AN ASSESSMENT OF THE CUMULATIVE IMPACTS OF DEVELOPMENT AND HUMAN USES ON FISH HABITAT IN THE KENAI RIVER

By
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Habitat Biologist

Technical Report No. 94-6

Alaska Department of Fish and Game
Habitat and Restoration Division

FINAL REPORT

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Technical Advisory Group . . . . (TAG)
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ACKNOWLEDGEMENTS

The Kenai River 309 project benefitted from the willing participation of numerous individuals representing many federal, state, and local government agencies as well as private citizens and volunteers.

This project was made possible through the diligent efforts of Glenn Seaman, Coastal Management Program Coordinator for the Alaska Department of Fish and Game (ADF&G). Glenn's development of the initial project proposal, solicitation and acquisition of project funding, participation in project design, and review of the draft report have been instrumental in the development of this timely and much needed Kenai River cumulative impact assessment.

Several individuals assisting in the Kenai River 309 study provided invaluable assistance as participants on the Technical Advisory Group which, as a peer review of regulatory agency experts, was organized to evaluate alternative approaches to a Kenai River habitat classification procedure and cumulative impact assessment methodology. Persons that contributed to the overall design of the Kenai River 309 study and its implementation include Glenn Seaman, Gay Muhlberg, Terry Bendock, Christopher Estes, Carl Burger, Larry Dugan, Barbara Mahoney, Phil North, Dan LaPlant, Suzanne Fisler, and Hank Baij.

In addition to those listed above, dozens of others assisted in the enormous field data gathering efforts of the 309 study. The Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation (DNR/DPOR) graciously provided field survey boats and operators with extensive knowledge of the Kenai River including Suzanne Fisler, Sam Evanoff, William "Bill" Berkhahn, Lori Landstrom, and Walter Ward. The compilation of development information, which was used to define the existing level of habitat conditions on the Kenai River, was a time consuming process that included the efforts of the following people: Lance Trasky, Gay Muhlberg, Glenn Seaman, Stewart Seaberg, Kathrin Sundet, Mark Fink, Pat Houghton, Betsy McCracken, Laurie Fairchild, Mary Whalen, William Dieters, William Henson, Mary Pearsall, and Harriet Wegner.

The production of the Kenai River 309 project study and draft report included staff from the ADF&G's Habitat and Restoration Division. Celia Rozen provided extensive literature acquisition assistance for assessing cumulative impacts and also assisted in field data manipulation. Pat Houghton performed extensive field data organization, data set corroboration, personal computer data set entry, and quality control assessment for the Kenai River 309 database. Susan Peyer provided assistance in the editing and organization of this draft report.

The study required the development of an extensive Geographic Information System (GIS) database. This effort was accomplished through the technical abilities of ADF&G staff including

Frank Wallis, analyst/programmer, and Carol Barnhill, cartographer. Kenai Peninsula Borough staff including Dick Troeger, planning director; Dale Bertelson; Mary Toll; Chris Clough; and Bob Jones, analyst/programmer, were instrumental in providing baseline soils and vegetation maps, land ownership data, and public access site information for inclusion on ADF&G's GIS.

The Habitat Evaluation Procedure (HEP) assessment was facilitated by U.S. Fish and Wildlife Service (FWS) staff including Larry Dugan and Laurie Fairchild with technical assistance provided by the FWS HEP technical staff in Fort Collins, Colorado.

This study was funded in part by the Alaska Coastal Management Program (ACMP) through funding from the State of Alaska and the Office of Oceans and Coastal Resource Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Funding was made available to the ADF&G through the 309 Enhancement Grant Program. These funds are administered by the State of Alaska Office of Management and Budget, Division of Governmental Coordination.

EXECUTIVE SUMMARY

The Kenai River Cumulative Impacts Assessment of Development Impacts on Fish Habitat, was funded in part by the Alaska Coastal Management Program's (ACMP) Section 309 Enhancement Grant Program. This study was designed to identify and evaluate the cumulative impacts of development actions including public and private land use impacts on Kenai River fish habitat. The Alaska Department of Fish and Game (ADF&G) established a Technical Advisory Group (TAG) to help define the issues and identify an acceptable methodology to be used for the assessment. The TAG was composed of representatives from all state and federal resource agencies with regulatory and management responsibilities on the Kenai River. The TAG was provided a summary of the results of the ADF&G's literature search of cumulative impact methodologies. The ADF&G also recommended the TAG consider the use of the U.S. Fish and Wildlife Service's (FWS) developed Habitat Evaluation Procedures (HEP) as the process to be used for the impacts analysis portion of this study. The group concurred with this recommendation. They concurred with the ADF&G recommendation for the development of a habitat classification process for the Kenai River's fish habitats that incorporates a combination of assessment techniques including aerial photograph assessment, field inventory, and the use of a Geographic Information System (GIS) for data compilation and analysis.

Existing mapped and/or digitized data for land ownership, soils and vegetation types were obtained through the Soil Conservation Service (SCS) and the Kenai Peninsula Borough (KPB). This information was edited and stored for use in our assessment efforts on the GIS at the ADF&G's regional office in Anchorage. Information from this data set was edited and provided to the SCS for inclusion in their technical report.

Field data compilation and ground truthing of aerial photograph interpretation data was initiated during the fall 1992 low water period and was completed during the summer and fall of 1993. The field survey resulted in an inventory of existing bank and fish habitat conditions occurring along the entire 67 miles of Kenai River mainstem from the outlet of Kenai Lake to the Skilak Lake inlet and from Skilak Lake's outlet downstream to its confluence with Upper Cook Inlet near the City of Kenai. All natural and disturbed bank habitat conditions were inventoried using a field data inventory form and color photo documentation. Data collected included vegetation type and coverage at both the river's ordinary high water (OHW) mark and the top of bank, nearshore substrate composition, fish cover characteristics, and documentation (description and measurement) of all structures and bank alterations observed. Positions were confirmed using Global Position Satellite (GPS) receivers that were differentially corrected to a resolution of 10.0 feet.

The diverse habitat types occurring along the river's 67 mile length (approximately 166 miles of water frontage) provide a varying degree of habitat value to juvenile salmon. The nearshore waters of the Kenai River provide critical early life stage rearing habitat for juvenile chinook salmon during that period of the year when these fish are using this important part or the river (this includeds the late spring, summer and early fall period). Mainstem rearing habitat within the Kenai River, which occurs primarily in a very narrow (6.0 foot wide) corridor adjacent to the river's banks, has been described in previous studies by the ADF&G and FWS. ADF&G surveys of fish rearing habitat indicates that over 80 percent of all rearing juvenile chinook are found within this corridor. The total area within this narrow corridor including both the river's upland and island shorelines amounts to a mere 121 acres. It should be noted, however, that much of this 121 acres does not constitute preferred juvenile chinook salmon rearing habitat because: a) it is a tidally influenced reach with brackish water conditions and no cover habitat or lacks an adequate food source; b) it is naturally unsuitable to rearing juvenile salmon due to high water velocities and/or a lack of cover habitat; c) alteration of natural conditions by man associated with river access have led to vegetation loss and/or bank erosion; or d) the nearshore fish habitat has been degraded as a result of bank stabilization and property protection efforts.

The field inventory and fish habitat classification analysis completed in this study has documented that 11.1 percent to 12.4 percent (18.4 to 20.6 miles) of the river's 134 miles of upland and 32 miles of island shoreline and nearshore habitats have been impacted by bank trampling, vegetation denuding, and structural development along the river's banks. The two different lengths or percentages cited above relate to the habitat impacts measured at either the OHW line or at the top of the bank. Optimum fish rearing conditions (i.e., water velocities less than 1.0 foot per second, undercut banks with overhanging vegetation, and gravel/cobble substrates) occur on only 80,440 feet (15.2 miles or 9.2 percent) of this important fish rearing corridor along the entire river length. Study results indicate that 63,299.0 feet (12.0 miles) of this corridor is currently in the developed/impacted category, amounting to approximately 8.7 acres of the total 121 acres of available juvenile rearing habitat. The sum of the impacted or altered habitats (8.7 acres) plus the lower quality habitat for rearing fish (which includes all of the Kenai River 309 Study's Reach 1 or lower 10 miles of river nearshore habitat)(15.7 acres) and the heavily trampled/denuded areas documented on the river (5.1 acres) equals 29.5 acres or 24.4 percent of the river's total nearshore habitat. This leaves a total of 91.5 acres (75.6 percent) of mainstem nearshore rearing habitat for juvenile fish of which only 11.0 acres (9.2 percent) provide their ideal rearing conditions.

The field inventory data was entered into the GIS database for tabulation and graphical analysis. The tabulated data was then used to complete a Habitat Evaluation Procedure (HEP) analysis. HEP converts both the natural and developed habitat areas into a relative value for fish habitat. HEP was developed as a tool to document the quantity and quality of available habitat for a selected fish and/or wildlife species in a given area and uses a species/habitat relationship approach to impact assessment. HEP identifies key habitat components for a species of interest (e.g., an indicator species) which are used for a comparison of existing or future habitat conditions to the optimum habitat conditions for that species.

The HEP assessment approach is based on the fundamental assumption that certain specified habitat parameters can be described numerically and ranked. This ranking allows for the comparative analysis of habitat change over time resulting from individual or multiple development projects or other habitat altering activities (e.g., public and private access, recreational uses, etc.). Comparative analysis determines the overall impact of habitat change within a system in terms of net gain or loss of habitat units (HU's) associated with these activities.

HEP characterizes habitat quality using a Habitat Suitability Index (HSI) value. HSI's are derived from established or project-developed Suitability Indices (SI) or Curves. The HSI is a numerical value ranging from 0.0 to 1.0 and is generated from an analysis of the ability of key habitat components to supply the life requisites of the indicator species. HSI's assign a value to a species' key habitat component(s) or <u>variables</u>. This value represents that habitat component's relative importance to the evaluation species and is based upon what is considered optimum habitat for that species.

Overall habitat impact can be assessed by calculating the gain or loss of Habitat Units (HU's) associated with a land use or development action affecting fish habitat. Mean HSI values (the sum of all the suitability index values identified for a species' individual habitat components divided by the total number of habitat component SI's defined) are used to calculate the HU's available for the species of concern. The mean HSI values, which are calculated for the habitat conditions occurring as a result of a project or use that has changed the naturally occurring habitat characteristics, are multiplied by the area affected by the habitat altering activity. The product of this calculation defines the HU's available to the indicator species as a result of the activity. The HU's can be used for comparative analysis or an assessment of the amount of habitat gained or lost to the overall system resulting from an action or group of actions which has or will likely affect the system.

Study results indicate that there are 1,482,790 HU's currently available to juvenile chinook salmon in the Kenai River mainstem (see Table 14). These units are distributed throughout six different undeveloped shoreline habitat categories and another six developed shoreline or structures categories. These fish habitat classification categories include: ideal rearing habitat, vegetated undeveloped habitat, vegetated slightly degraded habitat, heavily degraded habitat, non-eroding gravel banks, and erosional gravel banks. The developed categories include: boat launches and access; docks, decks, and other structures; bank protection measures; bulkheads; jetties and groins; and "other development".

Of the total 877,070 feet (166.1 miles) of waterfront on the river, 813,775 feet (154.1 miles) is in a natural state and provides 1,416,783 HU's for rearing chinook salmon. There is currently another 63,299.0 feet (12.0 miles) of water frontage in some form of developed status which, while providing less favorable conditions for rearing fish than that of the natural bank, comprises another 73,189 HU's for these fish. Together they amount to 1,489,972 HU's in the Kenai River currently available for rearing juvenile chinook salmon.

By defining the area of habitat within the river's 6.0 foot corridor along the banks that is either currently developed or altered by man-made structures or that which has been severely impacted by access resulting in heavy trampling, vegetation loss, and bank instability, we have estimated that prior to the presence of these impacts, there was originally 1,523,144 HU's available to rearing juvenile chinook salmon in the Kenai River mainstem (see Table 15). The difference between this figure and the 1,489,972 HU's which currently exist is the amount of habitat lost or gained (lost in this case) to rearing fish. This amounts to 33,172 HU's or 2.2 percent of the total Habitat Units originally available to rearing juvenile chinook salmon prior to any man induced alteration of the river's shoreline habitat.

A Development Trends Analysis was completed to provide important insight into the rate at which this habitat loss has been occurring on the Kenai River. This analysis used aerial photograph interpretation of development conditions that existed within and adjacent to the river in 1963/64 and compares those conditions to the documented development scenario observed during the 1993 Kenai River 309 field surveys. Such an analysis can be used not only to determine how much development has taken place over the last 30 years, but can also be used as an interpretive tool to extrapolate future development scenarios and estimate the level of additional impact and habitat change (loss or gain) that can be anticipated in the future.

Using the GIS system, the ADF&G developed mylar overlays of the property ownership land use patterns that correlated to the varying scales of the 1963 and 1964 aerial photo coverage of the Kenai River mainstem. This allowed for a direct visual comparison of the amount of development affecting the river shoreline and nearshore habitat over a 30 year time period. The ADF&G, with assistance from the FWS used stereo scopes to interpret the photos which allowed for a resolution of up to two feet. All manmade alterations observed through the scopes were identified and measured.

The final results indicate that over 76 percent of the modified banks and structures that were observed in the field surveys in 1993 and 94 have been introduced since 1963/64. The vast majority of these changes include the large increase in bank stabilization efforts and the construction of boat docks and groins or jetties.

All future development projects, maintenance projects, and land uses that affect the river and its shoreline will have to consider the limits of available habitat within this system, which is critical to the continued production of the Kenai's world class chinook salmon population. If we are to continue to be afforded the opportunity to harvest these fish either commercially, recreationally, or for personal use, we must avoid the continued cumulative loss of their nursery habitat.

The results of this analysis are intended to provide a basic understanding of the current condition of the nearshore fish habitat occurring on the Kenai River mainstem. This information is intended to help educate the general public of the effects of development and access-related habitat impacts that potentially affect the river's ability to continue to produce healthy runs of chinook salmon. The data will provide a basis for the ADF&G to draft Alaska Coastal Management Program project descriptions that result in the approval of sound development projects while promoting efficiency in the application of the coastal review process.

One of the primary objectives for the use of the Kenai River 309 project results has been to assist the local coastal district (KPB) in the review of their existing coastal management plan's policies. The study results are intended to be used as a tool in the district's effort to develop revised or new enforceable policies that can be implemented by the KPB as well as the existing state and federal regulatory agencies charged with Kenai River management responsibilities.

The developed database and analysis process will be used by the ADF&G and hopefully other management agencies to evaluate all future development actions using a cumulative impacts assessment approach which considers the entire Kenai River watershed rather than just the individual project and its immediate and/or local effects.

The application of the type of cumulative impact analysis completed during this study not only allows for the natural resource managers to make a decision to approve or deny an activity based upon the level of impact that would occur as a result of action, it would also allow for an comparison evaluation of alternatives to the proposed action and for the identification of mitigative measures necessary to offset or compensate for the unavoidable losses associated with the activity.

An important strength of this type of impact analysis is the ability for non-technical persons to better grasp the big picture of what an individual project or activity can do to the river system as a whole. By comparing HU changes that result from a proposed project, the degree of habitat impact can be defined. This should be a significant aid in helping individuals that proposing a certain project or activity to understand why that activity is denied or modified during the permitting process. It will also help explain to project proponents how to avoid or minimize project related impacts with a project redesign or the use of an alternative that reduces the identified impact. This assessment process can also be used as a tool to define those actions that improve the habitat quality or availability.

The Kenai River Cumulative Impact Assessment process can be readily used by inexperienced personnel with a minimum of training in the application of the HEP procedures and the existing software systems developed by the FWS.

With regard to the application of this cumulative impact assessment process to other similar riverine systems, it is extremely applicable. Other drainages would likely be less time consuming to evaluate in as much as the development pressure in these drainages is much less than that which has already occurred in the Kenai River and they have not been subdivided into as many small (100 foot) parcels as the Kenai River's riparian areas. Even so, the ability of aerial photograph and videography resolution can allow for detailed habitat classification of these small parcel sizes.

One of the benefits to the impact assessment approach used in this study is that it is a habitat based assessment which evaluates the actual or potential end result of an action as it affects the pre-existing habitat condition(s) which can occur as the result of the initial or primary activity or a spin-off effect such as a secondary impact affect. It can also effectively quantify the cumulative impact of multiple actions affecting a specific system. For example, this methodology can be used to quantify the effects of the construction of a boat launch at a given site based upon pre-project conditions. It can also quantify the effects of secondary uses such as habitat alterations in the vicinity of the project associated with the other uses that may occur as result of the initial project or action such as bank trampling associated with fisherman access provided by the launch installation. It can also assess habitat change related to bank scour or erosion (or lack thereof) associated with mooring boats either temporarily or long term and depending on the measures taken to either protect or not protect the bank associated with the launch and the effects of accessing the moored boats.

The HEP analysis, which is a substantial part of this cumulative impact assessment methodology, has been developed with a variety of species specific suitability curves including avian, mammal and fish species, that can be used to quantify habitat loss related, not only to aquatic habitats but to wetland habitats as well. The Kenai River Cumulative Impact Assessment approach would certainly be applicable to evaluating the effects of cumulative impacts on wetland habitats within and outside of Alaska.

In reviewing the development and application of this impact assessment methodology, I would recommend that, for large scale drainage basin applications at least, a joint agency approach be used especially to accomplish the field survey and ground-truthing portion of this assessment process. This can help reduce costs to any one agency or group completing the assessment and lends credibility to the overall study results through the benefits of interagency cooperation and the sharing of technical and local biological expertise.

I. INTRODUCTION

A. STUDY BACKGROUND/PROJECT PURPOSE AND SCOPE

The ADF&G, in its role as manager of the Kenai River fish stocks, as well as other management agencies and river user groups, have become increasingly concerned over the expanding level of growth and development occurring in and adjacent to the Kenai River. This concern centers on large and small-scale development projects and access-related land uses that pose the potential for significant adverse impact to the river's resident and anadromous fish populations, and their habitat. To better understand and avoid further impact, the ADF&G requested and received funding through the Coastal Zone Enhancement Grants program administered under Section 309 of the Coastal Zone Management Act (CZMA) to quantify fish habitat impact and assess mechanisms and policies that would control the cumulative impacts of shoreline development on Kenai River fish habitat.

A fish habitat classification system (HCS) and a development inventory were completed for the Kenai River's mainstem as the initial phase of this project. The results of this inventory provided the basis for completing a cumulative impact assessment of development and land use impacts on the Kenai River. A detailed literature review was also completed in phase 1 which included a review of existing fish habitat classification systems and cumulative and secondary impact assessment methodologies.

The cumulative impact assessment results and will be used by the KPB to develop enforceable policies for the management of the Kenai River. The development of enforceable policies, nonregulatory mechanisms, and an effective implementation strategy will also require the participation of those agencies with regulatory management authorities on the Kenai River, local governments including the cities of Kenai and Soldotna, and active participation by the general public. This policy and implementation phase will be led by the KPB. This effort will also consider other means such as nonregulatory practices that encourage private landowners to voluntarily avoid or minimize cumulative impacts associated with development or other land use activities affecting the Kenai River and its shoreline through the use of positive incentive measures such as reduced taxes.

The Kenai River's status as the major fish producing system in Southcentral Alaska has made it a focal point for intensive public use, but exposure to severe habitat impacts from intensive use and shoreline habitat alteration is cause for concern. Previous studies by state and federal resource agencies (Bendock and Bingham, 1988, and Burger, et al., 1983) indicate that shoreline alterations and land uses can seriously impact juvenile chinook salmon, which rely on this habitat for their rearing lifestage. While the total amount of habitat alteration along the Kenai River as a result of development and other land use practices including public access associated with sport fishing effort has never been assessed, there is concern by fisheries and land managers and local residents over the cumulative effects of past and future development and land uses on the health and productivity of the Kenai River system.

II. CONCEPT OF CUMULATIVE IMPACT ASSESSMENT

A. CUMULATIVE IMPACT DEFINITION

The Kenai River cumulative impacts study was funded under the CZMA section 309 objective "cumulative and secondary impacts". This 309 objective is further defined in 15 Code of Federal Regulations (CFR) section 932.2(b)(5) implementing the federal CZMA, as follows:

> "Development and adoption of procedures to assess, consider, and control cumulative and secondary impacts of coastal growth and development, including the collective effect on various individual uses or activities on coastal resources, such as wetlands and fishery resources."

The terms "cumulative" or "secondary" impacts or effects can be interpreted in many ways. These terms are not defined in either the CZMA, the Alaska Coastal Management Act, or their implementing regulations. The State of Alaska's Division of Governmental Coordination (DGC), the lead state agency responsible for administering the ACMP, undertook a study of the regulation of cumulative and secondary impacts in Alaska (Gray, 1993). This study includes a discussion (Chapter 1) of definitions and typology pertaining to cumulative and secondary impacts. DGC also initiated an effort to develop a regulatory definition of cumulative impacts. These efforts were put on hold pending a legal review by the Alaska Department of Law of federal and state legal requirements regarding cumulative impacts.

For purposes of this study, *cumulative impacts* will be defined as follows:

> *Cumulative impacts* means the consequences of one or more actions which cause or result in a net change to coastal resources or uses when added to other past, present, or reasonably foreseeable future actions. Cumulative impacts are the same as cumulative effects and can result from individually minor but collectively significant actions taking place over time. Cumulative impacts may include:
>
> (a) *direct impacts*, which are first-order consequences or actions that typically occur close to the primary or initial project or activity in time and space; and
>
> (b) *indirect or secondary impacts*, which are second-order consequences or actions that are typically removed from the initial project or activity in time and space, and which would not likely occur in absence of the original action(s). These impacts may result from other actions induced or made possible by the original action(s).

These definitions allow for the following considerations with respect to cumulative impacts of actions on fish habitat:

- The consequences of an action on fish habitat may be to enhance, maintain (have no net effect), or adversely effect fish habitat.

- Cumulative impacts may result from multiple similar actions (e.g., multiple similar bank stabilization structures) or multiple dissimilar actions (e.g., pollution in addition to bank stabilization structures).

- The term "cumulative" implies that effects of actions persist over time and collectively combine with present actions. While some individual actions when viewed alone have insignificant consequences, these consequences may persist over time and combine to have significant cumulative effects on fish habitat.

Cumulative impacts may also include the identification of additive and/or synergistic effects. Additive impacts are the collective consequences of two or more actions where the individual impacts add to the total impact to equal the sum of the individual parts. Synergistic impacts are the collective consequences of two or more actions where the individual impacts interact to provide an effect greater than the sum the individual parts.

Cumulative impact assessment is the evaluation of the impacts of multiple actions on multiple resources. In cumulative impact assessment, the methodology must consider each impact in relation to past and potential future impacts. An assessment of cumulative impacts should consider the spatial, temporal, and ecological extension of these effects. In addition, a cumulative impact assessment also considers the positive and/or negative effects of an individual action.

The purpose of performing a cumulative impact assessment is to determine how best to achieve individual project goals while avoiding or minimizing negative consequences, to aid in adapting management programs and their policies to changing conditions, and to facilitate communication and understanding between project proponents and entities responsible for protection of resources likely to be affected by development of the project or its associated (secondary) effects.

B. METHODS FOR EVALUATING CUMULATIVE IMPACTS

Presently, there is no single state-of-the-art or comprehensive methodology for assessing cumulative impacts. In most cases, quantitative assessments are not possible because information on the response of resources to various impacts is lacking, baseline data is lacking, empirical data from one ecosystem is not readily applicable to other systems, or the cost of compiling required quantitative and qualitative data is prohibitive. Quantitative assessments often provide questionable results that are difficult to interpret. Utilizing a standard impact analysis of individual projects does not apply to a cumulative impact analysis because, thus far, the ability to combine the relatively insignificant impacts of each permit-type action into ecosystem consequences has not been achieved. A review of the current literature applicable to cumulative impact assessment indicates that most cumulative assessment methodologies comprise general guidelines or descriptive accounts of potential cumulative impacts, relying heavily upon qualitative and subjective judgements.

The general categories of cumulative impact assessment methodologies include: checklists (for initial documentation of impacts), matrices (to display initial broad judgements), networks or system (flow) diagrams (to classify, organize, and display problems, processes, and interactions), cartographic techniques, mathematical modeling (to estimate and communicate long-term and indirect effects in conjunction with other techniques), evaluation techniques (to compare the impacts of development alternatives), and adaptive methods (when utilizing a combination of assessment methodologies) (Irwin and Rodes, 1992).

In a cumulative impact assessment (where time and funding are limited), it is important to focus or prioritize assessment efforts to define the major causes and effects (clearly define the results of an action which need to be evaluated); have a sufficient boundary area to include the major factors that cause variation in the effect (the assessment should not go beyond the geographic area that is relevant to the decision, such as the watershed boundary); and distinguish causes and effects that result from natural events from those which are human-induced.

C. IMPACT ASSESSMENT OF DEVELOPMENT ACTIONS ON KENAI RIVER FISH HABITAT

Development has been occurring along the Kenai River at a rapid rate over the last several years. Construction of commercial businesses catering to sport fishing, boating, and other recreational activities, lodges, bed-and-breakfast establishments, and residential dwellings are at an all-time high. Because much of this activity alters riparian habitat, the cumulative environmental consequences are of considerable concern. In order to ensure that the fishery resources of the Kenai River are maintained, it is essential accurately assess the impacts on fish habitat caused by such land use activities.

Project impacts are usually assessed by regulatory agency personnel (e.g., ADF&G, U.S. Army Corps of Engineers, DGC, KPB) on a project-by-project basis as, for example, in the case of an individual boat launch or a bank stabilization project. This generally results in an evaluation of the direct effects of the initial construction activity only and fails to consider the additive or interactive effects of the project or action in relation to other uses or development actions already existing or likely to be developed in the future. Therefore, the true impact or impacts of the proposed action may be underestimated because the assessment does not include the cumulative effects of the project. Cumulative impacts of an action include the immediate and long-term physical, biological, socioeconomic, and cultural effects resulting from decisions at many individual permit sites, as well as activities that are not regulated. Hence, cumulative impacts are often external to the focus of an individual project review. If cumulative impacts are to be identified, assessed, and effectively managed, the regulatory analysis of individual projects affecting the Kenai River must consider impacts specific to the proposed project in combination with all other habitat-altering resource development and land use actions affecting the Kenai River.

III. PROJECT OBJECTIVES, STUDY AREA AND FOCUS

A. STUDY OBJECTIVES

The primary objective of the Kenai River 309 study is to identify and evaluate the cumulative impacts of uses and activities affecting the physical and biological integrity of the Kenai River's fish habitat. In addition, the analysis would inventory, describe, and quantify past instream and shoreline fish habitat degradation or loss from development or land use activities. This assessment would identify areas where future impacts are likely to occur and would establish a baseline for the continuing assessment of cumulative impacts associated with those future uses. Finally, the Kenai River 309 study is intended to be used as a tool for the development of regulatory policies and nonregulatory management mechanisms designed to control cumulative impacts on the Kenai River. This would be accomplished through formulation and evaluation of enforceable guidelines, policies, and a management strategy to control the identified cumulative impacts of shoreline and instream developments and uses affecting fish habitat.

The results of this study will be used to assess the effectiveness of existing management and regulatory programs and policies in providing adequate protection to the Kenai River's fish resources. This analysis of policy and regulations will allow for the review and revision of existing management plans such as the Alaska Department of Natural Resources Kenai River Comprehensive Management Plan (KRCMP), drafted in 1986, and the KPB's District Coastal Management Program. Further, it will provide the basis on which to identify projects or activities that may be included on the state's list of actions that do not require a full coastal consistency review, thereby expediting the permit process.

B. STUDY AREA BOUNDARIES

The Kenai River is located in southcentral Alaska on the Kenai Peninsula. The Kenai River drainage encompasses approximately 2,200 square miles from its headwaters in the Kenai Mountains and Kenai Lake, to its outlet into Upper Cook Inlet (Figure 1). The ADF&G established the Kenai River 309 study area boundary to include a 1/2-mile corridor above the ordinary high water (OHW) line of the river. This study area was further divided into five distinct Study Reaches based upon thier unique physical and hydraulic features (Figure 2). This boundary was selected because it allowed for the development of a GIS mapped area which could be used for the evaluation of a wide variety of current and past land uses and alterations (including access to the river) which have a potential to either directly or indirectly affect the river. The study area boundary was later narrowed to focus on the assessment of development and land uses occurring in and immediately adjacent to the river mainstem, effectively limiting the off-stream area to the riverfront properties located on each bank of the river mainstem.

A management corridor of all lands within a 100-foot wide corridor measured from the OHW line on each side of the river was considered in the cumulative impact assessment analysis. In some areas, additional uplands outside this assessment corridor warrant consideration because of their sensitive nature and significant potential for impact on the river's fish habitat. These areas of importance to the Kenai River watershed are currently being defined under a cooperative agreement with The Nature Conservancy who will delineate those critical habitats associated with the river drainage basin based upon the physical and biological values of each unique area and it's susceptibility to development or other stress factors. Figure 2 depicts Kenai River 309 study area boundaries.

C. THE KENAI RIVER SETTING

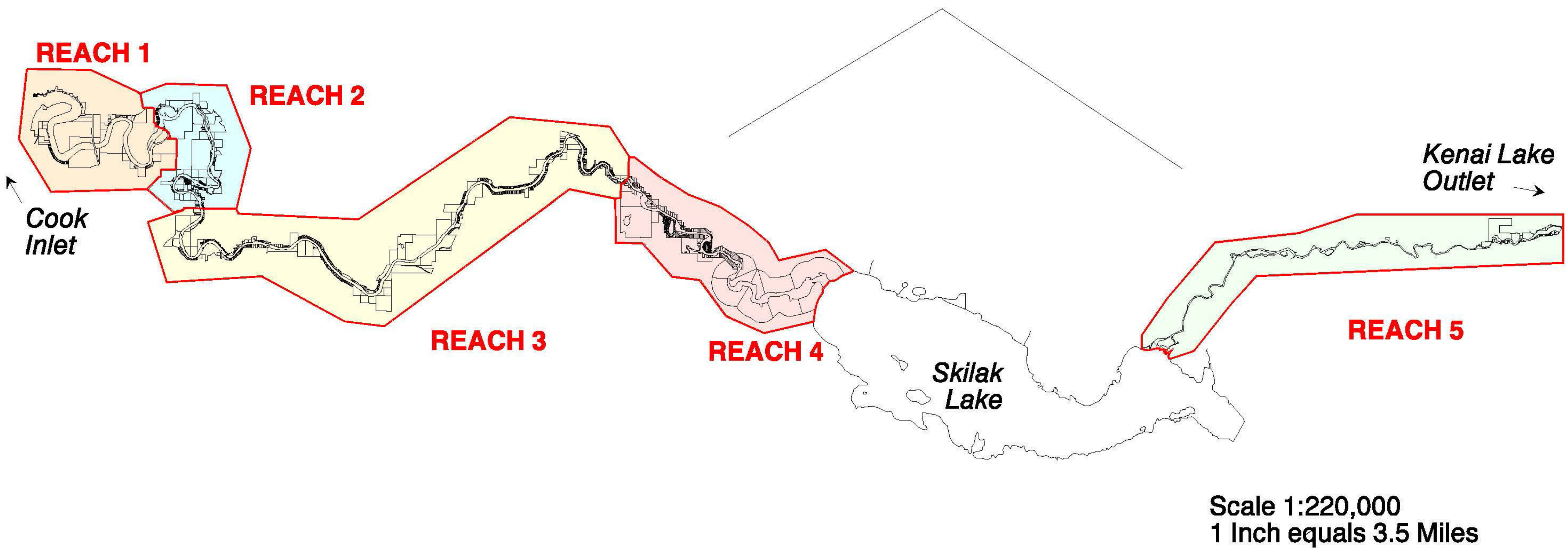
Physical Environment

The Kenai River basin has a predominantly maritime climate with an annual average rainfall ranging between 16 to 19 inches. Snowfall averages approximately 65 inches per year. Fall and winter temperatures range from the mid-20's to low 50's (degrees F) in August/September to 12 degrees F in January, with a record low of -50 degrees F recorded in Kenai in 1989. Spring and summer temperatures range from the mid 40's to the high 80's.

Prevailing winds are from the north during the winter and are generally from the south and southwest during the summer. Both the presence of Cook Inlet and the glacial characteristics of the Kenai Mountains have a significant influence on the local temperatures and winds affecting the drainage.

Figure 2.
Kenai River 309 Project
Study Area Boundary

(One-Half Mile Corridor Adjacent To Kenai River Mainstem)



Hydrology

The glacial Kenai River headwaters are high in the Kenai Mountains and are augmented by many small and medium sized tributaries along its 82 mile length. Kenai Lake is fed by the Paradise Lakes and Snow River system and the discharge from Ptarmigan, Grant, Trail and Crescent lakes. The 67 miles of Kenai River mainstem is composed of a lower reach (river mile 0 to 50) which extends from the river's mouth in Cook Inlet, upstream to the outlet of Skilak Lake, and an upper reach (river mile 65 to 82) which extends from the inlet of Skilak Lake to the outlet of Kenai Lake. Within the lower reach, approximately 15 miles of the river drainage (river mile 50 to 65) is composed of Skilak Lake, a deep, cold glacier fed lake, believed to provide overwintering habitat for several species of anadromous fish including sockeye and chinook salmon.

Major tributaries to the Kenai River include Cooper Creek which empties into the Kenai River at river mile (RM) 79, the Russian River mouth at RM 55, Skilak River which contributes melt water from Skilak Glacier at the east end of Skilak Lake, the two Killey River confluences at RM 46 and 45, the Moose River confluence at RM 36, the Funny River confluence at RM 30.5, and the Beaver Creek confluence at RM 10.

The river's mean annual discharge at Soldotna is 5,900 cubic feet per second (cfs) (Bigelow, et al., 1985). Typically, the river exhibits sustained high summer flows ranging from 5,000 to 30,000 cfs resulting primarily from glacial ice melt and precipitation. Winter flows range from 800 to 5,000 cfs. The source of winter flows is primarily from ground water sources and large natural lake reservoirs. There are three causes of flooding on the Kenai River: precipitation flooding associated with large precipitation events, ice-jam flooding associated with spring thaw events, and glacial outburst flooding caused by the rapid draining of glacial dammed lakes.

The Kenai River channel is comprised of a variety of channel types based upon the degree of entrenchment, the degree of armoring, the underfit conditions (ability to carry river flows), and the rate of bank erosion.

Fisheries Resources and Importance

The Kenai River is an extremely important and productive Southcentral Alaska river system supporting 27 different species of fish. Five species of Pacific salmon migrate, spawn, and rear in the river including, chinook [Oncorhynchus tshawytscha (Walbaum)], coho [O. kisutch (Walbaum)], sockeye [O. nerka (Walbaum)], pink [O. gorbuscha (Walbaum)] and, to a lesser extent, chum [O. keta (Walbaum)]. In addition, other fish species of importance include Dolly Varden [Salvelinus malma (Walbaum)], rainbow/steelhead trout [O. mykiss (Walbaum)], and round whitefish [Prosopium cylindraceum (Pallas)].

The Kenai River provides commercial, recreational, and personal use fishing interests with strong runs of chinook, sockeye, and coho salmon. Over the past 10 years the Kenai River system has produced approximately 40 percent of the commercial sockeye salmon harvest in Cook Inlet and 30 percent of the commercial chinook salmon harvest. During this period, the chinook harvest ranged from 8,000 to 40,000 fish and the sockeye harvest ranged from 2.5 to

9.5 million fish. The 1993 Upper Cook Inlet commercial salmon fishery produced a harvest of 5.3 million fish with an ex-vessel value of 30.4 million dollars.

The 1992 sockeye salmon sport harvest included 242,492 sockeye, 52,310 coho, 10,592 chinook, and 10,029 pink salmon. The total 1992 sport fishing effort for all sport caught (includes catch and release fish) or harvested fish species was 332,573 angler-days. This represents 13.1 percent of the total sport fishing effort occurring in the State of Alaska (Mills, 1993), making the Kenai River the number one sport fishing system in the entire state. It should also be noted the Kenai River strain of chinook salmon ranks among the world's largest. The Kenai River is the largest producer of sockeye salmon in the Cook Inlet drainage, signifying its importance to the Upper Cook Inlet commercial fishery (Cross, 1985). In a good year the Kenai River sport fishery contributes approximately 38 million dollars, and the commercial fishery approximately 40 million dollars to the state's economy.

Riparian Vegetation

The Kenai River watershed lies in a transition zone between the Pacific rain forest regional vegetation type and the Arctic-alpine regional vegetation type. The vegetation types occurring along the river corridor can be categorized into three general groups: 1) forested uplands or climax forest consisting of coastal western hemlock, Sitka spruce forest and upland spruce, and lowland spruce hardwood forest; 2) poorly drained soils with black spruce, willow and poplar tree species; and 3) contiguous wetlands and bogs with sphagnum mosses, dwarf willow, labrador tea, crowberry and lowbush cranberry (Alaska Department of Natural Resources, 1986).

Soils

The most common soil type occurring in and adjacent to the mainstem Kenai River is Kasilof silt loam with a slope of less than 3 percent (Rieger, 1962). Kasilof silt loam is a well drained, very shallow soil underlain by a gravelly substratum. This soil type is common along both the Kenai and the Kasilof River and their tributaries. Kasilof silt loam typically supports a young, open stand of white spruce, birch, and aspen although there are also examples of this soil type supporting older stands of mature white spruce and birch. A second soil type common to the lower Kenai River drainage is Tustumena silt loam with a 0 to 7 percent slope. This soil type occurs as wide terrace plains along the Kenai River in the Sterling and Soldotna areas. It consists of well-drained, moderately-deep deposits of wind-laid silty material underlain by water-worked sand and gravel or coarse sand. This soil type characteristically supports sparse young forests of aspen and white spruce with a scattering of birches.

Lower on the river mainstem (from the mouth to Soldotna) the soils are predominantly comprised of tidal flats and Clunie peat. Tidal flats soils are found in large flats near the mouth that are inundated by daily tidal changes. Tidal flat soils consist chiefly of layers of clay and sand and support no vegetation. The Clunie peat soils include small patches of tidal marsh soils and consist of poorly drained moss peat soils. They occur as fairly broad flats near the mouth of the Kenai and Kasilof rivers in areas affected by the tides. Plant species associated with the clunie peat soil type include sedges, bog birch, Labradortea, and other low shrubs.

IV. STUDY METHODOLOGY

A. ASSESSMENT METHODOLOGY

The following chapter describes the analysis methods used in the Kenai River 309 study. The ADF&G assessment method incorporates the use of several data inventory, storage, and assessment processes combined. The first step in the assessment process required the development of a baseline (1993) description of the natural and developed (man made or altered) conditions occurring along the river. This was accomplished through a combination of interpretation of existing aerial photography and the completion of a detailed field survey/inventory. Land ownership data, specifying individual parcel coverage (separate property ownership) for the entire Kenai River area within a one-half mile corridor, was obtained from the KPB and entered into the ADF&G GIS database. Soils and vegetation type data provided by the Soil Conservation Service (SCS) occurring within a one-quarter mile corridor along the lower 50 miles of Kenai River mainstem, was also developed as an overlay within the GIS. Next a detailed field survey/inventory of the physical, biological, and developmental conditions occurring along the entire 67 miles of river mainstem was completed by an interagency team of biologists from the ADF&G, Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation (DNR/DPOR), U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), and the SCS. The inventory information was documented in narrative form in a Personal Computer (PC) database and graphic form in the GIS. The ADF&G's analysis system uses both a PC database for data storage and retrieval and a SUN graphics work station which uses ARC/INFO or AutoCAD mapping programs for storage of the graphics data. Upon completion of data entry and database quality control checks of the PC database against the graphics database, an assessment of development impacts was performed through the application of a modified HEP analysis described in Section E of this chapter. The HEP process provided for the identification of the relative value of various habitat components or conditions that were ranked in the GIS system. HEP characterizes these relative values as HU's. An analysis of the HU's available to an indicator species, such as rearing juvenile chinook salmon, was then completed.

B. GEOGRAPHIC INFORMATION SYSTEM (GIS)

A GIS uses an integrated database and graphics management system capable of input, storage, retrieval, analysis, output, and display of geographic or spatially indexed data. A GIS can be utilized for detecting visible habitat fragmentation or alteration and to evaluate resource loss rates by comparing data layers representing different points in time. The GIS analysis approach typically includes the digitizing of existing cartographic and photographic field observation information into a computer database for use in an assessment process. The GIS methodology for resource and development cataloging and mapping provided a foundation for the Kenai River 309 cumulative impact assessment. GIS was used to compile and synthesize both the descriptive and spatial data accumulated for each ownership parcel and habitat category occurring along the Kenai River mainstem. This data was obtained from a variety of sources (e.g., existing maps, reference materials, discussions with local experts, previous project studies and results, and the

Kenai River 309 field surveys). Due to the diversity of sources used to obtain this information, it existed in a wide variety of formats requiring conversion in some cases.

The various physical, biological, and land use conditions identified through the collection of mapped data and field analysis was then evaluated using HEP to determine the current condition and/or relative importance of these habitat types to the indicator species selected for assessment. The values derived from the impact assessment process are then used to assess the amount of habitat units available for fish use and can be used to assess the degree of change over time occurring within these habitats. This calculation of the quantity and quality of habitat within the system can be used to facilitate management planning and the development of policies and implementation strategies that provide for the protection of these habitats in the future.

Baseline information obtained from the KPB, SCS, FWS, and ADF&G included soils and vegetation types and wetland habitats. Current land ownership patterns and development status, including structures constructed in and adjacent to the river, and areas impacted by public and private access, have been incorporated in the ADF&G's GIS database using the "ARC/INFO" program. Land ownership information from the KPB includes mapped property boundaries along the river, landowner and address information, property values and dimensions, improvement values, soils types, vegetation types, access and easement information and state plane coordinate data (specific site locations based upon an x and y coordinate system similar to Latitude/Longitude). The "ARC/INFO" program provides the capability to map discrete areas such as individual lots/parcels or a specific river reach using computer line segments. These line segments or "arcs" can be closed into a distinct unit or "polygon" which represents a unique area. These polygons or areas can then be directly linked with a separate computer database file through the use of a unique location identifier (pointer) contained in both the graphics and database systems. Site-specific information such as that identified above can be entered, stored, and retrieved for comparison analysis, modification as conditions at the individual sites change over time, or for other analysis purposes. The data layers or "coverages" (such as soil types, vegetation types, land ownership, developmental status, structures inventory, etc.) can be overlain to depict the varying level of development and habitat conditions that existed in the past, currently exist, or may exist under a suggested future scenario.

The Kenai River 309 computerized database contains site-specific information for the 1,799 individual parcels located along the banks of the river. Figure 3 is a map printout from the GIS graphics database which depicts some of the pattern of land ownership parcels occurring in Study Reach 3. Information stored in the GIS database includes vegetation types and percent of parcel coverage at both the OHW line and at the top of the bank, soil types, natural and altered habitat descriptions (e.g., undeveloped overhanging vegetation with undercut banks, denuded banks, docks, bank stabilization efforts, etc.), substrate types and percentage of coverage for each parcel, fish cover conditions, land ownership information, permitted project data, and other parameters that can be used to assess development impacts on the Kenai River drainage and its fish habitats. Figure 4 is an example of map output from the graphics database for individual ownership parcels contained in the ADF&G's GIS database. Depicted is site-specific information including: individual parcel identification number (KPB tax identification number), ownership status (e.g., residential, commercial, federal, state, city, borough, or native lands),

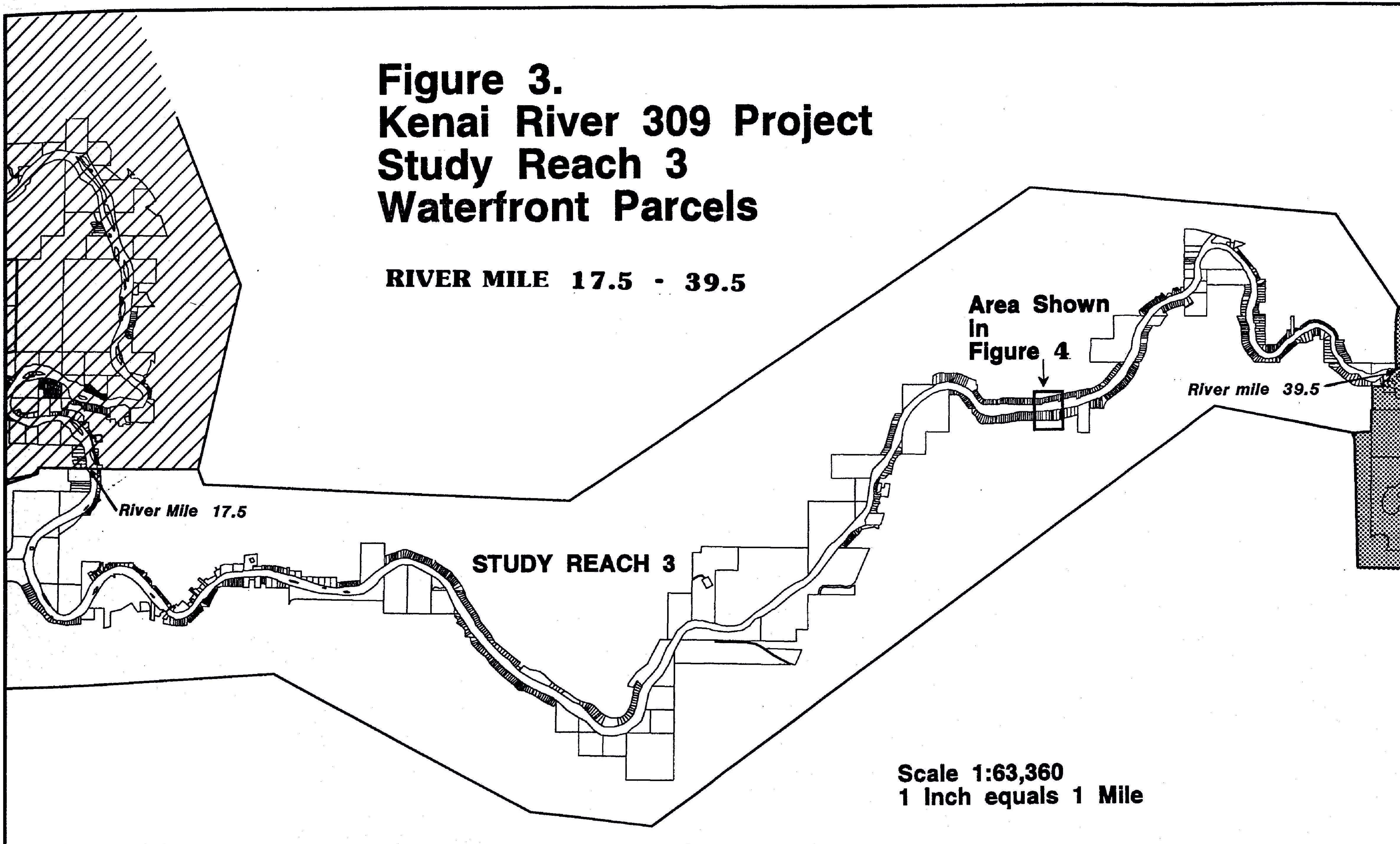


Figure 3.
Kenai River 309 Project
Study Reach 3
Waterfront Parcels
RIVER MILE 17.5 - 39.5
Area Shown in Figure 4
River mile 39.5
River Mile 17.5
STUDY REACH 3
Scale 1:63,360
1 Inch equals 1 Mile

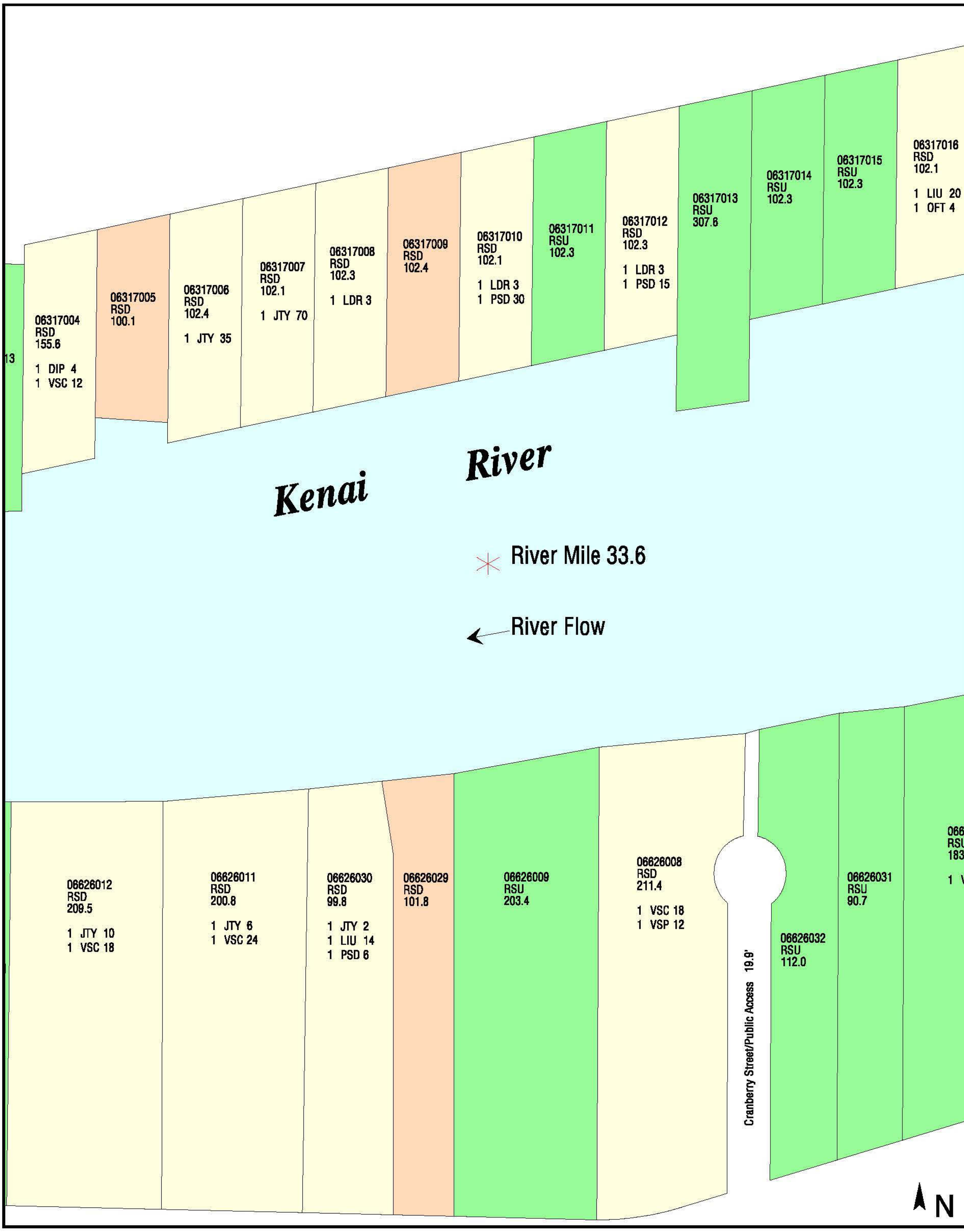


Figure 4. Kenai Riverfront Property Development

Undeveloped Parcel

Developed Parcel With Altered Waterfrontage

Developed Parcel With Unaltered Waterfrontage

Taxid = 06626012
Ownership = RSD
Waterfront Length = 209.5

Structures-Number,Type,Length = 1 JTY 10
Structures-Number,Type,Length = 1 VSC 18

ALL LENGTHS ARE IN FEET.

See Table 1 for definition of structure type abbreviations.

See Table 2 for land ownership code definitions.

Note: Total structure type lengths do not necessarily equal total waterfront length for each parcel.

Source: ADF&G Kenai River 309 Studies, ? 1992/1993 Structures Survey developed or undeveloped status, total parcel waterfront length, and a listing of each structure affecting the river shoreline and its length (measured parallel to the river shoreline).

C. FISH HABITAT CLASSIFICATION

Habitat classification schemes that link habitat components (e.g., the physical, biological and chemical characteristics of a stream environment) directly to fish community structure and productivity are not readily available. One of the main reasons is that the comparative analysis approach used in defining these classification schemes generally requires extensive multivariate (the assessment of multiple conditions or parameters) analysis with demands for large computer capacity. HCS's usually result in the incorporation of some degree of subjectivity in the assignment of fish life cycle values to the various physical and biological parameters that denote the various components of a specie's habitat.

Previous studies of Kenai River fish populations and fish habitat have determined that an impact assessment can be narrowed down to a single fish species which is most prone to adverse effects associated with continued habitat alteration (Bendock, pers. comm.; Burger, et al., 1983). Within the Kenai River this species is the juvenile chinook salmon due to its long-term exposure (2-3 year freshwater juvenile rearing stage) and dependence on mainstem river shoreline habitat during this critical life stage. In fact, specific attributes of the river system are deemed critical to the juvenile chinook salmon including stream bank cover, substrate type, and water velocity. ADF&G, therefore, utilized this species and its life stage requirements as the indicator species on which to base its cumulative impact assessment and in selecting a HCS.

As a result of our literature search, a variety of fish habitat classification strategies or methodologies were identified. Of all those reviewed, a HCS defined for the Kenai River system in an earlier study by the ADF&G (Estes and Kuntz, 1986) appeared the most applicable and is described below.

The ADF&G had previously undertaken a multi-year study of fish habitat (specifically juvenile chinook rearing habitat) and riparian vegetation using aerial photography interpretive methods. This information was verified through field ground truthing of the habitats identified (Estes and Kuntz, 1986) and was based on a series of earlier studies conducted by William D. Platts (Platts, 1984, and Platts, et al., 1985).

The ADF&G's 1986 study evaluated fish habitat and use within a 40-mile reach of the Kenai River between Beaver Creek and Kenai Lake. The river was segmented into three distinct evaluation reaches based on geomorphic differences as described by Scott (1982). A field survey of the river resulted in the identification of four predominant macrohabitat types including erosional banks, grassy banks, sloughs, and gravel bars. Bank-type habitats were selected for evaluation as earlier studies indicated little utilization of nonbank type habitats by rearing juvenile fish due to typically high velocities and lack of cover conditions (Burger, et al., 1983; Litchfield, 1985). Table 1 lists the habitat components or cover types evaluated in the present study. The cover types were identified using procedures described in Suchanek, et al., (1985).

The results of this earlier Kenai River fish habitat study indicate that there is a significant relationship between habitat use by juvenile chinook salmon and cover type on a seasonal basis. Undercut banks with overhanging vegetation was the preferred habitat used by rearing juvenile chinook. When this habitat type is removed or unavailable to the young salmon, alternate habitat such as large substrate material or emergent or aquatic vegetation is utilized. Removal of cover causes juvenile salmon use to decline. Recruitment into the various study reaches was also variable indicating significant movement of juvenile salmon within the river on a seasonal basis. This transitory condition appears to be a response to varying water levels, changing water velocities, and loss of available cover occurring seasonally. These conditions would have to be considered in the development of a Kenai River habitat classification system.

D. KENAI RIVER 309 STUDY HABITAT CLASSIFICATION

The ADF&G elected to use a modified habitat classification method used in previous studies of the Kenai River (Bendock and Bingham, 1988 and Estes and Kuntz, 1986). The river was divided into five separate study reaches which were inventoried to delineate their natural bank and substrate conditions as well as any man-made bank alteration or other structural changes that affect the natural bank condition. Within these macrohabitat types, juvenile chinook salmon microhabitats were described based upon water velocity, available cover, water depth, and substrate composition. Finally, the entire study area was divided into those river lengths which are categorized as "developed" (i.e., exhibit bank alteration in the form of bank stabilization or access related structures) or "undeveloped" with no bank or shoreline alteration affecting the natural bank condition.

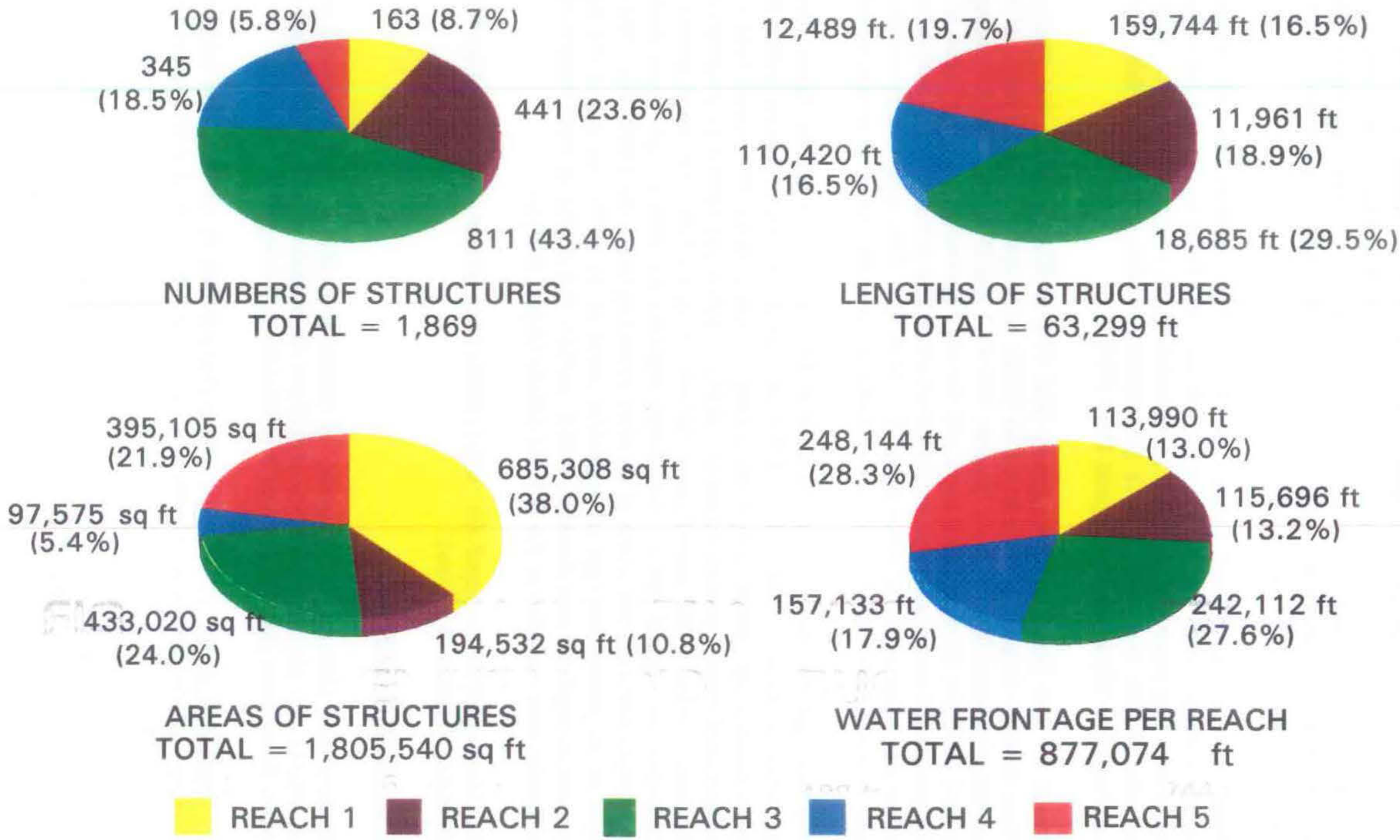
The five distinct study reaches or macrohabitat subdivisions were selected based upon the river's geomorphology and its hydraulic characteristics. These five reaches are depicted in Figure 2 and Figure 5.

KENAI RIVER STUDY REACHES

Reach 1. The Intertidal River Reach (RM 0.0 to 10.0) is primarily an area of tidal influence, with a predominantly mud and clay substrate. This reach provides little spawning or rearing habitat and generally serves as a migration corridor for juvenile and adult salmon movement to more opportunistic and preferred habitat upstream or into the marine waters of Cook Inlet (Burger, et al., 1983)

Reach 2. The Transition River Reach (RM 10.0 to 17.6) is characterized overall by a low gradient with low mid-channel velocities. The substrate is comprised of smaller, less armored types than that of the Entrenched and Upper Reaches with more gravel and cobble type of materials. However, this reach includes areas containing submerged debris with surrounding accumulations of sand and silt. The river channel here is only partially entrenched (an entrenched channel means the river channel is capable of holding all flows within its banks) which enables the river to easily meander and results in it being prone to bank erosion.

FIG. 5 SUMMARY OF KENAI RIVER WATERFRONT LENGTHS AND STRUCTURES



Reach 3. The Entrenched River Reach (RM 17.6 to 39.5) includes that river reach between the Soldotna Terrace subdivision upstream to the Naptowne Rapids. Within this reach the substrate is of a more coarse material and armored. The river channel here is generally more straightened with short sinuous segments. It is defined as an entrenched channel and is, therefore, a more stable section of river than the other reaches.

Reach 4. The Upper River Reach (RM 39.5 to 50.0) extends from Naptowne Rapids to the outlet of Skilak Lake. The substrate is predominantly fine-grained material ranging from sands to cobble. The channel is described as meandering and is prone to erosion. High bank cuts are prevalent within this reach. Bank development is also prevalent in this reach from Bings Landing (RM 39) to Lower Torpedo Hole (RM 45).

Reach 5. The Inter-lake River Reach (RM 65.0 to 82.0) includes that portion of the Kenai River between its point of discharge into Skilak Lake upstream to the outlet of Kenai Lake. It includes the Kenai River canyon between RM 67.1 and 69.5, the "Jim's Landing" area located at RM 69.8, the Russian River ferry and the old "Sportsman's Lodge" sites at RM 73.6, and the private and commercial waterfront parcel ownership at the Cooper Landing area located just below the outlet of Kenai Lake (RM 79.5 to 82.0). This area is characterized by a gravel, cobble, and rubble substrate; an entrenched channel; and moderate stream velocities.

The five study reaches outlined above provided the baseline for the Kenai River 309 habitat classification system. Each of the 1,810 individual ownership parcels within these five river study reaches was further categorized during the Kenai River 309 project field survey as either undeveloped habitat (natural conditions exist) or developed habitat (man-induced alterations of the habitat exist). This classification considered each of the individual parcels' riparian area (shoreline and upland habitat immediately adjacent the river's high water line), its shoreline conditions, and a six foot width of the river extending below the OHW line. Site characteristics such as the percent and type of vegetative cover at the OHW line and at the top of the bank, percent of vegetated area denuded/altered, percent and degree of bank undercutting, and water velocities were included in the GIS for habitat impact analysis.

The Developed/Undeveloped site classifications were further characterized by their physical and biological features as follows:

UNDEVELOPED SITES

Undeveloped sites are distinguished by naturally occurring bank conditions which have not undergone any physical manmade alterations or modifications. Undeveloped reaches of the Kenai River were also divided into four microhabitat categories including:

1. Erosional Banks This habitat type is characterized by steep eroded banks that often have slumped (overhanging) mats of vegetation and unstable slopes of gravel or rubble. An example of this habitat type is a site where the dominant vegetation of spruce or cottonwood has either fallen into the water or generally lists toward the surface of the water before actually entering the water. The vegetation and water velocity break created within or below it offers excellent cover to rearing juvenile chinook salmon.

2. Natural Undisturbed Vegetated Banks This habitat type is characterized by three to eight foot high moderately stable banks that are vegetated with low shrubs/alder and/or grasses. The banks are typically scalloped or irregularly shaped due to slumping of the river bank. The shoreline indentations are often undercut and typically exhibit overhanging riparian vegetation. This habitat type also exhibits numerous velocity breaks which slow the natural flow and provide resting areas for juvenile chinook salmon. These conditions provide good cover for rearing juvenile chinook salmon at medium to high flows.

3. Disturbed or Degraded Vegetated Banks This habitat category is essentially the same as that described in 2. above with the exception that the natural vegetation has been lightly to severely damaged or eliminated by human use, primarily from access-related activity. These areas are prone to erosion during high water events as a result of the loss of grass and woody shrub cover, the roots for which provide stability to the shoreline.

4. Gravel bars/Islands This habitat type typically occurs along the inside banks of river meanders and at up and downstream ends of islands within the mainstem. The habitat is characterized as generally having very shallow, gently sloping banks, consistent substrate size ranging from cobble to sandy gravels, and gradually increasing velocities at greater distances from the bank. Little object cover is present at lower flows. At higher flows water levels can reach up and into the grasses and shrubs on the bank. This habitat type provides moderate rearing habitat throughout the open-water season (spring through fall). However, due to favorable velocities and substrate conditions, they are often used by spawning salmon.

5. Sloughs/Side Channels This habitat type is characterized by lower velocity waters than the mainstem and is associated with an upstream cobble-bar barrier. The lower velocity waters act as a settling area. Substrate is often silt, sand, or fine organic material over a base of rubble, cobble, or gravel (larger material). Cover within this type of habitat is generally low throughout the year, increasing only when higher flows move the water's edge up against the bank vegetation. This habitat type provides extremely low to moderate levels of chinook salmon rearing habitat throughout much of the year due to low water levels and icing conditions.

DEVELOPED SITES

Developed sites were further classified by the type of natural bank alteration(s) observed at each site during the aerial photo analysis and field inventory. Development activities or groups of activities such as bank stabilization methods (e.g., placement of rock rip-rap, cabled trees, vertical bulkheads, etc.) access activities (e.g., boat ramps, launches, docks, trails, etc.), and flow alterations (e.g., groins, jetties, fills, bank excavations, etc.) were identified for analysis using the GIS and HEP process.

The application of this HCS approach resulted in a detailed classification scheme of the Kenai River's riparian and nearshore habitat that is based upon the natural versus the developed site conditions. An example field survey form that was used to document site-specific as well as project-specific permit information is included as Appendix E of this report. The information collected was used to determine the general habitat value for the natural conditions or the development categories inventoried and listed in the GIS. Habitat values were assigned through the application of the HEP analysis procedure using the established habitat suitability curves for juvenile chinook salmon.

E. FIELD SURVEY/RIPARIAN DEVELOPMENT INVENTORY

The department initiated a survey of all development projects or actions occurring in or adjacent to the Kenai River mainstem in September 1992, to take advantage of the extreme low flow conditions in the river. Initiating the field survey during this time period provided for an optimum assessment of stream substrate type and bank alteration that had occurred below the OHW mark. A 10-mile segment (RM 39.5 to 50.0) of the Kenai River was surveyed during this period. Types of data inventoried for the entire river length are indicated on the sample field survey form in Appendix E. Survey techniques developed for this study by a joint agency team with representatives from the ADF&G, FWS, and DNR/DPOR were evaluated during this trial effort.

The remaining 57 miles of river mainstem were surveyed during the low water period in the fall of 1992 and during the 1993 field season (May through September). Prior to the field survey, mylar overlays depicting all the individual land ownership parcels on the river were generated at a scale of 1:1,200 using the GIS. These were used with the 1992 aerial photographic coverage to aid the survey teams in determining which specific parcel they were surveying. Two survey teams of 4 people were used. The survey teams worked downstream on each side of the river surveying the mainstem river banks, channels, and island shoreline from the outlet of Kenai Lake to the mouth of the Kenai River at its terminus in Cook Inlet. Information at all developed or utilized lots or parcels along the river was documented on the survey form and by still photography. Site location was determined using aerial photography, Kenai Peninsula tax parcel maps, 1:63,360 scale (one inch equals one mile) recreational maps, and GPS location devices. The existing natural or altered bank habitat conditions and all development structures observed were described, measured and photographed. Vegetation type and any alteration was noted at both the OHW mark and at top of the river bank. Vegetation coverage was classified by type (herbaceous, woody stem, tree, or no cover) and the percent of vegetation coverage at these two locations was noted for each separate parcel. Estimates of percent of area denuded or vegetation removed were also recorded. Measurement of bank scarring, erosion, or alteration was included as was substrate type. The data compiled during this project phase was entered into a GIS database for subsequent HEP analysis. A tabular and narrative summary of this information is contained in Section V, STUDY RESULTS, of this report.

F. HABITAT EVALUATION PROCEDURES (HEP)

Much of the variability observed in species diversity and numbers of individuals within a discrete habitat results from differences in availability of food, cover, water, and other requirements. The correlation between quality and quantity of habitat components (e.g., water velocity and cover in a riverine system) provides the basis for an evaluation of that habitat's ability to provide optimum life-stage requirements for a selected species. Attempts to quantify habitat quality often involve the use of indices, applied at the individual, population, or community levels.

The Kenai River 309 project TAG evaluated several methodologies to assess cumulative affects of riverine structures in relation to fish habitat and carrying capacity. This evaluation included established methodologies (Physical Habitat Simulation System and HEP) as well as creation of a model unique to the Kenai River system, based on input from the TAG. The existence and availability of a peer-reviewed chinook salmon model specific to the Kenai River (Raleigh, et al., 1986. see Appendix D) partially incorporating data compiled by TAG members, made HEP the preferred impact assessment methodology. A description of HEP methods (taken largely from the FWS HEP Manual, 1980) is, therefore, appropriate to introduce the reader to the basic concepts behind the model.

The HEP assessment method evolved from an impact assessment approach developed in Missouri (Daniel and Lamaire, 1974). It was developed as a tool to document the quality and quantity of available habitat for a selected fish and/or wildlife species and uses a species/habitat relationship approach to impact assessment. It involves the use of key habitat components for a species of interest (i.e., an indicator species) to compare existing habitat conditions to the optimum habitat conditions for that species. An indicator species is that species or list of different species that is representative of the variety of species occurring within a study area and is most susceptible to the impacts of habitat alteration.

HEP is based on the fundamental assumption that certain specified habitat parameters can be numerically ranked. This ranking allows for the comparative analysis of habitat change over time resulting from individual or multiple development projects or other habitat- altering activities. Comparative analysis is used to determine the overall impact of habitat change within a system in terms of net gain or loss of habitat units associated with these activities.

This assessment process provides for two distinct types of fish and wildlife habitat comparisons including: 1) the relative value of *different areas* at the *same point in time*, and 2) the relative value of the *same area* at *different points in time*. Combining these two types of habitat comparisons quantifies the impact of proposed or anticipated land and/or water use changes on fish and wildlife habitat by describing the number of habitat units either gained or lost over time. In addition, HEP analysis allows for a comparison and assessment of an indicator specie's optimum habitat conditions (i.e., those conditions associated with the highest potential densities of the indicator species within a defined area) to existing habitat conditions within an area.

HEP is a method of calculating habitat quality, based on the assumption that habitat for a selected species can be described by an HSI. An HSI is derived from established or project developed Suitability Indices (SI) or Curves. These variables are chosen from chemical, physical, and vegetative factors (e.g. food, reproductive cover, stream velocity, etc.) which have been determined to meet project goals for measuring habitat quality in the system under consideration. The SI is an index value ranging from 0-1, and is a ratio of the estimate of habitat conditions in the study area to the optimum habitat conditions for a species. All SI variables are mathematically aggregated into an HSI value. This HSI value is used as a weighting factor in the calculation of the amount of area, within a given study area, that has the potential to provide optimum habitat conditions.

The sum of the habitat variable SI's, divided by the number of variables considered, equals the mean HSI for the study area (or subarea) being evaluated. The goal in the identification of an HSI value is that it be linearly and quantifiably related to the study area's carrying capacity for the indicator species.

To derive the number of Habitat Units (HU's) available to an indicator species, mean HSI values identified for a project's various habitat conditions or habitat-altering actions are multiplied by the area of each habitat category or classification defined for the study area. The HU's can be used for comparative analysis or an assessment of habitat gained or lost to the overall system resulting from an action or group of actions that affect the system.

In the case of mixed cover types within a system (e.g., 30 percent emergent vegetation and 70 percent no cover), the SI values are weighted by multiplying the HSI value by the percentage of available mixed cover type present. For operational purposes when using HEP, an important premise to be remembered is that each increment of change in HSI must be identical to any other. For example, a change in HSI from 0.1 to 0.2 must represent the same magnitude of change as a change from 0.2 to 0.3, and so forth. This is an operational restriction imposed by the use of the HSI in HEP; however, it is a restriction easily complied with. If the relationship between HSI and carrying capacity is unknown, it is assumed to be linear. If the relationship is nonlinear, it is converted to a linear function.

G. KENAI RIVER 309 PROJECT HEP ANALYSIS METHODOLOGY

The physical and biological characteristics that comprise Kenai River fish habitats were identified and cataloged into the ADF&G's GIS for use in the Kenai River 309 projects cumulative impact assessment process. The many and varied habitat types occurring within the river were classified into one of six different habitat types to enable the study team to apply the HEP procedures to each classification. The primary difference between the six habitat classifications is in their physical characteristics. These include their cover characteristics, substrate type and water velocity characteristics.

The reliability of HSI values and corresponding HU's are directly dependent on the validity of assumptions made while designing the HSI model and collecting data. HEP procedures recommend model verification through: 1) review by the project analyst applying the HEP procedures to a specific study area, 2) analysis with sample data, 3) review by a species authority, and 4) testing with field data. Study assumptions may have to be adjusted after model verification to better reflect individual habitat variables and their degree of importance in defining habitat suitability for a particular species or species guild.

In the case of the Kenai River 309 study, the model parameters used for assessment of juvenile rearing chinook salmon had been developed for the Kenai River and the Susitna River in previous FWS and ADF&G studies (Burger, et al., 1983; Estes and Kuntz, 1986). Habitat suitability index (SI) curves for water velocity, water depth, and fish cover types were used in our application of the HEP. These curves are included in Appendix D of this report.

HSI values for a species can be developed through the use of documented habitat suitability models which utilize measurable key habitat components or variables. HSI curves for juvenile chinook salmon had already been developed and adjusted for Alaskan waters, particularly the Susitna River system and the Kenai River (Estes and Kuntz, 1986; Burger, et al., 1983).

HSI values are not synonymous with the entire HEP system. HEP is a data management system. It is the data it images, i.e., an index of quality and quantity of available habitat, which are of interest in this form of impact assessment. As is the case with all modeling methods, HEP has several attributes and limitations. HEP attributes include: a) HEP can provide several methods of output and consideration for comparison of management plans for both single and multiple species models; b) HEP can be applied at any level of detail or assessment, and does not necessarily require a lengthy or costly procedure; and c) HEP is amenable to benefit/cost analyses through annualizaton of HU's.

Limitations of the HEP process include: a) HEP cannot Reliably predict future impacts because the methodology does not include parameters to adjust for change over time in a given system. Future predictions made with such adjustments are based solely on best professional judgement; and b) As with other impact assessment approaches, the results of an impact assessment using HEP are no better than the reliability of resource data collected.

KENAI RIVER 309 PROJECT SPECIFIC ASSUMPTIONS:

Based upon earlier studies of Kenai River salmon populations and use (Bendock and Bingham, 1988; Burger, et al., 1983; Estes and Kuntz, 1986; Litchfield, 1985), the juvenile chinook salmon was identified as the target evaluation species because it has the most limiting life stage requirements of all salmon species found in the Kenai River. Our literature analysis indicated that the primary useable and available habitat for juvenile chinook salmon is restricted to a narrow 6-foot wide strip along the banks. This is predominantly due to limitations of rearing juvenile chinook to utilize: 1) river reaches with water velocities exceeding 64.0 cm/sec (optimum velocities for juvenile chinook salmon are between 3 and 18 cm/sec) (Burger, et al., 1983; Delaney and Wadman, 1979; Estes and Kuntz, 1986; Rubin et al., 1991); 2) areas with limited or no cover such as emergent or overhanging vegetation, inwater debris or deadfall material; and 3) areas with a lack of suitably sized substrate (i.e., river bottom material ranging from gravel to large cobble). River reaches exhibiting velocities above those preferred by juvenile chinook salmon may not preclude temporary use of these areas by rearing salmon if accompanied by compensatory factors sufficient to mitigate for the swift currents such as suitable cover or substrate conditions (Bendock, et al. 1988; Estes, et al., 1986).

The HEP analysis portion of this study limited the number and selection of habitat components to be modeled to those predominant habitat components influencing the success of juvenile chinook salmon. The habitat components selected were water velocity, depth, substrate, and cover type. For this model, cover type represents only that cover found at or below OHW, including immediately adjacent riparian habitat. Although data was collected above the OHW mark, it did not reflect the true extent of areal cover beneficial to fish to gain inclusion in the analysis.

The calculation of HSI's for the various representative sample sites studied was accomplished using the criteria described here. The formulas were reviewed by FWS HEP technical assistance staff in Fort Collins, Colorado.

HSI's were calculated for each habitat type identified along the Kenai River mainstem. The specific formula for this calculation is listed in Table 16 in Appendix A.

A hypothetical natural bank configuration, where all conditions for fish rearing were optimum, was modeled. A water velocity of 0.4 feet/second (SI=1.0) is low enough to allow juvenile chinook to maintain their feeding position nearshore without expending critical energy. A depth of 0.2 feet or greater (SI = 1.0) is considered optimum for juvenile chinook salmon. Cover variables for vegetation, debris, and substrate were assumed ideal at the site. Both aquatic and emergent vegetation have the same SI value of 0.65. Unlike the SI values for depth and velocity, aquatic and emergent SI values cannot exceed 0.65 either separately or in combination. The optimum site is assumed to contain 100 percent overhanging vegetation and 100 percent undercut bank. Debris (e.g., snags, etc.) is a naturally sporadic cover type; consequently, the optimum benefit is based on no more than 50 percent debris at the site. The optimum site was also characterized as having 100 percent of the substrate comprised of cobble material three inches or larger.

The following depicts the HSI score for ideal chinook salmon habitat described above.

Variable	SI score	Percent of Variable Potentially Available in System
Velocity (ft/s)	1.0	100
Depth (ft)	1.0	100
Vegetation:		
(Aquatic/Emerg)	0.65	100
Debris	1.0	50
Overhanging Veg.	0.5	100
Undercut bank	0.9	100
Substrate	0.35	100
TOTAL	5.40	

HSI for optimum conditions within a system $= \text{HSI} = \frac{5.4}{7} = 0.77$

According to the above calculations, the best bank and inwater conditions in the study area could not exceed an HSI value of 0.77. The HSI can never reach 1.0 because the majority of cover type SI's have maximum scores below the full range possible.

V. STUDY RESULTS

A. FIELD SURVEY FINDINGS

1. LAND OWNERSHIP AND DEVELOPMENT STATUS

Land ownership on the Kenai River is divided among seven distinct groups which include: federal lands, state lands, private residential and commercial lands, native corporation-owned lands, city properties of Kenai and Soldotna, the KPB lands, and University of Alaska lands. Figure 6 and Table 2 summarizes the land ownership patterns along the river by river study reach and the total river mainstem length.

The greatest percentage of land ownership on the Kenai River is owned and managed by the federal government. Currently federal lands comprise 30 percent (269,079 feet or 51.0 miles) of the total 877,074.2 feet of water frontage found along the Kenai River. The majority of this land has been designated federal wildlife refuge (Kenai National Moose Range) and is managed for the protection and preservation of fish and wildlife species endemic to this area. Approximately one-quarter of the federally owned land along the river is part of the Chugach National Forest and is managed by the U.S. Forest Service.

Private residential lands (including both developed and undeveloped lands) is the next largest land ownership category with approximately 28 percent (244,966 feet or 46.4 miles) of the total water frontage. Approximately one-half of those lands which are in private ownership have been developed to some extent, either by the construction of a cabin or home, the installation of a dock or other river access structure or by the installation of shoreline erosion control structure or structures. In some cases all of the above have been constructed. Many of the private land owners have complained about the damage done to their property by the general public who make use of these private lands for sport fishing access. Garbage and human waste are left on the shoreline and bank damage from foot traffic and boat landings are a common problem. A major problem facing the private sector is how to avoid damaging the shoreline habitat and still provide unrestricted access to the river. Another is how to effectively protect private property from erosion while avoiding fish habitat loss or accelerating the erosion problem for an up, downstream or opposite river bank neighbor's property.

The State of Alaska ranks third in land ownership with 19 percent (162,247 feet or 30.7 miles) of the waterfront, followed by native-owned lands belonging to Cook Inlet Region, Inc. and Salamatof Native Corporation at approximately 9 percent (68,032 feet or 12.9 miles). All of the public access sites developed by the state have experienced severe vegetation loss and bank erosion from the large numbers of bank anglers and boaters using these areas. A significant effort on the part of the state is needed to arrest further damage to these sites and restore them to productive fish rearing habitat.

The City of Kenai is next with approximately 8 percent (75,056 feet or 14.2 miles) most of which is in the form of wetlands near the mouth of the Kenai River or is leased and developed for commercial uses such as fish processing facilities. Commercial property ownership accounts for 5 percent (35,318 feet or 6.7 miles) of the river waterfront. These sites are severely impacted by heavy foot traffic and boat scour from boat mooring along the banks. This is at its worst in study reach 2.

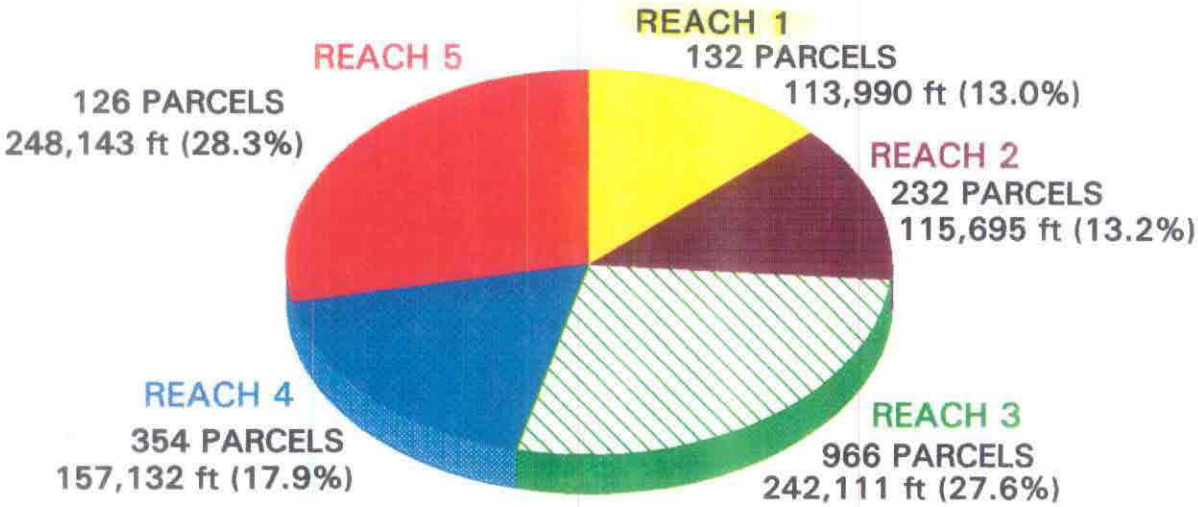
The City of Soldotna (16,890 feet or 3.2 miles) and the KPB (3,994 feet or 0.75 miles) own the least amount of Kenai River water frontage with under 1 percent of the waterfront land ownership.

Figures 7, 8, and 9 contrast this land ownership pattern for developed and undeveloped by river reaches 1 through 4 (RM 0 to 50), Reach 5 (RM 65 to 82), and all reaches combined.

While data analysis indicates that up to one-half of the residential and commercial property on the river is currently developed, most of the federal, state, and City of Kenai lands are in an undeveloped status (Figures 7, 8 and 9). Although this is indicative with regard to the amount of bank and shoreline affected by access structures and bank stabilization, it does not reflect the level of impact associated with bank trampling (those areas where heavy foot traffic has resulted in the denuding of the vegetation which protects against erosion) which is greatest on federal lands subject to intensive public use.

FIG. 6 KENAI RIVER OWNERSHIP BY PARCEL

PARCELS/PERCENTAGE OF WATER FRONTAGE BY REACH

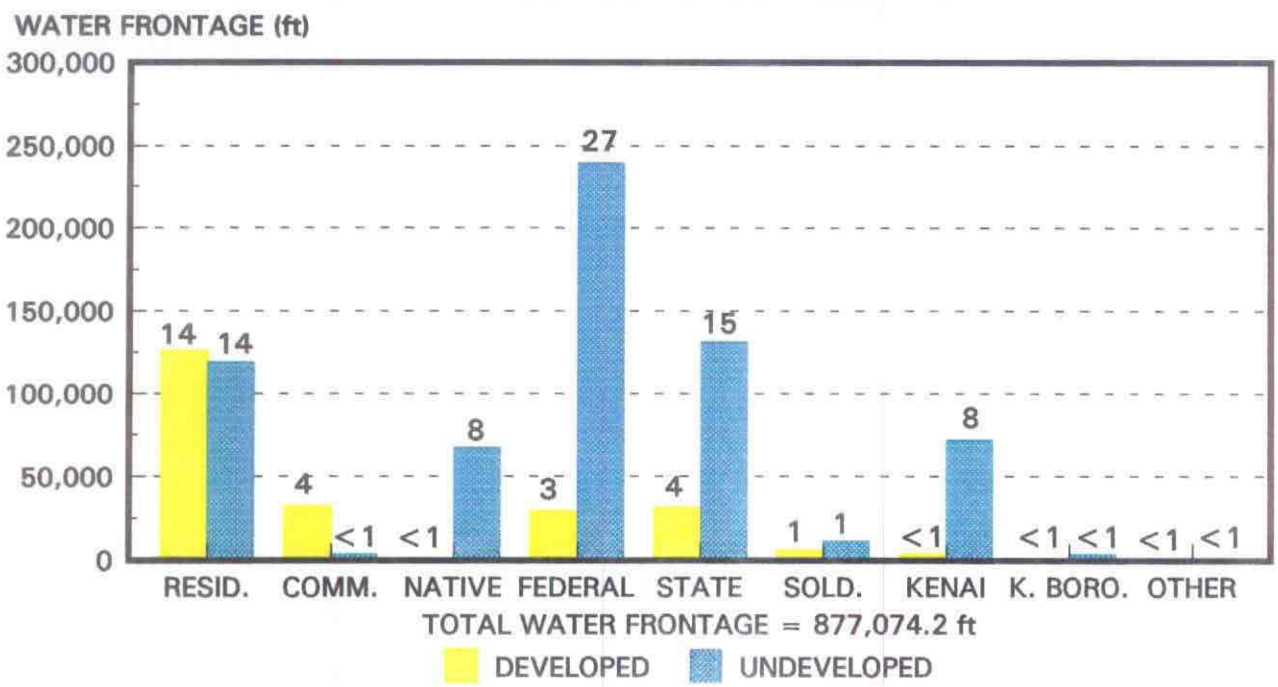


TOTAL PARCELS = 1,810
TOTAL WATER FRONTAGE = 877,074 ft

% = PERCENTAGE OF TOTAL WATER FRONTAGE FOR THE ENTIRE RIVER MAINSTEM

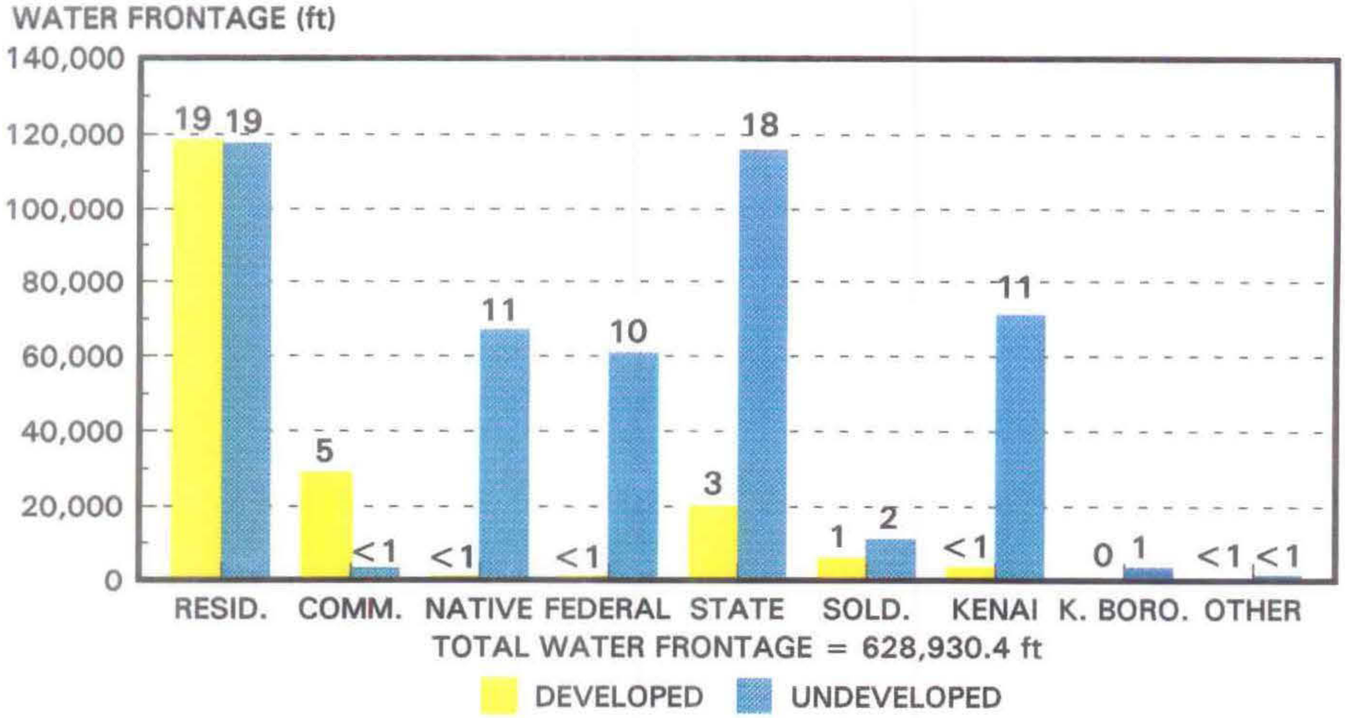
FIG. 7 KENAI RIVER OWNERSHIP CATEGORIES

ALL FIVE RIVER REACHES COMBINED



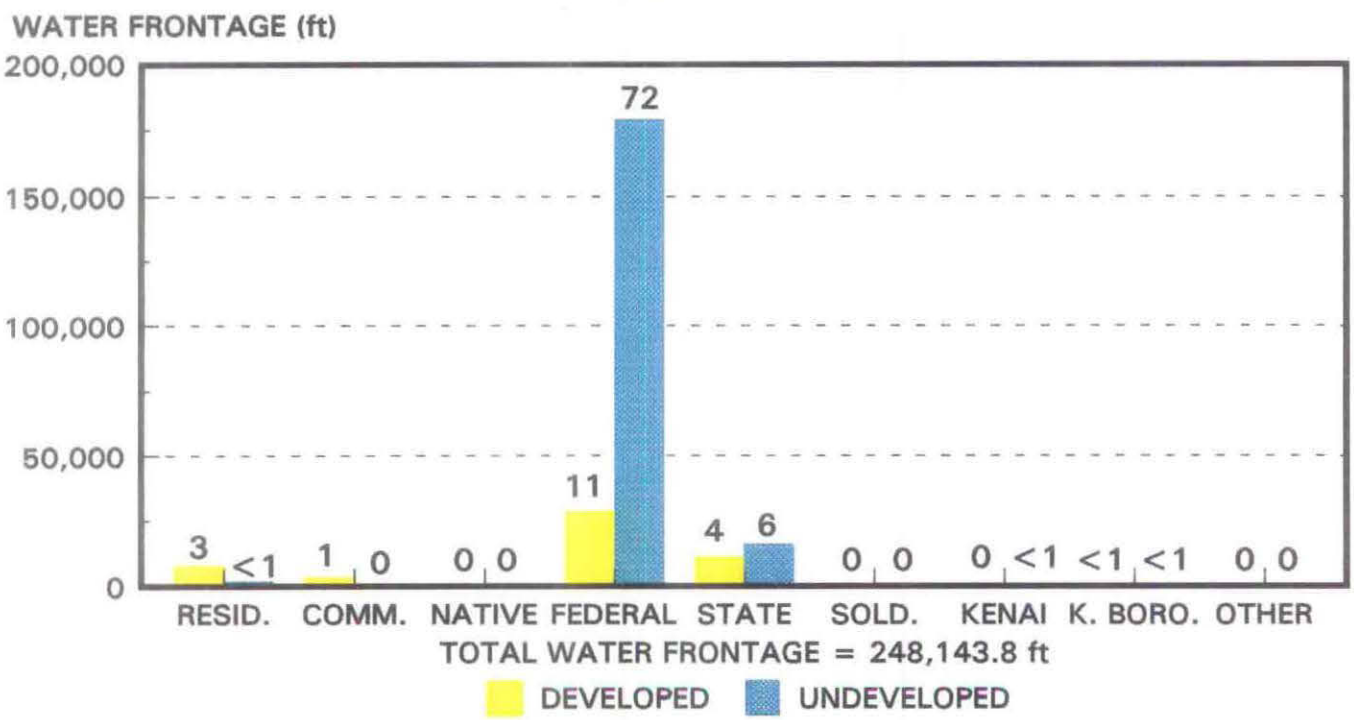
NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

FIG. 8 KENAI RIVER OWNERSHIP CATEGORIES
REACHES 1-4 COMBINED



NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

FIG. 9 KENAI RIVER OWNERSHIP CATEGORIES
REACH 5



NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

2. RANKING OF STUDY REACHES BY DEVELOPMENT STRUCTURE AND BANK TRAMPLING IMPACTS

The results of the 1992/93 field survey/inventory of Kenai River fish habitats, public and private access sites and conditions, bank stabilization structures, and land use/access related impacts occurring along the river have been tabulated and are summarized in the figures listed in this section and the tables contained in Appendix C of this report.

The number of structures occurring on the Kenai River are depicted graphically in Figure 5 (page 17). This graphic also portrays the waterfront length of all structures combined by reach, the area covered by all structures and the waterfront length for each study reach defined in the Kenai River 309 study. Tables 3 through 8 specify the actual structure types and structure lengths for each of the 5 study reaches. The overall effect of development and access related impacts by study reach are depicted in Figure 10. From this graphic, it is easy to see that the large majority of natural habitat conditions still exist in each reach evaluated. However, when one considers the total effect of damaged or existing types of altered bank equates to 11.1 percent of the total available habitat for rearing juvenile fish, this cumulative effect is a concern, especially in light of the fact that some of the remaining available habitat is of less than optimum value to the rearing salmon.

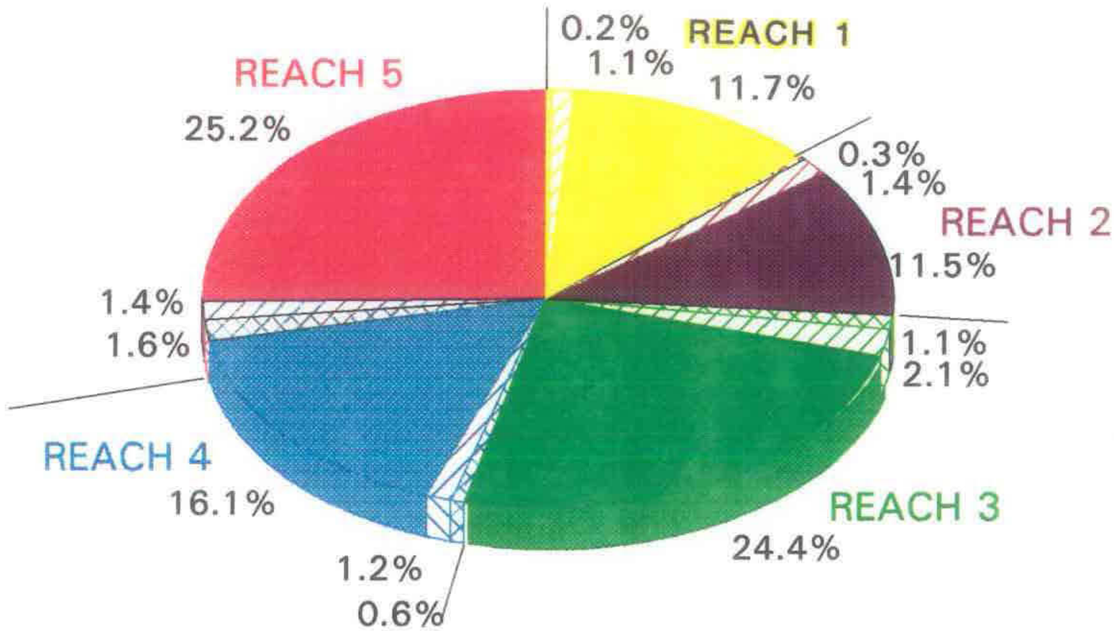
The 67 linear miles of Kenai River shoreline is equivalent to 877,074.2 feet (166.1 miles) of river frontage. As of September 1993, 63,299 feet (12.0 miles) of this length or 6.89 percent has been altered from its natural condition for public and private access and as a result of bank stabilization practices (see Table 9, Appendix C). An additional 34,230 feet (6.5 miles) have been severely trampled or denuded as a result of public and private access along the shoreline for recreational pursuits such as sport fishing or boating. Together these total 11.1 percent of Kenai River banks which are no longer in a natural state. Table 8 summarizes the level of development activity by study reach and for the entire Kenai River mainstem. Table 9 correlates development structures and bank trampling impacts both at ordinary high water and at the top of the bank. The ordinary high water line is defined by the DNR and under the State of Alaska's Administrative Code as that point on the shoreline "that reflects the highest level of water during an ordinary year and is established by fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of the soil; destruction of terrestrial vegetation; the presence of litter or debris" [11 AAC 20.990 (11)]. These two elevations vary along the entire river length. Figure 12 depicts these reference points as they appear along the river mainstem.

The greatest level of shoreline impact observed on the river occurs within study reach 3 (RM 17.5 to 39.5) which contained 811 different structures or 43.4 percent of all structures occurring on the river and its shoreline. Within this 22 mile long reach, 18,685 feet of the total reach 3 shoreline length of 242,111 feet has been altered with docks, armor rock, boat launches and boat tie-up scour damage along the river banks, representing 2.13 percent of the total river frontage. This river reach is also the most severely impacted by bank trampling and shoreline vegetation loss in terms of total length of river bank affected. Study reach 3 exhibits a total of 12,352.7 feet of trampled bank, representing 1.41 percent of the total trampled bank conditions occurring along the entire river mainstem. A total of 30,592.6 feet (3.49 percent) of river bank at its OHW line has been impacted by trampling (see Table 10). Methods to halt this degradation should be implemented immediately. These could include the mandatory installation of properly installed floating boat docks to stop the bank scouring and residual erosion associated with high water velocity increases and boat generated wave action from the boat wakes. Elevated boardwalks and ramps to the docks would eliminate the bank trampling and vegetation loss associated with over 95 % of all the boat tie-up sites observed along the river.

Study reach 5 (RM 65 to 82, between Skilak and Kenai Lakes) was the second most impacted river reach. The majority of this 17 mile reach is in federal ownership and managed by either the FWS as a National Wildlife Refuge or by the U.S. Forest Service as part of Chugach National Forest. Much of the habitat impacts occurring within this reach are attributed to severe shoreline trampling at or near the Russian River confluence and the presence of rock riprap to protect the Sterling Highway at five locations within this reach. This reach exhibits a total of 12,489 feet of waterfront affected by structures (Table 7) amounting to 1.42 percent of the total river waterfront. The amount of bank trampling occurring in reach 5 which amounts to 11,234.7 feet of bank impacted (1.28 percent of the total river waterfront) makes this reach a close second to study reach 3 in terms of fish habitat impact.

Study reach 2 (RM 10.0 to 17.5) is the next most affected area. This reach contains 441 structures covering 11,961 feet of shoreline (1.36 percent of the total river waterfront). Most of the structures occurring in this study reach are associated with private and commercial property waterfront erosion protection and fishing access. Rock rip-rap and other bank stabilization materials are extremely common within RM 16 to 17 along the right bank of the river (looking downstream). The most common and severe shoreline impact in this reach is bank trampling and natural vegetation loss associated with public access sites and riverside camping areas. Over 3,400 feet of the total reach water frontage of 115,695.6 feet has been impacted by severe trampling (10.8 percent of the total reach length, 0.39 percent of the entire Kenai River's water frontage).

FIG. 10 KENAI RIVER WATER FRONTAGE ALTERATIONS
FOR EACH REACH AT ORDINARY HIGH WATER



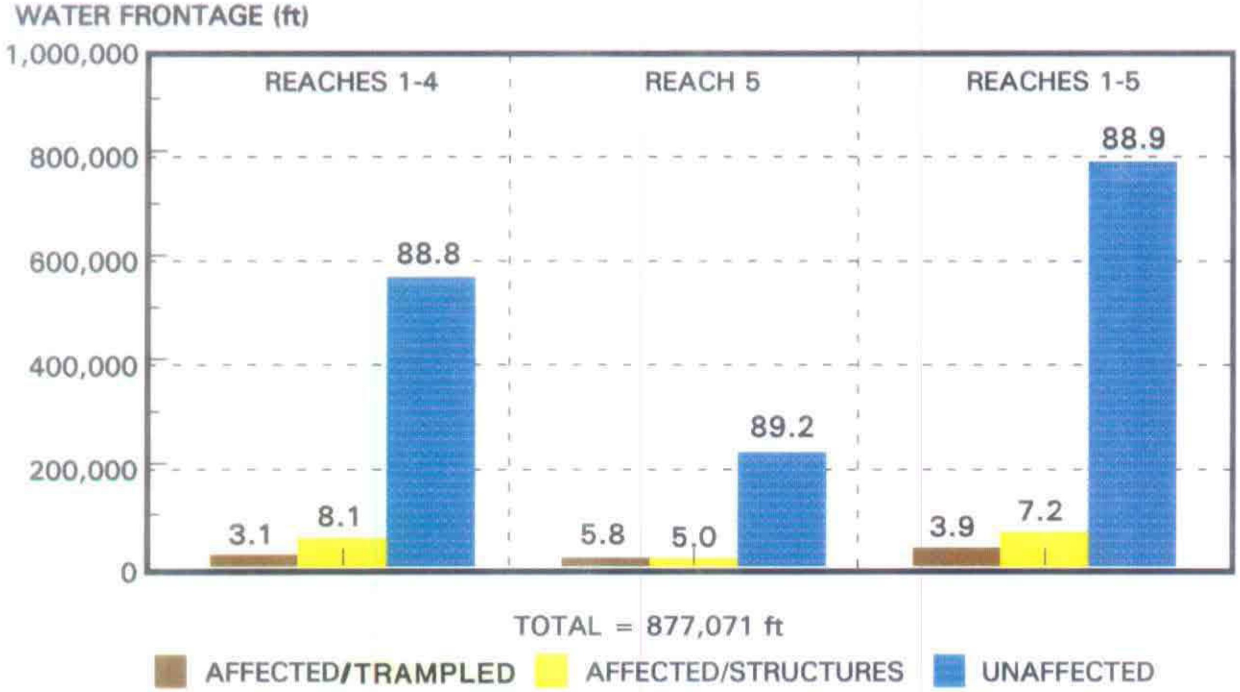
TOTAL = 877,071 ft

AFFECTED/TRAMPLED AFFECTED/STRUCTURES
UNAFFECTED

% = PERCENT OF TOTAL WATER FRONTAGE FOR THE ENTIRE RIVER MAINSTEM

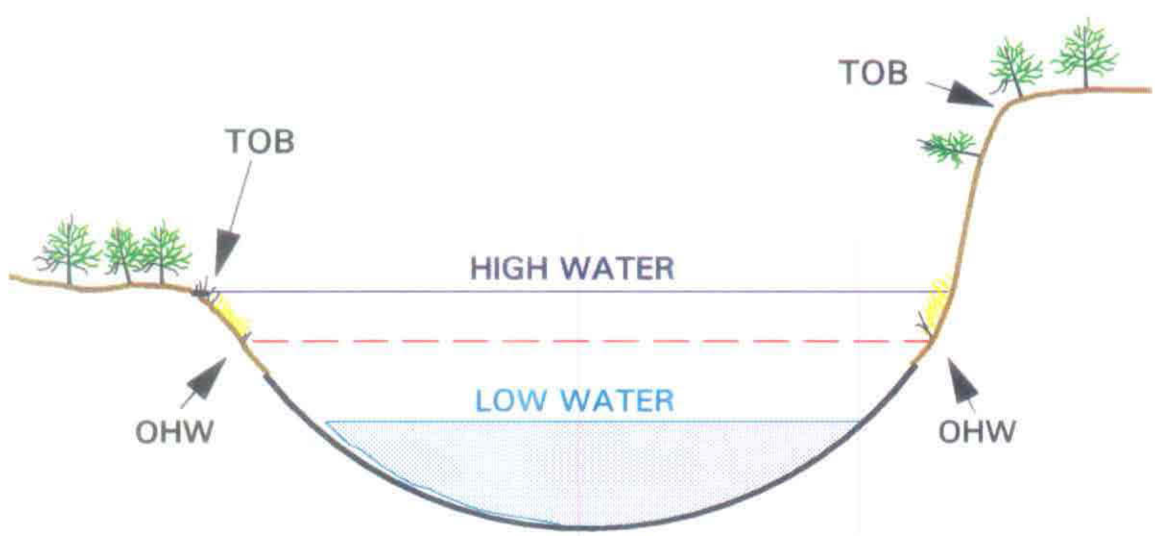
FIG. 11 KENAI RIVER WATER FRONTAGE ALTERATIONS

FOR COMBINED REACHES AT ORDINARY HIGH WATER



NUMBERS ABOVE BARS REFLECT % OF TOTAL WATER FRONTAGE FOR EACH SET OF REACHES

FIG. 12 WATER LEVEL AND BANK LOCATION DEFINITIONS



TOB = TOP OF BANK
OHW = ORDINARY HIGH WATER

Study reach 1 (RM 0 to 10) is ranked fourth of the five study reaches with respect to river bank alteration and development structure introduction. This area exhibits a relatively moderate amount of erosional gravel banks, large commercial docks, and a small amount of bank stabilization activity associated with the fish processing plants located in the lower two miles of the river and a relatively small number of residential parcels located at the confluence of Beaver Creek and the Kenai River. This reach has had over 9,744 feet of its 113,990.3 feet of waterfront developed, which represents 1.11 percent of the entire river waterfront. All of this reach is within the tidally influenced portion of the river (RM 0 to 12) and exhibits a mud/silt/sand substrate composition that is of a lesser value to rearing juvenile chinook salmon than the other four study reaches. This is not to say there is no value to rearing juvenile fish in this reach as previous studies have resulted in the documentation of juvenile fish use here. It is believed that the majority of these juveniles are either preparing to outmigrate into Cook Inlet or are weaker swimming fish that have been washed downstream into the tidally influenced portion of the river. It should be noted however, that other fish species are only found in this reach due to its brackish water condition.

Study reach 4 is the final and least affected reach with regard to structures and bank trampling. It contains 345 structures covering 10,420 feet of waterfront (1.18 percent of the total river waterfront) and exhibits more bank trampling than reach 1 with 5,702 feet of the OHW line trampled (0.65 percent of the entire river water frontage). One third of this reach is federal lands within the Kenai National Moose Range and not subject to commercial or residential development however, there are numerous campsite locations between RM 45.5 and 50.0 that exhibit significant bank erosion and vegetation loss from seasonal high use. This area is regulated against motorized boat use during swan nesting season.This restriction reduces the level of use and some of the potential for boat wake bank disturbance for a portion of the summer fishing season. This reach, as in study reach 3, is further restricted in terms of public use in the limited number of public boat launching facilities.

River-wide, the most severe bank trampling and vegetation loss has occurred at public access sites (both boat launches and road accessible sites) and at commercial use sites such as recreational vehicle and fishing camps located adjacent the river. These intensively used sites support hundreds of thousands of recreational users who access the river at these locations. In fact, many commercial guides use these locations as a pick-up and drop-off point for clients or to launch and retrieve their boats. Each of these sites is severely denuded along the banks from foot traffic and boat scour associated with boat tie-ups. Due to the high volume of human use occurring at these sites and the fact that these sites are significant revenue generating locations, the riparian areas should be protected to maintain the integrity of the riverbank. These areas, much like the federal and state public access areas need to be the focus of intensive bank restoration and protection efforts in the immediate future.

When comparing the amount of altered habitat between the lower 50 miles of river to that of the upper river (between Skilak and Kenai Lakes) it is interesting to note that approximately the same ratio of altered habitat versus natural conditions occurs within each river segment. Roughly 11 percent of the river's riparian and nearshore habitat have been damaged due to development and access.

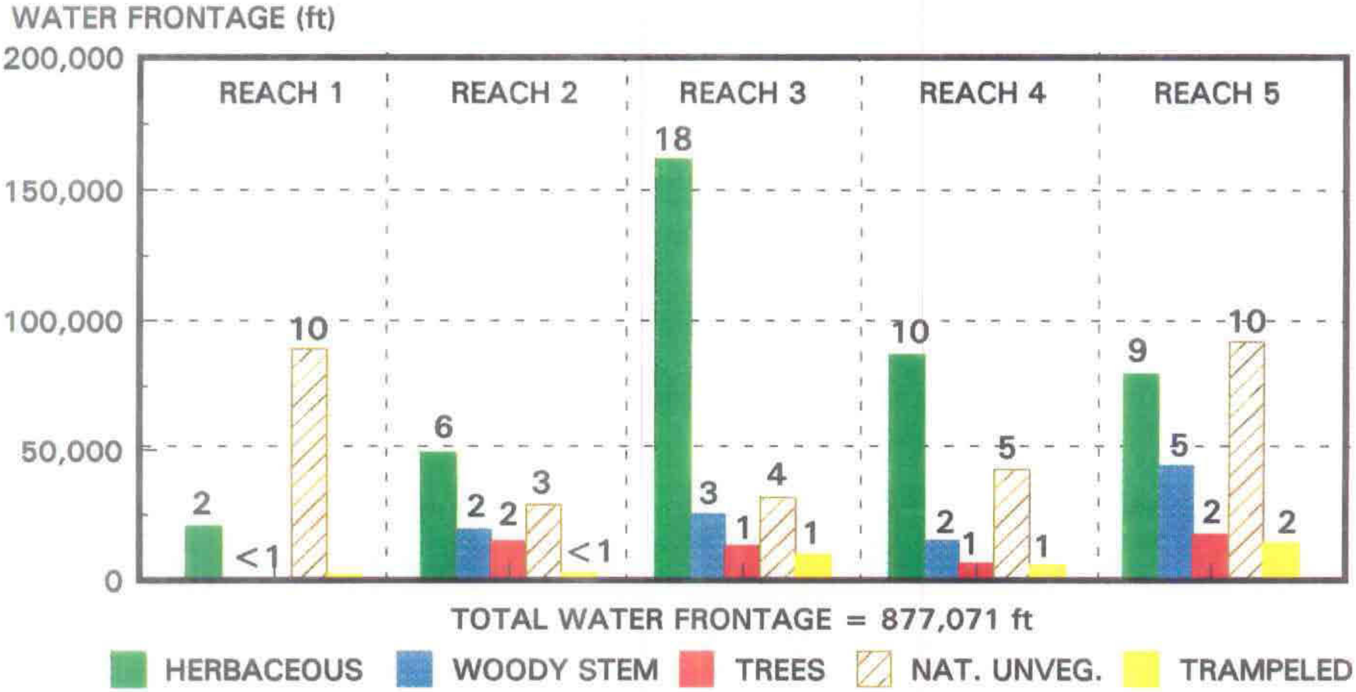
3. SHORELINE VEGETATION CONDITIONS

River bank vegetation along the Kenai River is important for a variety of reasons. It provides the basis for bank stability. The shoreline vegetation's roots serve to bind the soils to the bank and reduces the ability of the flowing water to erode the banks. Vegetation also reduces the overland surface flows from spring melt and storm events that result in erosion as the water washes downslope into the Kenai River. It also retards the soil robbing effects of wave slap and wake action that undermine the shoreline and result in the gradual erosion of the riverbank.

The Kenai River shoreline vegetation was surveyed during this study to identify the type of ground cover occurring at the ordinary high water line and at the top of the bank. The top of bank along the Kenai River can vary from the ordinary high water line to bluffs several hundred feet high. Vegetation type and density is an important component of fish habitat use and preference. It not only serves to stabilize the river bank and riparian areas, it can provide cover in the form of overhanging vegetation or shade and shadows. It can help regulate water temperatures especially in areas of little or no circulation. It also provides food materials to rearing fish in the form of organic debris which serve as food for the invertebrates fed upon by juvenile fish. Other insects often fall into the river nearshore waters from overhanging vegetation and are preyed upon by juvenile fish.

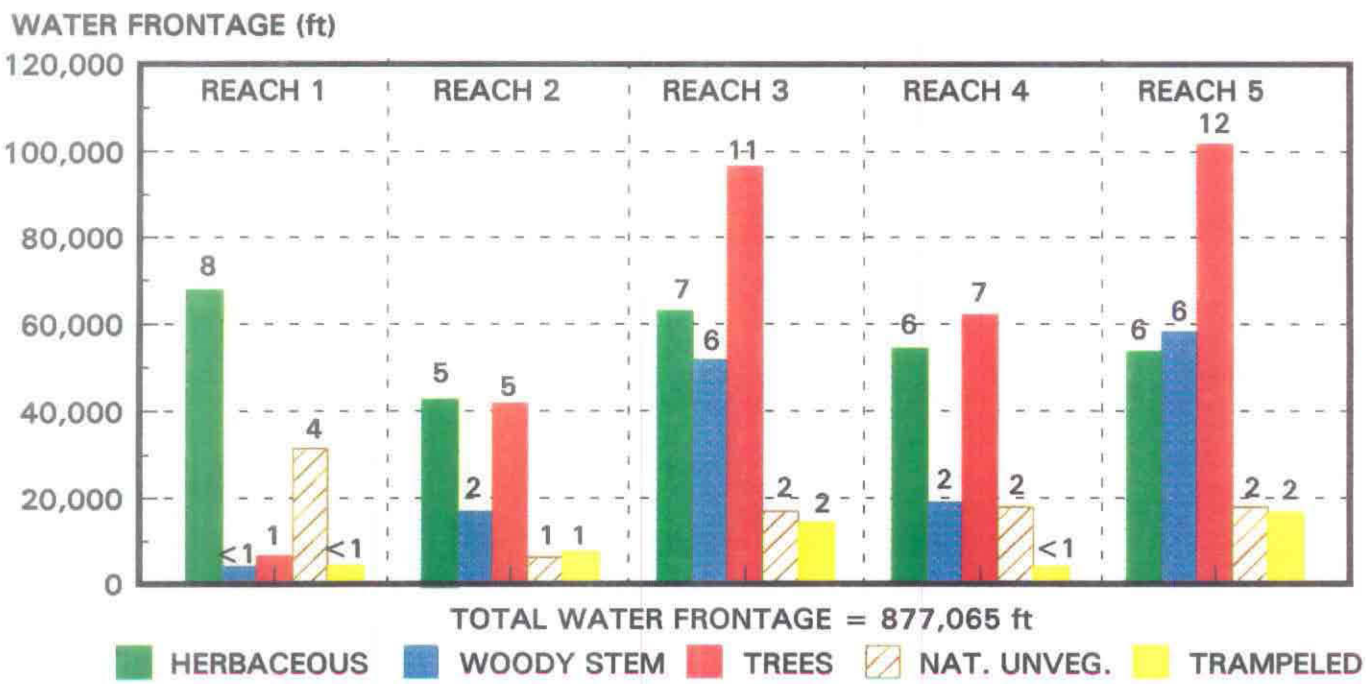
Vegetation types and coverage were inventoried at both the OHW line (see Figure 13) and the top of bank (see Figure 14). A comparison of these two bank elevations and their vegetative cover is made in Figure 15. Shoreline vegetation types are summarized in Table 11. As can be seen by comparing the two different sites in figures 13 and 14, the same parcel of land or site location can be characterized quite differently depending on where the vegetative cover is surveyed.

FIG. 13 KENAI RIVER BANK VEGETATION TYPES
AT ORDINARY HIGH WATER



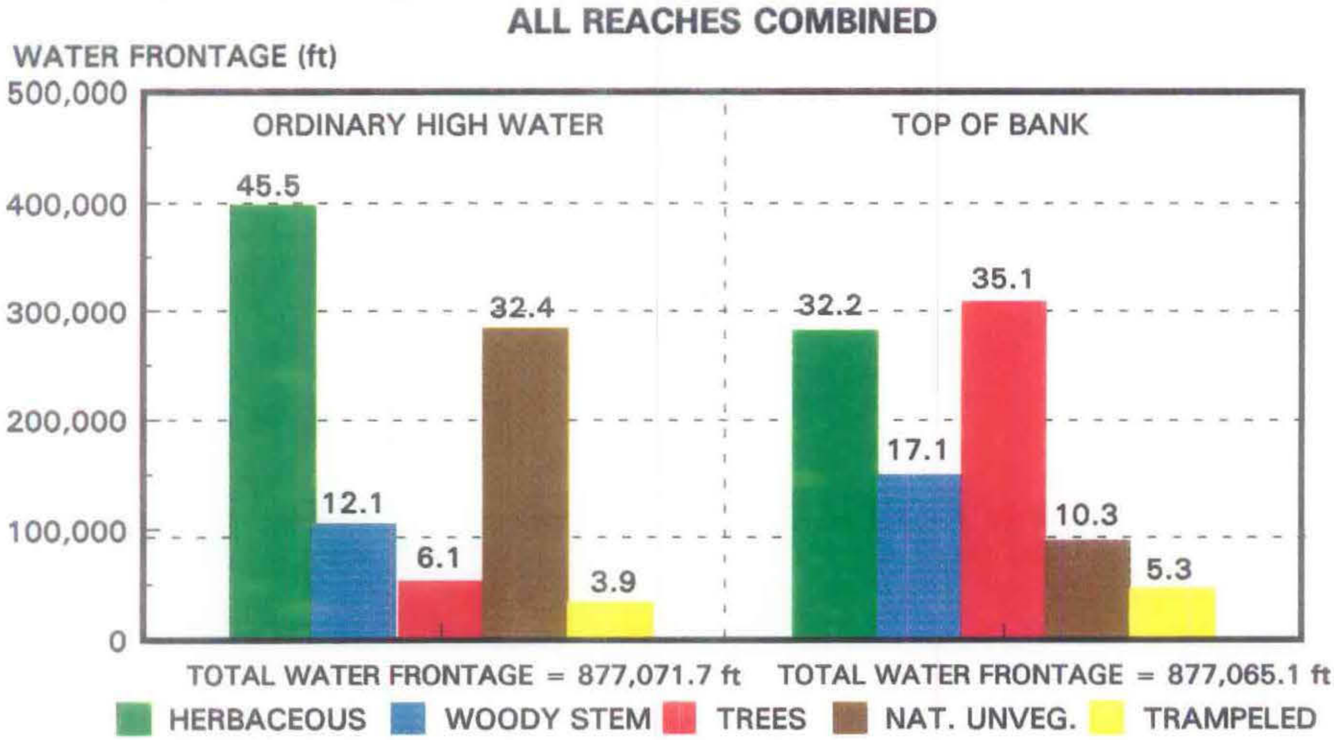
NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

FIG. 14 KENAI RIVER BANK VEGETATION TYPES
AT TOP OF BANK



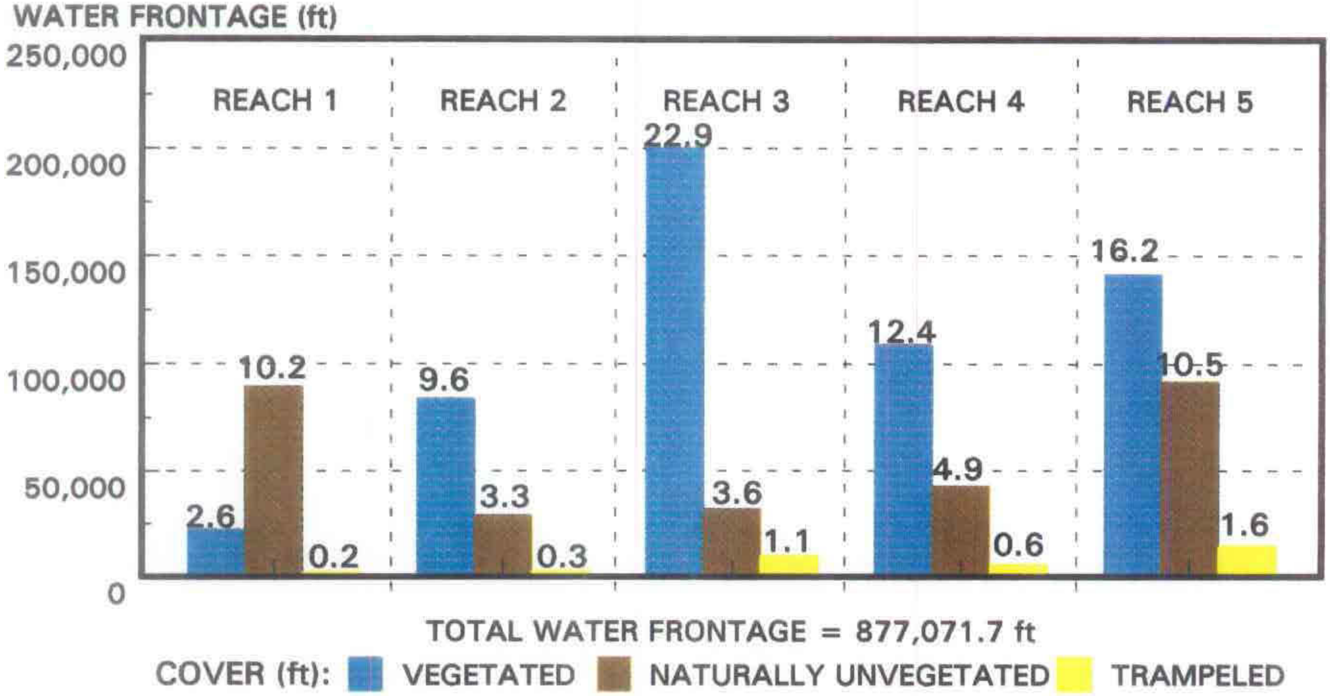
NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

FIG. 15 KENAI RIVER BANK VEGETATION



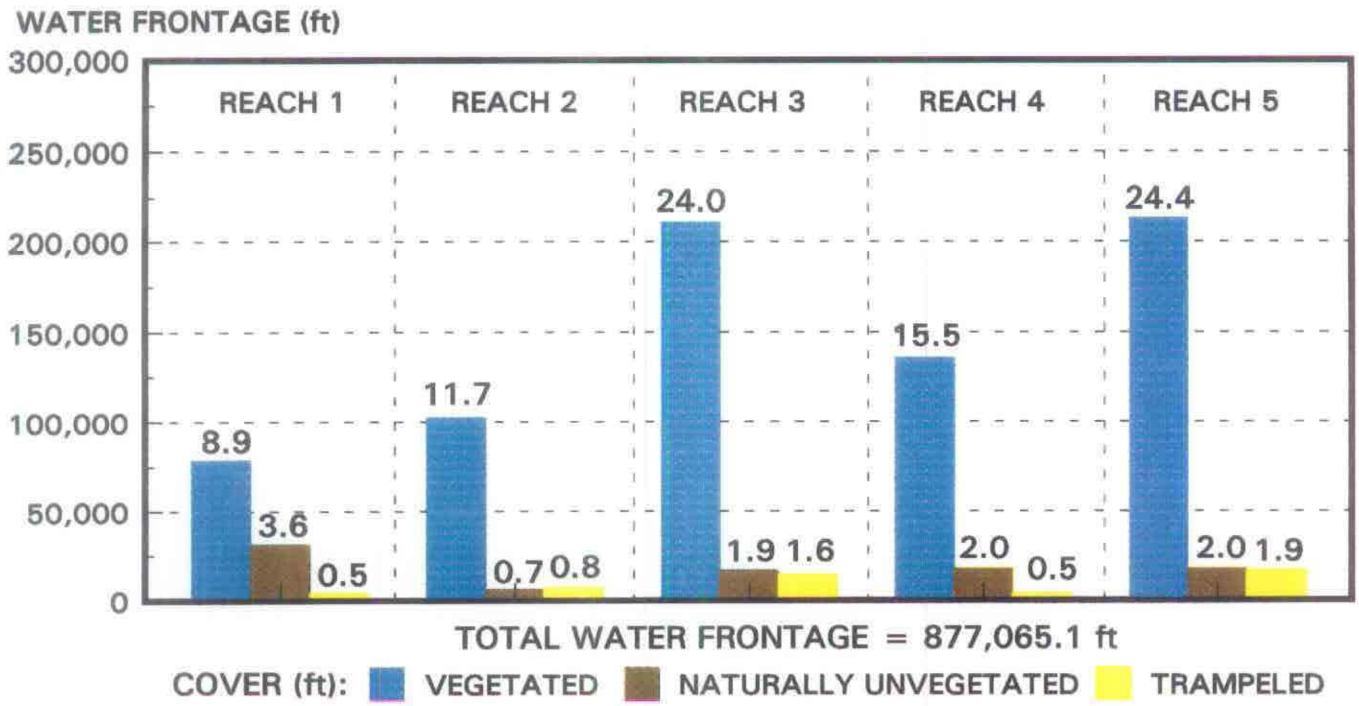
NUMBERS ABOVE BARS REFLECT % OF TOTAL WATER FRONTAGE FOR OHW OR TOB

FIG. 16 KENAI RIVER BANK VEGETATION FOR ALL REACHES AT ORDINARY HIGH WATER



NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

FIG. 17 KENAI RIVER BANK VEGETATION FOR ALL REACHES AT TOP OF BANK



NUMBERS ABOVE BARS REFLECT % OF TOTAL MAINSTEM WATER FRONTAGE

4. NEARSHORE SUBSTRATE TYPE AND COVERAGES

The four substrate categories observed and inventoried in the field survey and used in the HEP analysis are summarized by study reach in Table 12 and Figures 18 and 19. Generally, the lower river which includes virtually all of study reach 1 is composed of a combination mud, silt and sand type of substrate overlaying a gravel base. This material is fine grained sediments that are deposited as a result of the tidal influence occurring within this reach.

River reaches 2, 3 and 4 are predominantly composed of gravel and cobble substrates. This is material that ranges between one-half inch and less than five inches in diameter. This type of material is good spawning habitat as it allows for redd (nest) excavation and allows adequate water circulation of the eggs. Previous studies by ADF&G and FWS have determined that while the early run of Kenai River chinook spawn predominantly in tributaries to the river, the late run spawns in the Kenai mainstem (Burger, et al.). Good water circulation is important as it carries oxygenated water to the incubating eggs and juvenile fish and removes metabolic wastes from the redd. It also helps maintain suitable temperatures for the eggs and allows the young fish to move up or down into the spaces between the gravels and cobble to seek optimum incubation conditions. While nearly all that reach of river mainstem which exhibits gravel substrate is capable of being used as spawning area, much of the mainstem dewaters during the winter low flow period.

Reach 5 is composed of a gravel base but contains more cobble and rubble than the other reaches, especially through the Kenai River canyon between river mile 67 and 69.5. This larger-sized material is important as it can be used as cover by juvenile fish, especially in the absence of other preferred cover types such as overhanging vegetation, undercut banks and/or debris.

Rivers are constantly moving substrate material down gradient. As sediments and eroded materials are deposited into the river mainstem, increased water velocities associated with the river's high water periods and peak flows move this material in the direction of flow. This bedload transport helps maintain the river's equilibrium and reduces the potential for excessive erosion. If this equilibrium is altered, through the installation of an inwater structure like a jetty, the river will tend to deposit its bedload at the lesser velocity area behind the jetty. This can result in an increase in erosion further downstream or even across the river on the opposite bank. It can also result in the desire to excavate or dredge out the deposited materials over time to maintain navigable water where the deposited materials build up. This generally results in the entrainment of more fines within the water column which can move downstream and silt in other important spawning gravels and suffocate invertebrates used by juveniles as a food source.

Excavations into and adjacent the shallow nearshore area which provides preferred water depths for rearing juveniles during the spring, summer and fall periods, alters circulation patterns by creating eddys and gyres that increase bank erosion. It can also subject the juvenile salmon to increase predation by larger fish species that would not normally forage in the shallow water nearshore areas.

Compaction of the river substrate resulting from vehicle fords or grounding of bank stabilization materials like logs or floating docks can make these areas unsuitable for construction of nests and crush any eggs or young salmon fry incubating within these gravels.

From the comparison made in Figure 18, it appears that study reach 3 contains the greatest amount of gravel and cobble material within the entire mainstem. This area supports the greatest opportunity for spawning and provides ample cover habitat in the crevices between the cobbles for juveniles to rest, feed and rear.

Study reach 4 exhibits less cobble material and more sand sized particles which is due primarily to the material contributed from Skilak Lake and the dampening effect on river velocities resulting from the ability of Skilak Lake to assimilate increases in water contributions to the river from its tributary streams and regulate flow into the lower river to a great extent. This area of the river is known to support high levels of sockeye salmon spawning.

Study reach 5 with its preponderance of rubble and large rock (larger than 5 inch diameter) substrate provides good rearing cover habitat for juvenile fish in the form of crevices and pools created by the larger material. This positive habitat characteristic can be offset however by high water velocities which can wash very young and weaker swimming juveniles out of the upper river reach. Reach 5 contains 11 percent of all of the rubble and larger sized material found in the Kenai mainstem. The other four study reaches contain a total of 6 percent.

The bar chart in Figure 19 demonstrates that the nearshore substrate of the river's mainstem is composed of 34.2 percent gravels, 27.4 percent cobble, 21.3 percent mud,sands and silt and 17.1 percent rubble. The majority of the preferred substrate materials used by rearing juvenile chinook salmon which includes the gravel and cobble sized materials occurs within study reaches 3 and 4.

FIG. 18 KENAI RIVER NEARSHORE SUBSTRATES
BY REACH

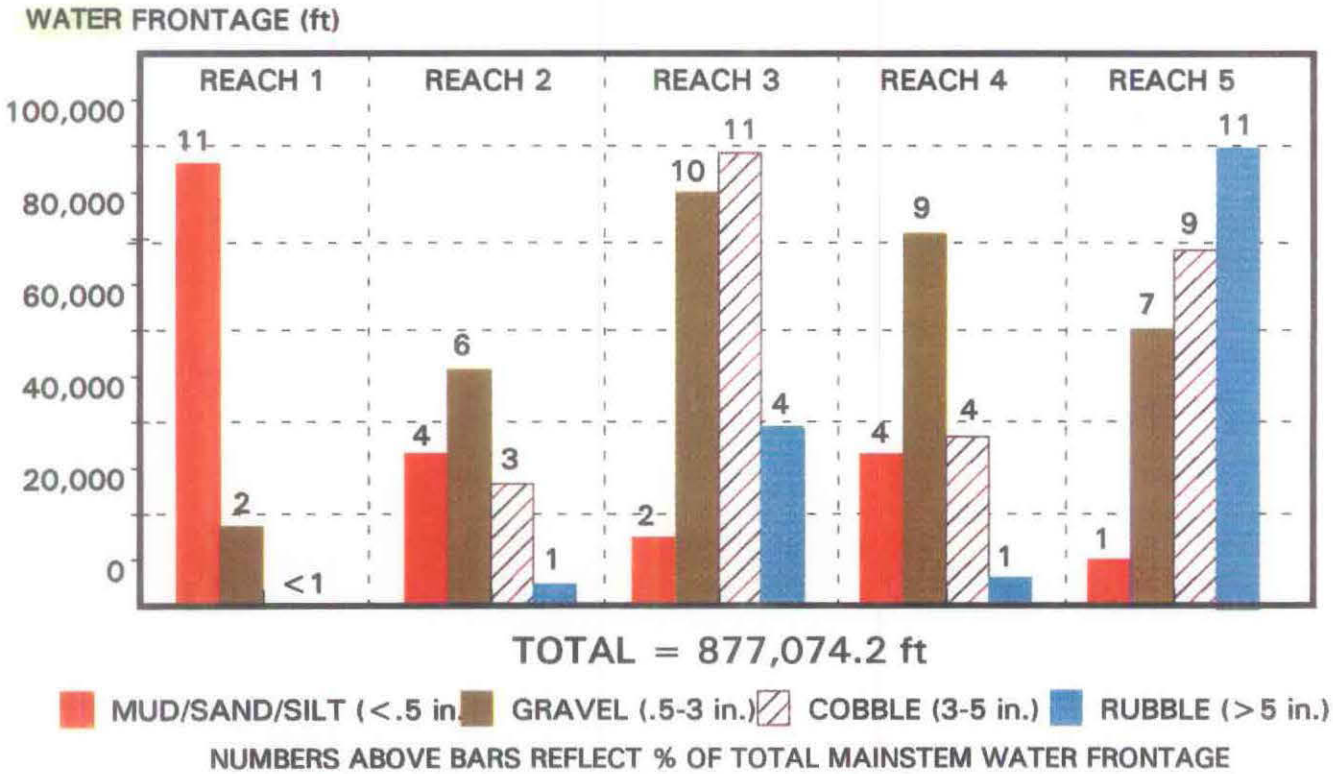
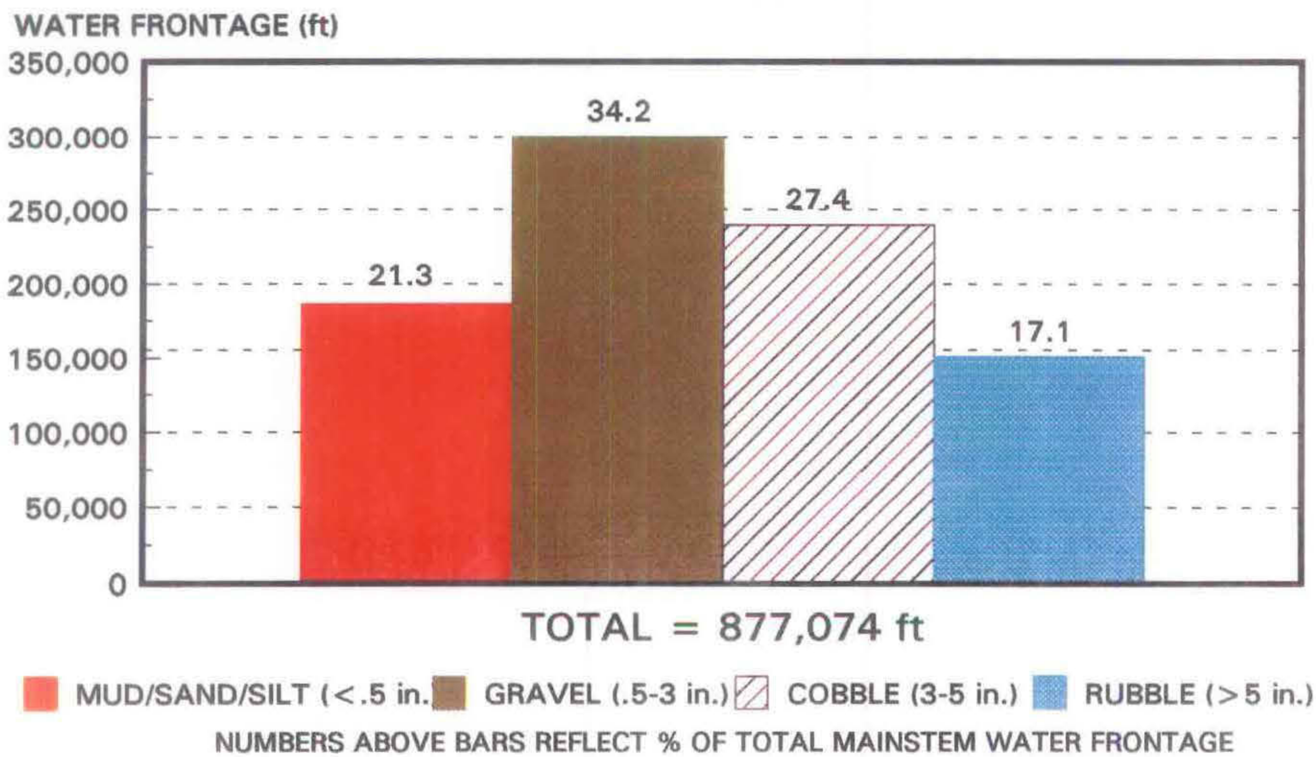


FIG. 19 KENAI RIVER NEARSHORE SUBSTRATES
ALL REACHES COMBINED



5. AVAILABLE FISH COVER CONDITIONS

Cover characteristics for rearing juvenile chinook salmon can include a wide variety of habitat components such as: substrate type, aquatic vegetation, riparian vegetation, riverbank configuration, debris, water clarity and water color. It should be noted that, unlike other habitat characteristics evaluated in this study, juvenile fish cover components can overlap. For example, a particular parcel on the river may exhibit emergent vegetation, overhanging vegetation, an undercut bank and cobble substrate all in the same area. For this reason total footage of fish cover components exceeds the linear footage of the river's shoreline. The Kenai River 309 field survey resulted in the identification of 1,241,791 feet of fish cover habitat occurring within the total 877,074 feet of river shoreline. This is due to the overlap of fish cover types (Table 13).

Previous studies by the ADF&G (Bendock, et al., 1978, Burger, et al., 1983, Delaney, et al., 1979) have documented that juvenile fish prefer the slower moving waters associated with the river nearshore areas and favor areas with overhanging vegetation and undercut banks. These habitat characteristics would be considered optimum cover habitat for rearing juvenile salmonids as they provide exposed roots and limbs that provide hiding areas for the young fish. In the absence of this type of habitat, the young fish will seek alternative cover such as debris and deadfall materials within and over the stream or larger cobble/rock substrate where they can hide in the crevices and crannys. Some of the cover values associated with substrate material size has been described in the previous section of this report. Water depth can also provide cover for these juveniles where light penetration is reduced making it more difficult to be seen by predators.

The fish cover types and conditions that were documented on the Kenai River during this study and used to perform the HEP analysis are summarized by Study Reach in Table 13 and graphically depicted in Figures 20 and 21. Table 13 shows the cover types that occur in each study reach, the number of linear feet of each cover type observed and the percentage of the study reach exhibiting this cover type. in each reach. It also identifies the linear footage and percent coverage of the total available cover for the study area by cover type. A summary of how each reach compares by cover type follows.

The areas which exhibited the least amount of cover included study reach 1 and study reach 5. The lower river nearshore habitat is characterized by shallow slopes of mud and silt with little or no overhanging vegetation. This area is tidally influenced with fluctuations in water levels in excess of 29 feet (Kenai River tides range from a low of -4.6 feet to a high of +25.1 feet) While some overhanging and undercut bank cover is available to juvenile fish during the higher tide series, this would only occur a few hours at a time twice a day and only during higher tides (high tides that exceed the plus 22 foot height which occurs less than 20 percent of the time. The vast majority of the tidal series juvenile fish are subjected to the shallow waters along the shoreline with little or no vegetation or substrate cover available. This reach does however provide cover in the form of high turbidity or low water clarity which reduces juvenile fish visibility to predators. Study results indicate that there is a total of 343,832 feet total of "no cover" conditions in the Kenai River nearshore study zone of which 104,020 feet or 30 percent occurs within study reach 1. This represents 83 percent of the cover for fish rearing in the nearshore areas within zone 1 and 8.4 percent of the total cover types available within the entire study area.

There is a significant greater level of available cover conditions for juvenile fish occurring within study reaches 2,3 and 5. These reaches contain the greatest linear footage of overhanging vegetation and undercut bank conditions. Study reach 3 ranks number one with 183046 feet of this cover type which represents 42.3 percent of the total overhanging vegetation coverage in the entire study corridor, followed by reach 5 with 25.0 percent. Reach 2 is third with 16.7 percent followed closely by reach 4 with 14.9 percent of the available overhanging vegetation. Reach one has very little of this cover type available to fish with only 1.1 percent of the river's total overhanging vegetation occurring within this reach.

Undercut banks are a highly sought after cover type by juvenile fish. Study reach 3 again ranks first with 46.0 percent of all of the available nearshore area with this cover type, followed by reach 2 with 20.2 percent. Reach 5 ranks third with 18.8 percent followed by reach 4 with 13.5 percent and reach 1 exhibits the least available undercut bank cover type with 1.5 percent of the total available.

Emergent vegetation (that vegetation type that grows below the waters surface and extends above the surface of the water) and debris/deadfall cover types are also important to rearing juvenile chinook salmon. Field survey results indicate that study reach 3 contains the greatest amount of emergent vegetation of all the study reaches with 34.7 of the total of this cover type available. Study reach 1 is second with 21.5 percent followed by reach 2 with 18.5 percent. Reach 5 is fourth with 15.0 percent of this cover type and lastly reach 4 contains only 10.3 percent of this cover type found within the study boundaries.

Debris and deadfall accounts for only 6.3 percent of the total cover available to nearshore rearing fish. Study reach 5 contained the greatest amount of debris observed during the field survey with 58.8 percent of the total followed by reach 4 with 14.2 percent. Reach 2 was ranked third with 14.1 percent followed by reach 3 with 10 .5 percent. Reach 1 was last with 2.5 percent debris and deadfall present.

Aquatic vegetation (that vegetation which at or below the river's water surface) was the least available cover type observed with only 3,860 feet of this cover type noted, it represents on 0.3 percent of the cover available for rearing juvenile salmon.

FIG. 20 KENAI RIVER FISH COVER
BY REACH

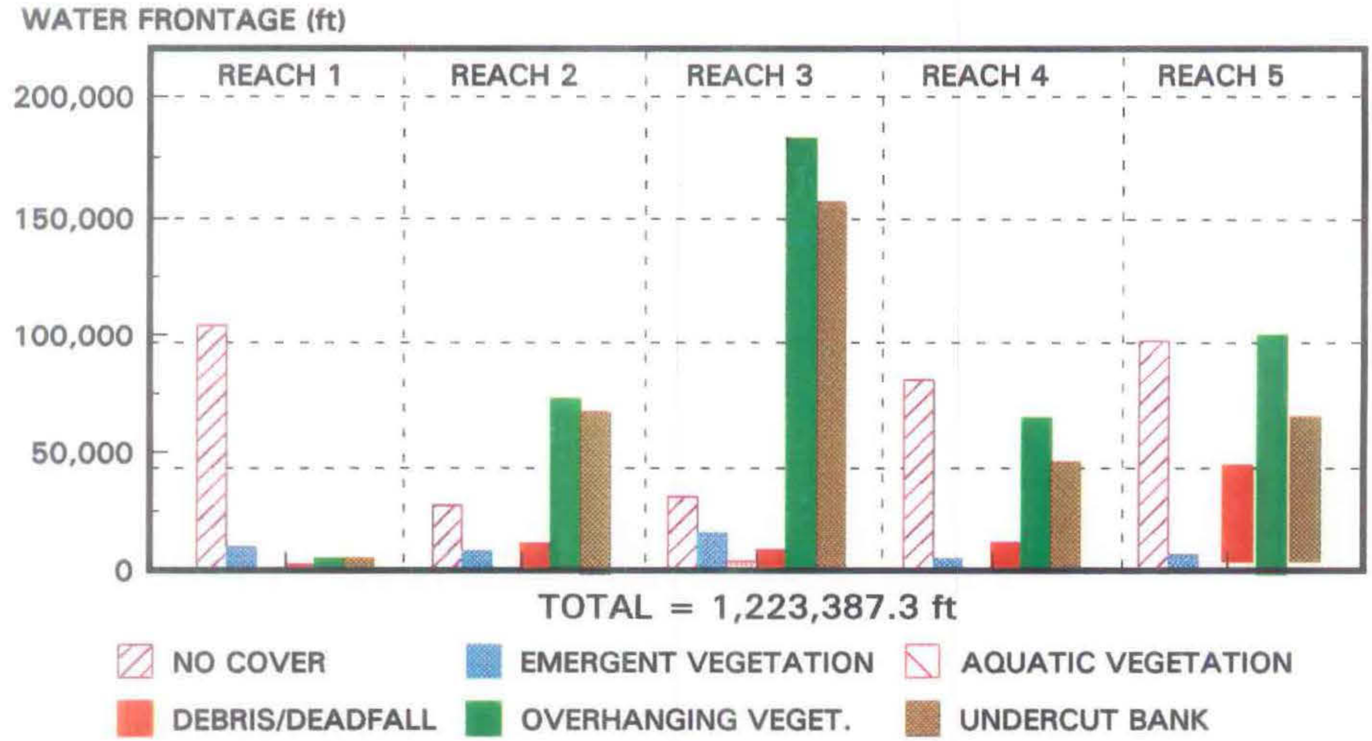
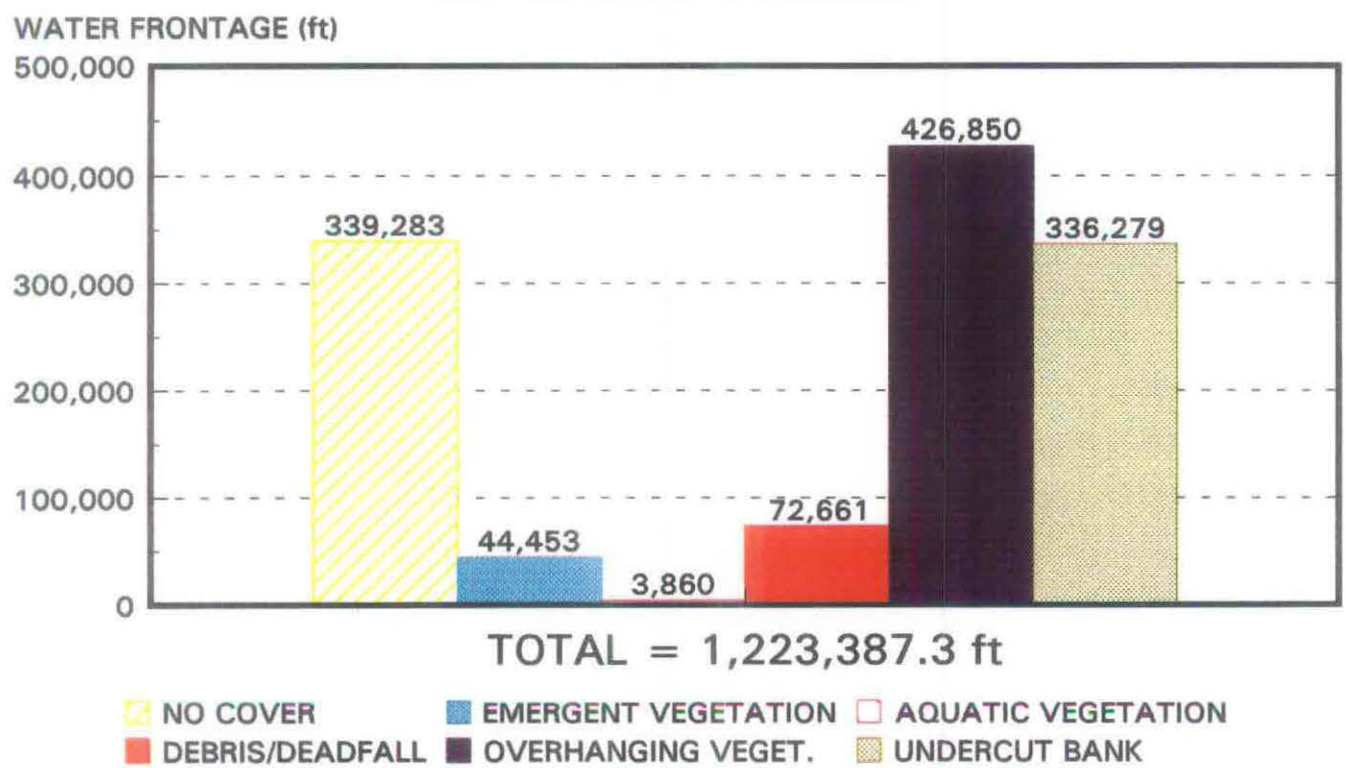


FIG. 21 KENAI RIVER FISH COVER
ALL REACHES COMBINED



B. HABITAT EVALUATION PROCEDURE (HEP) ANALYSIS RESULTS

Table 14 outlines the results of the HEP application to the Kenai River's 1993 current natural and developed habitat components.

The HEP analysis process was used to quantify the amount of available habitat for juvenile chinook salmon which serve as an indicator species for the river. The results of this analysis indicates in 1993, there was a total of 1,489,972 HU's available to rearing juvenile salmon along the entire river waterfront. Table 14 breaks this down into those reaches that are undeveloped (without any structures or habitat alteration) and the developed reaches. Within the entire river's undeveloped waterfront length there was 1,416,783 HU's available for rearing juvenile fish. This compares to 73,189 HU's of available habitat in the waterfront that has been altered by bank development or inwater structures.

By delineating the areas of altered water frontages in correlation to the habitat characteristics that were present before the development was introduced (comparing the developed site to the undeveloped conditions immediately upstream and downstream of the site) we can determine what the total HU's were previous to the man-made alterations. A comparison of this HU value to the existing HU value signifies the net change (gain or loss) of habitat value resulting from the cumulative impacts identified.

This comparison indicates that the Kenai River, without human-induced habitat alteration, provided 1,523,144 HU's for rearing juvenile salmon. Therefore, development of structures and associated bank impacts have resulted in a net loss of 33,172 habitat units (See Table 15).

C. DEVELOPMENT TRENDS ANALYSIS

The analysis of existing conditions observed in and along the Kenai River mainstem provides a summary of developmental impacts which is limited in scope to a single time period. To effectively use the information developed in this study, an analysis of the degree of change of natural conditions over time on the river is essential. To effect this analysis, the ADF&G, in partnership with the FWS, completed an assessment of the extent of development which affected the Kenai River mainstem in 1963/64 using aerial photograph interpretation techniques.

The ADF&G acquired low altitude stereo pair aerial photography of the study area dating from 1963 through 1992. Photography for the entire Kenai River study corridor (RM 0 to 50 and 65 to 82), was obtained at varying scales in black and white, color and color-infrared coverages. Appendix B lists the aerial photography which the ADF&G has acquired. This development trends analysis made use the existing 1993/94 Kenai River 309 project database as a point of reference to compare the change over time in riparian vegetation and structural development along the entire length of river mainstem.

A Development Trends Analysis was completed to provide important insight into the rate at which this habitat loss has been occurring on the Kenai River. This analysis used aerial photograph interpretation of development conditions that existed within and adjacent to the river in 1963/64 and compares those conditions to the documented development scenario observed during the 1993 Kenai River 309 field surveys. Such an analysis can be used not only to determine how much development has taken place over the last 30 years, but can also be used as an interpretive tool to extrapolate future development scenarios and estimate the level of additional impact and habitat change (loss or gain) that can be anticipated in the future.

Using the GIS system, the ADF&G developed mylar overlays of the property ownership land use patterns that correlated to the varying scales of the 1963 and 1964 aerial photo coverage of the Kenai River mainstem. This allowed for a direct visual comparison of the amount of development affecting the river shoreline and nearshore habitat over a 30 year time period. The ADF&G, with assistance from the FWS used stereo scopes to interpret the photos which allowed for a resolution of up to two feet. All manmade alterations observed through the scopes were identified and measured.

The final results indicate that over 76 percent of the modified banks and structures that were observed in the field surveys in 1993 and 94 have been introduced since 1963/64. The vast majority of these changes include the large increase in bank stabilization efforts and the construction of boat docks and groins or jetties.

VI. METHODOLOGY EVALUATION AND FUTURE STUDY RECOMMENDATIONS

A. CUMULATIVE IMPACT ASSESSMENT METHODOLOGY ANALYSIS

The Kenai River cumulative impact assessment approach used a multiple analysis approach involving: 1) the development of baseline fish habitat conditions correlated to individual land ownership patterns; 2) the development of a fish habitat classification scheme for assessment purposes, 3) the selection and application of a qualitative fish habitat value model (i.e. HEP) procedure, 4) a development trends analysis using aerial photograph imagery that spanned a 30 year time period between 1963/64 and 1993/94.

Baseline habitat conditions were identified and mapped through a field survey of the entire 67 miles of Kenai River mainstem. The habitat conditions identified were subjected to an analysis of fish habitat quality using the FWS developed HEP procedures which compares the observed habitat conditions to those conditions which are considered to be optimal for the species evaluated. Each individual study segment (in this case each individually owned parcel of land adjacent to the river) is then described in terms of HU's available for the study indicator species (juvenile chinook salmon in the case of this analysis). With the identification of fish habitat value for each segment, an analysis of the entire river mainstem could be accomplished yielding a cumulative impact assessment of activities affecting the fish habitat conditions within the river mainstem.

By comparing the observed habitat conditions and computing the HU's currently available in the river to the habitat conditions that were present in 1963/64 using low level aerial photograph interpretation, an understanding of the rate at which habitat alteration has been occurring over time can be obtained.

Further, with the development of the database and GIS mapped information resulting from this analysis, it is possible to model future changes in habitat characteristics that either do occur or are likely to occur and obtain an estimate of habitat value increases or losses associated with the development(s) before being constructed in a planning context or after the fact once the development project or land use is in place.

This kind of analysis allows for an assessment of habitat altering activities on a cumulative impacts basis rather than on a individual project-by-project basis. Knowing what the available HU's are for a given parcel or location prior to a proposed project or alteration allows for the modeling of the proposed action and an evaluation of the degree of change in HU's that would occur as a result of the activity. Also knowing the amount of available HU's for the entire river system allows for an assessment of the overall impact of an activity to the river system as a whole.

The application of this type of analysis not only allows for the natural resources managers to make a decision to approve or deny an activity based upon the level of impact that would occur as a result of action, it would also allow for an comparison evaluation of alternatives to the proposed action and for the identification of mitigative measures necessary to offset or compensate for the unavoidable losses associated with the activity.

An important strength of this type of impact analysis is the ability for non-technical persons to better grasp the big picture of what an individual project or activity can do to the river system as a whole. By comparing HU changes that result from a proposed project, the degree of habitat impact can be defined. This should be a significant aid in helping individuals that propose a project or activity to understand why that activity is denied or modified during the permitting process. It will also help explain to project proponents how to avoid or minimize project-related impacts with a project redesign or the use of an alternative that reduces the identified impact. This assessment process can also be used as a tool to define those actions that improve the habitat quality or availability.

The Kenai River Cumulative Impact Assessment process can be readily used by inexperienced personnel with a minimum of training in the application of the HEP procedures and the existing software systems developed by the FWS.

Currently the GIS systems that can be used to map and store the graphics data associated with this impact assessment method tend to be expensive making it unlikely an individual project analysis would justify the acquisition of a GIS. However, as with other state-of-the-art assessment and management tools, the GIS systems are not only improving in quality and function capability (i.e. increased processing speed and data storage abilities), they are becoming less costly.

One potential weakness in the methodology used in this cumulative impact analysis would be in the high level of baseline data development and ground truthing of the database required to initially define the habitat characteristics of study area. The need for accuracy in the definition of the habitat categories used to complete the HEP analysis is a major cost to the development of this methodology. This cost can be minimized through the use of high quality aerial photography/videography or satellite imagery. This remote sensing information is becoming more readily available and with limited spot checking or ground truthing of the photo interpretation, habitat classification costs can be significantly reduced.

We believe this cumulative impact assessment process applied in the Kenai River 309 project is applicable to other similar riverine systems. Most other drainages within Alaska would likely be less time consuming to evaluate in as much as there has been much less development pressure in other Alaskan river drainages than that which has already occurred in the Kenai River to date. Most other Alaskan river systems have also not been subdivided into as many small (100 foot) parcels as the Kenai River's riparian areas. Even so, the ability of aerial photograph and videography resolution can allow for detailed habitat classification of these small parcel sizes.

A second concern would be the reliability of the use of an individual or group of indicator species and the development of suitability curves for that species for the specific system being evaluated. Given the wide variety of habitats that occur within a state as large as Alaska and the ability of a species to adapt to the unique habitat conditions that might occur in a system, it would be necessary to determine that existing suitability curves for that species are in fact applicable to the specific system being assessed, or if new suitability curves would have to be generated for that system.

One of the benefits to the impact assessment approach used in this study is that it is a habitat-based assessment which evaluates the actual or potential end result of an action as it affects the pre-existing habitat condition(s) which can occur as the result of the initial or primary activity or a spin-off effect such as a secondary impact affect. It can also effectively quantify the cumulative impact of multiple actions affecting a specific system. For example, this methodology can be used to quantify the effects of the construction of a boat launch at a given site based upon pre-project conditions. It can also quantify the effects of secondary uses such as habitat alterations in the vicinity of the project associated with the other uses that may occur as result of the initial project or action such as bank trampling associated with fisherman access provided by the launch installation. It can also assess habitat change related to bank scour or erosion (or lack thereof) associated with mooring boats either temporarily or long term and depending on the measures taken to either protect or not protect the bank associated with the launch and the effects of accessing the moored boats.

Measuring the effects of indirect impacts is a more difficult effort. For instance, given the above example of the installation of a new boat launch, the methodology used in this study is not designed to assess the impacts of a large increase in boating traffic as it affects the recreational values on a given segment of river frequented by boats from that boat launch (i.e. what is the effect on salmon stocks or escapement resulting from the harvest of fish from these boats, or what is the aesthetic effect of a ten fold increase in boating traffic on a given segment of the river). Nor does this methodology provide for the ability to assess the effects of increased pollutants, albeit petroleum products, noise levels or garbage tossed or lost overboard or left onshore from the boats occupants that are contributed to the river by the increase in boat traffic resulting from this boat launch project. The intrinsic values of a natural system do not lend themselves to any type of justifiable assessment process due to the many variables and different opinions and feelings held for such values.

The developed impact assessment methodology has application to other riverine systems within and outside the State of Alaska. As mentioned above, given the application of existing or with the development of specific species suitability curves the combination HEP/GIS assessment methodology could be used to evaluate habitat changes on any given system. In fact, the FWS has already proposed the application of and solicited funding to use this impact assessment approach on several heavily used recreational fishing streams within the road accessible areas of Southcentral Alaska (Larry Dugan, pers. comm.)

The HEP analysis, which is a substantial part of this cumulative impact assessment methodology, has been developed with a variety of species specific suitability curves including avian, mammal and fish species, that can be used to quantify habitat loss related, not only to aquatic habitats but to wetland habitats as well. The Kenai River Cumulative Impact Assessment approach would certainly be applicable to evaluating the effects of cumulative impacts on wetland habitats within and outside of Alaska.

In reviewing the development and application of this impact assessment methodology, I would recommend that, for large scale drainage basin applications at least, a joint agency approach be used especially to accomplish the field survey and ground-truthing portion of this assessment process. This can help reduce costs to any one agency or group completing the assessment and lends credibility to the overall study results through the benefits of interagency cooperation and the sharing of technical and local biological expertise. Without interagency cooperation, the Kenai River 309 project database, using available funding, would not have been possible.

B. FUTURE STUDY RECOMMENDATIONS/VERIFICATION OF THE HEP MODEL PROCESS RESULTS

In order to ascertain the degree of reliability in the modeling techniques used to assign fish habitat values to the natural conditions and man-made alterations of the Kenai River shoreline, additional data acquisition and analysis of velocity, substrate, and cover conditions for a larger sample of the river is necessary. The ADF&G has received additional funding from the Office of Oceans and Coastal Resource Management to conduct field verification analysis of the HEP results based on this initial study effort. In addition, the ADF&G is cooperating with the United States Geological Services to complete a detailed hydraulic evaluation of the variety of structures identified in this report. This information will be used to verify or, if appropriate, modify the habitat assessment values (Habitat Units - HU's) that are included in this draft report.

Additional analysis of the Kenai River that would assist in the fine tuning of this impact assessment method would include:

1. The Kenai River Cumulative Impact Assessment project was limited to the 67 miles of river mainstem due primarily to the amount of available funds and time limits for the study. This project would benefit from an application of the developed methodology to the Kenai River's tributary streams which provide additional spawning and rearing habitat and seasonal use to the variety of fish species using the Kenai River. This would provide a drainage wide perspective of the importance of these contributors to the overall system. In addition, the development of additional layers of impact assessment concerns such as the hydraulic effects listed above and the important spawning areas within the river mainstem could be incorporated into the impact assessment analysis. Additional indicator species such as the coho and sockeye salmon or other wildlife species could also be evaluated and compared to the results published in this report which used the chinook salmon as the important indicator specie.

2. The development of a shoreline erosion assessment related to wave action generated by boat wake activity is needed. While there is a considerable level of natural erosion occurring in certain reaches of the Kenai River, this natural action is believed to be significantly increased by human induced wave generated erosion forces caused by the large number of boats using the river. It is also an unknown if certain types of boats or boat handling methods serve to increase or reduce wake action affecting the river's banks. An analysis of those river segments which have already been subjected to motorized boat restrictions for biological reasons, including an analysis of historical aerial photographs and the

development and monitoring of boat generated wave attenuation structures would provide meaningful information that could assist management agencies in addressing methods to avoid or reduce this fish habitat impact.

3. The cumulative impact assessment process would also greatly benefit from an analysis of the level of littoral drift of food organisms occurring within the river mainstem. With an understanding of the naturally occurring food transport system at work in the river, the effects of riparian and nearshore habitat alteration and development on the availability of food for rearing fish could be evaluated.

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APPENDICES

APPENDIX A

TABLES

TABLE 1

FISH COVER TYPES AND SUBSTRATE CATEGORIES WITHIN THE KENAI RIVER

COVER AND SUBSTRATE TYPE	CODE
COVER TYPE	
No Object Cover	COV-NC
Emergent Vegetation	COV-EV
Aquatic Vegetation	COV-AV
Debris or Deadfall	COV-DD
Overhanging Riparian Vegetation	COV-OV
Undercut Banks	COV-UB
SUBSTRATE CATEGORIES	
Mud, Silt or Sand (0" to 0.25")	SUB_M
Gravel (0.25" to 3" diameter)	SUB_G
Cobble (3" to 5" diameter)	SUB_C
Rubble (5" or greater in diameter)	SUB_R

TABLE 2
(Code Key)

PROPERTY OWNERSHIP CODE DEFINITIONS

CODE LAND OWNERSHIP	CODE LAND OWNERSHIP
RSU - Residential, Undeveloped	**NCU** - Native Land, CIRI, Undeveloped
RSD - Residential, Developed	**NCD** - Native Land, CIRI, Developed
COU - Commercial, Undeveloped	**NSU** - Native Land, Salamatof Corp., Undeveloped
COD - Commercial, Developed	**NSD** - Native Land, Salamatof Corp., Developed
FBU - Federal Bureau of Land Management, Undeveloped	**KBU** - Kenai Peninsula Borough, Undeveloped
FBD - Federal Bureau of Land Management, Developed	**KBD** - Kenai Peninsula Borough, Developed
FSU - Federal Forest Service Lands, Undeveloped	**CSU** - City of Soldotna, Undeveloped
FSD - Federal Forest Service Lands, Developed	**CSD** - City of Soldotna, Developed
FWU - Federal Fish and Wildlife Service, Undeveloped	**CKU** - City of Kenai, Undeveloped
FWD - Federal Fish and Wildlife Service, Developed	**CKD** - City of Kenai, Developed
SPU - State Parks and Outdoor Recreation, Undeveloped	**UAU** - Univeresity of Alaska, Undeveloped
SPD - State Parks and Outdoor Recreation, Developed	**UAD** - University of Alaska, Developed
SOU - State Division of Lands, Undeveloped	**OTH** - Other (Church of Kenai)
SOD - State Division of Lands, Developed	

TABLE 2

LAND OWNERSHIP, DEVELOPMENT STATUS AND WATERFRONTAGES BY STUDY REACH

OWNER CODE	STUDY REACH 1			STUDY REACH 2			STUDY REACH 3		
	OWNER COUNT	WATER FRONTAGE	% OF ZONE	OWNER COUNT	WATER FRONTAGE	% OF ZONE	OWNER COUNT	WATER FRONTAGE	% OF ZONE
CKD	6	3302.8	2.9	0	0	0	0	0	0
CKU	19	66026.9	57.9	2	4980.3	4.3	0	0	0
COD	8	5129.6	4.5	25	14836.1	12.8	30	8230.2	3.4
COU	0	0	0	0	0	0	6	3199.6	1.3
CSD	0	0	0	0	0	0	4	5909.5	2.4
CSU	0	0	0	0	0	0	12	10980.6	4.5
FBD	0	0	0	0	0	0	0	0	0
FBU	0	0	0	0	0	0	0	0	0
FSD	0	0	0	0	0	0	0	0	0
FSU	0	0	0	0	0	0	0	0	0
FWD	0	0	0	0	0	0	0	0	0
FWU	0	0	0	0	0	0	0	0	0
KBD	0	0	0	0	0	0	0	0	0
KBU	0	0	0	2	68.0	0.1	3	2996.2	1.2
NCU	0	0	0	3	3725.0	3.2	1	6262.1	2.6
NSD	0	0	0	0	0	0	4	1022.6	0.4
NSU	0	0	0	0	0	0	52	27949.7	11.5
OTH	1	140.0	0.1	0	0	0	0	0	0
RSD	35	7851.0	6.9	91	14613.0	12.6	397	67571.6	27.9
RSU	59	14215.0	12.5	84	17166.3	14.8	432	72543.1	30.1
SOD	0	0	0	1	600.0	0.5	6	5146.2	2.1
SOU	4	17325.0	15.2	20	53095.8	45.9	14	23293.1	9.6
SPD	0	0	0	2	2775.0	2.4	3	4383.8	1.8
SPU	0	0	0	2	3836.1	3.4	1	1273.6	0.5
UAU	0	0	0	0	0	0	1	1350.0	0.7
TOTAL	132	113,990.3	101.0	232	115,695.6	100.0	966	242,111.9	100.0

TABLE 2 (Continued)

LAND OWNERSHIP, DEVELOPMENT STATUS AND WATER FRONTAGE BY STUDY REACH

OWNER CODE	STUDY REACH 4			STUDY REACH 5			TOTAL KENAI RIVER		
	OWNER COUNT	WATER FRONTAGE	% OF REACH	OWNER COUNT	WATER FRONTAGE	% OF REACH	OWNER COUNT	WATER FRONTAGE	% OF TOTAL
CKD	0	0	0	0	0	0	6	3302.8	0.4
CKU	0	0	0	1	746.1	0.3	22	71753.3	8.2
COD	4	624.4	0.4	5	3298.2	1.3	72	32118.5	3.7
COU	0	0	0	0	0	0	6	3199.6	0.4
CSD	0	0	0	0	0	0	4	5909.5	0.8
CSU	0	0	0	0	0	0	12	10980.6	1.3
FBD	0	0	0	1	2917.3	1.2	1	2917.3	0.3
FBU	0	0	0	1	1265.8	0.5	1	1265.8	0.1
FSD	0	0	0	3	15170.6	6.1	3	15170.6	1.7
FSU	0	0	0	8	36065.3	14.5	8	36065.3	4.1
FWD	9	910.0	0.6	3	10299.9	4.2	12	11209.9	1.3
FWU	21	60863.7	38.7	24	141587.1	57.1	45	202450.8	23.1
KBD	0	0	0	1	450.6	0.2	1	450.6	0.1
KBU	2	330.5	0.2	1	148.8	0.1	8	3543.5	0.4
NCU	36	29072.2	18.5	0	0	0	40	39059.3	4.4
NSD	0	0	0	0	0	0	4	1022.6	0.1
NSU	0	0	0	0	0	0	52	27949.7	3.2
OTH	0	0	0	0	0	0	1	140.0	0.1
RSD	136	28208.4	18.0	40	7704.6	3.1	699	125948.6	14.3
RSU	69	13420.9	8.5	13	1672.4	0.7	657	119017.7	13.5
SOD	27	6909.3	4.4	12	11126.7	4.5	46	23782.2	2.6
SOU	34	10523.8	6.7	13	15690.4	6.2	85	119928.1	13.6
SPD	0	0	0	0	0	0	5	7158.8	0.8
SPU	16	6269.4	4.0	0	0	0	19	11379.1	1.3
UAU	0	0	0	0	0	0	1	1350.0	0.2
TOTAL	354	157,132.6	100.0	126	248,143.8	100.0	1,810	877,074.2	100.0

TABLE 3
(Code Key)

KENAI RIVER STRUCTURES DATABASE CODES

Structure Code	Structure/Activity
Buoys - B	
BMO	Mooring
BSN	Set Net
BNM	Navigation or Marker
Docks - D	
DPP	Public Permanent Pile Supported
DTP	Public Temporary Pile Supported
DPF	Public Permanent Floating
DTF	Public Temporary Floating
DCP	Commercial Permanent Pile Supported
DCT	Commercial Temporary Pile Supported
DCF	Commercial Permanent Floating
DCS	Commercial Seasonal Floating
DIP	Private/Individual Permanent Pile Supported
DIT	Private/Individual Temporary Pile Supported
DIF	Private/Individual Permanent Floating
DIS	Private Individual Temporary Seasonal Floating
DCL	Dock, Cantilevered
DOT	Dock, Other (describe)
CST	Deck, Cantilevered
Piling - P	
PSS	Piling Structure/Pile Supported Structure
PSD	Pile Supported Deck
PSB	Pile Supported Boat House
PDW	Pile Supported Boardwalk
SDL	Piling, Mooring/Dolphin
Launches - L	
LPI	Public Improved Boat Launch
LPU	Public Unimproved Boat Launch
LCI	Commercial Improved Boat Launch
LCU	Commercial Unimproved Boat Launch
LII	PVT/Individual Improved Boat Launch
LIU	PVT/Individual Unimproved Boat Launch
CMP	Campsite Bank Damage
CNL	Canals
VSC	Vessel Bank Scour/Scars
VSP	Vessel Slips
VSN	Vessel Basins
LDR	Bank Ladder/Stairway

Structure Code	Structure/Activity
Outfalls - O	
OSW	Stormwater Outfall
OSR	Sewer Outfall
OSP	Seafood Processing Waste Outfall
OFT	Fish Cleaning Table Outfall
Bank Stabilization - S	
SLG	Logs
STB	Timbers
SCT	Cabled Trees
SCR	Concrete Rubble
SSP	Sheet Piling
SLM	Landing Mat
SCB	Concrete Block
SRM	Rock Mortar
SPE	Pipe
SCF	Chain-Link Fence
STR	Tires
SMC	Caskets
SGB	Gabions
SRR	Rock Rip-Rap
SBE	Soil Bioengineering
SOT	Other (Describe)
BRL	Barrels/55 Gallon Drums
BRG	Bridge/Right-of-Way
BDW	Boardwalk
Ford - F	
FSU	Seasonal Use Only Ford
FYR	Year Around Use Ford
FWS	Fishwheel Site
SRF	Sonar Facility
WLF	Wetlands Fill
UFL	Uplands Fill
Mining - M	
MRD	Recreational Placer Mining, Dredging
MCD	Commercial Placer Mining, Dredging
MCP	Commercial Placer Mining, Other Means
RMP	Pedestrian Access Ramp/Catwalk
OTH	Other (Describe)
JTY	Jetties/Groins

TABLE 3

DEVELOPMENT/ACCESS STRUCTURES INVENTORY BY STUDY REACH

STUDY REACH 1

RIVER MILE 0.0 - 10.0

(NOTE : TOTAL AREA = SUM OF THE AREA FOR EACH STRUCTURE IN COUNT)

STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
1	BMO	40	82	82	172
1	BNM	1	20	10	200
1	BRL	1	3	2	6
1	DCF	2	240	44	5280
1	DCP	9	699	1026	76194
1	DCS	7	997	153	10542
1	DIF	1	40	10	400
1	DPF	1	10	175	1750
1	DPP	1	168	37	6216
1	LCI	4	116	327	8151
1	LDR	8	29	429	1346
1	LPI	2	40	400	8000
1	LPU	2	95	60	1750
1	OSP	9	21	1339	2944
1	OSR	1	3	200	600
1	OSW	3	7	220	460
1	OTH	3	12	12	48
1	PDW	4	193	384	2670
1	PSS	1	20	203	4060
1	RMP	2	66	73	600
1	SCB	4	119	64	1116
1	SCF	3	202	136	1330
1	SCR	5	265	87	4240
1	SCT	1	300	10	3000
1	SDL	9	50	50	300
1	SGB	2	480	137	59130
1	SLG	6	205	18	770

TABLE 3 Continued					
STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
1	SLM	3	48	6	96
1	SPE	2	280	8	1120
1	SRF	1	15	20	300
1	SRR	1	30	5	150
1	SSP	7	1506	254	67178
1	STB	7	1360	117	6953
1	STR	2	18	4	36
1	UFL	8	2005	1117	408200
	TOTAL	163	9,744	7,219	685,308

TABLE 4

DEVELOPMENT/ACCESS STRUCTURES INVENTORY BY STUDY REACH

STUDY REACH 2

RIVER MILE 10.0 - 17.5
(NOTE : TOTAL AREA = SUM OF AREAS FOR EACH STRUCTURE IN COUNT)

REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
2	BDW	3	129	20	540
2	BMO	4	6	6	10
2	BRG	1	4	35	140
2	BRL	7	177	23	561
2	CMP	1	35	12	420
2	CNL	1	750	38	28500
2	CST	4	90	68	1695
2	DCL	4	12	50	150
2	DCP	1	8	6	48
2	DCS	4	54	30	388
2	DIF	1	12	10	120
2	DIP	4	32	25	173
2	DIS	5	119	26	540
2	DIT	1	2	3	6
2	DOT	1	20	3	60
2	DTF	2	21	11	113
2	FEN	3	3	250	250
2	JTY	8	90	122	1754
2	LCI	8	223	401	15254
2	LCU	4	143	153	5899
2	LDR	95	297	1219	3796
2	LII	3	55	99	1785
2	LIU	8	151	240	5050
2	LPU	1	30	15	450
2	OFT	55	190	525	11114
2	OSR	1	1	15	15
2	OSW	1	2	100	200
2	OTH	1	200	1	200

TABLE 4 Continued					
REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
2	PDW	9	389	243	1837
2	PSD	17	280	235	4561
2	PSS	1	4	1	4
2	RMP	14	55	184	735
2	SBE	2	279	12	1674
2	SCB	6	156	23	535
2	SCR	1	15	3	45
2	SCT	14	820	45	4715
2	SGB	2	12	7	44
2	SLG	6	320	59	3790
2	SLM	3	51	32	846
2	SOT	7	457	242	8710
2	SRR	41	4482	316	34988
2	SSP	1	10	30	300
2	STB	12	191	107	1550
2	STR	14	236	52	990
2	UFL	4	105	58	1480
2	VSC	49	906	274	5497
2	VSN	3	192	850	49000
2	VSP	3	145	95	4000
	TOTAL	441	11,961	6,374	194,532

TABLE 5

DEVELOPMENT/ACCESS STRUCTURES INVENTORY BY STUDY REACH

STUDY REACH 3

RIVER MILE 17.5 - 39.0
(NOTE : TOTAL AREA = SUM OF AREAS FOR EACH STRUCTURE IN COUNT)

STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
3	BDW	19	856	188	2844
3	BMO	2	3	2	3
3	BRL	3	30	12	72
3	CMP	5	1501	28	7393
3	CST	10	233	135	3348
3	DCF	1	30	6	180
3	DCL	9	113	96	1176
3	DCP	5	133	60	1852
3	DCS	1	3	8	24
3	DIF	2	28	10	128
3	DIP	31	453	204	2494
3	DIS	14	165	84	975
3	DTF	1	12	4	48
3	FEN	6	6	455	455
3	FWS	2	45	20	500
3	JTY	68	1012	1646	32085
3	LCI	2	55	32	1066
3	LCU	1	40	60	2400
3	LDR	122	470	3984	15223
3	LII	4	106	152	4336
3	LIU	30	625	1377	27860
3	LPI	5	106	257	6266

TABLE 5 Continued					
STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
3	LPU	3	62	86	1822
3	OFT	68	217	395	936
3	OSW	3	4	1903	3503
3	OTH	6	1048	645	205655
3	PDW	24	2083	122	7388
3	PSB	1	12	12	144
3	PSD	61	971	626	11880
3	PSS	8	78	64	1196
3	RMP	13	60	166	673
3	SCB	6	161	22	598
3	SCR	3	26	37	310
3	SCT	5	215	25	1262
3	SGB	4	93	12	336
3	SLG	12	272	73	1384
3	SLM	2	30	46	900
3	SOT	7	122	51	875
3	SPE	1	15	1	15
3	SRM	5	126	30	483
3	SRR	58	3408	425	25837
3	SSP	1	4	36	144
3	STB	17	848	179	9368
3	STR	7	125	23	356
3	UFL	2	32	12	208
3	VSC	134	2090	587	9193
3	VSN	6	364	526	34402
3	VSP	11	194	174	3424
	TOTAL	811	18,685	15,098	433,020

TABLE 6

DEVELOPMENT/ACCESS STRUCTURES INVENTORY BY STUDY REACH

STUDY REACH 4

RIVER MILE 39.5 - 50.0

(NOTE : TOTAL AREA = SUM OF AREAS FOR EACH STRUCTURE IN COUNT)

STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
4	BDW	9	33	280	974
4	BMO	3	3	3	3
4	BRG	1	15	3	45
4	CMP	13	525	373	9460
4	CST	4	30	33	261
4	DCS	5	44	35	236
4	DIF	15	225	112	1414
4	DIP	7	93	66	723
4	DIS	17	241	206	2752
4	JTY	2	5	12	30
4	LCU	2	26	62	1072
4	LDR	39	155	928	3359
4	LII	3	42	80	1140
4	LIU	16	257	517	9214
4	OFT	22	55	89	206
4	OSR	1	1	75	75
4	PDW	10	190	202	1423
4	PSB	1	20	30	600
4	PSD	6	98	51	752
4	PSS	2	15	12	80
4	RMP	19	85	251	1052

TABLE 6 Continued					
STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
4	SBE	1	110	20	2200
4	SCB	3	126	8	256
4	SCF	1	300	8	2400
4	SCT	26	2389	147	15965
4	SGB	1	100	6	600
4	SLG	7	212	44	1262
4	SLM	5	283	15	979
4	SMC	1	31	10	310
4	SOT	9	1028	59	7690
4	SPE	1	20	1	20
4	SRR	27	2092	193	15811
4	STB	11	746	25	1281
4	STR	11	62	30	184
4	VSC	34	507	212	3205
4	VSN	3	95	210	6400
4	VSP	6	111	139	3141
4	WLF	1	50	20	1000
	TOTAL	345	10,420	4,567	97,575

TABLE 7

DEVELOPMENT/ACCESS STRUCTURES INVENTORY BY STUDY REACH

STUDY REACH 5

RIVER MILE 65.0 - 82.0

(NOTE : TOTAL AREA = SUM OF AREAS FOR EACH STRUCTURE IN COUNT)

STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
5	BDW	3	7	62	154
5	BRG	2	78	525	20450
5	CMP	5	2863	123	134041
5	DIF	6	112	123	1382
5	DIP	4	36	47	436
5	DIS	1	10	3	30
5	JTY	2	45	43	1245
5	LCU	3	78	75	1770
5	LDR	5	19	93	348
5	LIU	3	45	46	870
5	LPU	2	50	175	4375
5	OFT	1	1	16	16
5	OSR	2	2	85	85
5	OSW	3	7	150	350
5	OTH	3	23	262	987
5	PDW	7	56	148	617
5	PSD	7	102	64	920
5	PSS	6	42	31	248
5	RMP	8	34	141	580
5	SCB	1	6	3	18

TABLE 7 Continued					
STUDY REACH #	STRUCTURE CODE	STRUCTURE COUNT	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA (SQ. FT.)
5	SCR	2	36	36	720
5	SLG	2	133	6	585
5	SLM	3	74	11	312
5	SOT	1	10	10	100
5	SRR	20	8351	339	220604
5	SSP	1	75	2	150
5	STB	1	12	1	12
5	STR	2	26	9	110
5	UFL	1	125	25	3125
5	VSC	2	31	7	105
	TOTAL	109	12,489	2,661	394,745

TABLE 8

DEVELOPMENT/ACCESS STRUCTURES INVENTORY BY STUDY REACH

TOTAL FOR ALL FIVE STUDY REACHES

RIVER MILE 0.0 - 82.0

(NOTE : TOTAL AREA = SUM OF AREAS FOR EACH STRUCTURE IN COUNT)

STUDY REACH #	STRUCTURE COUNT	% OF TOTAL STRUCTURES	TOTAL LENGTHS (FEET)	TOTAL WIDTHS (FEET)	TOTAL AREA COVERED BY ALL STRUCTURES (SQ. FT.)	% OF TOTAL AREA COVERED
1	163	8.7	9,744	7,219	685,308	38.0
2	441	23.6	11,961	6,374	194,532	10.8
3	811	43.4	18,685	15,098	433,020	24.0
4	345	18.5	10,420	4,567	97,575	5.4
5	109	5.8	12,489	2,661	394,745	21.8
TOTAL	1,869	100.0	63,299	35,919	1,805,180	100.0

TABLE 9

PERCENTAGE OF TOTAL WATERFRONT AFFECTED BY STRUCTURES AND/OR BANK TRAMPLING

RIVER MILE 0.0 - 82.0

STUDY REACH #	STRUCTURE COUNT	% OF TOTAL STRUCTURES	TOTAL WATERFRONT LENGTHS (FEET)	% OF WATERFRONT COVERED BY STRUCTURES (FEET) (%)	% OF BANK TRAMPELED AT OHW AND TOB OHW (FEET) (%)	TOB (FEET) (%)	% OF STUDY REACH WATERFRONT IMPACTED BY STRUCTURES OR ACCESS OHW (FEET) (%)	TOB (FEET) (%)
1	163	8.7	113,990.3	9,744 8.55	1,990.4 1.75	4,149.4 3.64	11,734.4 10.29	13,893.4 12.19
2	441	23.6	115,695.6	11,961 10.34	2,697.0 2.33	7,261.7 6.28	14,658.0 12.67	19,222.7 16.62
3	811	43.5	242,111.9	18,685 7.72	9,696.3 4.00	14,187.0 5.86	28,381.3 11.72	32,872.0 13.58
4	345	18.5	157,132.6	10,420 6.63	5,426.7 3.45	3,809.6 2.42	15,846.7 10.08	14,229.6 9.06
5	109	5.7	248,148.8	12,489 3.83	14,419.7 5.81	16,539.2 6.67	26,908.7 10.84	29,028.2 11.70
TOTAL	1,869	100.0	877,074.2	63,299 6.89	34,230.1 3.90	45,946.9 5.24	97,529.1 11.12	109,245.9 12.46

TABLE 10

TRAMPLED VERSUS NATURALLY NON-VEGETATED RIVERBANK

AT ORDINARY HIGH WATER AND TOP OF RIVER BANK

STUDY REACH #	RIVER BANK SITE	REACH WATER-FRONTAGE (FEET)	TOTAL NO VEG. COVER (FEET)	NATURAL NO VEG. COVER (FEET)	% OF TOTAL NO VEG. COVER	% REACH WATER FRONT	TRAMPLED NO VEG. COVER (FEET)	% OF TOTAL NO VEG. COVER	% OF REACH WATER FRONT
1	OHW	113990.3	91376.4	89244.7	97.68	78.29	2131.7	2.33	1.87
1	TOB	113990.3	35593.6	31380.4	88.16	27.53	4213.2	11.84	3.70
2	OHW	115695.6	31737.1	28309.1	89.20	24.47	3428.0	10.80	2.96
2	TOB	115695.6	13419.0	5834.1	43.48	5.04	7584.9	56.52	6.56
3	OHW	242111.9	41480.0	33384.0	80.48	13.79	8096.0	19.52	3.34
3	TOB	242111.9	30974.6	18621.9	60.12	7.69	12352.7	39.88	5.10
4	OHW	157132.6	48076.2	42374.0	88.14	26.97	5702.2	11.86	3.63
4	TOB	157132.6	21678.6	16950.9	78.19	10.79	4727.7	21.81	3.01
5	OHW	248143.8	97058.5	85823.8	88.43	34.59	11234.7	11.58	4.53
5	TOB	248143.8	15252.6	7813.1	51.22	3.15	7439.5	48.78	3.00
TOTAL	OHW	877074.2	309728.2	279135.6	90.12	31.83	30592.6	9.88	3.49
TOTAL	TOB	877074.2	116918.4	80600.4	68.94	9.19	36318.0	31.06	4.14

TABLE 11

VEGETATION TYPES BY STUDY REACH AT ORDINARY HIGH WATER AND TOP OF RIVER BANK

STUDY REACH #	RIVER BANK SITE	HERB-ACEOUS COVER	% TOTAL REACH COVER	WOODY COVER (FEET)	% TOTAL REACH COVER	TREE COVER (FEET)	% TOTAL REACH COVER	NO VEG. NO COVER	% TOTAL REACH COVER	TOTAL COVER (FEET)
1	OHW	20667.2	18.13	1236.9	1.08	709.8	0.63	91376.4	80.16	113990.3
1	TOB	67820.8	59.49	4095.6	3.59	6480.5	5.69	35593.6	31.23	113990.5
2	OHW	49116.8	42.45	19669.4	17.01	15171.0	13.11	31737.1	27.43	115694.3
2	TOB	43610.1	37.68	16990.9	14.69	41682.3	36.03	13419.0	11.60	115702.3
3	OHW	162008.0	66.90	25369.1	10.47	13248.4	5.48	41483.6	17.13	242109.1
3	TOB	62892.4	25.98	51676.0	21.35	96533.8	39.89	30990.8	12.80	242093.0
4	OHW	87175.2	55.47	15300.4	9.74	6582.6	4.19	48076.2	30.60	157134.4
4	TOB	54430.7	34.64	18935.5	12.05	62089.7	39.51	21678.6	13.80	157134.5
5	OHW	79729.5	32.13	44109.5	17.78	17905.3	7.22	106399.3	42.89	248143.6
5	TOB	53657.0	21.62	58272.9	23.48	101714.0	40.99	34500.9	13.90	248144.8
TOTAL	OHW	398696.7	45.46	105685.3	12.05	53617.1	6.11	319072.6	36.38	877071.7
TOTAL	TOB	282411.0	32.20	149970.9	17.10	308500.3	35.17	136182.9	15.53	877065.1

TABLE 12

SUBSTRATE TYPES LISTED BY STUDY REACH

(Measured in Feet)

STUDY REACH #	SUBSTRATE				TYPE					
	MUD, SILT SAND	%	GRAVEL (1 - 3")	%	COBBLE (3 - 5")	%	RUBBLE (> 5")	%	TOTAL SUB FOOTAGE	%
1	96086.8	84.3	17259.9	15.1	226.0	0.2	417.6	0.4	113990.3	100.0
2	33068.3	28.6	51506.2	44.5	26646.8	23.0	4561.7	3.9	115783.0	100.0
3	14645.6	6.1	89980.5	37.2	98542.6	40.7	38943.2	16.1	242111.9	100.0
4	32963.9	21.0	81223.1	51.7	36857.1	23.5	6085.7	3.9	157129.8	100.0
5	9810.4	4.0	60280.1	24.3	77655.5	31.3	100313.2	40.4	248059.2	100.0
TOTAL	186,575.0	21.3	300,249.8	34.2	239,928.0	27.4	150,321.4	17.1	877,074.2	100.0

TABLE 13

AVAILABLE FISH HABITAT COVER TYPES AT OR BELOW ORDINARY HIGH WATER LINE BY STUDY REACH

(Measured in Feet)

STUDY REACH #	FISH COVER TYPES							
	NO COVER	%	EMER. VEG.	%	AQUA. VEG.	%	DEBRIS	%
1	104019.6	82.9	9572.5	07.6	25.0	00.1	1912.6	01.5
2	27330.0	14.6	8262.0	04.4	108.0	00.1	10954.6	05.8
3	30682.4	07.7	15457.8	03.9	3297.1	00.8	8152.5	02.1
4	80223.9	38.8	4586.7	02.2	430.0	00.1	11073.5	05.4
5	97027.5	31.6	6574.4	02.1	0.0	00.0	40568.1	13.2
TOTAL	339,283.4	27.7	44,453.4	3.6	3,860.1	0.3	72,661.3	6.0

STUDY REACH #	FISH COVER TYPES					
	OVERHANG VEG.	%	UNDERCUT BANKS	%	TOTAL COVER	%
1	4873.7	03.9	5033.5	4.1	125436.9	100.0
2	72576.9	38.6	68379.9	36.5	187611.4	100.0
3	183062.8	46.2	155704.3	39.3	396356.9	100.0
4	64389.6	31.2	45790.2	22.2	206493.9	100.0
5	101946.9	33.2	61371.3	20.0	307488.2	100.0
TOTAL	426,849.9	34.9	336,279.2	27.6	1,223,387.3	100.0

TABLE 14

HABITAT SUITABILITY INDICES AND AVAILABLE HABITAT UNITS FOR JUVENILE CHINOOK SALMON IN THE KENAI RIVER MAINSTEM

TOTAL HABITAT UNITS (HU'S) FOR THE KENAI RIVER MAINSTEM

1,489,972 HU'S

COVER TYPE STRUCTURE OR USE	WATER-FRONTAGE (MILES)	WATER-FRONTAGE (FEET)	TOTAL AREA AFFECTED (ACRES)	TOTAL AREA AFFECTED (FT^2)	MEAN HSI'S	HABITAT UNITS (HU'S)
UNDEVELOPED WATERFRONTAGE						
IDEAL REARING	15.2	80,108.0	11.0	480,648.0	0.77	370,099.0
VEGETATED UNDEVELOPED	19.5	102,921.4	14.2	617,528.4	0.30	185,258.5
VEGETATED SLIGHTLY DEGRADED	82.7	436,528.8	60.1	2,619,172.8	0.26	680,984.9
HEAVILY DEGRADED	3.6	18,817.5	2.6	112,905.0	0.20	22,581.0
GRAVEL NON ERODING	5.3	27,805.5	3.8	166,833.0	0.15	25,025.0
EROSIONAL GRAVEL BANK	28.0	147,594.0	20.3	885,564.0	0.15	132,834.6
SUBTOTAL	154.1	813,775.2	112.1	4,882,651.2	N/A	1,416,783.0
DEVELOPED WATERFRONTAGE						
BOAT LAUNCHES	0.5	2,391.0	0.3	14,346.0	0.17	2,438.8
DOCKS, DECKS & STRUCTURES	2.0	10,378.0	1.4	62,268.0	0.28	17,435.0
BANK PROTECTION MEASURES	4.3	22,757.0	3.1	136,542.0	0.17	23,212.1
BULKHEADS	1.5	7,806.0	1.1	46,836.0	0.14	6,557.0
JETTY'S	0.2	1,152	0.2	6,912.0	0.14	967.7
OTHER DEV.	3.6	18,815.0	2.6	112,890.0	0.20	22,578.0
SUBTOTAL	12.0	63,299.0	8.7	379,794.0	N/A	73,188.6
TOTALS	166.1	877,074.2	120.8	5,262,445.0	N/A	1,489,972.0

TABLE 15

HABITAT SUITABILITY INDICES AND AVAILABLE HABITAT UNITS FOR JUVENILE CHINOOK SALMON IN THE KENAI RIVER MAINSTEM

TOTAL HABITAT UNITS (HU'S) FOR THE KENAI RIVER MAINSTEM WITHOUT STRUCTURES OR TRAMPLING

1,523,144 HU'S

COVER TYPE STRUCTURE OR USE	WATER-FRONTAGE (MILES)	(FEET)	TOTAL AREA AFFECTED (ACRES)	(FT^2)	MEAN HSI'S	HABITAT UNITS (HU'S)
	UNDEVELOPED		WATERFRONTAGE			
IDEAL REARING	15.3	80,779.0	11.1	484,674.0	0.77	373,199.0
VEGETATED UNDEVELOPED	26.6	106,309.0	19.4	843,234.6	0.30	252,970.4
VEGETATED SLIGHTLY DEGRADED	87.1	459,941.6	63.4	2,759,649.6	0.26	717,508.9
NATURALLY DEGRADED	2.0	10,776.1	1.5	64,656.6	0.20	12,931.3
GRAVEL NON ERODING	6.8	35,840.5	4.9	215,043.0	0.15	32,256.5
EROSIONAL GRAVEL BANK	28.3	149,198.0	20.6	895,188.0	0.15	134,278.2
TOTAL W/O STRUCTURES OR TRAMPLING	166.1	877,074.2	120.9	5,262,445.8	N/A	1,523,144.3
TOTAL WITH STRUCTURES & HABITAT ALTERATIONS	166.1	877,074.2	120.8	5,262,445.8	N/A	1,489,972.0
TOTAL HABITAT UNITS LOST (-) GAINED (+)						- 33,172.3

TABLE 16

HABITAT SUITABILITY INDEX FORMULA

$$HSI = \frac{SI_v + SI_d + SI_{nc} + SI_e + SI_a + SI_{db} + SI_{obv} + SI_{uc} + SI_r + SI_c + SI_b}{11 \text{ (\# of Variables measured)}}$$

The Velocity Component for each site:

SI_v = suitability index value for a measured average velocity (ft/s)

The Depth Component for each site:

SI_d = suitability index value for a measured depth (ft)

The Cover Components for each site:

SI_{nc} = suitability index value for the percent of area with no cover (%)
SI_e = suitability index value for percent of area with emergent vegetation (%)
SI_a = suitability index value for percent of area with aquatic vegetation (%)
SI_{db} = suitability index value for percent of area with debris (%)
SI_{ohv} = suitability index value for percent of area with overhanging vegetation (%)
SI_{uc} = suitability index value for percent of area with undercut bank (%)

The Substrate Components for each site:

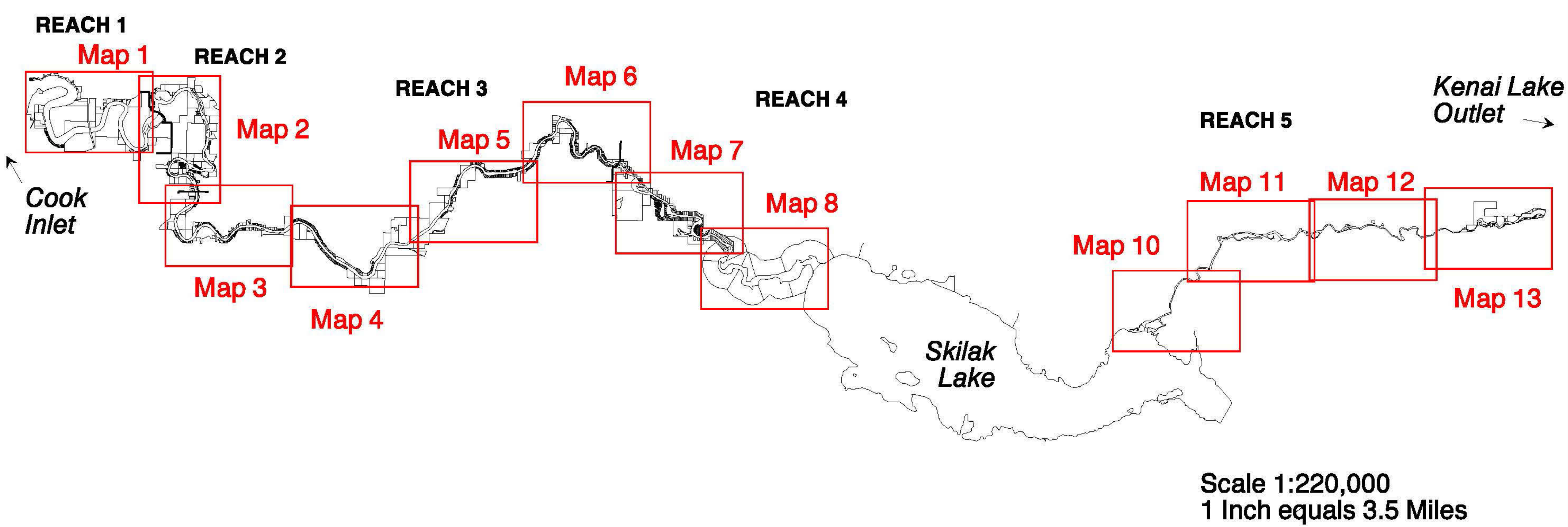
SI_r = suitability index value for percent of area with substrate <3" (%)
SI_c = suitability index value for percent of area with substrate 3-5" (%)
SI_b = suitability value for percent of area with substrate >5" (%)

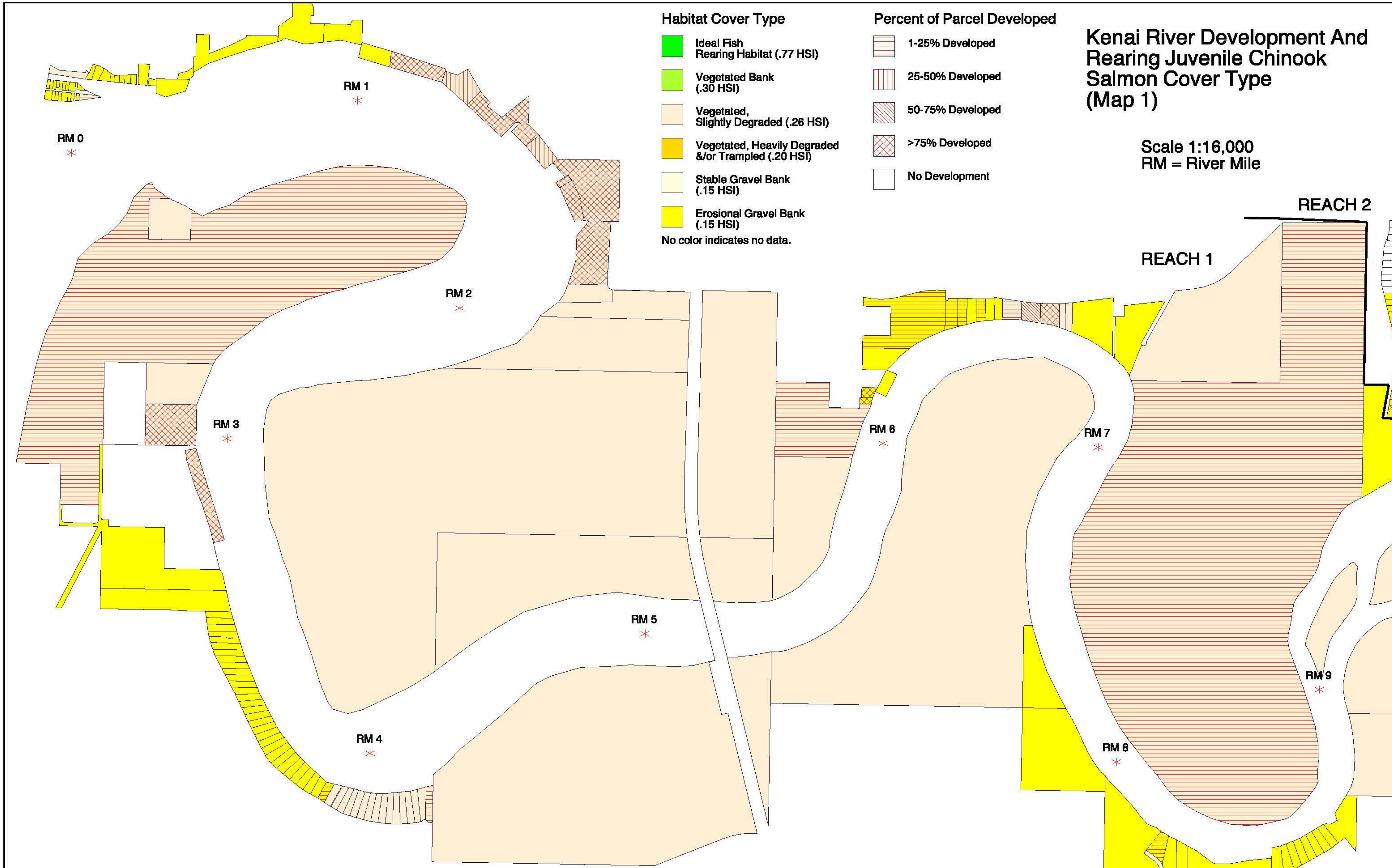
For the purposes of this study, we are assuming HSI's will not change over time in terms of future projections (no erosion or succession is taken into account for natural conditions; e.g., gravel banks or vegetated banks). We are further assuming these areas will not increase beyond the sum of the two conditions (e.g., no structures will be removed or banks rehabilitated) in the future. Our HEP analysis does not attempt to compare various management plan scenarios and no compensation units were calculated for the study area.

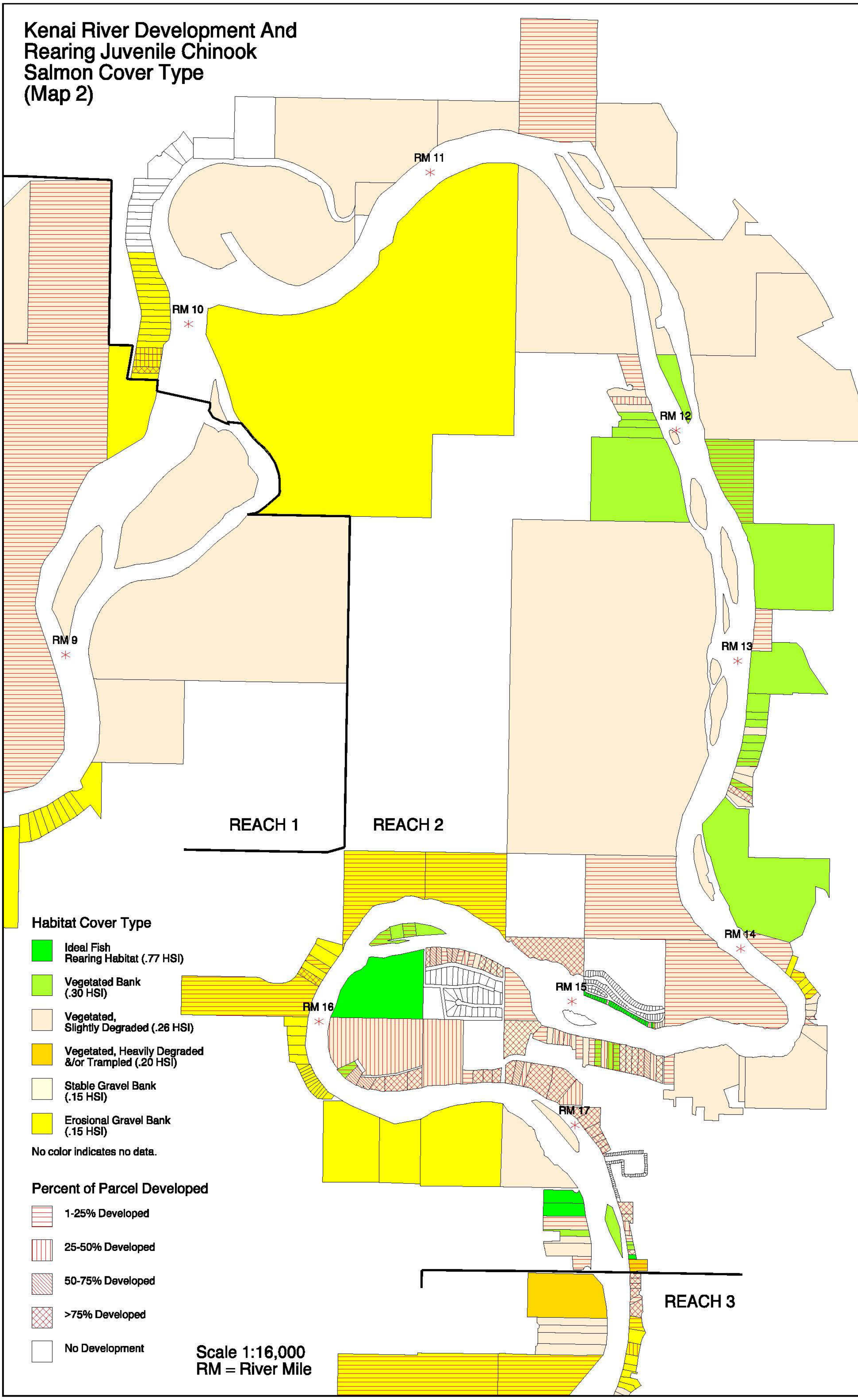
APPENDIX B

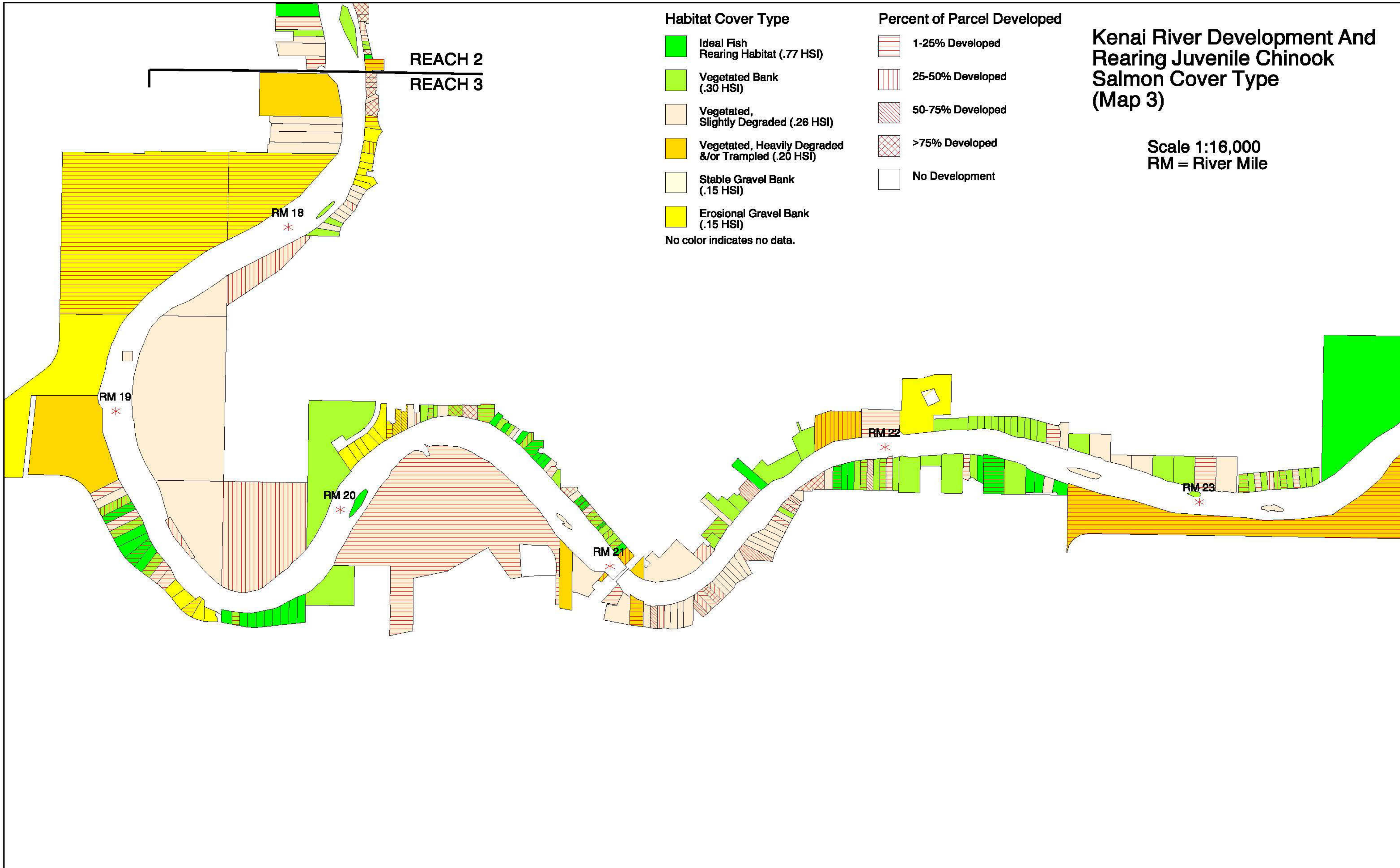
DEVELOPMENT AND HABITAT COVER TYPE MAPS

Kenai River 309 Project Development And Cover Type Index Map

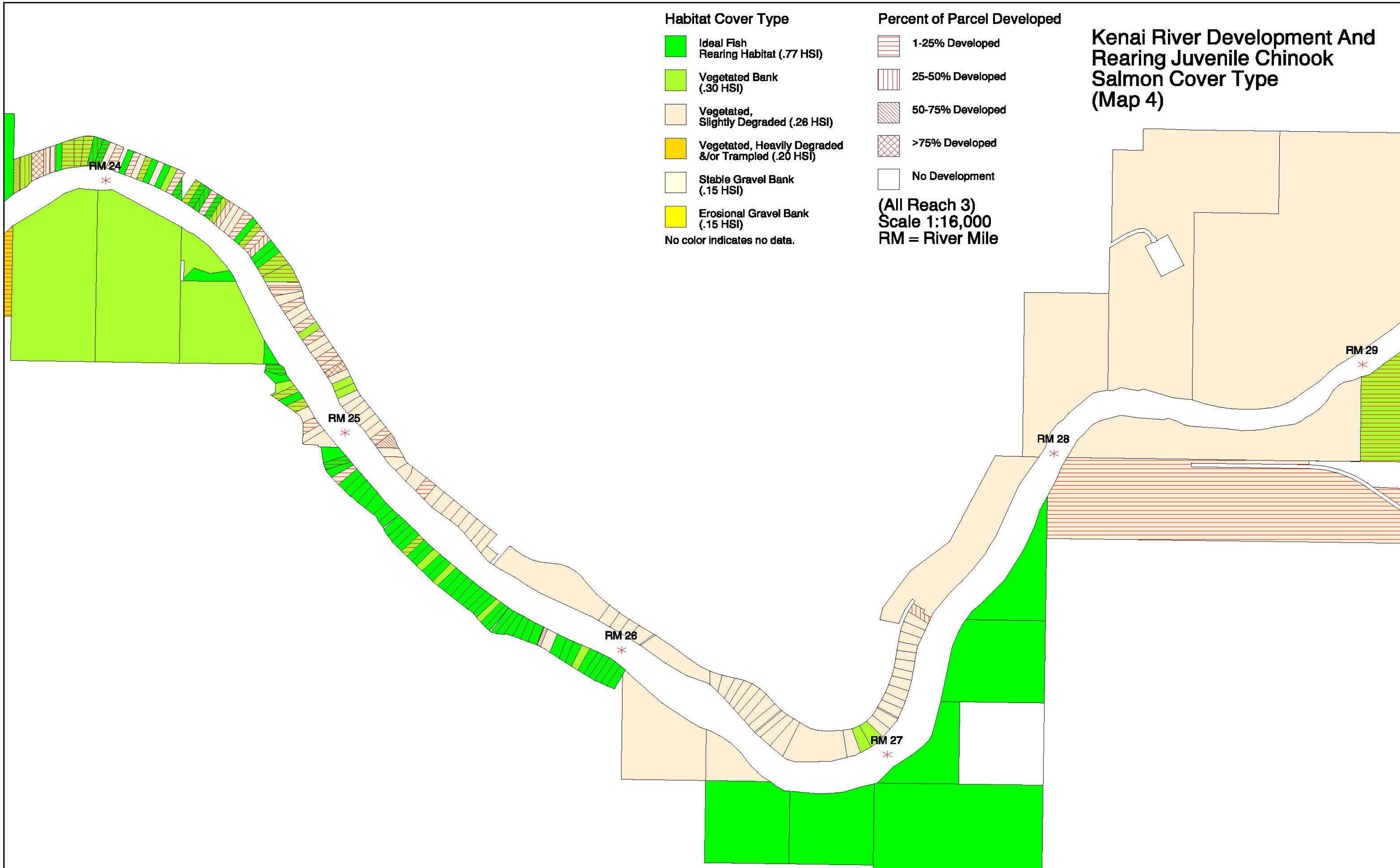


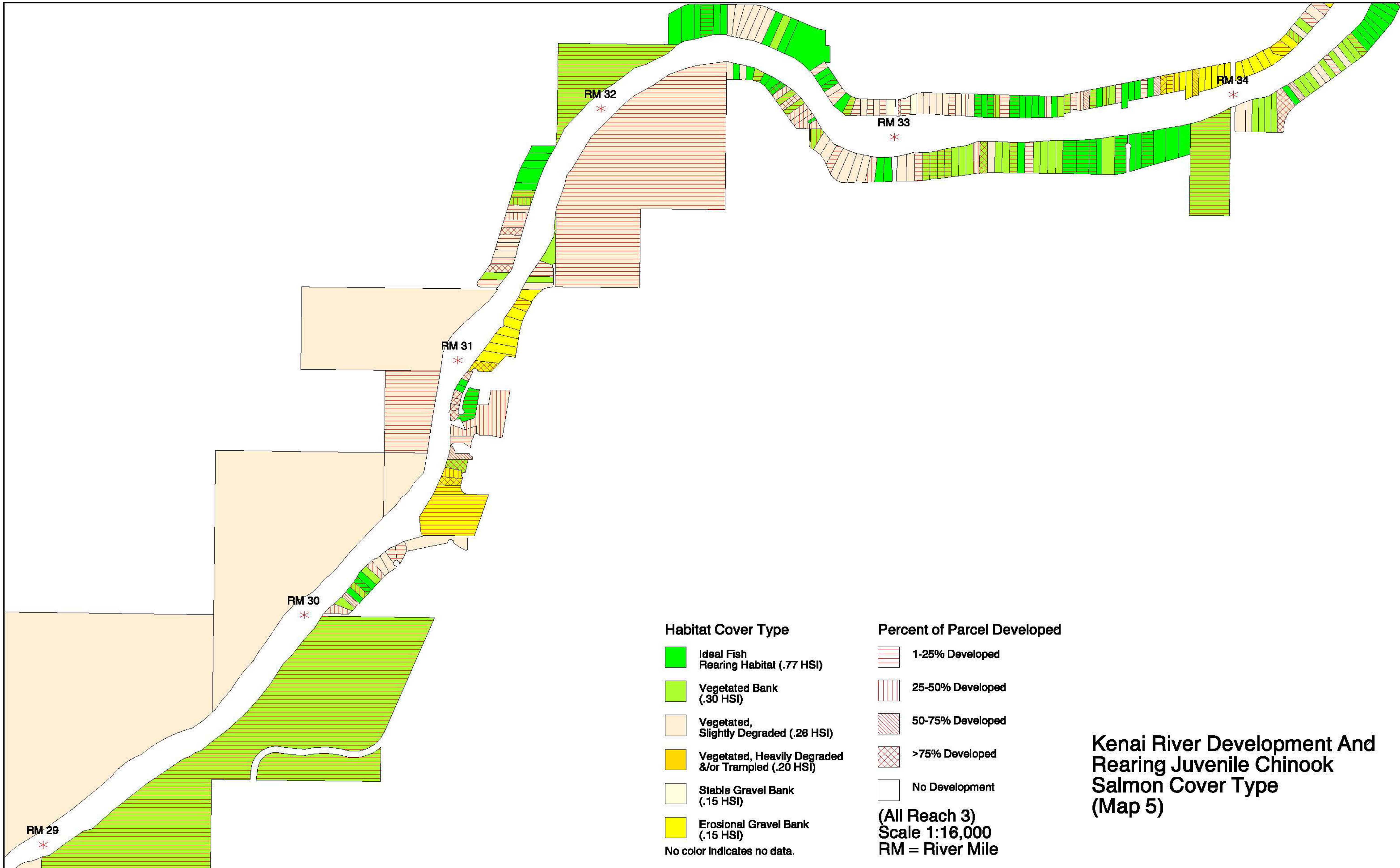

Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 1)
Scale 1:16,000
RM = River Mile
REACH 2
REACH 1
RM 0
RM 1
RM 2
RM 3
RM 4
RM 5
RM 6
RM 7
RM 8
RM 9

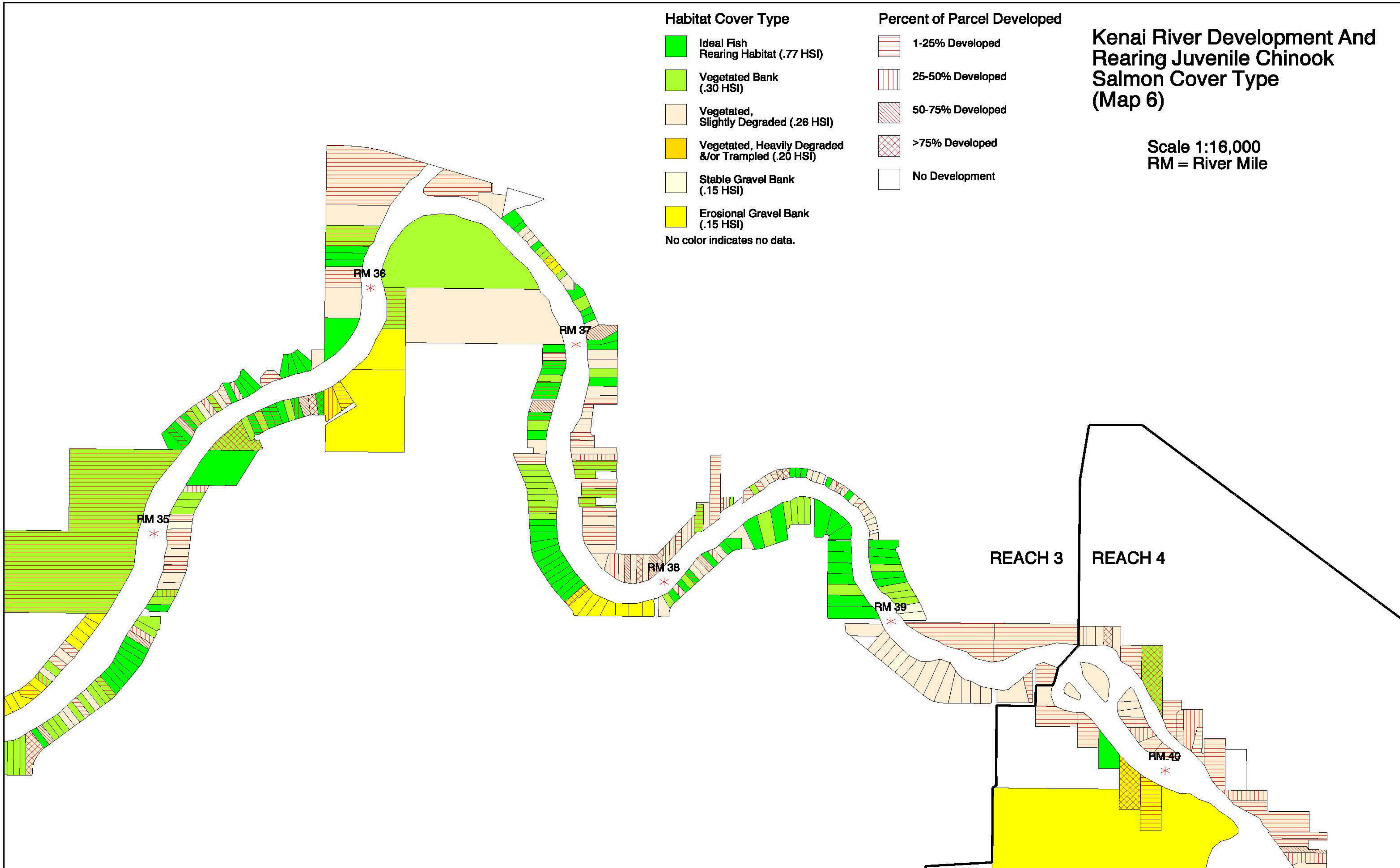

Kenai River Development And
Rearing Juvenile Chinook
Salmon Cover Type
(Map 2)
RM 9
RM 10
RM 11
RM 12
RM 13
RM 14
RM 15
RM 16
RM 17
REACH 1
REACH 2
REACH 3
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
Scale 1:16,000
RM = River Mile



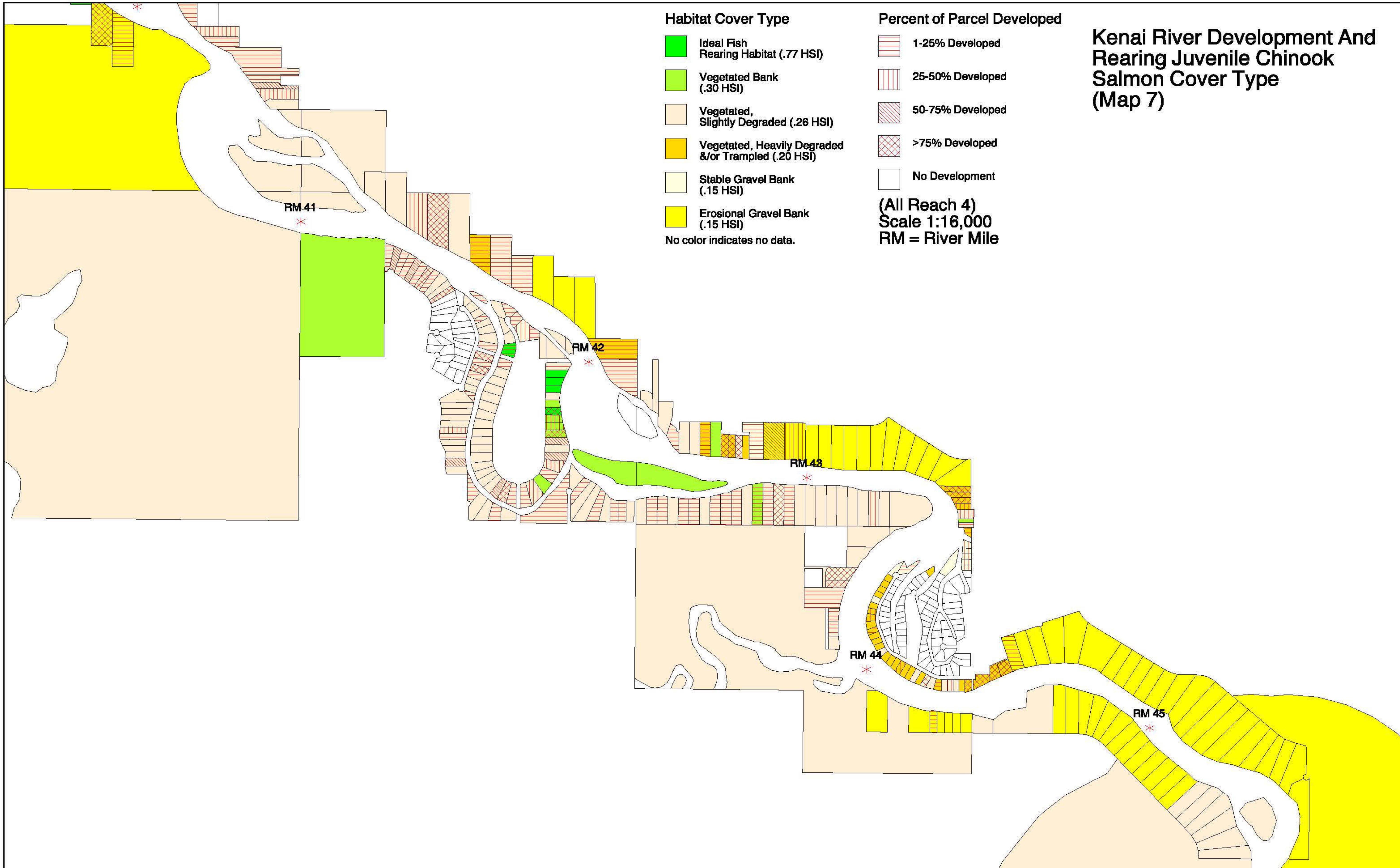
Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 3)
Scale 1:16,000
RM = River Mile
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
REACH 2
REACH 3
RM 18
RM 19
RM 20
RM 21
RM 22
RM 23

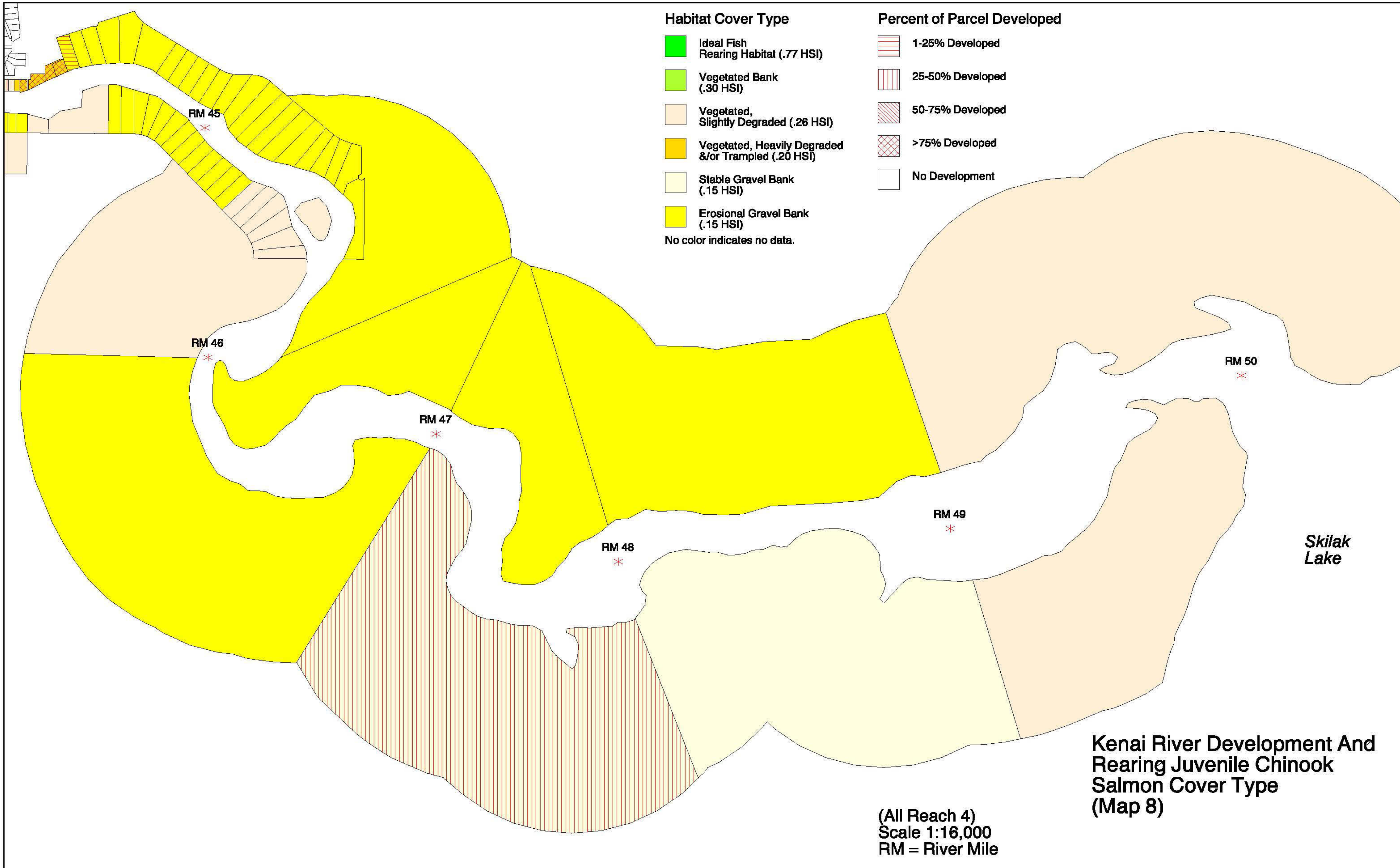

Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 4)
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 3)
Scale 1:16,000
RM = River Mile
RM 24
RM 25
RM 26
RM 27
RM 28
RM 29

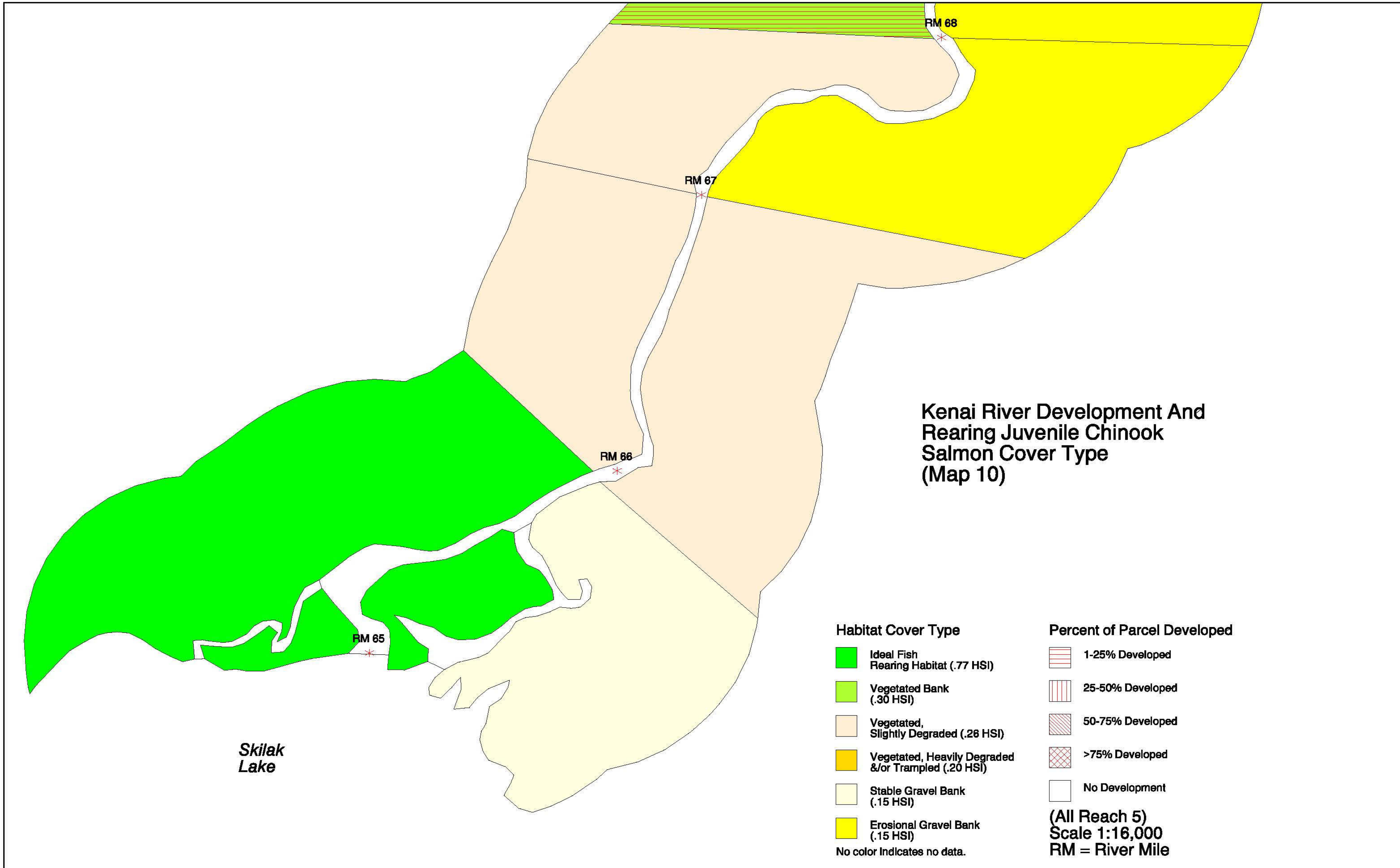

RM 29
RM 30
RM 31
RM 32
RM 33
RM 34
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 3)
Scale 1:16,000
RM = River Mile
Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 5)

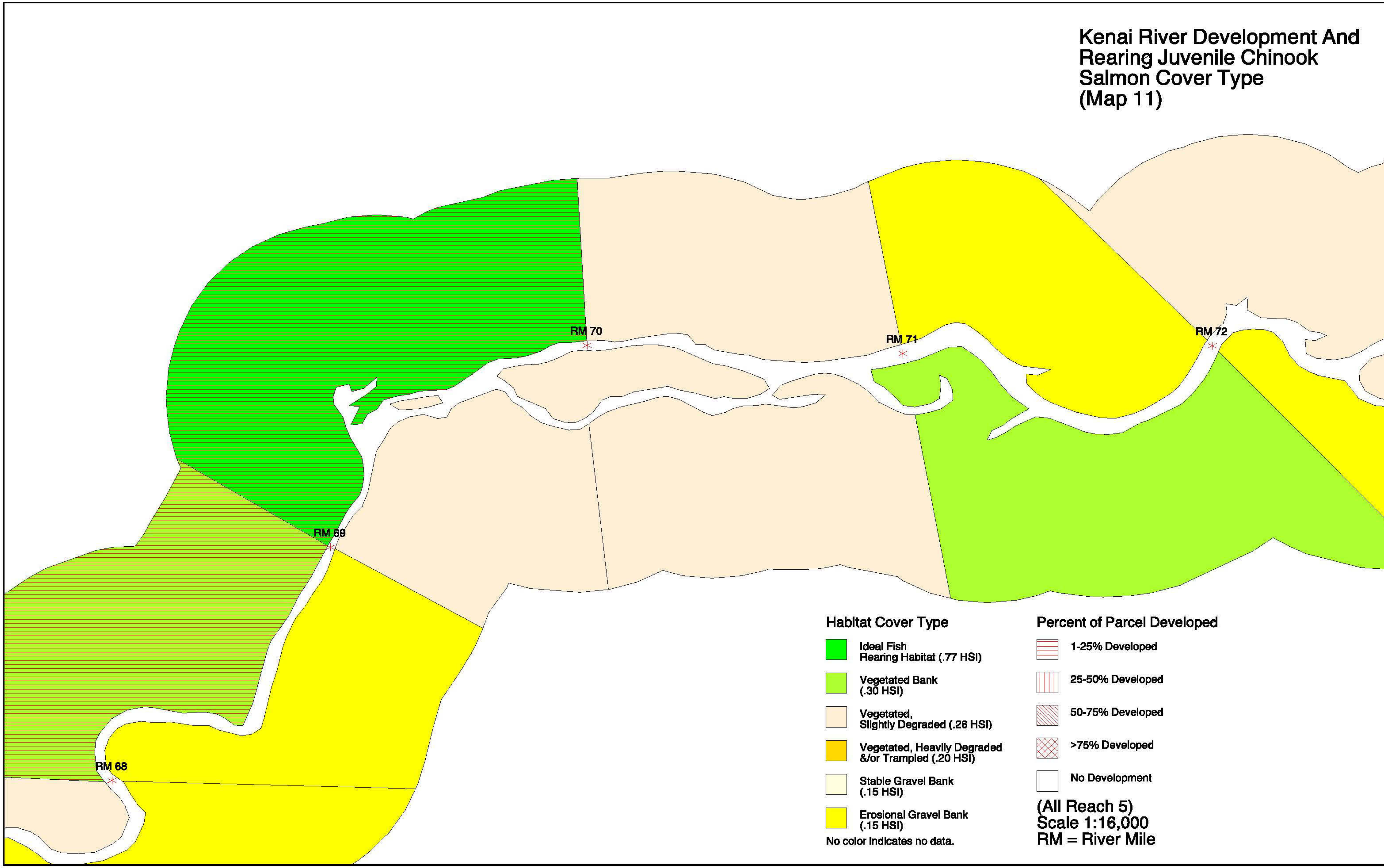


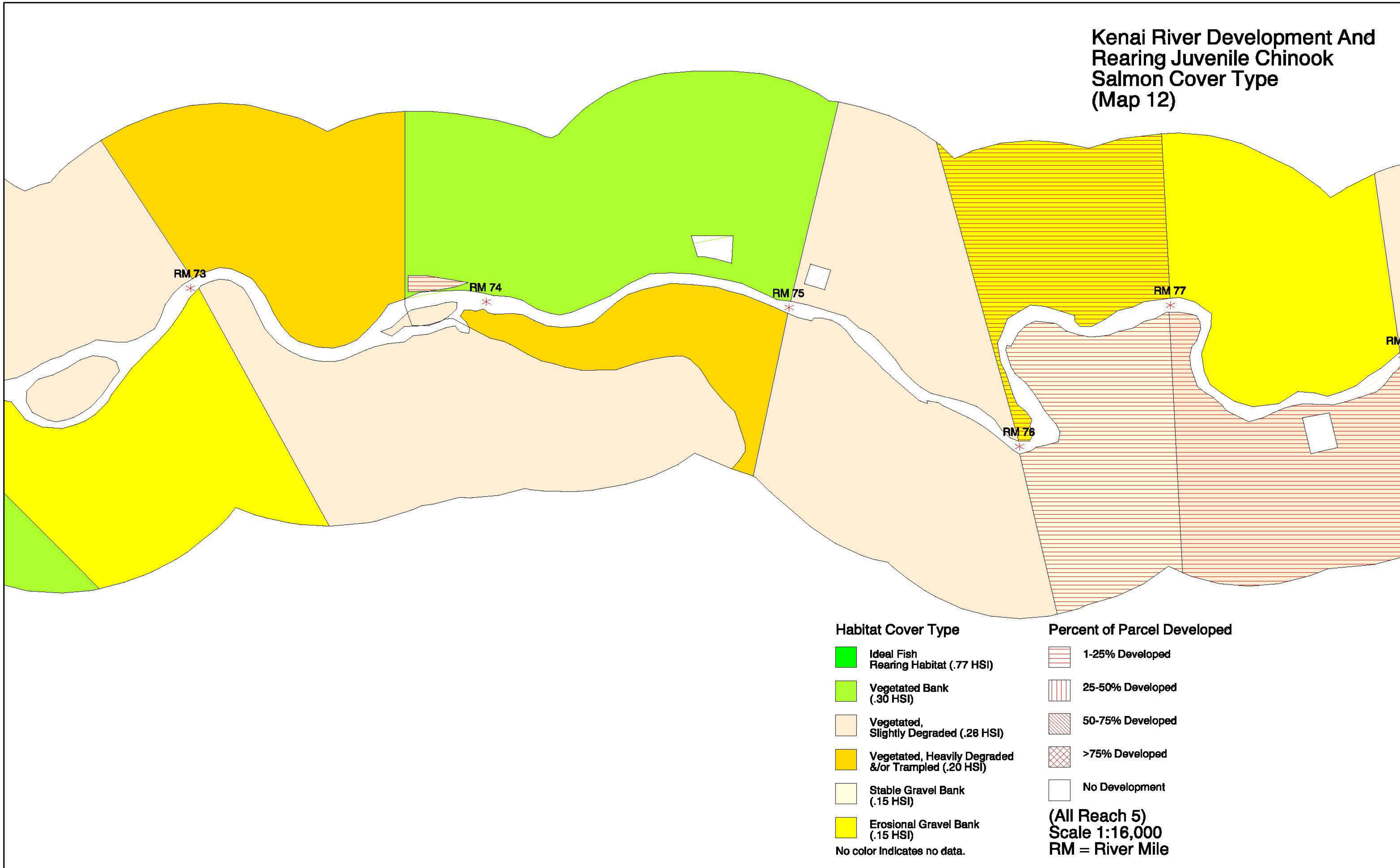
Habitat Cover Type
Ideal Fish
Rearing Habitat (.77 HSI)
Vegetated Bank
(.30 HSI)
Vegetated,
Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded
&or Trampled (.20 HSI)
Stable Gravel Bank
(.15 HSI)
Erosional Gravel Bank
(.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
Kenai River Development And
Rearing Juvenile Chinook
Salmon Cover Type
(Map 6)
Scale 1:16,000
RM = River Mile
RM 35
RM 36
RM 37
RM 38
RM 39
RM 40
REACH 3
REACH 4

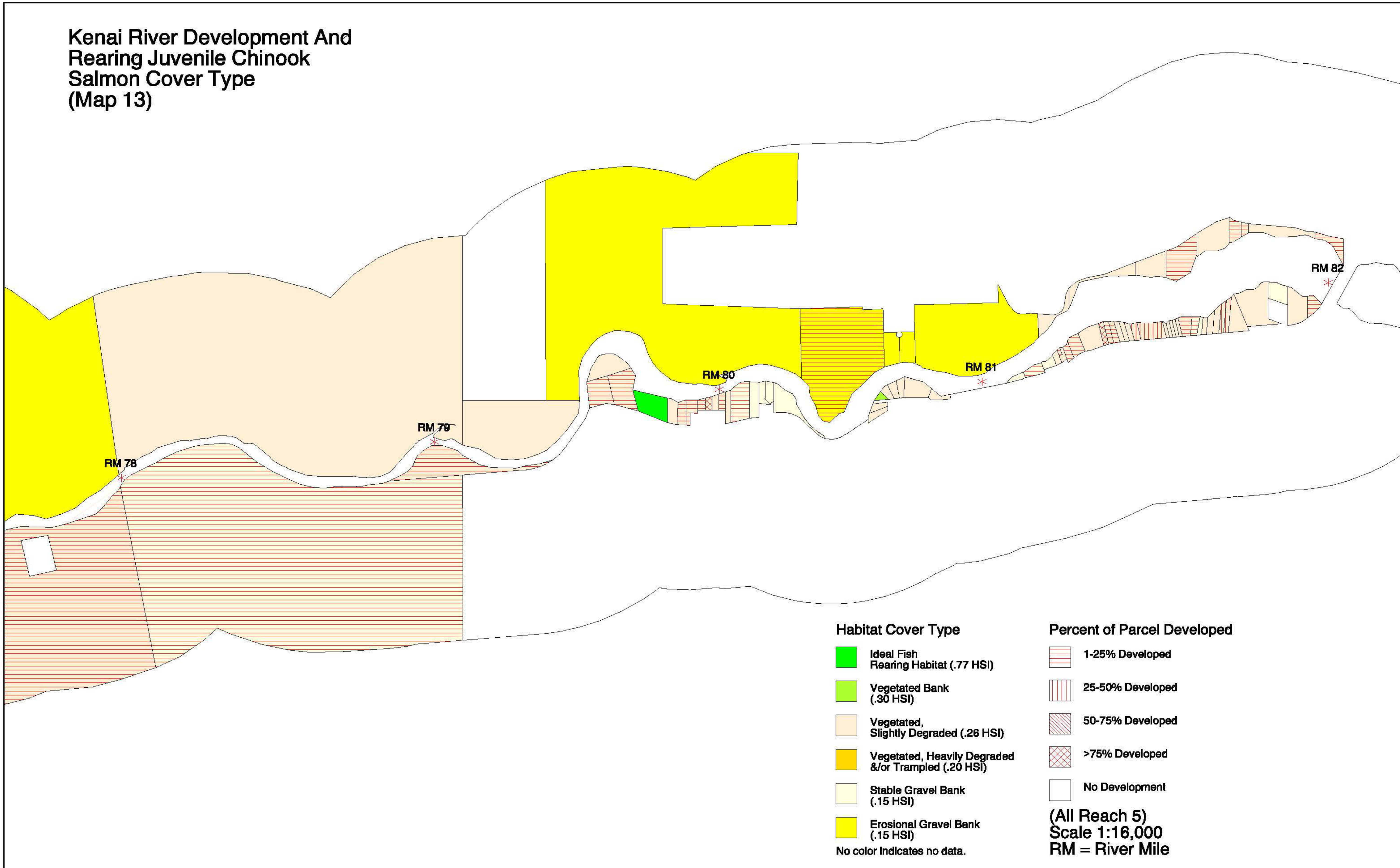

Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 7)
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 4)
Scale 1:16,000
RM = River Mile
RM 41
RM 42
RM 43
RM 44
RM 45


Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
RM 45
RM 46
RM 47
RM 48
RM 49
RM 50
Skilak Lake
Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 8)
(All Reach 4)
Scale 1:16,000
RM = River Mile


RM 68
RM 67
RM 66
RM 65
Skilak
Lake
Kenai River Development And
Rearing Juvenile Chinook
Salmon Cover Type
(Map 10)
Habitat Cover Type
Ideal Fish
Rearing Habitat (.77 HSI)
Vegetated Bank
(.30 HSI)
Vegetated,
Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded
&/or Trampled (.20 HSI)
Stable Gravel Bank
(.15 HSI)
Erosional Gravel Bank
(.15 HSI)
No color Indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 5)
Scale 1:16,000
RM = River Mile


Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 11)
RM 68
RM 69
RM 70
RM 71
RM 72
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color Indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 5)
Scale 1:16,000
RM = River Mile


Kenai River Development And Rearing Juvenile Chinook Salmon Cover Type (Map 12)
RM 73
RM 74
RM 75
RM 76
RM 77
Habitat Cover Type
Ideal Fish Rearing Habitat (.77 HSI)
Vegetated Bank (.30 HSI)
Vegetated, Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded &/or Trampled (.20 HSI)
Stable Gravel Bank (.15 HSI)
Erosional Gravel Bank (.15 HSI)
No color indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 5)
Scale 1:16,000
RM = River Mile

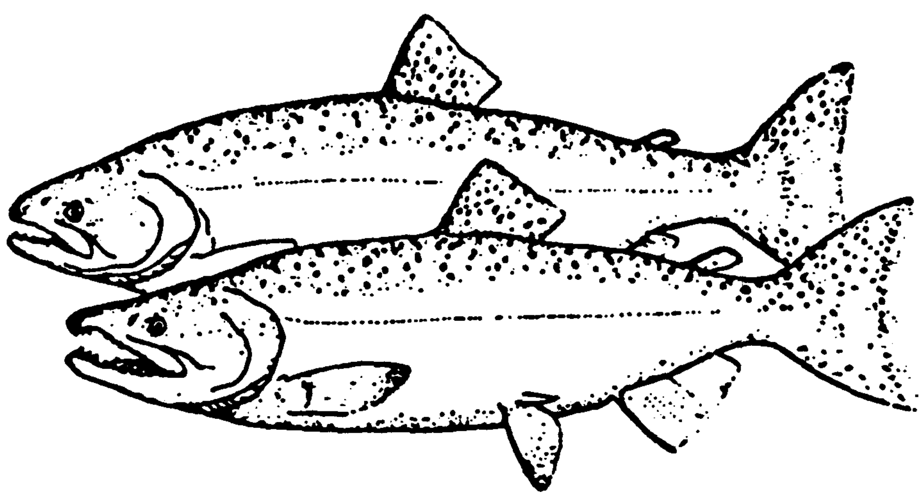

Kenai River Development And
Rearing Juvenile Chinook
Salmon Cover Type
(Map 13)
RM 78
RM 79
RM 80
RM 81
RM 82
Habitat Cover Type
Ideal Fish
Rearing Habitat (.77 HSI)
Vegetated Bank
(.30 HSI)
Vegetated,
Slightly Degraded (.26 HSI)
Vegetated, Heavily Degraded
&/or Trampled (.20 HSI)
Stable Gravel Bank
(.15 HSI)
Erosional Gravel Bank
(.15 HSI)
No color Indicates no data.
Percent of Parcel Developed
1-25% Developed
25-50% Developed
50-75% Developed
>75% Developed
No Development
(All Reach 5)
Scale 1:16,000
RM = River Mile

APPENDIX C

HEP SUITABILITY INDEX CURVES FOR JUVENILE CHINOOK SALMON

BIOLOGICAL REPORT 82(10.122)
SEPTEMBER 1986

HABITAT SUITABILITY INDEX MODELS AND INSTREAM FLOW SUITABILITY CURVES: CHINOOK SALMON



Fish and Wildlife Service
U.S. Department of the Interior

Biological Report 82(10.122)
September 1986

HABITAT SUITABILITY INDEX MODELS AND INSTREAM FLOW SUITABILITY CURVES: CHINOOK SALMON

by

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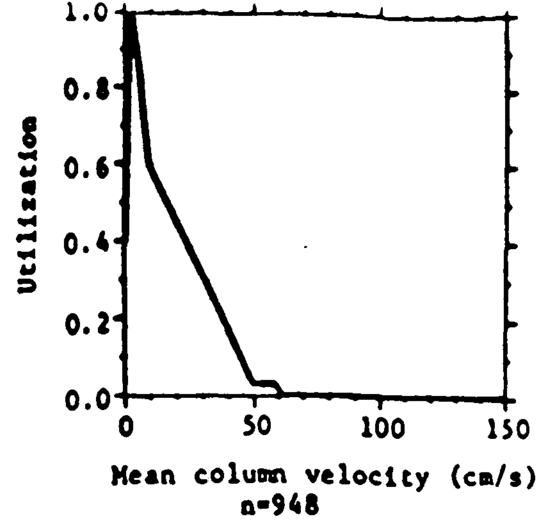
Performed for
National Ecology Center
Division of Wildlife and Contaminant Research
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

This report should be cited as:

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.122). 64 pp.

Coordinates

x cm/s	x ft/s	y SI
0.0	0.00	0.40
1.5	0.05	0.95
3.0	0.10	1.00
9.1	0.30	0.60
48.8	1.60	0.03
57.9	1.90	0.03
61.0	2.00	0.00
3048.0	100.00	0.00



x cm	x inches	y SI
0.0	0.00	0.00
0.1	0.04	0.40
1.6	0.63	1.00
2.2	0.87	1.00
3.0	1.18	0.20
10.0	3.94	0.30
12.0	4.72	0.05
18.4	7.24	0.10
100.0	39.40	0.10

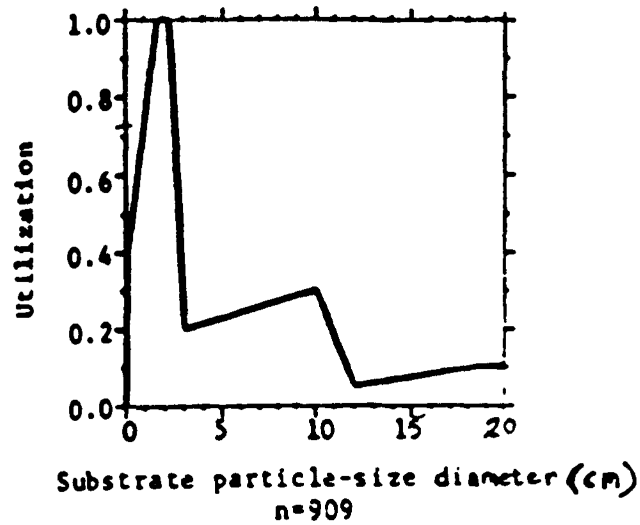
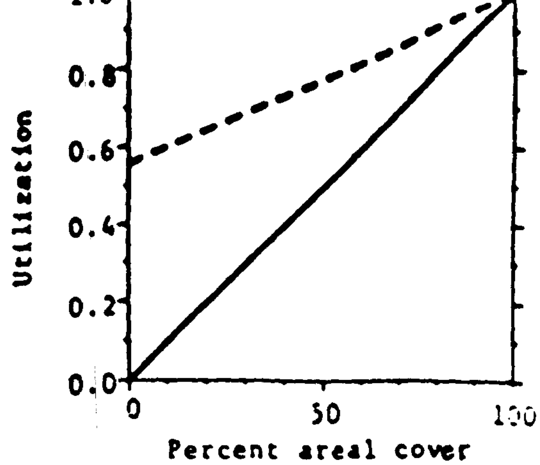


Figure 15. Category two SI curves for chinook salmon fry velocity and substrate utilization (from Burger et al. 1982).

	Coordinates	
x	y SI (clear water; solid line)	y SI (turbid; broken line)
0	0.0	0.56
50	0.5	-
100	1.0	1.00



x Code	Cover type description	y SI
1	Debris	0.90
2	Undercut bank	1.00
3	Rubble/cobble/boulder	0.20
4	Aquatic vegetation	0.65
5	Large gravel	0.25
6	Overhanging vegetation	0.38
7	Emergent vegetation	0.30
8	No cover	0.01

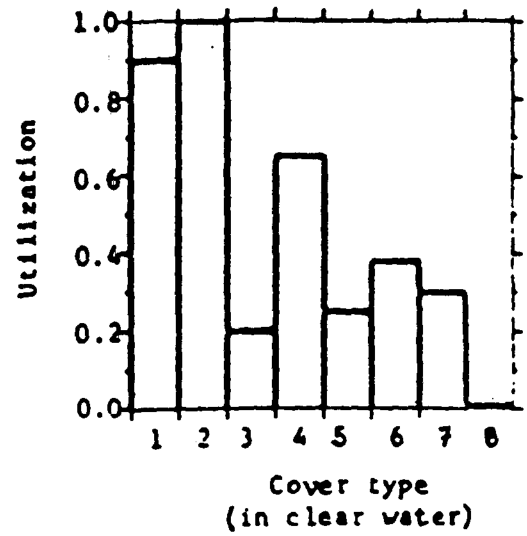
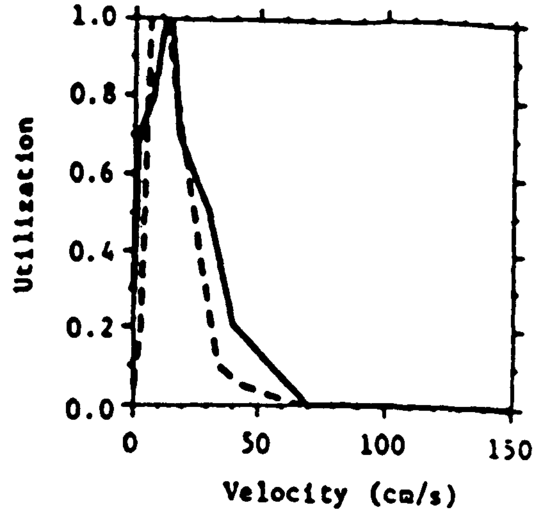


Figure 17 (concluded).

x cm/s	x ft/s	Coordinates y Mean column SI n=947 (solid line)	y Nose SI n=163 (broken line)
0.0	0.00	0.3	0.05
1.5	0.05	0.7	-
3.0	0.10	-	0.20
6.1	0.20	-	1.00
7.6	0.25	0.8	-
12.2	0.40	1.0	1.00
15.2	0.50	1.0	-
18.3	0.60	0.7	-
24.4	0.80	-	0.50
30.5	1.00	0.5	-
33.5	1.10	-	0.10
39.6	1.30	0.2	-
42.7	1.40	-	0.05
67.1	2.20	-	0.00
70.1	2.30	0.0	-
3048.0	100.00	0.0	0.00



x cm	x inches	y SI
0.0	0.00	0.00
0.2	0.08	0.60
1.6	0.63	1.00
2.2	0.87	1.00
2.6	1.02	0.20
9.2	3.62	0.03
10.0	3.94	0.20
18.4	7.24	0.20

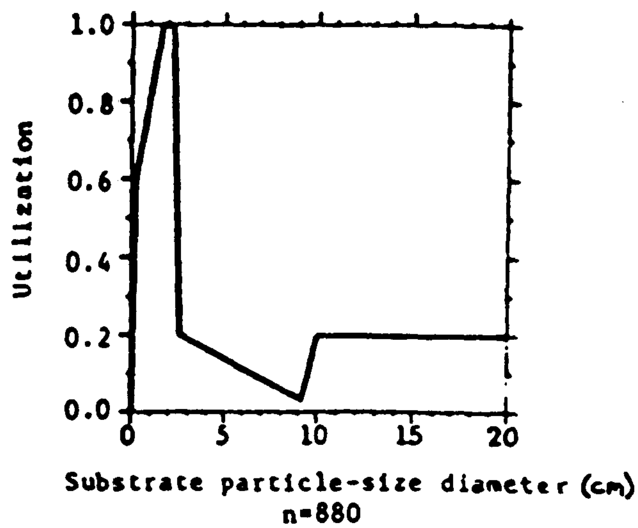
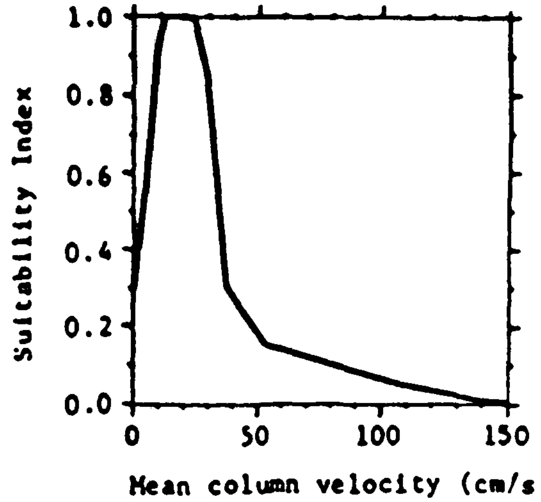


Figure 18. Category two SI curves for chinook salmon juvenile velocity and substrate utilization (from Burger et al. 1982).

x cm/s	x ft/s	y SI
Coordinates		
0.0	0.00	0.30
4.6	0.15	0.55
9.1	0.30	0.90
12.2	0.40	1.00
24.4	0.80	1.00
29.0	0.95	0.85
36.6	1.20	0.30
53.3	1.75	0.15
106.7	3.50	0.05
137.2	4.50	0.01
152.4	5.00	0.00
3048.0	100.00	0.00



x cm	x ft	y SI
0.0	0.0	0.00
6.1	0.2	0.00
24.4	0.8	0.90
30.5	1.0	1.00
76.2	2.5	1.00
91.4	3.0	0.75
121.9	4.0	0.20
152.4	5.0	0.10
304.8	10.0	0.10
762.0	25.0	0.01
3048.0	100.0	0.01

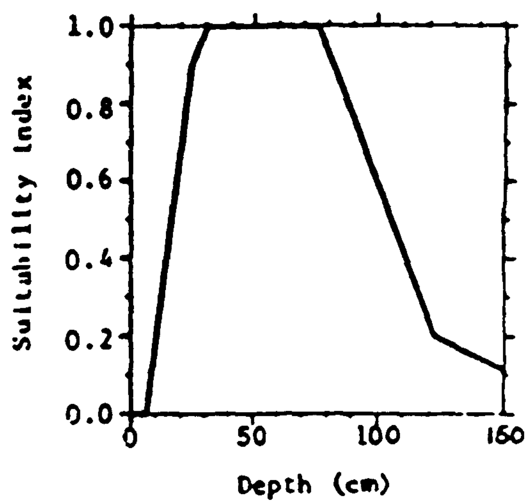


Figure 19. Category one SI curves for chinook salmon juvenile velocity and depth suitability (from U.S. Fish and Wildlife Service 1985).

APPENDIX D

AERIAL PHOTOGRAPH AVAILABILITY

ADF&G KENAI RIVER AERIAL PHOTOGRAPHY INVENTORY

Photo Date	Coverage	Scale	Color/Blk&Wht
04-02-63	RM 0 to 23	1 in. = 1,320 ft. (1 : 15,840)	Blk&Wht
05-02-63	RM 23 to 37	1 in. = 1,320 ft. (1 : 15,840)	Blk&Wht
03-14-64	RM 38 to 50	1 in. = 1,320 ft. (1 : 15,840)	Blk&Wht
08-08-64	RM 69 to 82	1 in. = 500 ft. (1 : 6,000)	Blk&Wht
07-06-75	RM 0 to 14	1 in. = 1,320 ft. (1 : 15, 840)	Color
09-26-81	RM 11 to 44	1 in. = 400 ft. (1 : 4,800)	Color
10-07-81	RM 0 to 69	1 in. = 400 ft. (1 : 4,800)	Color
09-09/24-86	RM 0 to 82	1 in. = 400 ft. (1 : 4,800)	Color IR
04-02-87	RM 0 to 50	1 in. = 400 ft. (1 : 4,800)	Color IR
07-26-87	RM 0 to 82	1 in. = 400 ft. (1 : 4,800)	Color IR
06-13-91	RM 67 to 71	1 in. = 875 ft. (1 : 10,500)	Color
07-02-92	RM 0 to 40	1 in. = 1,000 ft. (1 : 12,000)	Blk&Wht

APPENDIX E

FIELD SURVEY FORM

KENAI RIVER DEVELOPMENT INVENTORY

BOROUGH TAX PARCEL NO.:____________________

RIVER MILE:______ BANK LOCATION: LEFT RIGHT (Looking Downstream) (Circle One)

BRIEF LOCATION/IDENTIFIER(S) DESCRIPTION:____________________

____

INITIAL INSPECTION DATE:__________ LAST INSPECTION DATE:__________ BY:__________

NAME: LAST:____________________ FIRST:______________ MI:____

ADDRESS:____________________ CITY:__________ STATE:______

ZIPCODE:__________ TELEPHONE: (____) __________

OTHER NAME: LAST:____________________ FIRST:______________ MI:____

LEGAL DESCRIPTION: LOT:______ BLOCK:______ SUBD:______________

MERIDIAN: SEWARD TWN:________N. RGE:________W. SEC:______ QTR:______ QTR/QTR:______

LAT:______DEG.______'______" N. LON:______DEG.______ ______" W.

SITE DESCRIPTION:____________________

____

PHOTOGRAPHS: ROLL #:__________ FRAME #:__________

VIDEO TAPE #:__________ TAPE COUNTER/INCHES:________TO________

BANK CONDITION: NATURAL(Undeveloped)______ DEVELOPED(See other side)______

VEGETATION DESCRIPTION:

AT OHW: ______ % Herbaceous Cover ______ % Woody Stem Cover

______ % Tree Cover ______ % Unvegetated/Trampeled

AT TOP OF BANK: ______ % Herbaceous Cover ______ % Woody Stem Cover

______ % Tree Cover ______ % Unvegetated/Trampeled

PERMIT INFORMATION:

F&G #: FG__________ ISSUE DATE:__________ EXP DATE:__________

COE #:__________ ISSUE DATE:__________ EXP DATE:__________

DNR #:__________ ISSUE DATE:__________ EXP DATE:__________

OTHER:____________________

NOTES:____________________

____

Cover Type

____ No Obj. Cover

____ Emergent Veg.

____ Aquatic Veg.

____ Debris/Deadfall

____ Overhang Veg.

____ Undercut Banks

Substrate

____ Gravel (1-3" dia)

____ Rubble (3-5" dia)

____ Cobble (> 5" dia)

PROJECT DESCRIPTION

BANK MODIFICATIONS:

GABION(S):____ LENGTH:__________ WIDTH:__________ MATERIAL:____________ COND:____________

GROIN(S):____ LENGTH:__________ WIDTH:__________ MATERIAL:____________ COND:____________

BULKHEADS: MATERIAL:______________________ LENGTH:______________ COND:__________

ROCK RIP-RAP:______ LENGTH:___________ AVG. ROCK SIZE(Diameter)______________ COND:______

CABLED TREES:_____ BANK COVERAGE:_________ ANCHOR TYPE:_______ EFFECTIVE?__________

STATIONARY?_____ FLOATING?_____ SILTED-IN?_____ UNDETERMINABLE:_______

NOTES/COMMENTS:____

____

____

____

BOAT MOORAGE/BANK SCOUR/SCAR:Length:____

BOAT SLIP:_____ SIZE:____________________

BOAT BASIN:_____ SIZE:____________________

DREDGE/FILL:_______ LENGTH:__________ WIDTH:__________ DESCRIBE:______________

	CONDITION:			OWNER:		
____	GOOD	FAIR	POOR	PVT	PUB	COM
PILE SUPPORTED STRUCTURE:_______________________	___	___	___	___	___	___
ELEVATED/CANTILEVERED STRUCTURE:_________________	___	___	___	___	___	___
PIERS: ______ LENGTH:__________ WIDTH:____________	___	___	___	___	___	___
DOCK(S):_____ FLOATING:_____ PILE SUPPORTED:__________	___	___	___	___	___	___
LENGTH: ________ WIDTH:_______						
DISTANCE FROM BANK:_____________						
LAUNCH/RAMP:_____ LENGTH:_______ WIDTH:___________	___	___	___	___	___	___
LADDER(S):_______ LENGTH:______ WIDTH:____________	___	___	___	___	___	___
BOARDWALKS:_________ LENGTH:_____ WIDTH:__________	___	___	___	___	___	___
OUTFALL(S):_____ TYPE:Storm drain:Sewage:etc:__________	___	___	___	___	___	___
LENGTH:____________________________________						
BUOY(S):_____ DESCRIBE:________________________	___	___	___	___	___	___

APPENDIX F

TECHNICAL ADVISORY GROUP MEMBERS

KENAI RIVER 309 PROJECT

TECHNICAL ADVISORY GROUP MEMBERS

NAME	AGENCY	TELEPHONE
Gary Liepitz Habitat Biologist	Dept. of Fish and Game, H&R Division 333 Raspberry Road, Anchorage, AK 99518	267-2284
Gay Muhlberg Habitat Biologist	Dept. of Fish and Game, H&R Division 333 Raspberry Road, Anchorage, AK 99518	267-2284
Glenn Seaman Habitat Biologist	Dept. of Fish and Game, H&R Division 333 Raspberry Road, Anchorage, AK 99518	267-2331
Terry Bendock Fisheries Biologist	Dept. of Fish and Game, Sport Fish Division 34828 Kalifornsky Beach Rd., Soldotna, AK 99669	262-9368
Christopher Estes Statewide Instream Flow Coordinator	Dept. of Fish and Game, Sport Fish Division 333 Raspberry Road, Anchorage, AK 99518	267-2142
Larry Dugan Fish & Wildlife Biologist	U.S. Fish and Wildlife Service, Anchorage Field Office, 605 W. 4th Ave., Room G62, Anchorage, AK 99501	271-2888
Carl Burger Fisheries Biologist	U.S. Fish and Wildlife Service 1011 East Tudor Road, Anchorage, AK 99503-6199	786-3314
Barbara Mahoney Fisheries Biologist	National Marine Fisheries Service 222 W. 7th Ave., Suite #43, Anchorage, AK 99513	271-5006
Phil North Environmental Res. Specialist	U.S. Environmental Protection Agency 222 W. 7th Ave., Suite #19, Anchorage, AK 99513	271-5083
Dan LaPlant Biologist	Soil Conservation Service 201 E. 9th Ave., Suite 300, Anchorage, AK 99501	271-2424
Suzanne Fisler Park Ranger	Department of Natural Resources, Division of Parks & Outdoor Recreation P.O. Box 1247, Soldotna, AK 99669	262-5581
Hank Baij Biologist	Department of the Army, Alaska District Corps of Engineers, Regulatory Branch P.O. Box 898, Anchorage, AK 99506	753-2712