PRELIMINARY DRAFT REPORT

Characterization of Aquatic Habitats in the Talkeetna to Devil Canyon Segment of the Susitna River, Alaska

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TABLE OF CONTENTS

TABLE OF CONTENTS
(cont'd)

LIST OF TABLES

LIST OF TABLES
(cont'd)

LIST OF FIGURES

1. INTRODUCTION

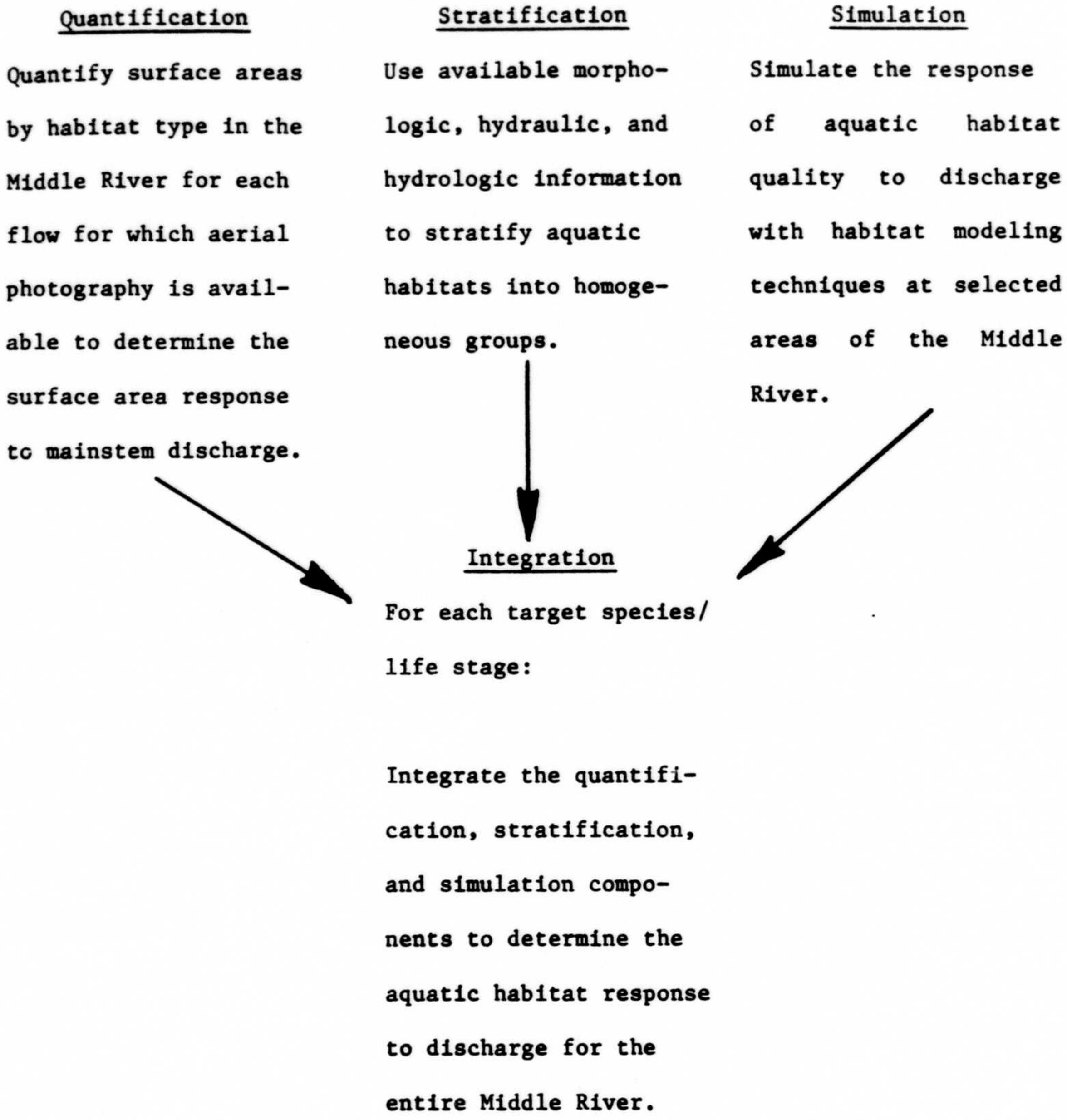
The Alaska Power Authority has proposed the construction of two dams on the Susitna River. Construction of the proposed hydroelectric project will alter the flow regime downstream of the dams which will result in corresponding changes to the quality and quantity of fish habitat. The most pronounced influences of the project are expected to occur in the Talkeetna to Devil Canyon segment of the Susitna River (the Middle River). Two major tributaries, the Talkeetna and Chulitna Rivers, will buffer the impacts of the project downstream of Talkeetna.

To evaluate the effects of constructing the project on juvenile salmon habitat, it is necessary to document natural conditions. Towards this objective, the Alaska Department of Fish and Game (ADF&G) and E. Woody Trihey and Associates (EWT&A), in a cooperative program, have applied fish habitat modeling techniques at 35 sites in the Middle River. These models provide insight to the response of aquatic habitat quality and quantity to discharge at these sites.

The Middle River is a large, frequently braided or split channel river with numerous sloughs, side channels, and tributaries providing the most important habitat for juvenile salmon (Schmidt et al. 1984). The areas of the Middle River that have been modeled amount to only a fraction of the total habitat available in the Middle River. It was impractical and cost prohibitive to model the entire Middle River.

To determine the response of aquatic habitat quality and quantity to discharge for the entire Middle River, it is necessary to extrapolate results from modeled sites to nonmodeled areas of the river. Extrapolation entails quantifying habitat, stratifying (grouping) habitats that are homogeneous, and forecasting habitat response to discharge through computer simulation. The integration of these three extrapolation components will allow the evaluation of the effects of with-project flows on aquatic habitats in the Middle River. This evaluation will be considered in the negotiation of a flow regime for the proposed Susitna Hydroelectric Project.

The focus of this report is on the stratification of aquatic habitats through habitat inventory and aerial photo interpretation procedures into groups that are hydrologically, hydraulically, and morphologically homogeneous. These analyses and procedures represent one component of the extrapolation methodology depicted in Figure 1.



Quantification

Quantify surface areas by habitat type in the Middle River for each flow for which aerial photography is available to determine the surface area response to mainstem discharge.

Stratification

Use available morphologic, hydraulic, and hydrologic information to stratify aquatic habitats into homogeneous groups.

Simulation

Simulate the response of aquatic habitat quality to discharge with habitat modeling techniques at selected areas of the Middle River.

Integration

For each target species/ life stage:

Integrate the quantification, stratification, and simulation components to determine the aquatic habitat response to discharge for the entire Middle River.

Figure 1. Flow chart for the extrapolation methodology.

2. INVESTIGATIVE FRAMEWORK

The investigative framework pursued in this paper is founded on the resolution of aquatic habitat into three components: (1) water (hydrologic); (2) potential energy (hydraulic); and (3) channel structure (Figure 2). Aquatic habitat was resolved in this manner to: (1) provide focus to the development of analytical procedures; (2) organize the data base into a manageable format; and (3) be consistent with the framework established in previous studies.

Primarily two data sources were used in the aquatic habitat characterization process: a habitat reconnaissance data base (based on field studies); and aerial photography. The investigators incorporated additional information from the Alaska Department of Fish and Game's (ADF&G) habitat modeling program, ADF&G fish utilization studies, and personal communications with ADF&G field personnel into their analyses.

Black and white aerial photography was available at Middle River discharges of 5100, 7400, 9000, 10600, 12500, 16000, 18000, 23000, and 26900 cubic feet per second (cfs), as measured at the U.S. Geological Survey (USGS) Gold Creek gaging station. The 23000 cfs photography represents average summer conditions and was used in this study as the "reference flow."

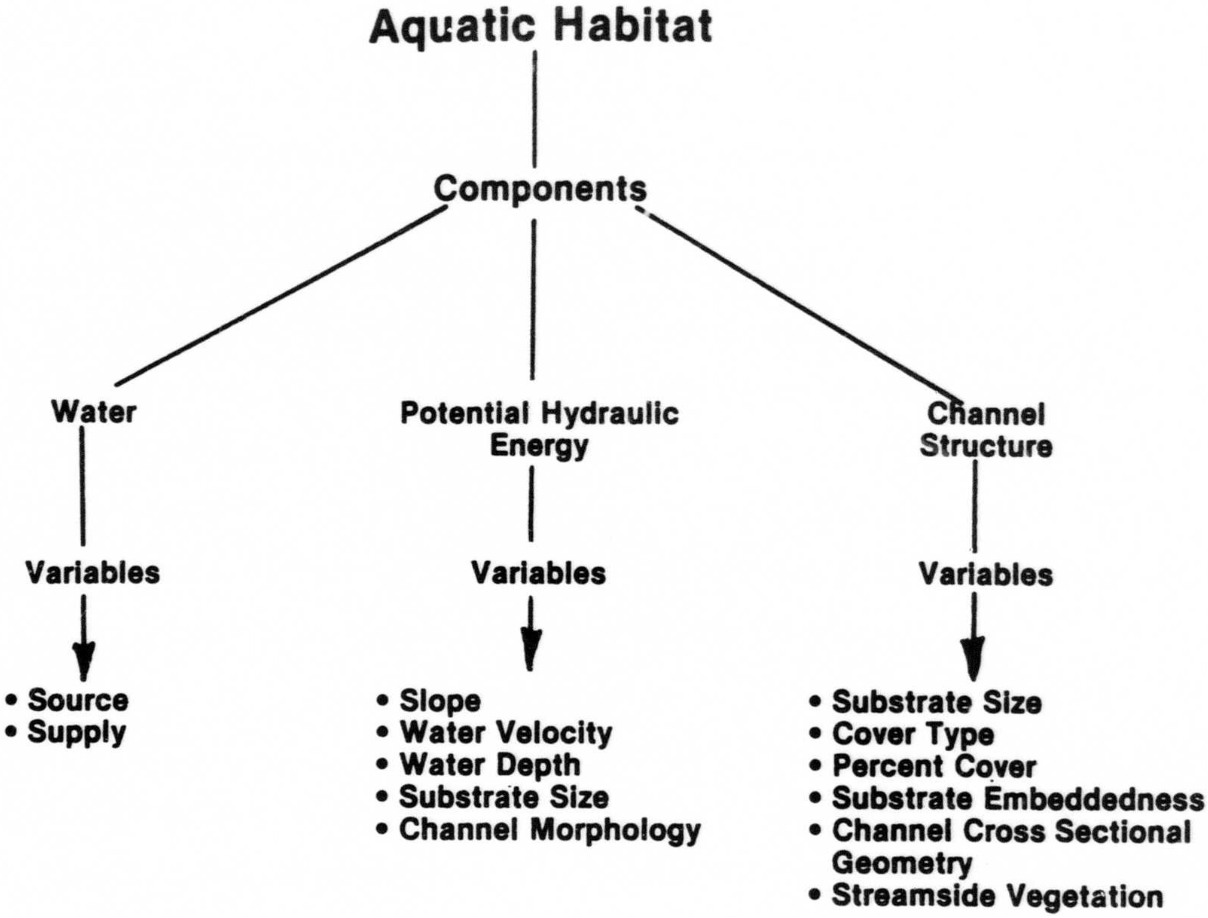


Figure 2. Schematic of aquatic habitat components and descriptive variables.

All wetted surface area at the reference flow which was not part of the main channel of the Middle River, or mainstem, was separated into specific areas. Side channels, side sloughs, and upland sloughs generally constituted a specific area. Occasionally a large side channel or slough was subdivided into two or more specific areas due to differences in habitat character. In addition to these nonmainstem habitats, some representative mainstem habitats were delineated as specific areas. Each specific area was referenced to a river mile (RM) and the side of the river it is on looking upstream: left (L), right (R), or middle (M) if between two mainstem forks. A total of 172 specific areas were delineated and are shown in Appendix 1.

2.1 HYDROLOGIC COMPONENT

The suitability of a given specific area of the Middle River as aquatic habitat is largely dependent on the quantity and quality of water supplied to the site. This hydrologic component of aquatic habitat was evaluated for each specific area using up to five indices.

Klinger and Trihey (1984) delineated and quantified six habitat types in the Middle River from black and white aerial photos taken when Middle River discharges at Gold Creek were 9000, 12500, 16000, and 23000 cfs. Water source and morphology were the principal variables used to discriminate between habitat types. Descriptions of each habitat type are as follows:

> Mainstem habitats are those channels of the river that convey more than approximately 10 percent of the total flow at a given site. During the open water season these channels are characterized by turbidity from glacial meltwater.

Side channel habitats are those channels of the river that convey less than approximately 10 percent of the total flow. During the open water season these channels are characterized by turbidity from glacial meltwater.

Side slough habitats contain clear water. Local surface water runoff and upwelling groundwater are the primary sources that supply these habitats. Side sloughs have nonvegetated upper thalwegs that are overtopped during periods of moderate to high mainstem discharge. Once overtopped, side sloughs are considered side channels.

Upland sloughs are clearwater habitats that depend upon upwelling groundwater and/or local runoff for their water scurces. Upland sloughs have vegetated upper thalwegs that are seldom overtopped by mainstem discharge.

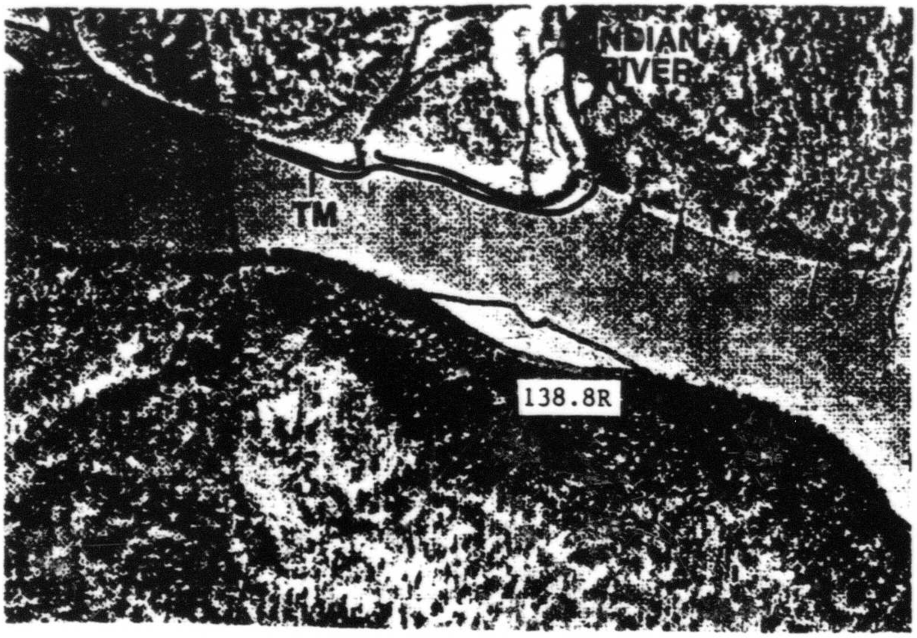
Tributary mouths are clearwater habitats at the confluences of tributaries, where clearwater mixes with turbid water. In the summer these habitats are readily apparent as clearwater plumes that extend into the turbid glacial flow of the mainstem or a side channel. The size of the plume is a function of tributary discharge and mainstem stage. Tributary mouth habitats can also occur in the tributary channel as a result of mainstem stage causing a backwater at the tributary mouth. If a backwater occurs, tributary mouth habitat extends into the tributary channel to the upstream extent of the backwater.

Tributary habitats are clearwater reaches of tributary streams upstream of the tributary mouth habitats.

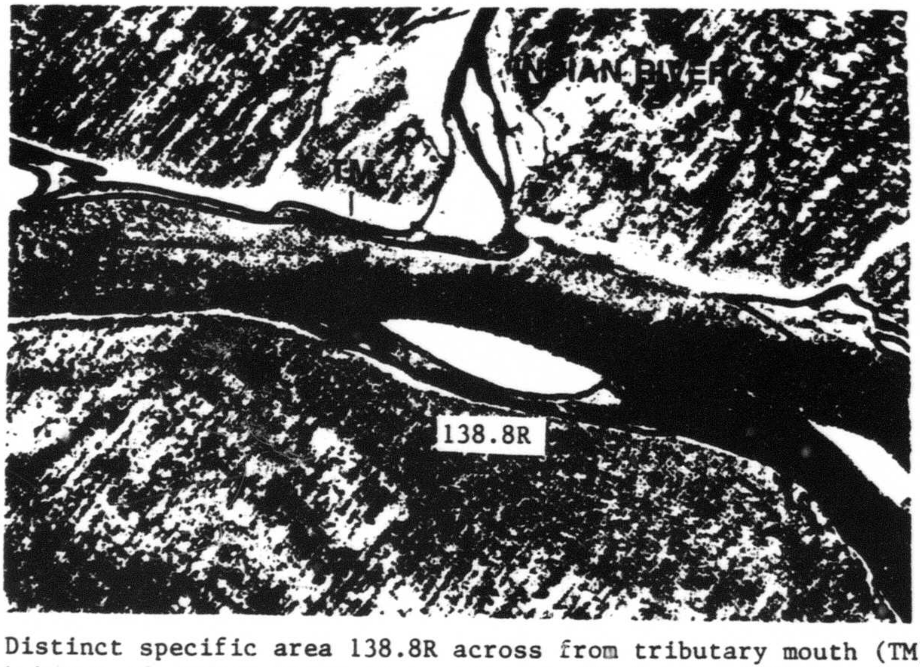
Subhabitat types were required by this study to be consistent with the resolution provided by aerial photography and are as follows:

Indistinct mainstem habitats occur at the margins of some mainstem channels. In the 23000 cfs photography they appear to be an integral part of a mainstem habitat. In photographs taken at lower flows, however, they are distinct channels separated from the mainstem by gravel bars or are shallow expanses (shoals) at the margins of a mainstem channel (Figure 3).

Indistinct side channel habitats occur at the margins of some mainstem and side channels. In the 23000 cfs photography they appear to be an integral part of a mainstem or side channel habitat. In photographs taken at lower flows, however, they are distinct channels separated from the mainstem or main side channel by gravel bars or are shallow expanses (shoals) at the margins of the mainstem or side channel.



Indistinct specific area 138.8R across from tributary mouth (TM) habitat of Indian River at a mainstem discharge of 23000 cfs



Distinct specific area 138.8R across from tributary mouth (TM) habitat of Indian River at a mainstem discharge of 23000 cfs

Figure 3. An indistinct side channel that becomes a distinct side channel with decreasing mainstem discharge.

2.1.1 HABITAT TRANSFORMATION TRACKING

Habitat type may change at an individual site as mainstem stage fluctuates. The most common habitat transformation occurs when a side channel becomes a side slough as mainstem stage recedes to a level that prevents the flow of turbid mainstem water through the side channel entrance. Another common transformation, with less obvious changes in habitat quality, occurs when mainstem habitat becomes side channel habitat as a result of decreasing mainstem stage. These habitat transformations are significant because they demonstrate the direct relationship between habitat type and quality and mainstem discharge. The development of a methodology to monitor habitat transformations in reference to discharge is thus a prerequisite to the assessment of the response of aquatic habitat quality to mainstem flow.

Habitat transformations resulting from lowered mainstem flow are of particular interest to this study since the proposed hydroelectric facility would result in substantially decreased flows during the summer. It was assumed that the distribution of aquatic habitat within the Middle River is constant for any given mainstem discharge. This is a valid assumption since the river has undergone very little change between 1949 and 1980 (AEIDC, 1984). Field observations also support this assumption. Thus, examination of aerial photographs in a decreasing order of mainstem discharge is indicative of how aquatic habitat responds to a steady decrease in discharge.

Aerial photography of the Middle River for mainstem discharges of 5100, 7400, 9000, 10600, 12500, 16000, 18000, and 23000 cfs were used in the analysis. Habitat transformations at each specific area were monitored between any two flows through photo comparison.

Eleven habitat transformation categories define the types of habitat transformation that a specific area might undergo as mainstem discharge declines (Table 1). These categories provide a useful means to systematically evaluate the hydrologic component of aquatic habitats as mainstem discharge decreases from the reference flow of 23000 cfs through each evaluation flow down to 5100 cfs. The total number of specific areas within each transformation category at each evaluation flow reflects the general trend of the response of aquatic habitat to mainstem flow.

Individual specific areas can be characterized by the sequence of habitat transformations that occur as mainstem discharge decreases from 23000 cfs to 5100 cfs. The importance of the category sequence in describing and classifying aquatic habitat is most pronounced for sites that are strongly influenced by the hydrologic component, as compared to the hydraulic and structural components. For example, upland slough habitats are strongly influenced by their relative isolation from a mainstem water supply (hence, by their hydrologic component) and could likely be discriminated from other habitat types by their category sequence alone (an unchanging Category I). Procedures for sequentially monitoring habitat transformations between the 23000 cfs photography and the photography at lower discharges are discussed in Appendix 2.

Table 1. Description of Habitat Transformation Categories*

Category 0	Tributary mouth habitats that persist as tributary mouth habitat at a lower flow.
Category 1	Upland slough and side slough habitats that persist as the same habitat type at a lower flow.
Category 2	Side channel habitats that transform to side slough habitats at a lower flow and possess upwelling which appears to persist throughout winter.
Category 3	Side channel habitats that transform to side slough habitats at a lower flow but do not appear to possess upwelling that persists throughout winter.
Category 4	Side channel habitats that persist as side channel habitats at a lower flow.
Category 5	Indistinct mainstem or side channel areas that transform into distinct side channels at a lower flow.
Category 6	Indistinct mainstem or side channel habitats that persist as indistinct areas at a lower flow.
Category 7	Indistinct mainstem or side channel areas that transform to side slough habitats at a lower flow and possess upwelling that appears to persist throughout winter.
Category 8	Indistinct mainstem or side channel habitats that transform to side slough habitats at a lower flow but do not appear to possess upwelling which persists throughout winter.
Category 9	Any water course that is wetted that dewaters or consists of isolated pools without habitat value at a lower flow.
Category 10	Mainstem habitats that persist as mainstem habitat at a lower flow.

*Habitats were based on a reference flow of 23000 cfs.

2.1.2 BREACHING FLOW

Breaching flow is defined as the mainstem discharge at which the water surface elevation in the main channel is sufficiently high to overtop the head berm of a peripheral channel and thus allow mainstem water to flow through the area. The frequency of flow events in a specific area is a product of the sites breaching flow and the frequency of flows in the mainstem. Not all specific areas have readily identifiable breaching flows, and some areas are breached gradually over a range of mainstem flows. For example, the overtopping of mainstem and side channel shoals is frequently a subtle process; water laterally inundates these areas with increasing stage. Water seldom overtops heads of upland sloughs because of their elevation relative to the mainstem. Mainstem channels are always breached. The procedure used to determine breaching flows is included in Appendix 2.

2.1.3 CROSS SECTIONAL GEOMETRY OF SIDE CHANNEL HEAD BERMS

Just as breaching flow is a descriptor of flow frequency in a specific area, the cross sectional geometry of the channel at the head berm determines flow magnitude at the site. Breaching flow and channel geometry might thus be considered an index of what would normally be termed climatic and basin characteristics in conventional basin hydrology. The analogue to a responsive, so-called "flashy", drainage basin would be a side channel with a broad, relatively gentle-sloped head berm. Such a channel would turn "on" and "off" much more suddenly than a channel with a relatively narrow and incised cross sectional geometry. This is due to the much greater increase in cross sectional area at the entrance with the same increase in mainstem stage. Increases in channel flow are directly proportional to increases in cross sectional area. The response of site flow to mainstem discharge is reflected in the corresponding response of the top width of wetted surface area at the channel entrance. Procedures for studying the cross-sectional geometry of channel head berms using the aerial photography are described in Appendix 2.

2.1.4 CROSS SECTIONAL GEOMETRY OF MAINSTEM

A regional analysis of cross sectional geometry in the mainstem was performed in conjunction with the site-specific analysis of channel geometry. The rate of change in mainstem water surface elevation to an incremental increase in discharge varies between subsegments. A subsegment of the mainstem that is constricted will have a steeper stage/discharge relationship than a less confined subsegment. The effect on side channels adjacent to constricted areas is an increased responsiveness of site flows to incremental changes in mainstem discharge. The opposite is true for side channels associated with subsegments where the mainstem stage/discharge relationship is flatter. A description of this analysis appears in Appendix 2.

2.1.5 EVALUATION OF UPWELLING

The presence of an upwelling groundwater source that persists through winter is the most important habitat variable influencing the selection of spawning areas by chum salmon (Oncorhynchus keta) (Estes and Vincent-Lang 1984). Upwelling also has a positive influence on the success of overwintering juvenile chinook salmon (O. tshawytscha) and on egg-to-fry survival for chum salmon (Vining et al. 1985). A description of the procedures used to identify the presence of upwelling at a specific area appears in Appendix 2.

2.2 HYDRAULIC COMPONENT

The hydrologic component of an aquatic habitat may indicate favorable conditions for fish when in fact the site's suitability for fish is limited by hydraulic conditions, such as high velocities. The energy-related environmental variables that describe the hydraulic component were evaluated primarily through field observations. Statistical analyses to correlate the variables that make up the plan form, or physical layout of a site were also performed. These analyses were limited to 70 of the 172 specific areas and the results serve as supporting evidence to results obtained from field observations.

In an open channel, gravity provides the energy to move water and sediments downstream. Slope is the conventional index of the rate of this potential energy expenditure. Because of the large number of side channels, it was impractical to determine the slope of each channel by differential leveling; therefore, three indices of hydraulic energy were used in characterizing specific areas: (1) estimated and measured mean reach velocity; (2) dominant bed material size; and (3) channel morphology.

2.2.1 MEAN REACH VELOCITY

Mean reach velocity offers the best estimate of channel slope and has the additional advantage of being a significant index of habitat quality. The weakness of mean reach velocities as an index of slope is their flow dependence. A comparison of mean reach velocities of several individual channels is meaningful only if the relationship between mean reach velocity, site specific discharge, and mainstem discharge is understood. Generally it is necessary to collect mean reach velocity data at several mainstem and site specific discharges to adequately describe this relationship. However, site specific breaching flow defines the highest mainstem flow in which site specific discharge and mean reach velocity have a magnitude of approximately zero. Breaching flows can thus be used to normalize mean reach velocity values with respect to mainstem discharge and provide a basis for comparing velocities of specific areas that have different breaching flows. This does not account for all the variability in velocity between specific areas caused by factors other than differences in channel bed slope, but it accounts for the variability in velocity at a given mainstem discharge attributed to differences in breaching flow between specific areas. Other variables, such as differences in channel bed roughness (n, dimensionless) and hydraulic radius (R, in feet), affect the relationship between velocity (V, in feet per second (fps)) and channel bed slope (S, in feet per feet). Channel bed roughness is an empirical energy loss coefficient and the hydraulic radius is a function of stage and channel cross sectional geometry, although for wide channels it is effectively dependent on depth of flow. Mannings' Equation relates the variables as follows:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

Although mean reach velocity alone is an unsatisfactory index of the hydraulic energy potential at each individual channel, velocities used in conjunction with corroborating evidence, such as substrate size and channel morphology, reveal much about channel hydraulics.

2.2.2 SUBSTRATE SIZE

Substrate, or bed material size, is also related to channel slope as can be deduced from tractive force theory (Chow 1959).

$$T = WRS$$

where T = tractive force, pounds per square foot (psf)
W = unit weight of water, pounds per cubic foot (pcf)

Tractive force is the force that water exerts on the channel bed. It can be thought of as a scour force. The threshold size of bed material that can be moved is directly proportional to T. Bed material sizes larger than the threshold size associated with a typical high flow event would theoretically make up the substrate.

The elevation, configuration, and orientation of head berms strongly affect the composition and size range of sediments delivered by mainstem flow into side channel areas. Local geology and alluvial deposits also influence the substrate composition of side channel beds. Smaller suspended sediments, skimmed from the upper portion of the mainstem water column, tend to dominate the sediment load entering side channels.

Despite these considerations, characteristic bed material size can be useful in the assessment of available energy in individual channels. It appears that the sediment in large side channel and mainstem rearing habitats of the Middle River is limited by available sediment and not by the capacity to transport sediment (Williams 1985). Large substrate would therefore suggest a steep channel gradient. Accumulation of fines in side channels and side sloughs is indicative of a mild (or low energy) channel slope.

2.2.3 CHANNEL MORPHOLOGY

Channel morphology is the least direct index of instream hydraulics that was considered in the analysis. The rationale for its use is that the form of a river is a function of river processes. River reaches undergoing similar processes would thus be expected to display similar form. There is little precedent in the literature concerning the relations between conventional morphological indices of river form, such as sinuosity or radius of curvature, and site-specific characteristics of individual side channels in a split channel or braided river such as the Susitna. Nonetheless, careful inspection of aerial photography reveals considerable evidence of repetitive form throughout the Middle River.

Specific areas may be grouped through statistical analyses that focus on correlating the morphologic variables that make up the areas plan form (such as channel length, channel width, and channel sinuosity). Statistics may also be applied to identify the variable that most strongly defines each group. Descriptions of the analyses and procedures for each of the aspects of the hydraulic component are discussed in Appendix 2.

2.3 STRUCTURAL COMPONENT

In the extrapolation methodology, aquatic habitat quality indices will be extrapolated from modeled specific areas to nonmodeled specific areas that they represent (i.e., same homogeneous group). Site-specific hydrologic and hydraulic indices are a rational approach to defining representativeness in terms of instream hydraulics. However, this concept of representativeness ignores the variation in aquatic habitat quality that results from differences in nonhydraulic attributes between specific areas. For this reason, it is necessary to incorporate the structural component. This was accomplished through structural habitat indices (SHI).

Six variables were used in the development of a structural habitat index for each specific area: (1) dominant cover type; (2) percent cover; (3) dominant substrate size; (4) substrate embeddedness; (5) channel cross sectional geometry; and (6) streambank vegetation. These variables were characterized for each specific area with data from the habitat reconnaissance surveys and aerial photography, as detailed in Appendix 2. The formula for synthesizing each of these variables into a single value (i.e., SHI) is also detailed in Appendix 2.

3. FUNCTION OF ANALYSES IN EXTRAPOLATION

In a cooperative program to study the relationship between mainstem discharge and the quality and quantity of fish habitat, ADF&G and EWT&A selected 35 sites in the Middle River to represent a spectrum of aquatic habitats. An extensive data collection program provided the basis for developing computer models to describe habitat response to mainstem discharge at each of these sites. Three modeling techniques were used: (1) the Instream Flow Group's[1] (IFG) habitat model (Milhous et al. 1984); (2) a habitat model (RJHAB) developed by ADF&G (Schmidt et al. 1984); and (3) a direct input variation of the IFG habitat model developed by EWT&A. Tributary habitats were not evaluated because they would not be affected by an altered mainstem flow regime. Tributary mouth habitats are more a function of hydraulic mixing phenomena than open channel hydraulics, and the modeling techniques are not well-suited to these habitats.

Inherent in each of the habitat models is a hydraulic model used to describe site-specific depth and velocity distributions. There are approximately 150 unique side channel areas in the Middle River. The development of a hydraulic model for each of these channels was impractical and the cost, prohibitive. The investigators used less data-intensive indices of channel hydraulics to characterize nonmodeled sites to provide a basis for discriminating homogeneous river subsegments that could be represented with a modeled site for extrapolation.

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[1] Now known as the Instream Flow and Aquatic Systems Group.

In the application of the IFG's instream flow incremental methodology (IFIM) to a single channel river, aquatic habitat response to discharge functions are routinely extrapolated from representative reaches to river subsegments that have been discriminated on the basis of their hydrologic, hydraulic, and morphologic homogeneity. The identification of homogeneous river subsegments in a split channel or braided river as large as the Susitna is considerably more complex.

3.1 CONCEPT OF REPRESENTATIVE GROUPS

Anadromous salmonids are the principal study species in the Susitna River. Their utilization of aquatic habitats is concentrated in side channels, sloughs, tributary mouths, and tributaries (Schmidt et al. 1984). Homogeneous subsegments should be differentiated to provide the resolution and focus necessary to develop aquatic habitat descriptions that are consistent with the utilization patterns of targeted study species.

Klinger and Trihey (1984), in their study of aquatic habitat response to mainstem discharge in the Middle River, noted that the spatial distribution of side channel and side slough habitats was strongly influenced by discharge. The dependence of habitat types on discharge, coupled with their sporadic location throughout the Middle River, effectively precludes the identification of continuous homogeneous subsegments, as is the convention in the study of single channel river systems. A homogeneous subsegment of the Middle River will be, instead, a composite of discontinuous specific areas that were judged to be hydrologically and hydraulically similar (Figure 4). In the context of this report, such a composite subsegment is termed a <u>representative group</u>.

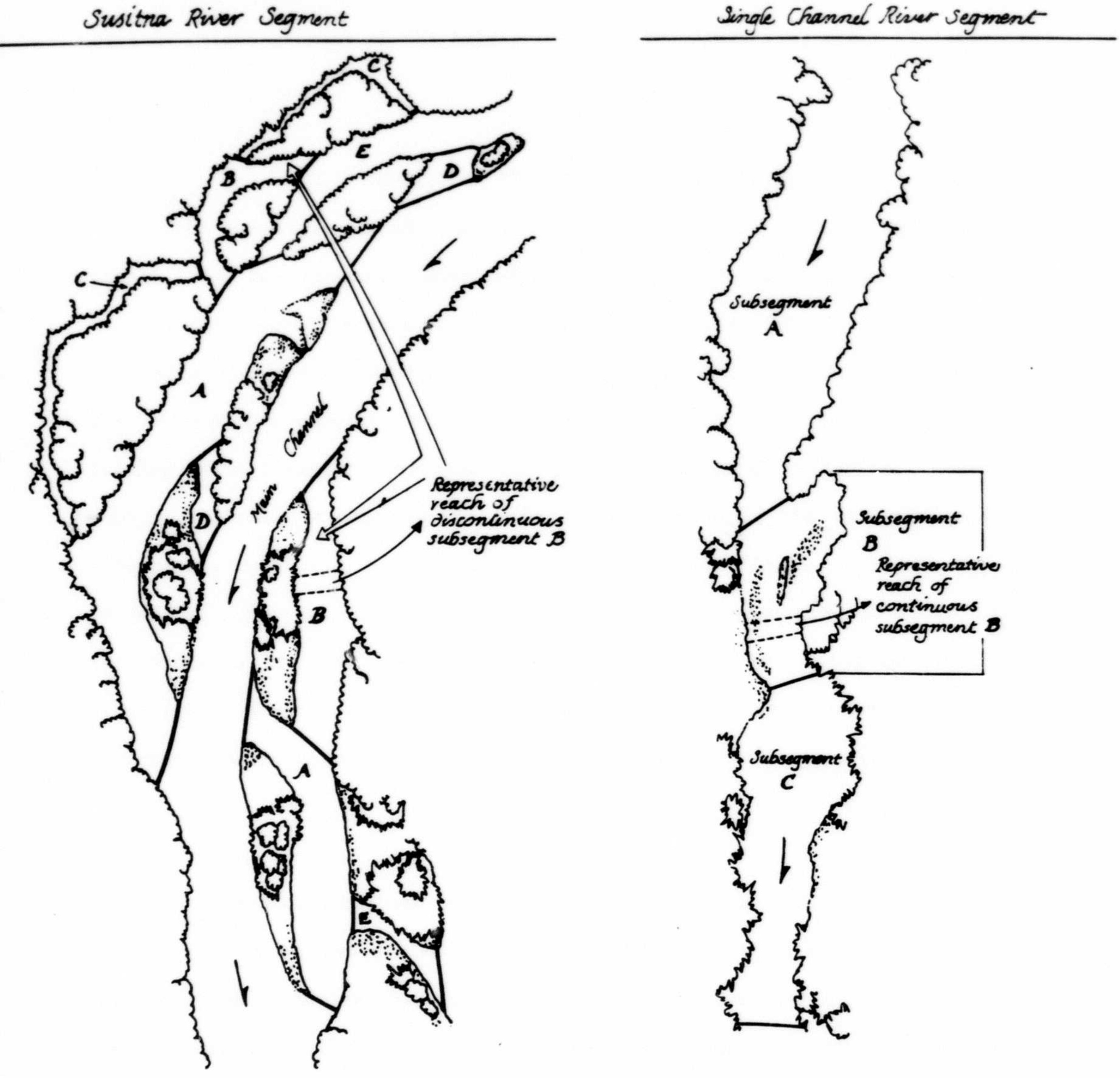


Figure 4. Examples of continuous and discontinuous subsegments.

The development of representative groups appears as the fifth step in the stratification pathway of the extrapolation methodology flow chart depicted in Figure 5.

3.2 CONCEPT OF STRUCTURAL HABITAT INDICES

The basic premises behind the concept of structural habitat indices are simple. If two channels have comparable hydraulics and different habitat values, then the difference in habitat value must be attributed to differences in channel structure. Outwardly, this is a simplistic conclusion which does not address the possible effects of differences in water quality, nutrient loading, site location, and numerous other environmental variables. However, when a judicious evaluation is made between sites within the same stream subsegment, many of these variables can be considered constant or of secondary, perhaps minor, importance. This reasoning provides the justification for many habitat improvement projects which utilize instream structures. Structural habitat index values are used as relative indices of structural habitat quality for specific areas within the same representative group.

In the extrapolation methodology, weighted useable area (WUA) versus discharge functions will be synthesized for nonmodeled specific areas using the WUA function from a modeled specific area(s) within the same representative group. The investigators will adjust the WUA curves for nonmodeled sites in two ways. Laterally shifting the WUA curve either right or left will normalize the curve on the basis of breaching flow (Figure 6). To account for differences in structural habitat quality, the ordinates of the WUA curve are multiplied by the ratio of nonmodeled to modeled specific area SHIs (Figure 7). In this manner, synthetic WUA versus discharge curves can be developed for each nonmodeled specific area within each representative group.

Stratification Pathway of the Extrapolation Methodology

Stratification Pathway

- Identify habitat types important to study species.
- Delineate specific areas of homogeneous aquatic habitat type on aerial photo plates.
- Conduct reconnaissance-level survey of aquatic habitat at each specific area.
- Analyze aerial photography and habitat reconnaissance data base to describe hydrologic, hydraulic, and structural components of each specific area.
- Stratify specific areas into Representative Groups using available hydrologic and hydraulic information.
- Develop Structural Habitat Indices for each specific area including modeled sites using the habitat reconnaissance data base.

↓

Quantification Pathway ↘

Integration

↙ **Simulation Pathway**

The following steps are completed for each target species/life stage.

- Use the weighted usable area (WUA) versus discharge curves of a modeled specific area to synthesize the WUA versus discharge curve for a nonmodeled specific area within the same Representative Group. Shift the curve laterally to compensate for differences in breaching flow between a modeled and nonmodeled specific area. Adjust the WUA curve vertically using the ratio of structural habitat indices to account for differences in structural habitat quality between modeled and nonmodeled specific areas.
- Calculate the amount of habitat present within each specific area using surface area and habitat quality indices for each mainstem evaluation flow.
- Sum the amount of habitat estimated for all specific areas within each Representative Group for each mainstem evaluation flow.
- Sum the amount of habitat estimated for all Representative Groups for each mainstem evaluation flow to forecast Middle River habitat response to flow variations.

Figure 5. Flow chart for the stratification pathway of the extrapolation methodology

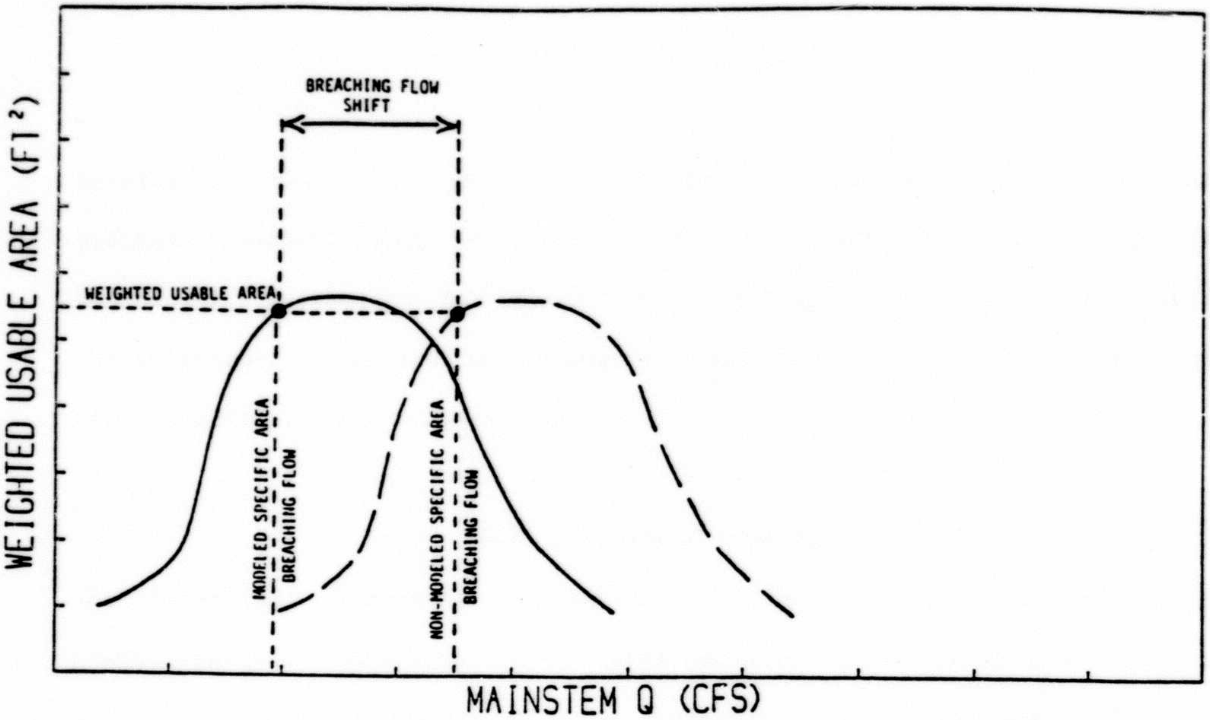


Figure 6. Lateral shift of weighted usable area (WUA) curve of a modeled specific area to synthesize the WUA curve of a nonmodeled specific area that has a different breaching flow.

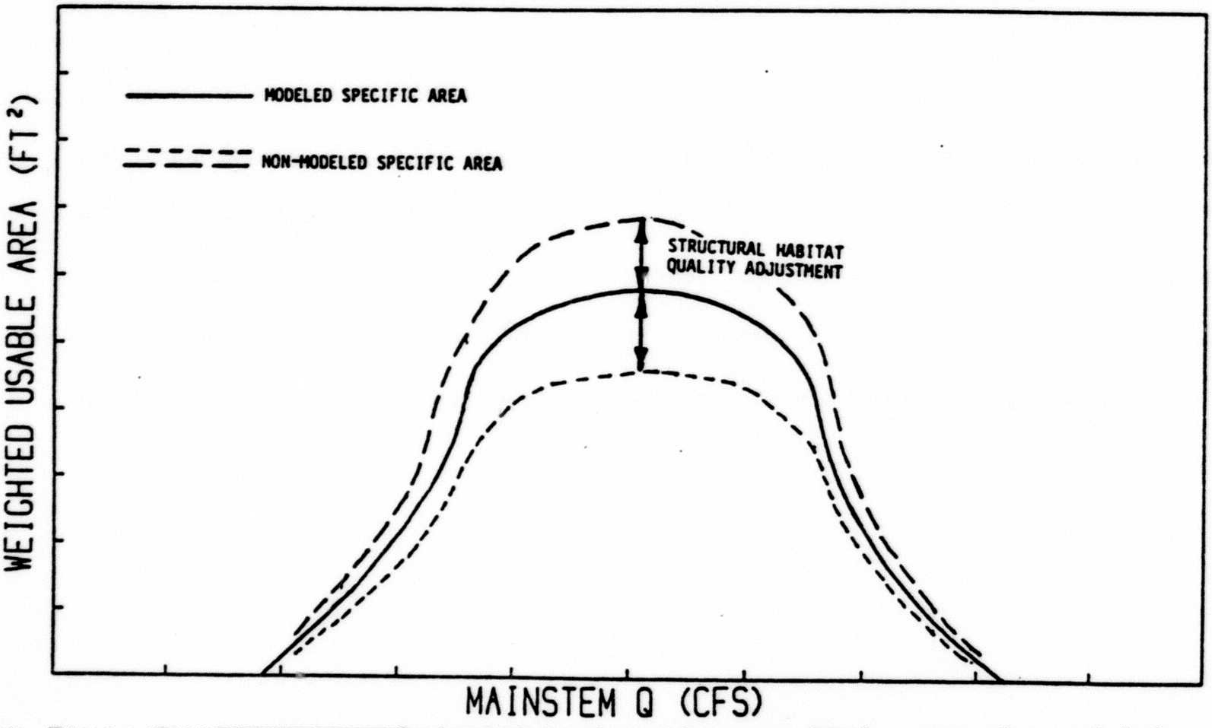


Figure 7. Adjustment of the weighted usable area (WUA) curve of a modeled specific area being used to synthesize the WUA curve of a nonmodeled specific area to account for differences in structural habitat quality between the two specific areas.

4. RESULTS AND DISCUSSION

Results and discussion pertaining to the characterization of each aquatic habitat component will be presented in the order of their development: hydrologic, hydraulic, and structural. The application of these habitat characterizations in the development of representative groups and structural habitat indices will follow.

4.1 HYDROLOGIC COMPONENT

The hydrologic component of aquatic habitat is described by habitat transformations, breaching flows, cross sectional geometry of the head berm, cross sectional geometry of the mainstem, and upwelling. Of these descriptors, habitat transformations, breaching flows, and upwelling were the most useful for characterizing aquatic habitat. The usefulness of the cross sectional geometry indices was limited by the lack of available information.

4.1.1 HABITAT TRANSFORMATION TRACKING

The methodology for tracking habitat transformations between 23000 cfs and 9000 cfs is depicted in the flow chart of Figure 8. It should be noted that the criteria can be applied between any two mainstem flows. However, for consistent evaluation, the 23000 cfs photography was used as the reference for monitoring transformations apparent in lower flow aerial photography.

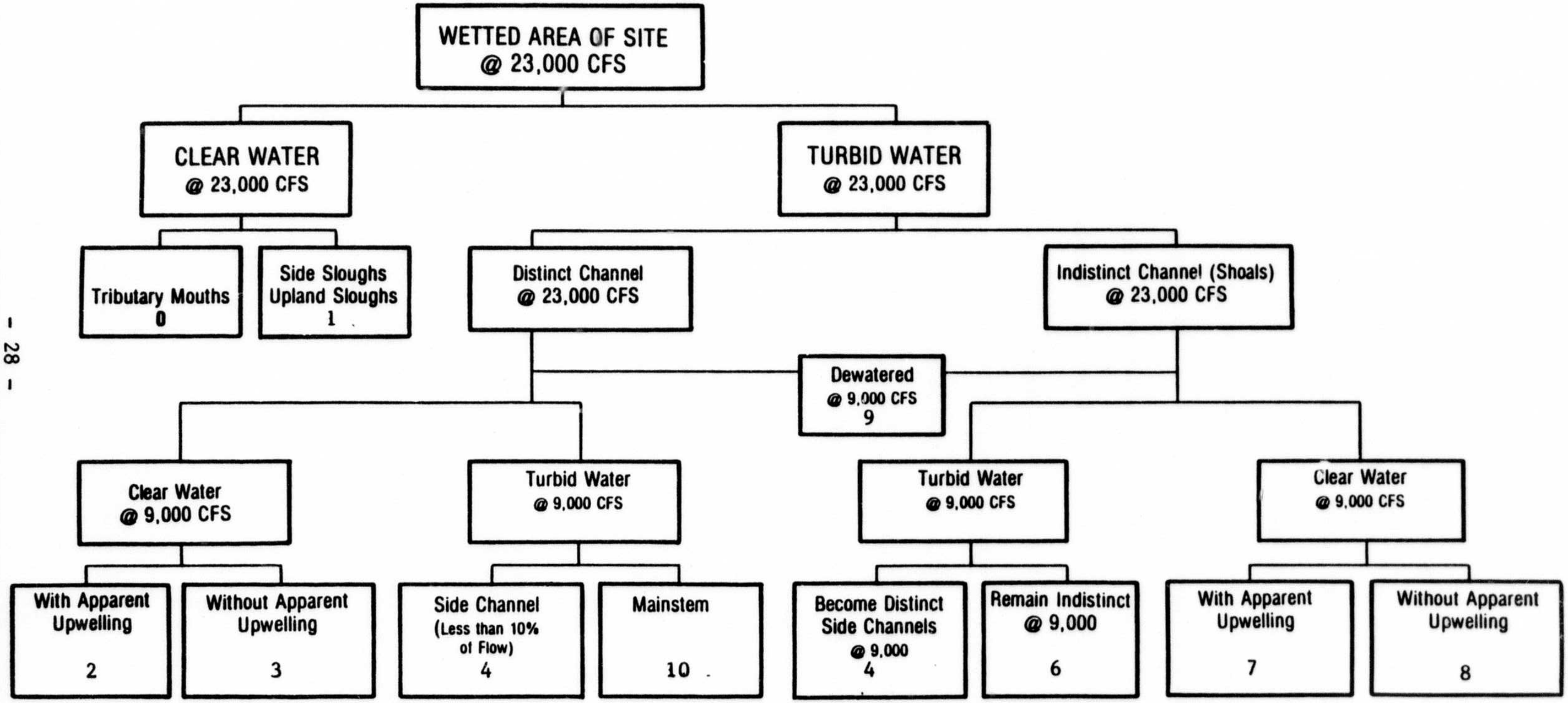


Figure 8. Flow chart for classifying the transformation of aquatic habitat types between two flows (Categories 0-10).

The results from the habitat transformation monitoring methodology appear in Appendix 3 where habitat transformation categories for each specific area between the reference flow of 23000 cfs and all lower flow aerial photography are listed. From the results, the number of specific areas in each habitat transformation category was determined for each evaluation flow. Table 2 and Figure 9 illustrate how the quality and quantity of riverine habitats in the Middle River change significantly as mainstem discharge decreases. The number of persistent clearwater habitats (Category 1) is relatively stable throughout the flow range. There is a substantial increase in number of side channels that transform to sloughs as mainstem discharge decreases (Category 2) and a corresponding decrease in number of persistent side channels (Category 4). As can be expected, the numbers of persistent indistinct areas (Category 6) and persistent mainstem areas (Category 10) also decrease. The number of areas that dewater (Category 9) showed the most dramatic change, with a fivefold increase between the highest and lowest flows. The numbers of areas described by the remaining categories (Categories 3, 5, 7, and 8) fluctuate somewhat over the flow range considered, but collectively account for only 10 to 20 percent of the 172 specific areas evaluated.

Table 2. Number of specific areas in each habitat transformation category by evaluation mainstem flow, referenced to 23000 cfs.

Evaluation Mainstem Q(cfs)

	18000	16000	12500	10600	9000	7400	5100
Category	Number of Specific Areas						
1	33	32	31	31	31	30	30
2	12	15	20	25	28	31	31
3	6	6	8	8	11	10	13
4	51	47	41	36	27	25	25
5	5	6	8	11	13	11	11
6	33	32	28	22	18	18	15
7	3	3	3	3	3	4	5
8	3	3	5	7	8	5	4
9	6	8	13	14	20	27	30
10	20	20	15	15	13	11	8

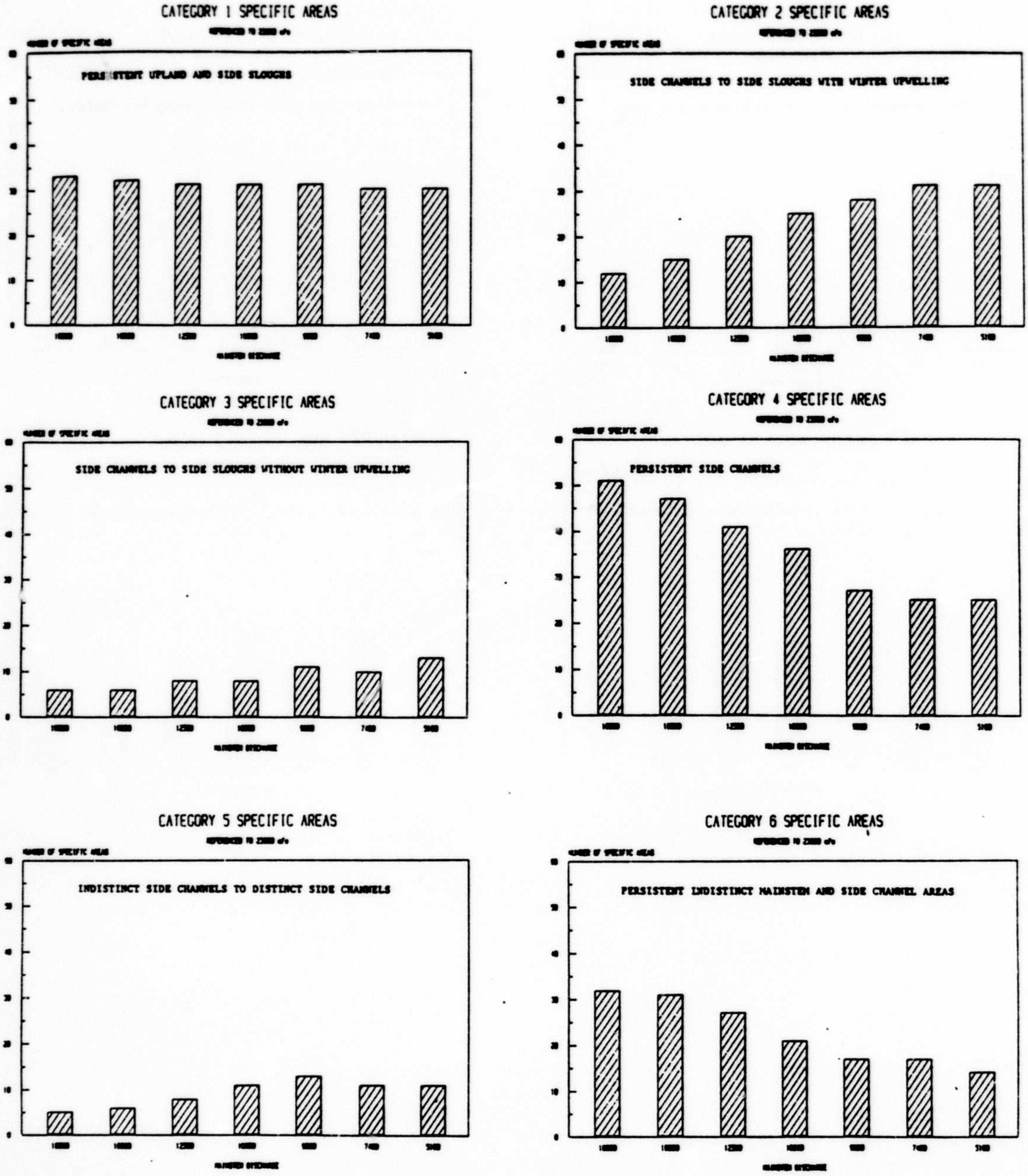


Figure 9. Number of specific areas in each habitat transformation category at various mainstem flows.

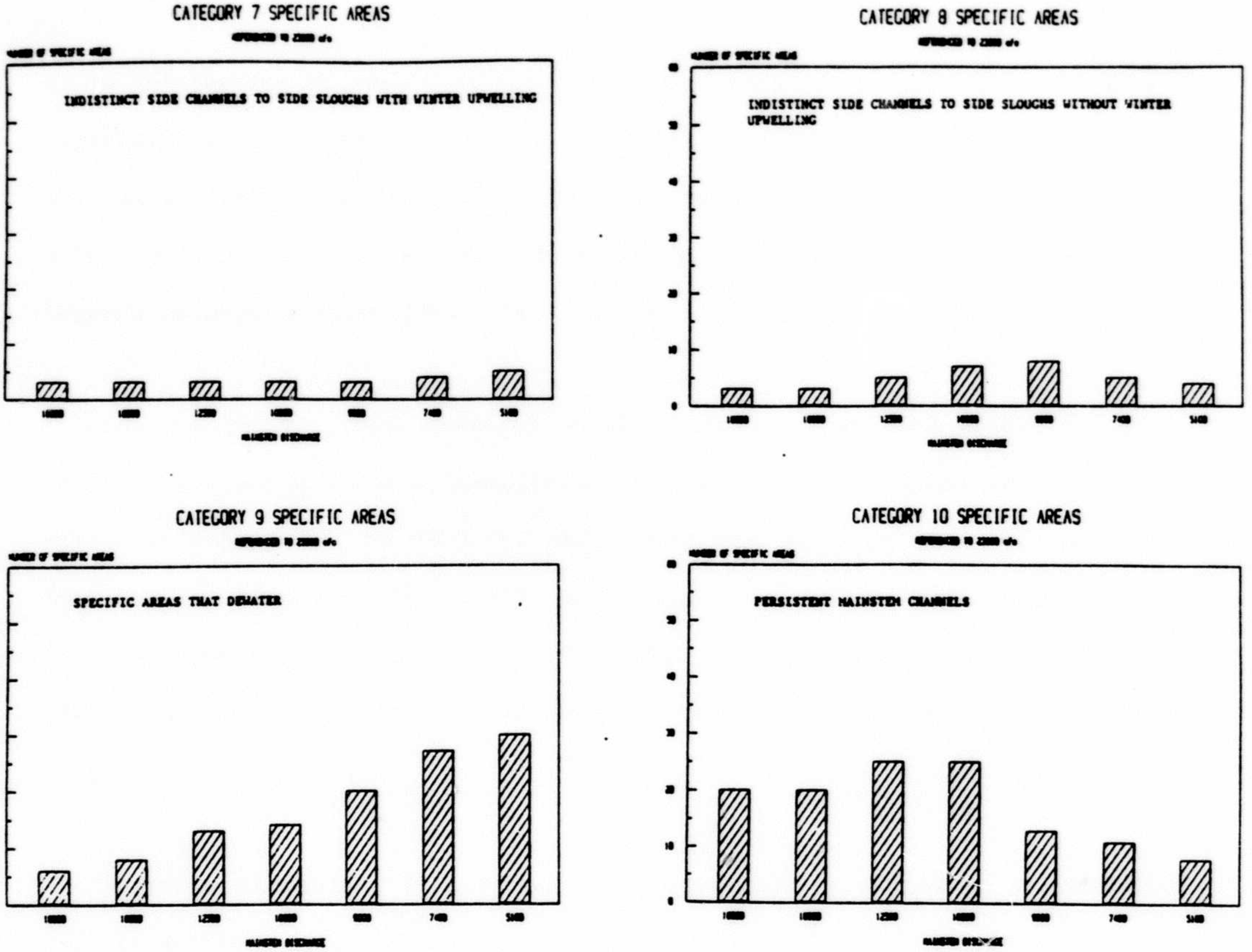


Figure 9. (cont'd)

It is interesting to note that the number of dewatered specific areas remains relatively stable between mainstem discharges of 12500 and 10600 cfs (13 and 14, respectively), but then almost doubles with a reduction in discharge to 7400 cfs (27). An accelerated change in overall riverine habitat character appears to occur between 10600 and 7400 cfs.

Klinger and Trihey (1984) observed similar trends. They used wetted surface area as an index of habitat quantity and determined that as mainstem discharge decreases from 23000 to 9000 cfs that there was an associated decrease in mainstem habitat (from 3737 to 2399 acres) and side channel habitat (from 1241 to 762 acres) and an increase in side slough habitat (from 53 to 156 acres). The wetted surface area of upland slough habitat was relatively stable within this flow range.

The sequence of habitat transformation categories that occurs at a specific area as mainstem stage decreases from 23000 to 5100 cfs is the dominant index of site specific habitat response to mainstem discharge. This sequence provides a concise reference of habitat type and process that is useful in the evaluation of representative groups.

4.1.2 BREACHING FLOW

In addition to habitat transformation sequence, breaching flow is useful in describing and classifying specific areas. It is the hydrologic focal point of gross habitat transformations and also identifies the relative position of specific area habitats in the hydrologic spectrum between mainstem and upland slough (Figure 10).

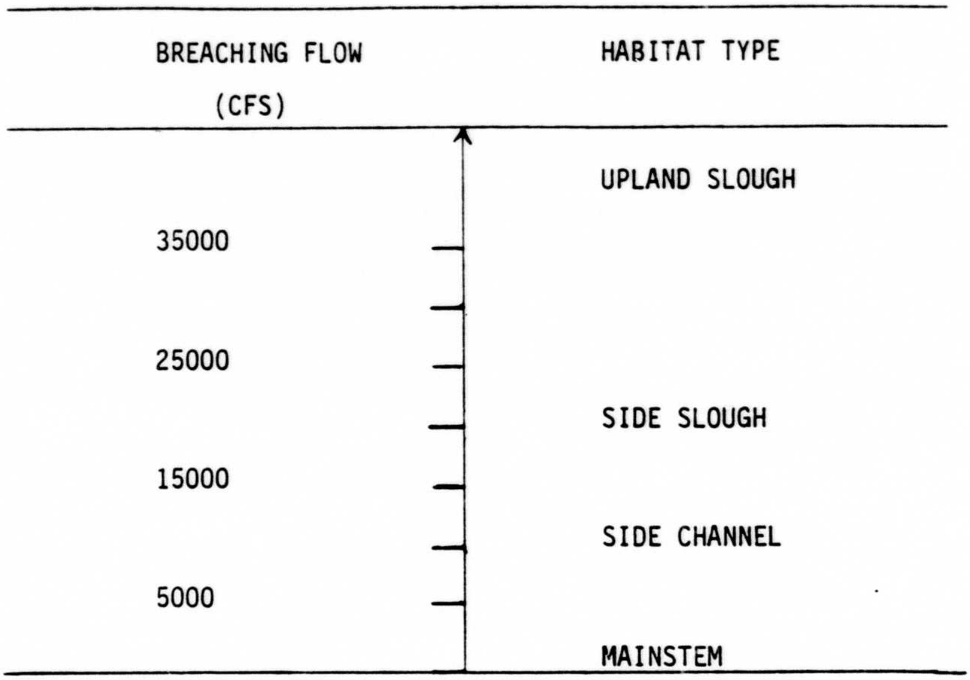


Figure 10. General relationship between breaching flow and habitat type in the Talkeetna to Devil Canyon segment of the Susitna River.

Breaching flows were determined with considerable confidence within the flow range for which aerial photography was available (5100 to 26900 cfs). Field observations were used to verify and refine approximations that were based on aerial photo interpretation. Above 26900 cfs, ADF&G field observations were the primary source of breaching flow estimates. It was generally not possible to refine breaching flow estimates for specific areas breached significantly below 5100 cfs because of the lack of available information. Specific areas that appeared to be "barely breached" in the 5100 cfs photography were assigned a breaching flow just under 5100 cfs. Breaching flows for each specific area are listed in Appendix 4.

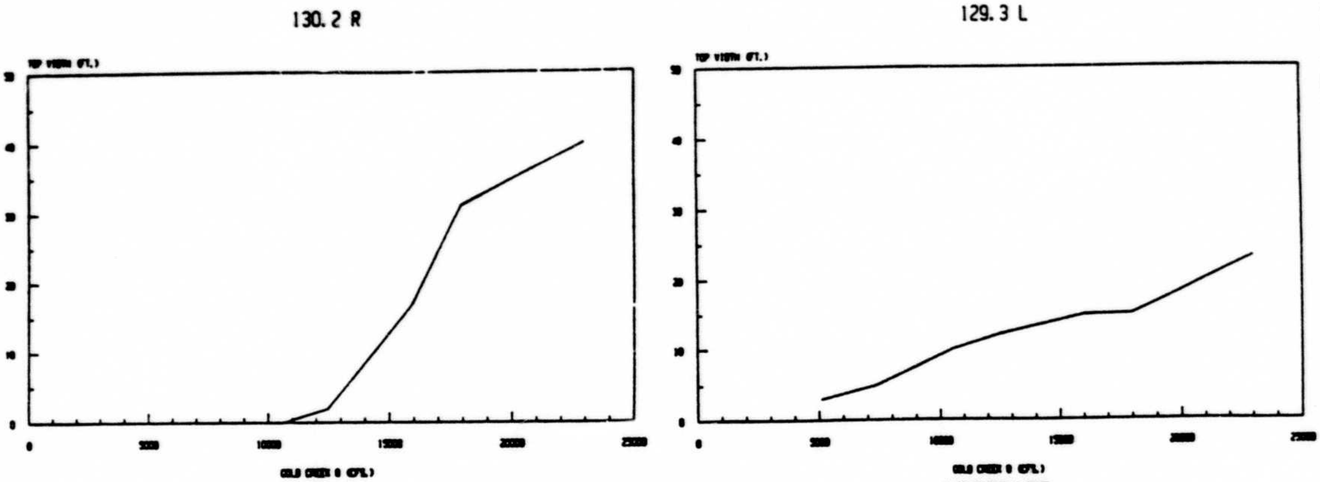
4.1.3 CROSS SECTIONAL GEOMETRY OF SIDE CHANNEL HEAD BERMS

Plots of wetted top width at the head berm versus mainstem discharge were developed for 46 specific area channels that had low breaching flows and readily identifiable head berms. These were classified by curve slope into four categories: (1) steep; (2) moderate; (3) flat; and (4) irregular (Figure 11). The interpretation of each category of curve slope is as follows:

(1) steep slopes are indicative of broad channel sections with relatively gentle-sloped sides at the head berm;

(2) moderate slopes are indicative of channels with a cross-sectional geometry at the head berm that is flat on one side and steep on the other;

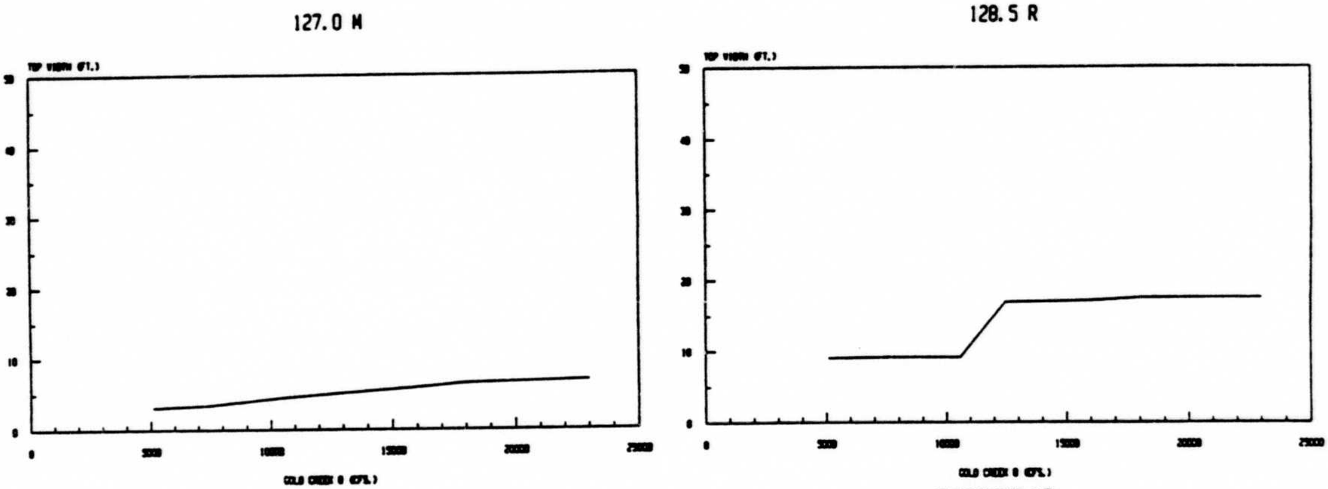
(3) flat slopes are indicative of channels with relatively narrow and incised cross-sectional geometry at the head berm; and


130.2 R

129.3 L

STEEP

MODERATE


127.0 M

128.5 R

FLAT

IRREGULAR

Figure 11. Representative wetted top width versus discharge plats for each category of curve slope.

(4) irregular or stepped curves are indicative of channels with irregular cross-sectional geometry at the head berm.

The significance of the cross sectional geometry at the head berm of channels in classifying aquatic habitat can be summarized best by examining the hypothetical flow apportionment to two parallel channels with comparable breaching flows, but different cross-sectional geometry (Figure 12). Note that for the same increase in stage at the head berm, a channel that is broad with gentle-sloping sides will receive more flow than a channel with a relatively narrow cross sectional geometry. The wetted surface area of the broad channel will likewise be greater than that for the narrow channel, and will increase at a faster rate per incremental increase in stage. In short, the broad channel will provide more, but less stable, aquatic habitat per unit of mainstem stage than will the narrow channel. In a hydrologic sense, the broad channel would be termed responsive or perhaps, "flashy." A listing of the curve slope classes for the 46 specific areas evaluated in the Middle River appears in Table 3.

The study of the cross sectional geometry at side channel head berms was of lesser value for the characterization of the hydrologic component of specific area habitats than either habitat transformation categories or breaching flows. Three factors limited the value of head berm cross sectional geometry to this study: (1) only specific areas that were distinct side channels could be studied; (2) only specific areas that had discernible head berms could be studied; and (3) only specific areas with relatively low breaching flows could be studied.

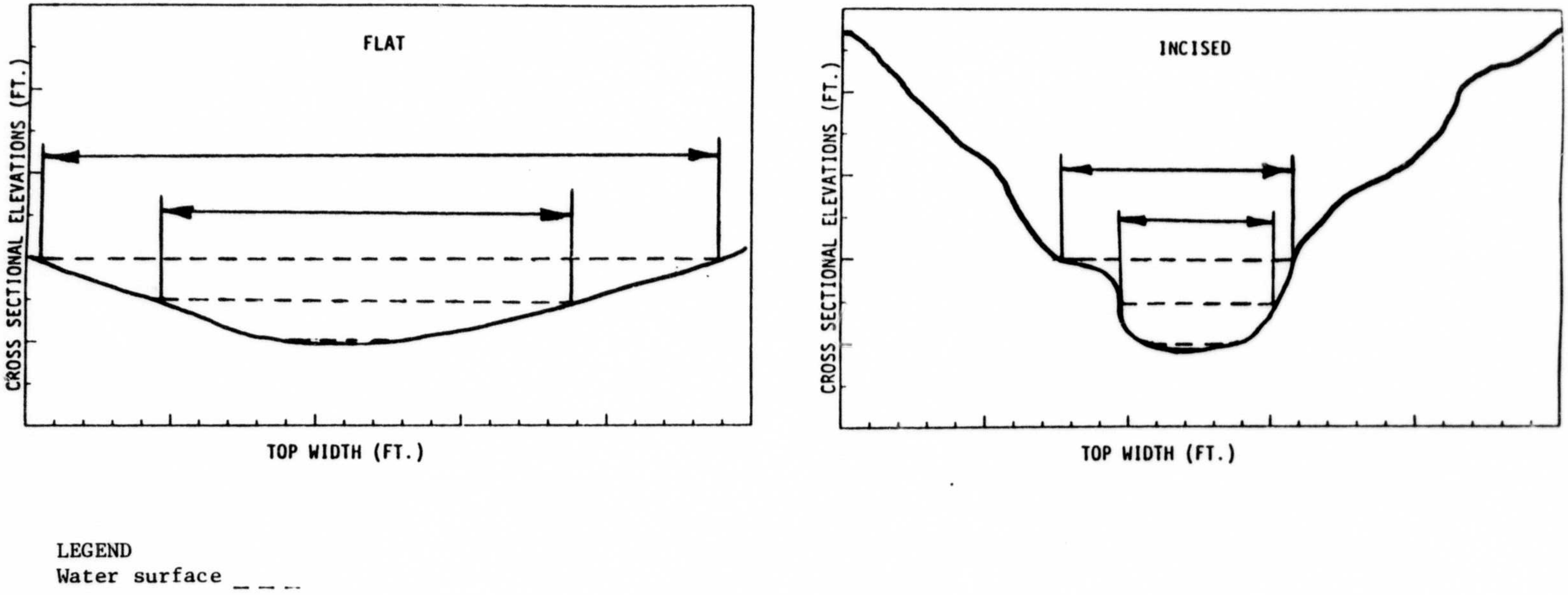


Figure 12. Cross sectional geometry at the head berm of two channels having the same breaching flow. Note how differences in cross sectional geometry affects the rate of wetted surface area development for a comparable increase in mainstem stage.

Table 3. Curve slope classes of plots of wetted top width versus discharge from measurements made at channel head berms at 46 specific areas in the Talkeetna to Devil Canyon segment of the Susitna River.

Specific Area	Curve Slope Class	Specific Area	Curve Slope Class
100.6L	3	123.0L	3
100.7R	2	124.1L	3
101.2R	2	125.2R	3
101.5L	2	125.6L	2
102.6L	4	127.0M	3
105.7R	4	127.1M	4
106.3R	4	127.4L	2
108.7L	3	128.5R	4
108.9L	2	129.3L	2
109.4M	3	130.2R	1
110.8M	3	130.2L	3
111.0R	3	131.7L	4
111.5R	3	132.6L	3
112.6L	1	134.9R	3
114.0R	3	135.0L	3
115.0R	1	136.0L	3
116.8R	4	137.2R	1
117.7L	3	138.0L	1
117.8L	2	138.8R	1
119.2R	2	139.4L	4
119.6L	3	139.6L	3
121.1L	2	144.2L	3
121.7R	3	145.3R	2

Curve slope classes: 1 = steep, 2 = moderate, 3 = flat, 4 = irregular

4.1.4 CROSS SECTIONAL GEOMETRY OF MAINSTEM

The increase in mainstem stage due to an increase in mainstem discharge varies between mainstem subsegments of the Middle River (Table 4). The responsiveness of mainstem stage to discharge in a subsegment has a direct influence on the hydrologic regimen of adjacent side channels. In subsegments where mainstem stage is relatively responsive to changing discharge, the volume of flow entering adjacent side channels will be relatively unstable. The opposite is true in subsegments where mainstem stage responds less dynamically to changing discharge. From the information in Table 4, it would be expected that side channel habitats within the continuous subsegment from river miles 131 to 137 would have less stable flow regimes than other channels in the Middle River. The use of mainstem stage dynamics as an index to characterize aquatic habitat is most useful when considered in conjunction with site specific indices of flow frequency and magnitude (i.e., breaching flow and cross sectional geometry of the head berm). However, the limitations of the data set describing cross sectional geometry of head berms precludes the use of regional mainstem geometry as a good index of site character for the specific areas delineated in the Middle River.

Characteristic mainstem stage fluctuations may prove useful in subsequent analyses; especially in the interpretation of weighted usable area curves. For example, a steep and laterally compressed weighted usable area curve could be explained by the relatively large response of mainstem stage to discharge at a mainstem subsegment.

Table 4. Stage increase at selected cross sections in the Talkeetna to Devil Canyon segment of the Susitna River as mainstem discharge increases from 9700 to 23400 cfs.

Cross Section No.	River Mile	Stage Increase (Ft.)
7	101.5	1.9
11	106.7	2.6
25	121.6	2.2
29	126.1	2.0
36	131.2	3.5
44	136.4	3.3
49	138.2	2.8
54	140.8	2.7
55	141.5	2.4

Source: R&M Consultants 1982

4.1.5 EVALUATION OF UPWELLING

Table 5 lists the specific areas that the investigators determined possess upwelling. Of 59 specific areas that had open leads in the winter photography, 40 (68%) were observed to have chum salmon spawning activity.

There was also a strong correlation between the presence of chum salmon spawners and those specific areas where upwelling was observed in the field but did not necessarily have open leads in the winter photography. Of these 85 sites, 48 (56%) were observed to have chum salmon spawning activity.

More indicative of the importance of upwelling to chum salmon spawners is the percentage of specific areas where spawning activity was observed that also had upwelling. Of the 53 specific areas where spawning activity was observed, 48 (91%) were observed to have upwelling. ADF&G maps of chum salmon spawning areas were thus used to corroborate upwelling. A summary of fish observations appears as Appendix 5.

Although there is considerable confidence that specific areas identified as possessing winter upwelling actually do, it is also probable that other riverine areas do as well. It is possible that the thermal quality of upwelling that occurs in relatively deep or swift and turbulent currents will become sufficiently diffused by mixing to preclude the formation of a thermal lead in the winter ice cover.

Table 5. Summary of the specific areas that possess upwelling in the Talkeetna to Devil Canyon segment of the Susitna River.

Specific Areas with Upwelling					
River Mile	Open Leads	Spawning* Activity	River Mile	Open Leads	Spawning* Activity
100.60R	X	X	129.40R	X	X
100.60L			130.20R	X	X
101.20R	X	X	130.20L		X
101.40L	X	X	131.30L	X	X
101.60L	X	X	131.70L		X
101.71L	X		131.80L		X
101.80L	X	X	132.60L		
102.20L	X	X	132.80R	X	X
107.60L			133.70R	X	X
110.40L	X		133.80L	X	
111.60R			133.90R	X	X
112.50L	X		133.90L	X	X
112.60L			134.00L	X	
113.70R	X	X	134.90R		X
115.00R	X	X	135.10R		
115.60R	X	X	135.30L		
116.30R			135.60R	X	X
117.80L	X		135.70R	X	
117.90L	X	X	136.30R	X	X
118.00L			136.90R	X	
118.60M			137.20R	X	X
118.91L	X	X	137.50R	X	
119.11L	X	X	137.50L		
119.30L	X	X	137.80L	X	
119.70L	X		137.90L	X	
120.00R	X	X	138.00L	X	
121.10L		X	138.71L		
122.40R	X	X	139.00L	X	X
122.50R	X	X	139.01L		X
123.20R			139.50R	X	
123.60R	X	X	139.70R	X	
124.00M	X		139.90R	X	X
125.10R	X		140.20R	X	X
125.90R	X	X	140.60R		X
126.00R	X	X	141.40R	X	X
126.30R	X	X	141.60R	X	X
127.00L			142.10R	X	X
127.20M	X		143.00L	X	X
127.40L			143.40L		X
128.50R	X		144.20L		
128.70R	X	X	144.40L	X	X
128.80R	X	X	145.60R		
129.30L					

*Spawning activity observed as indicated by the presence of redds or spawning behavior.

4.2 HYDRAULIC COMPONENT

Analysis of the hydraulic component of specific area habitats was focused on estimated or measured mean reach velocity during breached conditions, substrate size, and channel morphology. Of these three variables, mean reach velocity was the best and most direct index of channel hydraulics for use in the characterization of habitat.

4.2.1 MEAN REACH VELOCITY

The side channels of the Middle River constitute a complex flow delivery system with individual side channels beginning to flow at various mainstem discharges according to their breaching flows. A comparison of mean reach velocities between side channels for any given mainstem stage would yield a range of values depending on whether the channels were nonbreached, barely breached, or flowing vigorously. Mean reach velocity is thus a stage-dependent variable whose use as a comparative index of side channel hydraulics is complicated by a dependence on breaching flow.

Mean reach velocities were measured or estimated in this study at mainstem discharges ranging from approximately 8000 to 11000 cfs. In a few cases, estimates were made at 18000 cfs. Because of the relatively low flows that were coincident with the field trips, most channels where velocities were measured had relatively low breaching flows. This reduced the need to consider the variability of breaching flows between channels in the interpretation of mean reach velocity data. Although it is possible to normalize mean reach velocity measurements at different side channels on the basis of breaching flow, it was not considered necessary in this study. Mean reach velocities are presented in Tables 8-17.

Two factors restricted the value of mean reach velocities for use in the comparative evaluation of specific area hydraulics: (1) an incomplete data set; and (2) the stage dependence of velocity. It was not possible to obtain mean reach velocities during breached conditions for each specific area because channels were sometimes nonbreached coincident with the habitat reconnaissance field work. Most channels contained insufficient flow during nonbreached conditions to be useful in the characterization of channel hydraulics. Mean reach velocities were obtained during breached conditions for 61 of the 172 specific areas delineated in the Middle River.

The velocity data collected was useful in describing the hydraulic characteristics of each habitat transformation category. The following generalizations are provided to develop a qualitative appreciation of the trends depicted in Figure 9.

Category 0 - Tributary mouth habitat. These habitats exist as clear water plumes at the confluence of tributaries to the Middle River. This category has not been directly addressed within the extrapolation methodology because of the comparatively small amount of surface area associated with this habitat type.

Category 1 - Upland slough and side slough habitats that do not transform within the flow range of interest. These areas offer low velocities, frequently near-zero, with the greatest hydraulic disparity being depth.

Category 2 - Side slough habitats that have transformed from side channel habitats and which possess winter upwelling. These areas, nonbreached by definition, are typified as a series of clearwater pools connected by short shallow riffles. Riffle velocities are frequently less than 1 fps and 0.5 feet or less in depth. Pool velocities are near zero and depths are generally less than 3 feet.

Category 3 - Side slough habitats that have transformed from side channel habitats. Distinguished from Category 2 areas only by the lack of an upwelling groundwater source that persists throughout winter. The hydraulic characterization remains the same as for Category 2.

Category 4 - Side channel habitat that persists as side channel habitat through the flow range of interest. These areas, breached by definition, display greater hydraulic diversity than the previous categories. Velocities range from approximately 2-5 fps (10000 cfs mainstem) between specific areas.

Category 5 - Side channel habitat that has transformed from indistinct channels (Category 6). Distinguished from Category 4 areas primarily by the presence of one gravel-bar bank which becomes inundated at high mainstem discharges causing the channel to appear less visible (indistinct) in the aerial photography. These channels typically have higher velocities, often greater than 5 fps (10000 cfs mainstem), than Category 4 channels.

Category 6 - Indistinct areas that remain indistinct through the flow range of interest. This category includes those riverine areas termed shoals. By definition, they are breached, shallow water areas, typically marginal to a mainstem channel. Depths are generally under 4 feet and velocities reduced compared to mean mainstem velocities as a result of channel edge effects.

Category 7 - Side slough habitats that have transformed from turbid indistinct channels and which possess winter upwelling. These areas are distinguished from Category 2 areas primarily by their origin from indistinct rather than distinct channels. The hydraulic characterization remains the same as for Category 2.

Category 8 - Side slough habitats that have transformed from turbid indistinct areas. These areas are distinguished from Category 3 areas primarily by their origin from indistinct rather than distinct channels. The hydraulic characterization remains the same as for Category 3.

Category 9 - Specific areas that become dewatered. This is a terminal category that requires no hydraulic characterization. These areas may contain isolated pools that, by definition, have no habitat value.

Category 10 - Mainstem habitats that do not transform within the flow range of interest. These channels are typically deeper and swifter than any other habitat category. Mean velocities are frequently 5 fps (10000 cfs mainstem) or greater.

4.2.2 SUBSTRATE SIZE

In the evaluation of substrate size, dominant substrate codes were used. Frequently more than one code was selected because of the evenly balanced mixture of fine and coarse substrate size classes present at many specific areas. Sands were distributed throughout the Middle River segment, and were considered to be less indicative of specific area hydraulics. For this reason, when more than one dominant substrate size code was selected, the coarser size class was used as the index of channel hydraulics.

A shortcoming of using codes to characterize substrate size is the subjective nature of the determination. The use of two-person crews in a consensus arrangement likely eliminated much of the potential for individual bias. Dominant substrate sizes are presented in Tables 8-17.

Substrate size was a less valuable index of channel hydraulics than mean reach velocity. Although it was evident during the habitat reconnaissance work that mainstem channels had recognizably coarser substrate and swifter velocities than other habitats, it was more difficult to generalize substrate size and the hydraulic characteristics of side channels. Substrate size in side channels is less directly correlated with channel slope and more strongly influenced by factors relating to sediment supply. These factors are likely channel head berm geometry, channel orientation to the mainstem, and influences from localized sediment sources.

4.2.3 CHANNEL MORPHOLOGY

Channel morphology was the most indirect index of specific area hydraulics used to characterize habitat. During the course of the habitat reconnaissance field work, considerable evidence of repetitive form was observed throughout the Middle River. Sometimes a distinct plan form was recognized from the air in transit to a specific area. Other times a distinctive riffle/pool pattern was recognized while on the ground. Similarities between specific areas were recorded on the habitat inventory data form for future consideration in the development of representative groups. Careful inspection of aerial photography also revealed similarities in plan form between individual side channels.

R&M Consultants divided the Middle River into six discrete continuous subsegments based on characteristic mainstem channel pattern (Table 6). Dividing the mainstem in this manner provides the basis for evaluating long term trends in main channel morphology. More applicable to the study of juvenile salmon habitat, which is concentrated in the peripheral areas of the river, is the identification of side channel complexes. Complexes are systems of adjacent, often interconnected, side channels which convey mainstem water. Major side channel complexes of the Middle River are listed in Table 7 and are easily discernible in the aerial photography in Appendix 1.

Channels within a complex are sometimes hydraulically, hydrologically, and morphologically similar since they are influenced by the same mainstem conditions, such as slope, stage response to discharge, and sediment load. However, more than one habitat type is generally represented in a complex. Furthermore, each habitat type is sporadically represented in different side channel complexes throughout the Middle River.

Table 6. Definition of subsegments within the Talkeetna to Devil Canyon segment of the Susitna River.

River Mile	Average Slope	Description
RM 149 to 144	0.00195	Single channel confined by valley walls. Frequent bedrock control points.
RM 144 to 139	0.00260	Split channel confined by valley walls and terraces.
RM 139 to 129.5	0.00210	Split channel confined occasionally by terraces and valley walls. Main channels, side channels sloughs occupy valley bottom.
RM 129.5 to 119	0.00173	Split channel with occasional tendency to braid. Main channel frequently flows against west valley wall. Subchannels and sloughs occupy east flood plain.
RM 119 to 104	0.00153	Single channel frequently incised and occasional islands.
RM 104 to 95	0.00147	Transition from split channel to braided. Occasionally bounded by terraces. Braided through the confluence with Chulitna and Talkeetna Rivers.

Source: R&M Consultants 1982.

Table 7. Major side channel complexes of the Talkeetna to Devil Canyon segment of the Susitna River.

Reference Name	Location (RM)
Whiskers Creek	100-102
Bushrod Slough	117-118
Oxbow II	119-120
Slough 8B	121-123
Skull Creek	125-126
Fourth of July	131-132
Slough 21	141-142

A statistical approach was taken to study the similarities between side channel areas in the Middle River based on plan form. Through a cluster analysis of several side channel variables, including length, width, length to width ratio, channel sinuosity, and the number of bends, six distinct cluster groupings were identified. The findings corroborated subjective evaluations of morphologic similarities between side channels.

A discriminant function multivariate analysis was performed using the six cluster groupings to determine the relative importance of variables in defining morphologic groups. The length to width ratio was the most important variable, and channel width was second, followed by channel length. A limitation of the multivariate analysis was that it could be applied only for distinct side channels where it was possible to evaluate each of the previously mentioned variables. This limited the analysis to 70 cases (specific areas).

4.3 STRUCTURAL COMPONENT

Characterization of the structural component of aquatic habitats was focused primarily on six variables: (1) dominant cover code; (2) percent cover; (3) channel geometry; (4) dominant substrate size; (5) substrate embeddedness; and (6) streambank vegetation. Although the field evaluation of each of these variables relied on subjective judgements of field personnel, it is believed that the consensus arrangement provided by two-person crews limited individual bias. On-site photographs provided a vehicle for review and verification or adjustment of field evaluations.

The integration of the above six variables into a composite index of structural habitat quality is represented by structural habitat indices (SHI). In the formulation of structural habitat indices, it is necessary to rank and weigh the relative importance of each variable to juvenile salmonid habitat quality. There is little information in the literature pertaining to ranking or weighting schemes of habitat variables. Hynes (1970) notes that it is generally recognized that temperature, water quality, water depth and velocity, cover or shelter, and streambed material are the most important physical variables affecting the amount or quality of riverine fish habitat. Two of these variables, cover and streambed material, were directly included in the formulation of structural habitat indices.

The identification of the appropriate variables for describing structural habitat was considerably easier than the assignment of weighting factors of relative importance. The criterion that was used in the establishment of weighting factors was that resulting structural habitat indices must corroborate subjective habitat quality evaluations recorded on habitat inventory field forms. This was satisfied by the following weighting scheme for the respective variable/variable combinations: (1) dominant cover/percent cover (0.45); (2) channel morphology (0.30); (3) dominant substrate size/substrate embeddedness (0.20); and (4) streamside vegetation (0.05). Structural habitat indices for each specific area appear in Tables 8-17.

In viewing the range of SHI values within representative groups, two conclusions are apparent: (1) most specific areas have comparable SHI values; and (2) some specific areas are rated two or three times as valuable to juvenile salmonids for rearing as others. The first conclusion is explained as the result of similar river processes occurring within each representative group. The second conclusion is reasonable and reflects the importance of structure to overall juvenile salmonid habitat quality. Projects that utilize instream structures have demonstrated that cover for fish can mean the difference between fish utilizing an area or not (Claire 1978).

Although the basis for the SHIs was largely founded on subjective determinations, it is believed that the consensus arrangement used in subjective evaluations and the application of a common methodology significantly curtails individual bias and justifies their use as a relative index of structural habitat quality.

4.4 DEVELOPMENT OF REPRESENTATIVE GROUPS

Representative groups are composed of specific areas that are hydrologically, hydraulically, and morphologically similar. Variables that were considered in the development of representative groups are as follows: habitat transformation category sequence, breaching flow, mean reach velocity, substrate size, and channel length to width ratio. Field notes provided core groupings of specific areas that were observed to be similar. Field experience coupled with professional judgement provided the balance of the matrix needed to discern representative groups.

Although information pertaining to each of the components of aquatic habitat character was considered in the development of representative groups, frequently one or two components dominated the distinction of a group. Of the ten representative groups developed, hydraulic and morphologic variables each provided the primary distinction in three groups, and hydrologic variables provided the primary distinction in four. Descriptions of each representative group appear in Tables 8-17.

Table 8. Representative Group I

Description: Habitat character is dominated by high breaching flow. This group includes all upland sloughs and Slough 11 (RM 135.6R). Specific area hydraulics are characterized by pooled clear water with velocities frequently near-zero and depths greater than 1 ft. Pooled areas are commonly connected by short riffles where velocities are less than 1 fps and depths are less than 0.5 ft.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean[1] Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
100.6R	US	1	0+	9	--	0.60	--
102.2L	US	1	0+	1	--	0.83	--
105.2R	US	1	1.0	1	--	0.64	--
107.6L	US	1	0+	2	--	0.44	RJHAB
108.3L	US	1	1.0	1	--	0.70	--
112.5L	US	1	0	1	--	0.68	RJHAB
119.4L	US	1-9	0	1	--	0.45	--
120.0R	US	1	0+	1	--	0.50	--
121.9R	US	1	<1.0	9	--	0.83	--
123.1R	US	1	0+	1	--	0.45	--
123.3R	US	1	0	2	--	0.67	--
127.2M	US	1	0+	2	--	0.58	--
129.4R	US	1	0+	1	--	0.44	--
133.9R	US	1	<1.0	7	--	0.50	--
133.9L	US	1	<0.5	9	--	0.67	--
134.0L	US	1	0+	1	--	0.99	--
135.6R	42000	1	0+	6	--	0.54	--
136.9R	US	1	0+	2	--	0.69	--
137.5L	US	1	<0.5	1	--	0.60	--
139.0L	US	1	0	2	--	0.45	--
139.9R	US	1	0+	1	--	0.74	--

[1] Mean reach velocities for nonbreached conditions

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = Data Not Available

Table 9. Representative Group II

Description: Habitat character is dominated by relatively high breaching flows and the presence of upwelling groundwater sources that persist throughout winter. This group includes the specific areas that are commonly called sloughs. These specific areas typically have relatively large channel length to width ratios.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
101.4L	22000	2	--	10	38.4	0.54	RJHAB
101.8L	22000	2	--	10	77.8	0.60	--
113.7R	24000	1	--	6	100.0	0.51	RJHAB
115.6R	22000	4-2	--	9	21.2	0.54	--
117.9L	19500	2	--	9	29.3	0.62	--
122.4R	25000	1	--	1	23.1	0.29	--
122.5R	20000	2	--	8	104.5	0.51	--
125.1R	20000	2	--	3	25.5	0.48	--
125.9R	26000	1	--	12	74.7	0.56	--
126.0R	33000	1	--	9	71.8	0.51	IFG
126.3R	26000	4-2	--	9	39.6	0.59	--
131.8L	26900	1	--	8	--	0.45	--
137.5R	22000	2	--	12	--	0.44	DIM
137.8L	20000	2	--	11	15.0	0.64	--
137.9L	21000	2	--	11	76.0	0.50	--
140.2R	26500	1	--	11	73.3	0.50	--
142.1R	23000	1	--	11	--	0.65	--
144.4L	21000	2	--	13	91.5	0.60	RJHAB

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = Data Not Available

Table 10. Representative Group III

Description: Habitat character is dominated by intermediate breaching flows and relatively broad channel sections. This group includes side channels which become nonbreached at intermediate mainstem discharge levels and transform into slough habitat at lower discharges. Breaching flows are typically lower than for Group II, upwelling is present, and the length to width ratios of the channels are generally less than ratios for Group II.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
100.4R	12500	4-2	--	8	22.5	0.51	--
101.2R	9200	4-2	--	8	8.1	0.56	IFG
101.6L	14000	4-2	--	10	14.8	0.61	--
101.7L	9600	4-3	--	10	10.5	0.46	--
110.4L	12000	4-2	--	11	37.6	0.67	--
115.0R	12000	4-2	--	10	15.3	0.55	DIM
119.3L	16000	4-2	--	10	25.8	0.56	--
128.5R	10400	4-2	--	8	--	0.48	--
128.7R	15000	4-2	--	6	20.8	0.49	--
128.8R	16000	4-2	--	3	39.1	0.34	IFG
130.2R	12000	4-2	--	9	15.9	0.64	DIM
130.2L	8200	4-3	--	11	33.5	0.60	--
132.6L	10500	4-3	--	10	65.2	0.49	IFG/ RJHAB
133.7R	11500	4-2	3.5	10	71.4	0.44	--
137.2R	10400	4-2	2.5	12	8.6	0.49	--
141.4R	11500	4-2	--	12	--	0.56	IFG

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 11. Representative Group IV

Description: Habitat character is dominated by low breaching flows and intermediate mean reach velocities. This group includes the specific areas that are commonly called side channels. These specific areas possess mean reach velocities ranging from 2-5 fps at a mainstem discharge of approximately 10000 cfs.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
100.7R	<5100	10-4	3.8	8	14.5	0.49	--
101.5L	<5100	10-4	3.0	12	12.7	0.45	IFG
108.7L	<5100	10-4	3.0	11	6.9	0.53	--
110.8M	<5100	4	3.5	6	5.9	0.48	--
111.5R	<5100	10-4	2.5	9	13.8	0.48	--
112.6L	<5100	4	3.0	10	10.0	0.60	IFG
114.0R	<5100	4	3.0	9	--	0.43	--
116.8R	<5100	10-4	4.5	9	10.6	0.48	--
119.5L	5000	4	2.5	8	20.9	0.54	--
119.6L	<5100	4	3.0	10	54.6	0.53	--
121.7R	<5100	10-4	4.0	8	24.7	0.48	--
124.1L	<5100	10-4	3.5	11	17.0	0.46	--
125.2R	<5100	4	4.5	10	37.8	0.61	DIM
127.0L	<5100	4	2.5	7	10.1	0.65	--
127.4L	<5100	10-4	4.0	9	36.4	0.46	--
129.5R	<5100	6-5	3.0	8	13.5	0.56	--
131.7L	5000	4	2.6	10	48.6	0.47	IFG
134.9R	<5100	4	4.0	8	22.3	0.56	IFG
136.0L	<5100	4	2.0	5	24.0	0.55	IFG
139.4L	<5100	4	2.0	8	3.6	0.61	--
139.6L	<5100	10-4	3.2	13	14.9	0.51	--
140.4R	<5100	6	3.0	10	7.7	0.48	--
144.0R	<5100	10-4	>5.0	11	15.1	0.53	--
145.3R	<5100	10-4	4.5	12	11.8	0.53	--

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 12. Representative Group V

Description: Habitat character is dominated by channel morphology. This group includes shoal areas which transform to slough or clearwater habitats as mainstem discharge decreases.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
101.71L	MSS	7-9	--	9	--	0.48	DIM
113.1R	26000	1	--	6	--	0.43	--
117.0M	15500	6-7-9	--	3	--	0.31	--
118.91L	MSS	6	--	9	--	0.48	DIM
121.8R	22000	3	--	2	20.9	0.27	--
123.2R	22000	8-9	--	3	--	0.26	--
124.0M	20000	7	--	6	--	0.51	--
132.8R	19500	7	--	8	36.0	0.57	--
139.01L	MSS	6	--	6	--	0.37	DIM
139.7R	22000	2	--	3	--	0.51	--
141.6R	21000	7	--	3	--	0.56	IFG
143.0L	7000	6-7	--	5	--	0.31	--
146.6L	26500	1-9	--	12	--	0.48	--

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 13. Representative Group VI

Description: Habitat character is dominated by channel morphology. This group includes overflow channels that parallel the adjacent mainstem, usually separated by a sparsely vegetated gravel bar. These specific areas may or may not possess an upwelling groundwater source.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
100.6L	9200	4-3	--	11	12.0	0.42	--
102.6L	6500	4-3	2.0	12	14.2	0.69	--
106.3R	4800	4	2.5	11	17.4	0.53	--
107.1L	9600	4-3-9	--	12	--	0.69	--
117.8L	8000	4-2	--	9	19.2	0.48	--
117.9R	7300	4-3	2.0	12	24.7	0.49	--
118.0L	22000	3	--	9	12.8	0.39	--
119.7L	23000	2	--	9	--	0.51	--
123.6R	25500	1	--	2	--	0.43	--
133.8L	17500	4-2	--	9	24.0	0.49	IFG
135.3L	18500	3	--	12	19.1	0.30	--
135.7R	27500	1	--	3	26.0	0.32	--
136.3R	13000	4-2	--	11	14.4	0.54	IFG
138.0L	8000	4-2	--	11	--	0.53	--
138.8R	6000	6-5-9	3.0	9	15.0	0.31	--
139.5R	8900	6-5-7	2.5	12	--	0.31	--
140.6R	12000	6-5-8-9	--	10	--	0.61	--
142.0R	10500	5-8	--	12	--	0.53	--
143.4L	30000	1	--	13	60.0	0.55	--

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 14. Representative Group VII

Description: Habitat character is dominated by a characteristic riffle/pool sequence. The Little Rock IFG modeling site (RM 119.2R) is typical with a riffle just downstream of the side channel head that flows into a large backwater pool near the mouth.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
114.1R	<5100	5	2.5	8	22.8	0.31	DIM
119.2R	10000	4-3	3.6	10	15.1	0.41	IFG
121.1L	7400	4-3	3.0	6	41.2	0.43	--
123.0L	<5100	4	2.0	7	17.4	0.39	--
125.6L	<5100	6-5	3.5	12	9.5	0.52	--
125.7R	22000	4	--	9	10.7	0.62	--
127.5M	<5100	6-5	3.5	6	24.2	0.31	--
131.3L	8000	4-2	--	7	18.2	0.31	DIM

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 15. Representative Group VIII

Description: Habitat character is dominated by the tendency of these channels to dewater at a relatively high mainstem discharge. Channels in this group are frequently oriented with a 30°+ angle to the mainstem flowline at their heads.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
101.3M	9200	4-9	--	11	9.3	0.57	--
102.0L	10000	4-9	--	5	2.4	0.43	--
104.3M	16500	4-3-9	--	9	4.3	0.48	--
109.5M	16000	4-9	--	9	8.7	0.49	--
112.4L	22000	9	--	11	18.4	0.27	--
117.1M	15500	4-3	--	3	16.0	0.32	--
117.2M	20000	3-9	--	3	9.8	0.32	--
118.6M	14000	5-8	--	3	--	0.26	--
119.8L	15500	4-9	--	9	7.8	0.51	--
120.0L	12500	4-3-9	--	10	20.3	0.32	--
121.5R	19500	3-9	--	6	--	0.32	--
121.6R	15500	4-3-9	--	9	--	0.60	--
124.8R	19500	8-9	--	2	3.9	0.46	--
125.6R	22000	9	--	8	12.7	0.54	--
128.4R	9000	6-5-9	--	8	--	0.56	--
132.5L	14500	4-9	--	11	10.0	0.57	--
135.0R	21500	9	--	6	11.2	0.44	--
135.1R	20000	3	--	6	18.9	0.44	--
135.5R	21000	9	--	1	--	0.32	--
144.0M	22000	9	--	12	9.0	0.31	--
145.6R	22000	9	--	8	56.3	0.62	--

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 16. Representative Group IX

Description: Habitat character is dominated by low breaching flows and relatively swift velocities. This group includes specific areas that were categorized as mainstem at 5100 cfs, as well as side channels (Category 5) and indistinct side channels (Category 6) with mean reach velocities greater than 5 fps at 10000 cfs mainstem.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
104.0R	<5100	6	5.5	8	9.4	0.48	--
105.7R	<5100	10	3.0	11	8.6	0.53	--
108.9L	<5100	10	5.0	11	9.0	0.58	--
109.4R	<5100	10	>4.0	12	18.2	0.45	--
111.0R	<5100	10	3.5	6	12.3	0.35	--
113.8R	<5100	6	6.0	12	7.2	0.53	--
117.7L	<5100	6-5	5.5	8	8.5	0.41	--
127.1M	<5100	6-5	5.0	10	13.9	0.53	--
128.3R	<5100	6	>5.0	12	--	0.63	--
129.3L	<5100	10-5	>6.0	12	12.2	0.62	--
129.8R	<5100	10	>4.0	12	9.7	0.56	--
131.2R	<5100	5	>5.0	8	13.6	0.59	--
135.0L	<5100	10	4.5	12	6.1	0.48	--
139.2R	<5100	6	--	10	10.7	0.61	--
141.2R	<5100	6-5	>5.0	13	--	0.69	--
141.3R	<5100	5	>5.0	12	--	0.69	--
142.8R	<5100	6	>5.0	12	--	0.56	--
144.2L	<5100	10	3.5	12	21.0	0.53	--
147.1L	<5100	10	5.0	12	10.8	0.57	IFG

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

Table 17. Representative Group X

Description: Habitat character is dominated by channel morphology. This group includes large mainstem shoals, and mainstem margin areas that had open leads in the March 1983 photography.

Specific Area	Breaching Flow (cfs)	Habitat Transformation Category Sequence	Mean Reach Velocity (fps)	Dominant Substrate Code	Channel Length to Width Ratio	Structural Habitat Index	Model
105.81L	MSS	6	--	12	--	0.57	DIM
109.3M	MSS	6-9	--	8	--	0.48	--
111.6R	11500	6-8-9	--	10	--	0.49	--
113.6R	10500	6-8	--	8	--	0.55	--
113.9R	7000	6	--	8	--	0.48	--
119.11L	MSS	6	2.0	8	--	0.41	DIM
121.1R	MSS	6-5	3.5	10	4.8	0.47	--
133.81R	MSS	6	2.0	12	--	0.48	DIM
138.71L	MSS	6	3.0	12	--	0.57	DIM
139.3L	MSS	6	--	10	--	0.56	--
139.41L	MSS	6	3.5	11	--	0.41	DIM
142.8L	MSS	6	1.5	9	--	0.36	--
148.2R	MSS	6-9	--	12	--	0.48	--

US = Upland Slough
MSS = Mainstem Shoal
IFG = Instream Flow Group Habitat Model
DIM = Direct Input Model developed by EWT&A
RJHAB = ADF&G Habitat Model
-- = No Data Available

5. CONCLUSIONS

Aquatic habitat characterizations were developed for specific areas of the Talkeetna to Devil Canyon segment of the Susitna River using aerial photo interpretation and habitat inventory procedures. An accelerated change in overall riverine habitat character occurs in the flow interval from 10600 to 7400 cfs (USGS Gold Creek) as indicated by the number of specific areas that dewater in the aerial photography as mainstem discharge decreases.

Discontinuous subsegments composed of specific areas of the Middle River that are hydrologically, hydraulically, and morphologically similar were discriminated for use in the extrapolation of habitat quality and usability indices from modeled areas to nonmodeled areas. Ten of these composite subsegments, termed "representative groups," were developed (Tables 8-17).

Differences in habitat quality within representative groups may occur because of differences in structural habitat quality between specific areas. Structural habitat indices were formulated from six structural habitat variables to account for these differences in the extrapolation methodology.

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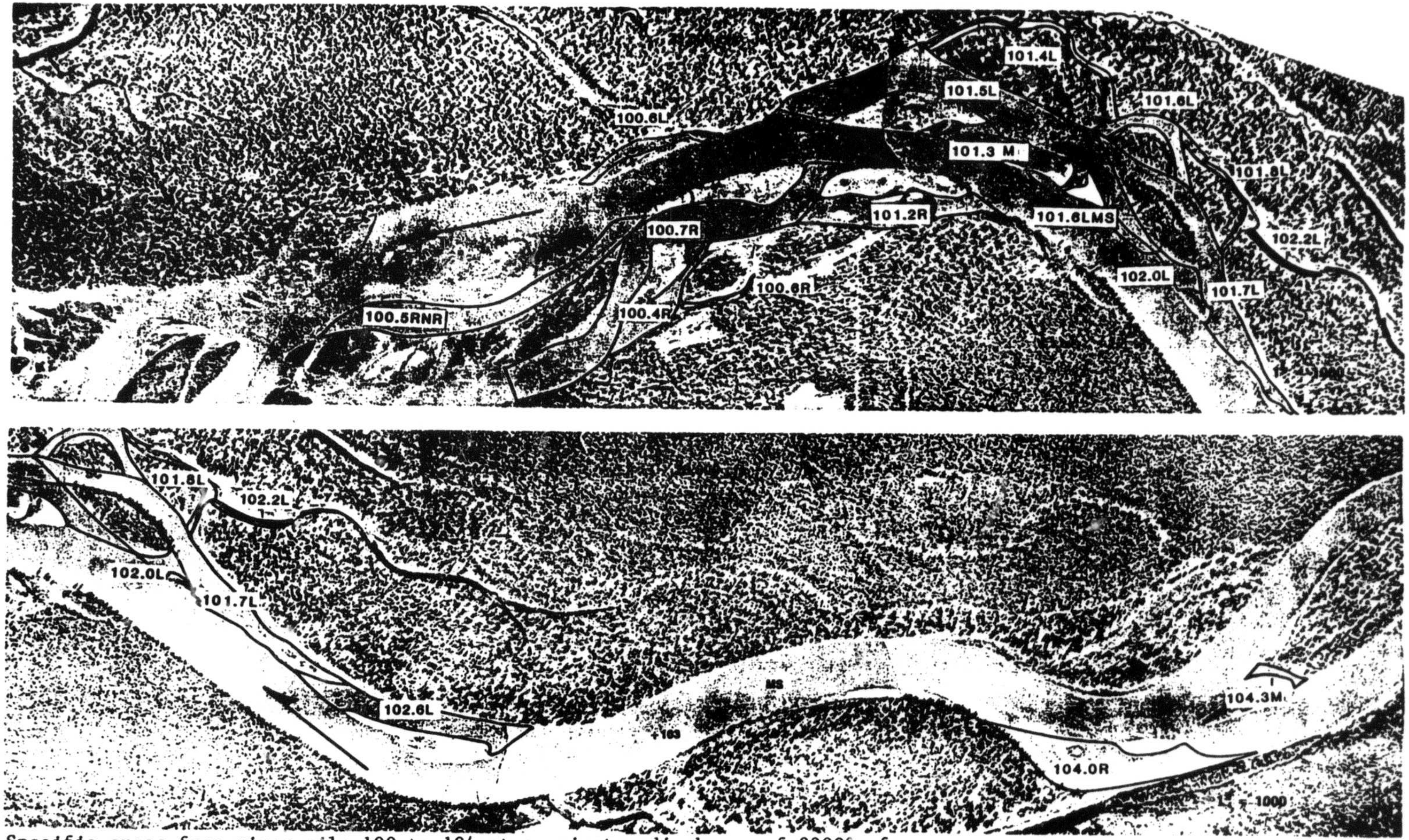
APPENDIX 1

SPECIFIC AREAS DELINEATED ON THE 23000 CFS AERIAL PHOTOGRAPHY



Specific areas from river mile 100 to 104 at a mainstem discharge of 23000 cfs.

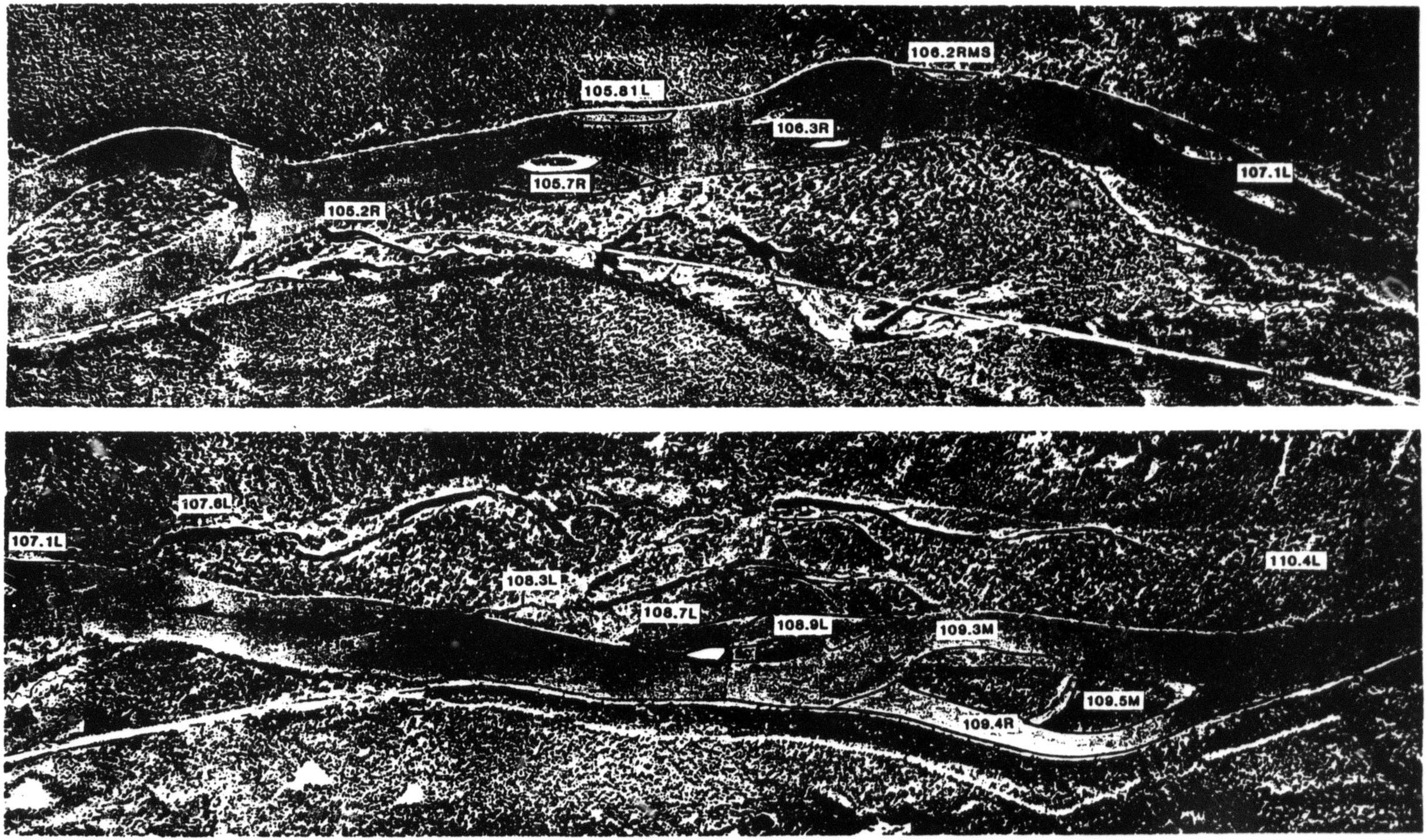
LEGEND:

L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
← = Flow Direction



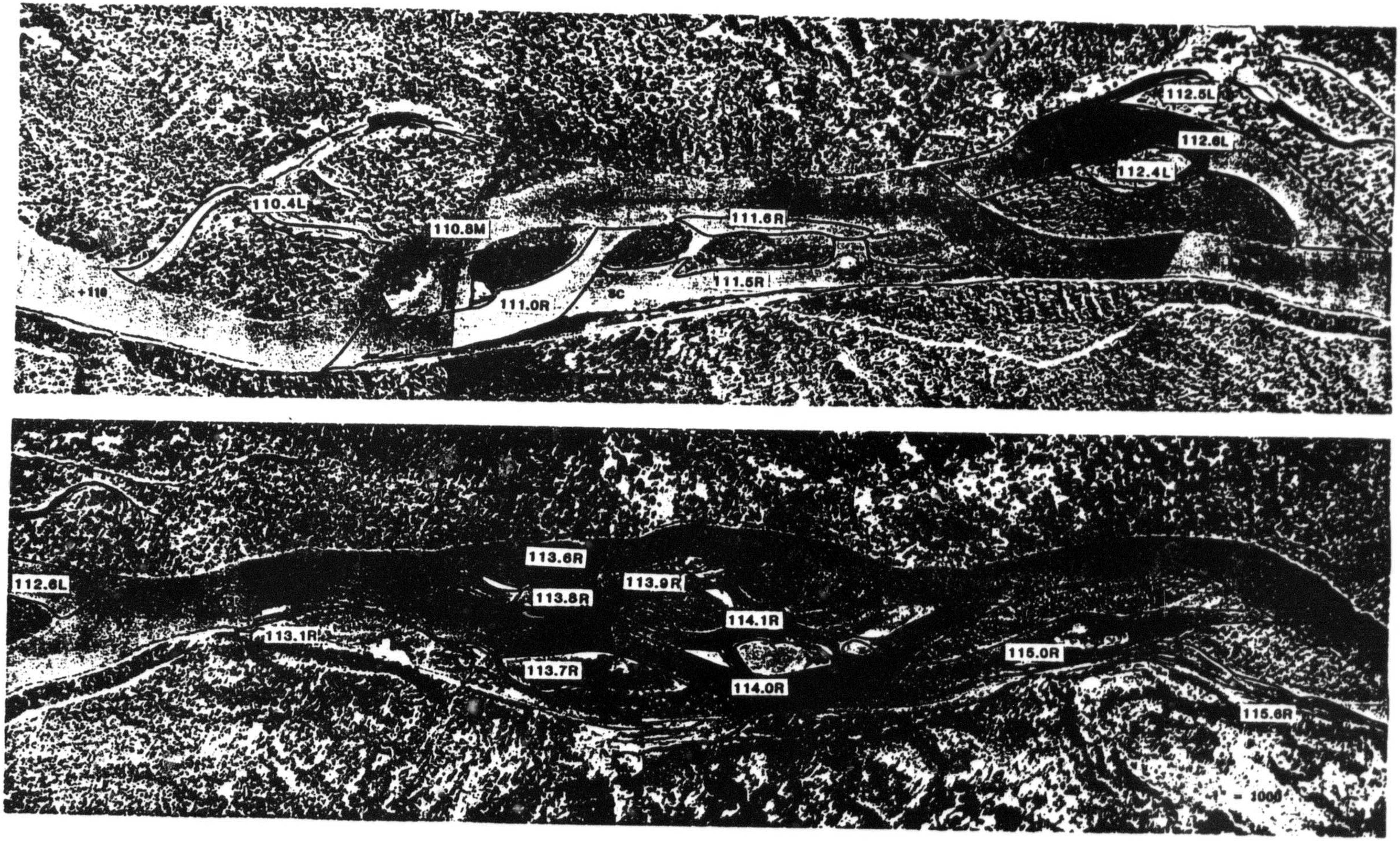
Specific areas from river mile 104 to 110 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
◄ = Flow Direction



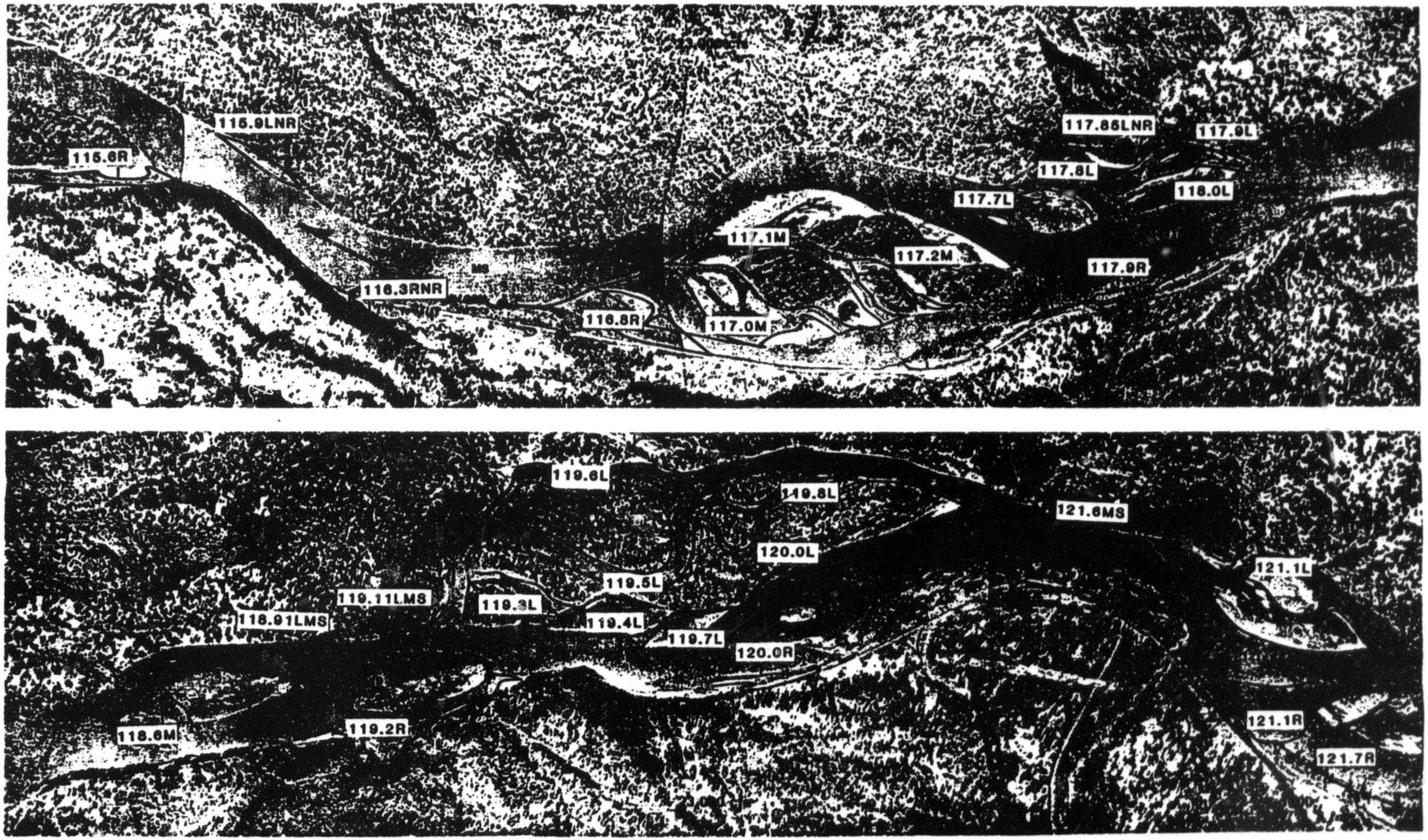
Specific areas from river mile 110 to 115 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
◄ = Flow Direction



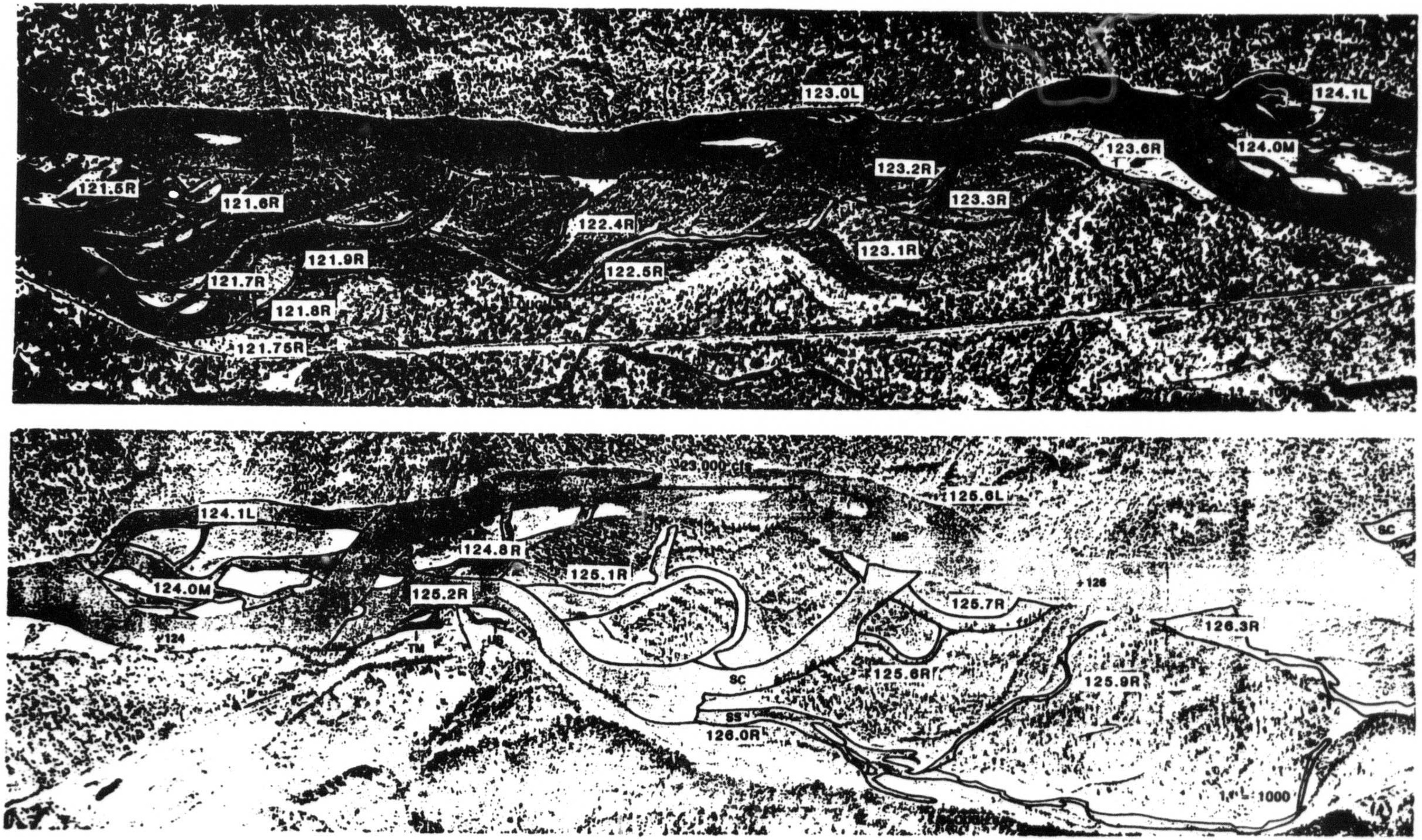
Specific areas from river mile 115 to 121 at a mainstem discharge of 23000 cfs.

LFGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
↲ = Flow Direction



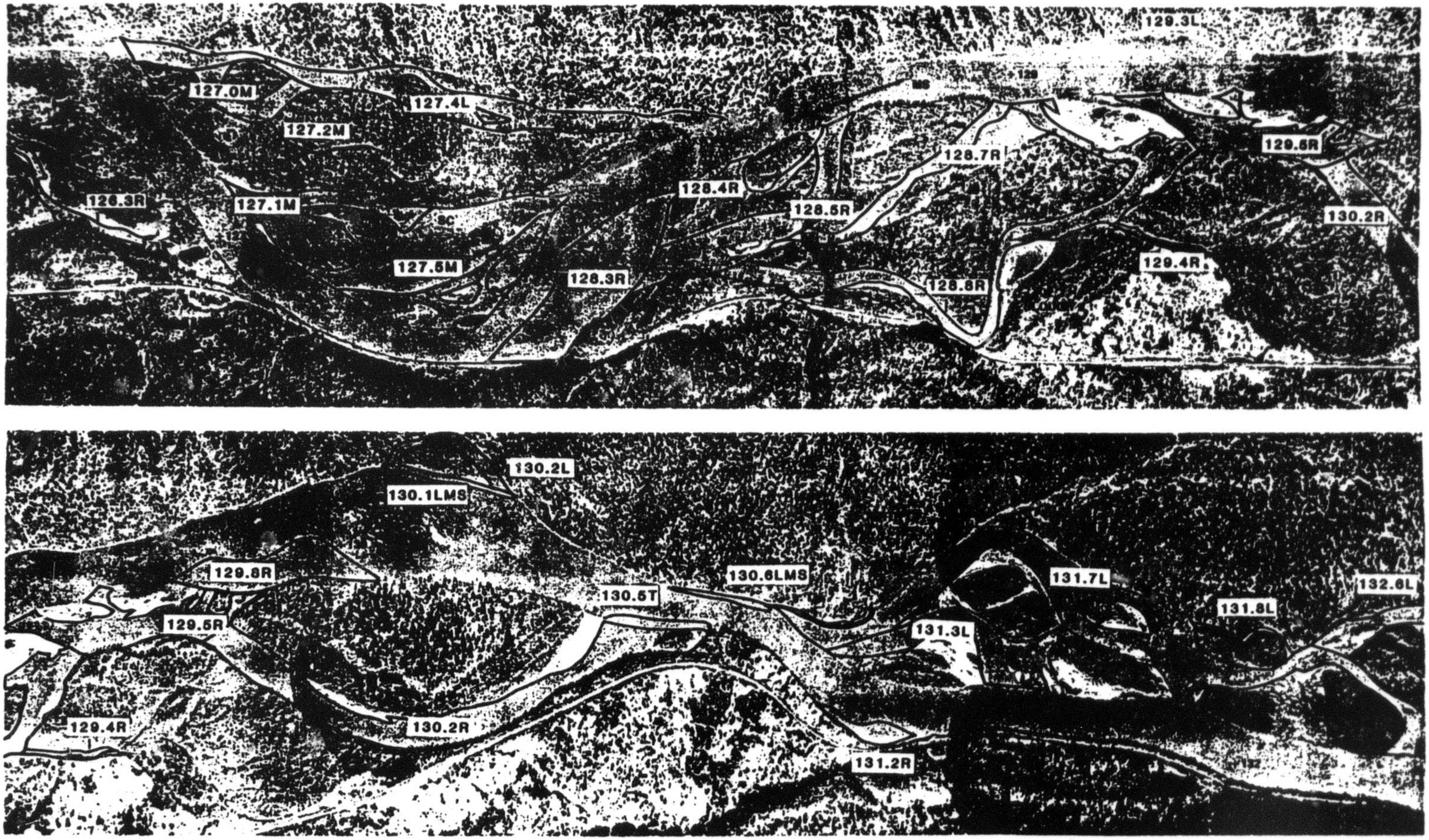
Specific areas from river mile 121 to 126 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
← = Flow Direction



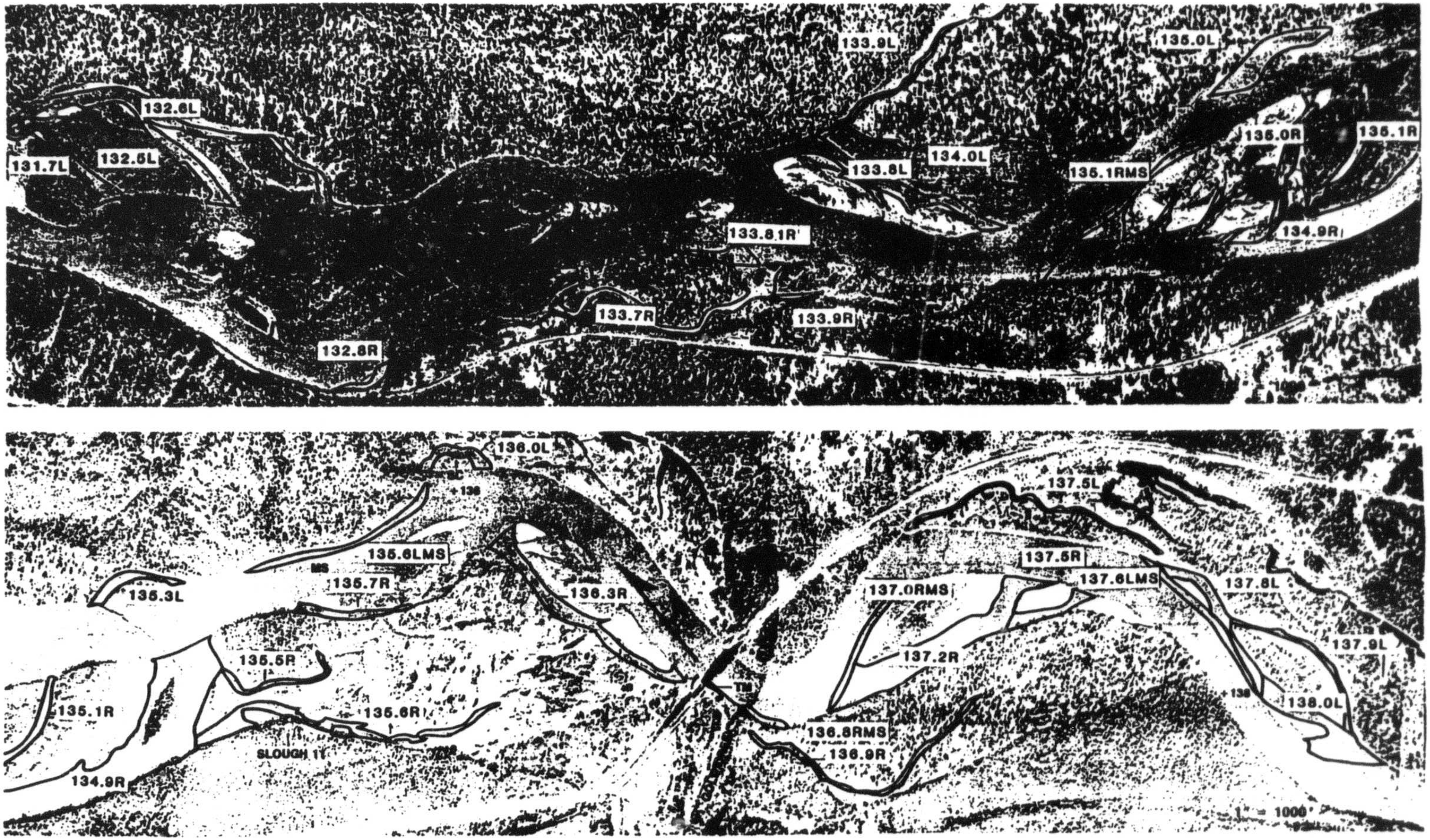
Specific areas from river mile 126 to 132 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
◢ = Flow Direction



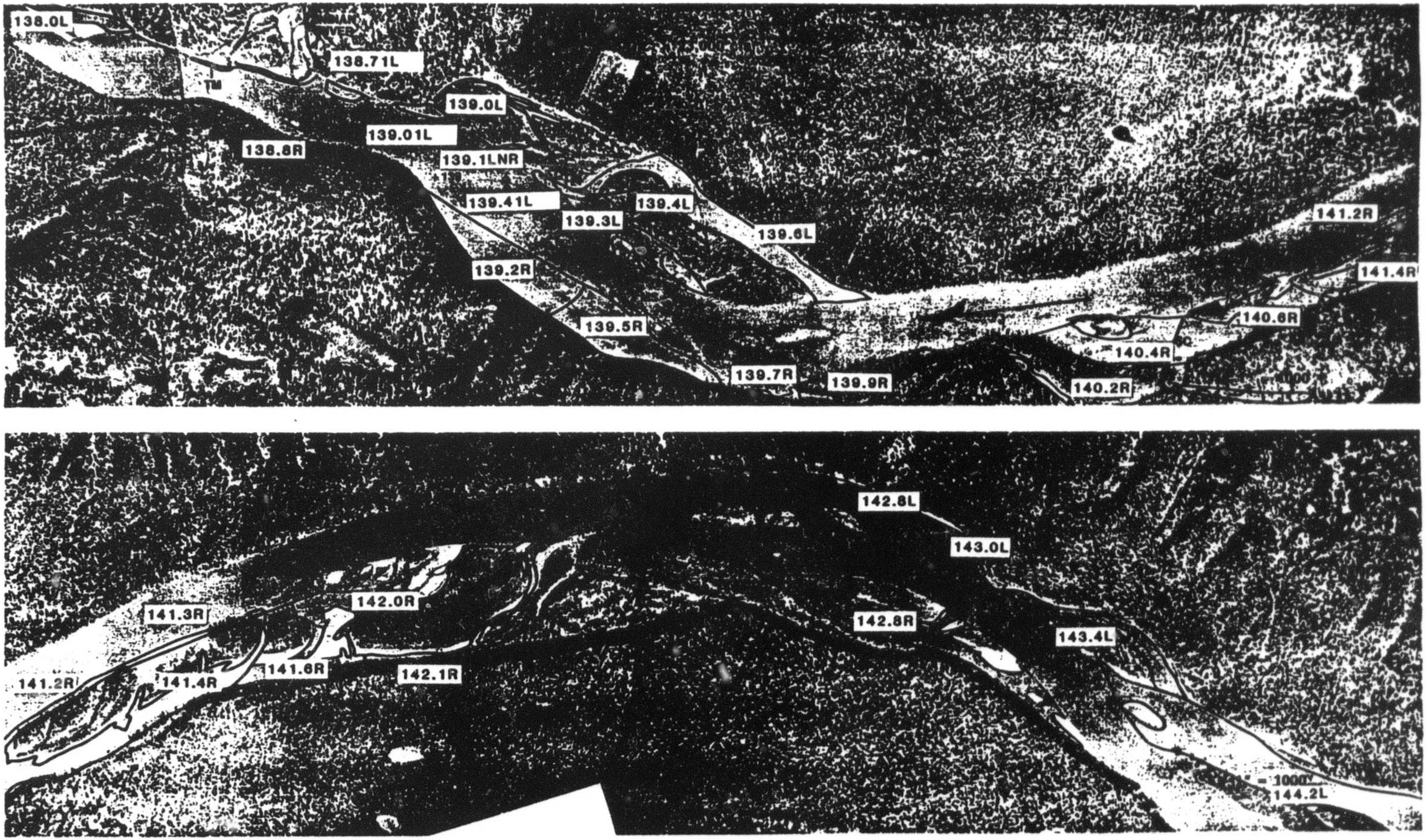
Specific areas from river mile 132 to 138 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

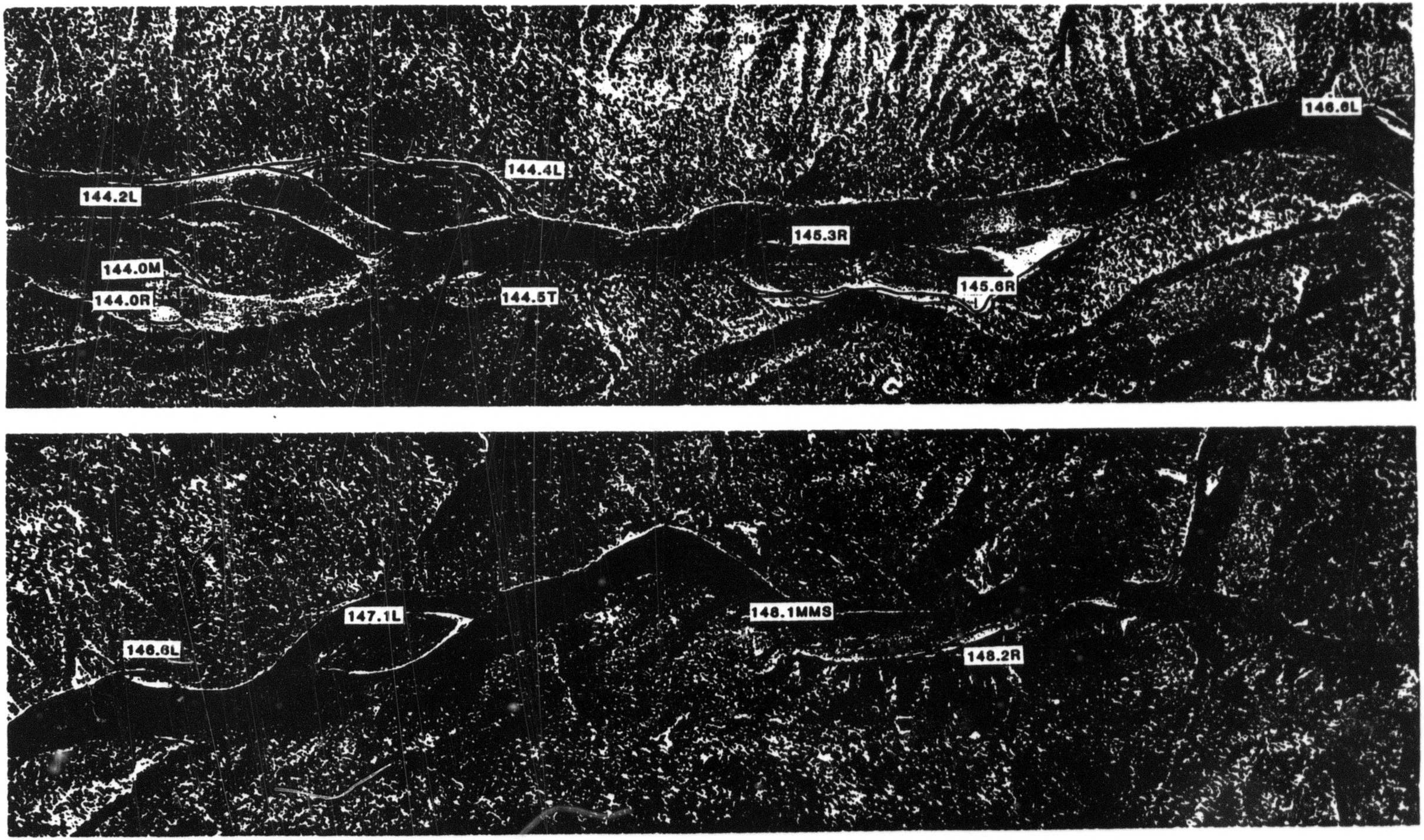
RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
← = Flow Direction



Specific areas from river mile 138 to 144 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle
RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning
RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning
T = Tributary
+ = River Mile
← = Flow Direction



Specific areas from river mile 144 to 148 at a mainstem discharge of 23000 cfs.

LEGEND:
L = Left
R = Right
M = Middle

RNR = Right Not Reconned
LNR = Left Not Reconned
LMS = Left Mainstem Spawning

RMS = Right Mainstem Spawning
MMS = Middle Mainstem Spawning

T = Tributary
+ = River Mile
↙ = Flow Direction

APPENDIX 2

METHODOLOGY

TABLE OF CONTENTS

INTRODUCTION

The project team used two data sources to develop aquatic habitat characterizations: (1) aerial photography; and (2) a habitat reconnaissance data base. Additional Alaska Department of Fish & Game (ADF&G) information was incorporated into the analyses from their habitat modeling program, their fish utilization studies, and personal communications with their field personnel.

Overlapping black and white aerial photography taken during the open water season were available for nine Middle River discharges as measured at the USGS Gold Creek gage (Table 18). These mainstem evaluation flows reflect probable with-project flow characteristics. One set of winter aerial photography was also available.

The investigators used aerial photography at several stages of the analysis: (1) delineation of specific areas including determination of the distinctness or indistinctness of channel boundaries at each evaluation flow; (2) determination of the breaching flow and wetted top width at the head berm (hydrologic component); (3) the evaluation of plan form (hydraulic component); and (4) structural component evaluation. The winter photography was useful in determining whether upwelling occurred at individual specific areas. These steps were required in order to track habitat transformation and stratify specific areas into Representative Groups.

Table 18. Use of black and white aerial photography in characterization of aquatic habitat.

Mainstem Discharge(s)	Date Taken	Specific Area Delineation	Breaching Flows	Transformation Tracking	Channel Geometry	Upwelling Evaluation
2000-3000	March 1983					X
5100	10-14-84		X	X	X	X
7400	10-04-84		X	X		
9000	10-08-83	X	X	X		
10600	09-09-84		X	X	X	
12500	09-11-83	X	X	X		
16000	09-06-83	X	X	X		
18000	08-20-80		X	X		
23000*	06-01-82	X	X	X		
26900	08-27-84		X			

*Reference flow for habitat transformation tracking.

Four field trips provided the habitat reconnaissance data: a one-day trip on August 21, 1984; a five-day trip September 3-7, 1984; a five-day trip September 10-14; 1984, and a four-day trip September 29 to October 2, 1984. The corresponding USGS Gold Creek gage discharges were approximately 18000, 11000, 10000, and 8000 cfs, respectively. The one-day field trip was a trial for the refinement of field procedures and the planning of future field work. Observers completed a habitat inventory form for each of the 172 specific areas over the course of the two five-day field trips. During the final field trip the observers collected additional information to verify upwelling and side channel breaching flows as well as mean reach velocities and habitat transformation categorizations. A detailed list of equipment and procedures used in the completion of the habitat inventory form appears in the Habitat Inventory Techniques section.

Following are detailed descriptions of the procedures and methods used in the hydrologic, hydraulic, and structural characterization of aquatic habitats of the Talkeetna to Devil Canyon segment of the Susitna River (the Middle River).

DELINEATION OF SPECIFIC AREAS

Aerial photography provided the basis for the delineation of portions of the Middle River which are potentially important aquatic habitats. These proposed study sites, termed specific areas, were outlined on composite copies of black and white photography at the mainstem evaluation flows of 23000, 16000, 12500, and 9000 cfs. The specific areas consisted of representative mainstem areas as well as nonmainstem areas such as side channels, upland sloughs, and side sloughs. Of particular interest to this study were areas of the river that exhibited different habitat characteristics at different flows, such as side channels that became side sloughs at lower flows, mainstem areas that became side channels, and wetted areas that dewatered. Determining areas of upwelling was also important to this study. Specific areas were delineated for study at areas of the Middle River where open leads were evident in the winter photography indicating the possible presence of upwelling.

DISTINCTNESS/INDISTINCTNESS

Locations that were not obvious channels at a particular mainstem evaluation flow sometimes transformed into obvious channels at a lower mainstem evaluation flow. The distinctness of such physical features was an important parameter in tracking habitat transformation.

An example of this is a margin of the mainstem which becomes a distinct side channel separated from the mainstem by a gravel bar as the mainstem flow recedes. The response of this "indistinct" mainstem habitat to receding flows is different than that of the adjacent mainstem habitat, and they are therefore separate specific areas.

An indistinct boundary of a different nature occurs in areas that are turbid mainstem shoals at a high mainstem evaluation flow, but are clearwater shoals at lower flows. This type of channel behavior is common in a number of the mainstem chum salmon spawning areas.

GROUND TRUTHING

Aerial photographs served as guides in the first field surveys, facilitating the location of each specific area from the air and on the ground. Generally, the specific area delineated on the aerial photograph correctly defined the bounds of a homogeneous aquatic habitat. In several instances shadows, dense foliage, or incorrect interpretation of the nature of the water course had led to a mistaken impression of the nature of a specific area. The outline of the specific area was modified on the photographs to better reflect the actual boundaries of the habitat type, or in several cases, a specific area was divided into two specific areas of different habitat types. Several specific areas were deleted from consideration after field observers determined that they were tributaries rather than upland sloughs, or that they offered no aquatic habitat value. As a result of these efforts, a total of 172 specific areas were defined. These served as the foundation for further evaluation.

HYDROLOGIC COMPONENT

HABITAT TRANSFORMATION TRACKING

Wetted surface area and site specific habitat type is a function of mainstem discharge. Evaluation of the specific area habitat characteristics apparent in aerial photography was accomplished by the development of four binary criteria. These flow dependent criteria included:

1. The presence of turbid or clear water. This is generally an indication of whether a specific area is breached (turbid) or nonbreached (clear) at the subject mainstem evaluation flow.

2. Visibly distinct or indistinct channel boundaries. This criterion distinguishes homogeneous habitats from adjacent habitats that respond differently to mainstem flow.

3. Presence or absence of water. This distinguishes specific areas that become dewatered. These specific areas may contain isolated pools that, by definition, have no habitat value.

In addition, the importance of upwelling as a component of aquatic habitat was acknowledged by the following criterion:

4. Presence or absence of upwelling which persists throughout the year. This is evidenced by the presence or absence of open leads in the March 1983 aerial photographs and the presence or absence of water in the 5100 cfs aerial photography, or by field observations.

The organization of these criteria into a flow chart for tracking habitat transformations between the mainstem evaluation flows of 23000 and 9000 cfs is depicted in Figure 8. It is important to note that these criteria can be applied between any two mainstem evaluation flows: however, for consistent evaluation the 23000 cfs photography was used as the reference for monitoring habitat transformation apparent in the lower flow aerial photography.

The determination of habitat transformation categories for each evaluation flow at specific areas was not always clear-cut, relying frequently on the discretion of the investigators. Three of the branches of the flow chart required more deliberation than others. These decision nodes concerned whether habitat was side channel or mainstem, a channel was distinct or indistinct, or whether a specific area was dewatered or not.

The distinction between side channel and mainstem habitat, as defined by Klinger and Trihey (1984), is a good guideline for classifying habitat based on aerial photo interpretation. Field experience gained during the habitat inventory work, however, provided a more sensitive perspective of the distinction between mainstem and side channel habitat than aerial photography. At approximately 10000 cfs, mainstem channels were observed to characteristically convey swifter velocities, have larger substrate, and be oriented more directly downstream than side channels. Although discharge was estimated for each channel during the field work, the observed character of the habitat was weighted more than the percent of discharge conveyed in discriminating between mainstem and side channel habitats.

The transformation of a channel from indistinct to distinct does not occur at a discrete discharge. This process occurs over a range of flows as inundated gravel-bars gradually dewater with decreasing mainstem stage, routing flow through increasingly distinct channels. The precise discharge at which a channel is judged to be distinct is not as important to the characterization of these habitats as the process by which these channels emerge. It was observed that indistinct channels typically have swifter flow velocities and contain coarser substrate than perennial side channels.

The determination of whether a specific area was dewatered or not, although sometimes apparent in the aerial photography, frequently relied on ground verification. The definition of dewatered was expanded to include channels that contained isolated pools that would imminently dewater or freeze solid, thus voiding their value as fish habitat. These determinations always required an on-site inspection.

BREACHING FLOW DETERMINATION

Two criteria of a specific area are fundamental to analysis of habitat type: the presence or absence of water, and the turbidity or clarity of water.

Any nonmainstem specific area is defined as being breached if turbid mainstem water is flowing through it. As mainstem flow decreases and the water surface elevation of the mainstem drops below the head berm of the specific area, the specific area transforms from breached to nonbreached. A nonbreached specific area may be dry or contain clear water. If the latter, the water source is upwelling groundwater or overland flow from a tributary.

The determination of the mainstem flow at which a specific area becomes breached or nonbreached is important in tracking habitat transformation. A field survey would be the most direct and precise method of establishing breaching flows, but such a survey would be very expensive. Field evaluation would entail having an observer at each specific area, over the range of flows under consideration, to record the mainstem flow at which the mainstem water surface elevation overtops the head berm.

The series of black and white aerial photography from 5100 to 26900 cfs was used as a visual reference frame for estimating breaching flows for specific areas. Breaching flows were interpolated between photographed flows using interpretive judgement and field observations where applicable. It was not possible to refine breaching flow estimates for specific areas that breached significantly below 5100 cfs because of the lack of available information. Some specific areas appeared "barely breached" in the 5100 cfs photography; breaching flows were estimated at those sites. Breaching flow estimates above 26900 cfs relied exclusively on available ADF&G field information.

CROSS SECTIONAL GEOMETRY OF SIDE CHANNEL HEAD BERMS

The wetted top widths at the head berm of specific areas that persisted as a distinct side channel throughout most mainstem evaluation flows were used in the analysis of channel geometry. The project team identified the head berm for each channel using the lowest reference flow photography available (5100 cfs). Wetted top width across the head berm cross section was determined at all mainstem evaluation flows with a divider. The distance between the divider points was measured with a 40-division-per-inch scale.

The investigators plotted top width versus mainstem discharge for 46 specific areas. The curves were then subjectively classified as steep, moderate, flat, and irregular, based on their characteristic slope.

CROSS SECTIONAL GEOMETRY OF MAINSTEM

To better understand the influence of mainstem stage on side channel habitats, the investigators performed a regional cross section analysis. They analyzed mainstem cross sectional data from R&M Consultants (1982) over a stage increase from 9700 to 23400 cfs at selected cross sections distributed throughout the Middle River (Table 4). The difference between the high and low flow water surface elevations at each section was scaled and the resultant stage increase was recorded in feet.

EVALUATION OF UPWELLING

Clearwater habitats occur in channels whose water source is local surface water runoff and/or upwelling groundwater. The investigators used aerial photography and field observations to determine upwelling areas.

The project team examined each specific area in the winter photography for the presence or absence of open leads. While open leads can be caused by high velocities, it was relatively easy to differentiate between velocity leads and those caused by a temperature differential created by upwelling groundwater. The presence of clearwater in the 5100 cfs photography suggested upwelling in many areas.

Field observers made an on site evaluation at every specific area. In clearwater areas, upwelling was indicated by the presence of small "volcanoes" in the substrate caused by upwelling flow. The presence of upwelling was impossible to determine in most breached areas unless the flow of turbid water was minimal. Upwelling in these specific areas could be determined only by evaluation of aerial photography.

HYDRAULIC COMPONENT

MEAN REACH VELOCITY

Three methods were used to determine mean reach velocity. The first method involved estimating the surface velocity by recording the time it took a floating object to travel a known distance. The mean reach velocity was estimated as 85 percent of this surface velocity. The second method involved measuring the height(h) that water "climbed" a survey rod held perpendicular to the flow (i.e., conversion of kinetic energy to potential energy). The relationship between h and mean reach velocity is depicted in Figure 13. Tabulated valves of velocity corresponding with particular heights appear in Table 19. On rare occasions, a Marsh McBirney Type 201 portable current meter with wading rod was used to measure velocity. Velocity was measured at a point 0.6 times the depth from the water surface elevation for depths less than or equal to 2.5 ft. Velocity was determined as the average of measurements made at 0.2 and 0.8 times the depth from the water surface elevation for depths greater than 2.5 ft. (Note: a Marsh McBirney was used primarily to check the accuracy of the two approximate methods of estimating mean reach velocities).

SUBSTRATE SIZE

Field observers coded the characteristic size of the largest bed materials of a specific area. Frequently, more than one code was selected because of the evenly balanced mixture of fine and coarse substrate size classes at many specific areas. The substrate type and corresponding code numbers are presented in the Habitat Inventory Techniques section.

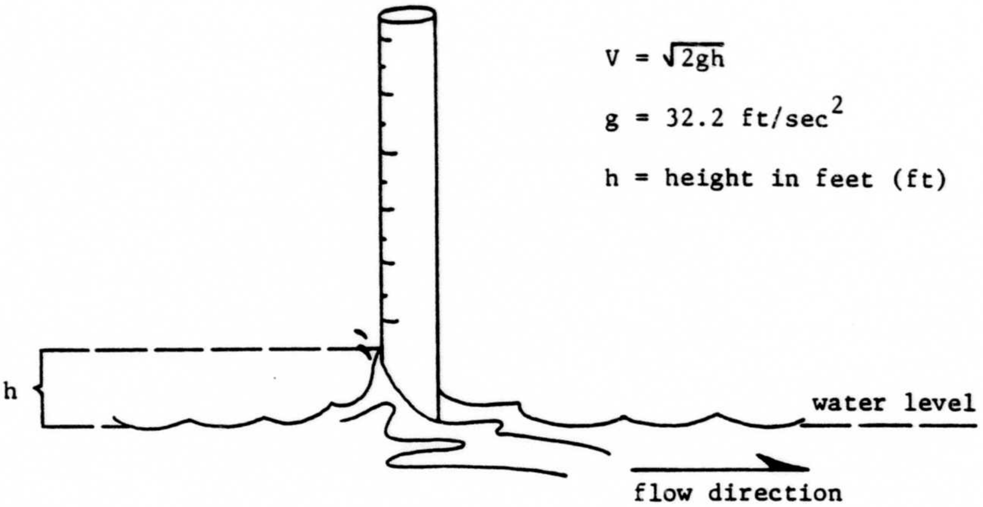


Figure 13. The relationship between height (h) and mean reach velocity as depicted by the rise of the water column against a staff held perpendicular to the flow.

Table 19. The relationship between the height (h) that water climbs a staff when held perpendicular to the flow and mean reach velocity.

Height (ft)	Velocity (fps)	Height (ft)	Velocity (fps)
0.01	0.8	0.14	3.0
0.02	1.1	0.15	3.1
0.03	1.4	0.16	3.2
0.04	1.6	0.17	3.3
0.05	1.8	0.18	3.4
0.06	2.0	0.19	3.5
0.07	2.1	0.20	3.6
0.08	2.3	0.21	3.7
0.09	2.4	0.22	3.8
0.10	2.5	0.24	3.9
0.11	2.6	0.26	4.1
0.12	2.8	0.28	4.2
0.13	2.9	0.30	4.4

CHANNEL MORPHOLOGY

Plan form analysis of each specific area containing a distinct side channel entailed measurement of selected physical parameters, such as angular orientation to the mainstem, total length, straight line length from channel head to mouth, and representative bank-full top width. Length and width were measured using a Numonics Corporation Electronic Graphics Calculator and Model 2400 Digi Tablet from aerial photographs that had been enlarged to a scale of 1 inch=250 feet. Orientation angle was determined by drawing two lines, one parallel to the mainstem flow, and one parallel to the flow of the side channel near the head. The inside angle formed by these lines was measured using a protractor.

Sinuosity was calculated for each specific area as the ratio of total channel length to straight-line length between channel head and mouth. A straight-line channel has a 1:1 ratio. This ratio increases with increased sinuosity. Channel length to width ratios were also calculated for each specific area.

The following groups of variables were subject to cluster analysis using Ward's Method, followed by a discriminant analysis using the direct entry method: length, width, length to width ratio, sinuosity, and number of bends. The number of cases (specific areas) utilized in the analysis was limited to 70. This was the total number of specific areas which contained a distinct side channel.

Cluster analysis is undertaken to sort cases into groups such that the degree of association is high between members of the same group and low between members of different groups (Wishart 1978). Seven clustering methods are available from the SPSS-X package (Statistical Procedures for the Social Sciences - Version X): Between groups average, Within groups average, Single, Complete, Centroid, Median, and Ward. Of these seven methods, Wishart (1978) considers Ward's method the best method for finding minimal variance spherical clusters. Ward's method was used in this study to identify groups of specific areas that are morphologically similar. Once well defined clusters are formed from a cluster analysis, it is possible to determine which variables contribute most to their separation. A suitable approach is to set up discriminate functions using a multiple discriminant analysis. The relative importance of the variables under consideration can be determined by reviewing the coefficients in these discriminating functions. It forms a number of linear functions of the environmental variables under consideration, usually one less than the number of groups used in the analysis. The weighting coefficients (standardized discriminant function coefficients) for each of the variables identify those which contribute most to the separation of the groups along each respective function (Klecka 1975). Numerical values give the percentage variances that are accounted for by each function. Signs for the coefficients indicate whether the variables are positively or negatively correlated. Multiple discriminant function analysis was used in this study to identify the most important variables for the discrimination of morphologically similar groups.

STRUCTURAL COMPONENT

The structural component was characterized by the following variables: dominant cover; percent cover; substrate size; substrate embeddedness; channel cross sectional geometry; and streambank vegetation.

Structural habitat indices (SHI) represent the synthesis of the six structural habitat variables into a single value. The procedure to derive structural habitat indices involves three steps: (1) rating the effect of each variable on juvenile salmonid habitat quality for each specific area; (2) ranking the relative importance of each variable to juvenile salmonid habitat quality; and (3) combining rating and weighting factors into a structural habitat index for each specific area. An explanation of each step follows.

The basis for rating each structural habitat variable was information obtained from habitat inventory and aerial photo procedures. The precision of this information permitted the rating of each variable into the following categories: excellent, good, fair, poor, and nonexistent. These rating categories were assigned numerical values of 1.0, 0.75, 0.50, 0.25, and 0.0, respectively.

Dominant cover and percent cover were rated as a variable combination to allow the use of ADF&G clearwater cover suitability criteria for juvenile chinook salmon in the rating process (Table 20). Clearwater criteria were selected rather than turbid water criteria because of their independence from the influence of turbidity as a cover variable. The clearwater criteria were thus assumed to be more directly related to structural cover as described by dominant cover and percent cover codes (see Habitat Inventory Techniques section). Juvenile chinook salmon criteria were used because they are primary evaluation species in Middle River instream flow studies (E. Woody Trihey & Associates and Woodward-Clyde Consultants 1985).

Table 20. Cover suitability criteria recommended for use in modeling juvenile chinook habitat under clear water conditions (Schmidt et al. 1984).

	COVER TYPE								
Percent Cover	No Cover	Emergent Veg.	Aquatic Veg.	Large Gravel	Rubble 3"-5"	Cobble or Boulders 5"	Debris & Deadfall	Overhanging Riparian	Undercut Banks
Clear Water (ADF&G)									
0-5%	0.01	0.01	0.07	0.07	0.09	0.09	0.11	0.06	0.10
6-25%	0.01	0.04	0.22	0.21	0.27	0.29	0.33	0.20	0.32
26-50%	0.01	0.07	0.38	0.35	0.45	0.49	0.56	0.34	0.54
51-75%	0.01	0.09	0.53	0.49	0.63	0.69	0.78	0.47	0.75
76-100%	0.01	0.12	0.68	0.63	0.81	0.89	1.00	0.61	0.97

The suitability criteria for cover were used in the rating process by dividing the range of suitability index values into discrete intervals, each corresponding to a rating factor, as follows: 0.0 (nonexistent), 0.01-0.10 (poor), 0.11-0.30 (fair), 0.31-0.50 (good), and 0.51-1.0 (excellent). The professional judgement of EWT&A and AEIDC staff biologists was used to establish these intervals. The rating factory for dominant cover and percent cover codes for each specific area was thus obtained by classifying the corresponding suitability index into one of the above intervals. A matrix of dominant cover and percent cover rating factors appears as Table 21.

Table 21. Dominant cover/percent cover rating factors.

	Dominant Cover Code								
Percent Cover Code	1	2	3	4	5	6	7	8	9
1	0.00	0.00	0.25	0.25	0.25	0.25	0.50	0.25	0.50
2	0.00	0.25	0.50	0.50	0.50	0.50	0.75	0.50	0.75
3	0.00	0.25	0.50	0.75	0.75	0.75	1.00	0.75	1.00
4	0.00	0.25	1.00	0.75	1.00	1.00	1.00	0.75	1.00
5	0.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	0.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Channel morphology was evaluated as a structural habitat variable on the basis of the approximate proportions that three general types of channel cross sectional geometry were represented at each specific area. The three cross sectional types are as follows: (1) broad cross sections with gentle-sloping banks; (2) cross sections with one gentle-sloping bank and one steep bank; and (3) cross sections that are incised with two steep banks. The first cross sectional geometry type has a positive correlation with habitat availability for juvenile salmonids by providing relatively large wetted surface area per unit discharge and proportionately larger areas along channel margins where edge effects retard velocities to suitable levels. Cross sectional geometry with one gentle-sloping bank was rated half as valuable as cross sectional geometry with two gentle-sloping banks. Incised cross sectional geometry with steep banks received a zero rating factor. Streambank slope codes (see Habitat Inventory Techniques section) and aerial photo interpretation were used to evaluate the cross sectional geometry of each specific area. Table 22 lists channel morphology rating factors for various proportions of cross sectional geometry types that could be represented at a specific area. These rating factors reflect the professional judgement of EWT&A and AEIDC staff biologists.

Table 22. Channel morphology rating factors.

Channel Cross Sectional Geometry Type	Percentage of Cross Sectional Geometry Type													
2 gentle-sloping sides	1.00	0.75	0.75	0.50	0.50	0.25	0.00	0.50	0.25	0.25	0.00	0.25	0.00	0.00
1 gentle-sloping side	0.00	0.25	0.00	0.50	0.25	0.75	1.00	0.00	0.50	0.25	0.75	0.00	0.25	0.00
2 steep sides	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.50	0.25	0.50	0.25	0.75	0.75	1.00
Rating Value	1.00	1.00	0.75	0.75	0.75	0.75	0.50	0.50	0.50	0.50	0.50	0.25	0.25	0.00

The channel morphology rating factors assume that velocities prohibitive to juvenile salmonids occur in the primary flow corridor of each specific area. While this is true for the preponderance of side channel habitats during breached conditions in the Middle River, it is not true for upland sloughs and side channel habitats that are nonbreached. For this reason, upland slough habitats, which seldom have velocities that are prohibitive to juvenile salmonids, were all rated as excellent for channel morphology. This effectively eliminated channel morphology as a discriminating factor of structural habitat quality between upland sloughs. Side channel habitats were evaluated for breached conditions only, when it could be assumed that cross sectional geometry was correlated with the availability of channel margin habitats possessing suitable velocity for juvenile chinook salmon. The nonbreached phase of side channel habitats (side slough habitat) is less heavily utilized by juvenile chinook salmon (Schmidt et al. 1984).

Dominant substrate size and substrate embeddedness were rated as a variable combination according to the rating factor matrix that appears as Table 23. Substrate size and embeddedness codes are explained in the Habitat Inventory Techniques section. Table 23 reflects the professional judgement of EWT&A and AEIDC staff biologists. In general, the larger and less embedded substrate was rated as having the most positive effect on juvenile salmonid habitat quality. Larger substrate provides more extensive protection from high flow velocities. Less embedded substrate has more interstitial space available for occupation by juvenile fish.

Table 23. Substrate size/embeddedness rating factors.

	Substrate Size Code												
Embeddedness Code	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.50	0.50	0.50	0.50	0.50
2	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.50	0.50	0.75	0.75	1.00	1.00
3	0.00	0.00	0.00	0.25	0.25	0.50	0.75	0.75	1.00	1.00	1.00	1.00	1.00

Streambank vegetation codes (see Habitat Inventory Techniques section) and aerial photography were used to evaluate the extensiveness of streambank vegetation for each specific area. Channel width was also considered in the evaluation of rating factors because the relative effect of streambank vegetation on overall channel habitat quality is a function of width. Streambank vegetation as a structural habitat variable affects shading, terrestrial insect import, and bank stability. Vegetation as a cover parameter is included in the dominant cover coding discussed earlier. The rationale behind the assignment of rating factors is reflected in Table 24.

Actual ratings of streambank vegetation were assessed for each specific area based on professional judgement.

Table 24. Streamside vegetation rating factors.

	Rating Factor
Narrow Channel/Extensive Vegetation	1.00
Moderate Channel Width/Extensive Vegetation	0.75
Moderate Channel Width/Moderate Vegetation	0.50
Wide Channel/Extensive Vegetation	0.25
Wide Channel/Moderate Vegetation	0.00

Weighting factors were developed for each of the variable/variable combinations based on the professional judgement of EWT&A and AEIDC staff biologists. Several relative rankings were discussed. In the final analysis, relative weighting factors were accepted because their application in the calculation of SHIs produced numerical results that corroborated subjective evaluations of structural habitat quality recorded during habitat inventory procedures. A summary of the weighting factors for each structural habitat variable appear in Table 25.

Table 25. Structural habitat variables and their corresponding weighting factors.

Habitat Variable/Order of Importance	Weighting Factor
Dominant/Percent Cover	0.45
Channel Cross Sectional Geometry	0.30
Substrate Size/Substrate Embeddedness	0.20
Streamside Vegetation	0.05

Rating and weighting factors were combined in a matrix that provided a convenient form for evaluating structural habitat indices (Figure 14). By summing the products of the rating and weighting factors for each structural habitat variable, a structural habitat index value is obtained for the subject specific area. This process was repeated for all 172 specific areas inventoried in the Middle River.

Figure 14. Structural habitat index form.

		Habitat Variable Weighting Factor			
Habitat Quality Rating Factor		Dominant Cover/Percent Cover (0.45)	Channel Geometry (0.30)	Substrate Size/ Substrate Embeddedness (0.20)	Streamside Vegetation (0.05)
Excellent	(1.00)	.45	.30	.20	.05
Good	(0.75)	.34	.225	.15	.037
Fair	(0.50)	.23	.15	.10	.025
Poor	(0.25)	.11	.075	.05	.0125
Non-Existent	(0.0)	.0	.0	.0	.0
Product of rating and weighting factors	]	?	?	?	?

SHI = ____________________

HABITAT INVENTORY TECHNIQUES

The habitat reconnaissance work was based on the premise that the habitat characteristics of each specific area could be averaged in order to develop a reliable composite description of the entire area. The intent was to describe the habitat in general terms (for example, mean reach velocity) and not to map localized habitat features.

The development of the habitat inventory forms (Figure 15) provided a framework for the field reconnaissance work. These forms were designed to facilitate a cost-effective means of gathering reliable field observations based on visual assessment and minimal field measurements.

Several factors were considered while developing the habitat inventory form. These included: (1) the total time frame allocated for the habitat inventory task (approximately one month); (2) the large number of specific areas to be surveyed; (3) a limitation of approximately one hour per specific area; (4) the use of minimal field gear for ease in transportation at each specific area and during helicopter transport; (5) compatibility with ADF&G data; and (6) ease in computer data management. The methods and field techniques for completing the habitat inventory form are described below.

Sheet 1 of __

Habitat Inventory

Crew: ______________________________ Date: ____________
______________________________ Time: ____________
______________________________ R.M.: ____________
____

Location: ______________________________ Category: ____________

Mainstem Discharge: ____________ Breached? Yes/No

Mean Reach Velocity: ____________ Estimated/Measured

Site Specific Discharge: ____________ Estimated/Measured

Does Upwelling Occur? Yes/No/Cannot Be Detected Visually

Do Tributaries Enter the Slough or Side Channel? Yes/No

If Yes, Description of Tributary (size, location):____________________
____
____
____

Head Gage: ____________ WSEL: ________ Remarks:
Mid-Reach Gage: ____________ WSEL: ________
Mouth Gage: ____________ WSEL: ________

Substrate: 1 2 3 4 5 6 7 8 9 10 11 12 13

Substrate Embeddedness: 1 2 3

Dominant Cover Code: 1 2 3 4 5 6 7 8 9

Percent Cover: 1 2 3 4 5 6

Streambank Slope: LB 1 2 3 Stable/Unstable RB 1 2 3 Stable/Unstable

Streambank Vegetation: LB 1 2 3 4 RB 1 2 3 4

Representative Top Width: ____________ Bankfull Top Width: ____________

Representative Depth: ____________ Bankfull Depth: ____________

Water Clarity: Clear/Turbid ________ ft.

Length of Backwater: ____________ Estimated/Measured

Were Fish Observed? Yes/No

Adult: Chinook _____ Coho _____ Sockeye _____ Chum _____ Pink _____

Juvenile: Chinook _____ Coho _____ Sockeye _____ Chum _____ Pink _____

Remarks:

Figure 15. Habitat inventory form.

Sheet 2 of _

Habitat Inventory

Crew: ______________________________ Date: ____________

______________________________ Time: ____________

____

______________________________ R.M.: ____________

Site Sketch & Habitat Mapping

Flow Description & Remarks

Habitat Type Proportions: Pool _______ Riffle _______ Run _______

Habitat Quality Proportions: 1 ______ 2 ______ 3 ______ 4 ______ 5 ______

Figure 15. (cont'd)

Sheet 3

Habitat Inventory

Crew: ______________________________

____

____

____

Date: ______________

Time: ______________

R.M.: ______________

Film I.D. No.: ________

PHOTOGRAPHS

No.	Description

Figure 15. (cont'd)

Sheet ___ ‹

Habitat Inventory

Crew: ______________________________

____

____

____

Date: ____________

Time: ____________

R.M.: ____________

DETAIL: Sketch and Description

Figure 15. (cont'd)

Both field crews were in the helicopter for initial morning flights. Upon reaching a specific area, an overflight of the area was used to: (1) ensure that the proper specific area was being visited; and (2) obtain a general overview of the area to determine features such as flow patterns, whether the specific area was breached or not, backwater influence, etc. Low altitude aerial photos ere also taken at this time. The helicopter would then land and drop off the first crew to complete the ground survey and fill in the habitat inventory form. A separate form for each specific area was filled out. The remaining crew would then proceed to the next specific area downstream of the first team and complete that area. This "leap-frogging" down the river was a fast and efficient way of covering many specific areas each day. On the average, 27 specific areas were visited per day.

DESCRIPTION AND USE OF THE HABITAT INVENTORY FORM

PAGE ONE

Crew: A minimum of two people were sent to evaluate each specific area. Two people were important because of the subjectivity of the work. The ability to discuss the habitat and work out perceived differences helped remove most of the individual bias from the data. The names of the individuals were entered.

Date and Time: The date and time a specific area was visited was recorded.

R.M.: Each specific area was referenced to a river mile with respect to the mainstem looking upriver: left (L), right (R), or middle (M) if between two mainstem forks. The river mile was entered.

Category: The perceived habitat transformation category of the specific area was recorded.

Location: This was used if another designation was commonly used to reference the specific area.

Mainstem Discharge: This data was obtained from USGS records at Gold Creek.

Breached: Whether the channel head berm was breached or not was recorded.

Mean Reach Velocity: Three methods were used in estimating mean reach velocities. These methods were discussed in detail in the Hydraulic Component section.

Site Specific Discharge: The discharge was estimated using the equation Q=V(W)(d), where V is estimated mean reach velocity (fps), W is the representative top width (ft), and d is the mean depth of the portion of the top width conveying most of the flow (ft).

Does Upwelling Occur: Visual detection was recorded as positive if actual upwelling was observed as a volcano-like structure in fine sediments or as gravel seepages seen primarily along and close to the banks. If an area was breached, turbidity made it difficult to determine if upwelling occurred. A response of "cannot be detected visually" was then appropriate. A negative response was recorded only if a channel was dewatered or consisted of isolated pools.

Do Tributaries Enter the Slough or Side Channel?: If one or more tributaries entered the specific area, a brief description of each was recorded. Information included where it entered the specific area, its estimated discharge, and the effect this additional inflow has on fish habitat.

Head Gage, Mid-Reach Gage, Mouth Gage: One or more staff gages were occasionally in place within the specific area. If so, the water surface elevation and gage number was recorded, as well as any remarks about the condition of the gage (bent or broken).

Substrate: The coding scheme and methods chosen for this habitat inventory parameter corresponded directly with ADF&G survey methodology (Estes and Vincent-Lang 1984). The preliminary field trip included ADF&G personnel to explain the coding procedure. The substrate type and corresponding code numbers follow:

Code	Type	Size (inches)
1	Silt	
2	Silt and Sand	
3	Sand	
4	Sand and Small Gravel	
5	Small Gravel	1/8 - 1
6	Small and Large Gravel	
7	Large Gravel	1 - 3
8	Large Gravel and Rubble	
9	Rubble	3 - 5
10	Rubble and Cobble	
11	Cobble	5 - 10
12	Cobble and Boulder	
13	Boulder	10+

This was one of the more difficult parameters to average for an entire specific area. For this reason, several codes indicating substrate size were often chosen and a map indicating substrate zones within the specific area was drawn on page two of the habitat inventory form. The overall characteristics of the substrate in a specific area were quickly and easily recorded in this manner.

Substrate Embeddedness: Substrate embeddedness descriptions and their code numbers are as follows:

Code	Description
1	Embedded, consolidated, and cemented
2	Embedded but not cemented
3	Not embedded

Embeddedness implies a larger substrate material partially or fully buried in smaller material. If a substrate constituent was not embedded in smaller material it was coded number 3. Substrate that was partially embedded but not consolidated was coded a number 2. The degree of consolidation was determined mainly by trying to penetrate the upper substrate layer with a boot. If the upper layer was difficult to break through, then the substrate was considered cemented for a substrate embeddedness code of 1.

Dominant Cover Code: The codes used were developed by ADF&G (Schmidt et al. 1984) and are as follows:

Code	Type
1	No Cover
2	Emergent Vegetation
3	Aquatic Vegetation
4	Large Gravel
5	Rubble
6	Cobble/Boulder
7	Debris/Deadfall
8	Overhanging Riparian
9	Undercut Banks

One code was chosen only if the cover available in the specific area was dominated by one type. More than one cover code was recorded if the available cover in a specific area was a mixture of types.

Percent Cover: This number indicates the percentage surface area available as cover to juvenile fish. These codes were developed by ADF&G (Schmidt et al. 1984) and are presented below:

Code	Percent Cover
1	0-5
2	6-25
3	26-50
4	51-75
5	76-95
6	96-100

Streambank Slope: Streambank slope and stability for both the left and right banks was recorded. The slope was determined to be steep if the horizontal to vertical ratio was greater than or equal to 1:1 (code number 1); moderate if the ratio was between 1:1 and 20:1 (code number 2); and flat if the ratio was greater than 20:1 (code number 3). The streambank stability was determined by observing the composition of each bank. Sandy banks and broad, flat gravel bars were generally considered the least stable while rocky or heavily vegetated banks were considered more stable.

Streambank Vegetation: The vegetation for each bank was recorded according to the following codes:

Code	Description
1	Less than 50 percent of streambank vegetated
2	Dominant vegetation is grass
3	Dominant vegetation is of tree form
4	Dominant vegetation is shrub

Two or more codes were used if one code did not adequately describe the vegetation. The areas of differing vegetation were then noted on page two of the habitat inventory form.

Representative Top Width, Bankfull Top Width, Representative Depth, and Bankfull Depth: Depth was measured using a yardstick or surveyor rod and distances were determined using either a Ranging 600 range finder or fiberglass tape. Bankfull top widths and bankfull depths were sometimes impossible to measure. A shoal is an excellent example; shoals areas have only one bank. Some difficulty in determining the water line for bankfull depths was encountered. This was overcome by observing indicators such as debris lines, water stained or dirty rocks, damage to streambank vegetation, or from the channel morphology.

Water Clarity: Water within each specific area was determined to be clear or turbid. If it was turbid the depth, in feet, of how far one could see into the water was determined by reading the lowest visible mark on a survey rod or yardstick.

Length of Backwater: The intrusion of backwater was either measured or estimated, in feet, from the point of the confluence with the mainstem.

Were Fish Observed?: Determination of fish presence was through visual observation. Information recorded included the presence or absence of fish, whether the fish was an adult or juvenile, the species, the abundance, and the activity (spawning adults for example). To ensure positive identification of juvenile fish, attempts were made to capture a sample using either a beach seine or a hand-held dip net. The beach seine, used primarily in turbid water, proved to be too time consuming. The use of this form of capture was discontinued after the first field trip.

PAGE TWO

Page two of the habitat inventory form again begins with the crew, date, time, and specific area designation.

Site Sketch and Habitat Mapping: A sketch of each specific area was drawn. Additionally, any notes or insights about the area were recorded here. Information on plan form; habitat types; discharge; velocities; size of pools, riffles, runs, and their relative proportions; fish usage; general slope or gradient of the streambed; substrate; vegetation; fish activities; and any other information which would help expand on the descriptions of page one to further characterize the habitat of each specific area was recorded.

Habitat Type Proportions: After the first field trip it became apparent that a description of the proportions of habitat would help more fully describe the specific area, so this parameter was added. An estimate of the percentage of pool and/or riffle and/or run for the entire specific area was recorded.

Habitat Quality Proportions: This was another parameter included after the first field trip. The study team felt it was very important to be able to record general impressions of the overall quality of the habitat at each specific area. The habitat quality proportions are only for juvenile fish. A percentage figure was recorded for each of the following codes:

Code	Description
1	No habitat value
2	Habitat quality was poor
3	Habitat quality was fair
4	Habitat quality was good
5	Habitat quality was excellent

For example, a specific area could have been recorded as 20%, code 2, poor habitat; 30%, code 3, fair habitat; and 50%, code 4, good habitat. Habitat quality proportions were based on the study teams knowledge of fishery habitats.

PAGE THREE

Page three of the habitat form was used to record photographs taken at each site. The header information is the same on this page as previous pages with the addition of film I.D. Number. The film roll number and initials of the photographer were recorded. The number of individual photos and their corresponding description make up the rest of the page. Photographs were taken to help describe the specific area in general, or a particular feature of the area (such as substrate).

PAGE FOUR

Page four of the form was used for additional notes or detailed drawings which would help further describe a specific area.

APPENDIX 3

AQUATIC HABITAT TRANSFORMATIONS OF SPECIFIC AREAS OF THE MIDDLE SUSITNA RIVER AT SEVERAL MAINSTEM DISCHARGES REFERENCED TO 23000 CFS

APPENDIX 3

Aquatic Habitat Transformations of Specific Areas of the Middle Susitna River at Several Mainstem Discharges Referenced to 23000 cfs

Mainstem Q(cfs)

River Mile	23000	18000	16000	12500	10600	9000	7400	5100
100.40 R	SC	4	4	2	2	2	2	2
100.60 R	SS	1	1	1	1	1	1	1
100.60 L	SC	4	4	4	4	3	3	3
100.70 R	MS	10	10	4	4	4	4	4
101.20 R	SC	4	4	4	4	2	2	2
101.30 M	SC	4	4	4	4	9	9	9
101.40 L	SC	2	2	2	2	2	2	2
101.50 L	MS	10	10	10	10	4	4	4
101.60 L	SC	4	4	2	2	2	2	2
101.70 L	SC	4	4	4	4	3	3	3
101.71 L	MSS	8	8	8	8	9	9	9
101.80 L	SC	2	2	2	2	2	2	2
102.00 L	SC	4	4	4	4	9	9	9
102.20 L	US	1	1	1	1	1	1	1
102.60 L	SC	4	4	4	4	4	4	3
104.00 R	IMS	6	6	6	6	6	6	6
104.30 M	SC	4	3	9	9	9	9	9
105.20 R	US	1	1	1	1	1	1	1
105.70 R	MS	10	10	10	10	10	10	10
105.81 L	MSS	6	6	6	6	6	6	6
106.30 R	SC	4	4	4	4	4	4	4
107.10 L	SC	4	4	4	4	3	9	9
107.60 L	US	1	1	1	1	1	1	1
108.30 L	US	1	1	1	1	1	1	1
108.70 L	MS	10	10	4	4	4	4	4
108.90 L	MS	10	10	10	10	10	10	10
109.30 M	MSS	6	6	6	6	9	9	9
109.40 R	MS	10	10	10	10	10	10	10
109.50 M	SC	4	4	9	9	9	9	9
110.40 L	SC	4	4	4	2	2	2	2
110.80 M	SC	4	4	4	4	4	4	4
111.00 R	MS	10	10	10	10	10	10	10
111.50 R	MS	10	10	4	4	4	4	4
111.60 R	MSS	6	6	6	8	8	9	9
112.40 L	SC	9	9	9	9	9	9	9
112.50 L	US	1	1	1	1	1	1	1
112.60 L	MS	4	4	4	4	4	4	4

Habitat Type at Reference Flow
IMS = Indistinct Mainstem
MSS = Mainstem Shoal
ISC = Indistinct Side Channel

SC = Side Channel
SS = Side Slough
US = Upland Slough
MS = Mainstem

River Mile	23000	18000	16000	12500	10600	9000	7400	5100
113.10 R	SS	1	1	1	1	1	1	1
113.60 R	IMS	6	6	6	6	8	8	8
113.70 R	SS	1	1	1	1	1	1	1
113.80 R	IMS	6	6	6	6	6	6	6
113.90 R	IMS	6	6	6	6	6	6	8
114.00 R	MS	4	4	4	4	4	4	4
114.10 R	ISC	5	5	5	5	5	5	5
115.00 R	SC	4	4	4	2	2	2	2
115.60 R	SC	2	2	2	2	2	2	2
116.80 R	MS	10	10	4	4	4	4	4
117.00 M	ISC	6	6	8	8	8	9	9
117.10 M	SC	4	4	3	3	3	3	3
117.20 M	SC	3	9	9	9	9	9	9
117.70 L	IMS	6	6	5	5	5	5	5
117.80 L	SC	4	4	4	4	4	2	2
117.90 R	SC	4	4	4	4	4	4	3
117.90 L	SC	2	2	2	2	2	2	2
118.00 L	SC	3	3	3	3	3	3	3
118.60 M	ISC	5	5	8	8	8	8	8
118.91 L	MSS	6	6	6	6	6	6	6
119.11 L	MSS	6	6	6	6	6	6	6
119.20 R	SC	4	4	4	4	3	3	3
119.30 L	SC	4	4	2	2	2	2	2
119.40 L	US	1	1	9	9	9	9	9
119.50 L	SC	4	4	4	4	4	4	4
119.60 L	SC	4	4	4	4	4	4	4
119.70 L	SC	2	2	2	2	2	2	2
119.80 L	SC	4	4	9	9	9	9	9
120.00 R	US	1	1	1	1	1	1	1
120.00 L	SC	4	4	3	3	3	9	9
121.10 R	IMS	6	6	6	6	6	6	5
121.10 L	SC	4	4	4	4	4	4	3
121.50 R	SC	3	3	3	3	9	9	9
121.60 R	SC	4	4	3	3	9	9	9
121.70 R	MS	10	10	4	4	4	4	4
121.80 R	SC	3	3	3	3	3	3	3
121.90 R	US	1	1	1	1	1	1	1
122.40 R	SS	1	1	1	1	1	1	1
122.50 R	SC	2	2	2	2	2	2	2
123.00 L	SC	4	4	4	4	4	4	4
123.10 R	US	1	1	1	1	1	1	1
123.20 R	ISC	8	8	8	8	8	8	9
123.30 R	US	1	1	1	1	1	1	1
123.60 R	SS	1	1	1	1	1	1	1

Habitat Type at Reference Flow

IMS = Indistinct Mainstem

MSS = Mainstem Shoal

ISC = Indistinct Side Channel

SC = Side Channel

SS = Side Slough

US = Upland Slough

MS = Mainstem

River Mile	23000	18000	16000	12500	10600	9000	7400	5100
124.00 M	ISC	7	7	7	7	7	7	7
124.10 L	MS	10	10	10	10	10	10	4
124.80 R	ISC	8	8	8	8	8	8	9
125.10 R	SC	2	2	2	2	2	2	2
125.20 R	MS	4	4	4	4	4	4	4
125.60 L	MSS	6	6	6	6	5	5	5
125.60 R	SC	9	9	9	9	9	9	9
125.70 R	SC	4	4	4	4	4	4	4
125.90 R	SS	1	1	1	1	1	1	1
126.00 R	SS	1	1	1	1	1	1	1
126.30 R	SC	4	2	2	2	2	2	2
127.00 M	SC	4	4	4	4	4	4	4
127.10 M	IMS	6	6	6	5	5	5	5
127.20 M	US	1	1	1	1	1	1	1
127.40 L	MS	10	10	10	10	10	4	4
127.50 M	ISC	6	6	6	6	5	5	5
128.30 R	IMS	6	6	6	6	6	6	6
128.40 R	MSS	6	6	6	5	5	9	9
128.50 R	SC	4	4	4	4	2	2	2
128.70 R	SC	4	4	2	2	2	2	2
128.80 R	SC	4	2	2	2	2	2	2
129.30 L	IMS	10	10	10	10	5	5	5
129.40 R	US	1	1	1	1	1	1	1
129.50 R	ISC	6	6	5	5	5	5	5
129.80 R	MS	10	10	10	10	10	10	10
130.20 R	SC	4	4	4	2	2	2	2
130.20 L	SC	4	4	4	4	4	3	3
131.20 R	IMS	5	5	5	5	5	5	5
131.30 L	SC	4	4	4	4	4	2	2
131.70 L	SC	4	4	4	4	4	4	4
131.80 L	SS	1	1	1	1	1	1	1
132.50 L	SC	4	4	9	9	9	9	9
132.60 L	SC	4	4	4	4	3	3	3
132.80 R	IMS	7	7	7	7	7	7	7
133.70 R	SC	4	4	4	2	2	2	2
133.80 L	SC	4	2	2	2	2	2	2
133.81 R	MSS	6	6	6	6	6	6	6
133.90 R	US	1	1	1	1	1	1	1
133.90 L	US	1	1	1	1	1	1	1
134.00 L	US	1	1	1	1	1	1	1
134.90 R	SC	4	4	4	4	4	4	4
135.00 R	SC	9	9	9	9	9	9	9
135.00 L	MS	10	10	10	10	10	10	10
135.10 R	SC	3	3	3	3	3	3	3
135.30 L	SC	3	3	3	3	3	3	3
135.50 R	SC	9	9	9	9	9	9	9

Habitat Type at Reference Flow

IMS = Indistinct Mainstem

MSS = Mainstem Shoal

ISC = Indistinct Side Channel

SC = Side Channel

SS = Side Slough

US = Upland Slough

MS = Mainstem

River Mile	23000	18000	16000	12500	10600	9000	7400	5100
135.60 R	SS	1	1	1	1	1	1	1
135.70 R	SS	1	1	1	1	1	1	1
136.00 L	SC	4	4	4	4	4	4	4
136.30 R	SC	4	4	2	2	2	2	2
136.90 R	US	1	1	1	1	1	1	1
137.20 R	SC	4	4	4	4	2	2	2
137.50 R	SC	2	2	2	2	2	2	2
137.50 L	US	1	1	1	1	1	1	1
137.80 L	SC	2	2	2	2	2	2	2
137.90 L	SC	2	2	2	2	2	2	2
138.00 L	SC	4	4	4	4	4	2	2
138.71 L	MSS	6	6	6	6	6	6	6
138.80 R	IMS	6	5	5	5	5	5	9
139.00 L	US	1	1	1	1	1	1	1
139.01 L	MSS	6	6	6	6	6	6	6
139.20 R	IMS	6	6	6	6	6	6	6
139.30 L	MSS	6	6	6	6	6	6	6
139.40 L	SC	4	4	4	4	4	4	4
139.41 L	MSS	6	6	6	6	6	6	6
139.50 R	IMS	6	6	6	5	5	7	7
139.60 L	MS	10	10	10	10	10	10	4
139.70 R	SC	2	2	2	2	2	2	2
139.90 R	US	1	1	1	1	1	1	1
140.20 R	SS	1	1	1	1	1	1	1
140.40 R	IMS	6	6	6	6	6	6	6
140.60 R	ISC	6	6	5	8	8	9	9
141.20 R	IMS	6	6	6	5	5	5	5
141.30 R	IMS	5	5	5	5	5	5	5
141.40 R	SC	4	4	4	2	2	2	2
141.60 R	ISC	7	7	7	7	7	7	7
142.00 R	ISC	5	5	5	5	8	8	8
142.10 R	SS	1	1	1	1	1	1	1
142.80 R	IMS	6	6	6	6	6	6	6
142.80 L	MSS	6	6	6	6	6	6	6
143.00 L	MSS	6	6	6	6	6	6	7
143.40 L	SS	1	1	1	1	1	9	9
144.00 R	MS	10	10	10	10	10	4	4
144.00 M	SC	9	9	9	9	9	9	9
144.20 L	MS	10	10	10	10	10	10	10
144.40 L	SC	2	2	2	2	2	2	2
145.30 R	MS	10	10	10	10	10	10	4
145.60 R	SC	9	9	9	9	9	9	9
146.60 L	SS	1	9	9	9	9	9	9
147.10 L	MS	10	10	10	10	10	10	10
148.20 R	MSS	6	6	6	9	9	9	9

Habitat Type at Reference Flow
IMS = Indistinct Mainstem
MSS = Mainstem Shoal
ISC = Indistinct Side Channel
SC = Side Channel
SS = Side Slough
US = Upland Slough
MS = Mainstem

APPENDIX 4

APPROXIMATE BREACHING FLOWS OF SPECIFIC AREAS OF THE MIDDLE SUSITNA RIVER

APPENDIX 4

Approximate Breaching Flows of Specific Areas of the Middle Susitna River

River Mile	Breaching Flow	Model Type	River Mile	Breaching Flow	Model Type
100.40 R	12500		113.80 R	<5100	
100.60 R	US		113.90 R	7000	
100.60 L	9200		114.00 R	<5100	
100.70 R	<5100		114.10 R	<5100	DIM
101.20 R	9200	IFG	115.00 R	12000	DIM
101.30 M	9200		115.60 R	22000	
101.40 L	22000	RJHAB	116.80 R	<5100	
101.50 L	<5100	IFG	117.00 M	15500	
101.60 L	14000		117.10 M	15500	
101.70 L	9600		117.20 M	20000	
101.71 L	MSS	DIM	117.70 L	<5100	
101.80 L	22000		117.80 L	8000	
102.00 L	10000		117.90 R	7300	
102.20 L	US		117.90 L	19500	
102.60 L	6500		118.00 L	22000	
104.00 R	<5100		118.60 M	14000	
104.30 M	16500		118.91 L	MSS	DIM
105.20 R	US		119.11 L	MSS	DIM
105.70 R	<5100		119.20 R	10000	IFG
105.81 L	MSS	DIM	119.30 L	16000	
106.30 R	4800		119.40 L	US	
107.10 L	9600		119.50 L	5000	
107.60 L	US	RJHAB	119.60 L	<5100	
108.30 L	US		119.70 L	23000	
108.70 L	<5100		119.80 L	15500	
108.90 L	<5100		120.00 R	US	
109.30 M	MSS		120.00 L	12500	
109.40 R	<5100		121.10 R	<5100	
109.50 M	16000		121.10 L	7400	
110.40 L	12000		121.50 R	19500	
110.80 M	<5100		121.60 R	15500	
111.00 R	<5100		121.70 R	<5100	
111.50 R	<5100		121.80 R	22000	
111.60 R	11500		121.90 R	US	
112.40 L	22000		122.40 R	25000	
112.50 L	US	RJHAB	122.50 R	20000	
112.60 L	<5100	IFG	123.00 L	<5100	
113.10 R	26000		123.10 R	US	
113.60 R	10500		123.20 R	22000	
113.70 R	24000	RJHAB	123.30 R	US	

US = Upland Slough
RJHAB = ADF&G Habitat Model
MSS = Mainstem Shoal
DIM = EWT&A Direct Input Model
IFG = Instream Flow Group

River Mile	Breaching Flow	Model Type
123.60 R	25500	
124.00 M	20000	
124.10 L	<5100	
124.80 R	19500	
125.10 R	20000	
125.20 R	<5100	DIM
125.60 L	<5100	
125.60 R	22000	
125.70 R	22000	
125.90 R	26000	
126.00 R	33000	IFG
126.30 R	26000	
127.00 M	<5100	
127.10 M	<5100	
127.20 M	US	
127.40 L	<5100	
127.50 M	<5100	
128.30 R	<5100	
128.40 R	9000	
128.50 R	10400	
128.70 R	15000	
128.80 R	16000	IFG
129.30 L	<5100	
129.40 R	US	
129.50 R	<5100	
129.80 R	<5100	
130.20 R	12000	DIM
130.20 L	8200	
131.20 R	<5100	
131.30 L	8000	DIM
131.70 L	5000	IFG
131.80 L	26900	
132.50 L	14500	
132.60 L	10500	IFG, RJHAB
132.80 R	19500	
133.70 R	11500	
133.80 L	17500	IFG
133.81 R	MSS	DIM
133.90 R	US	
133.90 L	US	
134.00 L	US	
134.90 R	<5100	IFG
135.00 R	21500	
135.00 L	<5100	
135.10 R	20000	
135.30 L	18500	
135.50 R	21000	
135.60 R	42000	
135.70 R	27500	
136.00 L	<5100	IFG
136.30 R	13000	IFG
136.90 R	US	
137.20 R	10400	
137.50 R	22000	DIM
137.50 L	US	
137.80 L	20000	
137.90 L	21000	
138.00 L	8000	
138.71 L	MSS	DIM
138.80 R	6000	
139.00 L	US	
139.01 L	MSS	DIM
139.20 R	<5100	
139.30 L	MSS	
139.40 L	<5100	
139.41 L	MSS	DIM
139.50 R	8900	
139.60 L	<5100	
139.70 R	22000	
139.90 R	US	
140.20 R	26500	
140.40 R	<5100	
140.60 R	12000	
141.20 R	<5100	
141.30 R	<5100	
141.40 R	11500	IFG
141.60 R	21000	IFG
142.00 R	10500	
142.10 R	23000	
142.80 R	<5100	
142.80 L	<5100	
143.00 L	7000	
143.40 L	30000	
144.00 R	<5100	
144.00 M	22000	
144.20 L	<5100	
144.40 L	21000	RJHAB
145.30 R	<5100	
145.60 R	22000	
146.60 L	26500	
147.10 L	<5100	IFG
148.20 R	MSS	

US = Upland Slough
RJHAB = ADF&G Habitat Model
MSS = Mainstem Shoal
DIM = EWT&A Direct Input Model
IFG = Instream Flow Group

APPENDIX 5

FISH OBSERVATIONS

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All fish observations made during the field reconnaissance are presented below. Most observations were made late in the spawning season. Consequently, some of the specific areas may have had spawning activity before the field investigations took place. There were no fish observed in 58 (34%) of the 172 specific areas visited during the field work. Fish observations included an estimate of numbers, species, and life stage (i.e., adult or juvenile). In addition, any spawning activity and the number of redds observed were also recorded.

ADULT AND JUVENILE SALMON OBSERVATIONS
HABITAT INVENTORY 8-21-84 THROUGH 10-2-84

RM = River Mile
L = Left Bank Looking Upstream
R = Right Bank Looking Upstream
M = Middle of River (usually island)
* = Spawning Activity Observed As Indicated by the Presence of Redds or Spawning Behavior.

SPECIFIC AREA (RM)	DATE	OBSERVATIONS
100.4R	09-11-84	Lots of coho juveniles
100.4R	10-02-84	One unidentified juvenile in pool (dry channel)
100.5R	09-11-84	Chum salmon adults
100.6R*	08-22-84	Chum salmon adults, unidentified juveniles, redds
100.6R*	10-02-84	Unidentified juveniles, several redds, scattered salmon eggs
100.6L	09-11-84	Pink and chum adults, few unidentified juveniles
101.2R*	09-11-84	Twenty+ chum adults and several redds
101.3L	09-11-84	Two dead chum, 1 dead pink
101.4L*	09-10-84	Coho juvenile (dead), juvenile chinooks
101.4L*	08-22-84	Chum, pink adults, several unidentified juveniles
101.6L	08-22-84	About 10 chum adults
101.6L*	09-10-84	Spawning chum, adult sockeye, numerous unidentified juveniles
101.7L	09-10-84	One adult chum, 1 chum carcass
101.8L*	09-10-84	Hundreds of juvenile (coho), 3 adult sockeye, 3 adult chum
101.8L*	10-02-84	Lots of unidentified juvenile salmonids
102.0L	09-10-84	One unidentified juvenile salmonid, 2 unidentified carcasses
102.2L*	09-10-84	Thousands of salmonid juveniles (identified 2 coho and 1 sockeye
102.2L*	10-02-84	Hundreds of unidentified salmonid juveniles, 15 redds, 1 sockeye adult, 2 chum adults, 1 dead pink
105.2R	09-10-84	Few juveniles (chino, coho)
107.1L	09-10-84	Chum and pink carcasses
107.6L	09-10-84	One pink carcass, several juveniles (2 identified as coho)
109.3M	09-10-84	One chum carcass
109.5M	09-10-84	One chum carcass
110.4L	08-22-84	One chum adult, 1 chum carcass
111.5R	09-06-84	Several chum carcasses, couple of unidentified juveniles
111.5R	10-01-84	Several chum carcasses, lots of unidentified juveniles
111.6R	09-06-84	Three chum carcasses

SPECIFIC AREA (RM)	DATE	OBSERVATIONS
112.5L	09-06-84	Several unidentified juveniles
112.5L	09-06-84	Thousands of juveniles unidentified
112.5L	08-22-84	Unidentified juveniles
112.6L	09-06-84	Several juvenile chinook
112.6L	09-11-84	Juvenile salmonids - unidentified
113.6R	09-06-84	Chum and pink carcasses - 1 juvenile unidentified
113.7R*	09-06-84	About 40 adult chum, lots of juveniles (chinook and coho)
113.7R*	08-22-84	About 50 adult chum
113.7R*	09-11-84	Greater than 20 adult chum, redds, juvenile chinook, coho, sockeye
114.0R	09-06-84	Chum carcasses, 1 adult chum, chinook juvenile (1)
114.1R	09-06-84	One chum carcass
115.0R*	09-06-84	Fourteen+ adult chums, 1 sockeye adult, 1 unidentified juvenile
115.0R*	08-22-84	Several adult chums
115.0R*	09-06-84	Several chinook juveniles, 1 rainbow juvenile
115.6R*	09-06-84	Sixty+ adult chum, several chinook juveniles, 1 rainbow juvenile
116.3R	09-06-84	One chum carcass, several unidentified juveniles
117.0M	09-06-84	Several chum carcasses
117.1M	09-06-84	Chinook juveniles
117.1M	08-22-84	Several unidentified juveniles
117.2M	09-06-84	Scattered eggs
117.85L	10-01-84	Chinook and coho juveniles
117.9R	09-06-84	Adult coho (in tributary), chum carcass, unidentified juveniles
117.9L*	09-06-84	Two coho juveniles
118.91L*	09-07-84	About 16 chum adults
119.11L*	09-07-84	About 6 chum adults, 3 redds
119.2R	09-07-84	Several unidentified juveniles
119.3L*	09-07-84	Two chum adults, chinook and sockeye juveniles, 1 grayling
119.4L	09-07-84	A few unidentified juveniles
119.4L*	08-22-84	Redds
119.5L	09-07-84	Several chinook juveniles and unidentified
119.7L	09-07-84	Coho juveniles
120.0L	09-07-84	Unidentified juveniles
120.0R*	09-07-84	One redd observed
121.1L*	09-07-84	One chum adult, 2 unidentified juveniles
121.5R	09-07-84	Chinook juveniles
121.6R	09-07-84	Chinook juveniles
121.7R	09-07-84	Chum adults, chinook juveniles
121.8R*	08-22-84	Chum adults, unidentified juveniles
121.8R*	09-07-84	Greater than 40 chum adults
121.9R*	09-07-84	One chum carcass, chinook juvenile, obvious spawning activity

SPECIFIC AREA (RM)	DATE	OBSERVATIONS
122.4R*	09-07-84	Several chum adults, several redds, coho juvenile
122.5R*	09-07-84	About 150 chum adults, unidentified juveniles, chinook juvenile
122.5R*	08-21-84	Chum adults
123.1R	09-07-84	Several unidentified juveniles
123.1R	09-30-84	Many unidentified juveniles
123.2R	09-07-84	Several chinook and coho juveniles, 1 grayling juvenile
123.3R	09-30-84	One unidentified juvenile
123.6R*	08-21-84	Sockeye and chum adults
123.6R*	09-07-84	Chum adults, chinook and coho juveniles
124.0M	09-07-84	Several chinook juveniles
125.1R	09-05-84	Two chum carcasses
125.1R	09-05-84	Several unidentified juveniles
125.2R	09-05-84	One chum adult, few unidentified juveniles
125.9R*	08-21-84	Few sockeye adults, 75+ chum adults, school of unidentified juveniles
125.9R*	09-05-84	Sockeye and chum adults
126.0R*	09-05-84	Sockeye and chum adults, several unidentified juveniles
126.0R*	08-21-84	Some sockeye adults, few pink adults, hundreds of chum adults
126.3R*	08-05-84	Sockeye and chum adults
127.0L	09-05-84	One chum carcass, several unidentified juveniles
127.4L	09-05-84	Several unidentified juveniles
127.5M	09-05-84	One chum carcass
128.3R	09-05-84	One chum, chinook juveniles
128.5R	09-05-84	Chinook juveniles
128.7R*	09-05-84	Chum adults
128.8R*	08-21-84	Several adult chums
128.8R*	09-05-84	Several unidentified juveniles
129.4R*	09-05-84	Several chum adults, unidentified juveniles
129.5R	09-05-84	Chum adults
129.5R	09-30-84	One coho carcass
130.2R*	09-05-84	Chum adults, chinook juveniles
130.2L*	09-05-84	One chum carcass, unidentified juveniles (1 chinook identified)
131.3L*	09-05-84	Chum adults, redds
131.7L*	09-04-84	Lots of chum adults, few unidentified juveniles
131.8L*	09-04-84	About 20 chum adults, lots of redds, 1 unidentified juvenile
132.6L	09-05-84	Unidentified juveniles
132.8R*	09-05-84	Chum adults, 1 dead chinook juvenile
133.7R*	08-21-84	Some chum adults
133.7R*	09-04-84	Chum adults, few chinook juveniles
133.8R	09-04-84	Chum adults, 1 unidentified juvenile
133.8L	08-21-84	Chum adult
133.8L	09-05-84	Chinook juveniles
133.9R*	09-04-84	Chinook juveniles
133.9L*	09-04-84	Chum adults, chinook juveniles

SPECIFIC AREA (RM)	DATE	OBSERVATIONS
134.0L	09-04-84	One chum carcass, few unidentified juveniles
134.9R*	08-21-84	One chum adult, 1 chum carcass
134.9R*	09-04-84	Several chum adults, several unidentified juveniles
135.0L*	09-04-84	Chinook and unidentified juveniles
135.1R	09-04-84	Several unidentified juveniles
135.6R*	09-04-84	Hundreds of sockeye adults, thousands of chum adults, chinook juveniles
135.6R*	08-21-84	Sockeye, chum, pink adults greater than 400 fish
135.7R	08-21-84	Some chum adults, 2 pink carcasses, several unidentified juveniles (1 chinook)
136.0L	09-04-84	Two chum carcasses, unidentified adults
136.3R*	09-04-84	Chum adults, chinook juveniles
137.2R*	09-04-84	Chum adults, 2 unidentified juveniles
137.5R	09-04-84	Chum adults, 2 chum carcasses, chinook juveniles
137.5L	09-04-84	Chum carcasses, chinook juveniles
137.9L	08-21-84	Few unidentified juveniles
138.7L	09-04-84	One chum carcass, 1 unidentified adult
139.01L*	09-04-84	About 30 chum adults
139.0L*	08-21-84	Some sockeye adults, 50+ chum adults, 1 pink carcass
139.4L	09-03-84	Several chum carcasses, several unidentified juveniles (1 chinook identified)
139.5R	09-03-84	Sockeye and chum adults
139.6L	09-03-84	Several chum carcasses, several unidentified juveniles (1 chinook identified)
139.9R*	09-03-84	Sockeye and chum adults, chinook juveniles
140.2R*	08-21-84	Lots of chum adults, lots of unidentified juveniles
140.2R*	09-03-84	About 12 chum adults, lots of coho and chinook juveniles
140.6R*	09-03-84	Several chum carcasses, redds, few unidentified adults (1 chinook identified)
141.4R*	09-03-84	Hundreds to thousands of sockeye and chum adults, chinook juveniles
141.6R*	08-21-84	Some sockeye adults, hundreds of chum adults, 1 unidentified juvenile
142.0R	09-03-84	Chum adults, unidentified juveniles
142.0R	09-29-84	Fifteen+ unidentified juvenile fish
142.1R*	09-03-84	Sockeye and chum adults, greater than 500 chinook juveniles, several unidentified juveniles
142.8L*	09-03-84	Fifty+ chum adults
143.0L*	09-03-84	Twelve+ chum adults, unidentified juveniles
143.4L*	09-03-84	Thirty-two+ chum adults, unidentified juveniles (1 chinook identified)
144.2L	09-03-84	Chum carcass, chinook juveniles
144.4L*	08-21-84	Fifty+ chum adults
145.6R	08-21-84	One chinook juvenile