2909

SUSITNA HYDROELECTRIC PROJECT

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INSTREAM FLOW RELATIONSHIPS REPORT SERIES

RESPONSE OF JUVENILE CHINOOK HABITAT TO DISCHARGE IN THE TALKEETNA-TO-DEVIL CANYON SEGMENT OF THE SUSITNA RIVER, ALASKA

TECHNICAL REPORT No. 5
PART A

PREPARED BY

Trihey & Associates
Aquatic Resource Specialists

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

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SUSITNA HYDROELECTRIC PROJECT

RESPONSE OF JUVENILE CHINOOK HABITAT TO MAINSTEM DISCHARGE IN THE TALKEETNA-TO-DEVIL CANYON SEGMENT OF THE SUSITNA RIVER, ALASKA

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Under Contract to
Harza-Ebasco Susitna Joint Venture

Prepared for
Alaska Power Authority

Final Report
December 1985

NOTICE

ANY QUESTIONS OR COMMENTS CONCERNING
THIS REPORT SHOULD BE DIRECTED TO
THE ALASKA POWER AUTHORITY
SUSITNA PROJECT OFFICE

PREFACE

The goal of the Alaska Power Authority in identifying environmentally acceptable flow regimes for the proposed Susitna Hydroelectric Project is the maintenance of existing fish resources and levels of production. This goal is consistent with mitigation goals of the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game. Maintenance of naturally occurring fish populations and habitats is the preferred goal in agency mitigation policies.

In 1982, following two years of baseline studies, a multi-disciplinary approach to quantify effects of the proposed Susitna Hydroelectric Project on existing fish habitats and to identify mitigation opportunities was initiated. The Insteam Flow Relationships Studies (IFRS) focus on the response of fish habitats in the middle Susitna River to incremental changes in mainstem discharge, temperature and water quality. As part of this multi-disciplinary effort, a technical report series was planned that would (1) describe the existing fish resources of the Susitna River and identify the seasonal habitat requirements of selected species, and (2) evaluate the effects of alternative project designs and operating scenarios on physical processes which most influence the seasonal availability of fish habitat.

The summary report for the IFRS, the Instream Flow Relationships Report (IFRR), (1) identifies the biologic significance of the physical processes evaluated in the technical report series, (2) integrates the findings of the technical report series, and (3) provides quantitative relationships and discussions regarding the influences of incremental changes in streamflow, stream temperature, and water quality on fish habitats in the middle Susitna River on a seasonal basis.

The IFRR consists of two volumes. Volume I uses project reports, data and professional judgment to identify evaluation species, important life stages, and habitats. The report ranks a variety of physical habitat components with regard to their degree of influence on fish habitat at different times of the year. This ranking considers the biologic requirements of the evaluation species and life stage, as well as the physical characteristics of different habitat types, under both natural and anticipated with-project conditions. Volume II of the IFRR will address the third objective of the IFRR and provide quantitative relationships on a seasonal basis regarding the influences of incremental changes in streamflow, stream temperature, and water quality on fish habitats in the middle Susitna River.

The influence of incremental changes in streamflow on the availability and quality of fish habitat is the central theme of the IFRR Volume II analysis. Project-induced changes in stream temperature and water quality are used to condition or qualify the forecasted responses of fish habitat to instream hydraulics. The influence of streamflow on fish habitat will be evaluated at the microhabitat level and presented at the macrohabitat level in terms of a composite weighted usable area curve. This composite curve will describe the combined response of fish habitat, at all sites within the same representative group (to incremental changes in mainstem discharge).

Four technical reports are being prepared by E. Woody Trihey and Associates in support of the IFRR Volume II analysis. The function of each report is depicted in a flow diagram and described below.

1) Quantify Wetted Surface Area Response

2) Assess the Representativeness of Modeled and Non-modeled Sites

3) Determine Site-Specific Hydraulic Conditions

4) Quantify Streamflow-Dependent Habitat Response Functions for Juvenile Chinook and Spawning Chum Salmon

1) RESPONSE OF AQUATIC HABITAT SURFACE AREAS TO MAINSTEM DISCHARGE IN THE TALKEETNA-TO-DEVIL CANYON SEGMENT OF THE SUSITNA RIVER, ALASKA

This report identifies five aquatic habitat types within the middle Susitna River directly influenced by changes in mainstem discharge and presents the necessary photography and surface area measurements to quantify the change in wetted surface area associated with incremental decreases in mainstem discharge between 23,000 and 5,100 cfs. The report also describes the influence of mainstem discharge on habitat transformations and tabulates the wetted surface area responses for 172 specific areas using the ten representative groups presented in the Habitat Characterization Report. Surface area measurements presented in this report provide a basis for extrapolating results from intensively studied modeling sites to the remainder of the middle Susitna River.

2) CHARACTERIZATION OF AQUATIC HABITATS IN THE TALKEETNA-TO-DEVIL CANYON SEGMENT OF THE SUSITNA RIVER, ALASKA

This report describes the characterization and classification of 172 specific areas into ten representative groups that are hydrologically, hydraulically and morphologically similar. Emphasis is placed on the transformation of specific areas from one habitat type to another in response to incremental decreases in mainstem discharge from 23,000 cfs to 5,100 cfs. Both modeled and non-modeled sites are classified and a structural habitat index is presented for each specific area based upon subjective evaluation of data obtained through field reconnaissance surveys.

Representative groups and structural habitat indices presented in this report provide a basis for extrapolating habitat response functions developed at modeled sites to non-modeled areas within the remainder of the river.

3) HYDRAULIC RELATIONSHIPS AND MODEL CALIBRATION PROCEDURES AT 1984 STUDY SITES IN THE TALKEETNA-TO-DEVIL CANYON SEGMENT OF THE SUSITNA RIVER, ALASKA

This report describes the influence of site-specific hydraulic conditions on the availability of habitat for juvenile chinook and spawning chum salmon. Two aquatic habitat models are applied to quantify site-specific habitat responses to incremental changes in depth and velocity for both steady and spatially varied streamflow conditions. Summaries of site-specific stage-discharge and flow-discharge relationships are presented as well as a description of data reduction methods and model calibration procedures. Weighted usable area forecasts are provided for juvenile chinook at 8 side channel sites and for spawning chum salmon at 14 side channel and mainstem sites. These habitat response functions provide the basis for the instream flow assessment of the middle Susitna River.

4) RESPONSE OF JUVENILE CHINOOK AND SPAWNING CHUM SALMON HABITAT TO MAINSTEM DISCHARGE IN THE TALKEETNA-TO-DEVIL CANYON SEGMENT OF THE SUSITNA RIVER, ALASKA

This report integrates results from the surface area mapping, habitat characterization, and hydraulic modeling reports to provide streamflow dependent habitat response functions for juvenile chinook and spawning chum salmon. Wetted surface area and weighted usable area are the principal determinants of habitat indices provided in Part A of the report for juvenile chinook at each specific area and the ten representative groups identified in the habitat characterization report. Part B of this report provides habitat response functions for existing chum salmon spawning sites. The habitat response functions contained in this report will be used for an incremental assessment of the rearing and spawning potential of the entire middle Susitna River under a wide range of natural and with-project streamflows.

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1.0 INTRODUCTION

Due to the economic importance of the species, the ecological sensitivity of the life stage, and their extensive use of mainstem-associated habitats, juvenile chinook have been designated as a primary evaluation species to be used in analyses of existing and with-project conditions. Chum salmon spawning and incubation life stages comprise the other two primary species/life stages selected for evaluation (EWT&A and Entrix 1985).

This report addresses the effects of flow variation on the availability and quality of juvenile chinook salmon habitat within the Talkeetna to Devil Canyon reach of the Susitna River. The response of juvenile chinook habitat to changes in streamflow within this middle reach of the Susitna River has been the subject of several years of data collection and modeling studies conducted by the Alaska Department of Fish and Game (ADF&G) and Trihey and Associates (EWT&A). These investigations are part of an extensive environmental assessment program conducted to fulfill licensing requirements for the proposed Susitna Hydroelectric Project.

The Alaska Power Authority (APA), the state agency responsible for developing the hydropower potential of the Susitna River, has indicated a desire to maintain existing fish resources and levels of production within affected reaches of the river (APA 1985). This goal may be attainable through a variety of mitigative options (Moulton et al. 1984). However, to protect existing fisheries resources and to ensure the success of selected mitigation and enhancement efforts, it is necessary to identify and adopt instream flows and reservoir operation schedules which will provide for the needs of the fish species inhabiting the middle Susitna River.

The storage and release of water to meet the instream flow needs of fishes downstream is not necessarily incompatible with hydropower interests. The recharge and storage capabilities of the proposed Devil Canyon and Watana reservoirs [refer to APA (1985) for a description of the design criteria and construction schedule for these facilities] will permit water to be stored during periods when natural runoff exceeds both the water demand for power generation and the instream flow needs of resident and anadromous fishes. This will allow for the controlled release of water during periods of greatest demand for power.

Under the license application presently before the Federal Energy Regulatory Commission the development of the Susitna hydroelectric project is planned to occur in three stages (APA 1985).

- Stage I is the construction and operation of the Watana dam by 1999 which will provide 2.37 million acre feet of active storage. This is approximately 40 percent of the mean annual flow at the damsite and affords some seasonal regulation.
- Stage II is construction of a dam by 2005 in the narrow Devil Canyon. The principal purpose is to develop head relying upon the Watana dam to regulate flows for power production.
- Stage III involves raising the Watana dam 180 feet by 2012 to increase active storage to 3.7 million acre feet, approximately 64 percent of the mean annual flow.

The license application presents environmental flow cases E-1 through E-VI which are aimed to provide different maintenance levels of habitats most responsive to mainstem flows. Case E-VI is the selected flow case in the application and is designed to maintain 75 percent of the existing chinook salmon side channel rearing habitat in all years except low flow years. There are four projected flow scenarios for Case E-VI depending upon the stage of development of the project. Figure 1 compares natural with simulated with-project mean weekly discharges at Gold Creek for these four scenarios.

The frequency and rate of change of daily flow fluctuations in the middle Susitna River will be highest during Stage I and II. However, by Stage III daily flow fluctuations are expected to be minimal. Over the long-term, use of the combined storage volume of the two reservoirs will result in lower summer and higher winter flows than presently occur.

As the demand for electricity varies over time, so do the instream flow needs of a fish species vary according to their life history stage. Adult chinook spawn exclusively within tributaries of the middle reach of the Susitna River, principally Indian River and Portage Creek. Consequently, the reproductive and early post-emergent fry life stages of chinook (unlike those of chum, pink and sockeye salmon which spawn in both tributary and non-tributary habitats of the middle Susitna River) are not likely to be affected by project operation. The later freshwater life stages of chinook salmon, including juvenile and migratory phases, will be subjected to altered streamflow regimes since they utilize mainstem and mainstem-influenced habitats (Figure 2). The summer growth season is an important period for chinook juveniles since it is at this time that density-dependent factors will typically have their greatest effect on the population.

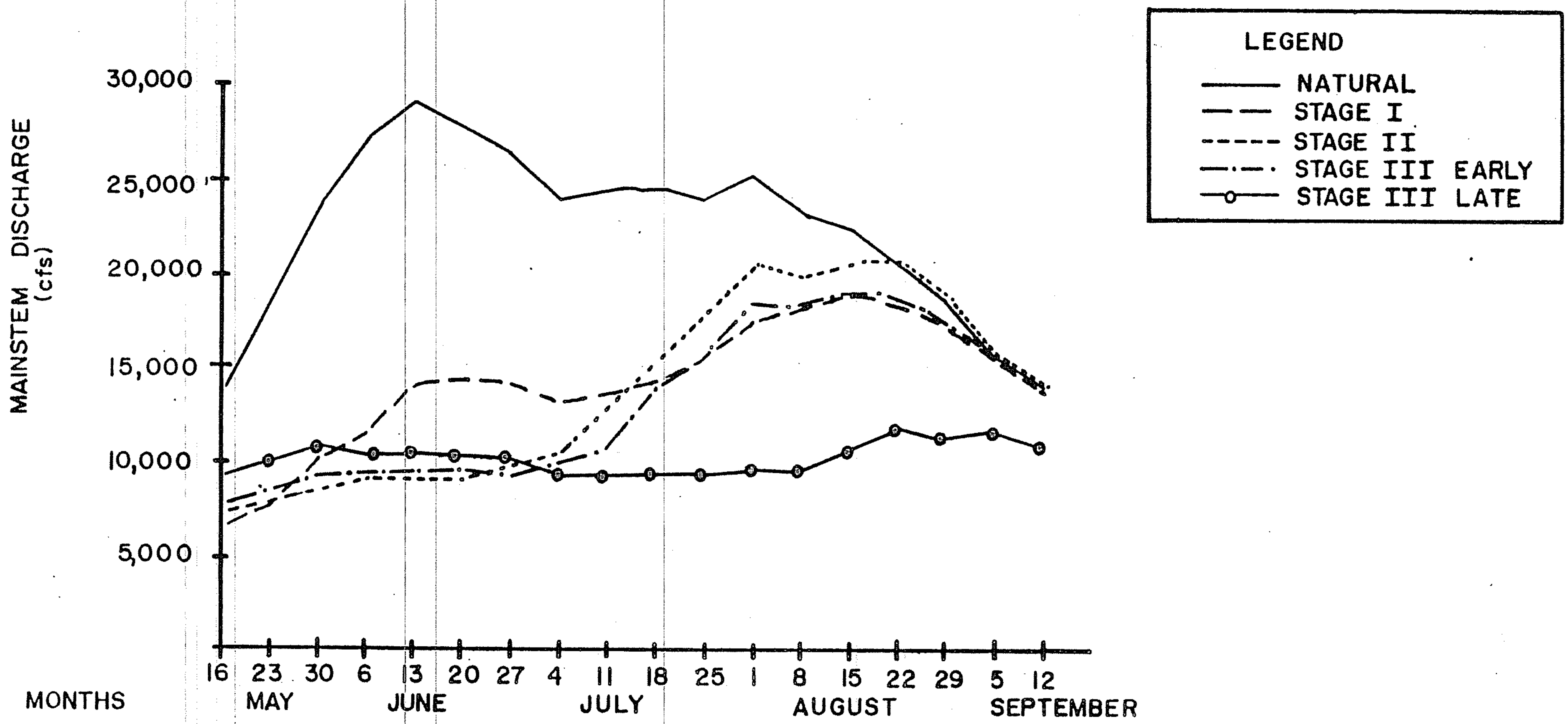


Figure 1. Natural and with-project mean weekly discharges for the middle Susitna River. Natural flows are based on 35 year record (1950-1984) from USGS Station 15292000 at Gold Creek. Simulated with-project flows are based on Case E-VI, demand levels Stage I, Stage II, early and late Stage III (data from APA 1985).

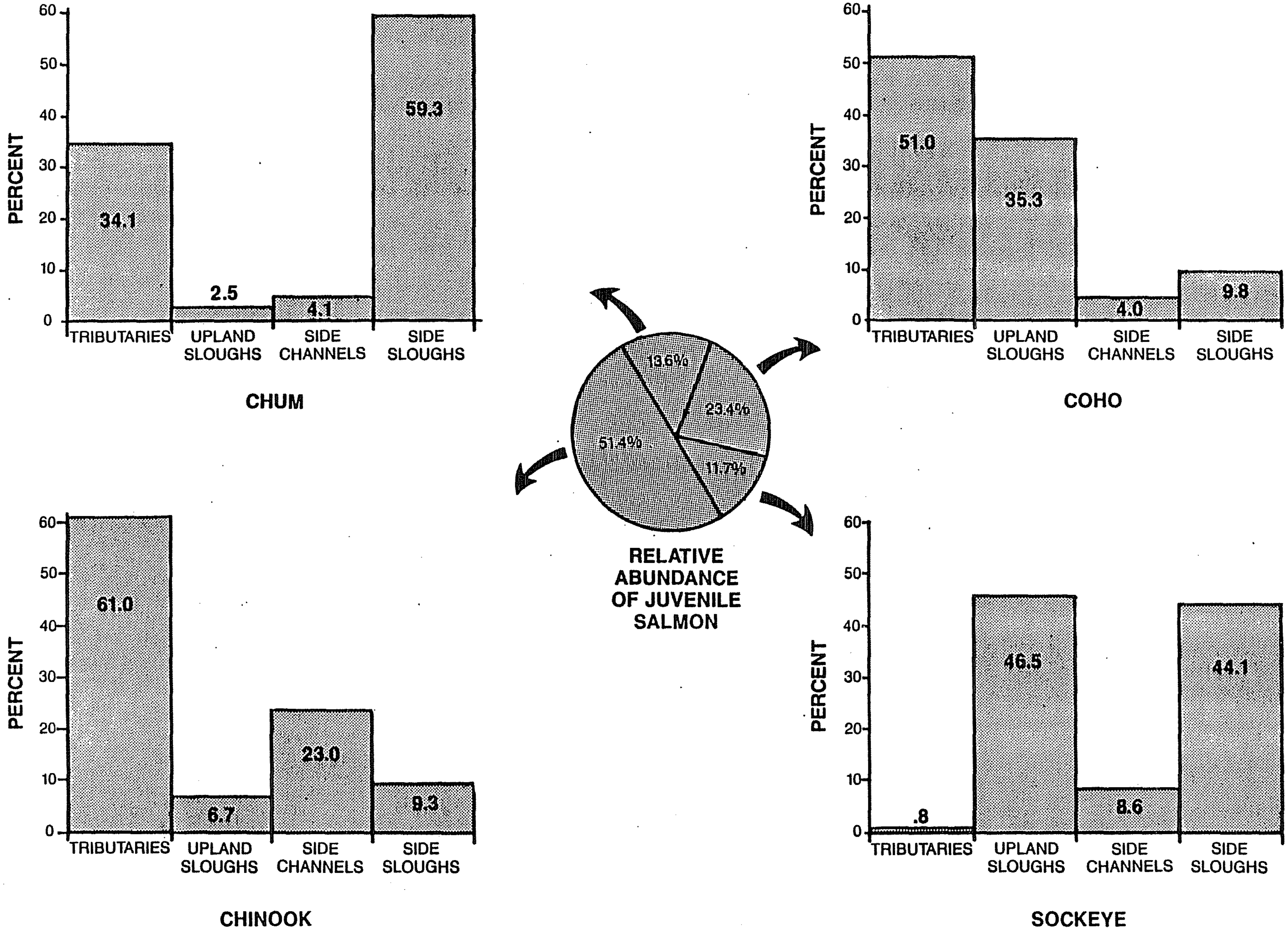


Figure 2. Percentage distribution of juvenile salmon within different habitat types of the middle Susitna River during the open water period (Dugan, Sterritt, and Stratton 1984).

Following emergence in March and April juvenile chinook typically spend several months rearing in their natal streams. However, the numbers and biomass of juvenile fish may exceed the carrying capacity of the tributaries by midsummer and a percentage of the chinook population respond by emigrating to the Susitna River. During the remainder of their freshwater residency, which usually lasts until the spring of the following year, juvenile chinook typically occupy a range of habitats. Densities are highest in tributaries, side channels and side sloughs, respectively, during July to September of the open water season (Figure 3). Chinook distribution during the winter months is not well documented other than a noted tendency for individuals in mainstem and side channel areas to seek relatively warmer upwelling areas in side sloughs. During the fall a significant number of young-of-the-year chinook apparently migrate downstream late in the summer, although it is uncertain whether they overwinter in fresh or saltwater (Dugan et al. 1984).

The biological and physical factors affecting juvenile chinook salmon in their rearing environment and their interrelationships are complex. Milner (1985) reviewed these environmental factors and their potential effects. Food availability, predation, and competition are among the more important biological factors. All are mediated to some degree by the quantity and quality of physical habitat which constitute the fish's living space. Physical habitat includes the combination of hydraulic, structural and chemical variables to which juvenile chinook respond either behaviorally or physiologically. Stream temperature, turbidity, suspended sediment level, water depth and velocity, cover, and substrate texture are important physical habitat variables which are either directly or indirectly influenced by the volume and pattern of streamflow.

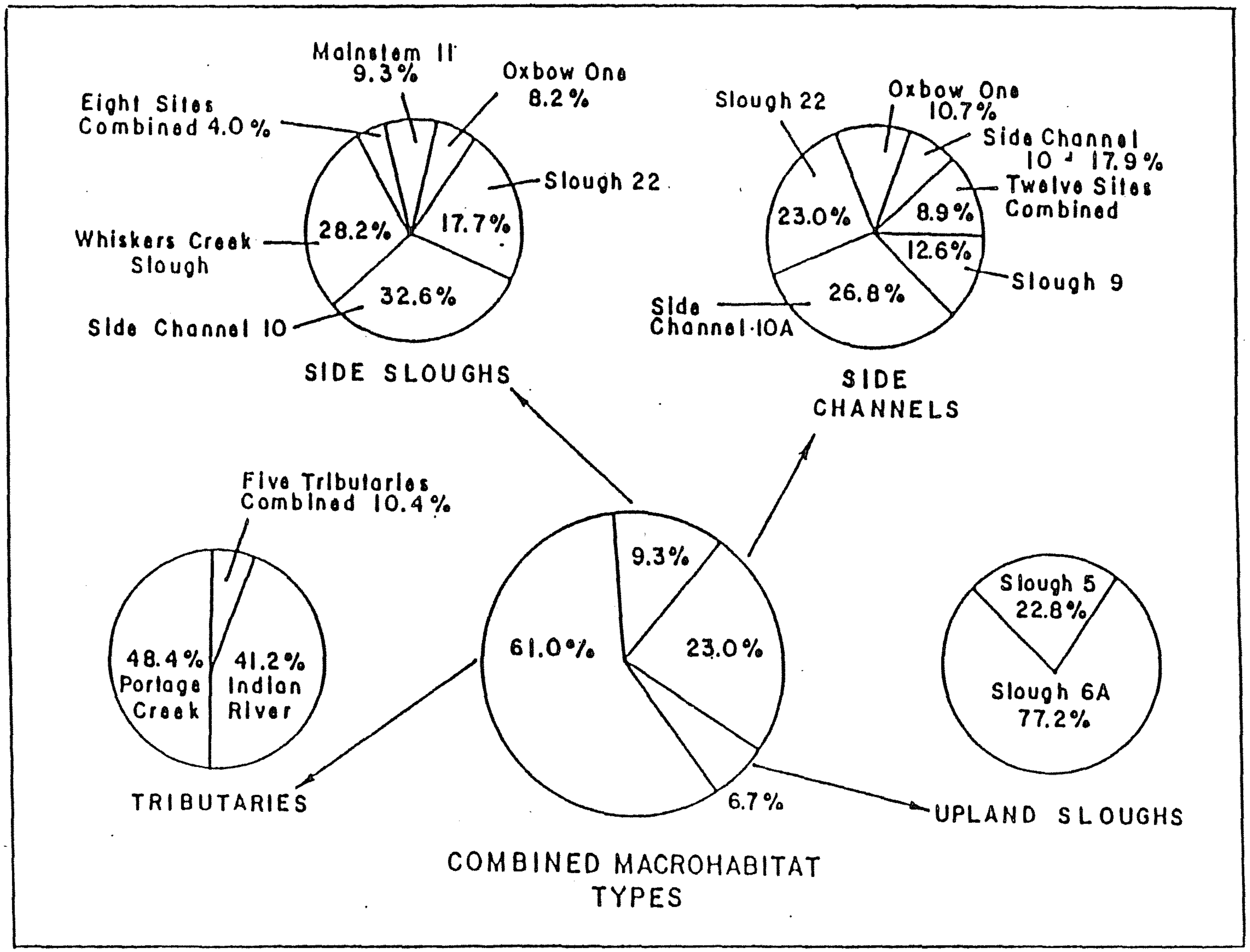


Figure 3. Density distribution of juvenile chinook salmon by macrohabitat type on the Susitna River between Chulitna River confluence and Devil Canyon, May through November 1983. Percentages are based on mean catch per cell (Dugan, Sterritt, and Stratton 1984).

The goal of minimizing potentially adverse effects of flow alterations associated with hydropower generation is possible only if the magnitude of the impacts is known, thereby presenting two major problems. The first relates to the quantification of existing resources and the relationships which sustain them. The second problem is methodological: how can predictions of with-project conditions be superimposed on natural conditions to enable accurate forecasts?

For example, our knowledge of the population dynamics of chinook salmon stocks of the middle Susitna River yields little insight into their likely long-term response to with-project flow regimes. Population adjustments are frequently determined by combinations of environmental properties occuring far in advance of the biological response. Thus, although fish production and its component parameters (i.e., density, mortality, growth, etc.) may eventually reflect the influence of causative environmental factors, the complexity of these relationships is too great and there is too much variability in our estimates to base our forecasts entirely on population studies. We are not limited as much by our ability to conceptualize the relationships linking juvenile chinook to their environment as we are by our ability to measure and test these relationships.

This problem is not a new one. Fisheries biologists faced with the task of identifying acceptable instream flows often make their selection because it appears to make biological sense, and not on the basis of mathematically defined relationships between streamflow and biological response. In the past decade, however, an instream flow assessment methodology has been developed which partially bridges this gap. The Instream Flow Incremental Methodology (IFIM) described by Bovee (1982) provides a computer assisted capability of simulating important components of fish habitat based on site-specific field measurements. The suitability of fish habitat at a given flow is evaluated by reference to preference criteria. These are frequency distributions which describe the probability that a fish will be found in association with a particular level or interval of the habitat component in question. Once the spatial distribution and levels of habitat components are known or are reliably simulated for a range of flows, and the relationships between these components and behavioral preferences have been quantified, then a habitat response index may be calculated for each flow of interest. Following standard IFIM terminology, this habitat response index is termed Weighted Usable Area (WUA). From an assumption that the amount of suitable habitat in a stream varies with flow, the direction and magnitude of WUA may be considered reliable indicators of the probable population response to discharge alterations. This assumption has been verified for some salmonid streams but not for others (Nelson 1980, Loar 1985). Factors other than the amount of usable habitat, such as inadequate food supplies and catastrophic events (e.g., floods), may have been responsible for the conflicting results.

Nevertheless, the concept of habitat preference appears valid for this study and the linkage between biological response and flow-related habitat changes, as indexed by WUA should be strong enough to make inferences concerning the present status and likely trends in juvenile chinook populations.

Included in this report are WUA functions and related habitat indices defining the relationship between mainstem discharge and chinook rearing habitat potential at 20 study (modeling) sites on the middle Susitna River. Modeling results are extrapolated from individual study sites to describe the response of juvenile chinook habitat within a number of different sub-environments of the middle Susitna River. Conventional methods of extrapolating WUA in single channel rivers based on the concept of continuous homogeneous subsegments represented by individual modeling sites are not applicable to large braided rivers like the the Susitna River due to large spatial variations in hydraulic and morphologic character (see Aaserude et al. 1985). Consequently, investigators concentrated on sampling smaller areas or portions of the middle Susitna River possessing relatively uniform yet comparatively distinct hydrologic, hydraulic and water clarity characteristics. This sampling design prompted the development of an extrapolation methodology, first outlined by Steward and Trihey (1984), which weights WUA indices developed for each modeling site according to the portions of the middle reach possessing similar hydrologic, hydraulic and water clarity attributes. Characterizing fish habitat at this level acts to overcome problems associated with the large degree of environmental variability present in the system and improves the applicability of these results to the entire middle Susitna River.

Within the overall framework of the Susitna aquatic habitat assessment program, habitat modeling results obtained for individual habitat types are particularly appropriate since related studies of juvenile fish distribution were conducted at this level (Hoffman 1985). An evaluation of habitat modeling results in combination with fish utilization data will permit an accurate assessment of rearing habitat response to natural and project-induced changes in streamflow for the entire middle Susitna river segment.

Figure 4 illustrates the primary steps in the extrapolation analysis. An outline of the data requirements and steps which comprise the methodology follows in order that the reader gain an appreciation of the utility of the rearing habitat response curves. The results of applying the full extrapolation analysis to existing flow regimes will be detailed in Volume II of the Instream Flow Relationships Report, scheduled for release by EWT&A in December 1985.

Quantification

Quantify surface areas of individual channel branches in the middle Susitna 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 individual aquatic habitats into groups that are hydrologically and morphologically similar.

Simulation

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

Integration

For each evaluation species/life stage:

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

Figure 4. Flow chart indicating steps followed in the extrapolation of site-specific juvenile chinook habitat indices to the entire middle Susitna River.

2.0 METHODS

2.1 Habitat Characterization of the Middle Susitna River

2.1.1 Study Site Classification

For the middle reach of the Susitna River, Klinger and Trihey (1984) describe six habitat types, on the basis of water source and morphology: mainstem, side channel, side slough, upland slough, tributary, and tributary mouth. Rearing habitat modeling sites were initially selected to conform with the concept of aquatic habitat types. The degree to which these habitat types are utilized by juvenile salmon as well as their susceptibility to project impacts determined the extent to which they were represented in modeling studies. Of the large number of locations sampled for juveniles in 1981 and 1982, significant numbers of chum, sockeye, and chinook salmon were found in tributary, side channel, side slough and upland slough locations. Chinook salmon utilization of these habitat types was summarized in Figure 3. Recognizing that rearing habitat in tributaries will not be affected by project operation, investigators excluded this habitat type from modeling studies. Utilization of mainstem and tributary mouth areas by juvenile salmon was low and not intensively studied. The sites chosen for modeling studies of juvenile chinook habitat are identified by river mile and bank orientation (L and R denote left and right bank looking upstream) in Figure 5.

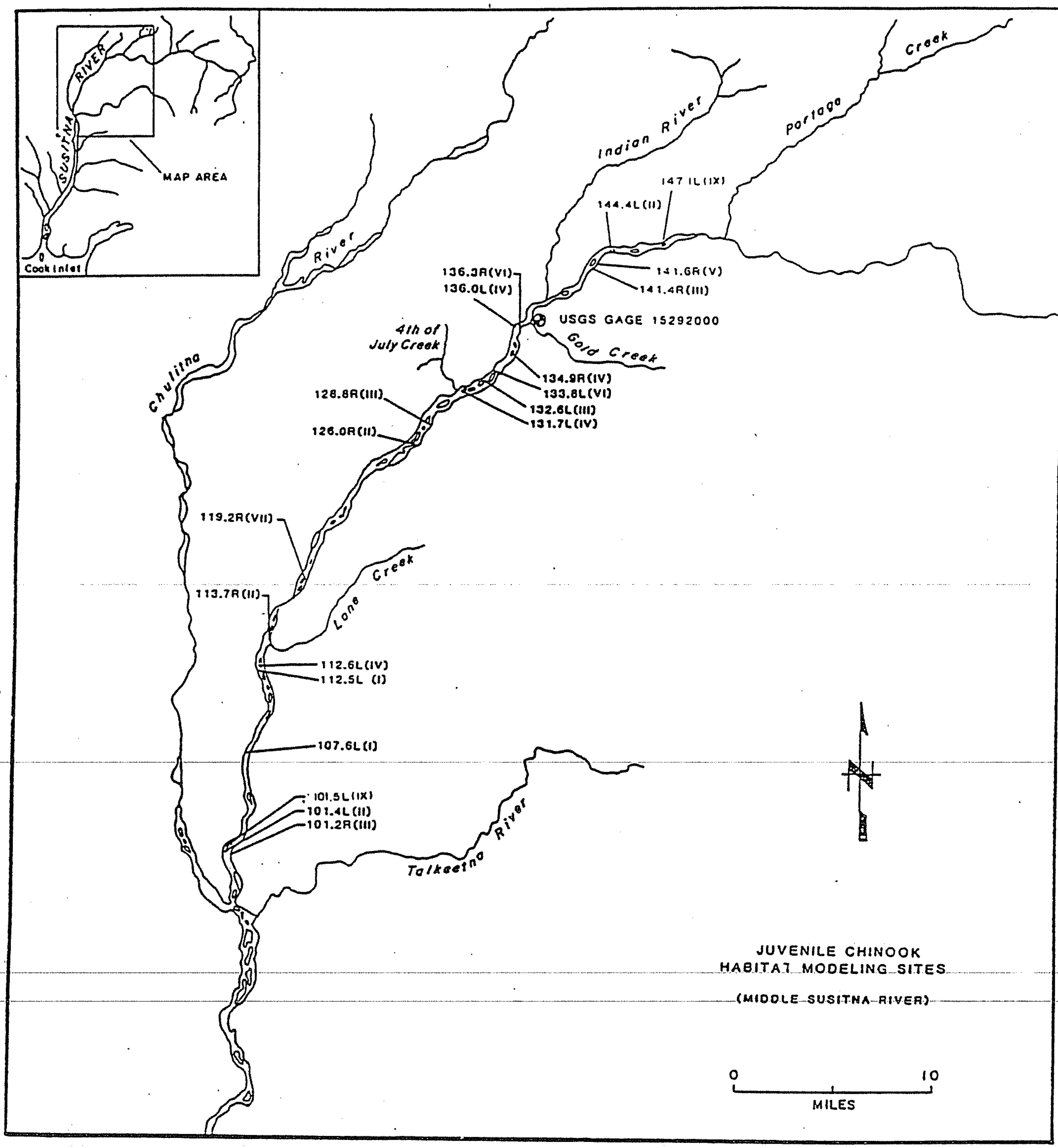


Figure 5. Juvenile chinook habitat modeling sites in the middle Susitna River. Sites are identified by river mile and bank orientation, where L and R denote left and right bank looking upstream.

2.1.2 Representative Groups

While the habitat type concept described by Klinger and Trihey (1984) is useful in the identification of attributes characterizing a particular location within the middle Susitna River at a given time, the static quality implicit in the concept makes it less practical as a means of stratifying the river for extrapolation purposes. The results of the habitat modeling analyses are WUA forecasts for sites which frequently transform from one of these habitat types to another over the range of evaluation flows. The habitat quality and the distribution of the juvenile chinook is dependent upon these transformations and the progressive physical changes which attend them.

In order that the dynamic and site-specific nature of rearing habitat response to a constantly changing aquatic environment be acknowledged by the extrapolation methodology, an alternate means of stratifying the middle Susitna River was developed. The concept of representative groups as a further set of distinct portions of the middle Susitna River and the criteria used by Aaserude et al. (1985) to define them ensures that the modeling sites are truly representative of the habitats of the river they are intended to characterize. Accurate forecasts of the response of juvenile chinook to natural or imposed changes in flow regime require that this condition be satisfied.

Aaserude et al. (1985) delineated 172 specific areas of the middle Susitna River from aerial photography interpretation and field verification studies. Specific areas formerly divided among four habitat types (side channel, side slough, upland slough, and in some cases mainstem habitats) were reassigned among ten representative groups, each characterized by unique and readily identifiable combinations of flow-related attributes. Representative groups and the primary hydrologic, hydraulic and morphologic forms and processes which distinguish them are summarized in Table 1.

Each modeling site is associated with a corresponding specific area; from an analysis of aerial photography and reconnaissance level field data, a modeled specific area may also be determined to be representative of several non-modeled specific areas within the same representative group. Within the framework of the extrapolation methodology, the collection of modeled and non-modeled specific areas which comprise a particular representative group may be thought of as a discontinuous (i.e., spatially discontinuous) yet homogeneous subsegment of the river.

Figure 5 indicates the representative group designation of each rearing habitat modeling site. Because the delineation of representative groups occurred subsequent to study site selection and data collection, some representative groups do not possess specific areas in which modeling studies were conducted. In particular, specific areas which dewater at relatively high mainstem discharges (Group VIII) and mainstem areas which remain shoal-like at most evaluation flows (Group X) are not represented by juvenile chinook habitat modeling sites. The remainder of the representative groups have at least one specific area with an associated modeling study site. This fact is important since the objective is to extrapolate habitat indices from specific areas with modeled sites to non-modeled specific areas, assuming that modeling sites generally reflect the habitat character of non-modeled areas within the same representative group. As

REPRESENTATIVE GROUP	NUMBER OF SPECIFIC AREAS	DESCRIPTION	HABITAT MODELING SITES
I	19	Predominantly upland sloughs. The specific areas comprising this group are highly stable due to the persistence of non-breached conditions (i.e., possess high breaching flows). Specific area hydraulics are characterized by pooled clear water with velocities frequently near 0.0 fps and depths greater than 1.0 ft. Pools are commonly connected by short riffles where velocities are less than 1.0 fps and depths are less than 0.5 ft.	107.6L, 112.5L
II	28	This group includes specific areas commonly referred to as side sloughs. These sites are characterized by relatively high breaching flows (>19,500 cfs), clear water caused by upwelling groundwater, and large channel length to width ratios (>15:1).	101.4L, 113.7R, 126.0R, 144.4L
III	18	Intermediate breaching flows and relatively broad channel sections typify the specific areas within this Representative Group. These sites are side channels which transform into side sloughs at mainstem discharges ranging from 8,200 to 16,000 cfs. Lower breaching flows and smaller length to width ratios distinguish these sites from those in Group II. Upwelling groundwater is present.	101.2R, 128.8R, 132.6L, 141.4R
IV	21	Specific areas in this group are side channels that are breached at low discharges and possess intermediate mean reach velocities (2.0-5.0 fps) at a mainstem discharge of approximately 10,000 cfs.	112.6L, 137.7L 134.9R, 136.0L
V	9	This group includes mainstem and side channel shoal areas which transform to clear water side sloughs as mainstem flows recede. Transformations generally occur at moderate to high breaching discharges.	141.6R
VI	13	This group is similar to the preceding one in that the habitat character of the specific areas is dominated by channel morphology. These sites are primarily overflow channels that parallel the adjacent mainstem, usually separated by a sparsely vegetated gravel bar. Upwelling groundwater may or may not be present. Habitat transformations within this group are variable both in type and timing of occurrence.	133.8L, 136.3R
VII	7	These specific areas are typically side channels which breach at variable yet fairly low mainstem discharges and exhibit a characteristic riffle/pool sequence. Pools are frequently large backwater areas near the mouth of the sites.	119.2R
VIII	24	The specific areas in this group tend to dewater at relatively high mainstem discharges. The direction of flow at the head of these channels tends to deviate sharply (>30 degrees) from the adjacent mainstem. Modeling sites from Groups II and III possessing representative post-breaching hydraulic characteristics are used to model these specific areas.	132.6L, 144.4L
IX	21	This group consists of secondary mainstem channels which are similar to primary mainstem channels in habitat character, but distinguished as being smaller, and conveying a lesser proportion of the total discharge. Specific areas in this group have low breaching discharges and are frequently similar in size to large side channels, but have characteristic mainstem features, such as relatively swift velocities (>5 fps) and visibly coarser substrate.	101.5L, 147.1L
X	13	Large mainstem shoals and the margins of mainstem channels which show signs of upwelling are included in this representative group.	105.81L, 119.11L, 138.71L, 139.41L, 133.81R

Table 1. Primary hydrologic, hydraulic and morphologic characteristics of representative groups identified for the middle Susitna River.

will be discussed later in section 3.8, juvenile chinook habitat response within Group VIII was represented using modeling results from study sites in Groups II and III. The response for Group X was evaluated using Direct Input Habitat (DIHAB) models for spawning chum habitat at five of the sites, as outlined in section 3.10.

Important criteria used to partition specific areas into representative groups are the type and rate of change in hydrologic character documented for the specific areas. The hydrologic component of the method used by Aaserude et al. (1985) to stratify the middle Susitna River focuses on the systematic transformation in habitat type of specific areas within the 5,100 to 23,000 cfs flow range. For example, as flows recede mainstem areas frequently become shallow water shoals, and side channels may transform into side sloughs; both habitat types may eventually dewater as flows decrease further. The emphasis on habitat transformation acknowledges the transient nature of riverine habitat availability and distribution. The dichotomous key in Figure 6 delineates the eleven habitat transformation categories derived from an evaluation of the 172 specific areas and eight streamflows for the middle river. Note that the final categories approximate the original "habitat type" designations used by Klinger and Trihey (1984) and ADF&G (1983). Two important modifications to the habitat type classification system are the inclusion of shoal habitat and the presence/absence of upwelling. Shoals are areas which at high flows are visually inseparable from adjacent mainstem or side channel areas. As flows recede the shoal or riffle character of these sites becomes obvious, even though the boundaries separating shoals and adjacent

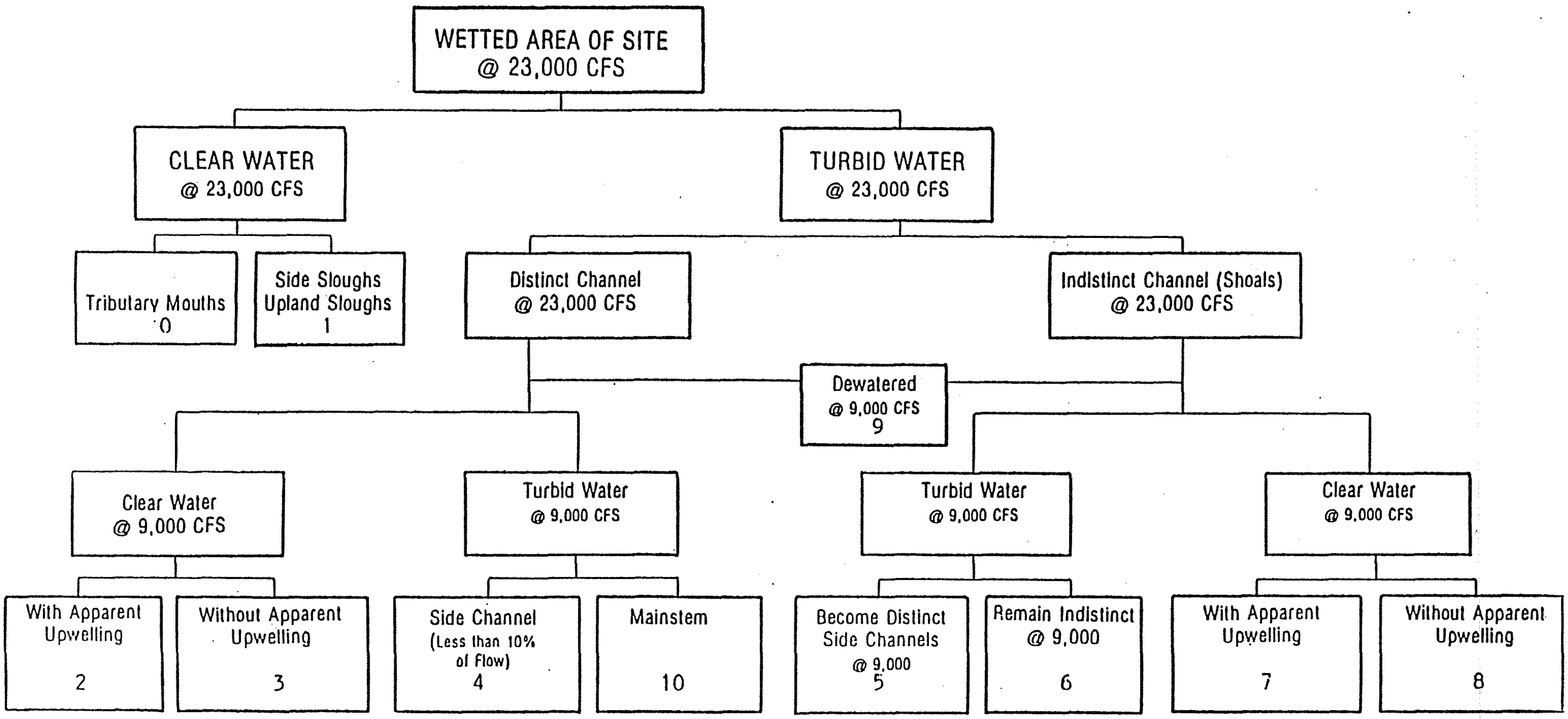


Figure 6. Flow chart for classifying the transformation of aquatic habitat types between two flows (Categories 0-10). It is important to note that habitat transformations can be monitored between any two flows of interest.

habitat types are usually indistinct. Specific areas fitting this description are further distinguished on the basis of whether their boundaries remain indistinct or transform into well-defined channels at lower flows.

Upwelling groundwater, usually discernable in aerial photos by the presence of clear water, is accentuated in the classification step of the extrapolation methodology because of its pronounced effect on the distribution of juvenile and adult salmon within the middle Susitna River.

Using habitat types present at 23,000 cfs as a point of reference, site-specific habitat transformations have been defined for several discharges of 18,000 cfs and less. The sequential changes in habitat type observed within this flow range offers a powerful tool with which to combine specific areas into representative groups. Other hydrologic parameters used with varying degrees of confidence to cluster specific areas into representative groups are breaching flow, cross-sectional profiles of the head berm and adjacent mainstem channel, and upwelling.

Of the hydraulic variables examined by Aaserude et al. (1985), mean reach velocity under breached conditions was considered the most appropriate for classifying specific areas within the middle Susitna River. Unfortunately, the relatively low flows (8,000 - 11,000 cfs) at which field sampling was conducted precluded standardization of mean reach velocities on the basis of a common flow or transformational state. Mean reach velocities were unavailable at sampling flows for two-thirds of the specific areas delineated in the middle Susitna River; the majority of the sites were unbreached during reconnaissance field studies. Nonetheless, the velocity data collected was used to further refine transformation category definitions.

Of more practical value in the development of representative groups were channel morphology indices derived from aerial photo interpretation and on-site visits in the field. Specific areas within the middle Susitna River exhibit sufficient similarities in plan form to provide a theoretically attractive means of grouping sites together. Use of channel geometry, sinuosity, length-to-width ratios and related morphologic indices to classify specific areas according to representative group is justified by the repetitiveness of similar channel features within the middle Susitna River segment.

2.2 Quantification

2.2.1 Description of Wetted Surface Area Responses

Although each specific area is assigned to the same representative group for all flows, the wetted perimeter and therefore its wetted surface area (WSA) varies with discharge. Furthermore, the rate of change in WSA relative to mainstem discharge varies between specific areas. Successful application of the extrapolation methodology requires that the WSA response to mainstem discharge be quantified, since the amount of rearing habitat available within a specific area is dependent on its areal extent at different flows.

The concept of a specific area requires fixed upstream and downstream boundaries. For example, a side slough specific area has a line across the head berm and a line across the mouth which do not change with flow. The WSA response for the side slough is due to flow-induced changes in length, width and convolution of the wetted perimeter within these boundaries. Once the head berm is overtopped, all increases in WSA are related to increases in channel width with increasing flow, as the channel length should remain constant.

The end product of the extrapolation methodology is the Representative Groups' WUA responses to mainstem discharge. Therefore, the WSA response curves should not include WSA response due to any sources other than mainstem discharge. If the WSA response of a site is not correlated with mainstem discharge, i.e., it varies widely or is constant, an average WSA value should be used to show the absence of mainstem influence. If the site WSA is correlated to mainstem discharge, then the WSA response should approximate a loglinear function.

To illustrate these concepts, consider a specific area which transforms from a side slough to a side channel at a mainstem flow of 15,000 cfs. Although for all flows below the 15,000 cfs breaching flow the specific area is a side slough, there are two ways mainstem flow can affect the WSA response of the site. Firstly, a backwater zone at the mouth would increase the WSA with increasing mainstem stage and, secondly, the mainstem may be a source of upwelling which increases the site flow with a concommitant increase in WSA. If these effects are strong, they will approximate a loglinear function, otherwise the site will have a flat WSA response to mainstem discharge. The WSA need not be constant, but may vary widely due to other local variables. Above breaching, the mainstem flow is the driving variable and again WSA should display a log linear relationship depending on the degree of irregularity of the channel geometry. Smooth parabolic cross sections should fit the loglinear relationship better than irregular cross sections.

2.2.2 Aerial Photography Database

Klinger and Trihey (1984) describe a methodology for obtaining wetted surface areas from aerial photographic plates, and are the source of the database of WSA's used in the WUA extrapolation for juvenile chinook salmon. There are two differences between the digitizing methods described for habitat types and those used for specific areas. Delineation of habitat types was not limited by the upstream and downstream boundaries used for specific areas, and, secondly, the control corridors used for habitat types were not employed for specific areas.

The aerial photography database consists of WSA measurements for all specific areas at seven mainstem discharges: 5,100, 7,400, 10,600, 12,500, 16,000, 18,000, and 23,000 cfs. To forecast WUA above 23,000 cfs and below 5,100 cfs, a method of extrapolating WSA beyond the range of the database was required. Since WSA is expected to follow a loglinear function, an extrapolation above 23,000 cfs using a logarithmic regression was the obvious choice. The use of logarithmic regression equations to approximate WSA response below 23,000 cfs would have the added benefit of minimizing errors in the aerial photography database.

The accuracy of the database in forecasting WSA response to mainstem discharge is dependent on two major forms of error:

1. Errors in estimating the true WSA of a specific area. These errors are caused by photographic distortion, shadows which obscure the sites, delineation of the specific area, and digitizing errors. There are two principal types of photographic error. Firstly, the aerial photography was not ground survey controlled, so when mosaics of the photographs were made into plates, there was a significant amount of topological distortion which varied from plate to plate. Second, due to differences in weather conditions at the flight time, slight variations in scale occurred in the sets of photography. These sources of error were not significant in the habitat type analysis since WSA's for each habitat type were summed for each flow, and distortions tended to cancel out. However, the extrapolation methodology follows the WSA response of individual specific areas, and this increased resolution over habitat type analysis is much more susceptible to distortion errors.

The 23,000 cfs photography, taken on June 1, 1982, was obtained at the time of year corresponding to high solar altitude and the deciduous vegetation had not fully leafed-out. This resulted in few shadows, thereby enabling excellent delineation of the wetted perimeter. However, the 5,100 and 7,400 cfs photography, obtained on October 4 and 14, 1984, respectively, have extensive areas of shadows along the south and east shorelines due to the low autumn solar altitude. These shadows obscured the water's edge of some specific areas making WSA delineation difficult and sometimes speculative. The remaining sets of photography have isolated shadow problems.

As mentioned previously, specific areas have upper and lower boundaries. Proper delineation of the WSA necessitates consistent positioning of the boundaries on each plate. The best method for accomplishing this is to first define the boundaries on the 5,100 cfs plate, where control points which may be submerged at a higher flow are readily identifiable, and use these bounds as a template for the higher flows. Unfortunately, the 5,100 and 7,400 cfs plates were not available until early 1985 after the other flows had already been digitized. This fact, and photographic distortion, lead to less than optimal control of WSA delineation. For some specific areas, determination of the wetted perimeter was exacerbated by the difficulty in discriminating between gravel bars and highly turbid water, both of which had approximately the same shade of grey on the black-and-white photography.

The Numonics Digitizing Tablet, used to convert delineated areas to a digital value, is accurate to a thousandth of an inch. However, since the photographic plates are taken at a scale of 1" = 1,000', some specific areas have a WSA value of only a few thousandths of an inch at certain flows and thus have a higher percent error.

2. Error induced by natural covariables. These are not true errors, but simply variables we do not want to include in the WSA responses used in the extrapolation methodology. These covariables fall into two types: firstly, those which affect the water mass, and secondly those related to channel geometry. In the first group, the effects are most noticeable in the nonbreached state. Some sites have large amounts of subsurface intragravel flow which acts as storage. If the hydrograph is falling at the time the photography was taken, there is a time lag between the stage of the nonbreached site and what we expect when the stage has stabilized. This timelag effect was quite pronounced for some sites. Also, local water sources such as small tributaries and runoff, may have greater influence on

the stage of some specific areas, most notably in Representative Groups I and II, than the mainstem when the sites are nonbreached. Since WSA is related to channel geometry as well as flow, any changes in the channel structure between the time different photo sets were taken will cause WSA errors. High-flow events following the 18,000 cfs photography caused small changes at some sites which, although negligible for habitat type summations, made the 18,000 cfs photography inappropriate for several specific areas.

2.2.3 Forecasting WSA with Regression Equations

Regression equations were used to predict WSA for specific areas in order to:

1. Extrapolate beyond the limits of the aerial photography
2. Minimize errors in estimating WSA for the photographic plates
3. Minimize variance of WSA due to "local" variables

The aim of this methodology was to produce WSA response curves which when used in the extrapolation methodology will produce WUA response curves relative to mainstem discharge only. It should be understood that these regression equations do not show observed WSA at a particular flow, but are a good approximation of the rate of change for WSA due to mainstem discharge.

Figure 7, which outlines the quantification process, shows the analytical steps and the direction of flow for particular representative groups. The first step was to identify outliers in the digitized data set; if due to

QUANTIFICATION

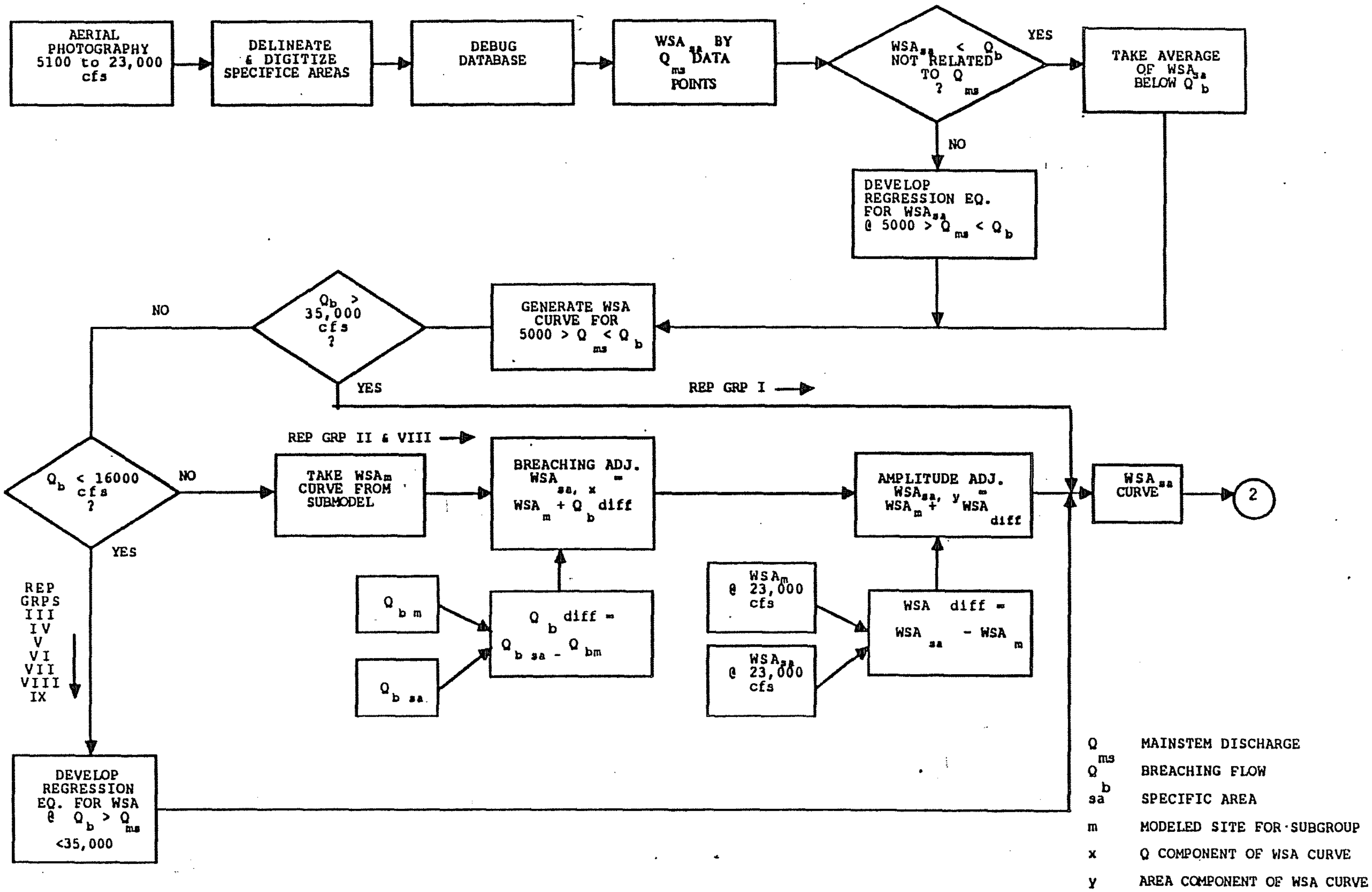


Figure 7. Flow chart indicating the steps followed in the quantification of wetted surface area response to mainstem discharge for specific areas used in the extrapolation methodology.

noncorrectable errors, they were not used in the analysis. If a specific area had a nonbreached range, the data points below breaching were visually inspected for an apparent increasing trend in WSA. If a trend was observable, a loglinear regression was performed and used to predict WSA in this range. If WSA was constant or highly variable below breaching, an average WSA value was computed and subsequently used as a representative WSA for the nonbreached state. Above breaching, if two or more reliable data points were available, a regression was taken and used to forecast WSA for the specific area from the breaching flow to 35,000 cfs. The predictions thus developed were "spliced" at the breaching flow by visual examination.

Unfortunately, specific areas for Representative Group II and some specific areas in V, VI, and VIII did not have enough data points above breaching to develop regression equations. This required an alternative procedure to forecast the WSA of these sites above 23,000 cfs. WSA response for these specific areas were obtained by extrapolating the WSA response of the modeled sites in the respective Representative Group to the nonmodeled sites. This was done using the extrapolation methods, described in section 2.4, with minor revisions. Firstly, the WSA curve from the subgroup model site was adjusted for breaching, thus normalizing the curve to the breaching flow. The amplitude of the curve was then adjusted by raising or lowering the curve to coincide with the aerial photography WSA value for 23,000 cfs.

The WSA responses for specific areas used in the extrapolation process are listed in Appendix C.

2.3 Physical Habitat Modeling Studies

2.3.1 Overview of Modeling Techniques

The quantitative assessment of juvenile chinook rearing habitat response to streamflow in the middle Susitna River is based on investigations conducted by ADF&G and EWT&A from 1982 through 1985. Sufficient data were collected to model chinook rearing habitat potential at 20 modeling sites typical of 9 of the 10 representative groups which characterize the middle Susitna River. These studies utilized two modeling techniques: 1) the Resident Juvenile Habitat (RJHAB) model developed by ADF&G; and 2) the Physical Habitat Simulation (PHABSIM) System developed by the Instream Flow and Aquatic Systems Group of the U.S. Fish and Wildlife Service. Data requirements and sampling methods employed by the two models are similar, and model parameters and standard output variables are identical (Figure 8). The major differences between RJHAB and PHABSIM modeling approaches relate to the resolution of input and output data and the techniques used to process these data. The RJHAB model generates surface area and WUA output only for those discharges for which hydraulic information was collected. The PHABSIM modeling system incorporates hydraulic models which may be used to forecast synthetic hydraulic data for any streamflow within an acceptable calibration range. These data serve as input to a program (HABTAT) which calculates wetted surface area and various habitat indices for the modeling site. WUA forecasts for unobserved flows based on the PHABSIM models are more reliable than those obtained using the RJHAB modeling technique.

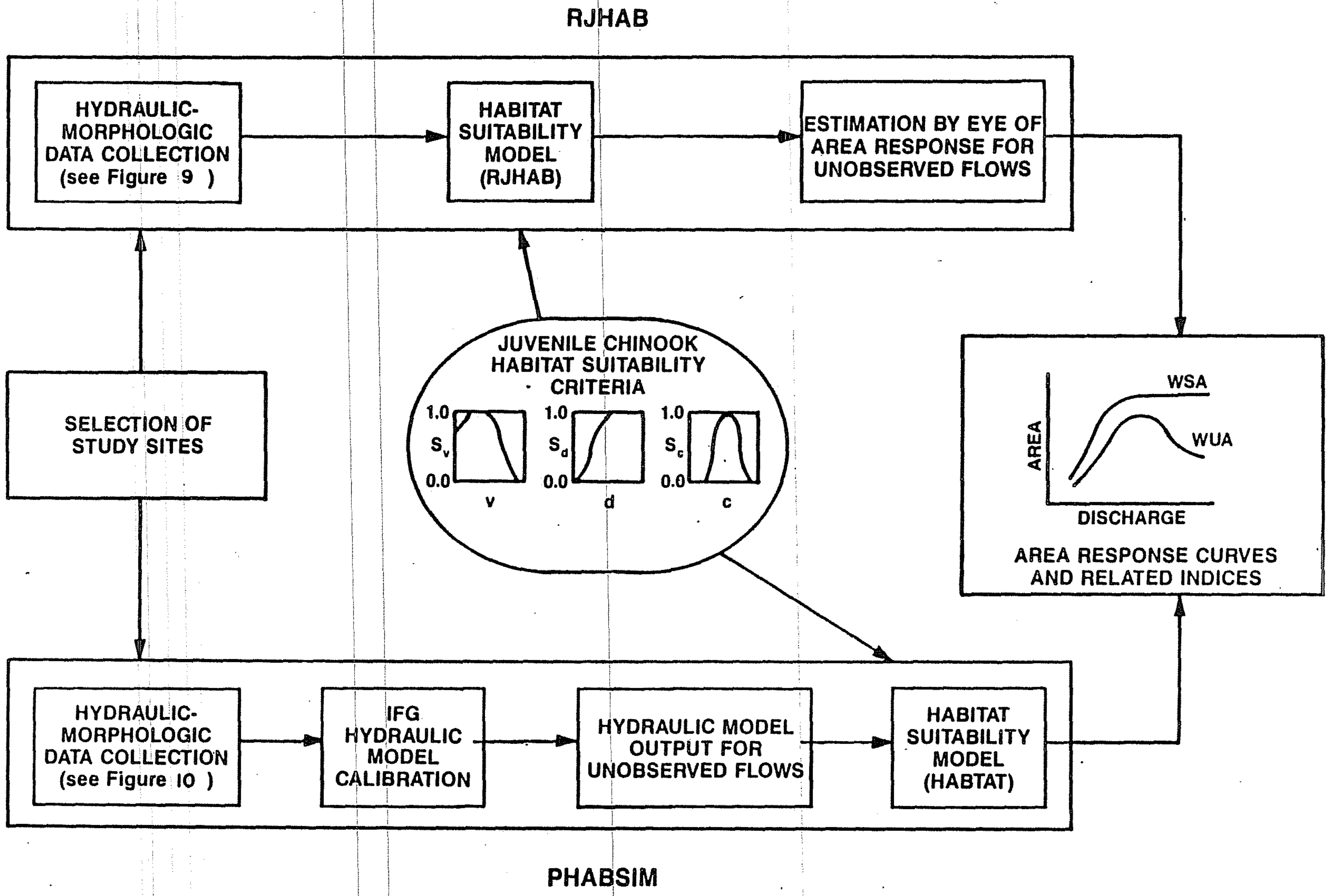


Figure 8. RJHAB and PHABSIM modeling pathways followed in the analysis of juvenile chinook salmon habitat.

Source documents for information relating to RJHAB and PHABSIM model development for middle Susitna River study sites include Estes and Vincent-Lang (1984), Hale et al. (1984), Marshall et al. (1984), and EWT&A and Entrix (1985). Habitat suitability criteria serving as model parameters for HABTAT are described in Steward (1985).

2.3.2 Hydraulic Data Requirements

RJHAB and PHABSIM models applied in this study assess the influence of three key physical habitat variables known to significantly influence juvenile chinook salmon distribution, namely instream and overhead cover, water velocity and water depth. The availability of areas characterized by suitable combinations of these variables varies directly with changes in streamflow. The primary objectives of both habitat models are to quantify the distribution of various combinations of these habitat variables within a representative segment of stream and to describe this distribution in terms of its usability or potential as rearing habitat for juvenile chinook.

In order to describe rearing habitat potential based on the availability of suitable cover, velocity and depth within a study site, field measurements were obtained at discrete intervals along multiple transects. Figures 9 and 10 illustrate the basic differences between the RJHAB and PHABSIM sampling methods, including transect placement, number of verticals where hydraulic variables are sampled and the dimensions of the cells or mapping elements represented by these point measurements. In the case of the RJHAB modeling sites, cover and hydraulic data were collected at four to seven

$$d_i = \frac{\sum_{j=1}^{n} d_j}{n}$$

$$v_i = \frac{\sum_{j=1}^{n} v_j}{n}$$

where d_i = depth (ft) for i^{th} cell
d_j = depth (ft) at j^{th} vertical
d_n = depth (ft) at n^{th} vertical
v_i = velocity (ft/sec) for i^{th} cell
v_j = velocity (ft/sec) at j^{th} vertical
v_n = velocity (ft/sec) at n^{th} vertical
n = number of verticals

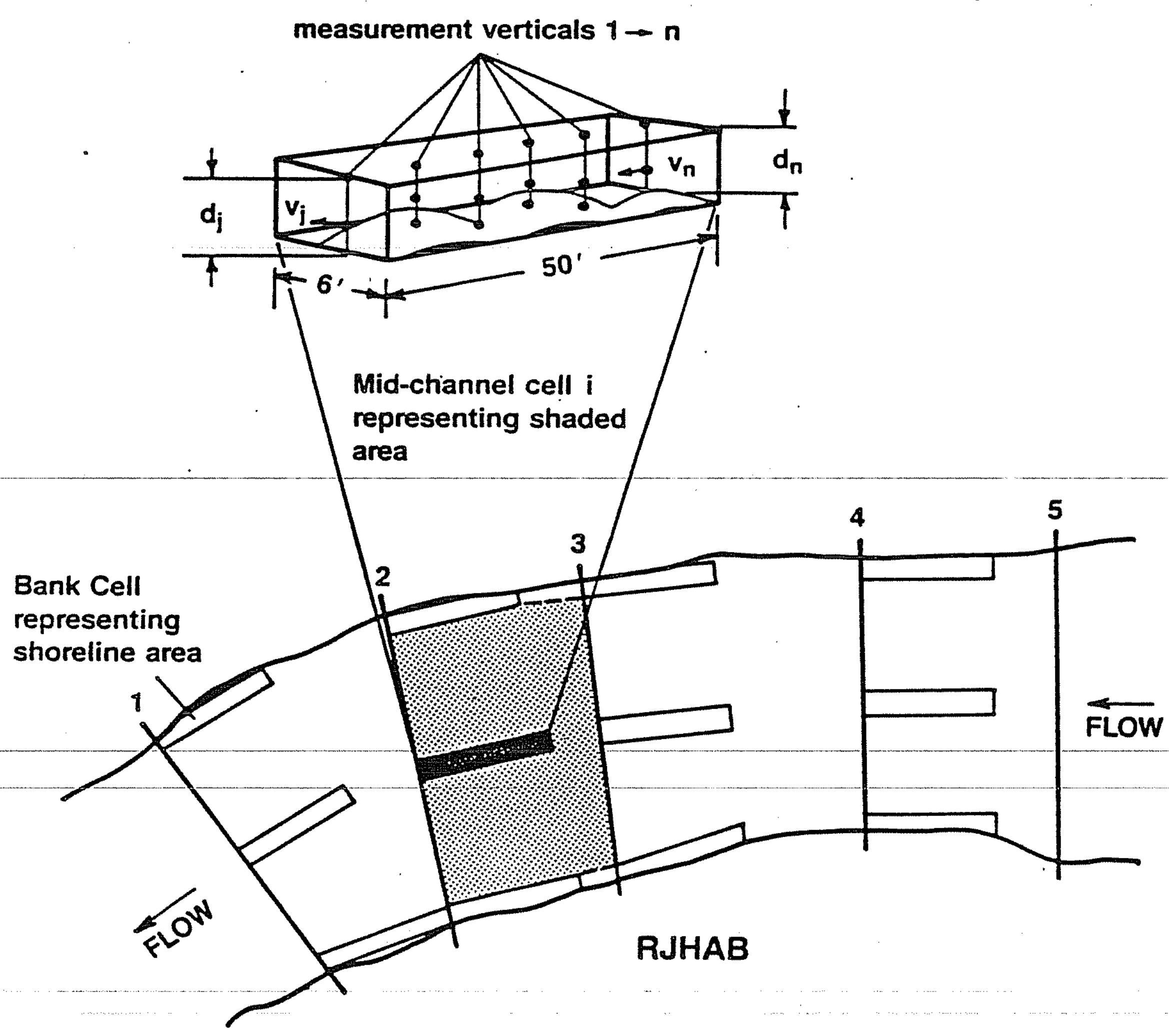


Figure 9. Sampling design for RJHAB modeling sites. The RJHAB model assumes that average values obtained for habitat variables within 6' x 50' bank and mid-channel cells are representative of larger areas within the modeling site.

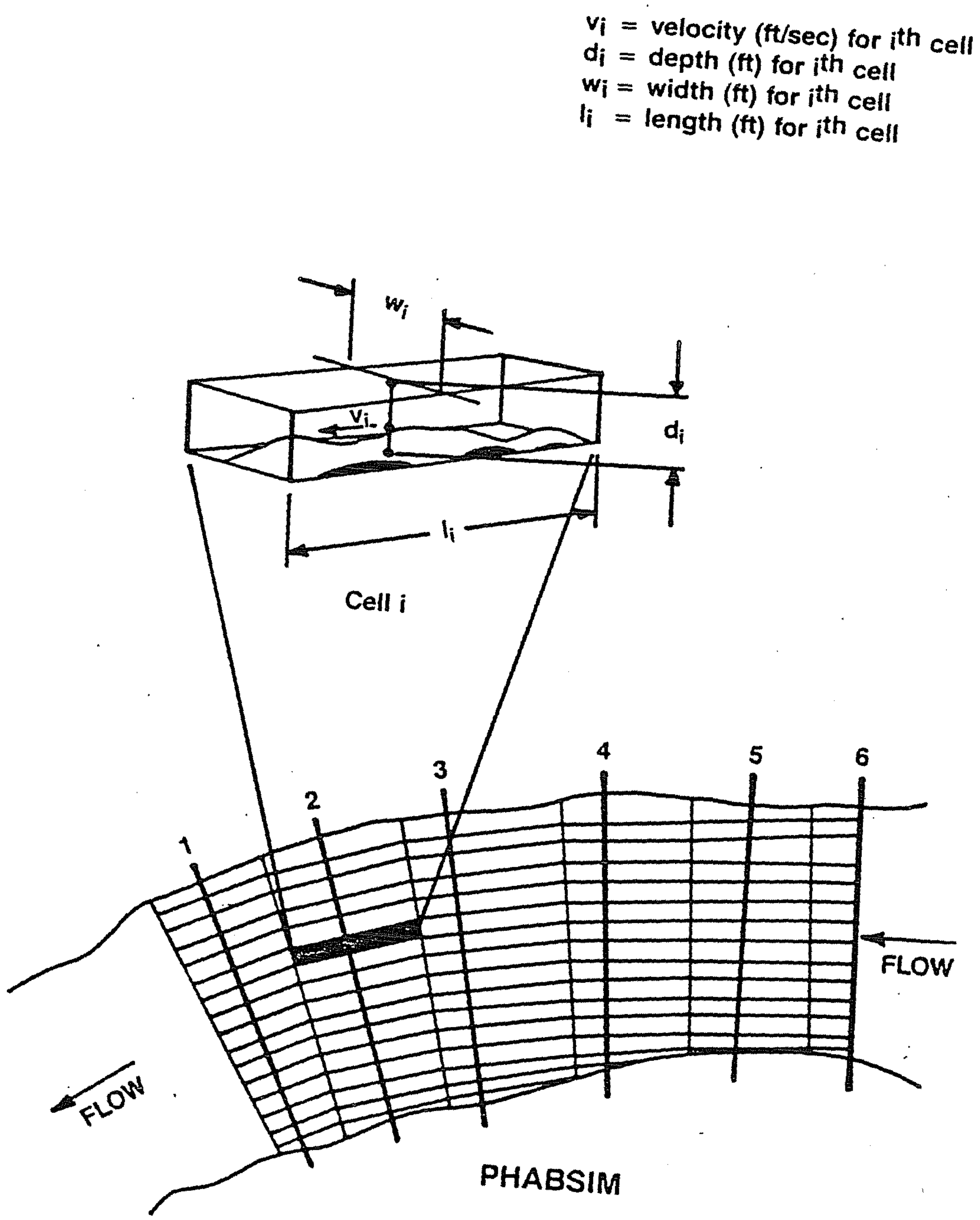


Figure 10. Sampling design for PHABSIM modeling sites.

different discharges. Two bank cells and one mid-channel cell, each 6 ft wide by 50 ft long, were sampled per transect. However, the areas represented as bank cells in surface area and WUA calculations extended 6 ft out from the left or right banks and upstream to the next transect. The mid-channel cells were considered representative of the area located between the 6 foot wide bank cells.

Cover, velocity and depth data for PHABSIM models were collected at several irregularly spaced verticals along the study site transects. The surface area associated with each cell extended halfway to adjacent verticals and transects (Figure 10). In contrast to the RJHAB model, the field data obtained in the PHABSIM analysis are used to calibrate a hydraulic model capable of forecasting depth-velocity combinations for each cell at unsampled discharges. Two types of hydraulic models were used for this purpose, depending primarily on hydraulic conditions at the study site. The IFG-2 model is a water surface profile type model based on the Manning equation and the principle of conservation of mass and energy (Milhous et al. 1984). Data requirements for the IFG-2 model include a single set of velocity data and several measurements of transect water surface elevations. Model calibration involves iterative adjustments of Manning's n values until agreement between observed and predicted water surface elevations is obtained. Once reliably calibrated, the IFG-2 model may be used to predict velocities within each cell across the transect at different discharges.

The second type of model used to simulate hydraulic data in rearing habitat investigations was the IFG-4, which employs linear regression analysis to predict depth and velocity as a function of discharge for each cell. The

IFG-4 model requires a minimum of two hydraulic data sets but is better suited than the IFG-2 model for simulating rapidly varied flow conditions (Trihey and Baldrige 1985).

Estes and Vincent-Lang (1984), Hale et al. (1984), and Hilliard et al. (1985) provide further information on hydraulic data collection and analytical procedures.

2.3.3 Habitat Suitability Criteria

The next stage in the RJHAB and PHABSIM modeling process requires that habitat suitability criteria be developed for the species/life stages of interest. Habitat suitability criteria (curves) indicate the preference of a fish for different levels of a particular habitat variable; suitability curves are needed for each physical habitat variable incorporated in the habitat models. The cover, velocity and depth suitability criteria used in this study to evaluate chinook rearing habitat potential in the middle Susitna River are based primarily on field observations of juvenile chinook densities in side channel and side slough areas of the middle Susitna River (Suchanek et al. 1984). EWT&A and Entrix (1985) and Steward (1985) discuss these data with regard to their applicability to mainstem, side channel and side slough habitats. The juvenile chinook suitability criteria recommended by Steward (1984) and summarized in Figures 11, 12, and 13 were applied in this study.

Of particular interest are the separate velocity and cover habitat suitability criteria which apply under clear and turbid water conditions.

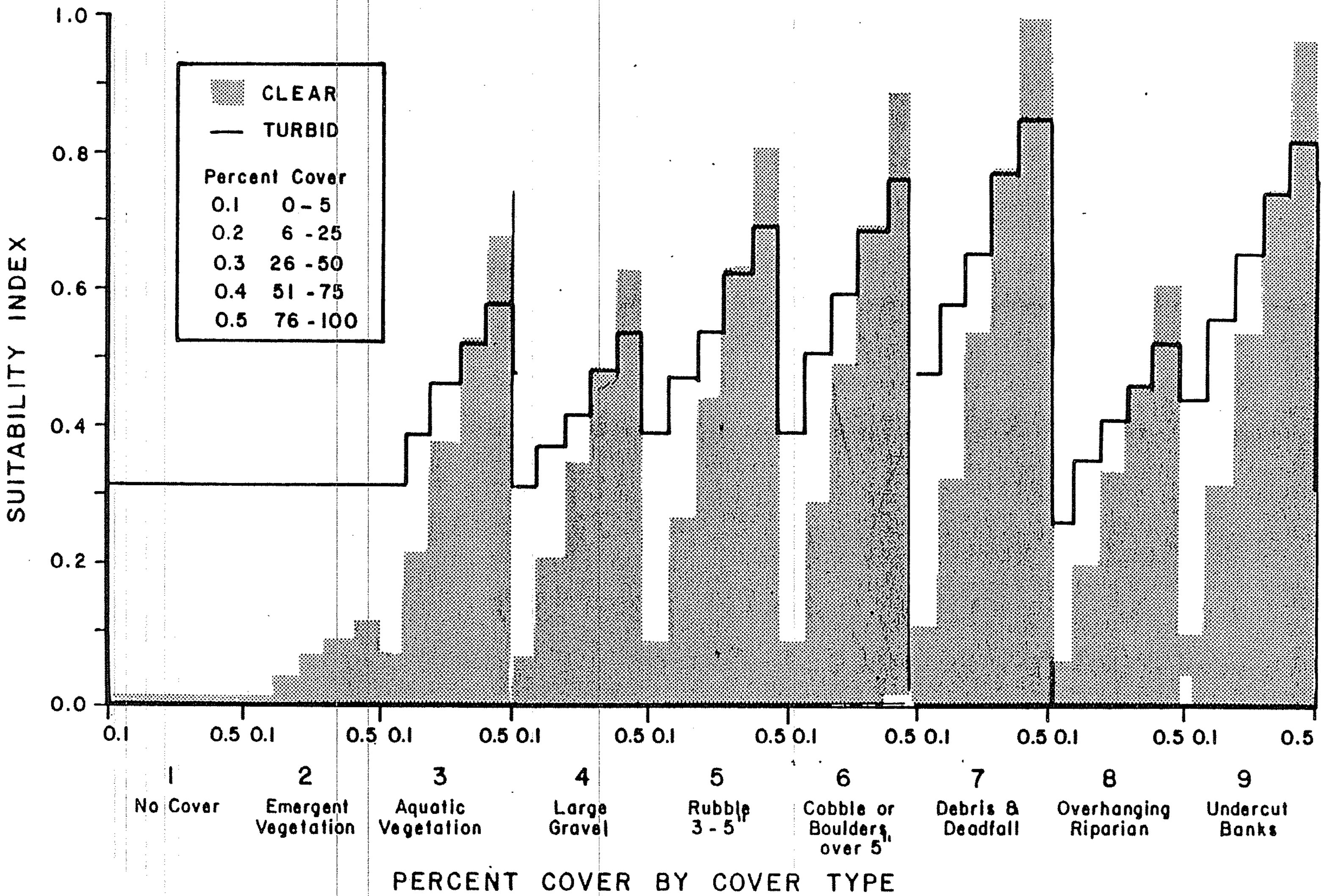


Figure 11. Cover suitability criteria used to model juvenile chinook habitat (WUA) in the middle Susitna River. Separate criteria are presented for clear and turbid water conditions (from Steward 1985).

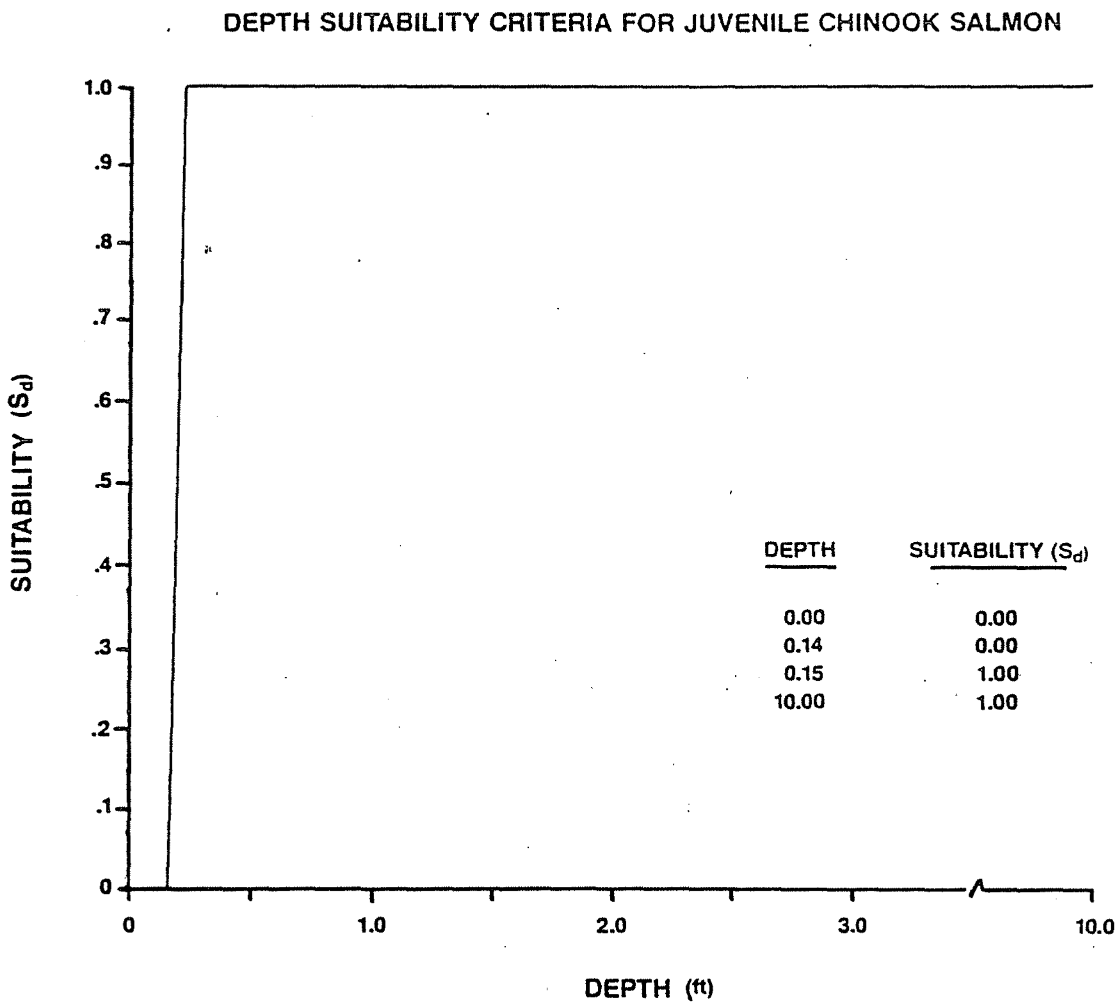


Figure 12. Depth suitability criteria used to model juvenile chinook habitat (WUA) under clear and turbid water conditions in the middle Susitna River (from Steward 1985).

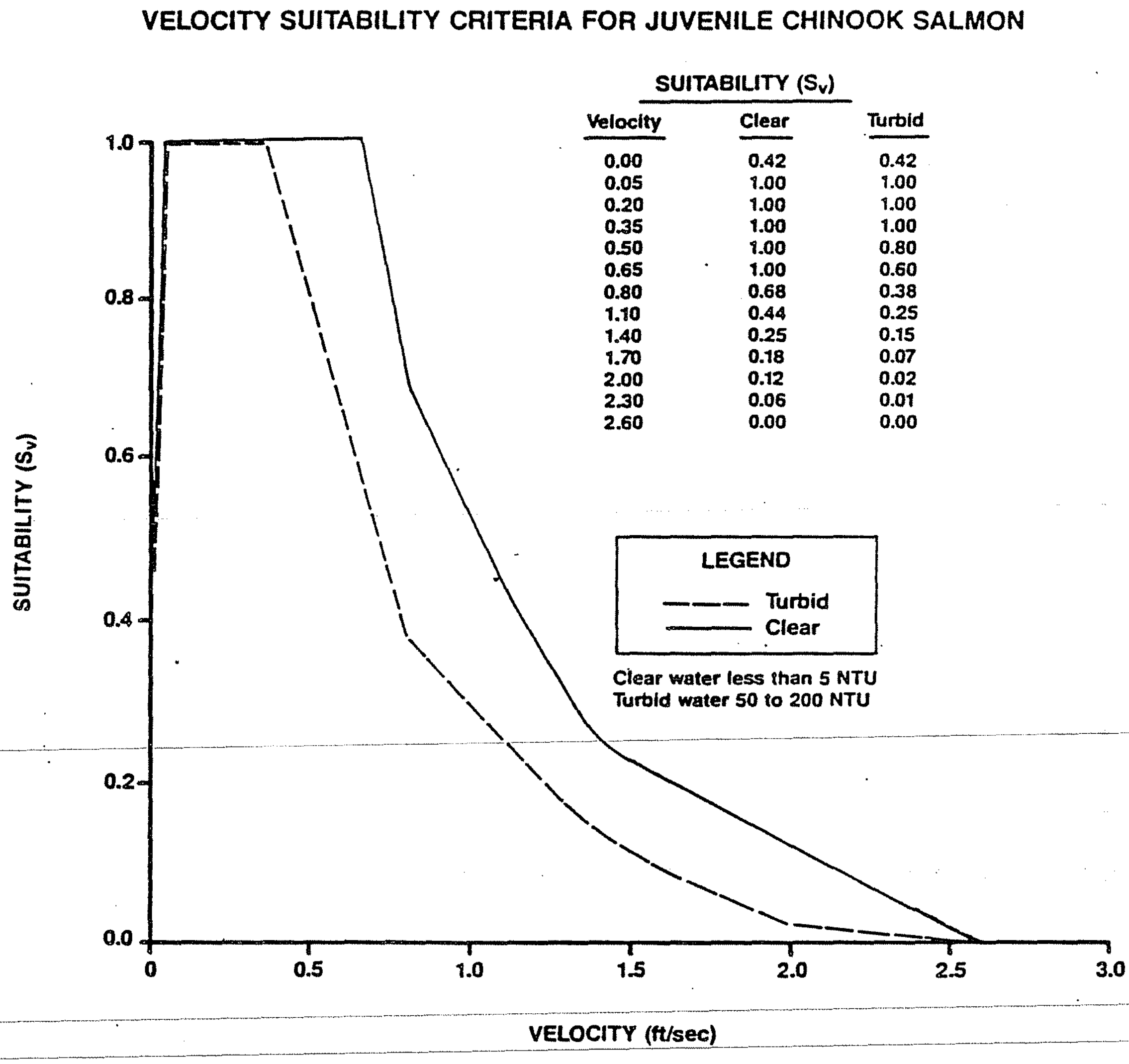


Figure 13. Velocity suitability criteria used to model juvenile chinook habitat (WUA) under clear and turbid water conditions in the middle Susitna River (from Steward 1985).

Clear water habitats occur in side channel areas which are not breached by the turbid waters of the mainstem river yet maintain a base flow via groundwater upwelling or tributary inflow. The frequency and duration of this condition depends on the elevation of the thalweg at the head of the site relative to the water surface elevation of the adjacent mainstem. Site flow versus mainstem discharge relationships were used to determine when clear and turbid water velocity and cover criteria were to be applied.

Rearing salmon use cover to avoid predation and unfavorable water velocities. Instream objects such as submerged macrophytes, large substrates and organic debris, and overhanging vegetation in near shore areas can provide cover for juvenile chinook salmon. Instream object cover in most rearing areas of the middle Susitna River is provided by larger streambed materials, primarily rubble (3-5 inch diameter) and boulder (>5 inches) size substrates. The cover suitability criteria presented in Figure 11 and Table 2 suggest that juvenile chinook tend to associate with some form of object cover in both clear and turbid water habitats. Preference generally increases in proportion to the percentage of object cover present, particularly under clear water conditions. The different preferences for the same type and percent of object cover indicated by the clear and turbid water suitability criteria are due to the utilization of turbidity as cover by rearing chinook. Dugan et al. (1984) documented higher densities of chinook in breached, turbid water side channels than were found at the same sites under nonbreached, clear water conditions. This disparity was most pronounced at sampling sites possessing minimal object cover.

Table 2. Cover suitability criteria recommended for use in modeling juvenile chinook habitat under clear and turbid water conditions. Sources: Suchanek et al. 1984; Steward 1985.

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 (Suchanek et al. 1984))									
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	0.39	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
Turbid Water (EWT&A and WCC 1985)[1]									
0-5%	0.31	0.31	0.31	0.31	0.39	0.39	0.48	0.26	0.44
6-25%	0.31	0.31	0.39	0.37	0.47	0.51	0.58	0.35	0.56
26-50%	0.31	0.31	0.46	0.42	0.54	0.59	0.67	0.41	0.65
51-75%	0.31	0.31	0.52	0.48	0.62	0.68	0.77	0.46	0.74
76-100%	0.31	0.31	0.58	0.54	0.69	0.76	0.85	0.52	0.82

[1]Multiplication factors: 0-5% - 4.38; 6-25% - 1.75; 26-50% - 1.20; 51-75% - 0.98; 76-100% - 0.85

Water depth is not a significant factor limiting juvenile chinook habitat potential, as indicated by the open ended depth suitability curve in Figure 12. Provided that other microhabitat conditions are suitable, juveniles tend to prefer depths exceeding 0.15 feet to an equal degree. This observation has been corroborated in other habitat utilization studies of juvenile chinook salmon (Steward 1985).

A distinct preference by juveniles for low velocities under turbid water conditions was noted by Suchanek et al. (1984). Turbid water habitat suitability criteria identify optimal velocities in the 0.05 to 0.35 fps range, as compared to 0.05 to 0.65 fps indicated by clear water velocity criteria (Figure 13). The preference for lower velocities in areas of high turbidity may be twofold: 1) at faster currents there is a lack of visual cues to maintain position; and 2) at higher velocities it is more difficult to detect drifting prey items (Milner 1985).

2.3.4 Habitat Model Response Variables

The RJHAB model was modified slightly in order that the methods of calculating various indices of habitat potential, including WUA, and wetted surface areas were consistent for all modeling sites. Wetted surface area (WSA) estimates based on RJHAB and PHABSIM modeling approaches were computed by summing the surface areas of watered cells within the modeling site (Table 3). Flow related increases in wetted surface area at RJHAB sites were apportioned among mid-channel cells of the sites since the dimensions of the area represented by bank cells remained essentially unchanged for all flows. At study sites modeled with IFG-2 or IFG-4

Table 3. Wetted surface area (WSA), weighted usable area (WUA) and related habitat indices used in the evaluation of chinook rearing habitat potential within the middle Susitna River.

Statistic	Equation	Parameters/Units
Calculations Performed for Each Cell (i)		
Surface Area (A_i)	$A_i = w_i l_i$	w_i = cell width (ft) l_i = cell length (ft) (ft^2)
Composite Suitability (S_i)	$S_i = s(c_i)\ s(v_i)\ s(d_i)$	$s(c_i)$, $s(v_i)$ and $s(d_i)$ are weighting factors for cover, velocity and depth (dimensionless)
Weighted Usable Area (WUA_i)	$WUA_i = A_i\ S_i$	(ft^2)
Calculations Performed for a Modeling Site Comprised of (n) Cells		
Wetted Surface Area (WSA)	$WSA = \sum_{i=1}^{n} A_i$	includes all cells (ft^2)
Gross Habitat Area (GHA)	$GHA = \sum_{i=1}^{n} A_i$	includes cells with WUA > 0.0 (ft^2)
Weighted Usable Area (WUA)	$WUA = \sum_{i=1}^{n} A_i\ S_i$	(ft^2)
Habitat Availability Index (HAI)	HAI = WUA / WSA	(dimensionless)
Habitat Distribution Index (HDI)	HDI = GHA / WSA	(dimensionless)
Habitat Quality Index (HQI)	HQI = WUA / GHA	(dimensionless)

hydraulic models, the size and location of cells generally remained constant but the total number of cells increased or decreased as wetted top widths responded to changes in flow. Hence, the cumulative surface area of the IFG modeling sites increased through the addition of new cells along the shoreline.

The composite suitability of each cell within the RJHAB and IFG modeling sites was determined by multiplying the individual suitability values associated with prevailing velocity, depth and cover conditions (Table 3). This method of calculation implies that the physical habitat variables evaluated by the models are assumed to be independent in their influence on habitat selection by juvenile chinook. Weighted usable area is computed for each cell by multiplying the cell's composite suitability by its surface area. The sum of the cell WUAs obtained for a given discharge yields the modeling site WUA; when plotted as a function of discharge, the modeling site WUA curve indicates the response of usable rearing habitat to changes in streamflow.

Habitat simulation results include WUA and WSA estimates for each study site for mainstem discharges ranging from 5,000 to 35,000 cfs as measured at the USGS Gold Creek gaging station. In order to facilitate comparisons between modeling sites, WSA is expressed in units of square feet per linear foot of stream. WSA is therefore proportional to the mean width of the modeling site. These units are less satisfactory for comparisons of WUA since usable habitat at a site is a function of surface area weighted by the suitability of its physical habitat attributes. An interpretation of habitat availability should not be made without reference to the total wetted surface area of the site. As an example, consider two study sites possessing relatively equal amounts of weighted usable area; the smaller site, particularly where there is a large disparity in size, possesses a greater amount of usable habitat relative to the prevailing wetted surface area. Therefore, a more meaningful index of habitat availability is the ratio of WUA to WSA, which is designated the Habitat Availability Index (HAI).

In the context of the extrapolation analysis, the Habitat Availability Index has the added merit of being unitless. Assuming that the HAI of a modeling site is representative of the associated specific area (i.e., both possess the same frequency distributions of cover, velocity and depth), the WUA of the specific area is equal to the product of the HAI and the total wetted surface area of the specific area. Total surface areas are known, as discussed in Section 2.2, and therefore a flow-dependent habitat response curve may be derived for any specific area represented by a modeling site.

The HABTAT program of the PHABSIM modeling system and the RJHAB model were modified to compute the Gross Habitat Area (GHA) for each discharge of interest. The GHA is the cumulative (unweighted) surface area of cells possessing non-zero WUA values within a site. Gross Habitat Area is important because it represents the maximum area of rearing habitat available. Two other habitat response indices, the Habitat Distribution Index (HDI) and the Habitat Quality Index (HQI) are calculated by the following formulas:

$$HDI\ (\%) = GHA/WSA \times 100$$

and

$$HQI\ (\%) = WUA/GHA \times 100$$

The use of HDI and HQI indices partially overcomes a major criticism of most WUA-based interpretations of habitat potential, namely, that WUA is a quantification of the amount of suboptimal habitat within a study site expressed as an equivalent amount of optimal habitat. In other words, a cell with a surface area of 100 sq. ft. and a joint preference factor of 1.0, that is, optimal cover, velocity and depth conditions, is assumed to provide as much usable habitat as an area ten times its size which possesses a joint preference factor of 0.10. Although flow-related changes in the composite suitability of individual cells (i.e., at discrete locations within the modeling site) were not evaluated, we examined relationships between a modeling site's weighted usable area, gross habitat area and wetted surface area over a range of discharges to gain an understanding of probable changes in habitat quality within cells containing usable habitat.

Surface areas and habitat indices were simulated for site flows corresponding to mainstem flows ranging from 5,000 to 35,000 cfs at Gold Creek. Of the 20 study sites investigated, six were modeled using the RJHAB model and 15 were modeled using the PHABSIM modeling system. One study site, 132.6L (Representative Group III), was modeled using both RJHAB and PHABSIM techniques. In most instances, WSA, WUA and HAI values for unobserved site flows (in the case of RJHAB models) or flows lying outside the recommended extrapolation range of the hydraulic models (a frequently encountered situation in PHABSIM applications) were estimated by interpolation and trend analysis techniques (Hilliard et al. 1985). In fitting curves to data points forecast by the habitat models, reference was made to aerial photographs and site-specific channel geometry and breaching flow information.

2.4 Extrapolation of Modeling Results to Non-modeled Specific Areas

Whereas the general habitat characteristics of a modeling site may be assumed to be representative of the associated specific area, the same combination and quality of habitat attributes may not be found in other specific areas, even those classified in the same representative group. Aaserude et al. (1985) concluded that variations in structural characteristics, including several attributes known to affect the quality of juvenile chinook rearing habitat, are common among specific areas of the same representative group. These differences are significant enough that direct transfer of WUA functions from modeled to non-modeled specific areas is considered impracticable. For this reason, Structural Habitat Indices (SHIs) were developed from field data in order to rank specific areas within the same representative group according to their relative structural habitat quality. As indexed by SHI values, specific areas are evaluated on the basis of six variables: 1) dominant cover type, 2) percent cover, 3) dominant substrate size, 4) substrate embeddedness, 5) channel cross sectional geometry, and 6) riparian vegetation. These variables were weighted according to their relative importance to juvenile chinook salmon. For each variable, specific areas were placed in one of five descriptive categories, ranging from "non-existent" to "excellent" in quality. Each variable category received a corresponding numerical rating factor. A single SHI value was calculated for each specific area, including those containing modeling sites, by summing the products of variable weighting and rating factors. For further details concerning the collection and synthesis of data into structural habitat indices, see Aaserude et al. (1985).

In this, the integration step of the extrapolation methodology, Habitat Availability Indices (HAIs) derived for the modeling sites are used to estimate juvenile chinook WUA for each specific area of the middle Susitna River. As discussed above, the amount of usable rearing habitat at a specific area containing a modeling site may be calculated by multiplying the modeling site's HAI value (i.e., the WUA:WSA ratio obtained as model output) by the wetted surface area of the specific area. For each discharge, this calculation can be represented as

$$WUA_{sa} = HAI_{m,sa} \times WSA_{sa}$$

where the subscripts m and sa refer to the modeling site and the specific area within which it is found. As pointed out earlier, HAI values determined for the modeling site are assumed to be applicable to the entire specific area.

If it were reasonable to assume that the HAI response curves for all specific areas within a representative group were identical, then WUA values for non-modeled specific areas within the same group could be calculated by the above equation using a single HAI function. The structural habitat data of Aaserude et al. (1985), as well as the modeling results presented in this report do not support this assumption. Between-site variations in rearing habitat availability appear to result from dissimilarities in channel morphology (which are reflected by differences in breaching flows and the rate of change in WUA and WSA) and structural habitat quality (as indexed by SHI values). Therefore, each specific area of the middle Susitna River is assumed to possess a unique HAI curve which may nonetheless be patterned after the modeling site within the same representative group having the most similar hydrologic, hydraulic, and morphologic attributes. Specific areas within a representative group with more than one modeling site are divided between modeling sites by morphological similitude based on aerial photography and habitat reconnaissance surveys. Thus, each modeling site may be considered representative of a subgroup of specific areas.

HAI curves are developed for non-modeled specific areas by modifying the HAI functions of associated modeling sites using information obtained in the classification and quantification steps of the extrapolation analysis, including: 1) breaching flows to normalize HAI functions on the discharge axis; and 2) structural habitat indices to adjust for differences in the quality of usable rearing habitat. Table 4 summarizes breaching flow and SHI information used in the development of HAI curves for non-modeled specific areas within Representative Groups I through X.

The discharge at which the head berm of a specific area is breached is the dominant hydrologic variable affecting the availability of chinook rearing habitat. As will be demonstrated later, the vast majority of juvenile chinook HAI functions obtained for the middle Susitna River modeling sites exhibit a maxima just to the right of the breaching flow on the discharge (horizontal) axis. To develop an HAI response curve for a non-modeled specific area, the HAI curve obtained for the associated modeling site is shifted left or right on the abscissa depending on whether the breaching flow for the non-modeled specific area is lower or higher than that of the

GROUP I

Specific Area	Breaching Flow (cfs)	SHI
0 107.6L	>35,000	0.44
105.2R	>35,000	0.69
108.3L	>35,000	0.70
119.4L	>35,000	0.45
120.0R	>35,000	0.50
135.6R	>35,000	0.54
136.9R	>35,000	0.69
139.0L	>35,000	0.45
0 112.5L	>35,000	0.68
102.2L	>35,000	0.83
121.9R	>35,000	0.72
123.1R	>35,000	0.45
123.3R	>35,000	0.67
127.2M	>35,000	0.58
129.4R	>35,000	0.44
133.9L	>35,000	0.67
134.0L	>35,000	0.89
135.5R	>35,000	0.32
139.9R	>35,000	0.74

GROUP II

Specific Area	Breaching Flow (cfs)	SHI
0 101.4L	22,000	0.54
115.6R	23,000	0.54
118.0L	22,000	0.39
121.8R	22,000	0.27
125.1R	20,000	0.48
137.5R	22,000	0.44
137.8L	20,000	0.54
0 113.7R	24,000	0.51
113.1R	26,000	0.31
131.8L	26,900	0.45
133.9R	30,000	0.50
137.5L	29,000	0.44
137.9L	21,000	0.50
140.2R	26,500	0.50
142.2R	26,000	0.52
143.4L	23,000	0.55
+ 126.0R	33,000	0.51
122.4R	26,000	0.29
122.5R	20,000	0.51
123.6R	25,500	0.43
125.9R	26,000	0.56
126.3R	27,000	0.59
0 144.4L	21,000	0.60
100.6R	33,000	0.60
101.8L	22,000	0.65
117.9L	22,000	0.62
135.3L	23,000	0.30
142.1R	23,000	0.60

GROUP III

Specific Area	Breaching Flow (cfs)	SHI
+ 101.2R	9,200	0.56
100.4R	12,500	0.51
100.6L	9,200	0.42
115.0R	12,000	0.55
117.8L	8,000	0.48
128.5R	12,500	0.48
128.7R	15,000	0.49
130.2R	8,200	0.64
130.2L	12,000	0.60
137.2R	10,400	0.49
+ 128.8R	16,000	0.46
110.4L	12,000	0.67
133.7R	11,500	0.44
+0 132.6L	10,500	0.49
101.6L	14,000	0.56
101.7L	9,600	0.46
119.3L	16,000	0.56
+ 141.4R	11,500	0.56

GROUP IV

Specific Area	Breaching Flow (cfs)	SHI
+ 112.6L	<5,100	0.60
108.7L	<5,100	0.53
110.8M	<5,100	0.48
111.5R	<5,100	0.48
139.4L	<5,100	0.61
139.6L	<5,100	0.51
+ 131.7L	<5,100	0.47
119.5L	<5,100	0.54
119.6L	<5,100	0.53
124.1L	<5,100	0.46
127.4L	<5,100	0.46
+ 134.9R	<5,100	0.56
100.7R	<5,100	0.49
114.0R	<5,100	0.43
116.8R	<5,100	0.48
121.7R	<5,100	0.48
125.2R	<5,100	0.56
129.5R	<5,100	0.56
140.4R	<5,100	0.48
145.3R	<5,100	0.53
+ 136.0L	<5,100	0.55
127.0M	<5,100	0.65

GROUP V

Specific Area	Breaching Flow (cfs)	SHI
+ 141.6R	21,000	0.56
101.7L	9,600	0.48
117.0M	15,500	0.31
118.9L	<5,000	0.48
124.0M	23,000	0.51
132.8R	19,500	0.57
139.01L	<5,000	0.37
139.7R	22,000	0.51
143.0L	7,000	0.31

GROUP VI

Specific Area	Breaching Flow (cfs)	SHI
+ 133.8L	17,500	0.49
107.1L	9,600	0.69
117.9R	7,300	0.49
119.7L	23,000	0.51
138.0L	8,000	0.53
138.8R	6,000	0.31
139.5R	8,900	0.31
+ 136.3R	13,000	0.54
102.6L	6,500	0.69
106.3R	4,800	0.53
135.7R	27,500	0.32
140.6R	12,000	0.61
142.0R	10,500	0.53

GROUP VII

Specific Area	Breaching Flow (cfs)	SHI
+ 119.2R	10,000	0.41
114.1R	<5,100	0.31
121.1L	7,400	0.43
123.0L	<5,000	0.39
125.6L	<5,000	0.52
127.5M	<5,000	0.31
131.3L	9,000	0.31

GROUP VIII

Specific Area	Breaching Flow (cfs)	SHI
* 132.6L	10,500	0.49
112.4L	22,000	0.27
117.1M	15,500	0.32
117.2M	20,000	0.32
118.6M	14,000	0.36
119.8L	15,500	0.51
120.0R	12,500	0.32
121.5R	19,500	0.32
121.6R	15,500	0.60
123.2R	23,000	0.26
124.8R	19,500	0.46
132.5L	14,500	0.57
135.0R	21,500	0.44
135.1R	20,000	0.44
144.0M	22,000	0.31
* 144.4L	21,000	0.60
101.3M	9,200	0.57
102.0L	10,000	0.43
104.3M	21,000	0.48
109.5M	16,000	0.49
125.6R	26,000	0.44
128.4R	9,000	0.56
145.6R	22,000	0.62
146.6L	26,500	0.48

GROUP IX

Specific Area	Breaching Flow (cfs)	SHI
+ 101.5L	<5,100	0.45
104.0R	<5,100	0.48
109.4R	<5,100	0.45
111.0R	<5,100	0.35
113.8R	<5,100	0.35
117.7L	<5,100	0.41
128.3R	<5,100	0.63
129.3L	<5,100	0.62
131.2R	<5,100	0.48
139.2R	<5,100	0.61
142.8R	<5,100	0.56
+ 147.1L	<5,100	0.57
105.7R	<5,100	0.53
108.9L	<5,100	0.58
127.1M	<5,100	0.53
129.8R	<5,100	0.56
135.0L	<5,100	0.48
141.2R	<5,100	0.69
141.3R	<5,100	0.69
144.0R	<5,100	0.53
144.2R	<5,100	0.53

GROUP X

Specific Area	Breaching Flow (cfs)	SHI
# 105.81L	MSS	0.57
# 119.11L	MSS	0.41
121.1R	MSS	0.47
# 138.71L	MSS	0.57
# 139.41L	MSS	0.41
142.2R	MSS	0.48
# 133.81R	MSS	0.48
109.3M	MSS	0.48
111.6R	11,500	0.48
113.6R	10,500	0.55
113.9R	7,000	0.48
139.3L	MSS	0.56
148.2R	MSS	0.48

KEY:

0 Specific areas with RJHAB model
+ Specific areas with IFG model
# Specific areas with DIHAB model
* Modeled sites from other groups 132.6L from Group III and 144.4L from Group II
MSS Mainstem shoal

Table 4. Mainstem breaching discharges and structural habitat indices (SHI) determined for specific areas within the middle Susitna River.

modeling site. The distance moved is equal to the difference in the sites' breaching discharges. This lateral shift, diagrammed in Figure 14, identifies the horizontal coordinates of the HAI curve for the non-modeled specific area. The lefthand curve in Figure 14 represents HAI values forecast for a hypothetical modeling site. The curve on the right is an HAI function obtained for a related non-modeled specific area (also hypothetical) from the same representative group.

Structural habitat indices are used to determine the magnitude of the HAI response to flow at a non-modeled specific area (i.e., to "fix" the location of the HAI curve with respect to the vertical axis) as illustrated in Figure 14b. For each discharge, the following calculation is made:

$$HAI_{sa} = HAI_m \times (SHI_m/SHI_{sa})$$

In this case, the subscript m refers to the modeling site whose HAI function has been adjusted using the breaching flow of the non-modeled specific area, identified by the subscript sa.

The non-modeled specific area in Figure 14c HAI curve has been shifted to the right and downward to account for the higher breaching flow and the lower structural habitat quality of the non-modeled site relative to the modeled site. An HAI response curve derived in this fashion may be multiplied by wetted surface area estimates to calculate WUA values for each flow of interest. Preliminary HAI functions have been developed for all middle Susitna River specific areas and appear in Section 3.0 and Appendix B of this report.

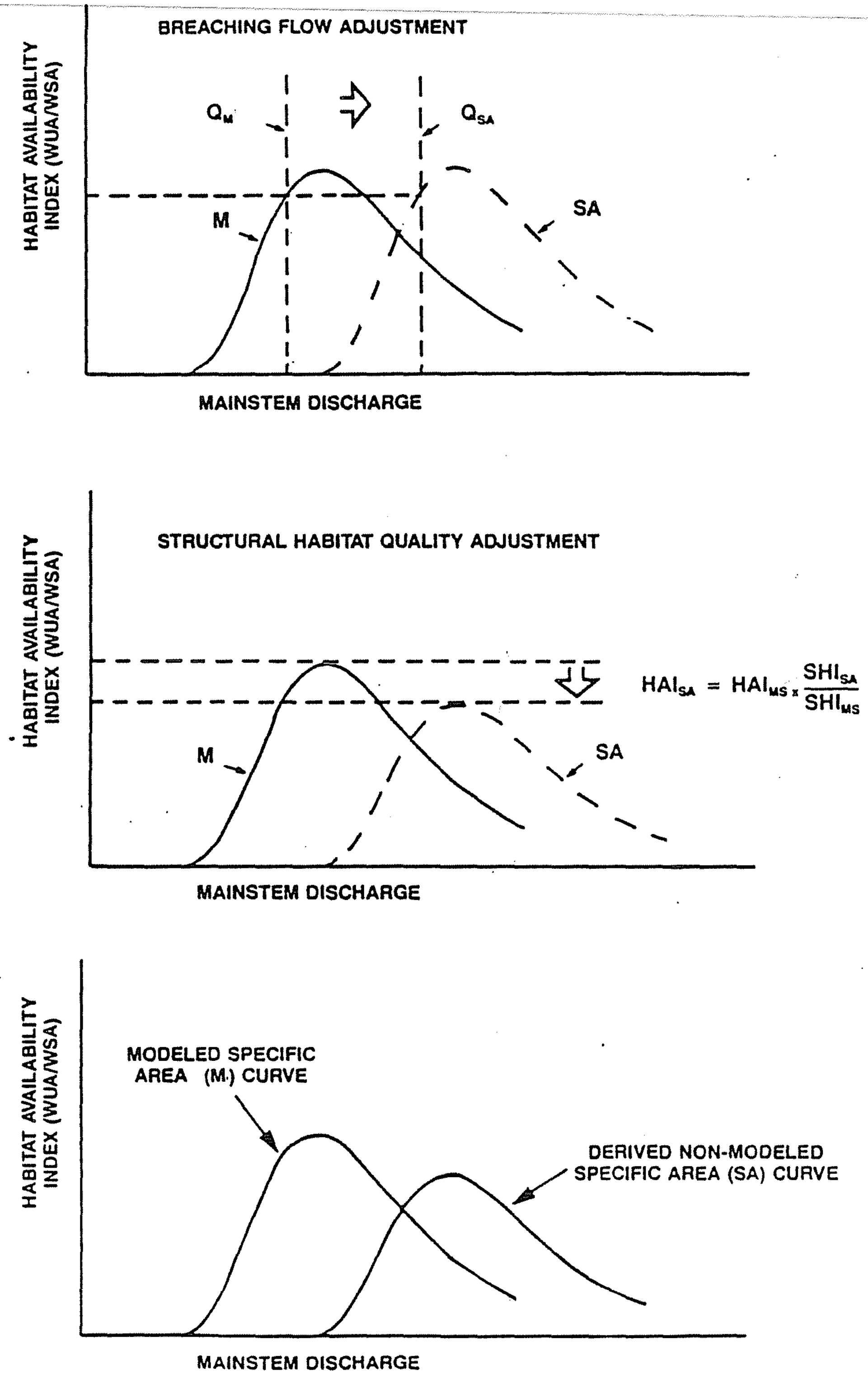
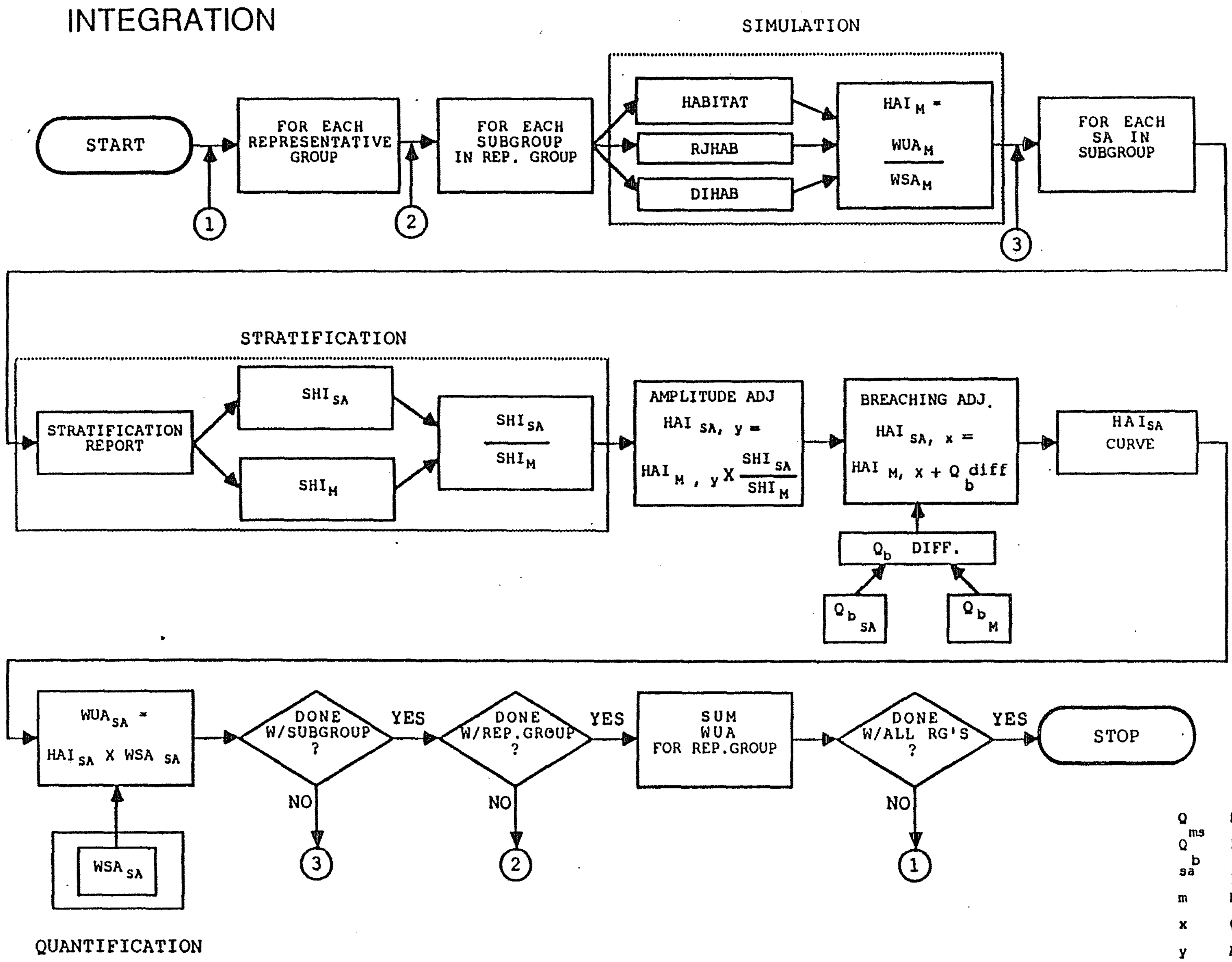


Figure 14. Derivation of a non-modeled specific area (sa) HAI curve using a modeled specific area (ms) HAI curve.
A. Lateral shift to account for differences in breaching discharge (Q_{ms} Q_{sa})
B. Vertical shift proportional to (SHI_{sa}/SHI_{ms}) to account for differences in structural habitat quality.
C. Final hypothetical modeled and non-modeled specific area curves.

2.5 Integration

The data obtained in the stratification, quantification, and simulation steps in the extrapolation analysis are integrated by following the process outlined in Figure 15. Inspection of the flow chart shows the integration is comprised of three nested loops. The inner loop (3) is repeated for each specific area in a subgroup. Functionally, it computes the WUA response curve for a specific area given the model site HAI curve, SHI ratio, and WSA curve for the specific area. The middle loop (2) drives the inner loop through all members of a subgroup and provides the HAI curve for the subgroup model site. The outer loop (1) drives the inner two loops through each representative group. This synthesis provides estimates of juvenile chinook rearing habitat for the 172 specific areas and their summation within each of the ten representative groups.

In regard to the rearing habitat potential of different representative groups, the relative significance of aggregate WUA functions in future decisions will likely be influenced by data concerning present and prospective utilization by juvenile chinook salmon under natural and with-project flow regimes. An assessment of the relative importance of the different representative groups in terms of their utilization by rearing chinook salmon will appear in Volume II of the Instream Flow Relationships Report. When coupled with information relating to food availability, water temperature, suspended sediment and other environmental factors, the aggregate physical habitat response functions will allow for conclusions and recommendations at the management level.



Q_{ms}	MAINSTEM DISCHARGE
Q_b	BREACHING FLOW
sa	SPECIFIC AREA
m	MODELED SITE FOR SUBGROUP
x	Q COMPONENT OF WSA CURVE
y	AREA COMPONENT OF WSA CURVE

Figure 15. Flow chart indicating the steps followed in the integration of stratification, simulation, and quantification for specific areas used in the extrapolation methodology.

3.0 RESULTS

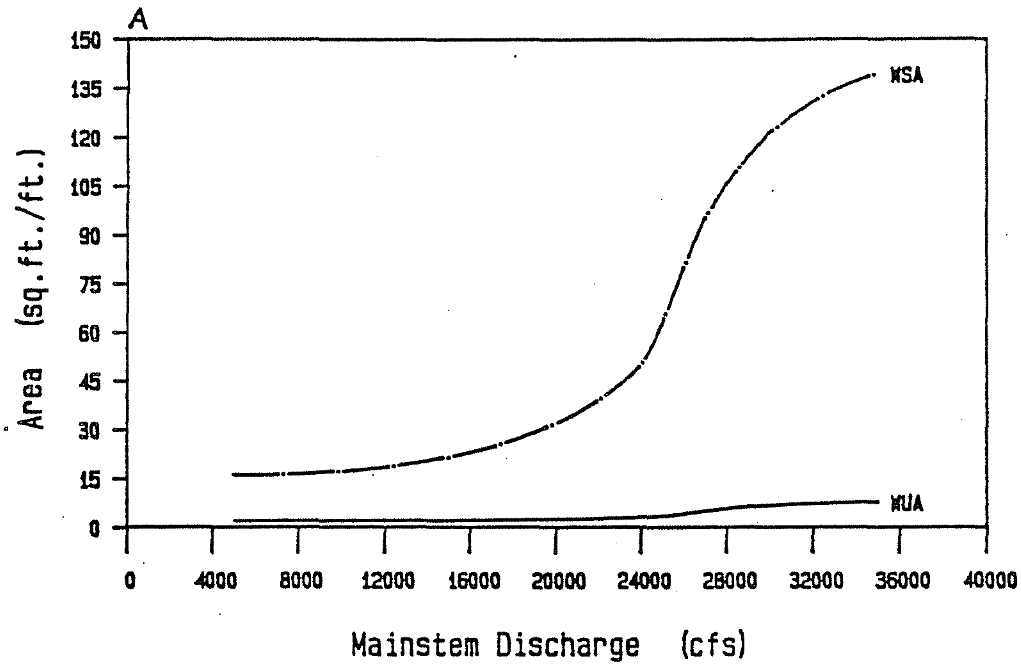
3.1 Representative Group I

The 19 specific areas within this group include all upland sloughs occuring in the middle Susitna River. Except during flood stage, these sloughs are connected to the main channel only at their downstream end. In addition to high breaching flows and low turbidity levels, typical features of specific areas in Representative Group I include low velocity pools of greater-than-average depth separated by short, higher velocity riffles. Clear water enters these sites via seepage or tributary inflow and maintains relatively stable base flows under non-breached conditions. Substrates are frequently homogeneous over large areas and are often characterized by fine silt/sand sediments overlaying cobble materials. Cover is usually provided by over-hanging and emergent vegetation. These sites are used only to a small extent by juvenile chinook salmon (Marshall et al. 1984).

Specific areas assigned to Representative Group I are represented by two RJHAB modeling sites: 107.6L and 112.5L. Photographs of these sites when mainstem discharges were 23,000 and 16,000 cfs are presented in Plates A-1 and A-2 (Appendix A). For much of its length, Site 107.6L is a low gradient, narrow meandering stream. At mainstem discharges above 20,000 cfs, the turbid backwater area at the slough mouth advances upstream and inundates lower sections of the site; this phenomenon accounts for the marked relative increase in wetted surface area indicated in Figure 16.

Usable chinook rearing habitat at Site 107.6L does not respond dramatically to increases in wetted surface area, as evidenced by the WUA and HAI curves

SITE 107.6L



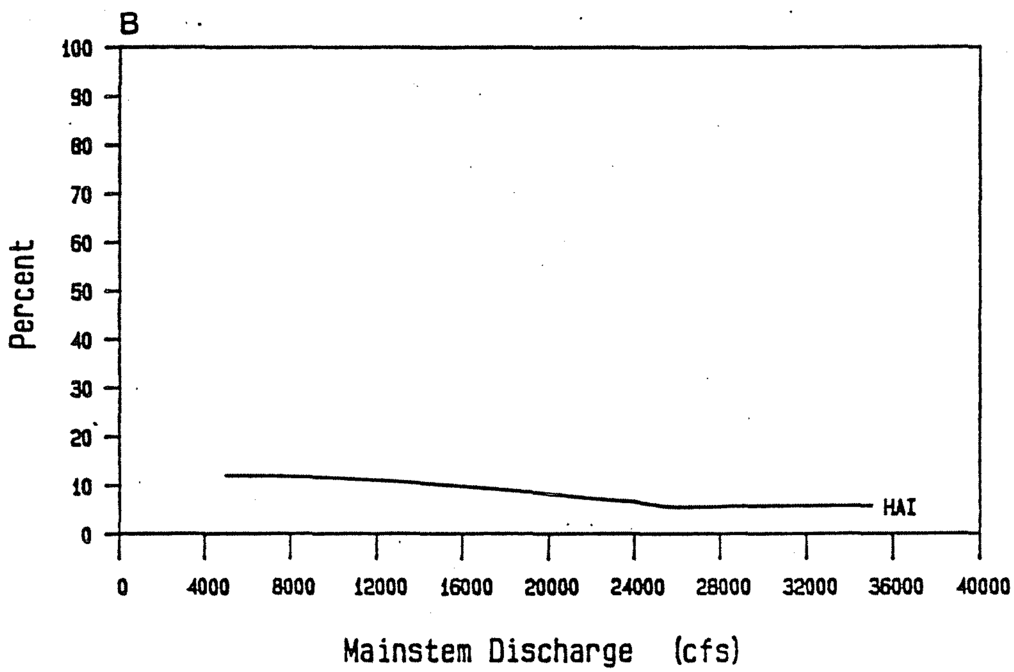


Figure 16. Surface area and chinook rearing habitat index response curves for modeling site 107.6L.
A - Wetted surface area (WSA) and weighted usable area (WUA).
B - Habitat availability index (HAI)

shown in Figure 16. WUA at this site gradually increases at higher flows due to the reduction in water velocity and water clarity caused by rising backwater. Water velocities ranging up to 0.8 fps are common at transects upstream of the backwater pool. Therefore, under clear water conditions nearly ideal velocities exist for juvenile chinook. A silt substrate is dominant, which affords little cover value for juvenile chinook, resulting in a low composite suitability for most cells within the site regardless of the suitability of their depths and velocities. As the extent of the backwater increases, velocities in these cells decrease to 0.0 fps, slightly reducing suitability with respect to this habitat variable, but turbidity levels increase, yielding a higher overall suitability (the weighting factor associated with the "no cover" class of cover using turbid water suitability criteria is 0.31, compared to 0.01 for clear water criteria). When coupled with an increase in surface area, this leads to the slight rise in WUA observed at higher flows. However, because the rate of change in WSA is so great relative to the change in WUA, the proportion of the site containing usable rearing habitat declines as flows increase. HAIs decrease from 11.9 percent at 5,000 cfs to 5.4 percent at 26,000 cfs.

In contrast to Site 107.6L, very little response in WSA, WUA, and HAI to changes in mainstem discharge were observed at Site 112.5L (Figure 17). The latter site is an upland slough with steep banks which prevents large changes in surface area as site water surface elevations change (Plate A-2). As a consequence, physical habitat conditions within this site remain relatively constant and little variation in WUA and HAI results from mainstem flow fluctuations below 35,000 cfs. Slight inconsistencies in ADF&G field data required that an average HAI value (4.2 percent) be used to back

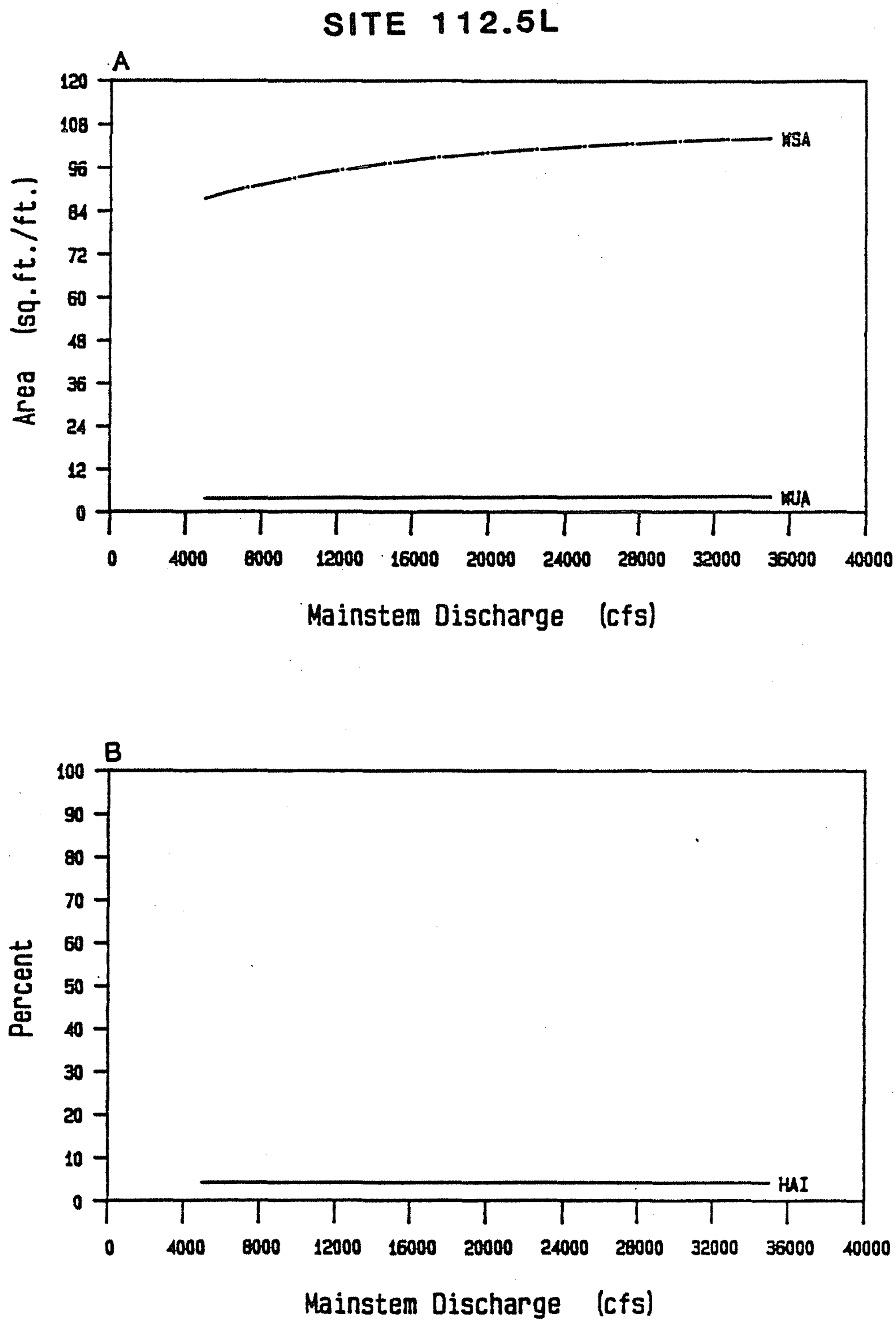


Figure 17. Surface area and chinook rearing habitat index response curves for modeling site 112.5L.
A - Wetted surface area (WSA) and weighted usable area (WUA).
B - Habitat availability index (HAI)

calculate WUA values for Site 112.5L. Values derived for these habitat indices were comparable to those recorded for Site 107.6L.

Specific areas assigned to Representative Group I are former side channels and side sloughs that have become increasingly isolated over time from the mainstem owing to long-term channel activity. Due to the infrequency of breaching events, the primary response in habitat character at these sites results from backwater effects at the upland slough/mainstem interface. Differences between specific areas are related primarily to the extent of backwater areas, and secondarily to the presence or absence of riparian and instream vegetation. Variations in local runoff resulting from precipitation may also affect short-term habitat availability and quality.

Of the two modeling sites in this Representative Group, Site 107.6L represents a subgroup of 8 specific areas whose habitat character is strongly influenced by tributary inflow. Site 112.5L represents the remaining 11 upland sloughs in Representative Group I whose habitat character appears more strongly influenced by groundwater inflow. HAI functions were derived for modeled and non-modeled specific areas associated with each of the modeling sites and are presented in Figures 18 and 19 (see also Appendix B). These HAI curves were not adjusted laterally on the discharge axis since the specific areas within Representative Group I are breached at extremely high mainstem discharges. Differences in habitat availability between specific areas are assumed to be due to dissimilarities in structural habitat quality.

For each specific area included in Representative Group I, HAI ratios representing the amount of usable rearing habitat per unit surface area at

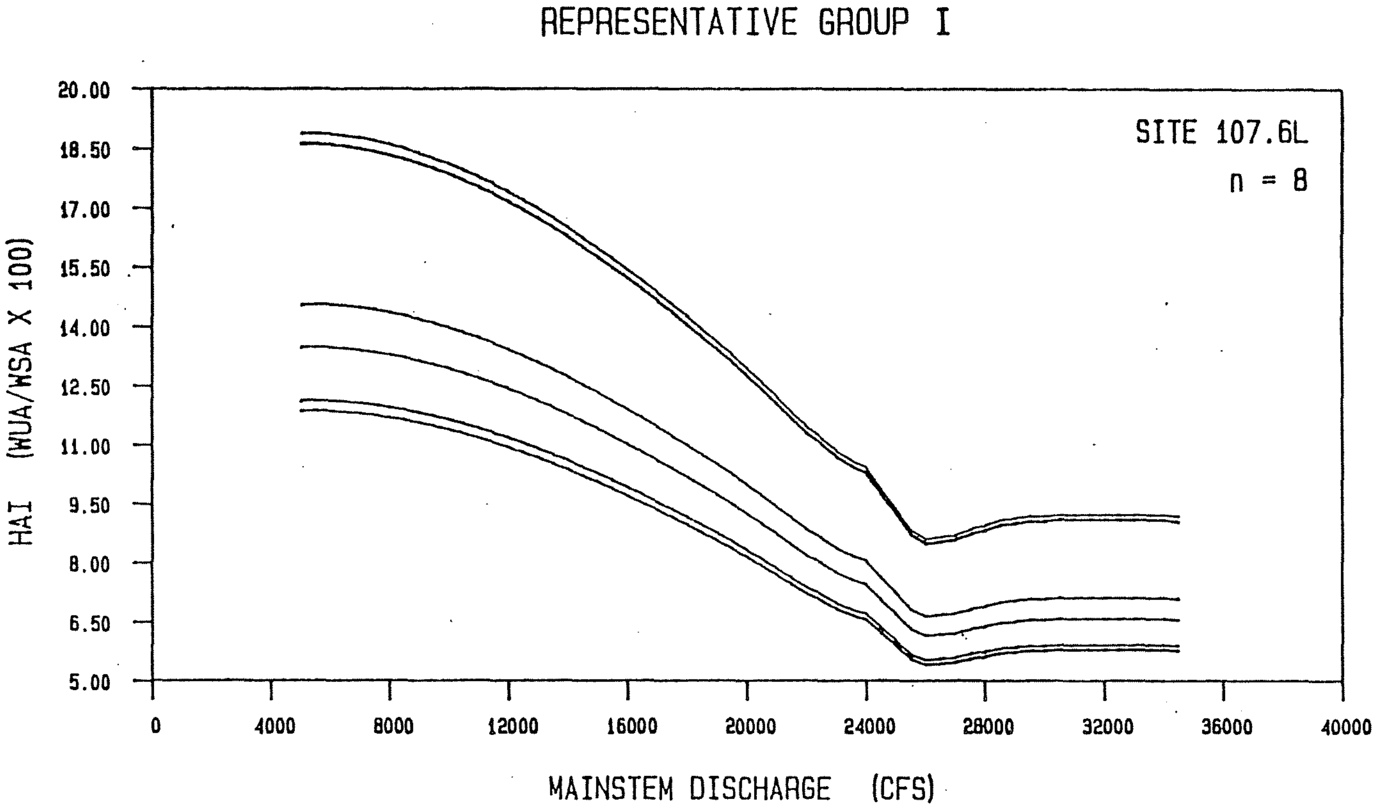


Figure 18. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 107.6L of Representative Group I.

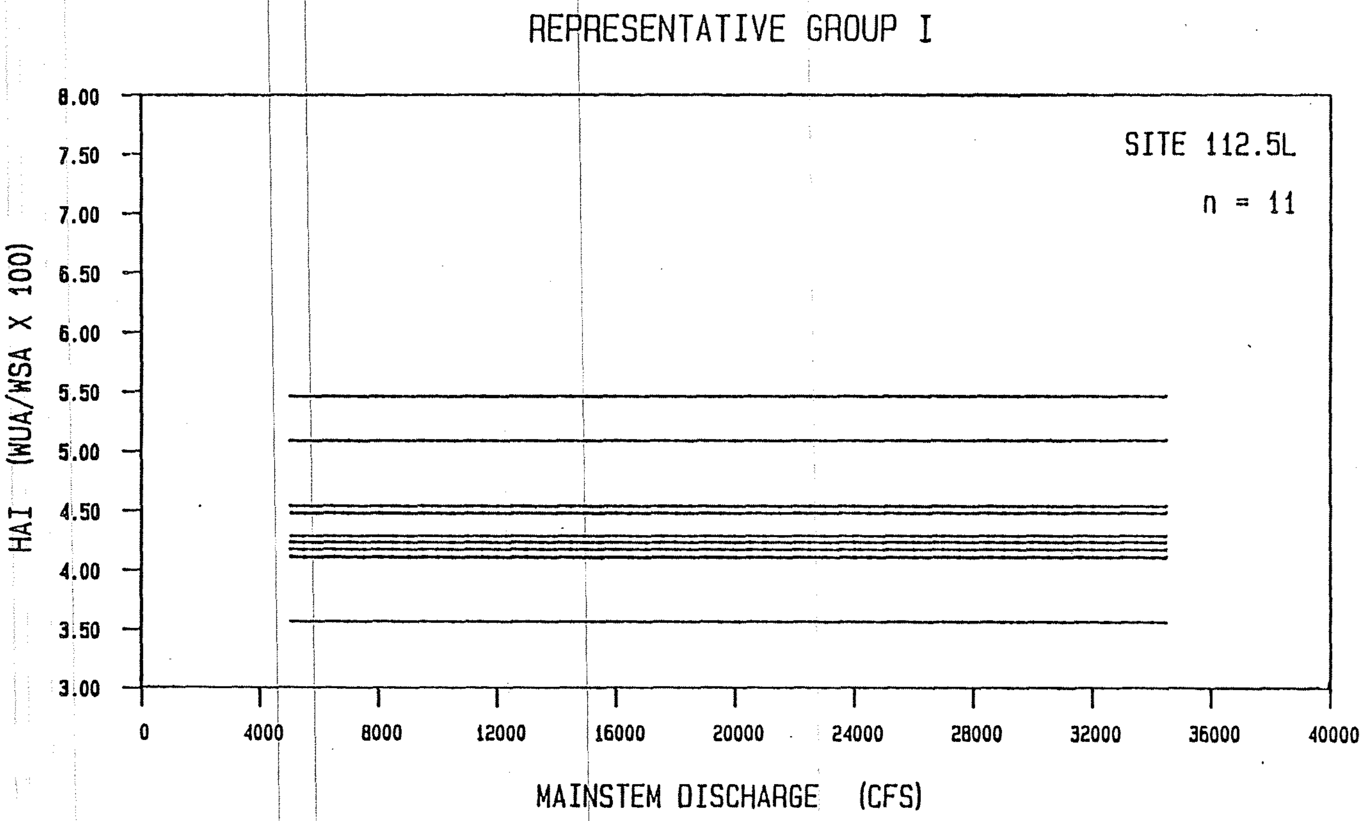


Figure 19. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 112.5L of Representative Group I.

flow increments of 500 cfs were multiplied by corresponding wetted surface area estimates interpolated from areas digitized from scaled aerial photography. The product of flow-specific HAI and WSA values are estimates of the total amount of WUA (in square feet) present at a particular site for mainstem flows ranging from 5,000 to 35,000 cfs. Aggregate WSA and WUA values were obtained for Representative Group I by summing individual specific area WSA and WUA forecasts. The results of these calculations are presented in Figure 20.

The overall response of juvenile chinook habitat for Group I sites is influenced by changes in backwater-related surface area and by the relative constancy of HAI values, particularly at lower flows. WUA tends to increase slightly as flows increase from 5,000 to 16,000 cfs; rearing habitat is maximal at the latter flow. Rearing habitat potential remains fairly constant between 16,000 and 35,000 cfs. It should be noted that the total amount of rearing habitat provided by Group I is small in comparison to other Representative Groups due to their comparatively low surface area and HAI values recorded for its individual specific areas.

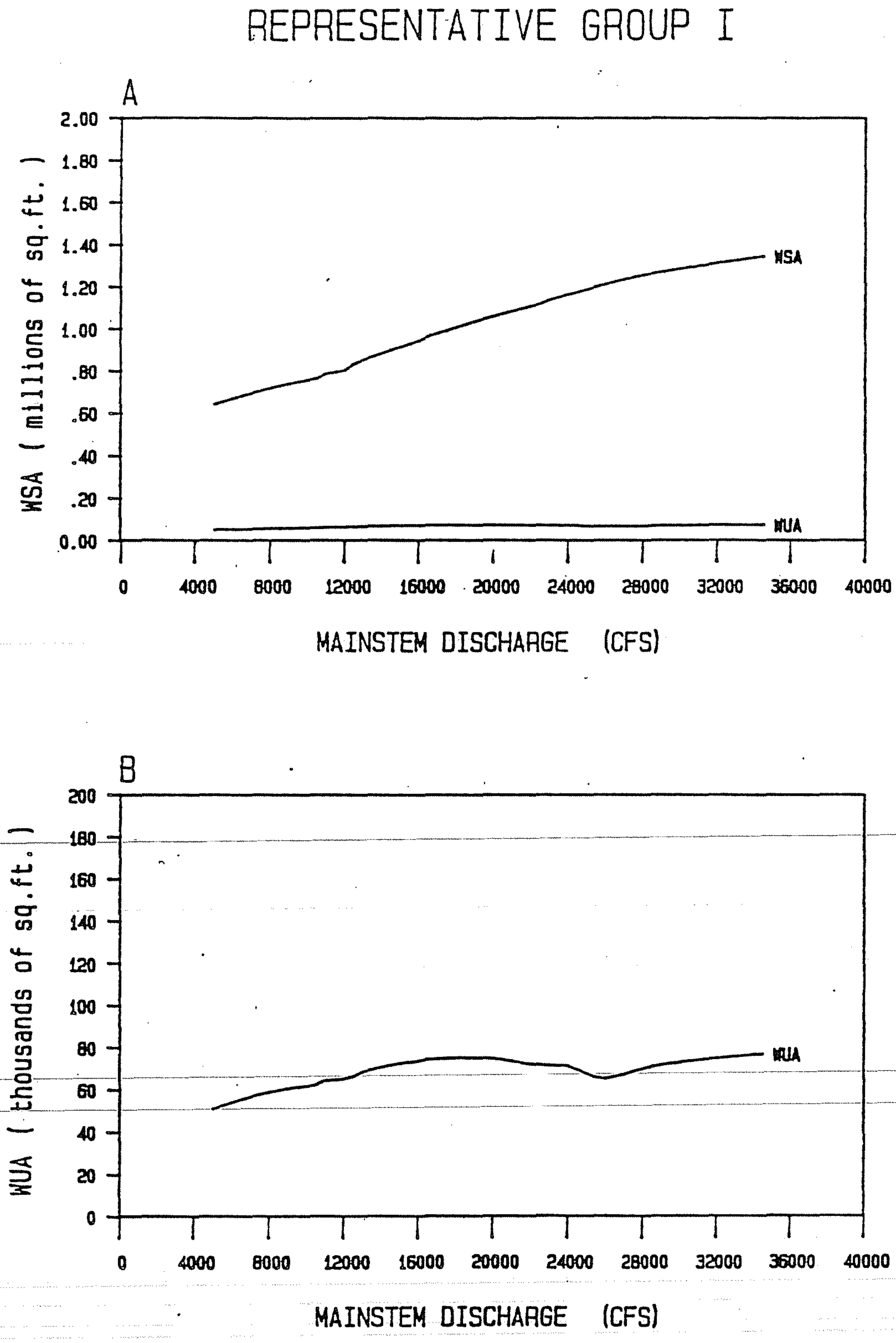


Figure 20. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group I of the middle Susitna River.

3.2 Representative Group II

Associated with this group are modeling sites 101.4L, 113.7R, 126.0R and 144.4L. These sites include side sloughs having moderately high breaching flows (> 20,000 cfs) and enough upwelling groundwater to keep portions of the sites ice-free during the winter months. Side sloughs classified in Representative Group II were found to contain significant numbers of juvenile chinook during the growth season, particularly in their breached state (Dugan et al. 1984).

The 28 specific areas included in this group are typically separated from the mainstem by large, vegetated islands or gravel bars. When breached, these channels convey only a small percentage of the total mainstem flow. Cross-sections vary from relatively broad, uniform and rectangular in shape to narrow, irregular and v-shaped in profile. Head berms generally fall in the former category. Backwater areas occur at the mouths of most specific areas within Group II but their effects on hydraulic conditions and therefore juvenile chinook habitat are not as extensive as those observed for upland sloughs. Substrates range from silt and sand in backwater areas to rubble/cobble/boulder throughout the rest of the site.

Aerial photography indicating the general features of modeling sites 101.4L, 113.7R, 126.0R, and 144.4L and their associated specific areas at 23,000 and 16,000 cfs are presented in Plates A-3, A-4, A-5, and A-6 (Appendix A). The appearance of these sites does not change appreciably at mainstem flows below 16,000 cfs.

Response curves for wetted surface area (WSA) and habitat indices (WUA, HAI) developed for the four modeling sites within Group II exhibit strong similarities in appearance due to the dominant influence of shared hydrologic, hydraulic and morphologic properties (cf Figures 21-24). In the non-breached state, wetted surface areas remain relatively constant, responding primarily to local runoff and upwelling conditions. Following breaching, rapid increases in WSA occur in response to further changes in mainstem flow. Increases in WSA are attenuated as flows approach bank full levels.

Juvenile chinook WUA values simulated for Group II modeling sites are generally constant until the sites are breached, whereupon large increases occur in response to incremental changes in site flow. The amount of usable rearing habitat tends to peak shortly after the head berms are overtopped. This relatively sudden and rapid increase in juvenile chinook habitat results from a combination of factors: 1) the rapid accrual of wetted surface area, 2) the enhanced cover value provided by higher turbidities, and 3) the preponderance of velocities falling within the optimal preference range for juvenile chinook. In general, the magnitude of the WUA increase is proportional to the increase in wetted surface area possessing suitable velocities. Site velocities, however, soon become limiting in mid-channel areas following breaching, leading to a reduction in rearing WUA at higher flows.

On the basis of limited gross habitat (GHA) and habitat quality (HQI) data obtained for Site 126.0R (Figure 23), usable rearing habitat appears to be more uniformly distributed and of better quality at flows associated with

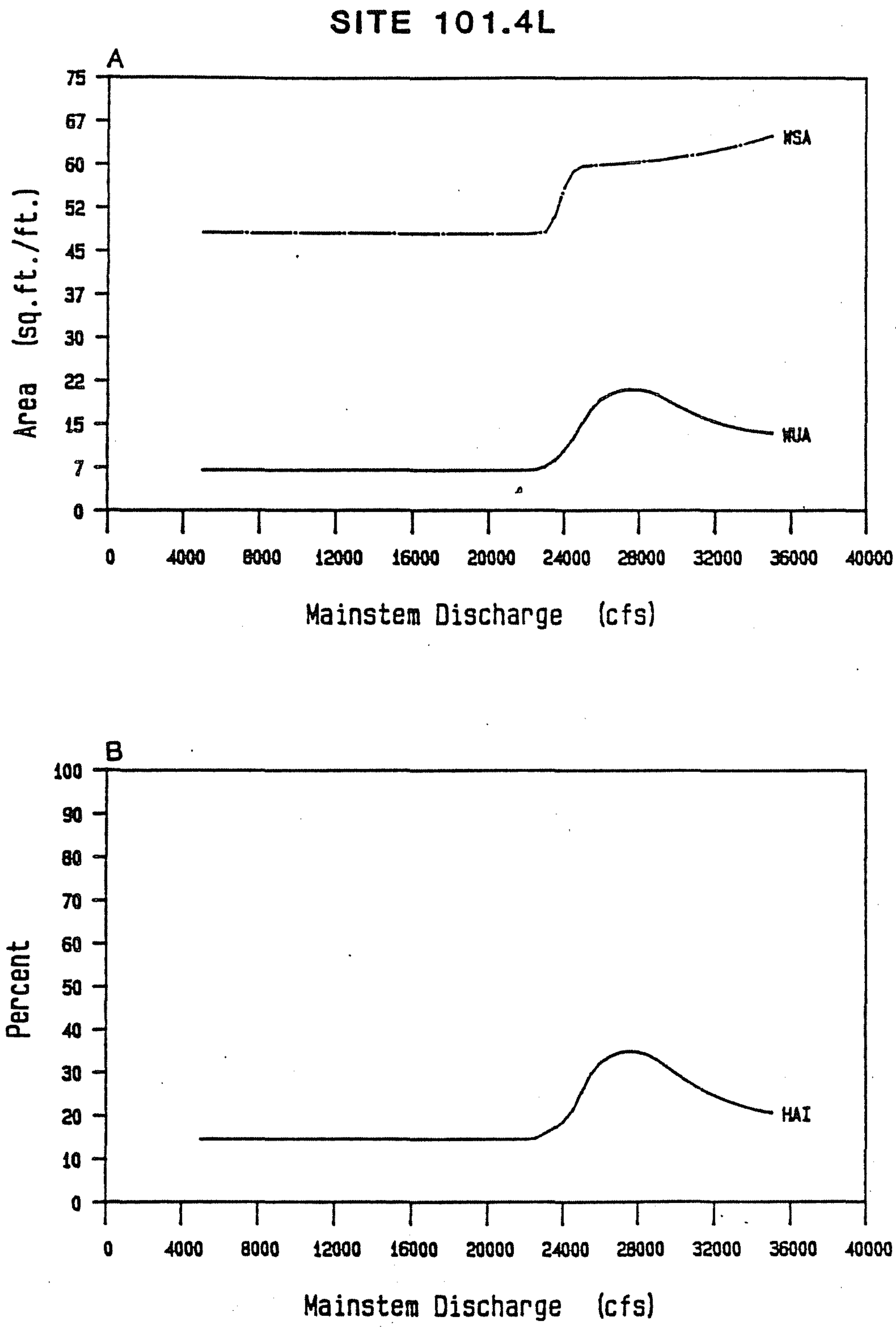
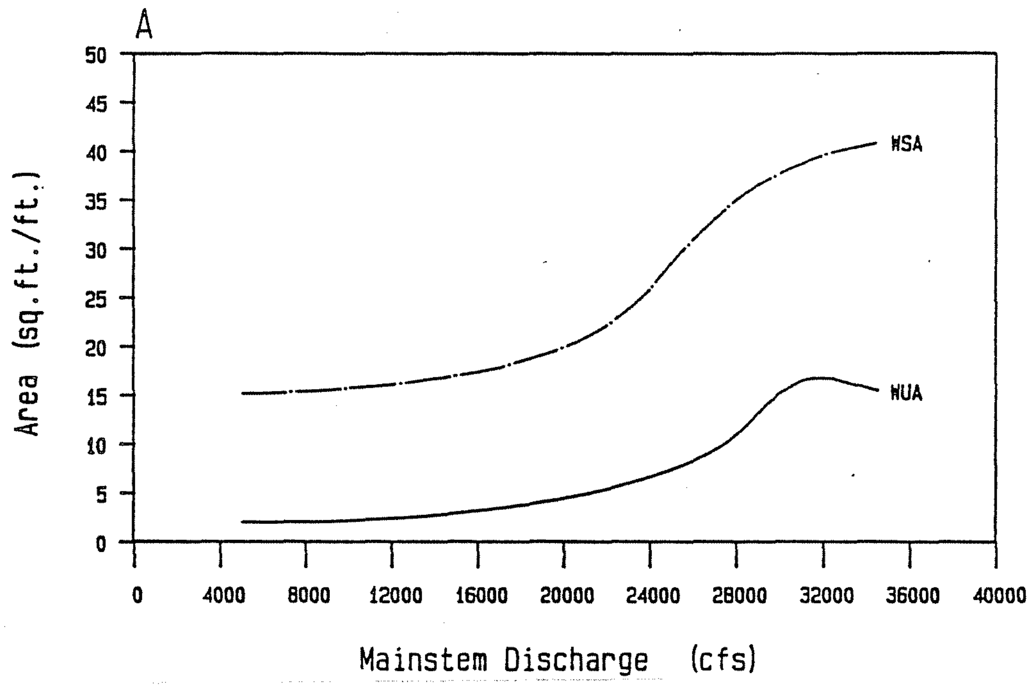


Figure 21. Surface area and chinook rearing habitat index response curves for modeling site 101.4L.
A - Wetted surface area (WSA) and weighted usable area (WUA).
B - Habitat availability index (HAI)

SITE 113.7R



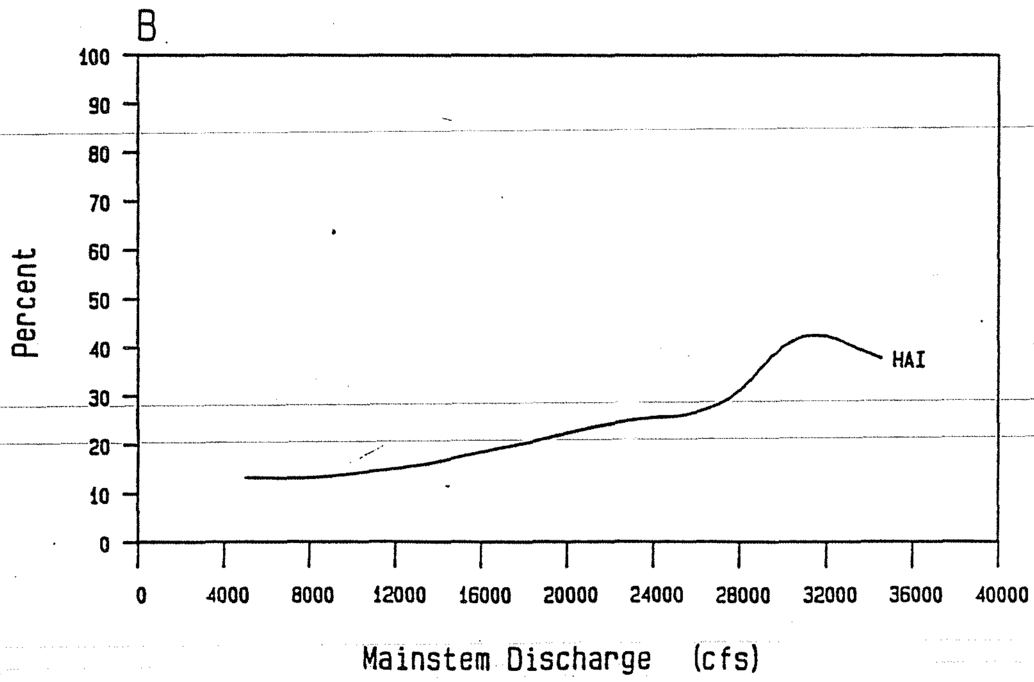


Figure 22. Surface area and chinook rearing habitat index response curves for modeling site 113.7R.
A - Wetted surface area (WSA) and weighted usable area (WUA).
B - Habitat availability index (HAI).

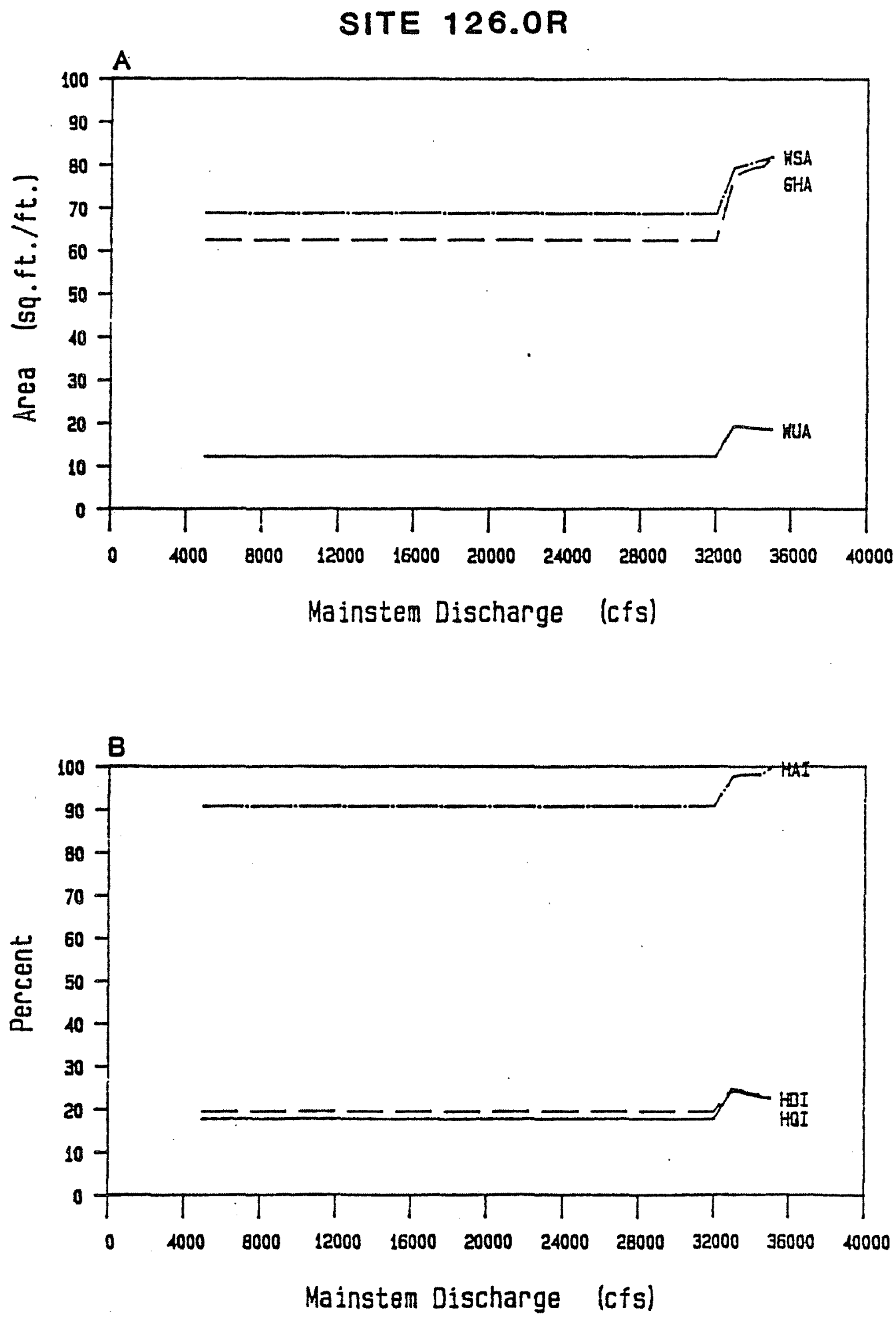


Figure 23. Surface area and chinook rearing habitat index response curves for modeling site 126.0R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

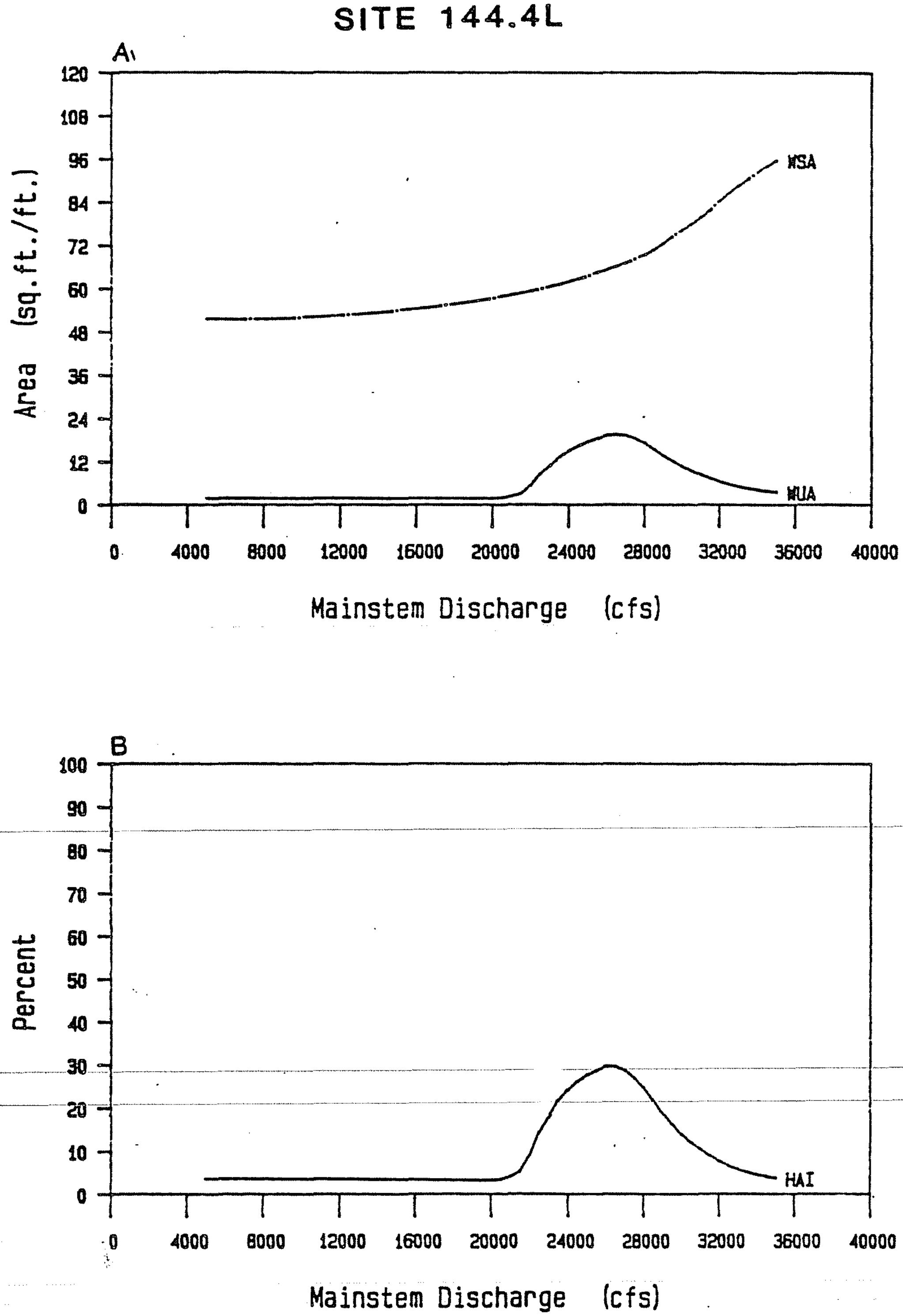


Figure 24. Surface area and chinook rearing habitat index response curves for modeling site 144.4L.
A - Wetted surface area (WSA) and weighted usable area (WUA).
B - Habitat availability index (HAI)

the ascending left hand limb of the WUA curve than at non-breached or high mainstem discharges. Under non-breached conditions, unsuitably shallow depths often occur in riffle areas of the site, resulting in slightly lower HQI values. Although surface area and habitat indices for Site 126.0R were not extrapolated to flows exceeding 35,000 cfs, it is likely that juvenile chinook habitat becomes more restricted to peripheral areas as mid-channel velocities increase.

Specific areas in Representative Group II are listed in four subgroups according to similarities among their morphologic and hydraulic characteristics. Site 101.4L represents 7 specific areas within Group II that have relatively large broad channels. Site 113.7R is associated with 9 smaller specific areas with narrower channels. The 6 specific areas associated with Site 126.0R are all from two similar side slough complexes within several miles of each other. The last subgroup is comprised of 6 specific areas that are similar in size and channel gradient to modeled site 144.4L. HAI functions are plotted for specific areas associated with each of these modeling sites in Figures 25 through 28. HAI values used to plot these curves are tabulated in Appendix B.

Figure 29 depicts the aggregate WUA curve obtained by multiplying Group II specific area HAI values by their wetted surface areas and summing the results for each flow of interest. Because of their high breaching flows, most specific areas exhibit peak HAI values in the range of 20,000 to 30,000 cfs. When adjusted by their wetted surface areas these sites yield cumulative WUA values which increase slowly at low to intermediate flows,

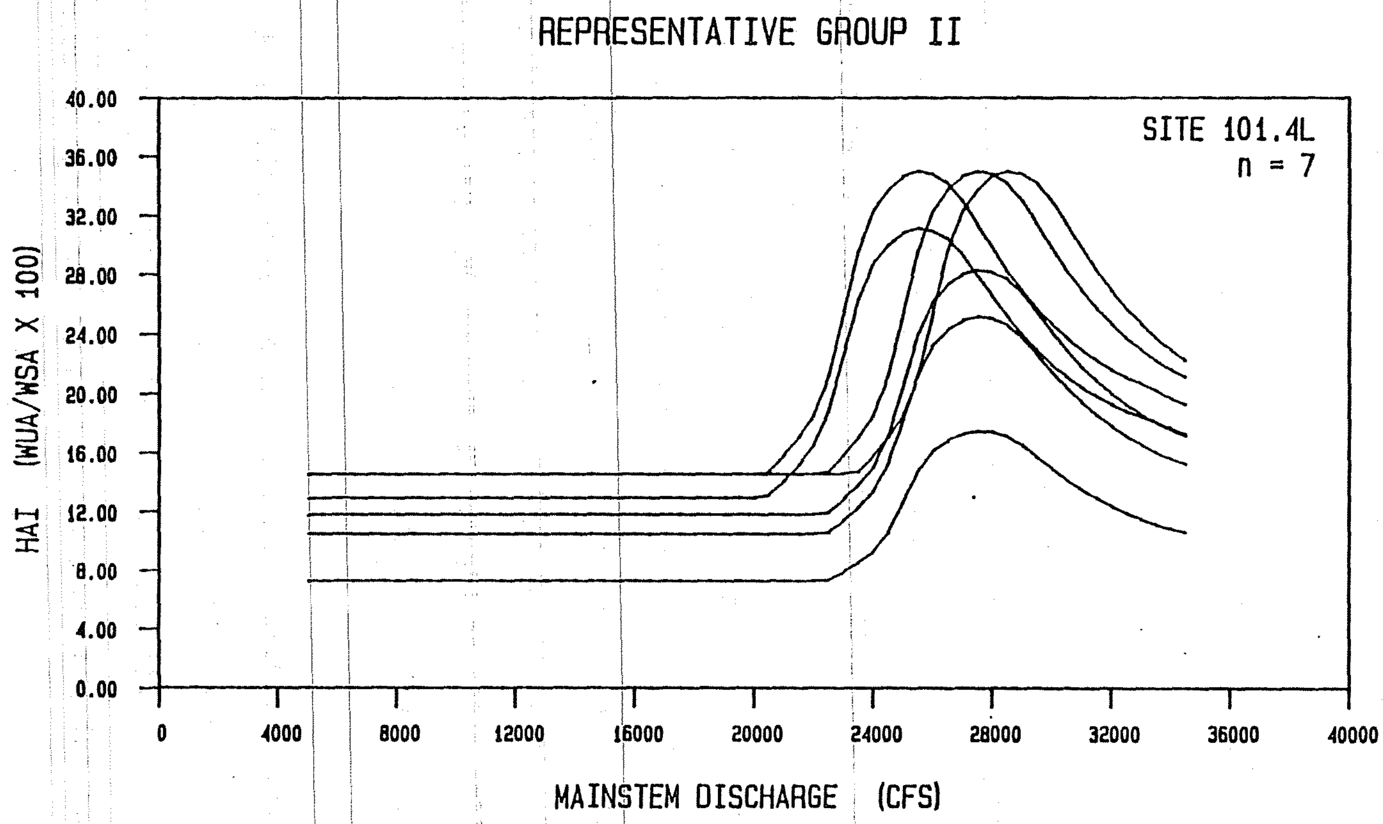


Figure 25. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 101.4L of Representative Group II.

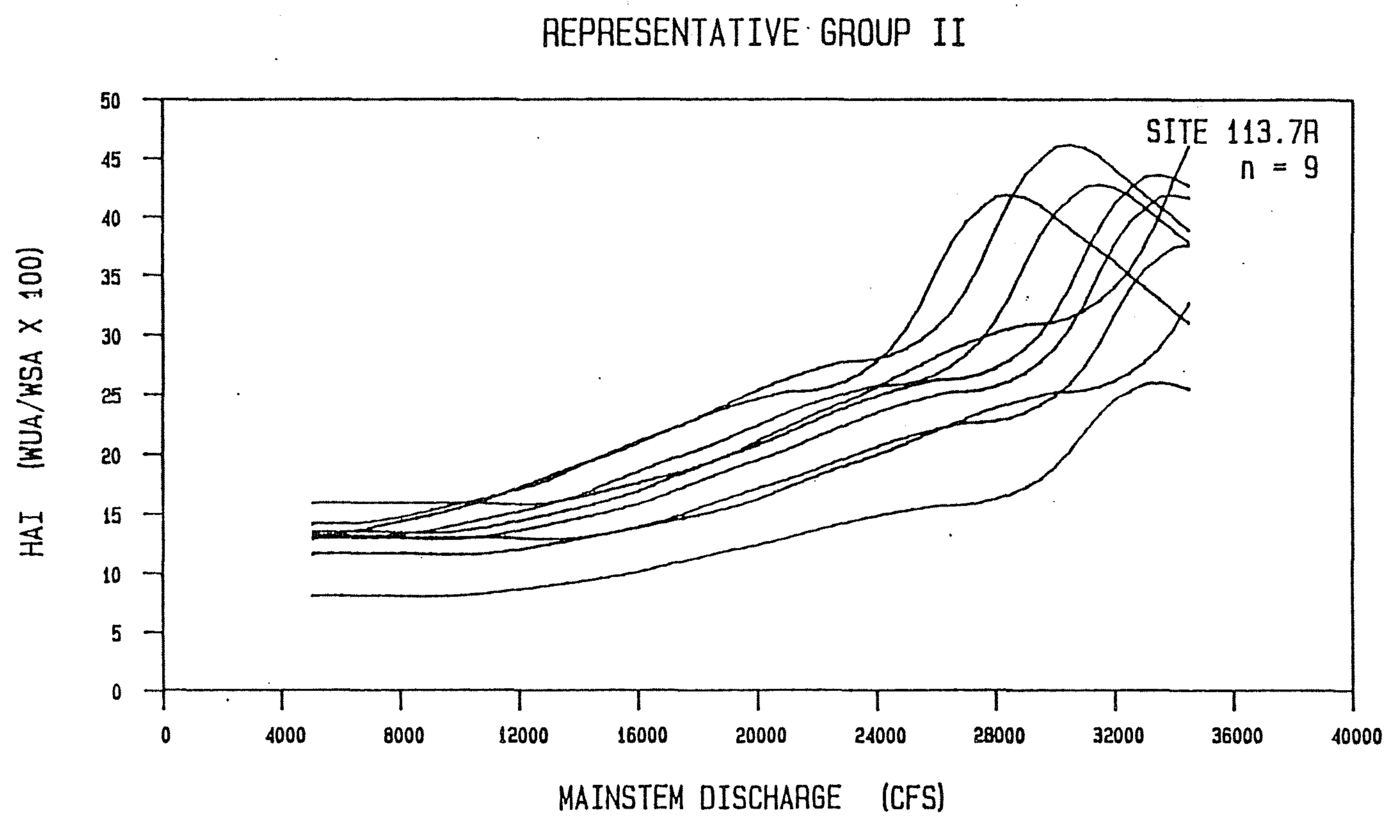


Figure 26. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 113.7R of Representative Group II.

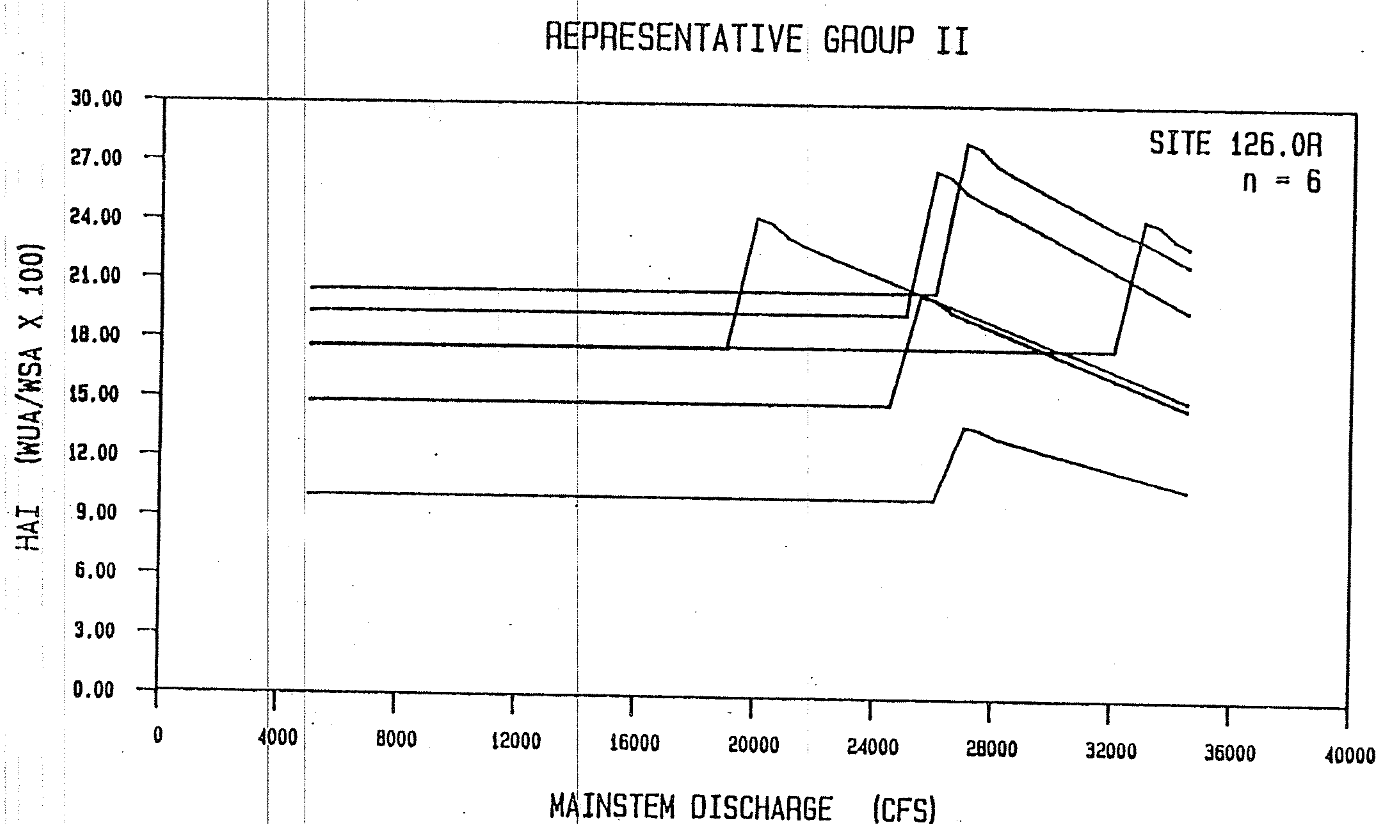


Figure 27. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 126.0R of Representative Group II.

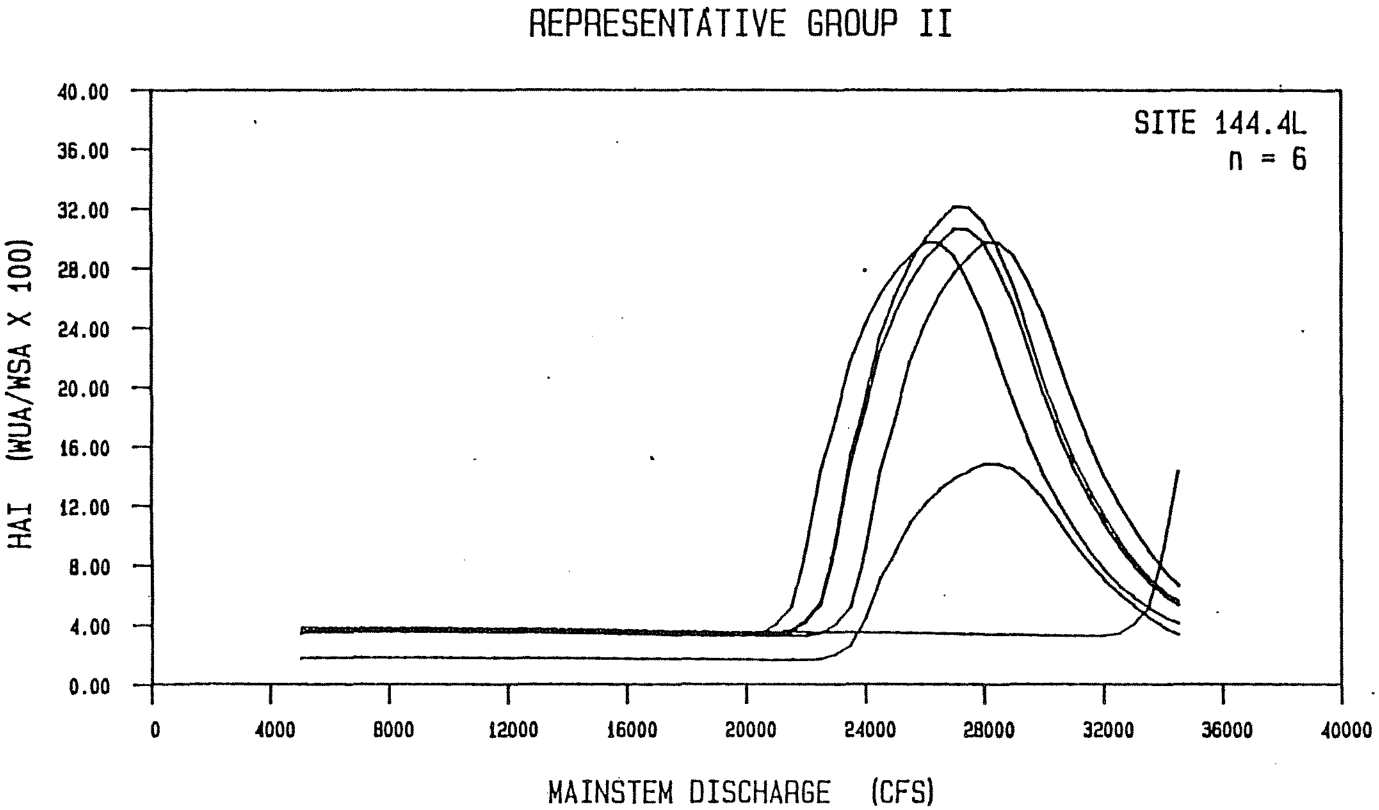


Figure 28. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 144.4L of Representative Group II.

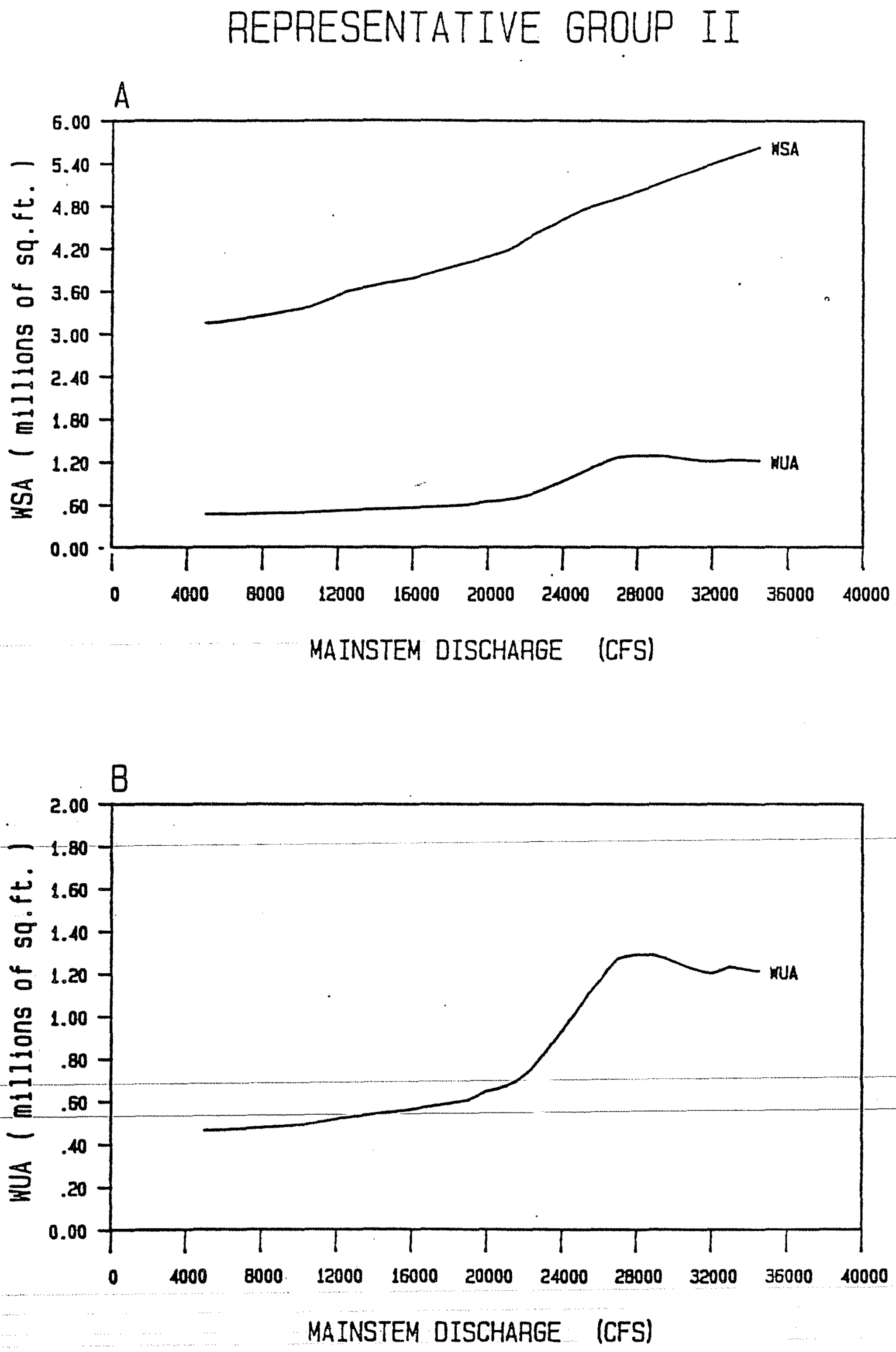


Figure 29. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group II of the middle Susitna River.

increase more rapidly after this point and peak at 29,000 cfs. Approximately 1.2 million square feet of juvenile chinook WUA is provided by Group II specific areas at this discharge. The large differences in WUA over the range of evaluation flows indicate that rearing habitat potential in Representative Group II as a whole may be considered highly sensitive to fluctuations in mainstem flow. Figure 29 also illustrates aggregate WSA response for Representative Group II.

3.3 Representative Group III

Sites 101.2R, 128.8R, 132.6L and 141.4R are all side channels which become nonbreached at intermediate (8,000 to 16,000 cfs) mainstem discharge levels, and transform into side sloughs at lower discharges. These modeling sites and the Group III specific areas they represent, shown in Plates A-7 through A-14 (Appendix A), are larger and convey greater volumes of water when breached than the side sloughs discussed in the preceding section. Site geometry tends toward broad cross-sections. Reach gradients are sufficient to promote mid-channel velocities of 2 to 5 fps following breaching. Upwelling occurs sporadically within these specific areas and in a few cases may be insufficient to provide for passage between clearwater pools formed at low mainstem flows.

The 18 specific areas comprising Group III represent some of the most heavily utilized rearing areas in the middle segment of the Susitna River. Juvenile chinook are found in these areas primarily under turbid water conditions (Dugan et al. 1984).

Surface area and juvenile chinook habitat response curves are portrayed in Figures 30, 31 and 33 for modeling sites 101.2R, 128.8R and 141.4R, respectively. These sites were modeled using IFG hydraulic simulation models coupled with the HABTAT model of the PHABSIM system. A fourth site, 132.6L was modeled using both PHABSIM and RJHAB modeling techniques applied to separate sets of data. Results for this site are found in Figure 32.

An inspection of the aerial photography (Plates A-7 through A-14, Appendix A) WSA curves developed for the modeling sites suggests a rapid response of

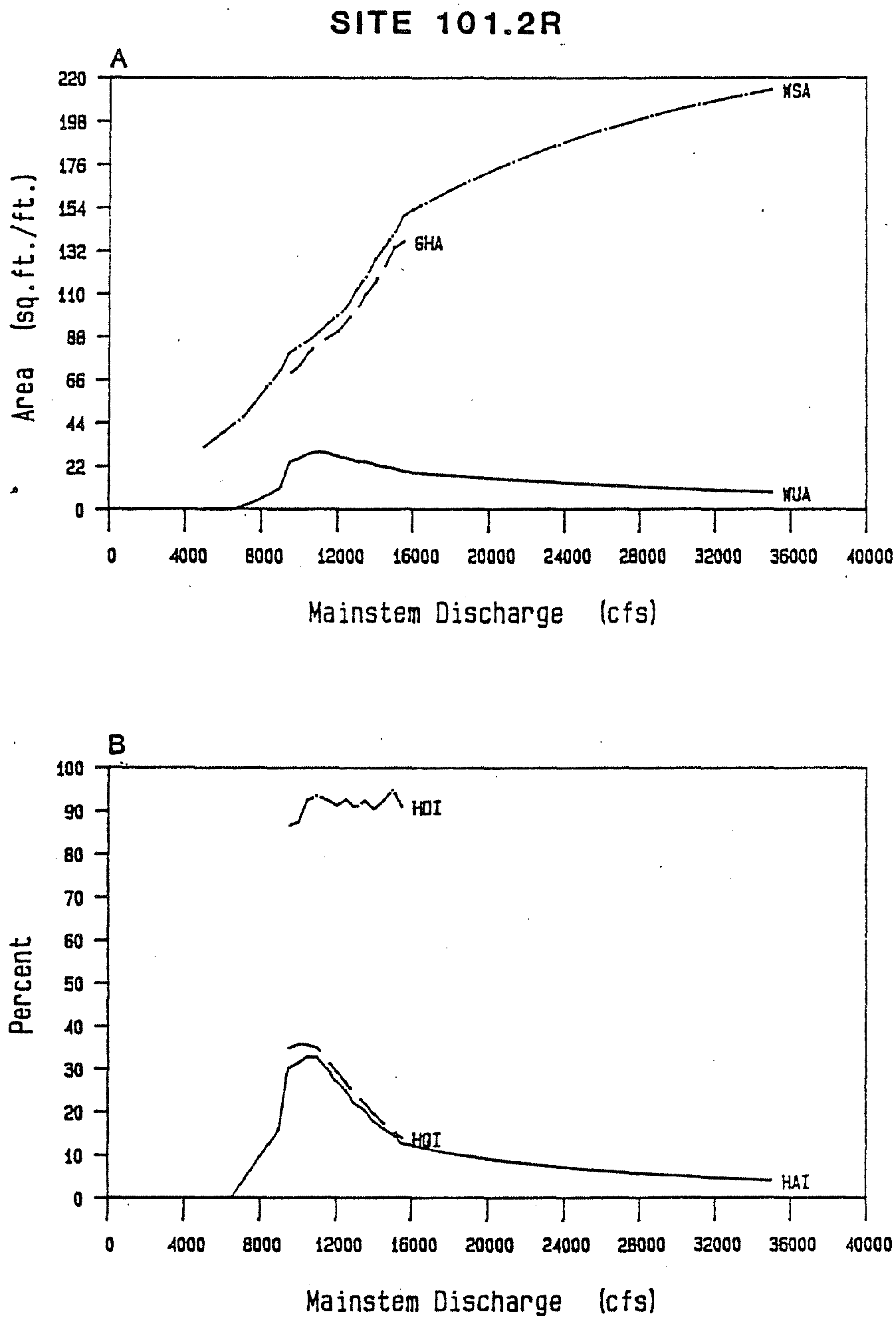


Figure 30. Surface area and chinook rearing habitat index response curves for modeling site 101.2R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

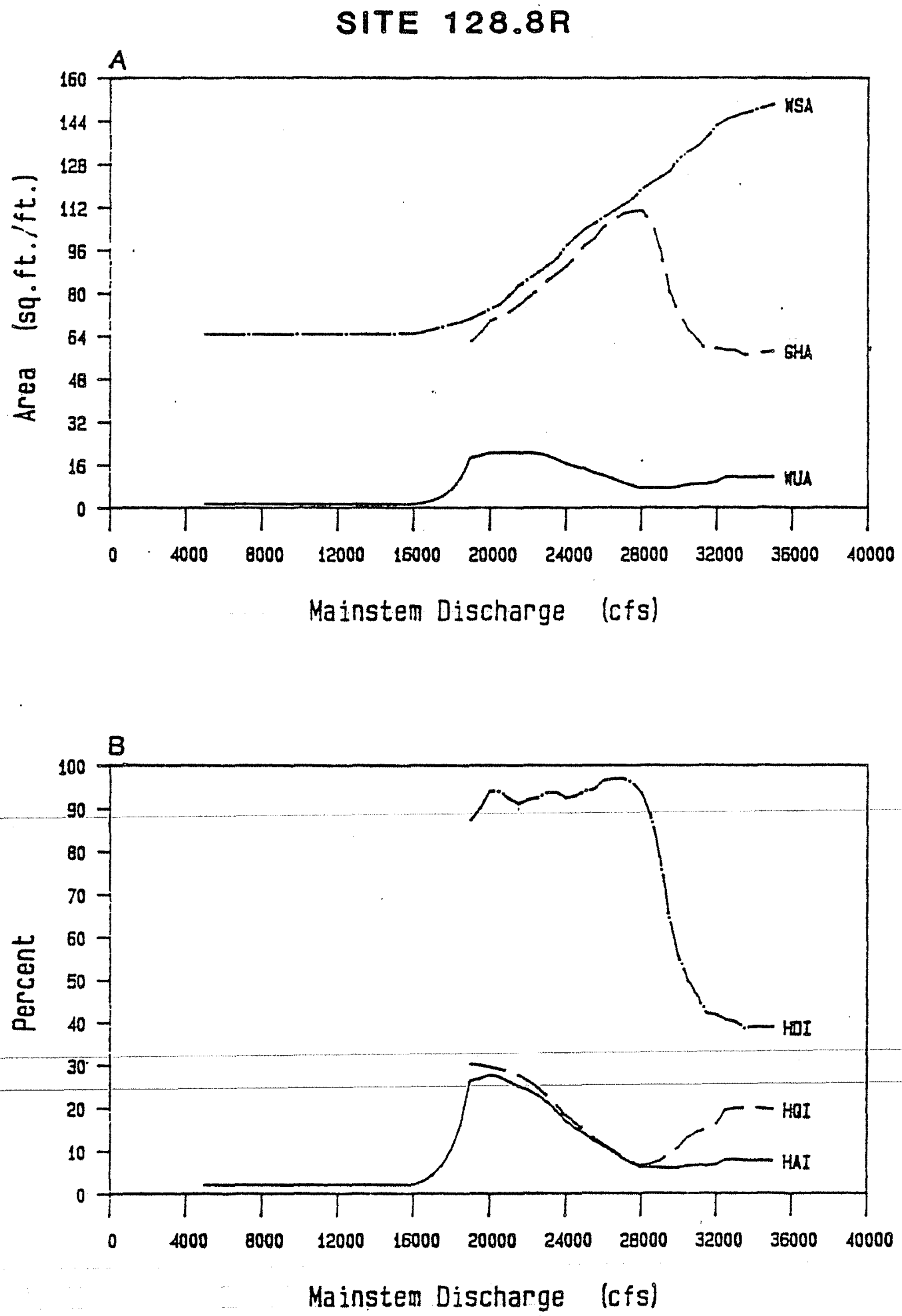


Figure 31. Surface area and chinook rearing habitat index response curves for modeling site 128.8R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

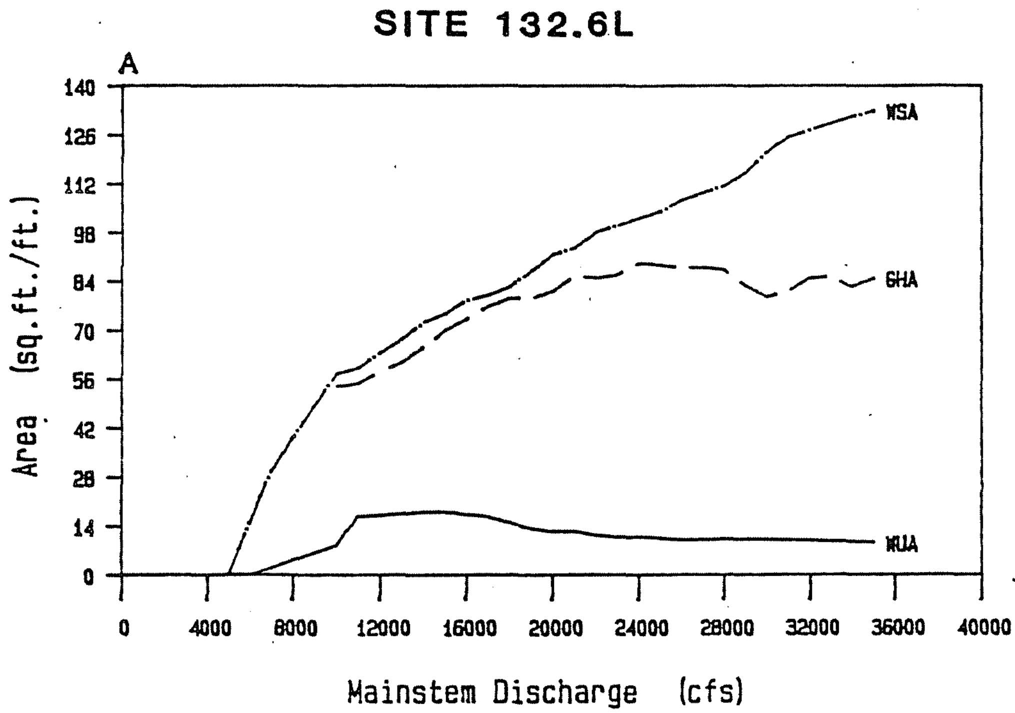


Figure 32. Surface area and chinook rearing habitat index response curves for modeling site 132.6L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

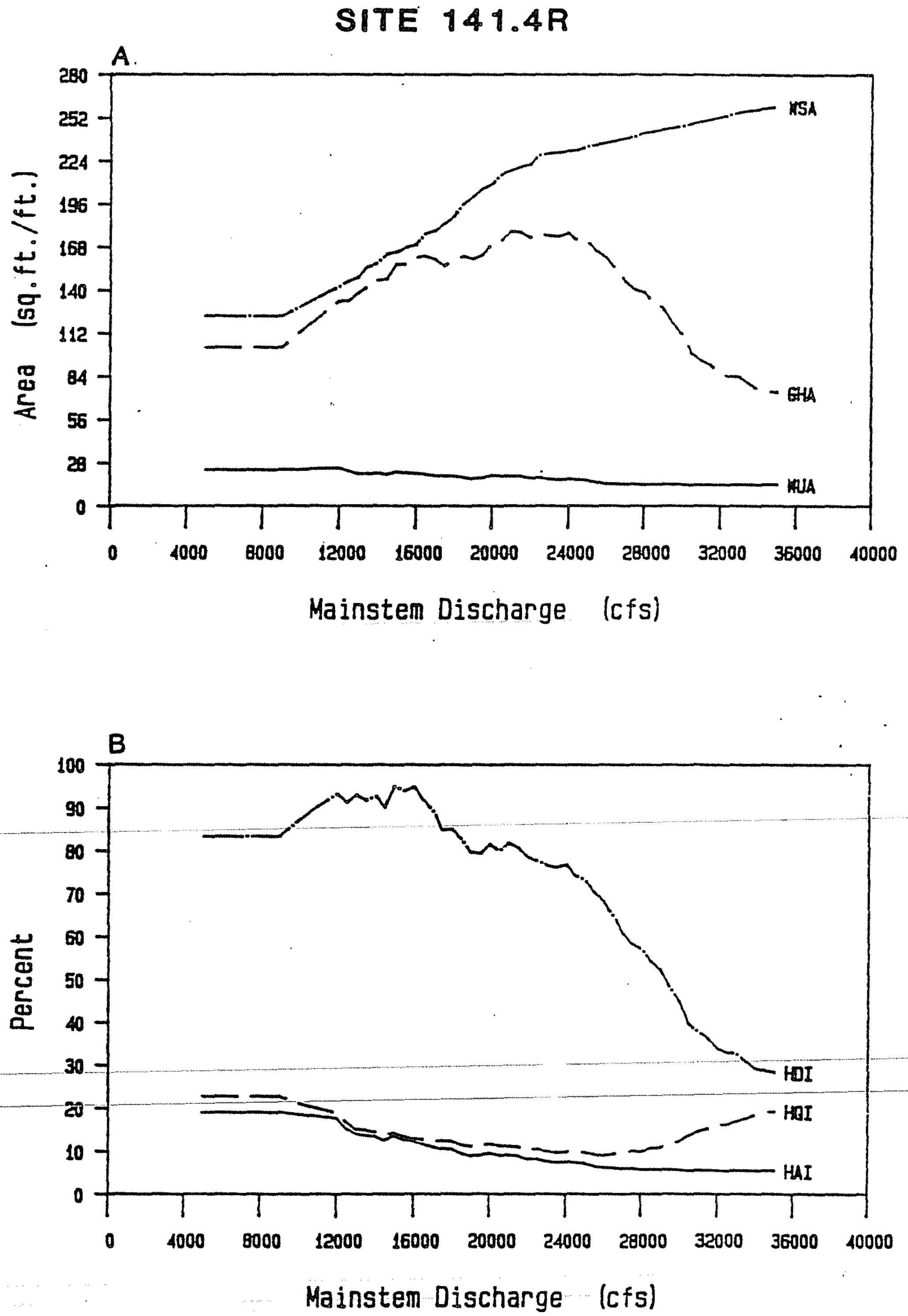


Figure 33. Surface area and chinook rearing habitat index response curves for modeling site 141.4R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

wetted surface area to changes in mainstem discharge following breaching. This response is paralleled by changes in gross habitat area until moderately high flows are attained, when the proportion of wetted surface area possessing usable rearing habitat falls off. Peak HDI values for the modeling sites typically range from 95 to 97 percent. These maxima usually occur at much higher flows than those associated with peak WUA values. Therefore, the quality of usable rearing habitat, as measured by the HQI index, tends to decline at higher flows; i.e., a greater proportion of the total WUA is concentrated in a smaller area within the modeling sites. This decline is caused by shifts in velocities in the majority of cells toward the suboptimal end of the velocity suitability curve.

Of the 18 specific areas classified within Group III, 17 are represented by sites 101.2R, 128.8R, and 132.6L. Site 141.4R is considered atypical due to its larger size and discharge under non-breached conditions. Therefore, this model site only represents that specific area. Site 101.2R was used to develop specific area HAI functions for 10 specific areas with relatively broad shallow channels with mild gradients. Top widths generally exceeded 100 feet and streambeds consisted of large gravels and cobbles. Site 128.8R represents three specific areas possessing long sinuous channels less than 100 feet wide. Site 132.6L was used to represent four specific areas with relatively low velocities and sandy to large gravel substrates.

Figures 34 to 37 illustrate HAI functions derived from modeling site habitat data and underscore the singularity of the habitat response to flow at Site 141.4R. HAI curves developed for the remainder of the other modeling sites in this representative group exhibit a strong unimodal peak in HAI following breaching, whereas the HAI response to increasing discharge at Site 141.4R is to progressively decrease for reasons stated above.

A comparison of the magnitudes and shapes of the WSA, WUA and HAI curves derived for Site 132.6L (Figure 32) suggests that the RJHAB and PHABSIM modeling approaches yield similar results. The RJHAB method appears well-suited to smaller channels where cross-sectional profiles (i.e., velocity and depth distributions) and cover characteristics are relatively homogeneous. We recommend limiting the use of RJHAB modeling techniques primarily to baseline evaluations of fish habitat in lotic subenvironments meeting these constraints.

The aggregate WUA function derived from individual rearing habitat response curves for specific areas in Representative Group III exhibits a pronounced peak in the vicinity of 15,500 cfs (Figure 38). The amount of juvenile chinook habitat provided by this flow (1.3 million square feet) represents an increase of 350 percent over WUA values forecast for 9,000 cfs (0.3 million square feet). This marked increase in usable habitat is directly attributable to the recruitment of side channel habitat within the 9,000 to 12,500 cfs flow range; 12 of the 18 specific areas which comprise Group III breach in this range (refer to Table 4 for site-specific breaching flows). After peaking at 15,000 cfs, juvenile chinook habitat

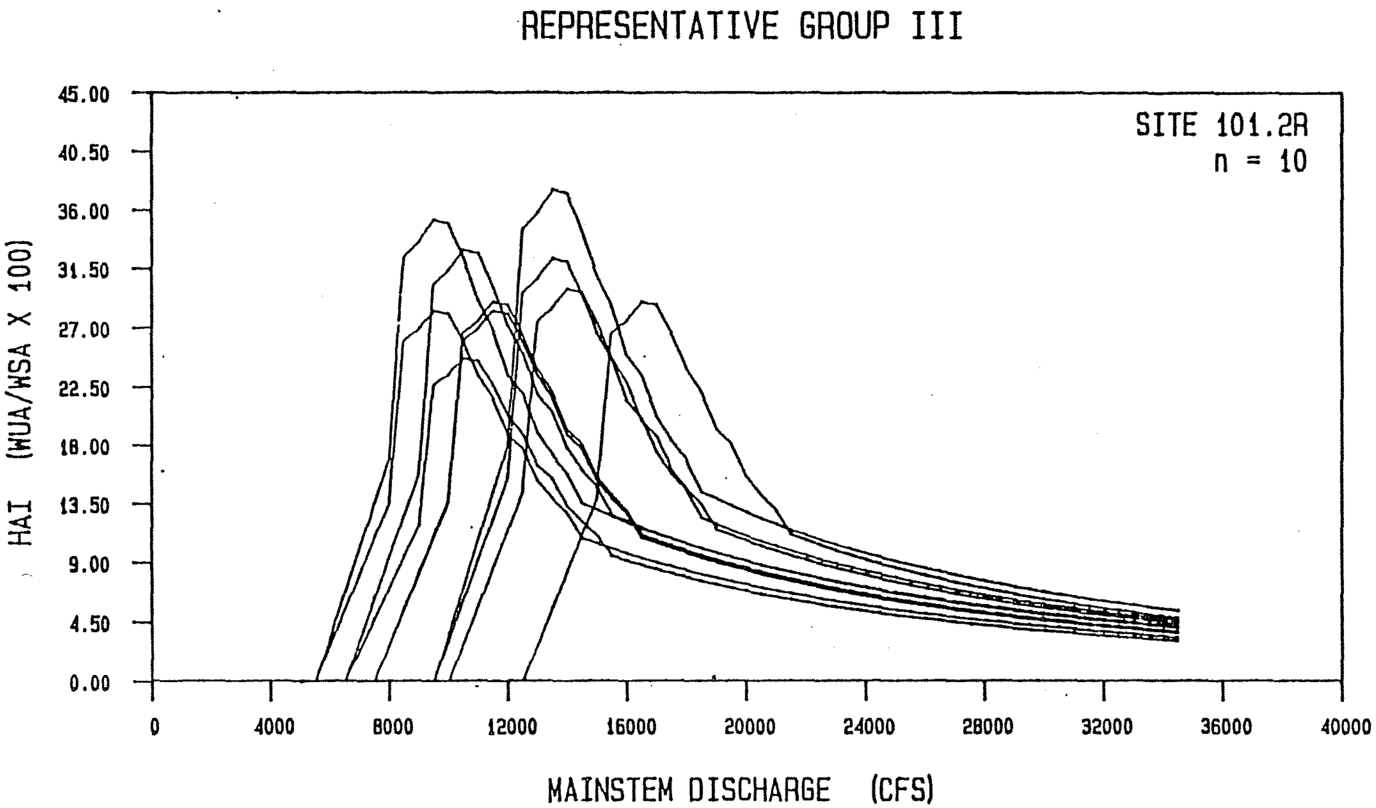


Figure 34. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 101.2R of Representative Group III.

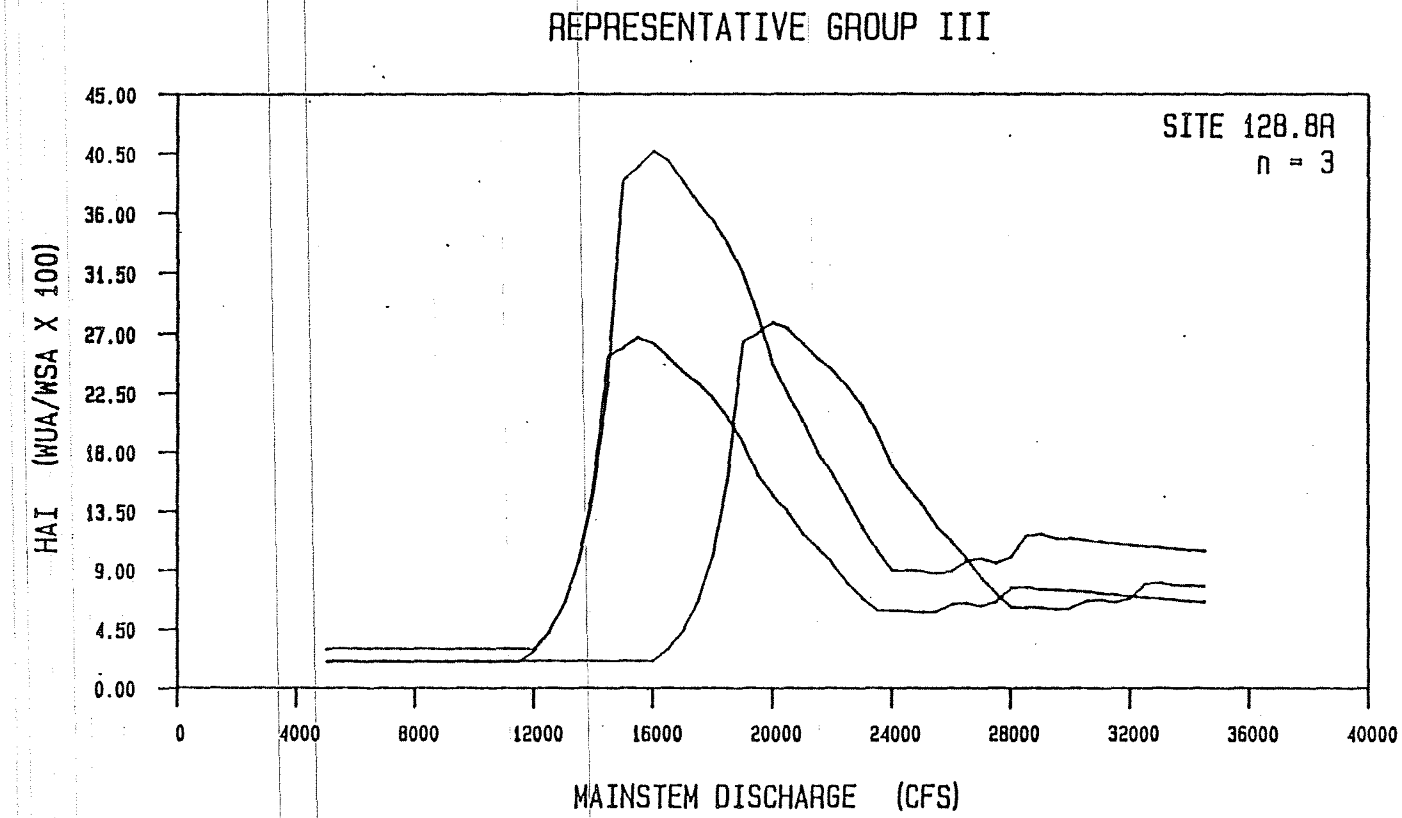


Figure 35. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 128.8R of Representative Group III.

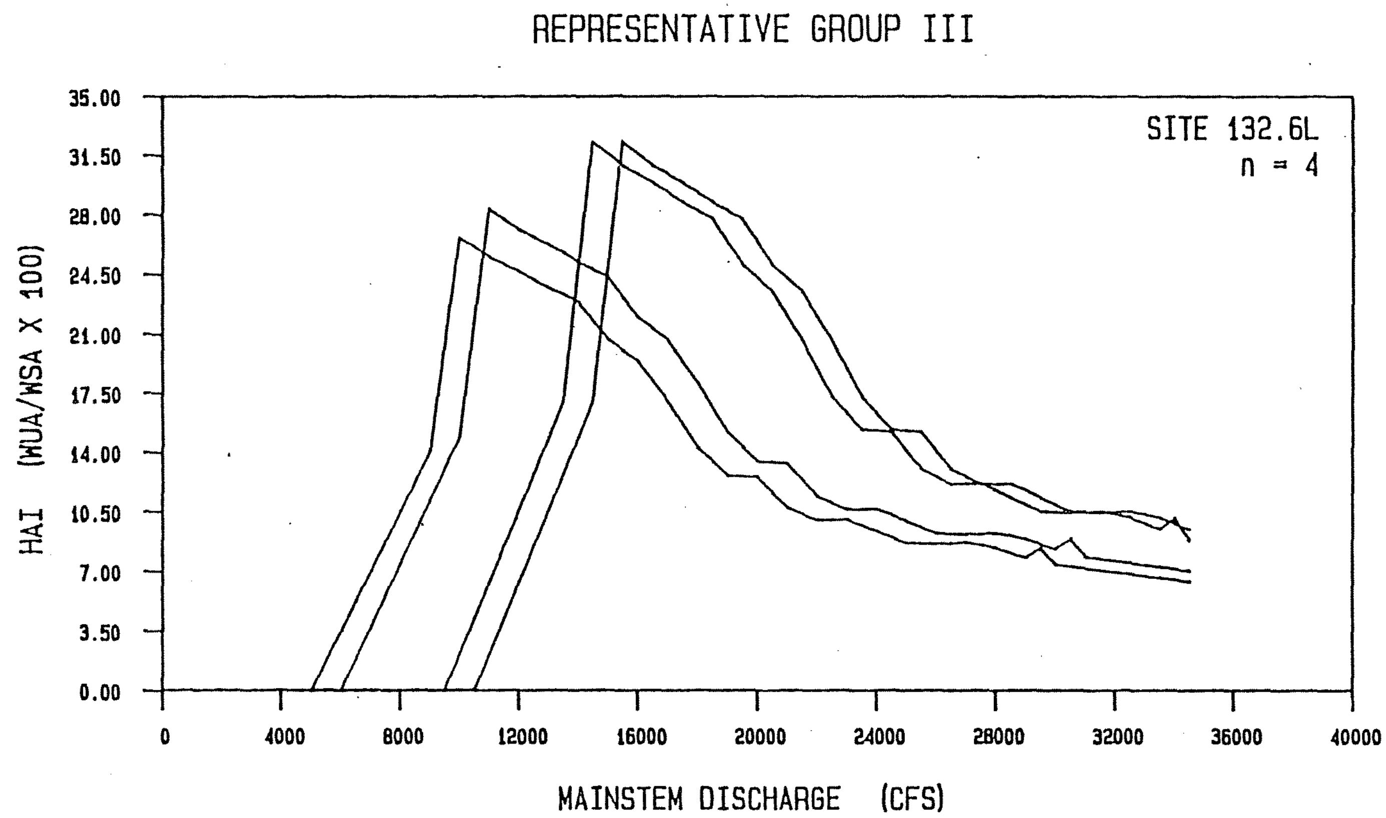


Figure 36. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 132.6L of Representative Group III.

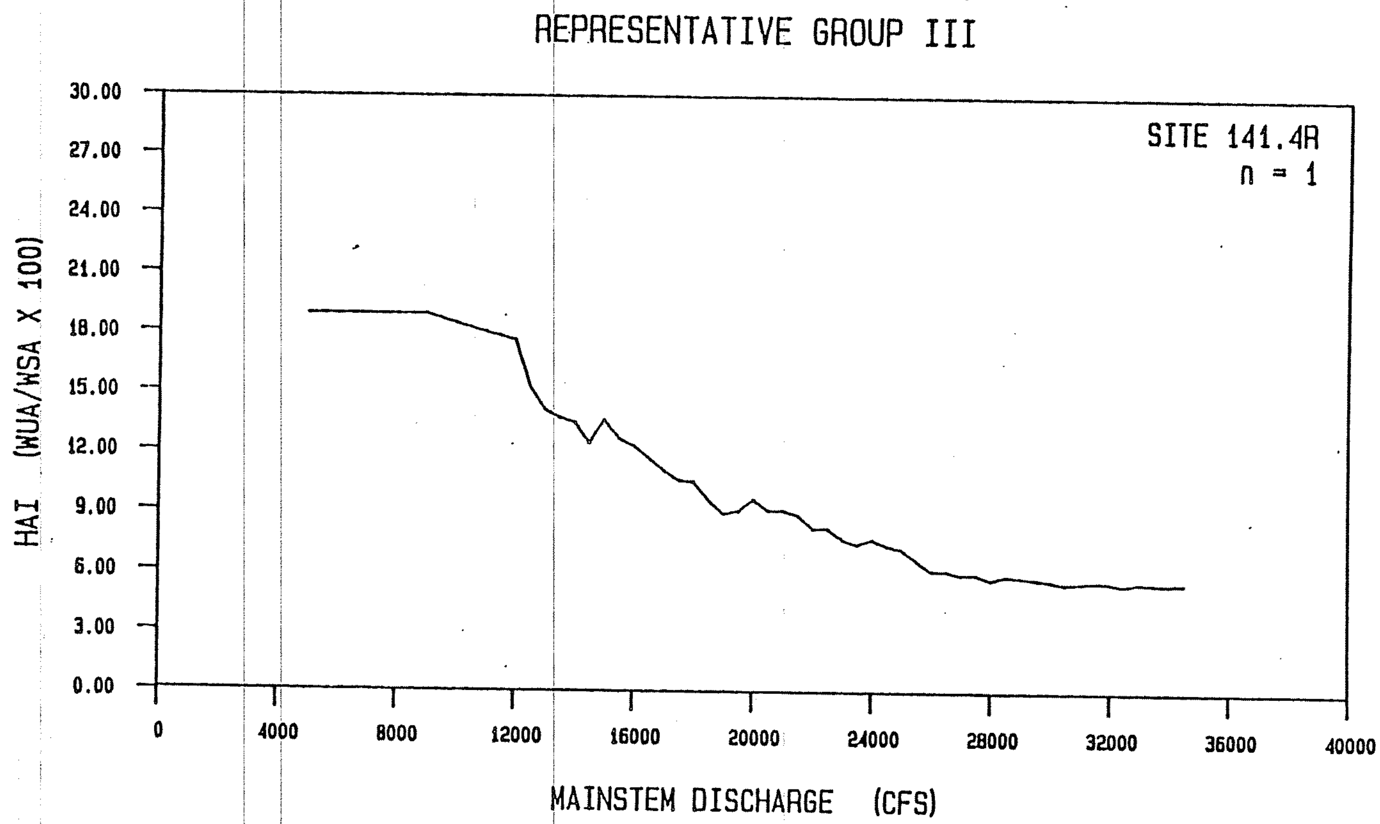


Figure 37. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 141.4R of Representative Group III.

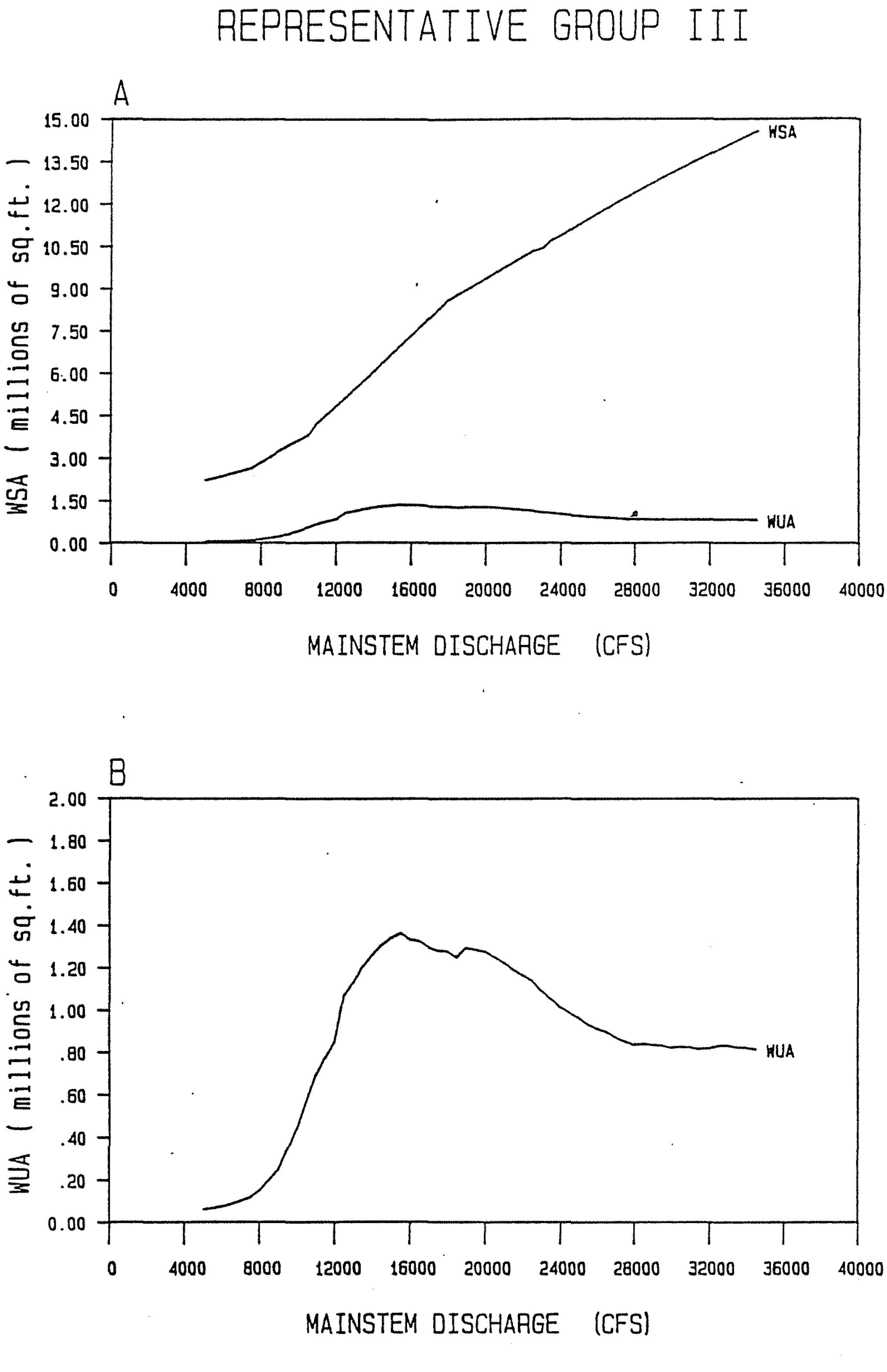


Figure 38. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group III of the middle Susitna River.

gradually declines to 0.9 million square feet at 26,000 cfs and remains at this level through 35,000 cfs. Decreases in HAI values which occur within this range are offset by gains in total wetted surface area, resulting in relatively stable rearing habitat potential at higher flows.

3.4 Representative Group IV

Aaserude et al. (1985) delineates the 22 specific areas within this group on the basis of their low breaching discharges and intermediate to high mean reach velocities. The side channels which comprise these specific areas possess lower mean reach velocities than adjacent mainstem channels. Substrates range primarily from cobble to boulder.

Four modeling sites represent Group IV: 112.6L, 131.7L, 134.9R and 136.0L. Of these, Site 112.6L is the largest and Site 136.0L the smallest of the sites investigated. In spite of their disparity in size, the modeling sites are characterized by similar surface area and habitat index response curves. Compare the aerial photographs of the modeling sites presented in Plates A-15 through A-22 (Appendix A) with the wetted surface curves in Figures 39 through 42. As is typical of most side channels of the middle river, wetted surface area responds to changes in streamflow more rapidly at lower than at higher flows; the rate of change in WSA per 1000 cfs increment in mainstem discharge declines perceptibly at flows exceeding 16,000 cfs. This response pattern is accentuated at sites with wide, shallow channel cross sections such as Site 131.7L (Plates A-17 and A-18, Figure 40).

In terms of juvenile chinook habitat potential, the most remarkable feature of Group IV modeling sites is the comparatively large amounts of WUA they provide at low to moderate mainstem flows. A comparison of the WUA values and, more appropriately, HAI functions (Figures 43 through 46) with estimates obtained for modeling sites from other Representative Groups suggests

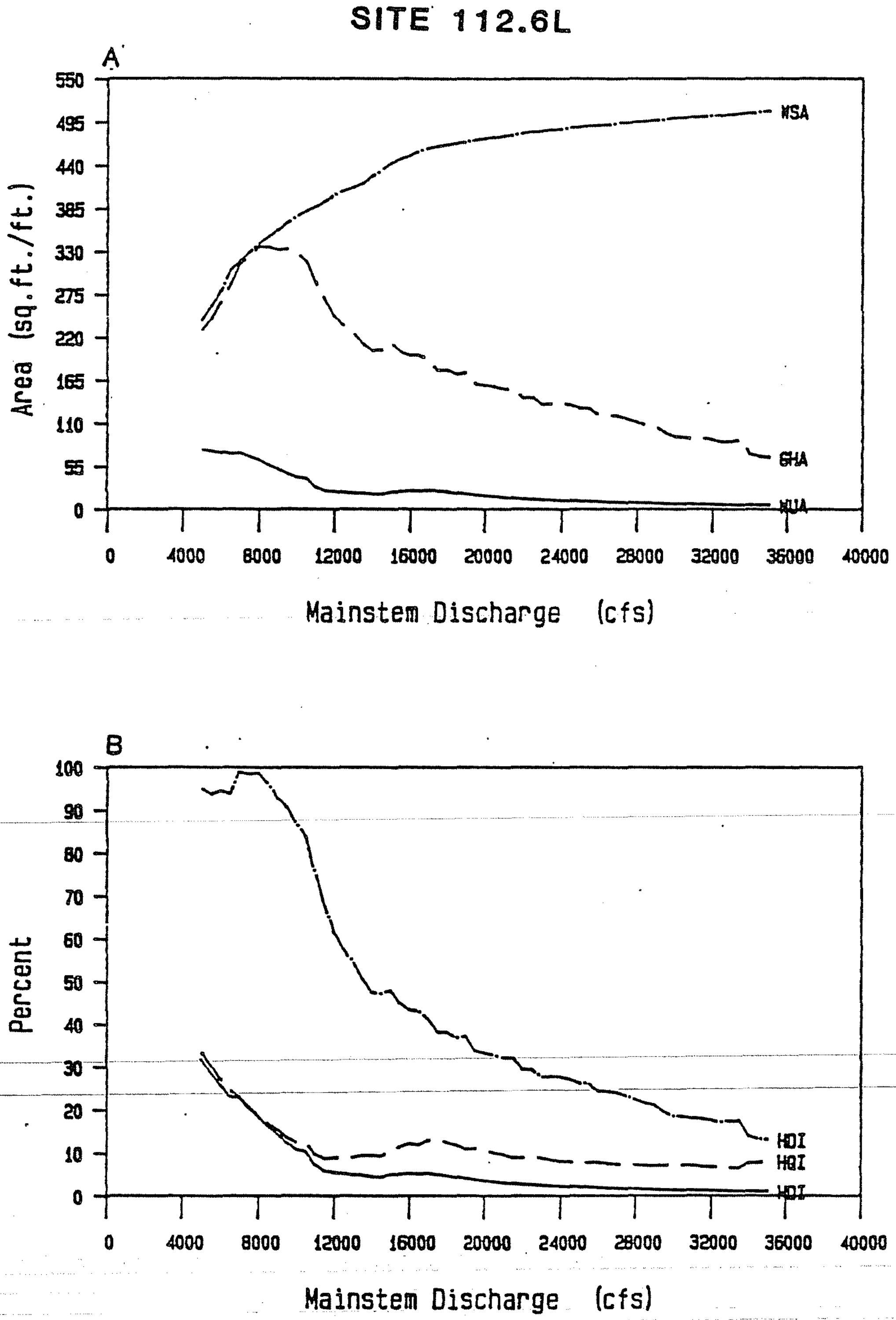


Figure 39. Surface area and chinook rearing habitat index response curves for modeling site 112.6L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

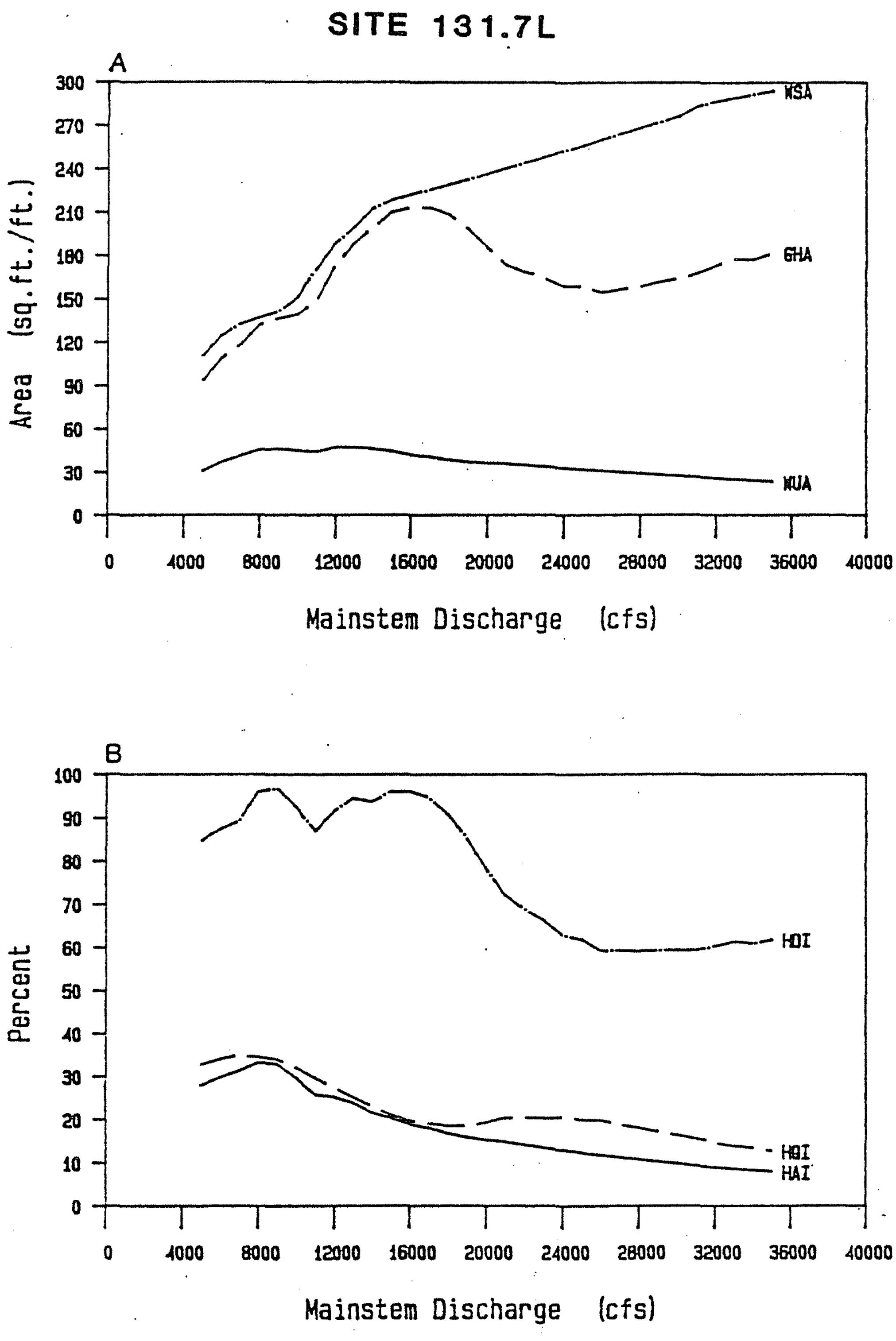
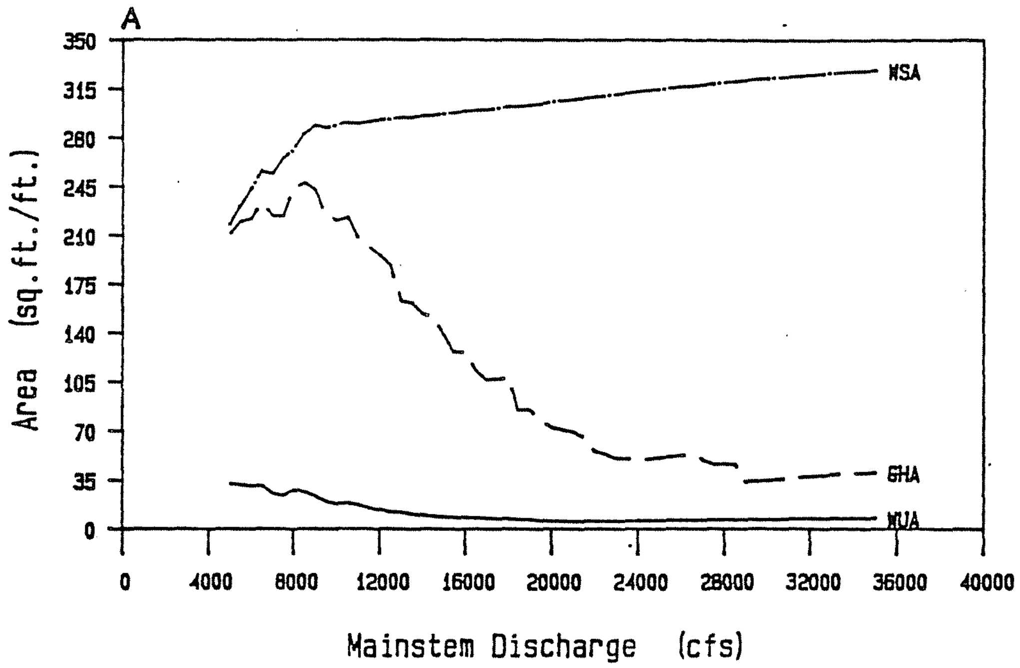


Figure 40. Surface area and chinook rearing habitat index response curves for modeling site 131.7L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

SITE 134.9R



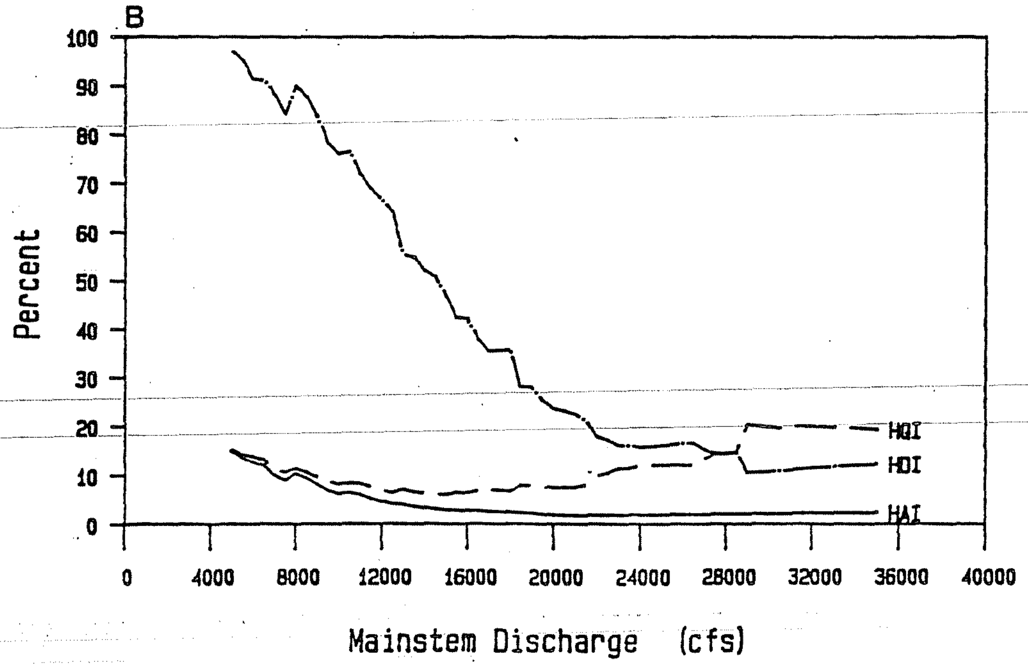


Figure 41. Surface area and chinook rearing habitat index response curves for modeling site 134.9R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

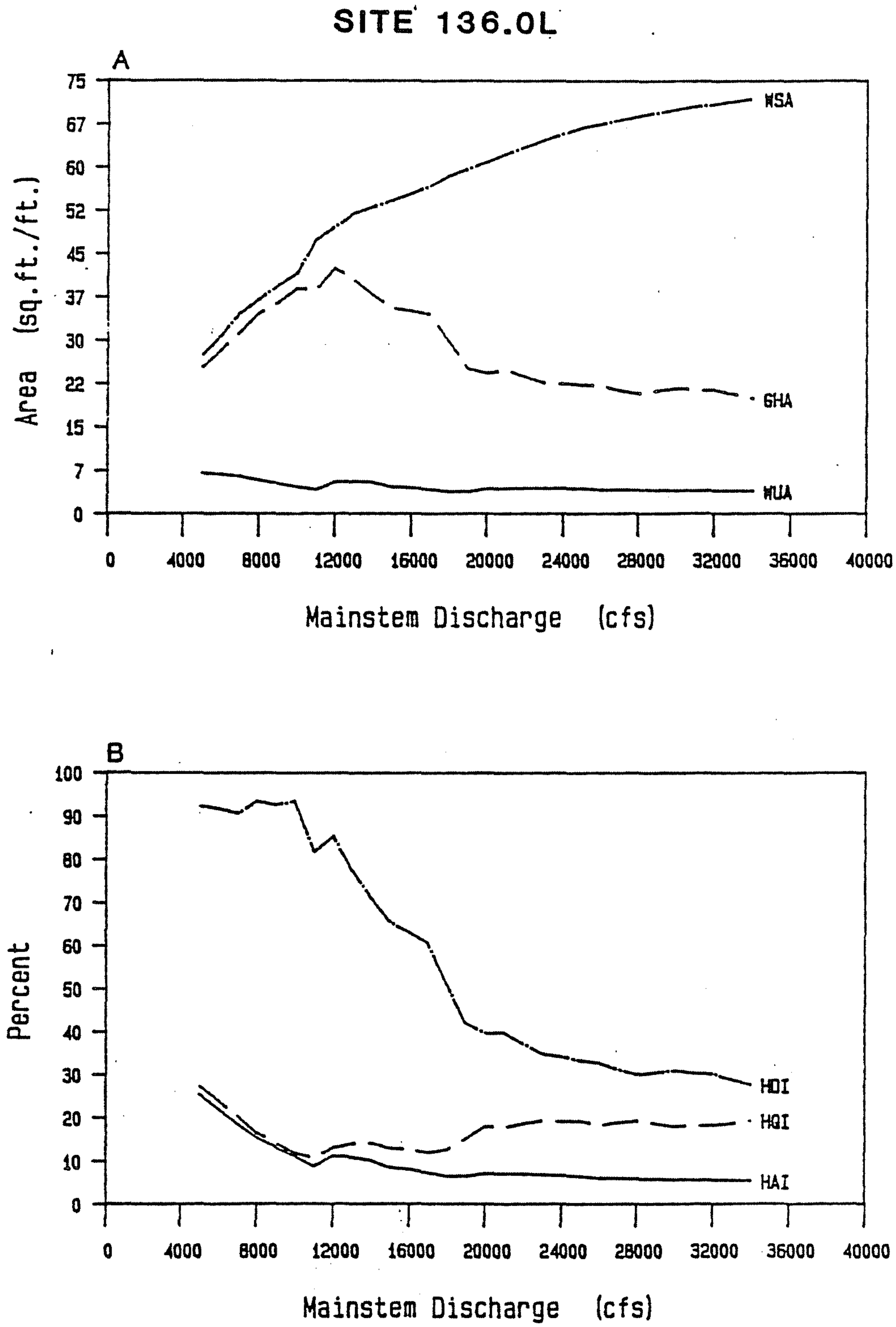


Figure 42. Surface area and chinook rearing habitat index response curves for modeling site 136.0L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

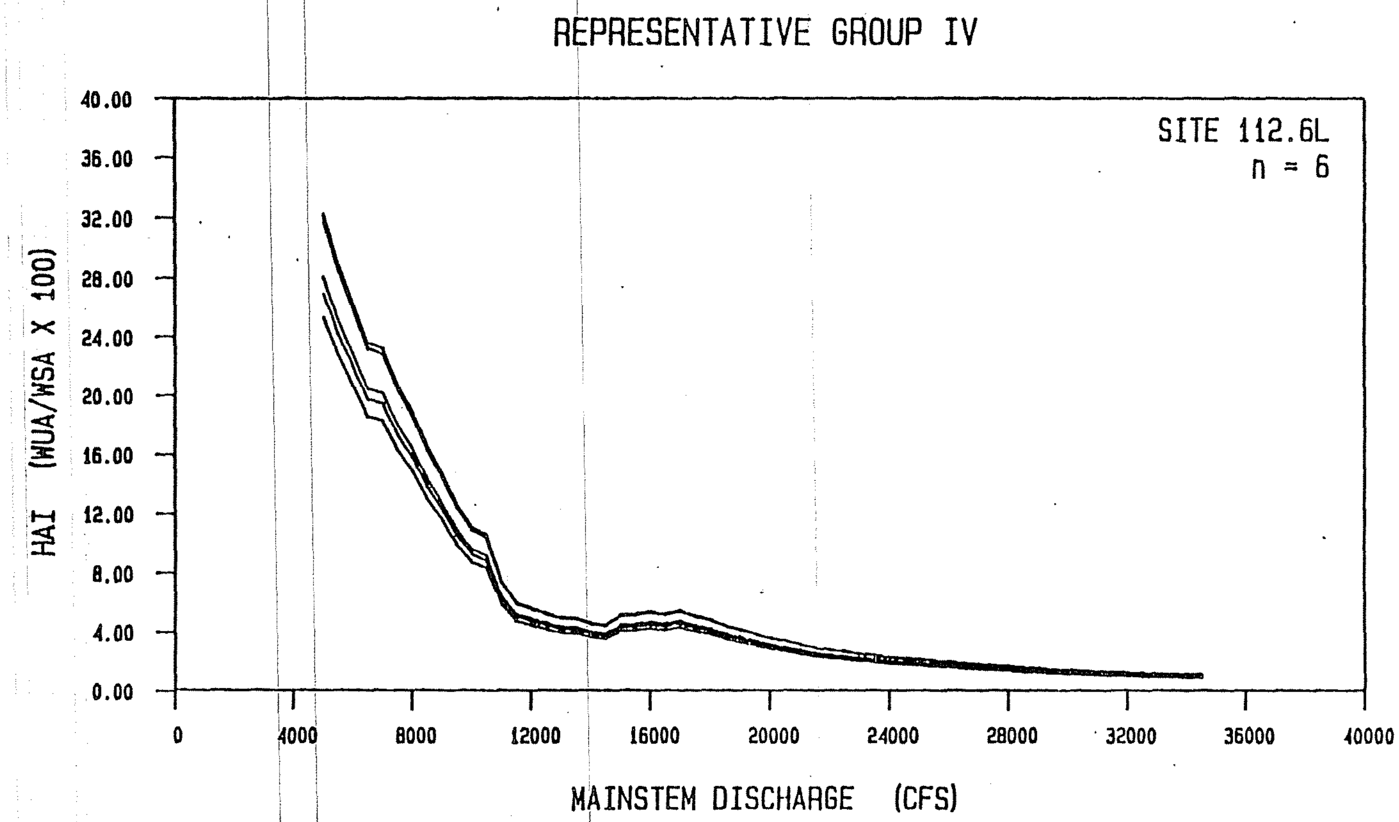


Figure 43. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 112.6L of Representative Group IV.

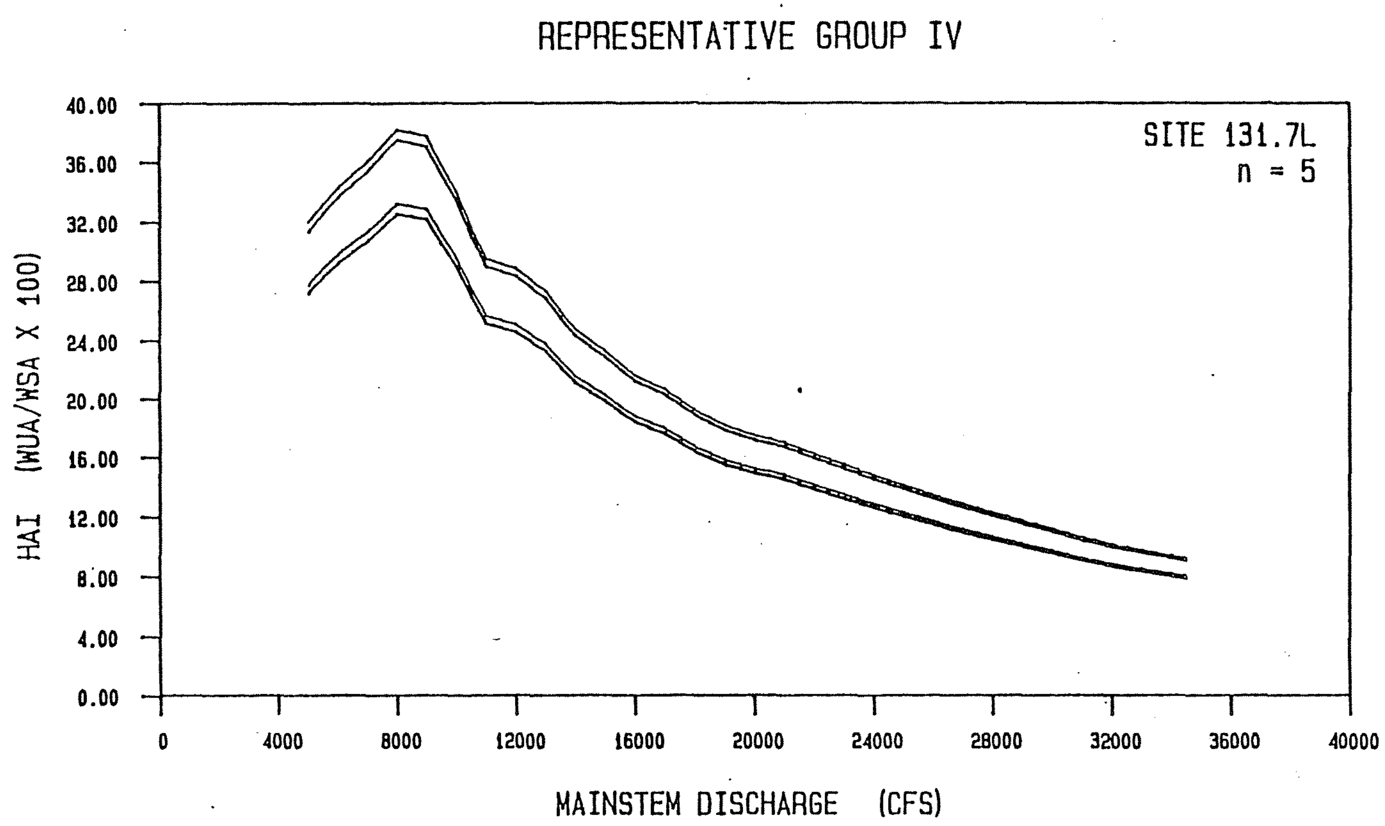


Figure 44. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 131.7L of Representative Group IV.

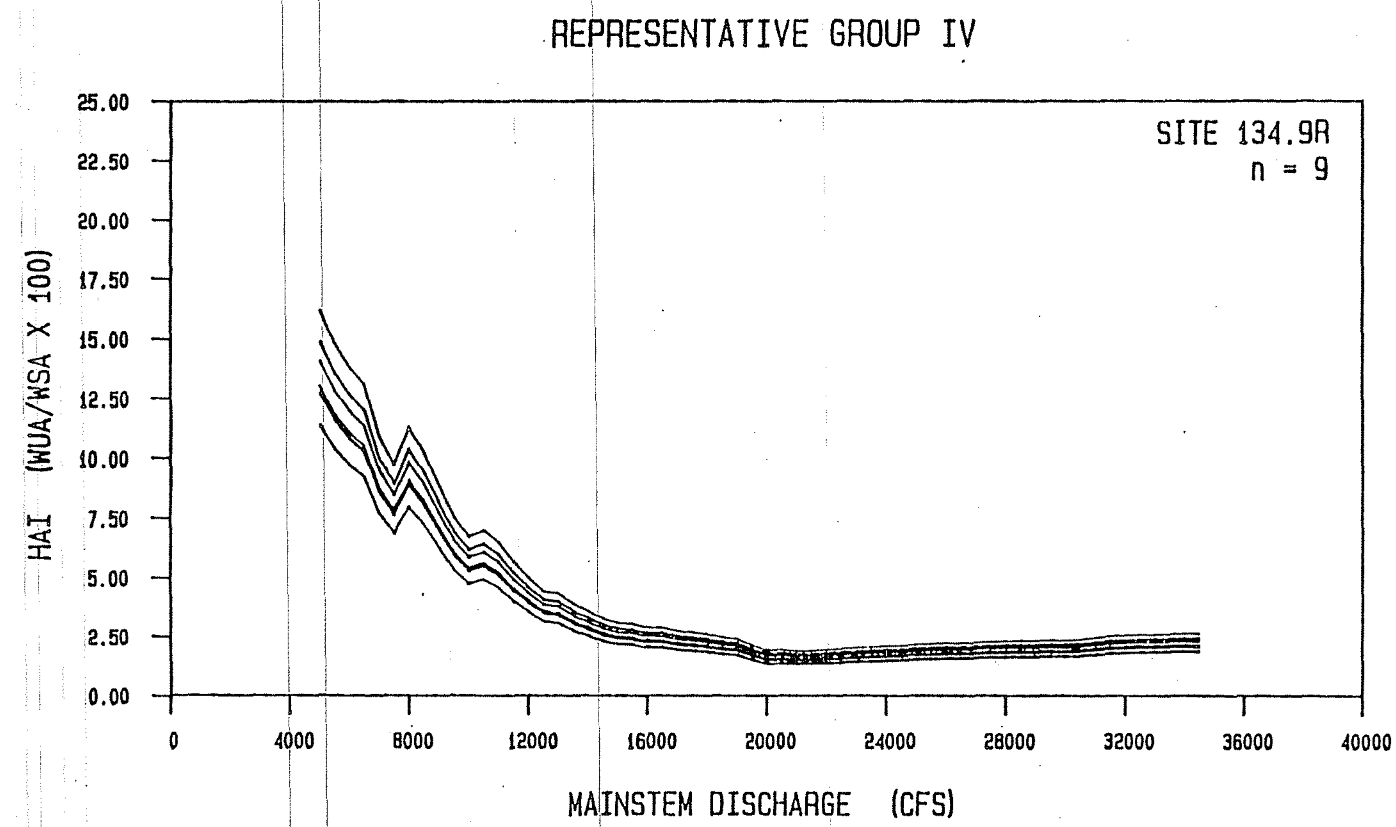


Figure 45. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 134.9R of Representative Group IV.

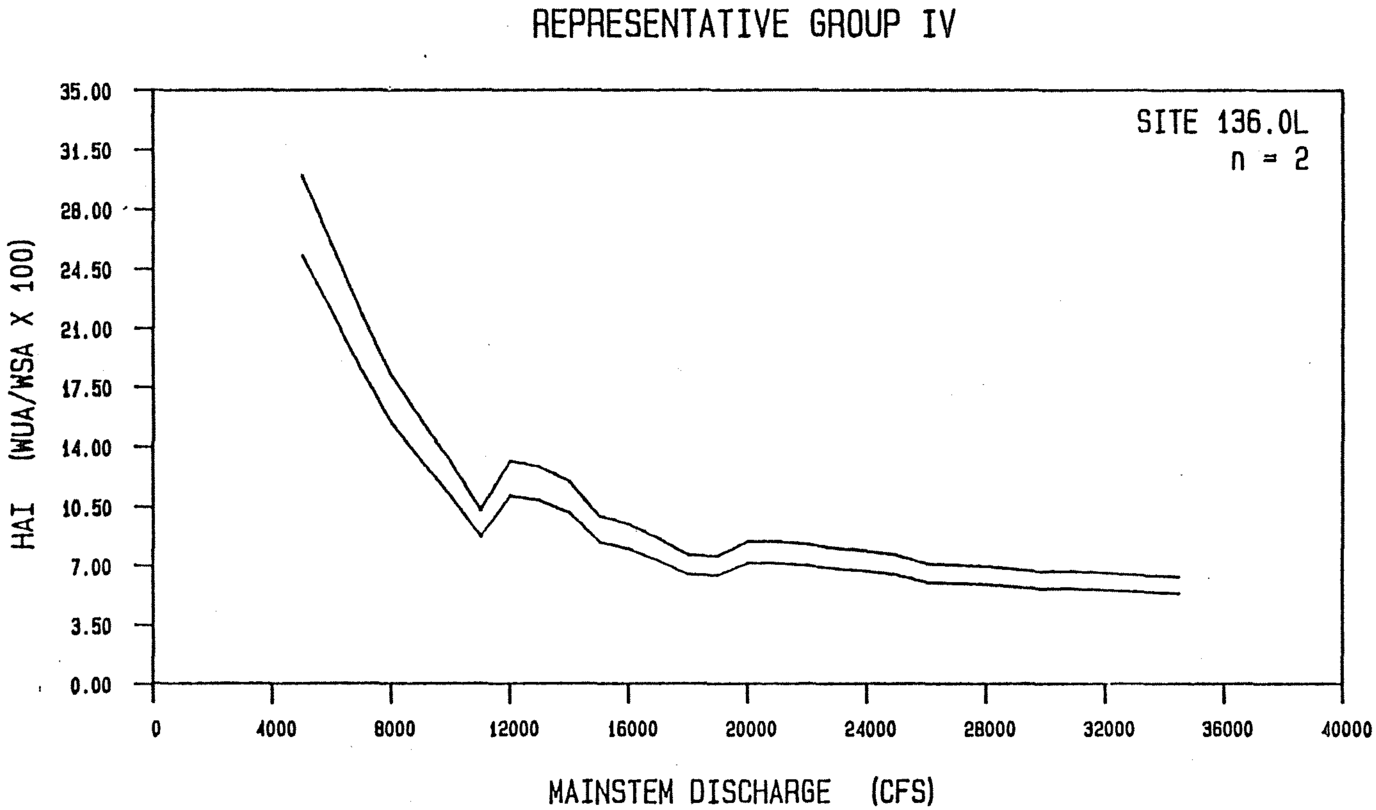


Figure 46. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 136.0L of Representative Group IV.

that Group IV specific areas provide a significant amount of rearing habitat within the middle river. This conclusion is supported by ADF&G sampling data indicating high utilization of these sites by juvenile chinook during the summer months (Dugan et al. 1984).

At all modeling sites except Site 131.7L, usable rearing habitat is greatest at the lowest evaluated flow (5,000 cfs), and after a gradual decline either continues to taper off or remains constant for flows above 16,000 cfs. Turbidity levels are high at all discharges and most areas of the sites possess suitable depths for rearing fish. Changes in WUA and HAI are therefore directly proportional to the increase or decrease in the availability of suitable velocities. As an example, Williams (1985) demonstrated that the total area within Site 112.6L possessing suitable rearing velocities is five times greater at 13,500 cfs than at 33,000 cfs. GHA and HDI curves reveal that the amount of gross habitat at the modeling sites is nearly equal to their total wetted surface area for flows ranging from 8,500 (Sites 112.6L and 134.9R) to 17,000 cfs (Site 131.7L). However, mean reach velocities measured at specific areas within this group averaged 3.3 fps at 10,000 cfs (Aaserude et al. 1985), well above the range of velocities tolerated by juvenile chinook salmon, suggesting that for the group as a whole, the amount and proportion of gross rearing habitat is probably greatest when flows are less than 10,000 cfs. Regardless of discharge levels, the quality and quantity of usable rearing habitat is greatest along the margins of the modeling sites due to the reduction of velocities in these areas.

The specific areas assigned to Representative Group IV have been divided among the four study sites on the basis of breaching flow, channel morphology, size and hydraulic characteristics. Five of the specific areas are grouped with Site 131.7L. All of these sites breach just below 5,000 cfs, and possess large amounts of shallow riffle habitat in comparison to their total wetted surface area. The 9 largest specific areas are grouped with Site 134.9R which are all characterized by deep, swift flows. These sites possess very little pool or riffle habitat. Site 112.6L represents six intermediate sized specific areas which, in general, contain a larger amount of submerged gravel bars and are not as deep or swift as those represented by 134.9R. Site 136.0L represents two small crescent-shaped specific areas with distinct riffle/pool patterns at low flows and high velocity runs at high flows.

The aggregate WSA response for the group is shown in Figure 47. As discussed above, the proportion of the wetted surface area providing usable chinook habitat in Group IV sites, particularly in the lower flow range, is high in comparison to specific areas from other representative groups. This characteristic, when coupled with the fairly large surface areas associated with Group IV specific areas, results in exceptionally large rearing WUA forecasts for Representative Group IV as a whole (Figure 47). The significance of this fact will be discussed in Section 4.0 following presentation of aggregate WUA curves for all representative groups.

Juvenile chinook potential in Group IV sites is highest at mainstem discharges of 10,000 cfs and less. Peak rearing WUA values (approximately 4.1 million square feet) are attained at 8 - 8,500 cfs. This trend is related to the low breaching flows characteristic of specific areas within

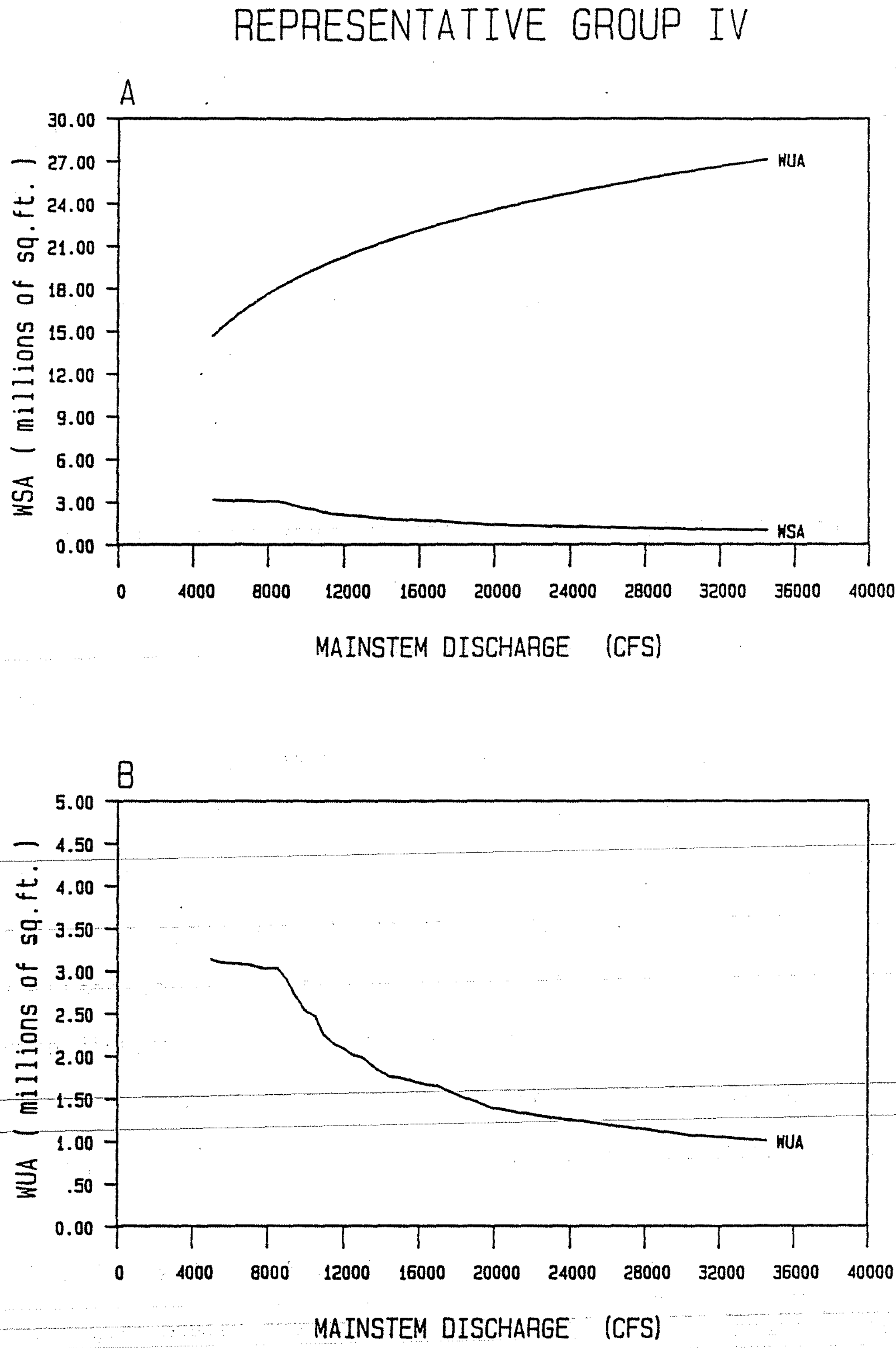


Figure 47. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group IV of the middle Susitna River.

this group. The composite suitability of velocity and depth within these sites decreases rapidly as flows increase; WUA declines concomitantly, reaching a low of 1.6 million square feet at 35,000 cfs.

3.5 Representative Group V

This group, comprised of nine specific areas, includes shoal areas which transform into clear water side sloughs at lower mainstem discharges. A shoal is similar to a riffle in that both are topographic high points in the longitudinal bed profile of the river and are therefore zones of accretion. Shoals, however, are easily distinguished from riffles by their morphological features and the hydraulic processes responsible for their existence. As a general rule, shoals form immediately downstream of point gravel bars located at bends of the river or at the lower end of established islands. Due to reduced velocity in these areas, shoals are characterized by sand and gravels deposited on the falling stages of floods and at low flow. Larger substrates are possible if the shoal has stabilized and begun to take on gravel bar characteristics.

Flow across shoal areas may be transverse to mainstem flow and velocities tend to be slower-than-average due to the drag effect exerted by the streambed. As water levels drop, flow is concentrated in a few small channels which feed a larger single channel on the inside of the shoal. When feeder channels dewater at lower discharges there is usually sufficient mainstem seepage through the head and sides of the channel berm to maintain a small amount of clear water slough habitat at the site.

The general morphologic features described above may be observed in aerial photographs (Plate A-23) of Site 141.6R--the only modeling site found in Representative Group V. Site 141.6R begins to convey mainstem water at 18,000 cfs but is not controlled by mainstem discharge until 22,000 cfs.

Site flows under non-breached conditions average 5 cfs. Wetted surface area and juvenile chinook weighted usable area at Site 141.6R are assumed to remain constant in the non-breached state; the ratio of WUA to WSA, expressed as a percentage, is 13.4 percent (Figure 48). Gross habitat area is estimated to comprise 83 percent of the total surface area when clear water conditions prevail.

As is common with most specific areas of the middle Susitna River, the introduction of turbid mainstem water has an immediate effect on the usability of Site 141.6R by juvenile chinook. Other than turbidity, the most significant factor contributing to the sharp rise in usable habitat is the large increase in wetted surface area. Most of the recruited habitat is shallow and slow velocity areas that may be used to some extent by young chinook. Figure 48 indicates that over 90 percent of the total surface area has at least some rearing habitat value at discharges between 23,000 and 32,000 cfs. Maximum WUA, HAI, and HQI values occur at the lower end of this flow range; each of these habitat indices peak in the range of 24,000 and 25,500 cfs. Habitat index curves are drawn out at their upper ends by the gradual loss of suitable velocity areas. Eventually, flow over the shoals is fast enough to significantly reduce the availability and quality of chinook rearing habitat at the site.

There are nine specific areas within Representative Group V. The areas breach over a wide range of mainstem discharges (<5,000 to 23,000 cfs) and exhibit large variations in structural habitat quality. The HAI function obtained for Site 141.6R, which breaches at 22,000 cfs and has a comparatively high SHI value, was used as a template for deriving HAI curves for all specific areas within the group (Figure 49 and Appendix B).

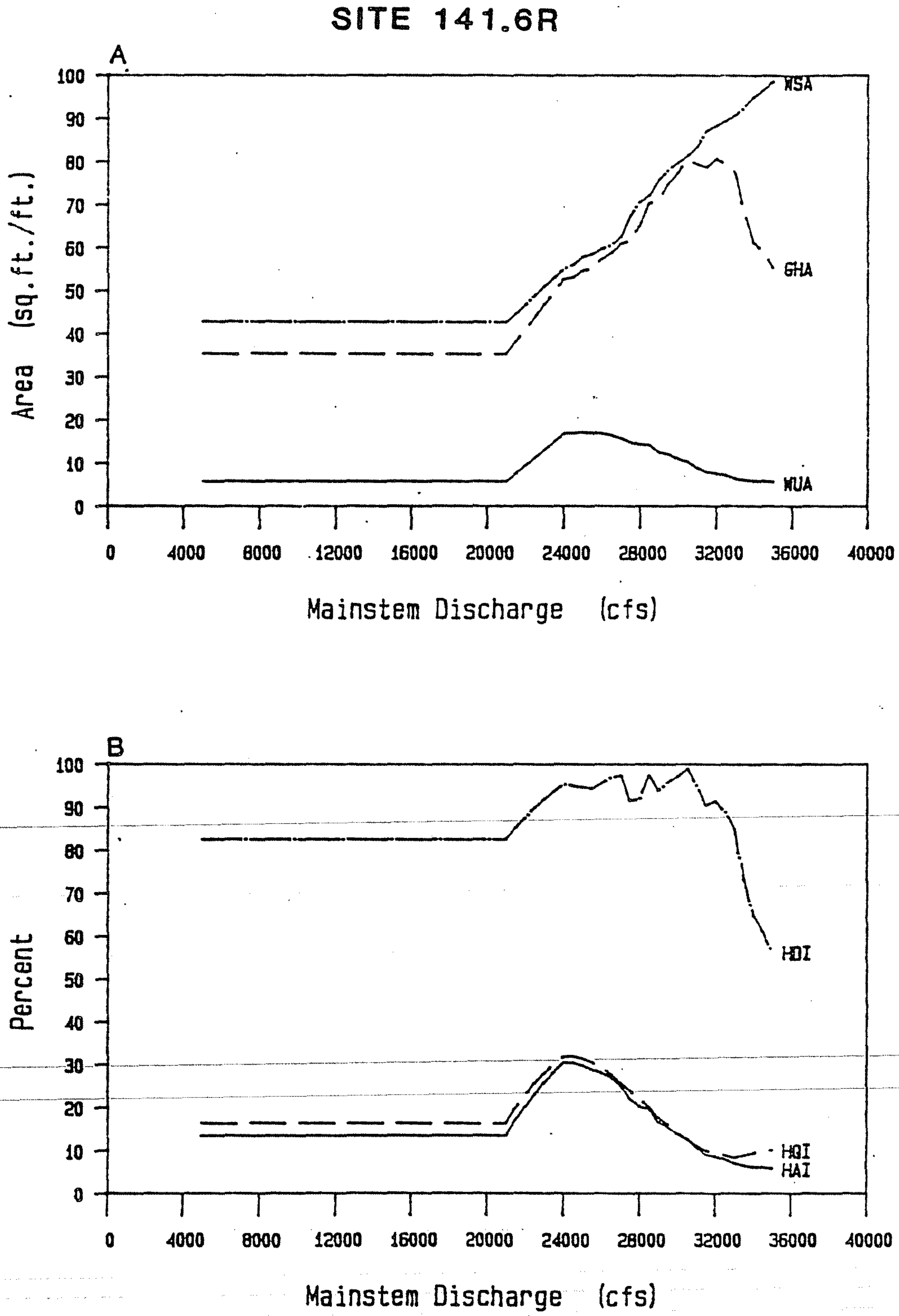


Figure 48. Surface area and chinook rearing habitat index response curves for modeling site 141.6R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

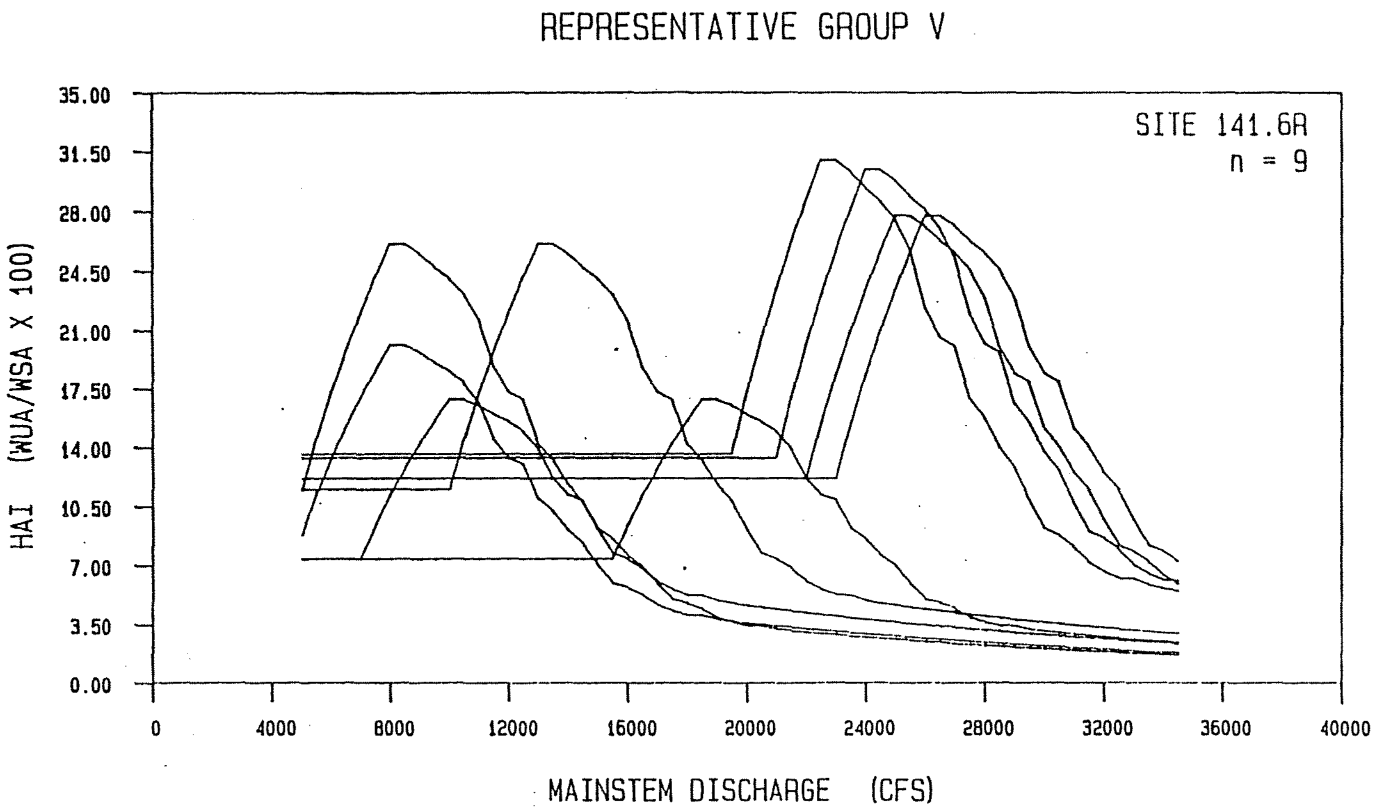


Figure 49. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 141.6R of Representative Group V.

There does not appear to be any correlation between the magnitude of breaching flow and structural habitat quality of peak habitat availability for these specific areas.

Collectively, the specific areas which make up Representative Group V do not provide significant amounts of juvenile chinook habitat, even under ideal flow conditions. The low aggregate WUA values portrayed in Figure 50 result from 1) the small number of specific areas assigned to Group V, and 2) the small amount of total wetted surface area associated with these sites. Overall, less than 0.4 million square feet of rearing WUA is provided by Representative Group V by streamflows within the range of 5,000 to 35,000 cfs. WUA values peak at approximately 26,000 cfs when joint surface area and HAI values are maximized (Figure 50).

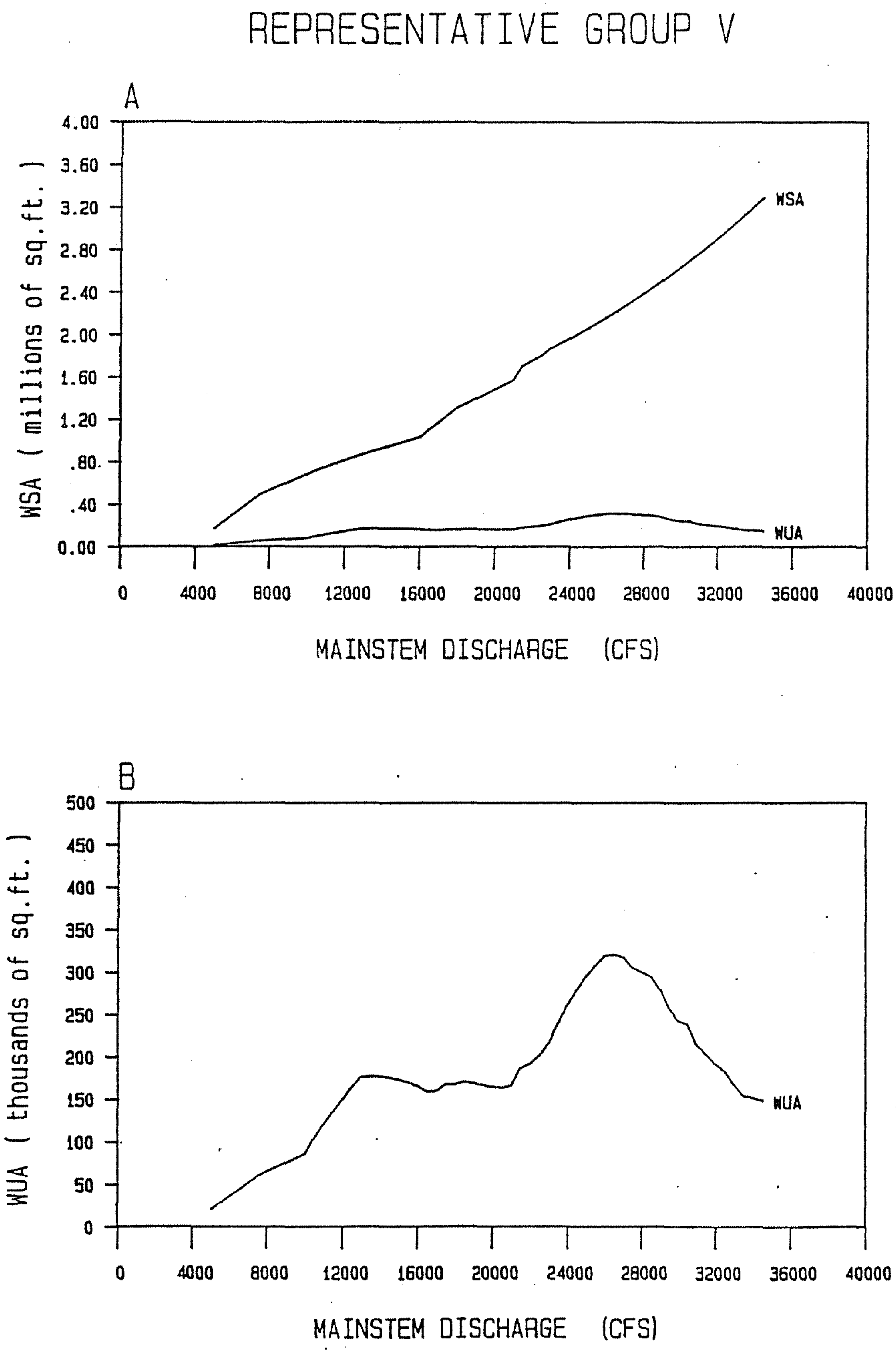


Figure 50. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group V of the middle Susitna River.

3.6 Representative Group VI

The 13 specific areas within this group are products of the channel braiding processes active in the high gradient middle segment of the Susitna River. Included are overflow channels which parallel the adjacent mainstem. Typically separated from the mainstem by a sparsely vegetated bar, these channels may or may not possess upwelling. These specific areas may represent more advanced stages of shoal development in which their gravel bars have stabilized due to the growth of vegetation and further high-stage sedimentation, and mainstem overflow is usually delivered by a single dominant feeder channel. Incision of the lateral channels has gradually occurred over time, leading to lower head berm elevations and coarser substrates. Side channel gradients are usually greater than adjacent mainstem channels as a result of hydraulic processes which adjust channel morphology to maintain transport continuity. The spectrum of shoal-to-side channel developmental stages represented by the specific areas of Group VI is indicated by the wide range of breaching discharges and structural habitat indices recorded by Aaserude et al. (1985).

Included in Representative Group VI are modeling sites 133.8L and 136.3R, which breach at 17,500 and 13,000 cfs, respectively, but remain watered at non-breached mainstem discharges. Plates A-24 through A-26 (Appendix A) give some idea of the morphologic features and wetted surface area response to flow of Group VI modeling sites. A large backwater occurs at their confluence with the mainstem channel. The gravel bar at Site 136.3R appears to be more stable than the bar at Site 133.8L, judging from differences in the type and amount of vegetation cover. Both modeling sites are relatively flat in cross section except for deep narrow channels running along banks opposite the gravel bars. These banks are steep-walled whereas banks formed by the gravel bars are gently sloping. These features are largely responsible for the type of response of juvenile chinook habitat to changes in mainstem discharge observed at the two Group VI modeling sites.

Habitat index and surface area response functions derived for Site 133.8L and 136.3R are conspicuously similar, particularly if allowance is made for differences in mean channel width (Figures 51 and 52). In both cases, the anticipated increase in WUA following breaching occurs, but after attaining moderate levels the amount of rearing habitat remains fairly constant at higher mainstem discharges. This pattern, which is uncharacteristic of more developed side channels (compare, for example, the WUA response curves for sites from Representative Group VI with results for Group III and IV modeling sites), is also apparent in the relationship between gross habitat area and river discharge. The constancy of WUA and GHA values at moderate-to-high mainstem flows results in generally stable habitat quality at the sites, implying that areas suitable for chinook rearing are recruited and lost at comparable rates. Regardless of flow levels, most juvenile chinook habitat at Sites 133.8L and 136.3R is associated with the gravel bar shoreline and backwater area of both sites.

HAI functions developed for the two modeling sites exhibit the expected rise and fall in juvenile chinook habitat availability which attends breaching and further increases in discharge. However, because WUA values remain constant at higher flows, the slope of the descending limb of the HAI curves is not as great as observed for other representative groups. Based on similaries in channel morphology and habitat reconnaissance data

SITE 133.8L

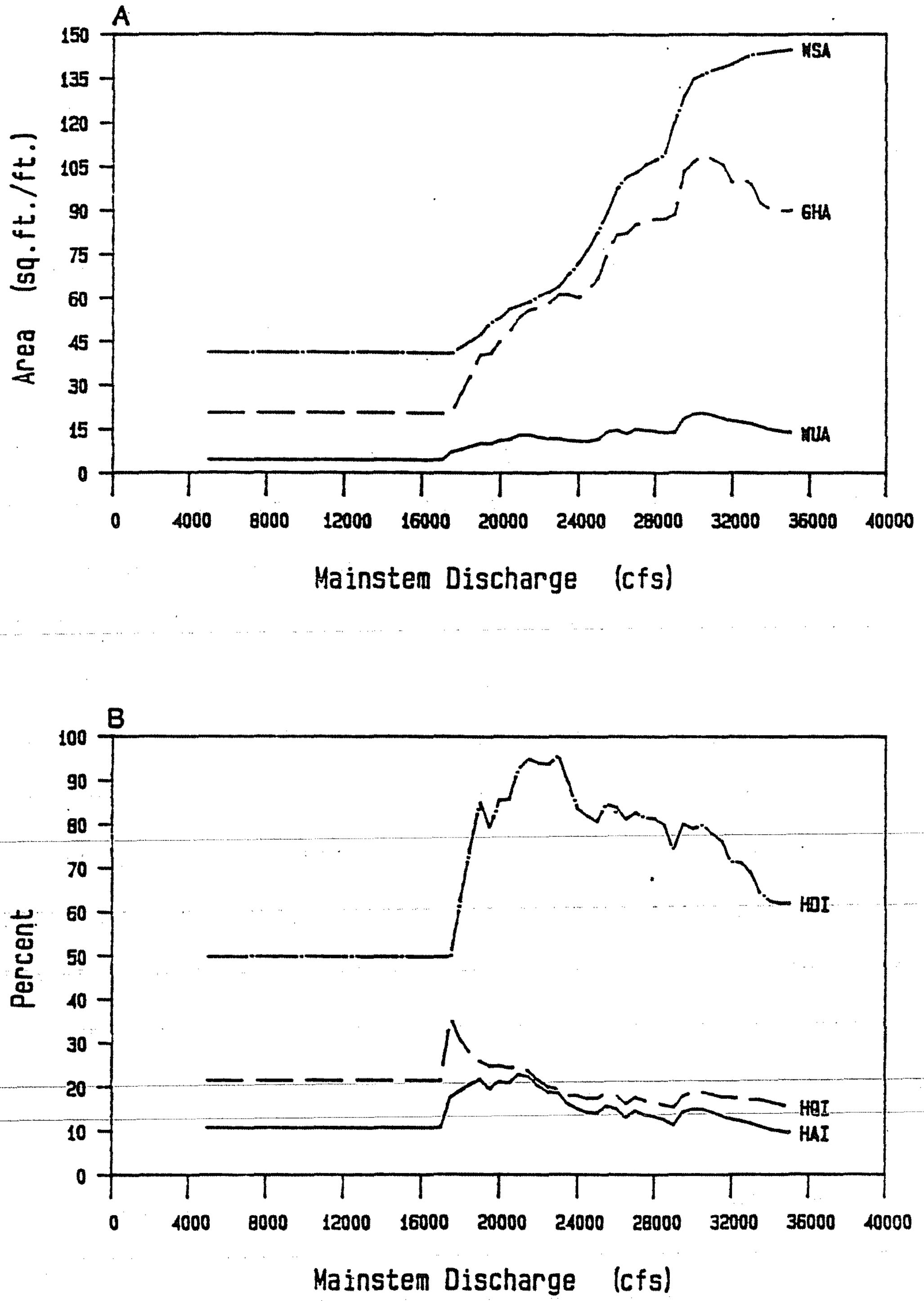


Figure 51. Surface area and chinook rearing habitat index response curves for modeling site 133.8L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

SITE 136.3R

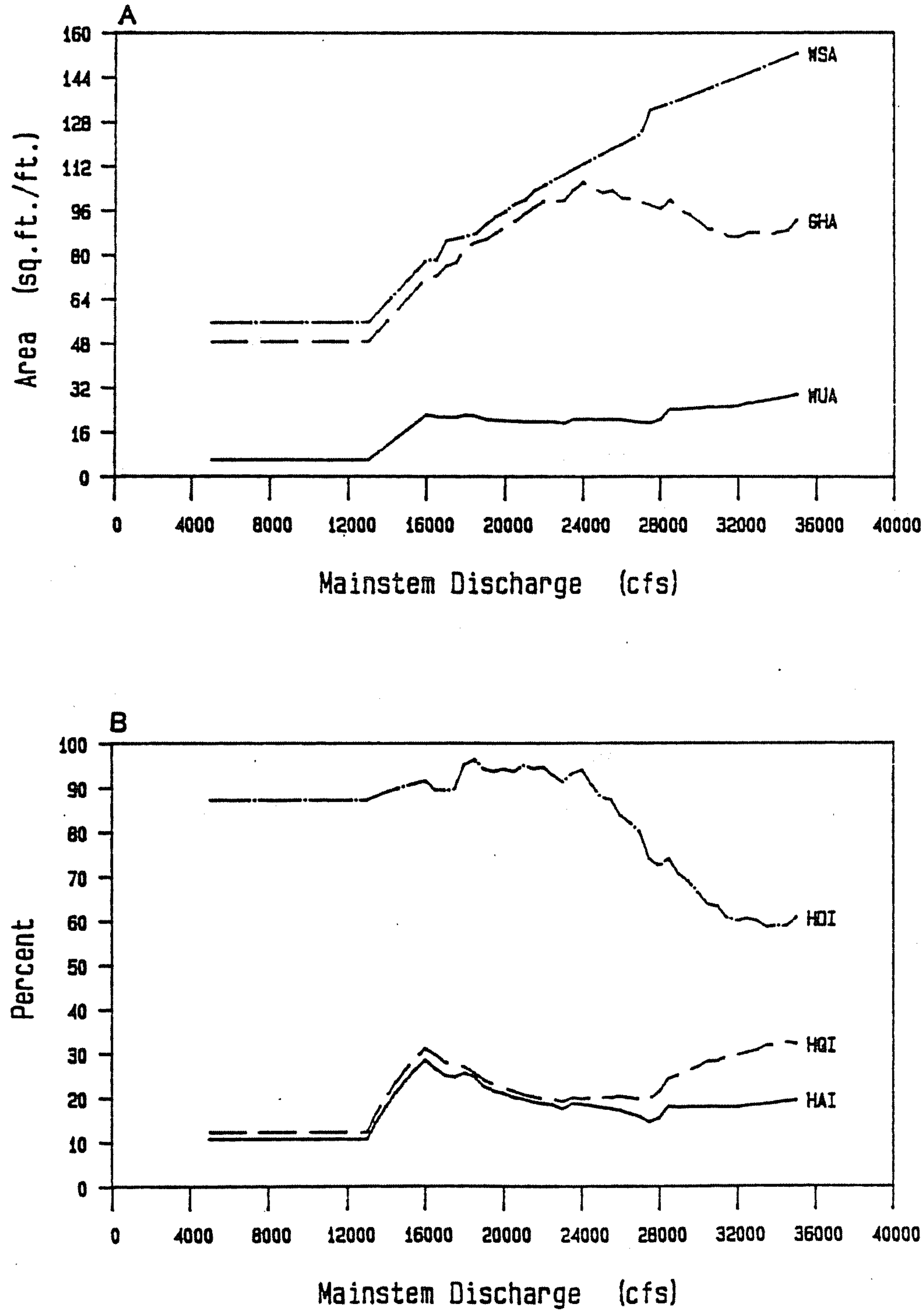


Figure 52. Surface area and chinook rearing habitat index response curves for modeling site 136.3R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

obtained at modeled and non-modeled specific areas in Group VI, 7 of the 13 specific areas are grouped with site 133.8L and 6 with site 136.3R. HAI functions derived from the modeling sites are presented for each subgroup in Figures 53 and 54 and Appendix B.

Due to their relatively high breaching flows and rapid wetted surface area response following breaching (Figure 55), specific areas within Representative Group VI provide considerably more juvenile chinook WUA at high as compared to low mainstem discharges. Figure 55 indicates the aggregate rearing WUA function derived as the sum of individual specific area habitat values for flows ranging from 5,000 to 35,000 cfs. Rearing habitat potential increases steadily as a function of flow throughout this range. The amount of juvenile chinook WUA forecast for 35,000 cfs (1.3 million square feet) represents over 30 times the amount of WUA forecast for 5,000 cfs (0.04 million square feet). The correlation between wetted surface area and aggregate rearing WUA values is more pronounced in Group VI than in other representative groups due to the relative constancy of HAI values across all flows.

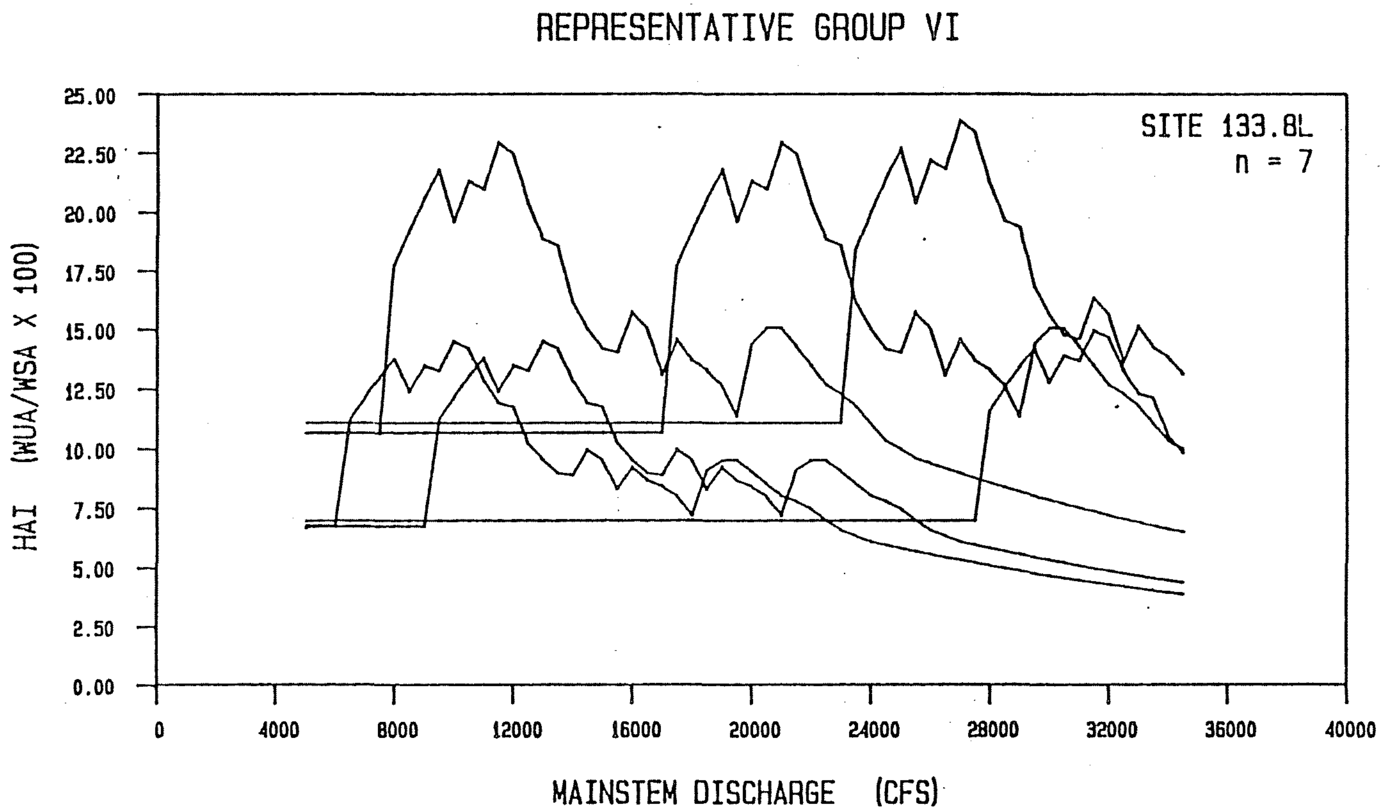


Figure 53. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 133.8L of Representative Group VI.

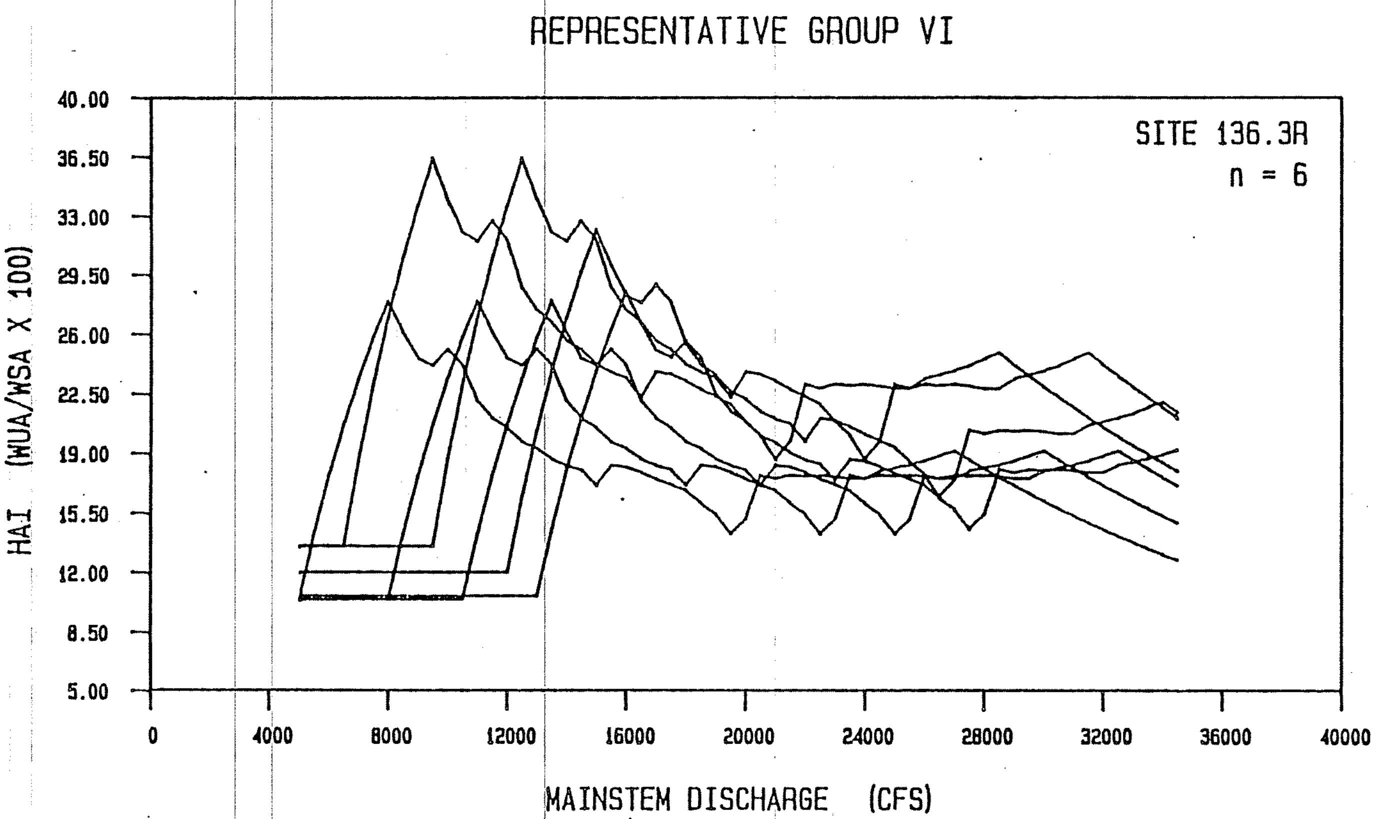
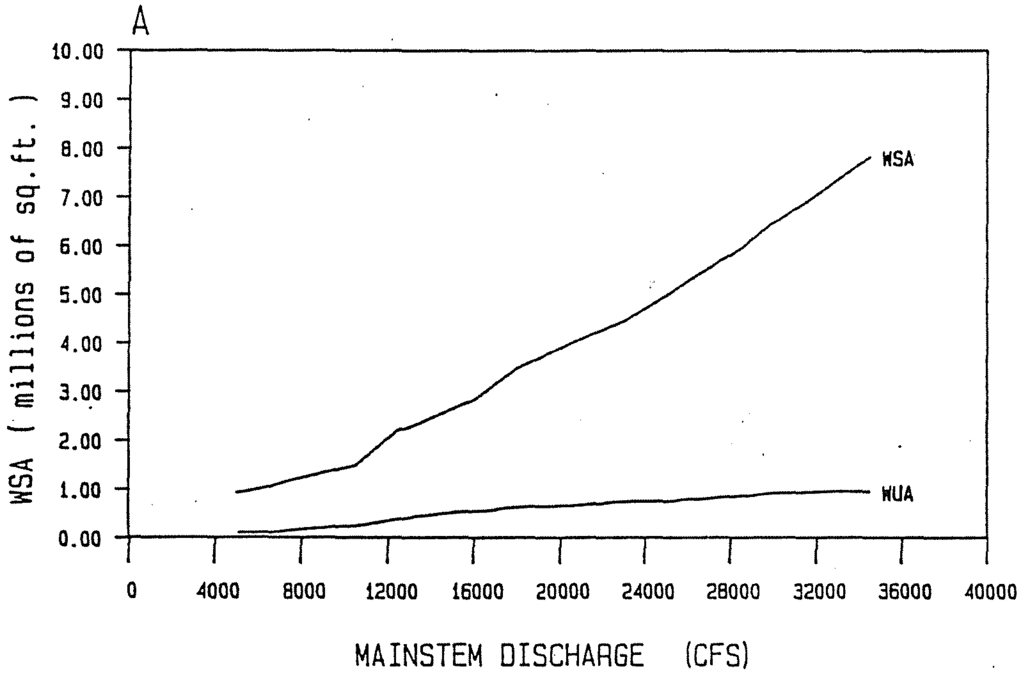


Figure 54. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 136.3R of Representative Group VI.

REPRESENTATIVE GROUP VI



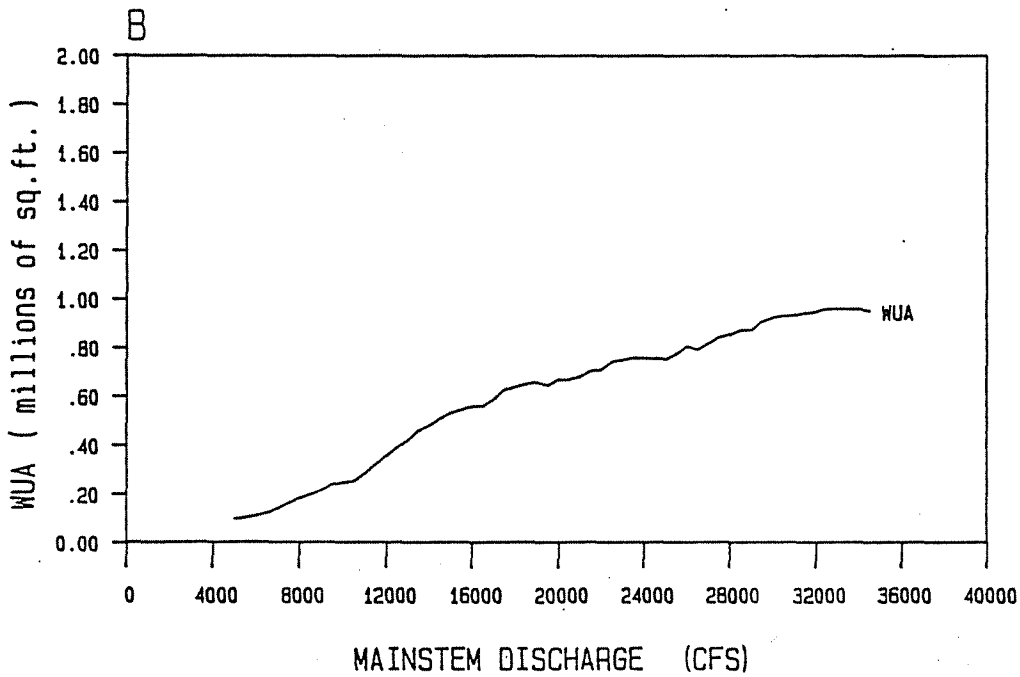


Figure 55. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group VI of the middle Susitna River.

3.7 Representative Group VII

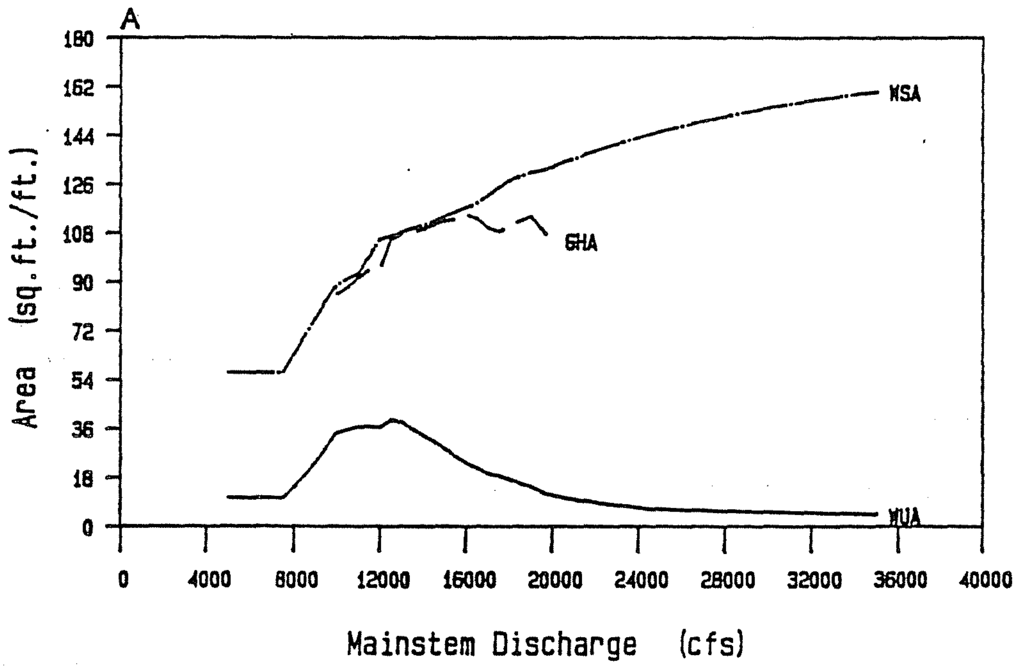
This group of seven specific areas is dominated by side channels possesing low breaching discharges and organized into distinctive riffle/pool flow patterns. In most cases, the specific areas are comparatively short with small length:width ratios and are composed of a single riffle extending from the head of the site down to a large backwater area at the mouth. The transition from riffle to backwater pool is defined by an abrupt step in bed and water surface profile. Head berms are generally broad-crested and the riffles of greater-than-average slope. The steep riffle gradients tend to increase in streamflow tends to mimimize the staging effect of rising mainstem flows at the mouth of the site. Consequently, the rate of change in backwater area is less than is observed at lower gradient sloughs and side channels over a comparable range of discharges. Backwater area varies at Group VII sites primarily by expanding or contracting laterally as flows change. Flow characteristics within backwater pools include near zero velocities and a calm surface, as compared to the broken and rapidly moving water of riffles.

Considerable longitudinal variation in streambed texture occurs in Group VII specific areas. Riffles are composed of rubble and boulder size substrates, whereas backwater areas tend to have sandy beds. Periodic high flows may temporarily expose coarse sediment in backwater pools which is subsequently covered by sand and silt during periods of low flow. High turbidities also prevail at these sites since upwelling is not present.

Modeling Site 119.2R is the sole representative of the 7 specific areas classified within Group VII. This site possesses the typical riffle/pool sequence characteristics just described (Plates A-27 and A-28 in Appendix A). As indicted in Figure 56, a basal level of wetted surface area and juvenile chinook WUA is maintained under non-breached conditions by backwater effects. Peak rearing habitat potential occurs shortly after the berm at the head of the site is overtopped and the riffle area is inundated. The relatively broad width and uniform elevation of the head berm strongly influences the distribution and amount of juvenile chinook habitat at Site 119.2R. Areas of usable habitat within the riffle rapidly expand until local velocities begin to exceed tolerable limits which in turn prompts a decline in rearing habitat. Maximum WUA values are forecast for discharges of 12,500 to 13,000 cfs, when juvenile chinook WUA is nearly four times greater than WUA present under non-breached conditions (39.3 versus 10.5 sq.ft./ft.).

Gross habitat is widely distributed throughout Site 119.2R at flows ranging up to 17,000 cfs, as demonstrated by the GHA response to discharge in Figure 56. However, habitat availability and quality, as indexed by HAI and HQI values, begins to diminish appreciably around 12,000 cfs. Peak HAI and HQI estimates were similar at 40 percent, a fairly high value in comparison to other modeling sites. The minimum HAI value was 3 percent at 35,000 cfs. This HAI value was estimated by extending the WSA and WUA curves by eye for discharges exceeding 20,000 cfs (Hilliard et al. 1985). The HQI curve was not extrapolated past 20,000 cfs, but HQI values may be expected to be higher than HAI values to a degree which is proportional to the difference between gross habitat area and wetted surface areas at high discharges.

SITE 119.2R



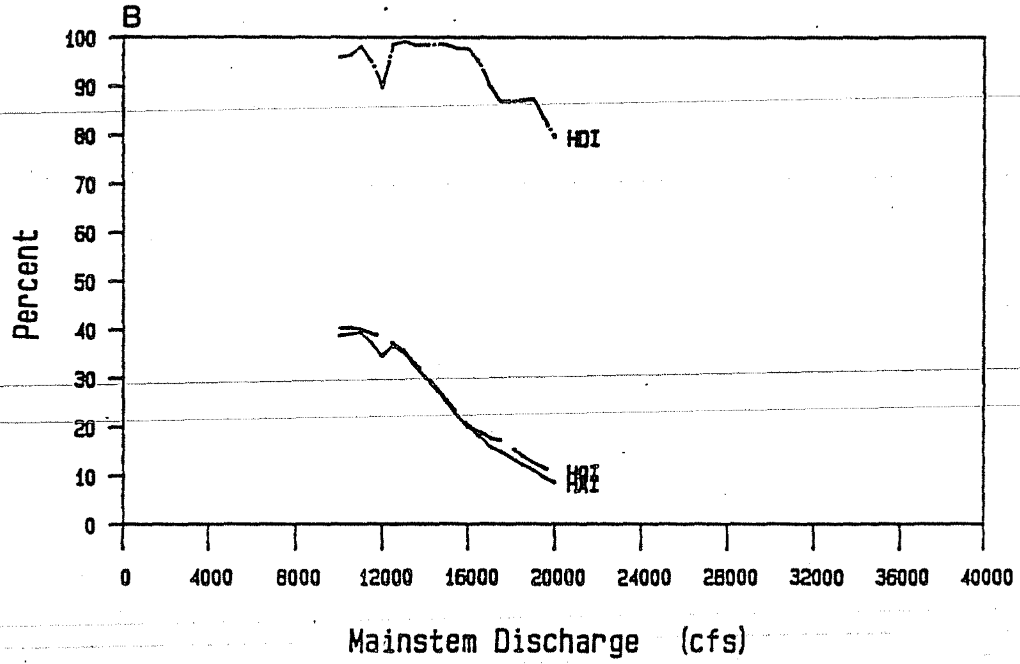


Figure 56. Surface area and chinook rearing habitat index response curves for modeling site 119.2R.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

HAI functions derived from modeling results for Site 119.2R display the low breaching flows and comparatively large habitat potential at low discharges associated with specific areas of Representative Group VII (Figure 57 and Appendix B). Within a narrow range of low mainstem discharges (10,000 to 13,000 cfs), HAI values compare favorably with peak HAI values recorded for specific areas from other groups. The marked decline in habitat availability at higher flows and the overall poor structural habitat quality (i.e., low SHI values) of Group VII sites suggests that hydraulic geometry plays a more important role than does object cover in determining the collective rearing habitat potential of this group.

As was the case for side channels comprising Representative Group IV, which are characterized by similarly low breaching discharges, the seven specific areas of Group VII provide notably greater amounts of usable rearing habitat at low than at high mainstem flows, as evidenced by the aggregate WUA function in Figure 58. This results from the comparatively high HAI values which occur immediately subsequent to breaching and their rapid decline at higher flows. Juvenile chinook WUA peaks at 0.3 million square feet at 8,000 cfs, remains at this level through 13,000 cfs and declines to 0.08 million square feet at 35,000 cfs.

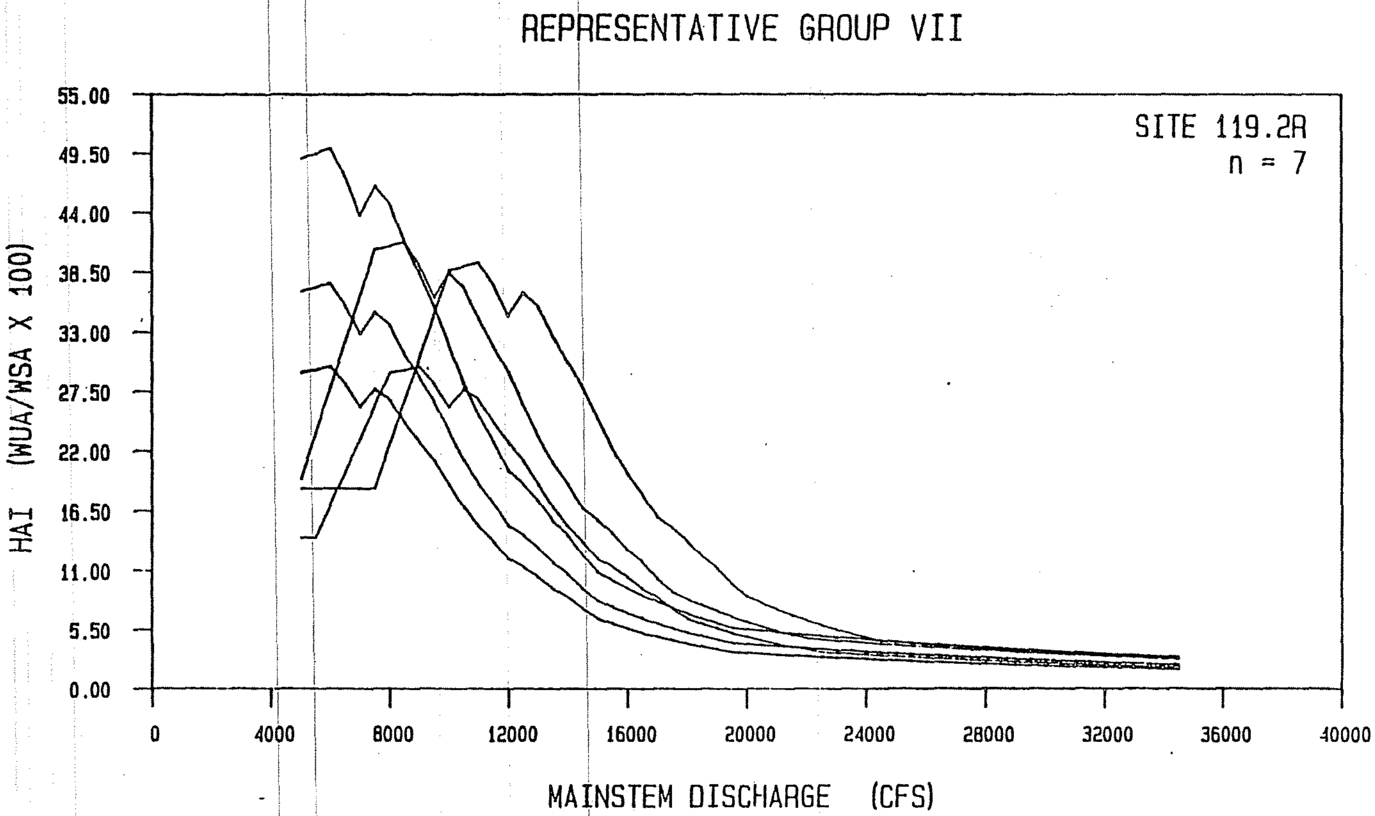


Figure 57. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 119.2R of Representative Group VII.

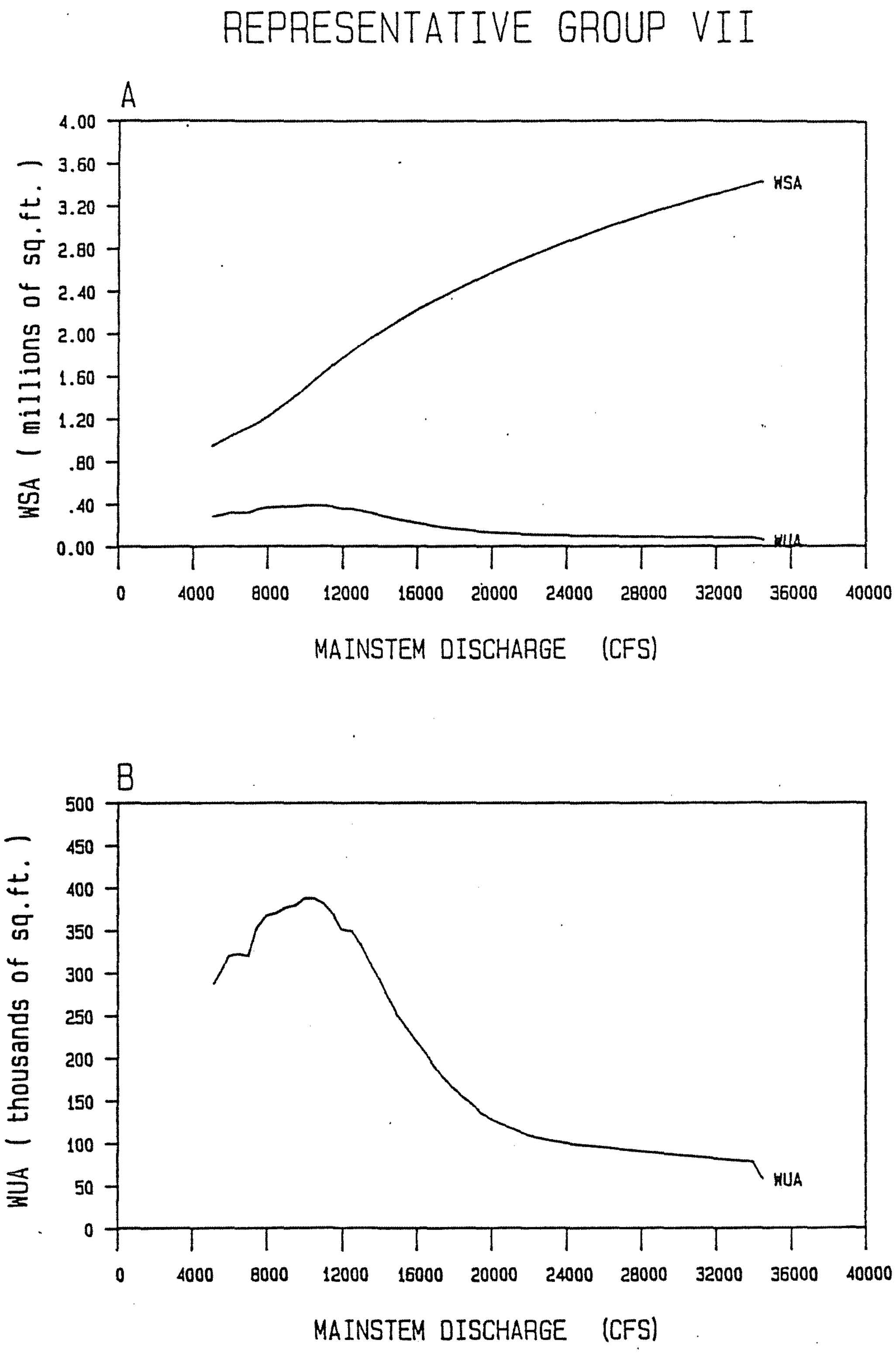


Figure 58. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group VII of the middle Susitna River.

3.8 Representative Group VIII

This group is comprised of 22 specific areas which tend to dewater at intermediate to high mainstem discharges. The absence of an upwelling groundwater supply may be due to the local structural geology and the location of the channels relative to sources of subsurface flow. Aaserude et al. (1985) noted that the heads of channels included in Group VIII were frequently oriented at a 30^{o}+ angle to the adjacent mainstem channel. Apparently groundwater flow is either diverted away from these sites or occurs at a lower elevation than the bed elevation of the exposed channels.

In spite of their tendency to dewater, specific areas in Group VIII are similar to specific areas assigned to Groups II and III in their hydrologic, hydraulic, and morphologic properties. Therefore, because Group VIII does not possess a specific area with a rearing habitat modeling site, HAI functions based on modeling sites from Representative Groups II and III were used to represent Group VIII in the habitat extrapolation process. An obvious requirement was that the habitat functions for modeling sites selected to represent this group be modified to reflect the total loss of rearing habitat as mainstem stage declines below head berm elevations. Candidate modeling sites include Site 144.4L from Group II and Site 132.6L from Group III. The first modeling site is recommended by its high breaching discharge, its morphological similitude with several Group VIII specific areas, and by the general shape of its habitat response curves. Figure 24 illustrates the WSA, WUA and HAI curves which have been derived from Site 144.4L to represent a subclass of Group VIII specific areas. Note that the lefthand limb of the curves have been truncated at a breaching flow of 21,000 cfs.

Site 132.6L has been selected to represent the subclass of specific areas from Group VIII which dewater at intermediate discharges. Based on an examination of aerial photography obtained at several mainstem flows, these specific areas and Site 132.6L possess similar longitudinal and cross sectional profiles. Site 132.6L, which breaches at 10,500 cfs, eventually dewaters at 6,000 cfs as the water surface elevation drops below the elevation of the groundwater table (Figure 32). However, the revised modeling site habitat response curves have been truncated at 10,500 cfs to accurately reflect the rapid dewatering which occurs at Group VIII specific areas.

HAI curves are presented in Figures 59 and 60 with aggregate WSA as Figure 61. All specific areas in this Representative Group dewater at intermediate discharge levels. Specific areas were grouped on the basis of exposed streambed composition. The 15 specific areas represented by site 132.6L all possess streambeds lined with sand indicating low velocity or backwater influenced hydraulic conditions exist when these sites are breached. The 9 specific areas associated with site 144.4L have channel beds consisting of large gravels and cobbles indicating that these specific areas possess much higher velocities when breached.

Since all of the specific areas associated with Group VIII are dewatered by 8,000 cfs, juvenile chinook habitat does not exist at flows below this value. This is reflected in the aggregate rearing WUA curve developed for Group VIII (Figure 61). WUA accumulates rapidly as the specific areas become breached and peak values (0.7 million square feet) are attained at 29,500 cfs. Rearing habitat potential declines slightly at higher flows.

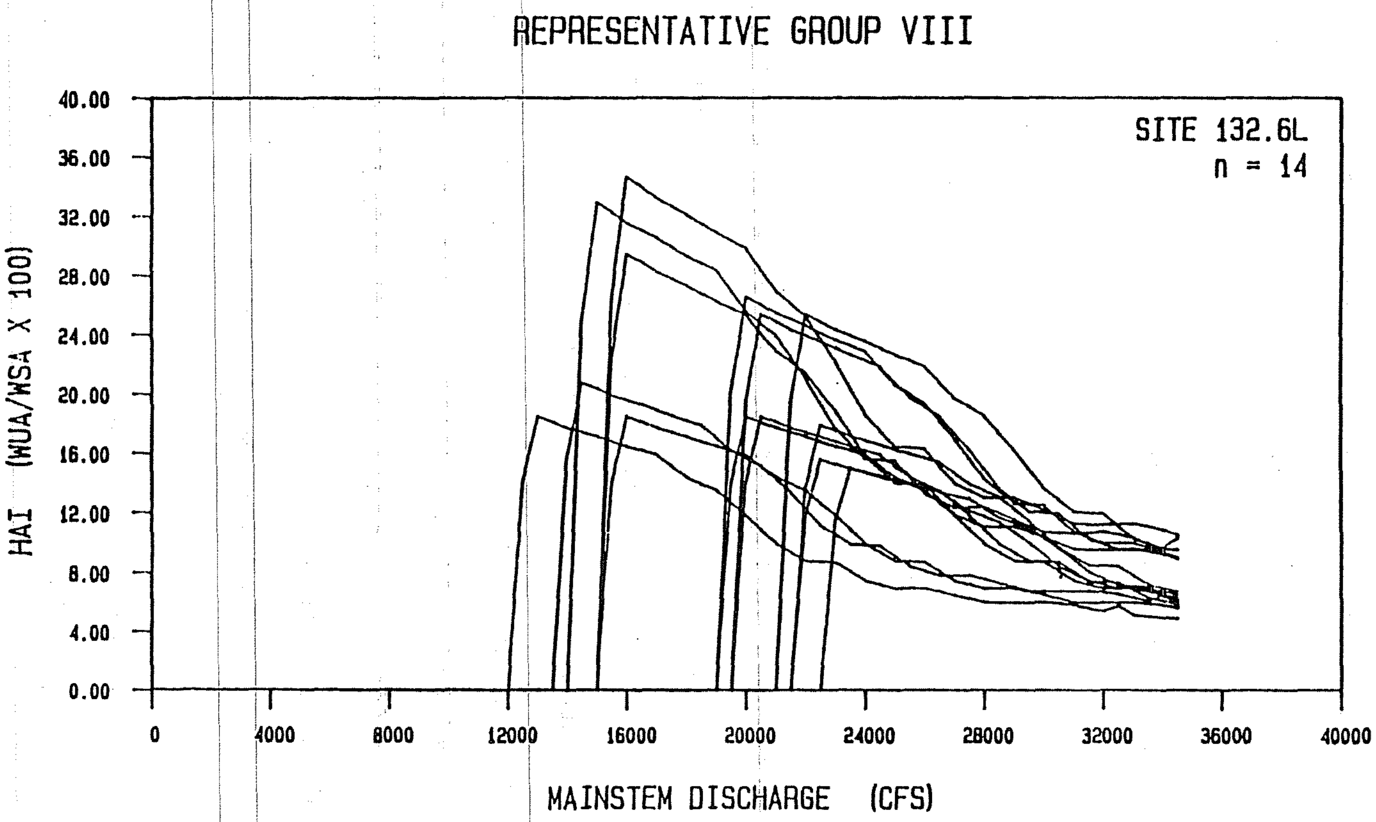


Figure 59. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 132.6L of Representative Group VIII.

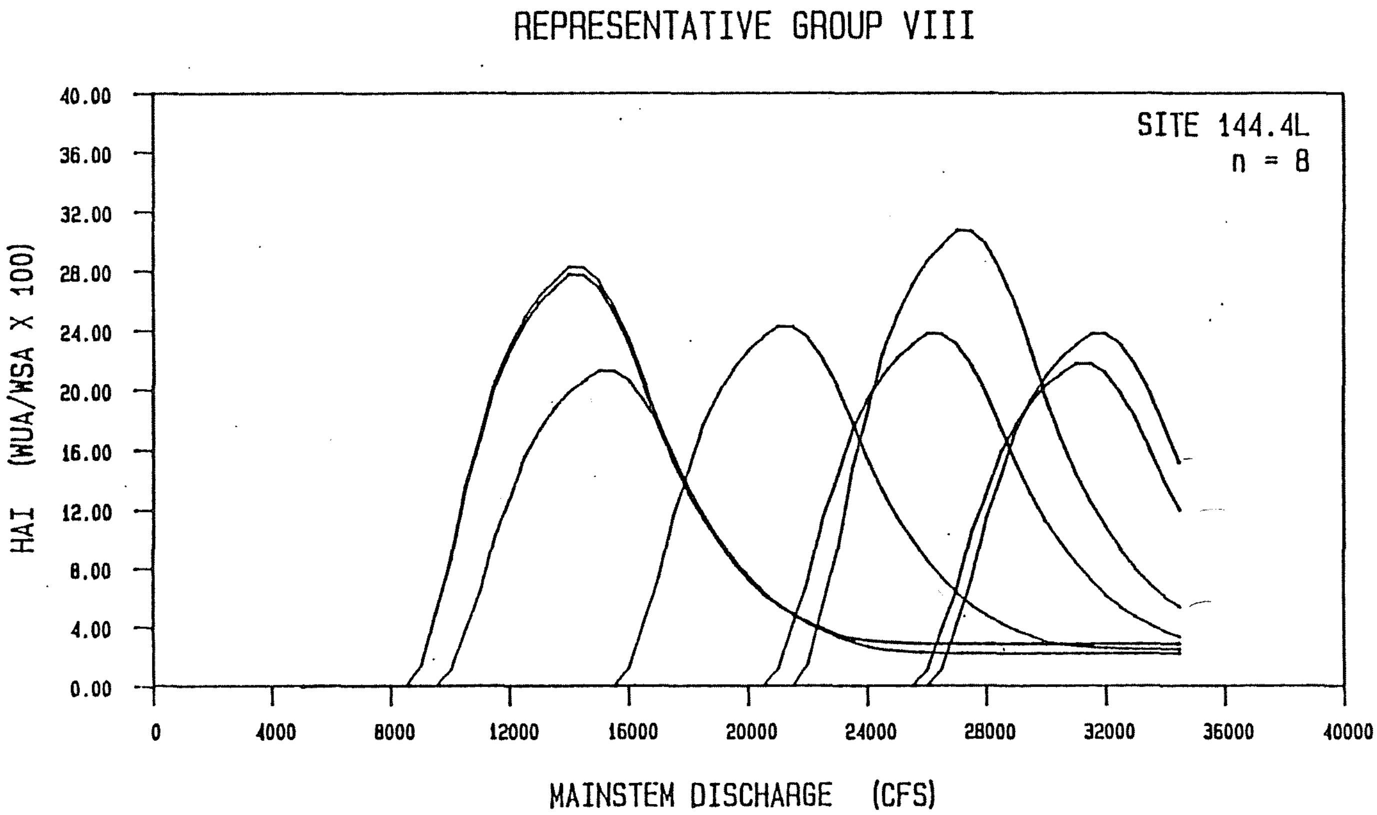


Figure 60. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 144.4L of Representative Group VIII.

REPRESENTATIVE GROUP VIII

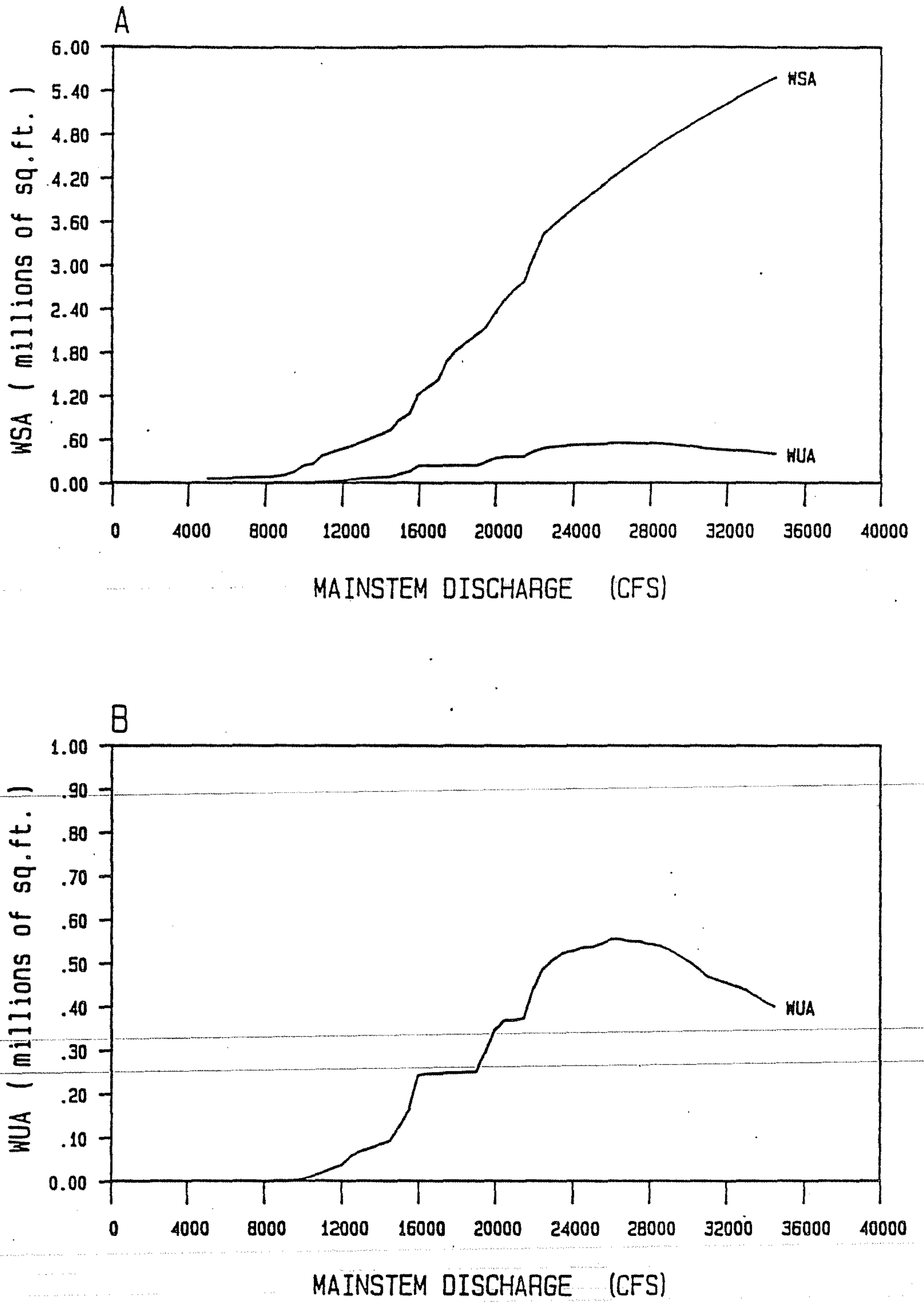


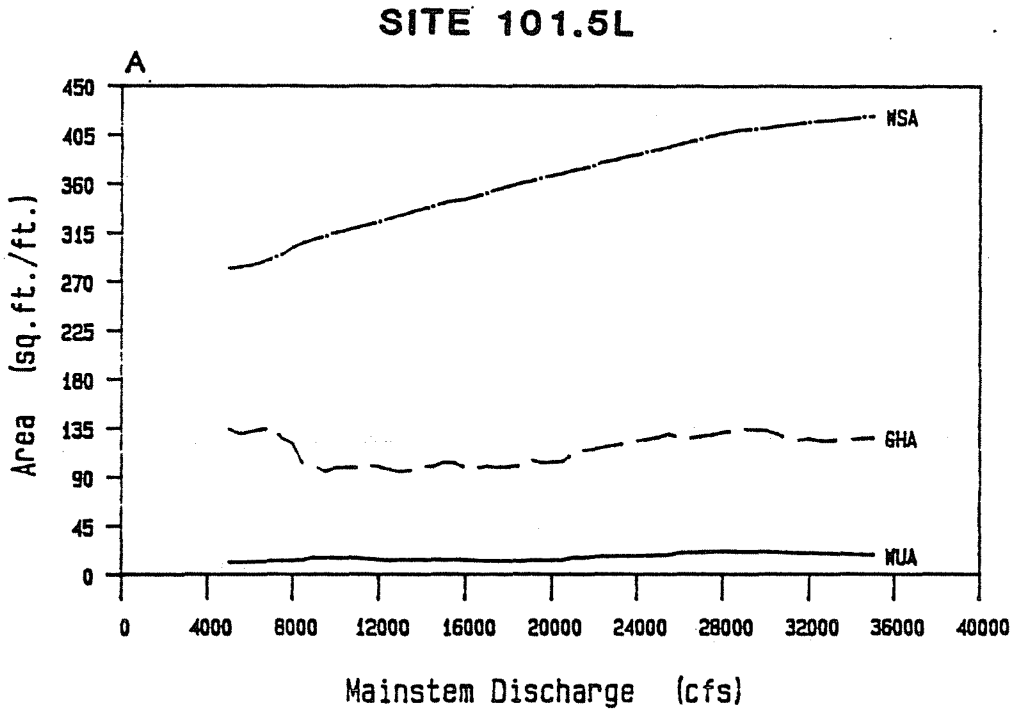
Figure 61. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group VIII of the middle Susitna River.

3.9 Representative Group IX

This group contains 21 specific areas categorized as mainstem and mainstem shoal habitat with mean reach velocities greater than 5 fps at 10,000 cfs. These sites usually convey a significant percentage of the total discharge, and possess small length to width ratios.

Modeling sites 101.5L and 147.1L are large channels classified as mainstem habitat over the entire 5,100 to 23,000 cfs flow range (Plates A-29 through A-32 in Appendix A). Site 101.5L represents those specific areas which are generally shallower and possess lower velocities than those represented by Site 147.1L. As many areas possess velocities greater than 2.5 fps the modeling sites provide little juvenile chinook habitat in relation to the total volume of water they convey. This conclusion is strengthened by the large differences observed between WSA and GHA estimates and the low rearing WUA values forecast for all mainstem discharges (Figures 62 and 63). Wetted surface areas change at comparatively slow rates as discharge varies at both sites due to their large size and a tendency to compensate for varying flow more through adjustments in water depth and velocity than in top width.

Both GHA and WUA increase slightly at higher mainstem discharges; thus, the availability of usable rearing habitat and its distribution within the modeling sites tends to remain constant throughout the range of evaluation flows. In a detailed analysis of cross section velocity profiles at Sites 101.5L and 147.1L, Williams (1985) noted that suitable rearing areas are confined to nearshore zones in the channels, primarily along the gently sloped island banks, due to high mid-channel velocities. The ratio of



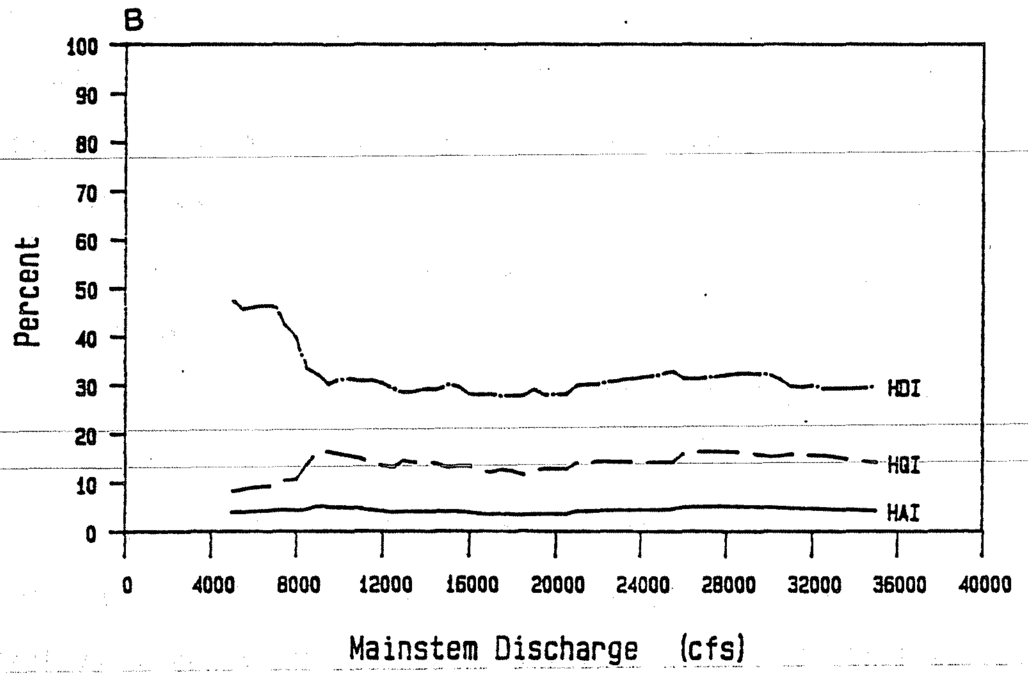


Figure 62. Surface area and chinook rearing habitat index response curves for modeling site 101.5L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

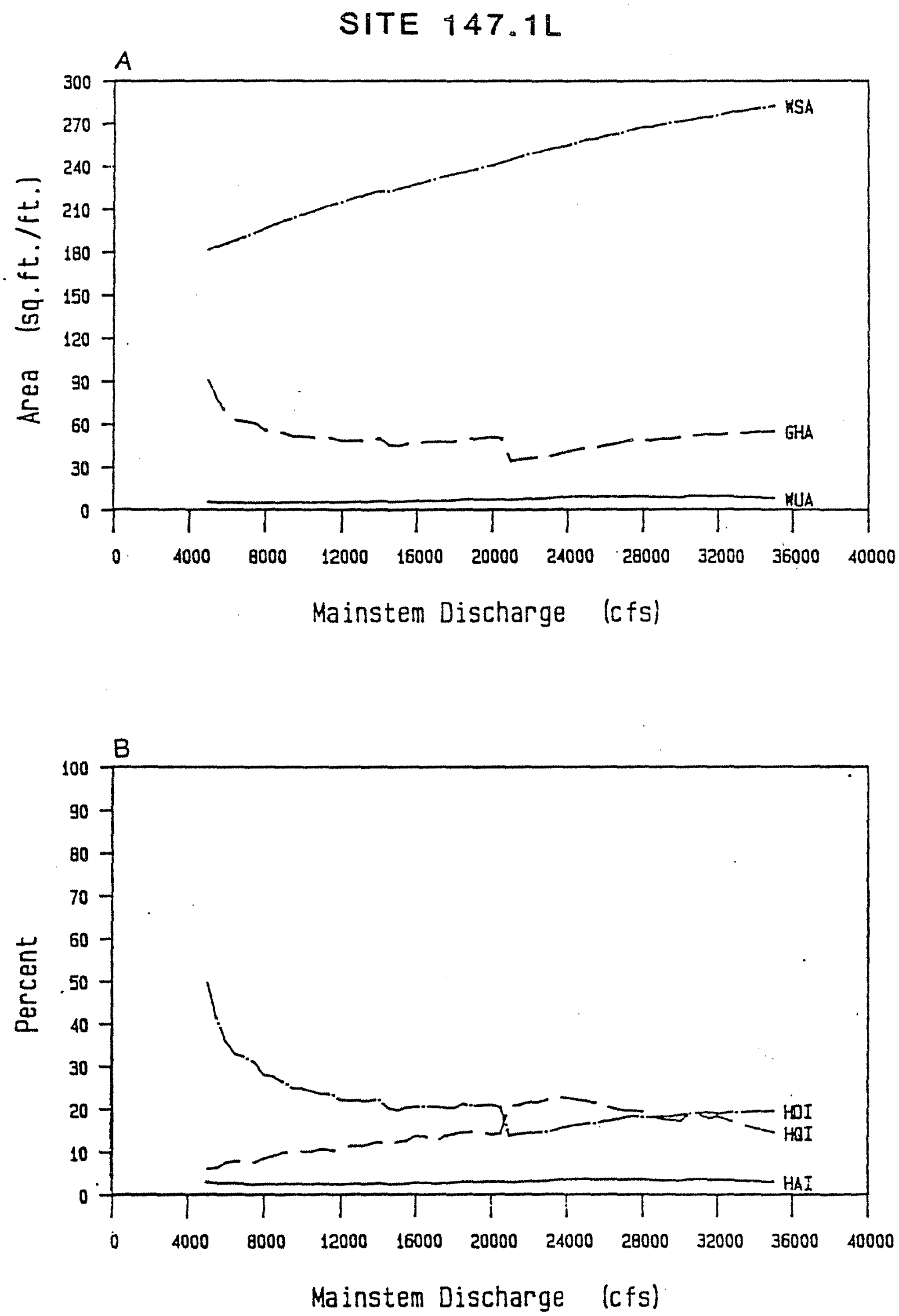


Figure 63. Surface area and chinook rearing habitat index response curves for modeling site 147.1L.
A - Wetted surface area (WSA), gross habitat area (GHA) and weighted usable area (WUA).
B - Habitat availability index (HAI), habitat distribution index (HDI) and habitat quality index (HQI) response functions.

juvenile chinook WUA to wetted surface area at these sites is very low, on the order of 5 percent or less. These values are considerably lower than HAI estimates obtained for modeling sites from other representative groups. The ratio of WUA to GHA is predictably higher, ranging up to 22 percent, but also slightly lower than HQI ratios calculated for other sites. Taking these indices into account, the juvenile chinook habitat potential within Group IX specific areas is judged to be inferior in quality.

Using the HAI functions developed for Sites 101.5L and 147.1L as templates, HAI curves were derived for specific areas within Group IX. Adjustments were made to account for differences in breaching flow and structural habitat quality. In regard to structural habitat, the mean SHI value for specific areas in this group is high compared to other representative groups. This results from the large substrate sizes which predominate in the high velocity channels and the high cover value assigned to them in the SHI calculations. Eleven of the 21 specific areas within Group IX have been grouped with Site 101.5L; the remaining 10 sites are represented by site 147.1L. HAI functions derived for modeled and non-modeled specific areas are presented in Figures 64 and 65 and the aggregate WSA response curve for Group IX in Figure 66.

The collective rearing habitat potential of the 20 specific areas in Group IX increases from 0.3 million square feet at 5,000 cfs to a peak of 0.6 million square feet at 27,500 cfs (Figure 66). Aggregate WUA values increase steadily over this flow range although the rate of change is very low in comparison to other representative groups, with the exception of Group I (upland sloughs), being only slightly greater than the rate of change in wetted surface area. Juvenile chinook WUA remains constant at

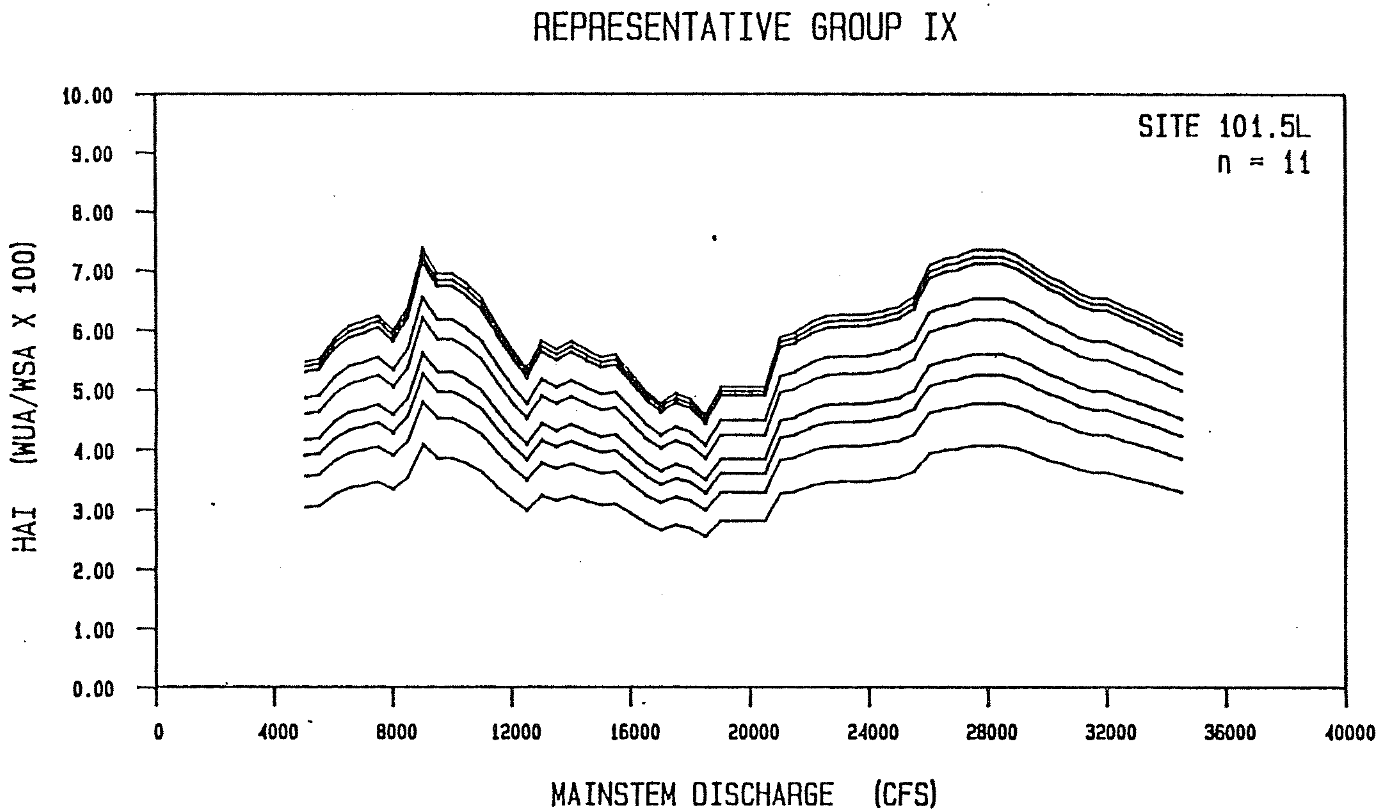


Figure 64. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 101.5L of Representative Group IX.

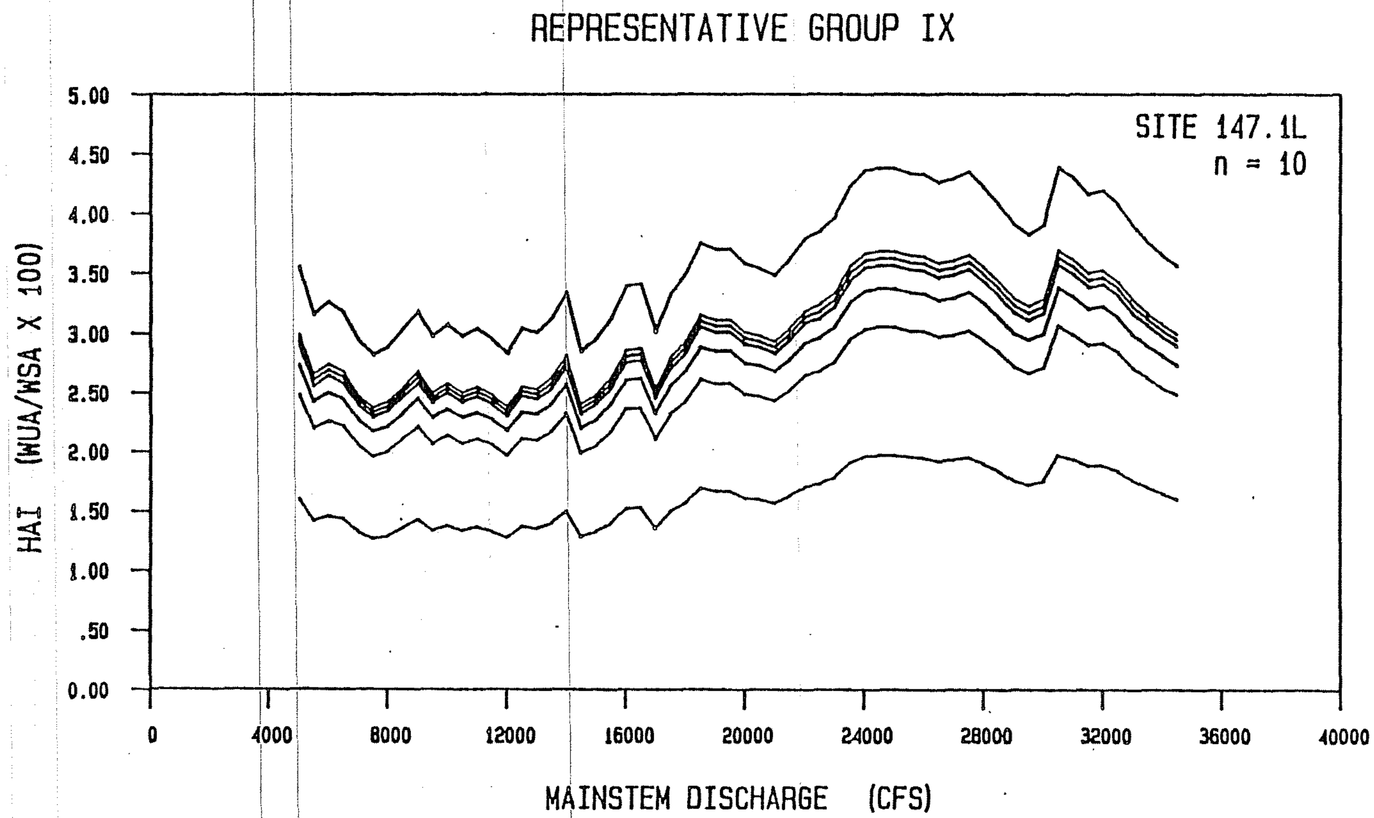


Figure 65. Response of chinook rearing habitat availability to mainstem discharge within non-modeled specific areas of the middle Susitna River which are associated with modeling site 147.1L of Representative Group IX.

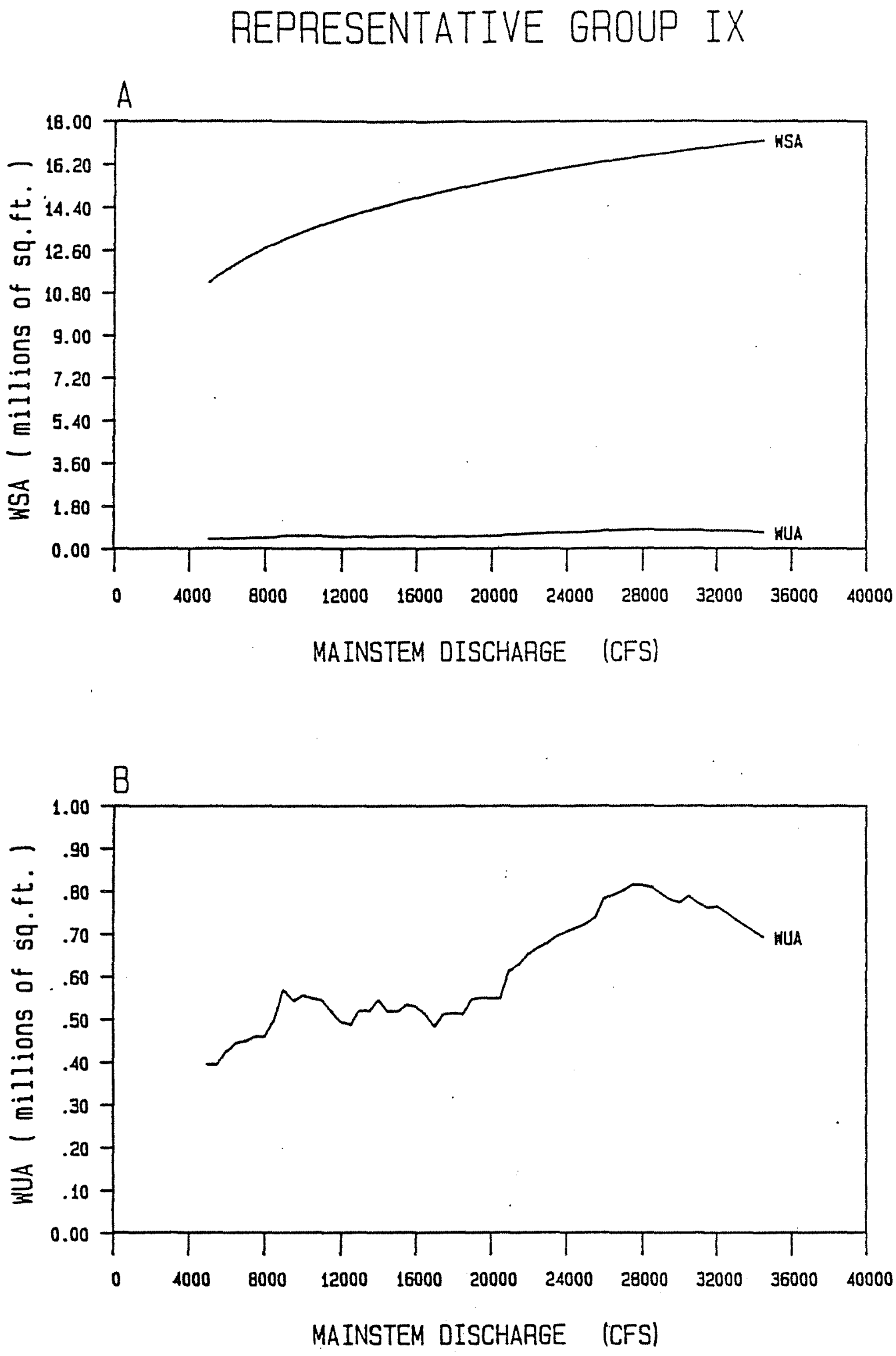


Figure 66. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group IX of the middle Susitna River.

higher flows as increases in wetted surface area are offset by gradual reductions in rearing habitat availability.

3.10 Representative Group X

Representative Group X is made up of mainstem shoals and mainstem margins which displayed signs of upwelling in the winter aerial photography.

As discussed in the methods section, Representative Group X did not possess RJHAB or PHABSIM models. Unlike Group VIII, which was in a similar position, none of the other models available were representative of the specific areas in this group. Therefore a WUA response curve was developed using Direct Input Habitat (DIHAB) models for spawning chum habitat which were available for five of the sites. These sites are illustrated in Plates A33 through A42.

The DIHAB model uses substrate composition and upwelling data from one or more cross sections as well as measured depths and velocities for several mainstem discharges to calculate WUA and WSA at each observed streamflow. WUA and WSA indices for unobserved streamflows within the range of observed values are determined by linear interpolation between calculated WUA and WSA indices. Outside the range of observed values, WUA and WSA indices may be estimated on the basis of trend analysis and field experience (Hilliard et al. 1985).

The chum spawning DIHAB models were converted to juvenile chinook DIHAB models as follows. Depth and velocity suitability curves for spawning chum were replaced by depth and velocity suitability curves for juvenile chinook. The substrate suitability curve for spawning chum was replaced by the cover suitability criteria for juvenile chinook under turbid water conditions. The upwelling criteria was eliminated.

WUA and WSA response curves were developed for each of the five modeled sites. They were extended beyond the range of available data by regression analyses to encompass the mainstem discharge range 5,000 to 35,000 cfs. Trends , apparent from the plotted points, indicated where more than one relationship was required to describe the response of WSA or WUA to mainstem discharge.

In all cases WSA increased with mainstem discharge. The maximum WSA for each site was determined by summing the product of cross section width and representative reach length for all cross sections within the site. Cross section plots, with water surface elevations at various mainstem discharges superimposed, were used to identify those discharges at which the relationship between WSA and mainstem discharge might be expected to change. For Representative Group X sites such changes were coincident with discharges at which shoals become inundated.

WUA generally decreased with mainstem discharge. Some fluctuations were noted. They were due to the optimal habitat at the cross sections of a site peaking at different mainstem discharges. Velocity data and cross sectional geometry were used to verify WUA forecasts beyond the range of data.

HAI values were calculated (as WUA/WSA x 100) for each discharge associated with a data set, for each discharge where a change in the relationship between WSA or WUA and mainstem discharge had been noted, and for 5,000 cfs and 35,000 cfs. Through linear interpolation, HAI values for 5,000 to 35,000 cfs in 500 cfs increments were obtained. The HAI curves for the five modeled sites were very similar. In all cases the HAI was maximum at 5,000 cfs, and the rate of decline decreased with mainstem discharge.

Values of WSA for the eight nonmodeled sites of Representative Group X were obtained through the use of aerial photography. The areas were digitized from 1" = 250' scaled aerial photos taken when mainstem discharge was 5,100, 10,600, 16,000, and 23,000 cfs. Regression analyses provided WSAs for 5,000 to 35,000 cfs in 500 cfs increments.

To calculate WUA for the eight nonmodeled sites, a composite HAI curve was first developed. Extrapolation of the HAI response curves for the modeled sites to the nonmodeled sites consisted of averaging the curves after first normalizing them to an SHI of 0.50.

$$HAI_{0.50} = HAI_{SHI} \times (0.50/SHI)$$

The composite curve was similarly adjusted for the SHI of each nonmodeled site before applying it to the corresponding WSA curve, or:

$$HAI_{SHI} = HAI_{0.50} \times (SHI/0.50)$$

HAI curves are given in Figure 67 and the summation of the WUA and WSA values for the thirteen sites in Figure 68.

This representative group contains a small subpopulation of shoal areas and mainstem margins which contain upwelling and retain a small amount of wetted surface area at low mainstem discharge levels. A much larger population of shoal areas become dewatered as mainstem flow decreases. Surface

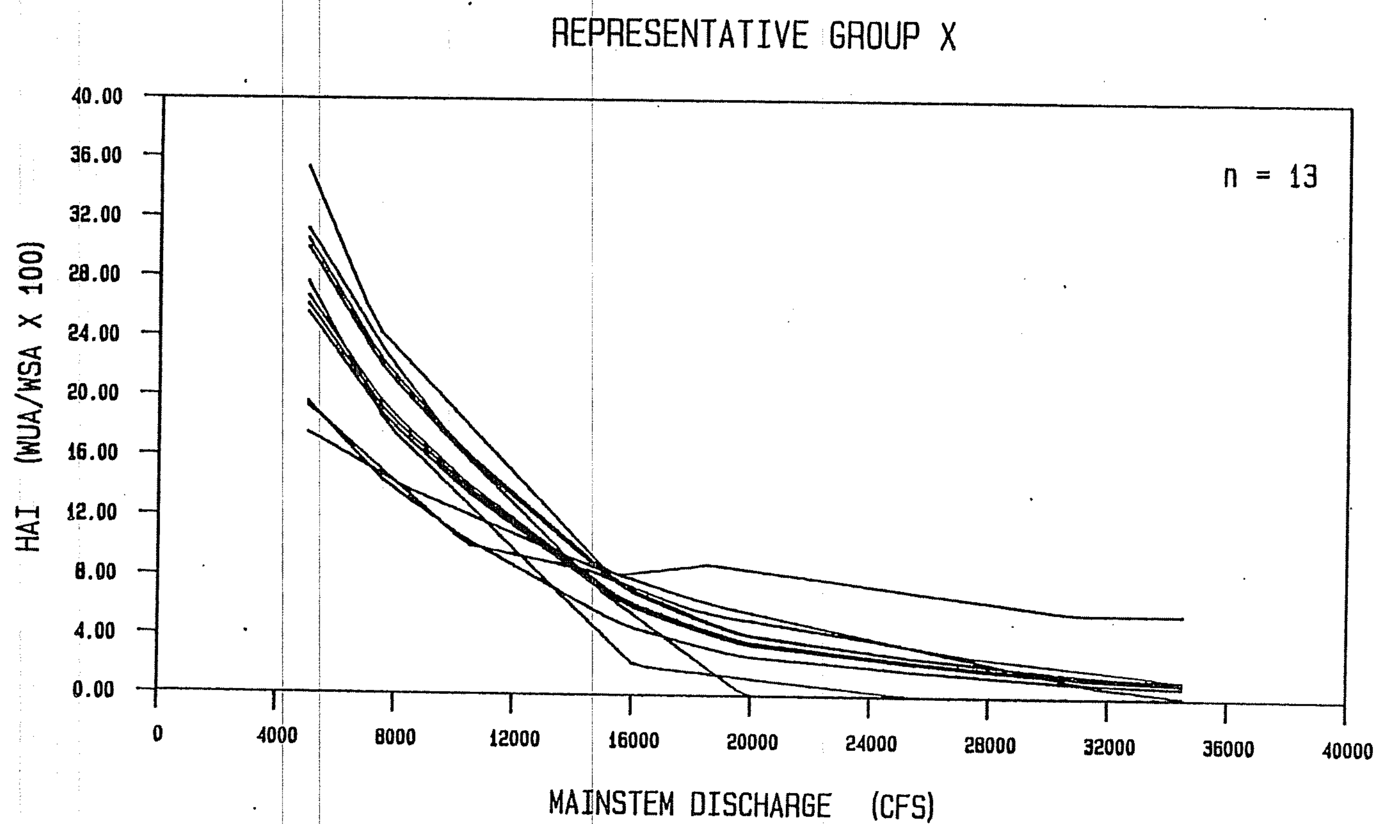


Figure 67. Response of chinook rearing habitat availability to mainstem discharge for specific areas of the middle Susitna River within Representative Group X.

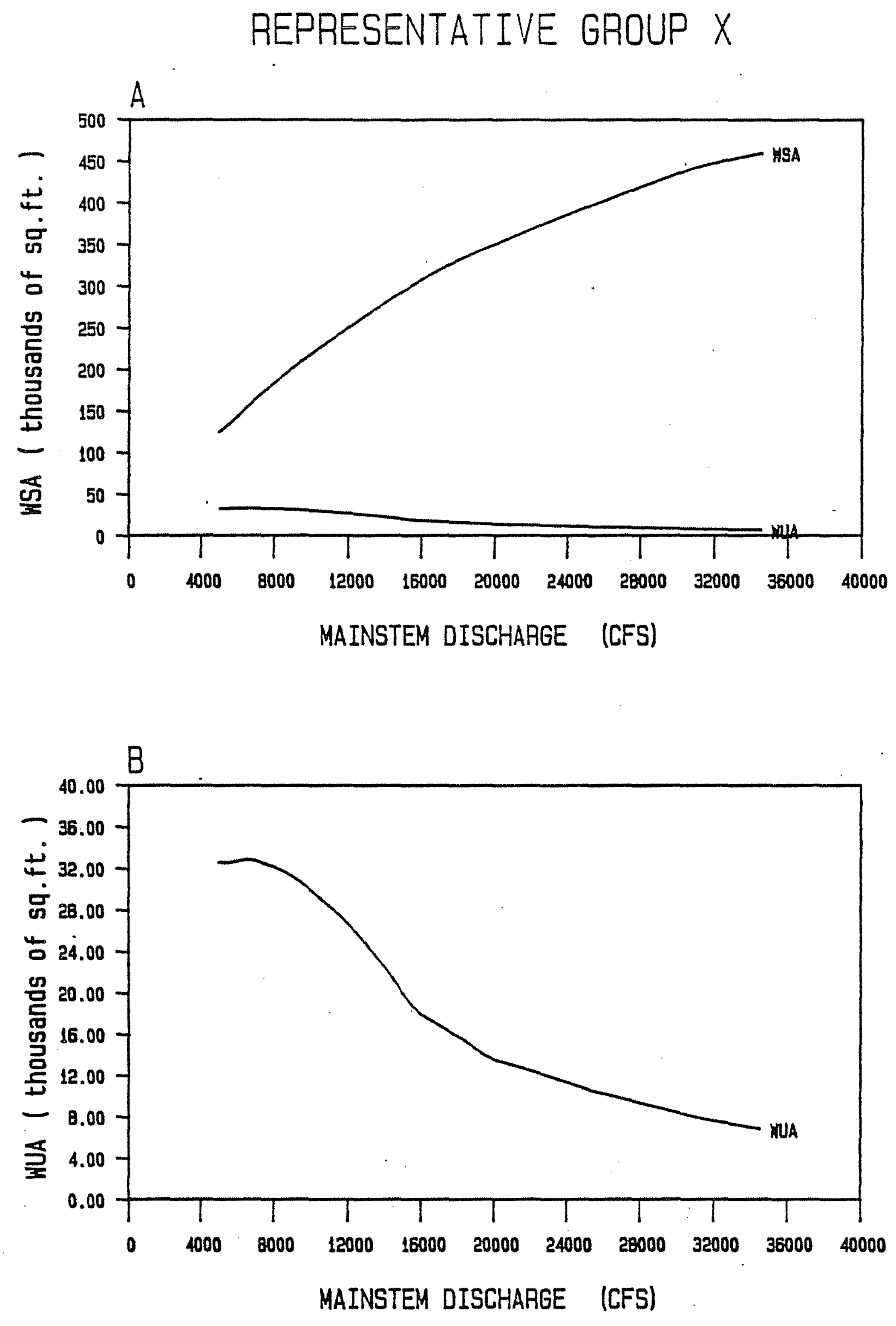


Figure 68. Aggregate response of A - wetted surface area (WSA) and B - chinook rearing habitat potential (WUA) to mainstem discharge in specific areas comprising Representative Group X of the middle Susitna River.

area measurements of exposed gravel bars (Klinger Kingsley 1985) indicated that dewatered surface area increases by approximately 1,037 acres as mainstem discharge decreases from 23,000 cfs to 10,600 cfs.

Because of the difficulty locating upwelling areas during moderate to high flow periods, the entire subpopulation of shoal areas with upwelling are not contained in Representative Group X. From examination of air photo mosaics it is apparent that at low mainstem discharges a large amount of shoal surface area is present that was not included in Representative Group X. Therefore, the surface area and WUA curves for this group are not directly compatible with the curve sets for other representative groups as they contain entire populations of specific areas belonging to a particular habitat type. In addition, the 13 specific areas which are included in Representative Group X all possess similar HAI curves (Figure 67) and result in a composite WUA curve (Figure 68) which is relatively insensitive to changes in mainstem discharge. Therefore, WUA forecasts for Representative Group X will be excluded from further consideration in the extrapolation process.

4.0 SUMMARY

The physical habitat modeling presented in this report provides a quantitative evaluation of the response of juvenile chinook weighted usable area to incremental changes in streamflow for the middle Susitna River. Underpinning the extrapolation methodology are several assumptions related to physical habitat modeling and river stratification procedures.

The primary assumption of the habitat modeling studies is that weighted usable area (WUA) is an index of physical habitat conditions and changes in WUA are attended by adjustments in the distribution and relative abundance of juvenile chinook populations. Although other physical and non-physical components of fish habitat not included in the calculation of WUA may influence the survival and growth of juvenile chinook salmon, the physical environment affects to a substantial degree biotic processes of the aquatic community. Moreover, considerable data exist which indicate the importance of individual microhabitat variables for influencing the distribution of juvenile chinook within different subenvironments of the middle Susitna River. Hence, physical habitat modeling is an appropriate method for assessing the influence of project-induced changes in streamflow on juvenile chinook habitat.

Numerous environmental variables influence the availability of chinook rearing habitat and these variables are typically not independent of one another. Under some circumstances, however, the availability or quality of juvenile chinook habitat may be governed primarily by one or two variables whose influence is more pronounced than the combined effect of all other environmental variables. An example is the positive correlation during the summer growing period between juvenile chinook distribution and turbid water. This may reflect the value of turbidity as cover for juvenile chinook as reported by Dugan et al. (1984) or it may reflect a greater abundance of drifting invertebrate prey in the turbid mainstem and side channel habitats than in clear water sloughs.

Water clarity was treated as a cover variable in the physical habitat modeling studies since our present understanding of turbidity, food availability, and juvenile chinook distribution does not warrant an evaluation of the relationship of turbidity to food supply. Nevertheless, if it is drifting invertebrate prey associated with turbid mainstem and side channel flow which juvenile chinook are responding to rather than the cover value of turbidity, the physical habitat model remains valid. It is the influence of turbidity on juvenile chinook distribution, not the cause, which is being modeled.

The influence of water clarity was incorporated into the modeling process through the application of separate clear and turbid water habitat suitability criteria for juvenile chinook. Clear water velocity and cover suitability criteria were used to calculate rearing WUA indices for modeling sites under non-breached conditions. Following breaching high turbidities prevailed at the modeling sites and turbid water criteria were applied.

The results of the rearing habitat modeling studies conducted at individual modeling sites indicate surface area and rearing habitat response curves are generally more similar within representative groups (where two or more modeling sites occur) than between groups. The amount of rearing habitat available at a particular site is strongly affected by the mainstem discharge at which its upstream berm is overtopped. Under non-breached conditions, juvenile chinook habitat is typically relatively small. The combination of the influx of turbid water to the channel and the increase in its wetted surface area which accompany breaching typically increases the availability of rearing habitat significantly. Positive gains of WUA continue, but at a gradually declining rate, as mainstem discharge increases and water velocities at the site remain favorable. Juvenile chinook habitat tends to decrease more rapidly in smaller channels as mainstem discharge increases than in larger channels due to a more gradual response of near shore velocities to changes in flow in large channels. Thus, relatively small changes in the availability of rearing habitat occur as flows increase or decrease in the large side channels and mainstem. It should be emphasized, however, that these large side channels and the mainstem contribute a disproportionately small amount of habitat in relation to their wetted surface area.

Based on the delineation of specific areas and their classification into the representative groups described by Aaserude et al. 1985, we have developed aggregate rearing habitat response functions for the majority of the subenvironments which directly respond to changes in mainstem discharge. These are summarized in Figure 69. We have not combined WUA values for the representative groups to obtain an aggregate WUA value for the entire middle Susitna River. Evidence of variability in juvenile chinook abundance and distribution between representative groups is provided by Hoffman (1985), suggesting that WUA indices for different

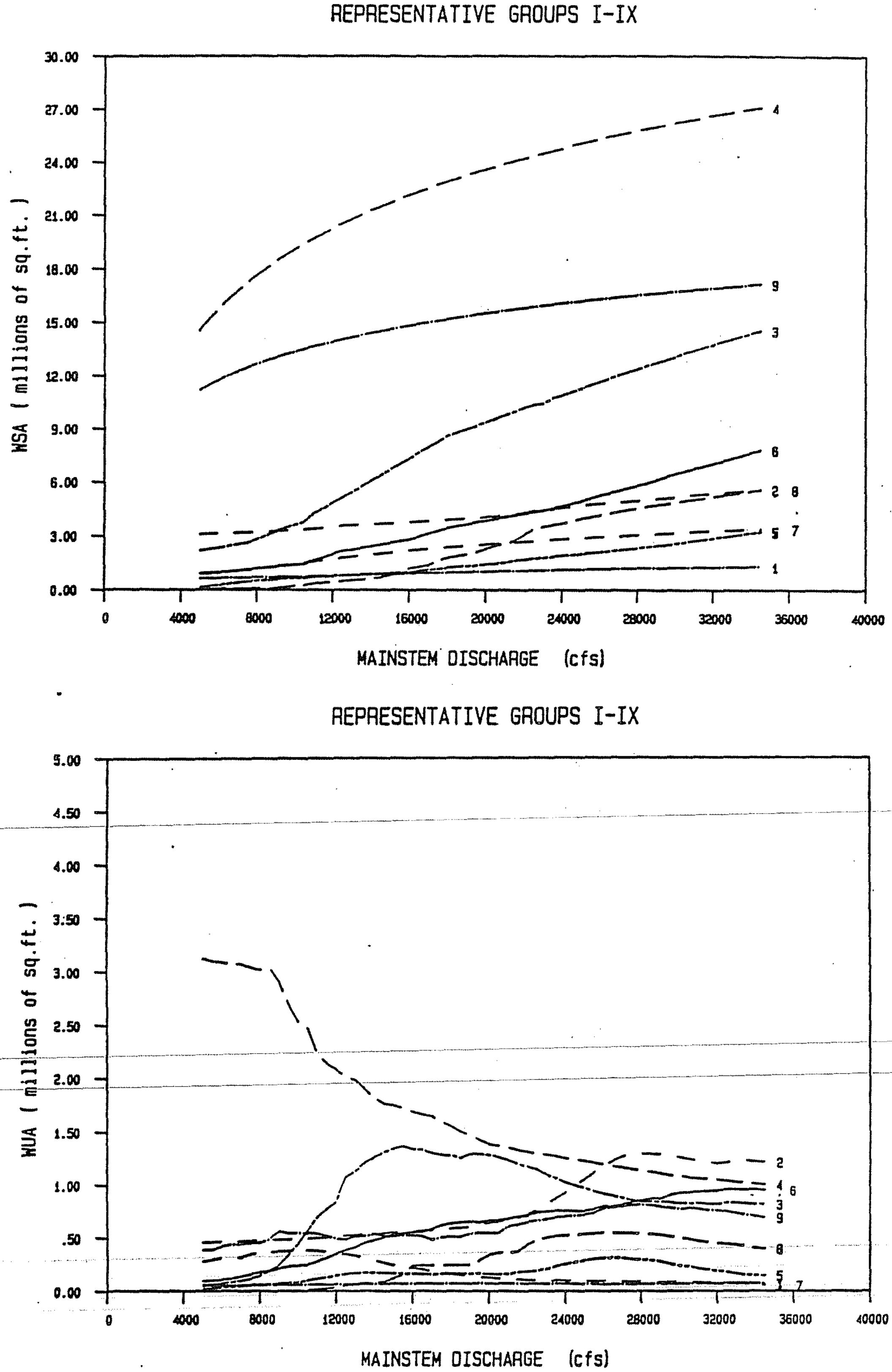


Figure 69. Comparison of the aggregate response of chinook rearing habitat [WUA] for Representative Groups I through IX.

representative groups may require adjusting for utilization prior to being aggregated.

Other considerations which should be addressed prior to drawing final conclusions from the habitat response functions provided in this report are the influences of food availability and water temperature on the quality of rearing habitats. In addition such seasonal aspects as availability of chinook overwintering habitat should be considered. The habitat modeling results presented in this report are not directly applicable to evaluations of winter habitat since hydraulic characteristics and fish behavior are different at this time of year. In regard to the open water period, however, time series and habitat duration analyses at the representative group level are recommended for comparisons between groups and flow regimes. Whereas the primary utility of the WUA response functions is their application to existing habitat conditions, the general shape of the WUA response functions are also well-suited to assessing with-project effects on juvenile chinook habitat.

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LITERATURE CITED

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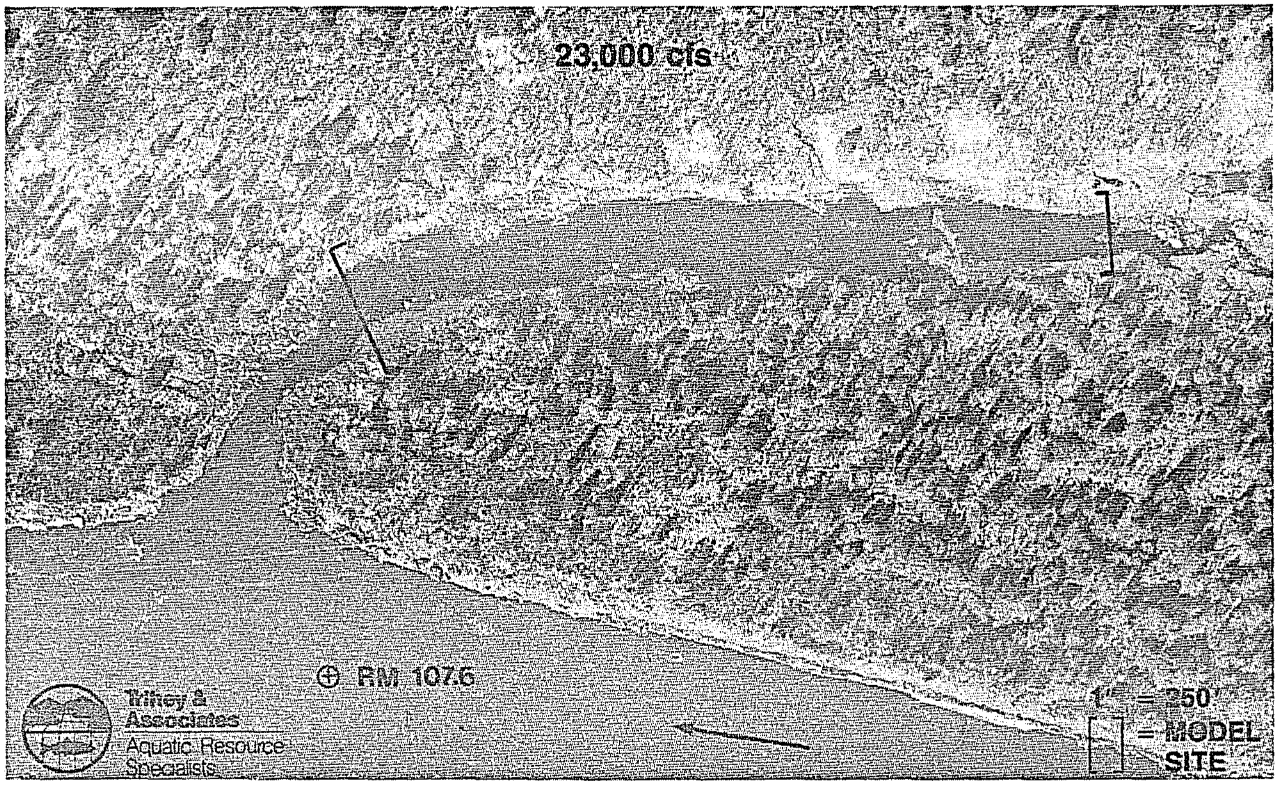
APPENDICES

APPENDIX A

AERIAL PHOTOGRAPHY OF MODELING SITES

(PLATES A-1 THROUGH A-42)



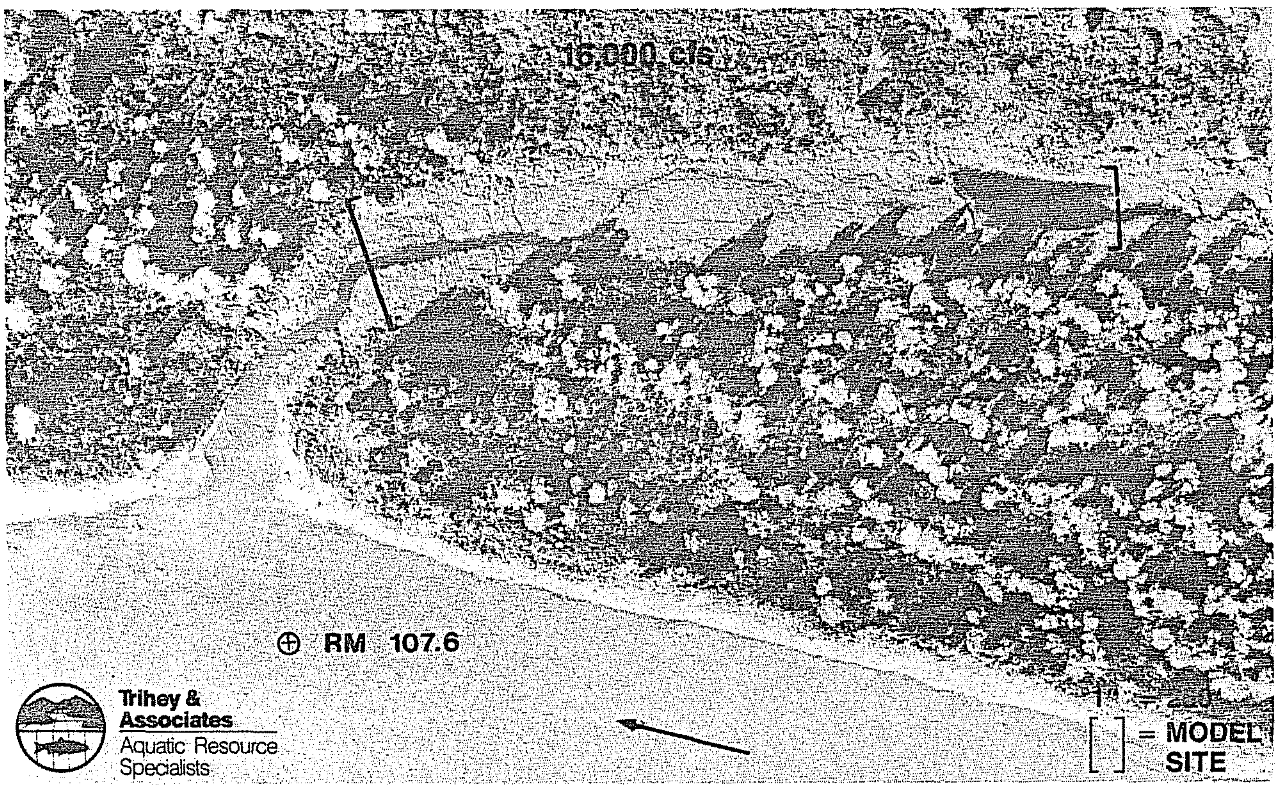
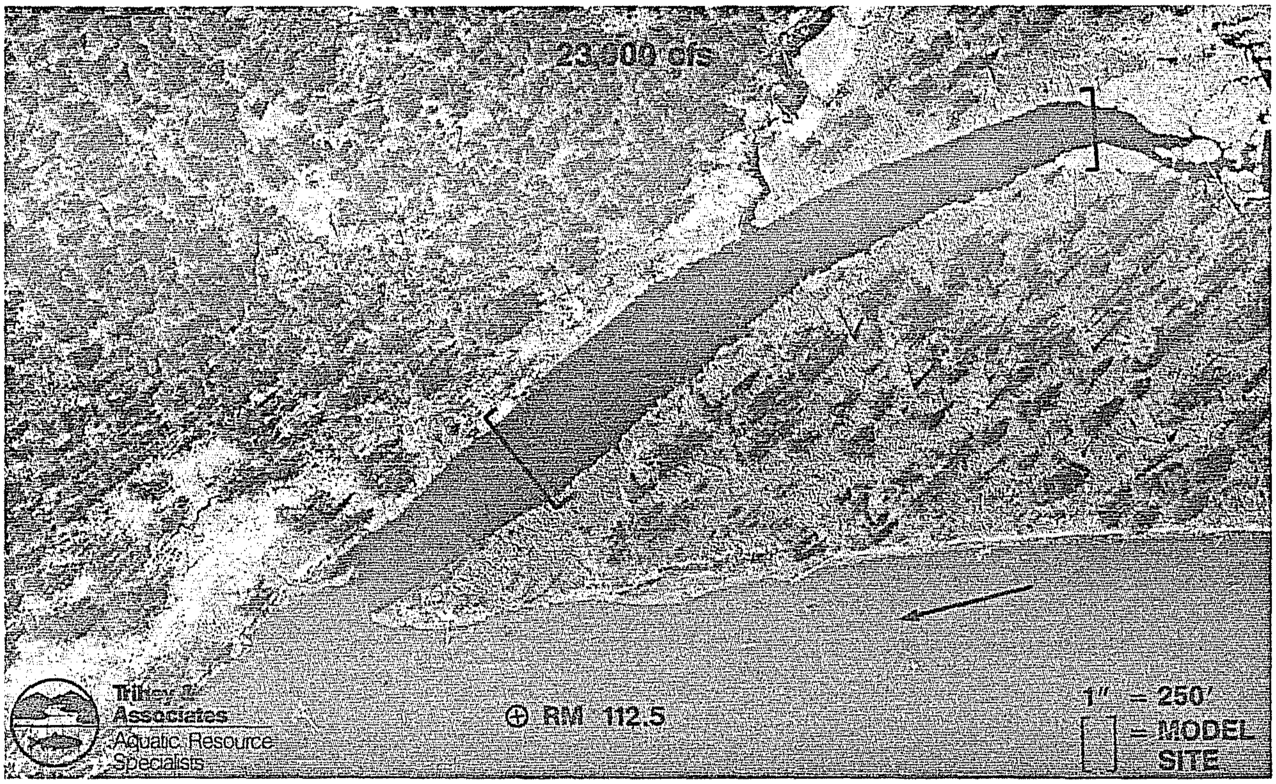


Plate A-1 Aerial photography of modeling site 107.6L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at > 35,000 cfs and is included in Representative Group I.



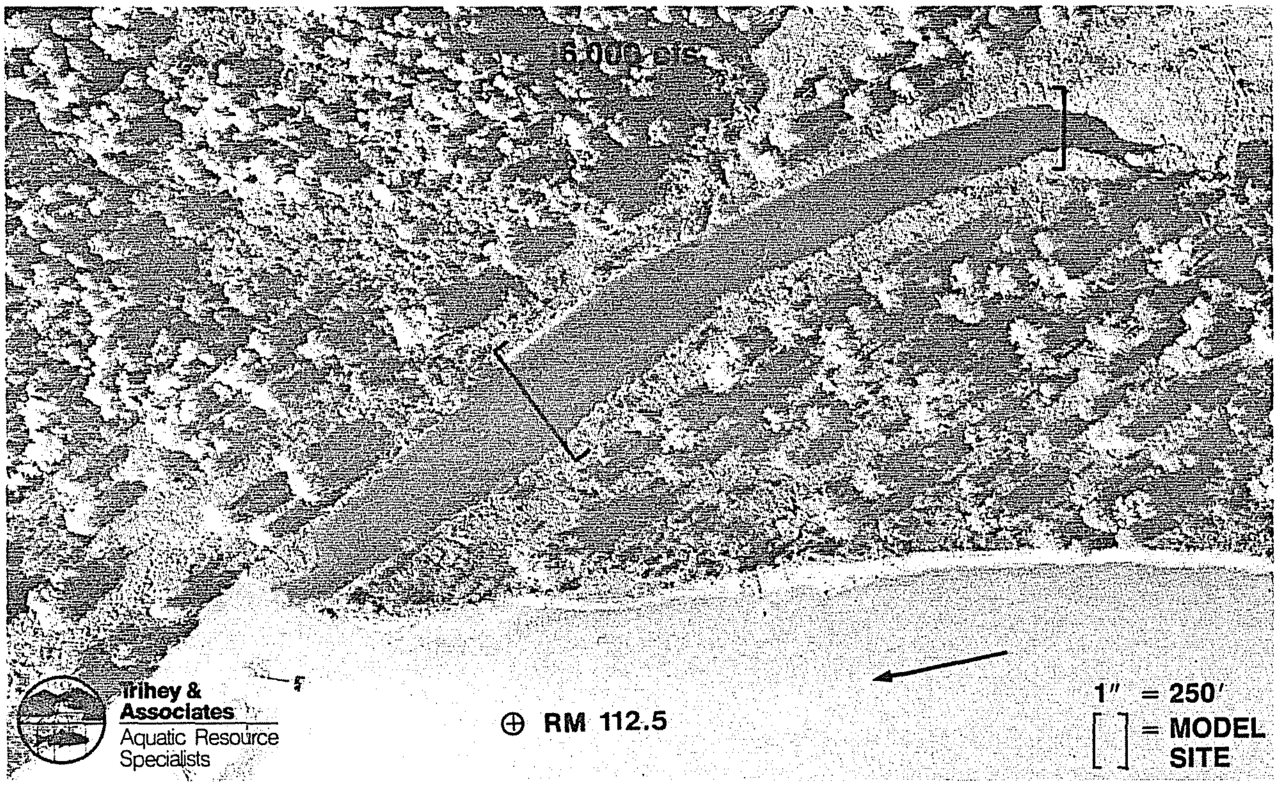
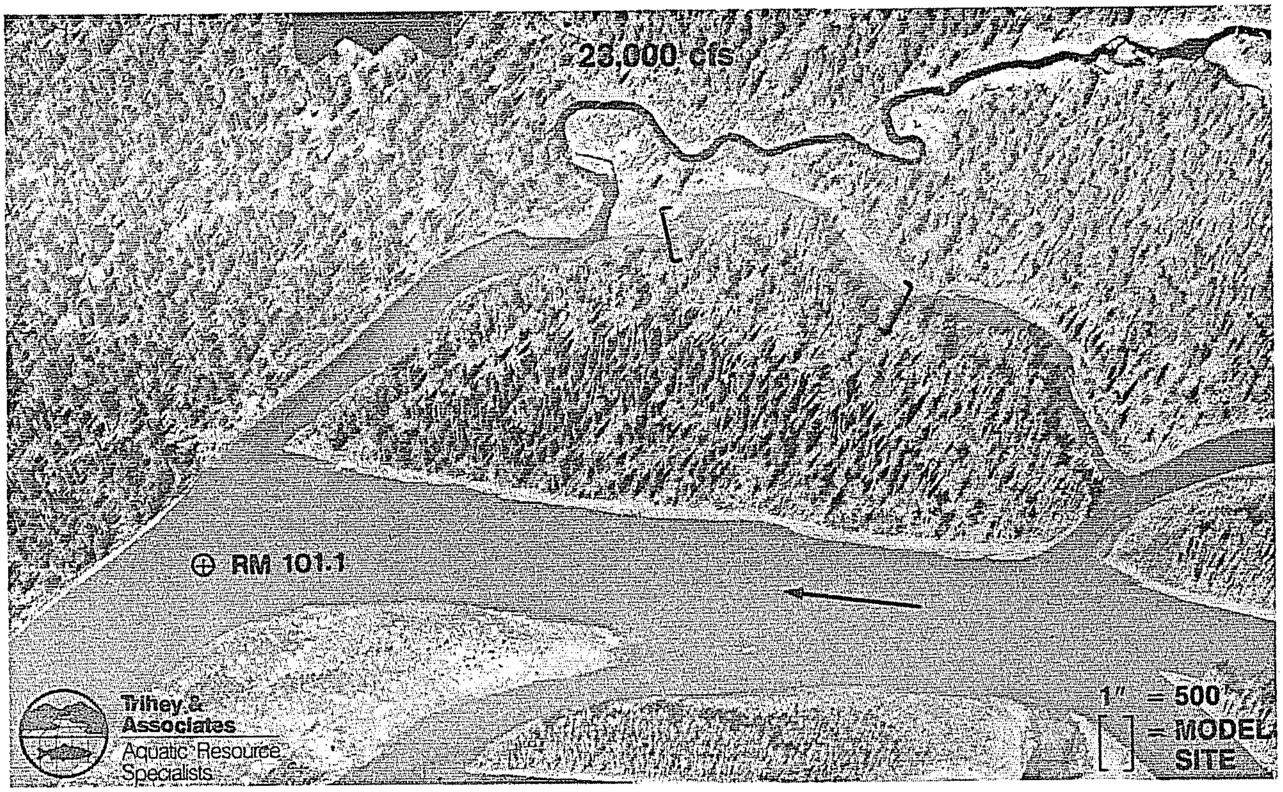


Plate A-2 Aerial photography of modeling site 112.5L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at > 35,000 cfs and is included in Representative Group I.



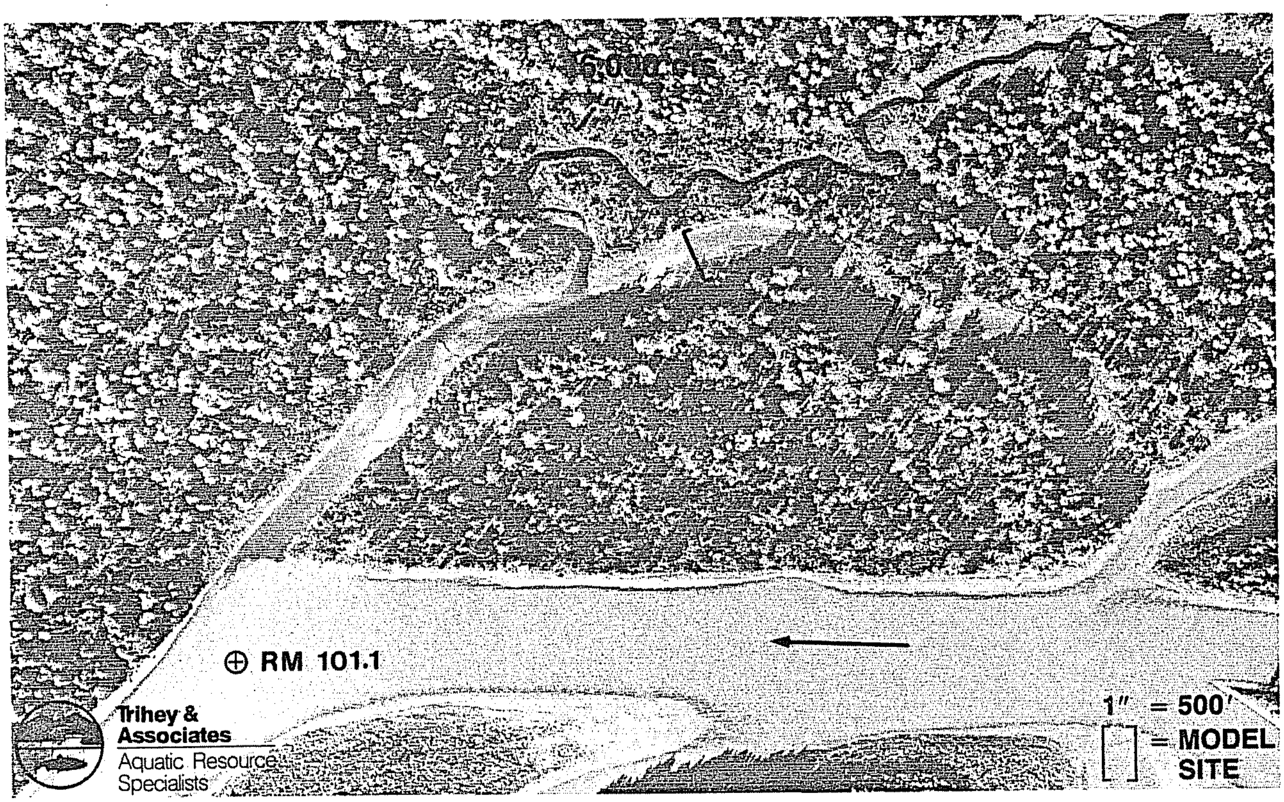
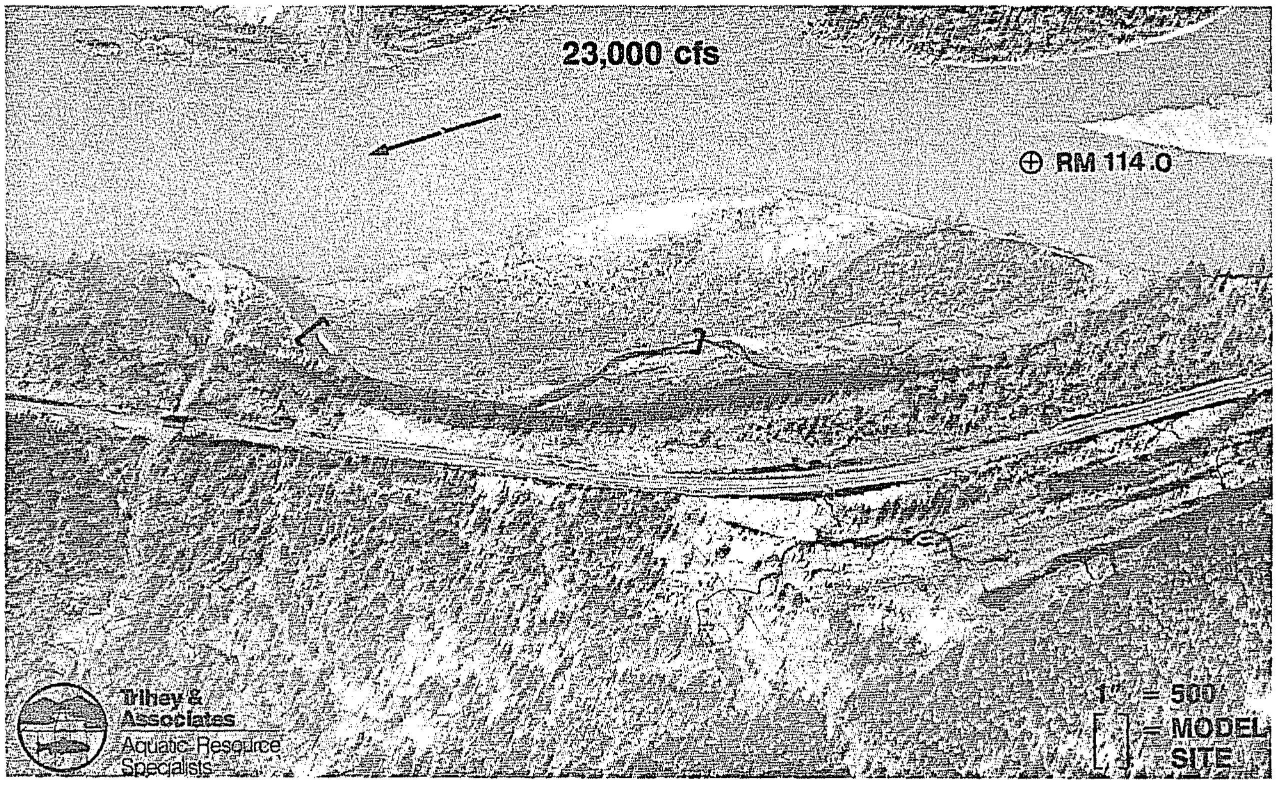


Plate A-3 Aerial photography of modeling site 101.4L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 22,000 cfs and is included in Representative Group II.



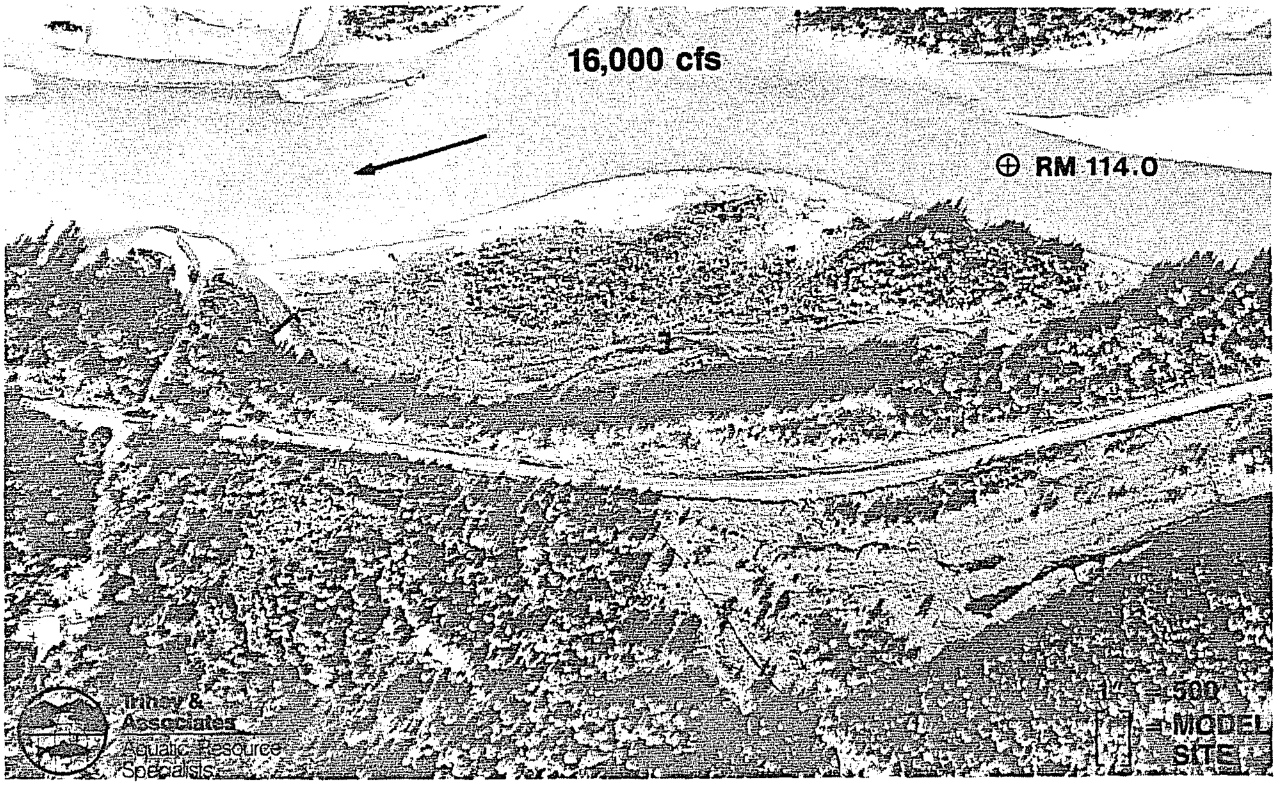
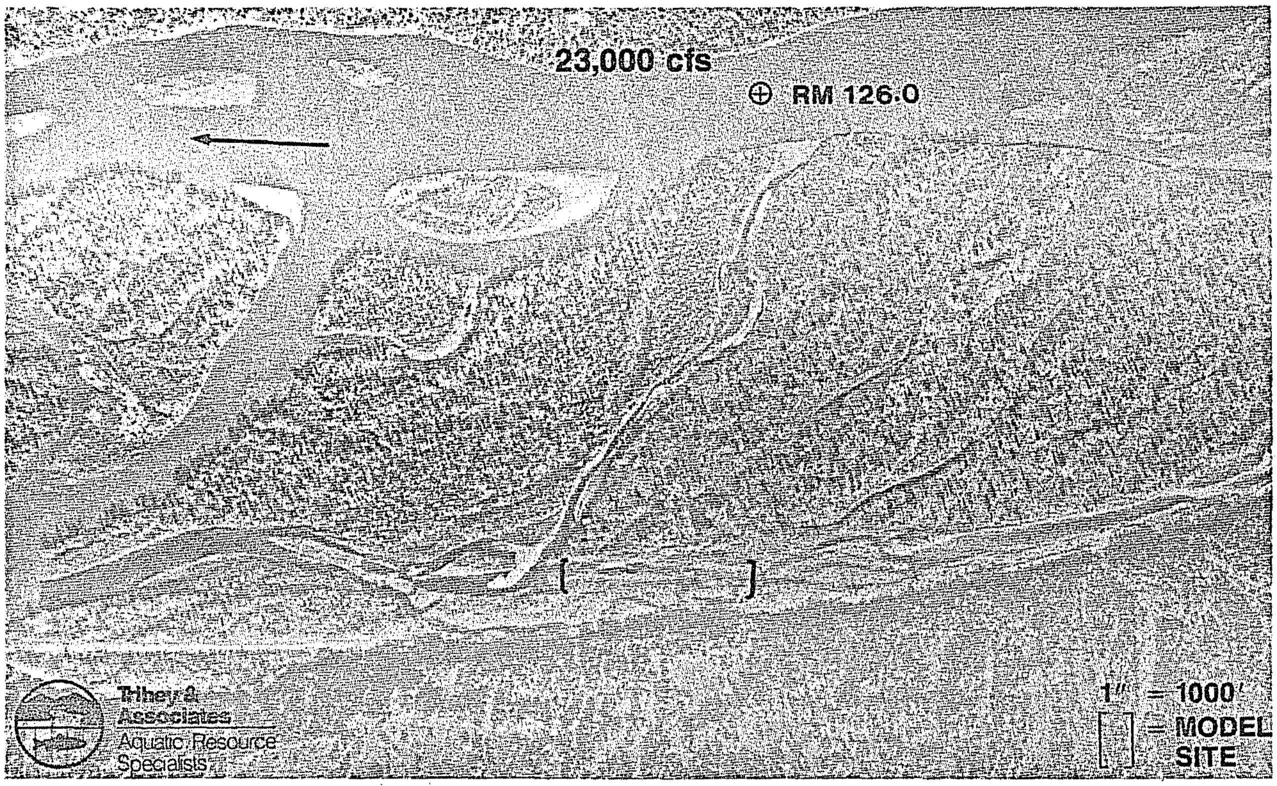


Plate A-4 Aerial photography of modeling site 113.7R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 24,000 cfs and is included in Representative Group II.



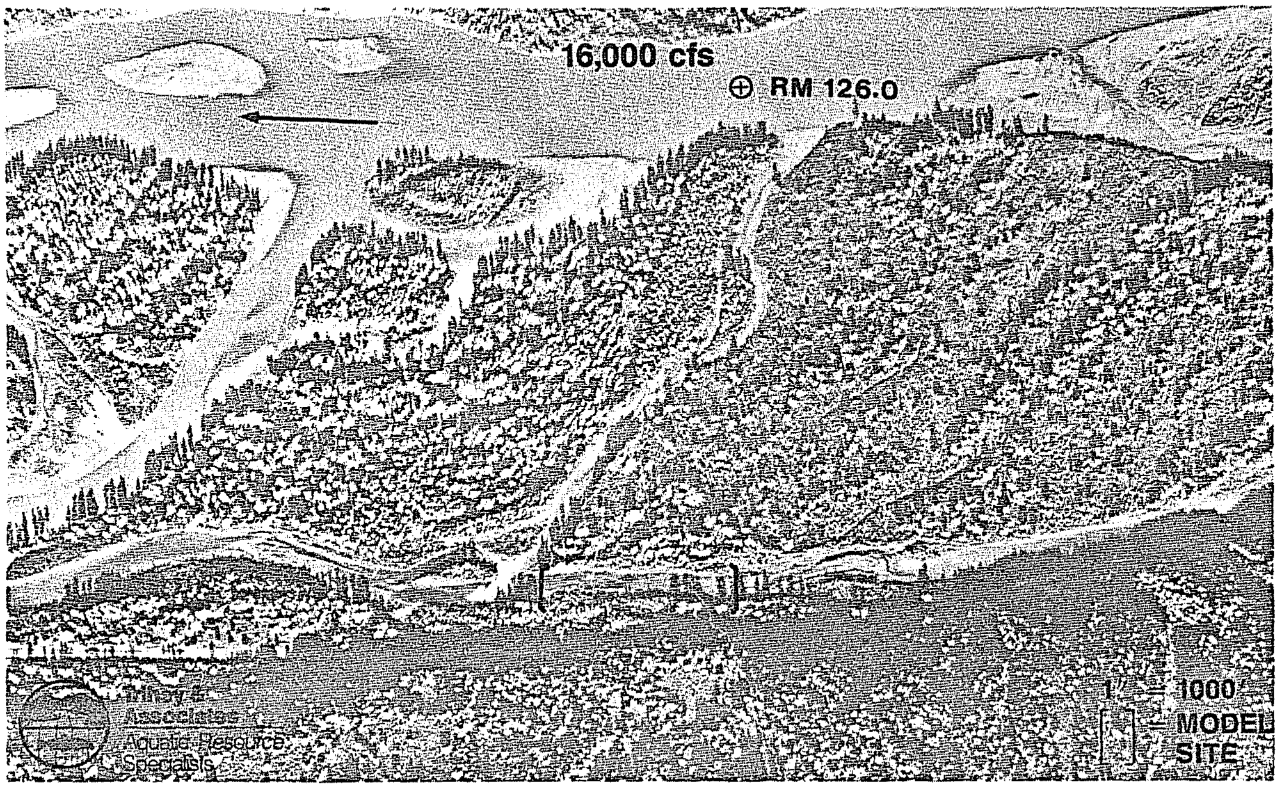
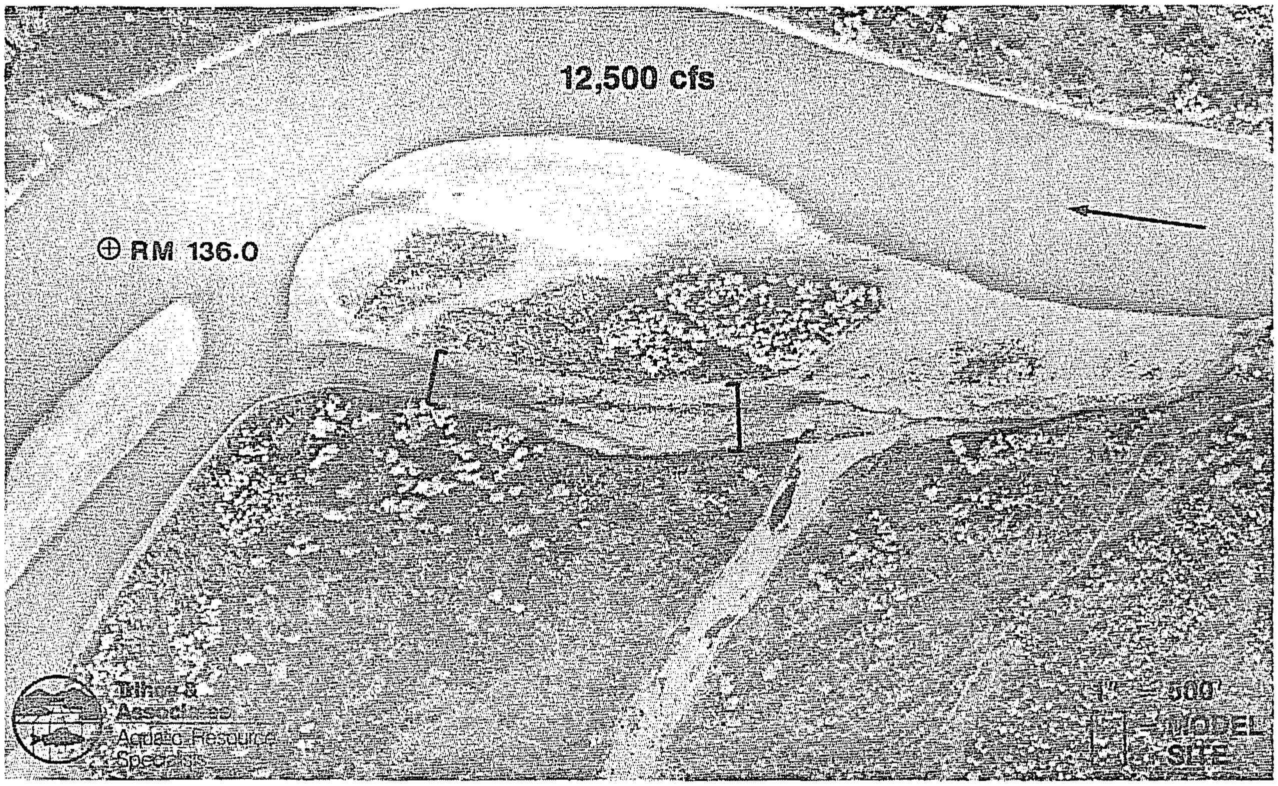


Plate A-5 Aerial photography of modeling site 126.0R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 33,000 cfs and is included in Representative Group II.



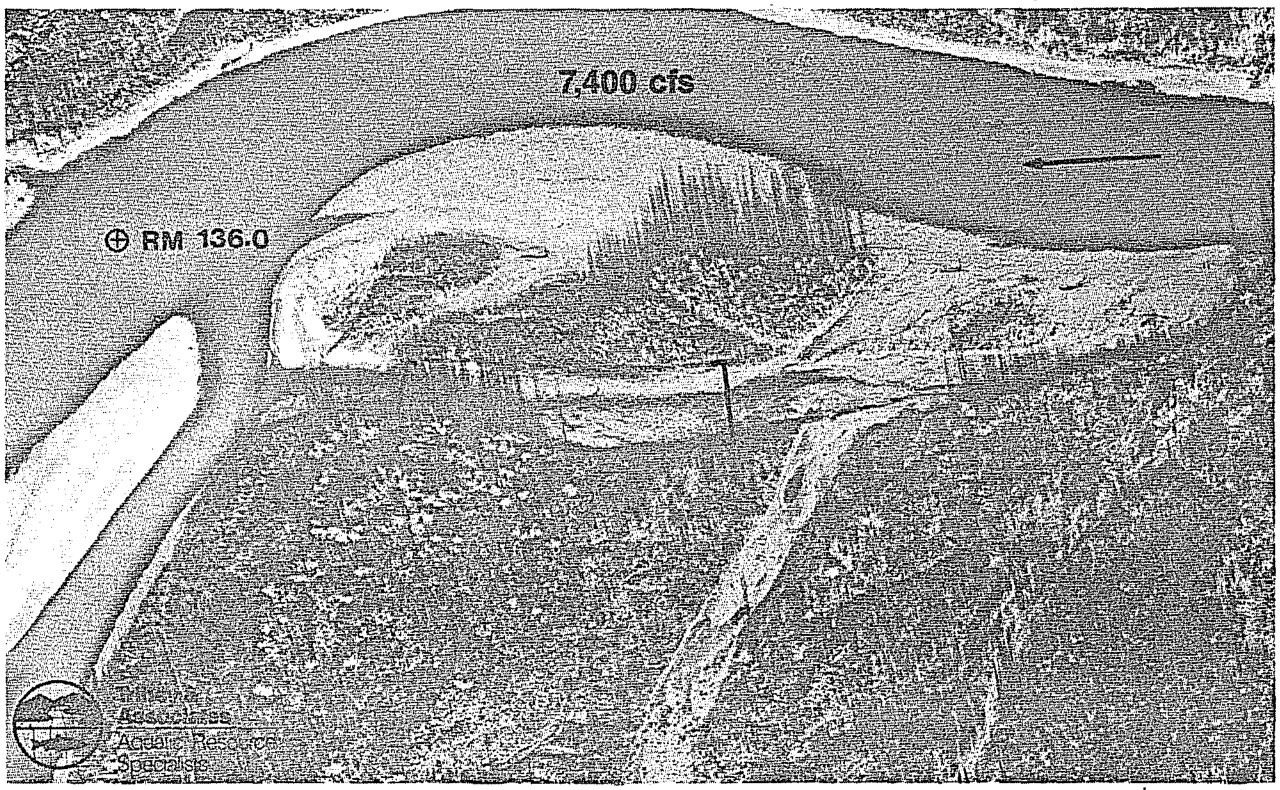
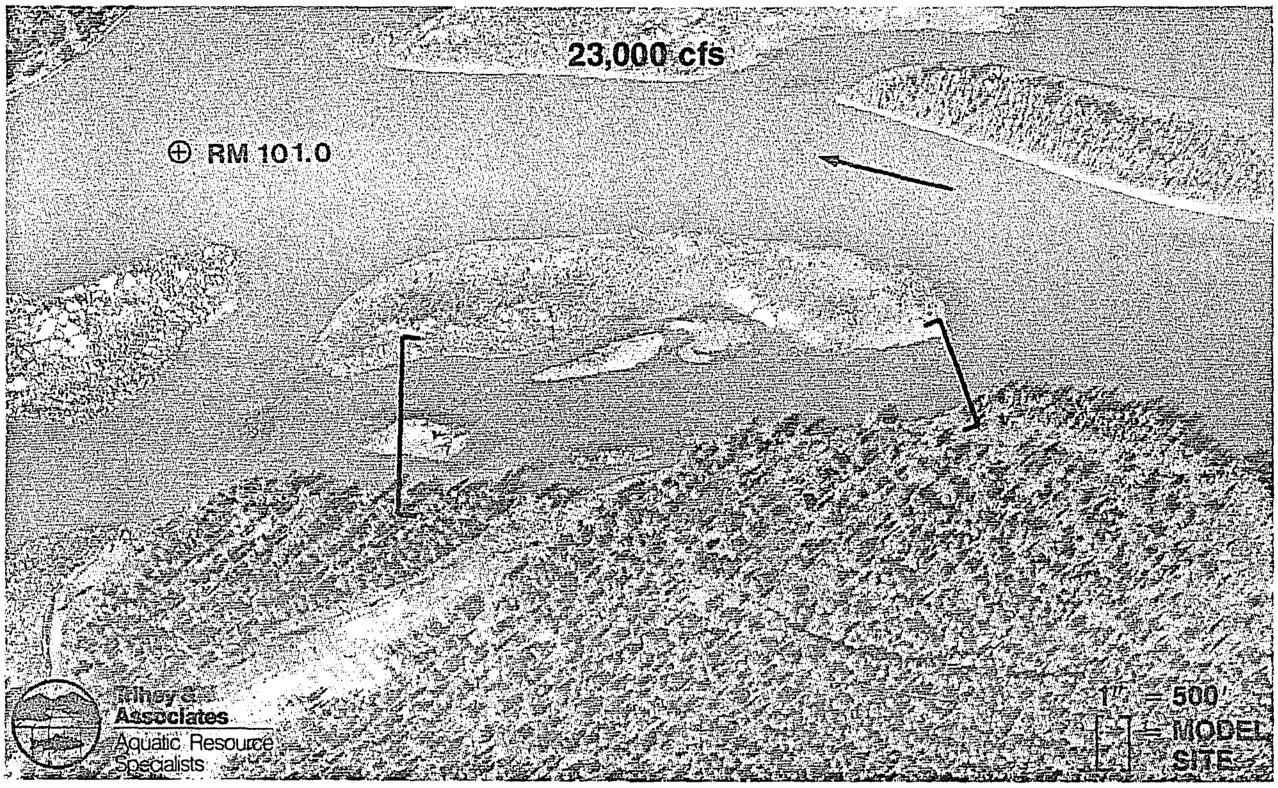


Plate A-26 Aerial photography of modeling site 136.3R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at 13,000 cfs and is included in Representative Group VI.



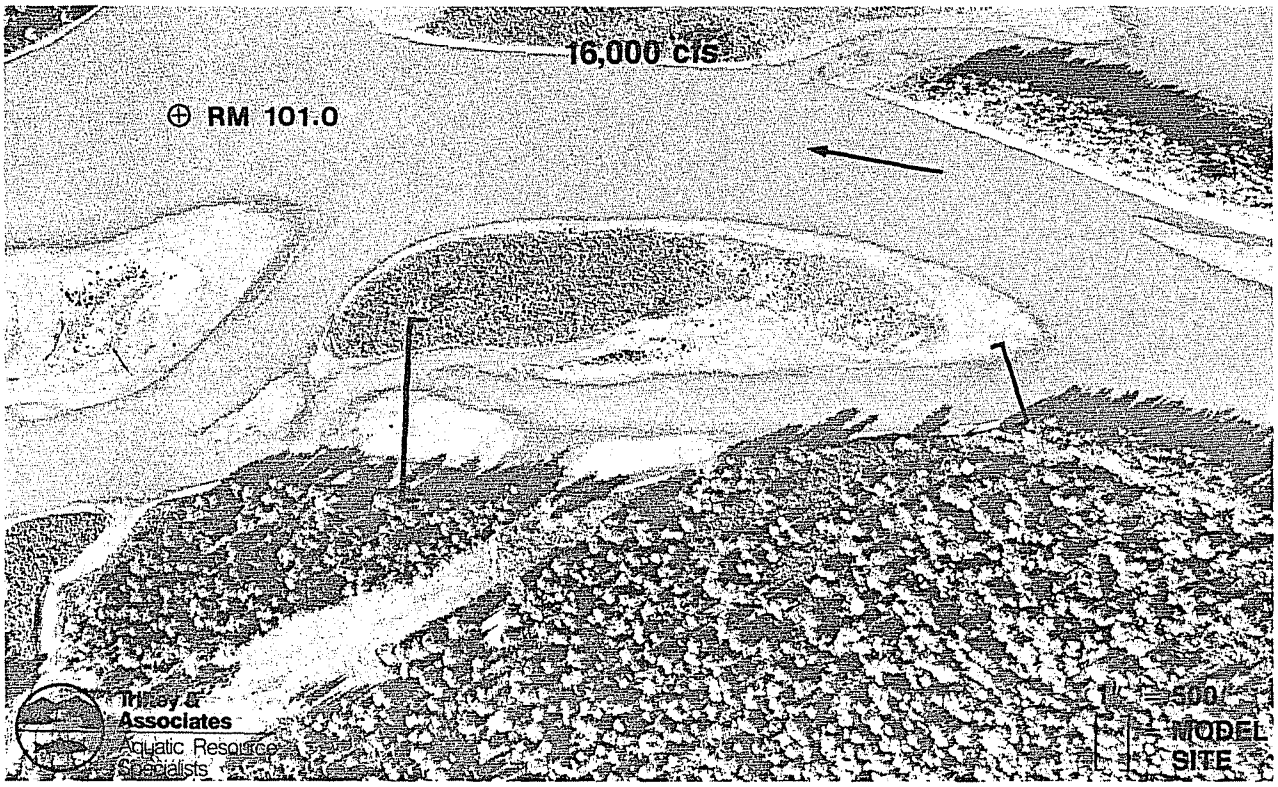
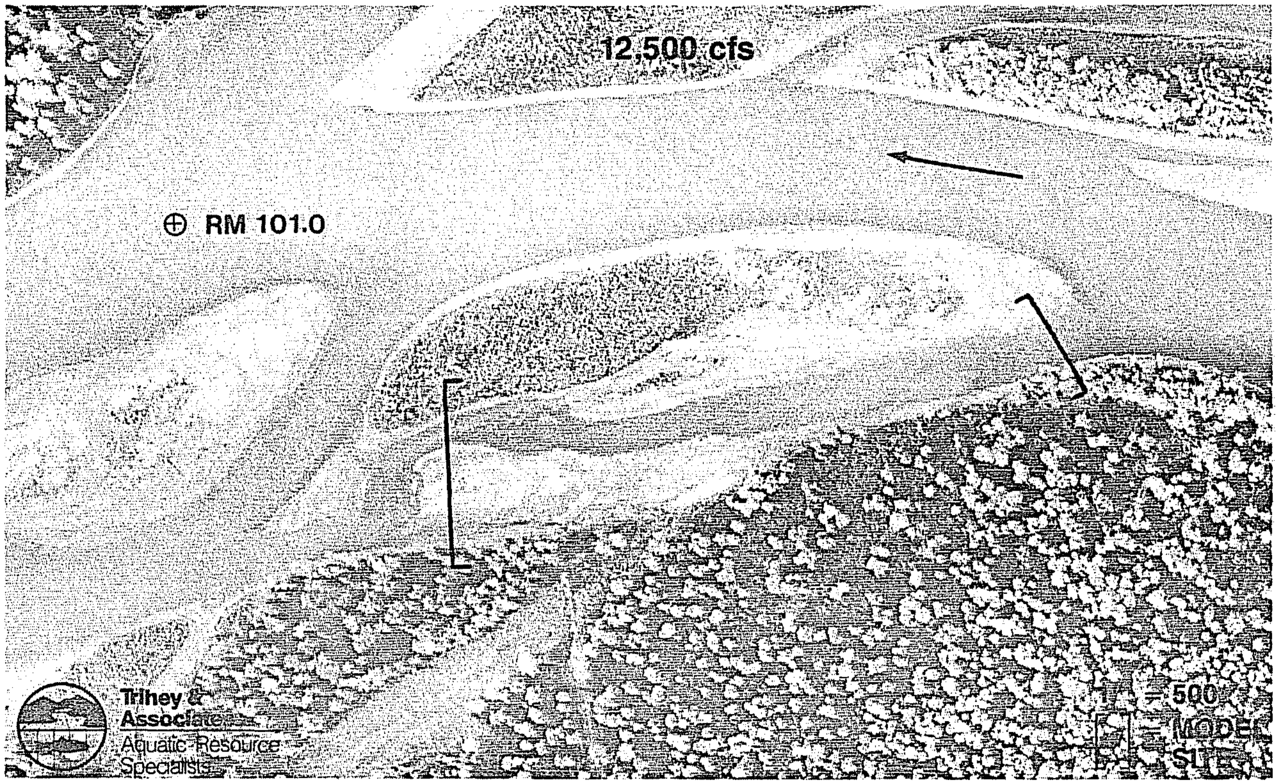


Plate A-7 Aerial photography of modeling site 101.2R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 9,200 cfs and is included in Representative Group III.



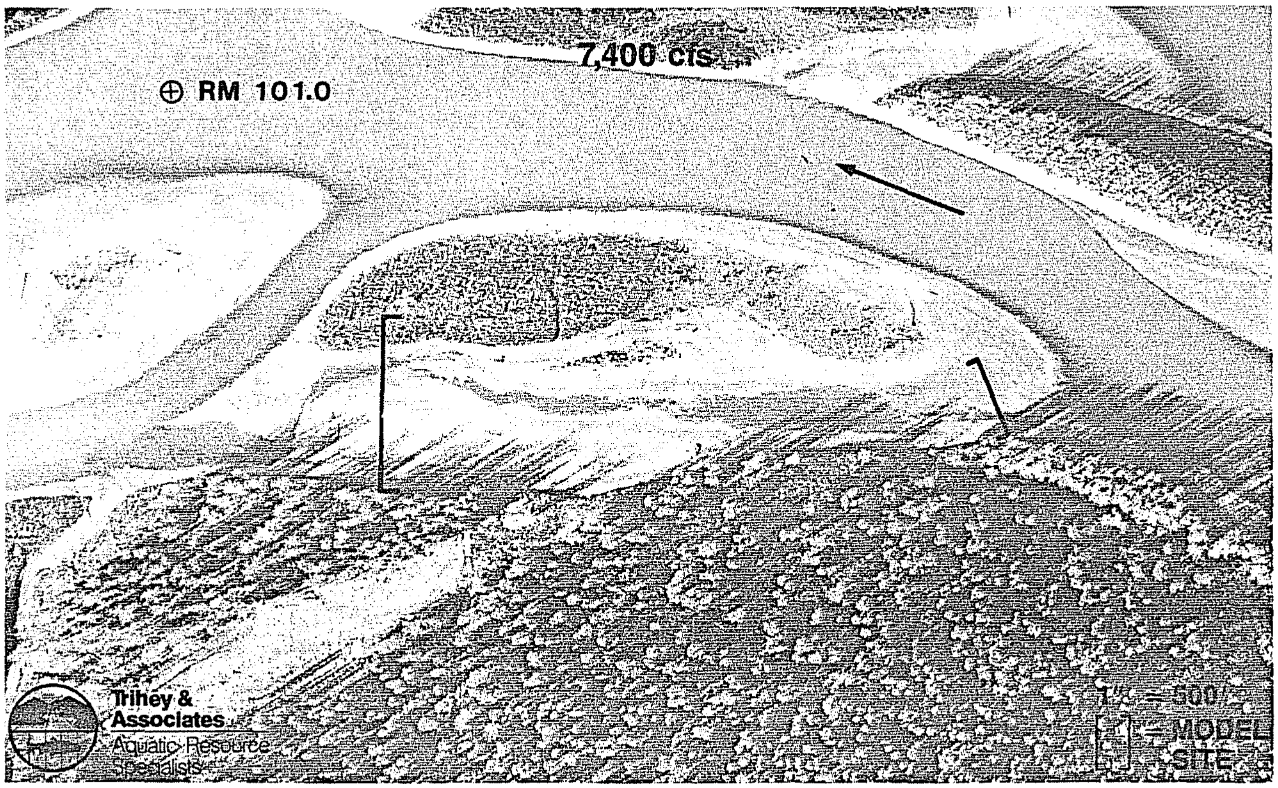
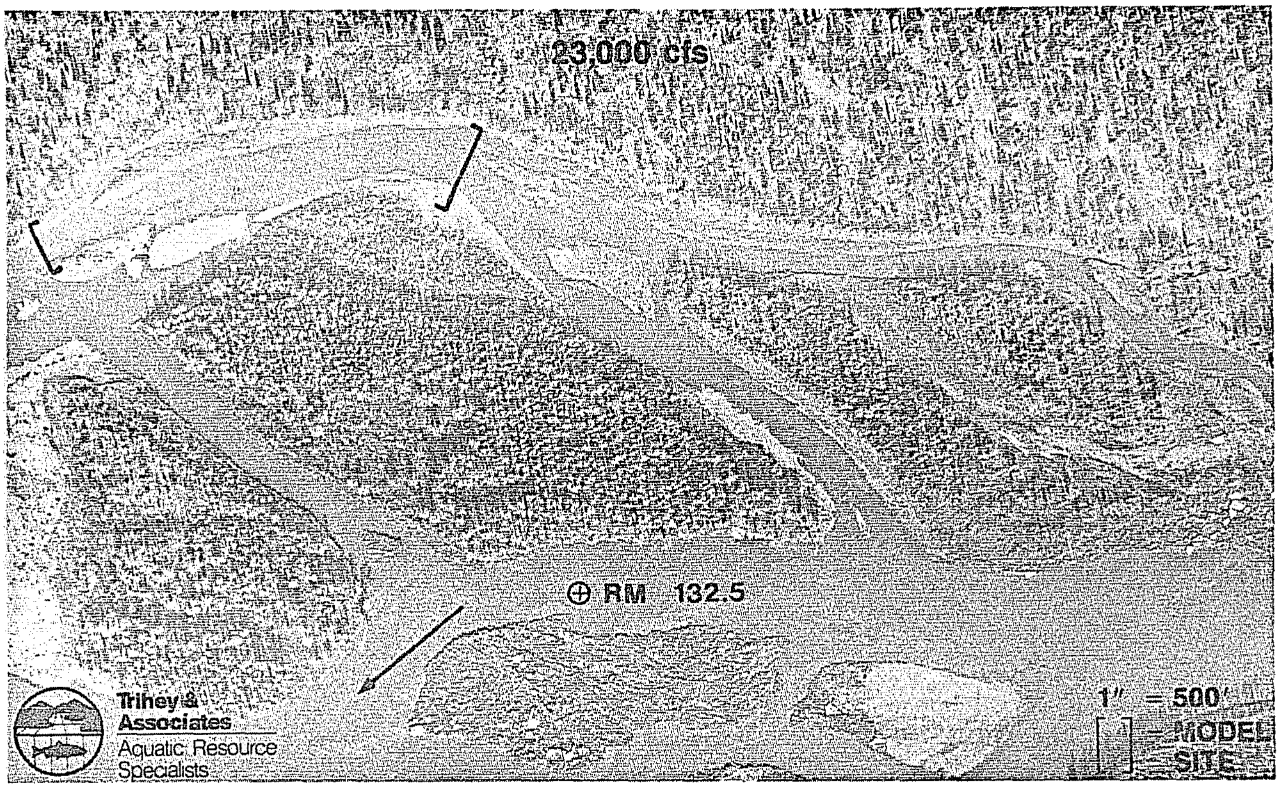


Plate A-8 **Aerial photography of modeling site 101.2R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at 9,200 cfs and is included in Representative Group III.**

Plate A-10 Aerial photography of modeling site 128.8R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at 16,000 cfs and is included in Representative Group III.



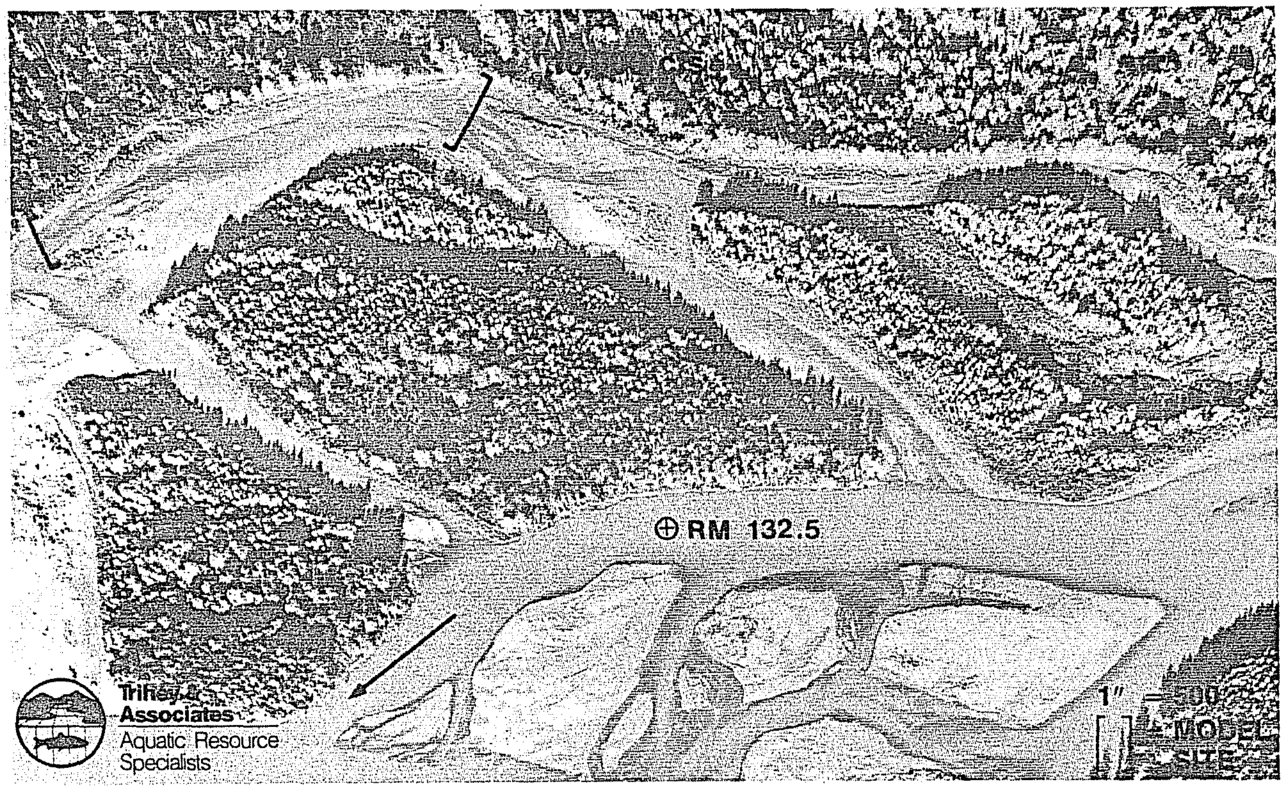
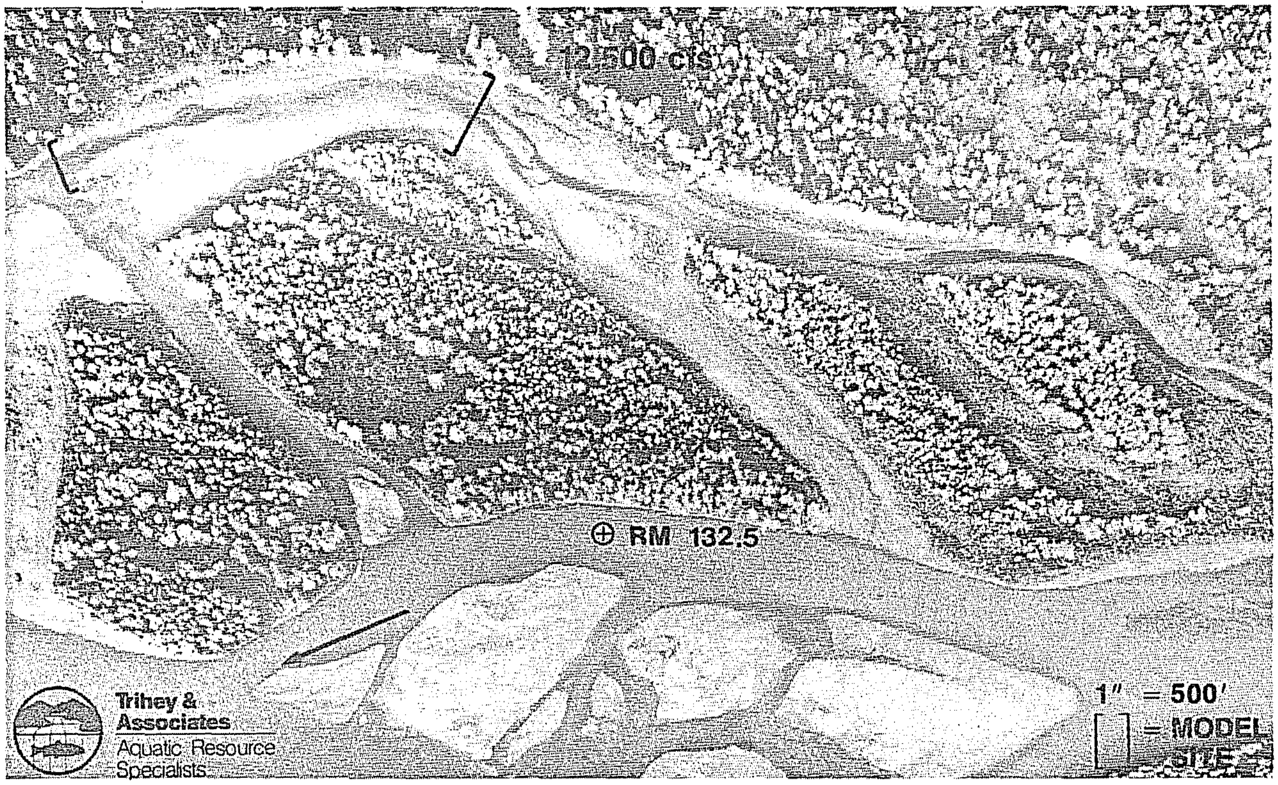


Plate A-11 **Aerial photography of modeling site 132.6L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 10,500 cfs and is included in Representative Group III.**



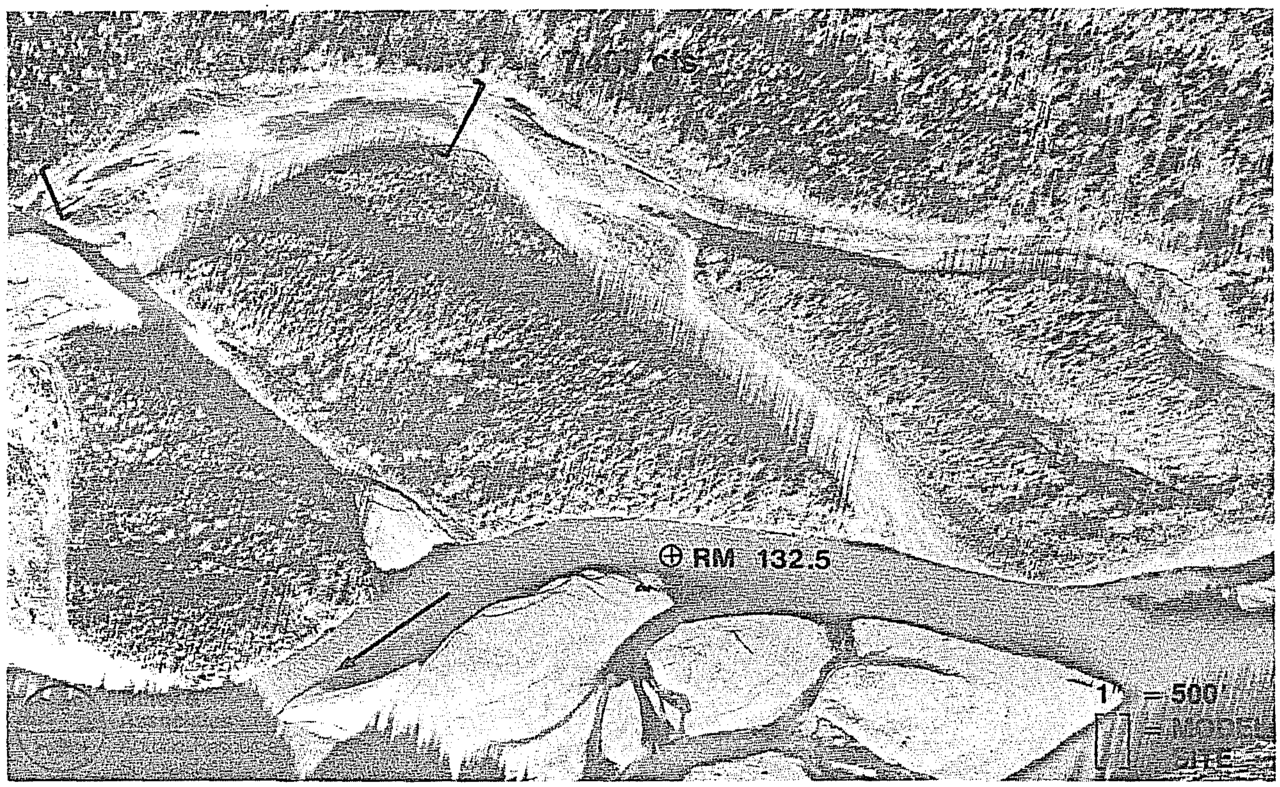


Plate A-12 Aerial photography of modeling site 132.6L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at 10,500 cfs and is included in Representative Group III.

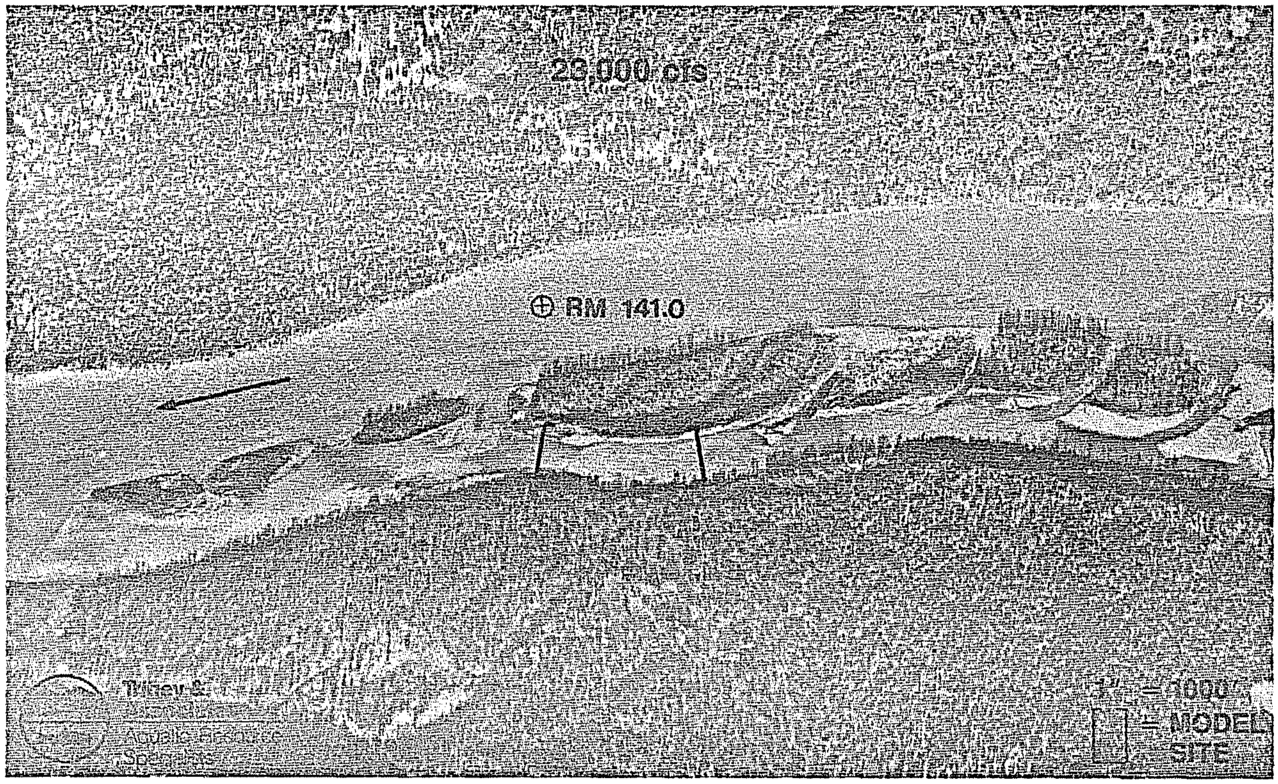


Plate A-13 Aerial photography of modeling site 141.4R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 11,500 cfs and is included in Representative Group III.

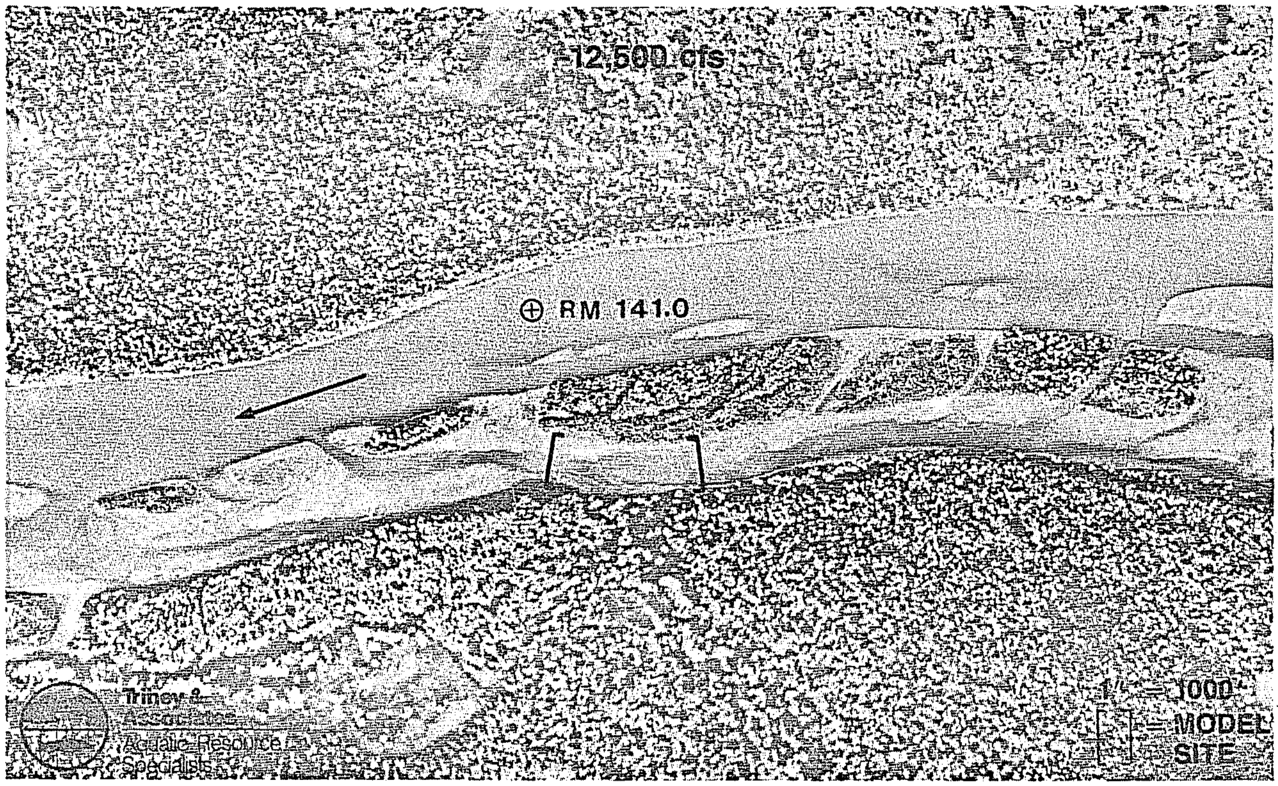
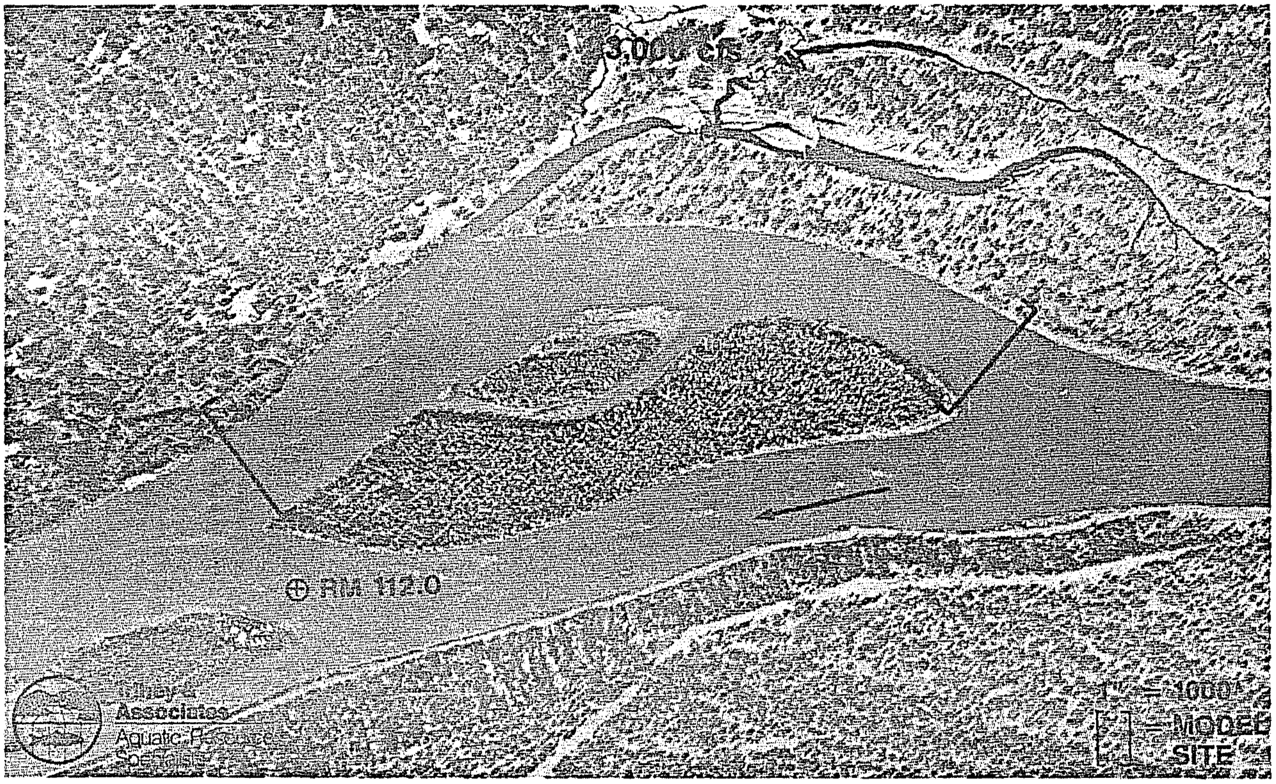


Plate A-14 Aerial photography of modeling site 141.1R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at 11,500 cfs and is included in Representative Group III.



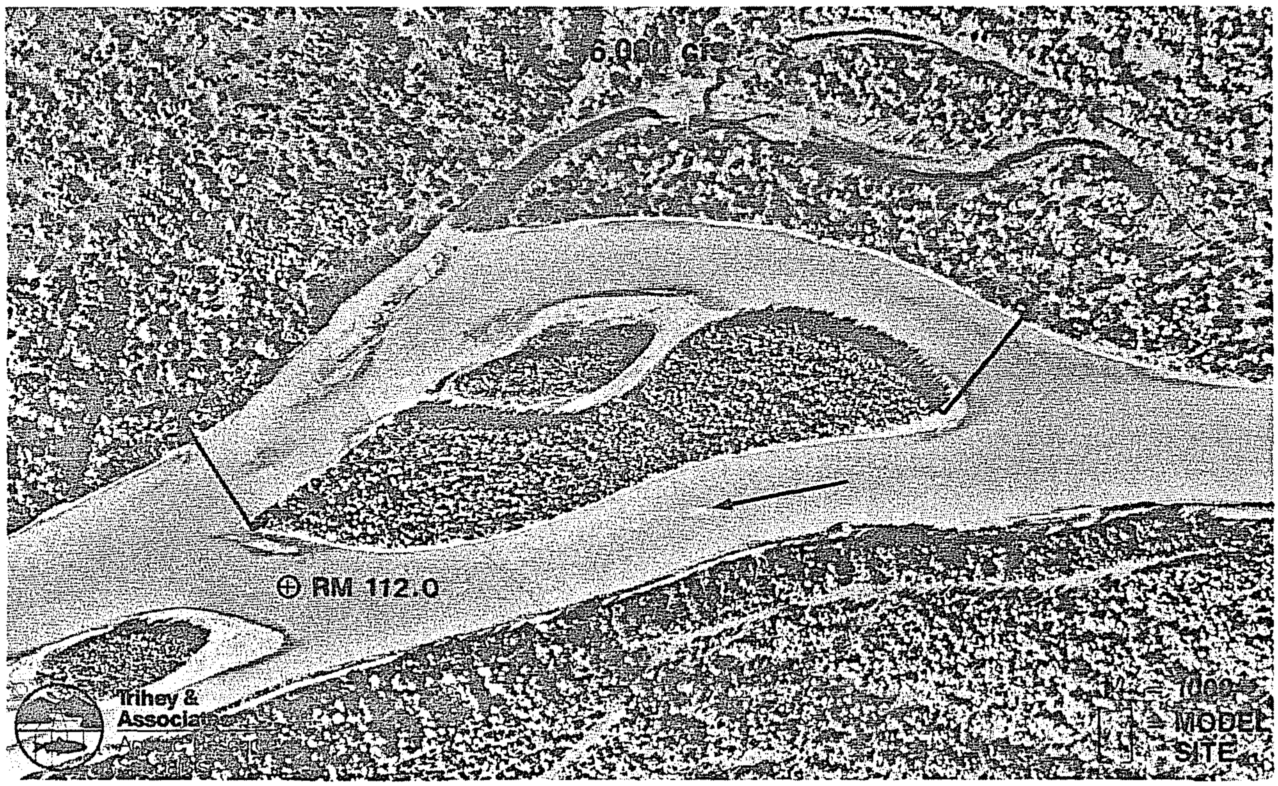
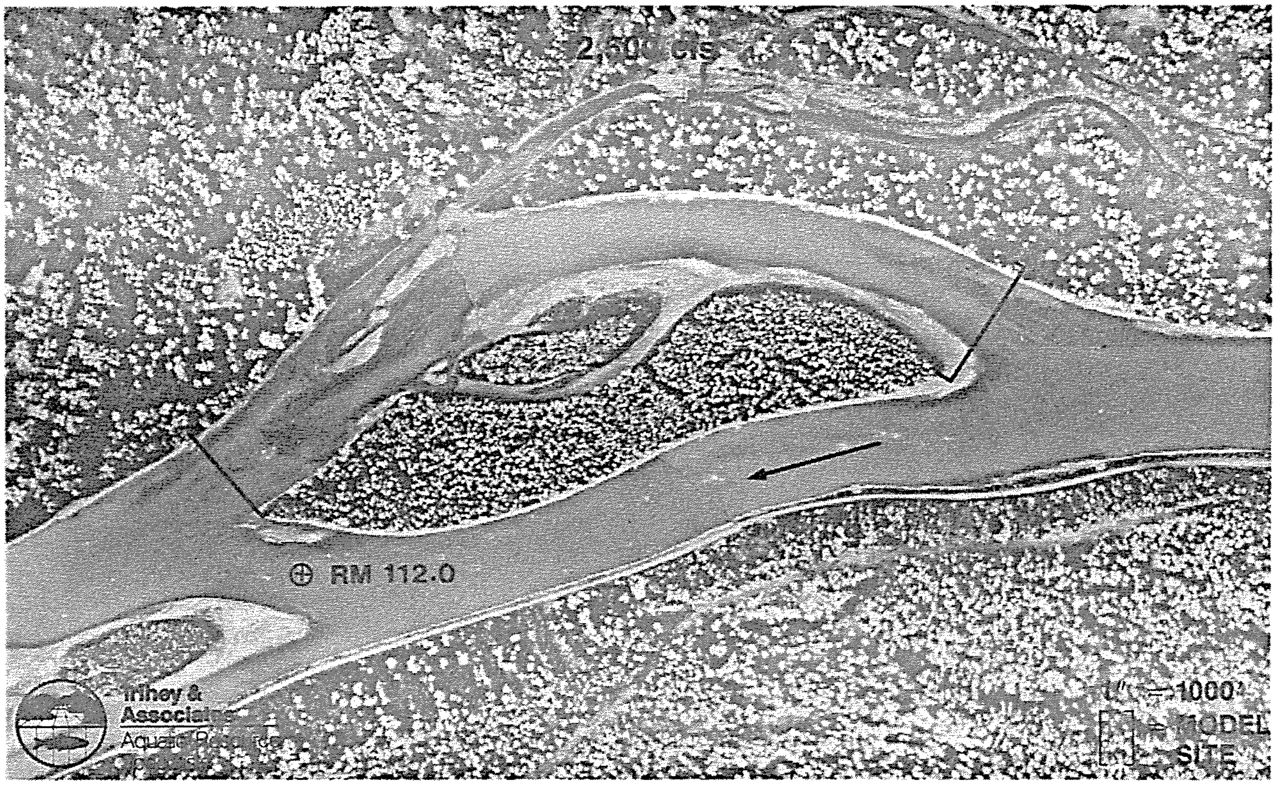


Plate A-15 Aerial photography of modeling site 112.6L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



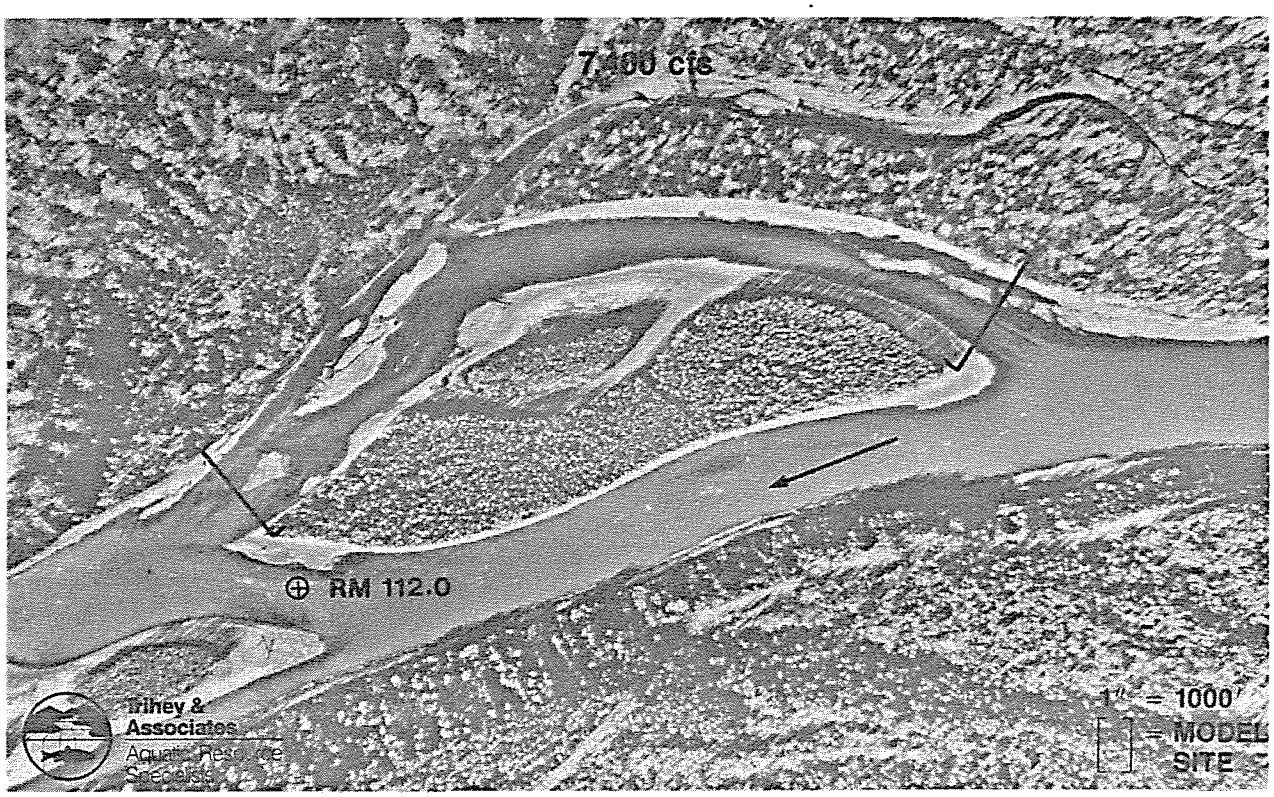
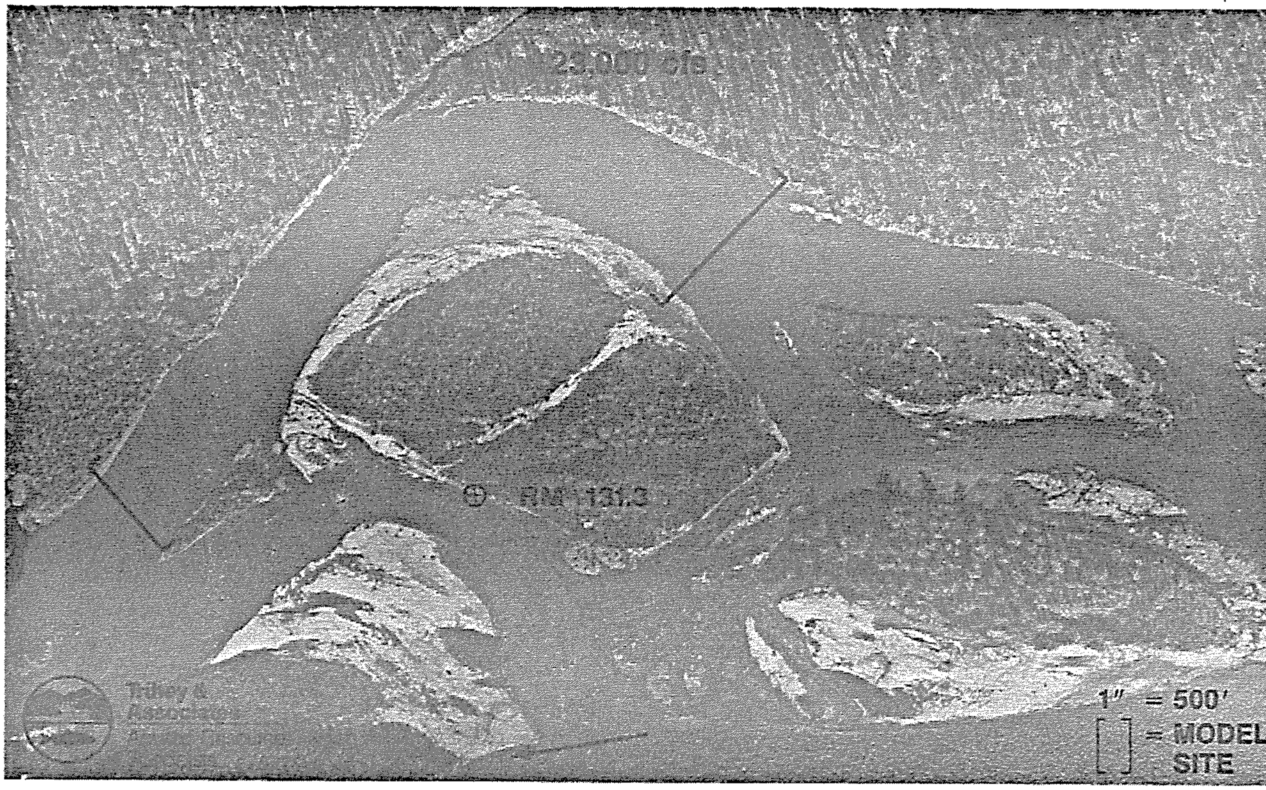


Plate A-16 Aerial photography of modeling site 112.6L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



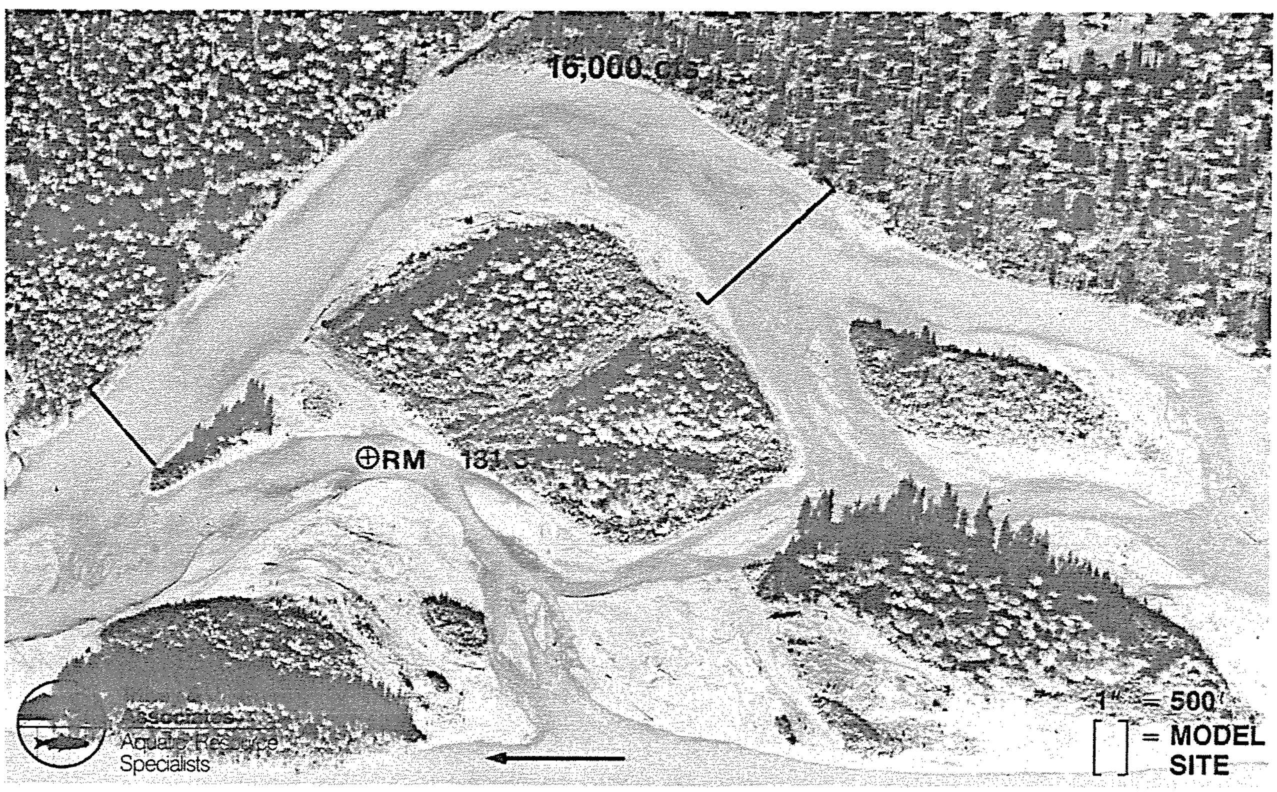
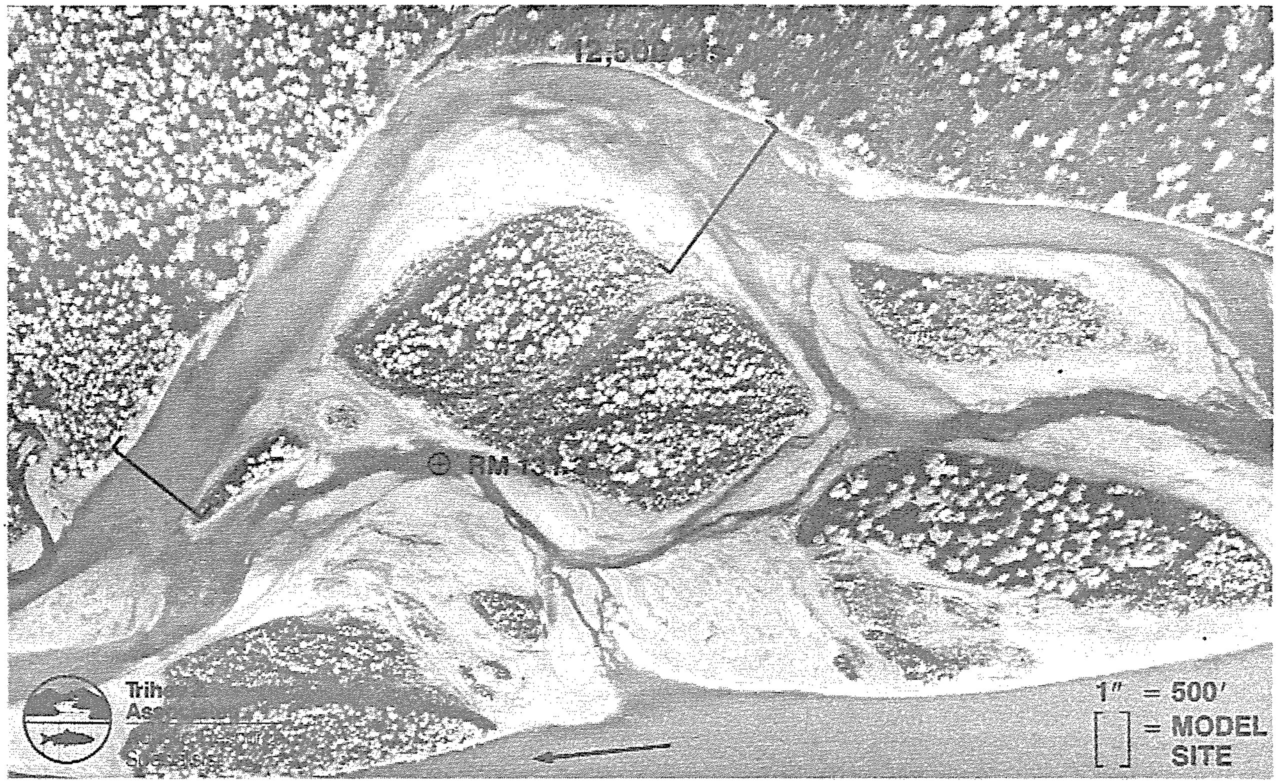


Plate A-17 Aerial photography of modeling site 131.7L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



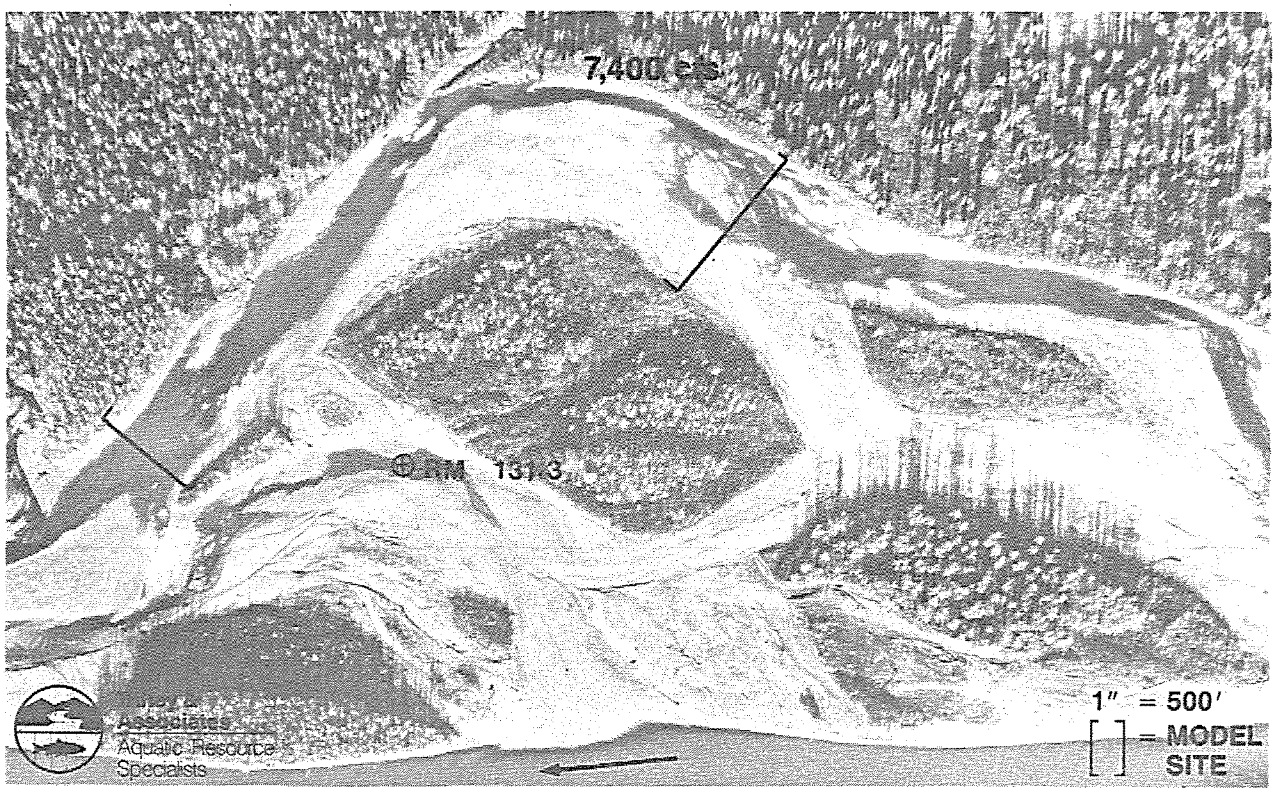
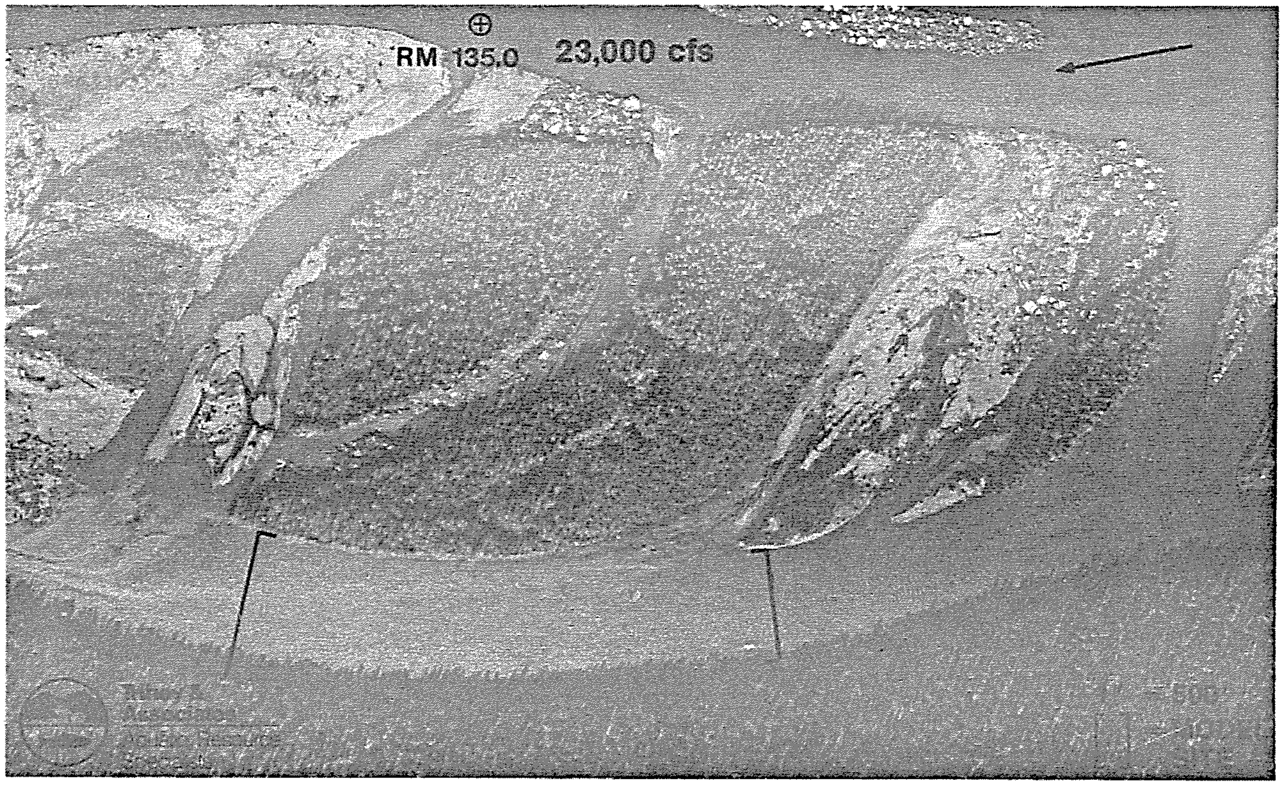


Plate A-18 Aerial photography of modeling site 131.7L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



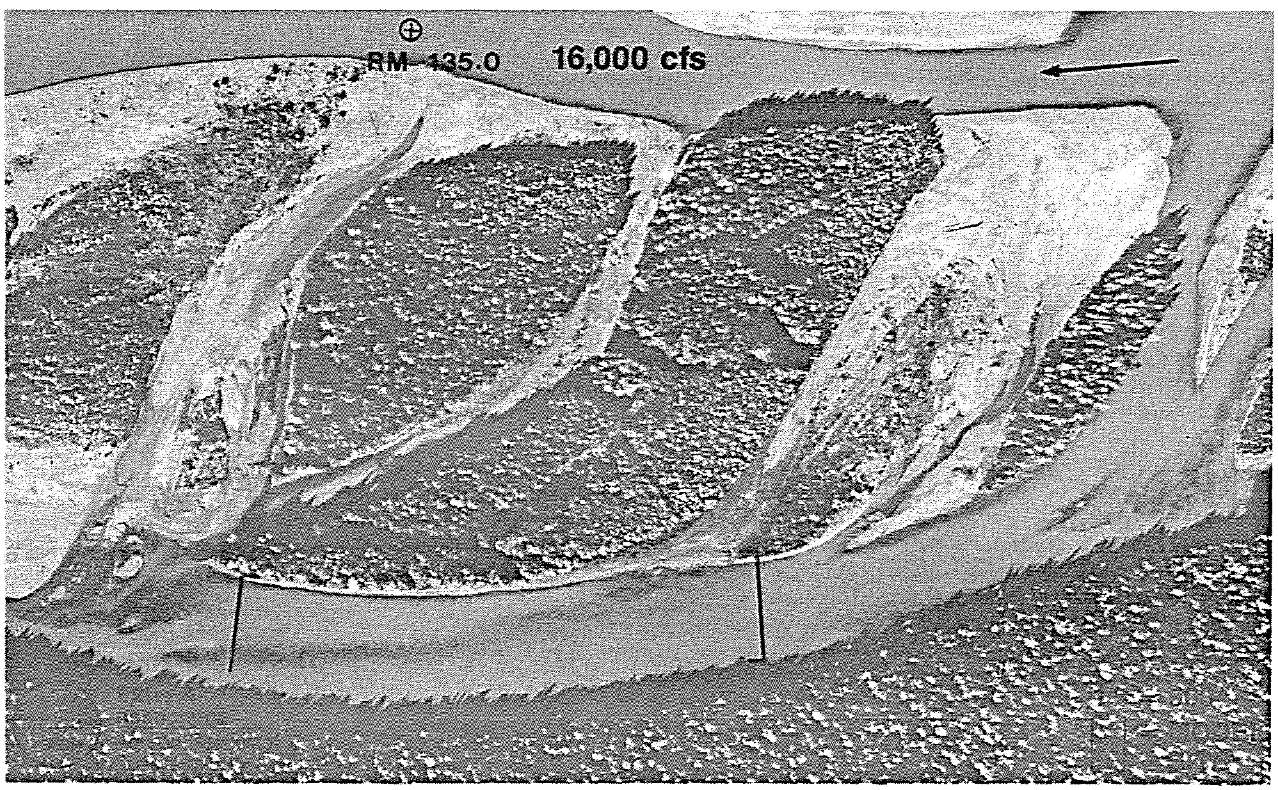
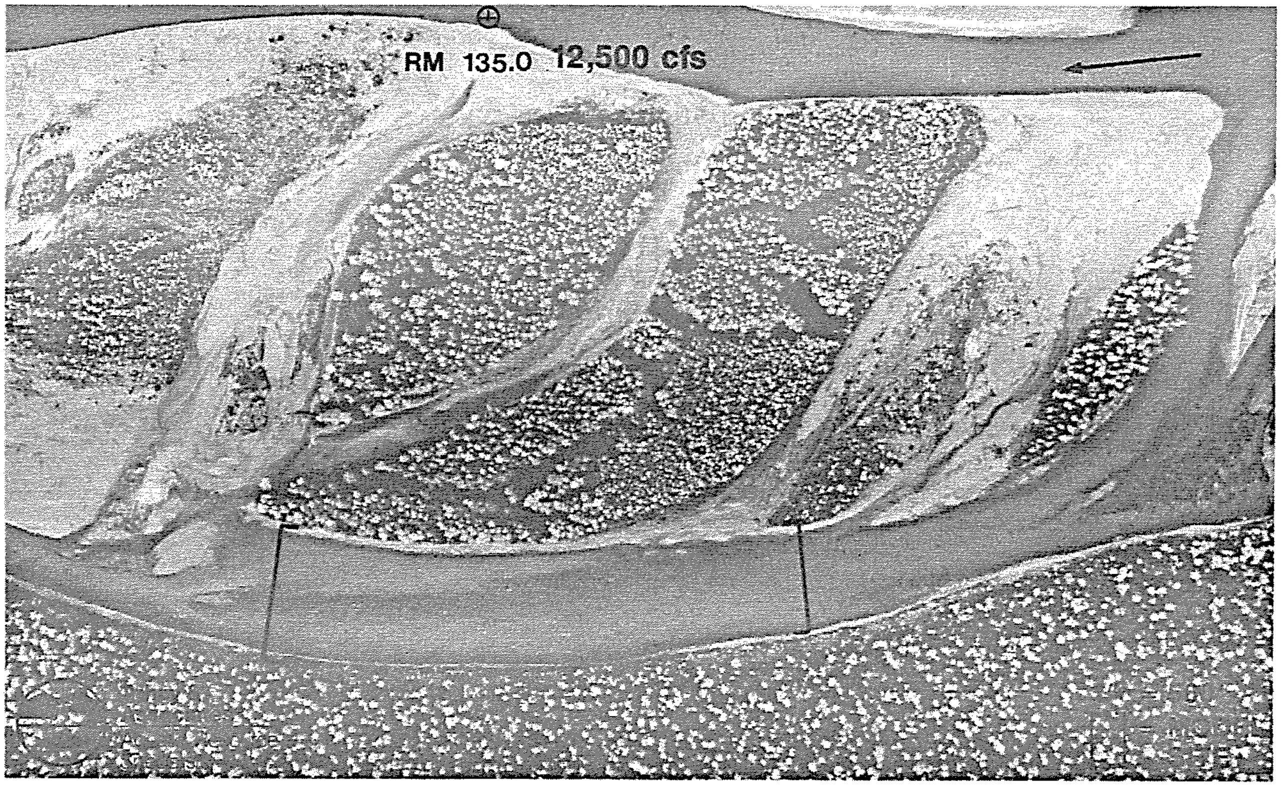


Plate A-19 Aerial photography of modeling site 134.9R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



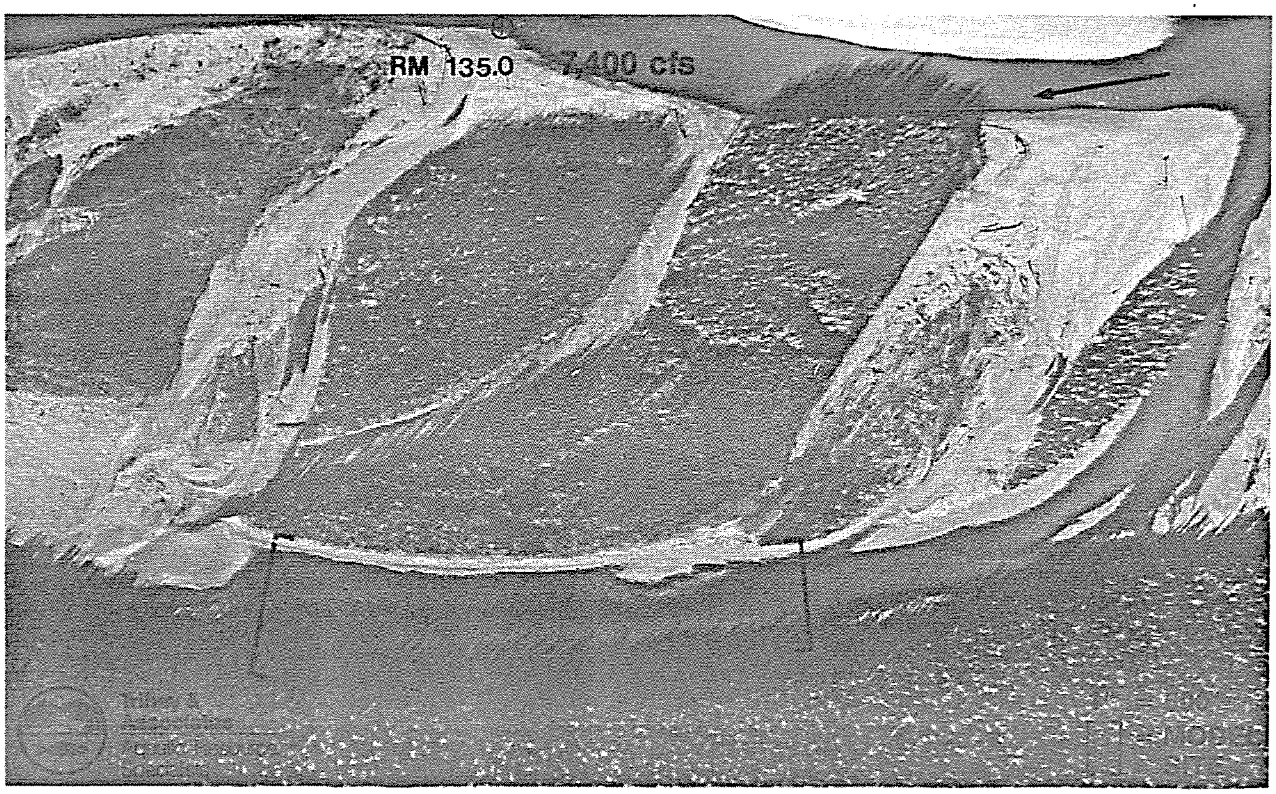
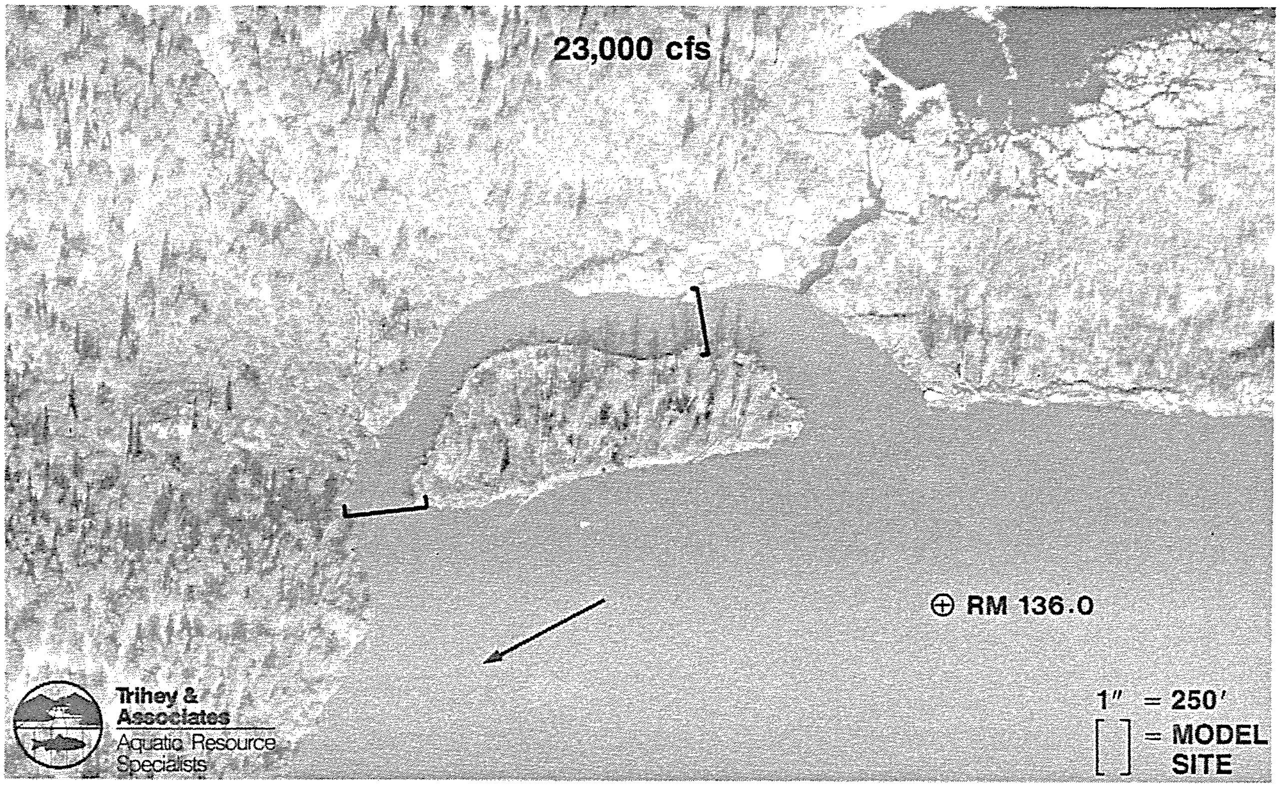


Plate A-20 Aerial photography of modeling site 134.9R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



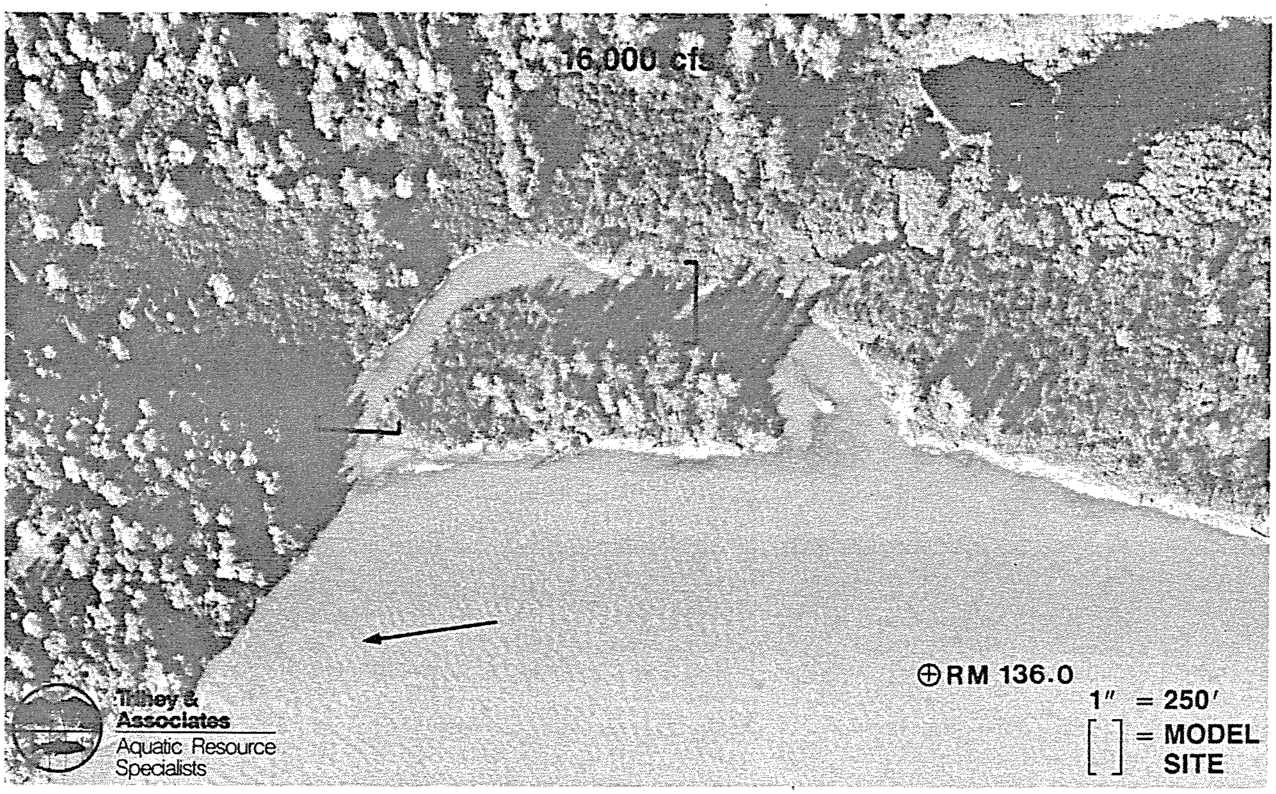
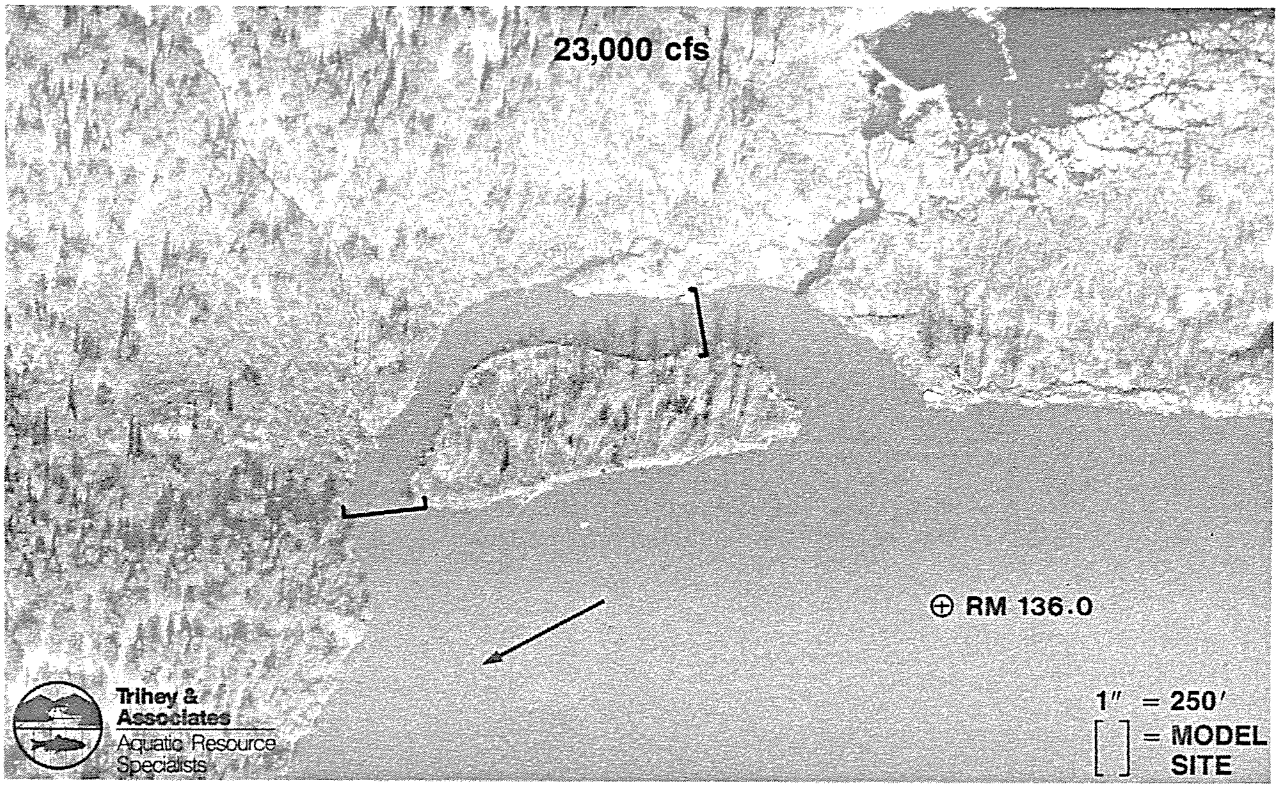


Plate A-21 Aerial photography of modeling site 136.0L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at $<$ 5,100 cfs and is included in Representative Group IV.



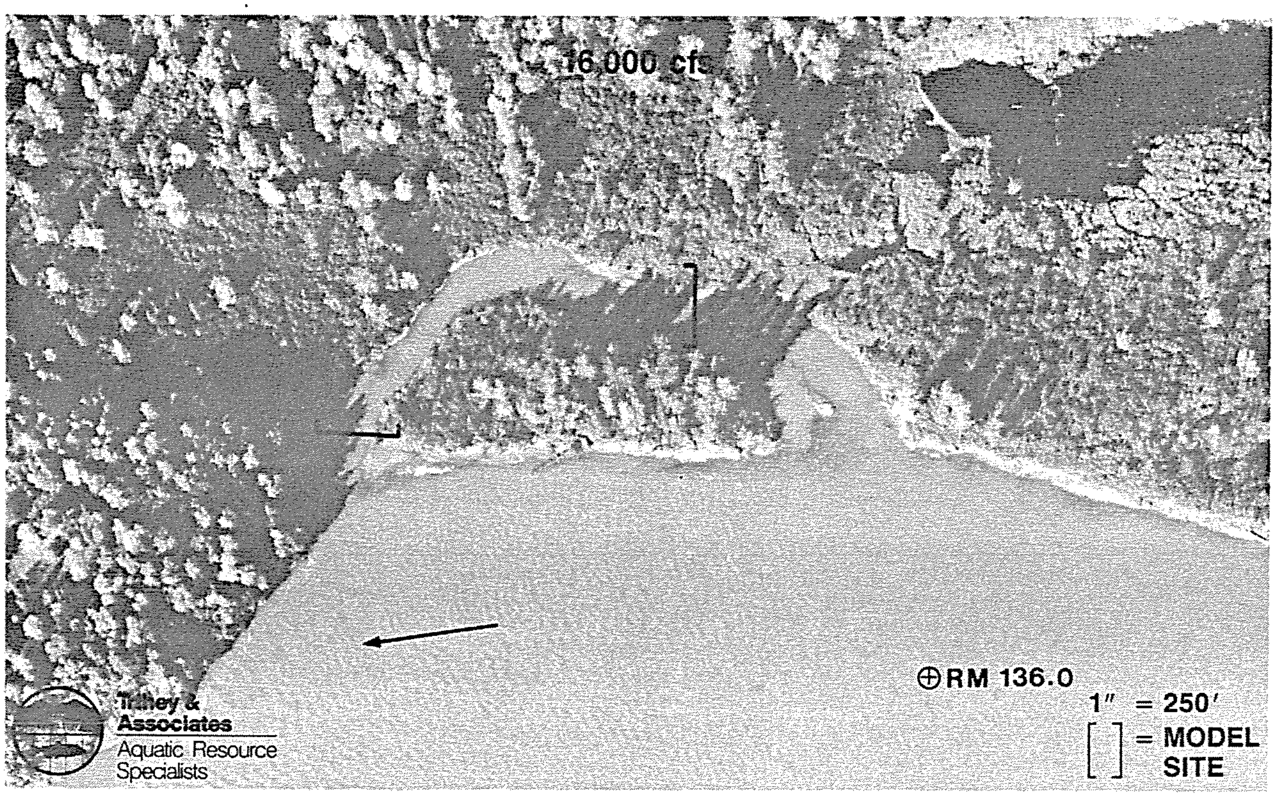
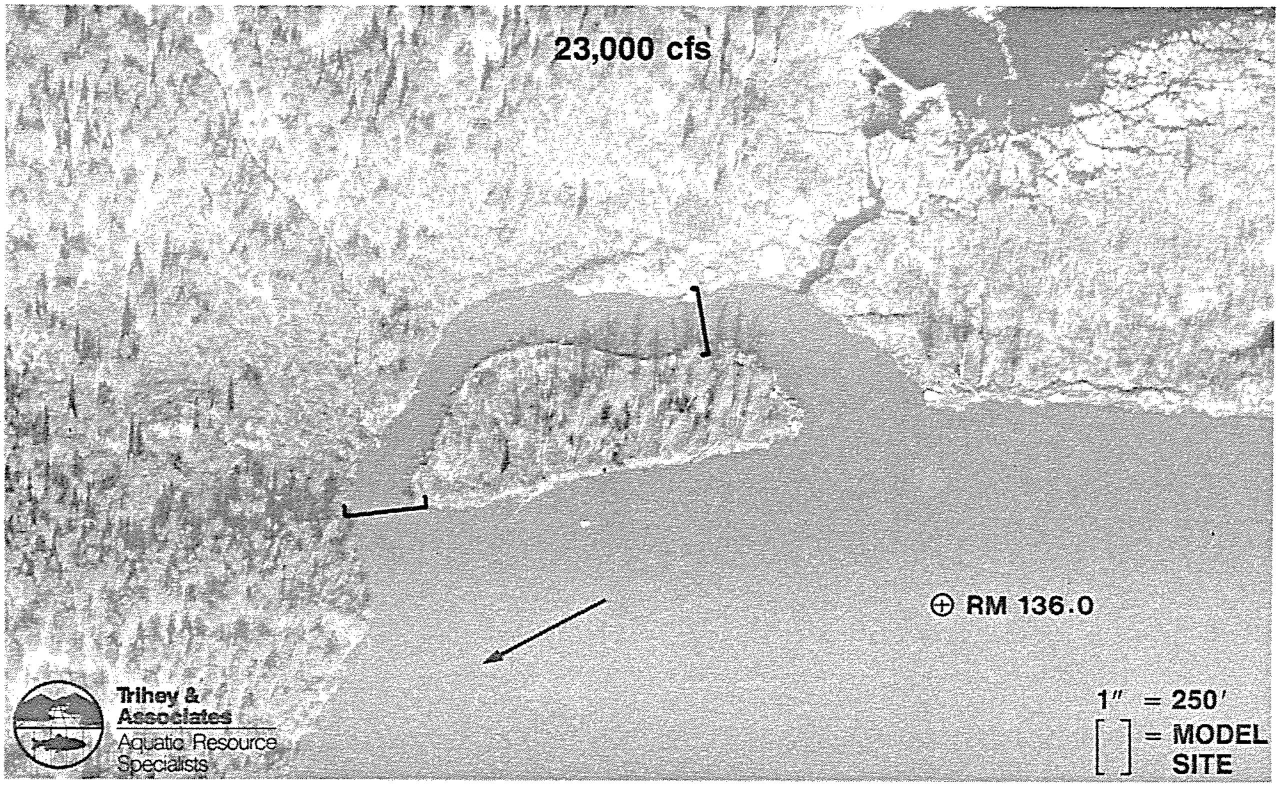


Plate A-21 Aerial photography of modeling site 136.0L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



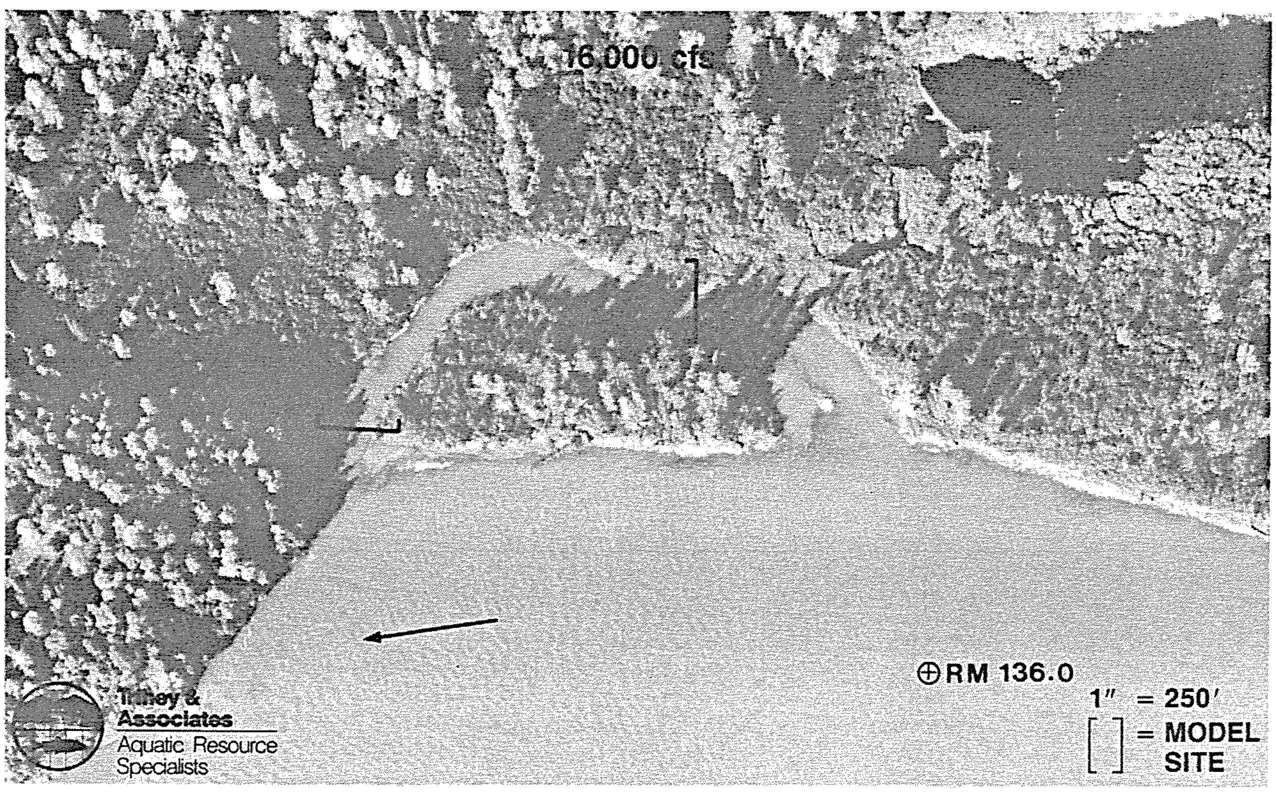
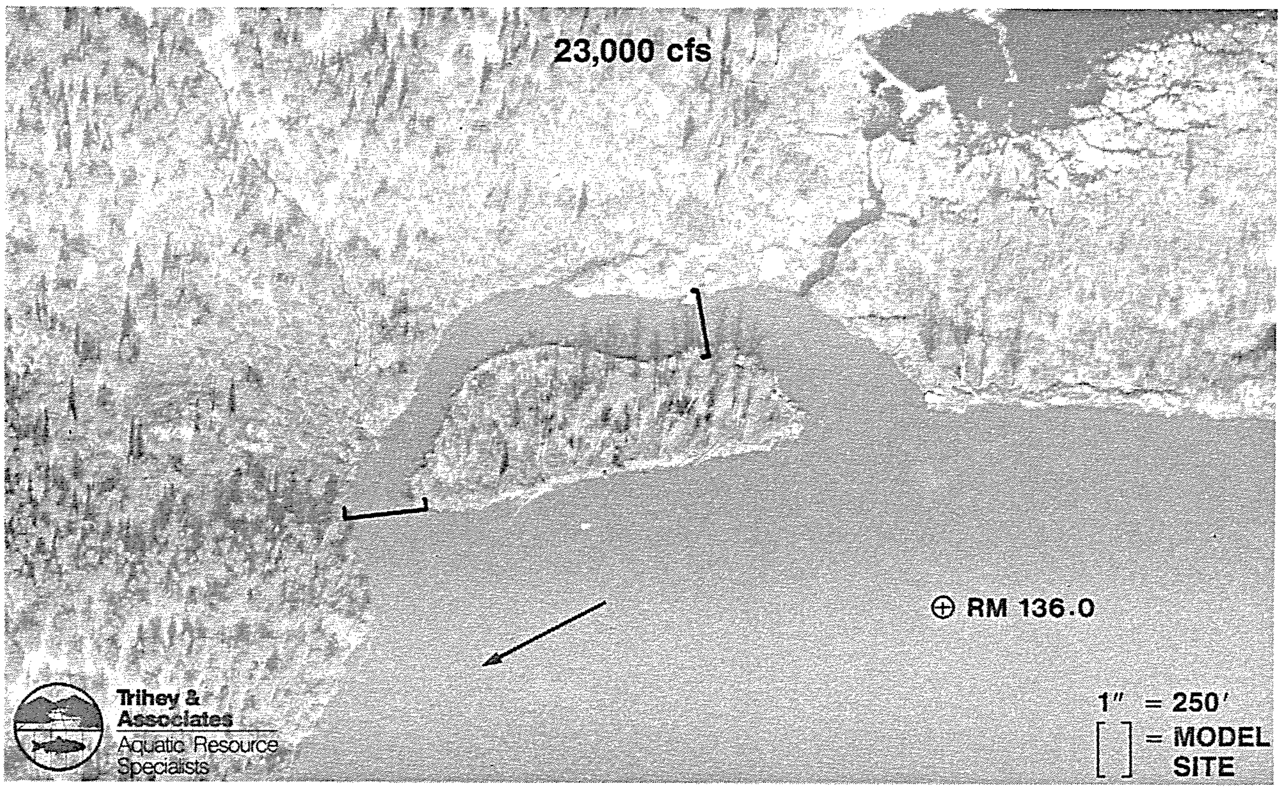


Plate A-21 Aerial photography of modeling site 136.0L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



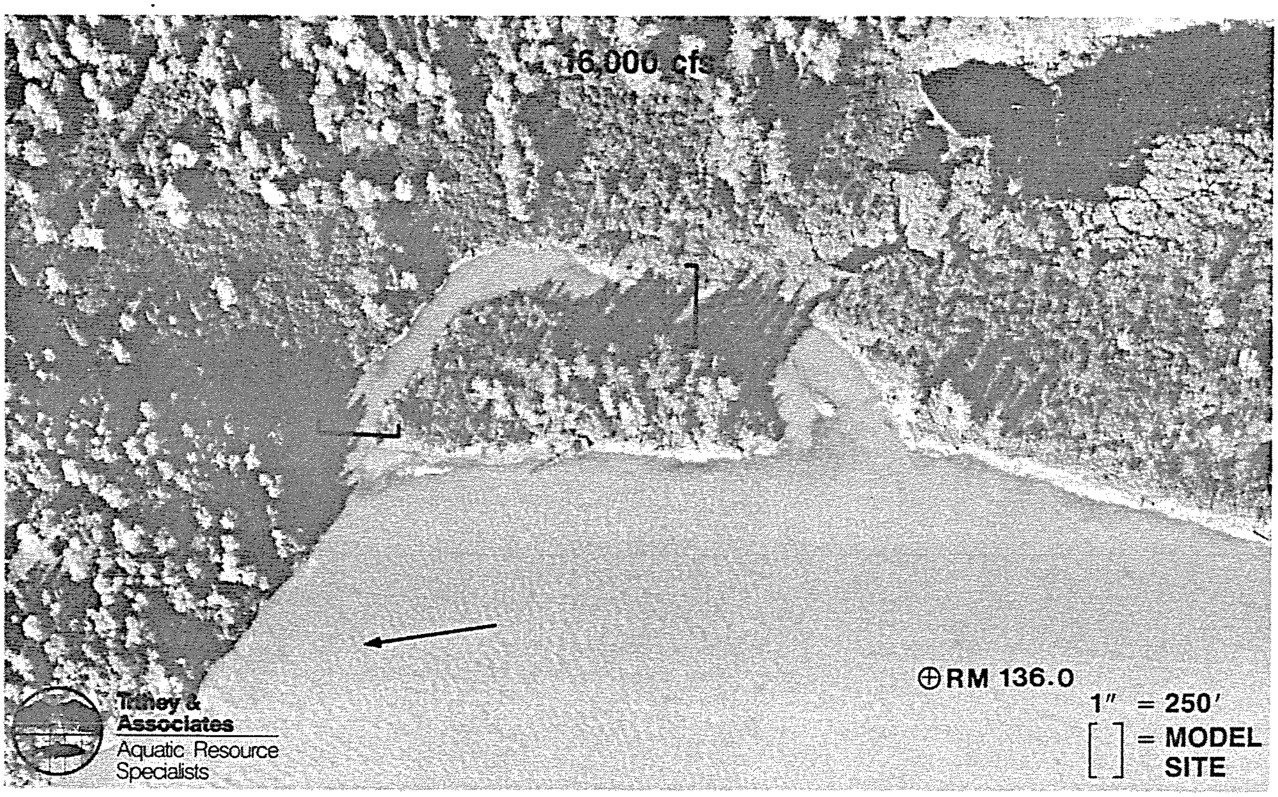
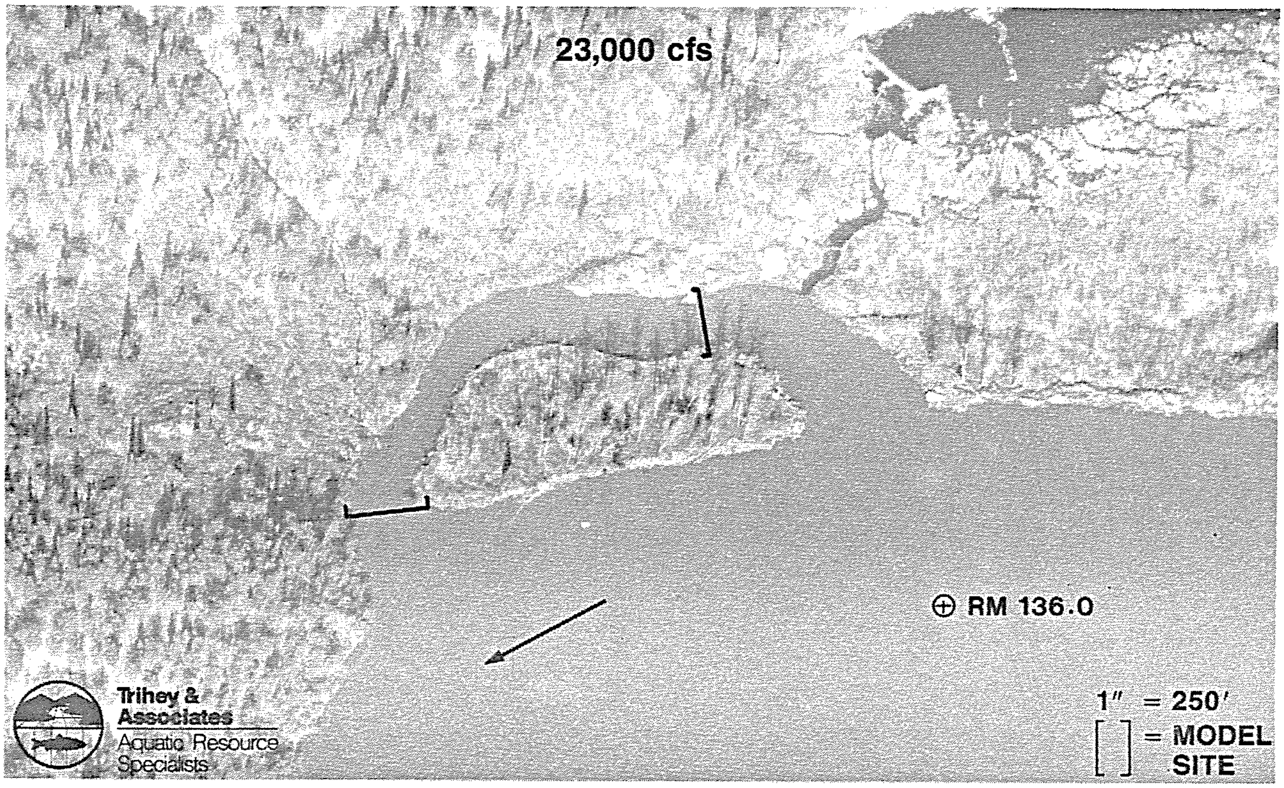


Plate A-21 Aerial photography of modeling site 136.0L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



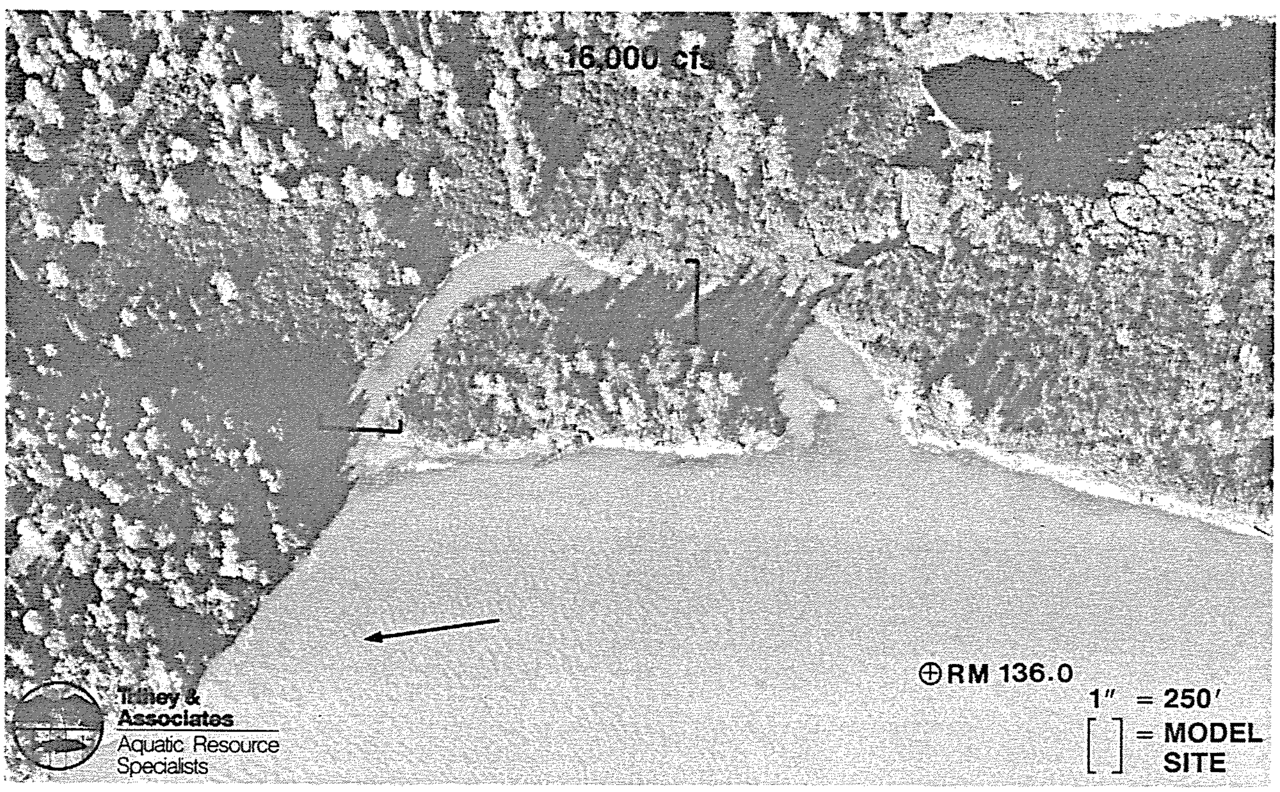
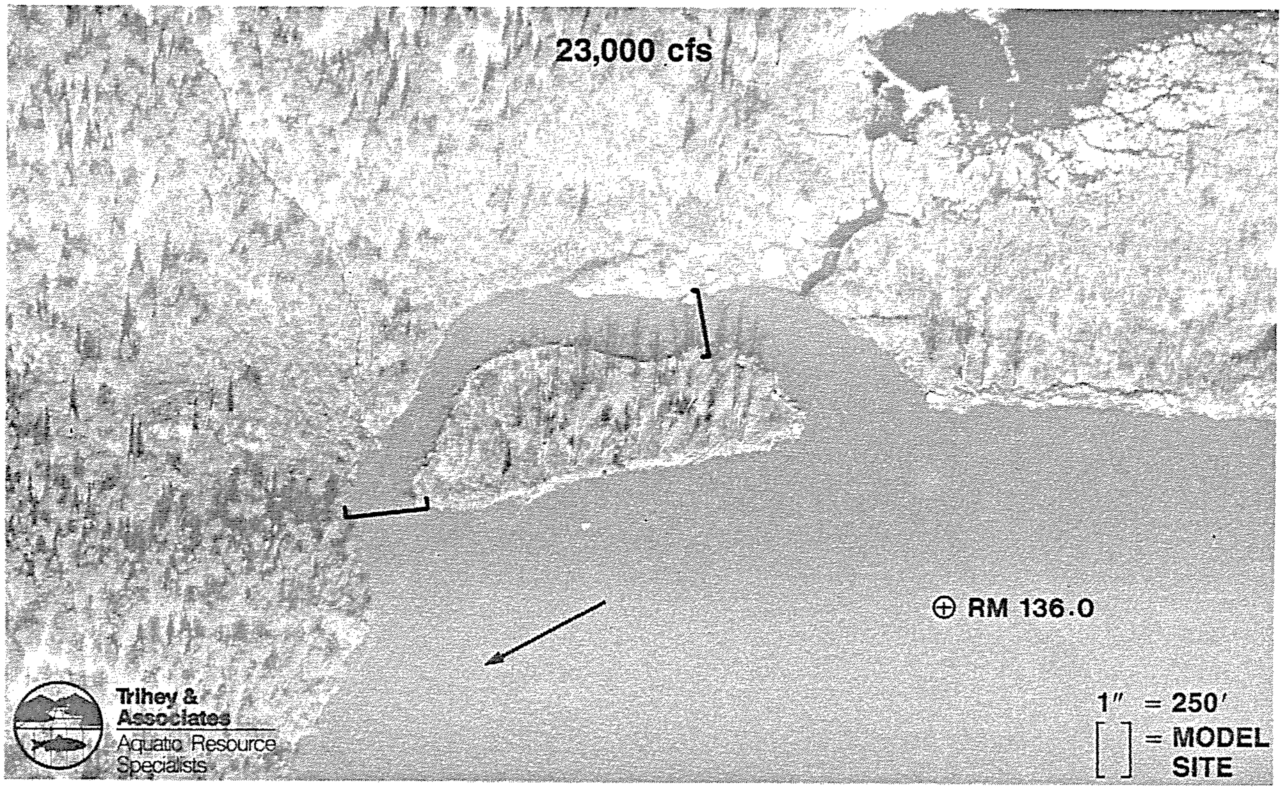


Plate A-21 Aerial photography of modeling site 136.0L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



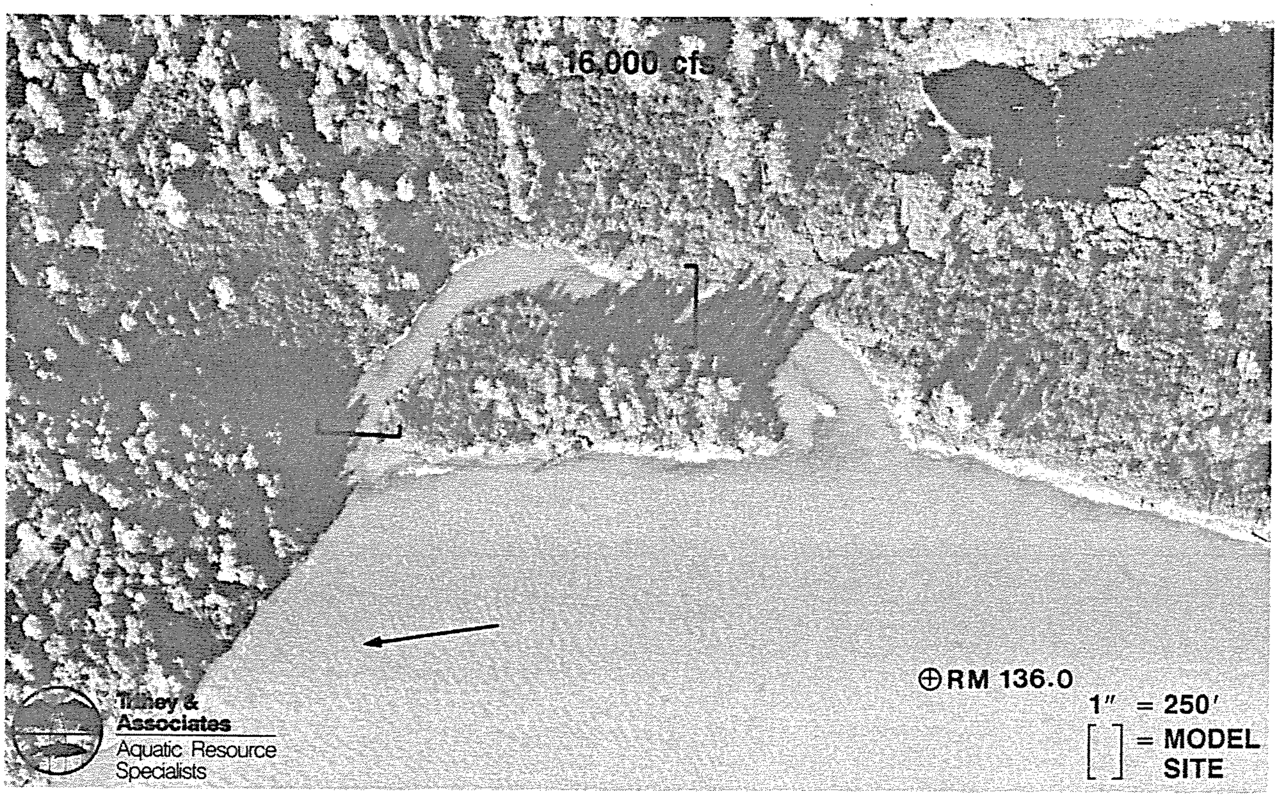
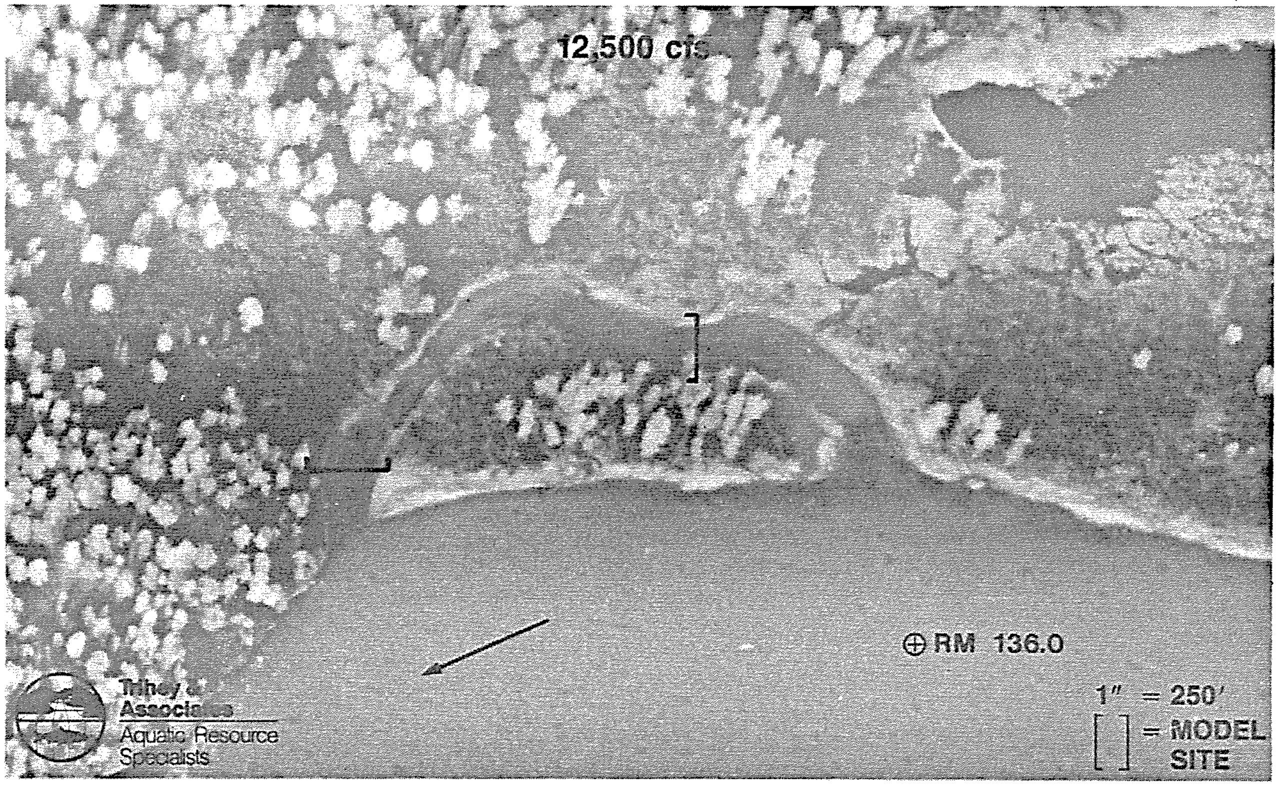


Plate A-21 Aerial photography of modeling site 136.0L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IV.



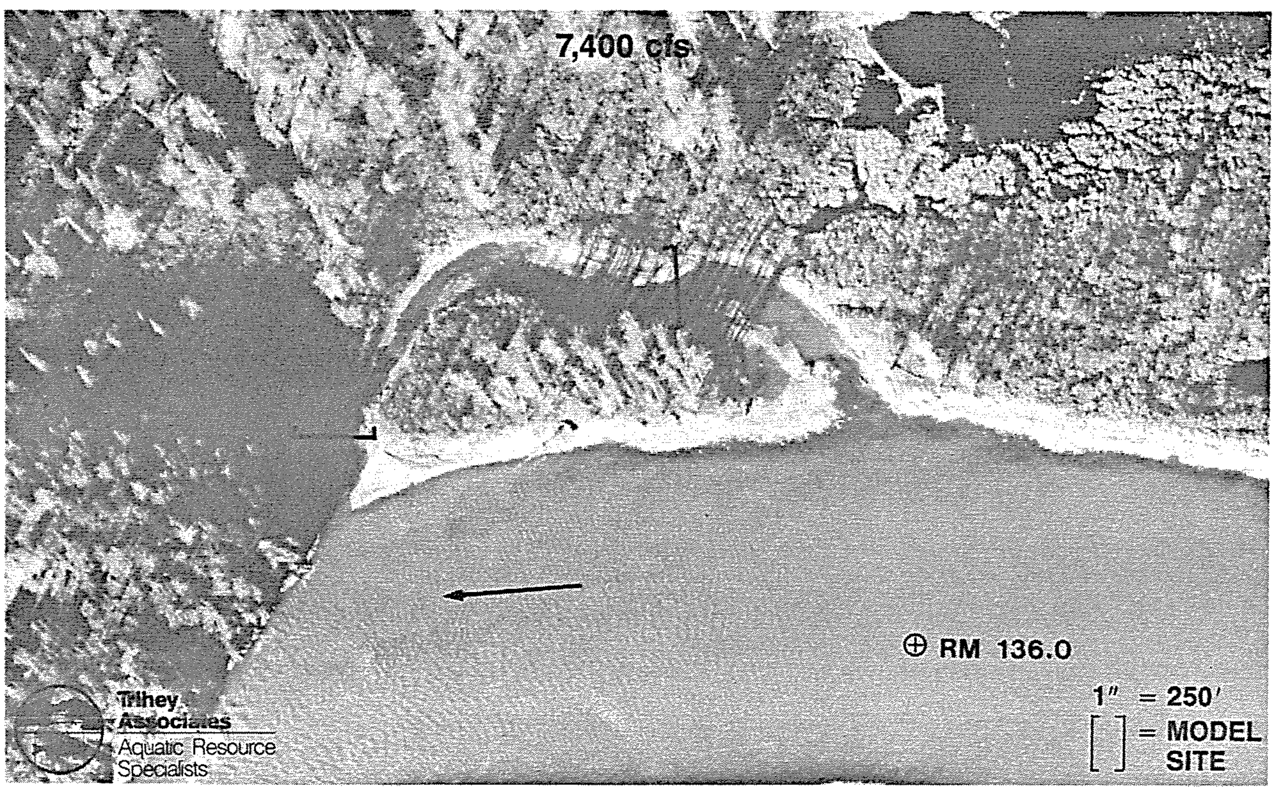
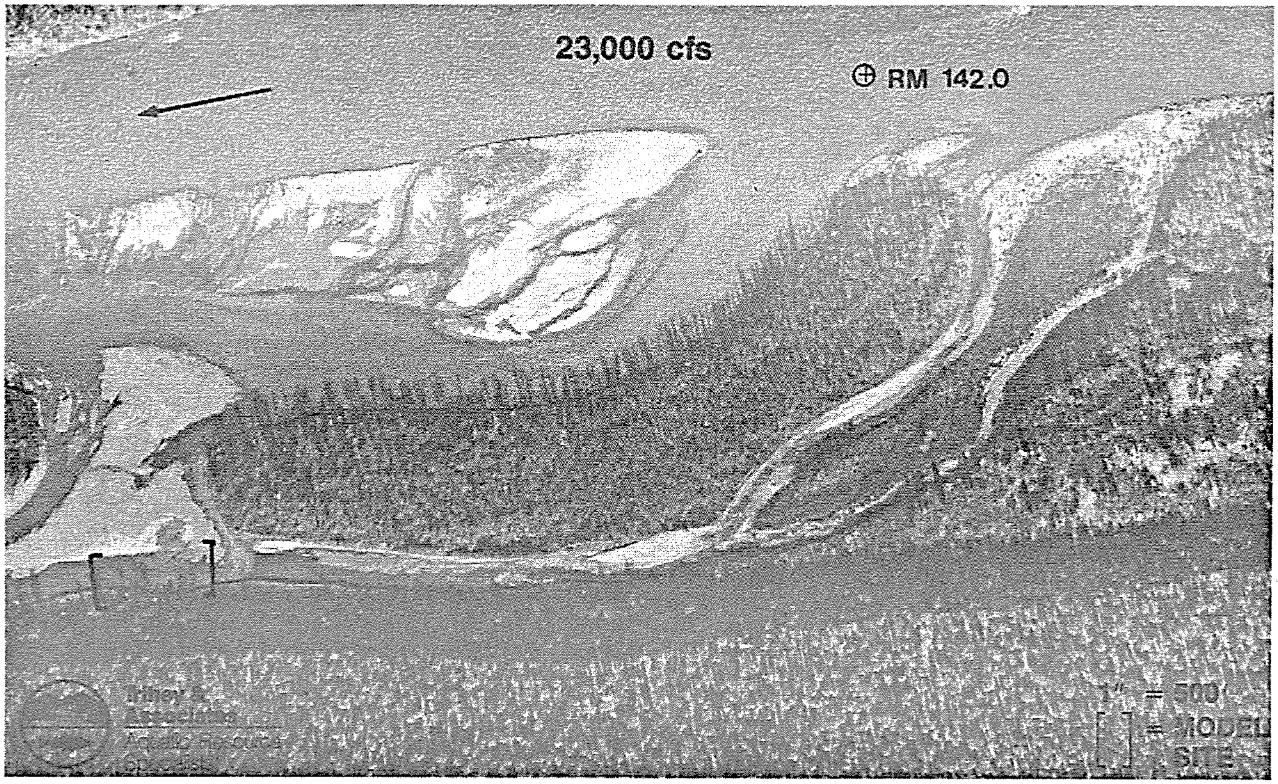


Plate A-22 Aerial photography of modeling site 136.0L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at < 5,100 and is included in Representative Group IV.



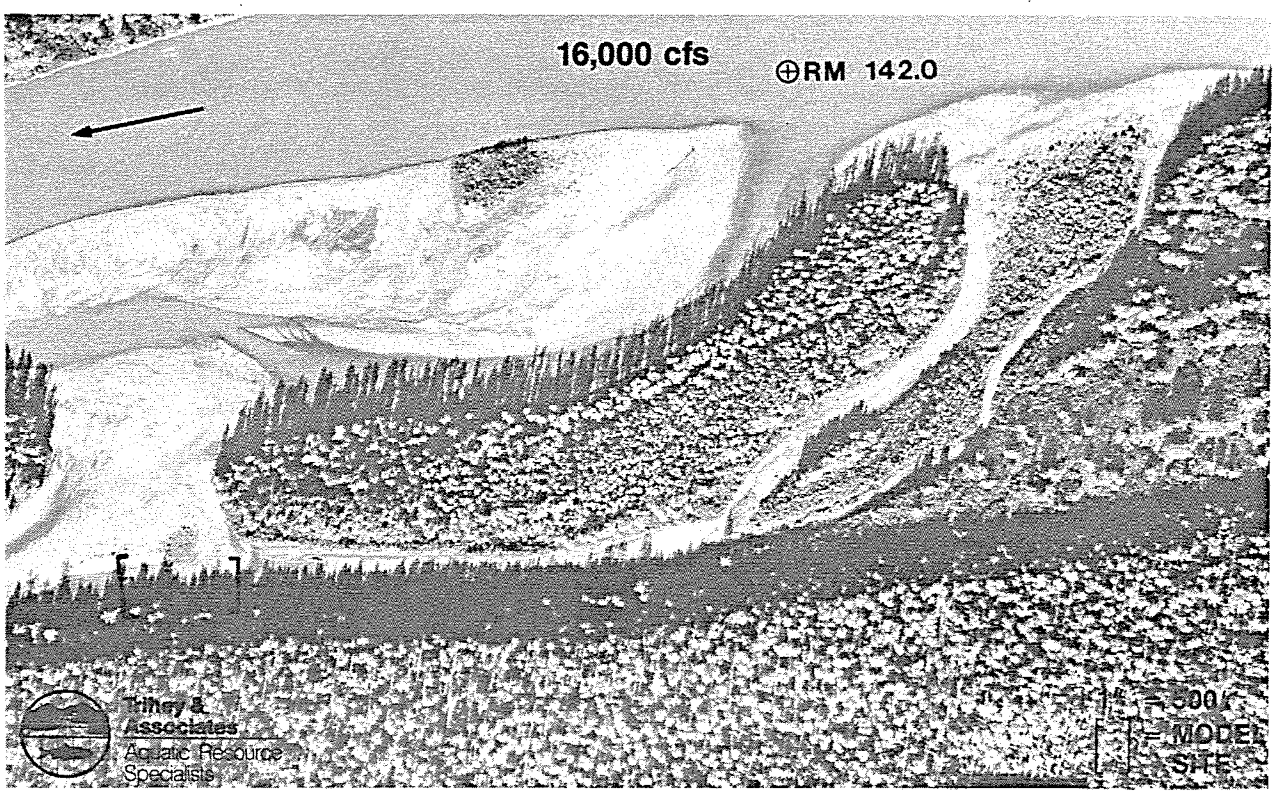
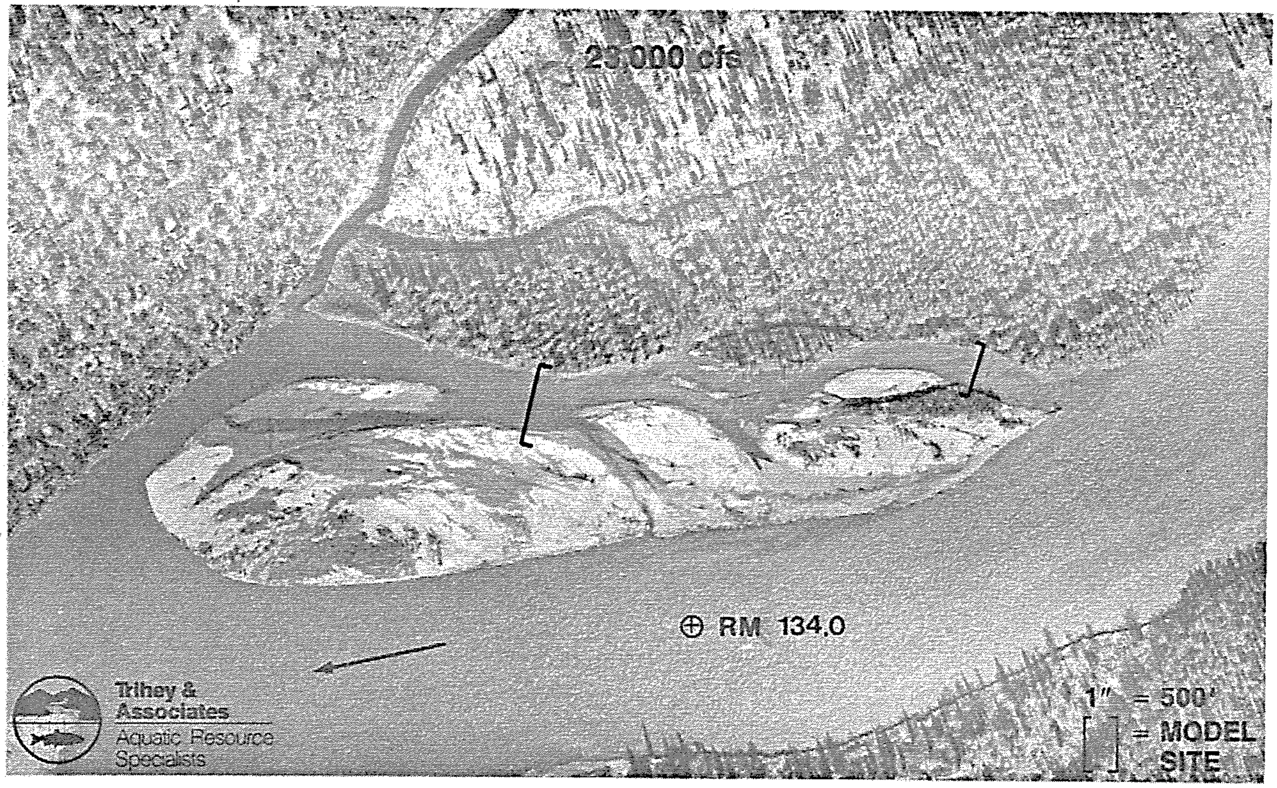


Plate A-23 Aerial photography of modeling site 141.6R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 21,000 cfs and is included in Representatibe Group V.



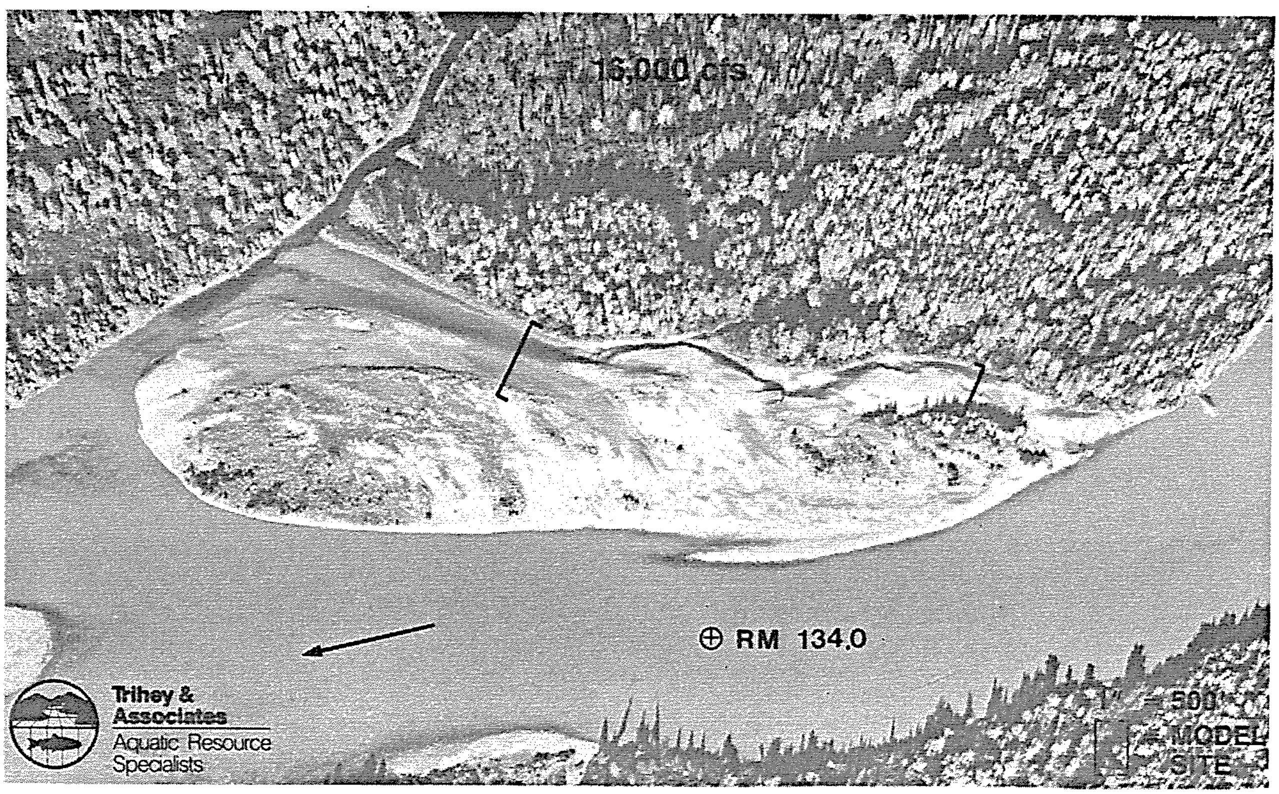
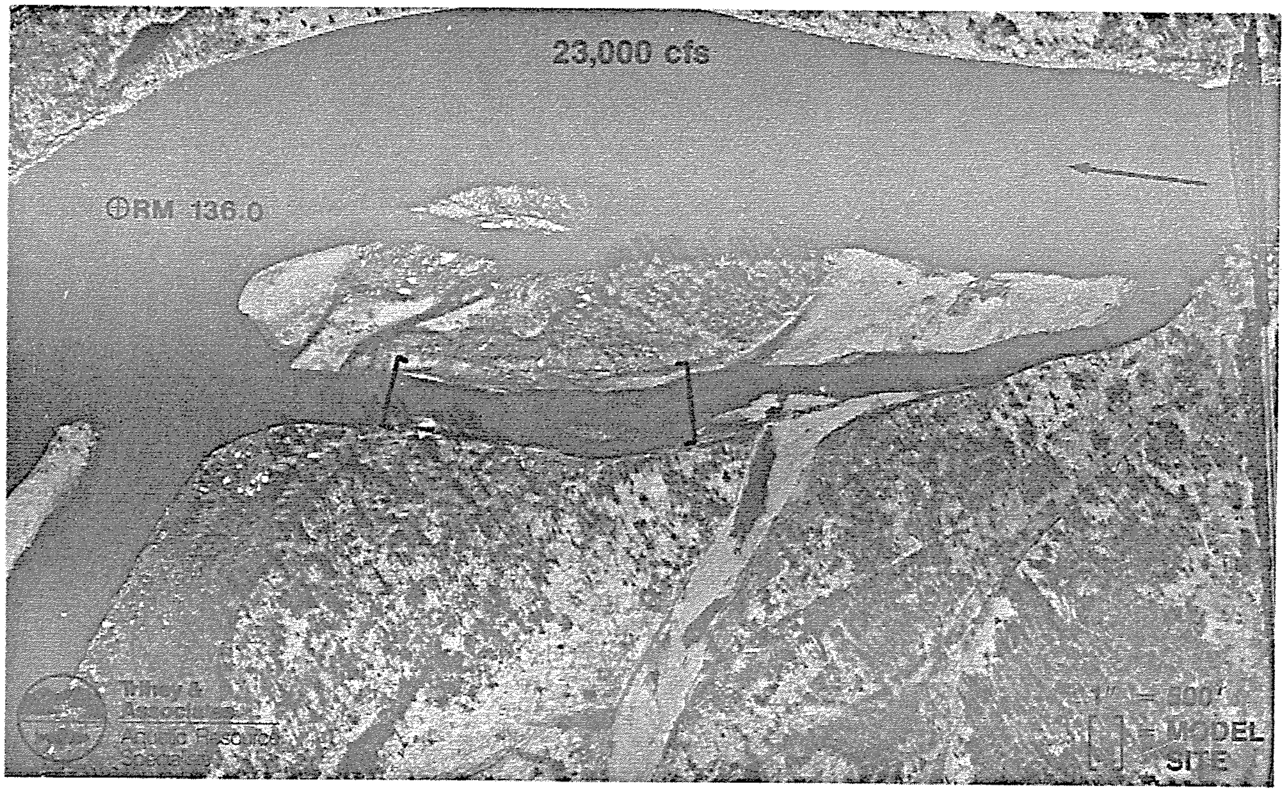


Plate A-24 Aerial photography of modeling site 133.8L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 17,500 cfs and is included in Representative Group VI.



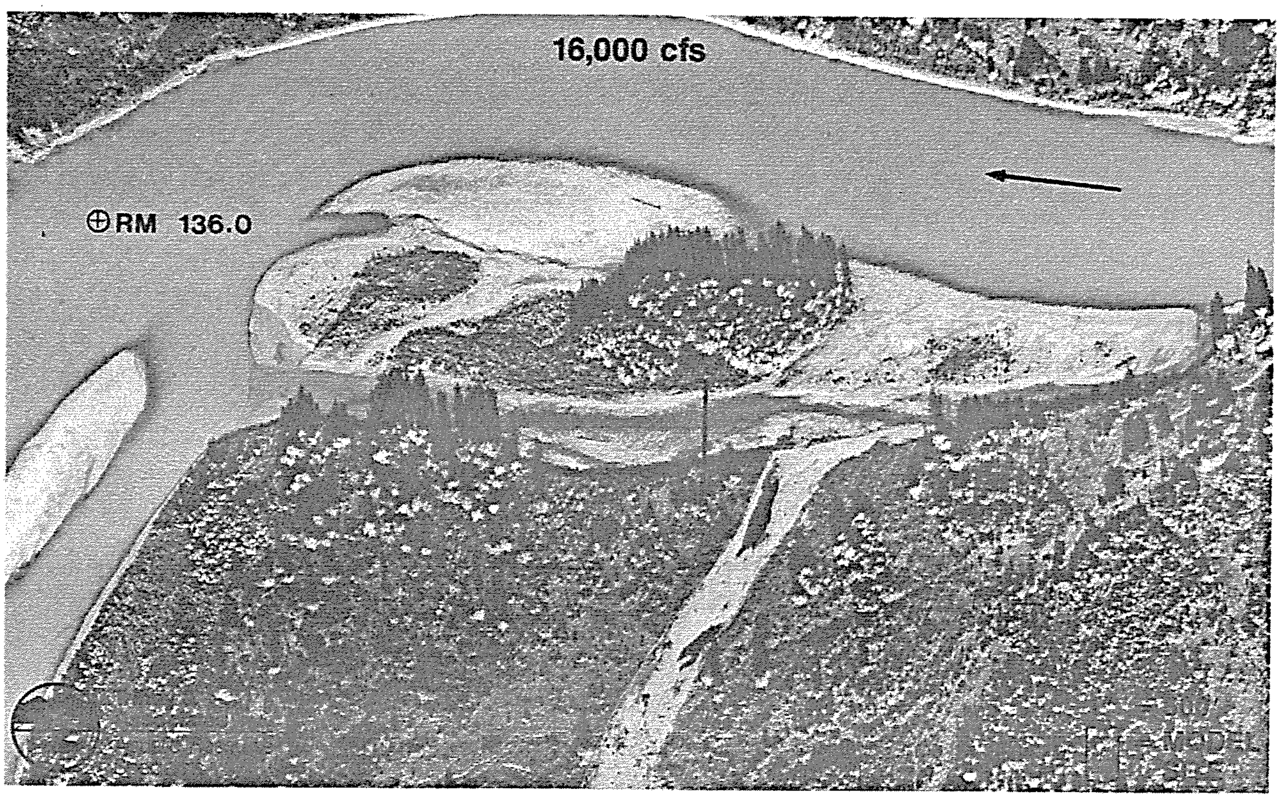
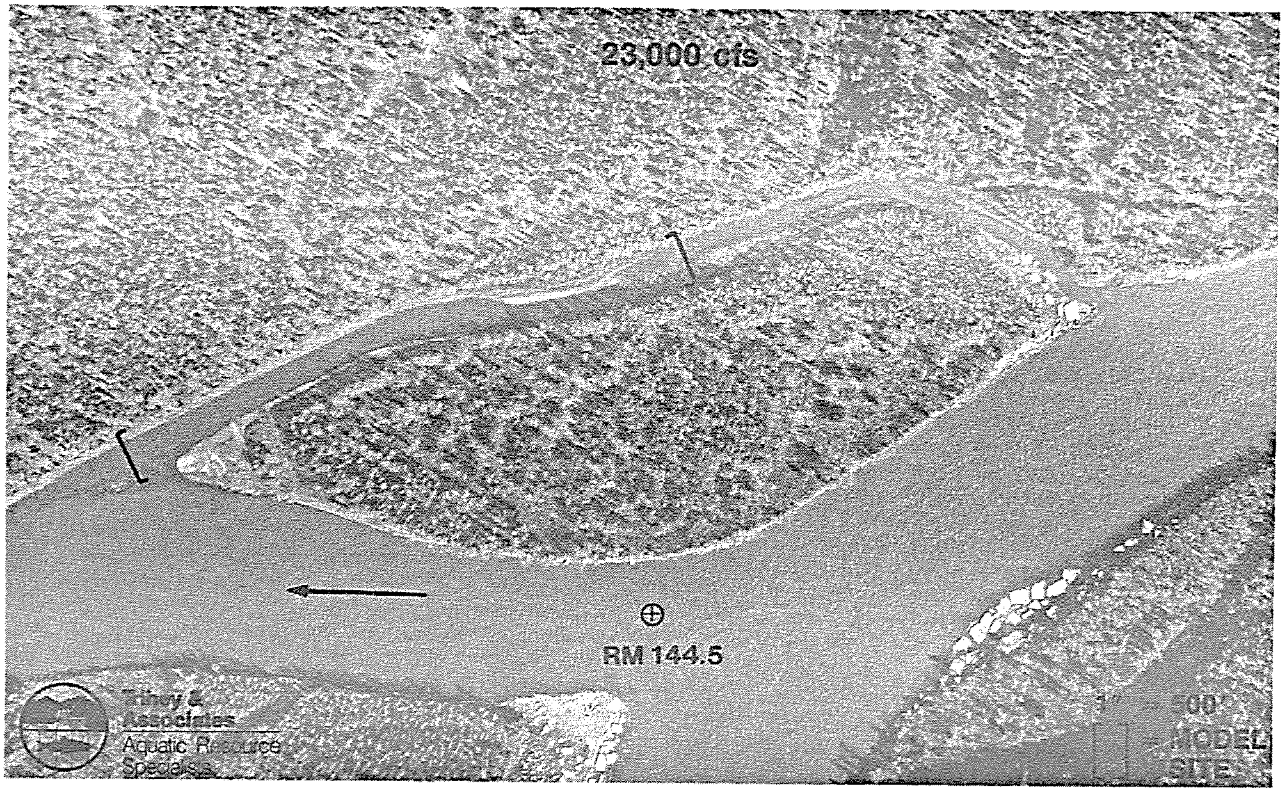


Plate A-25 Aerial photography of modeling site 136.3R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 13,000 cfs and is included in Representative Group VI.



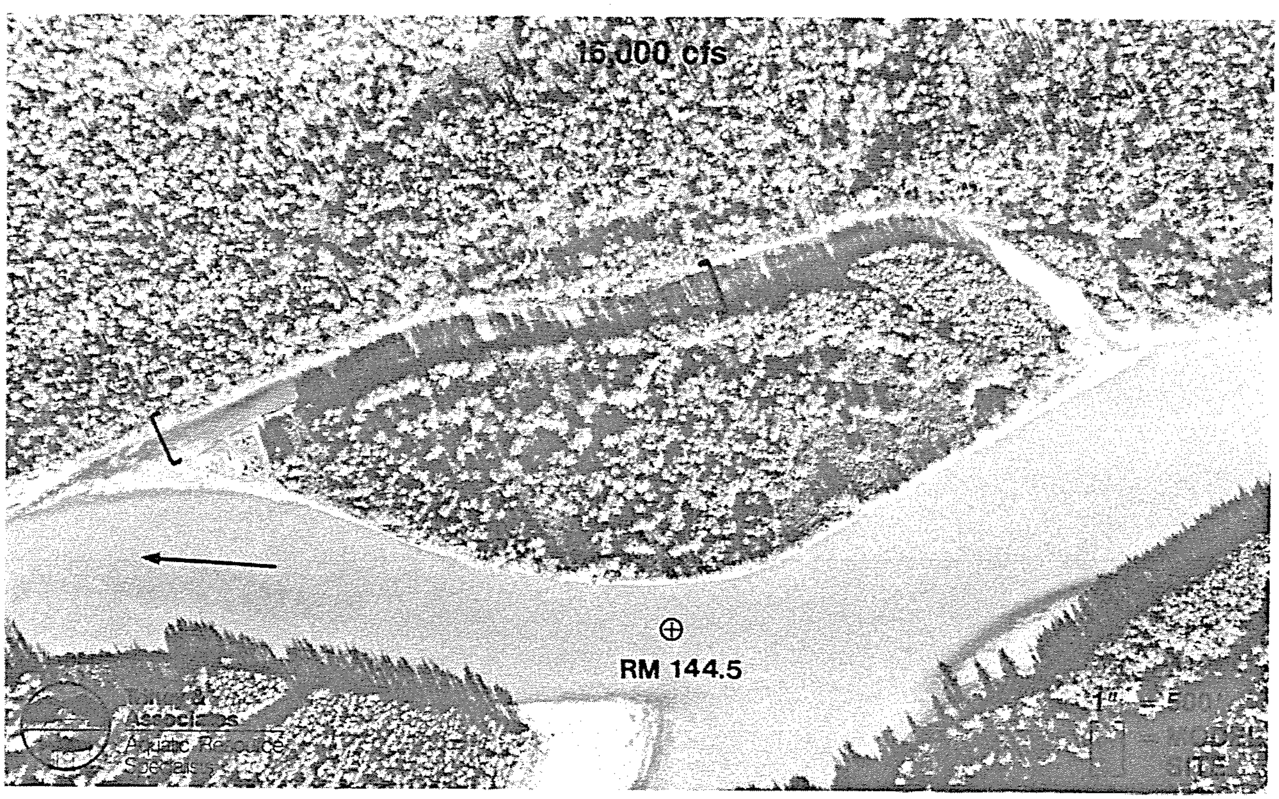
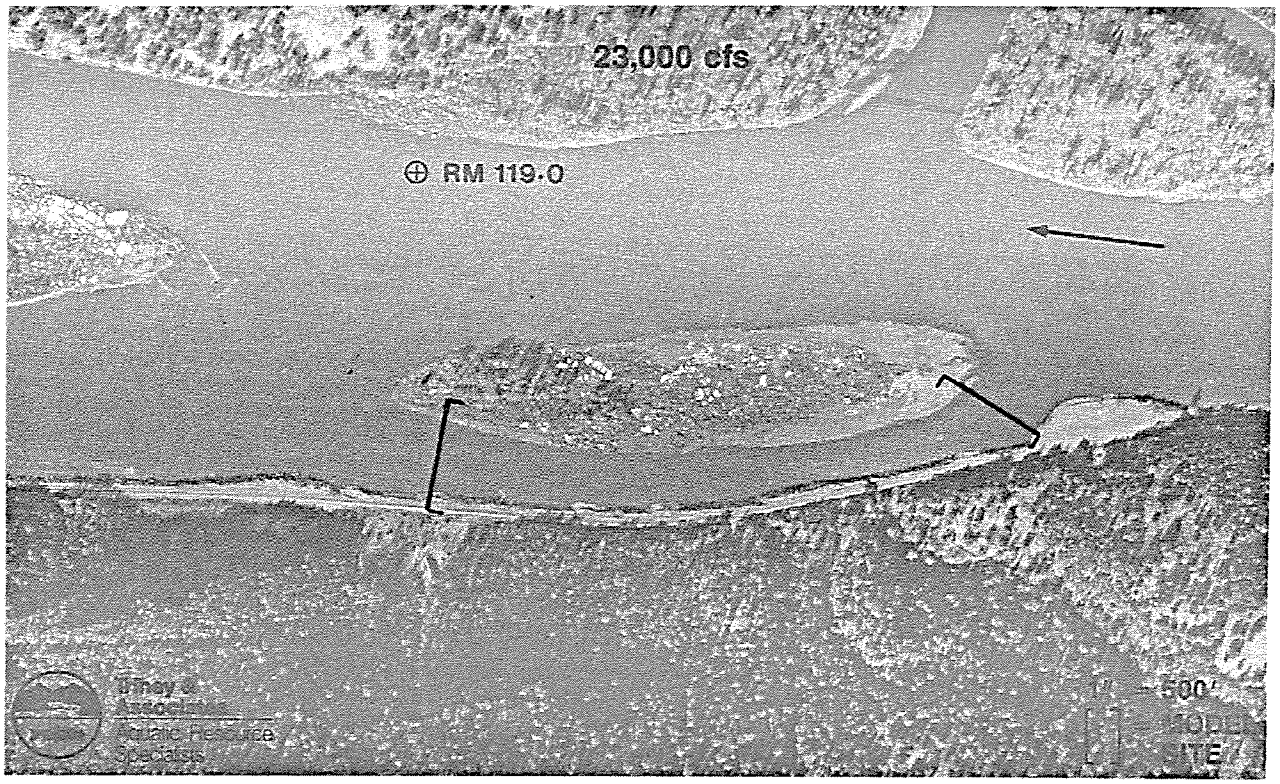


Plate A-6 Aerial photography of modeling site 144.4L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 21,000 cfs and is included in Representative Group II.



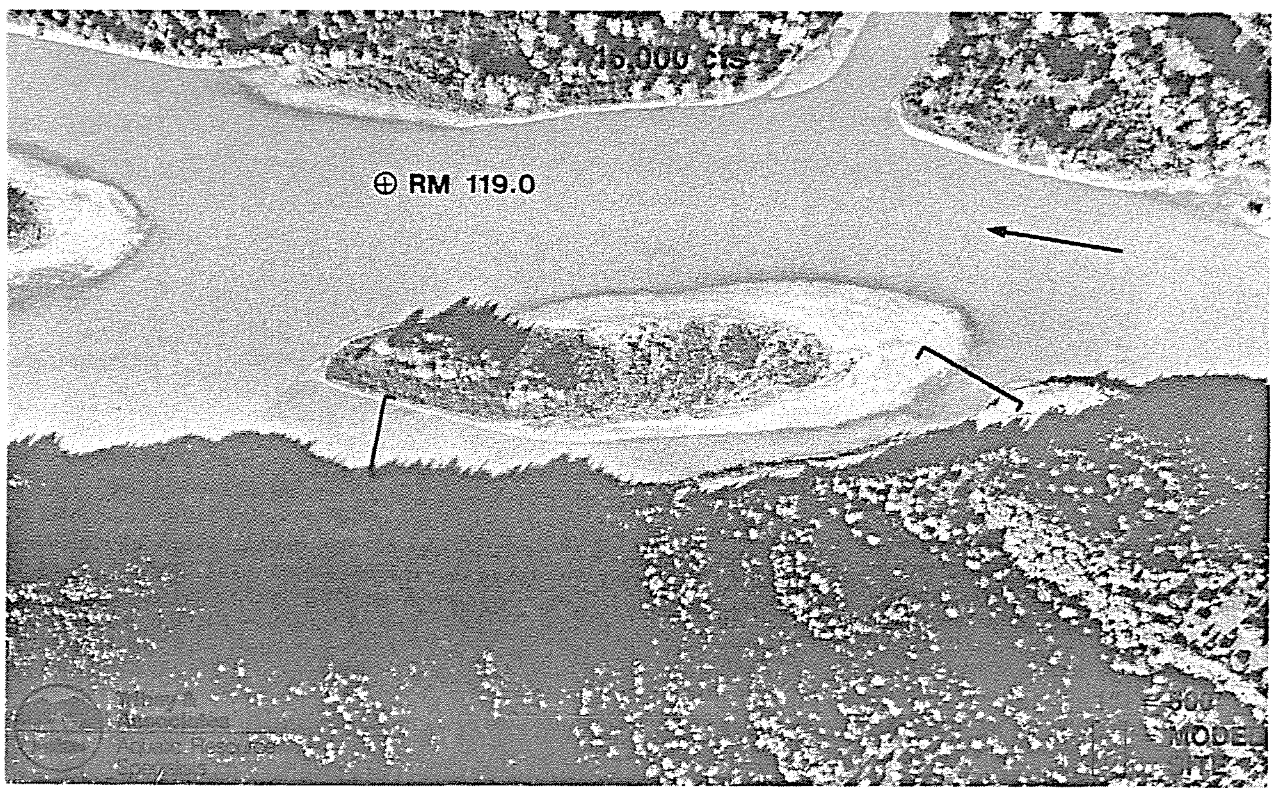
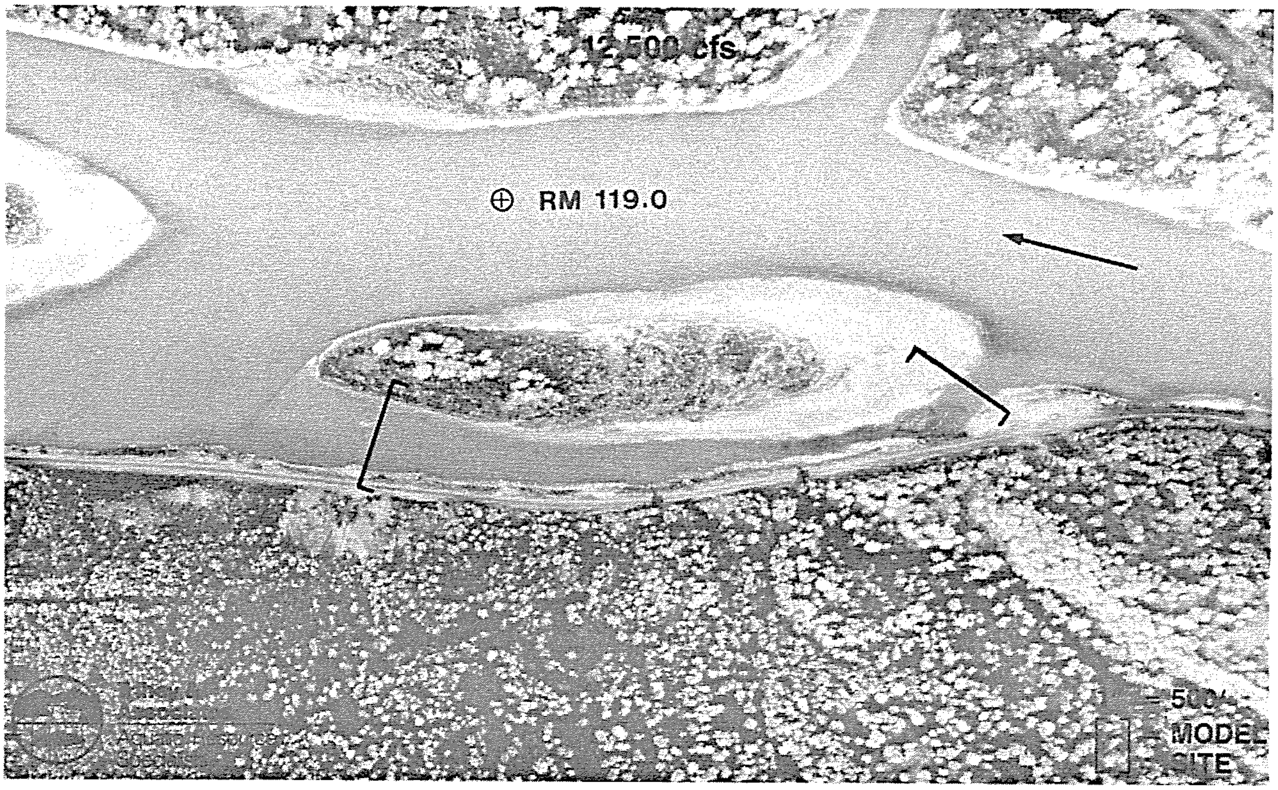


Plate A-27 Aerial photography of modeling site 119.2R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at 10,000 cfs and is included in Representative Group VII.



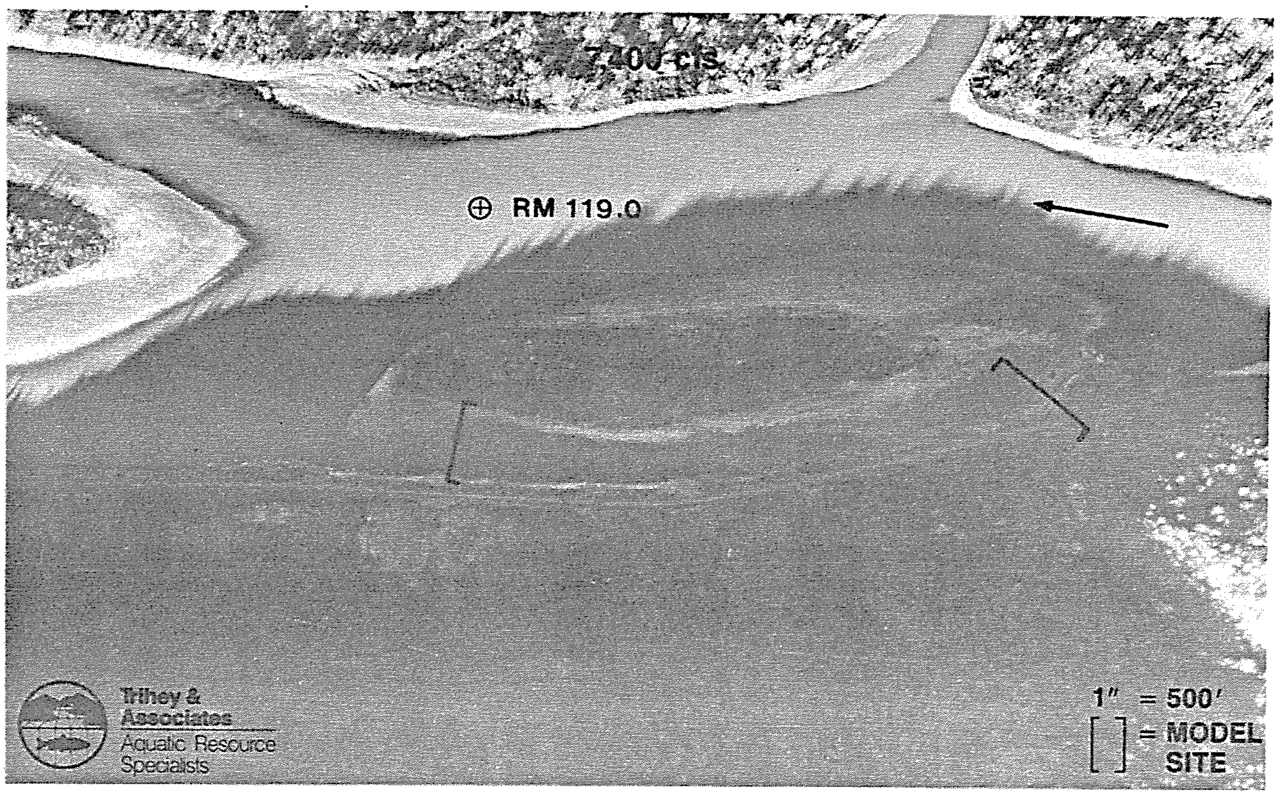
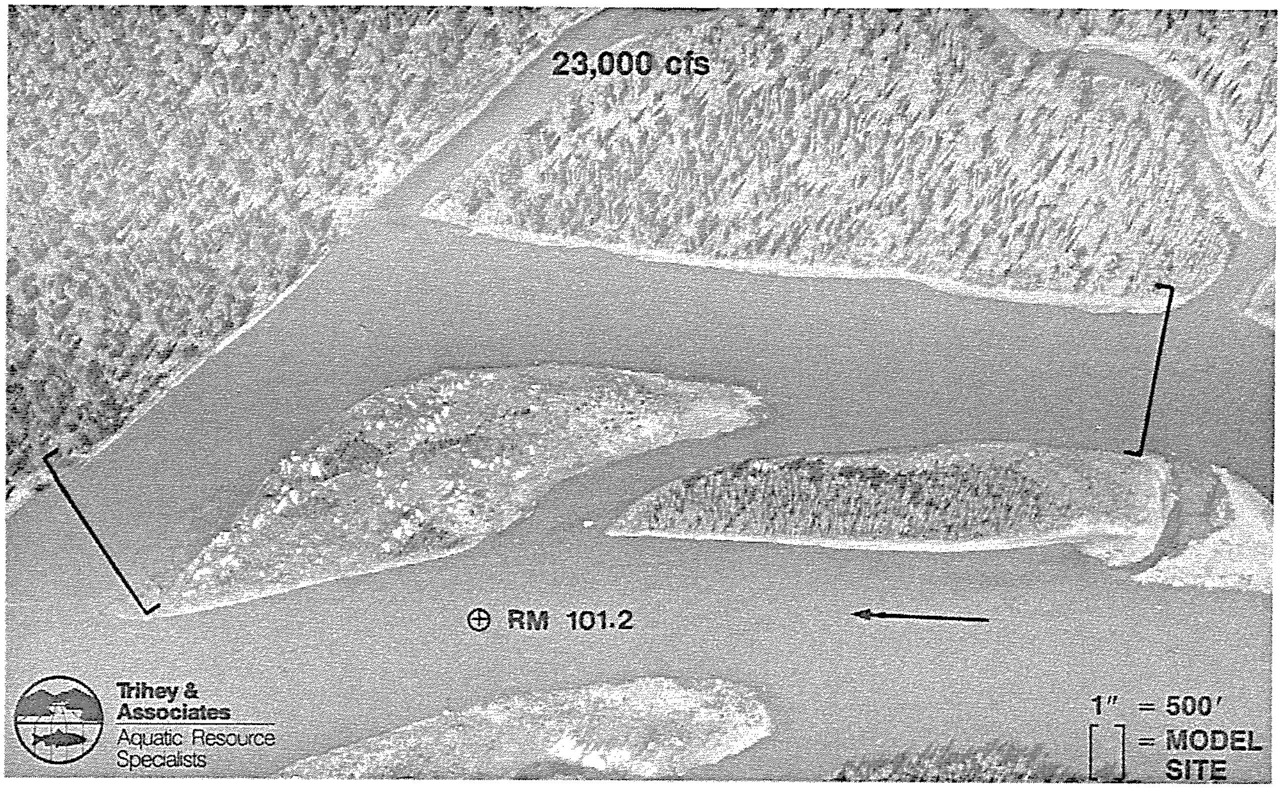


Plate A-28 Aerial photography of modeling site 119.2R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at 10,000 cfs and is included in Representative Group VII.



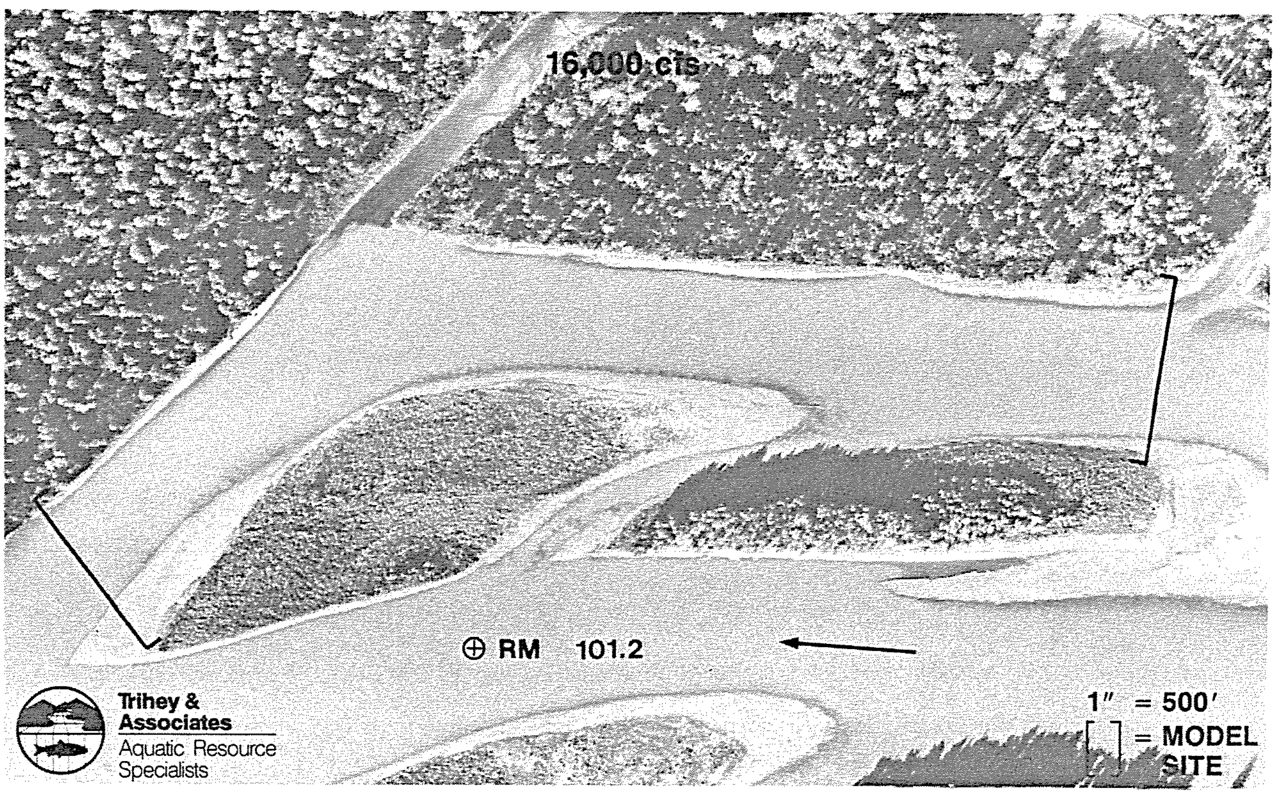
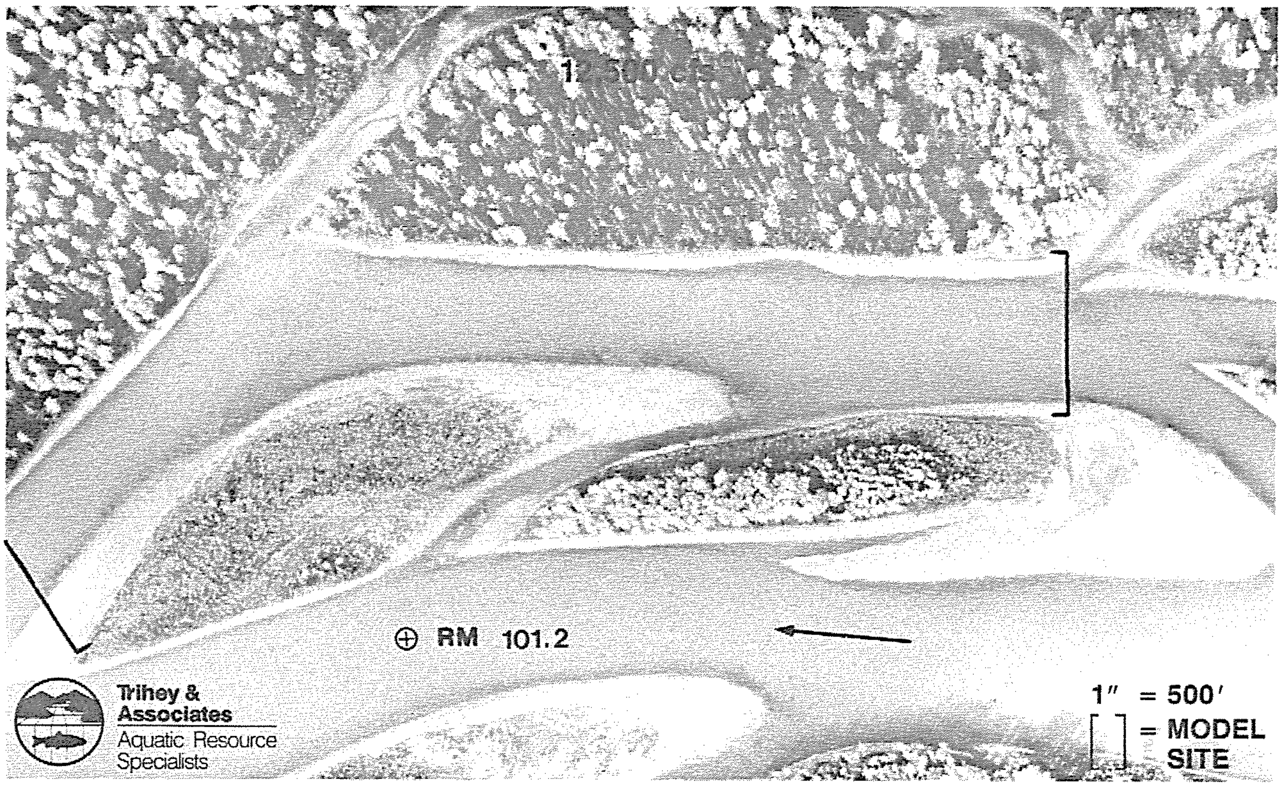


Plate A-29 Aerial photography of modeling site 101.5L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IX.



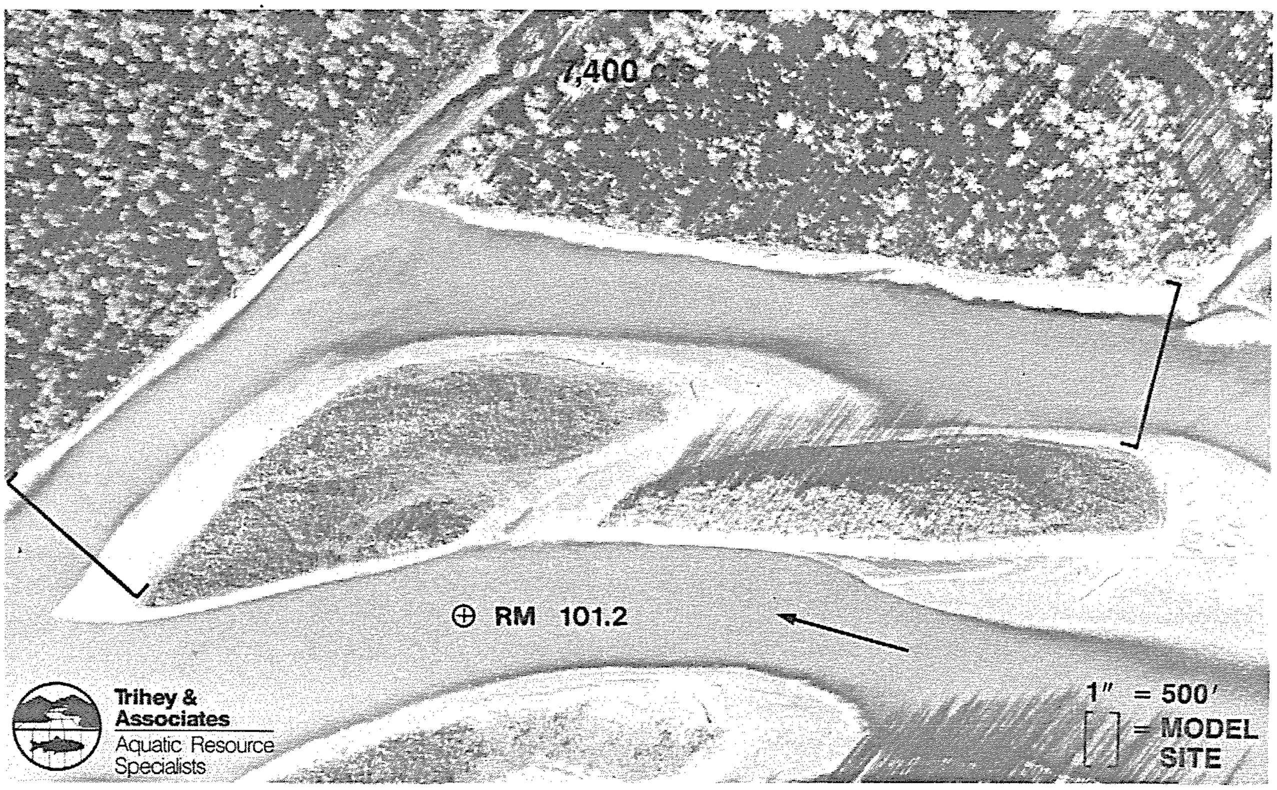
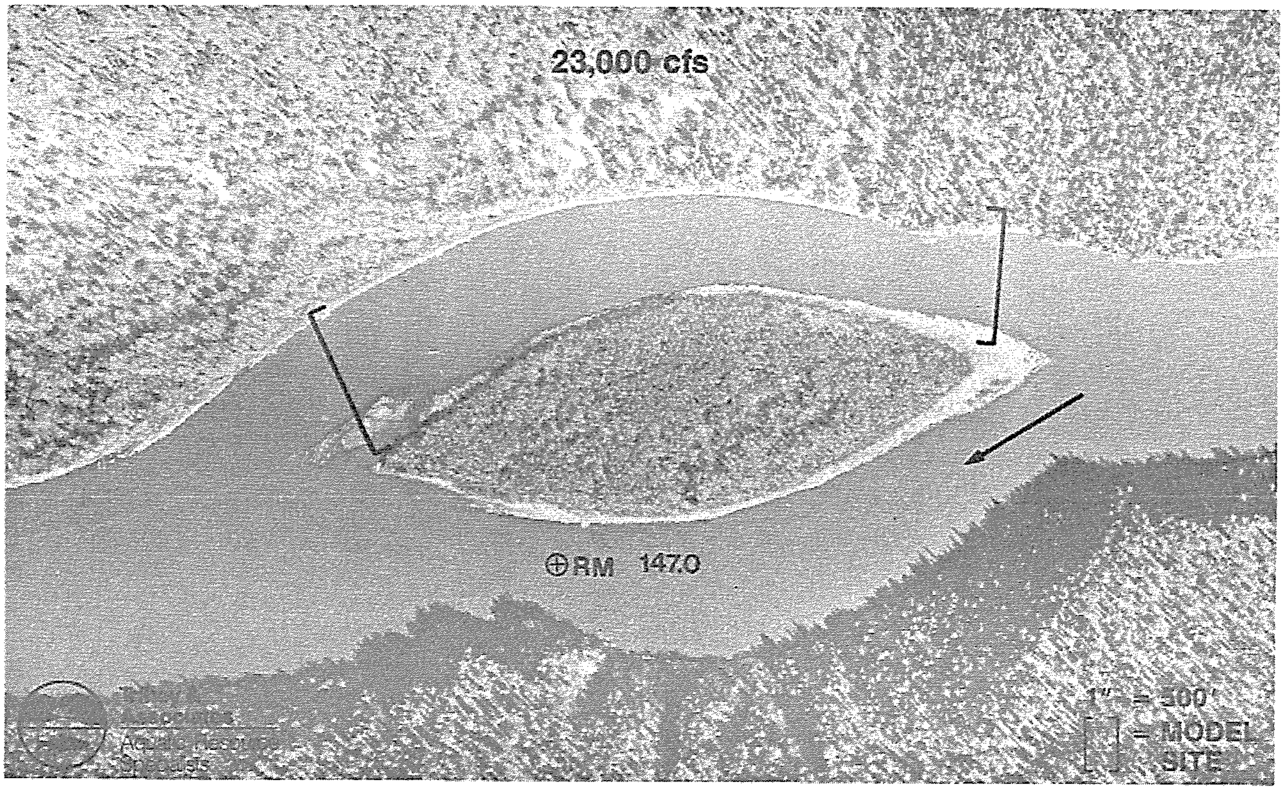


Plate A-30 Aerial photography of modeling site 101.5L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IX.



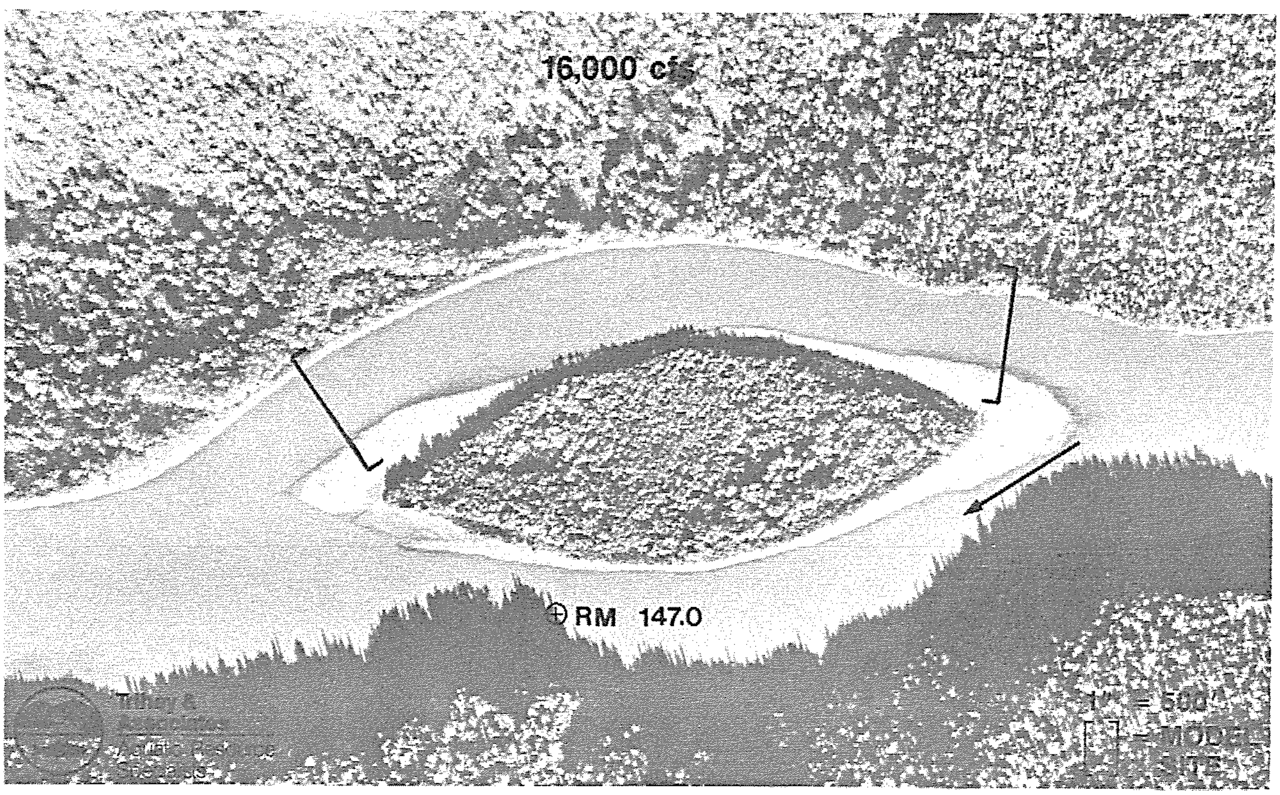
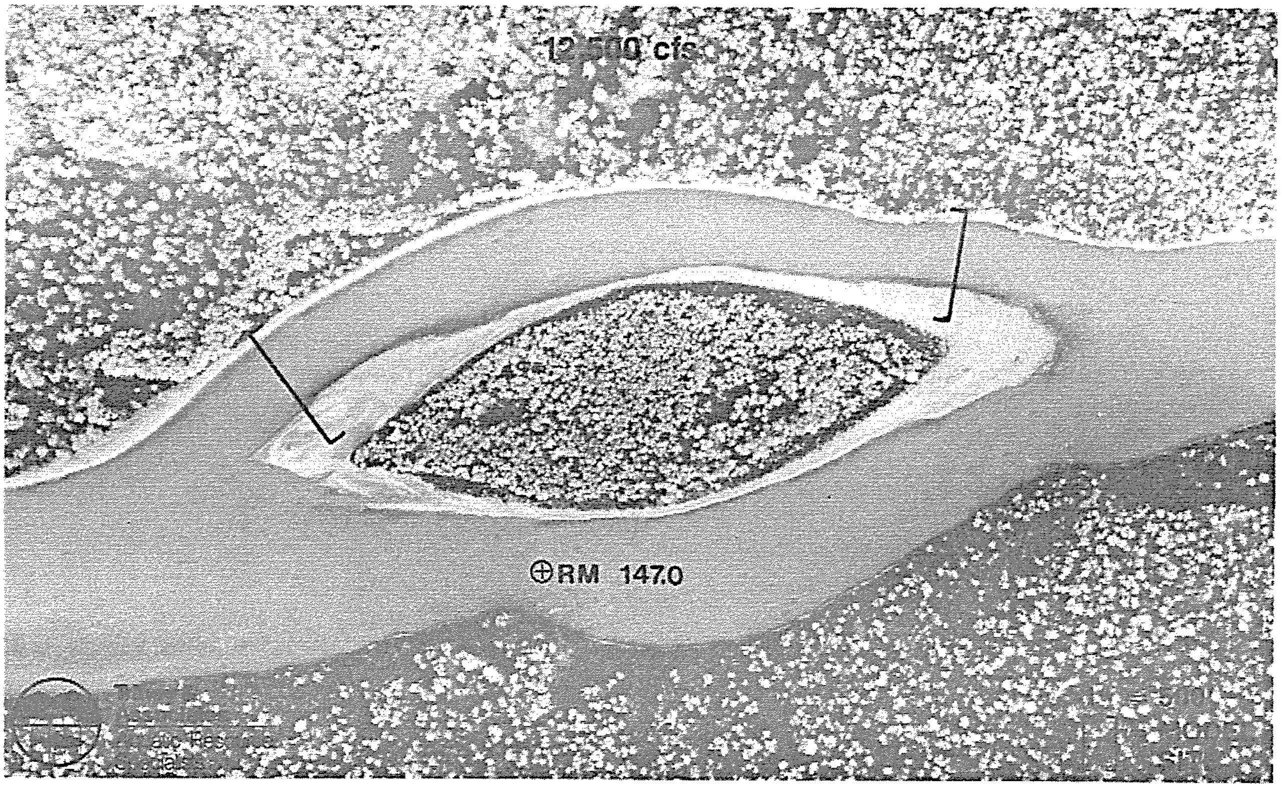


Plate A-31 Aerial photography of modeling site 147.1L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IX.



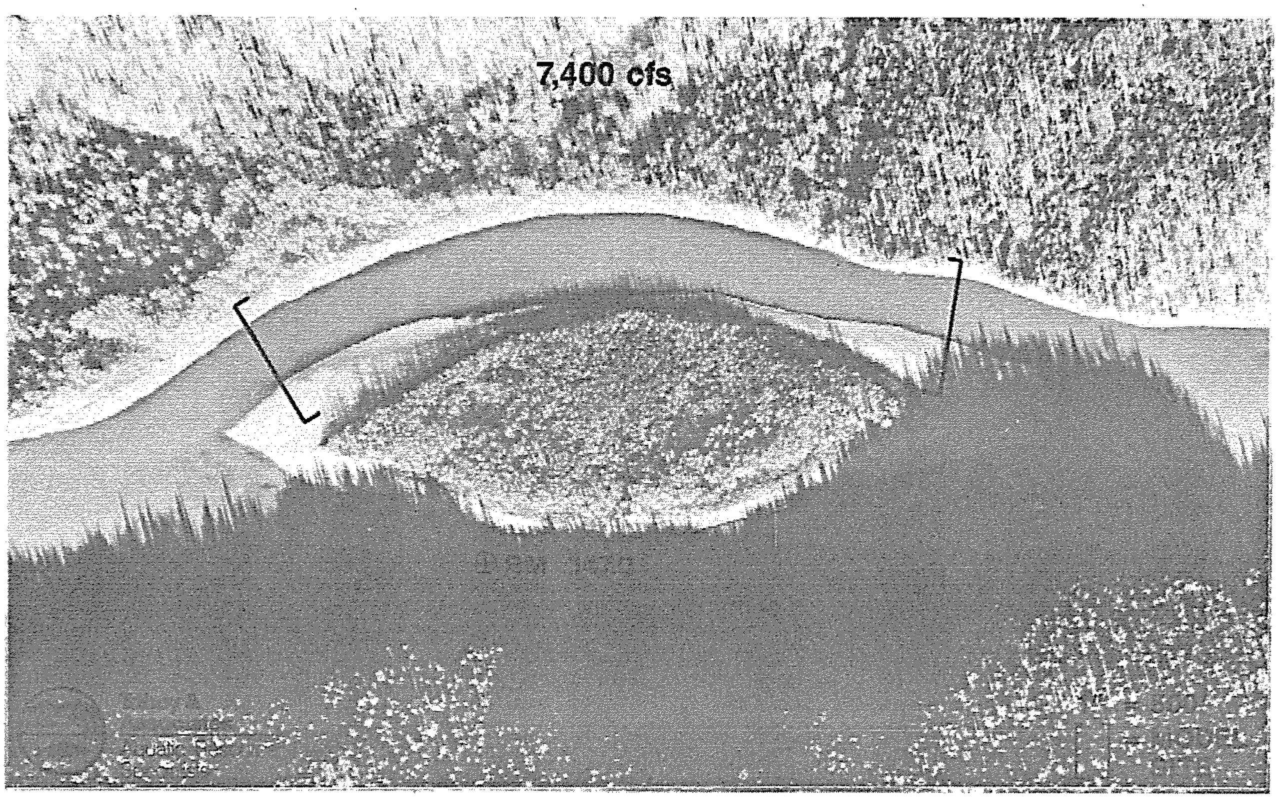
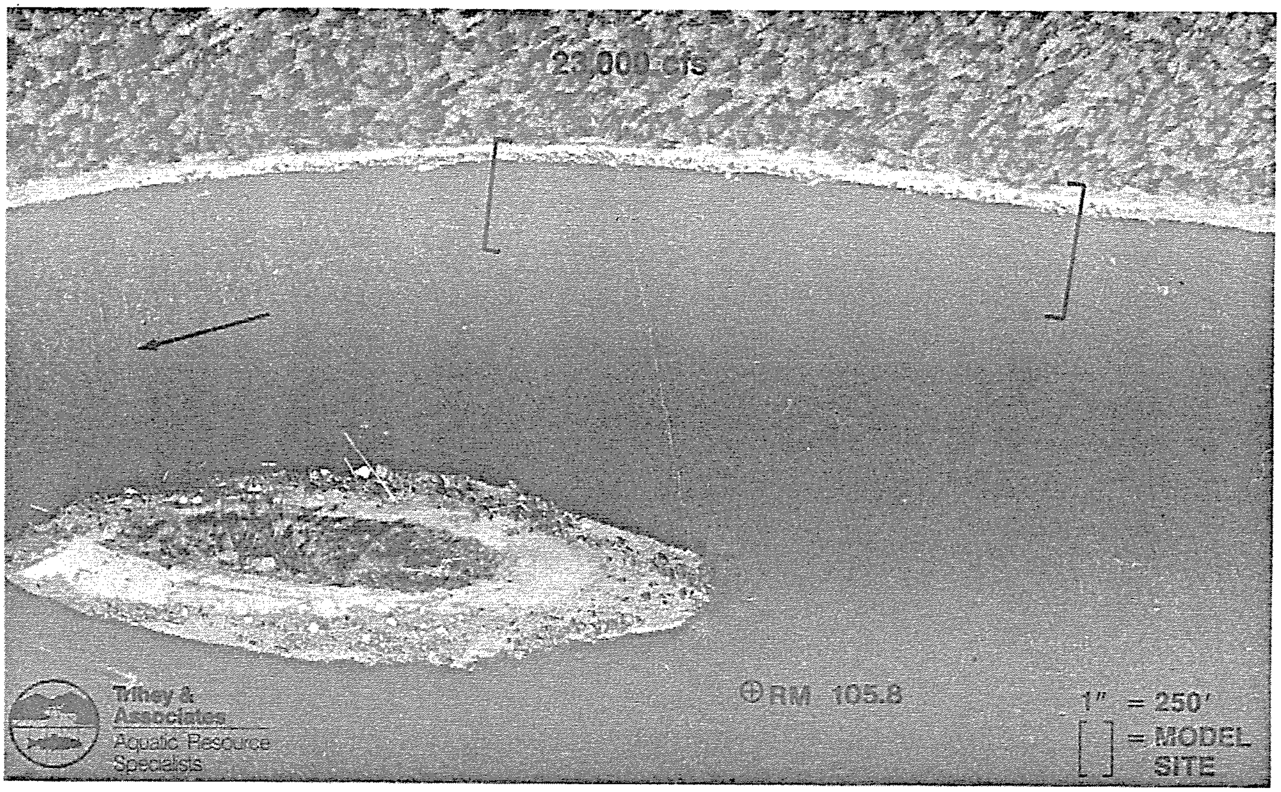


Plate A-32 Aerial photography of modeling site 147.1L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site breaches at < 5,100 cfs and is included in Representative Group IX.



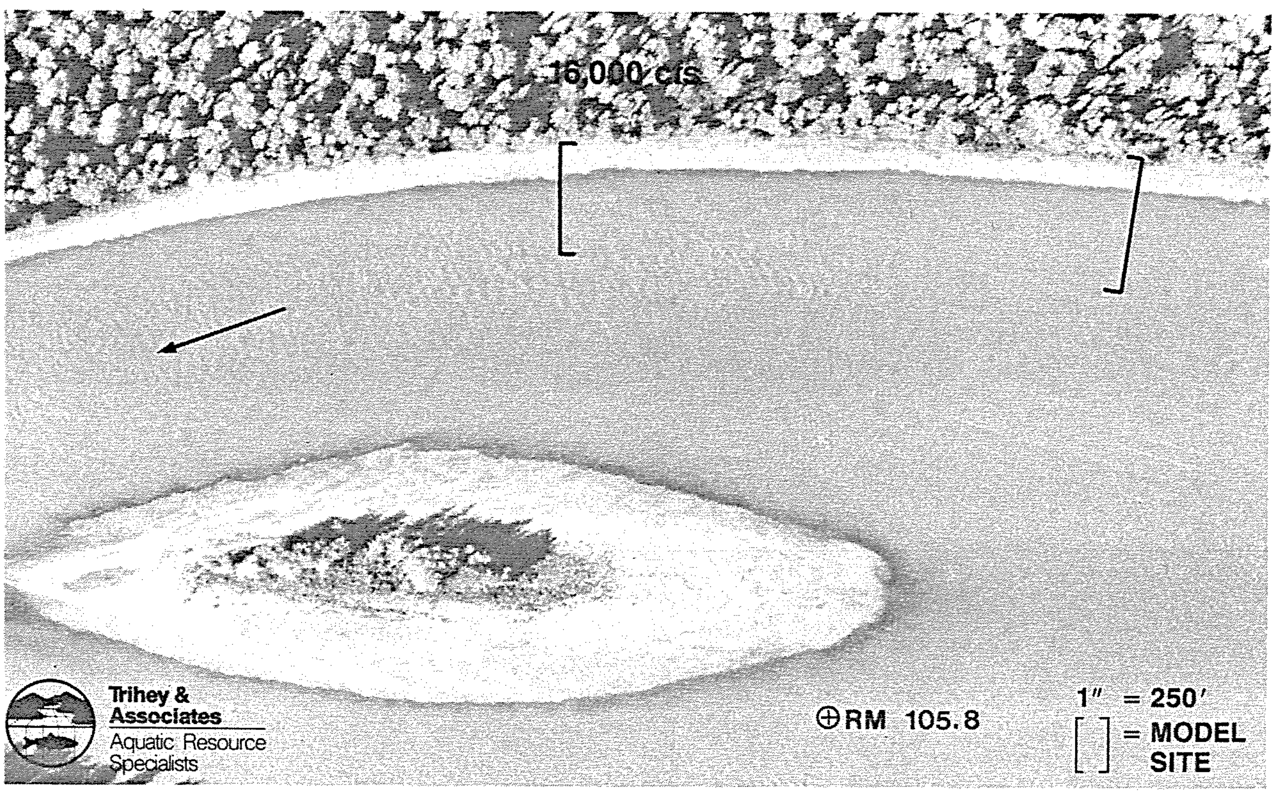
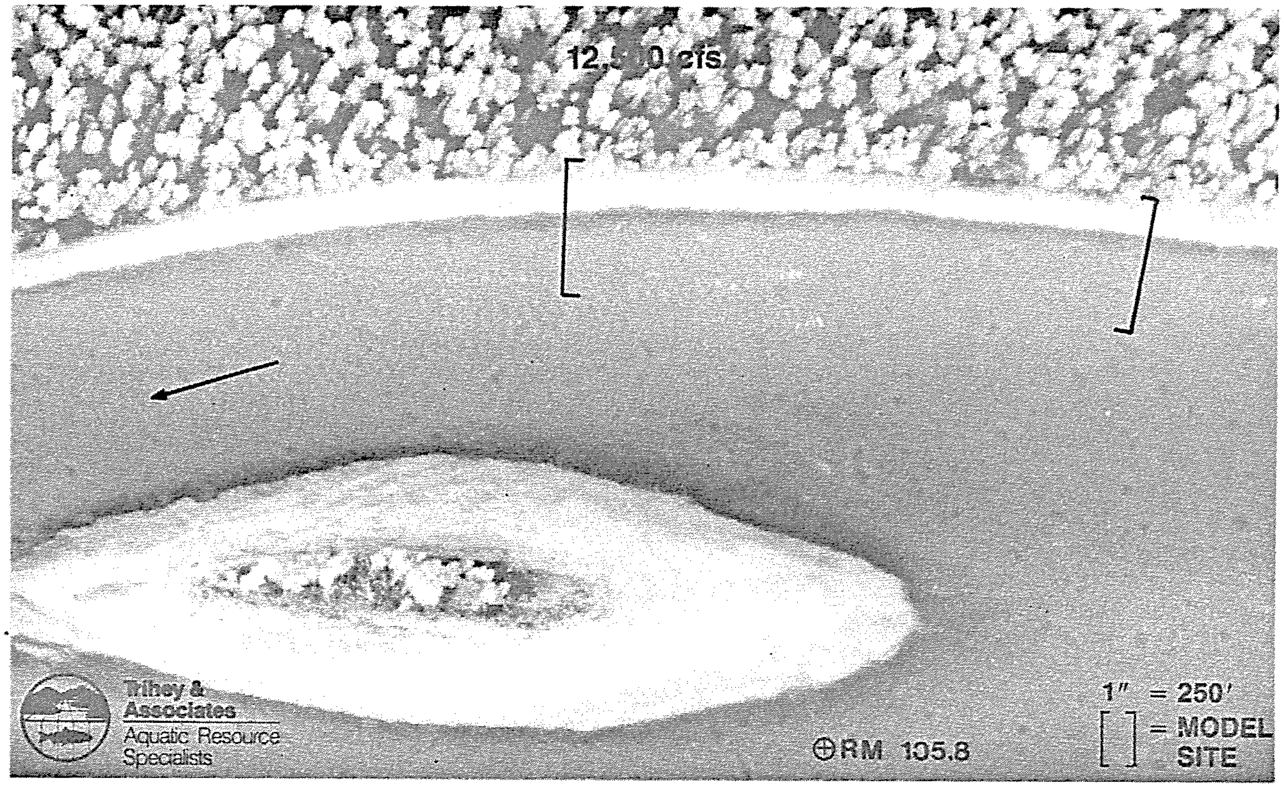


Plate A-33 Aerial photography of modeling site 105.8L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



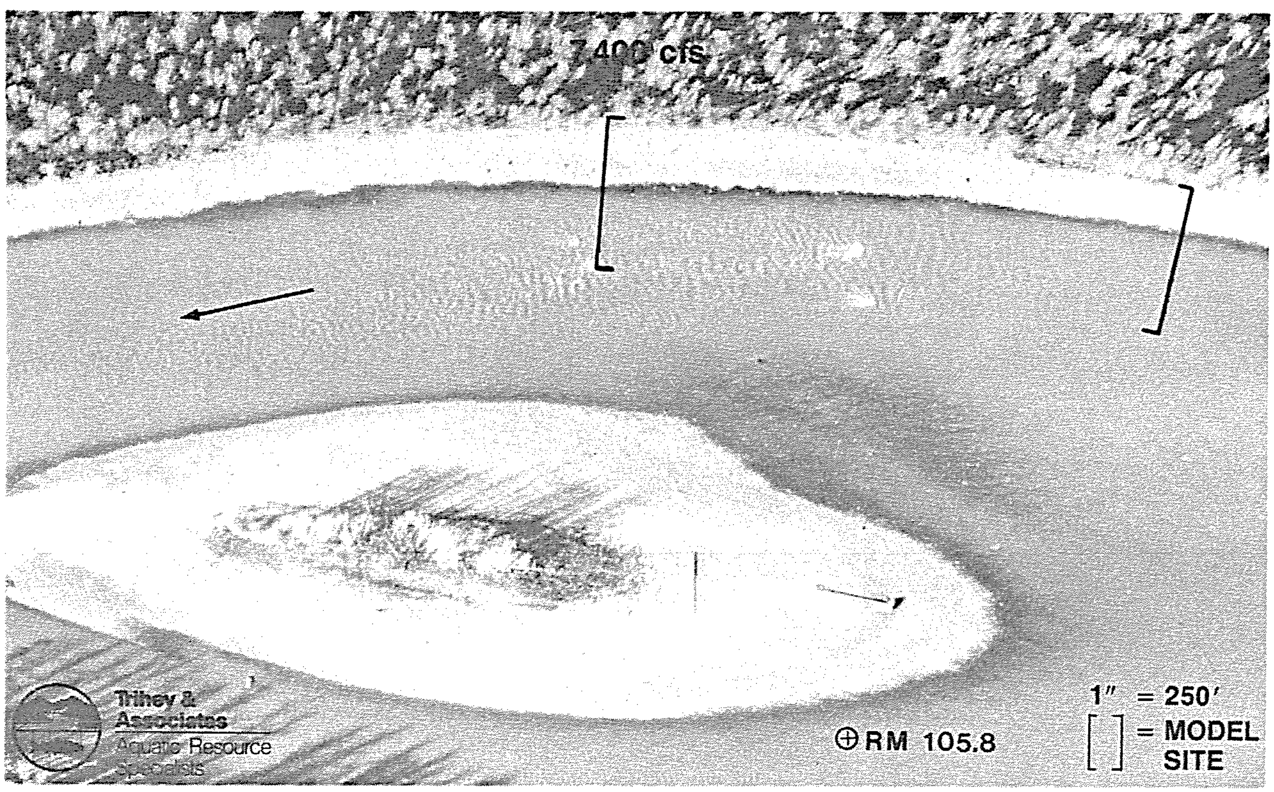
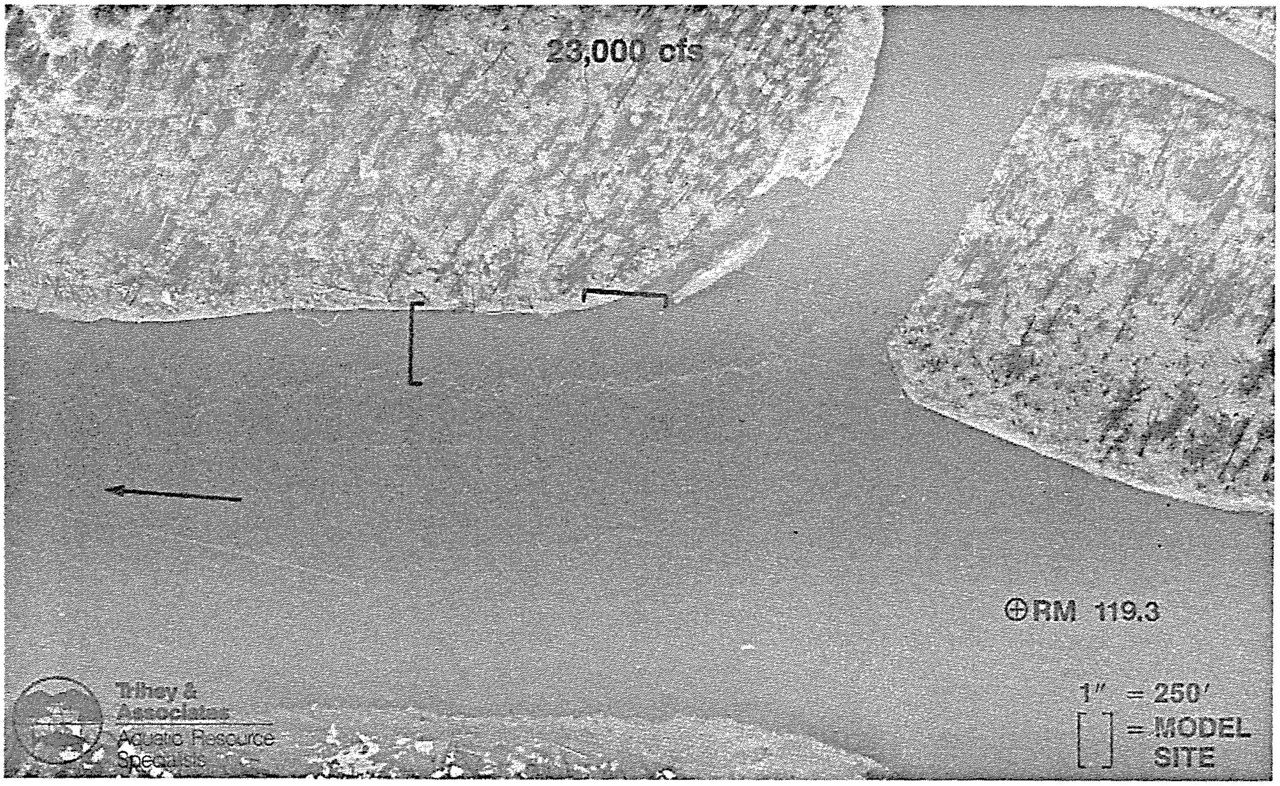


Plate A-34 Aerial photography of modeling site 105.8L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



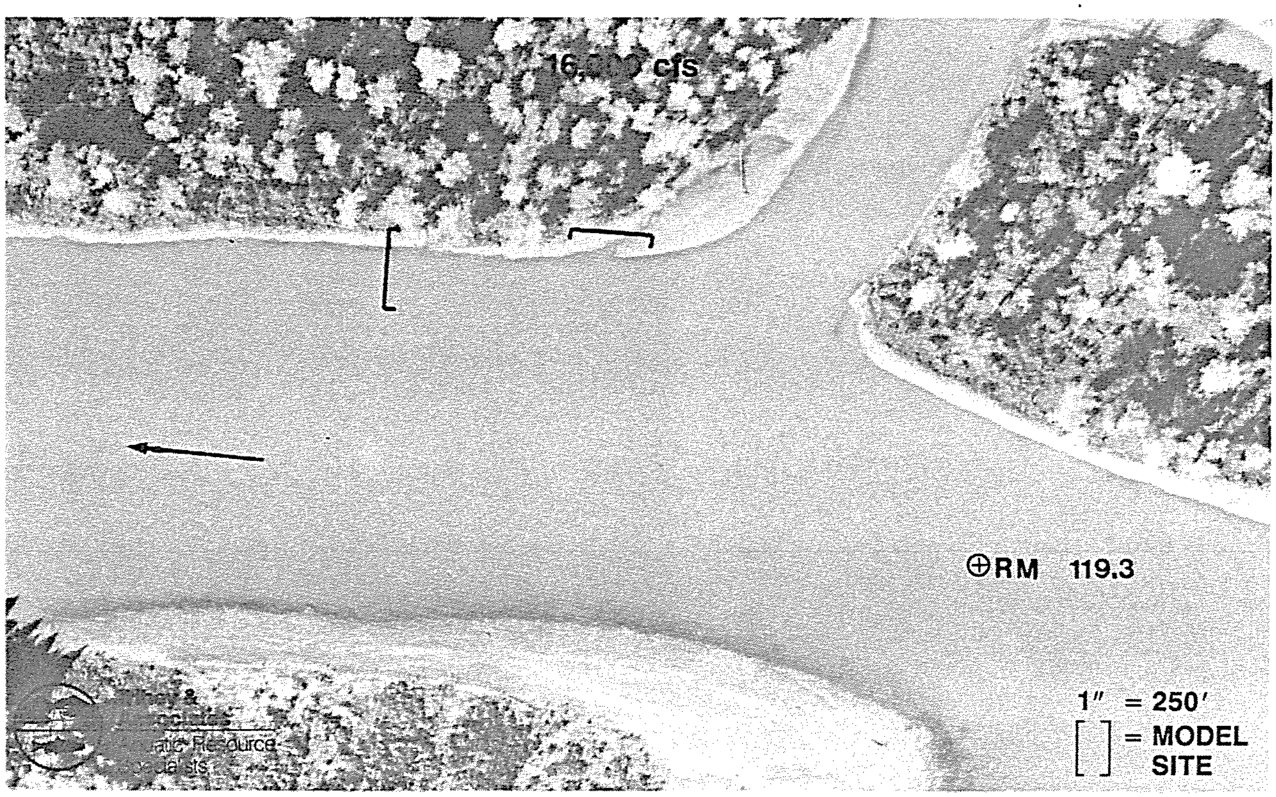
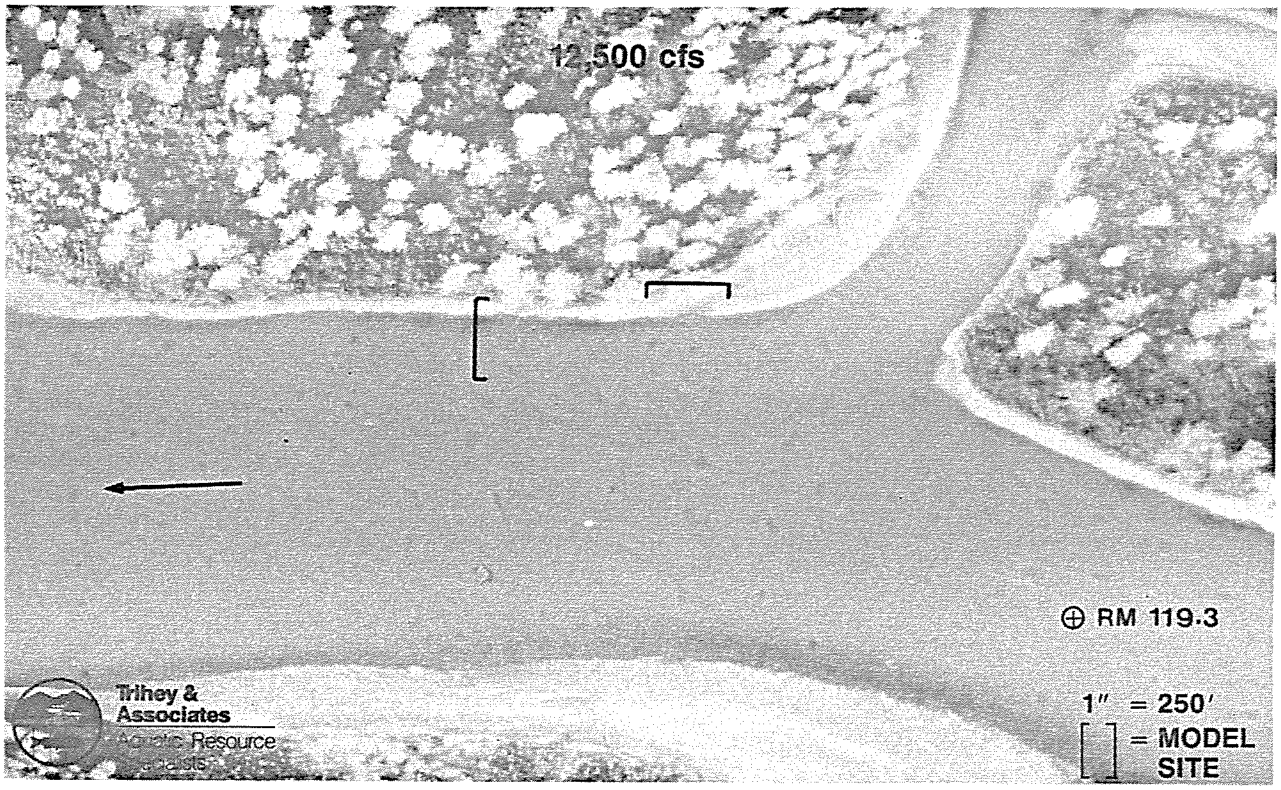


Plate A-35 Aerial photography of modeling site 119.1L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



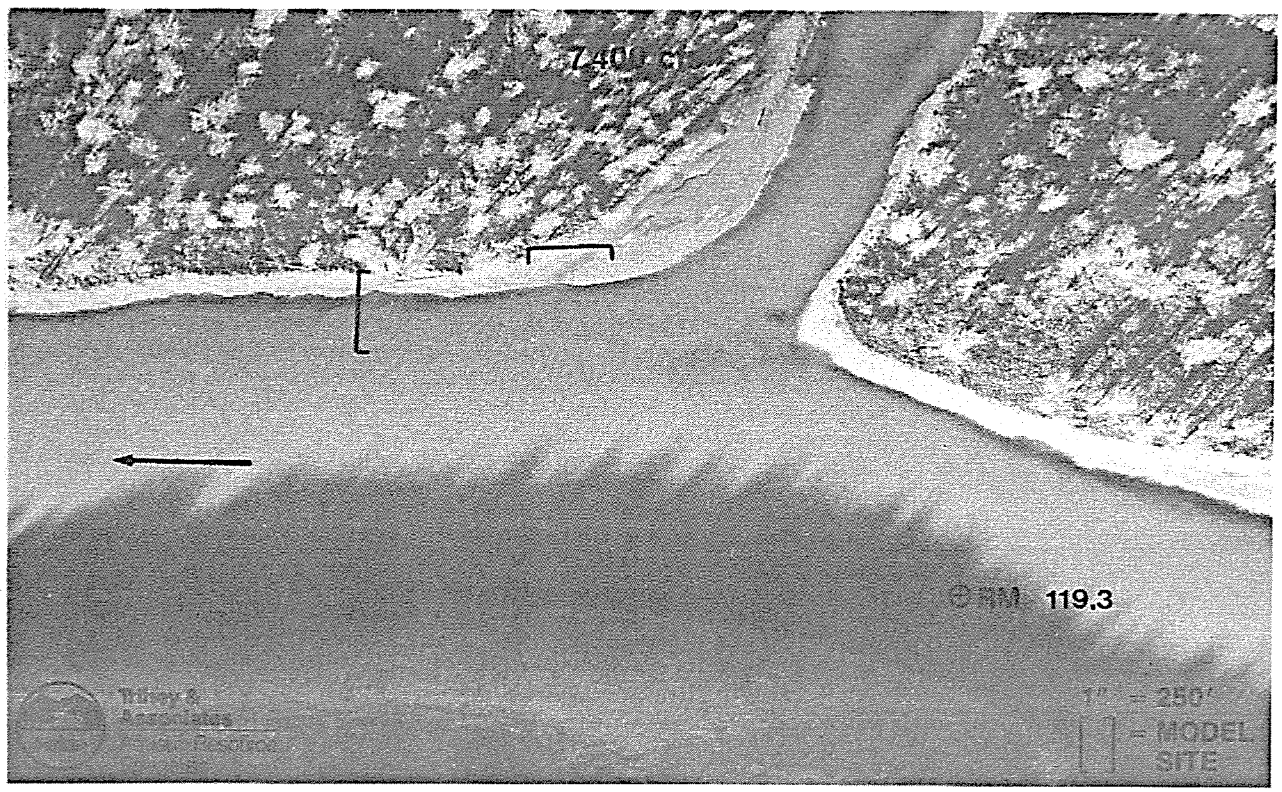
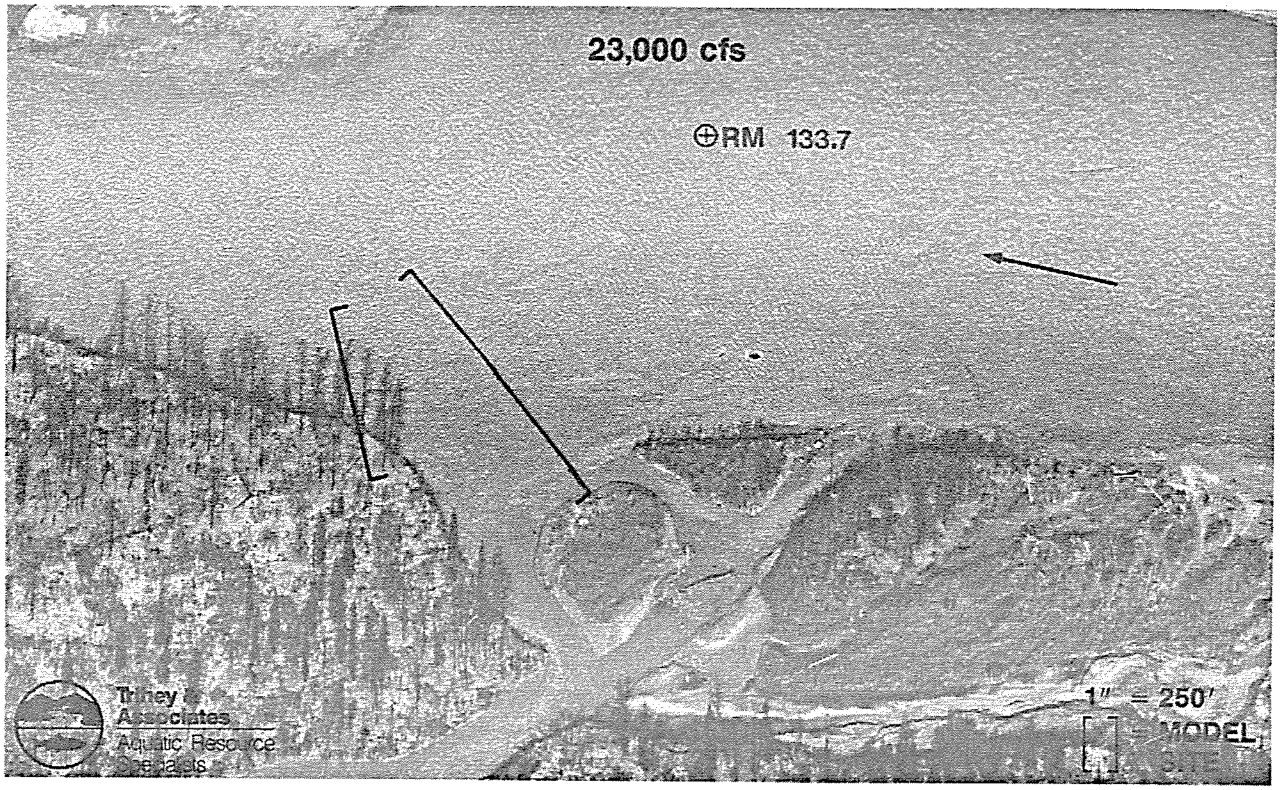


Plate A-36 Aerial photography of modeling site 119.1L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



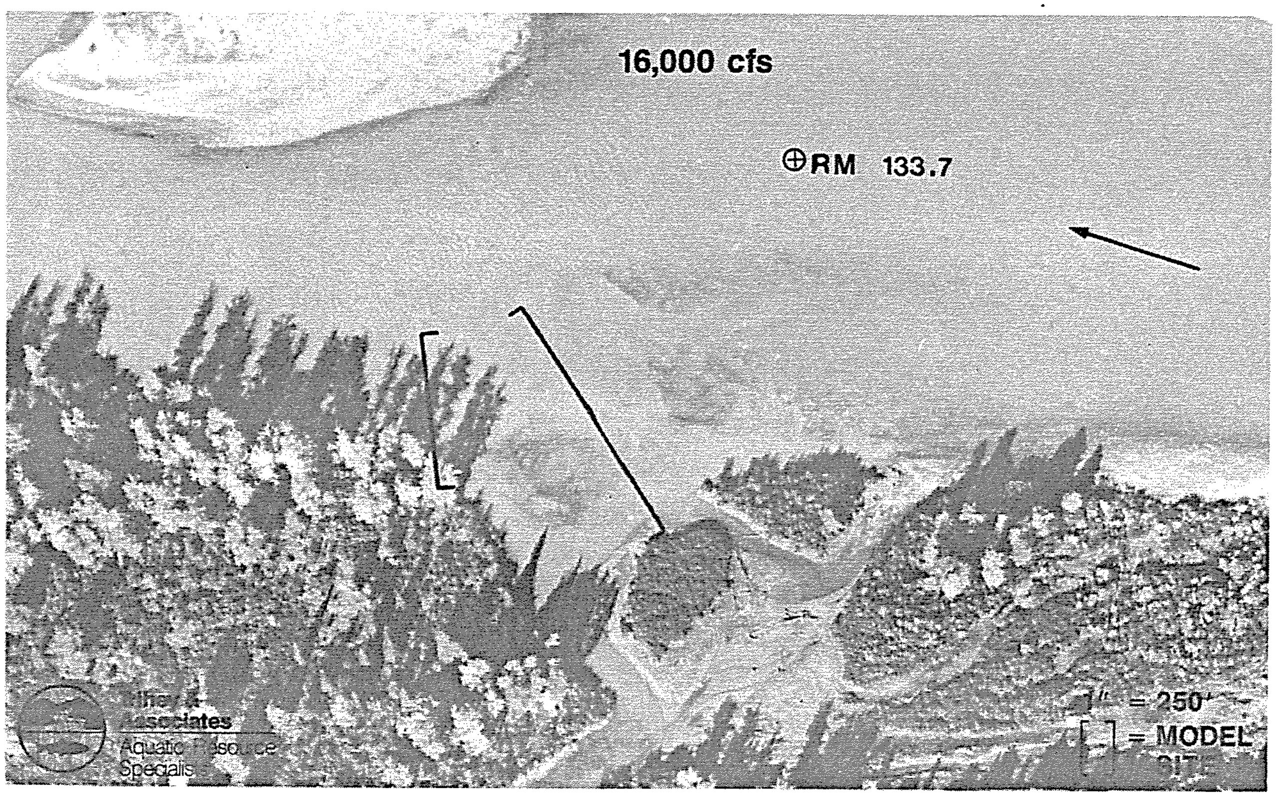
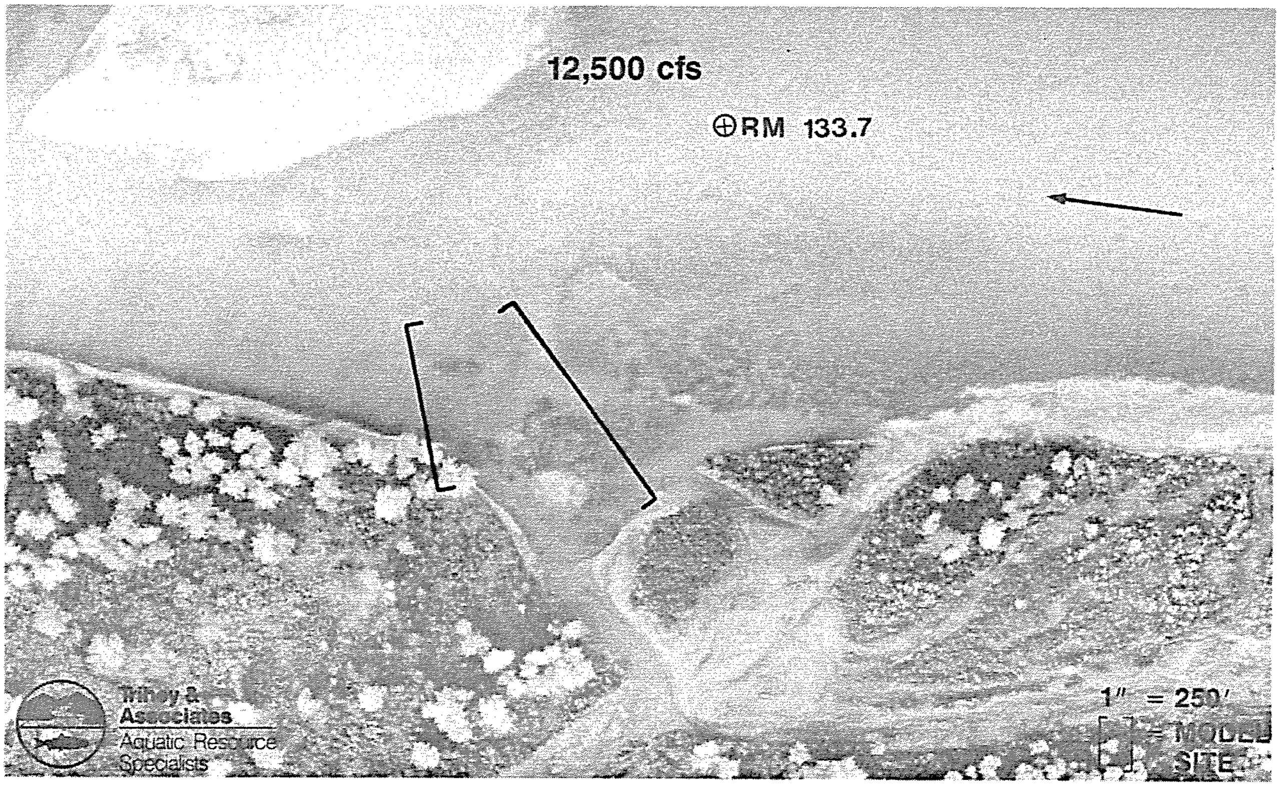


Plate A-37 Aerial photography of modeling site 133.8R at mainstem discharges of 23,000 cfs and 16,000 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



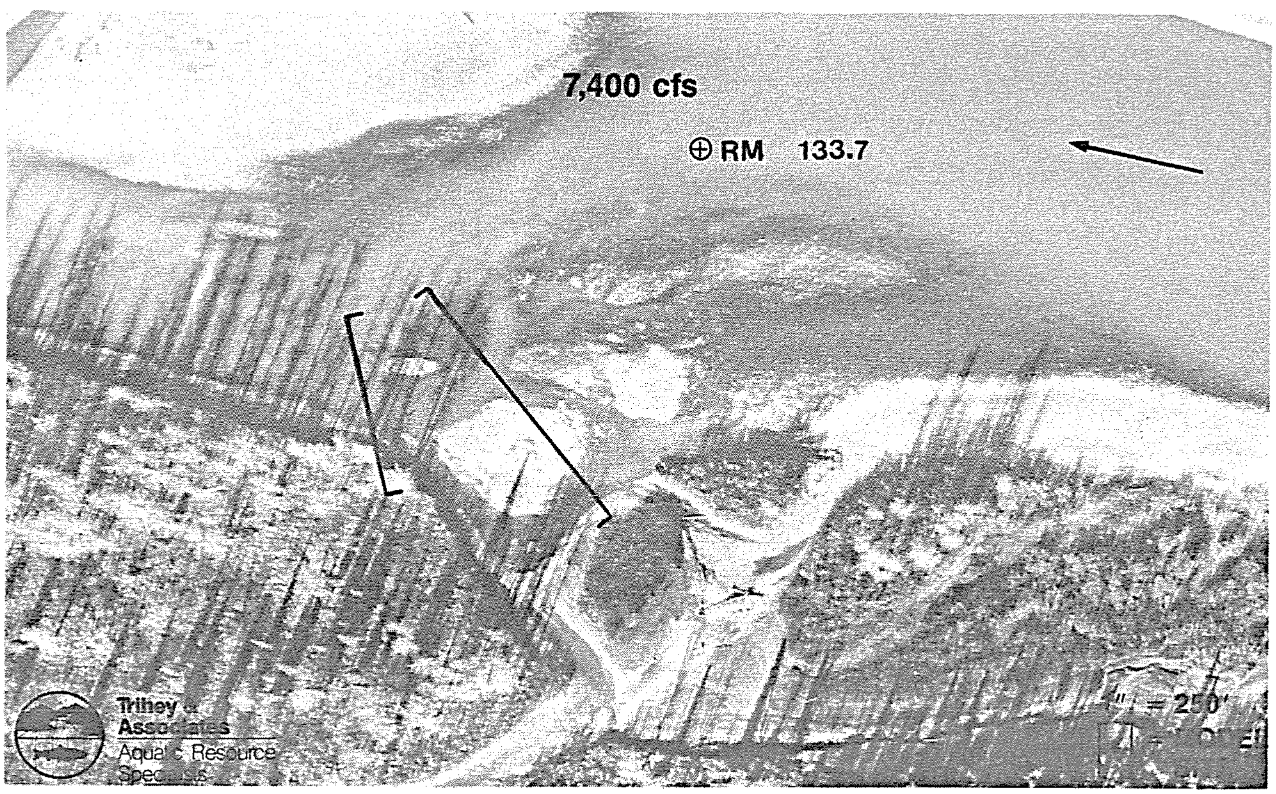
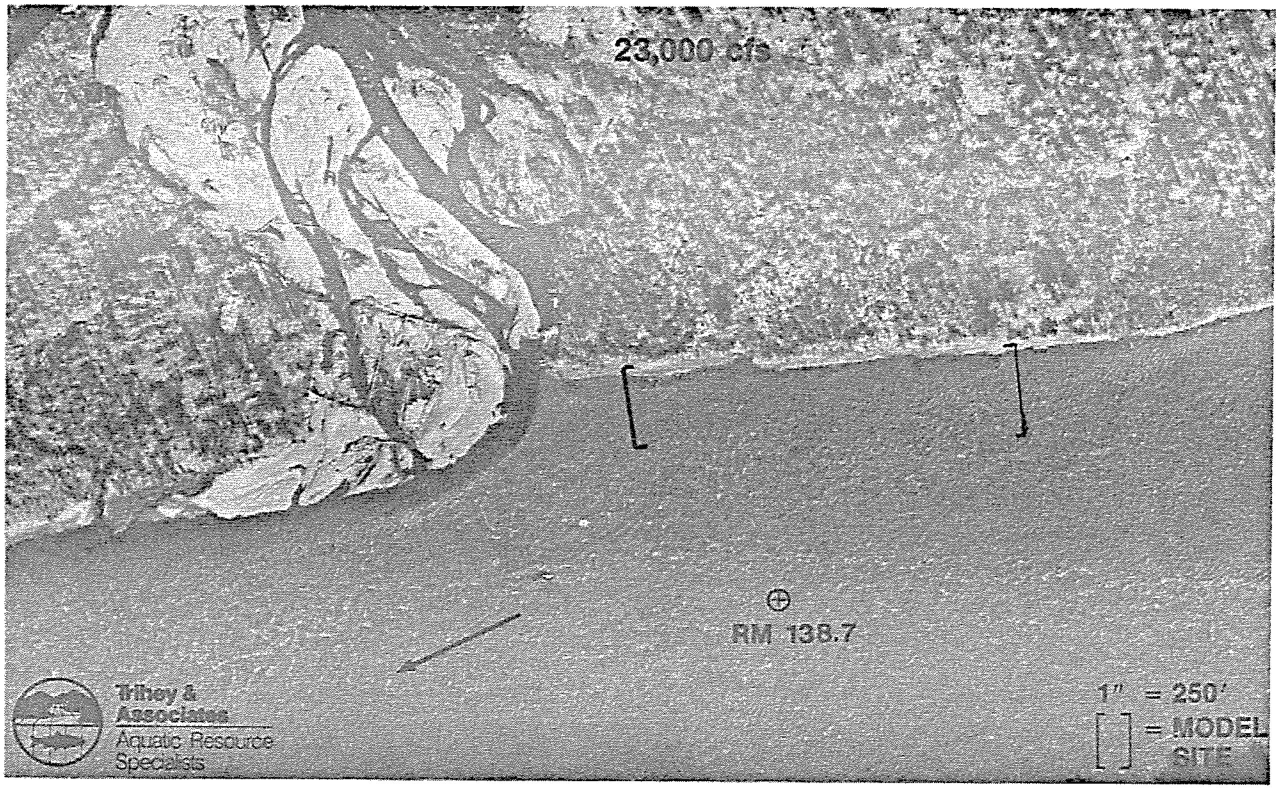


Plate A-38 Aerial photography of modeling site 133.8R at mainstem discharges of 12,500 cfs and 7,400 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



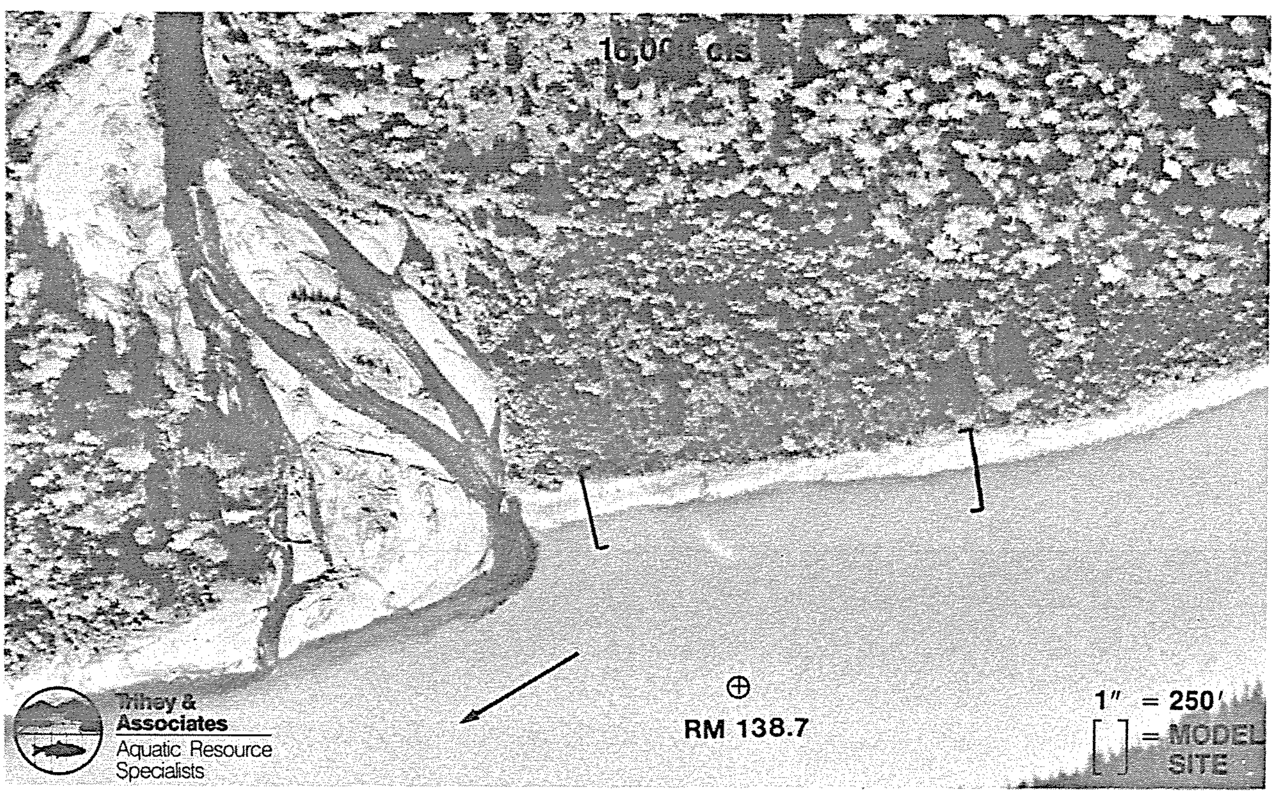
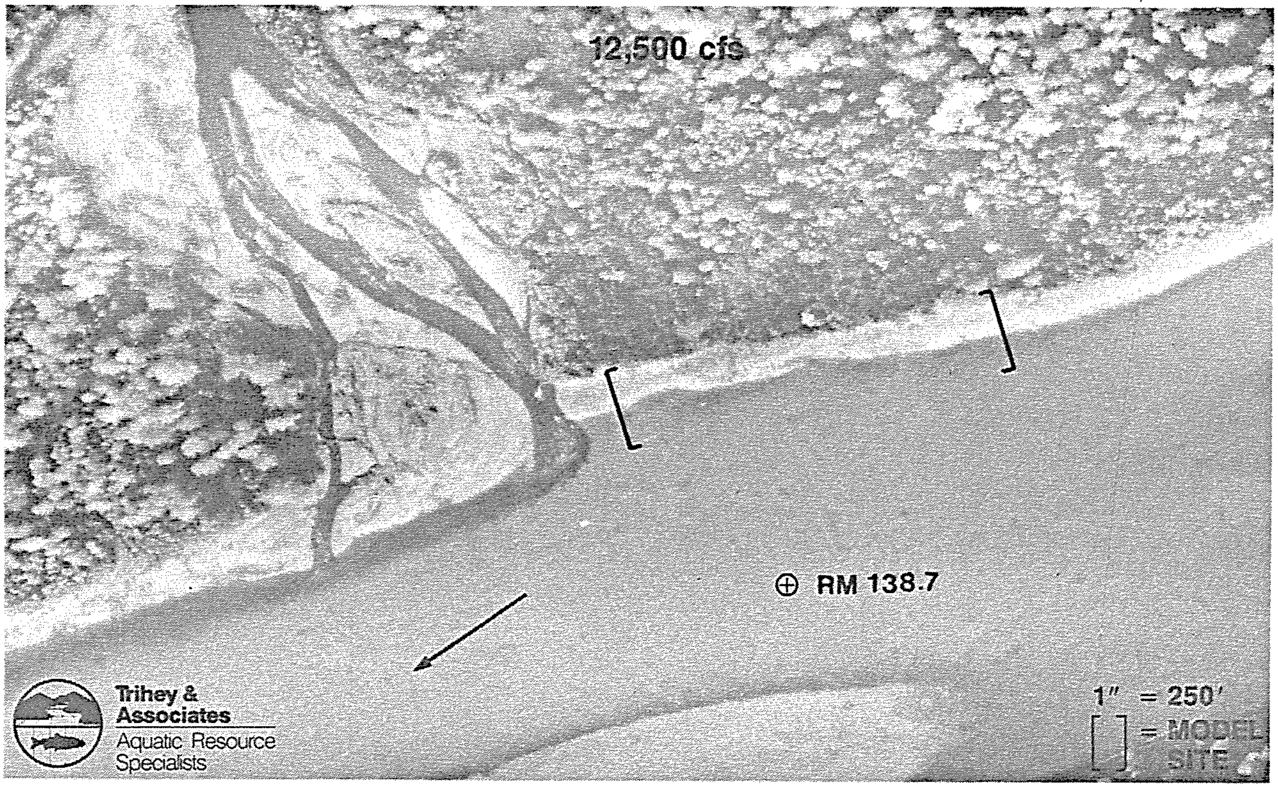


Plate A-39 Aerial photography of modeling site 138.7L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



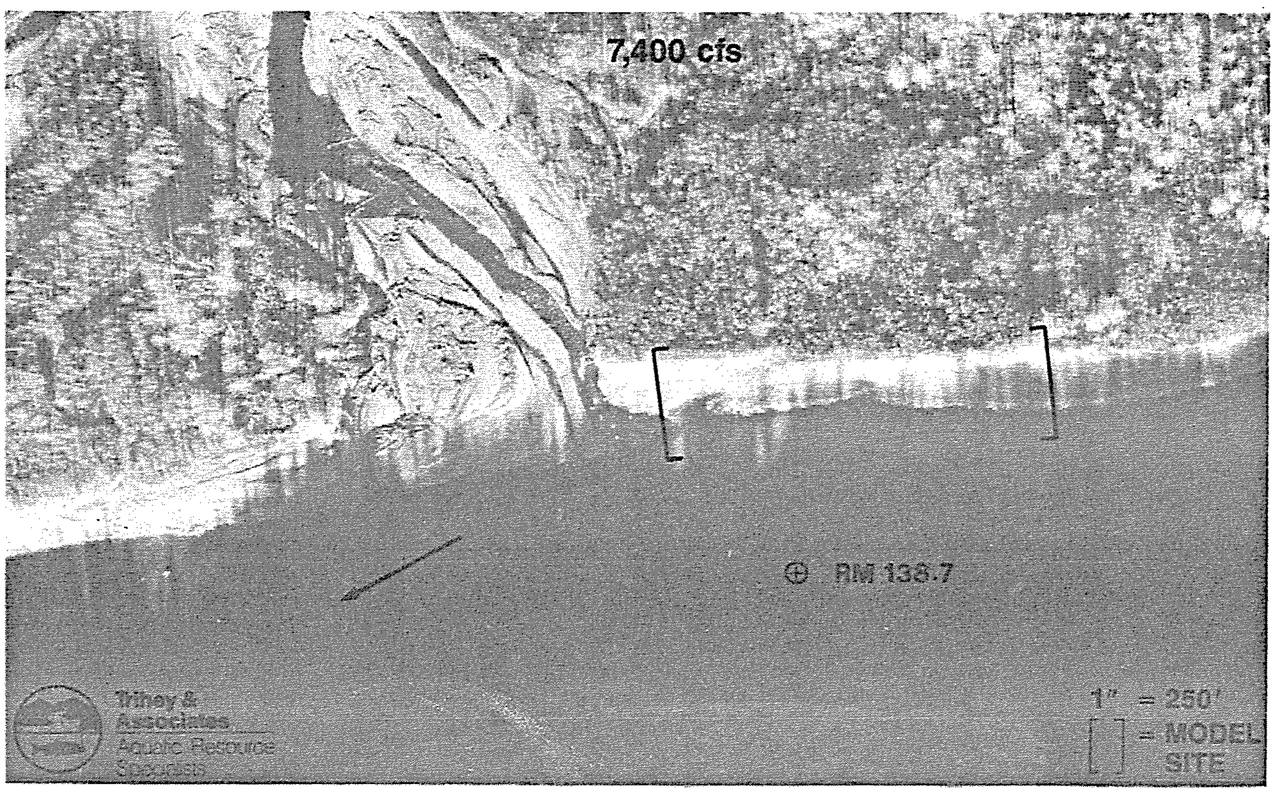
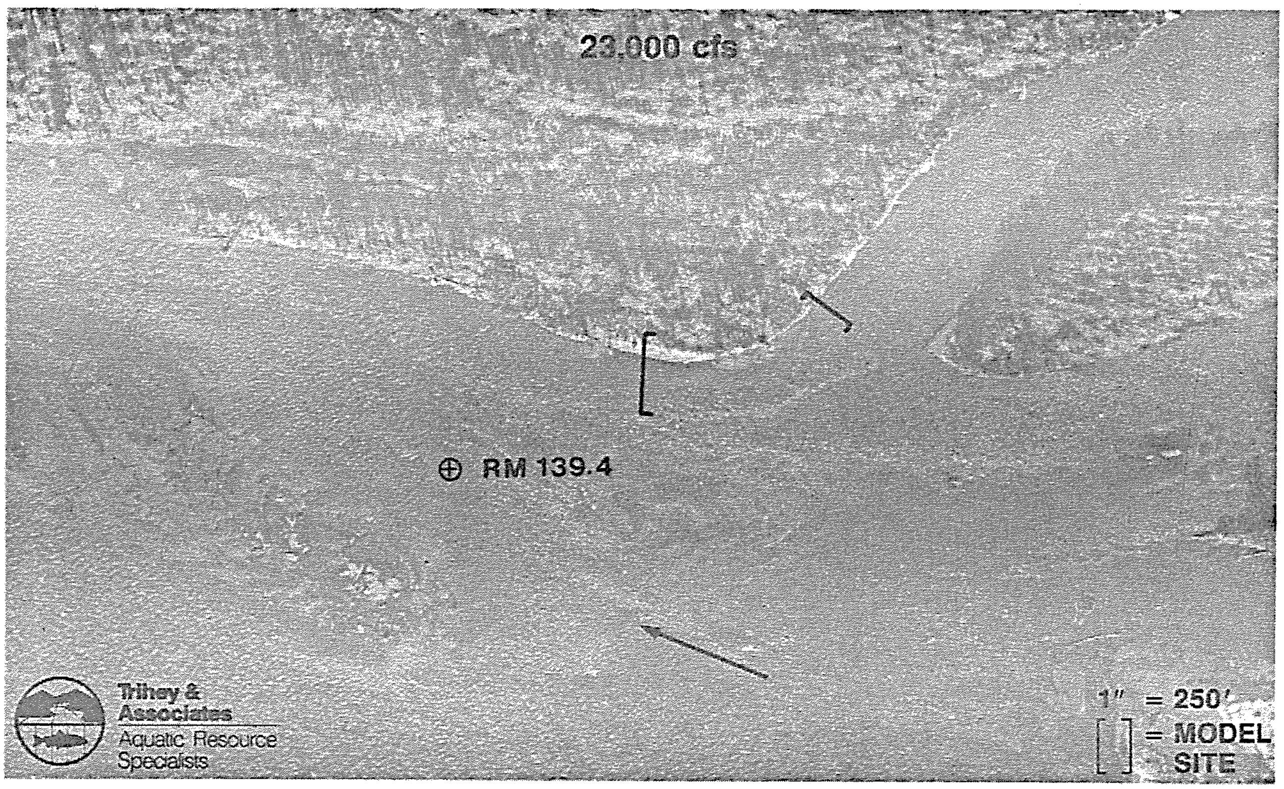


Plate A-40 Aerial photography of modeling site 138.7L at mainstem discharges of 12,500 cfs and 7,400 cfs. Site is mainstem shoal habitat and is included in Representative Group X.



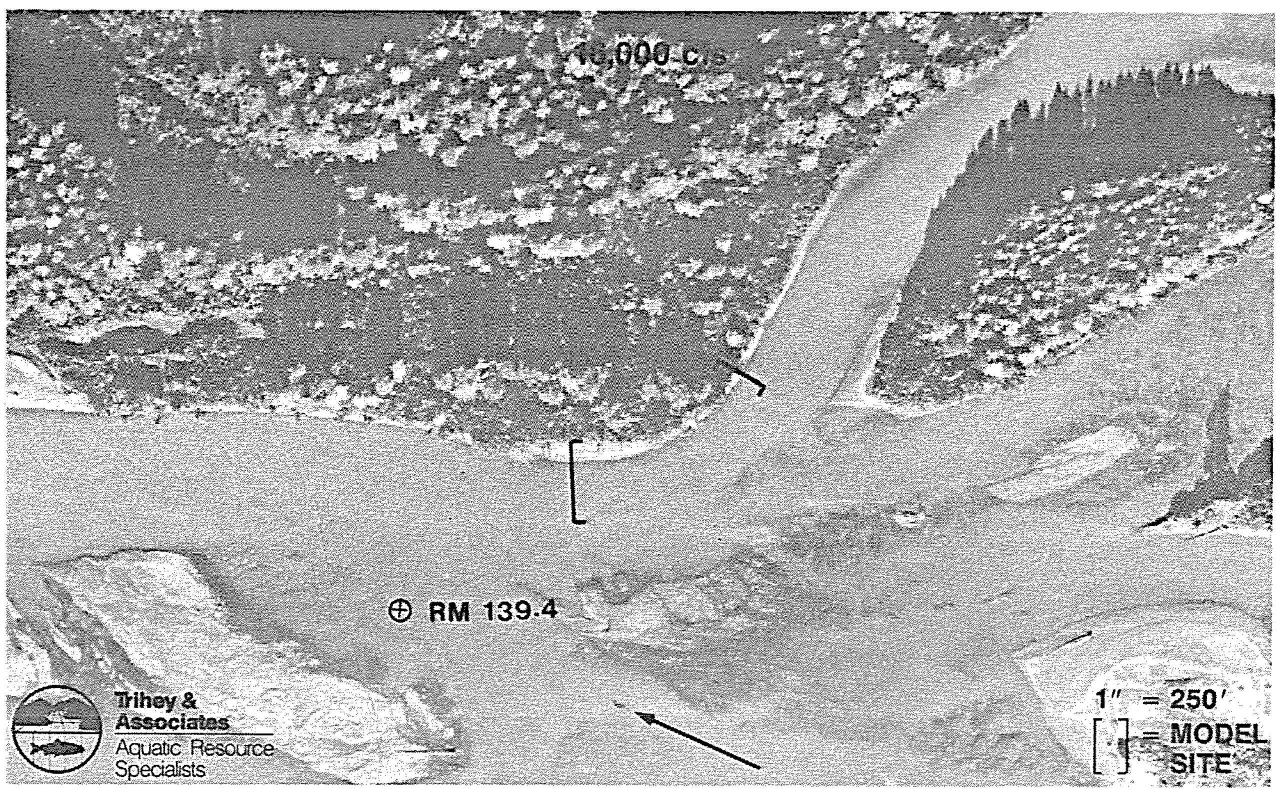


Plate A-41 Aerial photography of modeling site 139.4L at mainstem discharges of 12,000 cfs and 7,400 cfs. Site is mainstem shoal habitat and is included in Representative Group X.

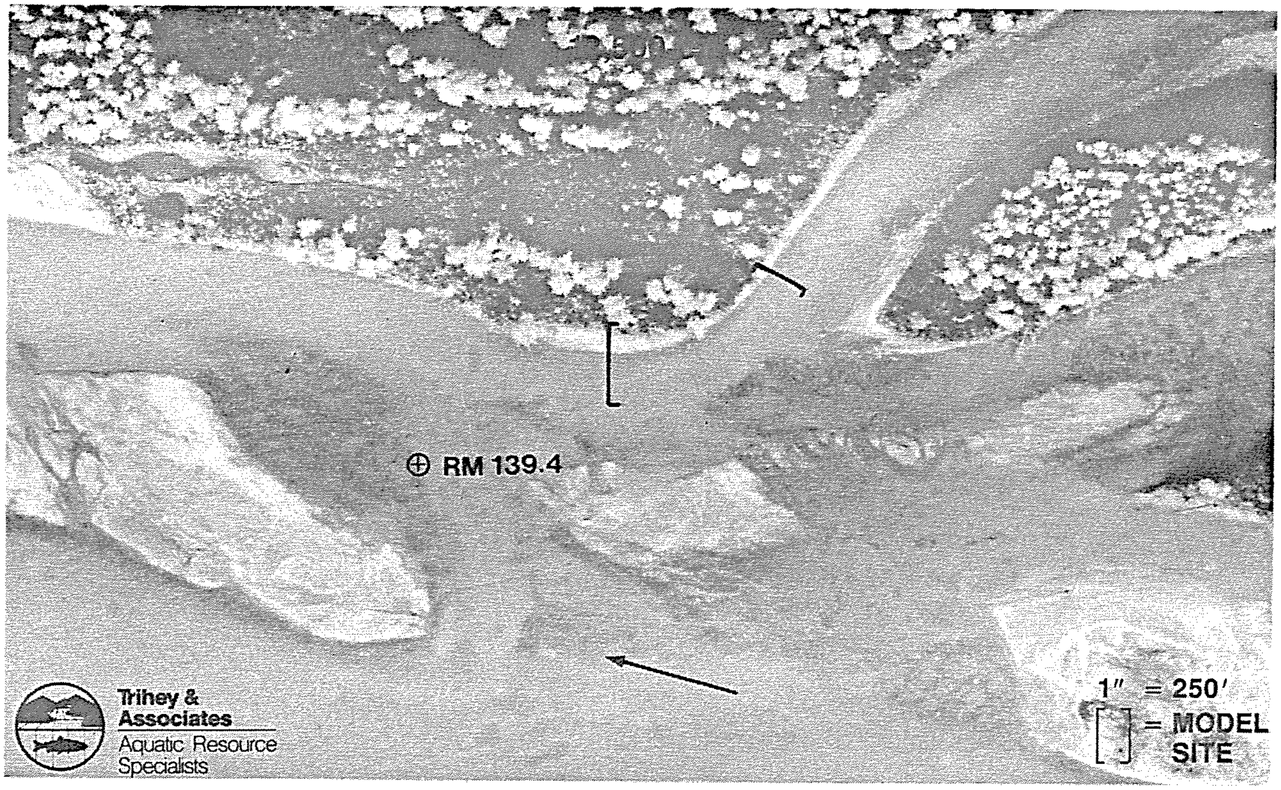


Plate A-42 Aerial photography of modeling site 139.4L at mainstem discharges of 23,000 cfs and 16,000 cfs. Site is mainstem shoal habitat and is included in Representative Group X.

APPENDIX B

HABITAT AVAILABILITY INDICES (HAI) FOR SPECIFIC AREAS

REPRESENTATIVE GROUP I
HAI VALUES (PERCENT)

Q	102.2L	105.2R	107.6L	108.3L	112.5L	119.4L	120.0R	121.9R	123.1R	123.3R	127.2M	129.4R	133.9L	134.0L
5000	5.09	18.62	11.88	18.89	4.17	12.14	13.49	4.48	2.76	4.11	3.56	2.70	4.11	5.46
5500	5.09	18.61	11.87	18.88	4.17	12.14	13.48	4.48	2.76	4.11	3.56	2.70	4.11	5.46
6000	5.09	18.58	11.85	18.85	4.17	12.12	13.46	4.48	2.76	4.11	3.56	2.70	4.11	5.46
6500	5.09	18.54	11.82	18.81	4.17	12.09	13.43	4.48	2.76	4.11	3.56	2.70	4.11	5.46
7000	5.09	18.48	11.79	18.75	4.17	12.05	13.39	4.48	2.76	4.11	3.56	2.70	4.11	5.46
7500	5.09	18.41	11.74	18.68	4.17	12.01	13.34	4.48	2.76	4.11	3.56	2.70	4.11	5.46
8000	5.09	18.32	11.68	18.59	4.17	11.95	13.28	4.48	2.76	4.11	3.56	2.70	4.11	5.46
8500	5.09	18.22	11.62	18.49	4.17	11.89	13.21	4.48	2.76	4.11	3.56	2.70	4.11	5.46
9000	5.09	18.11	11.55	18.37	4.17	11.81	13.12	4.48	2.76	4.11	3.56	2.70	4.11	5.46
9500	5.09	17.98	11.47	18.24	4.17	11.73	13.03	4.48	2.76	4.11	3.56	2.70	4.11	5.46
10000	5.09	17.84	11.38	18.10	4.17	11.63	12.93	4.48	2.76	4.11	3.56	2.70	4.11	5.46
10500	5.09	17.68	11.28	17.94	4.17	11.53	12.81	4.48	2.76	4.11	3.56	2.70	4.11	5.46
11000	5.09	17.51	11.17	17.77	4.17	11.42	12.69	4.48	2.76	4.11	3.56	2.70	4.11	5.46
11500	5.09	17.33	11.05	17.59	4.17	11.30	12.56	4.48	2.76	4.11	3.56	2.70	4.11	5.46
12000	5.09	17.14	10.93	17.39	4.17	11.18	12.42	4.48	2.76	4.11	3.56	2.70	4.11	5.46
12500	5.09	16.93	10.80	17.18	4.17	11.04	12.27	4.48	2.76	4.11	3.56	2.70	4.11	5.46
13000	5.09	16.71	10.66	16.96	4.17	10.90	12.11	4.48	2.76	4.11	3.56	2.70	4.11	5.46
13500	5.09	16.49	10.51	16.73	4.17	10.75	11.95	4.48	2.76	4.11	3.56	2.70	4.11	5.46
14000	5.09	16.25	10.36	16.48	4.17	10.60	11.77	4.48	2.76	4.11	3.56	2.70	4.11	5.46
14500	5.09	16.00	10.20	16.23	4.17	10.43	11.59	4.48	2.76	4.11	3.56	2.70	4.11	5.46
15000	5.09	15.74	10.04	15.97	4.17	10.27	11.41	4.48	2.76	4.11	3.56	2.70	4.11	5.46
15500	5.09	15.47	9.87	15.70	4.17	10.09	11.21	4.48	2.76	4.11	3.56	2.70	4.11	5.46
16000	5.09	15.20	9.69	15.42	4.17	9.91	11.01	4.48	2.76	4.11	3.56	2.70	4.11	5.46
16500	5.09	14.92	9.51	15.14	4.17	9.73	10.81	4.48	2.76	4.11	3.56	2.70	4.11	5.46
17000	5.09	14.63	9.33	14.84	4.17	9.54	10.60	4.48	2.76	4.11	3.56	2.70	4.11	5.46
17500	5.09	14.33	9.14	14.54	4.17	9.35	10.39	4.48	2.76	4.11	3.56	2.70	4.11	5.46
18000	5.09	14.03	8.95	14.24	4.17	9.15	10.17	4.48	2.76	4.11	3.56	2.70	4.11	5.46
18500	5.09	13.72	8.75	13.92	4.17	8.95	9.95	4.48	2.76	4.11	3.56	2.70	4.11	5.46
19000	5.09	13.41	8.55	13.61	4.17	8.75	9.72	4.48	2.76	4.11	3.56	2.70	4.11	5.46
19500	5.09	13.09	8.35	13.28	4.17	8.54	9.49	4.48	2.76	4.11	3.56	2.70	4.11	5.46
20000	5.09	12.75	8.13	12.94	4.17	8.32	9.24	4.48	2.76	4.11	3.56	2.70	4.11	5.46
20500	5.09	12.40	7.91	12.59	4.17	8.09	8.99	4.48	2.76	4.11	3.56	2.70	4.11	5.46
21000	5.09	12.04	7.68	12.22	4.17	7.85	8.73	4.48	2.76	4.11	3.56	2.70	4.11	5.46
21500	5.09	11.66	7.44	11.83	4.17	7.61	8.45	4.48	2.76	4.11	3.56	2.70	4.11	5.46
22000	5.09	11.29	7.20	11.46	4.17	7.37	8.18	4.48	2.76	4.11	3.56	2.70	4.11	5.46
22500	5.09	11.02	7.03	11.18	4.17	7.19	7.99	4.48	2.76	4.11	3.56	2.70	4.11	5.46
23000	5.09	10.69	6.82	10.85	4.17	6.97	7.75	4.48	2.76	4.11	3.56	2.70	4.11	5.46
23500	5.09	10.45	6.66	10.60	4.17	6.81	7.57	4.48	2.76	4.11	3.56	2.70	4.11	5.46
24000	5.09	10.27	6.55	10.42	4.17	6.70	7.44	4.48	2.76	4.11	3.56	2.70	4.11	5.46
24500	5.09	9.75	6.22	9.89	4.17	6.36	7.06	4.48	2.76	4.11	3.56	2.70	4.11	5.46
25000	5.09	9.23	5.89	9.37	4.17	6.02	6.69	4.48	2.76	4.11	3.56	2.70	4.11	5.46
25500	5.09	8.72	5.56	8.84	4.17	5.68	6.32	4.48	2.76	4.11	3.56	2.70	4.11	5.46
26000	5.09	8.47	5.40	8.59	4.17	5.52	6.14	4.48	2.76	4.11	3.56	2.70	4.11	5.46
26500	5.09	8.53	5.44	8.66	4.17	5.57	6.19	4.48	2.76	4.11	3.56	2.70	4.11	5.46
27000	5.09	8.59	5.48	8.71	4.17	5.60	6.22	4.48	2.76	4.11	3.56	2.70	4.11	5.46
27500	5.09	8.72	5.56	8.85	4.17	5.69	6.32	4.48	2.76	4.11	3.56	2.70	4.11	5.46
28000	5.09	8.83	5.63	8.96	4.17	5.76	6.40	4.48	2.76	4.11	3.56	2.70	4.11	5.46
28500	5.09	8.96	5.71	9.09	4.17	5.84	6.49	4.48	2.76	4.11	3.56	2.70	4.11	5.46
29000	5.09	9.00	5.74	9.14	4.17	5.87	6.52	4.48	2.76	4.11	3.56	2.70	4.11	5.46
29500	5.09	9.06	5.78	9.20	4.17	5.91	6.57	4.48	2.76	4.11	3.56	2.70	4.11	5.46
30000	5.09	9.04	5.76	9.17	4.17	5.89	6.55	4.48	2.76	4.11	3.56	2.70	4.11	5.46
30500	5.09	9.10	5.80	9.23	4.17	5.93	6.59	4.48	2.76	4.11	3.56	2.70	4.11	5.46
31000	5.09	9.10	5.80	9.23	4.17	5.93	6.59	4.48	2.76	4.11	3.56	2.70	4.11	5.46
31500	5.09	9.10	5.80	9.23	4.17	5.93	6.59	4.48	2.76	4.11	3.56	2.70	4.11	5.46
32000	5.09	9.08	5.79	9.22	4.17	5.93	6.58	4.48	2.76	4.11	3.56	2.70	4.11	5.46
32500	5.09	9.08	5.79	9.22	4.17	5.93	6.58	4.48	2.76	4.11	3.56	2.70	4.11	5.46
33000	5.09	9.07	5.79	9.21	4.17	5.92	6.58	4.48	2.76	4.11	3.56	2.70	4.11	5.46
33500	5.09	9.09	5.79	9.22	4.17	5.93	6.58	4.48	2.76	4.11	3.56	2.70	4.11	5.46
34000	5.09	9.08	5.79	9.21	4.17	5.92	6.58	4.48	2.76	4.11	3.56	2.70	4.11	5.46
34500	5.09	9.03	5.76	9.17	4.17	5.89	6.55	4.48	2.76	4.11	3.56	2.70	4.11	5.46
35000	5.09	8.99	5.73	9.12	4.17	5.87	6.52	4.48	2.76	4.11	3.56	2.70	4.11	5.46

REPRESENTATIVE GROUP II
HAI VALUES (PERCENT)

Q	100.6R	101.4L	101.8L	113.1R	113.7R	115.6R	117.9L	118.0L	121.8R	122.4R	122.5R	123.6R	125.1R	125.9R
5000	3.56	14.53	3.85	8.08	13.25	14.53	3.67	10.46	7.26	10.05	17.64	14.82	12.93	19.40
5500	3.56	14.53	3.85	8.08	13.20	14.53	3.67	10.46	7.26	10.05	17.64	14.82	12.93	19.40
6000	3.56	14.53	3.85	8.08	13.16	14.53	3.67	10.46	7.26	10.05	17.64	14.82	12.93	19.40
6500	3.56	14.53	3.85	8.08	13.11	14.53	3.67	10.46	7.26	10.05	17.64	14.82	12.93	19.40
7000	3.56	14.53	3.84	8.08	13.14	14.53	3.67	10.46	7.26	10.05	17.64	14.82	12.93	19.40
7500	3.56	14.53	3.84	8.05	13.19	14.53	3.66	10.46	7.26	10.05	17.64	14.82	12.93	19.40
8000	3.56	14.53	3.84	8.03	13.31	14.53	3.66	10.46	7.26	10.05	17.64	14.82	12.93	19.40
8500	3.56	14.53	3.83	8.00	13.48	14.53	3.66	10.46	7.26	10.05	17.64	14.82	12.93	19.40
9000	3.56	14.53	3.83	8.01	13.66	14.53	3.65	10.46	7.26	10.05	17.64	14.82	12.93	19.40
9500	3.56	14.53	3.82	8.05	13.91	14.53	3.65	10.46	7.26	10.05	17.64	14.82	12.93	19.40
10000	3.56	14.53	3.82	8.12	14.16	14.53	3.64	10.46	7.26	10.05	17.64	14.82	12.93	19.40
10500	3.56	14.53	3.81	8.22	14.42	14.53	3.63	10.46	7.26	10.05	17.64	14.82	12.93	19.40
11000	3.56	14.53	3.80	8.33	14.68	14.53	3.63	10.46	7.26	10.05	17.64	14.82	12.93	19.40
11500	3.56	14.53	3.79	8.49	14.96	14.53	3.62	10.46	7.26	10.05	17.64	14.82	12.93	19.40
12000	3.56	14.53	3.78	8.64	15.23	14.53	3.61	10.46	7.26	10.05	17.64	14.82	12.93	19.40
12500	3.56	14.53	3.77	8.80	15.51	14.53	3.60	10.46	7.26	10.05	17.64	14.82	12.93	19.40
13000	3.56	14.53	3.76	8.96	15.85	14.53	3.59	10.46	7.26	10.05	17.64	14.82	12.93	19.40
13500	3.56	14.53	3.75	9.13	16.18	14.53	3.57	10.46	7.26	10.05	17.64	14.82	12.93	19.40
14000	3.56	14.53	3.73	9.29	16.59	14.53	3.56	10.46	7.26	10.05	17.64	14.82	12.93	19.40
14500	3.56	14.53	3.72	9.46	17.09	14.53	3.55	10.46	7.26	10.05	17.64	14.82	12.93	19.40
15000	3.56	14.53	3.70	9.67	17.64	14.53	3.53	10.46	7.26	10.05	17.64	14.82	12.93	19.40
15500	3.56	14.53	3.69	9.87	18.11	14.53	3.52	10.46	7.26	10.05	17.64	14.82	12.93	19.40
16000	3.56	14.53	3.67	10.12	18.59	14.53	3.50	10.46	7.26	10.05	17.64	14.82	12.93	19.40
16500	3.56	14.53	3.65	10.43	19.08	14.53	3.48	10.46	7.26	10.05	17.64	14.82	12.93	19.40
17000	3.56	14.53	3.63	10.76	19.56	14.53	3.46	10.46	7.26	10.05	17.64	14.82	12.93	19.40
17500	3.56	14.53	3.61	11.05	19.95	14.53	3.44	10.46	7.26	10.05	17.64	14.82	12.93	19.40
18000	3.56	14.53	3.59	11.34	20.40	14.53	3.42	10.46	7.26	10.05	17.64	14.82	12.93	19.40
18500	3.56	14.53	3.57	11.64	20.87	14.53	3.40	10.46	7.26	10.05	17.64	14.82	12.93	19.40
19000	3.55	14.53	3.54	11.93	21.38	14.53	3.38	10.46	7.26	10.05	17.64	14.82	12.93	19.40
19500	3.55	14.53	3.52	12.17	21.95	14.53	3.36	10.46	7.26	10.05	20.95	14.82	12.93	19.40
20000	3.55	14.53	3.50	12.44	22.46	14.53	3.34	10.46	7.26	10.05	24.26	14.82	12.93	19.40
20500	3.54	14.53	3.51	12.73	22.99	14.53	3.34	10.46	7.26	10.05	23.93	14.82	13.12	19.40
21000	3.54	14.53	3.54	13.04	23.51	14.53	3.37	10.46	7.26	10.05	23.26	14.82	14.08	19.40
21500	3.53	14.53	3.73	13.39	23.99	14.53	3.56	10.46	7.26	10.05	22.85	14.82	15.18	19.40
22000	3.52	14.53	4.44	13.70	24.40	14.53	4.24	10.46	7.26	10.05	22.51	14.82	16.53	19.40
22500	3.51	14.74	5.69	14.02	24.79	14.53	5.43	10.61	7.37	10.05	22.20	14.82	18.86	19.40
23000	3.50	15.82	9.73	14.34	25.17	14.53	9.28	11.39	7.91	10.05	21.90	14.82	22.58	19.40
23500	3.49	17.06	15.48	14.63	25.49	14.74	14.77	12.28	8.53	10.05	21.60	14.82	26.33	19.40
24000	3.48	18.57	19.27	14.89	25.77	15.82	18.38	13.37	9.29	10.05	21.30	14.82	28.73	19.40
24500	3.47	21.19	23.43	15.12	25.82	17.06	22.35	15.25	10.59	10.05	21.00	14.82	30.01	19.40
25000	3.46	25.37	26.11	15.35	25.94	18.57	24.90	18.27	12.69	10.05	20.70	17.60	30.84	19.40
25500	3.44	29.59	28.27	15.55	26.25	21.19	26.96	21.30	14.79	10.05	20.40	20.38	31.16	23.05
26000	3.43	32.28	29.92	15.72	26.76	25.37	28.54	23.24	16.14	10.05	20.10	20.10	30.93	26.69
26500	3.41	33.71	31.06	15.75	27.45	29.59	29.62	24.27	16.86	11.94	19.80	19.54	30.41	26.32
27000	3.40	34.65	32.12	15.83	28.36	32.28	30.63	24.95	17.32	13.83	19.50	19.19	29.37	25.59
27500	3.38	35.01	32.06	16.01	29.52	33.71	30.57	25.21	17.51	13.64	19.20	18.91	27.96	25.14
28000	3.36	34.75	31.09	16.32	31.22	34.65	29.65	25.02	17.38	13.26	18.90	18.60	26.55	24.76
28500	3.34	34.17	29.17	16.74	33.36	35.01	27.82	24.60	17.09	13.02	18.60	18.30	25.18	24.40
29000	3.32	33.00	26.77	17.30	36.02	34.75	25.53	23.76	16.50	12.83	18.30	18.00	23.96	24.00
29500	3.30	31.42	23.65	18.01	38.39	34.17	22.56	22.62	15.71	12.60	18.00	17.70	22.89	23.60
30000	3.28	29.83	20.43	19.04	40.34	33.00	19.48	21.48	14.92	12.40	17.70	17.40	21.95	23.20
30500	3.26	28.29	17.64	20.35	41.51	31.42	16.82	20.37	14.14	12.20	17.50	17.10	21.12	22.80
31000	3.24	26.92	15.14	21.97	42.55	29.83	14.44	19.38	13.46	12.00	17.20	16.80	20.39	22.40
31500	3.25	25.72	13.15	23.42	42.74	28.29	12.54	18.52	12.86	11.80	16.90	16.50	19.76	22.00
32000	3.28	24.66	11.35	24.61	42.43	26.92	10.83	17.75	12.33	11.60	16.60	16.20	19.22	21.60
32500	3.46	23.73	9.75	25.32	41.78	25.72	9.30	17.08	11.86	11.40	16.30	15.90	18.76	21.20
33000	4.11	22.91	8.32	25.96	40.75	24.66	7.93	16.50	11.46	11.20	16.00	15.60	18.37	20.80
33500	5.27	22.21	7.17	26.07	39.75	23.73	6.84	15.99	11.10	11.00	15.70	15.30	18.00	20.40
34000	9.01	21.60	6.28	25.88	38.77	22.91	5.99	15.55	10.80	10.80	15.40	15.00	17.60	20.00
34500	14.34	21.08	5.56	25.48	37.83	22.21	5.30	15.17	10.54	10.60	15.10	14.70	17.20	19.60
35000	17.84	20.64	4.92	24.85	36.94	21.60	4.69	14.86	10.32	10.40	14.80	14.40	16.80	19.20

REPRESENTATIVE GROUP III
HAI VALUES (PERCENT)

Q	100.4R	100.6L	101.2R	101.6L	101.7L	110.4L	115.0R	117.8L	119.3L	128.5R	128.7R	128.8R	130.2R
5000	0.00	0.00	0.00	0.00	0.00	3.01	0.00	0.00	0.00	0.00	0.00	2.06	0.00
5500	0.00	0.00	0.00	0.00	1.75	3.01	0.00	0.00	0.00	0.00	0.00	2.06	0.00
6000	0.00	0.00	0.00	0.00	3.50	3.01	0.00	2.72	0.00	0.00	0.00	2.06	0.00
6500	0.00	0.00	0.00	0.00	5.25	3.01	0.00	5.45	0.00	0.00	0.00	2.06	0.00
7000	0.00	2.37	3.17	0.00	7.00	3.01	0.00	8.17	0.00	0.00	0.00	2.06	0.00
7500	0.00	4.75	6.33	0.00	8.75	3.01	0.00	10.89	0.00	0.00	0.00	2.06	0.00
8000	0.00	7.13	9.50	0.00	10.50	3.01	0.00	13.62	0.00	2.72	0.00	2.06	0.00
8500	0.00	9.50	12.67	0.00	12.26	3.01	0.00	26.03	0.00	5.45	0.00	2.06	0.00
9000	0.00	11.88	15.83	0.00	14.01	3.01	0.00	26.98	0.00	8.17	0.00	2.06	0.00
9500	0.00	22.70	30.27	0.00	20.32	3.01	0.00	28.33	0.00	10.89	0.00	2.06	0.00
10000	0.00	23.53	31.37	2.12	26.63	3.01	3.10	28.07	0.00	13.62	0.00	2.06	3.61
10500	2.88	24.71	32.94	4.25	26.05	3.01	6.21	25.97	0.00	26.03	0.00	2.06	7.22
11000	5.76	24.48	32.64	6.37	25.46	3.01	9.31	23.35	2.12	26.98	0.00	2.06	10.83
11500	8.65	22.64	30.19	8.49	25.05	3.01	12.41	21.58	4.25	28.33	0.00	2.06	14.44
12000	11.53	20.36	27.15	10.62	24.63	3.01	15.52	18.81	6.37	28.07	0.00	2.06	18.05
12500	14.41	18.82	25.09	12.74	24.14	4.35	29.66	17.66	8.49	25.97	0.00	2.06	34.51
13000	27.54	16.41	21.88	14.86	23.66	6.41	30.74	15.27	10.62	23.35	2.79	2.06	35.76
13500	28.55	15.40	20.53	16.99	23.26	9.64	32.28	13.86	12.74	21.58	5.57	2.06	37.55
14000	29.98	13.31	17.75	24.64	22.85	14.84	31.99	12.69	14.86	18.81	8.36	2.06	37.21
14500	29.71	12.09	16.11	32.30	21.75	23.38	29.59	10.87	16.99	17.66	11.15	2.06	34.42
15000	27.48	11.07	14.75	31.59	20.64	38.53	26.61	10.44	24.64	15.27	13.93	2.06	30.95
15500	24.70	9.48	12.64	30.88	19.99	39.49	24.59	10.04	32.30	13.86	26.64	2.06	28.60
16000	22.83	9.11	12.15	30.38	19.35	40.70	21.44	9.67	31.59	12.69	27.61	2.06	24.94
16500	19.91	8.76	11.68	29.87	18.17	39.93	20.12	9.31	30.88	10.87	28.99	2.98	23.41
17000	18.68	8.43	11.24	29.28	17.00	38.34	17.40	8.97	30.38	10.44	28.73	4.39	20.24
17500	16.15	8.12	10.83	28.69	15.63	36.69	15.79	8.66	29.87	10.04	26.57	6.61	18.37
18000	14.66	7.83	10.43	28.20	14.26	35.36	14.46	8.36	29.28	9.67	23.89	10.17	16.82
18500	13.43	7.55	10.07	27.71	13.44	33.58	12.39	8.07	28.69	9.31	22.08	16.02	14.41
19000	11.50	7.29	9.72	26.37	12.61	31.38	11.90	7.80	28.20	8.97	19.25	26.39	13.85
19500	11.05	7.04	9.39	25.03	12.55	28.38	11.44	7.55	27.71	8.66	18.07	27.05	13.31
20000	10.63	6.80	9.07	24.25	12.49	24.72	11.01	7.30	26.37	8.36	15.62	27.88	12.81
20500	10.23	6.58	8.77	23.46	11.60	22.41	10.61	7.07	25.03	8.07	14.18	27.35	12.34
21000	9.85	6.37	8.49	22.04	10.72	20.43	10.23	6.85	24.25	7.80	12.98	26.26	11.90
21500	9.50	6.17	8.22	20.61	10.33	17.97	9.86	6.64	23.46	7.55	11.13	25.13	11.48
22000	9.16	5.97	7.96	18.95	9.95	16.29	9.52	6.44	22.04	7.30	10.69	24.22	11.08
22500	8.84	5.79	7.72	17.29	9.98	14.38	9.20	6.24	20.61	7.07	10.28	23.00	10.70
23000	8.54	5.61	7.48	16.30	10.02	12.25	8.89	6.06	18.95	6.85	9.89	21.49	10.34
23500	8.26	5.45	7.26	15.30	9.67	10.47	8.60	5.88	17.29	6.64	9.53	19.44	10.00
24000	7.99	5.28	7.05	15.22	9.32	8.96	8.32	5.71	16.30	6.44	9.18	16.93	9.68
24500	7.73	5.13	6.84	15.15	8.97	8.98	8.06	5.55	15.30	6.24	8.86	15.35	9.37
25000	7.48	4.98	6.64	14.07	8.63	8.89	7.81	5.40	15.22	6.06	8.55	13.99	9.08
25500	7.25	4.84	6.46	13.00	8.60	8.69	7.56	5.25	15.15	5.88	8.26	12.31	8.80
26000	7.02	4.71	6.27	12.53	8.57	8.89	7.34	5.10	14.07	5.71	7.98	11.16	8.53
26500	6.81	4.58	6.10	12.06	8.63	9.69	7.12	4.97	13.00	5.55	7.72	9.85	8.28
27000	6.61	4.45	5.93	12.11	8.69	9.91	6.91	4.83	12.53	5.40	7.47	8.39	8.03
27500	6.41	4.33	5.77	12.15	8.51	9.45	6.70	4.70	12.06	5.25	7.24	7.17	7.80
28000	6.23	4.21	5.62	11.72	8.34	10.03	6.51	4.58	12.11	5.10	7.01	6.14	7.57
28500	6.05	4.10	5.47	11.30	8.06	11.61	6.33	4.46	12.15	4.97	6.79	6.15	7.36
29000	5.87	3.99	5.33	10.88	7.77	11.78	6.15	4.35	11.72	4.83	6.59	6.09	7.15
29500	5.71	3.89	5.19	10.47	8.36	11.39	5.98	4.24	11.30	4.70	6.39	5.95	6.96
30000	5.55	3.79	5.05	10.43	7.38	11.40	5.82	4.13	10.88	4.58	6.20	6.09	6.76
30500	5.40	3.69	4.93	10.40	7.25	11.26	5.66	4.03	10.47	4.46	6.02	6.64	6.58
31000	5.25	3.60	4.80	10.47	7.13	11.14	5.51	3.93	10.43	4.35	5.85	6.79	6.41
31500	5.11	3.51	4.68	10.53	7.01	11.00	5.36	3.83	10.40	4.24	5.68	6.47	6.24
32000	4.98	3.42	4.57	10.32	6.90	10.90	5.22	3.74	10.47	4.13	5.52	6.87	6.07
32500	4.85	3.34	4.45	10.11	6.79	10.80	5.08	3.65	10.53	4.03	5.37	7.95	5.91
33000	4.72	3.26	4.35	9.77	6.68	10.70	4.95	3.56	10.32	3.93	5.22	8.07	5.76
33500	4.60	3.18	4.24	9.43	6.57	10.60	4.83	3.47	10.11	3.83	5.08	7.80	5.62
34000	4.48	3.10	4.14	10.14	6.47	10.50	4.71	3.39	9.77	3.74	4.94	7.81	5.47
34500	4.37	3.03	4.04	8.81	6.37	10.40	4.59	3.29	9.43	3.65	4.81	7.71	5.34
35000	4.26	2.96	3.94	8.51	6.27	10.30	4.47	3.19	10.14	3.56	4.69	7.63	5.20

REPRESENTATIVE GROUP IV
HAI VALUES (PERCENT)

Q	100.7R	108.7L	110.8M	111.5R	112.6L	114.0R	116.8R	119.5L	119.6L	121.7R	124.1L
5000	13.04	28.04	25.40	25.40	31.75	11.44	12.77	31.97	31.38	12.77	27.24
5500	11.87	25.17	22.81	22.81	28.51	10.42	11.63	33.18	32.58	11.63	28.27
6000	11.07	22.84	20.70	20.70	25.87	9.72	10.84	34.26	33.64	10.84	29.19
6500	10.48	20.46	18.54	18.54	23.17	9.20	10.27	35.16	34.51	10.27	29.95
7000	8.77	20.11	18.22	18.22	22.78	7.70	8.59	36.00	35.34	8.59	30.67
7500	7.81	18.04	16.34	16.34	20.43	6.85	7.64	37.13	36.45	7.64	31.63
8000	9.08	16.41	14.87	14.87	18.59	7.97	8.90	38.22	37.52	8.90	32.56
8500	8.24	14.38	13.03	13.03	16.29	7.23	8.07	37.98	37.28	8.07	32.36
9000	7.12	12.75	11.55	11.55	14.44	6.25	6.98	37.74	37.05	6.98	32.16
9500	6.06	10.94	9.91	9.91	12.39	5.32	5.94	35.83	35.17	5.94	30.52
10000	5.39	9.62	8.72	8.72	10.90	4.73	5.28	34.03	33.41	5.28	29.00
10500	5.63	9.16	8.30	8.30	10.37	4.94	5.51	31.63	31.05	5.51	26.95
11000	5.20	6.49	5.88	5.88	7.36	4.56	5.09	29.51	28.97	5.09	25.14
11500	4.55	5.20	4.71	4.71	5.89	3.99	4.46	29.15	28.62	4.46	24.84
12000	4.01	4.88	4.42	4.42	5.53	3.52	3.93	28.82	28.29	3.93	24.55
12500	3.55	4.56	4.13	4.13	5.16	3.12	3.48	28.04	27.53	3.48	23.89
13000	3.47	4.31	3.90	3.90	4.88	3.05	3.40	27.30	26.80	3.40	23.26
13500	3.12	4.28	3.88	3.88	4.85	2.74	3.06	25.99	25.52	3.06	22.15
14000	2.85	3.97	3.60	3.60	4.50	2.50	2.79	24.76	24.31	2.79	21.10
14500	2.61	3.86	3.50	3.50	4.37	2.29	2.55	24.00	23.56	2.55	20.45
15000	2.46	4.48	4.06	4.06	5.07	2.16	2.41	23.26	22.83	2.41	19.81
15500	2.42	4.54	4.11	4.11	5.14	2.13	2.37	22.42	22.01	2.37	19.10
16000	2.30	4.71	4.26	4.26	5.33	2.02	2.25	21.59	21.20	2.25	18.40
16500	2.29	4.50	4.08	4.08	5.10	2.01	2.25	21.10	20.72	2.25	17.98
17000	2.18	4.76	4.31	4.31	5.39	1.91	2.13	20.64	20.26	2.13	17.58
17500	2.13	4.41	3.99	3.99	4.99	1.87	2.08	19.92	19.56	2.08	16.98
18000	2.07	4.19	3.80	3.80	4.75	1.82	2.03	19.22	18.87	2.03	16.38
18500	1.96	3.84	3.48	3.48	4.35	1.72	1.92	18.69	18.35	1.92	15.93
19000	1.92	3.60	3.26	3.26	4.08	1.68	1.88	18.17	17.83	1.88	15.48
19500	1.70	3.34	3.02	3.02	3.78	1.49	1.66	17.82	17.49	1.66	15.18
20000	1.53	3.11	2.82	2.82	3.52	1.34	1.50	17.46	17.15	1.50	14.88
20500	1.53	2.94	2.66	2.66	3.33	1.34	1.50	17.23	16.91	1.50	14.68
21000	1.51	2.74	2.48	2.48	3.10	1.32	1.47	17.00	16.69	1.47	14.48
21500	1.51	2.54	2.30	2.30	2.88	1.32	1.47	16.60	16.29	1.47	14.14
22000	1.57	2.39	2.17	2.17	2.71	1.37	1.53	16.21	15.91	1.53	13.81
22500	1.59	2.30	2.09	2.09	2.61	1.40	1.56	15.83	15.54	1.56	13.49
23000	1.63	2.18	1.98	1.98	2.47	1.43	1.59	15.47	15.18	1.59	13.18
23500	1.65	2.08	1.88	1.88	2.35	1.45	1.62	15.11	14.83	1.62	12.87
24000	1.68	1.96	1.78	1.78	2.22	1.47	1.65	14.76	14.49	1.65	12.58
24500	1.71	1.92	1.74	1.74	2.17	1.50	1.67	14.42	14.15	1.67	12.28
25000	1.74	1.82	1.65	1.65	2.06	1.53	1.71	14.09	13.83	1.71	12.00
25500	1.77	1.77	1.60	1.60	2.00	1.55	1.73	13.75	13.50	1.73	11.72
26000	1.79	1.69	1.53	1.53	1.91	1.57	1.76	13.43	13.19	1.76	11.45
26500	1.79	1.60	1.45	1.45	1.81	1.57	1.75	13.13	12.89	1.75	11.18
27000	1.81	1.55	1.41	1.41	1.76	1.59	1.77	12.83	12.59	1.77	10.93
27500	1.85	1.47	1.33	1.33	1.66	1.62	1.81	12.54	12.31	1.81	10.68
28000	1.86	1.43	1.30	1.30	1.62	1.63	1.82	12.25	12.03	1.82	10.44
28500	1.87	1.35	1.22	1.22	1.53	1.64	1.83	11.98	11.76	1.83	10.20
29000	1.87	1.31	1.18	1.18	1.48	1.64	1.83	11.71	11.49	1.83	9.98
29500	1.88	1.24	1.12	1.12	1.40	1.65	1.84	11.44	11.24	1.84	9.75
30000	1.88	1.21	1.10	1.10	1.37	1.65	1.84	11.19	10.98	1.84	9.53
30500	1.91	1.15	1.04	1.04	1.30	1.67	1.87	10.89	10.69	1.87	9.28
31000	1.99	1.13	1.02	1.02	1.28	1.74	1.95	10.59	10.40	1.95	9.03
31500	2.03	1.09	0.98	0.98	1.23	1.78	1.99	10.37	10.18	1.99	8.83
32000	2.06	1.05	0.95	0.95	1.19	1.80	2.01	10.15	9.96	2.01	8.65
32500	2.08	1.01	0.91	0.91	1.14	1.83	2.04	9.95	9.77	2.04	8.48
33000	2.09	0.97	0.88	0.88	1.10	1.84	2.05	9.76	9.58	2.05	8.32
33500	2.11	0.97	0.88	0.88	1.10	1.85	2.07	9.57	9.40	2.07	8.16
34000	2.12	0.96	0.87	0.87	1.09	1.86	2.07	9.39	9.22	2.07	8.00
34500	2.12	0.93	0.84	0.84	1.05	1.86	2.07	9.21	9.04	2.07	7.85
35000	2.13	0.94	0.86	0.86	1.07	1.87	2.08	9.04	8.87	2.08	7.70

REPRESENTATIVE GROUP V
HAI VALUES (PERCENT)

Q	101.7L	117.0M	118.9L	124.0M	132.8R	139.0L	139.7R	141.6R	143.0L
5000	11.48	7.42	11.49	12.20	13.64	8.85	12.20	13.40	7.42
5500	11.48	7.42	14.53	12.20	13.64	11.20	12.20	13.40	7.42
6000	11.48	7.42	17.26	12.20	13.64	13.31	12.20	13.40	7.42
6500	11.48	7.42	19.77	12.20	13.64	15.24	12.20	13.40	7.42
7000	11.48	7.42	22.06	12.20	13.64	17.01	12.20	13.40	7.42
7500	11.48	7.42	24.18	12.20	13.64	18.64	12.20	13.40	9.38
8000	11.48	7.42	26.13	12.20	13.64	20.15	12.20	13.40	11.15
8500	11.48	7.42	26.10	12.20	13.64	20.12	12.20	13.40	12.77
9000	11.48	7.42	25.52	12.20	13.64	19.67	12.20	13.40	14.25
9500	11.48	7.42	24.73	12.20	13.64	19.06	12.20	13.40	15.62
10000	11.49	7.42	24.06	12.20	13.64	18.55	12.20	13.40	16.88
10500	14.53	7.42	23.12	12.20	13.64	17.82	12.20	13.40	16.86
11000	17.26	7.42	21.58	12.20	13.64	16.64	12.20	13.40	16.48
11500	19.77	7.42	18.81	12.20	13.64	14.50	12.20	13.40	15.97
12000	22.06	7.42	17.31	12.20	13.64	13.35	12.20	13.40	15.54
12500	24.18	7.42	16.80	12.20	13.64	12.95	12.20	13.40	14.93
13000	26.13	7.42	14.25	12.20	13.64	10.99	12.20	13.40	13.94
13500	26.10	7.42	13.24	12.20	13.64	10.21	12.20	13.40	12.15
14000	25.52	7.42	11.81	12.20	13.64	9.10	12.20	13.40	11.18
14500	24.73	7.42	10.79	12.20	13.64	8.32	12.20	13.40	10.85
15000	24.06	7.42	9.16	12.20	13.64	7.06	12.20	13.40	9.21
15500	23.12	7.42	7.74	12.20	13.64	5.97	12.20	13.40	8.55
16000	21.58	9.38	7.37	12.20	13.64	5.68	12.20	13.40	7.63
16500	18.81	11.15	6.82	12.20	13.64	5.26	12.20	13.40	6.97
17000	17.31	12.77	6.05	12.20	13.64	4.66	12.20	13.40	5.92
17500	16.80	14.25	5.57	12.20	13.64	4.29	12.20	13.40	5.00
18000	14.25	15.62	5.24	12.20	13.64	4.04	12.20	13.40	4.76
18500	13.24	16.88	5.23	12.20	13.64	4.03	12.20	13.40	4.41
19000	11.81	16.86	4.92	12.20	13.64	3.79	12.20	13.40	3.91
19500	10.79	16.48	4.74	12.20	13.64	3.65	12.20	13.40	3.60
20000	9.16	15.97	4.62	12.20	17.25	3.56	12.20	13.40	3.38
20500	7.74	15.54	4.50	12.20	20.50	3.47	12.20	13.40	3.38
21000	7.37	14.93	4.38	12.20	23.47	3.38	12.20	13.40	3.18
21500	6.82	13.94	4.27	12.20	26.20	3.29	12.20	16.95	3.06
22000	6.05	12.15	4.17	12.20	28.72	3.21	12.20	20.14	2.98
22500	5.57	11.18	4.06	12.20	31.03	3.13	15.43	23.06	2.91
23000	5.24	10.85	3.97	12.20	30.99	3.06	18.34	25.74	2.83
23500	5.23	9.21	3.87	15.43	30.30	2.98	21.00	28.21	2.76
24000	4.92	8.55	3.77	18.34	29.37	2.91	23.44	30.49	2.69
24500	4.74	7.63	3.68	21.00	28.57	2.84	25.69	30.45	2.63
25000	4.62	6.97	3.60	23.44	27.45	2.77	27.77	29.77	2.56
25500	4.50	5.92	3.51	25.69	25.63	2.71	27.73	28.85	2.50
26000	4.38	5.00	3.43	27.77	22.33	2.64	27.11	28.07	2.44
26500	4.27	4.76	3.35	27.73	20.56	2.58	26.27	26.97	2.38
27000	4.17	4.41	3.27	27.11	19.95	2.52	25.56	25.18	2.32
27500	4.06	3.91	3.20	26.27	16.93	2.46	24.56	21.94	2.27
28000	3.97	3.60	3.12	25.56	15.73	2.41	22.93	20.20	2.21
28500	3.87	3.38	3.05	24.56	14.03	2.35	19.98	19.60	2.16
29000	3.77	3.38	2.98	22.93	12.81	2.30	18.40	16.63	2.11
29500	3.68	3.18	2.92	19.98	10.88	2.25	17.85	15.45	2.06
30000	3.60	3.06	2.85	18.40	9.19	2.20	15.15	13.78	2.02
30500	3.51	2.98	2.79	17.85	8.75	2.15	14.07	12.59	1.97
31000	3.43	2.91	2.73	15.15	8.10	2.10	12.55	10.69	1.93
31500	3.35	2.83	2.67	14.07	7.19	2.06	11.47	9.03	1.88
32000	3.27	2.76	2.61	12.55	6.62	2.01	9.74	8.60	1.84
32500	3.20	2.69	2.55	11.47	6.22	1.97	8.22	7.96	1.80
33000	3.12	2.63	2.50	9.74	6.21	1.92	7.83	7.06	1.76
33500	3.05	2.56	2.44	8.22	5.84	1.88	7.25	6.50	1.72
34000	2.98	2.50	2.39	7.83	5.63	1.84	6.43	6.11	1.68
34500	2.92	2.44	2.34	7.25	5.48	1.80	5.92	6.10	1.65
35000	2.85	2.38	2.29	6.43	5.34	1.77	5.56	5.74	1.61

REPRESENTATIVE GROUP VII
HAI VALUES (PERCENT)

Q	114.1R	119.2R	121.1L	123.0L	125.6L	127.5M	131.3L
5000	29.27	18.60	19.51	36.82	49.10	29.27	14.06
5500	29.53	18.60	23.72	37.15	49.54	29.53	14.06
6000	29.83	18.60	27.94	37.53	50.03	29.83	14.06
6500	28.21	18.60	32.16	35.49	47.32	28.21	14.06
7000	26.06	18.60	36.38	32.79	43.72	26.06	17.10
7500	27.72	18.60	40.60	34.87	46.50	27.72	20.14
8000	26.73	22.62	40.97	33.63	44.83	26.73	23.19
8500	24.64	26.64	41.37	31.00	41.33	24.64	26.22
9000	22.82	30.66	39.13	28.71	38.28	22.82	29.27
9500	21.09	34.68	36.15	26.53	35.37	21.09	29.53
10000	18.94	38.71	38.45	23.83	31.77	18.94	29.83
10500	16.81	39.06	37.07	21.15	28.19	16.81	28.21
11000	15.05	39.45	34.18	18.94	25.25	15.05	26.06
11500	13.63	37.31	31.65	17.15	22.87	13.63	27.72
12000	12.04	34.47	29.25	15.14	20.19	12.04	26.73
12500	11.28	36.66	26.27	14.19	18.92	11.28	24.64
13000	10.36	35.35	23.31	13.03	17.38	10.36	22.82
13500	9.28	32.59	20.88	11.68	15.57	9.28	21.09
14000	8.45	30.18	18.91	10.63	14.17	8.45	18.94
14500	7.37	27.89	16.70	9.27	12.37	7.37	16.81
15000	6.47	25.05	15.65	8.14	10.86	6.47	15.05
15500	5.98	22.23	14.37	7.52	10.03	5.98	13.63
16000	5.54	19.91	12.88	6.97	9.30	5.54	12.04
16500	5.15	18.03	11.71	6.47	8.63	5.15	11.28
17000	4.78	15.92	10.23	6.01	8.02	4.78	10.36
17500	4.45	14.92	8.98	5.59	7.46	4.45	9.28
18000	4.14	13.70	8.29	5.21	6.94	4.14	8.45
18500	3.85	12.28	7.69	4.85	6.46	3.85	7.37
19000	3.59	11.17	7.14	4.52	6.03	3.59	6.47
19500	3.35	9.75	6.63	4.22	5.62	3.35	5.98
20000	3.27	8.56	6.17	4.11	5.48	3.27	5.54
20500	3.19	7.91	5.74	4.01	5.35	3.19	5.15
21000	3.11	7.33	5.35	3.92	5.22	3.11	4.78
21500	3.04	6.81	4.98	3.82	5.10	3.04	4.45
22000	2.97	6.32	4.65	3.73	4.98	2.97	4.14
22500	2.90	5.88	4.53	3.65	4.86	2.90	3.85
23000	2.83	5.47	4.42	3.57	4.75	2.83	3.59
23500	2.77	5.10	4.32	3.49	4.65	2.77	3.35
24000	2.71	4.75	4.22	3.41	4.54	2.71	3.27
24500	2.65	4.43	4.12	3.33	4.44	2.65	3.19
25000	2.59	4.32	4.02	3.26	4.35	2.59	3.11
25500	2.54	4.22	3.93	3.19	4.25	2.54	3.04
26000	2.48	4.12	3.84	3.12	4.16	2.48	2.97
26500	2.43	4.02	3.76	3.06	4.07	2.43	2.90
27000	2.38	3.93	3.67	2.99	3.99	2.38	2.83
27500	2.33	3.84	3.59	2.93	3.91	2.33	2.77
28000	2.28	3.75	3.52	2.87	3.83	2.28	2.71
28500	2.23	3.66	3.44	2.81	3.75	2.23	2.65
29000	2.19	3.58	3.37	2.75	3.67	2.19	2.59
29500	2.14	3.50	3.30	2.70	3.60	2.14	2.54
30000	2.10	3.43	3.23	2.64	3.53	2.10	2.48
30500	2.06	3.35	3.16	2.59	3.46	2.06	2.43
31000	2.02	3.28	3.10	2.54	3.39	2.02	2.38
31500	1.98	3.21	3.04	2.49	3.32	1.98	2.33
32000	1.94	3.14	2.97	2.44	3.26	1.94	2.28
32500	1.91	3.08	2.92	2.40	3.20	1.91	2.23
33000	1.87	3.02	2.86	2.35	3.14	1.87	2.19
33500	1.83	2.95	2.80	2.31	3.08	1.83	2.14
34000	1.80	2.89	2.75	2.26	3.02	1.80	2.10
34500	1.77	2.84	2.69	2.22	2.96	1.77	2.06
35000	1.73	2.78	2.64	2.18	2.91	1.73	2.02

REPRESENTATIVE GROUP VIII
HAI VALUES (PERCENT)

Q	123.2R	124.8R	125.6R	128.4R	132.5L	135.0R	135.1R	144.0M	145.6R	146.6L
5000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9000	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00
9500	0.00	0.00	0.00	4.91	0.00	0.00	0.00	0.00	0.00	0.00
10000	0.00	0.00	0.00	8.40	0.00	0.00	0.00	0.00	0.00	0.00
10500	0.00	0.00	0.00	13.38	0.00	0.00	0.00	0.00	0.00	0.00
11000	0.00	0.00	0.00	16.65	0.00	0.00	0.00	0.00	0.00	0.00
11500	0.00	0.00	0.00	20.24	0.00	0.00	0.00	0.00	0.00	0.00
12000	0.00	0.00	0.00	22.56	0.00	0.00	0.00	0.00	0.00	0.00
12500	0.00	0.00	0.00	24.42	0.00	0.00	0.00	0.00	0.00	0.00
13000	0.00	0.00	0.00	25.85	0.00	0.00	0.00	0.00	0.00	0.00
13500	0.00	0.00	0.00	26.83	0.00	0.00	0.00	0.00	0.00	0.00
14000	0.00	0.00	0.00	27.75	0.00	0.00	0.00	0.00	0.00	0.00
14500	0.00	0.00	0.00	27.69	25.14	0.00	0.00	0.00	0.00	0.00
15000	0.00	0.00	0.00	26.85	32.95	0.00	0.00	0.00	0.00	0.00
15500	0.00	0.00	0.00	25.20	32.23	0.00	0.00	0.00	0.00	0.00
16000	0.00	0.00	0.00	23.12	31.51	0.00	0.00	0.00	0.00	0.00
16500	0.00	0.00	0.00	20.43	30.99	0.00	0.00	0.00	0.00	0.00
17000	0.00	0.00	0.00	17.65	30.47	0.00	0.00	0.00	0.00	0.00
17500	0.00	0.00	0.00	15.24	29.87	0.00	0.00	0.00	0.00	0.00
18000	0.00	0.00	0.00	13.08	29.27	0.00	0.00	0.00	0.00	0.00
18500	0.00	0.00	0.00	11.36	28.77	0.00	0.00	0.00	0.00	0.00
19000	0.00	0.00	0.00	9.81	28.27	0.00	0.00	0.00	0.00	0.00
19500	0.00	20.30	0.00	8.42	26.91	0.00	0.00	0.00	0.00	0.00
20000	0.00	26.60	0.00	7.19	25.54	0.00	19.41	0.00	0.00	0.00
20500	0.00	26.02	0.00	6.19	24.74	0.00	25.44	0.00	0.00	0.00
21000	0.00	25.44	0.00	5.43	23.93	0.00	24.88	0.00	0.00	0.00
21500	0.00	25.02	0.00	4.80	22.48	19.41	24.33	0.00	0.00	0.00
22000	0.00	24.60	0.00	4.25	21.03	25.44	23.93	13.69	1.58	0.00
22500	0.00	24.12	0.00	3.82	19.33	24.88	23.53	17.93	5.44	0.00
23000	11.48	23.63	0.00	3.41	17.64	24.33	23.07	17.54	9.30	0.00
23500	15.04	23.23	0.00	3.17	16.63	23.93	22.60	17.15	14.81	0.00
24000	14.71	22.83	0.00	3.03	15.61	23.53	22.22	16.87	18.43	0.00
24500	14.38	21.72	0.00	2.94	15.53	23.07	21.83	16.58	22.41	0.00
25000	14.15	20.62	0.00	2.89	15.46	22.60	20.78	16.26	24.98	0.00
25500	13.91	19.97	0.00	2.85	14.36	22.22	19.72	15.93	27.04	0.00
26000	13.64	19.32	1.12	2.80	13.26	21.83	19.10	15.66	28.62	0.00
26500	13.37	18.15	3.86	2.80	12.78	20.78	18.48	15.39	29.71	1.22
27000	13.14	16.98	6.60	2.80	12.30	19.72	17.36	14.64	30.72	4.21
27500	12.91	15.61	10.51	2.80	12.35	19.10	16.24	13.90	30.66	7.21
28000	12.28	14.24	13.08	2.80	12.40	18.48	14.93	13.46	29.73	11.47
28500	11.66	13.42	15.90	2.80	11.96	17.36	13.62	13.03	27.90	14.28
29000	11.29	12.60	17.72	2.80	11.53	16.24	12.84	12.24	25.60	17.36
29500	10.93	12.54	19.19	2.80	11.10	14.93	12.05	11.44	22.62	19.34
30000	10.26	12.48	20.31	2.80	10.68	13.62	11.99	10.52	19.54	20.94
30500	9.60	11.59	21.08	2.80	10.64	12.84	11.93	9.60	16.87	22.16
31000	8.83	10.70	21.80	2.80	10.61	12.05	11.09	9.05	14.48	23.01
31500	8.06	10.32	21.76	2.80	10.68	11.99	10.24	8.49	12.58	23.79
32000	7.59	9.93	21.10	2.80	10.75	11.93	9.87	8.45	10.86	23.75
32500	7.13	9.97	19.80	2.80	10.53	11.09	9.50	8.41	9.32	23.03
33000	7.09	10.01	18.17	2.80	10.32	10.24	9.54	7.81	7.96	21.61
33500	7.06	9.66	16.05	2.80	9.97	9.87	9.57	7.22	6.86	19.83
34000	6.56	9.31	13.86	2.80	9.62	9.50	9.24	6.96	6.01	17.52
34500	6.05	8.96	11.97	2.80	10.34	9.54	8.90	6.70	5.31	15.13
35000	5.84	8.62	10.28	2.80	9.13	9.57	8.57	6.72	4.70	13.07

REPRESENTATIVE GROUP IX
HAI VALUES

Q	129.8R	131.2R	135.0L	139.2R	141.2R	141.3R	142.8R	144.0R	144.2L	147.1L
5000	2.89	4.16	2.48	5.29	3.56	3.56	4.85	1.60	2.73	2.94
5500	2.55	4.20	2.19	5.34	3.15	3.15	4.90	1.41	2.42	2.60
6000	2.64	4.46	2.26	5.67	3.26	3.26	5.20	1.46	2.50	2.69
6500	2.57	4.62	2.21	5.87	3.17	3.17	5.39	1.43	2.44	2.62
7000	2.39	4.68	2.05	5.95	2.94	2.94	5.46	1.32	2.26	2.43
7500	2.28	4.76	1.95	6.05	2.81	2.81	5.55	1.26	2.16	2.32
8000	2.34	4.57	2.00	5.80	2.88	2.88	5.32	1.29	2.21	2.38
8500	2.46	4.87	2.11	6.20	3.03	3.03	5.69	1.36	2.32	2.50
9000	2.58	5.62	2.21	7.15	3.18	3.18	6.56	1.43	2.45	2.63
9500	2.41	5.29	2.06	6.73	2.97	2.97	6.17	1.33	2.28	2.45
10000	2.50	5.29	2.14	6.73	3.07	3.07	6.17	1.38	2.36	2.54
10500	2.41	5.15	2.06	6.55	2.97	2.97	6.01	1.33	2.28	2.45
11000	2.47	4.97	2.11	6.32	3.04	3.04	5.80	1.37	2.33	2.51
11500	2.39	4.64	2.05	5.90	2.94	2.94	5.41	1.32	2.26	2.43
12000	2.29	4.34	1.96	5.52	2.82	2.82	5.06	1.27	2.17	2.33
12500	2.47	4.09	2.11	5.19	3.04	3.04	4.76	1.37	2.33	2.51
13000	2.44	4.44	2.09	5.64	3.00	3.00	5.18	1.35	2.31	2.48
13500	2.53	4.31	2.17	5.48	3.12	3.12	5.03	1.40	2.40	2.58
14000	2.71	4.43	2.32	5.63	3.34	3.34	5.16	1.50	2.57	2.76
14500	2.31	4.31	1.98	5.48	2.84	2.84	5.03	1.28	2.19	2.35
15000	2.40	4.21	2.05	5.36	2.95	2.95	4.91	1.33	2.27	2.44
15500	2.53	4.26	2.17	5.41	3.12	3.12	4.96	1.40	2.40	2.58
16000	2.75	4.02	2.36	5.11	3.39	3.39	4.69	1.52	2.60	2.80
16500	2.77	3.80	2.37	4.83	3.41	3.41	4.43	1.53	2.62	2.82
17000	2.45	3.64	2.10	4.62	3.01	3.01	4.24	1.35	2.32	2.49
17500	2.70	3.77	2.32	4.79	3.33	3.33	4.39	1.50	2.56	2.75
18000	2.83	3.68	2.42	4.68	3.49	3.49	4.29	1.57	2.68	2.88
18500	3.05	3.49	2.61	4.43	3.75	3.75	4.07	1.69	2.88	3.10
19000	3.00	3.85	2.57	4.90	3.69	3.69	4.49	1.66	2.84	3.05
19500	3.01	3.85	2.58	4.90	3.70	3.70	4.49	1.66	2.85	3.06
20000	2.90	3.85	2.48	4.90	3.57	3.57	4.49	1.60	2.74	2.95
20500	2.87	3.85	2.46	4.90	3.53	3.53	4.49	1.59	2.72	2.92
21000	2.82	4.48	2.42	5.70	3.47	3.47	5.22	1.56	2.67	2.87
21500	2.94	4.54	2.52	5.78	3.62	3.62	5.30	1.63	2.78	2.99
22000	3.08	4.66	2.64	5.93	3.79	3.79	5.44	1.70	2.91	3.13
22500	3.12	4.75	2.68	6.03	3.85	3.85	5.54	1.73	2.96	3.18
23000	3.22	4.77	2.76	6.06	3.97	3.97	5.56	1.78	3.05	3.28
23500	3.43	4.77	2.94	6.06	4.22	4.22	5.56	1.90	3.25	3.49
24000	3.54	4.78	3.03	6.07	4.36	4.36	5.57	1.96	3.35	3.60
24500	3.56	4.82	3.05	6.13	4.38	4.38	5.62	1.97	3.37	3.62
25000	3.56	4.87	3.05	6.20	4.38	4.38	5.69	1.97	3.37	3.62
25500	3.52	5.00	3.01	6.36	4.33	4.33	5.83	1.95	3.33	3.58
26000	3.51	5.40	3.01	6.86	4.32	4.32	6.29	1.94	3.32	3.57
26500	3.45	5.48	2.96	6.97	4.25	4.25	6.39	1.91	3.26	3.51
27000	3.48	5.53	2.98	7.02	4.29	4.29	6.44	1.93	3.29	3.54
27500	3.53	5.60	3.02	7.12	4.35	4.35	6.53	1.95	3.34	3.59
28000	3.42	5.60	2.93	7.12	4.21	4.21	6.53	1.89	3.24	3.48
28500	3.30	5.60	2.83	7.12	4.07	4.07	6.53	1.83	3.12	3.36
29000	3.16	5.51	2.71	7.01	3.90	3.90	6.43	1.75	2.99	3.22
29500	3.09	5.39	2.65	6.85	3.81	3.81	6.29	1.71	2.93	3.15
30000	3.16	5.26	2.71	6.69	3.90	3.90	6.13	1.75	2.99	3.22
30500	3.57	5.17	3.06	6.58	4.39	4.39	6.03	1.97	3.38	3.63
31000	3.48	5.05	2.98	6.41	4.29	4.29	5.88	1.93	3.29	3.54
31500	3.37	4.97	2.89	6.32	4.15	4.15	5.80	1.87	3.19	3.43
32000	3.40	4.97	2.91	6.32	4.19	4.19	5.80	1.88	3.22	3.46
32500	3.30	4.87	2.83	6.20	4.07	4.07	5.69	1.83	3.12	3.36
33000	3.15	4.79	2.70	6.09	3.89	3.89	5.59	1.75	2.98	3.21
33500	3.05	4.70	2.61	5.98	3.75	3.75	5.49	1.69	2.88	3.10
34000	2.96	4.61	2.53	5.86	3.64	3.64	5.37	1.64	2.80	3.01
34500	2.88	4.51	2.47	5.74	3.55	3.55	5.26	1.59	2.72	2.93
35000	2.78	4.45	2.38	5.65	3.43	3.43	5.19	1.54	2.63	2.83

APPENDIX C

WETTED SURFACE AREAS (WSA) FOR SPECIFIC AREAS

REPRESENTATIVE GROUP I
WETTED SURFACE AREA (SQ.FT./10^6)

Q	102.2L	105.2R	107.6L	108.3L	112.5L	119.4L	120.0R	121.9R	123.1R	123.3R	127.2M	129.4R	133.9L	134.0L
5000	0.046	0.000	0.016	0.023	0.095	0.000	0.040	0.011	.000	0.025	0.004	0.097	0.047	0.014
5500	0.046	0.002	0.016	0.023	0.097	0.000	0.043	0.011	0.002	0.025	0.004	0.097	0.047	0.014
6000	0.046	0.004	0.016	0.023	0.099	0.000	0.045	0.011	0.004	0.025	0.005	0.097	0.047	0.014
6500	0.046	0.006	0.016	0.023	0.101	0.000	0.047	0.011	0.006	0.025	0.005	0.097	0.047	0.014
7000	0.046	0.008	0.016	0.023	0.103	0.000	0.049	0.011	0.008	0.025	0.005	0.097	0.047	0.014
7500	0.046	0.009	0.016	0.023	0.104	0.000	0.051	0.011	0.009	0.025	0.006	0.097	0.047	0.014
8000	0.046	0.011	0.016	0.023	0.106	0.000	0.053	0.011	0.011	0.025	0.006	0.097	0.047	0.014
8500	0.046	0.012	0.016	0.023	0.107	0.000	0.054	0.011	0.012	0.025	0.006	0.097	0.047	0.014
9000	0.046	0.013	0.016	0.023	0.108	0.000	0.056	0.011	0.013	0.025	0.006	0.097	0.047	0.014
9500	0.046	0.015	0.016	0.023	0.110	0.000	0.057	0.011	0.014	0.025	0.007	0.097	0.047	0.014
10000	0.046	0.016	0.016	0.023	0.111	0.000	0.059	0.011	0.016	0.025	0.007	0.097	0.047	0.014
10500	0.046	0.017	0.016	0.023	0.112	0.000	0.060	0.011	0.017	0.025	0.007	0.097	0.047	0.014
11000	0.046	0.018	0.016	0.023	0.113	0.014	0.061	0.011	0.018	0.025	0.007	0.097	0.047	0.014
11500	0.046	0.019	0.016	0.023	0.114	0.015	0.062	0.011	0.019	0.025	0.007	0.097	0.047	0.014
12000	0.046	0.020	0.016	0.023	0.115	0.016	0.064	0.011	0.020	0.025	0.008	0.097	0.047	0.014
12500	0.046	0.021	0.016	0.023	0.116	0.017	0.065	0.011	0.021	0.025	0.030	0.097	0.047	0.014
13000	0.046	0.022	0.016	0.024	0.117	0.018	0.066	0.011	0.021	0.025	0.030	0.097	0.047	0.014
13500	0.046	0.023	0.020	0.024	0.118	0.019	0.067	0.011	0.022	0.025	0.031	0.097	0.047	0.014
14000	0.046	0.024	0.025	0.024	0.119	0.020	0.068	0.011	0.023	0.025	0.031	0.097	0.047	0.014
14500	0.046	0.024	0.030	0.024	0.119	0.021	0.069	0.011	0.024	0.025	0.031	0.097	0.047	0.014
15000	0.046	0.025	0.034	0.024	0.120	0.022	0.070	0.011	0.025	0.025	0.031	0.097	0.047	0.014
15500	0.046	0.026	0.038	0.024	0.121	0.023	0.071	0.011	0.025	0.025	0.032	0.097	0.047	0.014
16000	0.046	0.027	0.042	0.024	0.122	0.023	0.071	0.011	0.026	0.025	0.032	0.097	0.047	0.014
16500	0.046	0.027	0.046	0.024	0.122	0.024	0.072	0.011	0.027	0.030	0.032	0.097	0.047	0.017
17000	0.046	0.028	0.050	0.024	0.123	0.025	0.073	0.011	0.027	0.031	0.032	0.097	0.047	0.017
17500	0.046	0.029	0.054	0.024	0.124	0.025	0.074	0.011	0.028	0.032	0.032	0.097	0.047	0.018
18000	0.046	0.029	0.058	0.024	0.124	0.026	0.075	0.011	0.029	0.033	0.033	0.097	0.047	0.018
18500	0.046	0.030	0.061	0.024	0.125	0.027	0.075	0.011	0.029	0.034	0.033	0.097	0.048	0.019
19000	0.046	0.031	0.065	0.024	0.126	0.027	0.076	0.011	0.030	0.035	0.033	0.097	0.048	0.019
19500	0.046	0.031	0.068	0.024	0.126	0.028	0.077	0.011	0.030	0.036	0.033	0.097	0.049	0.019
20000	0.046	0.032	0.071	0.024	0.127	0.029	0.077	0.011	0.031	0.037	0.033	0.097	0.049	0.020
20500	0.046	0.032	0.075	0.024	0.127	0.029	0.078	0.011	0.031	0.038	0.033	0.097	0.050	0.020
21000	0.046	0.033	0.078	0.024	0.128	0.030	0.079	0.011	0.032	0.039	0.034	0.097	0.050	0.020
21500	0.046	0.033	0.081	0.024	0.128	0.030	0.079	0.011	0.032	0.040	0.034	0.097	0.051	0.021
22000	0.046	0.034	0.084	0.024	0.129	0.031	0.080	0.011	0.033	0.041	0.034	0.097	0.051	0.021
22500	0.046	0.034	0.087	0.024	0.129	0.032	0.081	0.011	0.033	0.041	0.034	0.097	0.051	0.021
23000	0.046	0.035	0.090	0.024	0.130	0.032	0.088	0.011	0.034	0.041	0.034	0.097	0.052	0.022
23500	0.046	0.035	0.092	0.024	0.130	0.033	0.092	0.011	0.034	0.041	0.034	0.097	0.052	0.022
24000	0.046	0.036	0.095	0.024	0.131	0.033	0.096	0.011	0.035	0.041	0.035	0.097	0.053	0.022
24500	0.046	0.036	0.098	0.024	0.131	0.034	0.099	0.011	0.035	0.041	0.035	0.097	0.053	0.022
25000	0.046	0.037	0.100	0.024	0.132	0.034	0.103	0.011	0.036	0.041	0.035	0.097	0.053	0.022
25500	0.046	0.037	0.103	0.024	0.132	0.035	0.106	0.011	0.036	0.041	0.035	0.097	0.054	0.022
26000	0.046	0.038	0.106	0.024	0.133	0.035	0.109	0.011	0.037	0.041	0.035	0.097	0.054	0.022
26500	0.046	0.038	0.108	0.024	0.133	0.035	0.113	0.011	0.037	0.041	0.035	0.097	0.055	0.022
27000	0.046	0.039	0.110	0.024	0.134	0.036	0.116	0.011	0.037	0.041	0.035	0.097	0.055	0.022
27500	0.046	0.039	0.113	0.024	0.134	0.036	0.119	0.011	0.038	0.041	0.036	0.097	0.055	0.022
28000	0.046	0.040	0.115	0.024	0.135	0.037	0.120	0.011	0.038	0.041	0.036	0.097	0.056	0.022
28500	0.046	0.040	0.117	0.024	0.135	0.037	0.120	0.011	0.039	0.041	0.036	0.097	0.056	0.022
29000	0.046	0.040	0.120	0.024	0.135	0.038	0.120	0.011	0.039	0.041	0.036	0.097	0.056	0.022
29500	0.046	0.041	0.122	0.024	0.136	0.038	0.120	0.011	0.039	0.041	0.036	0.097	0.057	0.022
30000	0.046	0.041	0.124	0.024	0.136	0.038	0.120	0.011	0.040	0.041	0.036	0.097	0.057	0.022
30500	0.046	0.041	0.126	0.024	0.136	0.039	0.120	0.011	0.040	0.041	0.036	0.097	0.057	0.022
31000	0.046	0.042	0.128	0.024	0.137	0.039	0.120	0.011	0.041	0.041	0.036	0.097	0.057	0.022
31500	0.046	0.042	0.131	0.024	0.137	0.040	0.120	0.011	0.041	0.041	0.037	0.097	0.058	0.022
32000	0.046	0.043	0.133	0.024	0.138	0.040	0.120	0.011	0.041	0.041	0.037	0.097	0.058	0.022
32500	0.046	0.043	0.135	0.024	0.138	0.040	0.120	0.011	0.042	0.041	0.037	0.097	0.058	0.022
33000	0.046	0.043	0.137	0.024	0.138	0.041	0.120	0.011	0.042	0.041	0.037	0.097	0.059	0.022
33500	0.046	0.044	0.139	0.024	0.139	0.041	0.120	0.011	0.042	0.041	0.037	0.097	0.059	0.022
34000	0.046	0.044	0.140	0.024	0.139	0.041	0.120	0.011	0.043	0.041	0.037	0.097	0.059	0.022
34500	0.046	0.044	0.142	0.024	0.139	0.042	0.120	0.011	0.043	0.041	0.037	0.097	0.060	0.022
35000	0.046	0.045	0.144	0.024	0.140	0.042	0.120	0.011	0.043	0.041	0.037	0.097	0.060	0.022

REPRESENTATIVE GROUP II

WETTED SURFACE AREA (SQ.FT./10^6)

Q	100.6R	101.4L	101.8L	113.1R	113.7R	115.6R	117.9L	118.0L	121.8R	122.4R	122.5R	123.6R	125.1R	125.9R
5000	0.041	0.140	0.030	0.000	0.040	0.130	0.000	0.077	0.050	0.061	0.377	0.118	0.383	0.095
5500	0.041	0.143	0.031	0.000	0.040	0.132	0.000	0.077	0.050	0.061	0.377	0.118	0.383	0.095
6000	0.041	0.145	0.032	0.000	0.040	0.135	0.000	0.077	0.050	0.061	0.377	0.118	0.383	0.095
6500	0.041	0.148	0.032	0.000	0.040	0.137	0.000	0.077	0.050	0.061	0.377	0.118	0.383	0.095
7000	0.041	0.150	0.033	0.000	0.040	0.140	0.000	0.077	0.050	0.061	0.377	0.118	0.383	0.095
7500	0.041	0.153	0.034	0.000	0.040	0.142	0.000	0.077	0.050	0.061	0.377	0.118	0.383	0.095
8000	0.041	0.154	0.034	0.000	0.041	0.147	0.007	0.077	0.050	0.061	0.377	0.118	0.383	0.095
8500	0.041	0.155	0.034	0.000	0.041	0.153	0.015	0.077	0.050	0.061	0.377	0.118	0.383	0.095
9000	0.041	0.157	0.035	0.000	0.041	0.158	0.022	0.077	0.050	0.061	0.377	0.118	0.383	0.095
9500	0.041	0.158	0.035	0.000	0.041	0.163	0.029	0.077	0.050	0.061	0.377	0.118	0.383	0.095
10000	0.041	0.159	0.035	0.000	0.041	0.169	0.037	0.077	0.050	0.061	0.377	0.118	0.383	0.095
10500	0.041	0.160	0.035	0.000	0.042	0.174	0.044	0.077	0.050	0.061	0.377	0.118	0.383	0.095
11000	0.041	0.163	0.036	0.000	0.042	0.174	0.047	0.077	0.050	0.061	0.377	0.118	0.383	0.095
11500	0.041	0.165	0.037	0.000	0.042	0.175	0.049	0.077	0.050	0.061	0.377	0.118	0.383	0.095
12000	0.041	0.168	0.037	0.003	0.042	0.175	0.052	0.077	0.050	0.061	0.377	0.118	0.383	0.095
12500	0.041	0.170	0.038	0.003	0.043	0.175	0.054	0.077	0.050	0.061	0.377	0.118	0.383	0.095
13000	0.041	0.171	0.038	0.003	0.043	0.176	0.054	0.077	0.050	0.061	0.377	0.118	0.383	0.095
13500	0.041	0.173	0.039	0.007	0.044	0.176	0.055	0.077	0.050	0.061	0.377	0.118	0.383	0.095
14000	0.041	0.174	0.039	0.007	0.044	0.177	0.055	0.077	0.050	0.061	0.377	0.118	0.383	0.095
14500	0.041	0.176	0.039	0.014	0.045	0.178	0.055	0.077	0.050	0.061	0.377	0.118	0.383	0.095
15000	0.041	0.177	0.039	0.014	0.045	0.179	0.055	0.077	0.050	0.061	0.377	0.118	0.383	0.095
15500	0.041	0.179	0.040	0.014	0.045	0.179	0.056	0.077	0.050	0.061	0.377	0.118	0.383	0.095
16000	0.041	0.180	0.040	0.014	0.046	0.180	0.056	0.077	0.050	0.061	0.377	0.118	0.383	0.095
16500	0.041	0.187	0.041	0.015	0.046	0.185	0.068	0.077	0.050	0.061	0.377	0.118	0.383	0.095
17000	0.041	0.194	0.041	0.015	0.047	0.190	0.080	0.077	0.050	0.061	0.377	0.118	0.383	0.095
17500	0.041	0.200	0.042	0.015	0.048	0.195	0.092	0.077	0.050	0.061	0.377	0.118	0.383	0.095
18000	0.041	0.207	0.042	0.015	0.049	0.200	0.104	0.077	0.050	0.061	0.377	0.118	0.383	0.095
18500	0.041	0.208	0.043	0.015	0.050	0.204	0.109	0.077	0.050	0.061	0.377	0.118	0.383	0.095
19000	0.041	0.210	0.043	0.015	0.050	0.208	0.114	0.077	0.050	0.061	0.377	0.118	0.383	0.095
19500	0.041	0.211	0.045	0.016	0.051	0.212	0.119	0.077	0.050	0.061	0.377	0.118	0.383	0.095
20000	0.041	0.212	0.045	0.016	0.053	0.216	0.124	0.077	0.050	0.061	0.377	0.118	0.383	0.095
20500	0.041	0.213	0.045	0.016	0.054	0.220	0.130	0.077	0.050	0.061	0.380	0.118	0.384	0.095
21000	0.041	0.215	0.046	0.016	0.055	0.224	0.135	0.077	0.050	0.061	0.383	0.118	0.386	0.095
21500	0.041	0.216	0.046	0.017	0.057	0.228	0.140	0.077	0.050	0.061	0.386	0.118	0.407	0.095
22000	0.041	0.220	0.046	0.017	0.059	0.232	0.145	0.077	0.050	0.061	0.390	0.118	0.447	0.095
22500	0.041	0.221	0.047	0.018	0.061	0.236	0.150	0.078	0.050	0.061	0.395	0.118	0.471	0.095
23000	0.041	0.222	0.047	0.018	0.063	0.240	0.155	0.078	0.050	0.061	0.395	0.118	0.478	0.095
23500	0.041	0.234	0.048	0.019	0.066	0.241	0.158	0.082	0.053	0.061	0.395	0.118	0.479	0.095
24000	0.041	0.257	0.048	0.019	0.068	0.242	0.159	0.090	0.058	0.061	0.395	0.118	0.480	0.095
24500	0.042	0.270	0.049	0.020	0.072	0.255	0.161	0.095	0.061	0.061	0.395	0.118	0.480	0.095
25000	0.042	0.274	0.049	0.021	0.075	0.280	0.163	0.096	0.062	0.061	0.395	0.118	0.481	0.095
25500	0.042	0.275	0.050	0.021	0.079	0.295	0.165	0.097	0.062	0.062	0.395	0.118	0.482	0.095
26000	0.042	0.275	0.051	0.022	0.082	0.299	0.167	0.097	0.062	0.062	0.395	0.119	0.483	0.095
26500	0.042	0.276	0.051	0.023	0.085	0.300	0.169	0.097	0.062	0.063	0.395	0.120	0.485	0.096
27000	0.042	0.276	0.052	0.025	0.087	0.301	0.172	0.097	0.062	0.063	0.395	0.121	0.486	0.097
27500	0.043	0.277	0.053	0.026	0.090	0.301	0.174	0.097	0.062	0.064	0.395	0.122	0.488	0.098
28000	0.043	0.278	0.054	0.027	0.092	0.302	0.177	0.098	0.063	0.064	0.395	0.124	0.489	0.098
28500	0.043	0.278	0.055	0.028	0.095	0.302	0.180	0.098	0.063	0.065	0.395	0.124	0.491	0.100
29000	0.043	0.279	0.055	0.029	0.097	0.303	0.183	0.098	0.063	0.065	0.395	0.124	0.494	0.100
29500	0.044	0.280	0.057	0.029	0.098	0.304	0.187	0.098	0.063	0.066	0.395	0.124	0.496	0.100
30000	0.044	0.281	0.058	0.030	0.100	0.305	0.191	0.099	0.063	0.066	0.395	0.124	0.499	0.100
30500	0.044	0.282	0.060	0.031	0.101	0.306	0.196	0.099	0.064	0.067	0.395	0.124	0.502	0.100
31000	0.045	0.284	0.061	0.032	0.102	0.307	0.200	0.100	0.064	0.067	0.395	0.124	0.505	0.100
31500	0.045	0.285	0.062	0.032	0.103	0.308	0.205	0.100	0.064	0.068	0.395	0.124	0.508	0.100
32000	0.045	0.286	0.064	0.033	0.105	0.309	0.210	0.101	0.065	0.068	0.395	0.124	0.511	0.100
32500	0.046	0.288	0.065	0.033	0.105	0.311	0.215	0.101	0.065	0.069	0.395	0.124	0.515	0.100
33000	0.046	0.290	0.067	0.033	0.106	0.313	0.222	0.102	0.065	0.069	0.395	0.124	0.519	0.100
33500	0.046	0.292	0.069	0.034	0.107	0.314	0.227	0.103	0.066	0.070	0.395	0.124	0.520	0.100
34000	0.047	0.294	0.071	0.034	0.107	0.316	0.232	0.103	0.066	0.070	0.395	0.124	0.521	0.100
34500	0.047	0.296	0.072	0.034	0.108	0.318	0.237	0.104	0.067	0.071	0.395	0.124	0.522	0.100
35000	0.048	0.298	0.074	0.035	0.108	0.320	0.242	0.105	0.067	0.071	0.395	0.124	0.523	0.100

REPRESENTATIVE GROUP III
WETTED SURFACE AREA (SQ.FT./10^6)

Q	100.4R	100.6L	101.2R	101.6L	101.7L	110.4L	115.0R	117.8L	119.3L	128.5R	128.7R
5000	0.109	0.048	0.039	0.057	0.305	0.113	0.039	0.069	0.000	0.116	0.033
5500	0.110	0.050	0.059	0.060	0.305	0.126	0.098	0.069	.000	0.141	0.052
6000	0.110	0.051	0.077	0.063	0.305	0.138	0.152	0.069	0.007	0.142	0.069
6500	0.111	0.052	0.094	0.066	0.305	0.149	0.201	0.069	0.013	0.142	0.084
7000	0.112	0.054	0.110	0.068	0.305	0.160	0.247	0.069	0.019	0.143	0.099
7500	0.112	0.055	0.125	0.070	0.305	0.169	0.289	0.069	0.025	0.143	0.112
8000	0.113	0.056	0.138	0.073	0.305	0.178	0.329	0.069	0.030	0.165	0.125
8500	0.113	0.057	0.151	0.075	0.305	0.187	0.367	0.080	0.035	0.187	0.136
9000	0.114	0.058	0.163	0.077	0.305	0.195	0.402	0.090	0.040	0.210	0.147
9500	0.114	0.075	0.179	0.078	0.305	0.202	0.435	0.099	0.044	0.232	0.158
10000	0.115	0.080	0.197	0.080	0.496	0.209	0.467	0.109	0.048	0.240	0.168
10500	0.115	0.085	0.215	0.082	0.515	0.216	0.497	0.117	0.052	0.304	0.177
11000	0.116	0.090	0.231	0.083	0.533	0.222	0.526	0.126	0.056	0.345	0.186
11500	0.116	0.094	0.247	0.085	0.550	0.229	0.553	0.134	0.059	0.384	0.195
12000	0.117	0.098	0.263	0.086	0.567	0.235	0.579	0.141	0.063	0.422	0.203
12500	0.117	0.102	0.277	0.088	0.583	0.286	0.694	0.149	0.066	0.457	0.211
13000	0.111	0.106	0.291	0.089	0.598	0.296	0.729	0.156	0.069	0.492	0.219
13500	0.123	0.110	0.305	0.090	0.613	0.306	0.762	0.162	0.072	0.525	0.226
14000	0.135	0.114	0.318	0.092	0.627	0.315	0.795	0.169	0.075	0.557	0.233
14500	0.146	0.117	0.330	0.106	0.640	0.324	0.826	0.175	0.078	0.588	0.240
15000	0.157	0.121	0.342	0.111	0.653	0.332	0.856	0.181	0.081	0.618	0.246
15500	0.168	0.124	0.354	0.115	0.666	0.340	0.886	0.187	0.084	0.647	0.306
16000	0.178	0.127	0.366	0.119	0.678	0.348	0.914	0.193	0.086	0.675	0.313
16500	0.188	0.130	0.377	0.123	0.690	0.356	0.941	0.198	0.087	0.702	0.319
17000	0.197	0.133	0.387	0.127	0.702	0.364	0.968	0.204	0.089	0.728	0.325
17500	0.206	0.136	0.398	0.131	0.713	0.371	0.994	0.209	0.091	0.754	0.331
18000	0.215	0.139	0.408	0.135	0.724	0.378	1.019	0.214	0.092	0.778	0.336
18500	0.224	0.142	0.418	0.139	0.734	0.385	1.043	0.219	0.094	0.802	0.342
19000	0.233	0.144	0.427	0.142	0.745	0.392	1.067	0.224	0.095	0.826	0.347
19500	0.241	0.147	0.436	0.146	0.755	0.398	1.090	0.228	0.097	0.849	0.353
20000	0.249	0.149	0.445	0.149	0.765	0.405	1.113	0.233	0.098	0.871	0.358
20500	0.257	0.152	0.454	0.152	0.774	0.411	1.135	0.237	0.100	0.893	0.363
21000	0.265	0.154	0.463	0.156	0.784	0.417	1.156	0.241	0.101	0.914	0.367
21500	0.272	0.157	0.471	0.159	0.793	0.423	1.177	0.246	0.103	0.935	0.372
22000	0.280	0.159	0.480	0.162	0.802	0.429	1.198	0.250	0.104	0.955	0.377
22500	0.287	0.161	0.488	0.165	0.810	0.434	1.218	0.254	0.105	0.975	0.381
23000	0.294	0.163	0.495	0.168	0.819	0.440	1.238	0.258	0.107	0.994	0.386
23500	0.301	0.165	0.503	0.171	0.827	0.445	1.257	0.262	0.108	1.013	0.390
24000	0.307	0.168	0.511	0.173	0.835	0.451	1.276	0.265	0.109	1.032	0.394
24500	0.314	0.170	0.518	0.176	0.843	0.456	1.294	0.269	0.110	1.050	0.398
25000	0.321	0.172	0.525	0.179	0.851	0.461	1.312	0.273	0.111	1.067	0.402
25500	0.327	0.174	0.532	0.182	0.859	0.466	1.330	0.276	0.112	1.085	0.406
26000	0.333	0.176	0.539	0.184	0.866	0.471	1.347	0.280	0.114	1.102	0.410
26500	0.339	0.177	0.546	0.187	0.874	0.476	1.364	0.283	0.115	1.119	0.414
27000	0.345	0.179	0.553	0.189	0.881	0.480	1.381	0.286	0.116	1.135	0.418
27500	0.351	0.181	0.559	0.192	0.888	0.485	1.397	0.290	0.117	1.151	0.422
28000	0.357	0.183	0.566	0.194	0.895	0.489	1.413	0.293	0.118	1.167	0.425
28500	0.362	0.185	0.572	0.197	0.902	0.494	1.429	0.296	0.119	1.183	0.429
29000	0.368	0.187	0.578	0.199	0.908	0.498	1.444	0.299	0.120	1.198	0.432
29500	0.373	0.188	0.585	0.201	0.915	0.503	1.460	0.302	0.121	1.213	0.436
30000	0.379	0.190	0.591	0.203	0.922	0.507	1.475	0.305	0.122	1.228	0.439
30500	0.384	0.192	0.597	0.206	0.928	0.511	1.489	0.308	0.123	1.242	0.442
31000	0.389	0.193	0.602	0.208	0.934	0.515	1.504	0.311	0.124	1.257	0.446
31500	0.394	0.195	0.608	0.210	0.940	0.519	1.518	0.314	0.125	1.271	0.449
32000	0.400	0.196	0.614	0.212	0.947	0.523	1.532	0.317	0.126	1.285	0.452
32500	0.404	0.198	0.619	0.214	0.953	0.527	1.546	0.320	0.127	1.298	0.455
33000	0.409	0.199	0.625	0.216	0.958	0.531	1.560	0.322	0.127	1.312	0.458
33500	0.414	0.201	0.630	0.218	0.964	0.535	1.573	0.325	0.128	1.325	0.461
34000	0.419	0.202	0.635	0.220	0.970	0.538	1.586	0.328	0.129	1.338	0.464
34500	0.424	0.204	0.641	0.222	0.976	0.542	1.599	0.330	0.130	1.351	0.467
35000	0.428	0.205	0.646	0.224	0.981	0.546	1.612	0.333	0.131	1.364	0.470

REPRESENTATIVE GROUP IV
WETTED SURFACE AREA (SQ.FT./ 10^6)

Q	100.7R	108.7L	110.8M	111.5R	112.6L	114.0R	116.8R	119.5L	119.6L	121.7R	124.1L
5000	0.675	0.173	0.172	0.738	1.700	1.355	0.360	0.320	1.236	1.169	0.648
5500	0.704	0.177	0.174	0.776	1.742	1.433	0.364	0.336	1.244	1.236	0.676
6000	0.730	0.181	0.175	0.811	1.781	1.504	0.368	0.351	1.252	1.298	0.703
6500	0.754	0.185	0.177	0.843	1.816	1.570	0.371	0.364	1.259	1.354	0.727
7000	0.776	0.188	0.178	0.873	1.849	1.631	0.375	0.376	1.266	1.407	0.749
7500	0.797	0.191	0.180	0.900	1.880	1.688	0.378	0.388	1.272	1.455	0.770
8000	0.816	0.193	0.181	0.926	1.908	1.740	0.380	0.399	1.278	1.501	0.789
8500	0.834	0.196	0.182	0.950	1.935	1.790	0.383	0.409	1.283	1.544	0.807
9000	0.851	0.199	0.183	0.973	1.961	1.837	0.386	0.419	1.288	1.584	0.825
9500	0.868	0.201	0.184	0.994	1.984	1.882	0.388	0.428	1.293	1.622	0.841
10000	0.883	0.203	0.185	1.015	2.007	1.924	0.390	0.436	1.298	1.659	0.856
10500	0.898	0.205	0.186	1.034	2.029	1.964	0.392	0.445	1.302	1.693	0.871
11000	0.912	0.207	0.187	1.053	2.049	2.002	0.394	0.452	1.307	1.726	0.885
11500	0.925	0.209	0.188	1.071	2.069	2.038	0.396	0.460	1.311	1.758	0.898
12000	0.938	0.211	0.188	1.088	2.088	2.073	0.398	0.467	1.314	1.788	0.911
12500	0.950	0.213	0.189	1.104	2.106	2.107	0.400	0.474	1.318	1.816	0.923
13000	0.962	0.214	0.190	1.120	2.123	2.139	0.402	0.480	1.322	1.844	0.935
13500	0.973	0.216	0.191	1.135	2.140	2.170	0.403	0.487	1.325	1.871	0.947
14000	0.984	0.218	0.191	1.149	2.156	2.200	0.405	0.493	1.328	1.897	0.958
14500	0.995	0.219	0.192	1.163	2.172	2.229	0.407	0.499	1.331	1.921	0.968
15000	1.005	0.220	0.193	1.177	2.187	2.257	0.408	0.504	1.334	1.945	0.978
15500	1.015	0.222	0.193	1.190	2.201	2.283	0.410	0.510	1.337	1.969	0.988
16000	1.024	0.223	0.194	1.202	2.215	2.310	0.411	0.515	1.340	1.991	0.998
16500	1.033	0.225	0.195	1.215	2.229	2.335	0.412	0.520	1.343	2.013	1.007
17000	1.042	0.226	0.195	1.227	2.242	2.359	0.414	0.525	1.346	2.034	1.016
17500	1.051	0.227	0.196	1.238	2.255	2.383	0.415	0.530	1.348	2.054	1.025
18000	1.059	0.228	0.196	1.249	2.268	2.406	0.416	0.535	1.351	2.074	1.033
18500	1.068	0.229	0.197	1.260	2.280	2.429	0.417	0.540	1.353	2.094	1.041
19000	1.076	0.231	0.197	1.271	2.292	2.451	0.418	0.544	1.356	2.113	1.050
19500	1.083	0.232	0.198	1.281	2.303	2.472	0.420	0.549	1.358	2.131	1.057
20000	1.091	0.233	0.198	1.291	2.314	2.493	0.421	0.553	1.360	2.149	1.065
20500	1.098	0.234	0.199	1.301	2.325	2.513	0.422	0.557	1.363	2.166	1.072
21000	1.106	0.235	0.199	1.311	2.336	2.533	0.423	0.561	1.365	2.183	1.080
21500	1.113	0.236	0.200	1.320	2.346	2.552	0.424	0.565	1.367	2.200	1.087
22000	1.120	0.237	0.200	1.330	2.356	2.571	0.425	0.569	1.369	2.216	1.094
22500	1.126	0.238	0.200	1.338	2.366	2.589	0.426	0.573	1.371	2.232	1.100
23000	1.133	0.239	0.201	1.347	2.376	2.608	0.427	0.576	1.373	2.248	1.107
23500	1.139	0.240	0.201	1.356	2.386	2.625	0.428	0.580	1.375	2.263	1.113
24000	1.146	0.241	0.202	1.364	2.395	2.642	0.429	0.583	1.377	2.278	1.120
24500	1.152	0.242	0.202	1.372	2.404	2.659	0.430	0.587	1.379	2.292	1.126
25000	1.158	0.242	0.202	1.381	2.413	2.676	0.431	0.590	1.380	2.307	1.132
25500	1.164	0.243	0.203	1.388	2.422	2.692	0.431	0.594	1.382	2.321	1.138
26000	1.170	0.244	0.203	1.396	2.430	2.708	0.432	0.597	1.384	2.334	1.144
26500	1.175	0.245	0.204	1.404	2.439	2.724	0.433	0.600	1.386	2.348	1.150
27000	1.181	0.246	0.204	1.411	2.447	2.739	0.434	0.603	1.387	2.361	1.155
27500	1.187	0.247	0.204	1.419	2.455	2.754	0.435	0.606	1.389	2.374	1.161
28000	1.192	0.247	0.205	1.426	2.463	2.769	0.436	0.609	1.391	2.387	1.166
28500	1.197	0.248	0.205	1.433	2.471	2.784	0.436	0.612	1.392	2.399	1.172
29000	1.203	0.249	0.205	1.440	2.479	2.798	0.437	0.615	1.394	2.411	1.177
29500	1.208	0.250	0.206	1.447	2.486	2.812	0.438	0.618	1.395	2.424	1.182
30000	1.213	0.250	0.206	1.453	2.494	2.826	0.439	0.621	1.397	2.435	1.187
30500	1.218	0.251	0.206	1.460	2.501	2.839	0.439	0.624	1.398	2.447	1.192
31000	1.223	0.252	0.206	1.466	2.508	2.853	0.440	0.626	1.400	2.459	1.197
31500	1.227	0.252	0.207	1.473	2.515	2.866	0.441	0.629	1.401	2.470	1.202
32000	1.232	0.253	0.207	1.479	2.522	2.879	0.441	0.632	1.403	2.481	1.206
32500	1.237	0.254	0.207	1.485	2.529	2.891	0.442	0.634	1.404	2.492	1.211
33000	1.241	0.254	0.208	1.491	2.536	2.904	0.443	0.637	1.405	2.503	1.216
33500	1.246	0.255	0.208	1.497	2.543	2.916	0.443	0.639	1.407	2.513	1.220
34000	1.250	0.256	0.208	1.503	2.549	2.928	0.444	0.642	1.408	2.524	1.225
34500	1.255	0.256	0.209	1.509	2.556	2.940	0.445	0.644	1.409	2.534	1.229
35000	1.259	0.257	0.209	1.515	2.562	2.952	0.445	0.647	1.411	2.544	1.233

REPRESENTATIVE GROUP V

WETTED SURFACE AREA (SQ.FT./10^6)

Q	101.7L	117.0M	118.9L	124.0M	132.8R	139.0L	139.7R	141.6R	143.0L
5000	0.305	0.000	0.028	0.000	0.029	0.022	0.007	0.105	0.019
5500	0.305	0.000	0.030	0.000	0.029	0.026	0.007	0.105	0.019
6000	0.305	0.000	0.032	0.002	0.029	0.030	0.007	0.105	0.019
6500	0.305	0.000	0.033	0.011	0.029	0.033	0.007	0.105	0.019
7000	0.305	0.000	0.034	0.019	0.029	0.036	0.007	0.105	0.019
7500	0.305	0.000	0.036	0.026	0.029	0.039	0.007	0.105	0.020
8000	0.305	0.000	0.037	0.034	0.029	0.041	0.007	0.105	0.028
8500	0.305	0.000	0.038	0.040	0.029	0.044	0.007	0.105	0.034
9000	0.305	0.000	0.039	0.047	0.029	0.046	0.007	0.105	0.041
9500	0.305	0.000	0.040	0.053	0.029	0.049	0.007	0.105	0.047
10000	0.305	0.000	0.041	0.058	0.029	0.051	0.007	0.105	0.053
10500	0.450	0.000	0.042	0.064	0.029	0.053	0.007	0.105	0.058
11000	0.467	0.000	0.043	0.069	0.029	0.055	0.007	0.105	0.064
11500	0.483	0.000	0.043	0.074	0.029	0.056	0.007	0.105	0.069
12000	0.498	0.000	0.044	0.079	0.029	0.058	0.007	0.105	0.073
12500	0.513	0.032	0.045	0.083	0.029	0.060	0.007	0.105	0.078
13000	0.527	0.032	0.046	0.087	0.029	0.061	0.007	0.105	0.082
13500	0.541	0.032	0.046	0.092	0.029	0.063	0.007	0.105	0.087
14000	0.554	0.032	0.047	0.096	0.029	0.064	0.007	0.105	0.091
14500	0.567	0.032	0.047	0.100	0.029	0.066	0.007	0.105	0.095
15000	0.579	0.032	0.048	0.103	0.029	0.067	0.007	0.105	0.099
15500	0.591	0.032	0.049	0.107	0.029	0.069	0.007	0.105	0.102
16000	0.602	0.129	0.049	0.111	0.029	0.070	0.007	0.105	0.106
16500	0.613	0.148	0.050	0.114	0.029	0.071	0.007	0.105	0.109
17000	0.624	0.167	0.050	0.117	0.029	0.072	0.007	0.105	0.113
17500	0.635	0.186	0.051	0.120	0.029	0.074	0.007	0.105	0.116
18000	0.645	0.203	0.051	0.124	0.029	0.075	0.007	0.105	0.119
18500	0.655	0.221	0.052	0.127	0.029	0.076	0.007	0.105	0.122
19000	0.664	0.238	0.052	0.130	0.029	0.077	0.007	0.105	0.125
19500	0.674	0.254	0.053	0.132	0.029	0.078	0.007	0.105	0.128
20000	0.683	0.270	0.053	0.135	0.078	0.079	0.007	0.105	0.131
20500	0.692	0.286	0.053	0.138	0.078	0.080	0.007	0.105	0.134
21000	0.701	0.301	0.053	0.141	0.078	0.081	0.007	0.105	0.137
21500	0.709	0.316	0.053	0.143	0.078	0.082	0.007	0.196	0.139
22000	0.718	0.330	0.053	0.146	0.078	0.083	0.007	0.203	0.142
22500	0.726	0.344	0.053	0.148	0.078	0.084	0.026	0.210	0.144
23000	0.734	0.358	0.053	0.151	0.078	0.085	0.026	0.217	0.147
23500	0.741	0.372	0.053	0.526	0.078	0.086	0.026	0.223	0.149
24000	0.749	0.385	0.053	0.526	0.078	0.087	0.026	0.229	0.152
24500	0.757	0.398	0.053	0.526	0.078	0.087	0.026	0.235	0.154
25000	0.764	0.411	0.053	0.526	0.078	0.088	0.026	0.241	0.156
25500	0.771	0.424	0.053	0.526	0.078	0.089	0.026	0.248	0.159
26000	0.778	0.436	0.053	0.526	0.078	0.090	0.026	0.254	0.161
26500	0.785	0.448	0.053	0.526	0.078	0.091	0.026	0.261	0.163
27000	0.792	0.460	0.053	0.526	0.078	0.091	0.026	0.268	0.165
27500	0.798	0.471	0.053	0.526	0.078	0.092	0.026	0.275	0.167
28000	0.805	0.483	0.053	0.526	0.078	0.093	0.026	0.283	0.169
28500	0.811	0.494	0.053	0.526	0.078	0.093	0.026	0.290	0.171
29000	0.818	0.505	0.053	0.526	0.078	0.093	0.026	0.298	0.173
29500	0.824	0.516	0.053	0.526	0.078	0.093	0.026	0.306	0.175
30000	0.830	0.526	0.053	0.526	0.078	0.093	0.026	0.315	0.177
30500	0.836	0.537	0.053	0.526	0.078	0.093	0.026	0.323	0.179
31000	0.842	0.547	0.053	0.526	0.078	0.093	0.026	0.332	0.181
31500	0.848	0.557	0.053	0.526	0.078	0.093	0.026	0.341	0.182
32000	0.853	0.567	0.053	0.526	0.078	0.093	0.026	0.350	0.184
32500	0.859	0.577	0.053	0.526	0.078	0.093	0.026	0.359	0.186
33000	0.864	0.586	0.053	0.526	0.078	0.093	0.026	0.369	0.188
33500	0.870	0.596	0.053	0.526	0.078	0.093	0.026	0.379	0.189
34000	0.875	0.605	0.053	0.526	0.078	0.093	0.026	0.389	0.191
34500	0.880	0.615	0.053	0.526	0.078	0.093	0.026	0.399	0.193
35000	0.886	0.624	0.053	0.526	0.078	0.093	0.026	0.410	0.194

REPRESENTATIVE GROUP VII
WETTED SURFACE AREA (SQ.FT./10^6)

Q	114.1R	119.2R	121.1L	123.0L	125.6L	127.5M	131.3L
5000	0.269	0.100	0.060	0.036	0.139	0.285	0.050
5500	0.283	0.104	0.067	0.038	0.142	0.299	0.054
6000	0.296	0.108	0.074	0.040	0.146	0.312	0.059
6500	0.308	0.112	0.080	0.042	0.149	0.323	0.063
7000	0.319	0.116	0.087	0.044	0.151	0.334	0.068
7500	0.329	0.120	0.094	0.046	0.154	0.344	0.072
8000	0.339	0.133	0.100	0.048	0.157	0.353	0.086
8500	0.348	0.145	0.114	0.049	0.159	0.362	0.097
9000	0.357	0.158	0.138	0.051	0.161	0.370	0.109
9500	0.365	0.171	0.161	0.052	0.163	0.378	0.120
10000	0.373	0.193	0.183	0.053	0.165	0.385	0.132
10500	0.380	0.201	0.203	0.054	0.167	0.392	0.162
11000	0.387	0.209	0.223	0.056	0.169	0.399	0.191
11500	0.394	0.217	0.242	0.057	0.170	0.405	0.219
12000	0.400	0.224	0.260	0.058	0.172	0.412	0.246
12500	0.406	0.231	0.277	0.059	0.173	0.417	0.271
13000	0.412	0.238	0.293	0.060	0.175	0.423	0.296
13500	0.418	0.245	0.309	0.061	0.176	0.429	0.320
14000	0.423	0.251	0.325	0.062	0.178	0.434	0.342
14500	0.428	0.257	0.340	0.063	0.179	0.439	0.364
15000	0.433	0.263	0.354	0.063	0.180	0.444	0.385
15500	0.438	0.269	0.368	0.064	0.182	0.448	0.406
16000	0.443	0.274	0.381	0.065	0.183	0.453	0.426
16500	0.448	0.280	0.394	0.066	0.184	0.457	0.445
17000	0.452	0.285	0.407	0.067	0.185	0.462	0.464
17500	0.456	0.290	0.419	0.067	0.186	0.466	0.482
18000	0.461	0.295	0.431	0.068	0.187	0.470	0.500
18500	0.465	0.300	0.442	0.069	0.188	0.474	0.517
19000	0.469	0.304	0.454	0.069	0.189	0.478	0.533
19500	0.473	0.309	0.465	0.070	0.190	0.481	0.550
20000	0.477	0.313	0.475	0.071	0.191	0.485	0.566
20500	0.480	0.318	0.486	0.071	0.192	0.489	0.581
21000	0.484	0.322	0.496	0.072	0.193	0.492	0.596
21500	0.487	0.326	0.506	0.072	0.194	0.496	0.611
22000	0.491	0.330	0.515	0.073	0.195	0.499	0.625
22500	0.494	0.334	0.525	0.074	0.196	0.502	0.639
23000	0.497	0.338	0.534	0.074	0.197	0.505	0.653
23500	0.501	0.341	0.543	0.075	0.197	0.508	0.667
24000	0.504	0.345	0.552	0.075	0.198	0.511	0.680
24500	0.507	0.349	0.561	0.076	0.199	0.514	0.693
25000	0.510	0.352	0.569	0.076	0.200	0.517	0.705
25500	0.513	0.355	0.578	0.077	0.201	0.520	0.718
26000	0.516	0.359	0.586	0.077	0.201	0.523	0.730
26500	0.519	0.362	0.594	0.078	0.202	0.526	0.742
27000	0.522	0.365	0.602	0.078	0.203	0.528	0.753
27500	0.524	0.369	0.610	0.079	0.203	0.531	0.765
28000	0.527	0.372	0.617	0.079	0.204	0.534	0.776
28500	0.530	0.375	0.625	0.079	0.205	0.536	0.787
29000	0.532	0.378	0.632	0.080	0.205	0.539	0.798
29500	0.535	0.381	0.639	0.080	0.206	0.541	0.809
30000	0.537	0.384	0.646	0.081	0.207	0.543	0.819
30500	0.540	0.387	0.653	0.081	0.207	0.546	0.830
31000	0.542	0.389	0.660	0.082	0.208	0.548	0.840
31500	0.545	0.392	0.667	0.082	0.209	0.551	0.850
32000	0.547	0.395	0.674	0.082	0.209	0.553	0.860
32500	0.549	0.398	0.680	0.083	0.210	0.555	0.870
33000	0.552	0.400	0.687	0.083	0.210	0.557	0.879
33500	0.554	0.403	0.693	0.083	0.211	0.559	0.888
34000	0.556	0.406	0.699	0.084	0.211	0.562	0.898
34500	0.558	0.408	0.705	0.084	0.212	0.564	0.907
35000	0.560	0.411	0.711	0.085	0.213	0.566	0.916

REPRESENTATIVE GROUP VIII
WETTED SURFACE AREA (SQ.FT./10^6)

Q	123.2R	124.8R	125.6R	128.4R	132.5L	135.0R	135.1R	144.0M	145.6R	146.6L
5000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5500	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6500	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7000	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7500	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8500	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9000	0.021	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9500	0.022	0.000	0.013	0.012	0.000	0.000	0.000	0.000	0.000	0.000
10000	0.023	0.000	0.013	0.026	0.000	0.000	0.000	0.000	0.000	0.000
10500	0.024	0.005	0.013	0.040	0.000	0.000	0.000	0.000	0.000	0.000
11000	0.025	0.011	0.013	0.052	0.000	0.000	0.058	0.000	0.000	0.000
11500	0.026	0.017	0.013	0.065	0.000	0.000	0.058	0.000	0.000	0.000
12000	0.026	0.022	0.013	0.076	0.000	0.000	0.058	0.000	0.000	0.000
12500	0.027	0.028	0.013	0.088	0.000	0.000	0.058	0.000	0.000	0.000
13000	0.028	0.033	0.013	0.098	0.000	0.000	0.058	0.000	0.000	0.000
13500	0.029	0.038	0.013	0.109	0.000	0.000	0.058	0.000	0.000	0.000
14000	0.029	0.043	0.013	0.119	0.000	0.000	0.058	0.000	0.000	0.000
14500	0.030	0.047	0.013	0.129	0.000	0.000	0.058	0.000	0.000	0.000
15000	0.031	0.052	0.013	0.138	0.088	0.000	0.058	0.000	0.000	0.000
15500	0.033	0.056	0.013	0.147	0.093	0.000	0.058	0.000	0.000	0.000
16000	0.035	0.060	0.013	0.156	0.097	0.000	0.058	0.000	0.000	0.000
16500	0.037	0.064	0.023	0.164	0.101	0.000	0.058	0.000	0.000	0.005
17000	0.040	0.068	0.035	0.173	0.105	0.000	0.058	0.000	0.000	0.006
17500	0.042	0.072	0.047	0.181	0.109	0.000	0.058	0.000	0.174	0.006
18000	0.050	0.076	0.059	0.188	0.113	0.000	0.058	0.000	0.181	0.007
18500	0.058	0.079	0.070	0.196	0.116	0.000	0.058	0.000	0.188	0.007
19000	0.066	0.083	0.082	0.203	0.120	0.000	0.058	0.000	0.195	0.008
19500	0.073	0.086	0.092	0.210	0.124	0.000	0.058	0.000	0.201	0.008
20000	0.081	0.186	0.103	0.217	0.127	0.000	0.058	0.000	0.208	0.008
20500	0.088	0.200	0.113	0.224	0.130	0.000	0.097	0.000	0.214	0.009
21000	0.095	0.214	0.123	0.231	0.134	0.000	0.105	0.000	0.220	0.009
21500	0.102	0.227	0.133	0.237	0.137	0.000	0.112	0.000	0.226	0.010
22000	0.109	0.240	0.142	0.244	0.140	0.222	0.120	0.000	0.232	0.010
22500	0.115	0.253	0.152	0.250	0.143	0.235	0.127	0.100	0.237	0.010
23000	0.122	0.266	0.161	0.256	0.146	0.247	0.134	0.100	0.243	0.011
23500	0.128	0.278	0.170	0.262	0.149	0.259	0.140	0.100	0.248	0.011
24000	0.134	0.290	0.179	0.268	0.152	0.271	0.147	0.100	0.254	0.011
24500	0.140	0.302	0.187	0.273	0.154	0.282	0.153	0.100	0.259	0.012
25000	0.146	0.314	0.196	0.279	0.157	0.294	0.160	0.100	0.264	0.012
25500	0.152	0.325	0.204	0.284	0.160	0.305	0.166	0.100	0.269	0.012
26000	0.157	0.336	0.212	0.290	0.162	0.315	0.172	0.100	0.274	0.013
26500	0.163	0.347	0.220	0.295	0.165	0.326	0.178	0.100	0.279	0.013
27000	0.168	0.358	0.228	0.300	0.167	0.336	0.184	0.100	0.284	0.013
27500	0.174	0.369	0.235	0.305	0.170	0.347	0.190	0.100	0.288	0.014
28000	0.179	0.379	0.243	0.310	0.172	0.357	0.195	0.100	0.293	0.014
28500	0.184	0.389	0.250	0.315	0.175	0.367	0.201	0.100	0.297	0.014
29000	0.189	0.399	0.250	0.320	0.177	0.376	0.206	0.100	0.302	0.014
29500	0.194	0.409	0.250	0.325	0.179	0.386	0.212	0.100	0.306	0.015
30000	0.199	0.419	0.250	0.329	0.182	0.395	0.217	0.100	0.310	0.015
30500	0.204	0.428	0.250	0.334	0.184	0.404	0.222	0.100	0.314	0.015
31000	0.209	0.438	0.250	0.338	0.186	0.413	0.227	0.100	0.318	0.015
31500	0.213	0.447	0.250	0.343	0.188	0.422	0.232	0.100	0.323	0.016
32000	0.218	0.456	0.250	0.347	0.190	0.431	0.237	0.100	0.326	0.016
32500	0.223	0.465	0.250	0.351	0.193	0.440	0.242	0.100	0.330	0.016
33000	0.227	0.473	0.250	0.356	0.195	0.448	0.247	0.100	0.334	0.016
33500	0.231	0.482	0.250	0.360	0.197	0.457	0.252	0.100	0.338	0.017
34000	0.236	0.491	0.250	0.364	0.199	0.465	0.256	0.100	0.342	0.017
34500	0.240	0.499	0.250	0.368	0.201	0.473	0.261	0.100	0.346	0.017
35000	0.244	0.507	0.250	0.372	0.203	0.481	0.265	0.100	0.349	0.017

REPRESENTATIVE GROUP IX
WETTED SURFACE AREA (SQ.FT./10^6)

Q	129.8R	131.2R	135.0L	139.2R	141.2R	141.3R	142.8R	144.0R	144.2L	147.1L
5000	0.566	0.123	0.212	0.420	0.114	0.305	0.797	0.678	1.894	0.483
5500	0.573	0.128	0.212	0.434	0.120	0.305	0.826	0.649	1.894	0.492
6000	0.580	0.133	0.212	0.447	0.127	0.305	0.851	0.623	1.894	0.500
6500	0.586	0.137	0.212	0.458	0.132	0.305	0.875	0.599	1.894	0.508
7000	0.591	0.141	0.212	0.469	0.138	0.305	0.897	0.576	1.894	0.515
7500	0.596	0.144	0.212	0.480	0.143	0.305	0.918	0.555	1.894	0.522
8000	0.601	0.147	0.212	0.489	0.147	0.305	0.937	0.536	1.894	0.528
8500	0.606	0.150	0.212	0.498	0.151	0.305	0.955	0.518	1.894	0.534
9000	0.610	0.153	0.212	0.507	0.155	0.305	0.972	0.500	1.894	0.539
9500	0.614	0.156	0.212	0.515	0.159	0.305	0.988	0.484	1.894	0.544
10000	0.618	0.159	0.212	0.522	0.163	0.305	1.004	0.468	1.894	0.549
10500	0.621	0.161	0.212	0.529	0.166	0.305	1.018	0.453	1.894	0.554
11000	0.625	0.164	0.212	0.536	0.170	0.305	1.032	0.439	1.894	0.558
11500	0.628	0.166	0.212	0.543	0.173	0.305	1.045	0.426	1.894	0.563
12000	0.631	0.168	0.212	0.549	0.176	0.305	1.058	0.413	1.894	0.567
12500	0.634	0.170	0.212	0.555	0.179	0.305	1.070	0.401	1.894	0.571
13000	0.637	0.172	0.212	0.561	0.182	0.305	1.082	0.389	1.894	0.574
13500	0.640	0.174	0.212	0.567	0.184	0.305	1.093	0.377	1.894	0.578
14000	0.642	0.176	0.212	0.572	0.187	0.305	1.104	0.366	1.894	0.581
14500	0.645	0.178	0.212	0.577	0.189	0.305	1.114	0.356	1.894	0.585
15000	0.648	0.179	0.212	0.582	0.192	0.305	1.125	0.345	1.894	0.588
15500	0.650	0.181	0.212	0.587	0.194	0.305	1.134	0.335	1.894	0.591
16000	0.652	0.183	0.212	0.592	0.196	0.305	1.144	0.326	1.894	0.594
16500	0.655	0.184	0.212	0.596	0.198	0.305	1.153	0.317	1.894	0.597
17000	0.657	0.186	0.212	0.601	0.201	0.305	1.162	0.307	1.894	0.600
17500	0.659	0.187	0.212	0.605	0.203	0.305	1.170	0.299	1.894	0.603
18000	0.661	0.189	0.212	0.609	0.205	0.305	1.179	0.290	1.894	0.606
18500	0.663	0.190	0.212	0.613	0.207	0.305	1.187	0.282	1.894	0.608
19000	0.665	0.191	0.212	0.617	0.209	0.305	1.195	0.274	1.894	0.611
19500	0.667	0.193	0.212	0.621	0.210	0.305	1.203	0.266	1.894	0.613
20000	0.669	0.194	0.212	0.625	0.212	0.305	1.210	0.258	1.894	0.616
20500	0.671	0.195	0.212	0.628	0.214	0.305	1.218	0.251	1.894	0.618
21000	0.672	0.197	0.212	0.632	0.216	0.305	1.225	0.243	1.894	0.620
21500	0.674	0.198	0.212	0.635	0.217	0.305	1.232	0.236	1.894	0.623
22000	0.676	0.199	0.212	0.639	0.219	0.305	1.239	0.229	1.894	0.625
22500	0.678	0.200	0.212	0.642	0.221	0.305	1.245	0.223	1.894	0.627
23000	0.679	0.201	0.212	0.645	0.222	0.305	1.252	0.216	1.894	0.629
23500	0.681	0.202	0.212	0.649	0.224	0.305	1.258	0.209	1.894	0.631
24000	0.682	0.203	0.212	0.652	0.225	0.305	1.265	0.203	1.894	0.633
24500	0.684	0.204	0.212	0.655	0.227	0.305	1.271	0.197	1.894	0.635
25000	0.685	0.205	0.212	0.658	0.228	0.305	1.277	0.191	1.894	0.637
25500	0.687	0.206	0.212	0.661	0.229	0.305	1.283	0.185	1.894	0.639
26000	0.688	0.207	0.212	0.664	0.231	0.305	1.288	0.179	1.894	0.641
26500	0.690	0.208	0.212	0.666	0.232	0.305	1.294	0.173	1.894	0.643
27000	0.691	0.209	0.212	0.669	0.233	0.305	1.300	0.167	1.894	0.645
27500	0.692	0.210	0.212	0.672	0.235	0.305	1.305	0.162	1.894	0.646
28000	0.694	0.211	0.212	0.675	0.236	0.305	1.311	0.156	1.894	0.648
28500	0.695	0.212	0.212	0.677	0.237	0.305	1.316	0.151	1.894	0.650
29000	0.696	0.213	0.212	0.680	0.239	0.305	1.321	0.146	1.894	0.651
29500	0.698	0.214	0.212	0.682	0.240	0.305	1.326	0.140	1.894	0.653
30000	0.699	0.215	0.212	0.685	0.241	0.305	1.331	0.135	1.894	0.655
30500	0.700	0.216	0.212	0.687	0.242	0.305	1.336	0.130	1.894	0.656
31000	0.701	0.216	0.212	0.690	0.243	0.305	1.341	0.125	1.894	0.658
31500	0.702	0.217	0.212	0.692	0.244	0.305	1.346	0.121	1.894	0.659
32000	0.704	0.218	0.212	0.694	0.246	0.305	1.350	0.116	1.894	0.661
32500	0.705	0.219	0.212	0.697	0.247	0.305	1.355	0.111	1.894	0.662
33000	0.706	0.220	0.212	0.699	0.248	0.305	1.359	0.107	1.894	0.664
33500	0.707	0.220	0.212	0.701	0.249	0.305	1.364	0.102	1.894	0.665
34000	0.708	0.221	0.212	0.703	0.250	0.305	1.368	0.097	1.894	0.667
34500	0.709	0.222	0.212	0.705	0.251	0.305	1.373	0.093	1.894	0.668
35000	0.710	0.223	0.212	0.708	0.252	0.305	1.377	0.089	1.894	0.669

APPENDIX D

WEIGHTED USABEL AREAS (WUA) FOR SPECIFIC AREAS

REPRESENTATIVE GROUP I
WEIGHTED USABLE AREA (SQ. FT.)

Q	102.2L	105.2R	107.6L	108.3L	112.5L	119.4L	120.0R	121.9R	123.1R	123.3R	127.2M	129.4R	133.9L	134.0L
5000	2341	0	1900	4345	3957	0	5393	492	10	1027	145	2617	1931	764
5500	2341	388	1899	4342	4049	0	5736	492	68	1027	158	2617	1931	764
6000	2341	760	1896	4336	4132	0	6044	492	121	1027	171	2617	1931	764
6500	2341	1099	1892	4326	4209	0	6320	492	170	1027	182	2617	1931	764
7000	2341	1411	1886	4313	4280	0	6569	492	215	1027	193	2617	1931	764
7500	2341	1697	1878	4296	4346	0	6792	492	257	1027	202	2617	1931	764
8000	2341	1961	1870	4276	4408	0	6992	492	296	1027	212	2617	1931	764
8500	2341	2205	1859	4252	4466	0	7169	492	333	1027	220	2617	1931	764
9000	2341	2429	1848	4226	4521	0	7327	492	367	1027	228	2617	1931	764
9500	2341	2635	1835	4196	4573	0	7465	492	400	1027	236	2617	1931	764
10000	2341	2825	1820	4163	4622	0	7585	492	431	1027	243	2617	1931	764
10500	2341	2999	1804	4126	4669	0	7688	492	461	1027	250	2617	1931	764
11000	2341	3158	1787	4087	4713	1638	7774	492	489	1027	257	2617	1931	764
11500	2341	3302	1769	4045	4756	1741	7845	492	516	1027	263	2617	1931	764
12000	2341	3433	1749	4000	4797	1836	7900	492	542	1027	269	2617	1931	764
12500	2341	3551	1728	3952	4836	1922	7940	492	567	1027	1068	2617	1931	764
13000	2341	3656	1706	4070	4874	2000	7966	492	591	1027	1078	2617	1931	764
13500	2341	3749	2140	4015	4910	2070	7979	492	614	1027	1087	2617	1931	764
14000	2341	3830	2599	3956	4945	2132	7978	492	636	1027	1096	2617	1931	764
14500	2341	3901	3025	3896	4978	2188	7966	492	657	1027	1105	2617	1931	764
15000	2341	3960	3418	3833	5011	2236	7942	492	678	1027	1114	2617	1931	764
15500	2341	4010	3781	3768	5042	2277	7907	492	698	1027	1122	2617	1931	764
16000	2341	4050	4114	3701	5073	2313	7861	492	717	1027	1130	2617	1931	764
16500	2341	4081	4418	3633	5102	2342	7805	492	736	1222	1137	2617	1931	925
17000	2341	4102	4695	3562	5131	2365	7739	492	754	1269	1145	2617	1931	948
17500	2341	4115	4944	3490	5159	2382	7664	492	771	1316	1152	2617	1916	970
18000	2341	4119	5168	3417	5186	2394	7580	492	788	1361	1159	2617	1938	992
18500	2341	4115	5367	3342	5212	2400	7488	492	805	1405	1166	2617	1959	1013
19000	2341	4104	5541	3266	5238	2401	7387	492	821	1448	1173	2617	1980	1033
19500	2341	4084	5690	3188	5262	2397	7277	492	837	1489	1179	2617	2000	1053
20000	2341	4053	5812	3106	5287	2386	7153	492	852	1530	1185	2617	2020	1072
20500	2341	4012	5906	3021	5310	2369	7017	492	867	1569	1191	2617	2039	1091
21000	2341	3962	5974	2932	5334	2345	6869	492	882	1608	1197	2617	2058	1110
21500	2341	3901	6014	2840	5356	2314	6707	492	896	1646	1203	2617	2077	1128
22000	2341	3836	6038	2750	5378	2281	6544	492	910	1683	1209	2617	2094	1145
22500	2341	3801	6098	2684	5400	2265	6435	492	924	1685	1215	2617	2112	1162
23000	2341	3741	6110	2603	5421	2234	6848	492	937	1685	1220	2617	2129	1179
23500	2341	3708	6158	2544	5441	2218	6972	492	950	1685	1225	2617	2146	1196
24000	2341	3693	6230	2500	5462	2214	7118	492	963	1685	1231	2617	2162	1212
24500	2341	3553	6082	2374	5481	2133	7007	492	976	1685	1236	2617	2179	1201
25000	2341	3408	5915	2248	5501	2050	6868	492	988	1685	1241	2617	2194	1201
25500	2341	3257	5727	2123	5520	1962	6698	492	1000	1685	1246	2617	2210	1201
26000	2341	3202	5700	2062	5538	1932	6711	492	1012	1685	1251	2617	2225	1201
26500	2341	3265	5881	2078	5557	1973	6966	492	1023	1685	1255	2617	2240	1201
27000	2341	3322	6051	2092	5575	2010	7209	492	1035	1685	1260	2617	2254	1201
27500	2341	3409	6274	2123	5592	2066	7515	492	1046	1685	1265	2617	2269	1201
28000	2341	3490	6488	2151	5609	2117	7680	492	1057	1685	1269	2617	2283	1201
28500	2341	3576	6711	2181	5626	2172	7789	492	1067	1685	1273	2617	2297	1201
29000	2341	3631	6876	2192	5643	2208	7830	492	1078	1685	1278	2617	2310	1201
29500	2341	3690	7050	2207	5659	2247	7881	492	1088	1685	1282	2617	2323	1201
30000	2341	3715	7156	2201	5676	2264	7859	492	1099	1685	1286	2617	2337	1201
30500	2341	3774	7328	2215	5691	2303	7912	492	1109	1685	1290	2617	2350	1201
31000	2341	3808	7450	2215	5707	2326	7911	492	1119	1685	1294	2617	2362	1201
31500	2341	3842	7573	2216	5722	2349	7913	492	1128	1685	1298	2617	2375	1201
32000	2341	3869	7680	2212	5738	2368	7901	492	1138	1685	1302	2617	2387	1201
32500	2341	3902	7797	2212	5752	2390	7901	492	1147	1685	1306	2617	2399	1201
33000	2341	3929	7903	2210	5767	2409	7892	492	1156	1685	1310	2617	2411	1201
33500	2341	3965	8025	2212	5781	2433	7901	492	1166	1685	1314	2617	2423	1201
34000	2341	3993	8132	2211	5796	2453	7896	492	1175	1685	1317	2617	2434	1201
34500	2341	4004	8201	2200	5810	2461	7857	492	1183	1685	1321	2617	2446	1201
35000	2341	4015	8270	2190	5823	2470	7820	492	1192	1685	1325	2617	2457	1201

REPRESENTATIVE GROUP II
WEIGHTED USABLE AREA

Q	100.6R	101.4L	101.8L	113.1R	113.7R	115.6R	117.9L	118.0L	121.8R	122.4R	122.5R	123.6R	125.1R	125.9R
5000	1460	20335	1155	0	5273	18889	0	8085	3598	6152	66522	17536	49511	18488
5500	1460	20713	1186	0	5273	19238	0	8085	3598	6152	66522	17536	49511	18488
6000	1460	21090	1216	0	5273	19580	0	8085	3598	6152	66522	17536	49511	18488
6500	1460	21468	1246	0	5273	19928	0	8085	3598	6152	66522	17536	49511	18488
7000	1460	21846	1276	0	5299	20277	0	8085	3598	6152	66522	17536	49511	18488
7500	1460	22223	1306	0	5339	20626	0	8085	3598	6152	66522	17536	49511	18488
8000	1460	22393	1312	0	5404	21400	268	8085	3598	6152	66522	17536	49511	18488
8500	1460	22562	1317	0	5497	22175	536	8085	3598	6152	66522	17536	49511	18488
9000	1460	22732	1321	0	5602	22950	804	8085	3598	6152	66522	17536	49511	18488
9500	1460	22901	1326	0	5734	23724	1070	8085	3598	6152	66522	17536	49511	18488
10000	1460	23071	1330	0	5866	24499	1335	8085	3598	6152	66522	17536	49511	18488
10500	1460	23240	1334	0	6011	25274	1599	8085	3598	6152	66522	17536	49511	18488
11000	1460	23603	1359	0	6156	25310	1686	8085	3598	6152	66522	17536	49511	18488
11500	1460	23966	1385	0	6314	25346	1773	8085	3598	6152	66522	17536	49511	18488
12000	1460	24329	1409	259	6472	25382	1858	8085	3598	6152	66522	17536	49511	18488
12500	1460	24693	1434	264	6643	25419	1943	8085	3598	6152	66522	17536	49511	18488
13000	1460	24900	1440	269	6841	25523	1947	8085	3598	6152	66522	17536	49511	18488
13500	1460	25108	1445	639	7065	25626	1950	8085	3598	6152	66522	17536	49511	18488
14000	1460	25315	1451	650	7316	25730	1953	8085	3598	6152	66522	17536	49511	18488
14500	1460	25523	1456	1324	7606	25834	1956	8085	3598	6152	66522	17536	49511	18488
15000	1460	25730	1460	1363	7909	25938	1957	8085	3598	6152	66522	17536	49511	18488
15500	1460	25937	1464	1408	8212	26041	1959	8085	3598	6152	66522	17536	49511	18488
16000	1460	26145	1467	1457	8528	26145	1959	8085	3598	6152	66522	17536	49511	18488
16500	1460	27125	1478	1515	8858	26871	2367	8085	3598	6152	66522	17536	49511	18488
17000	1443	28106	1489	1576	9201	27598	2770	8085	3598	6152	66522	17536	49511	18488
17500	1443	29086	1498	1636	9557	28324	3168	8085	3598	6152	66522	17536	49511	18488
18000	1443	30067	1507	1699	9939	29050	3560	8085	3598	6152	66522	17536	49511	18488
18500	1443	30256	1516	1765	10347	29631	3712	8085	3598	6152	66522	17536	49511	18488
19000	1443	30444	1524	1833	10796	30212	3860	8085	3598	6152	66522	17536	49511	18488
19500	1443	30633	1576	1904	11283	30793	4006	8085	3598	6152	79004	17536	49511	18488
20000	1443	30822	1579	1980	11811	31374	4157	8085	3598	6152	91487	17536	49511	18488
20500	1443	31011	1592	2061	12377	31955	4331	8085	3598	6152	90916	17536	50420	18488
21000	1443	31200	1618	2151	12984	32536	4541	8085	3598	6152	89199	17536	54325	18488
21500	1443	31389	1722	2248	13630	33117	4974	8085	3598	6152	88244	17536	61782	18488
22000	1443	31953	2066	2353	14315	33698	6136	8085	3598	6152	87693	17536	73854	18488
22500	1443	32539	2668	2466	15066	34279	8133	8233	3664	6152	87646	17536	88767	18488
23000	1443	35060	4605	2587	15857	34860	14380	8871	3948	6152	86461	17536	107877	18488
23500	1443	39872	7403	2715	16701	35500	23270	10089	4490	6152	85277	17536	126049	18488
24000	1443	47663	9311	2852	17597	38250	29269	12060	5367	6152	84092	17536	137767	18488
24500	1443	57288	11448	3002	18546	43500	35987	14495	6451	6152	82908	17536	144158	18488
25000	1443	69620	12911	3159	19561	52000	40587	17616	7840	6152	81724	20827	148419	18488
25500	1443	81348	14160	3327	20655	62500	44511	20583	9160	6197	80539	24117	150272	21957
26000	1443	88910	15192	3506	21868	75955	47758	22496	10012	6256	79355	23967	149484	25426
26500	1443	93035	15967	3695	23226	88750	50193	23540	10476	7482	78170	23514	147353	25268
27000	1443	95785	16742	3897	24781	97000	52628	24236	10786	8740	76986	23263	142738	24791
27500	1443	96981	16965	4115	26574	101500	53329	24539	10921	8689	75802	23117	136346	24525
28000	1443	96472	16699	4357	28867	104500	52493	24410	10863	8512	74617	23045	129955	24372
28500	1443	95097	15924	4627	31570	105805	50057	24062	10709	8427	73433	22674	123732	24339
29000	1443	92118	14848	4937	34799	105250	46675	23308	10373	8366	72248	22302	118296	23940
29500	1443	87994	13385	5294	37699	103750	42075	22265	9909	8278	71064	21930	113564	23541
30000	1443	83869	11835	5751	40204	100500	37205	21221	9444	8209	69880	21559	109463	23142
30500	1443	79853	10501	6289	41917	96000	33011	20205	8992	8138	69090	21187	105932	22743
31000	1446	76345	9207	6933	43499	91500	28941	19317	8597	8064	67906	20815	102921	22344
31500	1458	73291	8177	7511	44224	87118	25705	18544	8253	7989	66721	20444	100389	21945
32000	1481	70644	7230	8009	44356	83291	22729	17875	7955	7911	65537	20072	98301	21546
32500	1576	68365	6370	8351	44026	79959	20023	17298	7698	7832	64352	19700	96628	21147
33000	1891	66422	5595	8666	43235	77072	17588	16806	7480	7751	63168	19328	95349	20748
33500	2443	64788	4949	8810	42444	74586	15558	16393	7296	7667	62015	18957	93619	20349
34000	4216	63440	4433	8837	41654	72466	13935	16052	7144	7582	60830	18585	91714	19950
34500	6777	62361	4003	8771	40863	70683	12582	15779	7022	7494	59645	18213	89802	19551
35000	8524	61535	3615	8613	40072	69212	11364	15570	6929	7405	58460	17842	87882	19152

REPRESENTATIVE GROUP III
WEIGHTED USABLE AREA (SQ. FT.)

Q	100.4R	100.6L	101.2R	101.6L	101.7L	110.4L	115.0R	117.8L	119.3L	128.5R	128.7R
5000	0	0	0	0	0	3395	0	0	0	0	0
5500	0	0	0	0	5340	3794	0	0	0	0	0
6000	0	0	0	0	10680	4157	0	1879	0	0	0
6500	0	0	0	0	16019	4492	0	3758	0	0	0
7000	0	1274	3482	0	21359	4802	0	5637	0	0	0
7500	0	2601	7892	0	26699	5090	0	7516	0	0	0
8000	0	3975	13137	0	32039	5360	0	9396	0	4497	0
8500	0	5393	19144	0	37379	5614	0	20710	0	10203	0
9000	0	6850	25850	0	42718	5853	0	24225	0	17116	0
9500	0	17004	54160	0	61970	6079	0	28180	0	25236	0
10000	0	18830	61895	1702	132193	6293	14483	30502	0	32633	0
10500	3323	20979	70750	3474	134218	6497	30840	30480	0	79141	0
11000	6671	21928	75545	5312	135799	6691	48933	29350	1184	93069	0
11500	10041	21288	74678	7211	137877	6877	68646	28843	2521	108814	0
12000	13432	20008	71284	9167	139631	7055	89886	26582	4001	118342	0
12500	16844	19260	69548	11177	140701	12454	205757	26237	5615	118785	0
13000	30646	17437	63712	13239	141471	18979	224011	23756	7356	114865	6093
13500	35211	16945	62567	15348	142450	29477	246102	22501	9217	113326	12597
14000	40464	15135	56407	22569	143191	46721	254249	21429	11190	104832	19486
14500	43432	14163	53227	34226	139223	75681	244423	19045	13272	103836	26739
15000	43153	13343	50528	34912	134860	127988	227820	18929	19930	94331	34342
15500	41393	11745	44781	35488	133160	134452	217746	18791	26979	89627	81602
16000	40576	11571	44398	36197	131217	141835	195927	18633	27201	85613	86338
16500	37339	11396	43977	36824	125411	142235	189400	18460	26943	76304	92457
17000	36827	11219	43524	37272	119265	139450	168387	18274	27027	76044	93342
17500	33339	11041	43046	37639	111420	136130	156934	18078	27078	75681	87883
18000	31585	10864	42546	38060	103223	133711	147332	17872	27024	75231	80373
18500	30098	10687	42030	38416	98694	129294	129273	17660	26938	74706	75498
19000	26772	10511	41501	37502	93955	122914	127016	17442	26914	74119	66859
19500	26637	10336	40962	36469	94762	113047	124782	17221	26864	73479	63691
20000	26474	10163	40415	36146	95525	100028	122577	16995	25953	72794	55862
20500	26286	9992	39864	35749	89841	92087	120402	16768	24993	72071	51411
21000	26078	9822	39309	34289	83963	85169	118259	16539	24547	71317	47704
21500	25853	9655	38752	32722	81884	76007	116151	16309	24070	70538	41403
22000	25613	9491	38196	30673	79714	69850	114077	16079	22902	69737	40267
22500	25361	9328	37640	28509	80884	62465	112040	15849	21690	68920	39182
23000	25099	9168	37086	27344	82041	53885	110039	15619	20186	68088	38146
23500	24829	9011	36535	26112	79959	46617	108075	15391	18635	67247	37153
24000	24551	8856	35988	26415	77803	40396	106148	15164	17759	66398	36203
24500	24268	8704	35445	26705	75653	40928	104257	14938	16855	65544	35290
25000	23981	8555	34906	25187	73435	40981	102402	14714	16952	64687	34414
25500	23690	8408	34373	23604	73854	40473	100583	14493	17043	63828	33572
26000	23397	8263	33846	23081	74256	41860	98800	14273	15990	62969	32762
26500	23101	8122	33324	22527	75381	46106	97052	14056	14910	62113	31982
27000	22805	7982	32808	22916	76502	47615	95339	13841	14509	61259	31230
27500	22509	7846	32299	23301	75575	45807	93659	13629	14096	60409	30504
28000	22212	7711	31796	22764	74612	49095	92013	13419	14276	59563	29804
28500	21916	7580	31300	22202	72640	57330	90400	13212	14455	58724	29127
29000	21621	7450	30811	21638	70621	58712	88820	13008	14064	57890	28473
29500	21327	7323	30328	21050	76511	57238	87270	12806	13664	57064	27841
30000	21035	7199	29853	21217	67977	57795	85752	12607	13266	56244	27228
30500	20744	7077	29384	21377	67289	57524	84264	12411	12859	55433	26635
31000	20456	6957	28923	21746	66608	57383	82805	12218	12916	54630	26061
31500	20170	6839	28468	22114	65944	57107	81376	12028	12970	53835	25504
32000	19886	6723	28020	21889	65284	57020	79975	11840	13151	53050	24963
32500	19605	6610	27579	21652	64642	56919	78602	11655	13332	52273	24439
33000	19326	6499	27145	21119	64005	56804	77256	11473	13156	51505	23930
33500	19051	6390	26717	20570	63383	56674	75936	11294	12975	50747	23435
34000	18778	6283	26297	22325	62766	56532	74642	11118	12621	49998	22955
34500	18509	6178	25883	19569	62149	56376	73374	10868	12259	49259	22488
35000	18242	6074	25475	19067	61523	56207	72130	10619	13270	48530	22033

REPRESENTATIVE GROUP IV
WEIGHTED USABLE AREA (SQ.FT.)

Q	100.7R	108.7L	110.8M	111.5R	112.6L	114.0R	116.8R	119.5L	119.6L	121.7R	124.1L
5000	88024	48568	43644	187543	539787	155011	45938	102253	387727	149229	176399
5500	83562	44644	39603	177079	496741	149330	42326	111463	405297	143745	191233
6000	80786	41364	36278	167867	460715	146146	39871	120099	421120	140669	205102
6500	79024	37751	32774	156267	420847	144452	38121	127954	434575	139028	217661
7000	68045	37757	32479	159025	421242	125500	32164	135503	447347	120782	229719
7500	62190	34397	29342	147119	384030	115603	28865	144052	463628	111251	243487
8000	74128	31755	26882	137699	354758	138749	33842	152423	479414	133519	256958
8500	68771	28201	23706	123815	315242	129518	30928	155340	478458	124631	261260
9000	60648	25312	21140	112388	283097	114852	26901	158013	477432	110515	265192
9500	52616	21973	18240	98571	245874	100142	23043	153233	454868	96357	256676
10000	47599	19542	16132	88502	218783	91007	20602	148500	433656	87565	248313
10500	50509	18784	15424	85813	210386	96974	21623	140607	404399	93304	234737
11000	47385	13453	10992	61956	150734	91327	20080	133472	378457	87868	222496
11500	42089	10873	8842	50451	121870	81407	17665	134028	375006	78322	223117
12000	37582	10297	8337	48119	115464	72930	15633	134566	371830	70165	223728
12500	33750	9688	7812	45571	108671	65695	13920	132856	362803	63203	220623
13000	33411	9235	7417	43710	103622	65220	13670	131154	354191	62745	217557
13500	30398	9248	7399	44025	103796	59498	12344	126519	338090	57240	209650
14000	28070	8643	6890	41370	97031	55079	11317	122038	322867	52987	202027
14500	25933	8451	6714	40665	94907	51008	10384	119714	313720	49070	197998
15000	24704	9870	7816	47727	110871	48699	9828	117315	304658	46848	193861
15500	24591	10071	7949	48924	113148	48578	9722	114310	294299	46731	188741
16000	23567	10507	8269	51273	118080	46649	9262	111251	284064	44875	183546
16500	23689	10113	7936	49561	113680	46980	9257	109843	278257	45193	181089
17000	22709	10750	8412	52893	120857	45118	8826	108439	272621	43401	178647
17500	22347	10007	7810	49429	112529	44475	8640	105671	263733	42782	173970
18000	21970	9576	7454	47479	107710	43798	8452	102858	254921	42130	169230
18500	20926	8815	6845	43861	99167	41782	8011	100893	248369	40191	165894
19000	20612	8309	6436	41486	93494	41218	7854	98852	241771	39648	162443
19500	18390	7736	5978	38749	87055	36827	6976	97722	237514	35424	160495
20000	16707	7237	5580	36368	81461	33503	6310	96543	233234	32226	158473
20500	16820	6878	5292	34668	77429	33775	6327	95959	230473	32488	157433
21000	16641	6431	4938	32512	72412	33458	6234	95348	227714	32182	156351
21500	16747	6001	4597	30421	67573	33713	6249	93770	222724	32427	153690
22000	17536	5670	4336	28824	63860	35344	6519	92207	217853	33996	151058
22500	17938	5483	4184	27948	61764	36194	6643	90657	213092	34814	148451
23000	18439	5210	3968	26622	58691	37248	6805	89123	208445	35827	145876
23500	18843	4976	3783	25490	56064	38105	6930	87604	203904	36651	143330
24000	19248	4718	3581	24229	53169	38965	7055	86104	199472	37478	140819
24500	19655	4629	3507	23826	52170	39827	7181	84613	195122	38307	138325
25000	20163	4410	3336	22751	49710	40897	7343	83141	190878	39336	135867
25500	20572	4297	3245	22215	48437	41766	7469	81647	186638	40172	133377
26000	20982	4117	3104	21334	46422	42637	7595	80176	182504	41009	130927
26500	20982	3915	2947	20327	44144	42674	7572	78760	178546	41045	128570
27000	21392	3819	2870	19870	43071	43546	7698	77366	174684	41883	126252
27500	21907	3614	2712	18838	40758	44631	7862	76000	170931	42927	123982
28000	22111	3538	2651	18478	39905	45084	7913	74656	167268	43362	121750
28500	22419	3352	2508	17538	37808	45748	8002	73330	163686	44000	119550
29000	22517	3252	2430	17047	36687	45983	8016	72025	160190	44226	117388
29500	22719	3085	2302	16202	34810	46429	8068	70739	156772	44655	115258
30000	22814	3028	2256	15928	34166	46657	8081	69474	153435	44874	113165
30500	23227	2881	2144	15183	32515	47535	8208	67893	149434	45718	110558
31000	24282	2845	2114	15015	32107	49731	8560	66353	145559	47830	108020
31500	24915	2741	2035	14492	30940	51060	8763	65218	142604	49108	106144
32000	25334	2659	1972	14080	30017	51954	8890	64100	139716	49967	104299
32500	25754	2554	1891	13545	28834	52850	9018	63127	137165	50829	102688
33000	25958	2471	1828	13123	27897	53302	9069	62165	134663	51263	101099
33500	26271	2477	1830	13176	27970	53976	9159	61216	132210	51912	99531
34000	26474	2461	1816	13108	27788	54426	9210	60279	129804	52345	97984
34500	26566	2376	1752	12676	26836	54649	9224	59354	127445	52559	96459
35000	26768	2427	1787	12967	27415	55095	9275	58441	125132	52988	94954

REPRESENTATIVE GROUP V
WEIGHTED USABLE AREA (SQ. FT.)

Q	101.7L	117.0M	118.9L	124.0M	132.8R	139.0L	139.7R	141.6R *1*	143.0L
5000	0	0	3252	1220	2864	601	854	14070	1409
5500	6821	0	4361	1440	2864	1251	854	14070	1409
6000	13643	0	5454	1660	2864	2020	854	14070	1409
6500	20464	0	6529	1879	2864	2874	854	14070	1409
7000	27286	0	7583	2099	2864	3787	854	14070	1484
7500	34107	0	8610	2319	2864	4742	854	14070	1901
8000	37035	124	9609	2542	2887	5723	854	14070	3072
8500	39964	247	9882	2766	2910	6277	854	14070	4392
9000	42892	371	9924	2990	2932	6654	854	14070	5823
9500	45820	495	9858	3214	2955	6922	854	14070	7336
10000	48757	618	9813	3437	2978	7173	854	14070	8906
10500	65365	742	9632	3661	3001	7292	854	14070	9824
11000	79841	1150	9173	4332	3035	7164	854	14070	10471
11500	93890	1558	8143	5003	3069	6538	854	14070	10950
12000	107564	1966	7630	5675	3103	6281	854	14070	11401
12500	120907	2374	7527	6346	3137	6338	854	14070	11643
13000	131455	3020	6487	7235	3507	5576	854	14070	11488
13500	132066	3667	6117	8124	3877	5357	854	14070	10528
14000	129882	4313	5533	9013	4248	4930	854	14070	10152
14500	126610	4959	5123	9902	4618	4639	854	14070	10281
15000	123909	5606	4406	10791	4988	4049	854	14070	9076
15500	119747	6252	3767	11681	5358	3510	854	14070	8749
16000	112447	8724	3630	12570	5729	3426	854	14070	8077
16500	96990	16417	3398	14217	5831	3246	854	14070	7622
17000	88389	25723	3046	15865	5933	2943	854	14070	6671
17500	84882	36444	2834	17512	6035	2767	854	14070	5799
18000	71271	48413	2690	19160	6138	2653	854	14070	5674
18500	65632	52863	2712	23663	6588	2699	854	14070	5388
19000	58018	53333	2575	28166	7038	2587	854	14070	4897
19500	52533	52670	2502	32669	7488	2535	854	14070	4614
20000	44202	51553	2459	37172	10039	2511	854	14070	4434
20500	36997	50656	2384	41675	12607	2486	854	14070	4521
21000	34911	49149	2324	46178	15210	2461	854	14070	4341
21500	32013	46333	2265	50681	17843	2435	854	33266	4262
22000	28127	40760	2209	55185	20503	2408	854	40925	4229
22500	25651	37885	2154	59688	23183	2381	1080	48451	4195
23000	23881	37107	2102	64191	24175	2353	4769	55860	4159
23500	24483	32330	2050	83361	24270	2325	5460	62864	4122
24000	23657	30843	2001	101733	24152	2297	6095	69766	4083
24500	23395	28248	1953	119615	24131	2269	6680	71547	4044
25000	23406	26502	1906	137109	23808	2241	7220	71829	4003
25500	23421	23107	1861	154301	22825	2212	7210	71479	3961
26000	23441	20044	1817	171243	20422	2184	7049	71415	3919
26500	23467	19602	1775	175614	19308	2156	6831	70460	3876
27000	23497	18631	1734	176305	19238	2127	6647	67551	3833
27500	23531	16968	1694	175447	16761	2099	6386	60441	3789
28000	23571	16042	1655	175290	15990	2071	5962	57142	3745
28500	23614	15485	1617	172946	14645	2043	5195	56935	3701
29000	23662	15875	1581	165806	13740	2015	4783	49605	3657
29500	23715	15339	1545	148353	11980	1988	4641	47324	3612
30000	23771	15169	1511	140257	10391	1960	3938	43343	3568
30500	23832	15176	1477	139748	10163	1933	3658	40664	3523
31000	23897	15186	1445	121758	9659	1906	3263	35455	3479
31500	23966	15199	1413	116157	8797	1880	2981	30754	3435
32000	24040	15216	1382	106386	8317	1853	2531	30076	3391
32500	24117	15235	1352	99810	8028	1827	2138	28586	3348
33000	24198	15258	1323	87024	8230	1801	2036	26035	3304
33500	24283	15283	1295	75486	7952	1776	1885	24614	3261
34000	24372	15311	1267	73823	7864	1751	1672	23759	3218
34500	24465	15343	1241	70165	7868	1726	1539	24357	3176
35000	24562	15377	1214	63904	7873	1701	1447	23536	3134

REPRESENTATIVE GROUP VII
WEIGHTED USABLE AREA (SQ. FT.)

Q	114.1R	119.2R	121.1L	123.0L	125.6L	127.5M	131.3L
5000	78609	18599	11704	13230	68073	83555	7030
5500	83542	19343	15848	14235	70482	88363	7649
6000	88269	20087	20565	15193	72840	92983	8269
6500	86868	20831	25857	15079	70328	91191	8888
7000	83153	21575	31720	14539	66206	87031	11562
7500	91305	22319	38162	16064	71632	95314	14504
8000	90629	30010	40965	16033	70171	94392	19939
8500	85794	38720	47242	15251	65645	89173	25438
9000	81406	48449	54117	14533	61622	84457	31903
9500	76939	59194	58246	13789	57673	79690	35440
10000	70562	74555	70269	12690	52419	72975	39276
10500	63849	78545	75392	11520	47041	65940	45761
11000	58236	82523	76216	10538	42578	60067	49868
11500	53646	80932	76517	9733	38944	55268	60749
12000	48136	77324	75964	8755	34713	49538	65699
12500	45803	84841	72755	8350	32826	47089	66867
13000	42667	84222	68423	7795	30401	43824	67524
13500	38771	79786	64608	7097	27473	39786	67383
14000	35727	75796	61410	6553	25186	36632	64833
14500	31573	71747	56696	5801	22149	32348	61227
15000	28049	65919	55373	5162	19585	28716	58032
15500	26203	59767	52833	4830	18216	26807	55351
16000	24563	54629	49083	4534	17005	25113	51265
16500	23038	50436	46167	4259	15886	23539	50218
17000	21618	45361	41586	4001	14849	22074	48048
17500	20295	43264	37609	3761	13891	20712	44752
18000	19062	40398	35725	3537	13001	19443	42197
18500	17912	36796	34019	3327	12176	18260	38097
19000	16841	33988	32382	3132	11411	17160	34527
19500	15841	30108	30811	2949	10701	16134	32865
20000	15576	26811	29310	2903	10491	15857	31356
20500	15317	25105	27874	2857	10287	15586	29902
21000	15063	23588	26504	2812	10088	15321	28501
21500	14814	22175	25202	2768	9896	15062	27158
22000	14571	20854	23961	2725	9708	14809	25869
22500	14333	19622	23803	2683	9526	14561	24636
23000	14100	18469	23636	2641	9349	14319	23459
23500	13872	17393	23463	2601	9176	14083	22336
24000	13647	16387	23283	2560	9007	13849	22218
24500	13429	15446	23097	2521	8844	13624	22092
25000	13214	15219	22908	2483	8684	13402	21957
25500	13004	14996	22715	2445	8529	13184	21814
26000	12799	14776	22518	2408	8378	12973	21666
26500	12599	14560	22316	2372	8231	12766	21512
27000	12401	14348	22116	2336	8086	12563	21354
27500	12206	14139	21911	2301	7945	12362	21192
28000	12019	13935	21705	2267	7809	12168	21023
28500	11831	13734	21500	2232	7673	11975	20855
29000	11650	13535	21294	2200	7543	11789	20681
29500	11469	13342	21086	2167	7414	11603	20506
30000	11296	13151	20874	2135	7290	11425	20329
30500	11124	12963	20668	2103	7168	11249	20153
31000	10955	12780	20456	2073	7048	11075	19972
31500	10790	12600	20250	2042	6931	10906	19788
32000	10627	12422	20038	2012	6817	10739	19609
32500	10468	12245	19833	1983	6705	10575	19422
33000	10311	12075	19626	1954	6596	10415	19241
33500	10157	11904	19419	1926	6488	10258	19054
34000	10006	11740	19213	1898	6383	10103	18873
34500	9858	11574	19007	1871	6281	9952	18688
35000	9712	11416	18803	1844	6180	9803	18504

REPRESENTATIVE GROUP VIII
WEIGHTED USABLE AREA (SQ.FT.)

Q	123.2R	124.8R	125.6R	128.4R	132.5L	135.0R	135.1R	144.0M	145.6R	146.6L
5000	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0
6500	0	0	0	0	0	0	0	0	0	0
7000	0	0	0	0	0	0	0	0	0	0
7500	0	0	0	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0	0	0	0
8500	0	0	0	0	0	0	0	0	0	0
9000	0	0	0	0	0	0	0	0	0	0
9500	0	0	0	585	0	0	0	0	0	0
10000	0	0	0	2190	0	0	0	0	0	0
10500	0	0	0	5286	0	0	0	0	0	0
11000	0	0	0	8717	0	0	0	0	0	0
11500	0	0	0	13082	0	0	0	0	0	0
12000	0	0	0	17228	0	0	0	0	0	0
12500	0	0	0	21405	0	0	0	0	0	0
13000	0	0	0	25452	0	0	0	0	0	0
13500	0	0	0	29216	0	0	0	0	0	0
14000	0	0	0	32997	0	0	0	0	0	0
14500	0	0	0	35615	0	0	0	0	0	0
15000	0	0	0	37050	29038	0	0	0	0	0
15500	0	0	0	37044	29829	0	0	0	0	0
16000	0	0	0	36021	30512	0	0	0	0	0
16500	0	0	0	33567	31298	0	0	0	0	0
17000	0	0	0	30441	32004	0	0	0	0	0
17500	0	0	0	27505	32543	0	0	0	0	0
18000	0	0	0	24626	33004	0	0	0	0	0
18500	0	0	0	22255	33505	0	0	0	0	0
19000	0	0	0	19932	33940	0	0	0	0	0
19500	0	17467	0	17713	33243	0	0	0	0	0
20000	0	49348	0	15618	32428	0	11261	0	0	0
20500	0	51962	0	13887	32233	0	24791	0	0	0
21000	0	54324	0	12532	31966	0	26132	0	0	0
21500	0	56817	0	11390	30739	0	27344	0	0	0
22000	0	59120	0	10351	29404	56562	28622	0	3662	0
22500	0	61075	0	9548	27624	58439	29805	17933	12918	0
23000	13963	62837	0	8733	25730	60109	30810	17540	22605	0
23500	19242	64636	0	8307	24728	61988	31719	17148	36786	0
24000	19725	66276	0	8117	23658	63712	32646	16866	46767	0
24500	20150	65648	0	8034	23976	65108	33492	16585	58030	0
25000	20653	64710	0	8068	24281	66346	33191	16259	65944	0
25500	21113	64951	0	8093	22938	67663	32731	15933	72753	0
26000	21471	65001	2377	8111	21530	68849	32868	15660	78405	0
26500	21784	63041	8492	8258	21084	67725	32907	15388	82822	159
27000	22129	60789	15033	8402	20608	66339	31927	14644	87098	559
27500	22436	57544	24731	8544	20992	66206	30798	13901	88352	976
28000	21998	53984	31761	8683	21373	65913	29164	13464	87032	1587
28500	21483	52236	39758	8820	20907	63621	27369	13027	82911	2016
29000	21382	50299	44305	8954	20415	61080	26491	12236	77214	2500
29500	21234	51288	47970	9086	19919	57586	25516	11445	69210	2838
30000	20448	52244	50769	9216	19400	53821	26026	10524	60598	3129
30500	19589	49631	52702	9344	19574	51899	26518	9603	53033	3371
31000	18432	46833	54499	9470	19743	49814	25199	9049	46116	3559
31500	17195	46098	54393	9593	20103	50641	23784	8495	40576	3741
32000	16552	45278	52746	9715	20463	51441	23417	8454	35457	3794
32500	15862	46338	49491	9835	20274	48741	23006	8413	30802	3736
33000	16101	47391	45418	9953	20072	45881	23550	7814	26594	3558
33500	16332	46559	40134	10069	19596	45057	24091	7216	23189	3313
34000	15455	45654	34659	10183	19102	44160	23673	6957	20548	2969
34500	14530	44725	29928	10296	20749	45103	23218	6697	18360	2599
35000	14252	43728	25689	10407	18482	46040	22750	6722	16422	2275

REPRESENTATIVE GROUP IX
WEIGHTED USABLE AREA (SQ.FT.)

Q	129.8R	131.2R	135.0L	139.2R	141.2R	141.3R	142.8R	144.0R	144.2L	147.1L
5000	16356	5132	5248	22187	4047	10855	38673	10846	51775	14190
5500	14645	5389	4641	23168	3792	9599	40462	9184	45787	12787
6000	15322	5916	4802	25310	4125	9932	44275	9116	47372	13454
6500	15076	6316	4677	26913	4198	9673	47149	8533	46139	13305
7000	14113	6581	4338	27939	4048	8972	49008	7617	42793	12513
7500	13591	6853	4141	29002	4002	8566	50930	7009	40856	12101
8000	14054	6727	4248	28386	4238	8787	49899	6937	41913	12561
8500	14873	7333	4463	30865	4582	9230	54307	7037	44026	13340
9000	15756	8621	4695	36198	4949	9710	63742	7155	46315	14178
9500	14774	8259	4373	34607	4724	9046	60986	6447	43146	13335
10000	15411	8398	4534	35117	5010	9378	61930	6469	44730	13949
10500	14952	8306	4373	34670	4935	9046	61180	6043	43146	13570
11000	15403	8131	4480	33885	5156	9267	59830	5998	44202	14014
11500	14990	7696	4338	32018	5085	8972	56567	5629	42793	13671
12000	14446	7295	4159	30305	4961	8603	53568	5234	41032	13204
12500	15636	6949	4480	28832	5432	9267	50989	5470	44202	14322
13000	15520	7637	4427	31644	5451	9156	55987	5244	43674	14245
13500	16217	7500	4605	31037	5754	9526	54937	5295	45435	14912
14000	17421	7786	4927	32185	6242	10190	56993	5499	48605	16049
14500	14893	7657	4195	31616	5386	8676	56007	4546	41384	13744
15000	15523	7559	4355	31181	5663	9009	55256	4584	42969	14350
15500	16476	7707	4605	31759	6060	9526	56301	4708	45435	15255
16000	17945	7347	4998	30248	6654	10338	53640	4963	49309	16641
16500	18136	6997	5034	28783	6776	10412	51058	4855	49661	16843
17000	16068	6758	4445	27774	6047	9193	49284	4164	43850	14943
17500	17804	7051	4909	28957	6747	10153	51398	4468	48429	16580
18000	18705	6944	5141	28496	7135	10633	50594	4545	50718	17442
18500	20195	6631	5534	27189	7753	11446	48286	4753	54592	18856
19000	19929	7373	5444	30209	7698	11261	53663	4542	53712	18630
19500	20052	7424	5462	30397	7792	11298	54011	4426	53888	18767
20000	19385	7473	5266	30581	7576	10892	54350	4144	51951	18164
20500	19240	7522	5212	30760	7561	10781	54680	3983	51422	18049
21000	18961	8806	5123	35990	7491	10596	63992	3800	50542	17806
21500	19805	8986	5337	36705	7864	11039	65278	3843	52655	18618
22000	20785	9273	5587	37855	8295	11556	67336	3905	55121	19559
22500	21169	9497	5676	38748	8488	11741	68939	3849	56001	19940
23000	21887	9593	5855	39120	8817	12110	69614	3852	57762	20636
23500	23343	9646	6230	39313	9446	12885	69970	3974	61460	22029
24000	24134	9719	6426	39590	9809	13292	70476	3975	63397	22797
24500	24322	9856	6462	40130	9928	13365	71451	3874	63750	22995
25000	24375	10015	6462	40760	9991	13365	72583	3753	63750	23065
25500	24157	10329	6390	42016	9941	13218	74834	3595	63045	22878
26000	24140	11197	6373	45528	9973	13181	81102	3471	62869	22881
26500	23783	11428	6265	46445	9863	12959	82747	3302	61813	22561
27000	24035	11569	6319	47000	10004	13070	83750	3221	62341	22817
27500	24422	11778	6408	47829	10202	13255	85239	3158	63221	23202
28000	23719	11829	6212	48019	9943	12849	85589	2958	61284	22552
28500	22945	11880	5998	48205	9652	12405	85934	2758	59171	21831
29000	22029	11748	5748	47651	9298	11889	84958	2551	56706	20975
29500	21589	11527	5623	46740	9142	11630	83345	2407	55473	20571
30000	22109	11293	5748	45774	9391	11889	81633	2371	56706	21080
30500	24967	11154	6480	45193	10639	13402	80606	2574	63926	23822
31000	24390	10920	6319	44229	10424	13070	78897	2415	62341	23286
31500	23672	10799	6123	43724	10148	12664	78005	2250	60404	22615
32000	23919	10838	6176	43871	10283	12775	78277	2180	60932	22866
32500	23265	10668	5998	43166	10031	12405	77028	2031	59171	22255
33000	22262	10518	5730	42548	9625	11852	75934	1860	56529	21308
33500	21533	10367	5534	41923	9335	11446	74827	1719	54592	20623
34000	20941	10190	5373	41196	9103	11113	73537	1596	53007	20067
34500	20415	10011	5230	40461	8898	10818	72234	1483	51599	19575
35000	19748	9902	5052	40008	8629	10449	71432	1365	49837	18946

APPENDIX E

REGRESSION EQUATIONS FOR SPECIFIC AREAS

Table 1. Relationships between digitized surface area and mainstem discharge for the specific areas of Representative Group I.

A = a + b(ln(Qms)) , where A = area (sq.in.) ; Qms = mainstem discharge (cfs)

Specific Area	Breaching Discharge (cfs)	Application Range (cfs)	a	b	r^2	n	Comments A = area (sq.in.)
102.2 L	>35,000	5,000 < Qms < 35,000					constant A=.046
105.2 R	>35,000	5,000					A = 0
		5,500 < Qms < 35,000	-.196	.023	.93	7	
107.6 L	>35,000	5,000 < Qms < 13,000					constant A=.016
		13,000 < Qms < 35,000	-1.216	.130	.89	3	
108.3 L	>35,000	5,000 < Qms < 12,500					constant A=.023
		12,500 < Qms < 35,000					constant A=.024
112.5 L	>35,000	5,000 < Qms < 35,000	-.101	.023	.98	7	
119.4 L	>35,000	5,000 < Qms < 10,500					constant A=0
		10,500 < Qms < 35,000	-.209	.024	.88	3	
120.0 R	>35,000	5,000 < Qms < 22,500	-.190	.027	1.00	2	
		22,500 < Qms < 27,500	-1.629	.171	1.00	2	
		27,500 < Qms < 35,000					constant A=.120
121.9 R	>35,000	5,000 < Qms < 35,000					constant A=.011
123.1 R	>35,000	5,000 < Qms < 35,000	-.187	.022	.96	7	
123.3 R	>35,000	5,000 < Qms < 16,000					constant A=.025
		16,000 < Qms < 22,000	-.349	.039	1.00	2	
		22,000 < Qms < 35,000					constant A=.041
127.2 M	>35,000	5,000 < Qms < 12,000	-.030	.004	.96	3	
		12,000 < Qms < 35,000	-.036	.007	.97	3	
129.4 R	>35,000	5,000 < Qms < 35,000					constant A=.097
133.9 L	>35,000	5,000 < Qms < 17,000					constant A=.047
		17,000 < Qms < 35,000	-.139	.019	1.00	2	
134.0 L	>35,000	5,000 < Qms < 16,000					constant A=.014
		16,000 < Qms < 24,000	-.119	.014	1.00	2	
		24,000 < Qms < 35,000					constant A=.022
135.5 R	>35,000	5,000 < Qms < 35,000					constant A=.041
135.6 R	>35,000	5,000 < Qms < 35,000	-.034	.021	.92	7	
136.9 R	>35,000	5,000 < Qms < 12,500	-.098	.012	1.00	2	
		12,500 < Qms < 35,000	-1.148	.124	1.00	3	
139.0 L	>35,000	5,000 < Qms < 35,000	-.286	.036	.91	6	
139.9 R	>35,000	5,000 < Qms < 20,500					constant A=.012
		20,500 < Qms < 35,000	-.068	.008	1.00	2	

Table 3. Relationships between digitized surface area and mainstem discharge for the specific areas of Representative Group VIII.

A = a + b(ln(Qms)) , where A = area (sq.in.) ; Qms = mainstem discharge (cfs)

Specific Area	Breaching Discharge	Application Range	a	b	r^2	n	Comments
101.3 M	9,200	5,000 < Qms < 9,200					constant A=.000
		9,200 < Qms < 35,000	-.880	.099	.88	4	
102.0 L	10,000	5,000 < Qms < 40,000					constant A=.000
		10,000 < Qms < 35,000	-.637	.076	.91	4	
104.3 M	21,000	5,000 < Qms < 21,000					constant A=.000
		21,000 < Qms < 35,000					constant A=.036
109.5 M	16,000	5,000 < Qms < 16,000					constant A=.000
		16,000 < Qms < 35,000	-1.665	.171	1.00	2	
112.4 L	22,000	5,000 < Qms < 17,500					constant A=.000
		17,500 < Qms < 22,000					constant A=.035
		22,000 < Qms < 35,000					constant A=.143
117.1 M	15,500	5,000 < Qms < 10,600					constant A=.000
		10,600 < Qms < 15,500	-6.226	.670	.98	3	
		15,500 < Qms < 35,000	-3.757	.416	1.00	2	
117.1 M	20,000	5,000 < Qms < 20,000					constant A=.000
		20,500 < Qms < 35,000	-.985	.103	.98	3	
118.6 M	14,000	5,000 < Qms < 14,000	-.108	.013	.82	3	
		14,000 < Qms < 35,000	-1.045	.112	.97	3	
119.8 L	15,500	5,000 < Qms < 15,500					constant A=.000
		15,500 < Qms < 35,000	-.007	.008	1.00	2	
120.0 L	12,500	5,000 < Qms < 12,500	-.338	.045	.96	4	
		12,500 < Qms < 35,000	-.006	.008	1.00	2	
121.5 R	19,500	5,000 < Qms < 15,500					constant A=.000
		15,500 < Qms < 35,000	-6.987	.725	1.00	3	
121.6 R	15,500	5,000 < Qms < 15,500					constant A=.000
		15,500 < Qms < 35,000	-6.534	.689	1.00	2	
123.2 R	23,000	5,000 < Qms < 16,000	-.152	.019	.92	5	
		16,000 < Qms < 35,000	-2.811	.292	1.00	3	
124.8 R	19,500	5,000 < Qms < 10,500					constant A=.000
		10,500 < Qms < 19,500	-1.208	.131	.97	4	
		19,500 < Qms < 35,000	-5.509	.575	1.00	2	
125.6 R	26,000	5,000 < Qms < 9,000					constant A=.000
		9,000 < Qms < 16,000					constant A=.013
		16,000 < Qms < 35,000	-4.017	.416	1.00	2	

Table 4. Relationships between digitized surface area and mainstem discharge for the specific areas of Representative Group IV.

A = a + b(ln(Qms)) , where A = area (sq.in.) ; Qms = mainstem discharge (cfs)

Specific Area	Breaching Discharge	Application Range	a	b	r^2	n	Comments
100.7 R	<5,100	5,000 < Qms < 35,000	-1.878	.305	.87	6	
108.7 L	<5,100	5,000 < Qms < 35,000	-.193	.043	.94	7	
110.8 M	<5,100	5,000 < Qms < 35,000	.007	.019	.75	3	
111.5 R	5,100	5,000 < Qms < 35,000	-2.658	.399	.96	7	
112.6 L	<5,100	5,000 < Qms < 35,000	-2.073	.443	.92	6	
114.0 R	<5,100	5,000 < Qms < 35,000	-5.638	.821	.90	6	
116.8 R	<5,100	5,000 < Qms < 35,000	-.015	.044	.87	4	
119.5 L	5,000	5,000 < Qms < 35,000	-1.111	.168	.91	7	
119.6 L	<5,100	5,000 < Qms < 35,000	.469	.090	.80	4	
121.7 R	<5,100	5,000 < Qms < 35,000	-4.853	.707	.95	7	
124.1 L	<5,100	5,000 < Qms < 35,000	-1.916	.301	.77	4	
125.2 R	<5,100	5,000 < Qms < 35,000	-3.782	.626	.92	6	
127.0 M	<5,100	5,000 < Qms < 35,000	-.741	.112	.95	4	
127.4 L	<5,100	5,000 < Qms < 35,000	-.358	.182	.87	3	
129.5 R	<5,100	5,000 < Qms < 35,000	-1.355	.205	.95	3	
131.7 L	5,000	5,000 < Qms < 35,000	-9.861	1.187	1.00	4	
134.9 R	<5,100	5,000 < Qms < 35,000	-3.710	.583	.99	3	
136.0 L	<5,100	5,000 < Qms < 35,000	-.147	.022	.98	3	
139.4 L	<5,100	5,000 < Qms < 35,000	-.099	.026	.99	3	
139.6 L	<5,100	5,000 < Qms < 35,000	-.229	.090	.91	3	
140.4 R	<5,100	5,000 < Qms < 35,000	-.677	.119	1.00	3	
145.3 R	<5,100	5,000 < Qms < 35,000	.138	.010	.84	3	

Table 6. Relationships between digitized surface area and mainstem discharge for the specific areas of Representative Group VI.

A = a + b(ln(Qms)) , where A = area (sq.in.) ; Qms = mainstem discharge (cfs)

Specific Area	Breaching Discharge	Application Range	a	b	r^2	n	Comments
102.6 L	6,500	5,000 < Qms < 6,500					constant A=.143
		6,500 < Qms < 35,000	-2.019	.254	.96	3	
106.3 R	4,800	5,000 < Qms < 35,000	-.453	.064	.97	3	
107.1 L	9,600	5,000 < Qms < 13,000					constant A=.012
		13,000 < Qms < 35,000	-5.648	.628	.94	3	
117.9 R	7,300	5,000 < Qms < 7,300					
		7,300 < Qms < 35,000	-.218	.028	.71	3	
119.7 L	23,000	5,000 < Qms < 23,000					constant A=.028
		23,000 < Qms < 35,000					constant A=.06
133.8 L	17,500	5,000 < Qms < 35,000					model extrapolation
135.7 R	27,500	5,000 < Qms < 27,500					constant A=.042
		27,500 < Qms < 35,000					constant A=.095
136.3 R	13,000	5,000 < Qms < 35,000					model extrapolation
138.0 R	6,000	5,000 < Qms < 35,000	-.654	.0836	.93	4	
139.5 R	8,900	5,000 < Qms < 9,000					constant A=.128
		9,000 < Qms < 35,000	-5.902	.665	.99	4	
140.6 R	12,000	5,000 < Qms < 12,000	-.601	.075	1.0	2	
		12,000 < Qms < 35,000	-3.674	.421	.93	3	
142.0 R	10,500	5,000 < Qms < 10,500	-1.203	.149	.97	3	
		10,500 < Qms < 35,000	-6.975	.768	.93	5	

Table 8. Relationships between digitized surface area and mainstem discharge for the specific areas of Representative Group VIII.

A = a + b(ln(Qms)) , where A = area (sq.in.) : Qms = mainstem discharge (cfs)

Specific Area	Breaching Discharge	Application Range	a	b	r^2	n	Comments
101.3 M	9,200	5,000 < Qms < 9,200					constant A=.000
		9,200 < Qms < 35,000	-.880	.099	.88	4	
102.0 L	10,000	5,000 < Qms < 40,000					constant A=.000
		10,000 < Qms < 35,000	-.637	.076	.91	4	
104.3 M	21,000	5,000 < Qms < 21,000					constant A=.000
		21,000 < Qms < 35,000					constant A=.036
109.5 M	16,000	5,000 < Qms < 16,000					constant A=.000
		16,000 < Qms < 35,000	-1.665	.171	1.00	2	
112.4 L	22,000	5,000 < Qms < 17,500					constant A=.000
		17,500 < Qms < 22,000					constant A=.035
		22,000 < Qms < 35,000					constant A=.143
117.1 M	15,500	5,000 < Qms < 10,600					constant A=.000
		10,600 < Qms < 15,500	-6.226	.670	.98	3	
		15,500 < Qms < 35,000	-3.757	.416	1.00	2	
117.1 M	20,000	5,000 < Qms < 20,000					constant A=.000
		20,500 < Qms < 35,000	-.985	.103	.98	3	
118.6 M	14,000	5,000 < Qms < 14,000	-.108	.013	.82	3	
		14,000 < Qms < 35,000	-1.045	.112	.97	3	
119.8 L	15,500	5,000 < Qms < 15,500					constant A=.000
		15,500 < Qms < 35,000	-.007	.008	1.00	2	
120.0 L	12,500	5,000 < Qms < 12,500	-.338	.045	.96	4	
		12,500 < Qms < 35,000	-.006	.008	1.00	2	
121.5 R	19,500	5,000 < Qms < 15,500					constant A=.000
		15,500 < Qms < 35,000	-6.987	.725	1.00	3	
121.6 R	15,500	5,000 < Qms < 15,500					constant A=.000
		15,500 < Qms < 35,000	-6.534	.689	1.00	2	
123.2 R	23,000	5,000 < Qms < 16,000	-.152	.019	.92	5	
		16,000 < Qms < 35,000	-2.811	.292	1.00	3	
124.8 R	19,500	5,000 < Qms < 10,500					constant A=.000
		10,500 < Qms < 19,500	-1.208	.131	.97	4	
		19,500 < Qms < 35,000	-5.509	.575	1.00	2	
125.6 R	26,000	5,000 < Qms < 9,000					constant A=.000
		9,000 < Qms < 16,000					constant A=.013
		16,000 < Qms < 35,000	-4.017	.416	1.00	2	

Table 9. Relationships between digitized surface area and mainstem discharge for the specific areas of Representative Group IX.

$A = a + b(\ln(Qms))$, where A = area (sq.in.) ; Qms = mainstem discharge (cfs)

Specific Area	Breaching Discharge	Application Range	a	b	r^2	n	Comments
101.5 L	<5,100	5,000 < Qms < 35,000	-5.733	.801	.59	3	
104.0 R	<5,100	5,000 < Qms < 35,000	-.722	.157	.89	3	
105.7 R	<5,100	5,000 < Qms < 35,000	-.110	.055	.99	3	
108.9 L	<5,100	5,000 < Qms < 35,000	-.190	.056	.46	3	
109.4 R	<5,100	5,000 < Qms < 35,000	-.782	.199	1.00	3	
111.0 R	<5,100	5,000 < Qms < 35,000	-1.782	.304	.92	3	
113.8 R	<5,100	5,000 < Qms < 35,000	-.122	.030	.96	3	
117.7 L	<5,100	5,000 < Qms < 35,000	-.776	.109	.86	3	
127.1 M	<5,100	5,000 < Qms < 35,000	-2.272	.309	.88	3	
128.3 R	<5,100	5,000 < Qms < 35,000	-4.264	.576	.98	3	
129.3 L	<5,100	5,000 < Qms < 35,000	-.291	.053	.64	3	
129.8 R	<5,100	5,000 < Qms < 35,000	-.064	.074	.95	3	
131.2 R	<5,100	5,000 < Qms < 35,000	-.311	.051	.62	3	
135.0 L	<5,100	5,000 < Qms < 35,000					constant A=.212
139.2 R	<5,100	5,000 < Qms < 35,000	-.841	.148	.96		
141.2 R	<5,100	5,000 < Qms < 35,000	-.491	.071	.74		
141.3 R	<5,100	5,000 < Qms < 35,000					constant A=.305
142.8 R	<5,100	5,000 < Qms < 35,000	-1.741	.298	.89	3	
144.2 L	<5,100	5,000 < Qms < 35,000					constant A=1.894
147.1 L	<5,100	5,000 < Qms < 35,000	-.335	.096	.56	3	