Susitna-Watana Hydroelectric Project Document
ARLIS Uniform Cover Page

Title:
Susitna-Watana Hydroelectric Project, FERC Project no. 14241-000

SuWa 87

Author(s) – Personal:
Sara Fisher-Goad

Author(s) – Corporate:
Alaska Energy Authority

AEA-identified category, if specified:
Correspondence

AEA-identified series, if specified:

Series (ARLIS-assigned report number):
Susitna-Watana Hydroelectric Project document number 87

Existing numbers on document:

Published by:
[Anchorage, Alaska : Alaska Energy Authority, 2013]

Date published:
January 7, 2013

Published for:
Kimberly D. Bose

Date or date range of report:

Volume and/or Part numbers:

Final or Draft status, as indicated:

Document type:
Letter

Pagination:
9, [161] p.

Related work(s):
This letter is a reply to: SuWa 86.
This letter has a response: SuWa 88.

Pages added/changed by ARLIS:

Notes:
With four attachments

ALASKA ENERGY AUTHORITY

January 7, 2013

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Susitna-Watana Hydroelectric Project, FERC Project No. 14241-000

Dear Secretary Bose:

This responds to the Federal Energy Regulatory Commission (Commission) Staff's December 31, 2012, letter to the Alaska Energy Authority (AEA) regarding the Revised Study Plan (RSP) for the referenced Project filed by AEA on December 14, 2012.

The December 31 letter states that 13 of the 58 study plans "lack sufficient detail" for the Commission to make a study plan determination (SPD). The Staff's letter appears to be based on concerns with the RSP identified in a letter filed by the National Marine Fisheries Service (NMFS) dated January 2, 2013.[1] As explained below, AEA disagrees with this characterization and requests that the Commission issue the SPD for the entire RSP under the Integrated Licensing Process (ILP) schedule previously established by the Commission. If the Commission denies this request, AEA proposes an alternative schedule which provides SPDs for the 13 studies to be made by April 1, 2013.

I. <u>Background and Context</u>

The Staff's December 31 letter states that 45 of the 58 study plans contain sufficient information for the Commission to make an SPD by the currently scheduled date of February 1, 2013, but that 13 of the plans, which are related to aquatic resources, do not include sufficient detail for the Commission to make an SPD at this time. Despite the fact that the 13 study plans total over 850 pages of detailed description, rationale, and methodology developed over a period of many months' collaboration with federal and state resource agencies, Commission staff, and other participants, the letter asserts that the studies provide only "conceptual details" regarding sampling methods, techniques, analytical approaches, and study site selection.

---

[1] AEA understands that NMFS communicated these concerns in a telephone call to Commission Staff prior to the December 31 letter. However, NMFS's January 2 letter, similar to Staff's December 31 letter, contains no detailed criticism or analysis of the RSP but only broad-brush, conclusory statements. NMFS's January 2 letter provides no basis or justification for altering the SPD schedule.

813 West Northern Lights Boulevard Anchorage, Alaska 99503 T 907.771.3000 Toll Free (Alaska Only) 888.300.8534 F 907.771.3044

Based on the Staff's conclusory finding, the December 31 letter modifies the SPD schedule for those 13 studies. It requires AEA to file by March 15, 2013: (1) implementation plans described in Sections 9.5.4, 9.6.4, and 9.8.4; and (2) final sampling site selections in "focus areas" for all other studies to be implemented in the middle and lower Susitna River. The letter also requires AEA to file by January 21, 2013, the results of open-water flow routing and initial habitat mapping studies conducted in 2012, and to hold a meeting with stakeholders no later than February 15, 2013, to discuss all of the above matters. Finally, the letter sets back the schedule for all 13 aquatic studies to provide for an SPD on May 14, 2013.

Since the beginning of the ILP one year ago, AEA has worked diligently with the Commission Staff, federal and state agencies, and other licensing participants to identify needed studies and develop and refine detailed study plans. As described in the RSP filed on December 14, 2012, at Section 1.1, AEA has undertaken extensive collaborative efforts for study plan development that exceed the requirements of the Commission's ILP regulations in order to ensure that the study plans are robust and comprehensive, and to ensure broad participation of agencies and other participants. Indeed, with 58 studies covering approximately 3,500 pages, the Susitna-Watana RSP is likely the most detailed, comprehensive study plan ever submitted in a hydroelectric licensing proceeding.

For the reasons discussed in detail below, AEA strongly believes that the Commission's SPD for the entire RSP can and should be made under the previously established schedule for all studies in the RSP. More importantly, AEA is extremely concerned that Staff's revised SPD schedule for the 13 aquatic studies may cause AEA to miss the entire 2013 field season for these studies. That would, in effect, set the license proceeding back a full year. AEA therefore requests that the Commission withdraw the Staff's December 31 letter and restore the previous schedule for issuing an SPD for the entire RSP. If the Commission believes additional information is needed prior to issuing its SPD on these 13 aquatic studies, AEA proposes an alternative schedule set forth in Appendix C that preserves the 2013 field season by providing for the SPD for these 13 studies to be made by April 1, 2013.

AEA addresses each of the matters raised by Staff's December 31 letter below.

II. Implementation Plans

AEA is surprised by Staff's conclusion that SPDs cannot be made in the absence of finalized study implementation plans for certain studies. That conclusion is inconsistent with the Commission's practice of issuing SPDs for study plans that contemplate future decisions and adjustments to be made during the study implementation phase. It is more surprising in this instance, because (as explained below) Commission Staff, in its recent comments on AEA's Proposed Study Plan (PSP), addressed this very issue and provided instructions on how future decisions and adjustments should be addressed in the RSP—instructions that AEA strictly adhered to when developing the RSP.

The three study plans in question are:

- RSP 9.5 – Study of Fish Distribution and Abundance in the Upper Susitna River
- RSP 9.6 – Study of Fish Distribution and Abundance in the Middle and Lower Susitna River; and
- RSP 9.8 – River Productivity.[2]

Fish Distribution and Abundance (RSP 9.5 and 9.6)

RSP 9.5 and 9.6 include: goals and objectives; comprehensive reviews of existing information; identification of study areas; and a description of how each study relates to other studies. Of signal importance here, they include a great deal of additional information requested by NMFS, U.S. Fish and Wildlife Service, Commission Staff, and the Alaska State agencies regarding site selection, sampling stratification, frequency and schedule, equipment specifications, identification of sampling protocols, and gear specificity by habitat.[3] The methodologies requested by the agencies have been substantially incorporated into the plans.[4] The plans were developed by highly qualified fisheries and aquatic biologists in collaboration with the Fish and Aquatic Technical Working Group (TWG) and are consistent with generally accepted scientific practice.

The only remaining components of these study plans are the implementation plans, which have the limited purpose of establishing protocols for: (i) identifying specific sampling locations within the study areas, (ii) sampling techniques and apparatuses, and (iii) recording the collected data. In November 2012 comments on the PSP, Commission Staff recognized the reality that certain elements of study plans, such as these, may need to be modified at a later time—such as once preliminary baseline studies are complete:

> In multiple study plans, you propose to modify the methods or geographic scope of the study in response to preliminary study results. . . . For each of these studies, the RSP should clearly describe any decision-making process or schedule by which study methods would be refined or adapted in consultation with agencies and other stakeholders during the study implementation period, including any criteria that will trigger changes in the study plan. [5]

---

[2] The study plans are attached to this letter in Attachment B. Excerpts from the NMFS and U.S. Fish and Wildlife Service crosswalk tables documenting AEA's responses to these agencies' comments on RSP 9.5, 9.6, and 9.8 are included as Attachment C.

[3] *See* RSP 9.5 and RSP 9.6; RSP Appendix 3, Comment Response Table of Informal Consultation (July – November 2012).

[4] *See* Attachment C, Crosswalk Tables Between U.S. Fish and Wildlife Service and National Marine Fisheries Service Study Requests (May 31, 2012) and Alaska Energy Authority Revised Study Plan (December 14, 2102), filed December 14, 2012, in Project No. 14241.

[5] *See* Letter to Wayne Dyok, AEA, from Dr. Jennifer Hill, Chief, Northwest Branch, Division of Hydropower Licensing (issued Nov. 14, 2012) (FERC PSP Comments) at A-2.

The RSP faithfully adheres to this direction. RSP 9.5 and 9.6 state that the Fish Distribution and Abundance Implementation Plans will include the following components:

- summarize relevant fisheries and an overview of the life history needs for fish species known to occur in the Susitna River to guide site selection and sampling protocols,
- review the preliminary results of habitat characterization and mapping efforts;
- describe site selection and sampling protocols;
- develop field data collection forms;
- develop database templates that comply with AEA's quality assurance procedures; and
- develop a protocol for randomizing sampling events to evaluate precision by habitat and gear type.[6]

These detailed implementation plans, particularly the location of specific sampling sites, could not be submitted with the rest of the RSP in December 2012 because fish sampling relies on a stratified random design of sampling by habitat types (that is, a random sampling component of mesohabitats within each focus area), and habitat typing. Although selection of specific sampling locations is not complete, the RSPs do lay out in great detail the methods that will be used to select those sites within systematically stratified habitats, as shown in the attachments.

River Productivity Study (9.8)

Like the fish distribution and abundance study plans, the river productivity study plan includes: a statement of goals and objectives, identification of the study area (not in dispute), discussion of existing and necessary additional data, and extensive discussion of study and sampling methods.[7] As with the other study plans, this plan was developed through extensive collaboration with the Fish and Aquatic TWG. The bulk of what remains to be completed is selection of sampling sites, timing, devices, and data processing. RSP 9.8 also adheres faithfully to Commission Staff's PSP comments to describe the decision-making process and schedule to accomplish these things during the implementation period. The implementation plan will:

- summarize relevant macroinvertebrate and algal studies;
- provide an overview of target species life-histories;
- review the preliminary results of habitat characterization and mapping efforts and the selected focus areas;
- describe site selection, sampling techniques and apparatus, and sample processing protocols;

[6] RSP 9.5, Section 9.5.4., Study Methods, at 9-9 and 9-10; RSP 9.6, Section 9.6.4, at 9-41and 9-42.

[7] *See* RSP Section 9.8.

- include specific sampling locations;
- discuss data analysis methods;
- develop field data collection forms; and
- develop database templates.[8]

In sum, there is no reason the Commission cannot issue SPDs for these study plans which, consistent with current practice, allows the details of sampling site locations, techniques, and protocols to be developed in a cooperative manner during the plan implementation phase.

III. Final Selection of Focus Area Sampling Sites for All Middle and Lower River Studies

The PSP proposed, and the RSP includes, 10 Focus Areas in the Middle Susitna River (Attachment D).[9] These are areas from 0.5 to 1.8 miles long identified by aerial imagery and selected in the context of TWG discussion for intensive study across resource disciplines. This will assist development of an overall understanding of interrelationships of river flow dynamics with the physical, chemical, and biological factors that influence fish habitat.

Consistent with the Commission's ILP regulations[10] and pursuant to the direction provided in the Commission's PSP comment letter, AEA's comprehensive study plans address (and substantially adopt) the study plans and study plan components proposed by licensing participants and Commission Staff. In particular, Staff's PSP comments requested AEA to include in the RSP with respect to the Focus Areas, the "criteria to be used for selecting focus areas and study-specific rationale for co-locating sites."[11] Staff explained, for example:

> [Y]ou propose to sample a total of 40 different habitat types (i.e., 8 each of 5 different habitat types: side slough, upland slough, side channel, beaver complex, and tributary mouth habitat types) within the 10 proposed Middle River focus areas. However, you do not describe how you will select these sites within the focus areas. *In your RSP, please describe how these habitat units will be selected within the ten focus areas.*[12]

The RSP faithfully describes the criteria and process for identifying the specific sampling sites within each Focus Area during the implementation phase, following the Commission's SPD. Yet, Staff's December 31 letter inexplicably changes course by

---

8 RSP Section 9.8.4 at 9-110 and 9-111.

9 The ten focus areas are fully discussed in the Instream Flow Study Plan in Section 8.5.4.2.1.2.

10 18 C.F.R. § 5.13(a).

11 FERC PSP Comments at A-3.

12 *Id.* at A-12 (emphasis added).

requiring AEA to complete selection of all sampling sites within the Focus Areas for these study plans prior to study implementation and the Commission's SPD.

AEA submits that the Commission should not depart from its established practice and the previous guidance provided to AEA. In order to assist the Commission's consideration of this matter, AEA describes below the Focus Area concept in more detail.

The Susitna River was stratified into geomorphic reaches based on channel type, gradient, confinement, bed material and tributary confluences in order to characterize the existing and proposed flow regimes and riverine habitats and organisms. The pros and cons of various approaches to study site selection, including representative: (i) reach/site selection; (ii) random reach/site selection; and (iii) critical area/site selection, are presented in RSP 8.5 (Instream Flow Study).

The concept of Focus Areas was developed in the TWG. AEA has conferred with the TWG repeatedly concerning the specific location of the Focus Areas. The concept combines all three of the selection methods noted above because: (i) the areas will contain habitat types representative of other areas; (ii) the areas will include certain habitat types repeatedly used by fish and therefore can be considered "critical;" and (iii) sampling of certain habitat features or mesohabitat types within the areas would be best approached via random sampling.

The 10 Focus Areas in the Middle Susitna River were discussed by the TWG and are proposed for detailed study across multiple resource disciplines, as discussed below. The Focus Areas encompass portions of the main channel, associated side channels, tributary mouths, side sloughs and upland sloughs. Confirmation of their representative nature will be determined though the habitat mapping studies conducted in 2012 and expanded in 2013. If habitat mapping indicates that some key habitat features are not represented in the proposed areas, additional sampling areas will be identified and studied in 2014. In addition, some habitat features within the proposed Focus Areas may be given greater consideration (i.e., weighting) if biological studies in 2013 and 2014 indicate that those habitats features are critical to species productivity.

The study program is not limited to the boundaries of the Focus Areas. Many other study sites and areas have already been or will be located in the resource specific investigations (*e.g.*, RSP 8.5, which identifies 80 Middle River and 8 Lower River transects, most of which are outside the Focus Areas. *See also* RSPs 5.0, 6.0, 7.5, 7.6, 9.6, 9.8 and 9.9).

Selection of specific sampling sites within the Focus Areas is not necessary for the Commission to make an SPD for these aquatic studies. As explained above, and as shown on Attachment D, the Focus Areas are necessarily, indeed intentionally, limited in size, so the habitat units to be sampled within the Focus Areas have already been bounded with reasonable certainty. Whether habitat units will be sampled or subsampled will depend on unit size as determined in the field. In many cases, the most appropriate sampling sites (*e.g.*, riffle A v. riffle B or C), including biological and field worker safety considerations, cannot be identified until ice out and with specific reference to conditions in the river at the time of sampling.

Finalization of sampling sites within the Focus Areas is particularly unnecessary for the SPD in the case of the three water quality studies (Baseline Water Quality (5.5), Water Quality Modeling (5.6), and Mercury Assessment and Potential for Bioaccumulation (5.7)) and the Ice Processes study (7.6). The water quality study Focus Areas are within the large-scale program both for sampling, but are independent of the large-scale program both for sampling and for water quality monitoring. Likewise, the water quality model calibration and operation will be conducted independently of the Focus Areas. The modeling in the Focus Areas will concentrate on influences of riverine and reservoir changes on fisheries, while the large scale monitoring program will address other aspects of water quality. Mercury studies in the Focus Areas are not needed to evaluate impacts on the river; rather, they are designed to supplement other studies in Focus Areas.

In sum, there is no reason that issuance of a SPD must await final selection of sampling sites within the Focus Areas.

IV. Proposed Schedule

The schedule in Staff's December 31 letter establishes an SPD date for the 13 studies of May 14, 2013. With respect, this is too late to ensure that all 2013 studies are conducted under a Commission-approved plan. The field study season in Alaska is short. For many studies (*e.g.*, fish distribution and abundance, instream flow, water quality, ice processes, groundwater monitoring, river productivity, geomorphology, and fluvial geomorphology) the sampling period must begin shortly after ice out (generally in April) and during spring snowmelt flow events. A significant amount of effort and lead time, 2-3 months, is necessary for planning, equipment procurement, fabrication, and installation. Thus, AEA requests that the Commission reestablish February 1 as the SPD date for all 58 of the RSP study plans.

If the Commission continues to believe that additional information and review time are needed to issue its SPD on the 13 aquatic studies, [13] AEA proposes an alternative schedule that will enable the SPD for the 13 aquatic studies to be issued by April 1, 2013 (Attachment A). This would allow AEA to timely complete the necessary prerequisites to field studies for the 2013 study season.

---

[13] AEA recognizes that the original SPD schedule of February 1 would require comments on the RSP by licensing participants to be filed by January 18, and that some accommodation might need to be made in light of the fact that participants now believe they have until April 15 to file comments on the 13 aquatic studies. Nonetheless, AEA notes that NMFS in its January 2 letter states that it is prepared to file detailed comments on the RSP by January 18.

AEA's proposed schedule would modify Staff's schedule in the December 31 letter as follows:

- AEA files open-water flow routing model and habitat mapping 2012 study results on January 31 instead of January 21. As indicated in the schedule presented in the RSP (Table 8.5-14), AEA intended to present the Middle River habitat mapping results and the verified open-water flow routing model results in February 2013. In response to Staff's request, AEA will complete and file the analysis by January 31. Data collection for the open-water flow routing model was suspended for safety reasons as a result of the September 2012 Susitna River flood. AEA resurveyed several cross sections after the flood to ensure that any bathymetry changes resulting from the flood are incorporated into the model.
- AEA posts draft implementation plans for RSP 9.5, 9.6, and 9.8 and final site selection for Focus Areas for Middle River studies on the Project website on January 31.
- AEA hosts a two-day meeting on February 14 and 15 to discuss the open-water flow routing model and Middle River habitat mapping results, the selected Middle River Focus Area sampling sites, the sampling strategy in the Middle Riverfor each of the 13 studies identified in the December 31 letter, and the two proposed implementation plans.
- AEA files final implementation plans for RSP 9.5, 9.6, and 9.8 and final sampling sites within focus areas for all 13 studies on March 1 instead of March 15.
- Consistent with ILP regulations, licensing participants submit comments on all 13 studies by March 18 (instead of April 14)—15 days following AEA's submission of the implementation plans.[14]
- Consistent with ILP regulations, the Commission issues its SPD for RSP 9.5, 9.6, and 9.8 by April 1(instead of May 14)—30 days following AEA's submission of the implementation plans.[15]

This proposed schedule modifies the amount of time from Staff's December 31 letter for comment on the study plans and for the Commission to issue its SPD. However, that is counterbalanced by the facts that: 1) Staff's December 31 letter is inconsistent with direction given to AEA in Staff's PSP comments; 2) few studies are involved; 3) the actions Staff has identified as remaining to be done are limited to a small part of those study plans; 4) the location of the specific sites are reasonably bounded by the Focus Areas; 5) many final sampling sites cannot be determined except with reference to conditions at the site and at the time of sampling; 6) the comments will be informed by the opportunity for participants to meet and discuss the relevant submittals at the February 14-15 meeting; and 6) there is an urgent need for timely study plan determinations in order not to miss the 2013 field season.[16]

---

[14] *See* 18 C.F.R. § 5.13(b).

[15] *See id.* § 5.13(c).

[16] In light of these facts, it is unclear why Staff's December 31 letter would *double* the amounts of time provided in the ILP regulations for participants to comment on RSPs and for Staff to issue the SPD for the *entire* study plan, particularly when only a minor portion of the complete plan is involved.

V. Other Matters

The schedule attached to the December 31 letter includes a date for filing "[a]ny study disputes due for studies 5.5, 5.6, 5.7, 6.5, 6.6, 7.5, 7.6, 8.5, 8.6, 9.5, 9.6, 9.8, and 9.9." AEA seeks clarification from the Commission that by specifically identifying these studies, the Commission has not made an *a priori* determination that the identified studies "pertain directly to the exercise of" the authorities of NMFS under Federal Power Act (FPA) Section 18 to prescribe fishways or the U.S. Bureau of Land Management (BLM) to require mandatory license conditions under FPA Section 4(e).[17] AEA reserves the right to contest any assertion that any particular study is directly related to the exercise by an agency of its relevant authorities.

VI. Conclusion

For the reasons discussed above, AEA requests that the Commission withdraw its December 31, 2012, letter modifying the ILP schedule and proceed toward issuance of study plan determinations under the previous schedule. If the Commission continues to believe that additional information is needed to resolve concerns related to the 13 aquatic studies, AEA requests that the Commission modify the schedule set forth in the December 31 letter for the identified study plans and adopt instead the schedule that is Attachment A to this letter.

If you have questions concerning this matter please contact AEA's Project Manager, Wayne Dyok, at wdyok@aidea.org or (907) 771-3955.

Sincerely,

Sara Fisher-Goad
Executive Director
Alaska Energy Authority

Attachments

Cc: Distribution List
Jeff Wright
Ann Miles
Vince Yearick
Dr. Jennifer Hill
David Turner

[17] *See* 18 C.F.R. § 5.14(a).

Attachment A
AEA Proposed Alternative Study Plan Determination Schedule
For Aquatic Studies

Responsible Party	Pre-Filing Milestone	Current Date	AEA Proposed Date
AEA	AEA files results of open-water flow routing model and habitat mapping.	January 21, 2013	January 31, 2013
AEA	AEA provides to FERC and licensing participants: • results of open-water flow routing model; • habitat mapping; • DRAFT Fish Distribution and Abundance Implementation Plan; • DRAFT River Productivity Implementation Plan; • Description of habitat units within the Focus Area for all aquatic studies to be implemented in the Middle a River.		January 31, 2013
AEA and All Stakeholders	Discuss study results, draft implementation plans, and site selection for all studies to be implemented in the Middle and Lower Susitna River.	February 15, 2013	February 14-15, 2013
AEA	AEA files studies 9.5 and 9.6, Fish Distribution and Abundance Implementation Plan; study 9.8, River Productivity Implementation Plan; and describes habitat units within the Focus Areas in studies 5.5, 5.6, 5.7, 6.5, 6.6, 7.5, 7.6, 8.5, 8.6, 9.6, 9.8, and 9.9 that will be sampled or subsampled depending on the size of the habitat unit, as determined in the field.	March 15, 2013	March 1, 2013
All Stakeholders	Revised Study Plan Comments Due for studies 5.5, 5.6, 5.7, 6.5, 6.6, 7.5, 7.6, 8.5, 8.6, 9.5, 9.6, 9.8, and 9.9.	April 14, 2013	March 18, 2013[1]
FERC	Director's Study Plan Determination for studies 5.5, 5.6, 5.7, 6.5, 6.6, 7.5, 7.6, 8.5, 8.6, 9.5, 9.6, 9.8, and 9.9.	May 14, 2013	April 1, 2013

[1] The 15 day response time for RSP comments and the 30 day time for issuance of an SPD fall on weekends. Therefore, the proposed comment dates for both are the next business day.

ATTACHMENT B

Revised Study Plans
RSP 9.5 (Fish Distribution and Abundance in the Upper Susitna River)
RSP 9.6 (Fish Distribution and Abundance in the Lower and Middle Susitna River)
RSP 9.8 (River Productivity)

9.5. Study of Fish Distribution and Abundance in the Upper Susitna River

9.5.1. General Description of the Proposed Study

This study is focused on describing the current fish assemblage including spatial and temporal distribution, and relative abundance by species and life stage in the Susitna River upstream of the proposed Watana Dam (RM 184). Fishery resources in the upper sections of the Susitna River basin consist of a variety of salmonid and non-salmonid resident fish (Table 9.5-1). With one known exception (i.e., Chinook salmon), existing information indicates that anadromous fish are restricted to the mainstem Susitna River and tributaries downstream of Devils Canyon near RM 150 due to their apparent inability to pass several steep rapids. In addition to investigating the resident salmonid and non-salmonid fishes present in this part of the river, this study will also investigate the distribution and abundance of any anadromous fish above the proposed Watana Dam site. Chinook salmon have been observed in relatively low numbers above Devils Canyon (maximum peak count of 46 adult Chinook salmon during 1984; Thompson et al. 1986).

The physical habitat modeling efforts proposed in the Fish and Aquatics Instream Flow Study (Section 8.5) require information on the distribution and periodicity of different life stages for the fish species of interest. Not all life stages of the target fish species may be present throughout the Upper Susitna River, and seasonal differences may occur in their use of some habitats. For example, some fish that use tributary streams during the open-water period may overwinter in mainstem habitats.

This study is designed to provide baseline biological information regarding periodicity and habitat suitability for the Instream Flow Modeling Study (see Section 8.5). Results of this study will include key life history information about fish species in the Upper Susitna River, which will provide inputs for the Study of Fish Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12) and the Study of Fish Passage Feasibility at Watana Dam (Section 9.11).

Study Goals and Objectives

The overarching goal of this study is to characterize the current distribution, relative abundance, run timing, and life history of resident and non-salmon anadromous species (e.g., Dolly Varden, humpback whitefish, round whitefish, Arctic grayling, northern pike, and Pacific lamprey), and freshwater rearing life stages of anadromous fish (fry and juveniles) in the Susitna River above the proposed dam site (RM 184). Specific objectives include the following:

1. Describe the seasonal distribution, relative abundance (as determined by catch per unit effort [CPUE], fish density, and counts), and fish-habitat associations of resident fishes, juvenile anadromous salmonids, and the freshwater life stages of non-salmon anadromous species.
2. Describe seasonal movements of juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Pacific lamprey, Arctic grayling and burbot within the hydrologic zone of influence upstream of the Project.

   a. Document the timing of downstream movement and catch using out-migrant traps.
   b. Describe seasonal movements using biotelemetry (passive integrated transponders [PIT] and radio-tags).
   c. Describe juvenile Chinook salmon movements.
3. Characterize the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
4. Determine whether Dolly Varden and humpback whitefish residing in the Upper River exhibit anadromous or resident life histories.
5. Determine baseline metal concentrations in fish tissues for resident fish species in the mainstem Susitna River (see Section 5.5 Water Quality and Section 5.7, Mercury Assessment and Potential for Bioaccumulation Study).
6. Document the seasonal distribution, relative abundance, and habitat associations of invasive species (northern pike).
7. Collect tissue samples to support the Genetic Baseline Study for Selected Fish Species (Section 9.14).

9.5.2. Existing Information and Need for Additional Information

Information regarding resident species, non-salmon anadromous species, and the freshwater rearing life stages of anadromous salmon was collected during studies in connection with Alaska Power Authority's (APA's) proposed Susitna Hydroelectric Project in the 1980s. Existing information includes the spatial and temporal distribution of fish species and their relative abundance. The Pre-Application Document (PAD) (AEA 2011a) and Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011b) summarized this existing information and also identified data gaps for resident and rearing anadromous fish.

A total of nine anadromous and resident fish species have been documented inhabiting the Susitna River drainage upstream of Devils Canyon (Table 9.5-1). Chinook salmon use of the Upper Susitna River was first documented during the 1980s studies; this is the only anadromous fish documented to pass the rapids at Devils Canyon. Resident species that have been identified in all three segments of the Susitna River include Arctic grayling, Dolly Varden, humpback whitefish, round whitefish, burbot, longnose sucker, and sculpin (Schmidt et al. 1985; Buckwalter 2011). To varying degrees, the relative abundance and distribution of these species were determined during the early 1980s studies. For most species, the dominant age classes and sex ratios were also determined, and movements, spawning habitats, and overwintering habitats were identified for certain species.

One species that has not been documented in the Susitna River, but may occur in the upper Susitna drainage, is lake trout. Lake trout have been observed in Sally Lake and Deadman Lake of the upper Susitna watershed (Delaney et al. 1981a) but have not been observed in the mainstem Susitna or tributary streams. Pacific lamprey have been observed in the Chuit River (Nemeth et al. 2010), which also drains into Cook Inlet. Northern pike is an introduced species that has been observed in the Lower and Middle River (Rutz 1999). Although it is considered unlikely that Pacific lamprey and northern pike are present in the Upper Susitna River, this study will be helpful for evaluating these species' distributions.

In the proposed impoundment zone, Arctic grayling are believed to be the most abundant fish species (Delaney et al. 1981a; Sautner and Stratton 1983) and were documented spawning in tributary pools. In tributaries, juvenile grayling were found in side channels, side sloughs, and pool margins and in the mainstem at tributary mouths and clear water sloughs during early summer. Dolly Varden populations in the Upper Susitna River are apparently small but widely distributed. Burbot in the Upper Susitna River were documented in mainstem habitats with backwater-eddies and gravel substrate. The abundance of longnose suckers in the Upper Susitna River was less than downstream of Devils Canyon. Specific information needs relative to fish distribution and abundance in the Upper Susitna River that were identified in the ARDGA (AEA 2011b) include the following:

- Population estimates of adult Arctic grayling and Dolly Varden in select tributaries within the proposed impoundment zone.
- The migration timing of Arctic grayling spawning in the proposed impoundment zone, the relative abundance and distribution of Dolly Varden, lake trout, and juvenile Chinook salmon in the impoundment zone.
- Physical habitat characteristics used by round whitefish, longnose sucker, and burbot within the impoundment zone.

Little is known about the density and distribution of juvenile salmon in the Susitna River upstream of Devils Canyon (RM 150) and the proposed dam site at RM 184. All five species of Pacific salmon were captured in the Lower and Middle Susitna River during the 1980s licensing studies. Coho, chum, sockeye, and pink salmon have not been observed upstream of the Devils Canyon rapids. Chinook salmon are the only anadromous species known to occur in the Upper Susitna River and tributaries although the information on the extent of their distribution is limited. In 1984, Chinook spawning was documented upstream of Devils Canyon but downstream of the proposed dam site at Chinook Creek (RM 156.8), and Fog Creek (RM 176.7) (ADF&G 1985). More recent sampling has documented adults in Fog and Tsusena Creeks (RM 181.3) and upstream of the proposed dam site in Kosina Creek (RM 201). Juvenile Chinook salmon have been documented recently upstream of Devils Canyon in Fog Creek, and upstream of the proposed dam site in Kosina Creek, and in the Oshetna River (RM 225) (Buckwalter 2011). Historic data indicate that Susitna River Chinook salmon spawn exclusively in tributary streams (Thompson et al. 1986;Barrett et al.1983; Barrett 1974, 1985) and that nearly all Chinook salmon juveniles in this system out-migrate to the ocean as age-1+ fish, and very few exit the system as fry.

Existing fish and aquatic resource information appears insufficient to address the following issues that were identified in the PAD (AEA 2011a):

- **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.

- **F3:** Potential effect of Watana Dam on fish movement.

Site-specific knowledge of the distribution, timing, and abundance of fish likely to occupy the proposed Watana Reservoir primarily depends on the results of surveys conducted by the Alaska Department of Fish and Game (ADF&G) during the early 1980s using multiple sampling methods (AEA 2011a). The existing information can provide a starting point for understanding the distribution and abundance of anadromous and resident freshwater fishes in the Susitna River and the functional relationship with the habitat types present. However, any significant differences in the patterns in abundance and distribution observed during the 1980s compared to current conditions need to be determined.

In addition to providing baseline information about aquatic resources in the proposed Project area, aspects of this study are designed to complement and support other fish and aquatic studies.

9.5.3. Study Area

The study area encompasses the mainstem Susitna River from the proposed Watana Dam site (RM 184) upstream to the Oshetna River confluence (RM 233.4) (Figure 9.5-1). The Upper Susitna River is delineated by the location of the proposed Watana Dam because effects of the Project are anticipated to be different upstream and downstream of the proposed dam. The mainstem Susitna River and its tributaries upstream of the proposed dam will be within the impoundment zone and subject to Project operations that affect daily, seasonal, and annual changes in pool elevation plus the effects of initial reservoir filling. Tributary surveys upstream of the proposed Watana Dam are further delineated by the 3,000-foot elevation contour, which is based on the known extent of juvenile Chinook salmon distribution. Some study components, such as resident fish life-history studies and juvenile Chinook salmon distribution sampling, may extend beyond the core area.

9.5.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the distribution and abundance of fish species in the Upper Susitna River. The following sections provide brief descriptions of study site selection, sampling frequency, the approach, and suite of methods that will be used to accomplish each objective of this study. This study was initiated in 2012 and will continue over the next two years to survey as much habitat as possible.

Fish Distribution and Abundance Sampling Plan

Some details of the sampling scheme have been provided for planning purposes; however, modifications may be appropriate as the results of 2012 data collection are reviewed. A final sampling scheme will be developed as part of the detailed Fish Distribution and Abundance Implementation Plan, for Sections 9.5 and 9.6, which will be submitted to FERC no later than March 15, 2013. Implementation plan development will include (1) a summary of relevant fisheries and an overview of the life history needs for fish species known to occur in the Susitna River to guide site selection and sampling protocols, (2) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9), (3) a description of site selection and sampling protocols, (4) development of field data collection forms, and (5) development of database templates that comply with 2012 AEA QA/QC procedures. The implementation plan will include the level of detail sufficient to instruct field crews in data collection efforts. In addition, the plan will include protocols and a guide to the decision-making process in the form of a chart or decision tree that will be used in the field, specific sampling locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The implementation plan will address how sampling events will be randomized to evaluate precision by habitat and gear type. The implementation plan will also help ensure that fish collection efforts occur in a consistent and repeatable fashion across field crews and river segments. Proposed sampling methods by objective are presented below and in Table 9.5-2. Brief descriptions of each sampling technique are provided in Section 9.5.4.4.

9.5.4.1 Study Site Selection

The Upper Susitna River will represent an area where the mainstem river will be inundated and tributaries will be partially altered. As a result, the sampling effort will be tailored to collect necessary information to document fish assemblages, distribution, and abundance generally within the mainstem river and more intensely within the tributary habitat inundated up to an elevation of 2,200 feet. The number of sites may be revisited after sampling in 2013, if Chinook are located in tributaries above 2,200 feet.

A nested stratified sampling scheme will be used to select study sites to cover the range of habitat type. The habitat classification hierarchy, as described in Section 9.9.5.4.1 of the Habitat Classification Study, will be composed of five levels representing (1) major hydraulic segment; (2) geomorphic reach; (3) mainstem habitat type; (4) main channel mesohabitat; and (5) edge habitat (Table 9.9-4, Nested and tiered habitat mapping units and categories).

Level 1 will generally identify the Lower River (RM 28-98), Middle River (RM 98-184), and Upper River (RM 184-233) from each other. The mainstem Susitna River and its tributaries upstream of the proposed dam will be within the impoundment zone and subject to Project operations that affect daily, seasonal, and annual changes in pool elevation plus the effects of initial reservoir filling. In contrast, the mainstem downstream of the Project will be subject to the effects of flow modification from Project operations, which will diminish below the Three Rivers Confluence.

Level 2 will identify unique reaches established from the channel's geomorphic characteristics (established from the Geomorphology Study [Section 6.0]). The Geomorphic Study Team will delineate the Lower, Middle, and Upper River segments into large-scale geomorphic river reaches with relatively homogeneous landform characteristics, including at generally decreasing scales: geology, hydrology (inflow from major tributaries), slope, channel planform, braiding or sinuosity index (where relevant), entrenchment ratio, channel width, and substrate size. Stratification of the river into relatively homogeneous segments will facilitate relatively unbiased extrapolation of sampled site data within the individual segments because sources of variability associated with large-scale features will be reduced.

Level 3 classifies the mainstem habitat into main channel, off-channel, and tributary habitat using an approach similar to the 1980s historical habitat mapping definitions (ADF&G 1983). The main channel includes five mainstem habitat types, whereas the off-channel habitat will be categorized into four types (Table 9.9-4). The 1980s classification of riverine habitats of the Susitna River included six major mainstem habitat categories consisting of main channel, side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1984). These mainstem habitat categories will be maintained in the 2012 classification system, but they are further categorized into main channel, off-channel, and tributary. These will be expanded to include five types of main channel (main channel, split main channel, multiple split main channel, side channel, and tributary), and four types of off-channel (slide slough, upland slough, backwater, and beaver complex) (Table 9.9-4).

Level 4 will further delineate Level 3 main channel and tributary habitats into mesohabitat types (pool, riffle, glide, and cascade) (Table 9.9-4). However, off-channel habitat will remain at Level 3 (side slough, upland slough, backwater, and beaver complex).

The presence, distribution, and frequency of these habitats vary longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. Thus, fish sampling in the Upper River will necessarily vary with habitat and will not be stratified equally among geomorphic reaches (Level 2). Stratification will occur across geomorphic reaches as much as possible but will be dictated by the distribution of habitat types present within each reach. For example, based on preliminary geomorphic reach delineation, we would expect to find multiple split main channel habitats in reaches UR1 and UR6 but not in the more confined and incised reaches UR2 through UR5. In order to ensure that representative habitats are sampled along the Upper River, six replicate sampling sites will be selected within each Level 3 habitat type for fish distribution sampling (27 sites). In addition, one replicate of each Level 4 main channel habitat nested within each Level 3 habitat will be selected for relative abundance sampling (Figure 9.5-2).

Habitat mapping in the tributaries will be completed differently than in the mainstem river due to the lack of complete aerial imagery, relatively smaller channel size, steep gradient, and limited on the ground accessibility for direct mapping. Because of this general inaccessibility, very rugged terrain, and mostly non-wadeable stream channels, near census mapping (100 percent coverage) is challenging and in some cases unsafe or impossible. For these reasons, only tributaries mapped by the Characterization and Mapping of Aquatic Habitats Study (Section 9.9; Table 9.9-2) will be selected for fish distribution and abundance sampling. Up to 18 tributary streams will be targeted for sampling during 2013 and 2014. All tributaries in which Chinook salmon juveniles or adults were observed within or at the mouth of a tributary during 2012, or during previous surveys by Buckwalter (2011) (i.e., Fog Creek, Kosina Creek, Tsusena Creek, Oshetna River), will be sampled. Of the remaining tributaries that are suitable for sampling (Table 9.9-2), efforts will be directed towards streams that are not already identified as supporting anadromous fishes in the ADF&G Anadromous Waters Catalog (AWC). Selected study sites will comprise a target of 25 percent of the mapped habitats in each tributary; this target will vary with access considerations. All known Chinook salmon-bearing tributaries will be sampled up to the 3,000-foot elevation contour, which is based on the known extent of Chinook salmon distribution.

Site selection includes first completing the geomorphic reach delineation and habitat mapping tasks. In addition to technical considerations, access and safety will be key non-technical attributes for site selection for all studies. This, too, influenced site selection in the 1980s studies, and will certainly influence site selection in the present studies.

9.5.4.2 Sampling Frequency

Sampling frequency will vary among sites based on specific objectives. Generally, sampling will occur seasonally during the ice-free period. Additional effort, up to bi-weekly sampling, will be required immediately following ice-out in an attempt to capture critical juvenile Chinook salmon out-migration from natal tributaries to rearing habitats.

9.5.4.3 Fish Sampling Approach

The initial task of this study will consist of a focused literature review to guide selection of appropriate sampling methods by species and habitat type, sampling event timing, and sampling event frequency. Anticipated products from the literature review include the following:

- A synthesis of existing information on life history, spatial and temporal distribution, and relative abundance by species and life stage.
- A review of sampling strategies, methods, and procedures used in the 1980s fish studies.
- Preparation of periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and out-migration).
- A summary of mainstem Susitna River habitat utilization for each species, by riverine habitat type (main channel, side channel, side slough, upland slough, tributary mouth, tributary).
- A summary of existing age, size, and genetics information.
- A summary of distribution of invasive species, such as northern pike.

Knowledge of behavior and life history of the target species is essential for effective survey design. Selected fish sampling techniques will vary based on habitat characteristics, season, and species/ life history of interest. Timing of surveys depends on the objectives of the study and the behavior of the target fish species. Since life stage-specific information is desirable, timing of the survey must match the use of the surveyed habitat by that life stage.

9.5.4.3.1 Objective 1: Fish Distribution, Relative Abundance, and Habitat Associations

Two general approaches to fish sampling will be used. The first is focused on gathering data on general fish distribution (presence/absence). This sampling involves a single pass with appropriate gear types. To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling event at a specific site to evaluate temporal changes in fish distribution. The second sampling approach is to gather data on relative abundance as determined by CPUE and density; complementary data on fish size, age, and condition factor will also be collected. The selected transects and fish capture methods (i.e., number of passes, amount of soak time) will be standardized such that they are repeatable on subsequent sampling occasions. This approach will also emphasize the identification of foraging and spawning habitats.

Long daylight hours during the summer may reduce the difference between day and night sampling effectiveness. The periods of twilight are important sampling periods. Sampling schedules will encompass daylight, twilight, and evening periods.

Task A: Fish Distribution Surveys

Fish distribution surveys will include seasonal sampling events during the ice-free seasons. Methods will be selected based on species, life stage, and water conditions. Snorkeling and electrofishing are preferred methods for juvenile fishes in clear water areas where velocities are safe for moving about in the creek. The use of minnow traps, beach seines, set nets, and fyke nets will be employed as alternatives in deeper waters and habitats with limited access, low visibility, and/or high velocities. For larger/adult fishes, gillnets, seines, trotlines, hoop traps, and angling will be used.

Survey methods will likely vary for the different study areas in the Upper Susitna River. Whereas snorkeling, minnow trapping, backpack electrofishing, and beach seines may be applicable to sloughs and other slow-moving waters, it is anticipated that gillnetting, boat electrofishing, hoop traps, and trot lines may be more applicable to the mainstem. The decisions about what methods to apply will be made by field crews after initial site selection in coordination with Fish Distribution and Abundance Study Lead and the Fish Program Lead and in accordance with state and federal fish sampling permit requirements.

Task B: Relative Abundance

Relative abundance surveys will include seasonal multi-pass sampling events during the ice-free seasons. As mentioned above, methods will be selected based on species, life stage, and water conditions. All methods will be conducted consistent with generating estimates of CPUE that are meaningful and facilitate comparison of counts or densities of fish over space and time. This includes calibration and quality control of methods and documentation of conditions that affect sampling efficiency—such as visibility, water temperature, and conductivity—to ensure that a consistent level of effort is applied over the sampling unit.

Task C: Fish-Habitat Associations

In conjunction with Tasks 1 and 2, data will be collected for fish distribution and abundance by habitat type. This task includes an analysis of fish presence, distribution, and density by mesohabitat type by season. The information on fish habitat use will help identify species and life stages potentially vulnerable to Project effects.

9.5.4.3.2 Objective 2: Seasonal Movements

Task A: Document the timing of downstream movement and catch for all fish species using out-migrant traps.

Understanding the timing of migration from natal tributaries to the mainstem Susitna River and from the Upper Susitna River to the proposed dam site (RM 184) is important for assessing the potential effects of the proposed Project. Out-migrant traps (rotary screw traps and inclined plane traps) are useful for determining the timing of downstream migrating juvenile salmonids and resident fish.

A maximum of two out-migrant traps will be deployed. In addition to collection of data on migratory timing, size at migration, and growth, out-migrant traps will also serve as a platform for tagging juvenile fish (Objective 2, Task C), recapturing previously tagged fish, collecting fish for stomach contents analysis in support of the River Productivity Study (Section 9.8), and collecting tissue samples (Objective 7) to support the Genetic Baseline Study for Selected Fish Species (Section 9.14).

Task B: Describe seasonal movements using biotelemetry.

Biotelemetry techniques will include radio telemetry and PIT technology. PIT tags will be surgically implanted in small fish >60 mm to monitor movement and growth; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally in the Upper River.

PIT tag antenna arrays with automated data logging will be used at selected side channels and tributary mouths to detect movement of tagged fish into or out of the site. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in length (growth).

Radio-tagged fish will be tracked with monthly aerial surveys and by boat, in conjunction with the Salmon Escapement Study (Section 9.7) to describe seasonal movements of selected fish species with emphasis on identifying spawning and overwintering habitats within the hydrologic zone of influence upstream of the Project.

Up to 30 radio transmitters will be implanted in selected species including Arctic grayling, Dolly Varden, burbot, round whitefish, humpback whitefish, and northern pike if present (Objective 6). A PIT tag will be implanted into up to 1,000 fish of these species per PIT tag array that are in close proximity to an array and approximately 60 mm and larger.

Task C: Describe juvenile Chinook salmon movements.

Juvenile Chinook salmon movement within the Upper River will be described using out-migrant traps and biotelemetry methods outlined in Objective 2, Tasks A and B. This study proposes to implant PIT tags in all juvenile Chinook salmon >60 mm in length to document seasonal movement within the Upper River using antenna arrays placed in tributary mouths, sloughs, and side channels and on out-migrant traps to recapture fish. Because of the low number of adult Chinook salmon tracked to the Upper River with radio-tags in 2012, all juvenile Chinook salmon of taggable size need to be tagged to obtain a sufficient sample size. Out-migrant traps will be used to document juvenile Chinook salmon migratory timing and size at migration from natal tributaries to the Upper River and out-migration from the Upper River to below the proposed dam site (RM 184). The data on juvenile Chinook salmon movement patterns and timing will support the Study of Fish Passage Feasibility at Watana Dam (Section 9.11).

9.5.4.3.3 Objective 3: Characterize the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.

In conjunction with Objectives 1 and 2, all captured fish will be identified to species, measured to the nearest millimeter (mm) fork length, and weighed to the nearest gram. Length frequency data by species will be compared to length-at-age data in the literature to infer age classes. Recaptured PIT-tagged fish (Objective 2, Task B) will provide information on changes in length and weight (growth). Recorded parameters in each habitat unit will include number of fish by species and life stage, fork length, global positioning system (GPS) location of sampling area, time of sampling, weather conditions, water temperature, water transparency, behavior, and location and distribution of observations.

9.5.4.3.4 Objective 4: Determine whether Dolly Varden and humpback whitefish residing in the Upper River exhibit anadromous or resident life histories.

Otoliths will be collected from Dolly Varden and humpback whitefish greater than 200 mm (7.8 inches) in length to test for marine-derived elements indicative of an anadromous life history pattern. It is assumed that larger fish are more likely to have exhibited anadromy and therefore otolith collection is proposed only from fish greater than 200 mm in length. A target of 30 fish of each species during 2013 and 2014 will be collected (60 fish of each species total).

9.5.4.3.5 Objective 5: Determine baseline metal and mercury concentrations in fish tissues for resident fish species in the mainstem Susitna River.

Tissue or whole fish samples will also be collected in the mainstem Susitna River for assessment of metals (see Section 5.5.4.7, Baseline Metal Levels in Fish Tissue) and mercury (see Section 5.7.4.2.6, Mercury Assessment and Potential for Bioaccumulation Study) concentrations. Target fish species for baseline metals testing include: Dolly Varden, Arctic grayling, whitefish species, long nose sucker, lake trout, burbot, and resident rainbow trout. Target fish species for mercury sampling include: Dolly Varden, arctic grayling, stickleback, long nose sucker, whitefish species, lake trout, burbot, and resident rainbow trout.

9.5.4.3.6 Objective 6: Document the seasonal distribution, relative abundance, and habitat associations of invasive species (northern pike).

Northern pike were likely established in the Susitna River drainage in the 1950s through a series of illegal introductions (Rutz 1999). The proliferation of this predatory species is of concern owing to its effect on salmonids and other species such as stickleback. At this time, northern pike have not been documented in the Upper River, so no targeted collection effort for pike will be made. However, the presence/absence and habitat associations of northern pike and other invasive fish species will be documented as a component of all fish capture and observation sampling events associated with Objectives 1 and 2.

9.5.4.3.7 Objective 7: Collect tissue samples from juvenile salmon and all resident and non-salmon anadromous fish.

In support of the Genetic Baseline Study for Selected Fish Species (Section 9.14), fish tissues will be collected opportunistically in conjunction with all fish capture events. The target number of samples, species of interest, and protocols are outlined in Section 9.14. Tissue samples include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

9.5.4.4 Fish Sampling Techniques

A combination of gillnetting, electrofishing, angling, trot lines, minnow traps, snorkeling, out-migrant trapping, beach seines, fyke nets, hoop nets, dual-frequency identification sonar (DIDSON), and underwater video camera techniques will be used to sample or observe fish in the Upper River, and moving in and out of selected sloughs and tributaries draining to the Susitna River. Several assumptions are associated with the use of the proposed methods:

- If it can be conducted safely, snorkeling, electrofishing, and gillnetting will require nighttime sampling in clear-water areas to increase the efficacy of fish capture or observation.
- Gillnetting is likely the most effective means of capturing fish in open-water areas of the main Susitna River channel.
- All fish sampling and handling techniques described within this study will be conducted under state and federal biological collection permits. Limitations on the use of some methods during particular time periods or locations may affect the ability to make statistical comparisons among spatial and temporal strata.
- Fish sampling techniques provide imperfect estimates of habitat use and relative fish abundance. Use and comparison of multiple sampling methods provides the opportunity

to identify potential biases, highlight strengths and weaknesses of each method, and ultimately improve estimates of fish distribution and relative abundance.

- Sampling in the reservoir inundation zone will be scaled based on elevation and Chinook salmon distribution. More intensive surveys will be conducted in tributaries to be inundated up to an elevation of 2,200 feet. Sampling from 2,200 feet to 3,000 feet elevation will be focused on Chinook salmon. If Chinook salmon are located, sub-sampling will continue upstream to the upper extent of suitable Chinook salmon habitat.

9.5.4.4.1 Gillnet Sampling

Variable mesh gillnets (7.5-foot-deep panels with 1-inch to 2.5-inch stretched mesh) will be deployed. In open water and at sites with high water velocity, gillnets will be deployed as drift nets, while in slow water sloughs, gillnets will be deployed as set (fixed) nets. The location of each gillnet set will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The length, number of panels, and mesh of the gillnets will be consistent with nets used by ADF&G to sample the river in the 1980s (ADF&G 1982, 1983, 1984). To reduce variability among sites, soak times for drift gillnets will be standardized; all nets will be retrieved a maximum of 30 minutes after the set is completed. The following formula will be used to determine drifting time:

T = ([(set time + retrieval time)/2] + soak time)

9.5.4.4.2 Electrofishing

Boat-mounted, barge, or backpack electrofishing surveys will be conducted using standardized transects. Boat-mounted electrofishing is the most effective means of capturing fish in shallow areas (<10 feet deep) near stream banks and within larger side channels. Barge-mounted electrofishing is effective in areas that are wadeable, but have relatively large areas to cover and are too shallow or otherwise inaccessible to a boat-mounted system. Backpack electrofishing is effective in wadeable areas that are relatively narrow. The effectiveness of barge and backpack electrofishing systems can be enhanced through the use of block nets. Electrofishing methods will follow NMFS (2000) Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.

Sites will be selected carefully, because electrofishing may have limited success in swift, turbid, or low conductivity waters. Suspended materials in turbid water can affect conductivity, which may result in harmful effects on fish, especially larger fish due to a larger body surface in contact with the electrical field. Sudden changes in turbidity can create zones of higher amperage, which can be fatal to young-of-year fish as well as larger fish. Electrofishing in swift current is problematic, with fish being swept away before they can be netted. Similarly, turbidity increases losses from samples. Electrofishing will be discontinued immediately in a sampling reach if large salmonids or resident fish are encountered.

Selection of the appropriate electrofishing system will be made as part of site selection, which will include a site reconnaissance. In all cases, the electrofishing unit will be operated and configured with settings consistent with guidelines established by Smith Root. The location of each electrofishing transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. To the extent possible, the selected electrofishing system and transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. Habitat measurements will be collected at each site using the characterization methods identified in Section 9.9. Any changes will be noted between sample periods. The electrofishing start and stop times and water conductivity will be recorded. Where safety concerns can be adequately addressed, electrofishing will also be conducted after sunset in clear water areas; otherwise, electrofishing surveys will be conducted during daylight hours.

9.5.4.4.3 Angling

Angling with hook and line can also be an effective way to collect fish samples depending on the target species. During field trips organized for other sampling methods, hook-and-line angling will be conducted on an opportunistic basis using artificial lures or flies with single barbless hooks. The primary objective of hook-and-line sampling will be to capture subject fish for tagging (e.g., northern pike) and to determine presence/absence; a secondary objective will be to evaluate seasonal fish distribution. Because it is labor and time intensive, angling is best used as an alternative method if other more effective means of sampling are not available. Angling can also be used in conjunction with other methods, particularly if information is required on the presence and size of adult fish.

9.5.4.4.4 Trot Lines

Trot lines can be an effective method for capturing burbot, rainbow trout, Dolly Varden, grayling, and whitefish. Trotlines are typically a long line with a multitude of baited hooks and are typically anchored at both ends and set in the water for a period of time. Trot line sampling was one of the more frequently used methods during the 1980s and was the primary method for capturing burbot; however, trot lines are generally lethal. Trot lines will consist of 14 to 21 feet of seine twine with six leaders and hooks lowered to the river bottom. Trot lines will be checked and rebaited after 24 hours and pulled after 48 hours. Hooks will be baited with salmon eggs, herring, or whitefish. Salmon eggs are usually effective for salmonids, whereas herring or whitefish are effective for burbot. Trot line construction and deployment will follow the techniques used during the 1980s studies as described by ADF&G (1982). As per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait will be commercially sterilized or disinfected with a 10-minute soak in a 1/100 Betadyne solution prior to use.

9.5.4.4.5 Minnow Traps

Minnow traps baited with salmon eggs are an effective method for passive capture of juvenile salmonids in pools and slow-moving water (Bryant 2000). In reaches where both electrofishing and snorkeling would be ineffective due to stream conditions such as deep, fast water, baited minnow traps will be used as an alternative to determine fish presence. During the 1980s, minnow traps were the primary method used for capturing sculpin, lamprey, and threespine stickleback. Minnow traps also captured rainbow trout and Arctic grayling. Minnow traps will be baited with salmon roe, checked, and rebaited after 90 minutes following protocols outlined by Bryant (2000). Between 5 and 10 minnow traps will be deployed, depending on the size of the sampling site. All fish captured will be identified to species, measured, and released alive near the point of capture. As per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait will be commercially sterilized or disinfected with a 10-minute soak in a 1/100 Betadyne solution prior to use.

9.5.4.4.6 Snorkel Surveys

This survey technique is most commonly used for juvenile salmonid populations, but can also be used to assess other species groups. Generally, snorkeling works well for detecting presence or absence of most species. Limits occur when water is turbid or deep due to the inability to see the fish, or the water is too swift to safely survey (Dolloff et al. 1993, 1996). To get relative abundance estimates, a closed population is needed within a single habitat unit, and block nets will be used to prevent fish from leaving the unit (Hillman et al. 1992).

In stream channels with a width of less than 4 m, the survey will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right counts. In stream channels with a width greater than 4 m, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. The counts from all snorkelers are then summed for the total count for the reach sampled. This expansion estimate assumes that counts are accurate and that snorkelers are not counting the same fish twice (Thurow 1994). Data will be recorded following completion of the survey. Survey reaches will be snorkeled starting at the downstream end and working upstream.

Snorkel surveys will also be used in combination with other techniques to estimate relative abundance. This use of snorkel surveys provides a calibration factor for the counting efficiency of snorkel surveys compared to other methods such as electrofishing and seining (Dolloff et al. 1996).

For most of the snorkel surveys in this study, two experienced biologists will snorkel along standardized transects in clear water areas during both day and night during each field survey effort. Snorkelers will visually identify and record the number of observed fish by size and species. The location of each snorkel survey transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs.

9.5.4.4.7 Fyke/Hoop Nets

Fyke or hoop nets will be deployed to collect fish in sloughs and side channels with moderate water velocity (< 3 feet per second). After a satisfactory location has been identified at each site, the same location will be used during each subsequent collection period. The nets will be operated continuously for up to two days. Each fyke net will be configured with two wings to guide the majority of water and fish to the net mouth. The fyke nets will have 1/8-inch mesh, 1-foot diameter hoops, and up to 4 hoops. Where possible, the guide nets will be configured to maintain a narrow open channel along one bank. Where the channel size or configuration does not allow an open channel to be maintained, the area below the fyke net will be checked regularly to assess whether fish are blocked and cannot pass upstream. A live car will be located at the downstream end of the fyke net throat to hold captured fish until they can be processed. The fyke net wings and live car will be checked daily to clear debris and to ensure that captured fish do not become injured. The location of the fyke net sets will be mapped using a hand-held GPS unit and marked on high-resolution aerial photographs.

9.5.4.4.8 Hoop Traps

Commercially available hoop traps have been used successfully by ADF&G on the Tanana River as a non-lethal method to capture burbot for tagging studies (Evenson 1993; Stuby and Evenson 1998). Two sizes of traps have been used. Small and large hoop traps are 3.05 meters (m) and

3.66 m long, respectively. The small hoop trap has seven 6.35-mm steel hoops with diameters tapered from 0.61 m at the entrance to 0.46 m at the cod end. The large trap has inside diameters tapering from 91 to 69 centimeters (cm) with throat diameters of 36 cm. Each trap has a double throat that narrows to an opening 10 cm in diameter. All netting is knotted nylon woven into 25-mm bar mesh. Each trap is kept stretched open with two sections of PVC pipe spreader bars attached by snap clips to the end hoops. Bernard et al. (1991) provides an account of the efficacy of the small and large traps.

Hoop traps will be deployed in mainstem areas of lower velocity to capture burbot from late August through early October for radio-tagging (Objectives 1 and 2). Soak times will generally be overnight, but not more than 12 hours (M. Evenson pers comm 2012). All burbot captured will be measured and released. Up to 10 radio tags will be surgically implanted in burbot spatially distributed throughout the Upper Susitna River.

9.5.4.4.9 Beach Seine

Beach seines are an effective method to capture fish in a wide variety of habitats and are most effective in shallow water areas free of large woody debris and snags such as boulders. Seining allows the sampling of relatively large areas in short periods of time as well as the capture and release of fish without significant stress or harm. Repetitive seining over time with standardized net sizes and standardized deployment in relatively similar habitat can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon (Hayes et al. 1996). Beach seines will be 5 feet in depth and 40 feet in length, 1/4-inch mesh (net body) with a 1/8-inch net bag; however, the actual length of seine used will depend on the site conditions. Low water conditions may be sampled using a shorter and shallower beach seine; as long as the area sampled is noted and the net is deep enough to fill the water column, then comparisons can be made. The location fished will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The area swept will be noted. Repetitive seining over time with standardized nets and soak times in relatively similar habitats can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon. To the extent possible, the same area will be fished during each sampling event; net sizes and soak times will be standardized.

9.5.4.4.10 Out-Migrant Trap

Rotary screw traps are useful for determining the timing of emigration by downstream migrating juvenile salmonids and resident fish (Objective 2). Out-migrant traps will be installed in a maximum of two sites: one site located near the proposed Watana Dam and one site near a tributary mouth. The location will occur with input from the Fish and Aquatic TWG and will be based on the physical conditions at the selected sites and logistics for deploying, retrieving, and maintaining the traps. Flow conditions permitting, traps will be fished on a cycle of 48 hours on, 72 hours off throughout the ice-free period. Each trap will be checked at least twice per day.

9.5.4.4.11 Fish Handling

Field crews will record the date, start and stop times, and level of effort for all sampling events, as well as water temperature and dissolved oxygen at sampling locations. All captured fish will be identified to species. Up to 100 individuals per species per life stage per season will be measured to the nearest mm fork length, and in Focus Areas up to 30 fish per species per site will be measured on a monthly basis. Sampling supplies will be prepared before sampling begins. For example, the date, location, habitat type, and gear type recorded in log book, beginning fish number in proper sequence, daily sample objective by gear type, and an adequate live box and clean area should be available. To increase efficiency, fish should be sampled in order in groups of 10, and the sample routine followed in a stepwise manner: (1) identify species and life stage, (2) measure lengths, (3) remove tissue samples for genetic analysis, and (4) cut all dead fish for accurate sex identification. Care will be taken to collect all data with a consistent routine and to record data neatly and legibly.

For methods in which fish are observed, but not captured (i.e., snorkeling, DIDSON, and underwater video), an attempt will be made to identify all fish to species. For snorkeling, fork length of fish observed will be estimated within 40-mm bin sizes. If present, observations of poor fish condition, lesions, external tumors, or other abnormalities will be noted. When more than 30 fish of a similar size class and species are collected at one time, the total number will be recorded and a subset of the sample will be measured to describe size classes for each species. All juvenile salmon, rainbow trout, Arctic grayling, Dolly Varden, burbot, and whitefish greater than 60 mm in length will be scanned for PIT tags using a portable tag reader. A PIT tag will be implanted into a sub-sample of fish of these species that do not have tags and are approximately 60 mm and larger. Because Chinook salmon are of particular interest and in low abundance, all captured juvenile Chinook salmon of taggable size will receive tags. For selected species, up to 1,000 fish per species per PIT tag array will be tagged based on proximity to PIT arrays. Target species are Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, and burbot. Radio transmitters will be surgically implanted in up to 30 adult fish of sufficient body size of each species and distributed temporally and longitudinally in the Upper River.

In support of the bioenergetics modeling (Objective 5, Section 9.8.4.5.1), fish species targeted for dietary analysis will include juvenile Chinook and coho salmon, juvenile and adult rainbow trout. Of these species Chinook salmon and rainbow trout may be encountered in the Upper River. A total of five fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods (described in Section 9.8.4.7). All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis. At two selected sample collection locations (one each in Upper and Middle River), punch samples of muscle tissue will be obtained from each fish for use in the stable isotope analysis (Section 9.8.4.5.2).

Otoliths will be collected from Dolly Varden and humpback whitefish greater than 200 mm (7.8 inches) in length to test for marine-derived elements indicative of an anadromous life history pattern (Objective 4). It is assumed that larger fish are more likely to have exhibited anadromy and therefore it is proposed to collect otoliths only from fish greater than 200 mm. A target of 30 fish of each species during 2013 and 2014 will be collected (60 fish of each species total). Tissue, fillets, and/or liver (burbot only) samples will also be collected in the mainstem Susitna River for assessment of metals concentrations (Objective 5) (see Section 5.5.4.7 Water Quality and Section 5.7.4.2.6, Mercury Assessment and Potential for Bioaccumulation Study). Target fish species in the vicinity of the Watana Reservoir will be Dolly Varden, Arctic grayling, stickleback, whitefish species, burbot, longnose sucker, and resident rainbow trout. If possible, fillets will be sampled from seven adult individuals from each species. Larger, older fish tend to have higher mercury concentrations; these fish will therefore be targeted with a desired sample size of seven per species. Body size targeted for collection will represent the non-anadromous phase of each species' life cycle. For stickleback, whole fish samples will need to be used. Collection times for fish samples will occur in late August and early September.

Tissue samples will be collected opportunistically in conjunction with all fish capture methods from selected resident and non-salmon fish to support the Genetic Baseline Study (Objective 7; Section 9.14). Tissue samples will include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm. The target number of samples, species of interest, and protocols are outlined in Section 9.14.

9.5.4.4.12 Remote Fish Telemetry

Remote telemetry techniques will include radio telemetry and PIT tags. Both of these methods are intended to provide detailed information from relatively few individual fish. PIT tags will be surgically implanted in small fish >60 mm; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally in the Upper River. The target species to radio-tag include Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, and burbot. Radio-tracking provides information on fine and large spatial scales related to location, speed of movement, and habitat utilization by surveying large areas and relocating tagged individuals during aerial, boat, and foot surveys. PIT tags can be used to document relatively localized movements of fish as well as growth information from tagged individuals across seasons and years. However, the "re-sighting" of PIT-tagged fish is limited to the sites where antenna arrays are placed. To determine movement in and out of side sloughs or tributaries requires that tagged fish pass within several feet of an antenna array, thereby limiting its use to sufficiently small water bodies. To characterize growth rates, fish must be recaptured, checked for a tag, and measured.

Radio Telemetry

The primary function of the telemetry component is to track tagged fish spatially and temporally with a combination of fixed station receivers and mobile tracking. Time/date stamped, coded radio signals from tags implanted in fish will be recorded by fixed station or mobile positioning. All telemetry gear (tags and receivers) across both studies will be provided by ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com).

The types of behavior to be characterized include the following:

- Arrival and departure timing at specific locations/positions
- Direction of travel
- Residence time at specific locations/positions
- Travel time between locations/positions
- Identification of migratory, holding, and spawning time and locations/positions
- Movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity)

Locating radio-tagged fish will be achieved by fixed receiver stations and mobile surveys (aerial, boat, and foot). Fixed stations will largely be those used for the Salmon Escapement Study (Section 9.7), of which, only one is slated for installation in the Upper River at the Kosina Creek confluence (RM 206.8). Up to three additional fixed stations may be established at strategic locations with input from the Fish and Aquatic TWG. These stations will be serviced in conjunction with the Salmon Escapement Study during the July through October period, but will be extended to begin on June 1 to track resident fish. Fixed stations will be downloaded as power supplies necessitate and up to twice monthly during the salmon spawning period (approximately July through October). The Salmon Escapement Study will provide approximately weekly aerial survey coverage of the study area (approximately July through October). At other times of the year, the frequency of aerial surveys will be monthly and during critical species-specific time periods (e.g., burbot spawning), bi-weekly. Using the guidance of fixed-station and aerial survey data on the known positions of tagged fish, specific locations of any concentrations of tagged fish that are suspected to be spawning will be visited to obtain individual fish positions. Foot and boat surveys will be conducted approximately July through October as part of the Salmon Escapement Study (Section 9.7). Spatial and temporal allocation of survey effort will be finalized based on the actual locations and number of each species of fish tagged.

The fundamental reason for using radio telemetry as a method to characterize resident and non-salmonid anadromous species is that it can provide useful information to address the overarching goal of the study and several of its objectives. In particular, radio telemetry can provide data on seasonal distribution and movement of the target fish throughout the range of potential habitats. Relocation data from the radio telemetry component of this study will be used to characterize the timing of use and degree of movements among macrohabitats and over periods during which the radio-tags remain active (potentially two or three seasons for large fish). This objective may be achieved by the use of long-life tags (e.g., greater than one year) and shorter life tags (e.g., three-month tags) applied to appropriate-sized fish over time. In general, successful radio telemetry studies use a tag weight to fish weight guideline of 3 percent (with a common range of 2 to 5 percent depending on the species). The range in size encountered for a particular species may be broad enough to warrant the use of different-sized tags with different operational life specifications. Actual tag life will be determined by the appropriate tag for the size of the fish available for tagging.

In this regard, the range in weights for the seven target species to be radio-tagged was estimated. Fish weights and the respective target weight of radio-tags (Table 9.5-3) were calculated using existing or derived length–weight relationships for Alaska fish (Figure 9.5-3), and length frequency distributions for Susitna River fish. This analysis illustrates that there is a relatively broad range of potential tag weights (0.5 grams [g] to 81 g) that are necessary to tag each species over the potential range in fish size. Further, it is evident that some species will require tags with a relatively short (30 to 200 days) operational period (tag life).

The broad range in tag weight complicates the scope of the task in terms of technological feasibility. In general, there is a preference for using coded tags because it allows the unique identification of a hundred tags on a single frequency. Conversely, standard tags (not coded) require a single frequency for each tagged fish to allow unique identification. The radio telemetry industry provides a variety of equipment to match research needs, but there are always trade-offs in terms of tracking performance and cost between different systems. This plan intends to capitalize on the use of the existing telemetry platform (ATS telemetry equipment) to sufficiently monitor the target species, but directly constrains the potential options for tagging and monitoring. More specifically, the smallest ATS coded tag weighs 6 g and therefore precludes application to all the species at the lower portion of their most frequently occurring size range (Table 9.5-3). For example, if fish need to weigh a minimum of 200 g to be tagged, then Dolly Varden would be tagged only at its largest samples, and burbot would be tagged almost across its entire adult size range (Table 9.5-3) based on their respective length–frequency distributions.

The use of non-coded tags on the smaller adult fish would require the use of many frequencies (e.g., 50 to 150) and an entirely separate array of receivers. Overall, tagging fish weighing less than 200 g would be expensive and logistically inefficient. The only viable option to cover the entire range of fish sizes would be to use alternative vendors' radio telemetry receivers and tags that use coded technology through the entire range of tag sizes (e.g., Lotek Wireless).

Tags will be surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally and longitudinally in the Upper River. These fish will be captured during sampling events targeting adult fish and with directed effort using a variety of methods. The final spatial and temporal allocation of tags will be determined after 2012 study results are available (i.e., preliminary fish abundance and distribution). The tag's signal pulse duration and frequency, and, where appropriate, the transmit duty cycle, will be a function of the life history of the fish and configured to maximize battery life and optimize the data collection. Larger tags can accommodate the greatest battery life and therefore will be used when fish are large enough, but smaller, shorter life tags will be used across the range of adult body sizes.

PIT Tag Antenna Arrays

As described above, fish of appropriate size from target species will be implanted with a PIT tagged for mark-recapture studies. Half-duplex PIT tags either 12 mm in length or 23 mm in length will be used, depending on the size of the fish to be implanted. Each PIT tag has a unique code that allows identification of individuals. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in fish length and weight.

PIT tag antenna arrays with automated data logging will be deployed at up to six selected side channel, slough, and tributary mouths to detect movement of tagged fish into or out of the site with particular focus on juvenile Chinook salmon. With input from the Fish and Aquatic TWG, site selection for antenna arrays will be based on habitats and tributaries identified as suitable habitat for juvenile Chinook salmon. A variety of antenna types may be used including hoop antennas, swim-over antennas, single rectangle (swim-through) antennas, or multiplexed rectangle antennas to determine the directionality of movement. Antennas will be deployed shortly after ice-out in 2013. Data loggers will be downloaded every two to four weeks depending on the need to replace batteries and on reliability of logging systems. Power to the antennas will be supplemented with solar panels.

All juvenile Chinook salmon 60 mm or greater in length will be PIT-tagged. For selected species, up to 1,000 fish per species per PIT tag array will be tagged based on proximity to PIT arrays. Target species are Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, and burbot.

9.5.4.4.13 DIDSON and Video Cameras

DIDSON and video cameras are proposed to survey selected sloughs and side channels. The deployment techniques will follow those described by Mueller et al. (2006). Mueller et al. (2006) found that DIDSON cameras were useful for counting and measuring fish up to 52.5 feet (16 meters) from the camera and were effective in turbid waters. In contrast, they found that video cameras were only effective in clear water areas with turbidity of less than four nephelometric turbidity units (NTU). However, Mueller et al. (2006) noted that identifying species and observing habitat conditions were more effective with video cameras than DIDSON cameras.

DIDSON is a high-resolution imaging sonar that provides video-type images over a 29-degree field of view and can thus be used to observe fish behavior associated with spawning, i.e., dynamic behavior that cannot be identified on the static side-scan sonar images. To obtain high-quality images of adult salmon, the maximum range will be limited to 15 meters (49 feet). Within this field of view, evidence of spawning behavior, e.g., redd digging, chasing, spawning, will be clearly identifiable. Furthermore, on DIDSON images fish can be classified by size category, e.g., <40 centimeters, 40 – 70 centimeters, >70 centimeters (<5 inches, 25-44 inches, >44 inches, respectively). Although this is not sufficient for definitive species identification, it will allow recognition of smaller resident fish, medium-sized adult salmon, and large Chinook salmon.

Underwater video imaging can record images in real-time over short time intervals and can provide information on fish species presence/absence in the immediate vicinity. Video systems can also be configured to record images for longer periods of time using time lapse or motion triggered recorders. Although water clarity and lighting can limit the effectiveness of video sampling, a distinct advantage of video over DIDSON is the ability to clearly identify fish species. In clear water under optimal lighting, video can capture a much larger coverage area than DIDSON (Mueller et al. 2006). Video is often combined with a white or infrared (IR) light source especially under ice and in low light northern latitudes; however, lighting may affect fish behavior. Since nighttime surveys will be required to identify possible diurnal changes in fish behavior and habitat use, the video system will be fitted with IR light in the form of light emitting diodes that will surround the lens of the camera. Muller et al. (2006) reported that most fish are unaffected by IR lights operated at longer wavelengths because it falls beyond their spectral range. In addition, the video system will be equipped with a digital video recorder for reviewing and archiving footage of fish observations.

9.5.5. Consistency with Generally Accepted Scientific Practices

This study plan was developed by fisheries scientists in collaboration with the Fish and Aquatic TWG and draws upon a variety of methods including many that have been published in peer-reviewed scientific journals. As such, the methods chosen to accomplish this effort are consistent with standard techniques used throughout the fisheries scientific community. However, logistical and safety constraints inherent in fish sampling in a large river in northern latitudes also play a role in selecting appropriate methodologies. In addition, some survey methods may not be used in the mainstem river immediately upstream of Devils Canyon to avoid any risk of being swept into the canyon. During the 1980s studies, no surveys were conducted on the mainstem river from RM 150 to RM 189.0, except for spawning surveys conducted by helicopter.

9.5.6. Schedule

Initial data collection efforts for this multi-year study began in the summer/fall of 2012 and will commence after the FERC study plan determination in early 2013 and continue through October 2014. The schedule allows for two complete open water study seasons. The proposed schedule

(Table 9.5-4) for completion of the Study of Fish Distribution and Abundance in the Upper Susitna River is as follows:

- Initial collection efforts (Chinook salmon spawning surveys and fish trapping targeting juvenile Chinook salmon) in Upper River tributary streams – July to October 2012
- File a supplemental memorandum with the FERC reporting interim 2012 collection results – First quarter 2013
- Development of Implementation Plan and selection of study sites – January to March 2013
- Open water fieldwork – May to October 2013 and May to October 2014
- Reporting of interim results – September 2013 and 2014
- Quality control check of geospatially-referenced relational database – December 2013 and 2014
- Data analysis – October to December 2013 and October to December 2014
- Initial and Revised Study Reports on 2013 and 2014 activities – anticipated to be filed during the first quarter of 2014 and 2015, one and two years, respectively, after the FERC Study Plan Determination (February 2013)

9.5.7. Relationship with Other Studies

Over the study implementation phase, an iterative process of information exchange will take place between interrelated studies that depend upon one another for specimen collection or data. As studies collect and synthesize data, findings will be disseminated to interdependent studies.

In addition to providing baseline information about aquatic resources in the Project area, aspects of this study are designed to complement and support other fish and aquatic studies (Figure 9.5-4). Fish collections in the Upper River will identify species that could colonize the future reservoir site (Section 9.10) and help validate fish periodicity, habitat associations, and selection of target species for reach-specific analyses for the Fish and Aquatics Instream Flow Study (Section 8.5). Patterns of distribution and abundance from traditional sampling methods will help validate and complement information from radio telemetry, fishwheel, and sonar observations of salmon in the Salmon Escapement Study (Section 9.7). The Salmon Escapement Study will provide fixed receiver and aerial tracking of fish radio-tagged in this study. Fish movement, habitat association, and growth data will provide inputs for bioenergetics and trophic analysis modeling for the River Productivity Study (Section 9.8). Additionally, targeted species will be sampled for fish stomach contents in support of the bioenergetics modeling component.

Fish distribution and abundance will complement information about harvest rates and effort expended by commercial, sport, and subsistence fisheries to support the Fish Harvest Study (Section 9.15). Fish collections and observations in conjunction with aquatic habitat characterization will aid in the development of fish and habitat associations for the Characterization and Mapping of Aquatic Habitats Study (Section 9.9). Fish collections will provide data on fish use in sloughs and tributaries with seasonal flow-related or permanent fish barriers for the Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12) and will provide information for the Study of Fish Passage

Feasibility at Watana Dam (Section 9.11). Fish tissue sample collections will support the Genetics Baseline Study for Selected Fish Species (Section 9.14) and the Mercury Assessment and Potential for Bioaccumulation Study (Section 5.7).

9.5.8. Level of Effort and Cost

Initial data collection efforts for this multi-year study began in the summer/fall 2012 and will commence after the FERC study plan determination in early 2013 and continue until March 2015. Sampling will be conducted according to a stratified scheme designed to cover a range of habitat types with a minimum of three replicates each. The level of effort at each sample site and sampling frequency will vary based on tasks and objectives. Selection of sampling sites will be influenced by the results of the Characterization and Mapping of Aquatic Habitats Study (Section 9.9) and tributary habitat mapping and fish sampling conducted by AEA during 2012, which may indicate that some tributaries are unsuitable for sampling because of safety issues or passage barriers.

The number and size of sample sites and sampling frequency require a large-scale field effort and subsequent data compilation, as well as quality assurance/quality control (QA/QC) and analysis efforts. Generally:

- Sampling will be conducted seasonally during the ice-free period in all study sites.
- Sampling will be conducted more frequently immediately following break-up to document seasonal movement patterns of juvenile Chinook salmon from natal tributaries to rearing habitats.
- Fish capture and observation methods may include snorkeling, seining, gillnetting, minnow trapping, angling, trot lines, and out-migrant traps depending on stream conditions such as depth, flow, and turbidity, target species, and life stage.
- Field crews will consist of two to four individuals, depending on sampling method used.
- Sampling in remote areas requires helicopter, fixed-wing airplane, and boat support.
- Radio-tracking of tagged fish includes 12 aerial surveys, and foot and boat surveys as necessary.

The estimated cost for implementing the Study of Fish Distribution and Abundance in the Upper Susitna River is $2,500,000.

9.5.9. Literature Cited

ADF&G (Alaska Department of Fish and Game). 1982. Aquatic Studies Procedures Manual: Phase I. Su-Hydro Aquatic Studies Program. Anchorage, Alaska. 111 pp.

ADF&G. 1983. Aquatic Studies Procedures Manual: Phase II - Final Draft 1982-1983. Alaska Department of Fish and Game. Su-Hydro Aquatic Studies Program. Anchorage, Alaska. 257 pp.

ADF&G. 1984. ADF&G Su Hydro Aquatic Studies May 1983 - June 1984 Procedures Manual Final Draft. Alaska Department of Fish and Game. Su-Hydro Aquatic Studies Program. Anchorage, Alaska.

ADF&G. 1985. Adult salmon investigations, May-October 1984. ADF&G Susitna Hydro Aquatic Studies Report No. 6 Susitna Hydro Document No. 2748. Anchorage, Alaska.

AEA (Alaska Energy Authority). 2011a. Pre-application Document (PAD): Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2011. Prepared for the Federal Energy Regulatory Commission, Washington, D.C.

AEA. 2011b. Aquatic Resources Gap Analysis. Prepared by HDR, Inc., Anchorage. 107 pp.Barrett, B. M. 1985. Adult Salmon Investigations, May - October 1984. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 528 pp.

Barrett, B. M., F. M. Thompson, S. Wick, and S. Krueger. 1983. Adult Anadromous Fish Studies, 1982. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 275 pp.

Bernard, D. R., G. A. Pearse, and R. H. Conrad. 1991. Hoop traps as a means to capture burbot. *North American Journal of Fisheries Management* 11:91-104.

Bryant, M. D. 2000. Estimating Fish Populations by Removal Methods with Minnow Traps in Southeast Alaska Streams. *North American Journal of Fisheries Management* 20:923-930, 2000.

Buckwalter, J.D. 2011. Synopsis of ADF&G's Upper Susitna Drainage Fish Inventory, August 2011. Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, Alaska. 27 pp.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K. Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P. Suchanek, R. Sundet, and M. Stratton. 1981a. Resident Fish Investigation on the Upper Susitna River. Alaska Department of Fish and Game, Anchorage, AK. 157 pp.

Dolloff, C.A., D.G. Hankin, G.H Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. USDA Forest Service General Technical Report SE-GTR-83. 25 p.

Dolloff, A., J. Kershner, R. Thurow. 1996. Underwater Observation. Pp. 533-554 *In* Fisheries Techniques, Murphy and Willis (eds), American Fisheries Society, Bethesda Maryland, 732 p.

Evenson, M. J. 1993. Seasonal movements of radio-implanted burbot in the Tanana River Drainage. Alaska Department of Fish and Game Fishery Data Series No. 93-47, Fairbanks, AK. 35 pp.

Hayes, D. B., C. P. Ferreri, and W. W. Taylor. 1996. Active fish capture methods. Pages 193–220 *In* B. R. Murphy and D. W. Willis, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Hillman, T. W., J. W. Mullan, J. S. Griffith. 1992. Accuracy of underwater counts of juvenile chinook salmon, coho salmon, and steelhead. *North American Journal of Fisheries Management*. 12:598-603.

Mueller, R.P., R.S. Brown, H. Hop, and L. Moulton. 2006. Video and acoustic camera techniques for studying fish under ice: a review and comparison. (16):213-226. Nemeth, M.J., A. M. Baker, B. C. Williams, S. W. Raborn, J. T. Priest, and S. T. Crawford. 2010. Movement and abundance of freshwater fish in the Chuit River, Alaska, May through July, 2009. Annual report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for PacRim Coal, L.P. 86 pp.

NMFS. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. 5 pp.

Rutz, D.S. 1999. Movements, food availability and stomach contents of Northern Pike in selected Susitna River drainages, 1996-1997. Alaska Department of Fish and Game Fishery Data Series No. 99-5. Anchorage, Alaska. 78 pp.

Sautner, J., and M. Stratton. 1983. Upper Susitna River Impoundment Studies 1982. Alaska Department of Fish and Game. Anchorage, Alaska. 220 pp.

Schmidt, D.C., S.S. Hale, and D.L. Crawford. 1985. Resident and juvenile anadromous fish investigations (May - October 1984). Alaska Department of Fish and Game, Anchorage, Alaska. 483 pp.

Stuby, L. and M. J. Evenson. 1998. Burbot research in rivers of the Tanana River Drainage, 1998. Alaska Department of Fish and Game Fishery Data Series No. 99-36, Fairbanks, AK. 66 pp.

Thompson, F. M., S. Wick, and B. Stratton. 1986. Report No 13, Volume I, Adult Salmon Investigations: May - October 1985. Alaska Department of Fish and Game, APA Document No 3412, Anchorage, Alaska. 173 pp.

Thurow, R.F. 1994. Underwater methods for study of salmonids in the Intermountain West. U.S. Dept of Agriculture, Forest Service, Intermountain Research Station. General Technical Report INT-GTR-307. Odgen, Utah. 28 p.

9.5.10. Tables

Table 9.5-1. Summary of life history, known Susitna River usage of fish species within the Upper Susitna River Segment (compiled from Delaney et al. 1981).

Common Name	Scientific Name	Life History[a]	Susitna Usage[b]	Distribution[c]
Arctic grayling	*Thymallus arcticus*	F	O, R, P	Low, Mid, Up
Burbot	*Lota lota*	F	O, R, P	Low, Mid, Up
Chinook salmon	*Oncorhynchus tshawytscha*	A	M_2, R	Low, Mid, Up
Dolly Varden	*Salvelinus malma*	A,F	O, P	Low, Mid, Up
Humpback whitefish[d]	*Coregonus pidschian*	A,F	O, R, P	Low, Mid, Up
Lake trout	*Salvelinus namaycush*	F	U	U
Longnose sucker	*Catostomus catostomus*	F	R, P	Low, Mid, Up
Round whitefish	*Prosopium cylindraceum*	F	O, M_2, P	Low, Mid, Up
Sculpin[e]	*Cottid*	M_1, F	P	Low, Mid, Up

[a] A = anadromous, F = freshwater, M_1 = marine

[b] O = overwintering, P = present, R = rearing, S = spawning, U = unknown, M_2 = migration

[c] Low = Lower River, Mid = Middle River, Up = Upper River, U = unknown

[d] Whitefish species that were not identifiable to species by physical characteristics in the field were called humpback by default. This group may have contained Lake (*Coregonus clupeaformis)*, or Alaska (*Coregonus nelsonii*) whitefish.

[e] Sculpin species generally were not differentiated in the field. This group may have included Slimy (*Cottus cognatus*), Prickly (*Cottus asper)*, Coastal range (*Cottus aleuticus*), and Pacific staghorn (*Leptocottus armatus*).

Table 9.5-2. Proposed methods by objective, task, species, and life stage.

Obj	Task	Species/ Life stage	Study Sites	Proposed Methods by Season
1A	Distribution	Juvenile salmon, non-salmon anadromous, resident	Representative habitat types	• Single pass sampling • Selection of methods will be site-specific, species-specific, and life-stage-specific. • For juvenile and small fish sampling, electrofishing, snorkeling, seining, fyke nets, angling, DIDSON and video camera where feasible and appropriate. • For adults, directed efforts with seines, gillnets, trot lines, and angling. • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Additional info from radio telemetry studies (Objective #2).
1B	Relative abundance	Juvenile salmon, non-salmon anadromous, resident	Representative habitat types	• Multi-pass sampling • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Snorkeling, beach seine, electrofishing, fyke nets, gillnet, minnow traps, fishwheels, out-migrant traps, etc.
1C	Fish habitat associations	Juvenile salmon, non-salmon anadromous, resident	Representative habitat types	• Analysis of data collected under Objective 1: Distribution. Combination of fish presence, distribution, and density by mesohabitat type by season.
2A	Timing of downstream movement and catch using out-migrant traps	All species; juveniles	At selected out-migrant trap & PIT tag array sites	• Out-migrant Traps: Maximum of 2. One near the proposed dam site; one near the mouth of a known Chinook salmon spawning tributary. • Combine with fyke net sampling to identify key site-specific differences. • Sampling in mainstem off-channel habitats downstream of tributaries with fyke nets, seines, and out-migrant traps
2B	Describe seasonal movements using biotelemetry (PIT and radio-tags)	All species	PIT arrays sites River-wide aerial tracking surveys	• PIT tags: tags opportunistically implanted from a variety of capture methods in Focus Areas. Antenna arrays in up to 6 sites at selected side channel, side slough, tributary mouth, and upland sloughs in the Upper River. • Radio-tags surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally & longitudinally.

Obj	Task	Species/ Life stage	Study Sites	Proposed Methods by Season
2C	Describe juvenile Chinook salmon movements	Juvenile Chinook salmon	Representative habitat types	• PIT tag arrays at tributary mouths, sloughs, and side channels (Obj 2B) • Outmigrant trap in known Chinook spawning tributary • DIDSON or underwater video to monitor movement into or out of specific habitats • Monthly measurements of fish size/ growth
5	Document age structure, growth, and condition by season	Juvenile anadromous and resident fish	All study sites for Obj 1B	• Stock biology measurements – length from captured fish up to 100 individuals per season per species per life stage . • Emphasis placed on juvenile Chinook salmon.
6	Seasonal presence/absence and habitat associations of invasive species	Northern pike	All study sites	• Same methods as #1 and #2 above. • The presence/absence of northern pike and other invasive fish species will be documented in all samples • Additional direct efforts with angling as necessary
7	Collect tissue samples to support the Genetic Baseline Study	All	All study sites in which fish are handled	• Opportunistic collections in conjunction with all capture methods listed above. • Tissue samples include axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

Table 9.5-3. Length and weight of fish species to be radio-tagged and respective target radio-tag weights.

	All sizes		Most likely to be caught					
Species	Length (mm)	Weight (g)	Fish Length (mm)	Est. Weight Min (g)	Est. Weight Max (g)	Tag Weight of Min (3%)	Tag Weight of Max (3%)	Fish length (mm) @ 200 g weight
Arctic grayling	36–444	<1–830	120–420	18	705	0.5	21.2	270
Dolly Varden	30–470	<1–1,007	130–300	20	256	0.6	7.7	277
Round whitefish	23–469	<1–1,035	150–390	23	553	0.7	16.6	287
Rainbow trout	27–612	<1–3,327	180–480	96	1635	2.9	49.1	232
Humpback whitefish	30–510	<1–1,544	210–450	180	1141	5.4	34.2	219
Burbot	26–791	<1–3,532	300–510	186	931	5.6	27.9	307
Northern pike	83–713	5–2707	200-700	62	2700	1.9	81.0	296

Table 9.5–4. Schedule for implementation of the Fish Distribution and Abundance in the Upper Susitna River.

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
Initial Studies and Technical Memo			—		●								
Study Site Selection					—								
Develop and File Implementation Plan					—♦								
Fish Sampling						—	—	—		---- —	—	—	
Data Entry							—	—			—	—	
Preliminary Data Analysis							—	—					
Initial Study Report								—	—Δ				
Final Data Analysis											—	—	
Updated Study Report											—	—	▲

Legend:

- —— Planned Activity
- ----- Follow-up activity (as needed)
- ● Technical Memorandum
- ♦ Implementation Plan
- Δ Initial Study Report
- ▲ Updated Study Report

9.5.11. Figures

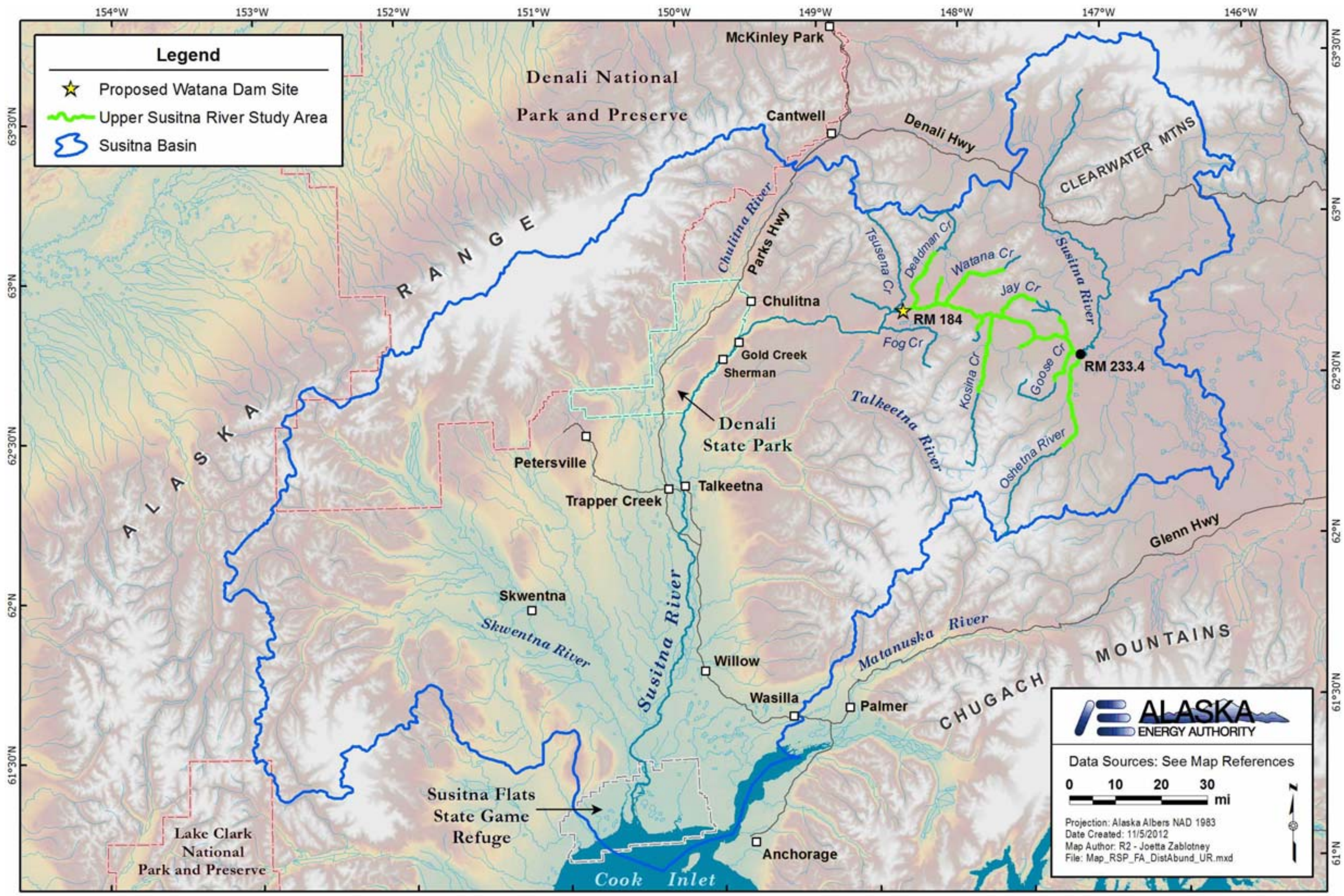

Figure 9.5-1. Fish distribution and abundance study area.

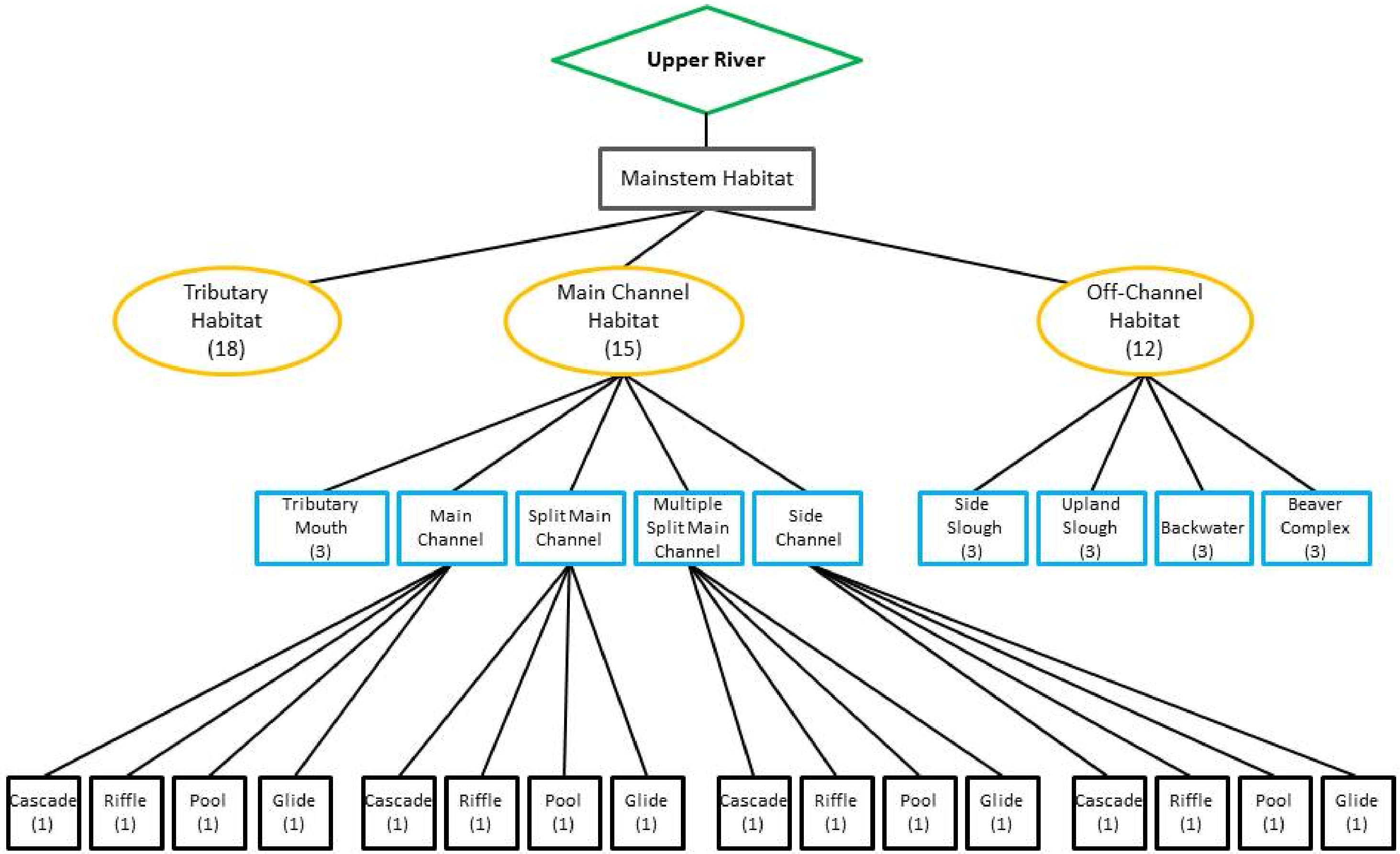

Figure 9.5-2. Schematic showing strata by habitat type for relative abundance sampling for the Upper River. Note that level two stratification within geomorphic reach, is not depicted in this figure because not all habitat types will be present within each geomorphic reach in the Upper River. The selection of habitats to sample will be distributed across geomorphic reaches as described in the Upper Susitna River Fish Distribution and Abundance Implementation Plan and in Section 9.5.4.1.

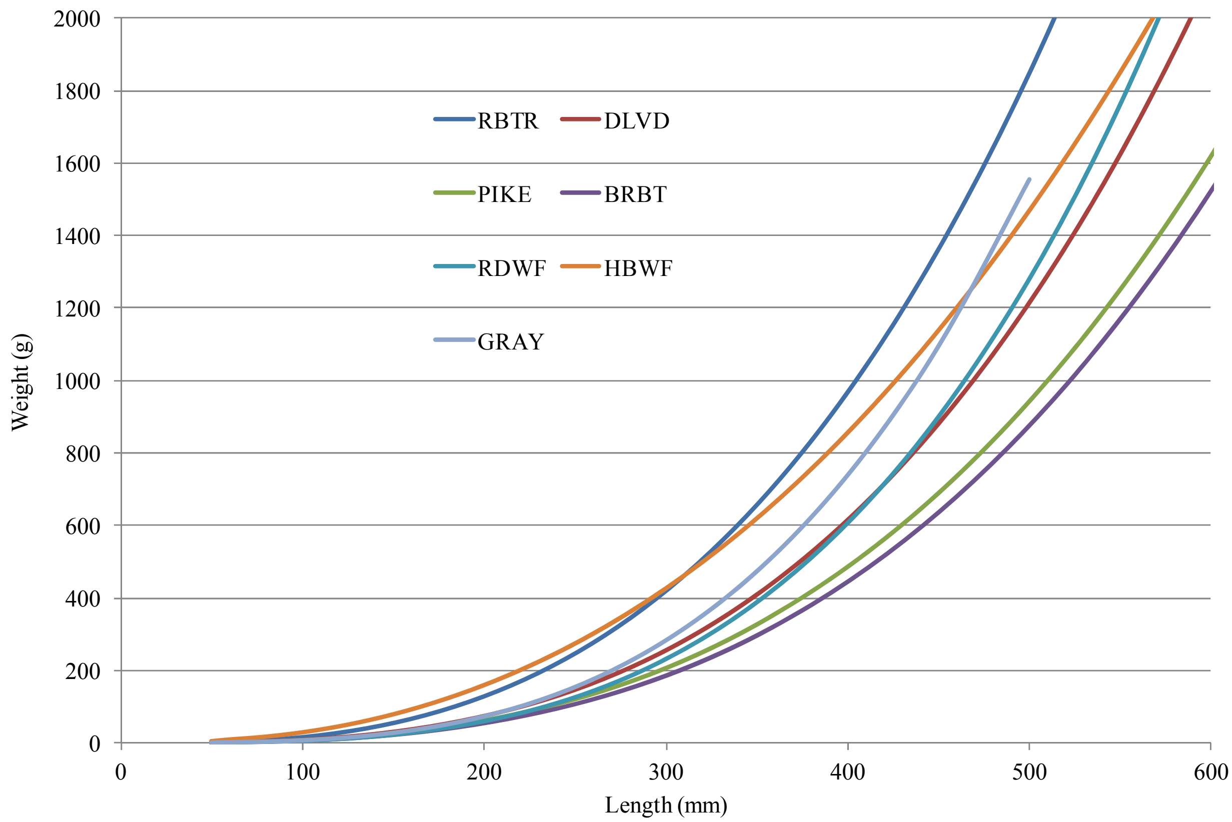

Figure 9.5–3. Existing or derived length–weight relationships for fish species to be radio-tagged.

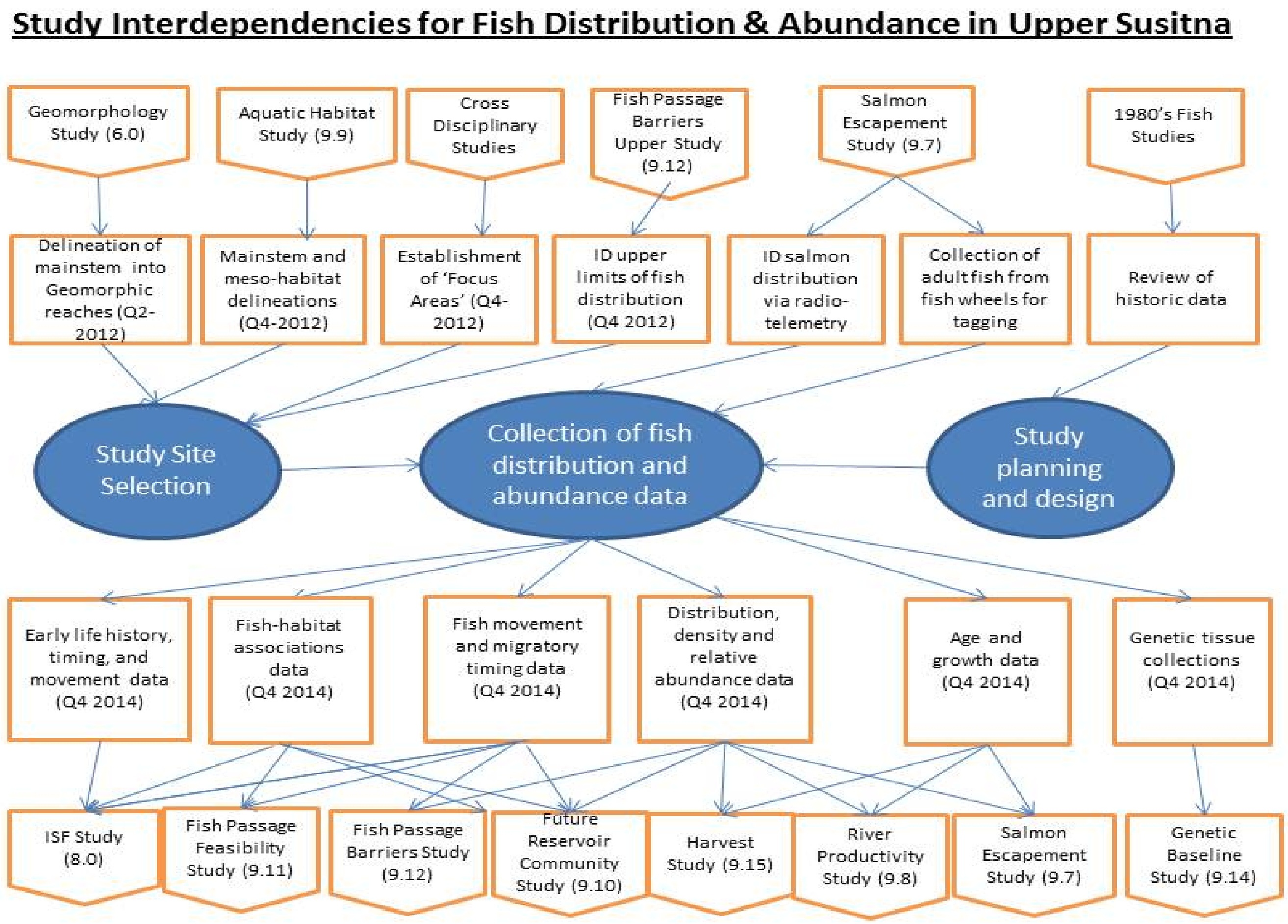

Figure 9.5-4. Flow chart showing study interdependencies for the Fish Distribution and Abundance Study in the Upper River.

9.6. Study of Fish Distribution and Abundance in the Middle and Lower Susitna River

9.6.1. General Description of the Proposed Study

This study is focused on describing the current fish assemblage including spatial and temporal distribution, and relative abundance by species and life stage in the Susitna River downstream of the proposed Watana Dam (river mile [RM] 184) with emphasis on early life history of salmonids and seasonal movements of selected species. Fishery resources in the Susitna River basin consist of a variety of salmonid and non-salmonid resident fish (Table 9.6-1). Adult salmon species are addressed in the Salmon Escapement Study (Section 9.7).

The physical habitat modeling efforts proposed elsewhere in this RSP require information on the distribution and periodicity of different life stages for the fish species of interest. Not all life stages of the target fish species may be present throughout the Middle and Lower Susitna River, and seasonal differences may occur in their use of some habitats. For example, some fish that use tributary streams during the open-water period may overwinter in mainstem habitats such as groundwater-fed sloughs.

This study is designed to provide baseline biological information and supporting information for the Fish and Aquatics Instream Flow Study (Section 8.5). This study will obtain key life history information about the fish in Middle and Lower Susitna River using two sampling approaches. The first sampling approach is focused on gathering data on general fish distribution (presence/absence); this approach generally involves a single pass with appropriate gear types. The second sampling approach is to gather data on relative abundance as determined by catch per unit effort (CPUE) along with complementary data on fish size, age, and condition; this generally involves multi-pass sampling with standardized transects and gear soak times. The second approach will also emphasize the identification of foraging, spawning, and overwintering habitats.

Study Goals and Objectives

Construction and operation of the Project will affect flow, water depth, surface water elevation, water temperature, and sediment dynamics, among other variables, in the mainstem channel as well as at tributary confluences, side channels, and sloughs, both in the area of inundation upstream from the Watana Dam site and downstream in the potential zone of Project hydrologic influence. These changes can have beneficial or adverse effects upon the aquatic communities residing in the river. To assess the effects of river regulation on fish populations, an understanding of existing conditions is needed. Baseline information will be used to predict the likely extent and nature of potential changes that will occur due to the Project's effects on instream flow and water quality.

The overarching goal of this study is to characterize the current distributions, relative abundances, run timings, and life histories of all resident and non-salmon anadromous species encountered including, but not limited to Dolly Varden, eulachon, humpback whitefish, round whitefish, arctic grayling, northern pike, burbot, and Arctic lamprey, as well as freshwater rearing life stages of anadromous salmonids (fry and juveniles) in the Middle and Lower Susitna River. Specific objectives include the following:

1) Describe the seasonal distribution, relative abundance (as determined by CPUE, fish density, and counts) and fish habitat associations of juvenile anadromous salmonids, non-salmonid anadromous fishes and resident fishes.
2) Describe seasonal movements of juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot, with emphasis on identifying foraging, spawning and overwintering habitats within the mainstem of the Susitna River.
    a. Document the timing of downstream movement and catch using out-migrant traps.
    b. Describe seasonal movements using biotelemetry (passive integrated transponder [PIT] and radio-tags).
3) Describe early life history, timing, and movements of anadromous salmonids.
    a. Describe emergence timing of salmonids.
    b. Determine movement patterns and timing of juvenile salmonids from spawning to rearing habitats.
    c. Determine juvenile salmonid diurnal behavior by season.
    d. Collect baseline data to support the Stranding and Trapping Study.
4) Document winter movements and timing and location of spawning for burbot, humpback whitefish, and round whitefish.
5) Document the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
6) Document the seasonal distribution, relative abundance, and habitat associations of invasive species (northern pike).
7) Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Fish Genetic Baseline Study (Section 9.14).

9.6.2. Existing Information and Need for Additional Information

Information regarding resident species, non-salmon anadromous species, and the freshwater rearing life stages of anadromous salmon was collected as part of the studies conducted during the early 1980s. Existing information includes the spatial and temporal distribution of fish species and their relative abundance. The Pre-Application Document (PAD) (AEA 2011a) and Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011b) summarized this existing information and also identified data gaps for resident and rearing anadromous fish.

Approximately 18 anadromous and resident fish species have been documented in the Susitna River drainage (Table 9.6-1). Three additional species are considered likely to be present, but have not been documented. To varying degrees, the relative abundances and distributions of these species were determined during the early 1980s studies. For most species, the dominant age classes and sex ratios were also determined, and movements, spawning habitats, and overwintering habitats were identified for certain species. Resident species that have been identified in all three segments of the Susitna River include Arctic grayling, Dolly Varden, humpback whitefish, round whitefish, burbot, longnose sucker, and sculpin. Other species that were observed in the Middle and Lower Susitna River Segments include Bering cisco, threespine stickleback, arctic lamprey, and rainbow trout. Eulachon have been documented only in the Lower Susitna River Segment.

Species that have not been documented, but may occur in the Susitna drainage include lake trout, Alaska blackfish, and Pacific lamprey. Lake trout have been observed in Sally Lake and Deadman Lake of the Upper Susitna watershed (Delaney et al. 1981a), but have not been observed in the mainstem Susitna or tributary streams. Pacific lamprey have been observed in the Chuit River (Nemeth et al. 2010), which also drains into Cook Inlet. Northern pike is an introduced species that has been observed in the Lower and Middle Susitna River Segments (Rutz 1999; Delaney et al. 1981b).

Non-salmon species that exhibit anadromous life histories in the Susitna River include eulachon, humpback whitefish, and Bering cisco. Dolly Varden may exhibit both anadromous and resident freshwater life history forms (Morrow 1980); however, Dolly Varden in the Susitna River were regarded primarily as a resident fish during studies conducted in the 1980s (FERC 1984). Other species that can exhibit an anadromous life history include humpback whitefish, threespine stickleback, Arctic lamprey, and Pacific lamprey (Morrow 1980). Northern pike are considered an invasive species in the Susitna drainage and have spread throughout the system from the Yenta drainage after being illegally introduced in the 1950s (Rutz 1999). Alaska blackfish would also be considered an invasive species in this basin, and while not previously captured in the Susitna River, may have been introduced.

Pacific salmon (all five species) were captured in the Lower and Middle Susitna River during the 1980s. Chinook salmon spawn exclusively in tributary streams (Thompson et al. 1986; Barrett 1985; Barrett 1984; Barrett et al. 1983); nearly all Chinook salmon juveniles out-migrate to the ocean as age 1+ fish, and very few exit the system as fry. Coho salmon typically out-migrate to sea as age 1+ or age 2+ fish. Because chum and pink salmon out-migrate to sea within a few months of emergence, little is known about their dependence on the Susitna River. Most age 0+ sockeye salmon out-migrate from the Middle River. It has not been determined whether they rear in the Lower River or if they go to sea at age 0+.

Existing fish and aquatic resource information appears insufficient to address the following issues identified in the PAD (AEA 2011a):

- 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.
- F6: Potential influence of the proposed Project flow regime and the associated response of tributary mouths on fish movement between the mainstem and tributaries within the Middle Susitna River Segment.

- F7: Influence of Project-induced changes to mainstem water surface elevations July through September on adult salmon access to upland sloughs, side sloughs, and side channels.
- F8: Potential effect of Project-induced changes to stream temperatures, particularly in winter, changing the distribution of fish communities, particularly invasive northern pike.

Agency staff have also expressed concerns that over time (i.e., 50 years), historic salmon spawning areas downstream of the Watana Dam site may become less productive due to potential changes in habitat conditions, in particular those areas affected by sediment transport, gravel recruitment, bed mobilization, and embeddedness. Further, understanding the timing of migration of juvenile salmonids from natal habitats to rearing areas and from the Middle Susitna River Segment to the Lower Susitna River Segment is important for assessing the potential Project effects.

Site-specific knowledge of the distribution, timing, and abundance of fish in the Susitna River is available from the results of surveys conducted by the Alaska Department of Fish and Game (ADF&G) during the early 1980s using multiple sampling methods (AEA 2011a). The existing information can provide a starting point for understanding the distribution and abundance of anadromous and resident freshwater fishes in the Susitna River and understanding the functional relationship with the habitat types present. However, any significant differences between current abundance and distribution patterns and those observed during the 1980s need to be documented.

In addition to providing baseline information about aquatic resources in the Project area, aspects of this study are designed to complement and support other fish and aquatic studies.

9.6.3. Study Area

The proposed study area encompasses the Susitna River from RM 61 upstream to the proposed Watana Dam site (RM 184) (Figure 9.6-1). RM 61, near the confluence with the Yentna River, approximates the upper extent of tidal influence and is the lower extent of the Characterization and Mapping of Aquatic Habitats Study (Section 9.9).

9.6.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the distribution and abundance of fish species in the Middle and Lower Susitna River. The following sections provide brief descriptions of study site selection, sampling frequency, the approach, and suite of methods that will be used to accomplish each objective of this study.

Fish Distribution and Abundance Implementation Plan

Some details of the sampling scheme have been provided for planning purposes; however, modifications may be appropriate as the results of 2012 data collection are reviewed. A final sampling scheme will be developed as part of a detailed Fish Distribution and Abundance Implementation Plan and will be submitted to FERC on March 15, 2013. Implementation plan development will include (1) a summary of relevant fisheries studies in the Susitna River, (2) an overview of the life-history needs for fish species known to occur in the Susitna River, (3) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9), (4) a description of site selection and sampling protocols, (5) development field data collection forms, and (6) development of database templates that comply with 2012 AEA QA/QC procedures. The implementation plan will include the level of detail sufficient to instruct field crews in data collection efforts. In addition, the plan will include protocols and a guide to the decision making process in the form of a chart or decision tree that will be used in the field, specific of sampling locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The implementation plan will address how sampling events will be randomized to evaluate precision by habitat and gear type. The implementation plan will also help ensure that fish collection efforts occur in a consistent and repeatable fashion across field crews and river segments. Proposed sampling methods by objective are presented below and in Table 9.6-2. Brief descriptions of each sampling technique are provided in Section 9.6.4.4.

9.6.4.1 Study Site Selection

A nested stratified sampling scheme will be used to select study sites to cover the range of habitat types. The habitat classification hierarchy, as described in Section 9.9.5.4.1 of the Habitat Classification Study, will be composed of five levels representing the following: (1) major hydraulic segment; (2) geomorphic reach; (3) mainstem habitat type; (4) main channel mesohabitat; and (5) edge habitat (Table 9.9-4, Nested and tiered habitat mapping units and categories).

Level 1 separates the Susitna River into three major hydrologic segments: Lower River (RM 61–98), Middle River (RM 98–RM 184), and Upper River (RM 184–233). The Upper River Hydrologic Segment consists of the mainstem Susitna River and its tributaries upstream of the proposed dam (RM 184) and will partially be within the impoundment zone and subject to Project operations that affect daily, seasonal, and annual changes in pool elevation plus the effects of initial reservoir filling (Section 9.5). In contrast, the Middle and Lower Hydrologic Segments include the mainstem downstream of the proposed dam will be subject to the effects of flow modification and water quality from Project operations, which will diminish in the Lower Segment below the Three Rivers Confluence (98.5).

Level 2 identifies unique reaches based on the channel's geomorphic characteristics (established from the Geomorphology Mapping Study). The Geomorphic Study Team will delineate the Lower, Middle, and Upper Susitna River reaches into large-scale geomorphic river segments with relatively homogeneous landform characteristics, including at generally decreasing scales: geology, hydrology (inflow from major tributaries), slope, channel planform, braiding or sinuosity index (where relevant), entrenchment ratio, channel width, and substrate size. Stratification of the river into relatively homogeneous segments will facilitate relatively unbiased extrapolation of sampled site data within the individual segments because sources of variability associated with large-scale features will be reduced. Stratification will occur across geomorphic reaches as much as possible but will be dictated by the distribution of habitat types present within each reach. For example, based on preliminary geomorphic reach delineation, we would expect to find multiple split main channel habitats in reaches MR 2, 6, and 8 but not in the more confined and incised reaches that include Devils Canyon MR 3, 4, 5, and 7.

Level 3 classifies the mainstem habitat into main channel, off-channel, and tributary habitat using a similar approach to the 1980s historical habitat mapping definitions (ADF&G 1983). The main channel includes five mainstem habitat types, whereas the off-channel habitat will be categorized into four types (Table 9.9-4). The 1980s classification of riverine habitats of the Susitna River included six major mainstem habitat categories consisting of main channel, side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1984). These mainstem habitat categories will be maintained in the 2012 classification system, but they are further categorized into main channel, off-channel, and tributary. These will be expanded to include five types of main channel (main channel, split main channel, multiple split main channel, side channel, and tributary), and four types of off-channel (side slough, upland slough, backwater, and beaver complex) (Table 9.9-4).

Level 4 will further delineate Level 3 main channel and tributary habitats into mesohabitat types (pool, riffle, glide, and cascade) (Table 9.9-4). However, off-channel habitat will remain at Level 3 (side slough, upland slough, backwater, and beaver complex).

The presence, distribution and frequency of these habitats vary longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. Thus, the fish sampling scheme also varies between the Middle and Lower River. Sampling in the Lower River Segment will focus on relative abundance in Lower River Geomorphic Reach LR1 (RM 61-98.5). This sampling will occur at 27 total sites (Figure 9.6-2) comprising three replicates in each of the four categories of mainstem off-channel habitats (12), three replicates within each of the four mainstem channel categories (12), and three replicates for tributary mouths. Sampling within Lower River Geomorphic Reaches LR2-4 (RM 28-61) and tributaries is not proposed at this time. It is assumed that the flow-related effects of Project operations on mainstem and tributary habitats will be attenuated with increased distance from the dam an increased flow inputs from tributaries and accretion. If results of the 2013 hydrology and geomorphology studies indicate potential effects in Lower River Geomorphic Reaches 2-4 and tributaries, this decision will be revisited during the Fish and Aquatic Technical Working Group (TWG) process early winter of 2013-2014.

In the Middle River, fish distribution sampling will occur at 96 sites (Figure 9.6-3). The number of replicates per habitat unit varies from three for mesohabitats within main channel, split channel, and multiple split main channel to six for most other mainstem habitats (side sloughs, upland sloughs, backwater habitats, beaver complexes, and tributary mouths). Due to the number and varied nature of tributaries, sampling in 18 of the 62 Middle River tributaries is proposed, and the team will select tributaries across the eight geomorphic reaches that represent multiple stream orders; tributaries that have not been previously identified as supporting anadromous fishes in the AWC will be prioritized. For relative abundance sampling, sampling of 54 sites in the Middle River (Figure 9.6-4) is proposed. Sampling will occur throughout the Middle River with the exception of Devils Canyon, where safety concerns prevent access.

Additionally, all "Focus Areas" will be sampled for relative abundance (Figure 9.6–5). Focus Areas are sites in which a full complement of cross-disciplinary intensive studies will occur to enhance the richness of the data. Focus Area sites are being selected based on a combination of recent and historic data along with the professional judgment of the various technical teams. The first selection criterion is to select one or more sites that are considered representative of the stratum or larger river and that contain all habitat types of importance. A suite of criteria includes, but is not limited to geomorphological, riparian/floodplain, fish presence, and habitat characteristics; groundwater, ice, and water quality; and constraints such as safety considerations, raptor nests, land ownership and access. Geospatial data for these individual attributes will be overlain in the Geographic Information System (GIS) to assist in site selection. Approximately 8 Focus Areas are anticipated for the Middle River as well as at least one study site below the Three Rivers Confluence in the Lower River.

Site selection includes completing the geomorphic reach delineation and habitat mapping tasks first. One sampling site representative of each mesohabitat type (side slough, upland slough, side channel, beaver pond, and tributary mouth) present will then be selected for sampling using techniques to determine relative abundance. It is anticipated that 50 Focus Area sites will be sampled (Figure 9.6-5; 10 Focus Areas x 5 habitat types); however it is likely that not all Focus Areas will contain each habitat type, therefore stratification will be finalized after results of habitat mapping have been completed in spring 2013.. In addition to technical considerations, access and safety will be key non-technical attributes for site selection for all studies. This, too, influenced site selection in the 1980s studies, and will certainly influence site selection in the present studies.

Finally, winter sites will be selected based on information gathered from winter 2012–2013 pilot studies at Whiskers Slough and Slough 8A (Section 9.6.4.5). At a minimum, attempts will be made to sample at all Focus Areas. The farthest upstream sites will need to be accessed by air travel; sites closer to Talkeetna may be accessed by snow machine. Safety and access are important considerations for the selection of these sites. Sampling methodologies including, but not limited to, under ice use of Dual Frequency Identification Sonar (DIDSON) and video cameras, minnow traps, seines, trot lines, pit tags, and radio tags will be tested in 2012–2013.

9.6.4.2 Sampling Frequency

Sampling frequency will vary among seasons and sites based on specific objectives. Generally, sampling will occur monthly at all sites for fish distribution and relative abundance surveys during the ice-free season. At Focus Areas, sampling will occur monthly year-round and biweekly after break-up through July 1 to characterize the movements of juvenile salmonids during critical transition periods from spawning to rearing habitats. More information on sampling frequency specific to each objective is presented in Table 9.6-2.

9.6.4.3 Fish Sampling Approach

The initial task of this study will consist of a focused literature review to guide selection of appropriate methods by species and habitat type, sampling event timing, and sampling event frequency. Anticipated products from the literature review include the following:

- A synthesis of existing information on life history, spatial and temporal distribution, and relative abundance by species and life stage.
- A review of sampling strategies, methods, and procedures used in the 1980s fish studies.
- Preparation of periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and out-migration).
- A summary of mainstem Susitna River habitat utilization for each species, by riverine habitat type (main channel, side channel, side slough, upland slough, tributary mouth, tributary).
- A summary of existing age, size, and genetics information.
- A summary of distribution of invasive species, such as northern pike.

Knowledge of behavior and life history of the target species is essential for effective survey design. Selected fish sampling methods will vary based on habitat characteristics, season, and species/ life history of interest. Timing of surveys depends on the objectives of the study and the behavior of the target fish species. Since life stage-specific information is desirable, timing of the survey must match the use of the surveyed habitat by that life stage.

9.6.4.3.1 Objective 1: Fish Distribution, Relative Abundance, and Habitat Associations

Two general approaches to fish sampling will be used. The first is focused on gathering data on general fish distribution (presence/absence). This sampling involves a single pass with appropriate gear types. To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling event at a specific site to evaluate temporal changes in fish distribution. The second sampling approach is to gather data on relative abundance as determined by catch per unit effort (CPUE) density; complementary data on fish size, age, and condition factor will also be collected. The selected transects and fish capture methods (i.e., number of passes, amount of soak time) will be standardized such that it is repeatable on subsequent sampling occasions. This approach will also emphasize the identification of foraging, spawning, and overwintering habitats.

Task A: Fish Distribution Surveys

Fish distribution surveys will include monthly 1-pass sampling events during the ice-free seasons with year-round monthly sampling in Focus Areas. Methods will be selected based on species, life stage, and water conditions. Snorkeling and electrofishing are preferred methods for juvenile fishes in clear water areas where velocities are safe for moving about in the creek. The use of minnow traps, beach seines, set nets, and fyke nets will be employed as alternatives in deeper waters and habitats with limited access, low visibility, and/or high velocities. For larger/adult fishes, gillnets, seines, trotlines, hoop traps, and angling will be used along with the opportunistic use of fishwheels in conjunction with the Salmon Escapement Study (Section 9.7).

Survey methods will likely vary for the different study areas in the Middle and Lower Susitna River Segments. Whereas snorkeling, minnow trapping, backpack electrofishing, and beach seines may be applicable to sloughs and other slow-moving waters, it is anticipated that gillnetting, boat electrofishing, hoop traps, and trot lines may be more applicable to the mainstem. The decisions as to what methods to apply will be made by field crews after initial site selection in coordination with Fish Distribution and Abundance Study Lead and the Fish Program Lead and in accordance with state and federal fish sampling permit requirements. Access may also influence survey methods and will be determined after a reconnaissance visit to the site early in the 2013 field season.

Lastly, methods will vary seasonally with the extent of ice cover. Methods for winter sampling will be based on winter 2012–2013 pilot studies. Selected methods will potentially include DIDSON, underwater video, minnow traps, e-fishing, seines, and trot lines.

Task B: Relative Abundance

Relative abundance surveys will include monthly multi-pass sampling events during the ice-free seasons with year-round monthly sampling in Focus Areas. As mentioned above, methods will be selected based on species, life stage, and water conditions. All methods will be conducted consistent with generating estimates of CPUE that are meaningful and facilitate comparison of counts or densities of fish over space and time. This includes calibration and quality control of methods and documentation of conditions that affect sampling efficiency—such as visibility, water temperature, and conductivity—to ensure that a consistent level of effort is applied over the sampling unit.

Task C: Fish Habitat Associations

In conjunction with Tasks 1 and 2, data will be collected for fish distribution and abundance by habitat type. This task includes an analysis of fish presence, distribution, and density by mesohabitat type by season. The information on fish habitat use will help identify species and life stages potentially vulnerable to Project effects.

9.6.4.3.2 Objective 2: Seasonal Movements

Task A: Document the timing of downstream movement and catch for all fish species using out-migrant traps.

Understanding the timing of migration from natal tributaries to the mainstem Susitna River and from the Middle Susitna River Segment to the Lower Susitna River Segment is important for assessing the potential effects of the proposed Project. Out-migrant traps (rotary screw traps, inclined plane traps) are useful for determining the timing of downstream-migrating juvenile salmonids and resident fish.

Historically, out-migrant traps were fished at Talkeetna Station (historical RM 103) during open water periods from 1982 to 1985 (Schmidt et al. 1983; Roth et al. 1984; Roth and Stratton 1985; Roth et al. 1986) and at Flathorn Station (historical RM 22.4) during 1984 and 1985 (Roth and Stratton 1985; Roth et al. 1986). Data from the 1980s suggests that the majority of Chinook salmon fry out-migrate from natal creeks by mid-August and redistribute into sloughs and side channels of the Middle River or migrate to the Lower River (Roth and Stratton 1985; Roth et al. 1986).

A maximum of six out-migrant traps will be deployed. Up to three traps will be stationed in the mainstem Susitna River to characterize downstream migratory timing. Specific locations will be determined with input from the Fish and Aquatic TWG. Because Chinook salmon are predominantly tributary spawners, out-migrant traps will also be deployed in tributary mouths such as Portage Creek, Indian River, and Whiskers Creek. In addition to collection of data on migratory timing, size at migration, and growth, out-migrant traps will also serve as a platform for tagging juvenile fish (Objective 2, Task B), recapturing previously tagged fish, and collecting tissue samples (Objective 7) to support the Genetic Baseline Study (Section 9.14).

Task B: Describe seasonal movements using biotelemetry.

Biotelemetry techniques will include radio telemetry and PIT technology. PIT tags will be surgically implanted in small fish >60 mm to monitor movement and growth; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally in the Middle and Lower River.

PIT tag antenna arrays with automated data logging will be used at selected side channel, side slough, tributary mouth, and upland slough sites to detect movement of tagged fish into or out of the site. Additionally, swim-over antennas will be deployed on an experimental basis at five sites prior to ice-over and maintained throughout the winter months. All juvenile Chinook salmon of appropriate size will be PIT-tagged; other target species will be tagged based on proximity to PIT antenna arrays with a goal of 1,000 tags per species per PIT tag array. Target species are juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in length (growth).

Radio-tagged fish will be tracked with monthly aerial surveys, by boat, and by snow machine in conjunction with the Salmon Escapement Study. The goal is to implant 30 radio transmitters per target species including Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, burbot, and rainbow trout.

9.6.4.3.3 Objective 3: Early Life History

Task A: Describe emergence timing of salmonids.

In conjunction with the Intergravel Monitoring component of the Fish and Aquatics Instream Flow Study (Section 8.5.4), salmon redds in selected side channels and sloughs will be monitored on a monthly basis throughout the winter in Focus Areas. Because chum salmon and sockeye salmon are the principal salmon species using side channels and side sloughs for spawning in the Susitna River (Sautner et al. 1984), 1980s egg development and incubation studies were conducted on these two species and focused on chum salmon. Studies included monitoring of surface and intergravel water temperatures, egg development, spawning substrate composition, and trapping of emergent fry.

Sample sites will be selected in known chum and/or sockeye salmon spawning locations within Focus Areas. Because water temperature is the most important determinant of egg development and the timing of emergence (Quinn 2005), a component of the Fish and Aquatics Instream Flow Study (Section 8.5.4) will include continuous monitoring stations for collection of temperature data. Following methods used in the 1980s, fyke nets will be used to capture emerging fry on a biweekly basis beginning in mid-April in each of the monitored side channels.

Task B: Determine movement patterns and timing of juvenile salmonids from spawning to rearing habitats.

Bi-weekly sampling of fish distribution (Objective 1, Task A) from ice-out through July 1 will occur in Focus Areas to identify changes in fish distribution by habitat type. Sampling methods will include snorkeling, seining, electrofishing, minnow traps, fyke nets, and out-migrant traps (Objective 2, Task A). Biotelemetry cannot be used for this task because juvenile salmonids will be too small to tag at this life stage.

Task C: Determine juvenile salmonid diurnal behavior by season.

Selected sloughs in Focus Area sites will be sampled based on results from the Winter 2012–2013 Pilot Study comparing the efficacy of underwater video and DIDSON for fish observation. A stratified random sampling program over a 24-hour period will be developed to observe underwater activity and ultimately to identify juvenile overwintering behavior to support stranding and trapping analyses. Holes will be drilled in the ice where no open leads exist in a few select sloughs; fish observation apparatus will also be deployed in open leads with low velocity at pre-determined observation points. This task will be implemented in conjunction with the Intergravel Monitoring component of the Fish and Aquatics Instream Flow Study (Section 8.5.4). Depending on the efficacy of underwater imaging techniques, they may be adopted for use during the ice-free season at selected Focus Area sites. Alternatively, sampling stratified by time of day using various techniques including but not limited to downstream migrant traps, seining, fyke nets, minor traps and possibly electrofishing will be used to characterize the diurnal distribution of juvenile salmonids.

Task D: Collect baseline data to support the Fish Stranding and Trapping Study.

Susceptibility to stranding can vary with fish size and species. Based on a review of available literature, the Washington Department of Fish and Wildlife (Hunter 1992) concluded that salmonid fry smaller than 50 mm in length are most susceptible to stranding whereas larger life stages (i.e., fingerlings, smolts, and adults), while also vulnerable, can be protected by less restrictive ramping criteria. Related to this, size (or life stage) periodicity will dictate the seasonal timing during which vulnerable size classes may be present in the varial zone. Stranding and trapping susceptibility may also vary by species based on differences in periodicity, as well as species-specific habitat preferences and behavior. The focus of this task is to support the stranding and trapping component of the Fish and Aquatics Instream Flow Study (Section 8.5.4). Fish distribution sampling will occur at Focus Areas and at representative habitat units to identify seasonal timing, size, and distribution among habitat types for fish (particularly < 50 mm). Electrofishing, seining, fyke nets, and minnow traps will be the primary methods for collecting salmon fry. Additional fish size data from downstream migrant traps (Objective 2, Task A) will help identify when fish exceed the 50-mm length threshold.

9.6.4.3.4 Objective 4: Document Winter Movements and Timing and Location of Spawning for Burbot, Humpback Whitefish, and Round Whitefish

Radio-tags will be surgically implanted in up to 30 burbot, humpback whitefish, and round whitefish. Fish capture methods include fishwheels, gillnets, hoop traps, and angling. Radio-tagged fish will be tracked by air, boat, and snow machine (Section 9.6.4.4.12). Following methods outlined by Sundet (1986), radio-tag locations will be pin-pointed in winter with snow machines, and trot lines will be set in the area of the radio-tag to identify winter spawning aggregations and capture additional fish. The gonadal development of each captured fish will be examined to determine spawning status; the gonads for all sampling mortalities will be preserved for laboratory examination. The timing and location of all captured fish will be documented.

9.6.4.3.5 Objective 5: Document the Seasonal Age Class Structure, Growth, and Condition of Juvenile Anadromous and Resident Fish by Habitat Type

In conjunction with Objectives 1 and 3, all captured fish will be identified to species. Up to 100 per season per species per life stage will be measured to the nearest millimeter (mm) fork length, and in Focus Areas up to 30 fish per species per site will be measured on a monthly basis. Length frequency data by species will be compared to length-at-age data in the literature to infer age classes. Recaptured PIT-tagged fish (Objective 2 Task B) will provide information on changes in length and weight (growth). Recorded parameters in each habitat unit will include number of fish by species and life stage; fork length; global positioning system (GPS) location of sampling area, time of sampling, weather conditions, water temperature, water transparency, behavior, and location and distribution of observations. In concert with Objective 3 Task D, seasonal timing, size, and distribution of fishes among habitat types, particularly fish <50 mm, will be used to support the Fish Stranding and Trapping Study.

9.6.4.3.6 Objective 6: Document the Seasonal Distribution, Relative Abundance, and Habitat Associations of Invasive Species (Northern Pike)

Northern pike were likely established in the Susitna River drainage in the 1950s through a series of illegal introductions (Rutz 1999). The proliferation of this predatory species is of concern owing to their effect on salmonids and other species such as stickleback. Rutz (1999) investigated movements of northern pike in the Susitna River using radio telemetry and investigated northern pike predation on salmonids by analyzing stomach contents of juveniles captured with minnow traps. Both of these fish capture methods used by Rutz (1999) will be used in the current study, as well as angling, to capture northern pike. The presence/absence and habitat associations of northern pike and other invasive fish species will be documented in all fish capture and observation sampling events associated with Objectives 1 and 2.

9.6.4.3.7 Objective 7: Collect Tissue Samples from Juvenile Salmon and All Resident and Non-Salmon Anadromous Fish

In support of the Fish Genetic Baseline Study (Section 9.14), fish tissues will be collected opportunistically in conjunction with all fish capture events. The target species and number of samples are given in Section 9.14. Tissue samples include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

9.6.4.4 Fish Sampling Techniques

A combination of gillnet, electrofishing, angling, trot lines, minnow traps, snorkeling, fishwheels, out-migrant trapping, beach seines, fyke nets, DIDSON, and video camera techniques will be used to sample or observe fish in the Lower River and Middle River, and moving in and out of selected sloughs and tributaries draining into the Susitna River. Selected methods will vary based on habitat characteristics, season, and species/life history of interest. All fish sampling and handling techniques described within this study will be selected in consultation with state and federal regulatory agencies and sampling will be conducted under state and federal biological collection permits. Limitations on the use of some methods during particular time periods or locations may affect the ability to make statistical comparisons among spatial and temporal strata.

9.6.4.4.1 Gillnets

Variable mesh gillnets (7.5-foot deep panels with 1-inch to 2.5-inch stretched mesh) will be deployed. In open water and at sites with high water velocity, gillnets will be deployed as drift nets, while in slow water sloughs, gillnets will be deployed as set (fixed) nets. Depending on conditions, gillnets may be deployed in ice-free areas, and under the ice during winter months. The location of each gillnet set will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The length, number of panels, and mesh of the gillnets will be consistent with nets used by ADF&G to sample the river in the 1980s (ADF&G 1982, 1983, 1984). To reduce variability among sites, soak times for drift gillnets will be standardized; all nets will be retrieved a maximum of 30 minutes after the set is completed. The following formula will be used to determine drifting time:

$$T = ([(\text{set time} + \text{retrieval time})/2] + \text{soak time})$$

9.6.4.4.2 Electrofishing

Boat-mounted, barge, or backpack electrofishing surveys will be conducted using standardized transects. Boat-mounted electrofishing is the most effective means of capturing fish in shallow areas (<10 feet deep) near stream banks and within larger side channels. Barge-mounted electrofishing is effective in areas that are wadeable, but have relatively large areas to cover and are too shallow or inaccessible to a boat-mounted system. Backpack electrofishing is effective in wadeable areas that are relatively narrow. The effectiveness of barge and backpack electrofishing systems can be enhanced through the use of block nets. Electrofishing methods will follow NMFS (2000) *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act*.

Sites will be selected carefully, because electrofishing may have limited success in swift, turbid, or low conductivity waters. Suspended materials in turbid water can affect conductivity, which may result in harmful effects on fish, especially larger fish due to a larger body surface in contact with the electrical field. Sudden changes in turbidity can create zones of higher amperage, which can be fatal to young-of-year fish as well as larger fish. Electrofishing in swift current is problematic, with fish being swept away before they can be netted. Similarly, turbidity increases losses from samples. Electrofishing will be discontinued immediately in a sampling reach if large salmonids or resident fish are encountered.

Selection of the appropriate electrofishing system will be made as part of site selection, which will include a site reconnaissance. In all cases, the electrofishing unit will be operated and configured with settings consistent with guidelines established by Smith Root. The location of each electrofishing transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. To the extent possible, the selected electrofishing system and transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. Habitat measurements will be collected at each site using the characterization methods identified in Section 9.9. Any changes will be noted between sample periods. The electrofishing start and stop times and water conductivity will be recorded. Where safety concerns can be adequately addressed, electrofishing will also be conducted after sunset in clear water areas; otherwise, electrofishing surveys will be conducted during daylight hours.

9.6.4.4.3 Angling

Angling with hook and line can also be an effective way to collect fish samples depending on the target species. During field trips organized for other sampling methods, hook-and-line angling will be conducted on an opportunistic basis using artificial lures or flies with single barbless hooks. The primary objective of hook-and-line sampling will be to capture subject fish for tagging (i.e., northern pike) and to determine presence/absence; a secondary objective will be to evaluate seasonal fish distribution. Because it is labor- and time-intensive, angling is best used as an alternative method if other more effective means of sampling are not available. Angling can also be used in conjunction with other methods, particularly if information is required on the presence and size of adult fish.

9.6.4.4.4 Trot Lines

Trot lines can be an effective method for capturing burbot, rainbow trout, Dolly Varden, grayling, and whitefish. Trot lines are typically long lines with a multitude of baited hooks and are typically anchored at both ends and set in the water for a period of time. Trot lines can also be used during periods of winter ice cover. Trot line sampling was one of the more frequently used methods during the 1980s and was the primary method for capturing burbot; however, trot lines are generally lethal. Trot lines will consist of 14 to 21 feet of seine twine with six leaders and hooks lowered to the river bottom. Trot lines will be checked and rebaited after 24 hours and pulled after 48 hours. Hooks will be baited with salmon eggs, herring, or whitefish. Salmon eggs are usually effective for salmonids, whereas the herring or whitefish are effective for Trot line construction and deployment will follow the techniques used during the 1980s studies as described in ADF&G (1982). As per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait will be commercially sterilized or disinfected with a 10-minute soak in a 1/100 Betadyne solution prior to use.

9.6.4.4.5 Minnow Traps

Minnow traps baited with salmon eggs are an effective method for passive capture of juvenile salmonids in pools and slow-moving water (Bryant 2000). In reaches where both electrofishing and snorkeling would be ineffective due to stream conditions such as deep, fast water, baited minnow traps will be used as an alternative to determine fish presence. During the 1980s, minnow traps were also the primary method used for capturing sculpin, lamprey, and threespine stickleback. Minnow traps also captured rainbow trout and Arctic grayling. Minnow traps will be baited with salmon roe, then checked and rebaited after 90 minutes following protocols outlined by Bryant (2000). Between 5 and 10 minnow traps will be deployed, depending upon the size of the sampling site. All fish captured will be identified to species, measured, and released alive near the point of capture. As per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait will be commercially sterilized or disinfected with a 10-minute soak in a 1/100 Betadyne solution prior to use.

9.6.4.4.6 Snorkel Surveys

This survey technique is most commonly used for juvenile salmonid populations, but can also be used to assess other species groups. Generally, snorkeling works well for detecting presence or absence of most species. Limits occur when water is or deep due to the inability to see the fish, or the water is too swift to safely survey (Dolloff et al. 1993, 1996). To get relative abundance estimates, a closed population is needed within a single habitat unit, and block nets will be used to prevent fish from leaving the unit (Hillman et al. 1992).

In stream channels with a width of less than 4 m, the survey will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right counts. In stream channels with a width greater than 4 m, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. The counts from all snorkelers are then summed for the total count for the reach sampled. This expansion estimate assumes that counts are accurate and that snorkelers are not counting the same fish twice (Thurow 1994). Data will be recorded following completion of the survey. Survey reaches will be snorkeled starting at the downstream end and working upstream.

Snorkel surveys will also be used in combination with other techniques to estimate relative abundance. This use of snorkel surveys provides a calibration factor for the counting efficiency of snorkel surveys compared to other methods such as electrofishing and seining (Dolloff et al. 1996).

For most of the snorkel surveys in this study, two experienced biologists will snorkel along standardized transects in clear water areas during both day and night during each field survey effort. Snorkelers will visually identify and record the number of observed fish by size and species. The location of each snorkel survey transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs.

9.6.4.4.7 Fyke/Hoop Nets

Fyke or hoop nets will be deployed to collect fish in sloughs and side channels with moderate water velocity (< 3 feet per second). After a satisfactory location has been identified at each site, the same location will be used during each subsequent collection period. The nets will be operated continuously for up to two days. Each fyke net will be configured with two wings to guide the majority of water and fish to the net mouth. The fyke nets will have 1/8-inch mesh, 1-foot diameter hoops, and up to 4 hoops. Where possible, the guide nets will be configured to maintain a narrow open channel along one bank. Where the channel size or configuration does not allow an open channel to be maintained, the area below the fyke net will be checked regularly to assess whether fish are blocked and cannot pass upstream. A live car will be located at the downstream end of the fyke net throat to hold captured fish until they can be processed. The fyke net wings and live car will be checked daily to clear debris and to ensure that captured fish do not become injured. The location of the fyke net sets will be mapped using a hand-held GPS unit and marked on high-resolution aerial photographs.

9.6.4.4.8 Hoop Traps

Commercially available hoop traps have been used successfully by ADF&G on the Tanana River as a non-lethal method to capture burbot for tagging studies (Evenson 1993; Stuby and Evenson 1998). Two sizes of traps have been used. Small and large hoop traps are 3.05 m and 3.66 m long, respectively. The small hoop trap has seven 6.35-mm steel hoops with diameters tapered from 0.61 m at the entrance to 0.46 m at the cod end. The large trap has inside diameters tapering from 91 to 69 cm with throat diameters of 36 cm. Each trap has a double throat that narrows to an opening 10 cm in diameter. All netting is knotted nylon woven into 25-mm bar mesh. Each trap is kept stretched open with two sections of PVC pipe spreader bars attached by snap clips to the end hoops. Bernard et al. (1991) provides an account of the efficacy of the small and large traps.

Hoop traps will be deployed in mainstem areas of lower velocity to capture burbot from late August through early October for radio-tagging (Objectives 1, 2, and 4). Soak times will generally be overnight, but not more than 12 hours (M. Evenson pers comm 2012). All burbot captured will be weighed, measured, and released. Up to 30 radio-tags will be surgically implanted in burbot spatially distributed throughout the Susitna River.

9.6.4.4.9 Beach Seines

Beach seines are an effective method to capture fish in a wide variety of habitats and are most effective in shallow water areas free of large woody debris and snags such as boulders. Seining allows the sampling of relatively large areas in short periods of time as well as the capture and release of fish without significant stress or harm. Repetitive seining over time with standardized net sizes and standardized deployment in relatively similar habitat can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon (Hayes et al. 1996). Beach seines will be 4 feet in depth and 40 feet in length, ¼-inch mesh (net body) with a 1/8-inch net bag; however, the actual length of seine used will depend on the site conditions. Low water conditions may be sampled using a shorter and shallower beach seine; as long as the area sampled is noted and the net is deep enough to fill the water column, then comparisons can be made. The location fished will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The area swept will be noted. Repetitive seining over time with standardized nets and soak times in relatively similar habitats can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon. To the extent possible, the same area will be fished during each sampling event; net sizes and soak times will be standardized.

9.6.4.4.10 Out-Migrant Traps

Rotary screw traps are useful for determining the timing of emigration by downstream-migrating juvenile salmonids and resident fish (Objective 2). In the 1980s, out-migrant trapping occurred at Talkeetna Station (RM 103) during open water periods from 1982 to 1985 to determine migratory timing and size at migration to the Lower Susitna River throughout the time traps were operating (Schmidt et al. 1983; Roth et al. 1984; Roth and Stratton 1985; Roth et al. 1986). Peak catch often occurred during periods of high flows. Out-migrant traps were also fished at Flathorn Station (RM 22.4) during 1984 and 1985.

Selection of rotary screw trap locations will occur with input from the Fish and Aquatic TWG and will be based on specific species, the physical conditions at the selected sites, and logistics for deploying, retrieving, and maintaining the traps. Up to six out-migrant traps will be deployed. Three to four traps will be located in mouths of important tributary streams or spawning areas such as Fog Creek, Kosina Creek, Portage Creek, Indian Creek, and possibly Gold Creek and Whiskers Slough. The remaining two or three traps will be situated in the main channel to describe the broad timing of out-migrants from all upstream sources. Flow conditions permitting, traps will be fished on a cycle of 48 hours on, 72 hours off throughout the ice-free period. Each trap will be checked at least twice per day.

9.6.4.4.11 Fishwheels

Fishwheels will primarily be deployed to capture anadromous salmon as part of the Adult Salmon Escapement Study (Section 9.7). However, non-salmon species are occasionally captured by fishwheel. Non-salmon species collected by fishwheel will provide additional data to support the objectives of this study and will be used opportunistically as a source of fish for tagging studies and tissue sampling.

9.6.4.4.12 Remote Fish Telemetry

Remote telemetry techniques will include radio telemetry and PIT technology. Both of these methods are intended to provide detailed information from relatively few individual fish. Radio-tracking provides information on fine and large spatial scales related to the location, speed of movement, and habitat utilization by surveying large areas and relocating tagged individuals during aerial, boat, and foot surveys. The target species to radio-tag include Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, burbot, and rainbow trout. PIT tags will be surgically implanted in small fish >60 mm; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally throughout the Susitna River. The target species to PIT-tag include juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot. PIT tags can be used to document relatively localized movements of fish as well as growth information from tagged individuals across seasons and years. However, the “re-sighting” of PIT-tagged fish is limited to the sites where antenna arrays are placed. To determine movement in and out of side sloughs or tributaries requires that tagged fish pass within several feet of an antenna array, thereby limiting its use to sufficiently small water bodies. To characterize growth rates, fish must be recaptured, checked for a tag, and measured.

Radio Telemetry

The primary function of the telemetry component is to track these tagged fish spatially and temporally with a combination of fixed station receivers and mobile tracking. Time/date stamped, coded radio signals from tags implanted in fish will be recorded by fixed station or mobile positioning. All telemetry gear (tags and receivers) across both studies will be provided by ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com).

The types of behavior to be characterized include the following:

- Arrival and departure timing at specific locations/positions
- Direction of travel
- Residence time at specific locations/positions
- Travel time between locations/positions
- Identification of migratory, holding, and spawning time and locations/positions
- Movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity)

Locating radio-tagged fish will be achieved by fixed receiver stations and mobile surveys (aerial, boat, snow machine, and foot). Fixed stations will largely be those used for the Salmon Escapement Study. In addition, up to five additional fixed stations will be established at strategic locations with input from the TWG. These stations will be serviced in conjunction with the Salmon Escapement Study during the July through October period and during dedicated trips outside this period. Fixed stations will be downloaded as power supplies necessitate and up to twice monthly during the salmon spawning period (approximately July through October). The Salmon Escapement Study will provide approximately weekly aerial survey coverage of the study area (approximately July through October). At other times of the year, the frequency and location of aerial surveys will be at least monthly and bi-weekly during critical species-specific time periods (e.g., burbot spawning). Telemetry surveys will also be conducted by boat, snow machine, and on foot to obtain the most accurate and highest resolution positions of spawning fish. Using the guidance of fixed-station and aerial survey data on the known positions of tagged fish, specific locations of any concentrations of tagged fish that are suspected to be spawning will be visited to obtain individual fish positions. Foot and boat surveys will be conducted approximately July through October as part of the spawning ground and habitat sampling in the Salmon Escapement Study. Spatial and temporal allocation of survey effort will be finalized based on the actual locations and number of each species of fish tagged.

The fundamental reason for using radio telemetry as a method to characterize resident and non-salmonid anadromous species is that it can provide useful information to address the overarching goal of the study and several of its objectives. In particular, radio telemetry can provide data on seasonal distribution and movement of the target fish throughout the range of potential habitats. Relocation data from the radio telemetry component of this study will be used to characterize the timing of use and degree of movements among habitats and over periods during which the radio-tags remain active (potentially two or three seasons for large fish). This objective may be achieved by the use of long-life tags (e.g., greater than one year) and shorter-life tags (e.g., three-month tags) applied to appropriate-sized fish over time. In general, successful radio telemetry studies use a tag weight to fish weight guideline of 3 percent (with a common range of 2 to 5 percent depending on the species). The range in size encountered for a particular species may be broad enough to warrant the use of different sized tags with different operational life specifications. Actual tag life will be determined by the appropriate tag for the size of the fish available for tagging.

In this regard, the range in weights for the seven target species to be radio-tagged has been estimated. Fish weights and the respective target weight of radio-tags (Table 9.6-3) were calculated using existing or derived length–weight relationships for Alaska fish (Figure 9.6-6), and length frequency distributions for Susitna River fish. This analysis illustrates that there is a relatively broad range of potential tag weights (0.5 g to 81 g) that are necessary to tag each species over the potential range in fish size. Further, it is evident that some life stages will require tags with a relatively short (30- to 200-day) operational period (tag life).

The broad range in tag weight complicates the scope of the task in terms of technological feasibility. In general, there is a preference for using coded tags because it allows the unique identification of a hundred tags on a single frequency. Conversely, standard tags (not coded) require a single frequency for each tagged fish to allow unique identification. The radio telemetry industry provides a variety of equipment to match research needs, but there are always trade-offs in terms of tracking performance and cost between different systems. This plan intends to capitalize on the use of the existing telemetry platform (ATS telemetry equipment) to sufficiently monitor the target species, but directly constrains the potential options for tagging and monitoring. More specifically, the smallest ATS coded tag weighs 6 g and therefore precludes application to all of the species at the lower portion of their most frequently occurring size range (Table 9.6–3). For example, if fish need to weigh a minimum of 200 g to be tagged, then Dolly Varden would be tagged only at its largest samples, and burbot would be tagged almost across its entire range (Table 9.6–3) based on its respective length–frequency distributions.

The use of non-coded tags on the smaller fish would require the use of many frequencies (e.g., 50–150) and an entirely separate array of receivers. Overall, tagging fish weighing less than 200 g would be expensive and logistically inefficient. The only viable option to cover the entire range of fish sizes would be to use alternate vendors' radio telemetry receivers and tags that use coded technology through the entire range of tag sizes (e.g., Lotek Wireless).

Tags will be surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally and longitudinally throughout the Middle and Lower River. These fish will be captured opportunistically during sampling events targeting adult fish and with directed effort using a variety of methods. Preference will be given fish caught with more benign techniques that cause minimal harm and stress to fish. The final spatial and temporal allocation of tags will be determined after 2012 study results are available (i.e., preliminary fish abundance and distribution). The tag's signal pulse duration and frequency, and, where appropriate, the transmit duty cycle, will be a function of the life history of the fish and configured to maximize battery life and optimize the data collection. Larger tags can accommodate the greatest battery life and therefore will be used when fish are large enough, but smaller, shorter-life tags will be used across the range of body sizes.

PIT Tag Antenna Arrays

Half-duplex PIT tags either 12 mm in length or 23 mm in length will be used, depending upon the size of the fish. Each PIT tag has a unique code that allows for identification of individuals. Half-duplex tags have been selected over full-duplex tags due to the increased flexibility and reduced cost of working with the Texas Instruments technology. Texas Instruments has recently produced a smaller half-duplex tag (12 mm) comparable to the original full-duplex (11 mm) tag; this will allow tagging of fish down to approximately 60 mm. Increased read distance and reduced power consumption are additional advantages of the half-duplex tag. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in length (growth).

PIT tag antenna arrays with automated data logging will be used at selected side channel, side slough, tributary mouth, and upland slough sites to detect movement of tagged fish into or out of the site. A variety of antenna types may be used including hoop antennas, swim-over antennas, single rectangle (swim-through) antennas, or multiplexed rectangle antennas to determine the directionality of movement.

Up to 10 sites will be selected with input from the Fish and Aquatic TWG for deploying PIT tag antenna arrays. Antennas will be tested in the Winter 2012–2013 Pilot Study and deployed shortly after ice-out in 2013 (See Section 9.6.4.5). Data loggers will be downloaded every two to four weeks, depending on the need to replace batteries and the reliability of logging systems. Power to the antennas will be supplemented with solar panels.

PIT tag arrays will be tested in a 2012 pilot study. Assuming the pilot testing is successful, swim-over antennas will be deployed at five sites prior to ice-over and will be maintained throughout the winter months. Downloading of data and battery replacement every three to four weeks, weather permitting, will be the objective during winter months. Depending on the detectability of tags during the winter of 2012–2013 Winter Pilot Study, winter deployment of antennas may be expanded during the two subsequent winter field seasons. Data on fish growth and movements into and out of habitats will inform bioenergetics and trophic analysis modeling in the River Productivity Study.

All juvenile Chinook salmon of appropriate size will be PIT-tagged. For other target species, up to 1,000 tags per species per PIT tag array will be tagged based on proximity to PIT arrays. Target species are juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot.

9.6.4.4.13 DIDSON and Video Cameras

Pending results of the 2012–2013 winter pilot study, the use of DIDSON and video cameras is proposed to survey selected sloughs and side channels. The sloughs will be the same as those selected for the wintertime deployment of PIT tag antennas. The deployment techniques will follow those described by Mueller et al. (2006). Mueller et al. (2006) found that DIDSON cameras were useful for counting and measuring fish up to 52.5 feet (16 meters) from the camera and were effective in turbid waters. In contrast, they found that video cameras were only effective in clear water areas with turbidity less than 4 nephelometric turbidity units (NTU). In addition to fish observations, video cameras may also be used to characterize micro-habitat attributes such as the presence of anchor ice, hanging dams, macrophytes, structure, and substrate type. Depending on the efficacy of underwater imaging techniques, they may be adopted for use during the ice-free season at selected Focus Area sites.

DIDSON is a high-resolution imaging sonar that provides video-type images over a 29-degree field of view and can thus be used to observe fish behavior associated with spawning, i.e., dynamic behavior that cannot be identified on the static side-scan images. To obtain high-quality images of adult salmon, the maximum range will be limited to 15 meters (49 feet). Within this field of view, evidence of spawning behavior, e.g., redd digging, chasing, and spawning, will be clearly identifiable. Furthermore, on DIDSON images fish can be classified by size category, e.g., <40 centimeters, 40–70 centimeters, >70 centimeters (<25 inches, 25–44 inches, >44 inches, respectively). Although this is not sufficient for definitive species identification, it will allow recognition of smaller resident fish, medium-sized adult salmon, and large Chinook salmon.

Underwater video imaging can record images in real-time over short time intervals and can provide information on fish species presence/absence in the immediate vicinity. Video systems can also be configured to record images for longer periods of time using time lapse or motion triggered recorders. Although water clarity and lighting can limit the effectiveness of video sampling, a distinct advantage of video over DIDSON is the ability to clearly identify fish species. In clear water under optimal lighting, video can capture a much larger coverage area than DIDSON (Mueller et al. 2006). Video is often combined with a white or infrared (IR) light source especially under ice and in low light northern latitudes; however, lighting may affect fish behavior. Since nighttime surveys will be required to identify possible diurnal changes in fish behavior and habitat use, the video system will be fitted with IR light in the form of light-emitting diodes that will surround the lens of the camera. Muller et al. (2006) reported that most fish are unaffected by IR lights operated at longer wavelengths because it falls beyond their spectral range. In addition, the video system will be equipped with a digital video recorder for reviewing and archiving footage of fish observations.

9.6.4.4.14 Fish Handling

Field crews will record the date, start and stop times, and level of effort for all sampling events, as well as water temperature and dissolved oxygen at sampling locations. All captured fish will be identified to species. Up to 30 individuals per species per life stage per site will be measured to the nearest millimeter (mm) fork length. Sampling supplies will be prepared before sampling begins. For example, the date, location, habitat type, and gear type recorded in log book, beginning fish number in proper sequence, daily sample objective by gear type, and an adequate live box and clean area should be available. To increase efficiency, fish should be sampled in order in groups of ten, and the sample routine followed in a stepwise manner: (1) identify species and life stage, (2) measure lengths, (3) remove tissue samples for genetic analysis, and (4) cut all dead fish for accurate sex identification. Care will be taken to collect all data with a consistent routine and to record data neatly and legibly.

For methods in which fish are observed, but not captured (i.e., snorkeling, DIDSON, and underwater video), an attempt will be made to identify all fish to species. For snorkeling, fork length of fish observed will be estimated within 40-mm bin sizes. When fish are captured observations of poor fish condition, lesions, external tumors, or other abnormalities will be noted if present. When more than 30 fish of a similar size class and species are collected at one time, the total number will be recorded and a subset of the sample will be measured to describe size classes for each species. All juvenile salmon, rainbow trout, Arctic grayling, Dolly Varden, burbot, longnose sucker, and whitefish greater than 60 mm in length will be scanned for PIT tags using a portable tag reader. A PIT tag will be implanted into up to 1,000 fish of these species per PIT tag array that do not have tags and are in close proximity to an array and approximately 60 mm and larger. Radio transmitters will be surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally and longitudinally throughout the Susitna River.

In support of the bioenergetics modeling component of the River Productivity Study (Section 9.8), targeted fish species will be collected for dietary analysis. These species include juvenile coho salmon, juvenile and adult rainbow trout, and juvenile and adult northern pike, as identified in consultation with agencies and other licensing participants. A total of five fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods. All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis.

Tissue samples will be collected opportunistically in conjunction with all fish capture methods from selected resident and non-salmon fish to support the Genetic Baseline Study (Objective 7; Section 9.14). Tissue samples include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm. The target number of samples, species of interest, and protocols are outlined in Section 9.14.

The number of fish per species or species assemblage and the handling protocols will be determined with input from the Fish and Aquatics TWG and the Subsistence Group for species consumed by humans, and the Wildlife TWG for piscivorous furbearers and birds.

9.6.4.5 Winter Sampling Approach

Over the 2012/2013 winter, pilot studies will be conducted at the Whiskers Slough (RM 101-102) and Slough 8A (RM 125-126) Middle Segment Focus Area sites of the Susitna River. These sites were selected based on their accessibility from Talkeetna, because they contain a diversity of habitat types, and because sampling in the 1980s and 2012 revealed that these sites were used for spawning as well as rearing by salmonids. Three winter pilot studies will be initiated in 2012–2013 focusing on (a) intergravel temperature, D.O., and water level monitoring; (b) winter fish observations using DIDSON and underwater video; and (c) winter fish sampling techniques.

Overall study objectives for the winter pilot study include:

1. Evaluate the effectiveness and feasibility of winter sampling methods for each study including: intergravel temperature, D.O. and water level monitoring, underwater fish observations via DIDSON sonar and underwater video, and fish populations using minnow traps, seines, electrofishing, trotlines, PIT tags, and radio tags.
2. Assess winter sampling logistics. This includes safety, sampling methods in different habitat types under varying degrees of ice cover, transportation and access to and from sample sites, travel time, and winter-specific gear needs.
3. Evaluate the feasibility of sampling during spring break up.

Develop recommendations for 2013–2014 study plans.

Intergravel Temperature Monitoring

For the intergravel temperature component (Section 8.5.4.5.1.2.1), a detailed sampling design will subsequently be developed that will be based on a stratified random sampling approach. Both Whiskers Slough and Slough 8A will be stratified into specific habitat types (Beaver complex, backwater, side slough, upland slough, tributary mouth, mainchannel) within which 10-12 candidate monitoring sites will be randomly selected. Special emphasis will be giving to including areas with known fish spawning. Dissolved oxygen will be measured in conjunction with intergravel temperature at one location at each of the two Focus Areas. To the extent possible, locations with groundwater upwelling will be distinguished from seepage locations that may represent lateral intergravel flow from mainstem Susitna River surface flow. Sites will include areas of recent spawning activity as well as areas with no spawning activity. Depending on individual site characteristics, temperature monitoring devices will be installed at locations of 1) groundwater upwelling, 2) bank seepage and lateral flow from mainstem, 3) mixing between upwelling and bank seepage, 4) no apparent intergravel discharge, fish spawning, and 5) main channel Susitna River flow.

At each intergravel temperature monitoring location, Hobo TidBit temperature probes will be deployed at three separate gravel depths (5 cm, 20 cm, and 35 cm) corresponding to observed burial depth ranges of chum and sockeye eggs (Bigler and Levesque 1985, DeVries 1997). Intergravel temperature probes will be attached to stainless steel cable and inserted into the gravel using a scour chain installation device (Nawa and Frissell 1993). Additional above gravel temperature recorders will be co-located at a subset of the intergravel sampling sites. These latter devices allow for the downloading of temperature data without removing the recorders from the gravel and allow for the detection of differences between surface and groundwater temperature. The D.O. sensors (HOBO D.O. logger with optical sensor) will likewise be inserted into the gravel to a depth of approximately 20 centimeters using a stainless steel cable. In addition, a series of pressure transducers (Solinst level loggers) will be deployed at the upper and lower ends of select side channel and slough habitats and in adjoining areas of the main channel Susitna River to monitor water surface elevations and stage response with changes in main channel stage. The final number and location of monitoring sites will vary depending on site conditions and safety concerns.

The temperature, D.O., and pressure transducers will be deployed in January 2012 following the chum and sockeye salmon spawning period and will be retrieved in April 2013 prior to ice break-up. Data from the above gravel recorders will be downloaded on a monthly basis and will occur concurrently with times specified as part of the under ice fish observation study.

Underwater Fish Observations

Under-ice fish observations will be made using DIDSON sonar and underwater video cameras. The two systems will be run concurrently in tannic water to determine which method is more effective for underwater fish observations in varying water clarity. Underwater video and DIDSON sonar observations will be made during the January–April 2013 sampling. Video sampling will occur in both slough and side channel habitats in the same general study sites as the intergravel temperature recorders. Observation will take place in 5 locations in Whiskers Slough and 6 locations in Slough 8A. A stratified random sampling program over a 24-hour period will be developed to observe underwater activity during day and nighttime conditions and ultimately to identify juvenile overwintering behavior to support stranding and trapping analyses. In addition to fish observations, Habitat Suitability Criteria (HSC) sampling methods will be used to characterize local habitat characteristics (velocity, water depth, substrate, cover, etc.) throughout the winter at all observed fish locations. Water velocity and depth measurements will be made either through the ice (ice holes) or in open water leads using a topset wading rod and Price AA meter. Channel substrate composition will be visually characterized using a modified Wentworth size scale. HSC measurements will only be collected at those fish observations points where positive fish species identification and estimates of total length can be made.

Winter Fish Sampling Techniques

Winter fish sampling will employ multiple methods to determine which are most effective for each fish species, life stage, and habitat type. Because sampling efforts will occur in both open water and ice covered sites, methods will vary depending on conditions. In ice-covered sites the primary sampling methods will be trotlines and minnow traps. In open water sites, the fish capture methods will be baited minnow traps, electrofishing, and beach seines. Remote telemetry techniques will include radio telemetry and PIT technology. Both of these methods need to be tested for detectability of tags fish under ice cover.

All fish sampling will occur once a month from January through March 2013 and will be coordinated with the intergravel temperature monitoring and the underwater fish observation components.

Trot Lines

Trot lines will be used to capture resident fish species including burbot, whitefish, Arctic grayling and possibly rainbow trout and Dolly Varden. This was the primary method for sampling resident fish (mostly burbot and whitefish) used by ADF&G during the 1980s winter studies (Sundet 1986). Following methods outlined by ADF&G, trotlines will be 15 to 20 feet in length with 6 hooks and leaders weighted to the bottom of the river. Holes will be drilled in the ice with a two-man ice auger. Trot lines will be baited with salmon roe or herring and set for 24 hours at a time once a month from January through March. Trot lines will be set in main channel sites at Whiskers Slough and at Slough 8A within slough (Figures 9.6-7 and 9.6-8). Sites will be marked with a hand-held GPS to ensure that sites can be relocated and resampled during future sampling events. All captured fish will be identified to species, measured for length, and. gonads examined to determine spawning status. The gonads for all sampling mortalities will be preserved for laboratory examination. Tissue samples will be collected from all captured fish and sent to the ADF&G Conservation Genetics Lab for genetic analysis.

Minnow Traps

Minnow traps will be deployed in attempt to capture juvenile salmonids and other juvenile resident fish species overwintering in mainstem and slough habitats. Minnow traps were a common winter method utilized by ADF&G in 1980s and were found to be effective for anadromous and resident juvenile fish species (Stratton 1986) but also were able to catch non-target species such as stickleback, sculpin and lamprey. Minnow traps will be deployed in the same holes drilled for trotlines, baited with salmon roe and set for 24 hours. Minnow traps will be deployed at 8 sites at Whiskers Slough and 3 sites at Slough 8A monthly from January – March 2013. Minnow trapping locations will be marked with hand-held GPS units in order to resample the same habitats each month. All captured fish will be identified to species, measured, and released to the stream unharmed.

Beach Seines

Beach seines will be used to collect a range of anadromous and resident fish species that may be present in open-water habitats. Beach seines will be used in shallow, open-water reaches free of woody debris and boulders and will be swept through the water walking upstream. Seines will be 15 and 25 feet wide by 5 feet depth with ¼ inch mesh. Locations of the habitats seined will be marked with hand-held GPS units such that transects are standardized and repeatable. Single passes with beach seines will occur at multiple locations between sites on a monthly basis. All fish captured by beach seining will be identified to species, measured for length, and returned to the stream unharmed.

Electrofishing

Single-pass backpack electrofishing surveys will be conducted in open-water leads (i.e., sloughs and side channels) in attempt to capture a range of anadromous and resident fish species. The location of each electrofishing transect will be mapped using a hand-held GPS unit. The electrofishing start and stop times and water conductivity will be recorded. To the extent possible, the selected electrofishing sites and transects will be standardized and the methods will be repeated during each sampling period at each specific site to evaluate temporal changes in fish distribution. All captured fish will be identified to species, measured for length, and returned to the stream unharmed.

PIT Tag Arrays

Using 12 and 23 mm PIT tags and a mobile antenna array, we will test PIT tag detection in varying ice thickness. This pilot effort will help determine the maximum depth of ice that PIT tags can be detected and inform future PIT tagging studies in 2013 and 2014. Holes will be drilled in the ice and PIT tags will be attached to floats at the end of a tethered fishing line and allowed to drift down stream under the ice. The orientation of a PIT tag relative to the antenna array field will affect the tag detection rate, so the position of all test PIT tags will be fixed within the float for each test. Mobile antenna arrays will be used to determine the maximum ice thickness and distance PIT tags can be detected.

Radio Tags

The primary function of the telemetry component is to track tagged fish spatially and temporally. Radio telemetry is intended to provide detailed information from relatively few individual fish. Locating radio-tagged fish will be achieved by fixed receiver stations and mobile surveys (aerial, boat, snow machine, and foot). Although wintertime radio tracking of adult fish was successfully completed during the 1980s studies, there is some question as to the limitations of detecting radio tags under ice cover. The process for testing the detectability of radio tags will follow similar methods as outlined above for testing PIT tags. Holes will be drilled in the ice and radio tags will be attached to the end of a fishing line and allowed to drift down stream under the ice. Mobile antenna arrays will be used to determine the maximum ice thickness and distance radio tags can be detected.

9.6.5. Consistency with Generally Accepted Scientific Practices

This study plan was developed by fisheries scientists in collaboration with the Fish and Aquatic TWG and draws upon a variety of methods including many that have been published in peer review scientific journals. As such, the methods chosen to accomplish this effort are consistent with standard techniques used throughout the fisheries scientific community. However, logistical and safety constraints inherent in fish sampling in a large river in northern latitudes also play a role in selecting appropriate methodologies. To describe the seasonal distribution, relative abundance, and habitat associations of the various fish species in winter, alternative methods involving snorkel and dive surveys were considered. These alternative methods were dismissed based on safety concerns owing to potentially extreme cold temperatures and remoteness of the sampling locations, and because sampling would most appropriately be conducted at night.

9.6.6. Schedule

Initial data collection efforts for this multi-year study will begin with the Winter Pilot Study (January-April 2013) and will continue through March 2015. The schedule allows for two open water and three ice-over study seasons. The proposed schedule for the completion of the Study of Fish Distribution and Abundance in the Middle and Lower Susitna River Segments is given below and in Table 9.6-4:

- Conduct Winter Pilot Studies to inform 2013/14 and 2014/15 efforts – January through April 2013
- Development of Implementation Plan and selection of study sites – January through March 2013
- Continuation of Field studies after FERC Study Plan Determination – May 2013 through March 2015

- Refined methods for winter sampling methods based on results of Winter 2012-2013 Pilot Study – June 2013
- Reporting of interim results – September 2013 and September 2014
- Quality control check of geospatially-referenced relational database – December 2013 and December 2014
- Data analysis – October to December 2013 and October to December 2014
- Initial and Revised Study Reports on 2013 and 2014 activities – anticipated to be filed during the first quarter of 2014 and 2015, one and two years, respectively, after the FERC Study Plan Determination (February 2013)
- Supplemental technical memorandum on winter 2014–2015 effort – May 2015

9.6.7. Relationship with Other Studies

Over the two-year study implementation phase, an iterative process of information exchange will take place between interrelated studies that depend upon one another for specimen collection or data (Figure 9.6-9). Planning milestones include: segment delineation (Q2 2012) from the Geomorphology Study (Section 6.0), mesohabitat delineation (Q4 2012) from the Aquatic Habitat Study (Section 9.9), and Focus Area selection (Q4 2012) by the interdisciplinary study (Section 8.5) will aid in site selection and development of the detailed Fish Distribution and Abundance in the Middle and Lower Susitna River Implementation Plan (Q1 2013). In addition to review of historic studies, the intergravel temperature component of the ISF Study (Q1 2013; Section 8.5) and the Winter Pilot Study (Q1 2013; Section 8.5 and 9.6.4.5) will aid with the estimation of fry emergence timing and planning and development of the Fish Distribution and Abundance in the Middle and Lower Susitna River Implementation Plan (Q1 2013). Delivery of information on spawning site locations and fishwheel collections from the Salmon Escapement Study (9.7) will occur in an iterative fashion during the migration and spawning seasons.

Data checked for quality on fish distribution from this study will be provided to many studies including the Instream Flow Study (Section 8.5) in the fourth quarter of 2014 to validate fish periodicity, habitat associations, and selection of target species for reach-specific analyses. Additionally, data collected on movement patterns and growth will be delivered to the Fish and Aquatics Instream Flow Study (Section 8.5) in the fourth quarter of 2014 to aid in the identification of seasonal timing, size and distribution among habitat types for fish (particularly < 50 mm) in support of the stranding and trapping component. Distribution and abundance data will be delivered to the Salmon Escapement Study (Section 9.7) in the fourth quarter of 2014 help validate and complement information from radio telemetry, fishwheel, and sonar observations of adult salmon. Fish movement, habitat association, and growth data will provide inputs for bioenergetics and trophic analysis modeling in the fourth quarter of 2014, a component of the River Productivity Study (Section 9.8). Further, target species will be sampled iteratively throughout the course of the study for fish stomach contents in support of bioenergetics modeling (Section 9.8). The opportunistic collection of tissue samples will occur iteratively throughout the course of the study and be coordinated with the Fish Genetics Study (Section 9.14). Information gathered on fish distribution and abundance will be delivered to the Fish Harvest Study (Section 9.15) in the fourth quarter of 2014 to complement information about harvest rates and to better understand commercial, sport, and subsistence fisheries. Fish collections and observations in conjunction with aquatic habitat characterization (Aquatic Habitat Study, Section 9.9) will occur iteratively throughout the course of the study and aid in the development of fish and habitat associations. In fourth quarter of 2014, fish collections will provide data on fish use in sloughs and tributaries with seasonal flow-related or permanent fish barriers to better classify barrier or corroborate the Fish Passage Barriers Study (Section 9.12).

9.6.8. Level of Effort and Cost

This is a multi-year study that will begin in early 2013 and end in March 2015. The study will include two winter periods and two ice-free periods. Sampling will be conducted according to a stratified sampling scheme designed to cover the range of habitat types with a minimum of six replicates each. The level of effort at each sample site and sampling frequency will vary based on tasks and objectives. The number and size of sample sites and sampling frequency require a large-scale field effort and subsequent data compilation, quality assurance/quality control (QA/QC), and analysis efforts. Generally:

- Sampling will be conducted monthly during the ice-free seasons in all study sites and year-round in Focus Area sites.
- Sampling will be conducted bi-weekly from ice-out through July 1 in selected Focus Areas to document seasonal movement patterns of juvenile salmonids from spawning to rearing habitats.
- Fish capture and observation methods may include snorkeling, seining, gillnetting, minnow trapping, angling, trot lines, out-migrant traps, DIDSON, and underwater video depending on stream conditions such as depth, flow, turbidity, target species, and life stage.
- Field crews will consist of two to four individuals, depending on the sampling method used.
- Sampling in remote areas requires helicopter, fixed-wing airplane, snow machine, and boat support.
- Radio-tracking of tagged fish includes 12 aerial surveys, and foot, boat, and snow machine surveys as necessary.

Total study costs are estimated at $4,500,000.

9.6.9. Literature Cited

Adams, N.S., D.W. Rondorf, S.D. Evans and J.E. Kelly. 1998. Effects of surgically and gastrically implanted radio transmitters on growth and feeding behavior of juvenile chinook salmon. *Trans. Am. Fish. Soc.* 127:128-136.

ADF&G (Alaska Department of Fish and Game). 1981. Adult Anadromous Fisheries Project ADF&G/Su Hydro 1981. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 467 pp.

ADF&G (Alaska Department of Fish and Game). 1982. Aquatic Studies Procedures Manual: Phase I. Su-Hydro Aquatic Studies Program. Anchorage, Alaska. 111 pp.

ADF&G (Alaska Department of Fish and Game). 1983. Aquatic Studies Procedures Manual: Phase II - Final Draft 1982-1983. Alaska Department of Fish and Game. Su-Hydro Aquatic Studies Program. Anchorage, Alaska. 257 pp.

ADF&G (Alaska Department of Fish and Game). 1984. ADF&G Su Hydro Aquatic Studies May 1983 - June 1984 Procedures Manual Final Draft. Alaska Department of Fish and Game. Su-Hydro Aquatic Studies Program. Anchorage, Alaska.

AEA (Alaska Energy Authority). 2011a. Pre-application Document (PAD): Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2011. Prepared for the Federal Energy Regulatory Commission, Washington, D.C.

AEA. 2011b. Aquatic Resources Data Gap Analysis. Prepared by HDR, Inc., Anchorage. 107 pp.

Barrett, B. M. 1985. Adult Salmon Investigations, May - October 1984. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 528 pp.

Barrett, B. M., F. M. Thompson, S. Wick, and S. Krueger. 1983. Adult Anadromous Fish Studies, 1982. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 275 pp.

Bernard, D. R., G. A. Pearse, and R. H. Conrad. 1991. Hoop traps as a means to capture burbot. *North American Journal of Fisheries Management* 11:91-104.

Bigler, J., and K. Levesque. 1985. Lower Susitna River Preliminary Chum Salmon Spawning Habitat Assessment. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies. 140 pp.

Bryant, M. D. 2000. Estimating Fish Populations by Removal Methods with Minnow Traps in Southeast Alaska Streams. *North American Journal of Fisheries Management* 20:923-930, 2000.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P Suchanek, R. Sundet, and M. Stratton. 1981a. Resident Fish Investigation on the Upper Susitna River. Alaska Department of Fish and Game, Anchorage, AK. 157 pp.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P Suchanek, R. Sundet, and M. Stratton. 1981b. Resident Fish Investigation on the Lower Susitna River Alaska Department of Fish and Wildlife, Anchorage, AK. 311 pp.

DeVries, P. 1997. Riverine salmonid egg burial depths: A review of published data and implications for scour studies. *Canadian Journal of Fisheries and Aquatic Sciences* 54: 1685-1698.

Dolloff, C.A., D.G. Hankin, G.H Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. USDA Forest Service General Technical Report SE-GTR-83. 25 p.

Dolloff, A., J. Kershner, R. Thurow. 1996. Underwater Observation. Pp. 533-554 *In* Murphy and Willis (eds), *Fisheries Techniques*, American Fisheries Society, Bethesda Maryland, 732 p.

Evenson, M. J. 1993. Seasonal movements of radio-implanted burbot in the Tanana River Drainage. Alaska Department of Fish and Game Fishery Data Series No. 93-47, Fairbanks, AK. 35 pp.

FERC (Federal Energy Regulatory Commission). 1984. Draft environmental impact statement: Susitna Hydroelectric Project. Appendices H and I, Volume 4. Applicant: Alaska Power Authority, Anchorage, Alaska.

Hayes, D. B., C. P. Ferreri, and W. W. Taylor. 1996. Active fish capture methods. Pages 193–220 *in* B. R. Murphy and D. W. Willis, editors. *Fisheries techniques*. American Fisheries Society, Bethesda, Maryland.

Hillman, T. W., J. W. Mullan, J. S. Griffith. 1992. Accuracy of underwater counts of juvenile chinook salmon, coho salmon, and steelhead. *North American Journal of Fisheries Management*. 12:598-603.

Hunter, M. A. 1992. *Hydropower Flow Fluctuations and Salmonids: A Review of the Biological Effects, Mechanical Causes, and Options for Mitigation*. Washington Department of Fisheries, Olympia, Washington, 58 p.

Morrow, J.E. 1980. *The freshwater fishes of Alaska*. Alaska Northwest Publishing Co., Anchorage.

Mueller, R.P., R.S. Brown, H. Hop, and L. Moulton. 2006. Video and acoustic camera techniques for studying fish under ice: a review and comparison. (16):213-226.

Nawa, K. R., C. A. Frissell. 1993. Measuring scour and fill of gravel streambeds with scour chains and siding-bead monitors. *North American Journal of Fisheries Management* 13: 634-639.

Nemeth, M.J., A.M. Baker, B.C. Williams, S.W. Raborn, J. T. Preist, and S.T. Crawford. 2010. Movement and abundance of freshwater fish in the Chuit River, Alaska, May through July 2009. Annual Report, Anchorage, Alaska.

NMFS (National Marine Fisheries Service). 2012. Comments of the National Marine Fisheries Service on the Pre-Application Document, Scoping Document 1, Study Requests for the Suistna-Watana Hydropower Project P-14241-000. Letter to Federal Energy Regulatory Commission. May 31, 2012.

NMFS. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. 5 pp.

Quinn, TP. 2005. *The behavior and ecology of Pacific salmon and trout*. University Press, Seattle. 320 p.

Roth, K.J., and M.E. Stratton. 1985. The Migration and Growth of Juvenile Salmon in the Suistna River. Pages 207 *In*: Schmidt, D.C., S.S. Hale, and D.L. Crawford. (eds.) Resident and Juvenile Anadromous Fish Investigations (May - October 1984). Prepared by Alaska Department of Fish and Game. Prepared for Alaska Power Authority, Anchorage, AK.

Roth, K.J., D.C. Gray, J.W. Anderson, A.C. Blaney, and J P. McDonell. 1986. The Migration and Growth of Juvenile Salmon in the Susitna River, 1985. Prepared by Alaska

Department of Fish and Game, Susitna Hydro Aquatics Studies. Prepared for Alaska Power Authority Anchorage, Alaska. 130 pp.

Rutz, D.S. 1999. Movements, food availability and stomach contents of Northern Pike in selected Susitna River drainages, 1996-1997. Alaska Department of Fish and Game Fishery Data Series No. 99-5. Anchorage, Alaska. 78 pp.

Sautner, J.S., L.J. Vining, and L.A. Rundquist. 1984. An evaluation of passage conditions for adult salmon in sloughs and side channels of the middle Susitna River. Pages 148 *In*: Estes, C.C., and D.S. Vincent-Lang. (eds.) Aquatic Habitat and Instream Flow Investigations (May - October 1983). Alaska Dept. Fish and Game. Susitna Hydro Aquatic Studies, Anchorage, Alaska.

Schmidt, D.C., S.S. Hale, and D.L. Crawford. 1985. Resident and juvenile anadromous fish investigations (May - October 1984). Alaska Department of Fish and Game, Anchorage, Alaska. 483 pp.

Stratton, M.S. 1986 Report 2, Part 2: Summary of juvenile Chinook and coho salmon winter studies in the middle Susitna River, 1984-1985. Alaska Department of Fish and Game, Anchorage, Alaska.

Stuby, L. and M. J. Evenson. 1998. Burbot research in rivers of the Tanana River Drainage, 1998. Alaska Department of Fish and Game Fishery Data Series No. 99-36, Fairbanks, AK. 66 pp.

Sundet, R.L. 1986. Winter Resident Fish Distribution and Habitat Studies Conducted in the Susitna River Below Devil Canyon, 1984-1985. Report to Alaska Power Authority by Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 80 pp.

Thompson, F. M., S. Wick, and B. Stratton. 1986. Report No 13., Volume I ,Adult Salmon Investigations: May - October 1985. Alaska Department of Fish and Game, APA Document No 3412, Anchorage, Alaska. 173 pp.

Thurow, R.F. 1994. Underwater methods for study of salmonids in the Intermountain West. US Dept of Agriculture, Forest Service, Intermountain Research Station. General Technical Report INT-GTR-307. Odgen, Utah. 28 p.

USFWS (United States Fish and Wildlife Service). 2012. Scoping Comments, Recommendations and Study Requests Notice of Intent to File License Applications; Filing of Pre-Application Document; Commencement of Licensing Proceeding and Scoping; Request for Comments on the Pre-Application Document and Scoping Document 1, and Identification of Issues and Associated Study Requests for the Susitna-Watana Project No. 14241-00. Letter to K.D. Bose of the Federal Energy Regulatory Commission. May 31, 2012.

9.6.10. Tables

Table 9.6-1. Summary of life history, known Susitna River usage, and known extent of distribution of fish species within the Lower, Middle, and Upper Susitna River Segments (from ADF&G 1981 a, b, c, etc.).

Common Name	Scientific Name	Life History[a]	Susitna Usage[b]	Distribution[c]
Alaska blackfish	*Dallia pectoralis*	F	U	U
Arctic grayling	*Thymallus arcticus*	F	O, R, P	Low, Mid, Up
Arctic lamprey	*Lethenteron japonicum*	A,F	O, M_2, R, P	Low, Mid
Bering cisco	*Coregonus laurettae*	A	M_2, S	Low, Mid
Burbot	*Lota lota*	F	O, R, P	Low, Mid, Up
Chinook salmon	*Oncorhynchus tshawytscha*	A	M_2, R	Low, Mid, Up
Chum salmon	*Oncorhynchus keta*	A	M_2, S	Low, Mid
Coho salmon	*Oncorhynchus kisutch*	A	M_2, S, R	Low, Mid
Dolly Varden	*Salvelinus malma*	A,F	O, P	Low, Mid, Up
Eulachon	*Thaleichthys pacificus*	A	M_2, S	Low
Humpback whitefish[d]	*Coregonus pidschian*	A,F	O, R, P	Low, Mid, Up
Lake trout	*Salvelinus namaycush*	F	U	U
Longnose sucker	*Catostomus catostomus*	F	R, P	Low, Mid, Up
Northern pike	*Esox lucius*	F	P	Low, Mid
Pacific lamprey	*Lampetra tridentata*	A,F	U	U
Pink salmon	*Oncorhynchus gorbuscha*	A	M_2, R	Low, Mid
Rainbow trout	*Oncorhynchus mykiss*	F	O, M_2, P	Low, Mid
Round whitefish	*Prosopium cylindraceum*	F	O, M_2, P	Low, Mid, Up
Sculpin[e]	*Cottid*	M_1[f], F	P	Low, Mid, Up
Sockeye salmon	*Oncorhynchus nerka*	A	M_2, S	Low, Mid
Threespine stickleback	*Gasterosteus aculeatus*	A,F	M_2, S, R, P	Low, Mid

[a] A = anadromous, F = freshwater, M_1 = marine

[b] O = overwintering, P = present, R = rearing, S = spawning, U = unknown, M_2 = migration

[c] Low = Lower River, Mid = Middle River, Up = Upper River, U = Unknown

[d] Whitefish species that were not identifiable to species by physical characteristics in the field were called humpback by default. This group may have contained Lake (*Coregonus clupeaformis)*, or Alaska (*Coregonus nelsonii*) whitefish.

[e] Sculpin species generally were not differentiated in the field. This group may have included Slimy (*Cottus cognatus*), Prickly (*Cottus asper)*, Coastal range (*Cottus aleuticus*), and Pacific staghorn (*Leptocottus armatus*).

[f] Pacific staghorn sculpin were found in freshwater habitat within the Lower Susitna River Segment.

Table 9.6-2. Proposed methods by objective, task, species, and life stage.

Obj	Task	Species/ Life Stage	Study Sites	Proposed Methods by Season
1A	Distribution	Juvenile salmon, non-salmon anadromous, resident	Focus Areas + representative habitat types Select Focus Areas (accessible)	Ice Free Season: • Single pass sampling • Selection of methods will be site-specific, species-specific, and life-stage-specific. • For juvenile and small fish sampling, electrofishing, snorkeling, seining, fyke nets, angling, DIDSON and video camera where feasible and appropriate. • For adults, directed efforts with seines, gillnets, trot lines, and angling. • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Additional info from radio telemetry studies (Objective #2). Winter: • Based on winter 2012-2013 pilot studies • Potentially DIDSON, video camera, minnow traps, e-fishing, seines, and trot lines.
1B	Relative abundance	Juvenile salmon, non-salmon anadromous, resident	Focus Area study sites + representative habitat types	• Multi-pass sampling • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Snorkeling, beach seine, electrofishing, fyke nets, gillnet, minnow traps, fishwheels, out-migrant traps, etc.
1C	Fish habitat associations	Juvenile salmon, non-salmon anadromous, resident	Focus Area study sites+ representative habitat types	• Analysis of data collected under Objective 1: Distribution. Combination of fish presence, distribution, and density by mesohabitat type by season.

Obj	Task	Species/ Life Stage	Study Sites	Proposed Methods by Season
2A	Timing of downstream movement and catch using out-migrant traps	All species; juveniles	At selected out-migrant trap & PIT tag array sites	• Out-migrant Traps: Maximum of 6. 2-3 Main channel to indicate broad timing of out-migrants from all upstream sources. 3-4 in tributary mouths and sloughs, such as Fog Creek, Kosina Creek, Portage Creek, Indian Creek and possibly Gold Creek and Whiskers Slough. Combine with fyke net sampling to identify key site-specific differences. • Sampling in mainstem off-channel habitats downstream of tributaries with fyke nets, seines, and out-migrant traps • Fishwheels (adults only) opportunistically in conjunction with the Salmon Escapement Study
2B	Describe seasonal movements using biotelemetry (PIT and radio-tags)	All species		Ice-Free Season: • PIT tags: tags opportunistically implanted in target species from a variety of capture methods in Focus Areas. Antenna arrays in up to 10 sites at selected side channel, side slough, tributary mouth, and upland sloughs in the Middle River and Lower River. • Radio-tags surgically implanted in up to 30 individuals of sufficient body size of each target species distributed temporally and longitudinally. . Winter: • Based on winter 2012-2013 pilot studies. • Potentially DIDSON, video camera, minnow traps, electrofishing, seines and trot lines. • Aerial tracking of radio-tags (adults).
3A	Describe emergence timing of salmonids;	Juvenile salmonids	Select Focus Areas	• Bi-weekly sampling using fyke nets, seines, electrofishing and minnow traps in salmon spawning areas within Focus Areas.
3B	Determine movement patterns and timing of juvenile salmonids from spawning to rearing habitats;	Juvenile salmonids	Focus Areas	• Focus on timing of emergence and movement of newly emergent fish from spawning to rearing areas or movement of juvenile fish <50 mm in winter (i.e., the post-emergent life stages most vulnerable to load-following operations) • DIDSON or underwater video to monitor movement into or out of specific habitats
3C	Determine juvenile salmonid diurnal behavior by season	Juvenile salmonids	Focus Areas	• Stratified time of day sampling to determine whether fish are more active day/night • DIDSON and/or video camera methods to observe fish activity • Potentially electrofishing and seining

Obj	Task	Species/ Life Stage	Study Sites	Proposed Methods by Season
3D	Collect baseline data to support the Stranding and Trapping Study		Focus Areas + supplement with additional representative habitat types as necessary.	• Opportunistic support to ID seasonal timing, size and distribution among habitat types for fish <50 mm in length. • Estimate presence/absence, relative abundance, and density using similar methods as Objectives 1A, 1B, 1C, and 2 for fish <50 mm • Focus on slough and other mainstem off-channel habitats • DIDSON, video camera, electrofishing, seines, out-migrant traps and fyke nets. • Monthly measurements of fish size/ growth
4	Winter movements, timing, and location of spawning	burbot, humpback whitefish, and round whitefish	Mainstem habitats	• Radio-tags surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally & longitudinally. • To capture burbot for radio-tagging, use hoop traps late Aug-early Oct following methods by Evenson (1993). • To capture whitefish for radio-tagging, use fishwheels opportunistically and directed efforts including angling, seines & gillnets. • Use aerial & snow machine tracking of radio-tags to pinpoint winter aggregations of fish; sample these areas with trot lines (similar to 1980s). Trot lines are lethal sampling. • Collect, examine, and preserve gonads to determine spawning status.
5	Document age structure, growth, and condition by season	juvenile anadromous and resident fish	All study sites for Obj 1B and Focus Areas	• Stock biology measurements- length from captured fish up to 100 individuals per season per species per life stage and up to 30 fish per month per species per habitat type in Focus Areas. • Emphasis placed on juvenile salmonids <50mm. • Opportunistically support Stranding and Trapping Study
6	Seasonal presence/absence and habitat associations of invasive species	northern pike	All study sites	• Same methods as #1 and #2 above. • The presence/absence of northern pike and other invasive fish species will be documented in all samples • Additional direct efforts with angling as necessary
7	Collect tissue samples to support the Genetic Baseline Study	All	All study sites in which fish are handled	• Opportunistic collections in conjunction with all capture methods listed above. • Tissue samples include axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

Table 9.6-3. Length and weight of fish species to be radio-tagged and respective target radio-tag weights.

	All sizes		Most likely to be caught					
Species	Length (mm)	Weight (g)	Fish Length (mm)	Est. Weight Min (g)	Est. Weight Max (g)	Tag Weight of Min (3%)	Tag Weight of Max (3%)	Fish length (mm) @ 200 g weight
Arctic grayling	36–444	<1–830	120–420	18	705	0.5	21.2	270
Dolly Varden	30–470	<1–1,007	130–300	20	256	0.6	7.7	277
Round whitefish	23–469	<1–1,035	150–390	23	553	0.7	16.6	287
Rainbow trout	27–612	<1–3,327	180–480	96	1635	2.9	49.1	232
Humpback whitefish	30–510	<1–1,544	210–450	180	1141	5.4	34.2	219
Burbot	26–791	<1–3,532	300–510	186	931	5.6	27.9	307
Northern pike	83–713	5–2707	200-700	62	2700	1.9	81.0	296

Table 9.6–4. Schedule for implementation of the Fish Distribution and Abundance in the Middle and Lower Susitna River 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	2Q
Winter Pilot Study					——									
Study Site Selection					——									
Develop and File Implementation Plan					——♦									
Open Water and Winter Fish Sampling						——	——	——	——	—— -----	——	——	——	
Data Entry							——	——			——	——		
Preliminary Data Analysis							——	——						
Initial Study Report								——	Δ					
Final Data Analysis											——	——		
Updated Study Report												——	▲	
Winter 2014-15 Technical Memo														●

Legend:

—— Planned Activity
----- Follow-up activity (as needed)
♦ Implementation Plan
Δ Initial Study Report
▲ Updated Study Report
● Winter 2014-15 Technical Memorandum

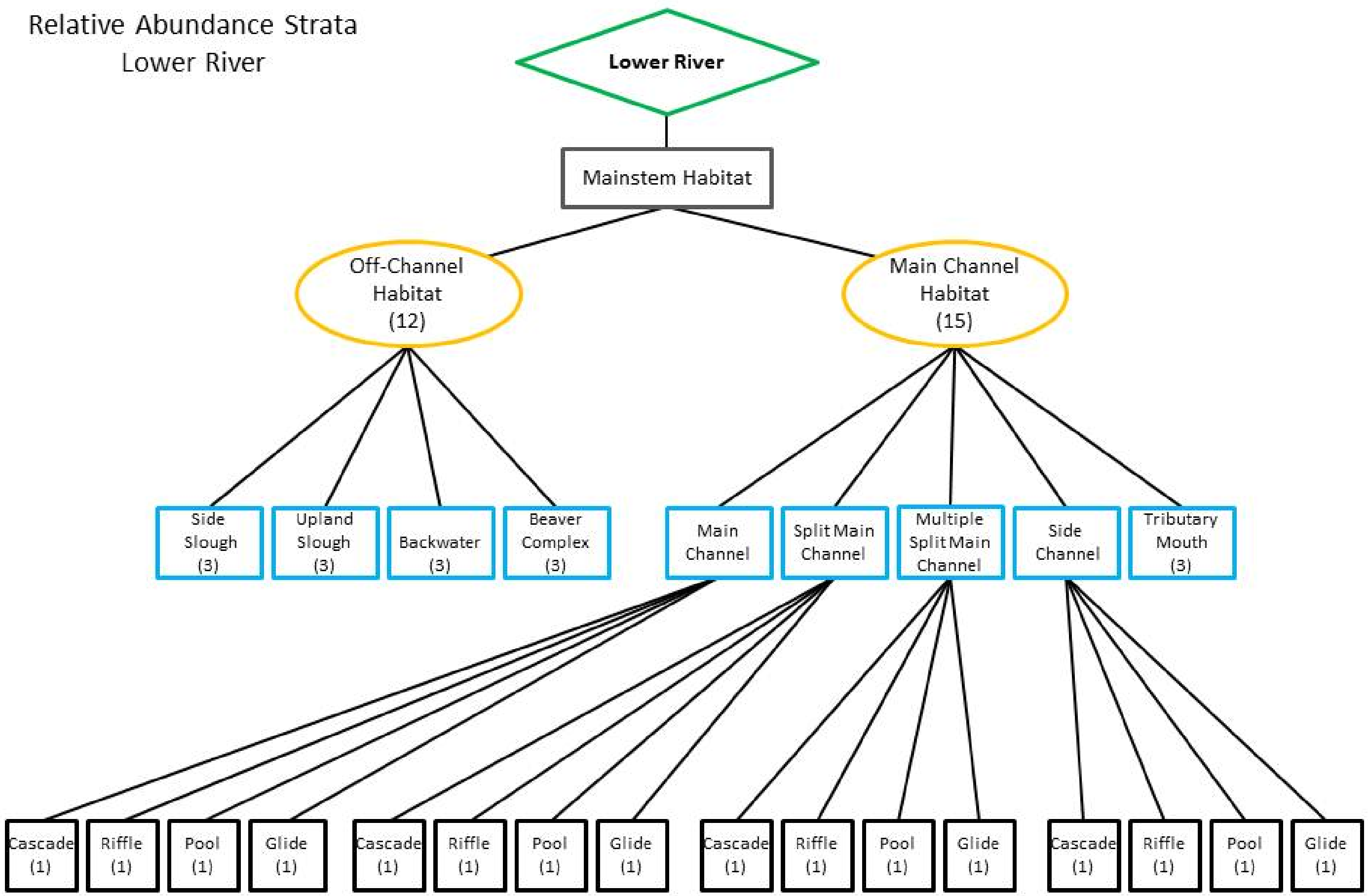

Figure 9.6-2. Schematic showing strata by habitat type for relative abundance sampling for the Lower River. Note that level two stratification within geomorphic segment, is not depicted in this figure because not all habitat types will be present within each geomorphic segment in the Upper River. The selection of habitats to sample will be distributed across geomorphic segments as described in the Fish Distribution and Abundance in the Lower and Middle Susitna River Implementation Plan and in Section 9.6.4.1.

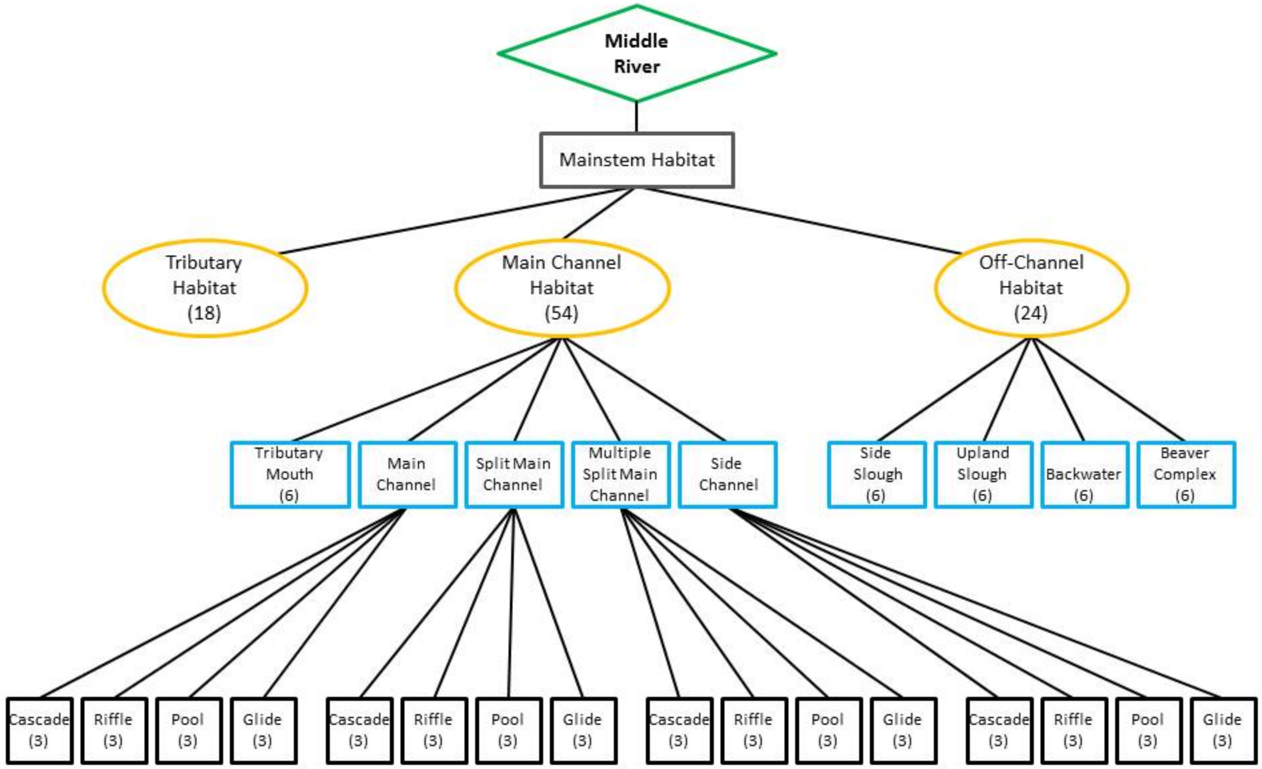

Figure 9.6-3. Schematic showing strata by habitat type for fish distribution sampling for the Middle River. Note that level two stratification within geomorphic segment, is not depicted in this figure because not all habitat types will be present within each geomorphic segment in the Upper River. The selection of habitats to sample will be distributed across geomorphic segments as described in the Fish Distribution and Abundance in the Lower and Middle Susitna River Implementation Plan and in Section 9.6.4.1.

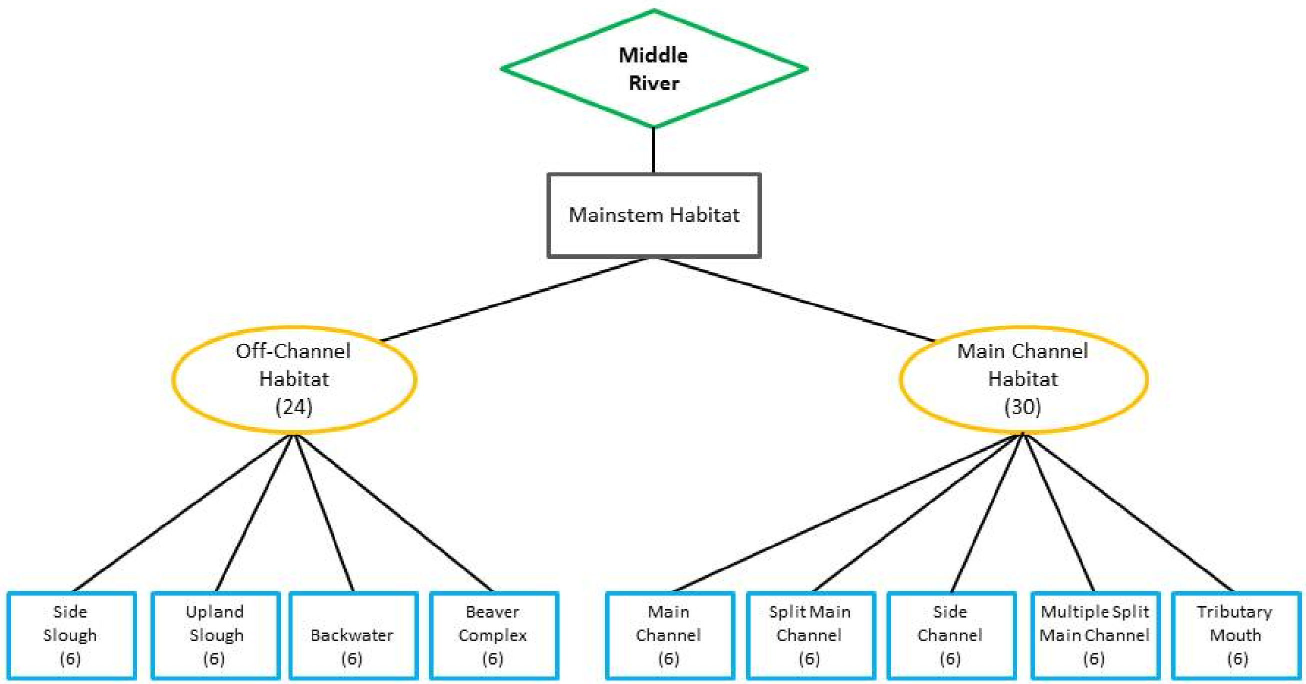

Figure 9.6-4. Schematic showing strata by habitat type for relative abundance sampling for the Middle River.

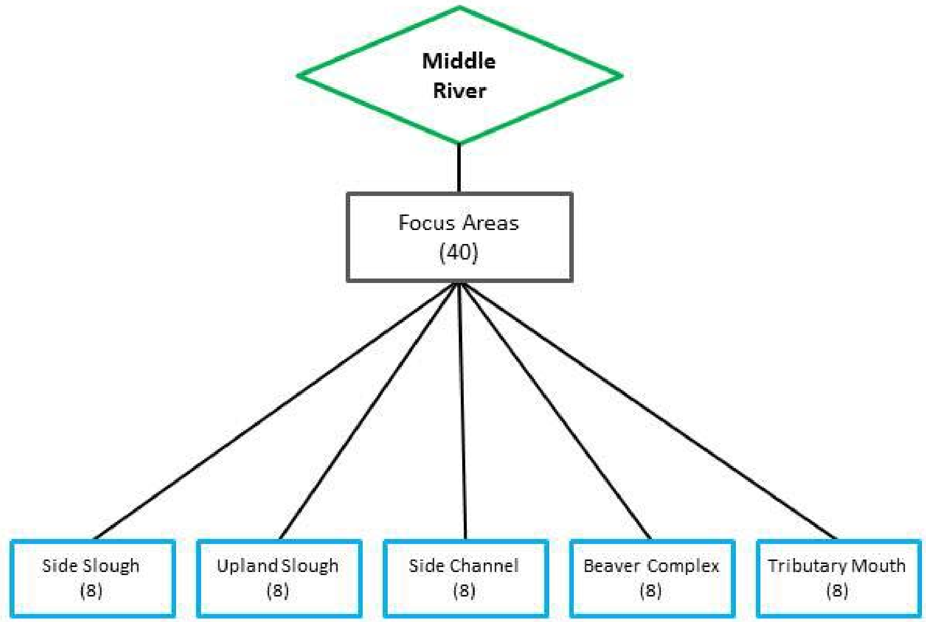

Figure 9.6-5. Schematic showing strata by habitat type for relative abundance sampling in Focus Areas.

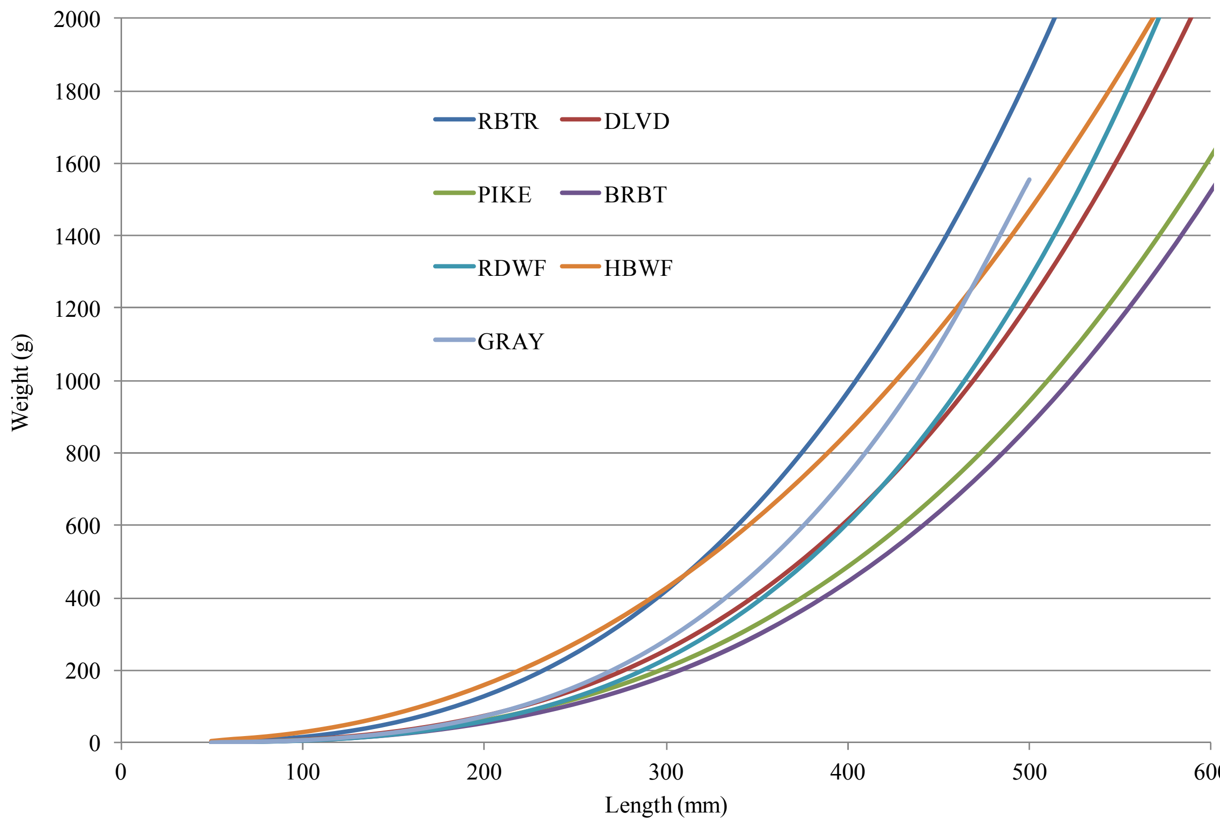

Figure 9.6-6. Existing or derived length-weight relationships for fish species to be radio-tagged.

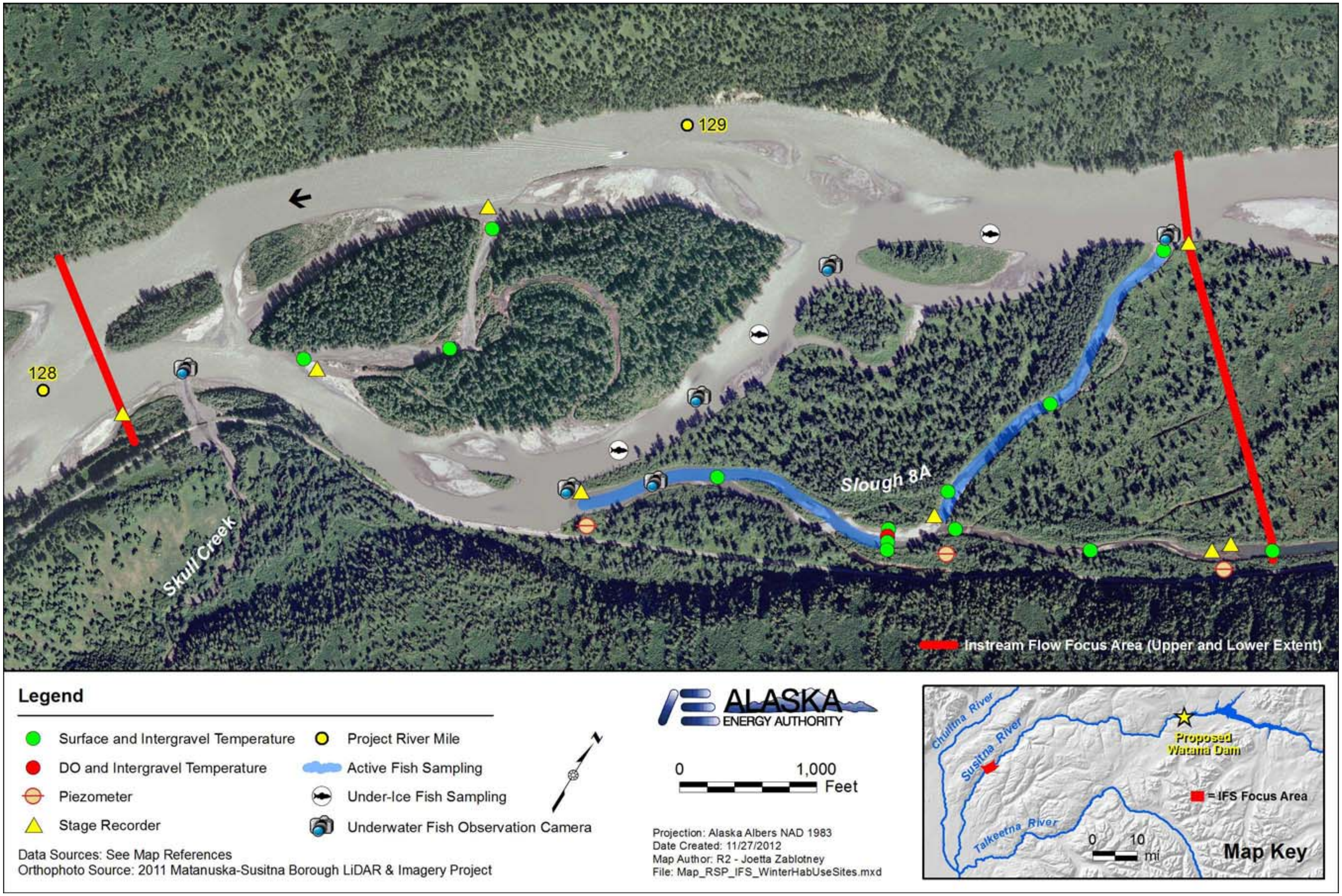

Figure 9.6.-7. **Distribution of winter sampling sites in Slough 8A, Susitna River.**

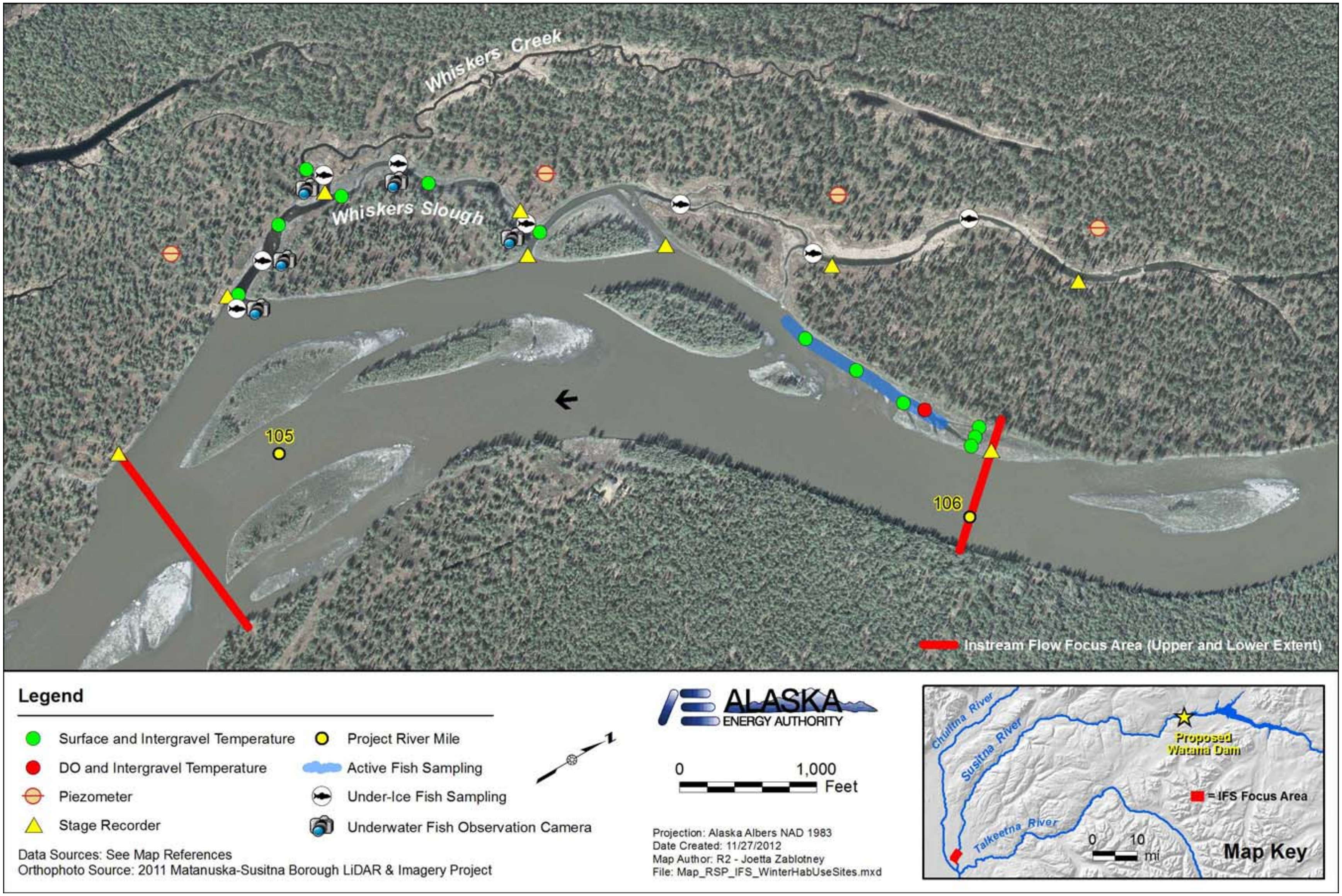

Figure 9.6-8. **Distribution of winter sampling sites in Whiskers Slough, Susitna River.**

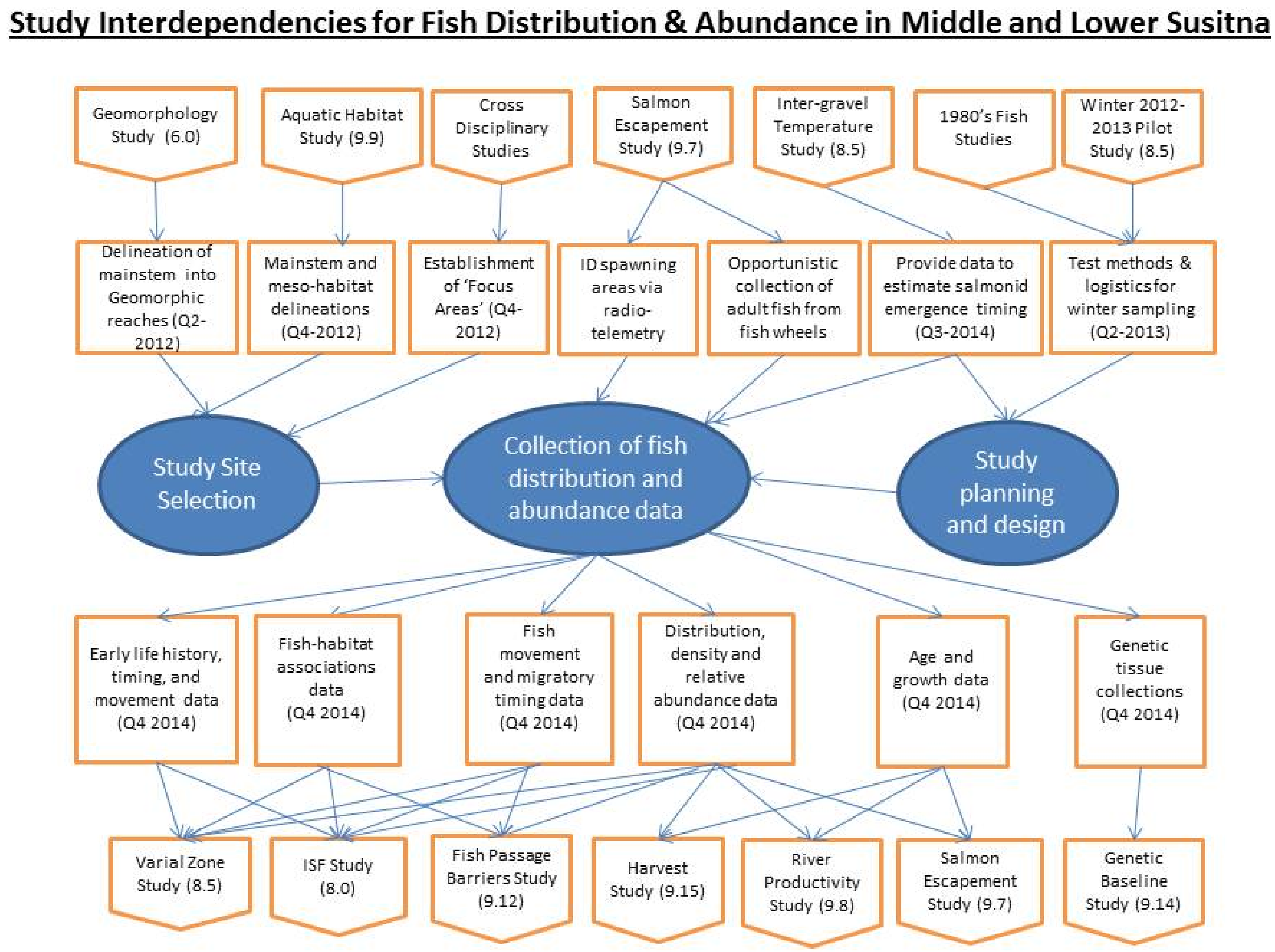

Figure 9.6-9. Flow chart of study interdependencies for Fish Distribution and Abundance in the Middle and Lower Susitna River Study Plan.

9.8. River Productivity Study

9.8.1. General Description of the Proposed Study

The production of freshwater fishes in a given habitat is constrained both by the suitability of the abiotic environment and by the availability of food resources (Wipfli and Baxter 2010). Algae are an important base component in the lotic food web, being responsible for the majority of photosynthesis in a river or stream and serving as an important food source to many benthic macroinvertebrates. In turn, benthic macroinvertebrates are an essential component in the processes of an aquatic ecosystem, due to their position as consumers at the intermediate trophic level of lotic food webs (Hynes 1970; Wallace and Webster 1996; Hershey and Lamberti 2001). Macroinvertebrates are involved in the recycling of nutrients and the decomposition of terrestrial organic materials in the aquatic environment, serving as a conduit for the energy flow from organic matter resources to vertebrate populations, namely fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). In turn, nutrients and energy provided by spawning salmon have the potential to increase freshwater and terrestrial ecosystem productivity (Wipfli et al. 1998; Cederholm et al. 1999; Chaloner and Wipfli 2002; Bilby et al. 2003; Hicks et al. 2005), and may subsidize otherwise nutrient-poor ecosystems (Cederholm et al. 1999).

The significant functional roles that macroinvertebrates and algae play in food webs and energy flow in the freshwater ecosystem make these communities important elements in the study of a stream's ecology. The operations of the proposed Project would likely affect one or more of the factors that can affect the abundance and distribution of benthic algae and benthic macroinvertebrate populations, which could ultimately affect fish growth and productivity in the system. The degree of impact on the benthic communities and fish resulting from hydropower operations will necessarily vary depending on the magnitude, frequency, duration, and timing of flows, as well as potential Project-related changes in geomorphology, ice processes, temperature, and turbidity. By investigating the current populations of algae, benthic macroinvertebrates, and fish in the Susitna River and the trophic relationships between them, this study will generate information about the current health and status of these populations throughout the varied habitats in the Susitna River, and provide a better understanding on the availability and utilization of food resources in the system. In addition, by applying what is known about the effects of river regulation and hydropower operation on these populations in riverine ecoysystems, AEA can begin to assess the potential impacts of Project operations on river productivity in the Susitna River, as well as provide information to inform development of any necessary protection, mitigation, and enhancement (PM&E) measures.

Study Goals and Objectives

The overarching goal of this study is to collect baseline data to assist in evaluating the effects of Project-induced changes in flow and the interrelated environmental factors (temperature, substrate, water quality) upon the benthic macroinvertebrate and algal communities in the Middle and Upper Susitna River. Individual objectives that will accomplish this are listed below.

1. Synthesize existing literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities.

2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Upper Susitna River.
3. Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Upper Susitna River to assess food availability to juvenile and resident fishes.
4. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.
5. Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Upper Susitna River.
6. Develop habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site.
7. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).
8. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Upper Susitna River.
9. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

9.8.2. Existing Information and Need for Additional Information

A number of evaluations of the benthic macroinvertebrate community were conducted on the Susitna River in the 1970s and in the 1980s for the original Alaska Power Authority (APA) Susitna Hydroelectric Project (Friese 1975; Riis 1975, 1977; ADF&G 1983; Hansen and Richards 1985; Van Nieuwenhuyse 1985; Trihey and Associates 1986). ADF&G studies in the 1970s included sampling of macroinvertebrates using artificial substrates (rock baskets) deployed for a set period of time to allow for colonization. Friese (1975) and Riis (1975) set a total of eight rock baskets in Waterfall Creek, Indian River, and the mainstem Middle Susitna River for 30 days during summer (July – September). Riis (1977) also deployed rock baskets in the Susitna River near the mouth of Gold Creek for a colonization period of 75 days; however, only two of seven baskets were retrieved. Results were limited to low numbers of invertebrates per basket, identified to taxonomic family.

Studies conducted in the 1980s for the original APA Susitna Hydroelectric Project focused on benthic macroinvertebrate communities in the sloughs, side channels, and tributaries of the Middle Segment of the Susitna River from river mile (RM) 125 to RM 142 during the period from May through October. Efforts included direct benthic sampling with a Hess bottom sampler and drift sampling. Alaska Department of Fish and Game (ADF&G) efforts in 1982 and 1984 also involved collection of juvenile salmon in these side channels and sloughs, and an analysis was conducted to compare gut contents with the drift and benthic sampling results (ADF&G 1983; Hansen and Richards 1985). In addition, Hansen and Richards (1985) collected water velocity, depth, and substrate-type data to develop habitat suitability criteria (HSC), which were used to estimate weighted usable areas for different invertebrate community guilds, based on their behavioral type (swimmers, burrowers, clingers) in slough and side channel habitats. Efforts in 1985 (Trihey and Associates 1986) expanded to include sampling at nine sites in the Middle Susitna River Segment: three side channels, two sloughs, two tributaries, and two mainstem sites.

Algal communities were periodically sampled and analyzed for chlorophyll-a at Susitna Station from 1978 to 1980. In the 1980s, algae samples were collected as part of the APA Susitna Hydroelectric Project water quality studies, with sampling conducted at Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna Station on the Susitna River, as well as on the Chulitna and Talkeetna rivers (Harza-Ebasco 1985 as cited in AEA 2011). Analysis showed low productivity (less than 1.25 mg/m^3 chlorophyll-a) and indicated algal abundance was most likely limited by high concentrations of turbidity (AEA 2011).

Baseline field data for benthic primary and secondary production was also collected in 1985, as part of the Primary Production Monitoring Effort (Van Nieuwenhuyse 1985). Chlorophyll-a (*chl-a*), and macroinvertebrates were collected from early April to late October 1985 from a variety of off-channel and mainstem habitat sites. Early April sampling took place in an open-water lead in Slough 8A, and revealed high macroinvertebrate densities (average 17,600 individuals/m^2) comprised almost entirely of chironomid larvae, and chlorophyll-a densities averaging 34.4 mg/m^2. Sampling in early May in Slough 8A revealed macroinvertebrate densities averaging 2,950 individuals/m^2, again almost entirely chironomids, and *chl-a* densities averaging 37mg/m^2. Results from five mainstem habitat sites showed similar macroinvertebrate numbers, with densities ranging from 393 to 8,820 individuals/m^2 in May 1985, but with considerably more diversity; chironomids accounted for an average of 53 percent of the density, and only 8 percent of the macroinvertebrate biomass. Algae samples beyond May 1985 had not been analyzed; therefore, no data were available for summer or fall. No sampling results were given for summer macroinvertebrate sampling (June and July). August and September 1985 sampling showed low average densities at mainstem sites (44 – 164 individuals/m^2), with large increases occurring in October 1985 (1,729 – 7,109 individuals/m^2). Average densities in Slough 8A in August 1985 remained similar to spring levels, at 2,851 individuals/m^2, with a surge in September 1985 (13,964 individuals/m^2); again, chironomids represented over 80 percent of the numbers. No further information or reports were available concerning the Primary Production Monitoring Effort task.

Benthic macroinvertebrate information from the 1980s is focused on a limited number of mainstem, side channel, and slough habitats located within a 17-mile reach of the Middle Susitna River. Additional information is needed on mainstem benthic communities, as well as those in side channel and slough habitats, within both the Middle and Upper Susitna River segments. Benthic algae information needs to be collected in conjunction with the macroinvertebrates to define their relationship in the river's trophic system. To assess the impact of future hydropower operations on the benthic communities within the Susitna River, additional information must be collected through an increased sampling effort, including more sampling sites along the river in relation to the distance both downstream from the proposed dam site and upstream from the proposed Project reservoir area.

9.8.3. Study Area

The River Productivity Study will entail field sampling throughout the Upper Segment and Middle Segment on the Susitna River (Table 9.8-1; Figures 9.8-1 through 9.8-2). The Upper

Susitna River Segment is defined as the section of river above the proposed Watana Dam site at RM 184 (Figure 9.8-1). Sampling in the upper portions of this segment above the proposed reservoir (RM 233 – 260) will investigate the benthic communities that will be unaffected by the Project. The Middle Susitna River Segment encompasses the 86-mile section of river between the proposed Watana Dam site and the Chulitna River confluence, located at RM 98 (Figure 9.8-2). Sampling activities within this segment will investigate the benthic communities that may be affected by the Project and its regulated flows. Sampling will be conducted at various distances from the proposed dam site to document longitudinal variability, and estimate the effects that the proposed Project will have on benthos in the river system downstream. The Lower Susitna River Segment, defined as the approximate 98-mile section of river between the Chulitna and Talkeetna rivers confluence and Cook Inlet, will not be sampled in this study because the larger influences of the Chulitna and Talkeetna rivers will attenuate Project operation effects, if any, that would affect benthic communities on the mainstem Susitna River below the Three Rivers Confluence.

AEA will reevaluate how far downstream Project operational significant effects extend based in part upon the results of the Open-water Flow Routing Model (see Section 8.5.4.3), which is scheduled to be completed in Q1 2013. Thus, an initial assessment of the downstream extent of Project effects will be developed in Q2 2013 with input of the TWG. This assessment will include a review of information developed during the 1980s studies and study efforts initiated in 2012, such as sediment transport (Section 6.5), habitat mapping (Sections 6.5 and 9.9), operations modeling (Section 8.5.4.2.2), and the Mainstem Open-water Flow Routing Model (Section 8.5.4.3). The assessment will guide the need to extend studies into the Lower River Segment and if needed, will identify which geomorphic reaches will be subject to detailed instream flow analysis in 2013. Results of the 2013 studies would then be used to determine the extent to which the study should be modified to include sampling in the Lower River Segment in 2014.

9.8.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the benthic macroinvertebrate and algal communities in the Upper and Middle Susitna River. The following sections provide brief descriptions of study site selection, sampling timing, the approach, and methods that will be used to accomplish each objective of this study.

River Productivity Implementation Plan

This study includes a description of the sampling scheme. However, specific details regarding site locations, timing, sampling devices, processing, and analyses will be dependent upon the results of 2012 data collection efforts.

The final sampling scheme will be included in the River Productivity Implementation Plan, which will be filed with FERC prior to March 15, 2013.

The Implementation Plan development will include: (1) a summary of relevant macroinvertebrate and algal studies in the Susitna River, (2) an overview of the life-histories of the target fish species in the Susitna River that are selected for the trophic analysis (Section 9.8.4.5.1), (3) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9) and "Focus Areas" (Section 8.5.4.2.1.2), (4) a description of site selection protocols, (5) a description of sampling protocols, (6) a description of sample processing protocols, (7) a discussion of data analysis methods, (8) development field data collection forms, and (9) development of database templates that comply with 2012 AEA QA/QC procedures.

The implementation plan will include the level of detail sufficient to instruct field crews in data collection efforts. In addition, the plan will include protocols and a guide to the decision-making process in the form of a chart or decision tree that will be used in the field, specific sampling locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The implementation plan will also help ensure that field collection efforts occur in a consistent and repeatable fashion across field crews and river segments. Proposed sampling methods by objective are presented below.

9.8.4.1. Synthesize existing information on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities

Several reviews have been written on the effects that modified flows have on the benthic communities residing below dams (Ward 1976; Ward and Stanford 1979; Armitage 1984; Petts 1984; Cushman 1985; Saltveit et al. 1987; Brittain and Saltveit 1989). A majority of these reviews indicate that temperature and flow regimes are often the most important factors affecting benthic macroinvertebrates below dams. The type of dam and its mode of operation will have a large influence over the type and magnitude of effects on the receiving stream below. General information on the effects of hydropower on riverine habitats, especially glacially-fed river systems, as well as Project-specific information, will be reviewed and synthesized in a written report. Specifically, AEA will prepare a written report that provides a literature review summarizing relevant literature on macroinvertebrate and algal community information in Alaska, including 1980s Susitna River data; review and summarize literature on general influences of changes in flow, temperature, substrates, nutrients, organic matter, turbidity, light penetration, and riparian habitat on benthic communities; and review and summarize the potential effects of dams and hydropower operations, including flushing flows and load-following, on benthic communities and their habitats. To the extent consistent with copyright laws, electronic copies of all cited publications will be provided through the ARLIS library.

9.8.4.2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Upper Susitna River

9.8.4.3. Benthic macroinvertebrate sampling

Macroinvertebrate sampling will be stratified by reach and mainstem habitat type defined in the Project-specific habitat classification scheme (mainstem, tributary confluences, side channels, and sloughs). To accomplish this objective, sampling will occur at six stations, each with three sites (one mainstem site and two off-channel sites associated with the mainstem site), for a total of 18 sites. Two stations will be located in the Upper Segment, above the proposed dam and reservoir area (upstream of RM 223) (Table 9.8-1; Figure 9.8-1). In the Middle Segment, two stations will be located between the dam site and the upper end of Devils Canyon, and two stations will be located below Devils Canyon, within the Geomorphic Reach MR-6 (Table 9.8-1; Figure 9.8-2). All stations established within the Middle Segment will be located at Focus Areas established by the Instream Flow Study (Section 8.5.4.2.1.2), in an attempt to correlate macroinvertebrate data with additional environmental data (flow, substrates, temperature, water quality, riparian habitat, etc.) for statistical analyses, and HSC/HSI development. Station and site locations will be determined during the first quarter of 2013, and detailed in the River Productivity Implementation Plan.

Three sampling periods will occur from April through October in both study years (2013–2014) to capture seasonal variation in community structure and productivity. Seasonal periods are tentatively scheduled for April through early June for Spring, late June through August for Summer, and September through October for Autumn. Specific details on timing will be provided in the River Productivity Implementation Plan. Timing of life history events for coho, Chinook salmon, and rainbow trout (target species for Objective 5, Section 9.8.4.5.1) will be consulted when scheduling sampling efforts.

Sampling will be conducted in riffle/run mesohabitats within mainstem and off-channel macrohabitat types (i.e., tributary confluences, side channels, and sloughs). Higher flows may inundate new shoreline substrates, which poses the risk of sampling in areas that are not fully colonized. The shoreline bathymetry for each site will be evaluated such that changes in water level due to increasing or decreasing flows must remain constant enough that the substrates accessible for sampling will be continually inundated for a period of at least one month, to facilitate colonization of those substrates.

Benthic macroinvertebrate sampling will be conducted using a stream-type sampler (Hess, Surber, Slack) commonly used for other Alaskan benthic macroinvertebrate studies to allow for comparable results; state and federal protocols (Hansen and Richards 1985; Barbour et al. 1999; Klemm et al. 1990; Klemm et al. 2000; Carter and Resh 2001; Moulton et al. 2002; Peck et al. 2006), as well as methods used in the Susitna River studies in the 1980s, will be considered when designing the sampling approach, which will be detailed in the River Productivity Implementation Plan. Replicate samples (n=5) will be collected to allow for statistical testing of results for short- and long-term monitoring. Measurements of depth, mean water column velocity, mean boundary layer velocity (near bed), and substrate composition will be taken concurrently with benthic macroinvertebrate sampling at the sample location for use in HSC/HSI development in the instream flow studies. Water temperatures will be monitored hourly at sites with submerged temperature loggers deployed at all sampling sites throughout the ice-free season. Fine-scale (1 meter vertical and horizontal resolution) measurements of flow will be recorded within a 5-m radius of selected sampling sites. Temperature and flow monitoring will be coordinated with the Baseline Water Quality Study (Section 5.5) and the Instream Flow Study (Section 8.5), and supplemental temperature loggers will be deployed if necessary to cover all River Productivity Study sites.

In addition, floating emergence traps will be deployed at each site to determine both the timing and the amount of adult insect emergence from the Susitna River (Cushman 1983). Adult aquatic insect emergence mass is a product of aquatic insect production from the stream, and is therefore a good surrogate for actual production (minus predation), and will be especially useful for relative comparisons between river sections and years (personal communication, M. Wipfli, University of Alaska-Fairbanks). Emergence traps will be checked and reset every month. Trapped adults will be identified, enumerated, and weighed. Exact trap design will be determined according to methods compatible with those used for other studies in comparable streams/basins in Alaska, and will be detailed in the River Productivity Implementation Plan.

Due to the prevalence of large woody debris in the Susitna River, woody snags, if present at a sampling site, also will be sampled as a substrate strata for benthic macroinvertebrates, as requested by the U.S. Fish and Wildlife Service (USFWS) (USFWS River Productivity Study Request; May 31, 2012). Sampling methods for woody snags will be semi-quantitative, based upon protocols established by the USGS (Moulton et al. 2002). Suitable woody snags will have been submerged for an extended period of time so as to be clearly colonized. Woody snags to be sampled will be removed from the water by using a saw and placed over a plastic bin or in a bucket, and all benthic macroinvertebrates will be removed by handpicking, brushing, and rinsing. The snags will be allowed to dry for a period of time so that missed organisms will crawl out of the crevices and can then be collected. Snag sections sampled will be measured for length and average diameter to determine surface area sampled. Each snag section will originate from a separate snag, and therefore count as a separate, replicate sample.

In order to address the effects of changing flow patterns on benthic macroinvertebrates, algae (Section 9.8.4.2.2), and benthic organic matter (BOM) (Section 9.8.4.8), baseline data will be collected to assess the benthic community responses to storm events within side slough habitats. Additional sampling will be conducted both before and after storm events that meet or exceed a 1.5-year flood event at two side slough sites, located in two separate Focus Areas in the Middle River Segment between Portage Creek and Talkeetna (Section 8.5.4.2.1.2). Replicate samples (n=5) will be collected at both the upstream and downstream ends of each slough, and will include benthic macroinvertebrates, algae, and BOM. Sampling will be conducted for two storm events per year. Specific details on locations and targeted flows will be based on information from the Instream Flow (Section 8.5) and Geomorphology (Section 6.5) studies available in early 2013, and will be provided in the River Productivity Implementation Plan.

Benthic macroinvertebrate replicate samples collected will be stored in individual containers and immediately preserved in the field with 95 percent ethanol (non-denatured). Samples will be processed in a laboratory using methods compatible with those used for other studies in comparable streams/basins in Alaska. State and federal protocols (Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered when making decisions about the sample processing protocols, including sub-sampling protocols and the taxonomic resolution of specimen identifications. Sampling and processing methodology will be detailed in the River Productivity Implementation Plan.

Results generated from the collections will include several descriptive metrics commonly used in aquatic ecological studies, such as density (individuals per unit of area), taxa richness (both mean and total), EPT taxa (i.e., *Ephemeroptera*, *Plecoptera*, *Trichoptera*) richness, diversity (H'), evenness (J'), percent dominant taxa, the relative abundance of major taxonomic groups, and the relative abundance of the functional feeding groups. In conjunction with the bioenergetics modeling (Section 9.8.4.5.1), biomass estimates will be taken for primary invertebrate taxa collected for benthic and emergence sampling. The fresh blotted wet mass of invertebrate taxa in samples will be recorded, the samples will be oven dried at 60˚C until reaching constant mass, and the dry mass will be recorded. For a select sub-sample of the collection, energy density (J / g wet weight) will be estimated from the percent dry mass (dry mass / wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). Energy density will be determined separately for the aquatic and terrestrial (adult) life-stages of each primary invertebrate taxon. For two selected stations, benthic macroinvertebrates and organic matter in samples will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2).

Data collected during this study will be compared to the results of 1980s studies (ADF&G 1983; Hansen and Richards 1985; Van Nieuwenhuyse 1985; Trihey and Associates 1986) to evaluate any differences between the historic and current community structure. In addition, any invasive benthic macroinvertebrates identified in the sample collections will be identified and their collection locations will be recorded using the Geographic Information System (GIS) (NAD 83).

9.8.4.4. Benthic algae sampling

Benthic algae sampling will be collected concurrently with benthic macroinvertebrate sampling at all six stations (18 sites total) to allow for correlation between the two collections (Table 9.8-1), plus the additional baseline sampling effort addressing the effects of changing flow patterns on benthic communities in sloughs, as discussed in Section 9.8.4.2.1. Benthic algae sampling will be conducted using methods compatible with other Alaska benthic algal studies, to allow for comparison of results. Algal sampling methods will be based on the EPA's field operations procedures for periphyton single or targeted habitat sampling when designing the sampling approach (Eaton et al. 1998; Barbour et al. 1999; Peck et al. 2006). Measurements of depth, mean water column velocity, mean boundary layer velocity, turbidity, and substrate composition will be taken concurrently with algae sampling at the sample location for use in HSC development in the instream flow studies. Light availability will be measured at each sample location with an underwater light sensor, to measure the photosynthetically active radiation (PAR) available to the algal community. Turbidity measurements will also be taken at the site to determine water clarity. Benthic algae samples will be processed in a laboratory, using methods compatible with those used for other studies in comparable streams/basins in Alaska, considering state and federal protocols (Eaton et al. 1998; Barbour et al. 1999; Moulton et al. 2002; Peck et al. 2006) to determine sample processing protocols, including sub-sampling protocols. Algal sampling and processing methods will be detailed in the River Productivity Implementation Plan.

Results generated from the collections would include both dry weight and chlorophyll-a, and several descriptive metrics to describe the algal community; full details will be provided in the River Productivity Implementation Plan. For two selected stations, portions of algal material will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2). In addition, any invasive algae taxa identified in the sample collections will be identified and their locations will be recorded using GIS (NAD 83).

9.8.4.5. Estimate drift of invertebrates in selected habitats within the Middle and Upper Susitna River to assess food availability to juvenile and resident fishes

Invertebrate drift sampling will be conducted concurrently with benthic macroinvertebrate sampling at all sites within the six established sampling stations to allow for comparisons between the drift component and the benthic macroinvertebrate community, as well as revealing the availability of terrestrial invertebrates to fish predation. Sampling will be conducted in riffle/run habitats within the mainstem sites, and their associated off-channel habitat sites (Table 9.8-1).

Invertebrate drift sampling will be conducted using a drift net similar to those used for other drift studies in Alaska to allow for comparison of results; state and federal protocols will be considered (Keup 1988; Klemm et al. 2000). Drift sampling will be conducted during pre-dawn hours, as a measure of drift that is available to feeding fish (Waters 1972; Brittain and Eikeland

1988; Keup 1988). Sampling methods will involve collecting duplicate samples to allow for statistical testing of results for short- and long-term monitoring (Klemm et al 1990; Klemm et al. 2000). Water velocity will be recorded with an in-net flow meter. Invertebrate drift samples will be processed in a laboratory, using methods compatible with other studies conducted in comparable streams/basins in Alaska. State and federal protocols (Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered when making decisions about the sample processing protocols, including sub-sampling protocols, taxonomic resolution of specimen identifications, and length measurements for individual specimens. Samples at two selected stations (one each in Upper and Middle segments) will be tested for the stable isotope analysis task (Section 9.8.4.5.2). Organic matter (OM) content will be retained and analyzed by size (coarse and fine particulate OM) as discussed in Section 9.8.4.8.

Results generated from these collections will include drift density, drift rate, and drift composition. In conjunction with the bioenergetics modeling (Section 9.8.4.5.1), biomass estimates will be taken for primary invertebrate taxa collected for drift sampling. The fresh blotted wet mass of invertebrate taxa in samples will be recorded, the samples will be oven-dried at 60˚C until reaching constant mass, and the dry mass will be recorded. For a select sub-sample of the collection, energy density (J / g wet weight) will be estimated from the percent dry mass (dry mass / wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). Energy density will be determined separately for the aquatic and terrestrial life stages of each primary invertebrate taxon. For two selected stations, portions of terrestrial invertebrate composition and organic matter in samples will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2).

Data collected as part of this study will be compared to data from the benthic macroinvertebrate collections (Section 9.8.4.2.1) and the fish dietary analysis (Section 9.8.4.7). In addition, drift results will be compared to the results of 1980s drift studies (ADF&G 1983; Hansen and Richards 1985; Trihey and Associates 1986) to evaluate any differences between the historic and current drift components of the macroinvertebrate communities.

9.8.4.6. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity

Sampling sites will be established in the Talkeetna River in areas that are physically similar to those sampled in the Middle Susitna River Segment, to ensure comparability. Sampling will be conducted in riffle habitats within the mainstem, side channels, and sloughs. One station will be established, with a mainstem site and two off-channel habitat sites associated with the mainstem site. Benthic and drift sampling will occur during approximately the same periods as sampling in the Middle Susitna River Segment (Objectives 2 and 3, Sections 9.8.4.2 and 9.8.4.3), with seasonal sampling during 2013. Benthic macroinvertebrate, benthic algal, and drift sampling methods and processing protocols will be identical to those used in sampling the Middle Susitna River Segment (Objective 2, Section 9.8.4.2). In the first quarter of 2014, sampling results from Talkeetna sites will be compared to results from similar sites in the Middle Susitna River Segment to determine whether the Talkeetna River would serve as a suitable reference site. Statistical analyses will test for similarities and significant differences between Talkeetna sites and Middle Susitna Segment sites by comparing community compositions and a collection of calculated metrics. Methods will be detailed in the River Productivity Implementation Plan, and may include ANOVA, MANOVA, cluster analysis using Non-Metric Multi-Dimensional Scaling (NMDS) ordinatation with the Bray-Curtis Dissimilarity Coefficient, and/or other multivariate ordination techniques (Principal Components Analysis, Canonical Correspondence Analysis). Results indicating close similarities, or no significant differences, between sites on the two rivers would indicate suitability as a reference. If suitable, sites on the Talkeetna River can be used in a long-term monitoring program with Susitna River sites to help differentiate potential long-term changes that are Project-related versus those occurring for other reasons outside Project influence. Such a monitoring program would ideally collect multiple years of both pre-Project and post-Project data.

9.8.4.7. Conduct a trophic analysis, using trophic modeling and stable isotope analysis, to describe the food web relationships in the current riverine community within the Middle and Upper Susitna River

9.8.4.8. Develop a trophic model to estimate how environmental factors and food availability affect the growth rate potential of focal fish species under current and future conditions

To complement the fish habitat suitability analysis (Section 9.8.4.6), which focuses on physical habitat features, trophic models will be developed to incorporate the density and quality of prey into an estimate of habitat quality. Growth rate potential models integrate knowledge of the foraging capabilities and bioenergetic physiology of a consumer with field data on its physical environment and prey base to quantify the values of different habitats (Brandt et al. 1992; Nislow et al. 2000; Jensen et al. 2006; Farley and Trudel 2009). The currency of these models, growth rate potential (GRP), is the expected growth rate of a consumer occupying a given habitat. For salmon, juvenile growth is strongly correlated with early marine survival and overall stock dynamics (Pearcy 1992; Beamish and Mahnken 2001; Moss et al. 2005; Duffy and Beauchamp 2011), making GRP a particularly valuable metric of freshwater habitat quality.

One drawback of typical GRP models is that modeled fish are often assumed to occupy a single uniform habitat (e.g., Brandt and Kirsch 1993). However, real fish may be able to exceed the growth rate predicted by these models by moving among nearby habitats to feed, rest, and digest. For example, by regularly moving between habitats of differing temperatures, some sculpin can increase their growth rates by as much as three-fold, relative to a strategy of using a single habitat (Wurtsbaugh and Neverman 1988; Neverman and Wurtsbaugh 1994). The growth of juvenile coho and Chinook salmon is relatively insensitive to the range of temperatures typically found in Alaskan streams, suggesting that small temperature differences among habitats may not substantially affect growth (Beauchamp 2009). However, thermal heterogeneity has a strong influence on the growth of juvenile coho salmon in the Bristol Bay region, due to the short growing season and the potential for faster-growing individuals to consume energy-rich salmon eggs (Armstrong et al. 2010). Further, resident fishes such as rainbow trout can exploit thermal variation patterns by moving from colder to warmer streams to prolong their access to salmon eggs and carcasses during the summer (Ruff et al. 2011). Thus, the local movement patterns of both juvenile salmon and non-anadromous resident fishes among habitat types within the Susitna River study area could potentially have important consequences for their growth rates.

Growth rate potential models will be developed to quantify the effects of environmental conditions and food availability on fish growth at each sampling location, while allowing for local movement among habitats. Due to the relatively data-intensive nature of GRP models, this analysis will focus on two species: coho salmon and rainbow trout. Coho salmon will be included due to their high ecological and economic value in the Susitna Basin and Cook Inlet. Rainbow trout will be included as a representative resident species and a potentially important competitor and predator of juvenile salmon. Importantly, detailed foraging parameters are available for both species (e.g., Dunbrack and Dill 1984; Berg and Northcote 1985; Piccolo et al. 2007; Piccolo et al. 2008a, 2008b), enabling the development of well-supported foraging models. The necessary bioenergetics model parameters are also available for both species (Stewart and Ibarra 1991; Rand et al. 1993).

Species-specific GRP models for coho salmon and rainbow trout will couple a foraging model (Fausch 1984; Hughes and Grand 2000; Hayes et al. 2007) with a Wisconsin bioenergetics model (Kitchell et al. 1977; Hanson et al. 1997). The foraging models will take inputs of flow, turbidity, and prey density and predict a consumption rate. The bioenergetics models will take inputs of consumption, body size, water temperature, diet composition, and the energy density of prey and predict a growth rate. Each GRP model will allow for the potential of local movement among habitats within a sampling location to enhance growth rates. Optimal simulated movement patterns will be estimated and compared with the observed movements documented by the radio telemetry and PIT tagging components of the Fish Distribution and Abundance Study (Section 9.6).

Preliminary growth models for each species will be developed using data from the 2013 field season as well as from prior Susitna Basin studies. Initial model predictions of the growth potential of particular sites will be tested by comparison with the observed growth and distribution of fish captured in those sites. A sensitivity analysis will be conducted to identify the most important parameters for further refinement (Beaudreau and Essington 2009). Field sampling during 2014 will focus on improving estimates for these parameters.

In addition, a separate trophic analysis will determine how water temperature, food availability, and food quality influence the growth performance of juvenile Chinook salmon in different habitats. Mechanistic drift foraging models for Chinook salmon are not yet available to allow the estimation of growth rate potential under changing conditions. However, field data and bioenergetics analysis will allow useful comparisons of growth rates, consumption rates, and growth efficiency (the growth achieved per gram of food consumed) among different habitats under current conditions. To make these comparisons, a Wisconsin bioenergetics model parameterized for Chinook salmon (Stewart and Ibarra 1991; Madenjian et al. 2004) will take field inputs of body size, growth rate, water temperature, diet composition, and the energy density of prey. The model will estimate the consumption rate and growth efficiency. These metrics will be compared among habitats to determine whether growth is currently limited primarily by water temperature, food consumption, or food quality in the study area, and whether these limiting factors differ among habitats (McCarthy et al. 2009).

9.8.4.9. Conduct stable isotope analysis of food web components to help determine energy sources and pathways in the riverine communities

Stable isotope analysis is a method which examines the naturally-occurring stable isotopes of elements (typically carbon and nitrogen) stored in organic materials. The analysis is frequently used to answer questions related to trophic structure and energy pathways within freshwater ecosystems and the interfaces with marine and terrestrial ecosystems (Chaloner et al. 2002;

Finlay and Kendall 2007). Carbon isotope ratios ($\delta^{13}C$) are indicators of an organism's diet because consumers tend to reflect the carbon isotope values of the food they consume, whereas nitrogen isotopes ($\delta^{15}N$) indicate an organism's trophic level because the heavier nitrogen isotope accumulates in the consumer with each successive trophic transfer (approximately 3– 4 parts per thousand, according to DeNiro and Epstein 1981) (Chaloner et al. 2002). If food resources move in a predictable manner through the food chains, these stable isotopes can be used to trace the sources of productivity within aquatic food webs and the trophic position of consumers, which can be essential information for understanding the food web dynamics or for detecting responses to environmental and human-driven change (Chaloner et al. 2002; Finlay and Kendall 2007).

Several recent studies have used stable isotopes to investigate the contribution of marine-derived nutrients (MDN) from spawning salmon to freshwater ecosystems, and have estimated that salmon can contribute 17–30 percent (Bilby et al. 1996) to > 50 percent (Kline et al. 1990) of the nitrogen, and 23–40 percent (Bilby et al. 1996) of the carbon present in freshwater organisms. Adult salmon incorporate rich marine nutrients during their time in the ocean and are thereby enriched with the heavier isotopes of nitrogen and carbon, which they retain after entering fresh water to spawn, as they do not feed in fresh waters, and therefore remain isotopically distinct from terrestrially-derived organic material (Kline et al. 1990). Stable isotope analysis can be used to trace MDN through freshwater ecosystems, and ultimately can be used to quantify the contribution of marine-derived nitrogen or carbon to freshwater food webs (Kline et al. 1990; Hicks et al. 2005).

To better understand the trophic relationships in the Upper and Middle Susitna River, a stable isotope analysis will be conducted at two selected stations (with three sampling sites each), with one in the Upper River Segment, and one in the Middle River Segment. Selection of these two stations will be made in the initial sampling efforts in the second quarter, based on how representative the site is in respect to the reach, and its suitability to provide ample materials for testing. Tissue samples from multiple study components (benthic macroinvertebrates, benthic algae, benthic organic matter, terrestrial invertebrates and organic matter in drift samples, salmon carcasses, and fin clip samples from the fish diet analysis collections) at the sites within these two stations will be collected for stable isotope analysis. Results will be used in conjunction with the bioenergetics model (Section 9.8.4.5.1) to further explain the energy source pathways and trophic relationships in the Susitna River food web.

9.8.4.10. Generate habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site

Habitat Suitability Index (HSI) models provide a quantitative relationship between numerous environmental variables and habitat suitability. An HSI model describes how well each habitat variable individually and collectively meets the habitat requirements of the target species and life stage under the structure of Habitat Evaluation Procedures (USFWS 1980). Alternatively, Habitat Suitability Criteria (HSC) curves are designed for use in the Instream Flow Incremental Methodology to quantify changes in habitat under various flow regimes (Bovee et al. 1998). HSC describes the instream suitability of habitat variables related only to stream hydraulics and channel structure. Both models and habitat index curves are hypotheses of species–habitat relationships and are intended to provide indicators of habitat change, not to directly quantify or predict the abundance of target organisms. For the Susitna-Watana Hydroelectric Project aquatic habitat studies, HSC (i.e., depth, velocity, and substrate/cover) and HSI (i.e., turbidity, duration of inundation, and dewatering) models will be integrated to analyze the effects of alternate operational scenarios.

Literature-based draft HSC/HSI curves will be developed for benthic macroinvertebrate and algae communities. Potential sources of information include the Internet, university libraries, peer-reviewed periodicals, and government and industry technical reports. Special emphasis will be given to the existing 1980s study (Hansen and Richards 1985) for applicable information and methodology. Because benthic macroinvertebrate (BMI) and periphyton communities are comprised of numerous taxa, the HSC/HSI curves will be developed for commonly used benthic metrics (e.g., biomass, chlorophyll-a [algae], density, diversity, or dominant taxa) selected to summarize and describe the communities. The selection of individual species of interest will consider the dietary preferences of the target fish species selected for the trophic analysis (Objective 5, Section 9.8.4.5.1). The review will also examine macroinvertebrate life histories, behavior, and functional feeding groups to assist in grouping taxa into guilds as possible metrics. Habitat suitability information will address BMI and algal responses to changes in depth, velocity, substrate, turbidity, and frequency of inundation and dewatering.

Next, a histogram (i.e., bar chart) will be developed for each of the habitat parameters (e.g., depth, velocity, substrate, frequency of dewatering) using site-specific field observations (from Objectives 2, Section 9.8.4.2, and Objective 9, Section 9.8.4.9). The histogram developed using field observations from 2013 will then be compared to the literature-based HSI curve to validate applicability of the literature-based HSI curve for aquatic habitat modeling. This stage will be conducted by the third quarter of 2014.

As a final step TWG will confirm HSC/HSI curves for each benthic metric. Using a roundtable discussion format, the TWG will review literature-based benthic community information and site-specific data to develop a final set of HSC/HSI curves. These curves will be used in the Instream Flow Study (Section 8.5) to define the relationship between habitat quantity and quality for each of the selected benthic metrics under various operational scenarios. Analysis and modeling efforts will be coordinated with the Instream Flow Study Team.

9.8.4.11. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component)

In order to investigate and understand the trophic relationships within a river system and how they ultimately relate to fish, it is critical to examine not only the food source (Objective 2, Section 9.8.4.2) and its availability to fish via drift (Objective 3, Section 9.8.4.3), but also the consumption by fish predators. Because both benthic macroinvertebrates and terrestrial invertebrates are a primary food source for fish and other organisms (Wipfli 1997; Hershey and Lamberti 2001; Allan et al. 2003), any significant disturbance to the benthic community and the shoreline riparian vegetation has the possibility of affecting their predators. Therefore, it is important to investigate the trophic relationship between fish and these food sources by conducting a fish gut analysis and comparing results to drift and benthic macroinvertebrate data. In support of the bioenergetics modeling (Objective 5, Section 9.8.4.5.1), fish species targeted for dietary analysis will include juvenile coho salmon, juvenile Chinook salmon, and juvenile and adult rainbow trout, as identified in consultation with the TWG. Fish collection sites will correspond to all sites within the six sampling stations identified for the study (Table 9.8-1), benthic macroinvertebrate collection sites (both benthic, , and drift sampling, to allow for comparison with the benthic macroinvertebrate community (Section 9.8.4.2.1) and drift compositions (Section 9.8.4).

A total of eight fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods (Meehan and Miller 1978; Hyslop 1980; Bowen 1996; Kamler and Pope 2001). All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis (DeVries and Frie 1996). At two selected sampling stations (one each in Upper Segment and Middle Segment), fin clips will be obtained from five fish at each site for use in the stable isotope analysis (Section 9.8.4.5.2). The fish collection methods and scheduled sampling efforts will be coordinated with the appropriate fish study team (Fish Distribution and Abundance in the Middle and Lower Susitna River Study, Section 9.6; Fish Distribution and Abundance in the Upper Susitna River Study, Section 9.5). Methods for collecting fish specimens are included in Sections 9.5.4.3, and 9.5.4.3.

Fish gut content samples will be processed in a laboratory using methods compatible with studies conducted in other comparable streams/basins in Alaska. State and federal protocols (Hyslop 1980; Bowen 1996; Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered in determining the sample processing protocols, the taxonomic resolution of specimen identifications, and data analysis approach. Data collected during this study will be compared to the results of 1980s fish diet studies (ADF&G 1983; Hansen and Richards 1985) to evaluate any differences between the historic and current fish diets. Additional details on sampling and processing methodology and analysis will be described in the River Productivity Implementation Plan.

9.8.4.12. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Upper Susitna River

Organic matter materials serve as an important food resource to benthic macroinvertebrates, serving as a conduit for the energy flow from organic matter resources to vertebrate populations, such as fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). Given the dominant characteristics of the Susitna River system (large, cold, and turbid during the growing season), secondary productivity is not likely to be driven by primary production or from the algal community within the system, but rather by allocthanous inputs of organic material from the terrestrial environment. Benthic organic material is one of the most important “interrelated environmental factors” influencing the macroinvertebrate community, and damming the river will have significant consequences for the transport of organic matter from the upper watershed. Therefore, to address the importance of organic matter to productivity in this type of system, quantifying benthic organic matter as part of this study is essential.

This organic matter exists as both fine particulate organic matter (FPOM) and coarse particulate organic matter (CPOM). FPOM includes particles ranging from 0.45 to 1000 µm in size, and can occur in the water column as seston, or deposited in lotic habitats as fine benthic organic matter (FBOM) (Wallace and Grubaugh 1996). CPOM is defined as any organic particle larger than 1 mm in size (Cummins 1974). In order to quantify the amounts of organic matter available in the Susitna River for river productivity, CPOM and FPOM (specifically FBOM) will be collected concurrently with all benthic macroinvertebrate sampling, including the baseline sampling effort addressing the effects of changing flow patterns on benthic communities in sloughs (Objective 2, Section 9.8.4.2.1). Organic debris collected within each sample will be retained after processing for organisms. In order to streamline the collection efforts, a net mesh size of 250 µm for sampling devices will retain FPOM in the 250–1,000 µm size range for analysis, as well as CPOM particles. Suspended FPOM (seston) will be collected from material in invertebrate drift samples, utilizing the 250-µm mesh size for drift nets, as well (Objective 3, Section 9.8.4.3). Organic matter retained after organism sorting and processing will be separated from inorganic material, rinsed through sieves to separate particles into size classes, oven-dried (60°C), and weighed. Results will be calculated as amounts of CPOM and FPOM per unit area (g/m^2 and g/m^3, respectively). For the two selected stations, portions of the material will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2). Additional details on sampling and processing methodology and analysis will be described in the River Productivity Implementation Plan.

9.8.4.13. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna River Segment t under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

Colonization is a process in which organisms move into and become established in new areas or habitats (Smock 1996). In disturbed habitats, this process is more accurately called recolonization. Numerous studies have shown that macroinvertebrates can rapidly colonize new or disturbed substrates (Shaw and Minshall 1980; Ciborowski and Clifford 1984; Williams and Hynes 1977; Townsend and Hildrew 1976; Miyake et al. 2003). The rate of recolonization is dependent on several factors, including time of the year, substratum particle size, the structure of the macroinvertebrate assemblages available to colonize at the time, and the distance of the colonist assemblages from the new or disturbed area (Robinson et al. 1990; Smock 1996; Mackay 1992).

Two additional factors, predicted as major post-Project effects, that may affect colonization rates are changes in turbidity and temperature. In order to assess the influences of turbidity and temperature on the benthic community colonization rates, a field study will be conducted for both study years (2013 and 2014) to estimate potential benthic macroinvertebrate colonization rates for four different habitat types that reflect these conditions in the Susitna River. Due to the difficulty of isolating each of these conditions under natural conditions, colonization will be examined under turbid/warm, clear/warm, turbid/cold, clear/cold conditions. Sampling locations and scheduling will be determined after a review of 2012 study results, from both AEA studies, as well as from data collected outside of AEA, and site reconnaissance to assess candidate sites.

Sets of three preconditioned artificial substrates will be deployed incrementally for set periods of colonization time (e.g., 8, 6, 4, 2, and 1 week[s]) and then pulled simultaneously at the conclusion of the colonization period. Artificial substrates will be deployed at two depths at fixed sites along the channel bed. Benthic macroinvertebrate processing protocols will be identical to those used in Objective 2 (Section 9.8.4.2.1). Specific details on site locations, the choice of artificial substrates, and timing of colonization tests will be provided in the River Productivity Implementation Plan.

Colonization information will be compared with colonization results from similar river systems and with post-Project colonization results. In addition, results will be utilized in HSC/HSI development (Objective 6, Section 9.8.4.6), and in the varial zone modeling task in the Instream Flow Study (Section 8.5.4.6.1.6) to assist in determining the potential Project effect of short-term flow fluctuations, most commonly the result of hydroelectric power generation, on benthic macroinvertebrates.

9.8.5. Consistency with Generally Accepted Scientific Practices

The methods described above have been developed in consultation with agency and Technical Workgroup (TWG) participants. All data collection and processing efforts will follow state (ADF&G) or federal (EPA, USGS) guidelines referenced throughout the study methods discussion (Agradi 2006; Barbour et al. 1999; Bovee et al. 1998; Eaton et al. 1998; Keup 1988; Klemm et al. 1990, 2000; Major and Barbour 2001; Moulton et al. 2002; Peck et al. 2006; USFWS 1980). In addition, any laboratory analysis will be conducted by a state- or federally-certified facility.

9.8.6. Schedule

The preliminary schedule for the river productivity study elements is presented in Table 9.8-2. During 2013, the literature review summarizing the impacts of hydropower development and operations on benthic macroinvertebrate and algal communities will be prepared and presented to the TWG. Research, field sampling, and sample processing and analysis will begin in the latter half of the first quarter of 2013, following FERC's approval of the study plan. Field sampling at the Susitna River sites and the Talkeetna River test reference sites for benthic macroinvertebrates, algae, organic matter, drift, fish diet analysis, and stable isotopes will be conducted for three seasonal sampling periods from April through October in both study years (20132014). These seasonal periods are tentatively scheduled for April through early June for Spring, late June through August for Summer, and September through October for Autumn (Table 9.8-2), due to annual variability in the timing of seasons. Specific details on timing will be provided in the River Productivity Implementation Plan. Two additional sampling events for benthic macroinvertebrates, algae, and organic matter to capture responses to storm events will occur during April through October. Exact timing is subject to storm event occurrences. Sample processing of organisms and materials collected in the 2013 field efforts will require extensive laboratory efforts, and will continue throughout the remainder of 2013 and into the first quarter of 2014. Trophic analysis efforts will also begin in the latter half of the first quarter of 2013 and continue throughout 2013 and 2014. The Initial Study Report summarizing these 2013 activities will be issued within one year of FERC's Study Plan Determination (i.e., February 1, 2013).

Results from the 2013 effort will be utilized in the effort to generate habitat suitability criteria, which begin early in the first quarter of 2014. Second-year field sampling efforts, adhering to the same tentative scheduling as in 2013, will resume in the latter half of the first quarter of 2014, with sample processing, data analysis, trophic analysis research continuing through the fourth quarter. The Updated Study Report will be produced within two years of FERC's Study Plan Determination.

9.8.7. Relationship with Other Studies

The flow of information into and out of the River Productivity Study is anticipated to occur over the two year study period through an iterative process. The River Productivity Study is interrelated to several AEA studies (Figure 9.8-3). The Instream Flow Study (Section 8.5), Characterization and Mapping of Aquatic Habitat Study (Section 9.9), and the Geomorphology studies (Sections 6.5 and 6.6) will provide useful information, expected by Q1 2013, to assist in the site selection process. The Baseline Water Quality Study (Section 5.5) will provide useful input information for analysis of river productivity for use in the trophic analysis (Section 9.8.4.5). The Upper (Section 9.5) and Middle and Lower River (Section 9.6) Fish Distribution and Abundance studies will provide information on target fish species for the trophic analysis, including life history event timing to assist in sampling scheduling and seasonal locations in Q1 2013 and Q1 2014, as well as throughout the 2013 and 2014 field seasons. The Fish Distribution and Abundance studies will also coordinate with the collection of samples for gut content analysis (Section 9.8.4.7) and stable isotope analysis (Section 9.8.4.5.2) throughout the field seasons. Output information from the multiple objectives of the River Productivity Study will provide additional input information to the trophic analysis, Objective 5, Section 9.8.4.5, of the River Productivity Study as well as any water quality field measurements (e.g., temperature, turbidity, and PAR data) collected to the Baseline Water Quality Study (Section 5.5) and site-specific field observations from Objective 2 and Objective 9 for use in the Instream Flow Study's IFIM and varial zone models (Section 8.5.4.6). Information flowing out from the River Productivity Study will be communicated with other Fish Progam Study Lead. Additional formal data sharing also will occur among study after completion of QA/QC procedures and with delivery of the Initial Study Report (Q1 2014) and Updated Study Report (Q1 2015).

9.8.8. Level of Effort and Cost

The initial cost estimate for completion of the nine study objectives described above is $1,200,000. Efforts such as the literature review, trophic analysis (bioenergetics model and stable isotope analysis), and HSC criteria development will be office-based studies. Collection of benthic macroinvertebrates, algae, and organic matter, drift samples, and the analysis of fish diets will require three extensive field efforts per year for the two study years. Adult emergence sampling will require monthly to bi-weekly site visits from April through October to collect samples and reset the traps. The colonization study will require frequent site visits each month to deploy additional sets of samplers over the course of the study. A majority of the work effort will take place in the laboratory to sub-sample, sort, and identify the macroinvertebrate and algae samples, as well as to conduct the stable isotope analyses on the numerous sample components. After sample processing, the remainder of the study effort will be office-based, consisting of data entry, analysis, and synthesis and report writing.

9.8.9. Literature Cited

AEA (Alaska Energy Authority). 2011. Pre-application Document: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2011. Prepared for the Federal Energy Regulatory Commission, Washington, DC.

ADF&G (Alaska Department of Fish and Game). 1983. Volume 3. Resident and juvenile anadromous fish studies on the Susitna River below Devil Canyon, 1982. Susitna Hydro

Aquatic Studies, Phase II Basic Data Report. Prepared for Alaska Power Authority. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document 486.

Allan, J.D., M.S. Wipfli, J.P. Caouette, A. Prussian, and J. Rodgers. 2003. Influence of streamside vegetation on inputs of terrestrial invertebrates to salmonid food webs. *Canadian Journal of Fisheries and Aquatic Sciences* 60:309–320.

Angradi, T.R. (editor). 2006. Environmental Monitoring and Assessment Program: Great River Ecosystems, Field Operations Manual. EPA/620/R-06/002. U.S. Environmental Protection Agency, Washington, D.C.

Armitage, P.D. 1984. Environmental changes induced by stream regulation and their effect on lotic macroinvertebrate communities. Pages 139-164 *in* A. Lillehammer and S.J. Saltveit, editors. Regulated Rivers. Universitetsforlaget AS, Norway.

Armstrong, J.B., D.E. Schindler, K.L. Omori, C.P. Ruff, and T.P. Quinn. 2010. Thermal heterogeneity mediates the effects of pulsed subsidies across a landscape. *Ecology* 91(5):1445-1454.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and fish*. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington D.C.

Bartell, S., J. Breck, R. Gardner, and A. Brenkert. 1986. Individual parameter perturbation and error analysis of fish bioenergetics models. *Canadian Journal of Fisheries and Aquatic Sciences* 43(1):160-168.

Beamish, R. J., and C. Mahnken. 2001. A critical size and period hypothesis to explain natural regulation of salmon abundance and the linkage to climate and climate change. *Progress in Oceanography* 49(1-4):423-437.

Beauchamp, D. 2009. Bioenergetic ontogeny: linking climate and mass-specific feeding to life-cycle growth and survival of salmon. Pages 53-72 *in* C Zimmerman, CC Krueger (eds), *Pacific Salmon: Ecology and Management of Western Alaska's Populations*. American Fisheries Society Symposium 70. Bethesda, Maryland.

Beaudreau, A.H., and T.E. Essington. 2009. Development of a new field-based approach for estimating consumption rates of fishes and comparison with a bioenergetics model for lingcod (*Ophiodon elongatus*). *Canadian Journal of Fisheries and Aquatic Sciences* 66(4):565-578.Berg, L., and T.G. Northcote. 1985. Changes in Territorial, Gill-flaring, and Feeding Behavior in Juvenile Coho Salmon (*Oncorhynchus kisutch*) following Short-term Pulses of Suspended Sediment. Canadian Journal of Fisheries and Aquatic Sciences 42(8):1410-1417.

Bevelhimer, M.S., R.A. Stein, and R.F. Carline. 1985. Assessing significance of physiological differences among 3 esocids with a bioenergetics model. *Canadian Journal of Fisheries and Aquatic Sciences* 42(1):57-69.

Bilby R.E., E.W. Beach, B.R. Fransen, J.K. Walter, and P.A. Bisson. 2003. Transfer of nutrients from spawning salmon to riparian vegetation in western Washington. *Transactions of the American Fisheries Society* 132:733–745.

Bilby, R.E., B.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. *Canadian Journal of Fisheries and Aquatic Sciences* 53: 164–173.

Bolker, B.M. 2008. Ecological models and data in R. Princeton University Press, Princeton, NJ.

Bovee, K.D., B.L. Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor, and J. Henriksen. 1998. Stream habitat analysis using the instream flow incremental methodology. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD-1998-0004. viii + 131 pp

Bowen, S.H. 1996. Quantitative description of the diet. Pages 513-529 *in* B. R. Murphy and D. W. Willis, eds., *Fisheries Techniques* (Second Edition). American Fisheries Society, Bethesda, Maryland, USA.

Brandt, S. B., and J. Kirsch. 1993. Spatially explicit models of striped bass growth potential in Chesapeake Bay. *Transactions of the American Fisheries Society* 122(5):845-869.

Brandt, S.B., D.M. Mason, and E.V. Patrick. 1992. Spatially explicit models of fish growth rate. *Fisheries* 17(2):23-&.

Brittain, J.E. and S.J. Saltveit. 1989. A review of the effect of river regulation on mayflies (Ephemeroptera). *Regulated Rivers: Research and Management* 3: 191-204.

Brittain, J.E. and T.J. Eikeland. 1988. Invertebrate drift – A review. *Hydrobiologia* 166: 77-93.

Carter, J.L. and V.H. Resh. 2001. After site selection and before data analysis: sampling, sorting, and laboratory procedures used in stream benthic macroinvertebrate monitoring programs by USA state agencies. *Journal of the North American Benthological Society* 20(4): 658-682.

Cederholm, C.J., Kunze, M.D., Murota, T., and A. Sibatani. 1999. Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. *Fisheries* 24: 6–15.

Chaloner, D.T., K.M. Martin, M.S. Wipfli, P.H. Ostrom, and G.A. Lamberti. 2002. Marine carbon and nitrogen in southeastern Alaska stream food webs: evidence from artificial and natural streams. *Canadian Journal of Fisheries and Aquatic Sciences* 59: 1257-1265.

Chaloner D.T., and M.S. Wipfli. 2002. Influence of decomposing Pacific salmon carcasses on macroinvertebrate growth and standing stock in southeastern Alaska streams. *Journal of the North American Benthological Society* 21:430–442.

Ciancio, J.E., M.A. Pascual, and D.A. Beauchamp. 2007. Energy density of patagonian aquatic organisms and empirical predictions based on water content. *Transactions of the American Fisheries Society* 136(5):1415-1422.

Ciborowski, J.J.H. and H.F. Clifford. 1984. Short-term colonization patterns of lotic macroinvertebrates. *Canadian Journal of Fisheries and Aquatic Sciences* 41: 1626-1633.

Cummins, K.W. 1974. Structure and function of stream ecosystems. *Bioscience* 24: 631-641.

Cushman, R.M. 1983. An inexpensive, floating, insect-emergence trap. *Bulletin of Environmental Contamination and Toxicology* 3(5): 547-550.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. *North American Journal of Fisheries Management* 5: 330-339.

DeNiro, M.J., and S. Epstein. 1981. Influence of diet on the distribution of nitrogen isotopes in animals. Geochim. Cosmochim.Acta, 45: 341–351.

DeVries, D.R., and R.V. Frie. 1996. Determination of age and growth. Pages 483–512 *in* B. R. Murphy, and D. W. Willis, editors. *Fisheries Techniques*, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Duffy, E.J., and D.A. Beauchamp. 2011. Rapid growth in the early marine period improves the marine survival of Chinook salmon (*Oncorhynchus tshawytscha*) in Puget Sound, Washington. *Canadian Journal of Fisheries and Aquatic Sciences* 68:232-240.

Dunbrack, R., and L. Dill. 1984. Three-dimensional prey reaction field of the juvenile coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences* 41(8):1176-1182.

Eaton, A., L. Clesceri, A. Greenberg. 1998. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, D.C.

Farley, E., and M. Trudel. 2009. Growth rate potential of juvenile sockeye salmon in warmer and cooler years on the eastern Bering Sea shelf. *Journal of Marine Biology* 2009.

Fausch, K.D. 1984. Profitable stream positions for salmonids: relating specific growth rate to net energy gain. *Canadian Journal of Zoology* 62(3):441-451.

Finlay, J.C., and C. Kendall. 2007. Stable isotope tracing of temporal and spatial variability in organic matter sources to freshwater ecosystems. Pages 283-333 *in* Michener, R.H., and K. Lajtha, eds. *Stable Isotopes in Ecology and Environmental Science*, 2nd ed. Blackwell Publishing.

Friese, N.Y. 1975. Pre-authorization assessment of anadromous fish populations of the Upper Susitna River watershed in the vicinity of the proposed Devil Canyon Hydroelectric Project. Prepared for the U.S. Fish and Wildlife Service, Anchorage, Alaska. Alaska Department of Fish and Game. APA Document 1611

Hansen, T.F. and J.C. Richards. 1985. Availability of invertebrate food sources for rearing juvenile Chinook salmon in turbid Susitna River habitats. Susitna Hydro Aquatic Studies, Report No. 8. Prepared for Alaska Power Authority. Alaska Department of Fish and Game, Anchorage, Alaska. APA Document No. 2846.

Hanson, P.C., T.B. Johnson, D.E. Schindler, and J.F. Kitchell. 1997. Fish Bioenergetics 3.0. University of Wisconsin Sea Grant Inst., Madison, Wis.

Hauer, F.R. and V.H. Resh. 1996. Benthic macroinvertebrates. Pages 339-369 *in* F.R. Hauer and G.A. Lamberti, editors. *Methods in stream ecology*. Academic Press, San Diego, California.

Hayes, J.W., N.F. Hughes, and L.H. Kelly. 2007. Process-based modeling of invertebrate drift transport, net energy intake and reach carrying capacity for drift-feeding salmonids. *Ecological Modeling* 207(2-4):171-188.

Hershey, A.E. and G.A. Lamberti. 2001. Aquatic insect ecology. Pages 733-775 *in* J.H. Thorp and A.P. Covich, editors. *Ecology and classification of North American freshwater invertebrates*. Academic Press, San Diego, California.

Hicks, B.J., M.S. Wipfli, D.W. Lang, and M.E. Lang. 2005. Marine-derived nitrogen and carbon in freshwater-riparian food webs of the Copper River Delta, southcentral Alaska. *Oecologia* 144: 558-569.

Hughes, N.F., and T.C. Grand. 2000. Physiological ecology meets the ideal-free distribution: Predicting the distribution of size-structured fish populations across temperature gradients. *Environmental Biology of Fishes* 59(3):285-298.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto, Ontario. 555 p.

Hyslop, E.J. 1980. Stomach content analysis: a review of methods and their applications. *Journal of Fish Biology* 17(4):411-429.

James, D.A., I.J. Csargo, A. Von Eschen, M.D. Thul, J.M. Baker, C.A. Hayer, J. Howell, J. Krause, A. Letvin, and S.R. Chipps. 2012. A generalized model for estimating the energy density of invertebrates. *Freshwater Science* 31(1):69-77.

Jensen, O.P., T.R. Hrabik, S.J. D. Martell, C.J. Walters, and J.F. Kitchell. 2006. Diel vertical migration in the Lake Superior pelagic community II. Modeling trade-offs at an intermediate trophic level. *Canadian Journal of Fisheries and Aquatic Sciences* 63(10):2296-2307.

Kamler, J. F. and K.L. Pope. 2001. Nonlethal methods of examining fish stomach contents. Nebraska Cooperative Fish & Wildlife Research Unit -- Staff Publications. Paper 55. http://digitalcommons.unl.edu/ncfwrustaff/55.

Keup, L.E. 1988. Invertebrate fish food resources of lotic environments. Instream Flow Information Paper No. 24. U.S. Fish and Wildlife Service Biological Report 88(13). 96 pp.

Kitchell, J., D. Stewart, and D. Weininger. 1977. Applications of a bioenergetics model to yellow perch (Perca flavescens) and walleye (*Stizostedion vitreum vitreum*). *Journal of the Fisheries Research Board of Canada* 34(10):1922–1935.

Klemm, D.J., J.M. Lazorchak, and D.V. Peck. 2000. Section 9. Benthic Macroinvertebrates *in* J.M. Lazorchak, B.H. Hill, D.K. Averill, D.V. Peck, and D.J. Klemm, editors. Environmental monitoring and assessment program – surface waters: Field operations and methods for measuring the ecological condition of non-wadeable rivers and streams. EPA/620/R-00/007, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. EPA/600/4-90/030, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Kline, T.C., J.J. Goering, O.A. Mathisen, P.H. Poe, and P.L. Parker. 1990. Recycling of elements transported upstream by runs of Pacific salmon: I. $\delta^{15}N$ and $\delta^{13}C$ evidence in Sashin Creek, southeastern Alaska. *Canadian Journal of Fisheries and Aquatic Sciences* 47: 136–144.

Mackay, R.J. 1992. Colonization by lotic macroinvertebrates: a review of processes and patterns. *Canadian Journal of Fisheries and Aquatic Sciences* 49: 617-628.

Madenjian, C.P., D.V. O'Connor, S.M. Chernyak, R.R. Rediske, and J.P. O'Keefe. 2004. Evaluation of a chinook salmon (*Oncorhynchus tshawytscha*) bioenergetics model. *Canadian Journal of Fisheries and Aquatic Sciences* 61(4):627-635.

Major, E.B., and M.T. Barbour. 2001. Standard operating procedures for the Alaska Stream Condition Index: A modification of the U.S. EPA rapid bioassessment protocols, 5th edition. Prepared for the Alaska Department of Environmental Conservation, Anchorage, Alaska.

McCarthy, S.G., J.J. Duda, J.M. Emlen, G.R. Hodgson, and D.A. Beauchamp. 2009. Linking Habitat Quality with Trophic Performance of Steelhead along Forest Gradients in the South Fork Trinity River Watershed, California. *Transactions of the American Fisheries Society* 138(3):506-521.

Meehan, W.R., and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. *Journal of the Fisheries Research Board of Canada*. 35(10): 1359-1363.

Miyake, Y., T. Hiura, N. Kuhara, and S. Nakano. 2003. Succession in a stream invertebrate community: A transition in species dominance through colonization. *Ecological Research* 18: 493-501.

Moss, J.H., D.A. Beauchamp, A.D. Cross, K.W. Myers, E.V. Farley, J.M. Murphy, and J.H. Helle. 2005. Evidence for size-selective mortality after the first summer of ocean growth by pink salmon. *Transactions of the American Fisheries Society* 134(5):1313-1322.

Moulton, S. R. II, J. G. Kennen, R. M. Goldstein, and J. A. Hambrook. 2002. Revised protocols for sampling algal, invertebrate, and fish communities as part of the national water-quality assessment program. USGS Open-File Report 02-150. U.S. Geological Survey, Reston, Virginia.

Neverman, D., and W.A. Wurtsbaugh. 1994. The thermoregulatory function of diel vertical migration for a juvenile fish, *Cottus extensus*. *Oecologia* 98(3):247-256.

Nislow, K.H., C.L. Folt, and D.L. Parrish. 2000. Spatially Explicit Bioenergetic Analysis of Habitat Quality for Age-0 Atlantic Salmon. *Transactions of the American Fisheries Society* 129(5):1067-1081.

Pearcy, W.G. 1992. *Ocean ecology of North Pacific salmonids*. Washington Sea Grant Program, University of Washington Press, Seattle.

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program – Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

Petts, G.E. 1984. *Impounded rivers: perspectives for ecological management*. John Wiley & Sons, New York.

Piccolo, J.J., H.F. Hughes, and M.Y. Bryant. 2007. The effects of water depth on prey detection and capture by juvenile coho salmon and steelhead. *Ecology of Freshwater Fish* 16(3):432-441.

Piccolo, J.J., N.F. Hughes, and M.D. Bryant. 2008a. Development of net energy intake models for drift-feeding juvenile coho salmon and steelhead. *Environmental Biology of Fishes* 83(3):259-267.

Piccolo, J.J., N.F. Hughes, and M.D. Bryant. 2008b. Water velocity influences prey detection and capture by drift-feeding juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss irideus*). *Canadian Journal of Fisheries and Aquatic Sciences* 65(2):266-275.

Rand, P.S., D.J. Stewart, P.W. Seelbach, M.L. Jones, and L.R. Wedge. 1993. Modeling steelhead population energetics in Lakes Michigan and Ontario. *Transactions of the American Fisheries Society* 122(5):977-1001.

Reice, S.R. and M. Wohlenberg. 1993. Monitoring freshwater benthic invertebrates and benthic processes: Measures for assessment of ecosystem health. Pages 287-305 *in* D.M. Rosenberg and V.H. Resh, editors. *Freshwater biomonitoring and benthic macroinvertebrates*. Routledge, Chapman and Hall, Inc., New York, New York.

Riis, J. 1975. Pre-authorization assessment of the proposed Susitna River Hydroelectric Projects: Preliminary investigations of water quality and aquatic species composition. Prepared for the U.S. Fish and Wildlife Service, Anchorage, Alaska. Alaska Department of Fish and Game. APA Document 1611.

Riis, J.C. 1977. Pre-authorization assessment of the proposed Susitna River Hydroelectric Projects: Preliminary investigations of water quality and aquatic species composition.

Prepared for the U.S. Fish and Wildlife Service, Anchorage, Alaska. Alaska Department of Fish and Game. APA Document 1610

Robinson, C.T., G.W. Minshall, and S.R. Rushforth. 1990. Seasonal colonization dynamics of macroinvertebrates in an Idaho stream. *Journal of the North American Benthological Society* 9(3): 240-248.

Ruff, C. P., D.E. Schindler, J.B. Armstrong, K.T. Bentley, G.T. Brooks, G.W. Holtgrieve, M.T. McGlauflin, C.E. Torgersen, and J.E. Seeb. 2011. Temperature-associated population diversity in salmon confers benefits to mobile consumers. *Ecology* 92(11):2073-2084.

Saltveit, S.J., J.E. Brittain, and A. Lillehammer. 1987. Stoneflies and river regulation – a review. Pages 117-129, *in* J.F. Craig and J.B. Kemper, editors. *Regulated Streams: Advances in Ecology*. Plenum Press, New York.

Shaw, D.W. and G.W. Minshall. 1980. Colonization of an introduced substrate by stream macroinvertebrates. *Oikos* 34: 259-271.

Smock, L.A. 1996. Macroinvertebrate movements: Drift, colonization, and emergence. Pages 371-390 *in* F.H. Hauer and G.A. Lamberti, editors. *Methods in stream ecology*. Academic Press, San Diego, California.

Stewart, D. J., and M. Ibarra. 1991. Predation and production by salmonine fishes in Lake Michigan, 1978-88. *Canadian Journal of Fisheries and Aquatic Sciences* 48(5):909-922.

Townsend, C.R. and A.G. Hildrew. 1976. Field experiments on the drifting, colonization and continuous redistribution of stream benthos. *Journal of Animal Ecology* 45(31): 759-772.

Trihey and Associates. 1986. Close-out status report for invertebrate analysis. Prepared for Alaska Power Authority. APA Document 3404

USFWS (U.S. Fish and Wildlife Service). 1980. Habitat evaluation procedures (HEP). ESM 102. U.S. Fish and Wildlife Service, Division of Ecological Services, Washington, D.C., March 31, 1980.

USFWS (U.S. Fish and Wildlife Service). 2012. Letter to the Federal Energy Regulatory Commission, subject: Scoping Comments, Recommendations and Study Requests Notice of Intent to File License Applications; Filing of Pre-Application Document; Commencement of Licenseing Proceeding and Scopeing; Request for Comments on the Pre-Application Docment and Scoping Document 1, and Identifcation of Issues of Associated Study Requests for the Susitna-Watana Hydoelectric Projects 14241-000. Enclosure 11 River Productivity Study Request, dated May 31, 2012

Van Nieuwenhuyse, E.E. 1985. Summary of Results: Task 71, Primary production monitoring effort. Technical Memorandum prepared for Harza-Ebasco Susitna Joint Venture. Arctic Environmental Information and Data Center, University of Alaska-Fairbanks, Anchorage, Alaska. December 1985. SUS Document 597.

Wallace, J.B. and J.W. Grubaugh. 1996. Transport and Storage of FPOM. Pages 191-215 *in* F.H. Hauer and G.A. Lamberti, editors. *Methods in stream ecology*. Academic Press, San Diego, California.

Wallace, J.B. and J.R. Webster. 1996. The role of macroinvertebrates in stream ecosystem function. *Annual Review of Entomology* 41: 115-139.

Ward, J.V. 1976. Effects of flow patterns below large dams on stream benthos: a review. Pages 235-253 *in* J.F. Orsborn and C.H. Allman, editors. Instream flow needs symposium, volume II. American Fisheries Society, Bethesda, Maryland.

Ward, J.V. and J.A. Stanford. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. Pages 215-236 *in* J. V. Ward, and J. A. Stanford, editors. *The Ecology of Regulated Streams*. Plenum Press, New York, New York.

Waters, T.F. 1972. The drift of stream insects. *Annual Review of Entomology* 17: 253-272.

Williams, D.D. and H.B.N. Hynes. 1977. Benthic community development in a new stream. *Canadian Journal of Zoology* 55: 1071-1077.

Wipfli, M.S. 1997. Terrestrial invertebrates as salmonid prey and nitrogen sources in streams: contrasting old-growth and young-growth riparian forests in southeastern Alaska, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 54:1259–1269

Wipfli, M.S., and C.V. Baxter. 2010. Linking Ecosystems, Food Webs, and Fish Production: Subsidies in Salmonid Watersheds. *Fisheries* 35(8):373-387.

Wipfli, M.S., J. Hudson, and J. Caouette. 1998. Influence of salmon carcasses on stream productivity: response of biofilm and benthic macroinvertebrates in southeastern Alaska, U.S.A. *Canadian Journal of Fisheries and Aquatic Sciences* 55: 1503–1511.

Wurtsbaugh, W.A., and D. Neverman. 1988. Post-feeding thermotaxis and daily vertical migration in a larval fish. *Nature* 333(6176):846-848.

9.8.10. Tables

Table 9.8-1. Preliminary macroinvertebrate and algae sampling sites, stratified by reach and habitats. Refer to Figures 9.8-1 – 9.8-2 for locations of the preliminary sampling reaches and stations.

Sampling Reach	Reach Description	Number of Mainstem Sites	Number of Associated Off-channel Sites[1]
Upper Segment			
UR-1, -2, -3	Reference upstream of reservoir	2	4
Middle Segment			
MR-1	Immediately below dam site	1	2
MR-2	Upstream of Devils Canyon	1	2
MR-6	Downstream of Devils Canyon	2	4
Susitna River Totals		6	12

Notes: 1 Side-channels, sloughs, tributary confluences associated with a mainstem sampling site.

Table 9.8-2. Preliminary schedule for River Productivity Study.

Activity	2013				2014				2015
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q
Literature Review on Hydropower Impacts		———	———	———					
Sampling benthic macroinvertebrate communities, algal communities, and organic matter.		⊙———	⊙———	⊙———	———	⊙———	⊙———	⊙———	
Invertebrate drift sampling		⊙———	⊙———	⊙———	———	⊙———	⊙———	⊙———	
Sampling Talkeetna for Reference Site Feasibility Study		⊙———	⊙———	⊙———	———				
Trophic analysis with bioenergetics and stable isotope analysis		⊙———	⊙———	⊙———	———	⊙———	⊙———	⊙———	
Generate habitat suitability criteria					———	———	———	———	
Conduct a fish gut analysis		⊙———	⊙———	⊙———	———	⊙———	⊙———	⊙———	
Establish baseline colonization rates		———	———⊙	———⊙	———	———	———⊙	———⊙	
Data Analysis and Reporting			———	———	———	———	———	———	———
Initial Study Report				———	———Δ				
Updated Study Report								———	———▲

Legend:
——— Planned Activity
⊙ Tentatively scheduled sampling event
Δ Initial Study Report
▲ Updated Study Report

9.8.11. Figures

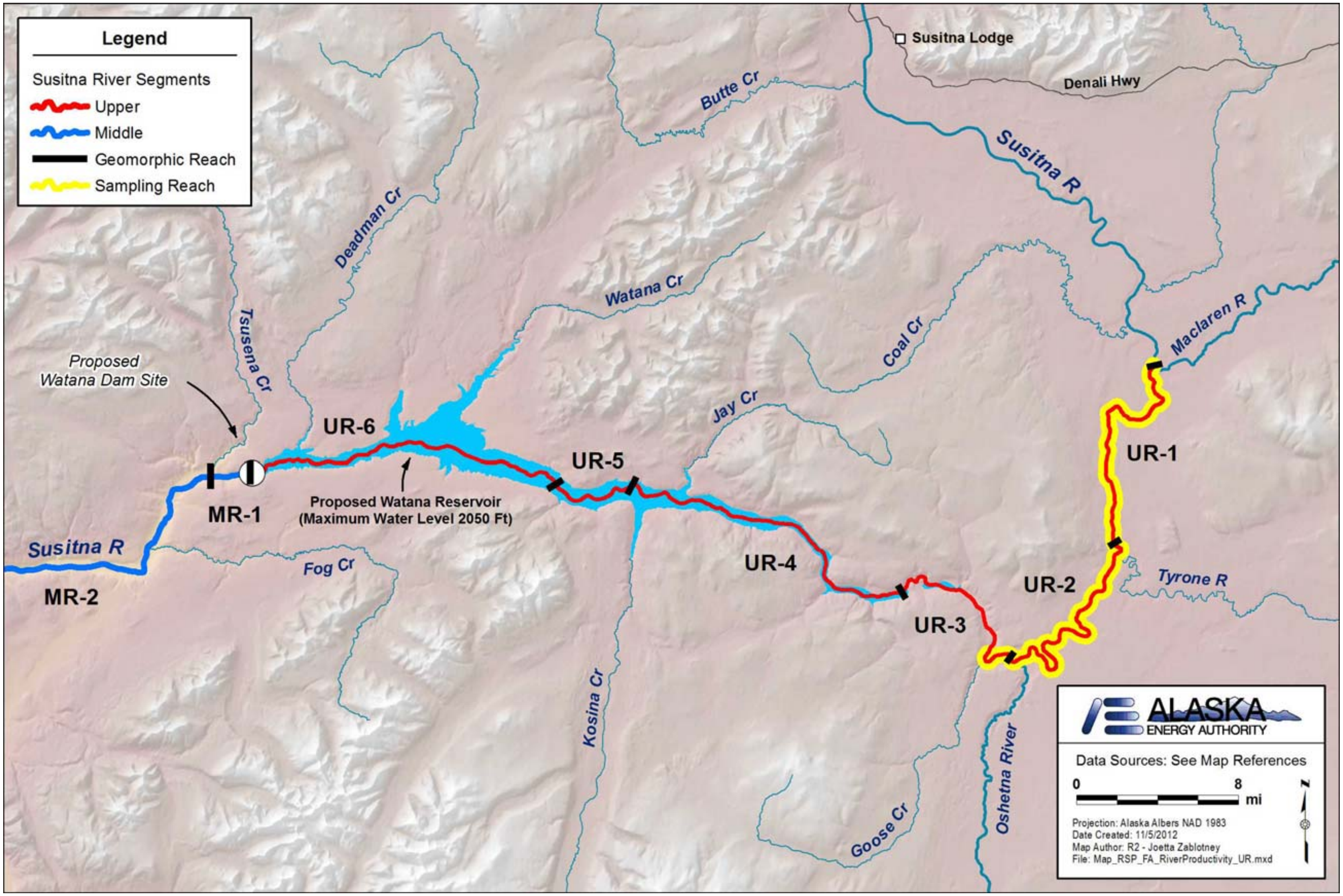

Figure 9.8-1. Upper Susitna River Segment, preliminary sampling reaches for the River Productivity Study.

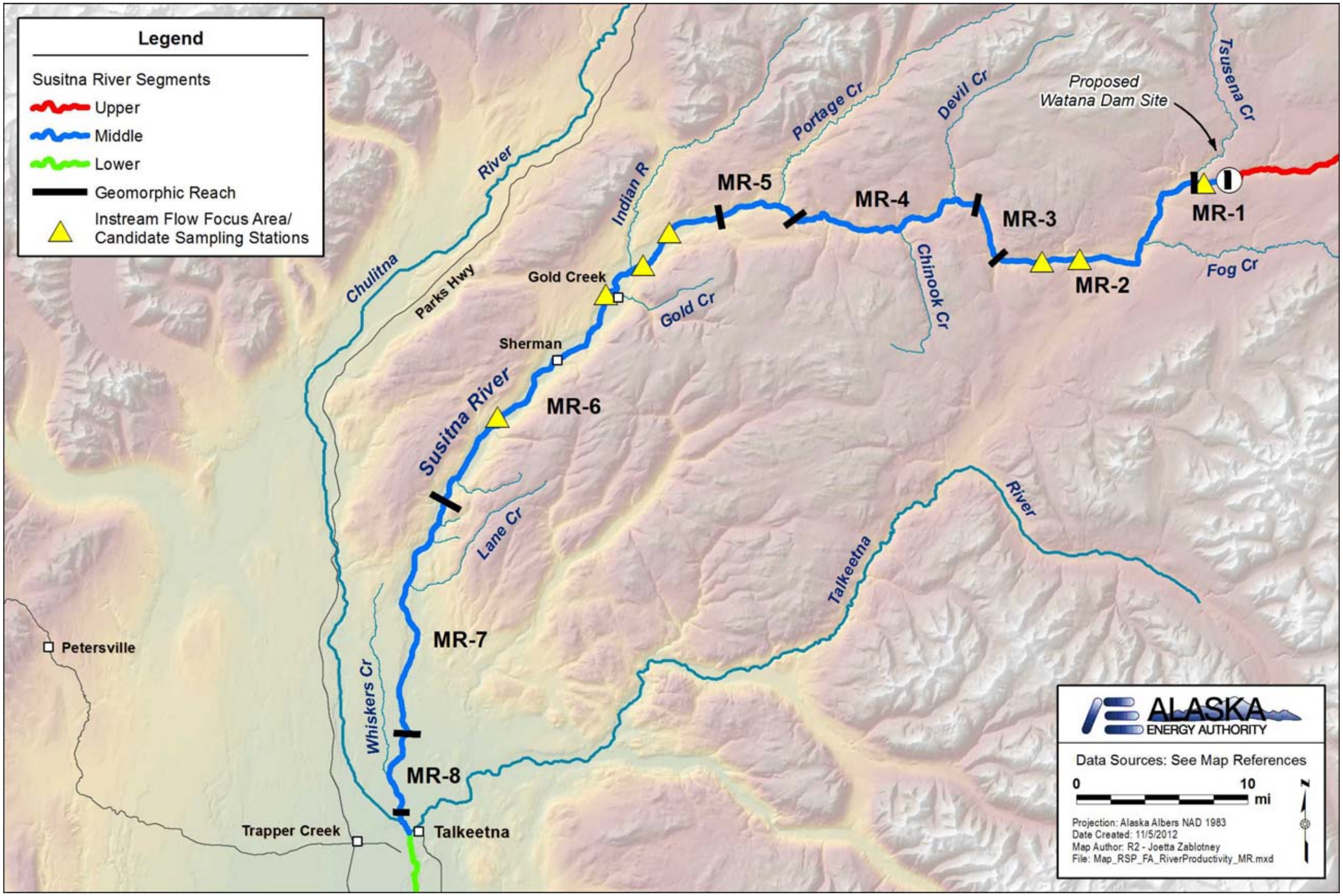

Figure 9.8-2. Middle Susitna River Segment, with the Instream Flow Focus Areas under consideration for the four sampling locations proposed within Geomorphic Reach MR-6 for the River Productivity Study.

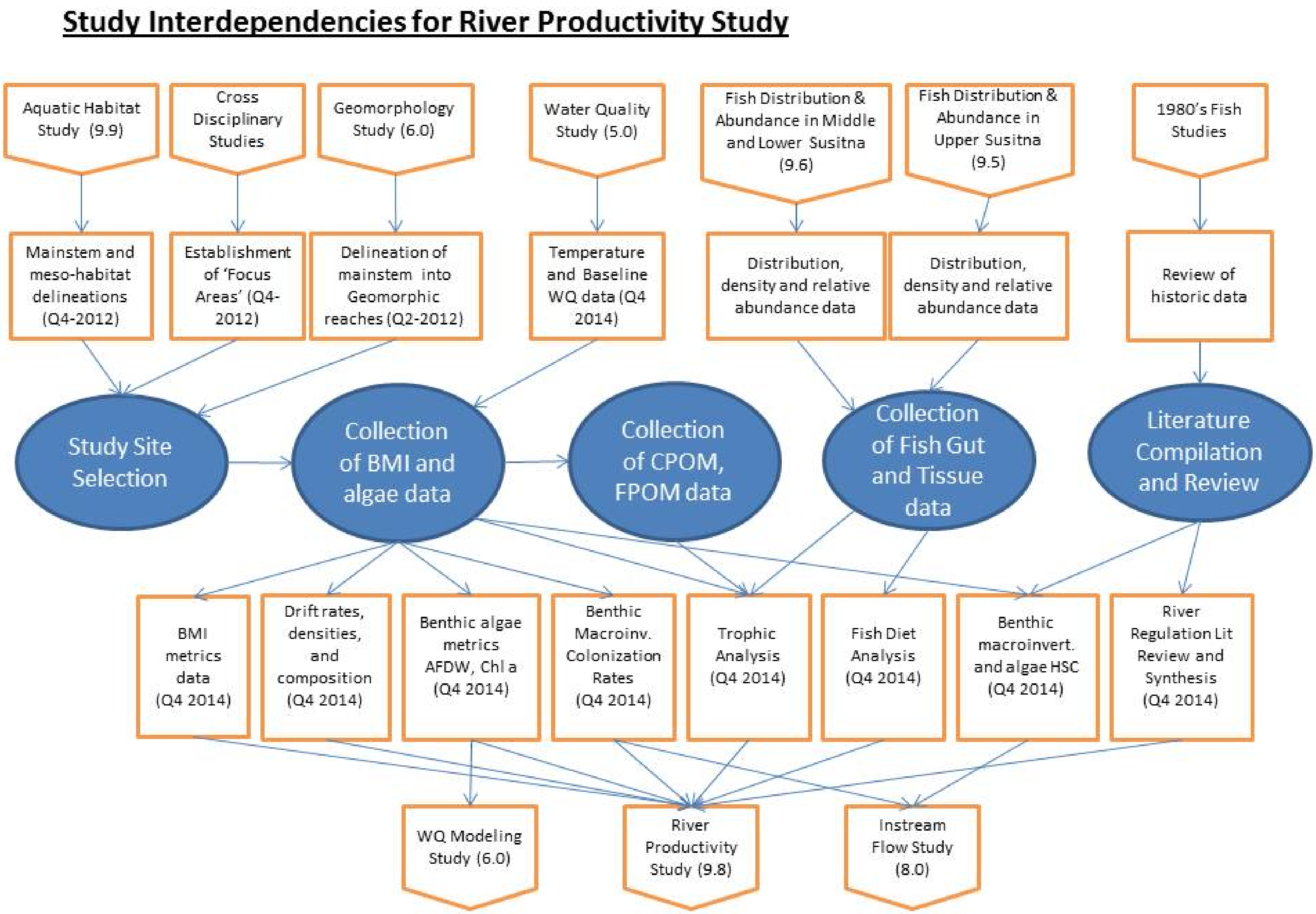

Figure 9.8-3. Study interdependencies for River Productivity Study.

ATTACHMENT C

Study Request Crosswalk Tables
U.S. Fish and Wildlife Service
National Marine Fisheries Service

December 14, 2012

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: Susitna-Watana Hydroelectric Project, Project No. 14241-000

Submission of USFWS and NMFS Study Requests Crosswalk Tables

Dear Secretary Bose:

Through this filing, the Alaska Energy Authority (AEA) is submitting written "crosswalk" tables that compare the original study requests of the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (collectively, the Services), filed with the Federal Energy Regulatory Commission (Commission or FERC) on May 31, 2012, with AEA's Revised Study Plan (RSP) for the original license application for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241 (Project). These crosswalk tables have been prepared at the request of the Commission Staff and the Services.

Concurrent with this filing, AEA is filing the RSP pursuant to the regulations of the Commission, 18 C.F.R. § 5.13(a). The RSP includes 58 individual study plans, organized into resource sections and by topic within each section. As detailed in RSP Section 1.1, AEA has been working closely with licensing participants, including the Services, over the last year to develop this study plan. Following AEA's development of the Proposed Study Plan (PSP) in July 2012, AEA continued to consult regularly with licensing participants on the PSP, which led to AEA's release of an interim draft RSP at the end of October 2012. AEA's responses to comments received during the numerous Technical Workgroup and other meetings during the July through October period appear in Appendix 3 of the RSP, and documentation supporting these comments (e.g., meeting summaries, e-mail messages) appears in Appendix 4 of the RSP. With regard to comments received after the interim draft RSP, the Appendix 1 sets forth AEA's responses to licensing participants' written comments filed with the Commission after November 1. As documented in the RSP and its appendices, AEA and licensing participants have resolved the majority of study-related issues in the Integrated Licensing Process.

With respect to the Services, the attached crosswalk tables document how the objectives and methodologies of the Services' original study requests—dating back to May 2012, prior to the PSP—have been addressed in the RSP. *See* RSP § 1.1.4 n.9. Specifically, the crosswalk tables identify the equivalent RSP sections where the Services' original study request objectives and methodologies have been substantially incorporated into the RSP. In instances where the RSP does not substantially incorporate an original study request objective or methodology submitted by one or both Services, the crosswalk tables either: (1) provide AEA's rationale for not incorporating the objective or methodology; or (2) document, by reference to Appendix 1 of the RSP, how the objective or methodology has been modified, resolved, or dropped from the study plan through the collaborative efforts of the licensing participants following AEA's filing of the PSP.

AEA notes that the Services included references to their specific resource management objectives in several of their study requests. While AEA did not incorporate equivalent resource management objectives in the RSP, it intends to consider those objectives in its Exhibit E Environmental Exhibit included in its License Application. As part of its effort in developing its Exhibit E, AEA will undertake a broader, more comprehensive integrated analysis of Project impacts in the timeframe leading up to its preparation of the Preliminary Licensing Proposal/Draft License Application, and continuing through its filing of the final License Application. The integrated resource analysis envisioned will involve the assimilation of individual study results, identification and understanding of issues and impacts across resources, and an assessment of how those impacts, and potential protection, mitigation, and enhancement measures to address those impacts, might be influenced by elements of other resource areas. This analysis will rely on a variety of analyses and computational models, at appropriate levels of quantification, to compare various "with Project" scenarios to the base case "without Project" conditions. AEA looks forward to interactive engagements with the Services and other licensing participants, starting in early 2015 following the filing of the Updated Study Report, in developing and conducting this integrated resource analysis. Through these engagements, AEA anticipates that the Services' resource management objectives will be comprehensively analyzed based upon study results.

If you have any questions regarding this matter or need additional information, please do not hesitate to contact the undersigned at wdyok@aidea.org or (907) 771-3955.

Sincerely,

Wayne M Dyok

Wayne Dyok
Project Manager
Alaska Energy Authority

Attachments
cc: Distribution List (w/o Attachments)

ATTACHMENT 1

CROSSWALK TABLE BETWEEN

U.S. FISH AND WILDLIFE SERVICE STUDY REQUESTS (MAY 31, 2012)

AND

ALASKA ENERGY AUTHORITY REVISED STUDY PLAN (DECEMBER 14, 2012)

USFWS Study Request Enclosure No. 11:
River Productivity Study

Study Objectives

Requested Study Objectives	RSP Equivalent	AEA Explanation
11.3.1: Develop a white paper on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities in cold climates.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.
11.3.1: Characterize the pre-project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the lower, middle and upper Susitna River.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan. See also AEA's response to comment RIVPRO-26.
11.3.1: Estimate drift of benthic macroinvertebrates in habitats within the lower, middle and upper Susitna River to assess food availability to juvenile and resident fishes.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan. See also AEA's response to comment RIVPRO-26.
11.3.1: Conduct a trophic analysis to describe potential changes in the primary and secondary productivity of the riverine community following post-project construction and operation.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.
11.3.1: Generate habitat suitability criteria (HSC) for Susitna River benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of proposed dam site.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
11.3.1: Characterize the benthic macroinvertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.
11.3.1: Evaluate the feasibility of reference sites on the Talkeetna and Chulitna Rivers to monitor baseline productivity, pre- and post-construction.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.
11.3.1: Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including course particulate organic matter, fine particulate organic matter, and suspended organic matter in the lower, middle, and upper Susitna River.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan. See also AEA's response to comment RIVPRO-26.
11.3.1: Estimate benthic macroinvertebrate colonization rates in the middle and lower reaches to monitor baseline conditions and evaluate future changes to productivity in the Susitna River.	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.

Study Methodologies

Requested Study Methodologies	RSP Equivalent	AEA Explanation
11.3.6: Review and summarize relevant literature, including 1980s Susitna River data.	Section 9.8.4.1.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
11.3.6: Review and summarize the potential effects of dams and hydropower operations, with an emphasis on comparably large hydroelectric projects in cold-weather climates	Section 9.8.4.1.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Sampling sites will be located in multiple locations above and below the proposed dam site (RM 184).	Section 9.8.4. Specific details regarding site locations, timing, sampling devices, processing, and analyses will be dependent upon the results of 2012 data collection efforts.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Sampling collections will be conducted in a variety of habitats (e.g., riffles and large woody debris) within mainstem, tributary confluences, side channels, and sloughs.	Section 9.8.4.2.1.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Sampling will be stratified by reach and mainstem habitat type defined in the project specific habitat classification scheme.	Section 9.8.4.2.1.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Sampling will occur in all study years in all seasons to capture seasonal community structure and productivity.	Section 9.8.4.2.1.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Efforts will be made to locate sampling sites at transects established by the instream flow team, in an attempt to correlate with additional environmental data (flow, substrates, temperature, water quality, riparian habitat, etc.) for statistical analyses, and HSC development.	Section 9.8.4.2.1: All stations established within the Middle River Segment will be located at Focus Areas established by the Instream Flow Study (Section 8.5.4.2.1.1.), in an attempt to correlate macroinvertebrate data with additional environmental data (flow, substrates, temperature, water quality, riparian habitat, etc.) for statistical analyses, and HSC/HSI development.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
11.3.6: Measurements of depth, mean water column velocity, and substrate composition will be taken concurrently with benthic macroinvertebrate sampling at each sample location for use in HSC development in the instream flow studies.	Section 9.8.4.6: describing the method for generating HSC for Susitna macroinvertebrate and algal habitats.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Investigate the ability of the river water quality model (Water Quality Modeling Study) to predict changes in primary productivity in the Susitna River with changes in turbidity and temperature.	Section 9.8.4.5.	USFWS Study Request methodology substantially incorporated into study plan.
11.3.6: Target fish species will be determined by consultation and coordination with fish distribution and abundance study teams (Fish Distribution and Abundance in the Middle and Lower Susitna River Study, Fish Distribution and Abundance in the Upper Susitna River Study, and/or Salmon Escapement Study teams).	Section 9.8.4.5.1.	USFWS Study Request methodology substantially incorporated into study plan.

USFWS Study Request Enclosure No. 13:
Early Life History and Juvenile Fish Distribution and Abundance in the Susitna River

Study Objectives

Requested Study Objectives	RSP Equivalent	AEA Explanation
13.3.1: Determine the seasonal distribution, relative abundance (as determined by CPUE, fish density, and counts), and fish-habitat associations of juvenile anadromous and juvenile resident fish species in the mainstem Susitna River (side channel, slough, backwater, and tributary confluence habitats.	Sections 9.5.1 and 9.6.1.	USFWS Study Request objective substantially incorporated into study plan.
13.3.1: Describe the seasonal movements and migratory patterns of juvenile anadromous and resident fish species among mainstem habitats and between tributaries and mainstem habitats with emphasis on identifying foraging and overwintering habitats.	Sections 9.5.1 and 9.6.1.	USFWS Study Request objective substantially incorporated into study plan.
13.3.1: Document the timing of downstream movement of all juvenile fish species and outmigration for anadromous salmon.	Sections 9.5.1 and 9.6.1.	USFWS Study Request objective substantially incorporated into study plan.
13.3.1: Document the age structure, growth, and condition of juvenile anadromous and juvenile resident fish by season.	Sections 9.5.1 and 9.6.1.	USFWS Study Request objective substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
13.3.1: Collect and analyze tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Genetic Analysis study.	Sections 9.5.1, 9.6.1 and 9.14.	USFWS Study Request objective substantially incorporated into study plan.
13.3.1: Collect and provide the Instream Flow study with habitat suitability criteria (HSC) data to support analysis of potential project impacts.	Section 8.5.1.2.	USFWS Study Request objective substantially incorporated into study plan.
13.3.1: Evaluate salmon incubation (embryo development, hatching success, and emergence times) and associated water quality conditions (e.g., temperature, DO, pH) at existing spawning habitats (slough, side channel, tributary, and mainstem) in areas with and without groundwater upwelling in the middle and lower reaches of the Susitna River.	Sections 8.5.1.2 and 9.6.1, except AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
13.3.1: Evaluate the potential for stranding of juvenile fish and stranding mortality by season under proposed operational conditions.	Sections 8.5.4.5.1.2.2, 8.5.4.6.1.1.4 and 8.5.4.6.1.6.1.	USFWS Study Request objective substantially incorporated into study plan.
13.3.1: Measure intragravel water temperature in spawning habitats and winter juvenile fish habitats at different surface elevations and different depths to determine the potential for freezing of redds, freezing of juvenile fish, and their habitats.	Section 8.5.1.2.	USFWS Study Request objective substantially incorporated into study plan.

Study Methodologies

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Collect data using standard sampling techniques (e.g., electrofishing, snorkeling, minnow trapping, and seining) by season. For winter sampling may also use PIT tag arrays, video systems, or both.	Sections 9.5.1, 9.5.4.3.1, 9.5.4.4 and 9.6.4.3.1.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Estimate and compare the relative abundance of juvenile salmon within and across mainstem habitats by season.	Sections 9.5.4.3.1 and 9.6.4.3.1: Relative abundance surveys will include seasonal multi-pass sampling events during the ice-free seasons. As mentioned above, methods will be selected based on species, life stage, and water conditions. Section 9.7.4.5: A comparison will be made of results from 2012–2014 studies to the historical results that characterized the relative abundance, locations of spawning and holding salmon, and use of mainstem, side channel, slough, and tributary habitat types by adult salmon.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Determine the seasonal use and movement patterns of marked/tagged juvenile fish between mainstem habitats strategically selected based on an appropriate sampling strategy (i.e., systematic, random, or stratified random design).	Sections 9.5.4.1 and 9.6.4.1.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Estimate juvenile salmon production of the Susitna River at selected sites.	No equivalent methodology in RSP.	AEA will not be collecting data to generate population estimates necessary for determining salmon production. At request of USFWS, AEA agreed to eliminate population estimates in order to expand the number of sampling sites by collecting only relative abundance and present-absence data. See AEA's response to comment FDAML-54, RSP Appendix 1.
13.3.5: Determine the relative timing, distribution, and abundance of juvenile salmon in mainstem habitats and compare to historical data.	Sections 9.5.4.3.1 and 9.6.4.3.1.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Determine the distribution, and abundance of juvenile salmon in mainstem and tributary habitats upstream of the proposed Watana Dam site during open water (May through October).	Sections 9.5.4.3.1.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Use systematic scheme for sampling across habitat types by season and randomize selection of habitat units to sample.	Sections 9.5.4.1 and 9.6.4.1.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Build upon and use, as appropriate, the 1980s data applicable to non-salmon anadromous, resident, and invasive fish species.	Sections 9.5.4.3 and 9.6.4.3.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Establish a seasonal sampling design that includes turbid and clearwater sampling for these species (as appropriate).	Section 9.6.4.2.	AEA is not specifically targeting turbid and clear water, but AEA anticipates that, by monthly sampling side-channel and sloughs, AEA will be sampling under turbid and clear water conditions.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Sample fish species using appropriate methods for the habitat and season (electrofishing, snorkeling, seining, minnow trapping) in the main channel, side channels, sloughs, and tributary mouths.	Sections 9.5.4.4 and 9.6.4.4.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Develop life stage specific periodicity information for the middle and lower reach in support of the Instream Flow Study.	Sections 9.5.4.3 and 9.6.4.3: Preparation of periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and out-migration).	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Collect additional data to support efforts to determine the timing, distribution, and relative abundance of eulachon in the lower reach of the Susitna River.	Section 9.16.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Coordinate with other Project studies as appropriate (e.g., fish and physical characteristics of the river).	Sections 9.5.7 and 9.6.7.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Coordinate with the Synthesis of Existing Fish Population Data Study to summarize and obtain the 1980s study data applicable to juvenile salmon, non-salmon anadromous, resident and invasive fish species.	Sections 9.5.4.3 and 9.6.4.3.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Use PIT tag antenna arrays near the mouths of select tributaries and sloughs or other mainstem habitats to determine seasonal habitat utilization (mainstem vs. tributary/slough) and movements of targeted fish species in the reach between the Deshka River and the Watana Dam site.	Sections 9.5.4.4.12 and 9.6.4.4.12.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Collect, radio tag, and track fish from selected species. Tag sizes will be chosen to maximize tag life within the constraints of the study fish size. Tracking duration will be determined based on the anticipated life span of the tags chosen.	Sections 9.5.4.4.12 and 9.6.4.4.12.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Operate PIT arrays at strategic side channels, sloughs, or other mainstem habitats, and the confluence of tributaries to allow for tracking of individual fish among mainstem habitats.	Sections 9.5.4.4.12 and 9.6.4.4.12.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Use data from inclined plane, rotary screw traps, or both, in the mainstem to determine the timing of all salmon species emigrating from the upper reach (i.e., Watana Dam site) and from the middle reach of the Susitna River.	Sections 9.5.4.4.10 and 9.6.4.4.10.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Collect fish length and weight data during seasonal fish surveys in Objectives 1 and 3.	Sections 9.5.4 and 9.6.4.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Collect fish length and weight data from fish recaptured with PIT tags during seasonal fish surveys in individual to determine individual fish growth rates by season.	Section 9.5.4.4.12 and 9.6.4.4.12.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Use fish length and weight data to calculate fish condition by season and possibly habitat (e.g., in areas with and without groundwater upwelling).	Sections 9.5.4.3.1, 9.5.4.3.3, 9.6.4.3.1 and 9.5.4.3.3.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Coordinate with the Genetic Analysis study to identify the appropriate target species and genetic sampling protocols to opportunistically collect genetic tissue samples from resident species.	Sections 9.5.4.3.7 and 9.6.4.3.7: In support of the Genetic Baseline Study for Selected Fish Species (Section 9.14), fish tissues will be collected opportunistically in conjunction with all fish capture events.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Coordinate with the Genetic Study to identify the appropriate target species, sampling locations, number of samples per species, and genetic sampling protocols to collect sufficient genetic samples from juvenile salmon.	Sections 9.5.4.3.7 and 9.6.4.3.7.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Systematic surveys will include collection of data for input parameters to IFIM analyses. Specifically, data will include species, length, location in the water column (distance from the bottom), substrate use classification, proximity/ affinity to habitat structure/cover features (e.g., boulder, undercut bank, overhanging vegetation, large woody debris), water depth, mean column velocity, water temperature, and relevant comments pertaining to cover associations and/or behavioral characteristics of the fish observed.	Section 8.5.1.2.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Use modified Whitlock-Vibert boxes or similar methodology to monitor egg development, hatching success, and emergence times in areas with and without groundwater upwelling. Consider using approved hatchery fish source or fish spawned in the field.	Sections 8.5.4.5.1.1.5 and 9.6.1, except AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
13.3.5: Use siphons to monitor egg development and emergence in naturally occurring salmon spawning areas.	Sections 8.5.4.5.1.1.5 and 9.6.1, except AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
13.3.5: Assess egg development and survival of embryos: one potential method could include creating artificial redds and burying egg tubes in known spawning habitats.	Sections 8.5.4.5.1.1.5 and 9.6.1, except AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
13.3.5: Monitor water quality parameters such as temperature and dissolved oxygen in spawning gravels and redds.	Sections 8.5.4.5.1.1.5 and 8.5.4.5.1.2.1.	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Refine and use methods similar to those used in the 1980s, or use other methodologies, to evaluate embryo development, hatching success, and emergence times.	Sections 8.5.4.5.1.1.5 and 9.6.1, except AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
13.3.5: Use or consider other potential methods to determine or estimate fry emergence times (e.g., incline plane traps, fry emergence traps), as appropriate.	Sections 8.5.4.5.1.1.5, 9.6.1, and 9.6.4.3.3, except AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
13.3.5: Monitor range and peak of emergence times and by time of day.	No equivalent methodology in RSP.	The method is not useful in assessing potential Project effects because the scale of this method is too fine and is influenced by variable site-specific conditions.
13.3.5: Identify habitats occupied by juvenile fish (<50 mm in length) using the distribution and abundance information obtained from Objectives 1 and 2.	Section 9.6.4.3.3. Section 9.5.4.1 and 9.6.4.1: Fish distribution sampling will occur at Focus Areas and at representative habitat units to identify seasonal timing, size, and distribution among habitat types for fish (particularly < 50 mm).	USFWS Study Request methodology substantially incorporated into study plan.
13.3.5: Monitor juvenile fish activity by season and time of day to determine periods of activity and inactivity (e.g., when using cover, interstices of gravel).	Section 9.6.4.3.3.	USFWS Study Request methodology substantially incorporated into study plan.

USFWS Study Request Enclosure No. 14:
Adult and Juvenile Non-Salmon Anadromous, Resident and Invasive Fish Studies in the Susitna River Basin (RM 0 - RM 233)

Study Objectives

Requested Study Objectives	**RSP Equivalent**	**AEA Explanation**
14.3.1: Characterize the seasonal (spring, summer, fall, winter) distribution, relative abundance, and habitat utilization in the Susitna River mainstem (RM 0-RM 233) for all life stages of non-salmon anadromous, resident, and invasive fish species. [Documenting both hierarchal nested habitat type and use-type as described in the resource agency Instream Flow Study and Habitat Utilization Study Request].	Section 9.5.1 and 9.6.3, except limited to upper reach of the Lower River, Middle River, and Upper River segments. Section 9.16.	See AEA's response to comment FDAML-01.
14.3.1: Characterize the seasonal (spring, summer, fall and winter) movement patterns of all subject fish species and life stages as they relate to foraging, spawning, rearing and overwintering habitats. The characterization of seasonal movements includes run timing (immigration and emigration) and extent (periodicity) of non-salmon anadromous species in the Susitna River (RM 0-RM 233) and movement into and out of tributary streams. [Interface with resource agency Instream Flow and Habitat Utilization Study Request hierarchal nested habitat types and habitat mapping].	Section 9.5.1 and 9.6.1, except limited to upper reach of the Lower River, Middle River, and Upper River segments.	See AEA's response to comment FDAML-01.

Requested Study Objectives	**RSP Equivalent**	**AEA Explanation**
14.3.1: Characterize the flow-related or synchronized life history strategies (migration, movement, spawning, rearing, hatching, emergence) of non-salmon anadromous, resident and invasive species, and their biological behavioral response (e.g., potential for false attraction, delayed migration or increased holding time, synchrony of spawning, relative hatching and emergence timing) to Project-affected flow alterations (flow, temperature, habitat, water quality).	Sections 8.5, 9.5.1 and 9.6.1 characterize life history strategy and habitat use of all target species.	See AEA's response to comment FISH-06.
14.3.1: Synthesize existing resource data, results and information from 1980's Susitna Hydroelectric studies, and other relevant literature to determine applicability and utility of results and information to the currently proposed project.	Sections 9.5.1 and 9.6.1.	USFWS Study Request objective substantially incorporated into study plan.
14.3.1: Collect tissue samples from all resident and non-salmon anadromous fish species for genetic population structure database and future stock identification analysis. This is particularly important for salmon species, anadromous lamprey, and Bering cisco of the Susitna River drainage.	Sections 9.5.1 and 9.6.1.	USFWS Study Request objective substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
14.3.1: Characterize trophic interactions using seasonal diets (stomach content analysis) of all age classes of non-salmon anadromous, resident and invasive fish species. [Interface with the productivity study, riparian, and instream flow study requests]	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.
14.3.1: Quantify the relative contribution (biomass) of marine-derived nutrients to the ecology of the Susitna River from adult returns of non-salmon anadromous fish species (e. g., Pacific and Arctic lamprey, eulachon, Bering cisco).	Section 9.8.1.	USFWS Study Request objective substantially incorporated into study plan.

Study Methodologies

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Fish distribution surveys should use the hierarchal nesting of habitats described in the resource agency's Instream Flow and Habitat Utilization Study Request to document and describe habitat types.	Sections 9.5.4.1 and 9.6.4.1.	USFWS Study Request methodology substantially incorporated into study plan.
1.3.6: The distribution and movement patterns of these fish should be characterized using remote tagging techniques, such as telemetry and pit-tagging.	Sections 9.5.4.4.12 and 9.6.4.4.12.	USFWS Study Request methodology substantially incorporated into study plan.
1.3.6: Relative abundances should be developed using weirs, mark-recapture, netting or trapping in combination with scientifically sound statistical analysis.	Sections 9.5.4.4, 9.6.4.4 and 9.7.4.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: A minimum of two years of baseline assessment of gear types, including that for winter sampling is necessary before valid fish distribution or habitat use data can be collected.	No equivalent methodology in RSP.	A minimum of two years of baseline assessment of gear types is not needed to meet the goals and objectives of the study plan. See Sections 9.5.5 and 9.6.5.
1.3.6: Electro-fishing, trap netting, gill netting, and telemetry studies are widely accepted methods for sampling and observing behavior and habitat selection of fish populations in stream, river and reservoir habitats.	Sections 9.5.4.4 and 9.6.4.4.	USFWS Study Request methodology substantially incorporated into study plan.
1.3.6: Seasonal representative stomach content samples of all species should be collected using current scientific methodologies and protocols for a quantitative analysis.	Section 9.5.4.4.11 and 9.6.4.4.14: A total of eight fish per target species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods (described in Section 9.8.4.7). Section 9.8.4.7: Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).	USFWS Study Request methodology substantially incorporated into study plan.
1.3.6: All data generated during this study will be incorporated into a geospatially-referenced relational database.	Generally incorporated into all applicable studies.	USFWS Study Request methodology substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
15.3.1: Estimate escapement of adult salmon spawning by mainstem reaches and tributaries.	Section 9.7.1.2: Estimate the system-wide Chinook salmon escapement to the entire Susitna River, the coho salmon escapement to the Susitna River above the its confluence with the Yentna River, and the distribution of Chinook, coho, and pink salmon among tributaries of the Susitna River (upstream of Yentna River confluence) in 2013 and 2014.	USFWS Study Request objective substantially incorporated into study plan.
15.3.1: Collect tissue samples to support the Genetic Analysis Study.	Section 9.7.1.2: Collect tissue samples to support the Fish Genetic Baseline Study (Section 9.14). Sections 9.5.1, 9.5.4.3.7 and 9.6.1: Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Genetic Baseline Study (Section 9.14, which includes a dedicated and focused sampling effort to collect salmon and resident fish tissues).	USFWS Study Request objective substantially incorporated into study plan.
15.3.1: Determine system-wide Susitna River escapement and run apportionment.	Section 9.7.1.2, by developing Chinook and coho salmon system and river-wide escapement estimates in 2013 and 2014. These will be added to and build upon the system-wide estimates developed in recent years for all other species except pink salmon.	USFWS Study Request objective substantially incorporated into study plan.

Requested Study Methodologies	**RSP Equivalent**	**AEA Explanation**
15.3.5: Identify potential barriers to salmon spawning habitats by species.	2012 Salmon Escapement and Upper Susitna River Fish Distribution and Habitat Study efforts began to address this objective (Sections 9.5.6 and 9.7.4). Additional data will be collected during 2013 and 2014 pursuant to Sections 9.12.1 and 9.9.4.	USFWS Study Request methodology substantially incorporated into study plan.
15.3.5: Determine flows needed for salmon access to tributaries and mainstem spawning habitats (e.g., sloughs and side channels).	Sections 9.12.4 and 8.5.4.6.1.2.3.	USFWS Study Request methodology substantially incorporated into study plan.
15.3.5: Estimate the available spawning habitat for all salmon species (Chinook, coho, chum, pink, and sockeye) in the mainstem Susitna River in all reaches.	No equivalent methodology in RSP.	Although AEA is not quantifying available habitat, AEA will, through instream flow modeling, quantify flow-habitat relationships for spawning habitat and will address potential project effects to that habitat. See Section 8.5.

ATTACHMENT 2

CROSSWALK TABLE BETWEEN

NATIONAL MARINE FISHERIES SERVICE STUDY REQUESTS (MAY 31, 2012)

AND

ALASKA ENERGY AUTHORITY REVISED STUDY PLAN (DECEMBER 14, 2012)

CROSSWALK TABLE BETWEEN
NATIONAL MARINE FISHERIES SERVICE STUDY REQUESTS (MAY 31, 2012)
AND
ALASKA ENERGY AUTHORITY REVISED STUDY PLAN (DECEMBER 14, 2012)

NMFS Study Request Enclosure No. 3:
Fish Passage Study Request

Study Objectives

Requested Study Objectives	RSP Equivalent	AEA Explanation
1.3.1: Determine the distribution of adult and juvenile Chinook salmon and relative abundance of juvenile Chinook salmon in the Susitna River and its tributaries above Devils Canyon for 2012.	2012 Salmon Escapement and Upper Susitna River Fish Distribution and Habitat Study efforts began to address this objective (Sections 9.5.6 and 9.7.4). Additional data will be collected during 2013 and 2014 pursuant to Sections 9.5.1, 9.6.1 and 9.7.1.2.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Characterize aquatic habitat in the Susitna River and its tributaries/lakes from Devils Canyon upstream to and including the Oshetna River and determine its suitability for Chinook salmon.	Section 9.9.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Determine the fish species composition and relative abundance of all fish species within the reservoir inundation zone in 2012.	2012 Salmon Escapement and Upper Susitna River Fish Distribution and Habitat Study efforts began to address this objective (Sections 9.5.6 and 9.7.4). Additional data will be collected during 2013 and 2014 pursuant to Section 9.5.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Characterize the type and amount of aquatic habitat within the reservoir inundation zone.	Section 9.9.2.	NMFS Study Request objective substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
1.3.1: Identify the locations of potential fish barriers in tributaries between Devils Canyon and the Oshetna River.	2012 Salmon Escapement and Upper Susitna River Fish Distribution and Habitat Study efforts began to address this objective (Sections 9.5.6 and 9.7.4). Additional data will be collected during 2013 and 2014 pursuant to Section 9.12.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Collect genetic samples of Chinook salmon.	Section 9.14.1: Develop a repository of genetic samples for fish species captured within the Susitna River drainage, with an emphasis on those species found in the Middle and Upper Susitna River.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Assist in the development of the 2013-2014 study plans for resident and anadromous fish upstream of Devils Canyon.	No equivalent objective in RSP.	AEA has involved NMFS and other licensing participants in the development of study plans.
1.3.2: Maintaining native and natural aquatic communities for their intrinsic and ecological value and their benefits to people. This includes habitat protection and maintenance to ensure the health and survival of all species and natural communities.	No equivalent objective in RSP.	While not an objective of AEA's study plan, this type of resource management objective will be considered when developing proposed protection, mitigation, and enhancement measures (PM&E measures). See cover letter for further explanation.
1.3.2: Maintaining stream flow regimes sufficient to sustain native riparian and aquatic habitats in the project-affected stream reaches.	No equivalent objective in RSP.	While not an objective of AEA's study plan, this type of resource management objective will be considered when developing proposed PM&E measures. See cover letter for further explanation.
1.3.2: Maintaining the diversified use of fish and wildlife including commercial, recreational, scientific and educational purposes.	No equivalent objective in RSP.	While not an objective of AEA's study plan, this type of resource management objective will be considered when developing proposed PM&E measures. See cover letter for further explanation.

NMFS Study Request Enclosure No. 4:
Early Life History and Juvenile Fish Distribution and Abundance in the Susitna River Study Request

Study Objectives

Requested Study Objectives	RSP Equivalent	AEA Explanation
1.3.1: Determine the seasonal distribution, relative abundance (as determined by CPUE, fish density, and counts), and fish-habitat associations of juvenile anadromous and resident juvenile fish species in the mainstem Susitna River (side channel, slough, backwater, and tributary confluence habitats.	Section 9.6.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Describe the seasonal movements of juvenile anadromous and resident juvenile fish species among mainstem habitats and between tributaries and mainstem habitats with emphasis on identifying foraging and over-wintering habitats.	Sections 9.5.1 and 9.6.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Document the timing of downstream movement of all juvenile fish species, and outmigration for anadromous salmon.	Sections 9.5.1 and 9.6.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Characterize the age structure, growth, and condition of juvenile anadromous and juvenile resident fish by season.	Sections 9.5.1 and 9.6.1.	NMFS Study Request objective substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
1.3.1: Collect and analyze tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Genetic Analysis study.	Sections 9.5.1, 9.6.1 and 9.14.4.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Collect and provide the instream flow study with habitat suitability criteria (HSC) data to support analysis of potential project impacts.	Section 8.5.1.2.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Evaluate salmon incubation (embryo development, hatching success, and emergence times) and monitor associated water quality conditions (e.g., temperature, DO, pH) at existing spawning habitats (slough, side channel, tributary, and mainstem) in areas with and without groundwater upwelling in the middle and lower reaches of the Susitna River.	Section 8.5.2.1 and Section 9.6.1, except that AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
1.3.1: Evaluate the potential for stranding of juvenile fish and stranding mortality by season under proposed project operational conditions.	Section 8.5.4.5.1.2.2, 8.5.4.6.1.1.4 and 8.5.4.6.1.6.1.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Measure intragravel water temperature in spawning habitats and winter juvenile fish habitats at different surface elevations and different depths to determine the potential for freezing of redds, freezing of juvenile fish, and their habitats.	Section 8.5.4.5.1.2.1.	NMFS Study Request objective substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
1.3.2: Maintaining riparian resources, channel conditions, and aquatic habitats.	No equivalent objective in RSP.	While not an objective of AEA's study plan, this type of resource management objective will be considered when developing proposed PM&E measures. See cover letter for further explanation.
1.3.2: Maintaining stream flow regimes sufficient to sustain desired conditions of native riparian, aquatic, and wetland habitats.	No equivalent objective in RSP.	While not an objective of AEA's study plan, this type of resource management objective will be considered when developing proposed PM&E measures. See cover letter for further explanation.
1.3.2: Protecting aquatic systems to which species are uniquely adapted.	No equivalent objective in RSP.	While not an objective of AEA's study plan, this type of resource management objective will be considered when developing proposed PM&E measures. See cover letter for further explanation.

Study Methodologies

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Collect data using standard sampling techniques (e.g., electrofishing, snorkeling, minnow trapping, and seining) by season. For winter sampling may also use PIT tag arrays, video systems, or both.	Sections 9.5.4.3.1 9.5.4.4 and 9.6.4.3.1.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Estimate and compare the relative abundance of juvenile salmon within and across mainstem habitats by season.	Sections 9.5.4.3.1 and 9.6.4.3.1: Relative abundance surveys will include seasonal multi-pass sampling events during the ice-free seasons. As mentioned above, methods will be selected based on species, life stage, and water conditions. Section 9.7.4.5: A comparison will be made of results from 2012–2014 studies to the historical results that characterized the relative abundance, locations of spawning and holding salmon, and use of mainstem, side channel, slough, and tributary habitat types by adult salmon.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Determine the seasonal use and movement patterns of marked/tagged juvenile fish between mainstem habitats strategically selected based on an appropriate sampling strategy (i.e., systematic, random, or stratified random design).	Sections 9.5.4.1, 9.5.4.3.2, 9.6.4.1 and 9.6.4.3.2.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Estimate juvenile salmon production of the Susitna River at selected sites.	No equivalent methodology in RSP.	AEA will not be collecting data to generate population estimates necessary for determining salmon production. At request of USFWS, AEA agreed to eliminate population estimates in order expand the number of sampling sites by collecting only relative abundance and present-absence data. See AEA's response to comment FDAML-54, RSP Appendix 1.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Determine the relative timing, distribution, and abundance of juvenile salmon in mainstem habitats and compare to historical data.	Sections 9.5.4.3.1 and 9.6.4.3.1.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Determine the distribution, and abundance of juvenile salmon in mainstem and tributary habitats upstream of the proposed Watana Dam site during open water (May through October).	Section 9.5.4.3.1.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use systematic scheme for sampling across habitat types by season and randomize selection of habitat units to sample.	Sections 9.5.4.1 and 9.6.4.1.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Build upon and use, as appropriate, the 1980s data applicable to non-salmon anadromous, resident, and invasive fish species.	Sections 9.5.4.3 and 9.6.4.3.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Establish a seasonal sampling design that includes turbid and clear water sampling for these species (as appropriate).	Section 9.6.4.2.	AEA is not specifically targeting turbid and clear water, but AEA anticipates that, by monthly sampling side-channel and sloughs, AEA will be sampling under turbid and clear water conditions.
1.3.6: Sample fish species using appropriate methods for the habitat and season (electrofishing, snorkeling, seining, minnow trapping) in the main channel, side channels, sloughs, and tributary mouths.	Sections 9.5.4.4 and 9.6.4.4.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	**RSP Equivalent**	**AEA Explanation**
1.3.6: Develop life stage specific periodicity information for the middle and lower reach in support of the Instream Flow Study.	Sections 9.5.4.3 and 9.6.4.3: Preparation of periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and out-migration).	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Collect additional data to support efforts to determine the timing, distribution, and relative abundance of eulachon in the lower reach of the Susitna River.	Section 9.16.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Coordinate with the Synthesis of Existing Fish Population Data Study to summarize and obtain the 1980s study data applicable to juvenile salmon, non-salmon anadromous, resident and invasive fish species.	Sections 9.5.4.3 and 9.6.4.3.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Selectively mark individual fish collected during seasonal surveys conducted under study Objective 1 and Objective 4 with PIT-tags.	Sections 9.5.4.4.12 and 9.6.4.12.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use PIT tag antenna arrays near the mouths of select tributaries and sloughs or other mainstem habitats to determine seasonal habitat utilization (mainstem vs. tributary/slough) and movements of targeted fish species in the reach between the Deshka River and the Watana Dam site.	Sections 9.5.4.4.12 and 9.6.4.12.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Coordinate with salmon escapement and fish survey teams to retrieve data from PIT-tag detections and from fish wheel operations related to non-salmon anadromous, resident, and invasive species collected during their studies.	Sections 9.5.7 and 9.6.7.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Collect, radio tag, and track fish from selected species. Tag sizes will be chosen to maximize tag life within the constraints of the study fish size. Tracking duration will be determined based on the anticipated life span of the tags chosen.	Sections 9.5.4.4.12 and 9.6.4.4.12.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use relative abundance and marking data from Objectives 1 and 2 to determine patterns of movement among mainstem habitats by season.	Sections 9.5.4.4.12 and 9.6.4.4.12.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Operate PIT arrays at strategic side channels, sloughs, or other mainstem habitats, and the confluence of tributaries to allow for tracking of individual fish among mainstem habitats.	Sections 9.5.4.4.12 and 9.6.4.4.12.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use data from inclined plane, rotary screw traps, or both, in the mainstem to determine the timing of all salmon species emigrating from the upper reach (i.e., Watana Dam site) and from the middle reach of the Susitna River.	Sections 9.5.4.4.10 and 9.6.4.4.10.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Collect fish length and weight data during seasonal fish surveys in Objectives 1 and 3.	Sections 9.5.4 and 9.6.4.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Collect fish length and weight data from fish recaptured with PIT tags during seasonal fish surveys in individual to determine individual fish growth rates by season.	Sections 9.5.4.4.12 and 9.6.4.4.12.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use fish length and weight data to calculate fish condition by season and possibly habitat (e.g., in areas with and without groundwater upwelling).	Sections 9.5.4.3.1, 9.5.4.3.3, 9.6.4.3.1 and 9.5.4.3.3.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Coordinate with the Genetic Analysis study to identify the appropriate target species and genetic sampling protocols to opportunistically collect genetic tissue samples from resident species.	Sections 9.5.4.3.7 and 9.6.4.3.7: In support of the Genetic Baseline Study for Selected Fish Species (Section 9.14), fish tissues will be collected opportunistically in conjunction with all fish capture events.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Coordinate with the Genetic Study to identify the appropriate target species, sampling locations, number of samples per species, and genetic sampling protocols to collect sufficient genetic samples from juvenile salmon.	Sections 9.5.4.3.7 and 9.6.4.3.7.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Systematic surveys will include collection of data for input parameters to IFIM analyses. Specifically, data will include species, length, location in the water column (distance from the bottom), substrate use classification, proximity/ affinity to habitat structure/cover features (e.g., boulder, undercut bank, overhanging vegetation, large woody debris), water depth, mean column velocity, water temperature, and relevant comments pertaining to cover associations and/or behavioral characteristics of the fish observed.	Section 8.5.1.2.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use modified Whitlock-Vibert boxes or similar methodology to monitor egg development, hatching success, and emergence times in areas with and without groundwater upwelling. Consider using approved hatchery fish source or fish spawned in the field.	Sections 8.5.4.5.1.1.5 and 9.6.1, except that AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
1.3.6: Use siphons to monitor egg development and emergence in naturally occurring salmon spawning areas.	Sections 8.5.4.5.1.1.5 and 9.6.1, except that AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.
1.3.6: Assess egg development and survival of embryos: one potential method could include creating artificial redds and burying egg tubes in known spawning habitats.	Sections 8.5.4.5.1.1.5 and 9.6.1, except that AEA's study plan does not include evaluation of embryo development and hatching success.	See AEA's response to comment FDAML-87, RSP Appendix 1.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Monitor water quality parameters such as temperature and dissolved oxygen in spawning gravels and redds.	Sections 8.5.4.5.1.1.5 and 8.5.4.5.1.2.1.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Refine and use methods similar to those used in the 1980s, or use other methodologies, to evaluate embryo development, hatching success, and emergence times.	Sections 8.5.4.5.1.1.5 and 9.6.1, except that AEA's study plan does not include evaluation of embryo development and hatching success.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Use or consider other potential methods to determine or estimate fry emergence times (e.g., incline plane traps, fry emergence traps), as appropriate.	Sections 8.5.4.5.1.1.5, 9.6.1, and 9.6.4.3.3, except that AEA's study plan does not include evaluation of embryo development and hatching success.	NMFS Study Request methodology substantially incorporated.
1.3.6: Monitor range and peak of emergence times and by time of day.	No equivalent methodology in RSP.	AEA does not believe this methodology would be useful in assessing potential Project effects because the scale of this method is too fine and is influenced by variable site- specific conditions.
1.3.6: Identify habitats occupied by juvenile fish (<50 mm in length) using the distribution and abundance information obtained from Objectives 1 and 2.	Section 9.6.4.3.3. Section 9.5.4.1: Fish distribution sampling will occur at Focus Areas and at representative habitat units to identify seasonal timing, size, and distribution among habitat types for fish (particularly < 50 mm).	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Monitor juvenile fish activity by season and time of day to determine periods of activity and inactivity (e.g., when using cover, interstices of gravel).	Section 9.6.4.3.3.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Objectives	RSP Equivalent	AEA Explanation
1.3.1: Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon to determine the persistence (if any) of habitat use and the utility of data collected during the early 1980s.	Section 9.7.1.2.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Estimate escapement of adult salmon spawning by mainstem reaches and tributaries.	Section 9.7.1.2: Estimate the system-wide Chinook salmon escapement to the entire Susitna River, the coho salmon escapement to the Susitna River above the its confluence with the Yentna River, and the distribution of Chinook, coho, and pink salmon among tributaries of the Susitna River (upstream of Yentna River confluence) in 2013 and 2014.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Collect and analyze tissue samples of all salmon species as described by ADF&G with emphasis on Chinook salmon, to support the Genetic Analysis Study.	Section 9.7.1.2: Collect tissue samples to support the Fish Genetic Baseline Study (Section 9.14). Sections 9.5.1, 9.5.4.3.7, and 9.6.1: Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Genetic Baseline Study (Section 9.14, which includes a dedicated and focused sampling effort to collect salmon and resident fish tissues).	NMFS Study Request objective substantially incorporated into study plan.

Requested Study Methodologies	RSP Equivalent	AEA Explanation
1.3.6: Track the locations and behavior of radio-tagged fish using an array of fixed-station receivers and mobile-tracking surveys. Aerial surveys are anticipated to begin in July and end in early October each year.	Section 9.7.4.2.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Conduct boat- and ground-based surveys to locate holding and spawning salmon to the level of microhabitat use.	Section 9.7.4.2.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Establish an array of fixed-station receivers at and above Devils Canyon to monitor the behavior of radio-tagged fish from approximately early June to October each year.	Sections 9.5.4.3.2 and 9.7.4.3.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Conduct aerial surveys of the upper river to locate tagged and other salmon.	Sections 9.5.4.3.2 and 9.7.4.1.5.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Locate spawning and holding salmon upstream of Devils Canyon.	Section 9.7.4.3.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Based on 2012 pilot study results use side-scan and/or DIDSON to determine salmon spawning locations in turbid water.	Section 9.7.4.3.7.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Compare results from current studies to historical results that characterized the relative abundance, locations of spawning and holding salmon, and use of mainstem, sidechannel, slough, and tributary habitat types by adult salmon.	Section 9.7.4.5.	NMFS Study Request methodology substantially incorporated into study plan.

Requested Study Methodologies	**RSP Equivalent**	**AEA Explanation**
1.3.6: Identify potential barriers to salmon spawning habitats by species.	2012 Salmon Escapement and Upper Susitna River Fish Distribution and Habitat Study efforts began to address this objective (Sections 9.5.6 and 9.7.4). Additional data will be collected during 2013 and 2014 pursuant to Sections 9.12.1 and 9.9.4.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Determine flows needed for salmon access to tributaries and mainstem spawning habitats (e.g., sloughs and side channels).	Sections 9.12.4 and 8.5.4.6.1.2.3.	NMFS Study Request methodology substantially incorporated into study plan.
1.3.6: Estimate the available spawning habitat for all salmon species (Chinook, coho, chum, pink, and sockeye) in the mainstem Susitna River in all reaches.	No equivalent methodology in RSP.	Although AEA is not quantifying available habitat, AEA will, through instream flow modeling, quantify flow-habitat relationships for spawning habitat and will address potential project effects to that habitat. See Section 8.5.

NMFS Study Request Enclosure No. 6:
Susitna River Instream Flow Study Request

Study Objectives

Requested Study Objectives	**RSP Equivalent**	**AEA Explanation**
1.3.1: Characterize the natural flow regime of the Susitna River and tributaries in the project area from the available U. S. Geological Survey (USGS) gage records, flow routing data and models, and other available data.	Section 8.5.4.4.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Identify, characterize, and integrate the timing, quantity and function of instream flow to riverine processes (Poff et al. 1996; Bragg et al. 2005; Schmidt et al. 2004; Assani 2007): geomorphology; floodplain and riparian form and vegetation; biological cues; water quality; surface/groundwater exchange; riverine habitat availability and quality, etc.	Section 8.5.4.7 and 8.5.4.8.	NMFS Study Request objective substantially incorporated into study plan.
1.3.1: Identify, characterize, and quantify the seasonal (time) and spatial distribution of all fish species and life-stages of each species within the defined habitat delineations of the Susitna River and floodplain.	Section 9.6.	NMFS Study Request objective substantially incorporated into study plan.

ATTACHMENT D

Instream Flow Focus Areas
Revised Study Plan 8.5, pp. 8-145 through 8-156

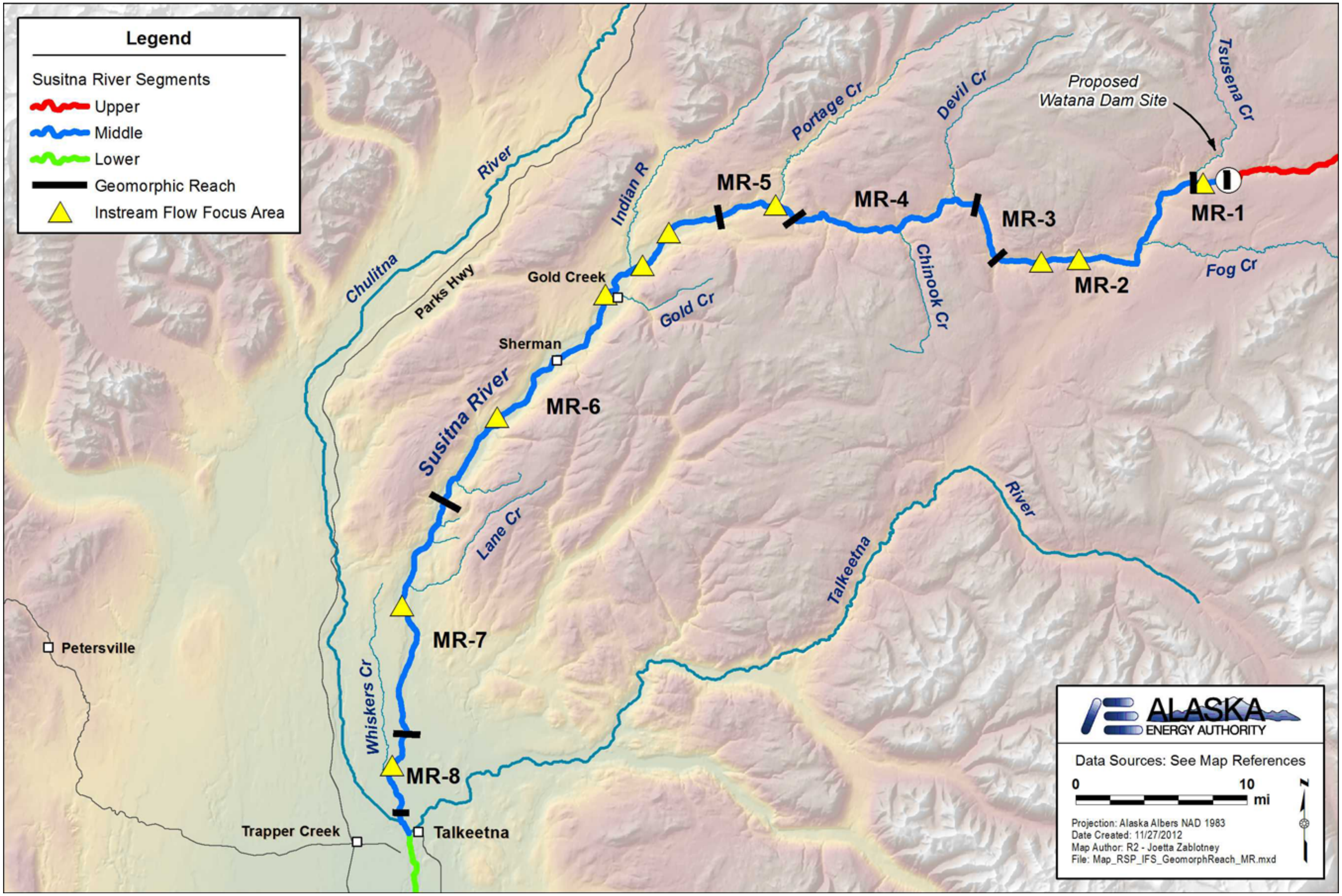

Figure 8.5-11. Map of the Middle Segment of the Susitna River depicting the eight Geomorphic Reaches and locations of proposed Focus Areas. No Focus Areas are proposed for in MR-3 and MR-4 due to safety issues related to sampling within or proximal to Devils Canyon.

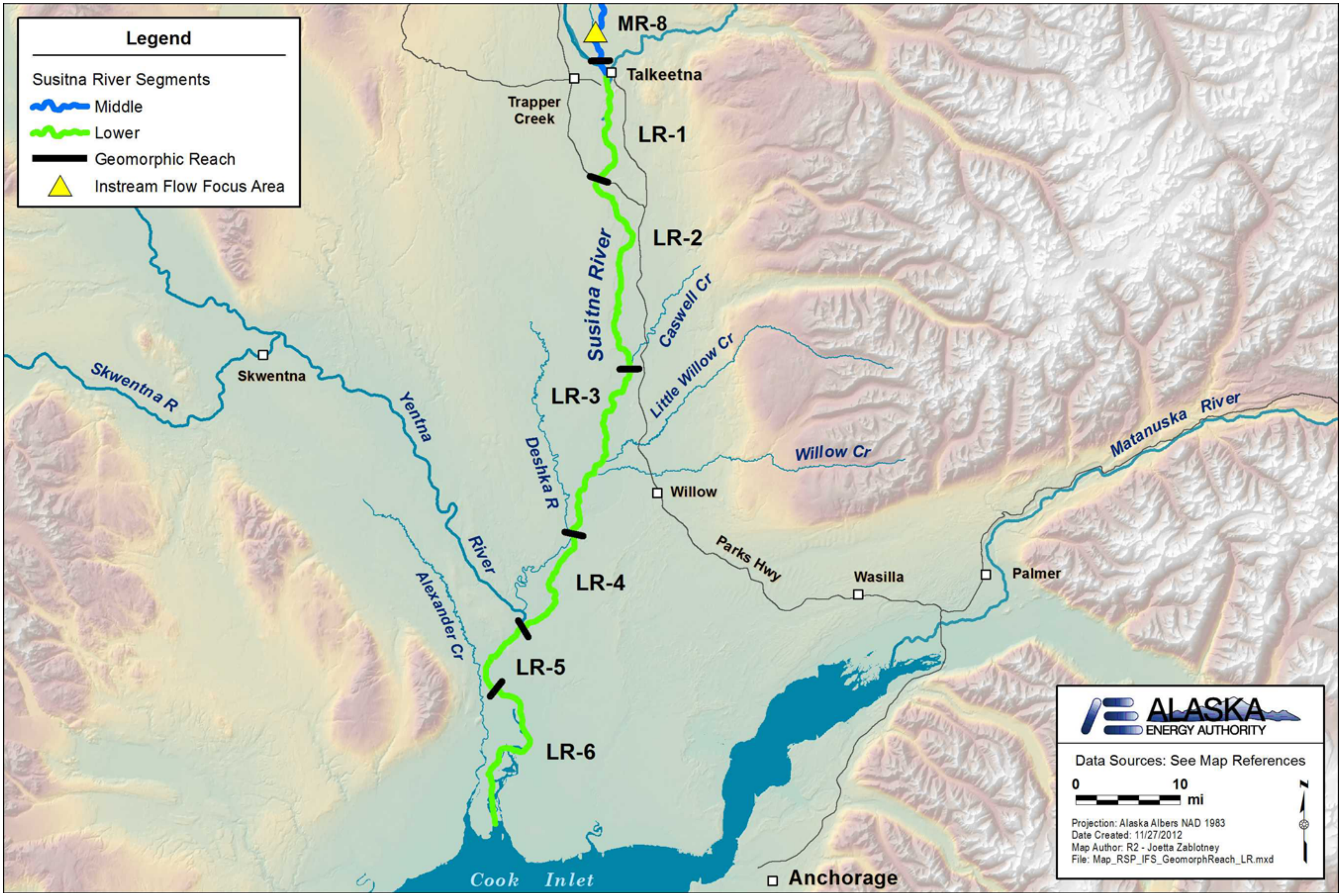

Figure 8.5-12. Map of the Lower Segment of the Susitna River depicting the six Geomorphic Reaches. Focus Areas have not been identified in this segment but will be considered pending results of open-water flow routing modeling.

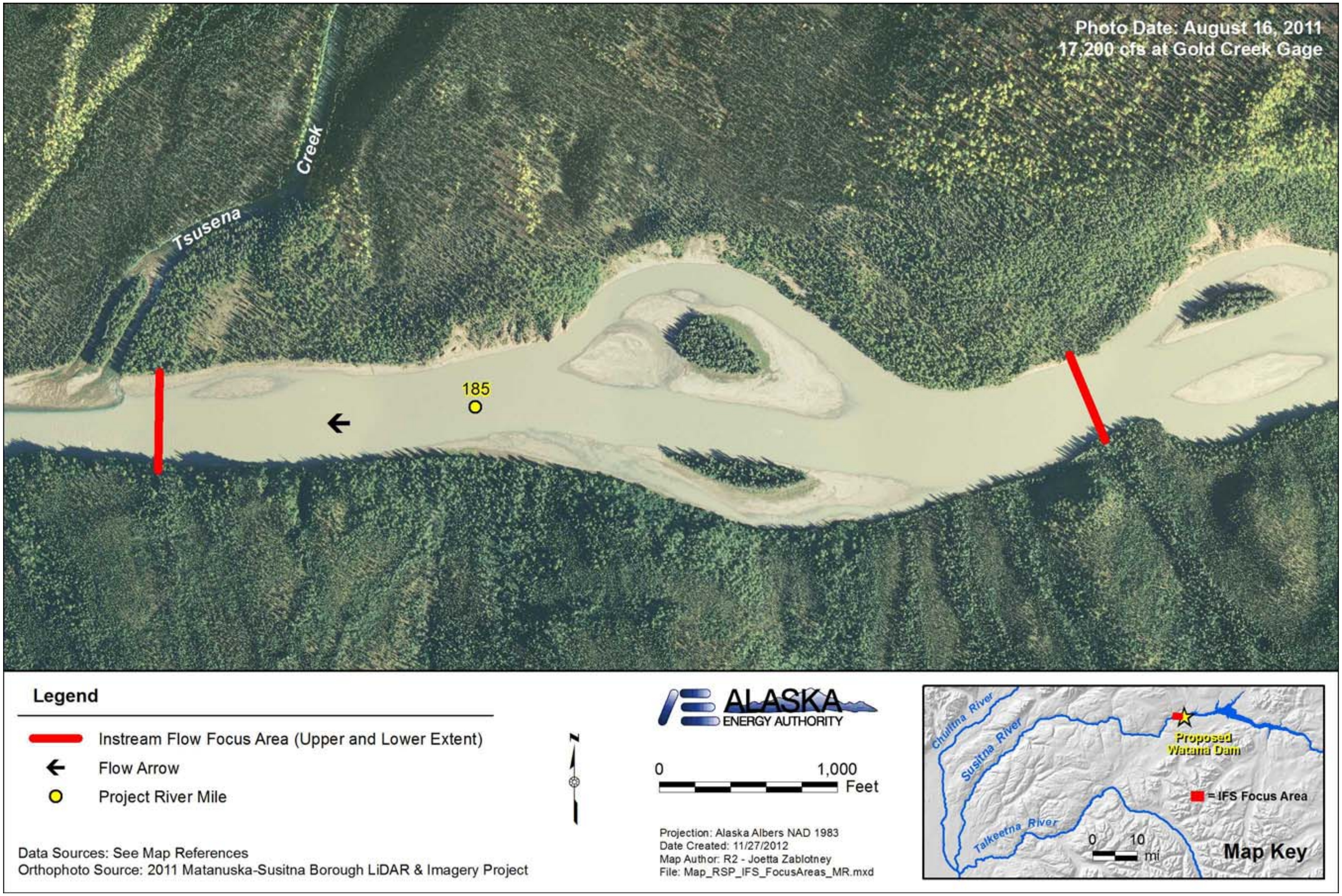

Figure 8.5-13. Map showing Focus Area 184 that begins at Project River Mile 184.7 and extends upstream to PRM 185.7. The Focus Area is located about 1.4 miles downstream of the proposed Watana Dam site near Tsusena Creek.

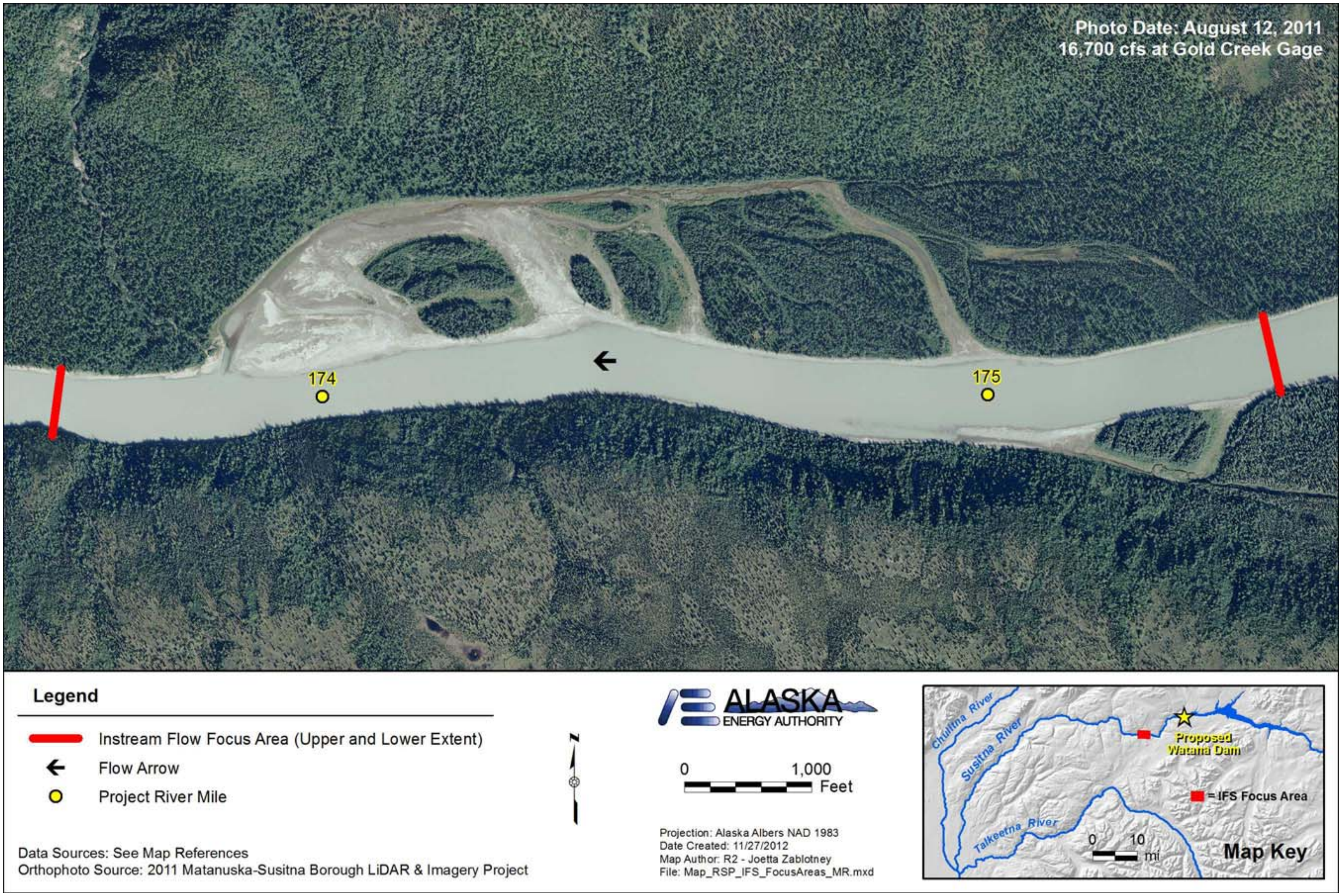

Figure 8.5-14. Map showing Focus Area 173 beginning at Project River Mile 173.6 and extends upstream to PRM 175.4. This Focus Area is near Stephan Lake and consists of main channel and a side channel complex.

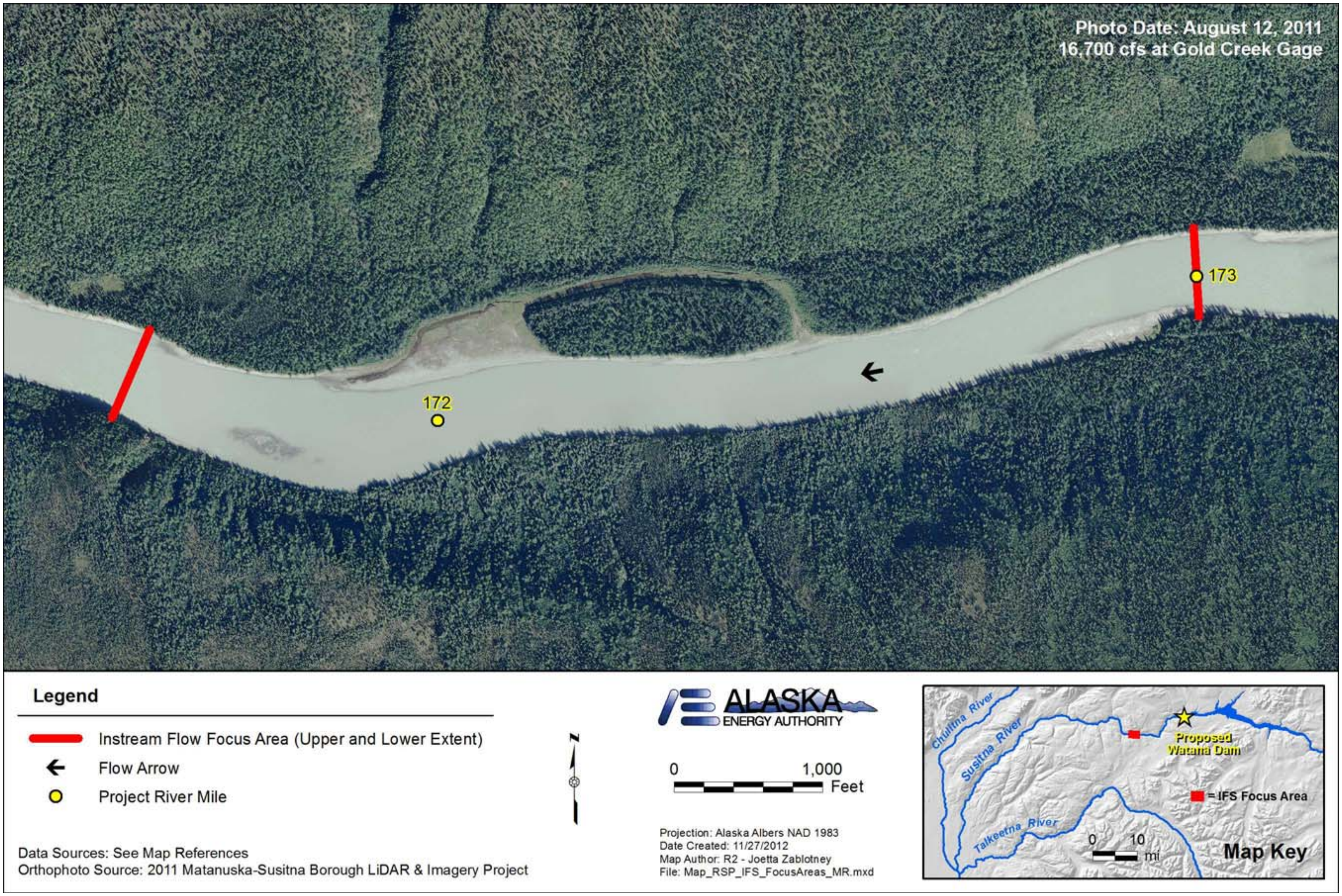

Figure 8.5-15. Map showing Focus Area 171 beginning at Project River Mile 171.6 and extends upstream to PRM 173. This Focus Area is near Stephan Lake and consists of main channel and a single side channel with vegetated island.

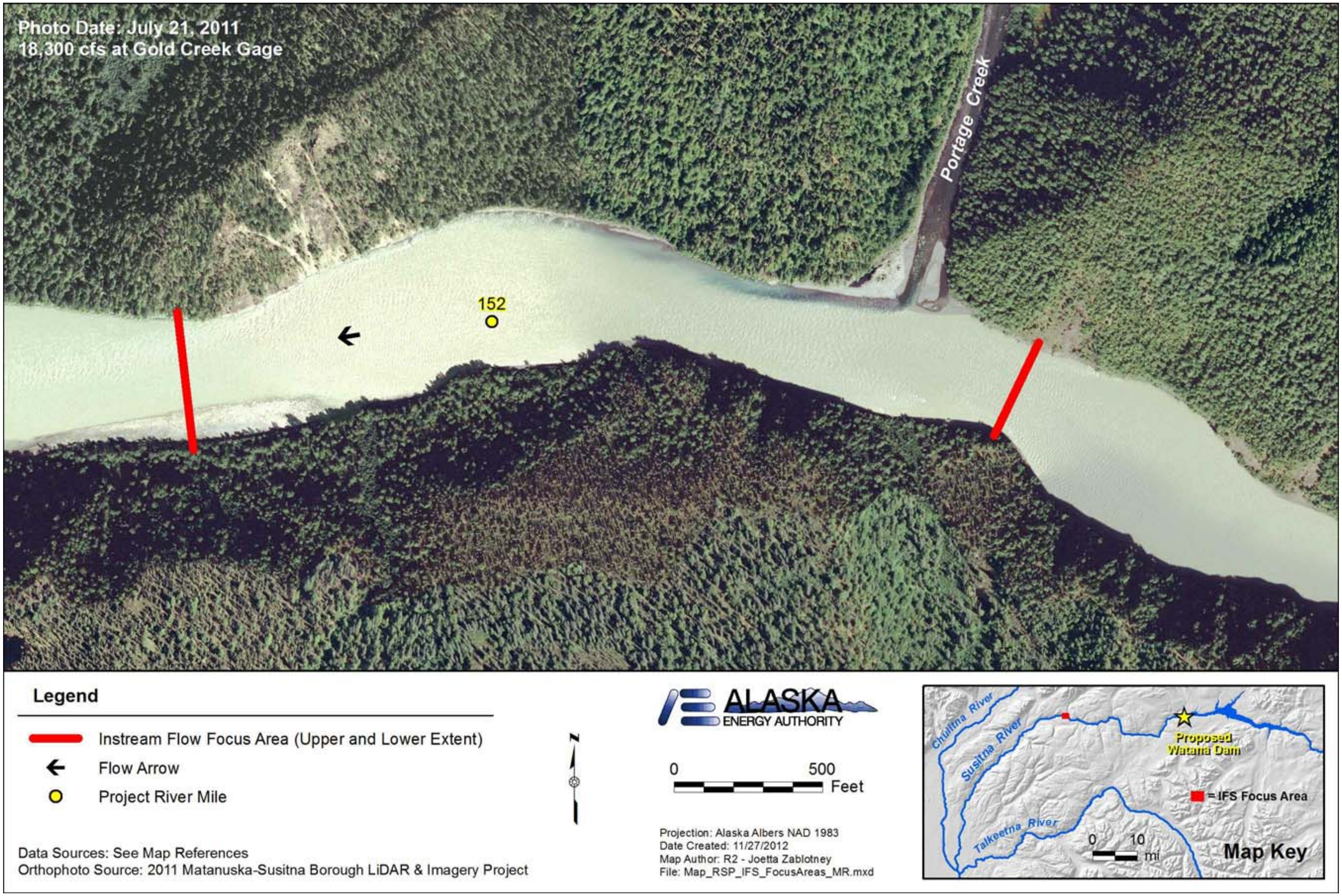

Figure 8.5-16. Map showing Focus Area 151 beginning at Project River Mile 151.8 and extends upstream to PRM 152.3. This single main channel Focus Area is at the Portage Creek confluence.

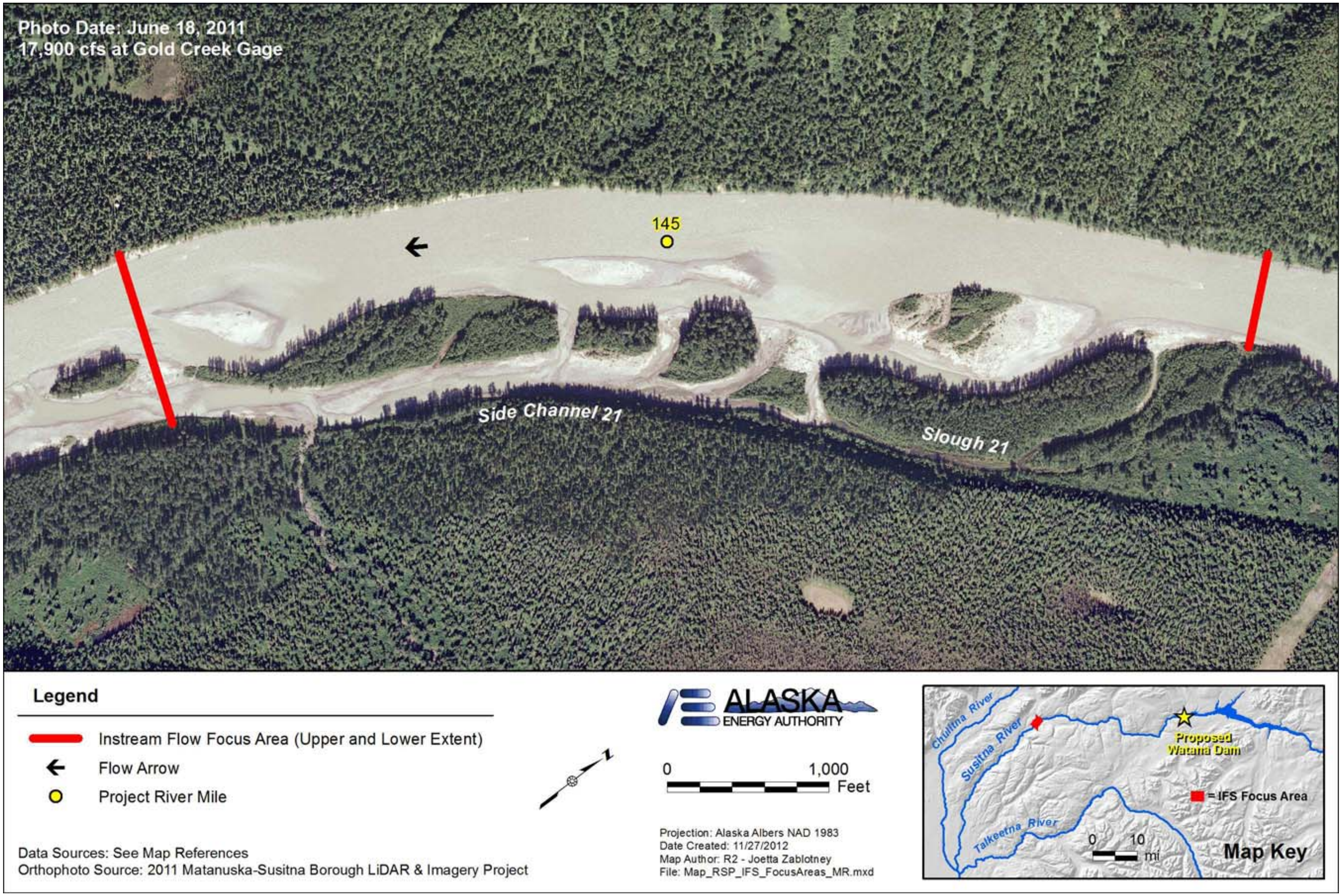

Figure 8.5-17. Map showing Focus Area 144 beginning at Project River Mile 144.4 and extends upstream to PRM 145.7. This Focus Area is located about 2.3 miles upstream of Indian River and includes Side Channel 21 and Slough 21.

Figure 8.5-18. Map showing Focus Area 141 beginning at Project River Mile 141.8 and extends upstream to PRM 143.4. This Focus Area includes the Indian River confluence and a range of main channel and off-channel habitats.

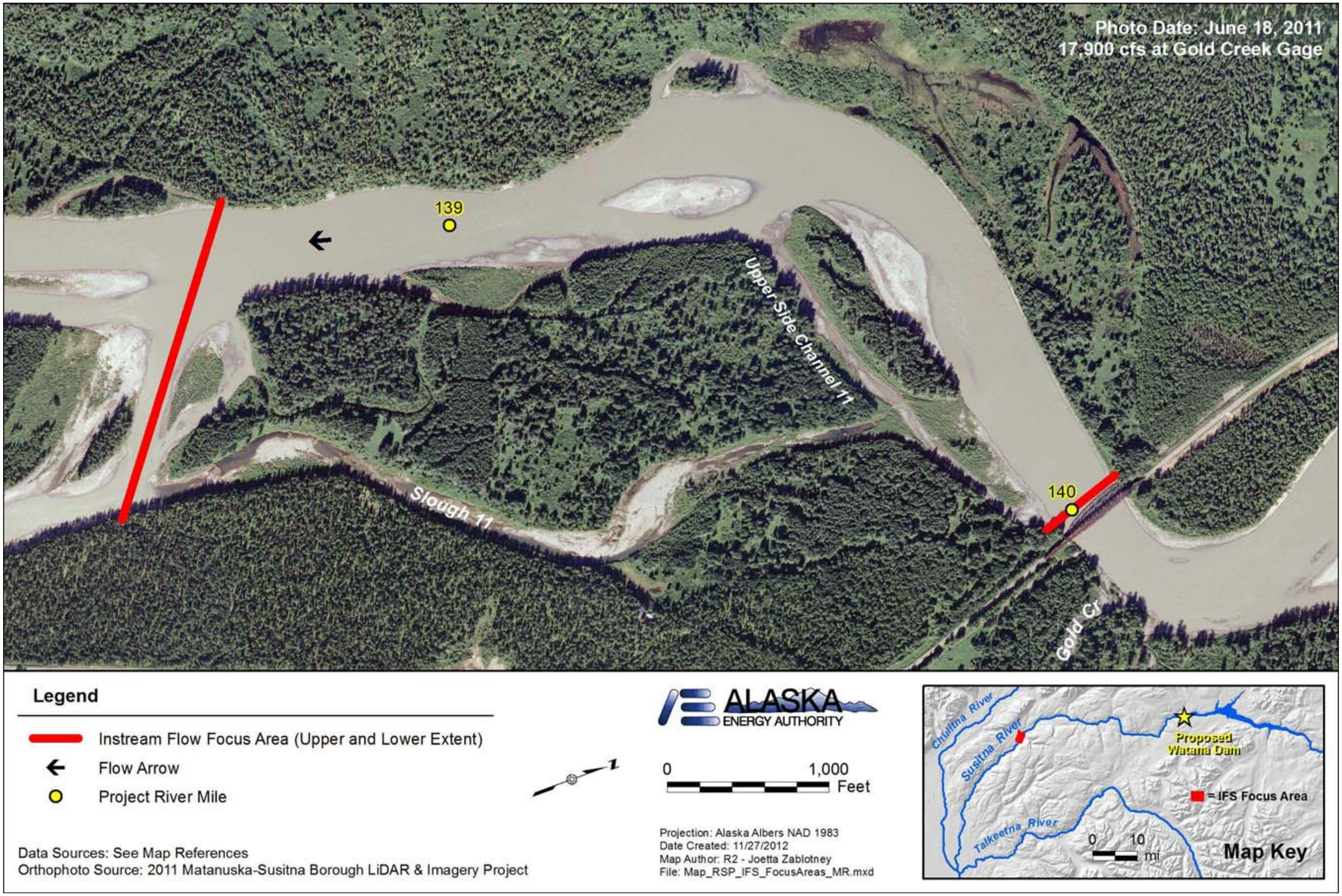

Figure 8.5-19. Map showing Focus Area 138 beginning at Project River Mile 138.7 and extends upstream to PRM 140. This Focus Area is near Gold Creek and consists of a complex of side channel, side slough and upland slough habitats including Upper Side Channel 11 and Slough 11.

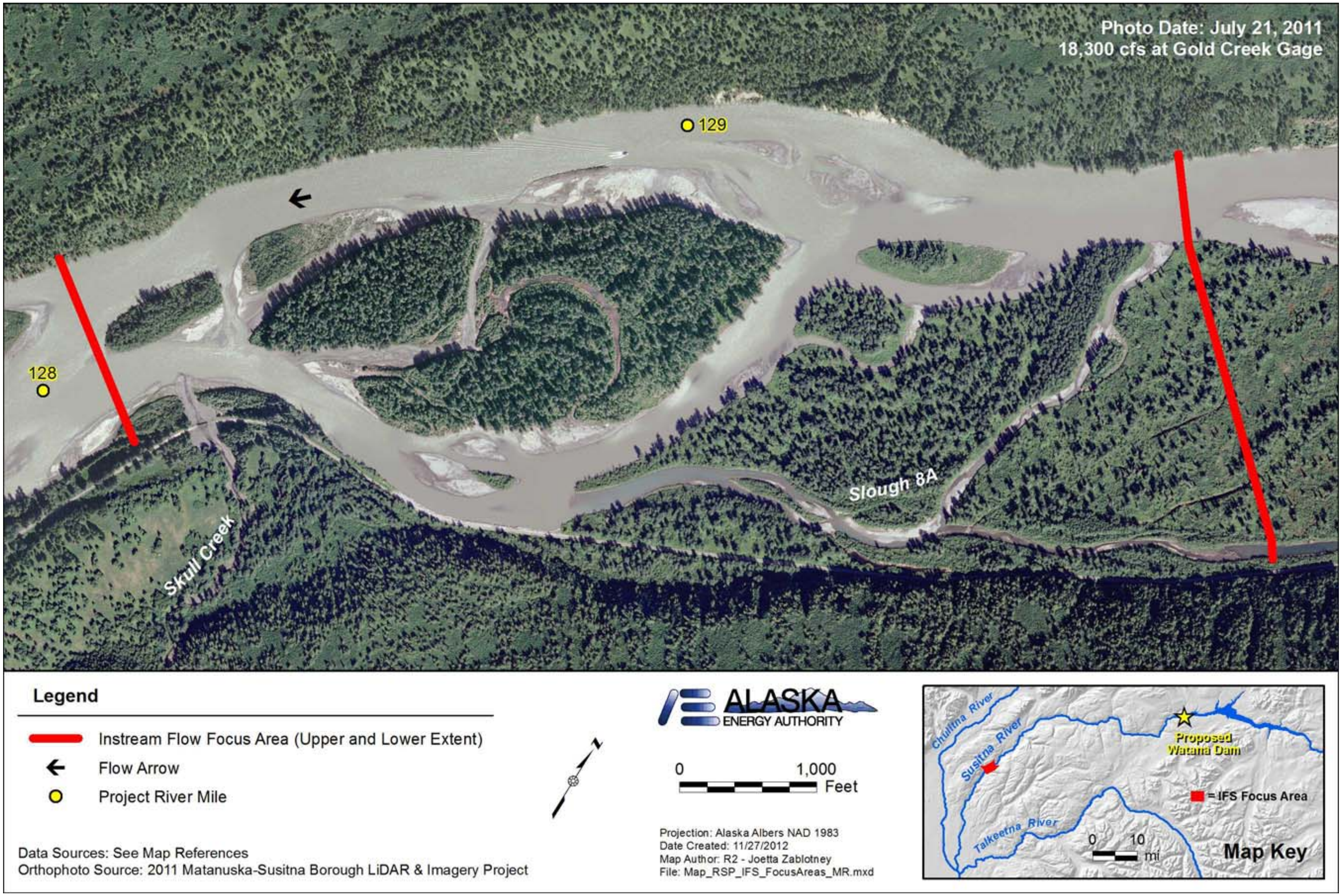

Figure 8.5-20. Map showing Focus Area 128 beginning at Project River Mile 128.1 and extends upstream to PRM 129.7. This Focus Area consists of side channel, side slough and tributary confluence habitat features including Skull Creek.

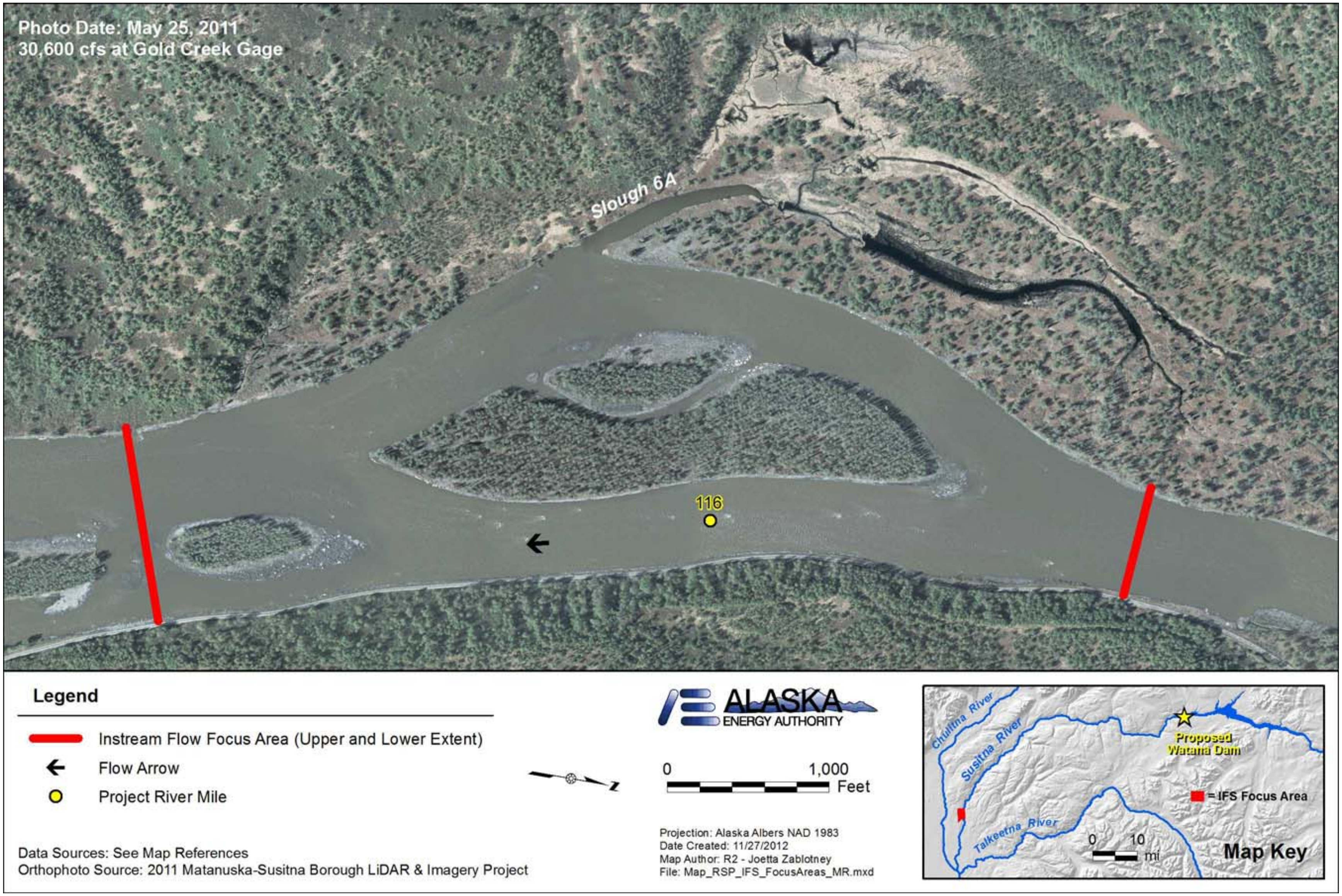

Figure 8.5-21. Map showing Focus Area 115 beginning at Project River Mile 115.3 and extends upstream to PRM 116.5. This Focus Area is located about 0.6 miles downstream of Lane Creek and consists of side channel and upland slough habitats including Slough 6A.

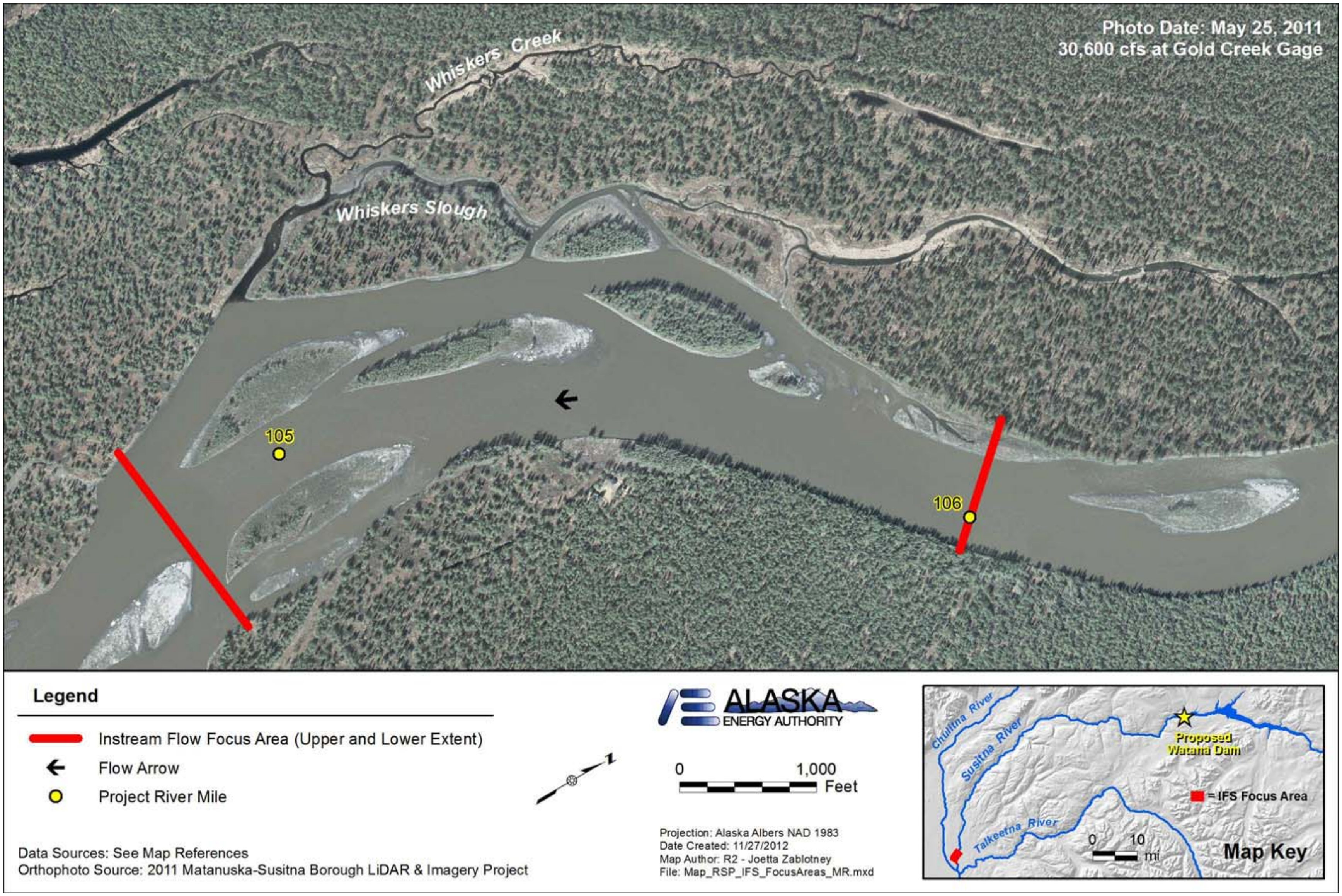

Figure 8.5-22. Map showing Focus Area 104 beginning at Project River Mile 104.8 and extends upstream to PRM 106. This Focus Area covers the diverse range of habitats in the Whiskers Slough complex.

Document Content(s)