# Susitna-Watana Hydroelectric Project
# (FERC No. 14241)

# Characterization and Mapping of Aquatic Habitats
# Study Plan Section 9.9

# Final Study Plan

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

August 2013

## 9.9. Characterization and Mapping of Aquatic Habitats

On December 14, 2012, Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP), which included 58 individual study plans (AEA 2012). Included within the RSP was the Characterization and Mapping of Aquatic Habitats, Section 9.9. RSP Section 9.9 focuses on describing the aquatic habitats of the Susitna River using a specific hierarchical and nested classification system based on historic and current data.

On February 1, 2013, FERC staff issued its study determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. FERC requested additional information before issuing a SPD on the remaining studies. On April 1, 2013 FERC issued its study determination (April 1 SPD) for the remaining 14 studies; approving 1 study as filed and 13 with modifications. RSP Section 9.9 was one of the 13 approved with modifications. In its April 1 SPD, FERC recommended the following:

*Edge Habitat*

> *- We recommend that AEA remove the level 5 calculation of edge habitat from the habitat classification system.*

*Backwater and Beaver Dam Habitats*

> *- We recommend changing the classification of backwater, beaver complex, and clearwater plume habitats from level 3 (mainstem habitat) to level 4 (mainstem and tributary mesohabitats).*

*Classification of Upper River Tributaries*

> *- We recommend that AEA consult with the TWG and file no later than June 30, 2012, the following information to quantify small and low-order tributaries in the Upper River study area:*
>
> > *1) A detailed description of the specific methods to be used for selecting a representative sample of small and low-order Upper River tributaries for aquatic habitat mapping.*
> >
> > *2) Documentation of consultation with the TWG, including how its comments were addressed.*

*Habitat Mapping at Multiple Flows*

> *- We recommend modifying the study plan to have AEA identify and give specific consideration to backwater habitats, as defined by the agencies (i.e., the confluence of off-channel habitats with main channel habitats), as a unique habitat feature and ensure a representative subsample of these locations when selecting transect locations for one-dimensional or two-dimensional aquatic habitat modeling within Middle River and Lower River instream flow study sites.*

*Classification of Middle and Lower River Tributaries*

> *- We recommend modifying the study plan to have AEA classify Middle River tributary reaches within the zone of hydrologic influence into geomorphic reaches based on tributary basin drainage area and stream gradient to provide a general understanding of the relative*

*potential value to fish and aquatic resources, and report on these attributes in the initial and updated study reports.*

*Habitat Mapping and Ground-Truthing*

*- We recommend that AEA provide a detailed description of methods and results of 2012 and 2013 habitat mapping in the initial study report, including a complete set of photographic base maps delineating macrohabitats (level 3) and mesohabitats (level 4) for all mapped locations.*

In accordance with the April 1 SPD, AEA has adopted the FERC requested modifications. On July 18, 2013, AEA filed the Characterization and Mapping of Aquatic Habitats Technical Memorandum with FERC. Information in the Technical Memorandum supersedes relevant details within this Final Study Plan.

### 9.9.1. General Description of the Proposed Study

This study plan describes a Susitna River-specific hierarchical and nested classification system developed with input from the Fish and Aquatics Technical Workgroup (TWG). The classification system as proposed includes modifications based on “lessons learned” during implementation of initial ground surveys in 2012, evolving needs of other dependent studies, completion of the aerial video in 2012, and inclusion of licensing participants’ comments and FERC recommendations on the Proposed Study Plan.

The Susitna River habitat classification system has four main mapping components that correspond to river segments and water bodies within those sections. The four components are: 1) the mainstem Susitna River from the Oshetna River confluence (approximately RM 233) downstream to the Chulitna River confluence (approximately RM 98); 2) Upper River and Middle River tributaries up to the upper limit of the zone of hydrologic influence (ZHI); 3) lakes that are within the proposed reservoir inundation zone and 4) the lower River from RM 98 to the upper end of tidal influence (approximately RM 28). The first three mapping components will delineate and map habitats to a mesohabitat level, Level 4 (Table 9.9-5). However, because of the very large size and channel complexity of the Lower River (Figure 9.9-18) it is impractical to map the Lower River Segment beyond Level 3 (Mainstem Habitat Type). Furthermore, results from the 2012 video imagery indicate that the Lower River appears to contain only two out of five mesohabitat types (glides and riffles). The low gradient and aggraded gravel bed of the Lower River is generally not conducive to the formation of other mesohabitat types, such as pools or runs, although they likely are present in very low numbers. Thus the need to delineate habitat to this finer scale is not necessary in the Lower River.

The Susitna River habitat classification system combines the historic approach (ADF&G 1983a) to mainstem habitat classification and a modified version of the mesohabitat classification system from the USFS Aquatic Habitat Surveys Protocol (USFS 2001). This hybrid classification system will describe habitats that are defined by the unique hydrology of this river system, yet are significant to the day-to-day function and behavior of fish and aquatic organisms.

This study will be valuable for gathering baseline habitat data that can be used along with other data being gathered (e.g., fish distribution and abundance, water surface elevation and discharge relationships, instream flow modeling, flow routing) to assess potential impacts associated with proposed Project operations.

## 9.9.2. Study Goals and Objectives

Construction and operation of the Project will modify the aquatic habitat in the area inundated by the Project reservoir and has the potential to alter aquatic habitats in the mainstem channel of the Susitna River downstream from the Project dam, including along channel margins, at tributary confluences, at the inlets and outlets to side channel sloughs, and off-channel water bodies in the zone of hydrologic influence. The goal of this study is to characterize and map all aquatic habitats with the potential to be altered and/or lost as the result of reservoir filling, hydropower operations, and associated changes in flow, water surface elevation, sediment regime, and temperature. Study objectives for collecting baseline data vary depending on the nature of the potential Project effects and where in the study area the effects may occur. Study methods will, therefore, also vary within the study area. Objectives are described below according to the following breakdown.

**Upper River Tributaries and Lakes:**

- **a.** Characterize and map Upper River tributary and lake habitat for the purpose of evaluating the potential loss or gain in available fluvial habitat that may result from dam emplacement and inundation by the reservoir.
- **b.** Characterize and map Upper River tributary and lake habitat for the purposes of informing other studies including Fish Distribution and Abundance in the Upper River (Section 9.5) and River Productivity (Section 9.8).

**Susitna Mainstem:** Objectives for the mainstem Susitna River vary depending on the river segment.

- **a.** Characterize and map the Upper River mainstem upstream from the Watana dam site to the confluence with the Oshetna River:
    - **i.** To provide baseline data for the purpose of evaluating the potential loss or gain in accessible available fluvial habitat that may result from dam emplacement and inundation by the reservoir.
    - **ii.** To inform other studies including Fish Distribution and Abundance in the Upper River (Section 9.5), River Productivity (Section 9.8), and Future Watana Reservoir Fish Community and Risk of Entrainment (Section 9.10).
- b. Characterize and map the Middle River mainstem from the Chulitna River confluence to the proposed Watana Dam site, including tributaries within the zone of hydrologic influence (ZHI[1]):
    - **i.** To provide baseline data for the purpose of evaluating the potential loss or gain in accessible available fluvial habitat that may result from flow regulation below the proposed Watana Dam.

[1] The ZHI (zone of hydrologic influence) is defined as the approximated section of tributary extending from the Susitna River's modeled water's edge at a 1.5 year flow return interval downstream to the tributary's confluence with the Susitna River at a base flow.

**ii.** To inform other studies including Fish Distribution and Abundance in the Middle and Lower River (Section 9.6), River Productivity (Section 9.8), and Instream Flow (Section 8.5).

**c.** Characterize and map the Lower River mainstem from the upper limit of tidal influence to the Three Rivers Confluence:

**i.** To provide baseline data for the purpose of evaluating the potential loss or gain in available fluvial habitat that may result from flow regulation below the proposed Watana Dam.

**ii.** To inform other studies including Fish Distribution and Abundance in the Middle and Lower River (Section 9.6), River Productivity (Section 9.8), and Instream Flow (Section 8.5).

### 9.9.3. Existing Information and Need for Additional Information

During the 1980s study efforts, habitat characterization and mapping in the Middle River mainstem were conducted at a relatively coarse scale; mainstem habitat types that were representative of distinct functional hydrology and channel morphology were identified. Under this system, the Susitna River was classified into seven mainstem habitat types: mainstem channel, side channel, side slough, upland slough, tributary mouth, tributary, and lakes, defined by source water and hydrologic connectivity (Trihey 1982; ADF&G 1983a). For example, side channels were described as side channels that carried less than 10 percent of the mainstem flow, whereas sloughs were identified as having a water source derived from some combination of groundwater, tributaries, and/or local runoff. Upland sloughs, unlike side sloughs, were those that were disconnected from mainstem flows at their heads. These seven mainstem habitat types were mapped in the Middle River based on aerial photography and were given individual alpha-numeric identifiers such as “Slough 22” (ADF&G 1983a). Subsequent sampling of fish populations and collection of water quality and habitat suitability data were conducted in subsets of the mapped habitats. Additional habitat characterization and mapping efforts developed during the 1980s defined unique categories of river habitat based on clear or turbid water conditions under specific flows, in combination with presence or absence of open water leads during winter (Steward and Trihey 1984 ) or hydrologic zones (ADF&G 1983a, 1983b). The habitat categories were focused on main channel and side channel habitats in intensively studied areas in an attempt to scale the information up to the entire Middle Susitna River Segment for simulating the relationship between habitat and flow.

Very little habitat information has been collected in the Upper Susitna River. In the early 2000s, the Alaska Department of Fish and Game (ADF&G) conducted sampling in the Upper Susitna River sub-basin as part of its Alaska Freshwater Fish Inventory (AFFI) program (Buckwalter 2011a). These surveys were focused on documenting fish presence and collecting reach-level habitat data in medium and large tributary drainages (Buckwalter 2011b). The AFFI habitat studies were conducted at a scale that is not necessarily informative for understanding impacts to fish use or productivity. Because the upper river surveys were focused on fish inventory, they applied a dispersed sampling design that covered 60 streams; however, habitat data were collected at only one transect per stream. The scale of these historic data collection efforts limits their applicability for evaluating fish-habitat relationships and the potential for changes in fish habitat use throughout the Susitna River as a result of hydropower facility development and operation.

To augment the historic habitat data, this study will characterize and map aquatic habitat at finer scales than did the 1980s studies, including to the mesohabitat level in the main channel and tributaries. Mapping of off-channel habitats will include refinements to the typing of off-channel habitats and typing and habitat metric sub-sampling in sloughs.

Characterization and mapping of mesohabitats is important in assessing potential impacts to fish populations because it is at this level that fish selectively use different habitats (Hardy and Addley 2001) to support different life stages and life functions. A full complement of mesohabitat types is required to sustain multiple life stages, support a diverse fish community, and furthermore, the distribution of these habitats throughout the river will influence fish distributions. Fine-scale habitat attributes, such as those found at the mesohabitat level, are thought to be particularly relevant to aquatic organisms. Organisms interact with their environment at different scales depending on their size and mobility (Parasiewicz 2007), both of which change with growth and development. Parasiewicz (2007) further suggested that mesohabitats are habitats within which an organism can be observed for a significant portion of its daily routine, similar to functional habitat discussed by Kemp et al. (1999). For this study, information will be collected to support the development of habitat descriptions at more ecologically significant scales by considering several attributes that are biologically important to fishes (Harper et al. 1992; Maddock 1999). The higher-scale mainstem habitat classifications used in the 1980s will be retained to allow for some level of comparison over time.

In addition to considering the scale of habitat classification, it is also important to consider the use of an objective classification approach that not only captures existing site-specific characteristics, but also can be used for comparisons across space and time. Mesohabitat assessments based on river morphology and ecologically significant habitat attributes should be consistent and reproducible. The USFS Aquatic Habitat Surveys Protocol (USFS 2001) is an example of a standardized protocol that was developed in Alaska to facilitate creation of a regional stream habitat database as well as one that allows for aggregation of habitat data at multiple scales. The USFS 2001 protocol is integrated into the habitat mapping study design described in this study.

Sources of existing information that will directly support habitat mapping are outlined in Table 9.9-1.

Existing fish, habitat, and aquatic resource information appears insufficient to address the following issues that were identified in the PAD (AEA 2011b).

- **F1:** Effect of change from riverine to reservoir lacustrine habitats resulting from Project development on aquatic habitats, fish distribution, composition, and abundance, including primary and secondary productivity.
- **F2:** Potential effect of fluctuating reservoir surface elevations on fish access and movement between the reservoir and its tributaries and habitats.
- **F4:** Effect of Project operations on flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity. The effect of Project-induced changes include stream flow, stream ice processes, and channel morphology (streambed coarsening) on anadromous fish spawning and incubation habitat availability and

suitability in the mainstem and side channels and sloughs in the Middle River above and below Devils Canyon.

- **F7:** Influence of Project-induced changes to mainstem water surface elevations from July through September on adult salmon access to upland sloughs, side sloughs, and side channels.
- **F9:** The degree to which Project operations affect flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity.

The information collected during this study will be essential to understanding fish habitat distribution and will provide information relevant to addressing the five potential fisheries issues listed above.

## 9.9.4. Study Area

The study area encompasses the mainstem Susitna River from the Oshetna River confluence at approximately RM 233 downstream to the upper extent of tidal influence at approximately RM 28. As described above, the mainstem study area is further divided according to geomorphic/hydrologic river segments; the Upper River, Middle River, and Lower River (see Figure 9.5-1). The study area also encompasses tributaries in the Upper River (RM 180 to 233) and Middle River segments (RM 98 to 18). The study area for tributaries is described as follows. Note that the study area for selected tributaries in the Upper River has been modified in accordance with the Characterization and Mapping of Aquatic Habitats Technical Memorandum that was reviewed by the agencies and filed with FERC on June 30, 2013.

- **Upper River:** For selected streams in watersheds known to support Chinook salmon, the habitat mapping study area extends up to 3,000 feet elevation, unless a permanent impassable barrier exists between 2,200 and 3,000 feet elevation. If a barrier exists within this range surveys will stop at the barrier. In watersheds not known to support Chinook salmon, the habitat mapping study area will terminate at 2,200 feet elevation regardless of the presence of a barrier below this elevation.
- **Middle River:**
    - For selected streams above Devils Canyon known to support Chinook salmon, the study area extends up to 3,000 feet elevation or the first impassable barrier, whichever is less.
    - For all other selected tributaries in the Middle River the study area extends from the confluence with the mainstem up to the upper limit of the zone of hydrologic influence.

## 9.9.5. Study Methods

### *9.9.5.1. Overview*

Given the linear extent and remoteness of the river, an approach that combines analysis of aerial imagery with ground-based collection of habitat data will be used. This combination of methods will allow for maximizing coverage of river habitats in concert with efficient collection of detailed data at selected habitats. Furthermore, the habitat characterization methods can be tailored to accommodate variations in channel size and overall stream length. Habitat data collected in this study will utilize the Susitna-Watana Hydroelectric Project habitat classification system that was developed during 2012 study design and planning process and standard protocols outlined in the USFS Aquatic Habitat Surveys Protocol (USFS 2001). The USFS protocol will be subject to minor modifications regarding parameter data collection to allow for site specific characterization, for example maximum depth will not be collected in deep mainstem channel habitats.

Because of the major differences in channel morphology and hydrology between tributaries and the mainstem river and because Project effects are different in different geomorphic segments of the river, habitat mapping methods are differentiated within the study area as follows.

- Tributaries
    - Tributaries in the Upper River
    - Tributary segments in the Middle River
- Mainstem
    - Upper River mainstem
    - Middle River mainstem
    - Lower River mainstem

#### *9.9.5.2. Overview of Aerial Video for Habitat Mapping*

Low altitude aerial video can be an excellent tool when mapping mesohabitats over long distances in remote and challenging topography. Low altitude aerial video combined with ground sub-sampling for habitat mapping studies has been used in numerous FERC hydro project relicensings in Washington, California, Texas, and North and South Carolina. When shot with a professional high definition (HD) camera from a helicopter at a slow speed (15 to 40 mph, depending on stream size), low height (75-300 feet), under good lighting conditions, good water clarity, and a fairly open canopy, the video provides an up-close and panoramic view of all the stream's features. To maximize the quality of the video, it is shot in an upstream direction from the right rear of a helicopter with its cabin door removed. A narrator/navigator is positioned in the left front next to the pilot. From this low elevation, the viewer can clearly discern mesohabitat types, channel character, dominant substrate classes, woody debris, and riparian vegetation. Figure 9.9-1 is a screen capture from an aerial video of an Upper Susitna River tributary.

Aerial video collected in early September 2012 (before the mid September flood) included the 12 primary and 4 secondary[2] tributaries above Devils Canyon (Table 9.9-2), the Upper River mainstem, and the Middle River mainstem. While glare and swirling winds were a problem on a few tributaries, conditions were excellent overall. In addition, test video was shot of the Lower River between RM 65 and RM 81 to determine the practical and technical application of aerial

[2] For the purpose of this Final Study Plan a tributary that confluences directly with the Susitna River is referred to as a primary tributary. A tributary that confluences with a primary tributary is referred to as a secondary tributary and a tributary that confluences with a secondary tributary is referred to as a tertiary tributary.

video for habitat characterization in the wide and highly braided Lower River. Use of video in the Lower River is discussed further in Section 9.9.5.4.3. The final video product will include live narration, on-screen continuous global positioning system (GPS) position, rivermile to the tenth of a mile, and running time to the tenth of a second.

The digital video file is playable using standard media player software, such as VLC, which supports many useful player controls including screen capture and can be downloaded as freeware at http://www.videolan.org/vlc/download-windows.html. Digital video files will be made available to licensing participants through AEA.

### *9.9.5.3. Upper and Middle River Tributary Habitat Mapping above Devils Canyon*

Upper River and Middle River tributaries above Devils Canyon will be mapped using results of the AEA 2012 low-altitude aerial video and in-river habitat ground survey sub-sampling. Low altitude video surveys will only be used to type mesohabitats where they are clearly visible; otherwise, ground based surveys will be conducted. Whether aerial video is also used to describe other habitat variables, such as woody debris or dominant substrate size, will be determined on a stream-by-stream basis and once such application is determined necessary and valid. Aerial video will not be used to directly estimate channel dimensions.

#### *9.9.5.3.1. Application of Aerial Video for Mapping Upper and Middle River Tributaries above Devils Canyon*

Habitat in the 12 primary tributaries and 4 secondary tributaries (Table 9.9-2) will be typed to the mesohabitat level shown in Table 9.9-3 using a video sampling method. Tributaries that are not conducive to aerial video mapping, such as those with obscured view of the river due to riparian vegetation, will be mapped using ground methods only. The need and method for mapping tributaries of a lower stream order than those listed in Table 9.9-2 will be determined with input from the TWG prior to the 2013 field season. Smaller tributaries may not support fish and as such may not require mapping. Alternatively, if they are mapped, it may be that they are sub-sampled or a representative subset of tributaries could be selected by a randomized method.

In response to the FERC April 1 SPD and consultation with the TWG, AEA will habitat map an additional 19 small primary and secondary tributaries in the Upper River that are not conducive to aerial video mapping. Refer to section 9.9.5.3.2.3 below and the attached Technical Memorandum for more information regarding selection and mapping methods for smaller non-videotaped tributaries.

In video sampling, first a string is stretched horizontally across the computer monitor at about the center. The video is then played from the beginning at normal or slow speed and paused at a predetermined time interval. When paused, the mesohabitat type that is directly crossed by the line is classified and entered into an Excel spreadsheet with the corresponding running time, e.g. 00hrs:12mins:3secs_riffle. A time interval between 3 and 5 seconds, depending on the stream width and mesohabitat length, e.g., geomorphic reaches with short habitat units may have 3-second intervals, while reaches with long habitat units may have 5-second intervals. For example, at an average speed of 18 mph and a recommended 3-second interval for tributaries, a sample is taken approximately every 80 feet or 66 samples per mile. Most of the of the video taped tributaries (Kosina, Watana, Deadman, etc.) are over 10 miles long, which would result in over 600 mesohabitat samples in each tributary under that time interval.

A library of aerial video screen captures (mesohabitat type-index) will be built that includes several variants of each mesohabitat type (Figure 9.9-3 through Figure 9.9-16). The video "mapper" will constantly refer to the library of image captures to ensure accuracy and consistency in mesohabitat typing. Ideally the type-index images would be ground-verified prior to use in the video mapping. However, ground sub-sampling of all tributaries will not be completed until 2013. Therefore, for some streams, the completed video frequency analysis will need to be reviewed and checked against ground mapping later in 2013 and revised if needed. Given the low altitude perspective and clarity of the video, most mesohabitat types will be easily and accurately classifiable without ground verification.

The primary result of the video mapping is a mesohabitat frequency of 100 percent of the tributary study area. This frequency analysis can also be subdivided by geomorphic reach. Histograms and tables of mesohabitat type frequency will be produced. The metadata can also be used for other studies such as selection of random mesohabitat units for fish population surveys.

The method proposed above is a random sampling and replicable method. It is random for several reasons: a) the speed of the helicopter is changing by a few tenths to a few miles per hour several times per minute; b) because the camera is hand-held and the altitude of the helicopter is constantly changing the angle of the lens relative to the ground is constantly changing; c) the height above the ground is constantly changing by a few to tens of feet; and, d) the sequence and lengths of mesohabitat types is highly variable in mountain streams. All these factors contribute to a constantly varying ground distance between sample points, even though the sample time interval is constant. The video sampling method has also been tested for "replicability", as described below.

To be certain mesohabitat typing using video is a reliable tool and the results are replicable, an analysis of the replicability of results was conducted recently in a California hydroelectric project relicensing. To check the general replicability of the habitat type identification, an independent reviewer conducted video mapping of randomly selected ground-verified segments representing 20 percent or more of three PHABSIM reaches. Because ground-truthing is an essential component of video mapping, the independent reviewer had also participated in the habitat mapping ground surveys, but not on the test stream segment. The three PHABSIM reaches selected represented a variety of channel and habitat types: wide, open canopy; variable gradient and canopy coverage; and a smaller, higher-gradient channel. The test concluded that the aerial video habitat mapping method is a reliable tool and that differences between replicates would be minimal; therefore, differences between one investigator and another would be minimal, as long as the investigators were involved with the ground mapping and were given clear definitions and type-index images of the various mesohabitat types. An added value of the video record is the ability to check a habitat typing call with another researcher, if in doubt.

Within each geomorphic reach, habitats will be typed to the mesohabitat level according to a nested hierarchical classification system developed in part with input from the Fish and Aquatic TWG (Table 9.9-4). Note that the mesohabitat categories have been nested and expanded to accommodate the high diversity of habitat types found in the tributaries during 2012 video and ground surveys.

##### *9.9.5.3.2. Ground Mapping Upper and Middle River Tributaries above Devils Canyon*

Because of the general inaccessibility, very rugged terrain, and mostly non-wadeable stream channels, near census mapping (100 percent coverage) would be very challenging and in some cases unsafe or impossible. For this reason AEA proposes to map habitat in 16 Upper and Middle Susitna River tributaries (Table 9.9-2) using a combination of video, as described above, and on-the-ground sub-sampling described below. Ground mapping will be done at a low to moderate flow that is relatively near in discharge as the flow during the aerial video. In other words, at a flow that will allow similar habitat type calls for the two methods. AEA, in collaboration with the TWG, will determine how many and which smaller independent tributaries, and how many and which smaller tributaries to the primary tributaries need to be mapped. Refer to section 9.9.5.3.2.3 below and the attached Technical Memorandum for more information regarding selection and mapping methods for smaller non-videotaped tributaries.

###### 9.9.5.3.2.1. Geomorphic Reach Delineation

Using desk-top tools including IFSAR topographic contour data, U.S. Geological Survey (USGS) topographic maps, aerial video, and information from reconnaissance flights, tributaries will first be segmented into geomorphic reaches where the channel is relatively homogeneous in stream gradient, confinement, and hydrology. Major breaks in each of these parameters will constitute a geomorphic/hydrologic reach boundary. Hydrologic reach breaks will be established at tributaries that appear to contribute more than approximately 10 percent of total flow to the parent tributary. A segment boundary will not be placed where downstream channel characteristics are primarily controlled by bedrock rather than fluvial processes. Bedrock channels are generally insensitive to short-term changes in sediment supply or discharge. Only a persistent decrease in discharge and/or an increase in sediment supply sufficient to convert the channel to an alluvial morphology would significantly alter fluvial bedrock channels (Montgomery and Buffington 1993). For this reason, flow accretion will only be used as a factor for segmentation at locations where channel characteristic below the contribution point are controlled by fluvial processes.

###### 9.9.5.3.2.2. Ground Mapping in Videotaped Streams

Within each geomorphic reach type, continuous habitat surveys will be conducted over a distance equivalent to at least 20 channel widths with the goal of sampling at least five units of each of the primary mesohabitat types occurring in the geomorphic reach. Primary is defined as mesohabitat types with a frequency in the geomorphic reach type of greater than 10 percent. Survey distance will be extended, either contiguously or at another location in the geomorphic reach, until the requisite number of replicates is obtained. If accessible by foot or helicopter, e.g. not in the bottom of a gorge, habitats with a frequency lower than 10 percent also will be surveyed, but data will be collected on five replicates or fewer.

Because helicopter landing zones in the uplands near the tributaries are extremely limited, a randomized approach for selecting mapping sections is impractical. A high percentage of randomly selected sites would likely not be accessible, and, when one was accessible, in-channel accessibility over a distance of 20 or more channel widths would likely also be a problem. Instead, sub-sample sites within each geomorphic reach will be selected based first on access to the site by helicopter and foot and second on the availability of multiple and varied mesohabitat types within safe and reasonable hiking/wading access. The concept of segmenting the stream into geomorphic reaches assumes that mesohabitat types within the segment are generally similar.

Channel metrics to be sub-sampled on the ground will be collected using a modified U.S. Department of Agriculture, Forest Service (USFS) Tier I and Tier III stream habitat survey protocol (2001). Note that some of the variables listed in the USFS protocol assume the stream being surveyed is wadeable.

Ground survey crews in 2012 were not able to effectively or safely collect some of the Tier I or Tier III variables that were proposed for collection in the PSP. In many of the primary tributaries in the Upper Susitna, habitat variables that involved crossing the streams were very difficult to collect given the difficult wading conditions in most reaches. Flows, even during late summer seasonal lows, were too fast and deep to negotiate at most points along the streams. Wading factors were typically above 8-9 (product of depth x velocity) over predominantly boulder substrate. Depths of 2.5 – 3 feet in combination with velocities of 3 to 4 feet per second around boulder substrates were very common in the Upper Susitna tributaries. Crossings with lesser wading factors were few and far between. As a result, some variables that were included for collection in the PSP have either been eliminated or the collection method or frequency of collection has been modified in this RSP.

Aquatic habitat surveys will be conducted by two-person survey crews. Each survey crew will consist of a fish biologist and qualified fisheries technician. Survey sections will begin at a predetermined location based on the survey section selection process described above and will progress in an upstream direction. If a permanent impassable barrier is encountered below the 2,200-foot elevation point, the barriers will be documented and surveys will continue upstream to the survey end. If a permanent impassable barrier is encountered above the 2,200-foot elevation point ground sub-sampling surveys will not be conducted beyond that point.

In stream sections with complex channel morphology (e.g., three or more parallel channels), the primary and one secondary channel will be designated and will be fully mapped. The remaining secondary channels will be identified and typed using the aerial video. In a highly complex channel type (Figure 9.9-16) the unit will be more characterized than mapped, e.g. length, width, number, type of sub-channels, and the general mesohabitat type present.

Habitat data will be recorded on the stream survey field data form. Separate stream survey data sheet(s) will be completed for each geomorphic reach. Habitat parameters to be measured for this component of the study are described in Section 9.9.5.3.2.4 and 9.9.5.3.2.5.

###### 9.9.5.3.2.3. Ground Mapping of Smaller Tributaries within the Upper River Inundation Zone

Most small tributaries in the Upper River inundation zone are obscured from overhead view due to a closed canopy of riparian vegetation. For this reason, small tributaries in the Upper River inundation zone can only be mapped using ground survey methods.

AEA will ground map 4 small unnamed tributaries in the Upper River that are also being sampled for fish distribution and abundance (Table 9.9.2). As described in the Attached Technical Memorandum, AEA will also ground map an additional 10 smaller primary tributaries and 5 secondary/tertiary tributaries in the Upper River inundation zone that are not being sampled for fish distribution and abundance. The total number of small primary and secondary tributaries to be ground mapped only (without video) in the Upper River inundation zone is 19.

Ground-map-only tributaries will be segmented into geomorphic reaches using the approach described above in Section 9.9.5.3.2.1.

Within each geomorphic reach type, habitat surveys will be conducted over a distance equivalent to 20 channel widths. Depending on access to and along the stream, the 20 channel width section may be a continuous section or broken up into 2 or more accessible lengths. Because most of the small tributaries in the inundation zone are heavily forested, access by helicopter or cross-country to any point along the stream will be problematic. Therefore, the starting and ending points of habitat mapping survey sections will largely depend on access. Most small and shorter streams will be accessed by helicopter to a landing zone along the Susitna River near the mouth of the tributary. In the lower geomorphic reach, surveyors will begin the 20 channel width mapping section just upstream of the ordinary high water line of the mainstem. Upstream geomorphic reaches will be mapped only if safe and reasonable access by helicopter is available. Whether a landing is safe will be determined by the helicopter pilot. Whether access is reasonable will be determined by the field crew lead and will depend primarily on the distance and difficulty of cross country travel from the helicopter landing zone to the stream section to be mapped. Conditions preventing access will be documented when access is not attempted.

Mapping methods and protocols for small tributaries will be the same as those for larger tributaries, as described in this section.

#### 9.9.5.3.2.4. Tier I Data Collection

The following habitat metrics will be collected for each geomorphic reach:

- Geomorphic reach type (confined, similar gradient, similar hydrology)
- Channel type (primarily single thread, primarily split, primarily braid, or combination with estimated percent of each type)
- Measured bankfull width
- Measured or estimated bankfull maximum depth
- Measured gradient
- Estimated dominant substrate composition
- GPS location of channel measurements

Note that incision depth was eliminated at Tier I because collection generally requires crossing the stream.

#### 9.9.5.3.2.5. Tier III Data Collection

The following habitat metrics will be collected for each mesohabitat unit.

- Habitat unit type
- Measured unit length
- Measured average wetted width (three measurements per unit)
- If pool, estimated or measured maximum depth
- If pool, estimated or measured pool crest depth

- Estimated average maximum depth of unit
- Measured width of unit
- Woody debris count in unit
- Estimated percent substrate composition in unit
- Estimated percent undercut, each bank in unit
- Estimated percent erosion, each bank in unit
- Estimated percent riparian vegetation cover in unit
- Dominant riparian vegetation type for each unit
- Estimated percent instream cover in unit
- Photograph of each unit
- GPS location of each unit

Habitat units within the survey section will be sequentially numbered as they are encountered during each survey, and data will be recorded for each habitat unit. Data collected for all habitat units will include the unit length, the mesohabitat type according to Table 9.9-3, three measurements of wetted width from which an average wetted width will be calculated, percent substrate composition, percent eroding bank on each side of the channel, percent undercut bank on each side of the channel, dominant riparian vegetation type, cover type, and cover percent.

Additional data will be recorded for pool habitat units. The maximum pool depth and depth at the pool tail crest will be measured to the nearest 0.1 foot, whenever possible. These data will be used to calculate residual pool depth. The structural feature responsible for forming the pool will be identified (e.g., boulder, undercut bank, large or small wood).

Split channels are defined as separate flow paths located within the bankfull channel and separated from each other by gravel bars that are barren or support only annual vegetation. When split flow is encountered, each split will be surveyed and the proportion of flow conveyed by the split will be estimated, recorded, and used to classify each channel as primary (majority of the flow) or secondary (minority of the flow). Habitat units in the split that convey the most flow will be designated primary units and will continue to be numbered sequentially as part of the main channel survey. Where more than two split channels exist, only the primary and secondary splits will be numbered. The data form will note the total number of split channels.

Side channels are defined as features with a fluvial-sorted mineral bed that are separated from the main channel by an island that is at least as long as the main channel bankfull width and that supports permanent vegetation. At a minimum, the inlet and outlet of each side channel will be documented by collecting a GPS waypoint and taking a photograph looking upstream from the outlet and downstream from the inlet. The side channel will be identified as entering from the left or right bank (looking downstream) and classified as wet or dry. Habitat data will be collected in wetted side channels according to the methodology described above. Where more than two side channels exist, only the primary and secondary channels will be numbered. The data form will note the total number of split channels.

Relative flow levels on the day of the survey will be estimated according to the following:

- **Dry**
- **Puddled:** Series of isolated pools connected by surface trickle or subsurface flow.
- **Low Flow:** Surface water flowing across 50 to 75 percent of the active channel surface. Consider general indications of low flow conditions.

- **Moderate Flow:** Surface water flowing across 75 to 90 percent of the active channel surface.
- **High Flow:** Stream flowing completely across active channel surface but not at bankfull.
- **Bankfull Flow:** Stream flowing at the upper level of the active channel bank.
- **Flood Flow:** Stream flowing over banks onto low terraces or floodplain.

In addition, Susitna River mean daily discharge will be obtained from the nearest downstream USGS stream gauge and entered onto each day's survey forms.

**Special Habitat Features**

Special habitat features include tributary channels, seeps and springs that contribute groundwater to the mainstem, and temporary (e.g., subsurface flow) or permanent barriers to upstream fish migration. A separate data sheet will be maintained for each reach listing the type, location, and a description of special habitat features.

For features classified as stream barriers, the following information will be recorded in the comments section. Only cursory information will be collected under the Habitat Mapping study as most of the following barrier data is being collected under the Fish Passage Barrier Study Plan (Section 9.12).

- Barrier type (beaver dam, debris dam, vertical falls, chute/cascade, boulder, other)
- Temporal nature (ephemeral or permanent)
- Maximum height of falls or biggest single step if cascading
- Maximum depth of plunge pool
- Chute/cascade gradient and length
- Length of feature.

A GPS waypoint and a photograph will be taken of each special feature. Additional photographs will be taken of representative channel conditions throughout each reach. The photo number, waypoint, date, and associated habitat unit or feature number will be recorded for each photograph.

### *9.9.5.4. Mainstem Habitat Mapping*

The mainstem Susitna River from the Oshetna River to the upper extent of tidal influence includes approximately 200 miles of river and many times more than that distance when the lengths of side channels, braided channels, and sloughs, are included. An approach that includes the use of aerial imagery and collection of ground-based habitat data is required given the linear extent of this large river, its channel complexity, and its remoteness. This combination of methods will allow for maximizing coverage of river habitats in concert with ground sub-sampling at selected habitat areas. Furthermore, this combination allows habitat characterization and mapping methods to be tailored to accommodate different study objectives, different mapping tools available, and different methods, depending on the specific river segment.

#### *9.9.5.4.1. Upper River Mainstem*

The Upper River will be mapped using hierarchically-nested habitat typing adapted to feasible identification levels based on the use of aerial still imagery, LiDAR, and aerial videography. A linear network will be created in GIS by drawing lines through the middle of the stream channel as viewed by aerial imagery or LiDAR. The reference imagery was collected at river flows generally ranging from 10,000 to 12,000 cfs, which will be considered a representative mid-flow to conduct mapping. Divided channels will have multiple lines representing that stream section. Main channel and off-channel habitat will be delineated. The length of the lines will be based on mesohabitat classification for the main channel and macrohabitat classification for off-channel habitat. Each individual vector line will have a length and a hierarchical-tiered habitat classification organized in "Levels".

The habitat classification hierarchy will be composed of four levels representing (1) major hydraulic segment; (2) geomorphic reach; (3) mainstem habitat type; and, (4) main channel mesohabitat (Table 9.9-5). Level 1 will generally identify the Upper, Middle, and Lower River from each other. Level 2 will identify one of six unique reaches established from the channel's geomorphic characteristics (established from the Geomorphology Mapping Study). Level 3 will classify the mainstem habitat type of main, off-channel, and tributary habitat using an approach similar to the 1980s historical habitat mapping definitions (ADF&G 1983a). All off-channel habitats will be classified to Level 3 and all main channel habitat will be identified to Level 4 mesohabitat type (i.e., riffle, pool, run, etc.).

A series of tables and figures were created to illustrate the habitat mapping approach and also the analyses that will be conducted from the data. Figure 9.9-17 shows an example of how habitat will be visually mapped from a GIS layer. An example of the raw database is shown in Table 9.9-6. The GIS database will create a hierarchical table that will be used to summarize the proportion of habitat by mapped unit of length (Tables 9.9-7 and 9.9-8). The tiered approach will allow for summaries at all five levels to support resource study planning. The table will also provide individual identification of all unique habitat types. This information will be important to understand how to best represent the Upper River.

Several controls will be established to ensure that the habitat mapping effort is both precise and accurate. Habitat typing will be conducted by no more than two GIS technicians to ensure typed habitat is consistent. Examples of specific aerial images of habitat as related to the levels will be created. These examples will be reviewed and confirmed by the technical lead and provide a voucher reference to help identify habitat types. Also, all typed data will be identified as having clear or turbid water to better identify slough habitat and correct any habitat typing errors. Final habitat typing will be reviewed by the technical lead to ensure consistency and accurate habitat mapping.

In addition to the remote mapping, on-the-ground truthing and refinement will occur. In 2013, a subset of off-channel and main channel habitat units will be ground-mapped and will include metrics described for tributaries, e.g., depth, width, wood, cover, etc., as appropriate, for off-channel and main channel habitats. Five to ten main channel mesohabitat units and five to ten off-channel habitat units of each type will be randomly selected for sub-sampling. If there is fewer than the selected number, all units of that habitat type all will be sub-sampled.

##### *9.9.5.4.2. Middle River Mainstem*

The Middle River mainstem will be mapped in similar fashion to the Upper River mainstem. The hierarchical tiered classification system will be implemented to identify habitat from aerial still imagery, LiDAR, and aerial videography. The Middle River habitat data will also be used by the Instream Flow study to establish habitat complexity and frequency. All habitat segments will be identified using a mid-channel line, which will provide habitat length; however, off-channel slough habitat will be drawn separately in an area (polygon) in the Middle River to identify the size of each slough and better characterize slough diversity for Instream Flow Study needs. Area mapping will be reported separately from the linear database.

On-the-ground habitat mapping (one hundred percent in Focus Areas) will identify backwater habitat as a unique habitat feature and will give special consideration to such features that meet the FWS and NMFS definition of backwater habitats[3]. This information will be used in the instream flow study to specifically include these habitat types in Middle River Focus Area 2D modeling.

The ten Focus Areas under consideration for modeling include a large number and diversity of side channels, side sloughs, upland sloughs, and tributary mouths, that in sum, would be representative of potential backwater habitats at off-channel and tributary mouths in the Middle River.

As described in RSP 8.5, the 2-D model will utilize a variable mesh (also referred to as flexible mesh) to model all off-channel and tributary confluences where backwater habitats are generally formed. A variable mesh allows a finer mesh to be used in areas where either the information desired or the condition being modeled requires higher spatial resolution (RSP 6.6.4).

As in the Upper River segment, in addition to the remote mapping, on-the-ground truthing and refinement will occur in the Middle River segment. In 2013, a subset of off-channel and main channel habitat units will be ground-mapped and will include metrics described for tributaries, e.g., depth, width, wood, cover, etc., as appropriate. Separate from Focus Area, 5 to 10 main channel mesohabitat units and 5 to 10 off-channel habitat units or each type will be randomly selected for sub-sampling. If there is fewer than the selected number of units of a habitat type, then all will be sub-sampled. Main channel and off-channel habitats in Focus Sites will be 100 percent mapped to the mesohabitat level. Ground mapping will include metrics described for tributaries, e.g., depth, width, wood, cover, etc., as appropriate, for off-channel and main channel

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[3] NMFS and FWS define backwater (i.e., mainstem and side channel backwater pools) as "Slow water habitats that form due to mainstem backwater up [to] abandon or active side channels separated from the mid channel by a visible current shear line. Water depth and velocity controlled by mainstem water surface elevation. Water physical and chemical characteristics reflect those of the dominant mainstem flow, however, the reduction in surface slope could increase sediment and organic matter deposition." In addition, NMFS and FWS have a separate definition for "tributary mouth backwater" habitats.

habitats. Mesohabitat metrics of surveyed sloughs will be directly extrapolated to non-surveyed sloughs of like type, i.e., slough or upland slough.

As defined for the Susitna-Watana licensing studies, the mainstem includes tributaries segments within the zone of hydrologic influence (ZHI). AEA proposes to habitat map the zone of hydrologic influence of 20 named and unnamed tributaries in the Middle River (Table 9.9-4). Nine tributaries occur within Focus Areas and 11 are located outside of Focus Areas. These 20 tributaries were selected based on their known fish use and based on their range of stream size and drainage basin area. Tributary segments in the Middle River mainstem that are within the zone of hydrologic influence will be mapped according to the methods described above for tributaries.

AEA will classify Middle River tributary reaches within the zone of hydrologic influence into geomorphic reaches based on tributary basin drainage area and stream gradient to provide a general understanding of the relative potential value to fish and aquatic resources, and report on these attributes in the initial and updated study reports.

#### *9.9.5.4.3. Lower River Mainstem*

Because of the very large size and channel complexity of the Lower River (Figure 9.9-18) it is impractical to map the entire river segment beyond Level 3 (Mainstem Habitat Type). Of the five mesohabitat types in Level 4, the Lower River appears to primarily differentiate into only glides and riffles. The low gradient and aggraded gravel bed of the Lower River is generally not conducive to the formation of other mesohabitat types, such as pools or runs, although they are likely present in very low numbers.

Whether the Lower River is mapped to Level 3 depends on the extent of mapping to be conducted under the Geomorphic Mapping Study, which will use existing LiDAR and aerial imagery from the Matanuska-Susitna Borough LiDAR and Imagery Project.

In early September 2012, AEA conducted a test to determine the possible application of aerial video for habitat mapping the Lower River. A one-mile wide segment was selected between RM 65 and RM 81. The test section was flown at three different heights above ground (AG). The number of parallel flight paths necessary to cover the river width at the three different elevations was as follows: one path at 2,650 feet AG; two paths at 1,700 feet AG; and four paths at 400 feet AG. The test showed that a height of 400 feet or lower with three to five paths in a mile-wide section would be necessary to visually differentiate mesohabitat types of riffle, glide, pool, or run, if they did occur. Further, several parallel paths would be extremely difficult to track even with GPS and would be very difficult to follow in the video.

In summary, this study will rely on the Geomorphic Mapping Study to map the Lower River to Level 3. Development of mapping methods beyond Level 3 will wait until results of the 2012 interim studies, particularly the hydrologic study, are reviewed and analyzed. The habitat characterization objectives for the Lower River will then be more clearly identified and defined.

### *9.9.5.5. Lake Mapping*

Lakes in the Upper River basin within the potential zone of reservoir inundation will be located, mapped, and identified in the Project GIS database. Mapping will include elevation, surface area, perimeter, maximum depth, presence of surface water connection to the Susitna River, and other relevant limnology information on a lake-by-lake basis.

There are 12 lakes currently known to be within the zone of reservoir inundation, according to the National Hydrography Database (NHD). These are shown by number in Figure 9.9-19

#### *9.9.5.6. Study Coordination and Updates*

Multiple studies will be collecting field data in 2013 to better refine habitat mapping databases. Instream flow studies (Section 8.5) will be conducting extensive physical and biological studies in 2013. Also, the Geomorphology studies (Sections 6.5 and 6.6) will be area mapping Focus Areas in 2013 that could provide more refined area habitat units, where available. All relevant collected data from other studies will be reviewed and assessed to determine if updating or modifying the habitat mapping database with the additional information will be beneficial and supportive to the overall study goals.

### 9.9.6. Consistency with Generally Accepted Scientific Practices

Studies to map and characterize aquatic habitats are commonly conducted during water resource development projects, including for hydroelectric projects as part of FERC licensing. Field studies will use protocols developed in consultation with agency representatives and modified from standard federal protocols developed for use in Alaska (USFS 2001) and will be consistent with the instream flow analysis. Remote mapping will utilize protocols similar to those performed at other hydroelectric projects.

### 9.9.7. Schedule

Habitat mapping ground surveys began in 2012 and will continue through 2013 with follow-up work in 2014 (Table 9.9-9). Aerial video data collection was conducted during the first two weeks of September 2012. Although not expected, any follow-up video work will occur in 2013. Habitat characterization of the Upper and Middle rivers began in 2012 and will continue into 2013. The Initial Study Report (ISR) and Updated Study Report (USR) will be filed in February 2014 and February 2015, respectively. Updates on study progress will be presented at Technical Workgroup meetings, to be held quarterly during 2013 and 2014.

### 9.9.8. Relationship with Other Studies

In addition to providing baseline information about aquatic resources in the Project area, aspects of the Characterization and Mapping of Aquatic Habitats Study are designed to complement and support other AEA studies (Figure 9.9-19). In addition to a review of background information that will aid in study planning and design, five study components will provide the necessary precursor or input information. Inputs from the Geomorphology Study (Section 6.5), Aerial Video Study, GIS Mapping and Aerial Imagery, Fish Distribution and Abundance in the Upper (Section 9.5) and Middle and Lower Susitna River (Section 9.6) will aid in the physical and biological delineation and mapping of habitat. The characterization of aquatic habitat will then provide useful output or feedback to understanding five AEA studies. The mapping of aquatic habitat will aid in understanding the behavior, movements, and spatial use of fish in the Fish Distribution and Abundance in the Upper (Section 9.5) and Middle and Lower Susitna River (Section 9.6). Habitat characterization will help in understanding the potential Project effects of the flow regime in the Instream Flow Study (Section 8). The characterization of aquatic habitat will allow for the identification of habitat affected by the Project reservoir and this may affect the future reservoir fish community (Section 9.10). Finally, the River Productivity Study (9.8) will use the habitat mapping for identification of study site selection and quantification of habitat types for interpolation.

### 9.9.9. Level of Effort and Cost

The total estimated cost of the study for 2013 and 2014 is $1,000,000 including remote mapping, field surveys, data analysis, and technical report preparation.

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## 9.9.11. Tables

**Table 9.9-1. Primary sources of existing information supporting the aquatic habitat study.**

| River Segment or Tributaries | Existing Information Available for Habitat Mapping |
|---|---|
| Upper River tributaries | IFSAR 20-foot contour topographic data<br>Low altitude aerial video |
| Upper River mainstem | IFSAR 20-foot contour topographic data<br>Low altitude aerial video<br>Matanuska-Susitna Borough LiDAR and Imagery<br>River cross-sectional profiles of depth and velocity<br>2012 geomorphic mapping of channel types |
| Middle River mainstem | IFSAR 20-foot contour topographic data<br>Low altitude aerial video<br>Matanuska-Susitna Borough LiDAR and Imagery<br>River cross-sectional profiles of depth and velocity<br>2012 geomorphic mapping of channel types<br>1980s geomorphic mapping of channel types |
| Lower River mainstem | IFSAR 20-foot contour topographic data<br>Matanuska-Susitna Borough LiDAR and Imagery<br>River cross-sectional profiles of depth and velocity<br>2012 partial geomorphic mapping of channel types |

[1] IFSAR. Interferometric synthetic aperture radar is a radar technique used in geodesy and remote sensing

**Table 9.9-2. Tributaries in the Upper River proposed for habitat mapping also proposed for fish distribution and abundance sampling.**

| Primary Tributary | Secondary Tributary | Geomorphic Reach | Project River Mile | Approximate Total Stream Length | Approximate Drainage Area Mi. | Approximate Elevation and River Mile of Anadromous Barrier | Habitat Mapping Study Area[1] | Documented Chinook in Watershed | Mapping Method | Species Known to be Present in Tributary or Plume[2] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Chinook | Dolly Varden | Lake Trout | Arctic Grayling | Round Whitefish | Humpback Whitefish | Whitefish spp. | Salmonid spp. | Burbot | Longnose Sucker | Slimy Sculpin | Sculpin spp. | Rainbow Trout | Sampled [NO FISH] |
| Oshetna River – LB | | UR 3 | 235.1 | 55.6 | 550 | None | PRM 0.0 to 3.000 ft | Yes | Aerial and Ground | X | X | | X | X | | | | X | X | X | X | | |
| | Black River - LB | UR 3 | 12.7 (LB) | NI | NI | None | PRM 0.0 to 3,000 ft | Yes | Aerial and Ground | | | | | | | | | | | | | | |
| Goose Creek – LB | | UR 3 | 232.8 | 25.2 | 103.9 | None | PRM 0.0 to 2,200 ft | NI | Aerial and Ground | | | | X | | | | | X | X | X | X | | |
| Jay Creek - RB | | UR 4 | 211.0 | 19.6 | 61.8 | None | PRM 0.0 to 2,200 ft | NI | Aerial and Ground | | X | | X | X | | | X | X | X | X | X | | |
| Kosina Creek - LB | | UR 4 | 209.1 | 39.5 | 400.2 | None | PRM 0.0 to 3,000 ft | Yes | Aerial and Ground | X | | | X | X | | X | X | X | X | X | X | | |
| | Tsisi Creek1 - LB | UR 4 | 7.4 (LB) | NI | NI | None | PRM 0.0 to 3,000 ft | Yes | Aerial and Ground | | | | | | | | | | | | | | |
| Unnamed Tributary - LB | | UR 5 | 206.3 | 7.43 | <31 | None | PRM 0.0 to 2,200 ft | NI | Ground only | | | | X | | | | | | | X | | | |
| Unnamed Tributary - LB | | UR 5 | 204.3 | 6.2 | <31 | Possible – PRM 0.5 | PRM 0.0 to 2,200 ft | NI | Ground only | | | | X | | | | | X | | | X | | |
| Unnamed Tributary - LB | | UR 6 | 197.7 | 5.4 | <31 | PRM 1.3 | PRM 0.0 to 2,200 ft | NI | Ground only | | | | | X | | | X | | | X | X | | |
| Watana Creek - RB | | UR 6 | 196.9 | 26.9 | 174.8 | None | PRM 0.0 to 3,000 | Yes | Aerial and Ground | X[3] | X | | X | X | | | X | X | X | X | X | | |
| | Watana Tributary - RB | UR 6 | 8.7 (RB) | UNI | NI | None | PRM 0.0 to 3,000 ft | Yes | Aerial and Ground | | | | | | | | | | | | | | |
| Unnamed Tributary - RB | | UR 6 | 194.8 | 7.1 | 124 | None | PRM 0.0 to 2,200 ft | NI | Ground only | | X | | X | X | | | X | | X | X | X | | |
| Deadman Creek - RB | | UR 6 | 189.4 | 41.9 | 175.1 | ≈1,700 ft - PRM 0.4 | PRM 0.0 to 3,000 ft | NI | Aerial and Ground | | X | | X | | | | | X | X | | X | | |
| Tsusena Creek - RB | | MR 2 | 184.6 | 30.7 | 145.3 | ≈1,700 ft – PRM 3.8 | PRM 0.0 to barrier | Yes | Aerial and Ground | X | | | X | X | X | | | X | X | X | X | | |
| Unnamed Tributary - RB | | MR 2 | 184.0 | 10.4 | <31 | ≈1700 ft – PRM 1.8 | PRM 0.0 to barrier | NI | Aerial and Ground | X | X | | X | X | | | X | | | X | X | | |
| Fog Creek - LB | | MR 2 | 179.3 | 27.8 | 147.2 | None | PRM 0.0 to 3,000 ft | Yes | Aerial and Ground | X | X | | X | X | | X | X | X | | X | X | | |
| | Fog Tributary[3] - LB | MR 2 | 5.2 (LB) | NI | NI | None | PRM 7.3 to 3,000 ft | Yes | Aerial and Ground | X | | | | | | | | | | | | | |
| Devil Creek - RB | | MR 4 | 164.8 | 15.8 | 74.8 | ≈1,400 – PRM 2.2 | PRM 0.0 to barrier | NI | Aerial and Ground | | X | | X | | | | | | | X | X | | |
| Chinook Creek - LB | | MR 4 | 160.5 | 10.6 | 24.7 | None | PRM 0.0 to 3,000 ft | Yes | Aerial and Ground | X | X | | | | | | | | | | | | |
| Cheechako Creek - LB | | MR 4 | 155.9 | 10.7 | 36.4 | ≈1,500 – PRM 2.5 | PRM 0.0 to barrier | Yes | Aerial and Ground | X | X | | X | | | | | | | | X | | |

1/ Upper extent of habitat mapping study area will extend to 3,000 feet for streams in watersheds known to support Chinook salmon. Othrerwise the survey will terminate at 2,200 feet or confirmed Chinook barrier, whichever is lower.
2/ Fish species presence based on historical and current surveys.
3/ Juvenile Chinook found in watershed during AEA 2013 fish distribution and abundance sampling.
NI: No information available at this time.

**Table 9.9-3. Upper River tributary mesohabitat types and descriptions.**

| Channel Type (# of channels) | Hydraulic Type | Mesohabitat Type | Definition |
|---|---|---|---|
| Single (1)<br>Split (2)<br>Channel Complex (3 or > channels) | Fast Water | Falls | Steep near vertical drop in water surface elevation greater than approximately 5 feet over a permanent feature, generally bedrock. |
| | | Cascade | A fast water habitat with turbulent flow; many hydraulic jumps, strong chutes, and eddies and between 30-80 percent white water. High gradient; usually greater than 4 percent slope. Much of the exposed substrate composed of boulders organized into clusters, partial bars, or step-pool sequences. [1] |
| | | Chute | An area where most of the flow is constricted to a channel much narrower than the average channel width. Laterally concentrated flow is generally created by a channel impingement or a laterally asymmetric bathymetric profile. Flow is fast and turbulent. |
| | | Rapid | Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0 percent slope, occasionally 7.0-8.0 percent. [1] |
| | | Boulder Riffle | Same flow and gradient as Riffle but with numerous boulders that can create sub-unit sized pools or pocket water created by scour. |
| | | Riffle | A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section.[1] Low gradient; usually 0.5-2.0 percent slope, rarely up to 6 percent. |
| | | Run/Glide | A habitat area with minimal surface turbulence with generally uniform depth that is greater than the maximum substrate size.[1] Velocities are on border of fast and slow water. Gradients are approximately 0 to less than 2 percent. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[1] |
| | Slow Water | Pool | A slow water habitat with a flat surface slope and low water velocity that is deeper than the average channel depth. Substrate is highly variable. [1] |
| | | Pool subtypes | **Straight Scour Pool**: Formed by mid-channel scour. Generally with a broad scour hole and symmetrical cross-section.[1] |
| | | | **Plunge Pool:** Formed by scour below a complete or nearly complete channel obstruction (logs, boulders, or bedrock). Pool must be Substrate is highly variable. Frequently, but not always, shorter than the active channel width.[1] |
| | | | **Lateral Scour Pool:** Formed by flow impinging against one stream bank or partial obstruction (logs, root wad, or bedrock). Asymmetrical cross-section. Includes corner pools in meandering lowland or valley bottom streams.[1] |
| | | | **Backwater Pool:** Found along channel margins; created by eddies around obstructions such as boulders, root wads, or woody debris. Part of active channel at most flows; scoured at high flow. Substrate typically sand, gravel, and cobble. Generally not as long as the full channel width. [1] |

| Channel Type (# of channels) | Hydraulic Type | Mesohabitat Type | Definition |
|---|---|---|---|
| Single (1)<br>Split (2)<br>Channel Complex (3 or > channels) | | Beaver Pond | Water impounded by the creation of a beaver dam. Maybe within main, side, or off-channel habitats. [1] |
| | | Alcove | An off-channel habitat that is laterally displaced from the general bounds of the active channel and formed during extreme flow events or by beaver activity; not scoured during typical high flows. Substrate is typically sand and organic matter. Generally not as long as the full channel width. An alcove is differentiated from a backwater being more protected and not scoured at high flows whereas a backwater is part of the active channel and is scoured at high flows [1] |
| | Off-channel | Percolation channel | A slough characterized by groundwater percolation through the floodplain that comes from main stream channel. Upstream surface connection to active channel cut off due to accumulation of sediment/debris at the upstream end. Upstream surface water connection to the active channel present only during high flows. |

[3] Adapted from Moore et al. 2006.

**Table 9.9-4. Named and unnamed tributaries in the Middle River below Devils Canyon selected for ground habitat mapping within the zone of hydroelectric influence.**

| Project Rivemile (PRM) | Tributary Name | Geomorphic Reach | Focus Area | Intensive Study in Focus Area | Mesohabitat Map and Survey for Potential Barriers in ZHI | Documented in Anadromous Waters Catalog | Historical Data Available | Proposed for FDA Fish Sampling in 2013 | Approximate Length of ZHI[1] (mi) | Approximate Drainage Area ($mi^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 152.3 | Portage Creek | MR-5 | FA151 | X | | X | X | Yes | 0.19 | 178.6 |
| 148.3 | Jack Long Creek | MR-6 | | | X | X | X | Yes | 0.03 | NI |
| 144.6 | Unnamed | MR-6 | FA144 | X | | | NI | Yes | 0.01 | NI |
| 142.1 | Indian River | MR-6 | FA141 | X | | X | X | Yes | 0.14 | 86.2 |
| 140.1 | Gold Creek | MR-6 | | | X | X | X | Yes | 0.15 | 23.7 |
| 134.3 | Fourth of July | MR-6 | | | X | X | X | Yes | 0.12 | NI |
| 134.1 | Sherman Creek | MR-6 | | | X | X | X | Yes | 0.02 | NI |
| 128.1 | Skull Creek | MR-6 | FA128 | X | | X | X | Yes | 0.04 | NI |
| 127.3 | Fifth of July Creek | MR-6 | | | X | X | X | Yes | 0.01 | NI |
| 124.4 | Deadhorse Creek | MR-6 | | | X | X | X | Yes | 0.18 | 6.5 |
| 121.4 | Little Portage | MR-7 | | | X | X | X | Yes | 0.12 | 2.4 |
| 120.2 | McKenzie Creek | MR-7 | | | X | X | X | Yes | 0.02 | 2.3 |
| 119.7 | Lower McKenzie | MR-7 | | | X | | X | Yes | 0.16 | NI |
| 117.2 | Lane Creek | MR-7 | | | X | X | X | Yes | 0.11 | 10.4 |
| 115.4 | Unnamed | MR-7 | FA115 | X | | | NI | Yes | 0.12 | NI |
| 115.0 | Gash Creek | MR-7 | FA 113 | X | | X | X | Yes | 0.01 | NI |
| 114.9 | Slash Creek | MR-7 | FA 113 | X | | X | X | Yes | 0.02 | NI |
| 113.7 | Unnamed | MR7 | FA 113 | X | | | NI | No | NI | NI |
| 110.5 | Chase Creek | MR-7 | | | X | X | X | Yes | 0.17 | NI |
| 105.1 | Whiskers Creek | MR-8 | FA104 | X | | X | X | Yes | 0.33 | 17.2 |

NI: No information available at this time.

**Table 9.9-5. Nested and tiered habitat mapping units and categories.**

| Level | Unit | Category | Definitions |
|---|---|---|---|
| 1 | Major Hydrologic Segment | Upper, Middle, Lower River | **Defined Segment Breaks**<br>***Upper River*** – RM 184 – 248 (*habitat mapping will only extend up to mainstem RM 233 and will include the Oshetna River.*<br>***Middle River*** - RM 98 - 184<br>***Lower River*** **-** RM 0 – 98 |
| 2 | Geomorphic Reach | Upper River Segment Geomorphic Reaches 1-6<br><br>Middle River Segment Geomorphic Reaches 1-8<br><br>Lower River Segment[1] Geomorphic Reaches 1-6 | Geomorphic reaches that uniquely divide the Major Hydrologic Segments based on geomorphic characteristics. |
| 3 | Mainstem Habitat | Main Channel Habitat<br><br>Off-Channel Habitat Types[2]<br><br>Tributary Habitat | **Main Channel Habitat:**<br>***Main Channel –*** Single dominant main channel.<br>***Split Main Channel –*** Three or fewer distributed dominant channels.<br>***Multiple Split Main Channel –*** Greater than three distributed dominant channels.<br>***Side Channel –*** Channel that is turbid and connected to the active main channel but represents non-dominant proportion of flow[3].<br>***Tributary Mouth -*** Clear water areas that exist where tributaries flow into Susitna River main channel or side channel habitats (upstream Tributary habitat will be mapped as a separate effort).<br><br>**Off-Channel Habitat (also referred to as macrohabitat):**<br>***Side Slough -*** Overflow channel contained in the floodplain, but disconnected from the main channel. Has clear water.[3,4]<br>***Upland Slough -*** Similar to a side slough, but contains a vegetated bar at the head that is rarely overtopped by mainstem flow. Has clear water.[3,4]<br><br>**Tributary Habitat:**<br>Tributary mesohabitats within the hydrologic zone of influence will be typed using the classification system described in Table 9.9-3, above. |
| 4 | Main Channel, Off-channel, and Tributary | Mesohabitat | **Main Channel**<br><br>***Pool –*** slow water habitat with minimal turbulence and deeper due to a strong hydraulic control. |

| Level | Unit | Category | Definitions |
|---|---|---|---|
| | | | ***Glide –*** An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 percent slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[5]<br><br>***Run –*** A habitat area with minimal surface turbulence over or around protruding boulders with generally uniform depth that is generally greater than the maximum substrate size.[5] Velocities are on border of fast and slow water. Gradients are approximately 0.5 percent to less than 2 percent. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[5]<br><br>***Riffle –*** A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section.<br>Low gradient; usually 0.5-2.0 percent slope.[5]<br><br>***Rapid*** - Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0 percent slope.[5]<br><br>***Clearwater Plume*** – Discharge from a tributary that forms a pronounced area of clearwater, in contrast to the turbid water of the main channel, along the main channel shoreline. The length, breadth, and depth of the clearwater plume depend on the relative discharge between the tributary and the main channel, their relative turbidity, and on mixing conditions along the shoreline. A clear water plume will be mapped as if it were a separate mesohabitat type.<br><br>**Off-channel:**<br><br>***Backwater -*** Found along channel margins and generally within the influence of the active main channel with no independent source of inflow. Water is not clear. A backwater will be mapped as if it were a separate mesohabitat type.<br><br>***Beaver Complex –*** Complex ponded water body created by beaver dams. A beaver dam will be mapped as if it were a separate mesohabitat type. |

[1]For the purposes of this RSP, classification of the Lower River segment will stop at Level 2. A classification system for the Lower River segment is still in development pending determination of Project effects in the Lower River.

[2] All habitat within this designation will receive an additional designation within the database of whether water was clear or turbid.
[3] The terms Side Channel, Slough, and Upland Slough are similar but not necessarily synonymous with the terms for macrohabitat type as applied by Trihey (1982) and ADF&G (1983a).
[4] All slough habitat will have an associated area created during the mapping process to better classify size. A sub-sample of side sloughs and upland sloughs will be mapped to the mesohabitat level using the tributary habitat classifications system shown in Table 9.9-3.
[5] Adapted from Moore et al. 2006.

**Table 9.9-6. Example of raw data from mapping displayed in Figure 9.9-17.**

| Map ID | Level 1 | Level 2 | Level 3 | Level 4 | Turbid | Unit Length |
|---|---|---|---|---|---|---|
| 1 | Middle | MR-7[1] | Main Channel | Glide | Yes | 2,819 |
| 2 | Middle | MR-7 | Main Channel | Glide | Yes | 2,339 |
| 3 | Middle | MR-7 | Side Channel | Run | Yes | 2,101 |
| 4 | Middle | MR-7 | Main Channel | Glide | Yes | 1,503 |
| 5 | Middle | MR-7 | Side Slough | Side Slough | No | 824 |
| 6 | Middle | MR-7 | Side Channel | Run | Yes | 978 |
| 7 | Middle | MR-7 | Side Channel | Glide | Yes | 1,356 |
| 8 | Middle | MR-7 | Main Channel | Riffle | Yes | 954 |

1 MR-7 represents Middle Reach 7 of the geomorphic reaches

**Table 9.9-7. Example data summarizing percent composition of unique habitat types.**

| Level 1 | Level 2 | Level 3 | Level 4 | Segment Count | Total Length (feet El.) | % of MR-7 |
|---|---|---|---|---|---|---|
| Middle | MR-7[1] | Main Channel | Glide | 3 | 6,661 | 51.7% |
| | | | Riffle | 1 | 954 | 7.4% |
| | | Side Channel | Glide | 1 | 1,356 | 10.5% |
| | | | Run | 2 | 3,079 | 23.9% |
| | | Side Slough | Side Slough | 1 | 824 | 6.4% |
| | | | **Total** | **8** | **12,874** | **100.0%** |

1 MR-7 represents Middle Reach 7 of the geomorphic reaches

**Table 9.9-8. Example data summarizing length and percent composition of general habitat units by main channel and off-channel habitat.**

| Main Channel Mesohabitat | Total Length (feet El.) | Percent | Off-Channel Habitat | Total Length (feet El.) | Percent |
|---|---|---|---|---|---|
| Glide | 8,017 | 66.5% | Main Channel | 7,615 | 59.2% |
| Riffle | 954 | 7.9% | Side Channel | 4,435 | 34.4% |
| Run | 3,079 | 25.6% | Side Slough | 824 | 6.4% |
| **Total** | **12,050** | **100.0%** | **Total** | **12,874** | **100.0%** |

**Table 9.9-9. Schedule for implementation of the Habitat Characterization and Mapping Study.**

| Activity | 2012 | | | | 2013 | | | | 2014 | | | | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 Q | 2 Q | 3 Q | 4 Q | 1 Q | 2 Q | 3 Q | 4 Q | 1 Q | 2 Q | 3 Q | 4 Q | 1 Q |
| Data Collection | | —— | —— | | | —— | —— | | | | | | |
| Initial Study Report | | | | | | | | | —— Δ | | | | |
| Follow up Data Collection | | | | | | | | | | —— | —— | | |
| Updated Study Report | | | | | | | | | | | | | —▲ |

Legend:
——Planned Activity
----- Follow-up activity (as needed)
Δ Initial Study Report
▲ Updated Study Report

## 9.9.12. Figures

**Figure 9.9-1. Video frame capture of a tributary mid-channel scour pool in a confined channel with boulder and cobble substrate and no stream wood visible.**

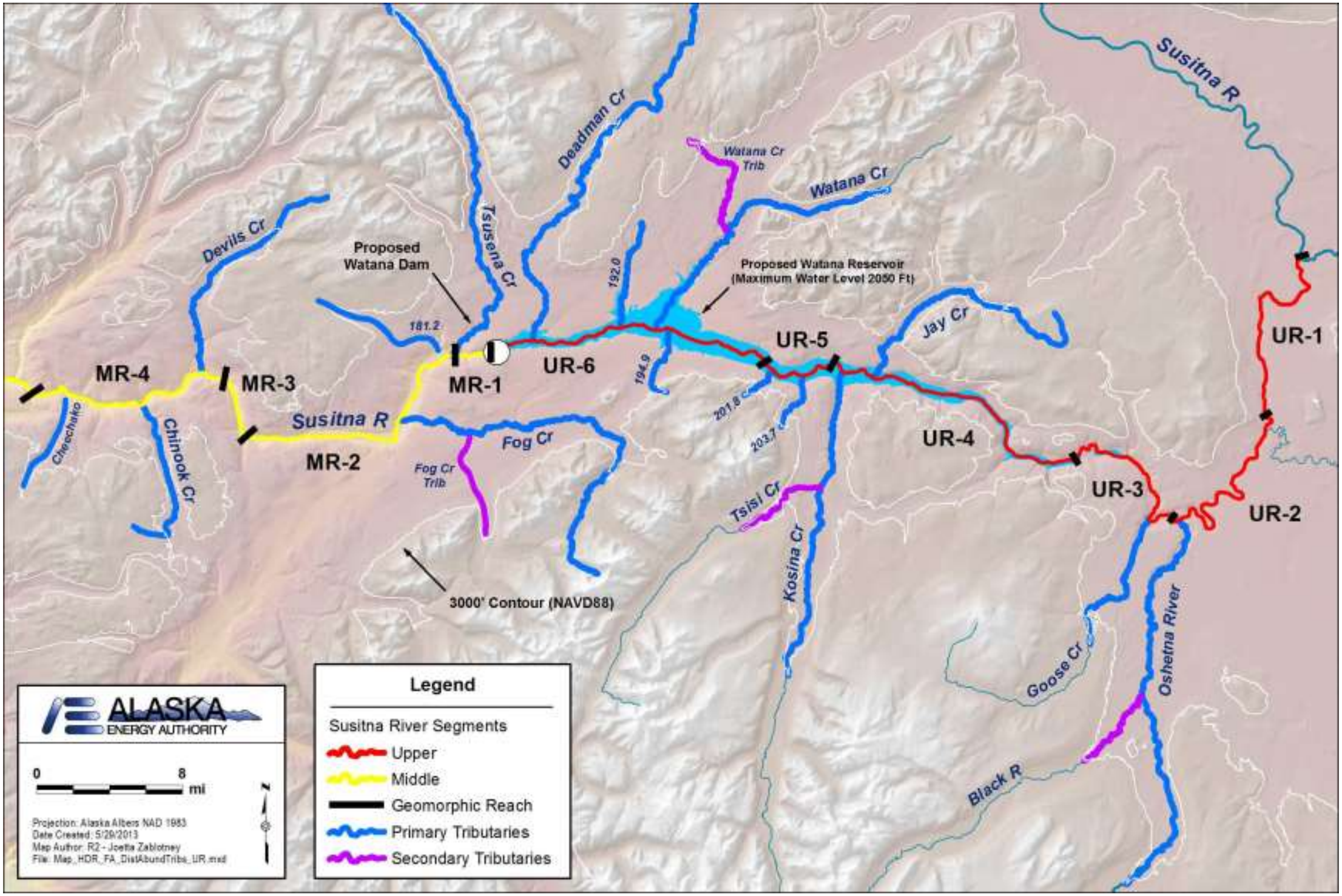


**Figure 9.9-2. Locations of 20 tributaries upstream of Devils Canyon selected for habitat mapping and fish distribution and abundance sampling.**

**Figure 9.9-3. Aerial video tributary habitat mapping type-index – Falls.**

**Figure 9.9-4. Aerial video tributary habitat mapping type-index – Cascade.**

**Figure 9.9-5. Aerial video tributary habitat mapping type-index – Chute.**

**Figure 9.9-6. Aerial video tributary habitat mapping type-index- Rapid.**

**Figure 9.9-7. Aerial video tributary habitat mapping type-index – Run.**

**Figure 9.9-8. Aerial video tributary habitat mapping type-index - Boulder Riffle.**

**Figure 9.9-9. Aerial video tributary habitat mapping type-index - Cobble/Gravel Riffle - Split Channel.**

**Figure 9.9-10. Aerial video tributary habitat mapping type-index – Glide.**

**Figure 9.9-11. Aerial video tributary habitat mapping type-index - Mid Channel Scour Pool.**

**Figure 9.9-12. Aerial video tributary habitat mapping type-index - Lateral Scour Pool - Braided Channel.**

**Figure 9.9-13. Aerial video tributary habitat mapping type-index – Alcove – Special Habitat Feature.**

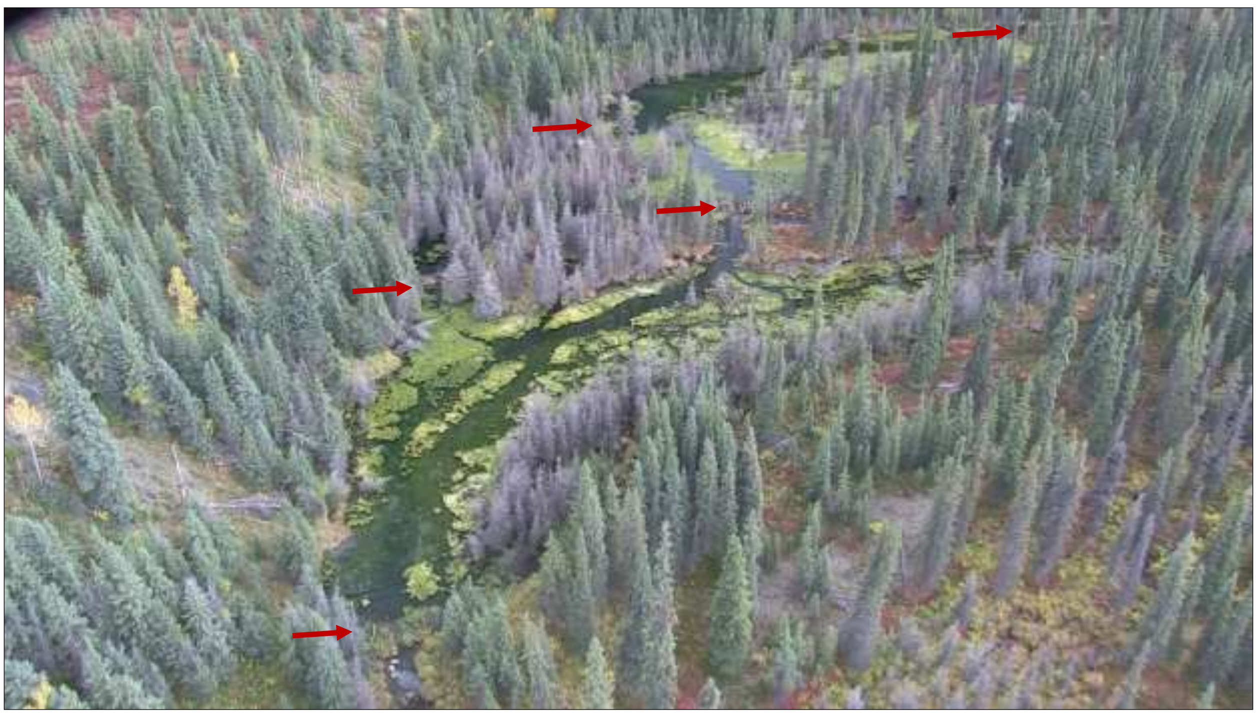

**Figure 9.9-14. Aerial video tributary habitat mapping type-index – Beaver Complex – Special Habitat Feature.**

**Figure 9.9-15. Aerial video tributary habitat mapping type-index - Unclassified - Boulder Riffle?**

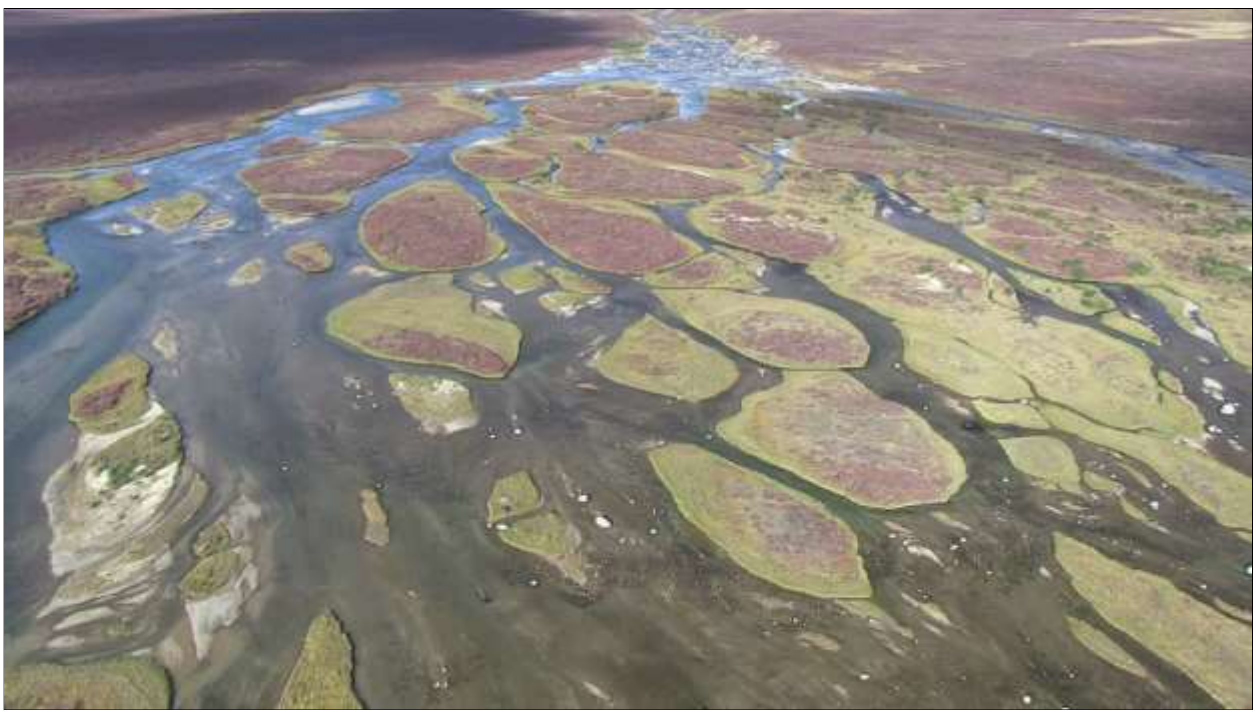

**Figure 9.9-16. Aerial video tributary habitat mapping type-index - Unclassified – Braided Channel?**

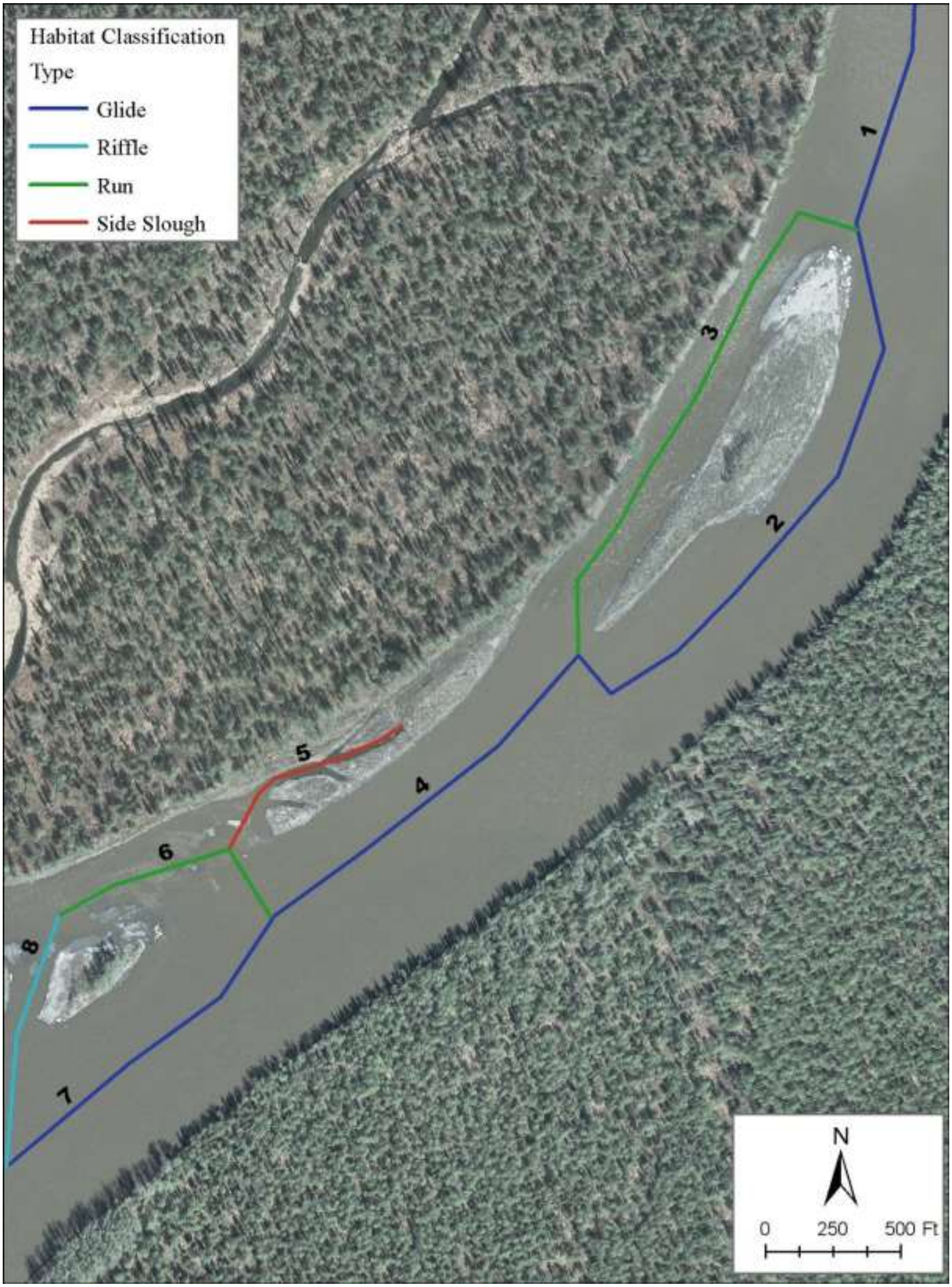


**Figure 9.9-17. Example of mapping using the tiered habitat classification system in GIS.**

**Figure 9.9-18. Aerial video capture of the Lower River mainstem.**

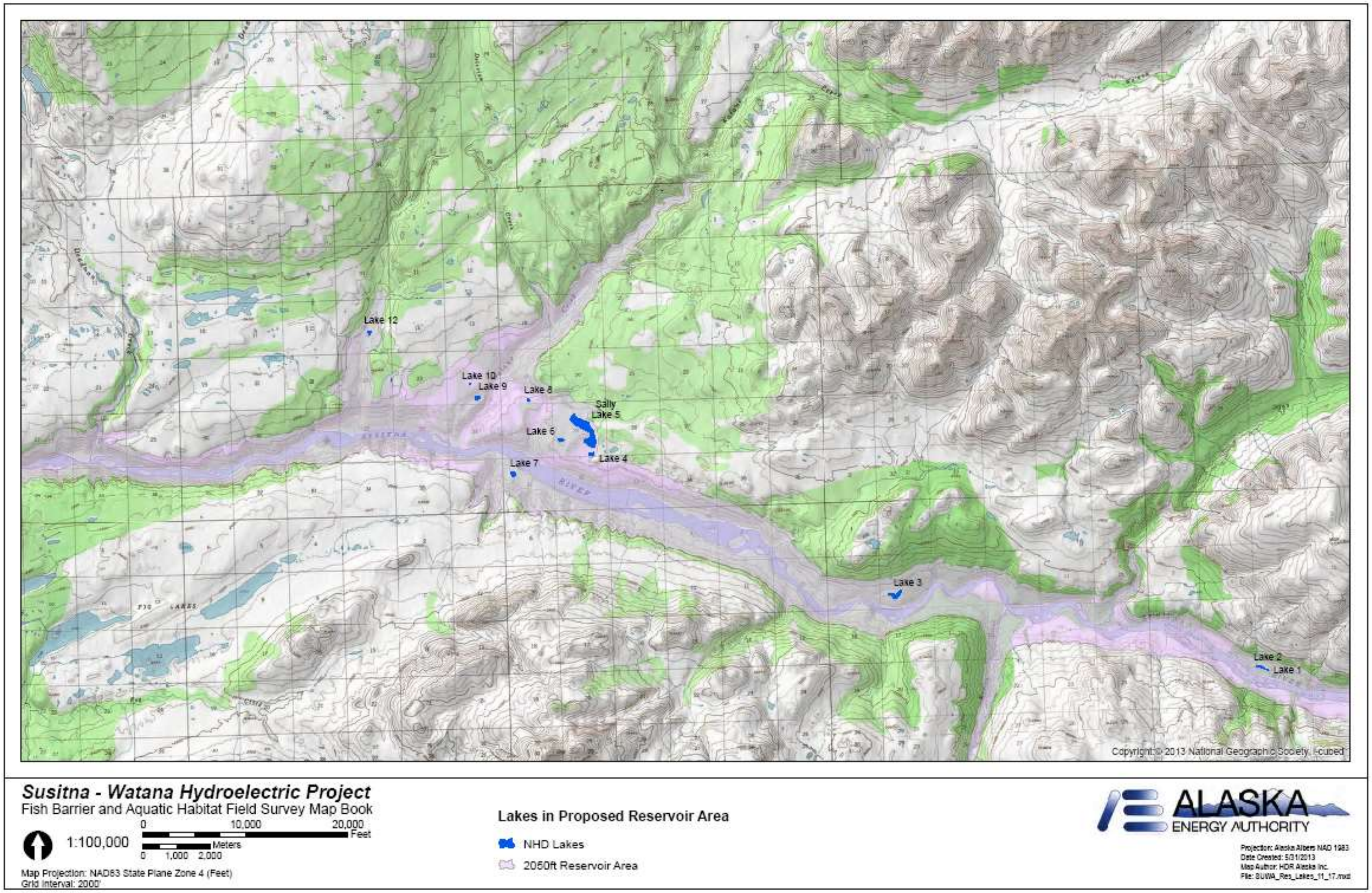


**Figure 9.9-19. Lakes located in Upper River inundation zone proposed for habitat mapping.**

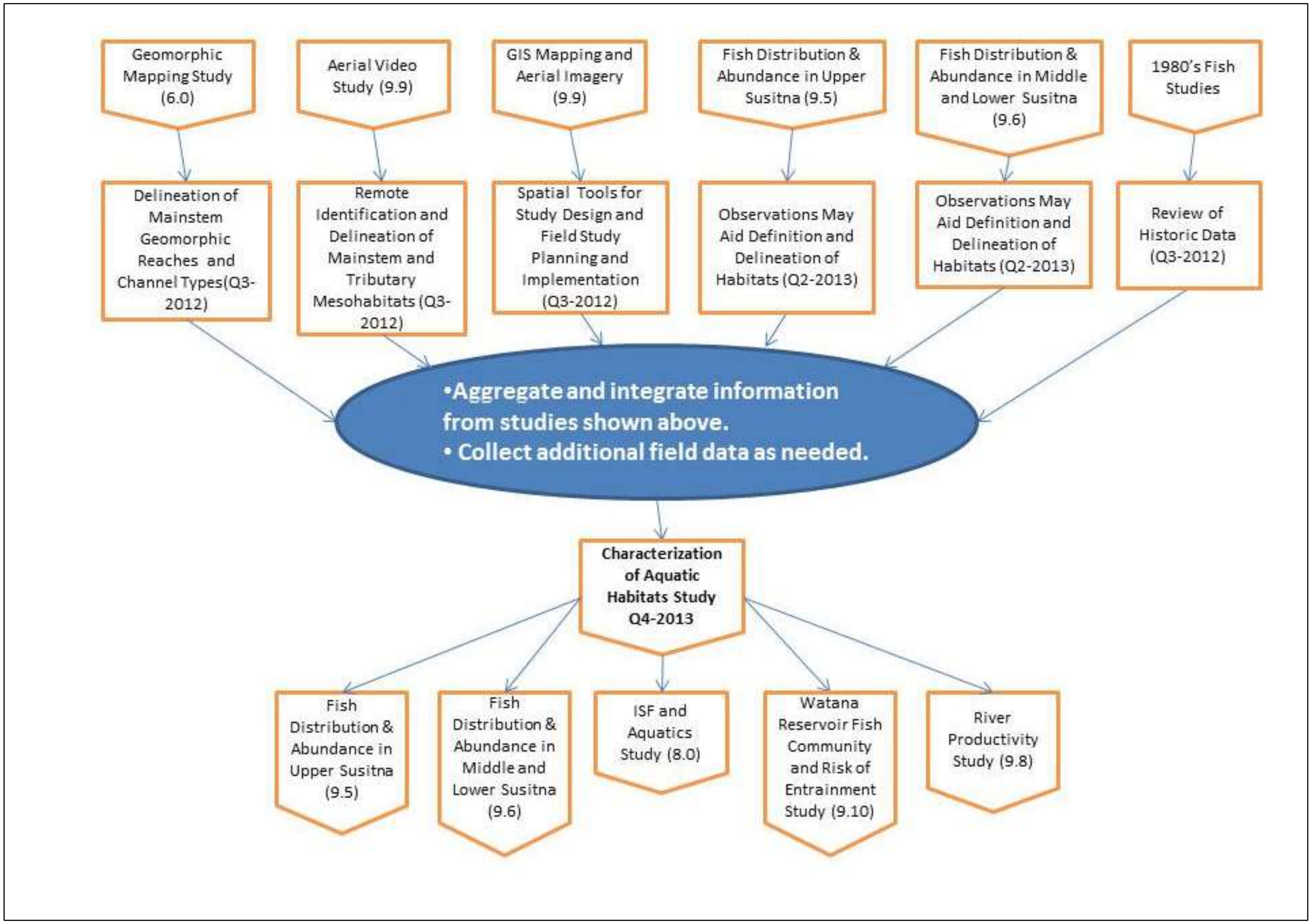


**Figure 9.9-20. Interdependencies for Characterization and Mapping of Aquatic Habitats.**