| 39 | 6,000 | | 13 | 5,000 | |

(1) Maximum flow constraints were not established for Case C
(2) 2 days at 5,000 cfs then 5 days at 6,000 cfs
(3) 5 days at 6,000, 1 day at 7,000, 1 day at 3,000 cfs
(4) 1 day each at 9,000, 10,000 and 11,000 and 4 days at 12,000 cfs
(5) 6 days at 12,000 cfs, 1 day at 11,000 cfs
(6) 1 day each at 10,000, 9,000, 8,000 and 7,000 cfs and 3 days at 6,000 cfs
(7) 8 days at 6,000 cfs

Table 2

SUSITNA HYDROELECTRIC PROJECT

WATER WEEKS FOR WATER YEAR N.

| WEEK NUMBER | FROM | | | TO | | | WEEK NUMBER | FROM | | | TO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | day | month | year | day | month | year | | day | month | year | day | month | year |
| 1 | 1 | Oct. | n-1 | 7 | Oct. | n-1 | 27 | 1 | Apr. | n | 7 | Apr. | n |
| 2 | 8 | Oct. | n-1 | 14 | Oct. | n-1 | 28 | 8 | Apr. | n | 14 | Apr. | n |
| 3 | 15 | Oct. | n-1 | 21 | Oct. | n-1 | 29 | 15 | Apr. | n | 21 | Apr. | n |
| 4 | 22 | Oct. | n-1 | 28 | Oct. | n-1 | 30 | 22 | Apr. | n | 28 | Apr. | n |
| 5 | 29 | Oct. | n-1 | 4 | Nov. | n-1 | 31 | 29 | Apr. | n | 5 | May | n |
| 6 | 5 | Nov. | n-1 | 11 | Nov. | n-1 | 32 | 6 | May | n | 12 | May | n |
| 7 | 12 | Nov. | n-1 | 18 | Nov. | n-1 | 33 | 13 | May | n | 19 | May | n |
| 8 | 19 | Nov. | n-1 | 25 | Nov. | n-1 | 34 | 20 | May | n | 26 | May | n |
| 9 | 26 | Nov. | n-1 | 2 | Dec. | n-1 | 35 | 27 | May | n | 2 | June | n |
| 10 | 3 | Dec. | n-1 | 9 | Dec. | n-1 | 36 | 3 | June | n | 9 | June | n |
| 11 | 10 | Dec. | n-1 | 16 | Dec. | n-1 | 37 | 10 | June | n | 16 | June | n |
| 12 | 17 | Dec. | n-1 | 23 | Dec. | n-1 | 38 | 17 | June | n | 23 | June | n |
| 13 | 24 | Dec. | n-1 | 30 | Dec. | n-1 | 39 | 24 | June | n | 30 | June | n |
| 14 | 31 | Dec. | n-1 | 6 | Jan. | n | 40 | 1 | July | n | 7 | July | n |
| 15 | 7 | Jan. | n | 13 | Jan. | n | 41 | 8 | July | n | 14 | July | n |
| 16 | 14 | Jan. | n | 20 | Jan. | n | 42 | 15 | July | n | 21 | July | n |
| 17 | 21 | Jan. | n | 27 | Jan. | n | 43 | 22 | July | n | 28 | July | n |
| 18 | 28 | Jan. | n | 3 | Feb. | n | 44 | 29 | July | n | 4 | Aug. | n |
| 19 | 4 | Feb. | n | 10 | Feb. | n | 45 | 5 | Aug. | n | 11 | Aug. | n |
| 20 | 11 | Feb. | n | 17 | Feb. | n | 46 | 12 | Aug. | n | 18 | Aug. | n |
| 21 | 18 | Feb. | n | 24 | Feb. | n | 47 | 19 | Aug. | n | 25 | Aug. | n |
| 22 | 25 | Feb. | n | 3 | Mar. | n | 48 | 26 | Aug. | n | 1 | Sep. | n |
| 23 | 4 | Mar. | n | 10 | Mar. | n | 49 | 2 | Sep. | n | 8 | Sep. | n |
| 24 | 11 | Mar. | n | 17 | Mar. | n | 50 | 9 | Sep. | n | 15 | Sep. | n |
| 25 | 18 | Mar. | n | 24 | Mar. | n | 51 | 16 | Sep. | n | 22 | Sep. | n |
| 26 | 25 | Mar. | n | 31 | Mar. | n | 52 | 23 | Sep. | n | 30 | Sep. | n |

## 2.0 DETAILED DISCUSSION OF REFINED FLOW CASES

### 2.1 ENVIRONMENTAL FLOW CASES

Environmental flow cases EI through EVI, as discussed below, are based on interpretation and analysis of all the data and information available regarding Susitna River fisheries resources and their habitats. Flow constraints contained in each case are based on the physical characteristics of particular habitats and uses of habitat by particular species and life stages under natural flow conditions. The potential for new habitat with the same characteristics but at different locations under project operation flows was not considered.

Development of the flow cases emphasized maintenance of habitats most responsive to mainstem flows. Rearing habitats in mainstem backwater areas, side channels and side sloughs were given greatest emphasis. Side sloughs are the most important spawning habitat affected by mainstem flows. Flow constraints for maintenance of summer rearing habitat included two important considerations. Minimum summer flow constraints were established to preserve the desired quantity of existing habitat and summer maximums were established to prevent extensive dislocation of rearing juveniles (i.e., provide greater flow stability). Flow constraints for juvenile over-wintering habitat were chosen to provide general flow stability and to minimize mainstem over-topping of side slough berms.

Mainstem flows affect both access to, and wetted area within, side sloughs. Minimum flow constraints were chosen to provide a specific minimum level of access and wetted area within chosen critical sloughs. These flow constraints are limited to August and

September when chum and sockeye salmon enter the sloughs and spawn. Several cases include spiking flows. These short duration releases of relatively high volumes of water fulfill two purposes. Spiking flows in June provide over-topping flows into side sloughs to clear debris and sediments out of spawning areas and are not required every year. Spiking flows during August and September are to augment access conditions in side sloughs.

Minimim flow constraints are generally used to maintain a specified level of habitat quantity. Maximum flow constraints are generally used to provide flow stability (habitat quality) or minimize over-topping of mainstem water into side sloughs.

The following sections present cases EI-EV. A more detailed description of EVI, the selected case, is presented in Section 4.0.

### 2.1.1 Case EI

- Management Objective

Case EI is a set of flow constraints necessary to maintain the quality and quantity of existing habitats, and represents the "no-impact" bound of the analysis. A corollary to this statement is that Case EI achieves no net loss in productivity strictly through flow control and proper timing of flow releases. Maintenance of existing habitat and productivity does not require exact duplication of natural flow patterns and, in fact, some productivity benefits can accrue to downstream aquatic resources through increased stability by flow regulation.

- Flow Constraints

The EI flow constraints are shown in Table 3 and Figure 1. Summer flow constraints were chosen principally to maintain existing juvenile salmon rearing habitats. These flows also provide passage conditions for upstream migration of adults. A 45,000 cfs spike is provided in June to purposely overtop sloughs and clean sediments and debris out of spawning areas. This spiking flow is not necessary in each year of operation. Flows of this magnitude may be necessary once every three to four years to achieve this purpose. Two flow spikes, 23,000 and 18,000 cfs, are provided in mid-August to allow unrestricted access by adult spawners into side sloughs. Winter minimum and maximum flows were chosen to maintain adequate over-wintering habitat and protect incubating eggs in side-slough habitats.

- Project Flows

Case EI flows average 8,000 cfs at Gold Creek during the October to April period. Powerhouse discharge is increased from October to December and then decreased from December to April. December discharge can be as high as 12,000 cfs, but averages 9,600 cfs. The high minimum summer flow requirements result in low flows during the months of October, March, and April in low flow years. October flows are always greater than 4,000 cfs but 50 percent of the time, they are less than 6,000 cfs. In March, minimum flows approach 4,000 cfs. In April, flow is as low as 2,300 cfs during dry years.

Because of the high minimum summer requirements of Case EI, flow during May is purposely held low. Average flow during May is 6,000 cfs. During years when snowmelt is delayed, minimum flow will be close to the minimum flow constraint of 2,000 cfs. During the months of June, July, August and September, project flows are the same as the minimum flow requirements 80 percent of the time. During the other 20 percent of the time, the project operation flows are usually only slightly greater than the minimum requirements. Flows would closely follow the minimum constraints during June through September, except during periods of high run off.

No Quantitative support -

o Impact assessment

The flow constraints in Case EI were chosen to maintain existing spawning and rearing habitats. No loss of production is anticipated. Certain aspects of water quality will be changed by project operation. The natural temperature and turbidity regimes will be altered. Mainstem water temperatures will be generally cooler in the summer and warmer in the winter. However, these changes are well within the known tolerances of fishes utilizing mainstem habitats (APA, 1984a) and no significant change of production is anticipated (see Power Authority comments on DEIS Nos, AQR100, AQR108, AQR119 and AQR123). Turbidity levels will be less in the summer and greater in the winter than under natural conditions. Turbidity levels in the winter will be less than natural summer levels and are within the range of tolerance for existing Susitna River stocks. The projected temperature and turbidity impacts are generally the same for all the cases and will not be repeated for each.

Table 3

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EI.

| Water Week | Gold Creek Flow (cfs) Minimum | Gold Creek Flow (cfs) Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Gold Creek Flow (cfs) Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 14,000 | 40 | 14,000 | |
| 15 | 2,000 | 14,000 | 41 | 14,000 | |
| 16 | 2,000 | 14,000 | 42 | 14,000 | |
| 17 | 2,000 | 14,000 | 43 | 14,000 | |
| 18 | 2,000 | 14,000 | 44 | 14,000 | 40,000 |
| 19 | 2,000 | 14,000 | 45 | 14,000 | 40,000 |
| 20 | 2,000 | 14,000 | 46 | (2) | 40,000 |
| 21 | 2,000 | 14,000 | 47 | (3) | 40,000 |
| 22 | 2,000 | 14,000 | 48 | 14,000 | 40,000 |
| 23 | 2,000 | 14,000 | 49 | 12,000 | 14,000 |
| 24 | 2,000 | 14,000 | 50 | 10,000 | 14,000 |
| 25 | 2,000 | 14,000 | 51 | 8,000 | 14,000 |
| 26 | 2,000 | 14,000 | 52 | 6,000 | 14,000 |
| 27 | 2,000 | 14,000 | 1 | 6,000 | 14,000 |
| 28 | 2,000 | 14,000 | 2 | 6,000 | 14,000 |
| 29 | 2,000 | 14,000 | 3 | 5,000 | 14,000 |
| 30 | 2,000 | 14,000 | 4 | 4,000 | 14,000 |
| 31 | 2,000 | 14,000 | 5 | 3,000 | 14,000 |
| 32 | 2,000 | 14,000 | 6 | 3,000 | 14,000 |
| 33 | 2,000 | 14,000 | 7 | 3,000 | 14,000 |
| 34 | 2,000 | 14,000 | 8 | 3,000 | 14,000 |
| 35 | 2,000 | 14,000 | 9 | 2,000 | 14,000 |
| 36 | 10,000 | | 10 | 2,000 | 14,000 |
| 37 | (1) | | 11 | 2,000 | 14,000 |
| 38 | 14,000 | | 12 | 2,000 | 14,000 |
| 39 | 14,000 | | 13 | 2,000 | 14,000 |

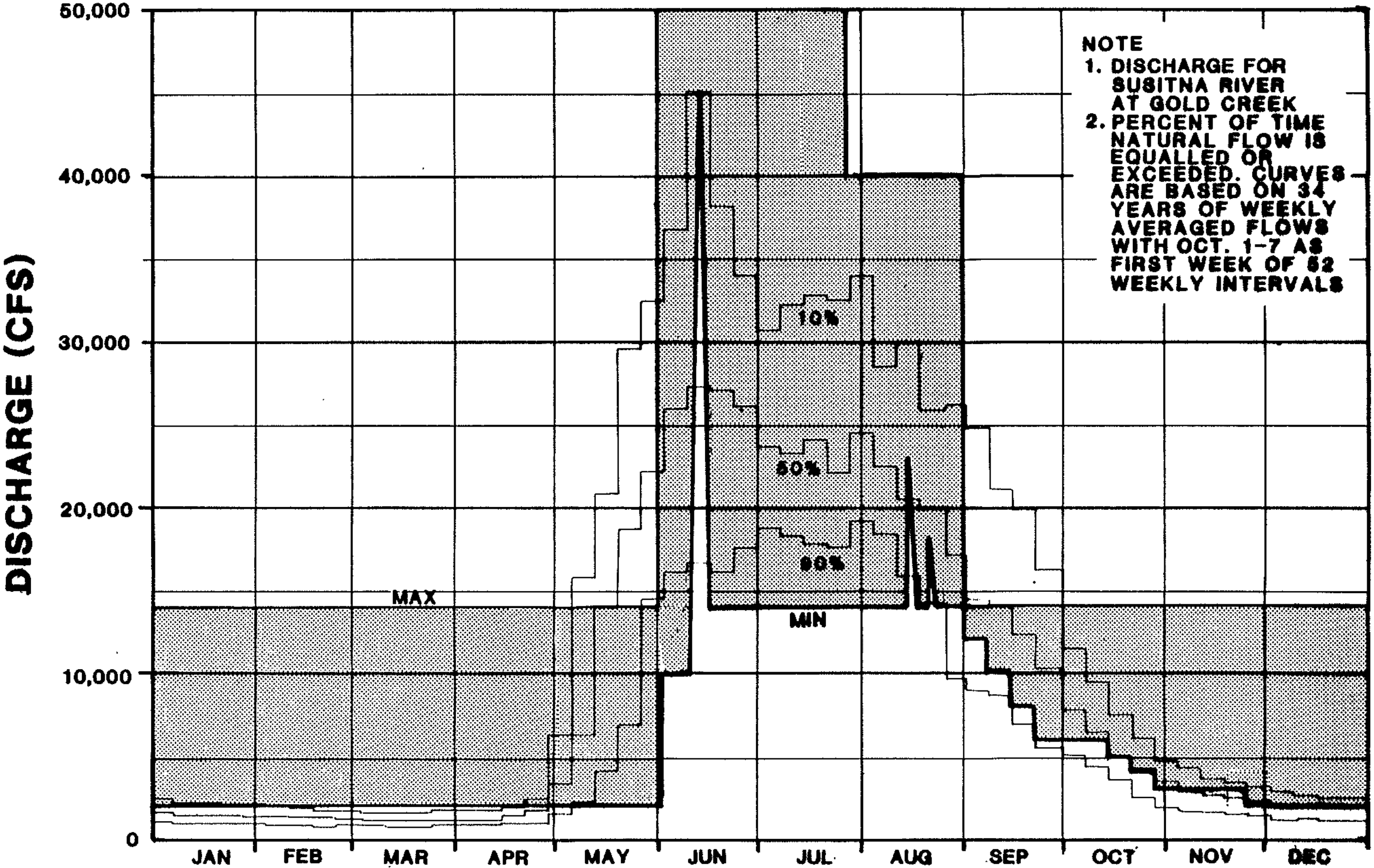
(1) Base minimum flow of 10,000 cfs. 45,000 cfs spike; 3 days up, 3 days down.

(2) Base minimum flow of 14,000 cfs. 23,000 cfs spike; 1 day up, 1 day down.

(3) Base minimum flow of 14,000 cfs. 18,000 cfs spike; 1 day up, 1 day down.

Figure 1

# ENVIRONMENTAL FLOW REQUIREMENTS CASE E I



- Mitigation

Case EI was designed to maintain existing habitat. Potential loss of these habitats would be minimized through timing and control of flow releases. Mitigation efforts to rectify, reduce or compensate for impacts would not be necessary. An extensive monitoring program would be conducted to measure the success of this plan in achieving the desired goal of no net loss in productivity.

### 2.1.2 Case EII

- Management objective

Case EII is a set of flow constraints necessary to maintain 75% of existing chum salmon side-slough spawning habitat. This is not synonomous with maintenance of 75% of chum salmon production in the Susitna River system. Estimated numbers of chum salmon spawners in side sloughs of the middle river were less than 2% of the total escapement past Sunshine Station during the past three seasons (1981-83:ADF&G, 1984a).

- Flow Constraints

Case EII flow constraints are presented in Table 4 and Figure 2. Early summer minimum flow constraints are intended to provide for successful exit of juvenile chum from slough spawning areas and for initial downstream passage and rearing. A 35,000 cfs spike is provided in mid-June to overtop sloughs and clear spawning areas of sediments and debris. Minimum July flows of 6,000 cfs will provide for successful upstream passage of migrating adults. Maximum flow constraints are not necessary during this period to satisfy the management objective. Minimum August flows of 12,000 cfs will provide access to side sloughs by adult spawners. An 18,000 cfs spike is provided in early September to augment access

Table 4

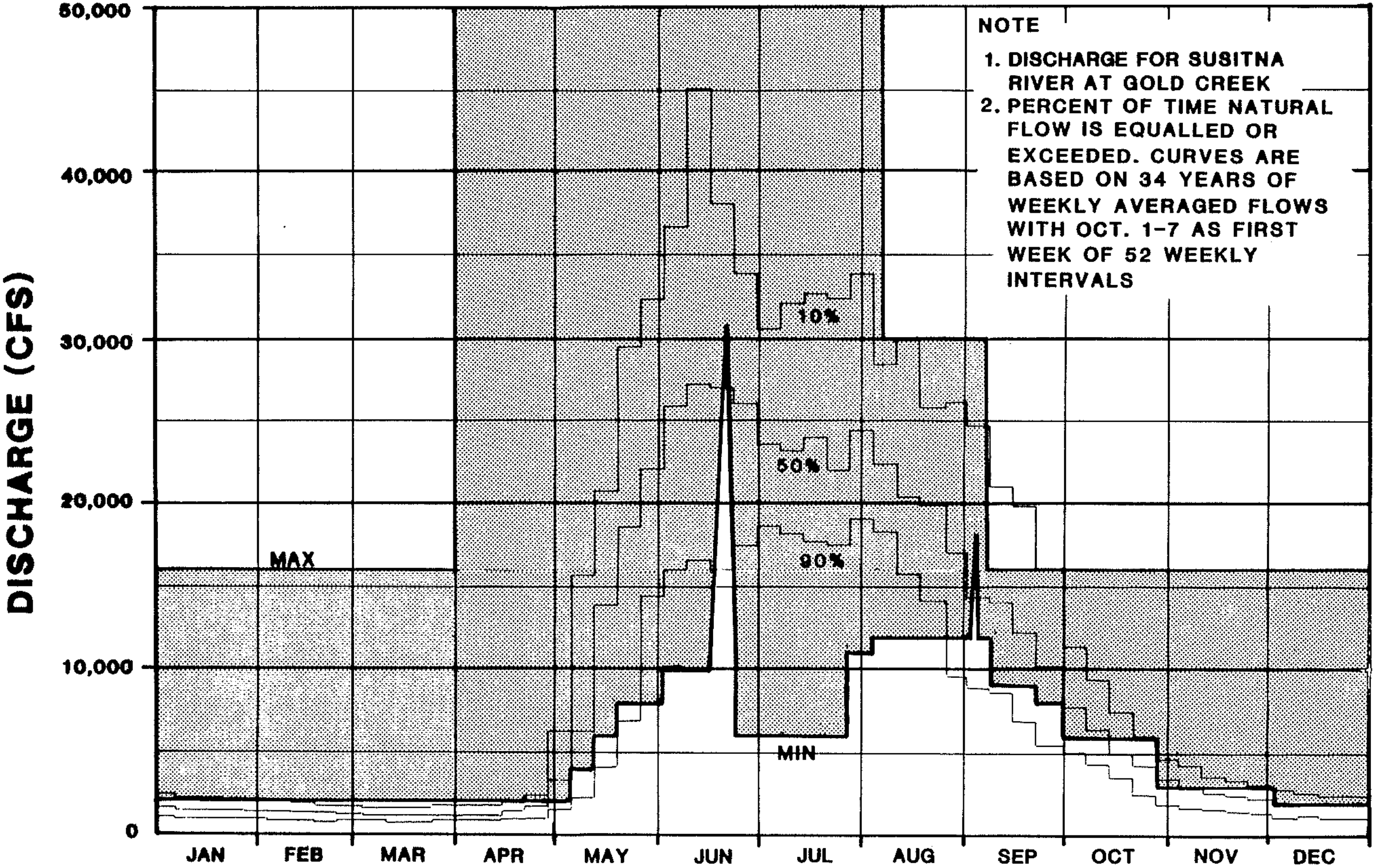
SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EII.

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 16,000 | 40 | 6,000 | |
| 15 | 2,000 | 16,000 | 41 | 6,000 | |
| 16 | 2,000 | 16,000 | 42 | 6,000 | |
| 17 | 2,000 | 16,000 | 43 | 6,000 | |
| 18 | 2,000 | 16,000 | 44 | 11,000 | |
| 19 | 2,000 | 16,000 | 45 | 12,000 | 30,000 |
| 20 | 2,000 | 16,000 | 46 | 12,000 | 30,000 |
| 21 | 2,000 | 16,000 | 47 | 12,000 | 30,000 |
| 22 | 2,000 | 16,000 | 48 | 12,000 | 30,000 |
| 23 | 2,000 | 16,000 | 49 | (2) | 30,000 |
| 24 | 2,000 | 16,000 | 50 | 9,000 | 16,000 |
| 25 | 2,000 | 16,000 | 51 | 9,000 | 16,000 |
| 26 | 2,000 | 16,000 | 52 | 8,000 | 16,000 |
| 27 | 2,000 | | 1 | 6,000 | 16,000 |
| 28 | 2,000 | | 2 | 6,000 | 16,000 |
| 29 | 2,000 | | 3 | 6,000 | 16,000 |
| 30 | 2,000 | | 4 | 6,000 | 16,000 |
| 31 | 2,000 | | 5 | 3,000 | 16,000 |
| 32 | 4,000 | | 6 | 3,000 | 16,000 |
| 33 | 6,000 | | 7 | 3,000 | 16,000 |
| 34 | 8,000 | | 8 | 3,000 | 16,000 |
| 35 | 8,000 | | 9 | 3,000 | 16,000 |
| 36 | 10,000 | | 10 | 2,000 | 16,000 |
| 37 | 10,000 | | 11 | 2,000 | 16,000 |
| 38 | (1) | | 12 | 2,000 | 16,000 |
| 39 | 6,000 | | 13 | 2,000 | 16,000 |

(1) Base minimum flow of 6,000 cfs. 35,000 cfs spike; 3 days up, 3 days down.

(2) Base minimum flow of 12,000 cfs. 18,000 cfs spike; 1 day up, 1 day down.

Figure 2
# ENVIRONMENTAL FLOW REQUIREMENTS CASE E II



to important side slough sites. Minimum flow constraints during the winter resemble natural flow conditions and are simply to prevent unusual dewatering of spawning sites. Maximum winter flow constraints of 16,000 cfs provide a moderate level of protection to eggs incubating in side sloughs.

o Project Flows

Project flows for Case EII are similar to those of Case EV except that the October to April flows would be higher for Case EII to reflect the fact that the July minimum flows for Case EII are lower than for Case EV. Flows from May to September would average 10,700 cfs and would be at the minimum flow about 55 percent of the time.

o Impact assessment

Several of the Case EII flow constraints are conservative. The June spiking flow to clean side slough spawning habitat does not have to occur every year. This spike could be provided once every several years and still achieve its purpose. The summer spiking flow may be in excess of that necessary to maintain access to 75% of the existing side slough spawning habitat (see Power Authority comment on DEIS No. AQR072). However, a 25% loss of chum salmon side slough spawning habitat will be assumed for this analysis.

Sockeye salmon also spawn in the side sloughs most frequently used by chum spawning. Spawning habitat loss for sockeye salmon is expected to be similar to the losses for chum. The minimum summer flows are adequate for upstream passage and tributary access to migrant adults and since coho, chinook and pink salmon spawn almost exclusively in tributaries, no loss of spawning habitat would occur for these species.

The summer minimum flow constraints established for Case EII would not maintain 100% of the existing juvenile chinook rearing habitat.

The 6,000 cfs minimum flows during water weeks 39 through 43 would result in the significant loss of existing chinook rearing habitat. A 75% loss of existing chinook rearing habitat in the middle river is thought to be a worst case estimate and will be assumed for this evaluation.

Chum salmon juveniles also utilize mainstem affected habitats for rearing. Sampling in the middle river indicates a majority (approximately 60%) of the chum have left this reach prior to water week 39 so the loss of rearing habitat would not be as great for chum as for chinook. A worst case estimate for loss of rearing habitat for the chum juveniles remaining in the middle river is assumed, therefore, to be 40%.

o Mitigation

Case EII minimizes some impacts through control and timing of flow releases. Potential impacts to slough spawning chum and sockeye salmon are minimized by special flow releases timed to clean spawning substrate and provide access to spawning areas. Impacts to rearing habitats are minimized through minimum summer flow constraints and increased stability through flow control.

The remaining impacts to slough spawning habitat would be rectified by structural modification of slough mouths to provide suitable access conditions at 12,000 cfs. Similar alterations would be made within the sloughs to provide passage through critical reaches. Loss of rearing habitat within the river would be rectified through replacement habitat naturally provided at other locations on the river at lower flows. The impact assessment only considered loss of habitats utilized under natural flow conditions. The channel structure of the middle Susitna River results in comparable habitat being created at different locations when discharge changes. This is supported by studies in the literature (Mosley, 1982) and by preliminary results of 1984 studies of the Susitna River. However, these studies do not suggest total replacement at flows as low as

6,000 cfs. Remaining impacts to rearing habitat that could not be rectified by flow control would be compensated by construction and operation of a propagation facility.

### 2.1.3 Case EIII

- Management Objectives

Case EIII is designed to maximize chinook salmon production (rearing) in existing habitats. Chinook do not use mainstem influenced habitats for spawning so maximization in this case does not include consideration of limitations to spawning habitat.

- Flow Constraints

Case EIII flow constraints are presented in Table 5 and Figure 3. Minimum summer flow constraints of 14,000 cfs are intended to maximize the quantity of mainstem influenced rearing habitat at sites utilized under natural conditions. These flows would also provide migrant adults with upstream passage and tributary access. Maximum summer constraints are not necessary. However, it is assumed the project would store the maximum possible quantity of water during the summer resulting in greater flow stability. Winter flow constraints provide adequate rearing habitat during the ice covered season.

- Project Flows

Case EIII flows during the October to April period average 7900 cfs at Gold Creek. The Case EIII winter flows are slightly less than the 8000 cfs average for Case EI because of the high minimum flow requirements for Case EIII during the month of May.

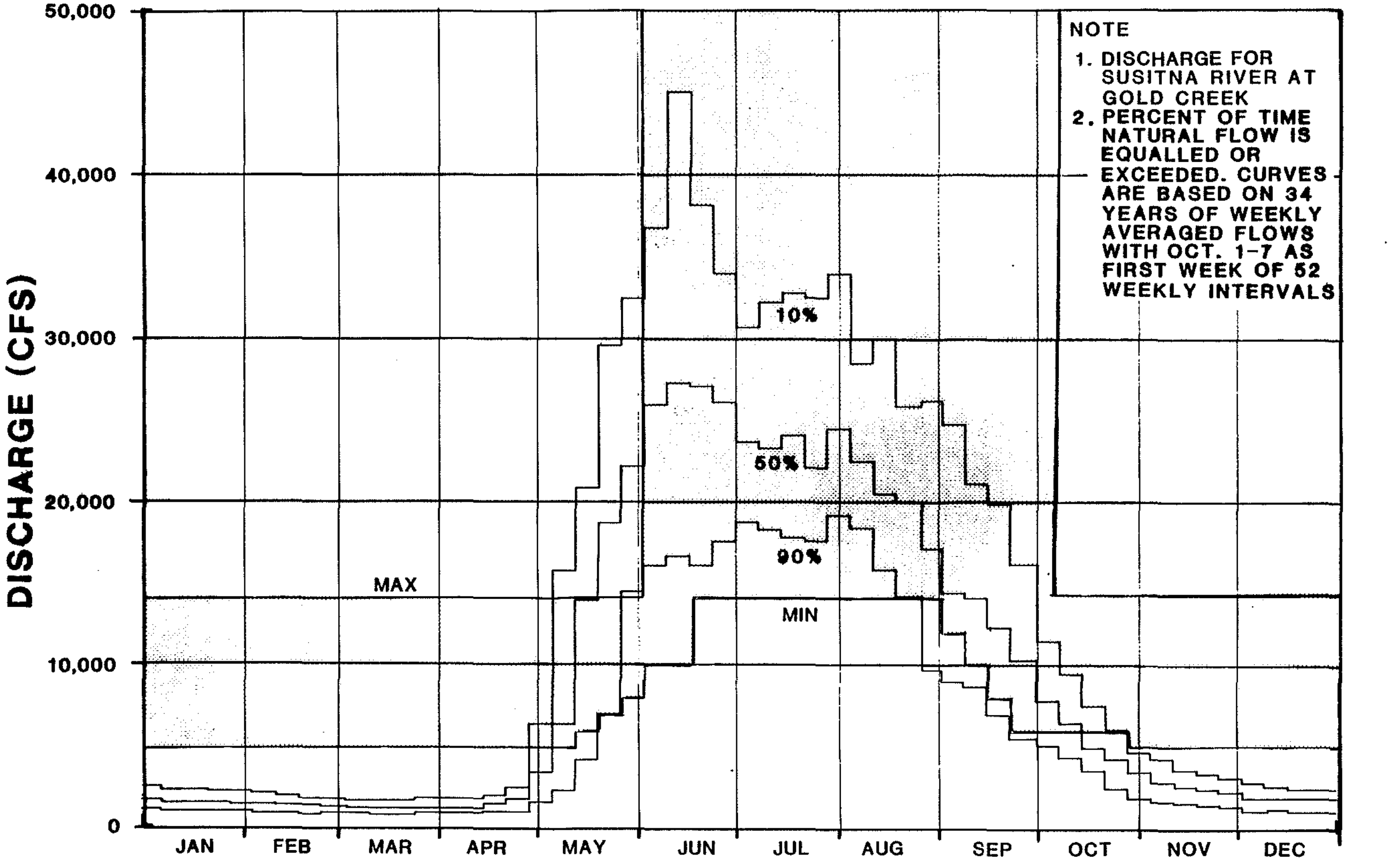
From May to September the average flow for Case EIII is 12,400 cfs. Project flow are at the minimum flow requirement during the period 75 percent of the time.

Table 5

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EIII.

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 5,000 | 14,000 | 40 | 14,000 | |
| 15 | 5,000 | 14,000 | 41 | 14,000 | |
| 16 | 5,000 | 14,000 | 42 | 14,000 | |
| 17 | 5,000 | 14,000 | 43 | 14,000 | |
| 18 | 5,000 | 14,000 | 44 | 14,000 | |
| 19 | 5,000 | 14,000 | 45 | 14,000 | |
| 20 | 5,000 | 14,000 | 46 | 14,000 | |
| 21 | 5,000 | 14,000 | 47 | 14,000 | |
| 22 | 5,000 | 14,000 | 48 | 14,000 | |
| 23 | 5,000 | 14,000 | 49 | 12,000 | |
| 24 | 5,000 | 14,000 | 50 | 10,000 | |
| 25 | 5,000 | 14,000 | 51 | 8,000 | |
| 26 | 5,000 | 14,000 | 52 | 6,000 | |
| 27 | 5,000 | 14,000 | 1 | 6,000 | 14,000 |
| 28 | 5,000 | 14,000 | 2 | 6,000 | 14,000 |
| 29 | 5,000 | 14,000 | 3 | 6,000 | 14,000 |
| 30 | 5,000 | 14,000 | 4 | 6,000 | 14,000 |
| 31 | 5,000 | 14,000 | 5 | 5,000 | 14,000 |
| 32 | 5,000 | 14,000 | 6 | 5,000 | 14,000 |
| 33 | 6,000 | 14,000 | 7 | 5,000 | 14,000 |
| 34 | 7,000 | 14,000 | 8 | 5,000 | 14,000 |
| 35 | 8,000 | 14,000 | 9 | 5,000 | 14,000 |
| 36 | 10,000 | | 10 | 5,000 | 14,000 |
| 37 | 10,000 | | 11 | 5,000 | 14,000 |
| 38 | 14,000 | | 12 | 5,000 | 14,000 |
| 39 | 14,000 | | 13 | 5,000 | 14,000 |

Figure 3
# ENVIRONMENTAL FLOW REQUIREMENTS CASE E III



- o Impact Assessment

No loss of chinook and chum rearing habitat is expected with Case EIII flows. The flow constraints and increased stability under project operation should improve rearing habitat quality and quantity compared to natural conditions.

Case EIII flows would affect access conditions into side sloughs for chum and sockeye spawning. The 14,000 cfs flows during August would provide some improvement over the 12,000 cfs flows in Case EII. However, some additional loss is anticipated due to elimination of spiking flows. Slough 11 would be the most affected of the major side slough spawning sites. Approximately 66% of the slough spawning sockeye and 17% of the slough spawning chum utilize slough 11 (1981-83 average). Restricted access conditions would not completely eliminate utilization of sloughs for spawning and, as noted for Case EII, the flow criteria used in this analysis is conservative (see Power Authority's comment on DEIS No. AQR072). However, for the purpose of this evaluation, a loss of 25% of existing slough spawning habitat for chum and 70% slough spawning habitat for sockeye will be assumed.

- o Mitigation

Potential impacts to rearing habitats, tributary access and upstream passage of adults will be avoided or minimized through timing and control of flow releases. Impacts to side-slough access will be minimized by flow release.

The remaining impacts to side-slough access for spawning will be rectified by structural modification at critical access reaches to provide successful access.

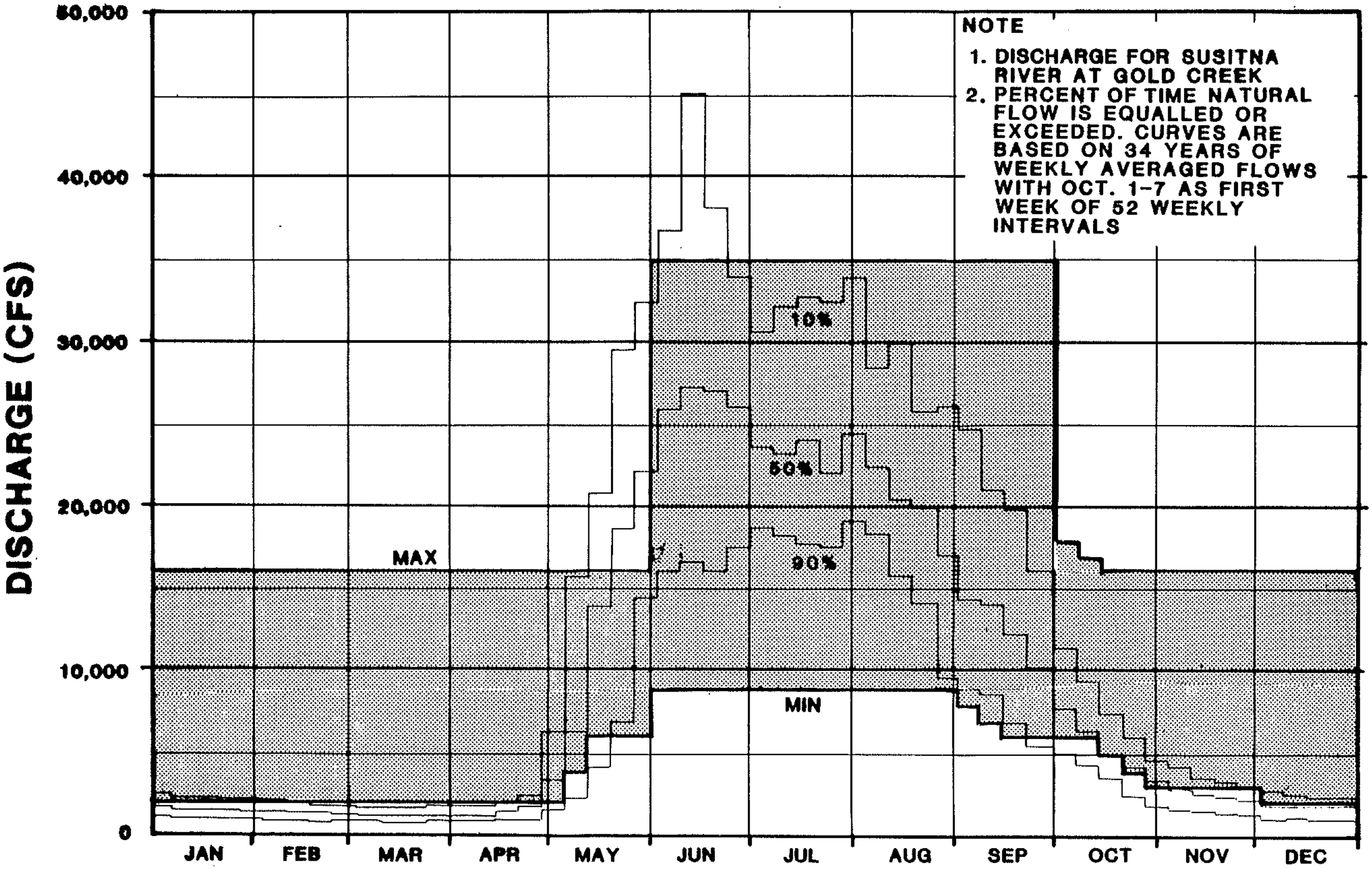
Table 6

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EIV.

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 16,000 | 40 | 9,000 | 35,000 |
| 15 | 2,000 | 16,000 | 41 | 9,000 | 35,000 |
| 16 | 2,000 | 16,000 | 42 | 9,000 | 35,000 |
| 17 | 2,000 | 16,000 | 43 | 9,000 | 35,000 |
| 18 | 2,000 | 16,000 | 44 | 9,000 | 35,000 |
| 19 | 2,000 | 16,000 | 45 | 9,000 | 35,000 |
| 20 | 2,000 | 16,000 | 46 | 9,000 | 35,000 |
| 21 | 2,000 | 16,000 | 47 | 9,000 | 35,000 |
| 22 | 2,000 | 16,000 | 48 | 9,000 | 35,000 |
| 23 | 2,000 | 16,000 | 49 | 8,000 | 35,000 |
| 24 | 2,000 | 16,000 | 50 | 7,000 | 35,000 |
| 25 | 2,000 | 16,000 | 51 | 6,000 | 35,000 |
| 26 | 2,000 | 16,000 | 52 | 6,000 | 35,000 |
| 27 | 2,000 | 16,000 | 1 | 6,000 | 18,000 |
| 28 | 2,000 | 16,000 | 2 | 6,000 | 17,000 |
| 29 | 2,000 | 16,000 | 3 | 5,000 | 16,000 |
| 30 | 2,000 | 16,000 | 4 | 4,000 | 16,000 |
| 31 | 2,000 | 16,000 | 5 | 3,000 | 16,000 |
| 32 | 4,000 | 16,000 | 6 | 3,000 | 16,000 |
| 33 | 6,000 | 16,000 | 7 | 3,000 | 16,000 |
| 34 | 6,000 | 16,000 | 8 | 3,000 | 16,000 |
| 35 | 6,000 | 16,000 | 9 | 3,000 | 16,000 |
| 36 | 9,000 | 35,000 | 10 | 2,000 | 16,000 |
| 37 | 9,000 | 35,000 | 11 | 2,000 | 16,000 |
| 38 | 9,000 | 35,000 | 12 | 2,000 | 16,000 |
| 39 | 9,000 | 35,000 | 13 | 2,000 | 16,000 |

Figure 4

# ENVIRONMENTAL FLOW REQUIREMENTS CASE E IV



### 2.1.4 Case EIV

- Management Objectives

Case EIV is designed to maintain 75% of the middle river side channel rearing habitat presently utilized by juvenile chinook salmon.

- Flow Constraints

The minimum summer flow constraint of 9,000 cfs (Table 6, Figure 4) is intended to maintain approximately 75% of the existing middle river side channel rearing habitat utilized by juvenile chinook salmon under natural flow conditions. The maximum summer flow constraint of 35,000 cfs is intended to produce moderate flow stability and prevent severe dislocation of rearing juveniles from preferred sites.

Winter constraints are designed to maintain flow stability within reasonable boundaries. The 2,000 cfs minimum is within the range of winter flows encountered under natural conditions, while the 16,000 cfs maximum would provide for flow stability and reduce the appearance and disappearance of transient rearing sites which occurs under natural conditions.

- Project Flows

Case EIV minimum summer flow requirements would result in an average flow of 9500 cfs at Gold Creek during the October to April period. This is only slightly lower than the winter average flow for Case P-1 (9700 cfs). During higher flow years, when the reservoir is filled prior to October, winter flows would be the same as for Case P-1. In lower flow years, flow at Gold Creek would be about 1000 cfs less than for Case P-1. Minimum flows in these years would be about 6000 cfs in October and March and about 4300 cfs in April.

May flows for Case E-IV would average 8400 cfs. These flows are lower than for Case P-1 in order to store as much water as possible prior to the 9000 cfs minimum requirement which takes effect in June. June, July, and August flows are at the 9000 cfs minimum requirement approximately 55 percent of the time. Average flow for these months is 10800 cfs. In September, project flows would be the same as the minimum flow requirement 35 percent of the time.

- Impact Assessment

Case EIV would reduce the availability of existing chinook salmon side channel rearing habitat by approximately 25% in the middle river. Rearing habitat now used by chum salmon juveniles would be reduced in side-sloughs. The major use of side slough habitat by juvenile chum salmon occurs during May and June and habitat reduction would result from loss of over-topping flows during this period. Loss of habitat could be as great as 50% at the sites utilized under natural flow conditions (ADF&G, 1984b: Fig. 9 and 10). No rearing habitat loss is expected in the lower river due to the dominant effects of the Chulitna and Talkeetna rivers.

Flow constraints during August and September would significantly restrict spawning access to sloughs by adult chum and sockeye salmon. Some successful access would still occur but with significant difficulty. A worst case assumption of 100% loss of access is assumed for this evaluation.

- Mitigation

Impacts on chinook and chum salmon rearing habitats would be minimized through timing and control of flow releases. A minimum summer flow constraint of 9,000 cfs would maintain a majority of the rearing habitat utilized under natural flow conditions. Increased flow stability under project operation would have an augmenting effect on over-all quality of the rearing habitats, especially for side channel sites utilized by chinook juveniles. Remaining loss of existing rearing habitat would be rectified by providing replacement habitat through control of flow releases. Flow reductions during the summer would reduce the quantity of and access to individual rearing sites utilized under natural flow conditions. However, the same flow reduction would result in new sites with the appropriate physical conditions for chinook and chum salmon rearing. This result is not unusual for rivers like the Susitna with moderately complex channel configurations. The availability of rearing habitat for chum and chinook salmon is actually expected to increase over natural conditions with operation under Case EIV (See Section 4.0 for further discussion).

Loss of access to side sloughs would be rectified by structural modification of critical access reaches.

### 2.1.5 Case EIVa

- Management Objective

  Case EIVa establishes flow constraints which would maintain 75% of the middle river side-channel rearing habitat presently utilized by chinook salmon juveniles and provide some access to the most productive side slough spawning sites for adult chum and sockeye salmon.

- Flow Constraints

  Case EIVa flow constraints are presented in Table 7 and Figure 5. These constraints are identical to those discussed for Case EIV above (Section 2.1.4) except for the inclusion of spiking flows in water weeks 38 and 48 thru 50. The purpose of the spiking flows is the same as discussed for Cases EI and EII (Sections 2.1.1 and 2.1.2). The 30,000 cfs spike in week 38 is to over-top slough berms to flush out accumulated sediments and debris. This flow

Table 7

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EIVa.

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 16,000 | 40 | 9,000 | 35,000 |
| 15 | 2,000 | 16,000 | 41 | 9,000 | 35,000 |
| 16 | 2,000 | 16,000 | 42 | 9,000 | 35,000 |
| 17 | 2,000 | 16,000 | 43 | 9,000 | 35,000 |
| 18 | 2,000 | 16,000 | 44 | 9,000 | 35,000 |
| 19 | 2,000 | 16,000 | 45 | 9,000 | 35,000 |
| 20 | 2,000 | 16,000 | 46 | 9,000 | 35,000 |
| 21 | 2,000 | 16,000 | 47 | 9,000 | 35,000 |
| 22 | 2,000 | 16,000 | 48 | (2) | 35,000 |
| 23 | 2,000 | 16,000 | 49 | (3) | 35,000 |
| 24 | 2,000 | 16,000 | 50 | (3) | 35,000 |
| 25 | 2,000 | 16,000 | 51 | 7,000 | 35,000 |
| 26 | 2,000 | 16,000 | 52 | 6,000 | 35,000 |
| 27 | 2,000 | 16,000 | 1 | 6,000 | 18,000 |
| 28 | 2,000 | 16,000 | 2 | 6,000 | 17,000 |
| 29 | 2,000 | 16,000 | 3 | 5,000 | 16,000 |
| 30 | 2,000 | 16,000 | 4 | 4,000 | 16,000 |
| 31 | 2,000 | 16,000 | 5 | 3,000 | 16,000 |
| 32 | 4,000 | 16,000 | 6 | 3,000 | 16,000 |
| 33 | 6,000 | 16,000 | 7 | 3,000 | 16,000 |
| 34 | 6,000 | 16,000 | 8 | 3,000 | 16,000 |
| 35 | 6,000 | 16,000 | 9 | 3,000 | 16,000 |
| 36 | 9,000 | 35,000 | 10 | 2,000 | 16,000 |
| 37 | 9,000 | 35,000 | 11 | 2,000 | 16,000 |
| 38 | (1) | 35,000 | 12 | 2,000 | 16,000 |
| 39 | 9,000 | 35,000 | 13 | 2,000 | 16,000 |

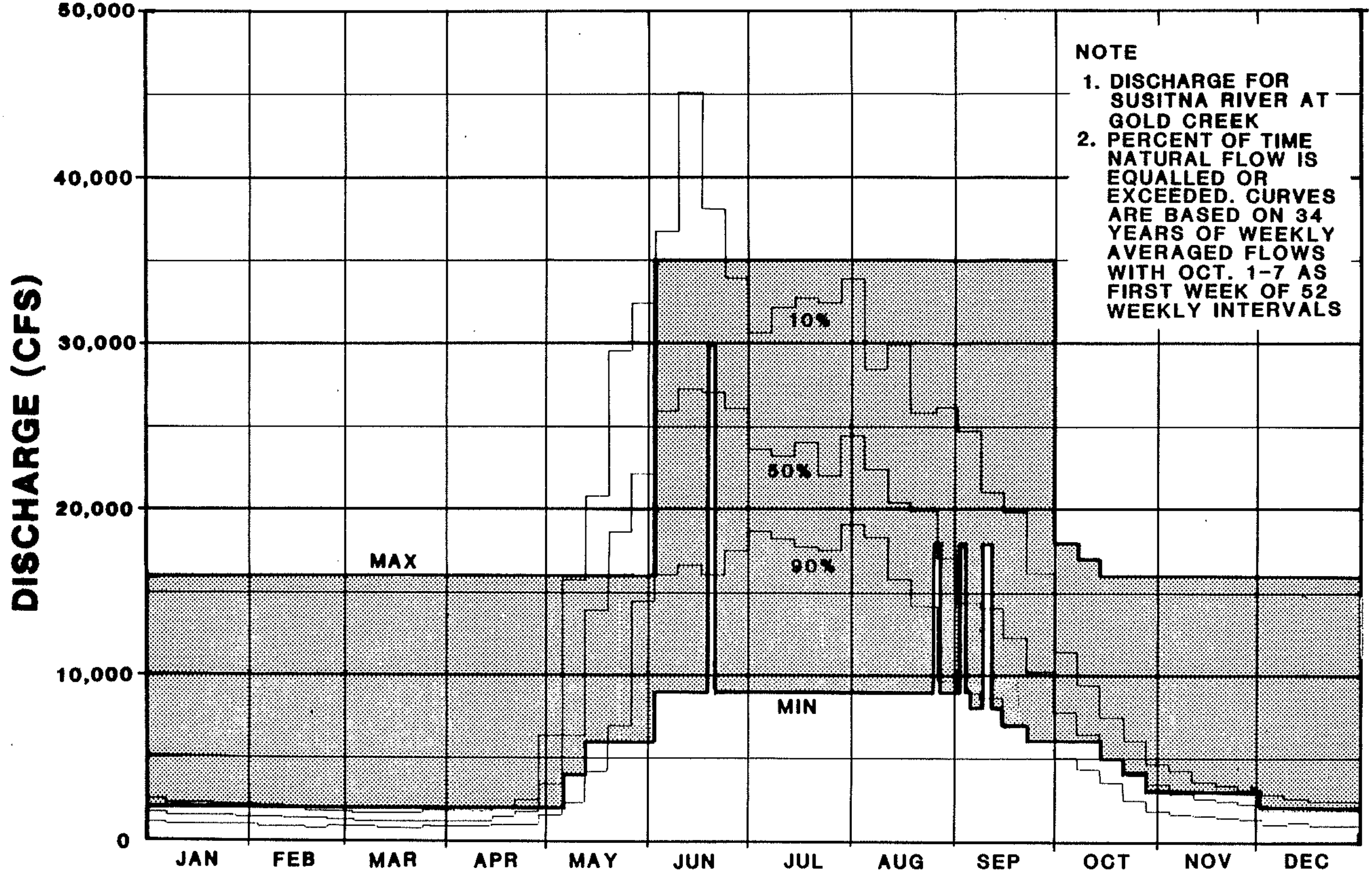
(1) Base minimum flow of 9,000 cfs. 30,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(2) Base minimum flow of 9,000 cfs. 18,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(3) Base minimum flow of 8,000 cfs 18,000 cfs. spike; 1 day up, 1 day hold, 1 day down.

Figure 5

# ENVIRONMENTAL FLOW REQUIREMENTS CASE IV a



would not be necessary each year of operation but would be provided at least once every three years. The spiking flows during weeks 48 thru 50 are to provide access to the most productive side slough spawning sites.

- Project Flows

Case EIVa flows would be similar to those of case EIV except that during winter operation, flows would be reduced from Case EIV during lower flow years to account for the reduced storage because of the required summer spiking flows.

Flow during June, July and August would be the same as the minimum requirements more than 55 percent of the time. Releases from the fixed cone valves would be required to augment the powerhouse discharge during those periods when spiking is required.

- Impact Assessment

Impacts on rearing habitats would be the same as discussed for Case EIV except for some momentary disturbance and dislocation caused by the spiking flows. The spiking flows would not cause a measurable effect since their magnitudes are well within the range of natural flood events and the rate of change in discharge would be limited.

Impacts on access to side slough spawning sites would be similar to Case EII. Case EIVa provides more spiking flows for access than EII, but the base flow would be 3-4,000 cfs less. Therefore, the expected net loss would be similar to Case EII, i.e., a 25% loss of slough spawning habitat for chum and sockeye salmon.

- Mitigation

Mitigation measures for loss of rearing habitat would be the same as discussed for Case EIV.

Measures to rectify loss of access to slough spawning sites would be similar to those discussed for Case EII (Section 2.1.2). Some additional alteration would be necessary for Case EIVa due to the lower base flows.

### 2.1.6 Case EIVb

- Management Objective

Case EIVb flow constraints are designed to maintain 75% of the side channel rearing habitat utilized by chinook salmon juveniles under natural flow conditions and provide for some limited spawning access to the most productive side sloughs by chum salmon adults.

- Flow Constraints

Flow constraints for Case EIVb (Table 8, Figure 6) are identical to those discussed for Cases EIV (Section 2.1.4) and EIVa (Section 2.1.5) except for the magnitude of spiking flows. Spiking flows for Case EIVb are of the same duration as those in EIVa, but peak at lower discharges (cfs).

- Project Flows

Case EIVb has flow requirements similar to Case EIVa except that during periods when spiking flows are provided, the magnitude of the spikes are reduced for Case EIVb. Therefore the average winter flows with Case EIVb would be greater than for Case EIVa and less than for Case EIV. However, because of the similarities between Cases EIV and EIVa, winter flows with Case EIVb operation would be the same as Case EIV and EIVa most of the time.

Summer flows would be almost the same as those of Case EIVa most of the time and only slightly different at other times.

Table 8

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EIVb

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 16,000 | 40 | 9,000 | 35,000 |
| 15 | 2,000 | 16,000 | 41 | 9,000 | 35,000 |
| 16 | 2,000 | 16,000 | 42 | 9,000 | 35,000 |
| 17 | 2,000 | 16,000 | 43 | 9,000 | 35,000 |
| 18 | 2,000 | 16,000 | 44 | 9,000 | 35,000 |
| 19 | 2,000 | 16,000 | 45 | 9,000 | 35,000 |
| 20 | 2,000 | 16,000 | 46 | 9,000 | 35,000 |
| 21 | 2,000 | 16,000 | 47 | 9,000 | 35,000 |
| 22 | 2,000 | 16,000 | 48 | (2) | 35,000 |
| 23 | 2,000 | 16,000 | 49 | (2) | 35,000 |
| 24 | 2,000 | 16,000 | 50 | (3) | 35,000 |
| 25 | 2,000 | 16,000 | 51 | 7,000 | 35,000 |
| 26 | 2,000 | 16,000 | 52 | 6,000 | 35,000 |
| 27 | 2,000 | 16,000 | 1 | 6,000 | 18,000 |
| 28 | 2,000 | 16,000 | 2 | 6,000 | 17,000 |
| 29 | 2,000 | 16,000 | 3 | 5,000 | 16,000 |
| 30 | 2,000 | 16,000 | 4 | 4,000 | 16,000 |
| 31 | 2,000 | 16,000 | 5 | 3,000 | 16,000 |
| 32 | 4,000 | 16,000 | 6 | 3,000 | 16,000 |
| 33 | 6,000 | 16,000 | 7 | 3,000 | 16,000 |
| 34 | 6,000 | 16,000 | 8 | 3,000 | 16,000 |
| 35 | 6,000 | 16,000 | 9 | 3,000 | 16,000 |
| 36 | 9,000 | 35,000 | 10 | 2,000 | 16,000 |
| 37 | 9,000 | 35,000 | 11 | 2,000 | 16,000 |
| 38 | (1) | 35,000 | 12 | 2,000 | 16,000 |
| 39 | 9,000 | 35,000 | 13 | 2,000 | 16,000 |

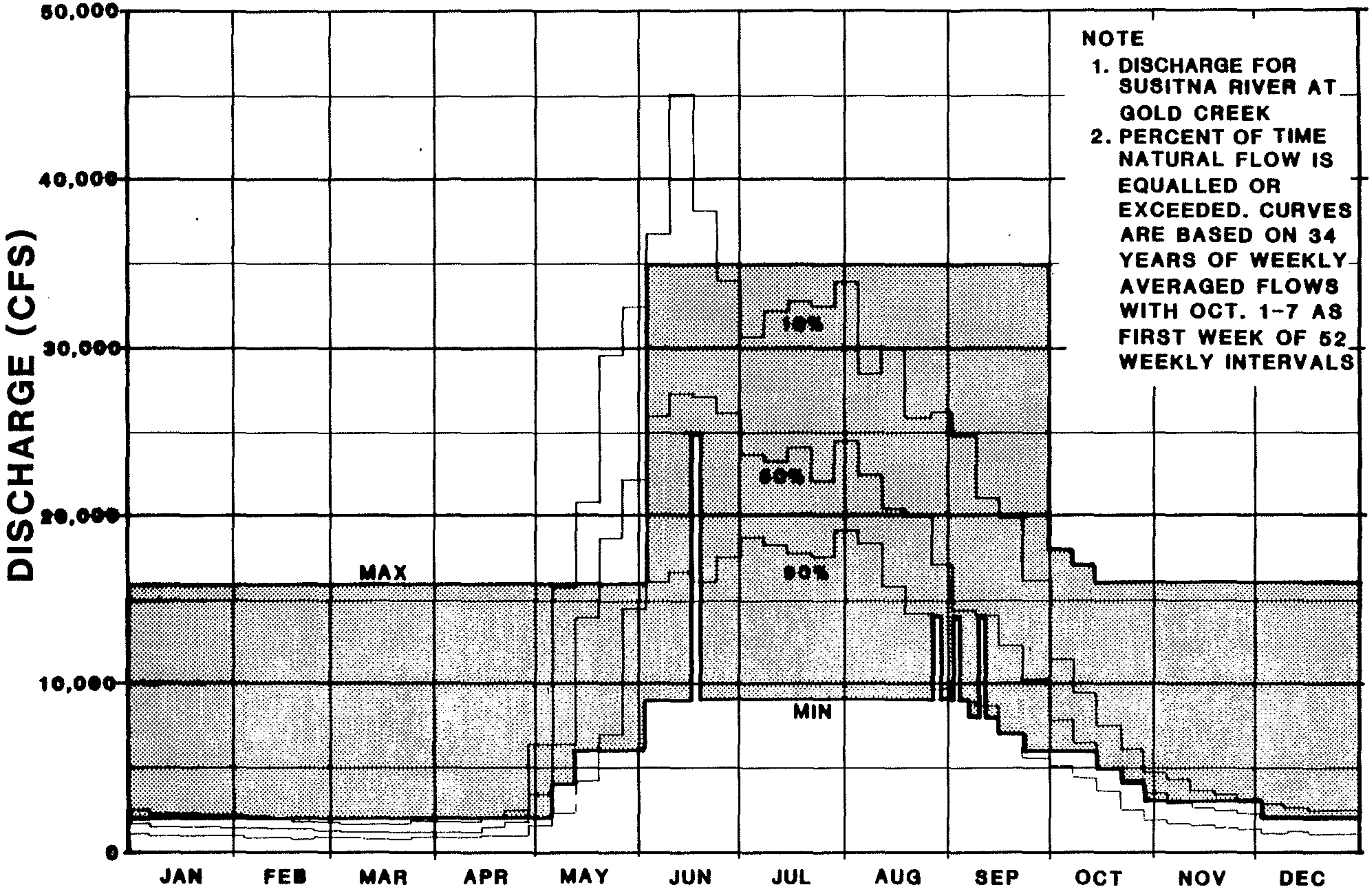
(1) Base minimum flow of 9,000 cfs. 25,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(2) Base minimum flow of 9,000 cfs. 14,000 cfs spike; 1 day up, 1 day hold, 1 day down.

(3) Base minimum flow of 8,000 cfs 14,000 cfs. spike; 1 day up, 1 day hold, 1 day down.

Figure 6

# ENVIRONMENTAL FLOW REQUIREMENTS CASE IV b



- o Impact Assessment

Impacts on rearing habitats would be similar to those discussed for cases EIV and EIVa above.

Impacts on access to slough spawning sites would be greater with this case than with Cases EII or EIVa. Severe access problems would occur at sloughs 8A and 11. Complete restriction at these sloughs would eliminate approximately 32% and 80% of the utilization of side sloughs for spawning by chum and sockeye salmon, respectively (ADF&G, 1984a). Flows that range from the 9,000 cfs base flow to the 14,000 cfs spiking flows would result in a loss of access to approximately 40% of the slough spawning areas (weighted for utilization: see Power Authority Comment on DEIS, No. AQR072). A worst case impact of a 50% loss of slough spawning habitat for chum and a 100% loss of slough spawning habitat for sockeye salmon is assumed for this evaluation.

- o Mitigation

Mitigation measures for loss of rearing habitat would be the same as discussed for Case EIV.

Loss of access to sloughs for spawning chum and sockeye salmon would be rectified by structural modification of the slough mouths and critical access reaches within the sloughs.

### 2.1.7 Case EV

- o Management Objective

Case EV flow constraints are designed to maintain 75% of the existing chum salmon slough spawning habitat and 75% of the existing chinook salmon side channel rearing habitat.

Table 9

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EV.

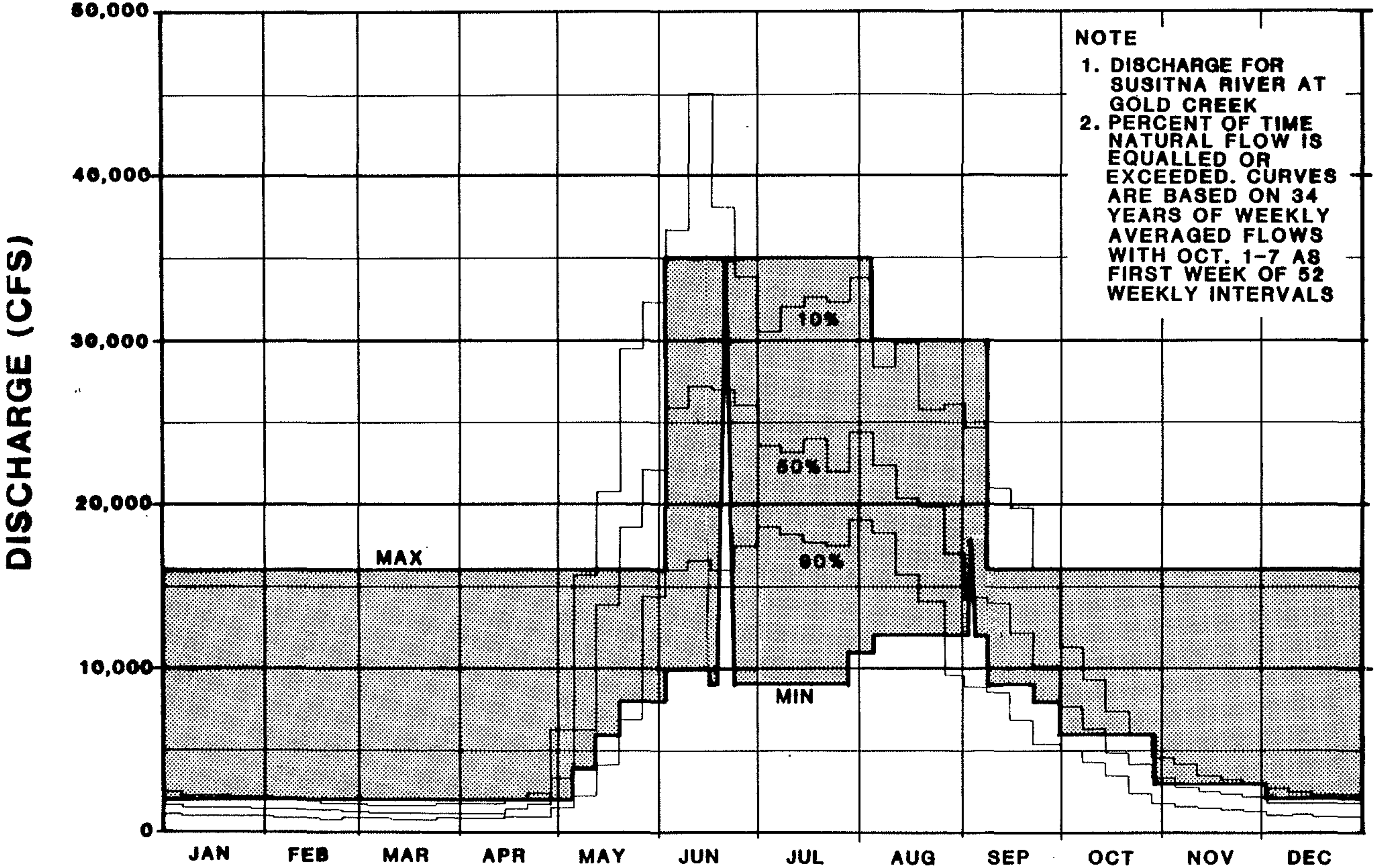
| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 16,000 | 40 | 9,000 | 35,000 |
| 15 | 2,000 | 16,000 | 41 | 9,000 | 35,000 |
| 16 | 2,000 | 16,000 | 42 | 9,000 | 35,000 |
| 17 | 2,000 | 16,000 | 43 | 9,000 | 35,000 |
| 18 | 2,000 | 16,000 | 44 | 11,000 | 35,000 |
| 19 | 2,000 | 16,000 | 45 | 12,000 | 30,000 |
| 20 | 2,000 | 16,000 | 46 | 12,000 | 30,000 |
| 21 | 2,000 | 16,000 | 47 | 12,000 | 30,000 |
| 22 | 2,000 | 16,000 | 48 | 12,000 | 30,000 |
| 23 | 2,000 | 16,000 | 49 | (2) | 30,000 |
| 24 | 2,000 | 16,000 | 50 | 9,000 | 16,000 |
| 25 | 2,000 | 16,000 | 51 | 9,000 | 16,000 |
| 26 | 2,000 | 16,000 | 52 | 8,000 | 16,000 |
| 27 | 2,000 | 16,000 | 1 | 6,000 | 16,000 |
| 28 | 2,000 | 16,000 | 2 | 6,000 | 16,000 |
| 29 | 2,000 | 16,000 | 3 | 6,000 | 16,000 |
| 30 | 2,000 | 16,000 | 4 | 6,000 | 16,000 |
| 31 | 2,000 | 16,000 | 5 | 3,000 | 16,000 |
| 32 | 4,000 | 16,000 | 6 | 3,000 | 16,000 |
| 33 | 6,000 | 16,000 | 7 | 3,000 | 16,000 |
| 34 | 8,000 | 16,000 | 8 | 3,000 | 16,000 |
| 35 | 8,000 | 16,000 | 9 | 3,000 | 16,000 |
| 36 | 10,000 | 35,000 | 10 | 2,000 | 16,000 |
| 37 | 10,000 | 35,000 | 11 | 2,000 | 16,000 |
| 38 | (1) | 35,000 | 12 | 2,000 | 16,000 |
| 39 | 9,000 | 35,000 | 13 | 2,000 | 16,000 |

(1) Base minimum flow of 9,000 cfs. 35,000 cfs spike; 3 days up, 3 days down.

(2) Base minimum flow of 12,000 cfs. 18,000 cfs spike; 1 day up, 1 day down.

Figure 7

# ENVIRONMENTAL FLOW REQUIREMENTS CASE V



- Flow Constraints

Case EV flow constraints were derived by combining Cases EII and EIV. The basic guideline used was to chose the maxima and minima for each week from Cases EII and EIV that were most restrictive on project operation. Flows to maintain chinook rearing habitat were chosen for most of the year (Table 9, Figure 7). Flows for chum spawning habitat were most important during weeks 36-38 and 44-49.

- Project Flows

Case EV would result in an average flow of 8,600 cfs at Gold Creek during the October to April period. Power house discharge would increase from October to December and then decrease from December to April. December discharge would be as high as 12,000 cfs but would average 10,100 cfs. Minimum flows would approach 5,000 cfs during October and March in low flow years. In these low flow years, April flows could be as low as 3,200 cfs.

During the May to September period, the flow at Gold Creek would be the same as the minimum flow requirements 55% of the time and, of course, higher, the remainder of the time. The average flow during this period would be 11,400 cfs.

- Impact Assessment

Loss of spawning habitat with Case EV flow constraints would be similar to losses under Case EII. Therefore, a 25% reduction of side slough spawning habitat for chum and sockeye salmon will be used for this evaluation.

The expected impacts on existing rearing habitat would be similar to those discussed for EIV and EIVa above. Case EV flows would result in a 25% loss of existing chinook salmon side channel rearing habitat.

- Mitigation

  Mitigation measures for impacts on slough spawning habitat are discussed for Case EII (Section 2.1.2).

  Mitigation measures for loss of existing rearing habitat are discussed for Case EIV (Section 2.1.4).

### 2.1.8 Case EVI

A detailed discussion of Case EVI is presented in Section 4.0. This case is separated in this report from the other environmental cases because it is the Power Authority's selected flow case (see Section 3.0) and a more detailed description is warranted. Basically Case EVI is a variant of EIV with a flexible summer minimum flow constraint to achieve more economic project operation during low flow years (one in ten year low flows).

Case EVI impact would be similar to Case EIV and proposed mitigation measures would result in no net loss of productivity. Naturally reproducing population would be maintained through steps to minimize and rectify project induced losses. A general improvement in the quantity and quality of rearing habitat is expected over natural conditions. See Section 4.0 for the detailed discussion of ths case.

## 3.0 COMPARISON OF FLOW CASES

### 3.1 ECONOMIC COMPARISON

Economic analyses of selected flow cases, ranging from P-1 to EVI, were performed to determine the present worth of the long term (1993-2051) production costs of each alternative. The analyses were completed using the OGP model and the monthly average and firm energies of each flow case obtained from the reservoir operation program. Railbelt system expansions for the period 1993 through 2020 were analyzed with the Watana project coming on line in 1993 and Devil Canyon in 2002. The long-term system costs for 2021 through 2050 were estimated from the 2020 annual costs, with adjustments for fuel escalation for the 30-year period.

The results of the analyses are illustrated in Table 10. They indicate that the energy benefits of the project are inversely proportional to the summer flow volume required for fish. When mitigation costs are not incorporated, Case P-1, with no environmental requirements, had the lowest cumulative present worth cost. For comparison with Case P-1, the maximum economic case presented in the License Application (Case A) was also run using OGP. The cumulative present worth of the costs was essentially the same as for Case P-1.

Case EVI ranked third in lowest cost, some $8,000,000 greater than Case P-1. Case EIV ranked next with a total present worth cost $15,000,000 greater than P-1. Case C (proposed flow requirements presented in the License Application), EV, and EI, had present worth costs increasingly greater than Case P-1.

Case C and Case EV required the addition of one 200 MW coal-fired plant and Case EI required the addition of two 200 MW coal units. The total installed capacity is increased as minimum flow requirements in the months of May through September are increased. This occurs because of the resulting decrease in available winter energy during low flow years, and the consequent requirement for additional thermal capacity to meet peak demand. (Note that the installed capacity from the Susitna Project remains the same for all cases.)

The OGP program is primarily a long-term expansion plan program. Therefore when small changes in flow requirements are assessed to determine cost differences, the differences determined by OGP may not be exact. However, it is believed that the relative economic ranking of the flow cases is correct and that the difference in costs among the flow cases actually is greater than shown in Table 10.

## 3.2 ENVIRONMENTAL COMPARISON

The environmental cases can be separated into three basic groups. Group 1 is designed to maintain rearing habitats and includes EIII, EIV, and EVI. Group 2 is designed to maintain chum spawning in side sloughs and includes only Case EII. Case EII is the most similar to Case C since protection of side slough spawning habitat was the primary environmental consideration in both. Group 3 is made up of cases designed to maintain both rearing and side slough spawning habitat. This group includes Cases EI, EIVa, EIVb and EV.

The two most important potential impacts of project operation are effects on mainstem influenced rearing habitats and spawning habitat in side sloughs. The Environmental cases can be compared based on potential impacts and mitigation measures regarding these two categories.

The objective of mitigation planning for fisheries impacts of the proposed project is to provide sufficient habitat to maintain naturally producing populations wherever compatible with project objectives. Compensation through construction and operation of propagation facilities is a least desirable action. Group 2 flow cases (EII, C) would require compensation for lost rearing habitat. Compensation within the Susitna Basin would likely require a propagation facility designed to replace lost chinook salmon production.

The major mitigation action (other than flow control) for Group 1 (EIII, EIV, EVI) and Group 3 (EI, EIVa, EIVb, EV) would involve rectifying for impacts on side-slough spawning habitat. The extent of necessary structural modification varies among the individual cases but the basic impacts and mitigation methods are the same. Group 3 flow cases would generally require less structural modification than for Group 1.

Mitigation actions described for all the environmental cases would result in no net loss of production due to project operation. However Group 2 flow cases are least desirable since they require actions at greatest variance from the mitigation objective. Group 3 cases are most desirable based only on environmental consideration of potential impacts and the level of required mitigation actions.

Representative cases were chosen from each group for evaluation and comparisons based on power and economic objectives of the project. Cases EIV and EVI were chosen to represent Group 1, Case C to represent Group 2 and EI and EV to represent Group 3.

## 3.3 SELECTION OF PREFERRED INSTREAM FLOW REQUIREMENTS

Cases P-1 and A provide benchmarks to which the economics of the various flow cases can be compared. These cases would require substantial mitigation, including the use of propagation facilities. As mentioned above, Power Authority policy is to avoid the use of propagation facilities if habitat for naturally reproducing populations can be maintained.

Cases EI and EV are considered to have unacceptable cost penalties. The additional fishery benefits from Case EI and EV flow requirements do not warrant the loss of energy benefits. The same management objectives can be obtained through effective mitigation techniques at much lower cost. Case C has a management objective to protect sloughs considered to be traditional salmon spawning areas. However, Case C does not adequately consider other management objectives which have been identified through ongoing studies. For example, it does not include flow constraints for juvenile rearing habitat. In addition, Case C, Case EV, and Case EI all require coal generating units which may themselves produce adverse impacts.

Cases EVI and EIV are judged to be the superior flow cases considered. Case EVI is selected as the preferred case because of superior energy benefits. With a rigorous analyses of Cases EVI and EIV, it is expected that the economic benefits of EVI over EIV would be greater than shown in Table 10.

TABLE 10

SUSITNA HYDROELECTRIC PROJECT

ECONOMIC ANALYSIS OF FLOW CASES

| Case | Cumulative present Worth of Costs (1993-2051) (1982 $ in MILLIONS[1]) | Difference from P-1 (1982 $ in MILLIONS) | Railbelt Generation Capacity in 2020 (MW) | |
|---|---|---|---|---|
| | | | Coal | Total |
| P-1 | 5484 | - | 0 | 2350 |
| A | 5486 | 2 | 0 | 2350 |
| EVI | 5492 | 8 | 0 | 2451 |
| EIV | 5499 | 15 | 0 | 2451 |
| C | 5590 | 106 | 200 | 2544 |
| EV | 5726 | 242 | 200 | 2633 |
| EI | 6069 | 585 | 400 | 2756 |

1/ Costs do not include mitigation costs.

# 4.0 ENVIRONMENTAL FLOW REQUIREMENT CASE EVI

## 4.1 MANAGEMENT OBJECTIVE

Case EVI flow constraints are designed to maintain 75% of the existing chinook salmon side channel rearing habitat in all years except low flow years (defined as years with expected summer discharge less than or equal to the one in ten year low flow occurrence). Minimum summer flows are reduced to a secondary but set level during low flow years to achieve necessary but limited flexibility for project operation.

Establishment of environmental flow constraints based on the requirements of chinook salmon is a reasonable approach. Chinook salmon is one of the species of major importance to commercial and non-commercial fisheries in South-Central Alaska (Lic. Appl., Ex. E, Chpt. 3, p. E-3-1 through E-3-15). Juvenile chinook utilize habitats within or closely associated to the mainstem river for rearing during the entire year (ADF&G 1984b). The high human use value and sensitivity to potential project impacts qualifies chinook salmon as an evaluation species. Chum salmon spawning in side sloughs has been identified as the combination of species and habitat that would be most significantly affected by project operation (APA, 1984b). However, loss of chum spawning can be rectified by slough modification whereas loss of chinook mainstem rearing habitat would have to be compensated by construction and operation of artificial rearing facilities (e.g. a traditional release-return hatchery). Compensation is the least desirable option under the mitigation policies applied to the Susitna Project (Lic. Appl., Ex. E, Chpt. 3, pp. E-3-3 through E-3-6).

## 4.2 FLOW CONSTRAINTS

Case EVI flow constraints are shown in Table 11 and Figure 8. The flow constraints can be separated into three major divisions; winter flows, summer flows and transitional flows.

Maximum flows are the most important winter constraints. Normal project operation would produce the greatest discharges during the winter months (November-March). The winter maximum is intended to establish a boundary near the upper range of operational flows that would result in flow stability and provide a reasonable level of protection to over-wintering habitat. Side sloughs are especially important in this context since chinook juveniles utilize this habitat for over-wintering. The 16,000 cfs maximum flow would prevent over-topping of all the major sloughs prior to freeze-up and stabilize habitat availability during ice covered periods.

The winter minimum flow is established to prevent dewatering of rearing habitats. The 2,000 cfs minimum is chosen based on natural flows and represents a high mean natural winter flow.

Flow constraints during the winter to summer transition period (water weeks 32-35) are intended to maintain flow stability and prevent rapid drops in discharge due to decreasing power demand in May. The minimum flow constraints are most important during this period.

Summer (water weeks 36-48) flow contraints are designed to maintain rearing habitats and provide greater flow stability. Chinook juveniles are accumulating the major portion of their freshwater growth during this period and they utilize side-channel sites that are directly affected by mainstem discharge (ADF&G, 1984b). A 9,000 cfs minimum flow would maintain 75% of the existing habitat quantity at sites presently utilized by chinook and increased flow stability would improve habitat quality over natural conditions.

Table 11

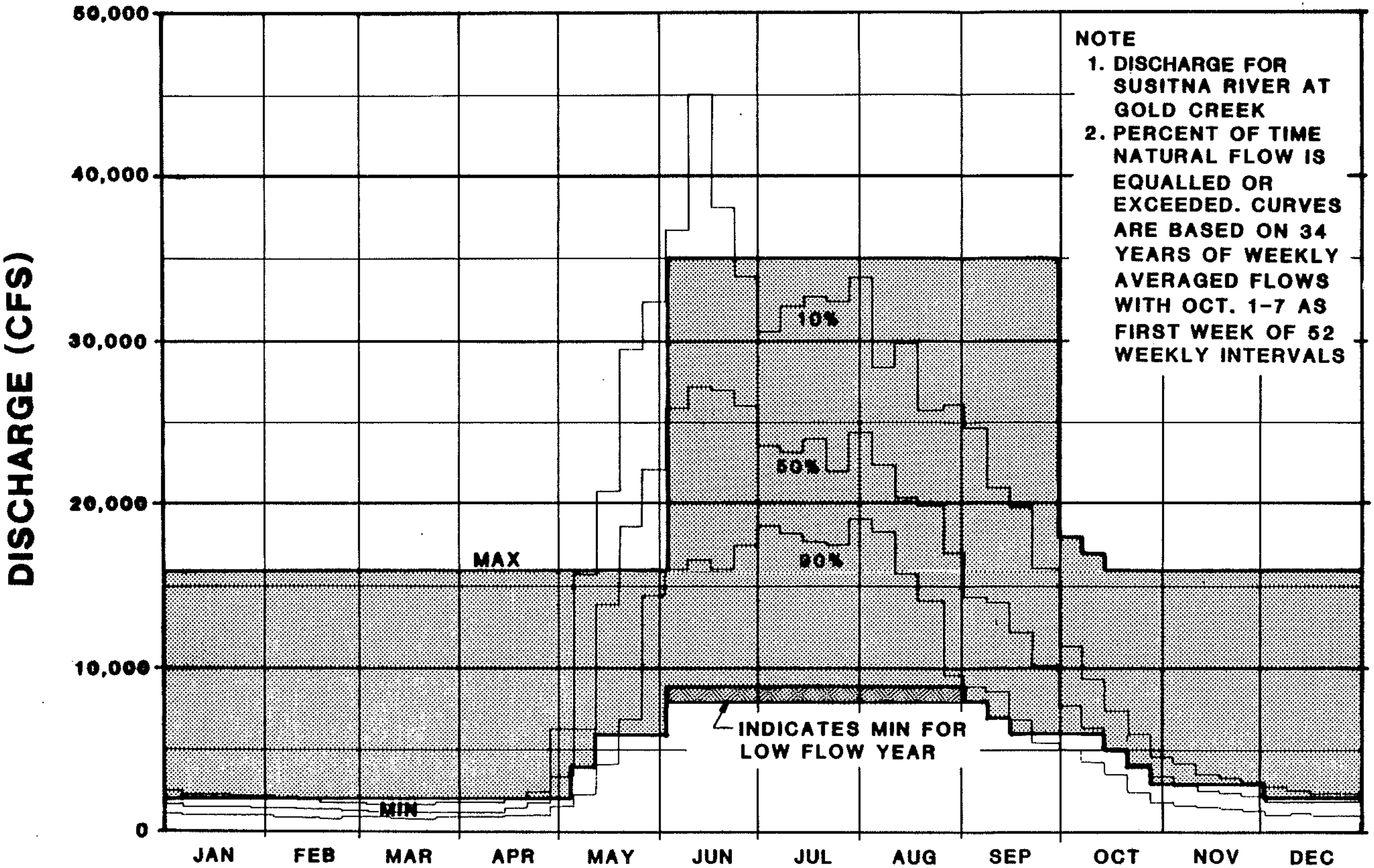
SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE EVI.

| Water Week | Gold Creek Flow (cfs) Minimum | Maximum | Water Week | Gold Creek Flow (cfs) Minimum | Maximum |
|---|---|---|---|---|---|
| 14 | 2,000 | 16,000 | 40 | 9,000* | 35,000 |
| 15 | 2,000 | 16,000 | 41 | 9,000* | 35,000 |
| 16 | 2,000 | 16,000 | 42 | 9,000* | 35,000 |
| 17 | 2,000 | 16,000 | 43 | 9,000* | 35,000 |
| 18 | 2,000 | 16,000 | 44 | 9,000* | 35,000 |
| 19 | 2,000 | 16,000 | 45 | 9,000* | 35,000 |
| 20 | 2,000 | 16,000 | 46 | 9,000* | 35,000 |
| 21 | 2,000 | 16,000 | 47 | 9,000* | 35,000 |
| 22 | 2,000 | 16,000 | 48 | 9,000* | 35,000 |
| 23 | 2,000 | 16,000 | 49 | 8,000 | 35,000 |
| 24 | 2,000 | 16,000 | 50 | 7,000 | 35,000 |
| 25 | 2,000 | 16,000 | 51 | 6,000 | 35,000 |
| 26 | 2,000 | 16,000 | 52 | 6,000 | 35,000 |
| 27 | 2,000 | 16,000 | 1 | 6,000 | 18,000 |
| 28 | 2,000 | 16,000 | 2 | 6,000 | 17,000 |
| 29 | 2,000 | 16,000 | 3 | 5,000 | 16,000 |
| 30 | 2,000 | 16,000 | 4 | 4,000 | 16,000 |
| 31 | 2,000 | 16,000 | 5 | 3,000 | 16,000 |
| 32 | 4,000 | 16,000 | 6 | 3,000 | 16,000 |
| 33 | 6,000 | 16,000 | 7 | 3,000 | 16,000 |
| 34 | 6,000 | 16,000 | 8 | 3,000 | 16,000 |
| 35 | 6,000 | 16,000 | 9 | 3,000 | 16,000 |
| 36 | 9,000* | 35,000 | 10 | 2,000 | 16,000 |
| 37 | 9,000* | 35,000 | 11 | 2,000 | 16,000 |
| 38 | 9,000* | 35,000 | 12 | 2,000 | 16,000 |
| 39 | 9,000* | 35,000 | 13 | 2,000 | 16,000 |

* Minimum summer flows are 9,000 cfs except in dry years when the minimum will be 8,000 cfs. A dry year is defined by the one-in-ten year low flow.

Figure 8

## ENVIRONMENTAL FLOW REQUIREMENTS CASE VI



## 4.3 PROJECT FLOWS

Project operation flows for Cases EIV and EVI would be the same for all but the lowest flow years. Only in one year in ten would there be a significant difference. Because of this occurrence, October to April flows would average only about 50 cfs more than for Case EIV. (Case EIV would result in an average flow of 9500 cfs from October to April)

May to September flows would be the same as Case EIV, except during the one in ten year low flow when the minimum flow would be 8000 cfs during June, July, and August. Actual flow would be the same as the minimum flow requirements 55% of the time during June, July and August.

## 4.4 IMPACT ASSESSMENT

Case EVI is designed to reduce impacts of project operation as compared to flow cases designed specifically for power generation. However, Case EVI does not mitigate all impacts by flow release alone so further impact assessment and mitigation planning is necessary. This section will address significant potential impacts to each life stage of the five Pacific salmon species.

- Juvenile Rearing

  Chinook salmon juveniles rear in both clear and turbid water habitats. Substantial rearing occurs in tributaries and side channels (ADF&G 1984b). Densities generally decrease in tributaries and increase in side channel habitats through the summer. Densities in side sloughs are relatively low during the summer but increase markedly during September and October. Tributary habitat would not be impacted by altered mainstem flows. Side channel habitat would be most directly affected. Case EVI flows would reduce the quantity of available rearing habitat at side channel sites presently used by chinook by approximately 25%.

Chum salmon rearing is essentially limited to tributaries and side sloughs during the early summer (May-early June). Highest densities during late June and July occur in upland sloughs and side channels. Essentially all the juvenile chum have moved downstream, out of the middle river, by the end of July. Case EVI flows would not impact rearing habitat in tributaries and upland sloughs. Chum salmon use of side channel sites is mostly for short-term holding and rearing during downstream migration. Case EVI flows would decrease the availabiliy of side channel sites presently used by chum by approximately the same magnitude estimated for chinook salmon. A 25% reduction will be assumed for this assessment. There would also be a loss of chum rearing habitat in side sloughs. Most of the loss would be due to a reduction or elimination of over-topped conditions in side sloughs during May and June under project operation. Loss of habitat could be as great as 50% at the sites utilized under natural flow conditions.

Sockeye juveniles rear predominantly in natal side sloughs during the early summer and then move mostly to upland sloughs by July. With project flows are not expected to affect upland slough habitats. The responses of weighted useable area for sockeye and chum are similar for side-slough rearing habitat. Therefore, loss of sockeye rearing habitat would be approximately 50%.

Coho salmon rear mostly in tributaries and upland sloughs. Impacts due to project operation are not expected in these habitats.

Pink salmon juveniles move rapidly from their natal tributaries to Cook Inlet. The mainstem and associated habitats are apparently used only for migration corridors so project flows would not impact pink salmon rearing.

o Downstream Migration

Downstream movement of salmon juveniles occurs throughout the summer (ADF&G, 1984b). Chum, pink and age 1+ chinook salmon migrate toward Cook Inlet during the early summer and are out of the middle river reach by July. Sockeye, coho and age 0+ chinook move gradually downstream throughout the summer. Most of this movement is associated with rearing and gradual relocation into available rearing and over-wintering habitat. Some of this downstream movement is influenced by discharge (ADF&G, 1984b). Increasing discharge during flood flows can act as a stimulus to initiate seaward migration, especially during the early summer. Flood flows later in the summer, when juveniles are rearing or seeking alternative habitat sites, can cause dislocation from preferred rearing areas. Project operation will reduce the frequency, duration and amplitude of flood events in the middle river. This impact is not expected to affect seaward migration in a significant way. Factors other than flow, such as increasing day length, water temperature and physiological condition, also trigger migration. Increased tributary flow and local run-off would also serve to stimulate migration.

o Upstream migration

Adult salmon migrate up the Susitna River toward spawning areas throughout the summer. The 9,000 cfs summer minimum flows will provide sufficient conditions for upstream passage of adults.

o Spawning

Salmon that spawn in the middle river basin are only a small proportion (less than 15%) of the total in the Susitna River System (ADF&G, 1984a). Most of the salmon that spawn in the middle river basin use tributary habitats outside the influence of mainstem discharge. The spawning habitat most sensitive to changes in mainstem discharge are the side sloughs used by chum and sockeye salmon. Mainstem flows influence spawning success in side sloughs through affects on access past critical reaches, total useable areas within the slough and groundwater discharge. Access into the major spawning sloughs (8A, 9, 9A, 11 and 21) would be restricted under Case EVI flows. An analysis using values of side sloughs weighted by observed spawning use provides an estimated loss of approximately 50% of side-slough spawning due to access restriction at 9,000 cfs (see Power Authority Comment on DEIS No. AQR072). However, considering the restricted access together with reduced area and flow within the sloughs, a worst case assumption of 100% loss of side-slough spawning habitat without mitigation is assumed for this evaluation.

o Mitigation

This section will present suggested actions to mitigate potential losses due to project operation. Project operation in the absence of environmental constraints is the appropriate starting point to discuss mitigation so flow Case P-1 will be used as a standard.

Project impacts would be minimized through timing and control of flow releases by adopting the environmental flow requirements in Case EVI. Case P-1 flows would fall below 9,000 cfs during June through August in approximately 75% of the years of operation. Mean monthly summer flows would be as low as 4,500 cfs in some years. This would result in total loss of most of the mainstem and side channel rearing habitat presently used by chinook and chum salmon juveniles. Case EVI flows would minimize this impact by maintaining 75% of the existing side channel rearing habitat. The residual 25% loss of side channel habitat and the loss of chum and sockeye rearing habitat in side sloughs would be rectified by habitat replacement at the more stable, lower flows (relative to natural flows) under Case EVI. The original rationale for design of Case EVI and the impact assessment discussed above are based on impacts to habitat sites that are available and used under natural flow conditions. The estimates of impact relied on data and information collected at habitat sites presently utilized. The analyses and estimates did not consider the addition of new habitat sites with appropriate characteristics and qualities that would become available at lower, more stable flows.

Chinook salmon prefer areas of moderate depth and velocity for rearing in side channel areas. The quantity of habitat with these characteristics depends largely on channel complexity. There is relatively little of this rearing habitat available at bank full flows. The habitat quantity increases as flows drop and the flow channels become more complex. This increase will continue until a maximum is reached and habitat quantity would then decrease as discharge decreases to a level sufficienty low to restrict flow to a single thalweg channel. Comparision of channel complexity at various flows gives some indication of how habitat quantities will be impacted by project operation. Channel complexity at 9-12,000 cfs. (approximate summer operational flows) is much greater than at 23,000 cfs (approximate mean summer natural flows: See APA, 1984c, plates 1-18 for pictoral illustration). The quantity of side channel and mainstem rearing habitat for both chinook and chum salmon is expected to increase over natural conditions during project operation under Case EVI flow requirements. Increased flow stability and decreased turbidity is expected to improve habitat quality and augment rearing potential in the middle river.

Case EVI minimum flow constraints during late August and early September will minimize impacts of the project on chum and sockeye spawning due to operation through control of flow releases (compared to Case P-1). However, the residual impacts would be considerable and further mitigation would be necessary. Loss of side slough habitat for chum and sockeye salmon spawning would be rectified by structural modification of existing sloughs. Details of these activities are given in APA, 1984b, and will not be repeated here.

The results of these mitigation measures are compatible with mitigation policies and objectives presented in the License Application (Ex. E, Chpt. 3, p. E-3-147). Habitat quantity and quality sufficient to maintain naturally reproducing populations is provided. All significant impacts would be minimized or rectified.

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