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Lower River Plan

Mr. Jon S. Ferguson
Project Manager
Alaska Power Authority
334 West 5th Avenue
Anchorage, Alaska 99501

Subject: Susitna Hydroelectric Project
Lower River Plan of Study

Dear Mr. Ferguson:

Enclosed for your review and comment is the second draft of the report entitled, "Lower Susitna River Fisheries Resources Plan of Study." We are requesting comments by Friday, February 17, 1984. I realize that with the first Agency Workshop scheduled this Wednesday time is at a premium. However, FY85 planning should proceed as rapidly as possible.

If you have any questions regarding these plans or schedule, please contact Dr. Jim Thrall or Dr. Larry Gilbertson.

Very truly yours,

N M Hernandez
for W.E. Larson
Project Director

la

cc Enc: as noted

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LOWER SUSITNA RIVER
FISHERIES RESOURCES
PLAN OF STUDY

SECOND DRAFT

HARZA-EBASCO
Susitna Joint Venture

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1.0 INTRODUCTION

The Alaska Power Authority (APA) is proposing to construct two hydroelectric dams on the Susitna River, Alaska. Licensing of the proposed projects with the Federal Energy Regulatory Commission (FERC) requires that APA provide an analysis of the environmental impacts of the project. It is expected that the distribution, abundance, and production of fish stocks both upstream and downstream of the dams will change as a result of the project. Thus far, the aquatic studies and hence the assessment of environmental impacts has been largely limited to the Susitna River from Talkeetna to the Oshetna River (the upstream boundary of the reservoir impoundment). This emphasis on the middle (Talkeetna to Devil Canyon) and upper (Devil Canyon to the Oshetna River) reaches of the Susitna occurred because project related impacts above Talkeetna are expected to be most severe. In the lower river, it is expected that streamflow from tributaries would reduce the magnitude of physical changes (e.g., changes in discharge) caused by the project. Therefore the assessment of potential environmental impacts downstream from Talkeetna has been limited.

Resource management agencies expressed concern that there was little quantitative support to justify the conclusion that project related impacts to fishery resources downstream of Talkeetna would not be significant. In response to this concern, the Harza-Ebasco Joint Venture (H/E) has developed a comprehensive program for the evaluation of impacts to fishery resources in the lower river. The level of effort required to accomplish this task will depend upon the existing data base and the magnitude of potential impacts. Since project operation cannot be used to control flow in the lower river, flow related impacts will not be mitigated through flow regulation at the project dam. Therefore, studies planned for the lower river will not need the high level of resolution as previous studies conducted for the middle river. Rather, studies outlined are designed to assess potential impacts for the purpose of identifying and planning an alternative mitigation program.

The plan of study will be used by the APA as a tool to coordinate and implement studies on the lower river, which will be conducted by participants of the aquatic studies team. The plan responds to agency issues and complies with state and federal statutes and regulations. As a "blueprint" the study plan is compared with the study results to determine whether the stated objectives have been accomplished.

2.0 GENERAL APPROACH

The general approach of the lower river study plan is to use an incremental process through which fishery impact issues can be evaluated. In Section 3.0, specific impact issues are identified through a review of the predicted physical changes expected in the lower river as a result of the project. In Section 4.0, the lower river is stratified into segments with common morphological and flow characteristics. An analysis of impact issues within each segment will provide a perspective or prioritization for assessing the significance of each impact. In Section 5.0, existing data and work in progress (e.g., fish distribution and abundance, computer simulation models) are surveyed, and information gaps are identified. If the impact is expected to be significant and more information is needed, then an outline of the study design and analysis required to accomplish the impact assessment is provided. The need for new field studies or model development will be conditional, i.e., dependent upon the results of other studies or data analysis of higher priority. Therefore the assessments of impact issues are coordinated for the purpose of eliminating unnecessary time and effort.

The primary emphasis of the lower river studies is focused on the abundance and distribution of the five Pacific salmon species which occur in the Susitna River. Previous studies in the middle river were concerned with salmon because of their high recreational and commercial importance. It is assumed that provisions to maintain salmon populations will also allow for the maintenance of the populations of other fish species, particularly sportfish such as rainbow trout and Arctic grayling.

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3.0 PHYSICAL CHANGES AND FISHERY IMPACT ISSUES

3.1 SUMMARY OF IMPACT ISSUES

Based on expected changes in stream discharge, water temperature, ice processes, and sediment processes, the following were identified as potentially significant fishery impact issues:

1) Restriction of access by resident and anadromous fish to spawning grounds in tributaries and side channels;

2) Change in availability of suitable spawning habitat;

3) Change in incubation success;

4) Change in availability of suitable rearing and overwintering habitat for juvenile and resident fish;

5) Altered juvenile outmigration patterns.

3.2 PHYSICAL CHANGES

Identification and assessment of impacts on fisheries resources in the lower river requires that project related changes in the physical conditions of the lower river be established. This requires an assessment of current conditions and a prediction of conditions during initial reservoir filling and project operations. The most significant project related changes are expected to involve discharge, temperature, turbidity, ice processes, and sediment processes; each of these are discussed separately below.

3.2.1 Discharge

The operation of the Susitna Hydroelectric Project is based on a power production scenario that provides beneficial economics while maintaining enough discharge to provide for downstream aquatic resources (Acres American 1983). Operating schedule C presented in the license application was defined as the most environmentally and economically feasible. Reservoirs will be drawn down during the peak energy demand months of winter and filled during the summer, thus resulting in downstream flows that will be greater than natural conditions in the winter and less than natural conditions in the summer.

Mainstem discharge patterns during reservoir operations were predicted initially by Acres American, Inc. for the FERC license application. Results of these simulations are given in the FERC license application in Chapters 1 and 2 of Exhibit E (Acres American 1983).

Recently, AEIDC (1983a) compared natural and with-project flow conditions in order to statistically find the point in the river where operational flows become indistinguishable from natural flow conditions. This was accomplished by reconstructing Susitna River mean monthly discharges for the water years 1950 through 1981 at all gage stations and significant tributary confluences between the Watana dam and RM 25 using historical streamflow data and a water balance computer program (H2OBAL). With-project streamflows are determined by using reservoir operations models developed by ACRES which estimate release discharge after accounting for power production. The reservoir operations model applies operation specifications to predict average discharge for each month in the 32 year water supply data base. Results of these simulations (for a 2 dam scenario) demonstrated that flow increase of greater than 100 percent will occur during the mid winter months (December, January, February, and March) as far downstream as the most downstream station used in the simulation (i.e., RM 26). At Sunshine, average flow agumentations are estimated to range between 219 percent and 301 percent for this period (Table 3-1). Lesser flow augmentation will also occur during October, November, and April; whereas flow decreases will occur between May and September and will be most severe in June and July (Table 3-1). At Susitna (RM 26), average flow reductions are predicted to range from 4 percent to 15

TABLE 1

PREDICTED AVERAGE MONTHLY DOWNSTREAM FLOWS AND PERCENT CHANGE AT SUNSHINE (RM 87) AND SUSITNA STATION (RM 26) FOR THE TWO DAM SCENARIO (FROM AEIDC 1983a)

	Sunshine			Susitna Station		
Month	Natural (cfs)	With-Project (cfs)	Percent Change	Natural (cfs)	With-Project (cfs)	Percent Change
October	14,287	16,271	+14	31,427	33,411	+6
November	6,139	13,196	+115	13,500	20,558	+52
December	4,318	13,773	+219	8,517	17,973	+111
January	3,614	12,722	+252	8,030	17,137	+113
February	3,045	11,969	+293	7,148	16,072	+125
March	2,706	10,856	+301	6,408	14,558	+127
April	3,271	9,993	+206	7,231	13,953	+93
May	28,021	23,381	-17	61,646	57,006	-8
June	64,597	46,581	-28	124,614	106,597	-15
July	64,953	48,834	-25	134,549	118,431	-12
August	57,252	47,630	-17	113,935	104,314	-8
September	32,104	29,258	-9	67,652	64,806	-4

percent, whereas at Sunshine (RM 87) reductions are estimated to be 9 percent to 28 percent. Data for eleven lower stations are provided for one and two dam scenarios by AEIDC (1983a).

While differences in flow from natural conditions clearly decrease moving downstream due to the influence of tributaries, efforts to statistically define river reaches where post project flows differ significantly from natural conditions were unsuccessful (AEIDC 1983). Consequently, it is not possible to limit the area where flow related impacts occur; it will be necessary to include the entire lower river when assessing discharge related impacts.

Decreases in streamflow during summery may restrict access to spawning areas and change the suitability of habitat utilized for spawning and rearing. The increased flows during winter and spring may change the area available for overwinter rearing and influence travel time of outmigrating smolts.

Monthly flow changes in the lower river have been adequately addressed, but flow changes on a shorter time period (i.e., weekly and daily) have yet to be adequately addressed. This may be especially important for changes in flood flows which have a significant effect on upstream migrations of adults (ADF&G 1983a), spawning habitat, ice processes (e.g., breakup), and bed scour. Flood events will be most severe in the late summer when the reservoir is full and least significant in the spring because the storage capacity of the reservoir will be greatest. For example, the license application predicts that the 1 in 10 year flood at Sunshine station will be reduced from 144,000 cfs to 89,000 cfs. Flood durations will be extended beyond the natural conditions because of the need to discharge until the storage volume criterion is reestablished. A weekly reservoir simulation model was developed to predict weekly downstream discharges in the FERC license application.

3.2.2 Water Temperature

The temperature regime of the Susitna River downstream of the project dams is expected to change during both filling and operations. Any changes, even small ones of 0.5°C to 1.0°C, may have a significant effect on aquatic resources in the lower river. Many behavioral and physiological attributes of fish are dependent on water temperature, including habitat selection, migration timing of juveniles and adults, instream movements, food consumption, development rates of incubating salmonid embryos, and growth of juvenile and adult fish. Thus, predicting downstream temperature regimes and relating these predictions to temperature preferences of and tolerances of aquatic resources is an important component of evaluating impacts in the lower river. Two of the major concerns about downstream temperature changes are that temperature differentials at tributary confluences will delay migrations of juvenile and adult salmonids and seasonal temperature regimes may change in various habitat types, thus affecting growth, development rate, and survival of fish in the lower Susitna River.

In the FERC license application, predictions of downstream temperatures were made using a downstream temperature model, HEATSIM. Input data to this model includes simulated reservoir temperatures (using a model DYRESM), reservoir operations, water balance data, and historical temperature data. Results of these simulations are discussed in Chapter 2 of the FERC license application. Recently, AEIDC has simulated downstream temperatures using another river temperature model, SNTEMP. A description of this model, including input data, validation, and calibration is provided in AEIDC (1983b). This model has some advantages over the HEATSIM model (e.g., tributary input) and will thus allow for a more realistic simulation.

Initial predictions of downstream temperatures using the SNTEMP model are described in AEIDC (1983b) in addition to efforts to statistically define where predicted downstream temperatures differ significantly from natural conditions. These analyses have only compared natural and with-project conditions during summer filling (second summer only) and summer operations using hydrologic and meteorologic data from periods of normal, maximum, and minimum downstream temperatures. However, reservoir release temperature information is very sparse for operational conditions as the DYRESM model has only been run for 1981 meteorological conditions and predictions are only possible to Sunshine station.

Utilizing simulations of both AEIDC and the FERC license application, the following points about lower river post project temperatures can be made:

1) During the second year of filling, the temperature regime, during June to August, in the reach downstream of Talkeetna is predicted to be 1° to 2° lower than the natural regime, regardless of hydrologic and meteorologic conditions in whatever year the filling occurs.

2) During operations, there will be observable temperature changes downstream of Talkeetna. The extent and magnitude of these changes cannot be predicted at present. Expected changes include:

   a) Lower summer temperatures because of the reduced mainstem flow and subsequent proportional increase in contribution by the Chulitna and Talkeetna rivers.

   b) During early fall, downstream temperatures would be above 0°C for some length of the river downstream of Talkeetna and for an undetermined period of time (depending on meteorologic and hydrologic conditions).

   c) In late fall and winter, the river is anticipated to be normal (i.e., 0°C) by the time it reaches Talkeetna, thus, conditions would be similar to natural.

d) Between Talkeetna and Sunshine station, June through August water temperatures will be reduced and those in September increased as compared to natural conditions (two dam scenario) (Table 3-2).

Project related changes in downstream temperatures have yet to be adequately addressed. Work in progress (by AEIDC) will address most of the information needs. For operation scenarios, DYRESM predictions for reservoir release temperatures will be expanded by AEIDC to include all months of the ice free season for a range of meteorologic conditions.

3.2.3 Suspended Sediment (Turbidity)

Sediment particles that are transported in a stream while being held in suspension by the turbulent components of the water are classified as suspended sediments. Within the Susitna, glacial outwash contributes most fine sediment. Analyses of suspended sediment and turbidity in the Susitna River has been conducted by R&M (1982c, see page E-2-200) and the USGS (unpubl.), while periodic measurements of turbidity at specific habitat locations in the lower river have been obtained by ADF&G as part of their Aquatic Habitat and Instream Flow Study program (e.g., Figures E.5.7 to E.5.34, ADF&G [AH] 1981, Chapter 2 of the FERC License Application [p. E-2-28 to E-2-30], and Table 4-D-45 ADF&G [AH] 1983). These measurements indicate that under natural conditions, summer turbidities are highest (up to 1,056 NTU, 1,620 mg/l as measured at Sunshine by the USGS); and winter turbidities are low (e.g., 0-2 mg/l in March as measured at Sunshine).

Most suspended sediment in the lower river is from the three major tributaries, especially the Chulitna River. Downstream of the confluence, the Yentna River is the major additional source of sediment because it is glacier fed. Although the glacier fed rivers are the major sediment source, some bank erosion and resuspension of deposited

TABLE 3-2

MONTHLY TEMPERATURES (°C) AT THE THREE RIVERS CONFLUENCE (RM 98) AND SUNSHINE (RM 84) IN JUNE-SEPTEMBER FOR SEVERAL PROJECT SCENARIOS (FROM AEIDC 1983b)

Month	Natural[a/] °C	Year 2 of Filling[a/] °C	One Dam Operation[b/] °C	Two Dam Operation[b/] °C
June				
Confluence	7.2-9.9	6.1-8.1	8.0	7.6
Sunshine	7.2-10.3	6.5-9.3	8.2	7.9
July				
Confluence	8.7-10.6	7.6-9.1	8.1	7.9
Sunshine	8.9-11.2	8.2-10.3	8.1	7.9
August				
Confluence	7.5-9.7	6.5-8.2	8.2	7.5
Sunshine	7.5-10.2	6.7-9.1	8.1	7.6
September				
Confluence	4.7-6.6	4.6-6.1	6.7	6.6
Sunshine	3.9-6.6	3.8-6.2	6.6	6.6

a/ 15 year simulation (1968-1982).

b/ Using 1981 hydrologic and meteorologic data and results of DYRESM model for 1981.

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sediment occurs. Because of the dilution of water by tributaries, turbidities and suspended sediment concentrations decrease between Sunshine and Susitna Station (Figures E-2-78, 81).

During filling and operation of the project, the reservoirs will act as sediment traps which will decrease the overall amount of suspended sediment moving downstream. A significant enough decrease in turbidity will enhance light penetration (thus increasing production) but eliminate the use of turbid water as cover by salmonid juveniles rearing in the river. A modeling study (on Watana Reservoir) was conducted by Peratrovich, Nottingham, and Drage (1982) to predict downstream turbidities in the middle river. The study predicted that turbidities in the middle river would range from 20-50 NTU in the summer and 10-20 NTU in the winter, and that the reservoir would retain about 80 percent of the natural sediment load (Figure E.2.80). The relative change in suspended sediment/turbidity levels below the confluence of the Chulitna, Talkeetna, and Susitna rivers was estimated using a mass balance relationship. The license application (Chapter 2) predicted that at a flow of 12,000 cfs, the suspended sediment below the confluence would be decreased by 3 percent in summer, whereas at a filling flow of 6,000 cfs, the suspended sediment concentration could increase by approximately 8 percent. Any decreases in the suspended sediment concentrations and turbidity in summer will not likely be of significance to the aquatic resources in the lower river. This is because that in order for turbidity decreases to be significant to benthic production or to decrease cover available for rearing fish, turbidity must be in the lower end of the 20-50 NTU range (AEIDC 1983b). Because of the high suspended sediment load of the Chulitna River (twice the Susitna above the confluence), decreases below 50 NTU will not occur.

During winter, suspended sediment concentrations have not yet been predicted quantitatively. Because the suspended sediment concentration of water released from the reservoir will be increased over natural conditions, concentrations in the lower river will also be evaluated.

Although the inflow of tributaries below the confluence will dilute the suspended sediments, concentrations will still be higher than under natural conditions. Also there is a concern that increased winter flows will re-suspend deposited sediments resulting in a further increase in concentration of suspended sediment. Juvenile and resident salmonids utilize riverine habitats during the winter. Therefore, unnaturally high suspended sediment levels at this time may affect fish behavior and adversely affect fish populations.

3.2.4 Bedload Sediment

In addition to the sediment that is suspended in the river, there is also considerable bedload sediment discharge. Bedload is coarse sediment (usually gravel, but in some cases sand) that is transported on or near the streambed. The heavily glaciated basin of the Chulitna River results in considerable bed material. Measurements of natural bedload sediment discharge for the Susitna River basin are available from the USGS (inpubl.) and R&M (1982c), (page E-2-200, Chapter 2, License Application), although data are only available for the summer months (June-September) in 1981 and 1982. At Sunshine in 1982, bedload discharge in the summer ranged from approximately 1,000 ton/day to 13,600 ton/day (USGS unpubl). In general, the total natural bedload measured in the Susitna, Chulitna, and Talkeetna rivers is two to five times larger than at Sunshine, indicating that the excess material is deposited somewhere above Sunshine (e.g., either between Talkeetna and Sunshine or the Chulitna confluence and Chulitna measuring station RM 18). A large portion of the load is derived from the Chulitna which contributes approximately 15 times the bedload volume of the Susitna River near the confluence (page E-2-26, Chapter 2, License Application).

Project related changes in the flow regime (i.e., decreased flow in the summer and increased flow in the winter compared to natural conditions) will affect the amount of bedload material movement. Sediment will be deposited if the supply exceeds the transport capacity of the stream (a function of sediment load and discharge) and picked up if the reverse situation develops. Thus, deposition of sediment (i.e., oversupply of sediment) will cause the channel to rise and widen (aggradation), whereas an undersupply results in the removal of sediment which leads to a channel shape that is narrower and deeper (degradation). Changes in channel morphology will affect bed elevation which affects river stage at a given discharge. Since the surface area of backwater areas are influenced by stage, available fish habitat and tributary access in the vicinity of the three river confluence could be changed. At this time only a qualitative evaluation of bedload sediment is possible.

During summer, decreases in flow and the trapping effect of the reservoirs will result in less bedload material movement in the Susitna upstream of Talkeetna; thus, below the confluence of the Talkeetna, Chulitna, and Susitna, the total amount of bed material being moved will be less than at present. It is possible that the decrease in flow will cause the Chulitna and Talkeetna to deposit some of their bed material at the three rivers confluence and could result in increased aggradation of the channel in this area. Below the three rivers confluence, less bed material will move because of the decreased magnitude of peak flood discharges. The combination of decreased flow, lower suspended sediment discharge, and lower bedload discharge may result in less streambed scour downstream which may cause some areas to become more favorable areas for fish spawning.

In the winter, flows will be increased. This may result in an increase in the amount of bedload discharge over natural winter levels. However, as the glaciers do not discharge sediment during this period, material moved by the rivers will be existing bed material (such as from the three rivers confluence area). Channel degradation during winter in the three rivers confluence area may counteract the increased degradation that may occur during the summer.

3.2.5 Ice Processes

Ice processes dominate the Susitna River and its hydraulic features for a major part (7-8 months) of the year. The presence of river ice and the dynamics of its formation and breakup significantly influence stage, temperature, some sediment related processes (for example, bed scour and bank erosion), and channel morphology (as a result of ice jam staging and flooding). Many of these features affected by the ice are variables that affect the usability of habitat by fish (e.g., depth and velocity).

Natural ice processes in the Susitna River have been qualitatively evaluated (i.e., observation) by R&M (1981, 1982a, 1982b, 1982c, 1983, Steve Bredthauer Personal Communication) and Schoch (1983) (see AEIDC). These studies and studies in progress have led to a partial understanding of natural ice processes (i.e., formation, ice cover, breakup), a description of which is provided in Chapter 2 of the License Application (p. E-2-22 to E-2-25).

Ice processes are primarily an interaction of temperature and discharge in addition to other factors (e.g., channel shape). Thus, project related changes in temperature and flow will cause changes in the natural ice process, which in turn will impact processes (e.g., scour) that affect fish habitat. An attempt to quantitatively model post project ice processes was attempted by ACRES (1983, page E-2-124 to E-2-127) using an ice simulation model (ICESIM). The downstream temperature model used was HEATSIM. This model could not be successfully calibrated using available field data, thus current predictions of project related ice processes are only qualitative. In the lower river, ice cover starts when an ice bridge forms in a constricted bend of the river near RM 10. Heavy slush ice from the upper Susitna, Chulitna, and Talkeetna basins where subfreezing temperature first occur begins to backup behind the ice bridge and causes an ice cover to progress upstream. With the project, frazil ice from the upper Susitna basin will be blocked by the dams and ice formation below the dams will be greatly delayed due to release of water that is warmer than natural conditions. Frazil ice will be generated on the lower river, but at a later date and possibly in much lower quantities. Consequently, the ice bridge at RM 10 and subsequent ice cover will form at a later date, or possibly not at all in warm years if insufficient ice is generated. The volume of ice passing Susitna Station from Yentna and Susitna needs to be quantified and correlated to time of ice bridge formation at RM 10. During ice formation, increases in river stage (e.g., 3-4 ft in area above Kashwitna River to Talkeetna, Steve Bredthauer, Personal Communication) cause side channels to be overtopped and large expanses of the floodplain are covered with water and ice. However, these high river levels are temporary, as water levels drop after the ice front progresses upstream and open leads developed. Higher winter flows with the project may increase staging and affect the availability of winter rearing habitat. Temporary stage increase may allow greater access to suitable wintering habitat. On the other hand, staging may cause fish to move into areas that may be dewatered, resulting in stranding and fish losses.

It must be recognized that ice processes may be so dynamic that quantitative predictions of post project conditions may be impossible through a modeling effort.

4.0 LOWER RIVER MORPHOLOGICAL ASSESSMENT

The lower river morphological assessment, currently in progress, is critical for the assessment of streamflow related impacts on fish habitat. Data based on aerial photographic reconnaissance, ground truthing and cross-sectional surveys are being analyzed to quantify fishery habitat changes that will result from the proposed alterations in streamflow. (R&M unpublished).

Since habitat quantity and quality in the lower river varies as a result of channel morphology and added tributary stream flow; potential impacts from flow alteration will vary depending upon location. Identifying the location and magnitude of potential impacts on fish is difficult because the lower river has a complex morphology and is 98 miles long. Therefore, in order to to facilitate an impact assessment, the river has been stratified into five segments that are distinguishable in flow and channel morphology.

Segment I: RM 98.5 to RM 78 - This segment is immediately downstream of the Chulitna confluence, extending to the side channel just above the confluence with Montana Creek. The river is braided, with the main channel meandering through a wide gravel floodplain. Relatively few side channel complexes through vegetated islands exist.

Segment II: RM 78 to RM 51 - This segment extends from the side channel above Montana Creek to the point at the head of the Delta Islands where the river splits into two major channels. The segment is characterized by side channel complexes along the entire reach.

Segment III: RM 51 to RM 42.5 (Delta Islands)

This segment encompasses the reach in which two major channels exist, one on the east and one on the west side. A major island side channel complex exists between the two main channels. The segment ends where the two main channels rejoin.

Segment IV: RM 42.5 to RM 28.5 - This segment extends from the lower end of the Delta Islands to the confluence with the Yentna River. The reach is characterized by a braided pattern, with several significant side channel complexes. The Deshka River enters this reach.

Segment V: RM 28.5 to RM 0 - This segment extends from the Yentna River confluence to Cook Inlet. The reach is primarily a split channel configuration down to RM 19, the head of Alexander Slough. The Susitna River has two channels from this point to Cook Inlet, with the main channel on the east side.

Within the segments, four major habitat classifications have been identified, based on morphological characteristics. These are defined below:

Mainstem Channel: That portion of the river floodplain between the vegetated boundaries. This includes the wide gravel floodplain, plus isolated vegetated islands. Two subclassifications exist:

1) Mainstem river
2) Alluvial island complex: areas of broad gravel islands with numerous subchannels which dewater as flow decreases.

Side Channel Complex: Groups of side channels flowing through vegetated islands. These are normally on one side of the river or the other, but may include areas (such as the Delta Islands) in the middle of the river. Two subclassifications exist:

1) Lateral side channel: the outside channel of the complex, closest to the edge of the floodplain. This channel collects any groundwater seepage or tributary inflow from the river banks.

2) Medial side channel: Overflow channels which dewater as mainstem flow decreases.

Sloughs: Simple channels which are generally overtopped only at high flows.

Tributary Mouths: The area between the downstream extent of a tributary plume and the upstream effect of backwater.

The variation in each of the habitat classifications with changes in flow are being determined from aerial photographic flights conducted at four streamflows ranging from 13,600 cfs to 56,500 cfs (flow measured at Sunshine). An analysis of water surface area change with changes in flow for the major habitat classifications will be used to determine the magnitude and location for project related impacts on aquatic habitat. By combining the results of this analysis with information on fish utilization by habitat classification, an assessment of flow related impacts on fish can be accomplished. Where fisheries information is not available, the stratification results will provide rationale based on habitat sensitivity to discharge, for selecting representative study sites for conducting further field investigations.

5.0 FISHERIES IMPACT ISSUES

Based upon discussions with aquatic studies team members, results of studies on the middle river, and the physical changes expected in the lower river. The following were identified in Section 3.0 as potentially significant fisheries impact issues:

1) Access to spawning grounds

2) Changes in availability of spawning habitat

3) Changes in incubation success

4) Changes in availability of suitable rearing and overwintering habitat for juvenile and resident fish.

5) Altered juvenile outmigration patterns.

5.1 ACCESS TO SPAWNING GROUNDS

5.1.1 Background

Within the lower Susitna River, very little spawning by Pacific salmon seems to occur in the mainstem or side channel sites. ADF&G examined potential mainstem and side channel spawning sites in the lower river using electroshockers and drift gill nets. In 1981, six locations were found in the mainstem where chum salmon were spawning (ADF&G 1981a [AA]). In 1982, 811 sites were surveyed between RM 7.0 and RM 98.5 and no spawning salmon were found (ADF&G 1983a Appendix 2-F [AA]). Turbid water in the lower river prevents visual observation of spawning; thus, it is possible that more spawning may occur than was detectable with electrofishing gear.

Most spawning apparently occurs in tributaries or sloughs (ADF&G 1980a, 1980b, 1981b, 1982, p. E-3-553) in the lower river. Between Talkeetna and Cook Inlet there are eight major and numerous smaller tributaries that are utilized by adult salmon to varying degrees. Surveys for spawning chinook have been conducted regularly in the lower river in July and August, 1976 to 1982 (Table 5-1). No systematic surveys of spawning by pink, chum, coho, and sockeye have been conducted in lower river tributaries. While escapement surveys have been conducted in tributaries (e.g., Birch Creek) between Sunshine and Talkeetna, these surveys have been very limited in scope (e.g., ADF&G 1981AA - Appendix Table EJ).

In addition to receiving the bulk of the salmon spawning in the lower river, tributaries in the lower river also provide the major spawning habitat for grayling and rainbow trout. Studies by ADF&G (1981, 1983AA) suggest resident fish migrate into tributaries to spawn and feed after overwintering in mainstem, sloughs, or side channel habitats. Dolly Varden apparently enter tributaries to spawn in the fall whereas most of the other species spawn in the spring.

Other than tributaries, tributary mouth habitat and adjacent sloughs probably receive most of the rest of the escapement of anadromous and resident fish. Sloughs without tributaries probably provide spawning habitat, but there has been no systematic evaluation of the magnitude of slough spawning in the lower river.

Several project related physical changes (primarily discharge) will occur that may make some sloughs and tributaries less accessible to adult anadromous and resident fish. Main channel stage is a function of discharge in the Susitna and thus influences the depths at the mouths of some sloughs. At sufficiently low discharge, water depths are insufficient to provide access for fish seeking to spawn in sloughs or tributaries that enter through sloughs. Thus far, access conditions as a function of discharge have only been evaluated at some middle river sloughs; no lower river evaluations have yet been conducted.

TABLE 5-1
CHINOOK SALMON ESCAPEMENT COUNTS IN THE
LOWER SUSITNA RIVER BASIN STREAMS FROM 1976 TO 1982a/

Stream	Year 1976	1977	1978	1979	1980	1981	1982
Alexander Creek	5,412	9,246	5,854	6,215	b/	b/	2,546
Deshka River	21,693	39,642	24,639	27,385	b/	b/	16,000 f/
Willow Creek	1,660	1,065	1,661	1,086	b/	1,357	592 e/
Little Willow Creek	833	598	436	324 d/	b/	459	316 e/
Kashwitna River (North Fork)	203	336	362	457	b/	557	156 e/
Sheep Creek	455	630	1,209	778	b/	1,013	527 e/
Goose Creek	160	133	283	c/	b/	262	140 e/
Montana Creek	1,445	1,443	881	1,094 d/	b/	814	887 e/
Prairie Creek	6,513	5,790	5,154	b/	b/	1,900	3,844
Clear Creek	1,237	769	997	864 d/	b/	b/	982
Chulitna River (East Fork)	112	168	59	b/	b/	b/	119 e/
Chulitna River (MF)	1,870	1,782	900	b/	b/	b/	644 e/
Chulitna River	124	229	62	b/	b/	b/	100 e/
Honolulu Creek	24	36	13	37	b/	b/	27 e/
Byers Creek	53	69	b/	28	b/	b/	7 e/
Troublesome Creek	92	95	b/	b/	b/	b/	36 e/
Bunco Creek	112	136	b/	58	b/	b/	198
Peters Creek	2,280	4,102	1,335	b/	b/	b/	b/
Lake Creek	3,735	7,391	8,931	4,196	b/	b/	3,577
Talachulitna River	1,319	1,856	1,375	1,648	b/	2,129	3,101
Canyon Creek	44	135	c/	c/	c/	84	c/
Quartz Creek	c/	8	c/	c/	c/	8	c/
Red Creek	c/	1,511	385	c/	c/	749	c/

a/ 1976-1980 counts (ADF&G/Kubik, S.W.), 1981 and 1982 from ADF&G Susitna Hydro (1981, 1983).
b/ No total count due to high turbid water.
c/ Not counted.
d/ Poor counting conditions.
e/ Counts conducted after peak spawning.
f/ Estimated peak spawning count (ADF&G/Delaney, K).

Project related changes in discharge may also affect access to tributaries. Changes in mainstem stage may cause some tributaries to become perched, forming shallow delta like areas impassable by salmon. If tributary mouths became sufficiently perched (i.e., above the level of the mainstem), access of anadromous and resident fish into them may be impeded. Specific studies of access into lower river tributaries have not been conducted. However, R&M (1982b - hydraulic studies) studied perching at the mouths of tributaries within the middle river and concluded that flows in most tributaries would be sufficient to downcut through the delta to establish a channel at a new gradient. Using this information and other data collected by ADF&G and R&M, Trihey (1983) conducted an incremental analysis of access into two tributaries in the middle river: Portage Creek and Indian River. He concluded that access into these tributaries would not be a problem at Gold Creek flows as low as 8,000 cfs because downcutting by the tributaries will establish new entrance conditions that allow access to spawning areas.

5.1.2 Information and Study Needs

Because of the large number of spawners that utilize the lower river tributaries, it is critical that access be adequately assessed in the lower river. Results of access studies conducted in the middle river cannot be extrapolated to the lower river because of differences in channel morphology and differences in the response of stage to flow. Due to the lack of information on salmon utilization of all riverine habitat types (see Section 4.0 for description of habitat types) and insufficient data on access, the following studies are needed:

1) Survey of riverine habitat types and tributaries to determine utilization by salmon (i.e., timing, abundance, and species composition).

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2) Evaluate salmon access vs mainstem flow for selected tributaries, side channels, and sloughs in the lower river.

5.1.3 Study Location

Since the lower river has eight major and numerous smaller tributaries plus riverine associated habitats extending over 98 miles, it is necessary to utilize a site selection procedure for evaluating salmon access. Therefore, study site selection will be based on: 1) degree of habitat utilization, and 2) extent of habitat dewatering expected with project flows. Sites considered most important based on this criteria will be studied. Sites of lesser importance but utilized for access will be evaluated from a study of a subsample of representative sites. Sites selected for the subsample will represent the various types of habitat (see Section 4.0) utilized by salmon during immigration.

5.1.4 Study Methodology

<u>Habitat Utilization</u>

The utilization of tributary habitat by migrating salmon will be determined by aerial surveys conducted weekly from mid July to the time of ice formation in autumn. All salmon will be counted in the area ~~extending from the~~ lower end of a clear tributary plume to one third of a mile upstream of the tributary mouth.

Utilization of the mainstem and side channels will be determined from weekly aerial surveys conducted from the end of August to early October; a period when water clarity is sufficient to allow visual determination of spawners. Surveys during this time period will likely miss pink salmon and chinook salmon spawners because of earlier run timing, but include chum salmon, sockeye salmon, and coho salmon spawners. The habitat utilized by the latter species should be indicative of the habitat used by the former. Thus, the surveys will provide an identification of run timing, an estimate of species composition, and an estimate of rélative extent of habitat utilization.

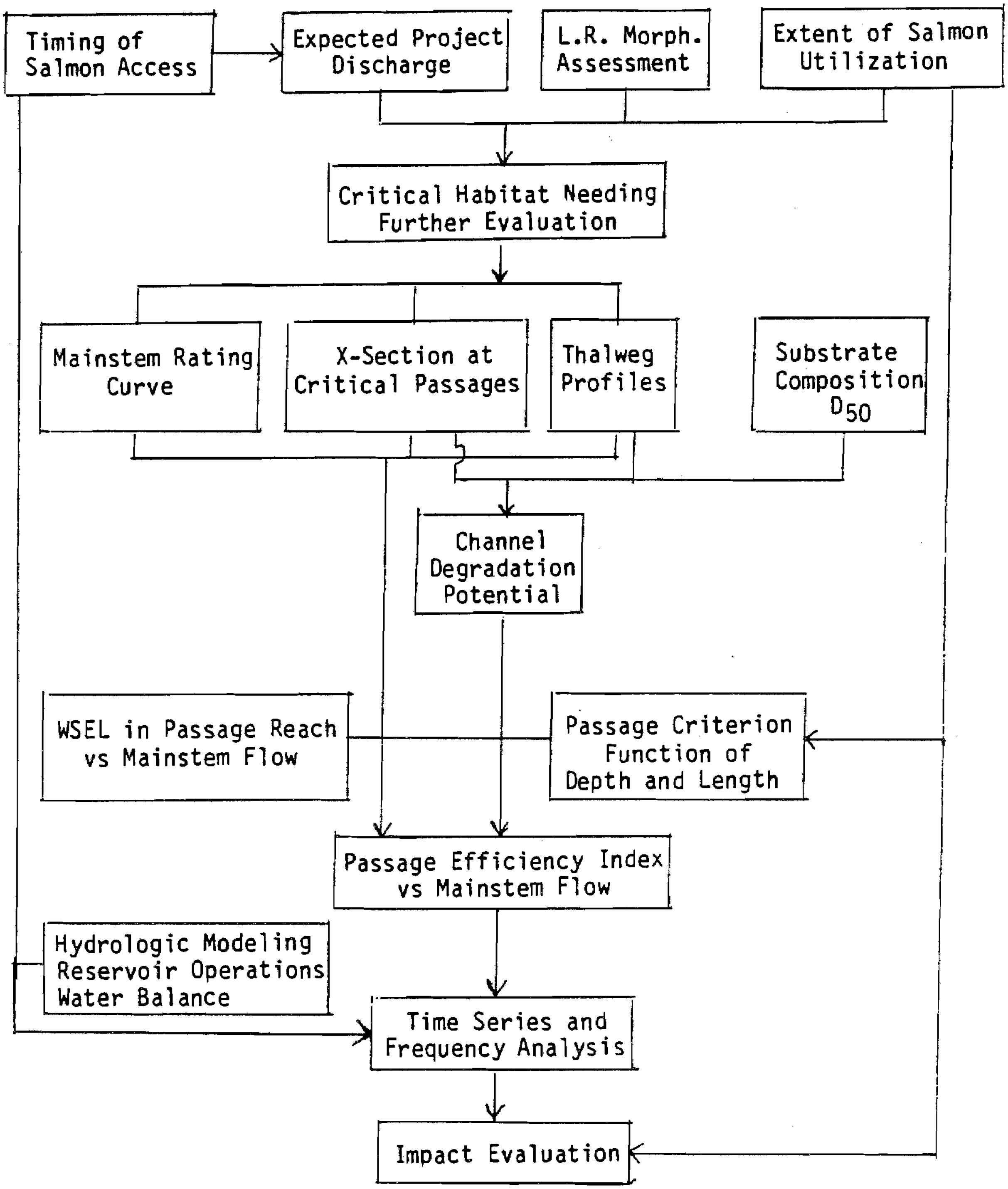
Access Evaluation

A preliminary assessment of the extent of habitat dewatering in critical access areas can be determined from the results of the lower river morphological assessment study. The response of water surface area to changes in flow in habitat utilized for access will be used as the first approach to identifying problem areas and to eliminate nonproblem sites.

Sites that cannot be eliminated by a simple analysis of cross-sectional depth versus river stage will require a more rigorous analysis of threshhold access conditions as outlined in Figure 5-1. An index of passage conditions for each study site will be developed based on morphological characteristics of any critical access reach which occurs in the site and an estimate of the percentage of the surface area within the critical reach which is navigable by salmon. These indices will be developed from thalweg profiles, cross-sections in the critical access reaches, and mainstem rating curves. These will be used to develop an average of water surface elevation for the critical passage reach against mainstem flow. For a series of mainstem flows, the proportion of cross-sectional areas which meet the 0.3 foot depth criterion (Trihey 1982) will be determined. The cross-sectional area proportions will be integrated with thalweg profiles and water surface profiles to determine the proportion of the critical passage reach which meets the less than 100 foot length criterion. In addition, the 0.3 foot minimum depth for less than 100 feet criterion will be verified through documentation of the numbers of fish gaining access under various flow conditions.

FIGURE 5-1

EVALUATION OF CONDITIONS FOR ADULT SALMON
ACCESS TO SPAWNING HABITATS



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A passage efficiency index for a continuum of mainstem flows will be developed for each study location and for each species. Each species/location index will consist of critical discharge values which define no access and uninhibited access conditions and a curve depicting access efficiency between these critical discharge levels. These indices will then be accumulated by habitat type and by species to define mainstem discharge necessary to provide adequate access conditions. In turn, the habitat indices will be accumulated into one index for all habitats in the lower Susitna River.

5.2 CHANGES IN AVAILABILITY OF SPAWNING HABITAT

5.2.1 Background

Relatively few fish seem to spawn in habitats that may be directly affected by project physical changes. The magnitude of spawning in side channels and the mainstem were evaluated in 1981 and 1982 by ADF&G (1981, 1983-AA). Other than 6 sites where spawning chum salmon were found in 1981, salmon were not found spawning in side channel or mainstem sites. The timing and abundance of adult spawning salmon in sloughs between Sunshine and Talkeetna were periodically surveyed by ADF&G in 1981 and 1982 (e.g., Birch Creek). However, no other sloughs in the lower river have been surveyed. Bering cisco have been found spawning in three mainstem sites located between RM 75 and 80 (ADF&G 1981, Summary Report). A preliminary evaluation of Bering cisco spawning habitat characteristics can be found in ADF&G (1981, summary; 1983c, AH - Appendix F).

Some data on habitat available for salmon spawning can be found in ADF&G Aquatic Habitat and Instream Flow Reports, including depths, velocity, substrate, and temperature (see Table 5-2 for the location of this data). However, this data is of limited use in comprehensively evaluating available habitat in the lower river because it is incomplete (i.e., missing data or some parameters were not collected)

TABLE 5-2

INFORMATION AVAILABLE IN ADF&G REPORTS ON HABITAT CHARACTERISTICS IN THE LOWER RIVER

Location and Variable	Citation	
Chum Channel		
Velocity	AH, Table 4-B-1	1983
Depth	AH, Table 4-B-1	1983
Discharge	AH, Table 4-A-1	1983
Rabideux Slough		
Velocity	AH, Table 4-B-2	1983
Depth	AH, Table 4-B-2	1983
Discharge	AH, Table 4-A-1	1983
Thermograph Sites (1981)		
(see page E--149 ADF&G 1981a AH for listing of sites)	AH, Appendix EC	1981
Thermograph Sites (1983)	AH, Appendix C	1983

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and the data was not collected in a representative manner. Moreover, because changes may occur in the river that alter the characteristics of habitat in an area, it is doubtful that this data could be compared with information on utilized habitat collected several years hence.

The quantity and quality of habitat available for salmon spawners in side channels and the mainstem is directly dependent on mainstem factors (e.g., discharge, temperature, ice and sediment processes). Side slough habitat is dependent on groundwater upwelling which may be influenced by discharge in the Susitna River. Additionally, the quality of slough habitat (i.e., siltation and aquatic vegetation) is affected by the frequency and magnitude of overtopping. (The only evaluation of overtopping in a lower river slough was conducted in Rabideux slough - see Appendix E.2.A of the license application.) Consequently, project operations may have an impact on the location and availability of spawning habitat in the mainstem, side channels, and sloughs. However, impacts may be both positive and negative. For example, reducing flows in the summer may dewater some spawning areas located on the river margins, whereas more stable flows and decreased bedload movement under project conditions may provide additional suitable conditions for spawning in new areas. Ultimately, the nature of many habitats could be altered as a result of operations of the project. Some side channels may become side sloughs (by reducing the frequency of overtopping) and become more usable by salmon.

5.2.2 Information and Study Needs

Because of the lack of information on utilization of riverine habitats by spawning salmon, it is necessary to assess the relative abundance and distribution of spawners in riverine habitats in order to determine if spawning habitat evaluation studies are needed. If spawner surveys demonstrate a significant number (defined by ADF&G) of spawners utilize riverine habitat, then potential changes in availability of spawning habitat with project flows must be evaluated. The following specific studies are needed:

1) Survey of riverine habitat types to determine utilization by spawning salmon (i.e., timing, abundance, and species composition).

2) Evaluation of the effects of project flows on the availability of habitat suitable for spawning salmon.

5.2.3 Study Location

Study site selection will be based on: 1) degree of habitat utilization, and 2) extent of habitat dewatering expected with project flows. Sites considered most important based on this criteria will be studied. Sites of lesser importance but utilized by spawners will be evaluated from a study of a subsample of representative sites. Sites selected from the subsample will represent the various types of habitat (see Section 4.0) utilized by salmon during spawning.

5.2.4 Study Methodology

Habitat Utilization

Use methods described for Section 5.1.4. In addition, an analysis of results from the lower river morphological assessment study will be used to target spawner surveys on habitats that are not dewatered under natural flows during the period of spawning and incubation. This selection procedure will concentrate effort of the survey on only those sites where spawning and incubation could be successful.

Evaluation of Spawning Habitat Availability

The first approach to evaluation of flow affects on spawning habitat will be based on changes in surface area. The response of water surface area in spawning habitats to changes in river flow will be determined with results from the lower river morphological assessment study. Changes in area of identified spawning sites will be plotted with river discharge to evalute the effects of expected project flows on availability of spawning habitats.

Spawning sites with a significant level of utilization may require modeling (IFG-4) of depth, velocity, and substrate conditions to enable prediction of changes in habitat availability with changes in flow. Data requirements and methods required for this approach are described in Harza-Ebasco (1983, Section 4.2.4.1).

5.3 CHANGE IN INCUBATION SUCCESS

5.3.1 Background

Eggs deposited in the lower river will be influenced by project changes in physical conditions. This includes eggs deposited in the mainstem, side channels, tributary mouths, and sloughs. At present, no surveys have been conducted to estimate the potential egg deposition, potential fry emergence, or time of emergence for these lower river habitats.

There are several physical impacts that the project may have that could affect incubation conditions. First, altered depth and velocities could affect incubation. Also, if the rate and amount of groundwater upwelling in sloughs is related to mainstem flow, then the intergravel flows incubating embryos may be altered. However, because eggs would be deposited at flows lower than normal and increases in flow (and hence upwelling) are expected to occur in winter, this impact is not expected to be significant and may be a positive impact.

Second, staging due to ice formation may be higher than during natural conditions as a result of increased winter streamflows. As a consequence, berms at the upstream end of some sloughs and side channels (where spawning has occurred) and downstream of the ice front could overtop and inundate incubating embryos with cold mainstem (0°C) water. As a result of overtopping, the developmental rate of these eggs could be delayed or eggs killed due to thermal shock. Studies during winter in Slough 8A of the middle river demonstrated that overtopping with cold mainstem water as a result of ice jams depressed the temperature of intragravel water and delayed development of chum and sockeye embryos (ADF&G 1983e). The net effect of reducing incubation temperatures could be a delay in emergence and/or a smaller size at emergence, both of which could decrease fry survival.

Third, in the fall the higher temperature of the release water will extend downstream into the lower river and increase the developmental rate of embryo's which could result in premature emergence. Fry emerging too early are desychronized with environmental conditions and may experience conditions (i.e., reduced food supply) that decrease their growth and survival.

Fourth, higher winter suspended sediment loads and bedload sediment could silt over some salmon redds. As a result, egg-to-fry survival may be reduced.

Fifth, if ice breakup is more severe than under natural conditions (e.g., because of an increase in the amount of ice), some scouring of redds in side channels or side sloughs may occur. Consequently, mortality of embryos or alevins may be increased.

Current assessment efforts are inadequate to assess impacts during incubation. Predictions of project temperature, suspended sediments, and ice processes are needed during the period of incubation; predictions of flow may be sufficient to assess impact during incubation. Relationships between surface water and intragravel temperature have been studied (ADF&G 1983e), but relationships between upwelling temperatures have yet to be established. The effects of delayed emergence due to cold water on embryos survival needs to be determined, but the effects of temperature on embryo development rates are known (Waangard and Burger 1983). There has been no information collected on when, where, and how many eggs are deposited in potentially affected lower river habitats.

5.3.2 Information and Study Needs

The utilization of riverine habitats by salmon for incubation must be assessed in order to determine if studies of incubation habitat are necessary. If riverine habitats provide a significant portion of the egg incubation sites for the lower Susitna River, then the following studies are needed:

1) Evaluation of the relationship between mainstem flow and the intragravel flow rate and temperature of incubation sites in riverine habitats utilized by incubating salmon embryos.

2) Determination of the effects of cold water downwelling from channel overtopping on the survival to emergence and condition of incubating salmon embryos.

3) Determination of the effects of changes in upwelling rate and temperature as a result of change in mainstem flow on the survival to emergence and condition of incubating salmon embryos.

5.3.3 Study Location

Study site selection will be based on: 1) degree of habitat utilization, and 2) extent of habitat dewatering expected with project flows. Sites considered most important based on this criteria will be studied. Sites of lesser importance but utilized for incubation will be evaluated from a study of a subsample of representative sites. Sites selected for the subsample will represent the various types of habitat (see Section 4.0) utilized for incubation by salmon.

5.3.4 Study Methodology

Habitat Utilization

Use methods described in Sections 5.1.4 and 5.2.4.

Relationship Between Mainstem Flow and Intragravel Flow Rate and Temperature

Methods for this task will be described by Harza/Ebasco hydrology group.

Evaluation of Cold Water Downwelling on Embryo Survival

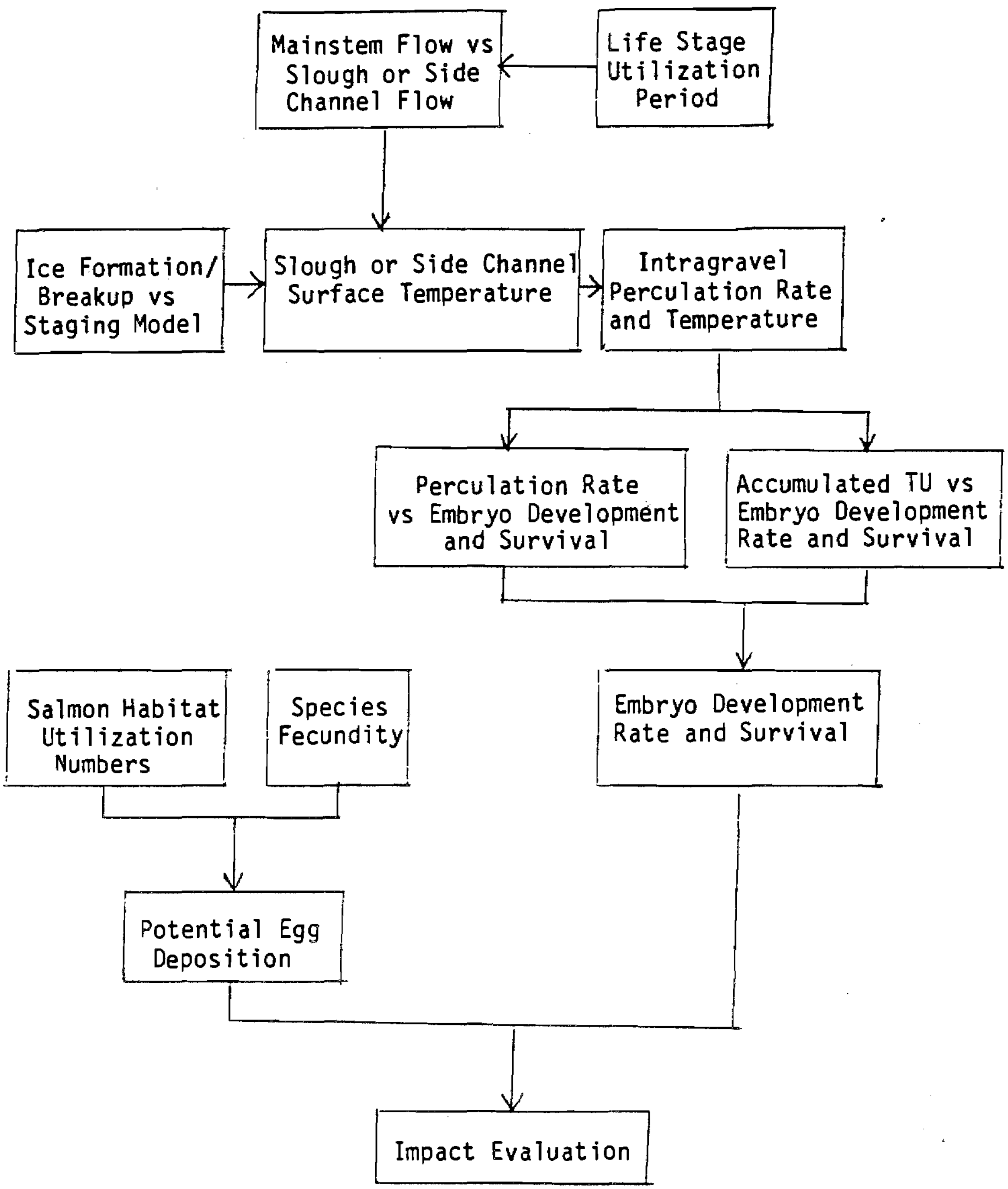
Side channel or slough habitats that are utilized by spawning salmon and are overtopped as a result of ice staging will be selected for study. Known lots of fertilized salmon eggs will be placed in Vibert boxes and buried in the gravel at typical spawning sites. Intragravel and surface water temperatures will be continuously monitored during the incubation period. Boxes will be removed at periodic intervals including immediately following a cold water overtopping event. Developmental rate and survival of embryos will be evaluated and relationships between temperature and overtopping events determined. Intragravel perculation rate and dissolved oxygen will also be measured periodically to assess these effects on embryo survival. Results of these analyses, combined with the extent of habitat utilization, will be used to assess overall impacts on incubation (Figure 5-2).

Evaluation of Upwelling and Temperature Changes on Embryo Survival

Results from the study on determining the relationship between mainstem flow and intragravel flow rate and temperature (Section 5.3.4) would be combined with results from the embryo development study (Section 5.3.4) and data from Waangard and Burger (1983), to develop a predictive

FIGURE 5-2

EVALUATION OF INCUBATION SUCCESS



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model. Intragravel flow and temperature conditions expected with project flows could be perdicted for selected representative habitat sites. Impacts on embryo survival would be estimated from relationships between embryo survival and predicted physical conditions.

5.4 CHANGES IN AVAILABILITY OF SUITABLE REARING AND OVERWINTERING HABITAT

5.4.1 Background

Juvenile anadromous and resident fish rear in Susitna riverine habitats throughout the year. Information on the distribution and abundance and size of these fish in lower river habitats has been collected by ADF&G in 1981 and 1982 (ADF&G 1981c, ADF&G 1983b - RJ). A variety of sampling gears were utilized (e.g., electroshocking, seines, trot lines, gillnets, minnow traps) to capture fish and samples were obtained in both summer and winter. In the lower river twice monthly samples were taken in both years from the vicinity of five designated fish habitat (DFH) sites: Radideux, Whitefish, Birch, Sunshine, and Goose Creeks (see Appendix A, ADF&G 1982 (RJ) and Appendix B ADF&G 1981c (RJ) for catch data, summary tables are also available in each report - for example ADF&G 1981 - Table E.3.2.8 and E. 3.2.9). A number of other sites (i.e., selected fish habitat (SFH sites) were also intermittenly sampled (see same appendices). Some information on water quality (e.g., temperature, turbidity), discharge, and watersurface elevations are available at some sites but in particular for the five creeks listed above (Table 5-3).

Results of fish surveys suggest the following major conclusions:

1) Coho and chinook were the most abundant species, especially in 1981. Early in outmigration, coho and chinook were more abundant below then above the Chulitna. Lower river coho tended to be larger. Towards the end of August, chinook and coho catches

TABLE 5-3

CATCH AND HABITAT DATA FOR RESIDENT AND JUVENILE ANADROMOUS FISH IN ADF&G REPORTS

DFH Sites	Years	Data
Catch Data	RJ, 1981c, ADF&G	Table E.3.2.8, E.3.2.9, E.3.2.15, E.3.1.4, E.3.1.5, E.3.1.9, E.3.2.1 E.3.2.2, E.3.2.3, Appendix EB.
	RJ,1983b, ADF&G	3-3-11, B-3-13, 3-13-16, 3-3-18, 3-3-21, 3-3-23, 3-3-32, 3-3-28 Appendix Table 3-A.
Water Quality	AH, 1983c, ADF&G	Appendix 4-D, (pp. 40-44 to 4-D-68), Appendix I (4-I-2 to 4-I-9), Appen.
	AH	
Water Velocity	AH, 1983c, ADF&G	Appendix I (4-I-2 to 4-I-9), Appendix B (Rabideux - 4-B-3).
Discharge, WSEL	AH, 1983c, ADF&G	Appendix A (4-A-46 to 4-A-48) (4-A-173 to 4-A-178)

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increased in the mainstem. In the summer, some fish reared in tributary mouths and sloughs. Coho exhibited a strong preference for non-turbid waters and both chinook and coho preferred warmer water conditions.

2) Chum and pinks were only rarely caught in the lower river and primarily in sloughs, probably as result of collection gear.

3) Rainbow trout were present in small numbers in the lower river and tended to be associated wih the clear water areas associated with tributaries. They overwintered in the mainstem near the mouth of tributaries. Extensive lower river migrantions were not apparent from radio tag data.

4) Burbot, whitefish, and longnose sucker used some mainstem and side channel areas for rearing. Catches tended to be very small. Burbot avoided clearwater areas and were mostly associated with the mainstem.

Project related physical changes in the lower river may have several impacts on resident and juvenile anadromous fish rearing in the lower river. A list of potential impacts in order of priority are:

1) Area of hydraulic habitat and cover availability may be increased in the winter and decreased in the summer.

2) Increased stage height and increased probability of side channel and slough overtopping during ice staging may reduce availability of overwintering habitat.

3) Increased suspended sediment and turbidity in winter may reduce the suitability and availability of overwinter habitat in the mainstem, side channels, and sloughs.

4) Warmer fall-winter temperatures and cooler summer temperatures may have an impact on growth rates.

To date, no analyses of growth rate effect relative to predicted temperature are available, but sufficient knowledge on the subject is available in the literature; effects of turbidity on fish behavior at low temperature is unknown, but a review of literature concerning winter habitats and data on turbidity could be used to evaluate the problem; and the effects of slough overtopping on winter habitat has not been studied. ADF&G has analyzed the relationship between mainstem discharge and the availability of hydraulic habitat for juvenile rearing at the five lower river DFH sites between June and September (ADF&G 1983d Appendix F Synopsis). This was accomplished by classifying DFH sites into zones (based upon water source, water velocity, and backwater influence). A habitat index (HI) that could be plotted against discharge was developed by relating catch variations between zones to changes in water surface area of the zones. These results are presented graphically and in tables for chinook at Goose, Rabideux and Birch creeks (Appendix Table F-13; Figure F-3, F-4, F-5), coho at Sunshine and Birch creeks (Appendix table F-14; Figure F-7, F-8), sockeye at Birch Creek (Appendix Tale F-15; Figure F-10) and chum at Birch Creek (Appendix Table F-16; Figure F-13). Variations in mainstem discharge clearly affected the habitat utilized by each of the species and there were considerable differences between species (Appendix Figure F-17). Appendix G of the ADF&Gd 1983 Synopsis report also provides an analysis of major habitat use by species in the summer that incorporates lower river sites (upland slough - Whitefish; side sloughs - Rabideux and Birch Creek; side channel - Goose and Sunshine Creeks). All of the lower river habitat sites that have been studied are located above RM 73. Therefore information will be needed from habitat sites located further downstream.

The HI approach for assessing flow related impacts is site specific and would be of limited use in the lower river. The HI can be used to distinguish habitat values at various flows within a site, but is not a good comparation between sites. The HI is very data dependent and does not provide an extrapolatable model; therefore, if fish data and water surface area measurements are not available for certain flows, rearing values must be subjectively assigned. An alternative procedure for evaluting flow related impacts on habitat will need to be developed for the lower river.

The utilization of lower river habitat for rearing during summer and winter has been documented by ADF&G studies (ADF&G 1981c, ADF&G 1983b - R.J.). But, the relative importance of riverine habitat compared to tributary habitat has not been quantified. Studies that provide the abundance of salmonids in the different habitat types would provide a perspective as to the importance of riverine versus tributary habitat to the fish population.

5.4.2 Information and Study Needs

1) Determination of the species composition, abundance, and timing of riverine habitat utilization by juvenile and resident salmonids during summer and winter.

2) Determination of the relationship between mainstem discharge and availability of suitable rearing habitat for summer and winter periods.

3) Determine the effects of side channel or slough overtopping as a result of ice staging on habitat utilization and survival of rearing salmonids.

4) Evaluate the potential effects of suspended sediment and turbidity on the behavior and survival of juvenile salmonids at low (less than 2°C) temperatures.

5) Evaluate the effects of small temperature change ($\pm$ 2°C) expected with project conditions on the growth of juvenile salmonids.

5.4.3 Study Location

Habitat utilization study sites will be stratified to include sampling of the four major riverine habitat types (see Section 4.0) with effort proportioned by river segment according to level of flow related impact. The level of impact among river segments will be determined from results of the lower river morphological assessment study.

Selection of study sites for determination of the relationship between mainstem discharge and rearing habitat will be based on a stratified sample design. Sites will be stratified on the basis of major habitat type and relative extent of utilization by rearing fish (or proximity to natal spawning area). The level of effort (i.e., number of study sites) will be proportioned within river segments by extent of fish utilization, and between river segments according to the level of flow related impact.

Habitats representative of the four habitat types that are utilized by rearing fish during winter, and have channel overtopping conditions based on observations during ice formation (R&M 1983, unpublished data) will be selected for studies of overtopping.

5.4.4 Study Methodology

Habitat Utilization

During summer, surveys will be conducted in selected study sites at bimonthly intervals. Samples will be collected with a variety of sampling gear (see ADF&G 1981c and 1983b - RJ) and catch data expressed as catch per unit effort (CPUE). During winter, utilization will be based on the distribution and CPUE data derived from samples collected on last sample date that is prior to ice formation. Because water temperatures will be close to 0°C at this time, it is assumed that juvenile fish will have completed any movements among habitats prior to the ice cover period.

Relationship Between Mainstem Discharge and Rearing Habitat in Summer

Determination of the relationship between juvenile salmon rearing habitat and mainstem flow involves two types of analysis. The first involves utilization of the IFG-4 hydraulic models and the PHABSIM habitat simulation model. This procedure will be used for habitats that are known to have a stable channel morphology. The second analysis makes use of an incremental analysis based on a regression of mainstem flow vs surface area of specific habitat units that are defined by: persence or absence of cover, certain depth-velocity-substrate combinations, presence or absence of turbid water, and certain temperature ranges. This procedure will be used for habitats that are not assumed to remain stable with time. The rationale for employing this procedure is based on the assumption that the size of habitat units will change with mainstem discharge, but the relative distribution of representative habitat units will remain constant for a given discharge regardless of periodic changes in channel morphology.

Both procedures will require habitat preference curves that relate the presence of juvenile salmon to depth, velocity, substrate composition, cover, turbidity, and temperature. Habitat preference data will be developed for each species from observations of individuals for coho and chinook, and observation of fish groups for sockeye and chum.

The IFG-4/PHABSIM model will be calibrated with hydraulic data collected at several different flows and will include measurements of depth, velocity, substrate composition, and cover. The habitat unit model will be calibrated with unit area data collected at six different flows that encompass the flow range expected with the project.

Evaluation of impacts from flow changes on rearing will be based on the timing of habitat utilization (Section 5.4.3), combined with analysis of predicted habitat conditions under natural historic flows and flows expected with the project.

Relationship Between Mainstem Discharge and Rearing Habitat in Winter

The determination of flow vs habitat relationships during winter cannot be developed until information on the feasibility of measuring physical and biological parameters under the ice is available. The first task will be to develop a set of efficient procedures for measuring physical parameters (i.e., depth, velocity, turbidity, temperature) underneath an ice cover. The second task will be to determine the variability in parameter values during winter and develop a relationship between mainstem flow and each parameter. The third task will be to develop a procedure for measuring the overwinter survival of fish rearing in specific habitat types. Perhaps a measure of the change in population size between the times of ice formation and ice breakup could be employed. The final task would be to develop a relationship between mainstem flow and overwinter survival for representative habitat types or habitat units.

Relationship Between Channel Overtopping and Survival of Rearing Salmonids

The procedures developed for winter habitat studies (Section 5.4.3) would be utilized for assessing the impacts of channel overtopping.

Effects of Suspended Sediment on Survival and Behavior of Juvenile Salmon

A review of the literature concerning juvenile salmonid behavior at low temperatures, and effects of suspended sediment on behavior and survival, will provide the information necessary for estimating the magnitude of impact expected with project conditions. If the predicted impacts are considered significant, then an impact assessment procedure will be developed.

Effects of Temperature on Growth of Juvenile Salmon

The relationship between temperature and fish growth is well documented in the scientific literature. Based on this information, fish growth vs water temperature curves will be developed for natural water temperature and project temperature regimes for each species during the summer rearing period. The growth vs temperature curves will be used to assess the time period and magnitude of project impacts.

5.5 ALTERED JUVENILE OUTMIGRATION PATTERN

5.5.1 Background

The outmigration of juvenile salmonids in the Susitna River has been studied in 1981 and 1982 by the ADF&G (ADF&G 1981c, ADF&G 1983b - R.J.). Limited data are available on the timing of migration, species composition, age structure, and size of outmigrating fish. In the lower river, samples were collected with minnow traps, beach seines, and electrofishing gear throughout the spring open water period. Based on these samples plus information from one smolt trap located above the confluence of the Chulitna River, the general migration timing is known. Chinook salmon outmigrants peak during May and June with all age 1+ fish leaving the stream by early August. The coho salmon outmigration also peaks during May and June, but continues through the summer to the onset of ice cover. Chum salmon fry rear for one to two months before the peak of their outmigration which occurs during June. The sockeye outmigration is similar to that of chinook with a peak in early July and ending by August. The pink salmon outmigration was not sampled adequately to determine the migration peaks, but limited captures of pink fry indicate most fish outmigrate before June.

The relationship between juvenile outmigration and environmental variables (i.e., discharge, water temperature, and day length) was examined for fish emigration from the river above the Chulitna confluence in 1982 (ADF&G 1983d - Appendix H). In general most relationships were significant, but correlation coefficients were moderate to low. Factors that could account for the low correlations include: incomplete catch data for entire outmigration period; attempting correlations with seasonal data rather than for shorter, daily or weekly events; and, lack of site specific data for most physical variables.

Several physical factors are considered to have a causal relationship with juvenile salmon outmigration. Discharge will effect the travel time of downstream migrants and river stage can influence access of juveniles migrating from sloughs to the mainstem. Spring freshets can displace juveniles resulting in pulses in timing and numbers of outmigrants. In some cases, rearing juveniles may be displaced downstream to the estuary or lower mainstem before reaching a preferred size for migration and smoltification. Survival of the outmigrant population could be highly dependent upon the mainstem flow regime. Conceivably, the projected reduction in streamflow during spring as a result of project operations would minimize fish displacements due to flushing flows. On the other hand, reduced flows may increase outmigration travel times, thus increasing vulnerability of migrants to predation. Turbidity is an important factor in providing cover for outmigrating juvenile salmon. This may be especially important in the Susitna River because periods of darkness (juvenile salmon migrate mostly at night in non-turbid rivers) are short during the spring migration. Some reductions in turbidity are expected during spring as a result of the reduction in river discharge (see section on suspended sediment). However the magnitude of reduction in turbidity will be small relative to the naturally high levels. Thus no changes in fish survival relative to this factor are expected.

5.5.2 Information and Study Needs

1) Determine the relationship between mainstem discharge and timing of habitat utilization, and types of riverine habitat utilized during the outmigration period.

2) Determine the relationship between short term (i.e., daily) and longer term (seasonal) mainstem flow fluctuations, and migration timing and travel time of juvenile salmon outmigrants.

5.5.3 Study Location

Studies on the timing of habitat utilization and types of habitat utilized during the outmigration period will be conducted at the same sites selected for the juvenile salmon habitat utilization study (Section 5.4.3). Studies of outmigration timing and travel time for the lower river between Cook Inlet and Talkeetna will be evaluated from outmigrant monitoring stations located at Talkeetna (RM 98) and near Flathorn Lake (RM 20).

5.5.4 Study Methodology

<u>Outmigrant Habitat Utilization</u>

Determination of the timing of habitat utilization and types of habitat utilized by outmigrant salmon will be evaluated from periodic sample collections following ice breakup as described in Section 5.4.4 for studies of rearing habitat.

<u>Relationship Between Mainstem Flow and Outmigration Timing and Migrant Travel Time</u>

The sizes, number, and timing of outmigrating juvenile salmon will be correlated with daily and seasonal flow fluctuations. This information will be used to evaluate the importance of mainstem flow on outmigration and to assess the potential impacts of project flows on changes in outmigration timing. Outmigration data from the Talkeetna Station will be compared with data from Flathorn to estimate the travel time and growth of juvenile salmon that migrate through the lower river. This information will be correlated with mainstem flow and the results will be used to assess the potential impacts of project flows.

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